State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SACRAMENTO-SAN JOAQUIN DELTA EMERGENCY WATER PLAN

\- Report to the Legislature -

December 1986

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Secretary for Resources
The Resources
Agency

George Deukmejian
Governor
State of California

David N. Kennedy
Director
Department of
Water Resources

FOREWORD

The Sacramento-San Joaquin Delta is a vital link in the State's water supply. Degradation of the supply by saline water could result from the failure of one or more Delta levees, making it unsuitable for use by about two-thirds of California's residents.

To be prepared for this potential problem, Assembly Bill 955 (Peace), Chapter 1271, required the Department of Water Resources to prepare an emergency plan that would allow the Central Valley Project, State Water Project, East Bay Municipal Utility District, and Contra Costa Water District to continue or to quickly resume exporting or delivering usable water.

This report is divided into eight chapters; the introduction is followed by chapters containing background information on the levees, previous levee failures, impacts on the water users, existing emergency plans, and actions and services available for restoring water service. Emergency plans for various scenarios, along with a discussion of responsibilities and implementation, are in the final chapter. The report is structured in this manner to allow those already familiar with the Sacramento-San Joaquin Delta to read only Chapters 1 and 8.

Approximate time to restore service has not been discussed in the report because of the infinite number of variables that determine the severity of an emergency caused by a levee failure or combination of levee failures and the resulting impact on the water supply facilities. One of the more significant variables is the potential competition from emergencies outside the Delta for use of available people, equipment, and supplies for response to the emergencies.

While this report fulfills the requirements of the legislation, more work is needed. The Department of Water Resources will continue the work described in Chapter 8 to help assure protection of this vital water supply.

David Kennedy

Director

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Chapter 1. INTRODUCTION

Assembly Bill 955, Chapter 1271, was signed by the Governor on September 30, 1985, and became effective January 1, 1986. The act contains two provisions. It requires the Department of Water Resources to prepare an emergency plan to allow the Central Valley Project and the State Water Project to continue exporting, or quickly resume exporting, usable water from the Delta in the event of failure of one or more critical levees in the Sacramento-San Joaquin Delta. The plan is also to provide for East Bay Municipal Utility District and Contra Costa Water District to continue delivering or quickly resume delivering usable water. Additionally, it amended Section 12981 of the Water Code whereby the Legislature now recognizes that it may not be economically justifiable to maintain all Delta islands. AB 955 requires this report to be submitted to the Legislature for consideration on or before January 1, 1987.

The Legislature identified a need to protect the Delta water supply and, thereby, the State's economy. This need for protection is due to the fragile condition of the Delta levees and their potential for failure from overtopping, liquefaction from earthquakes, foundation instability, or other failure modes.

The Delta has an area of about 750,000 acres separated into 70 islands and tracts by about 700 miles of waterways. Most of the islands are at or below sea level, and water in the channels fluctuates in response to Pacific Ocean tides.

One of the many public benefits provided by the Delta is water supply. The Federal Central Valley Project has two diversion points from the Delta: one near Tracy, at the southern end of the Delta, and a smaller one for Contra Costa Water District on the southwest edge of the Delta at Rock Slough. The State Water Project has one diversion near Tracy, and another under construction for the North Bay Aqueduct, which will divert from the Cache Slough system northwest of Rio Vista.

There have been about 38 levee failures since 1950, each inundating one or more islands or tracts. The Brannan-Andrus levee failure of 1972 occurred during low outflow summer conditions and resulted in intrusion of salt water into the Delta, forcing interruption of diversions by the Central Valley Project and the State Water Project.

Many types of levee failure are possible. For this report, four specific "emergencies" or "scenarios" were selected in an attempt to cover the broad range of situations that would result from levee failures. The consequence or "impact" of the emergencies was estimated, and plans are suggested to alleviate these impacts (see Plate 1). These plans are discussed in Chapter 8. In addition, Plate 1 shows three generalized plans and a Contra Costa Water District temporary supply plan.

This report provides supporting material to aid in estimating the impacts and recommends advance measures to facilitate rapid and effective implementation of the suggested actions during the emergencies. The report also contains information on risk of structural failure, overtopping, and seismic damage to levees in the Delta.

One of the emergencies considered is a large number of levees failing due to a major earthquake. Consideration of this emergency was specifically provided for in the legislation.

Another section of the legislation stated "...This section does not authorize the construction of physical works of any kind, including, but not limited to, any peripheral canal or through-delta channel plan..." While some of the responses include physical works, they are minimal in size, temporary, and easily removable. Therefore, these works were considered to be different than the type specifically excluded from consideration.

Chapter 2. THE SACRAMENTO-SAN JOAQUIN DELTA

Located in north-central California, the Sacramento-San Joaquin Delta was originally a tidal marsh formed in an overflow area of the Sacramento and San Joaquin Rivers. More than 80 percent of this former marsh was leveed and developed for agriculture during the mid-1800s to early 1900s.

The Physical Delta

The Delta is a unique area situated at the confluence of the Sacramento and San Joaquin rivers, which drain 43,000 square miles of watershed and discharge into San Francisco Bay and the Pacific Ocean. The statutory Delta, as defined in California Water Code Section 12220 (see Figure 1), occupies an area of more than 1,100 square miles, including over 700 miles of scenic waterways. The Delta encompasses about 70 leveed islands and tracts, many of which are 15 to 20 feet below sea level as a result of land subsidence. The network of levees totals about 1,100 miles and protects 550,000 acres of agricultural land.

The tributary streams that supply fresh water to the Delta have helped to create and define its unique shape, that of a triangle with its base facing away from tidal waters instead of toward them, as is typical in coastal plain deltas. The Sacramento River, which provides more than 80 percent of the Delta's inflow, enters from the north and, together with its tributaries and overflow channels, defines the northern portion of the Delta. The San Joaquin River enters the triangle from the south and thereafter divides into the three channels -- the San Joaquin River, Middle River, and Old River -- that are the principal waterways for the southern portion of the Delta. Major streams entering the eastern base of the triangle are the Mokelumne River and the Calaveras River.

Delta channels are used for conveying Central Valley floodwaters; for recreation; for migrating and resident fish; for commercial shipping; for local municipal, industrial, and agricultural water supply; and for transporting the abundant water from the basins of Northern California to the deficient areas of Central and Southern California via the State and Federal water projects. Tributary inflow not used in the Delta or exported for use elsewhere flows westward out of the Delta at Chipps Island, across Suisun Bay, and through a gap in the Coast Range into San Francisco Bay and the Pacific Ocean.

Three major population centers -- the San Francisco Bay Area, Sacramento, and Stockton -- are located near the Delta. Portions of six counties -- Alameda, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo -- are within the Delta. Although no major cities are entirely within the Delta, it does include a portion of Stockton, Sacramento, West Sacramento, and the small cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy, plus about 14 unincorporated towns and villages.

Much of the soil in the Delta is organic (largely composed of or derived from peat), and is subject to subsidence problems for a number of reasons. While certain measures and practices could be adopted to slow the rate, subsidence will continue as long as organic material remains and the land is used for farming.

Ground water levels under the Delta islands are maintained at depths of 0 to 10 feet below the soil surface, depending on agricultural practices and or the season.

The economy of the Delta depends almost entirely on the protection provided by the levees. The Delta is a productive agricultural area, supporting a wide variety of crops, such as corn, grain, asparagus, pears, tomatoes, sugar beets, and truck crops.

Sediments beneath the Delta contain one of the largest natural gas reservoirs in the Nation, making the Delta a gas producer and storage area of regional and national importance. There are 35 operating fields scattered throughout the area, with major fields near Rio Vista. To date, cumulative production of gas from these fields amounts to about 4.2 trillion cubic feet. Delta gas fields can probably produce until the turn of the century. Because of the Delta's strategic location, some of the depleted fields are being used to store imported gas.

The Delta's 50,000 acres of waterways provide aquatic habitat for an abundance of birds, mammals, fish, and other aquatic life. These waterways and adjacent land areas support one of California's largest and most diverse fisheries and provide habitat for over 100 species of waterfowl and wildlife, including game species and some rare and endangered species.

The Delta is also one of California's major outdoor recreation areas. Its abundant water, fish, wildlife, cultural, and historical resources offer a variety of recreational opportunities, such as fishing, boating, hunting, picnicking, camping, bicycling, and sightseeing. The estimated 12.3 million user-days of recreation in 1980 exceeded the capacity of existing facilities. As recreation use has grown, so have related problems for the levees. For example, more and larger recreational boats are being used, and waterside levee erosion from wakes has increased as a result.

Two major east-west roads, Highway 4 and Highway 12, bisect the Delta. Highway 160 follows a meandering north-south course along the Sacramento River. Interstate 5 skirts the eastern side of the Delta, Interstate 80 borders the northern boundary, and Interstate 205 goes near the southern border. In addition, two deepwater ship channels enable ocean-going vessels to travel to the inland ports of Sacramento and Stockton.

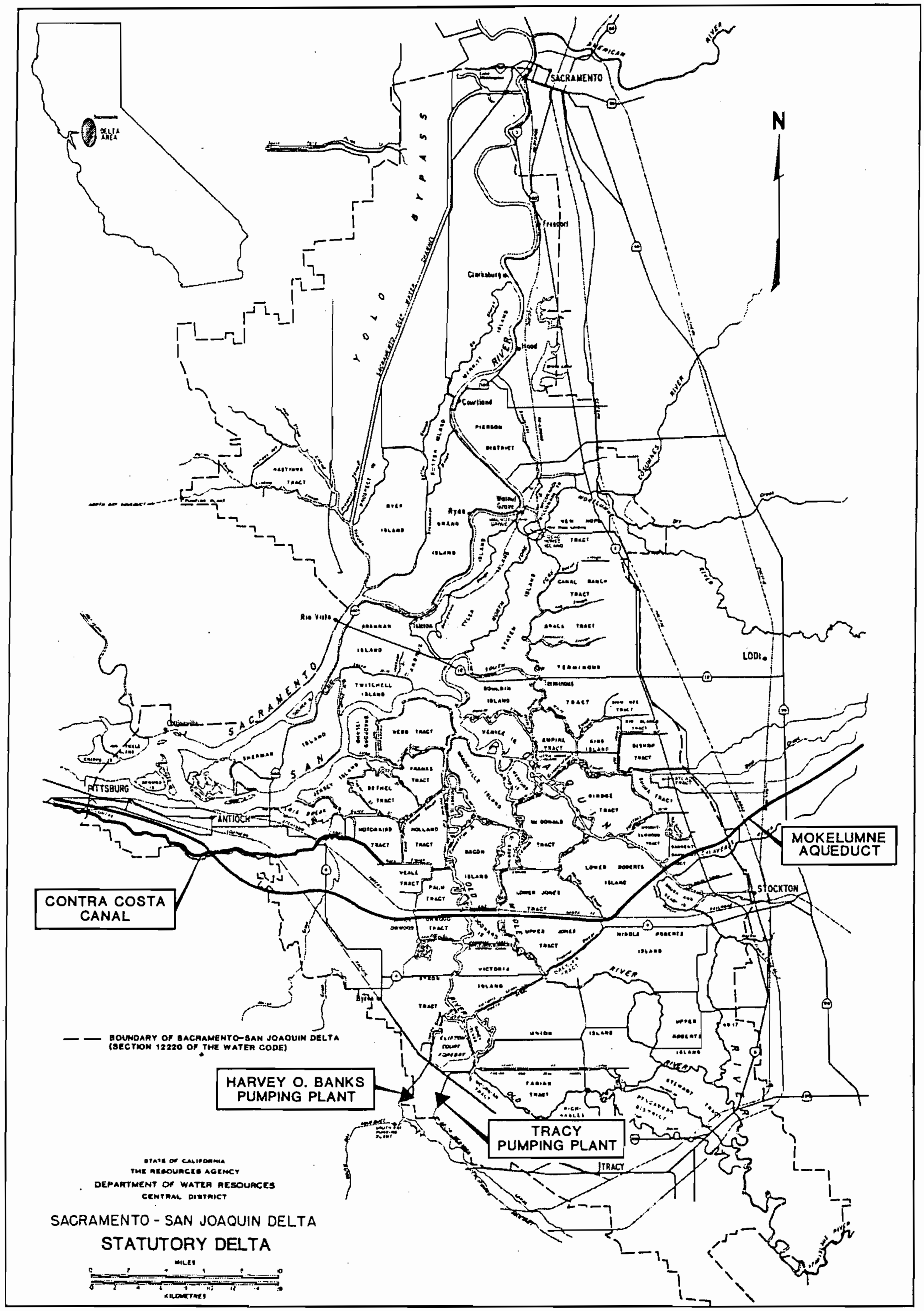
Delta Hydraulics

The four major hydraulic influences are:

- Inflow of water from tributary streams,
- Pacific Ocean tides,
- Water uses in the Delta and export of water from the Delta, and
- Configuration and geometry of the Delta channels.

The amount of water in Delta channels varies each day within the limits set between the high and low tide levels. Water levels in the channels cannot decrease significantly below low tide levels, because water flows in from Suisun Bay to make up any deficiency. However, water from Suisun Bay can bring large quantities of salt.

In most years, there is sufficient runoff into Delta tributaries to meet all water uses in and from the Delta during winter and spring. In summer and fall, water released from the Central Valley Project and State Water Project reservoirs supplies most of the inflow to the Delta.



SACRAMENTO
N
AMERICAN RIVER
YOLO BYPASS
SACRAMENTO DEEP WATER CHANNEL
Freeport
Clarksburg
Hood
RIVER
Courtland
PIERSON DISTRICT
Walnut Grove
Ryde
Rio Vista
LODI
SACRAMENTO
SAN JOAQUIN
PITTSBURG
ANTIOCH
STOCKTON
TRACY
MOKELUMNE AQUEDUCT
CONTRA COSTA CANAL
HARVEY O. BANKS PUMPING PLANT
TRACY PUMPING PLANT
BOUNDARY OF SACRAMENTO-SAN JOAQUIN DELTA (SECTION 12220 OF THE WATER CODE)
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
SACRAMENTO - SAN JOAQUIN DELTA
STATUTORY DELTA
MILES
KILOMETRES

Most of the water leaves the Delta as evapotranspiration from land, water, and plants; as outflow to Suisun Bay; and as export through pumping plants on the edges of the Delta.

Delta Navigation

The Bay-Delta estuary is relatively shallow; however, the Corps of Engineers has dredged deepwater channels to permit deep-draft vessels to travel through the estuary. Two channels for ocean-going ships serve the Ports of Stockton and Sacramento and carry most of the commercial navigation in the Delta. The Stockton Ship Channel (from Stockton to Suisun Bay) and the Sacramento Ship Channel (from Cache Slough near Rio Vista to Suisun Bay) are quite large compared to other Delta channels.

Most channels are used occasionally by tugs towing barges, dredges, and pile drivers for construction and levee repair throughout the Delta. The greatest use of the channels is for boating, fishing, and other water recreation throughout the Delta.

Water Use

Distribution of the Delta's 21.2 million acre-feet of average annual water supply (50-year average from 1920 to 1970) is:

- ° Delta consumptive use - 1.6 million acre-feet
- ° Central Valley Project and State Water Project export - 6.1 million acre-feet
- ° Outflow required to maintain water quality at the export pumps - 4.1 million acre-feet
- ° Outflow in excess of the minimum requirement - 9.4 million acre-feet

Some of the water exported from the Delta by these projects returns to the Delta by way of the San Joaquin River as return flow.

Facilities and Operations

The principal Delta diversions are the exports by the State and Federal water projects including the diversions of Central Valley Project water by Contra Costa Water District into the Contra Costa Canal (see Figure 2). During the wet season, when natural tributary inflow to the Delta is sufficient for all Central Valley uses, the State and Federal projects store surplus streamflow in upstream reservoirs and in San Luis Reservoir, an offstream reservoir south of the Delta. During the dry season, natural inflows must be augmented by releases from the upstream reservoirs. Water for export is pumped from southern Delta channels into the California Aqueduct, South Bay Aqueduct, Delta-Mendota Canal, and Contra Costa Canal.

The projects are required to maintain sufficient water in the Delta to ensure water quality at levels established by the State Water Resources Control Board as conditions in the projects' water right permits. The Department of Water Resources also has contracts with Delta water agencies. This may require reducing exports, modifying operations, or making additional releases from project reservoirs.

California State Water Project

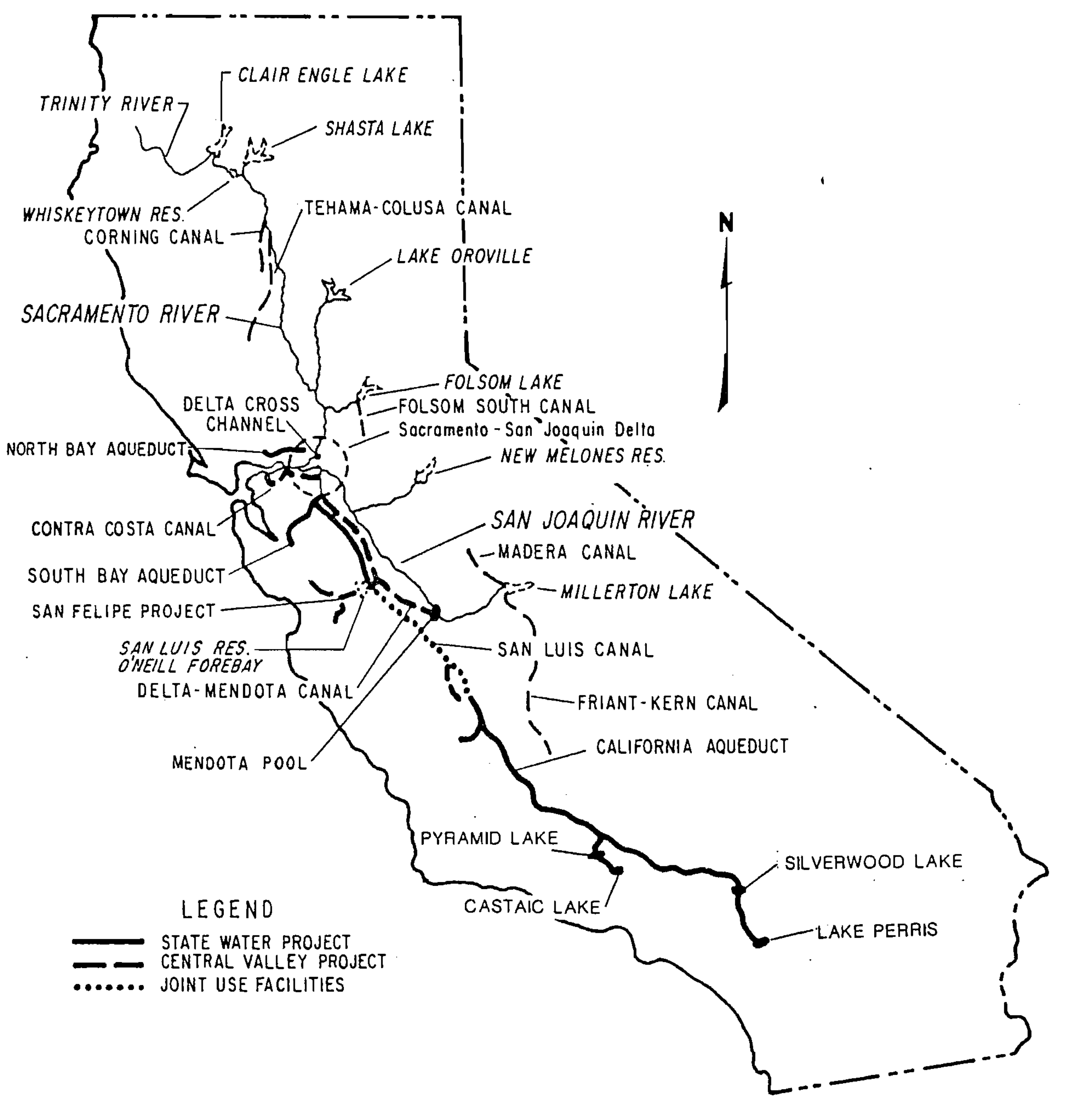
State Water Project facilities extend from Plumas County in the north to Riverside County in the south (see Figure 2). The 1959 Burns-Porter Act includes, as part of the State Water Project, Delta facilities "...for water conservation, water supply in the Delta, transfer of water across the Delta, flood and salinity control, and related functions". The State has contracted to eventually deliver 4.23 million acre-feet of water annually to service areas in Northern, Central, and Southern California.

Most of the water released from the main storage facility, Lake Oroville, flows through an underground hydroelectric power plant, through the Thermalito Afterbay, down the Feather River into the Sacramento River, and then into the network channels of the Delta.

Near the northern edge of the Delta, the North Bay Aqueduct, scheduled for completion in 1987, will deliver water to Napa and Solano counties. Interim

Figure 2

MAJOR FEATURES OF THE SWP AND CVP



facilities operated by the State serve water to Napa County, with water made available by the Solano Project of the U. S. Bureau of Reclamation.

At the southern edge of the Delta, 15 miles southwest of Stockton and 10 miles northwest of Tracy, are Clifton Court Forebay, the John E. Skinner Delta Fish Protective Facility, Harvey O. Banks Delta Pumping Plant, and the intake channel to the pumping plant.

Clifton Court Forebay, which has a capacity of 28,653 acre-feet serves as a water regulating reservoir. It ensures reliability and flexibility for pumping water at Banks Pumping Plant.

Seven pumps at Banks Pumping Plant lift as much as 6,400 cubic feet per second into the California Aqueduct. The South Bay Aqueduct branches at this point and delivers water to Alameda and Santa Clara counties. The 444-mile California Aqueduct conveys water to the San Joaquin Valley and Southern California and is the principal water conveyance facility of the State Water Project.

Federal Central Valley Project

A principal function of the Central Valley Project is to transport water from the Sacramento, Trinity, American, and San Joaquin river basins to water-deficient areas of the Sacramento and San Joaquin valleys (see Figure 2). The key water supply feature is Lake Shasta, on the Sacramento River. Water stored here is first used to generate power and then flows south in the natural channel of the Sacramento River toward the Delta. Additional flows come from Clair Engle Lake on the Trinity River through the Trinity diversion.

Twenty miles east of Sacramento, American River water is stored in Folsom Lake for use in the Folsom-South service area and for release into the Sacramento River upstream of the Delta.

Thirty miles south of Sacramento, the Delta Cross Channel serves as a controlled diversion channel between the Sacramento River and the Mokelumne River at the north edge of the Delta. In conjunction with Georgiana Slough, a natural channel, the Delta Cross Channel directs Sacramento River water across the Delta to the Rock Slough intake of the Contra Costa Canal and to the export pumps near Tracy, while improving the quality of irrigation supplies in the central Delta.

Six pumps at Tracy Pumping Plant lift as much as 4,600 cubic feet per second into the Delta-Mendota Canal, which delivers water to the lower San Joaquin Valley.

About 60 miles south of the Delta, between the Delta and the Mendota Pool, is San Luis Dam and Reservoir, a joint-use offstream storage facility of the Central Valley Project and the State Water Project. Water diverted from the Delta via the Delta-Mendota Canal and the California Aqueduct is pumped into San Luis Reservoir during winter and early spring for release to service areas during summer and fall.

The San Felipe Project, scheduled for completion in 1987, is designed to provide water from the San Luis Reservoir to coastal counties via a system of tunnels, pipelines, and pumping stations. Santa Clara County will receive a maximum of 152,200 acre-feet a year. San Benito County's maximum entitlement is 43,800 acre-feet. Eventually, Monterey and Santa Cruz counties will receive water from the system.

The Friant Division is responsible for distributing water in the San Joaquin Valley via the Madera and Friant-Kern canals.

Contra Costa Water District

Contra Costa Water District diverts water into the Contra Costa Canal from Rock Slough in the southwestern Delta for municipal and industrial use in Contra Costa County. Up to 350 cubic feet per second of water is lifted by a series of four pumps into the 48-mile-long canal, which terminates in Martinez Reservoir. The canal, which has been in service since 1940, was constructed by the Bureau of Reclamation as the initial feature of the Central Valley Project. Although a part of the Central Valley Project, Contra Costa Canal is now operated by Contra Costa Water District and is considered a separate facility for purposes of this report.

East Bay Municipal Utility District

East Bay Municipal Utility District holds water rights to divert up to 325 million gallons per day from the Mokelumne River at Pardee Reservoir and to use this water in portions of Alameda and Contra Costa counties for municipal and industrial purposes. Water from Pardee Reservoir is conveyed about 82 miles across central California via the Mokelumne Aqueduct. The three parallel pipelines of the aqueduct system, constructed in 1928, 1949, and 1963, have diameters of 65, 67, and 87 inches, respectively. A 15-mile section of the Mokelumne Aqueduct crosses the Delta between Stockton and Bixler, crossing Sargent-Barnhart Tract, Lower Roberts Island, Upper Jones Tract, Woodward Island, and Orwood Tract.

The Mokelumne River provides about 95 percent of East Bay MUD's water supply. The remaining 5 percent comes from local runoff captured by five reservoirs in the East Bay hills. In addition to collecting local runoff, the terminal reservoirs provide seasonal regulation of the Mokelumne supply and maintain a standby supply to protect against emergency outages.

Chapter 3. DELTA LEVEES

The Delta lowlands are protected from floods and high tides by a vast network of levees totaling about 1,100 miles in length. Some of these levees are over 100 years old, and many are in relatively poor condition and require rehabilitation. Levees along the channels have been constructed on peat and periodically must be raised and widened as the organic foundation soils consolidate. While most of the levees built between 1870 and 1875 were 4 to 6 feet high, today's levees range in height from 5 to 25 feet.

Levees in the Delta are maintained to varying standards, depending on whether they are project levees, direct agreement levees, or nonproject levees (see Figure 3). The differences in these categories are explained below.

- Project Levees: About 15 percent of the total levee system has been built or rebuilt, and adopted as Federal flood control levees. These levees are maintained to Federal standards by non-Federal interests. Project levees total about 165 miles and are primarily along the Sacramento River from Collinsville to Sacramento and along the San Joaquin River between Stockton and Vernalis.

- Direct Agreement Levees: Levees constructed or rehabilitated as part of a navigation project or rebuilt by the Federal Government following floods comprise about 10 percent (110 miles) of the total system. This category currently includes only the levees along the Stockton Ship Channel. These levees are maintained to Federal standards by local interests in direct agreement with and under the supervision of the Corps of Engineers.

- Nonproject Levees: The remaining 75 percent of the levees were constructed by private interests and/or reclamation districts. Nearly all are maintained by reclamation districts. These levees have not been constructed to uniform design standards, nor have they been maintained to any established standard. Maintenance is funded by landowners within the reclamation districts and supplemented by the State's subventions program.

Good maintenance practices prevail on most project levees and on certain islands, but, in general, routine maintenance on nonproject levees is limited. Assembly Bill 3473 (Johnston), which became effective in 1986, is an effort to improve maintenance practices. This bill amended Sections 12983, 12984, and 12989 of the Water Code and requires the short-term standards of the 1983 Delta Flood Hazard Mitigation Report to be implemented through the State Delta Levee Maintenance Subventions Program. The bill also requires the Department to annually inspect all levees to ascertain the degree of compliance toward meeting the standards.

Information on annual maintenance and rehabilitation for nonproject levees indicates a total expenditure of $16 million from 1980 to 1985; $10 million was provided by the reclamation districts and $6 million was funded under the State's Delta Levee Maintenance Subventions Program. In this same period, the Federal Government spent $67.4 million, the State Government spent $28.6 million, and local entities spent $5.8 million for emergency work and flood disaster relief in the Delta.

Levee Failure

Principal causes of levee failure are:

° Overtopping due to floodflows, tidal fluctuations, and wind-driven waves.

° Structural failure due to inadequate levee foundations or construction materials, subsidence of Delta soils, seepage through or under the levee, erosion of levee slopes, or rodent burrows in the levees.

A potential cause of levee failure that has not been documented in the Delta is liquefaction of the foundation due to earthquakes.

Overtopping

Overtopping failure occurs when the crest of a levee is lower than the water level. In some instances, overtopping failures have been prevented by raising levee crowns with sandbags during high water periods. Constant maintenance is required to maintain the elevations of the levee at or above peak water levels because of compaction and consolidation of the underlying soil materials.

Construction of upstream reservoirs since the mid-1940s has reduced the frequency of overtopping. However, when high river crests, high tidal fluctuations, and strong westerly winds coincide, overtopping of some Delta levees is probable.

Structural Failure

If a levee or its foundation is not structurally strong enough to withstand the force of the water, it will fail. Levee instability has become more acute in recent years due to higher levees and increased hydrostatic pressures resulting from island subsidence. As the island floor elevations drop, due mainly to peat oxidation, hydrostatic loads on the levees increase, thus decreasing levee stability. The problem is especially critical in the deep peat areas of the central Delta.

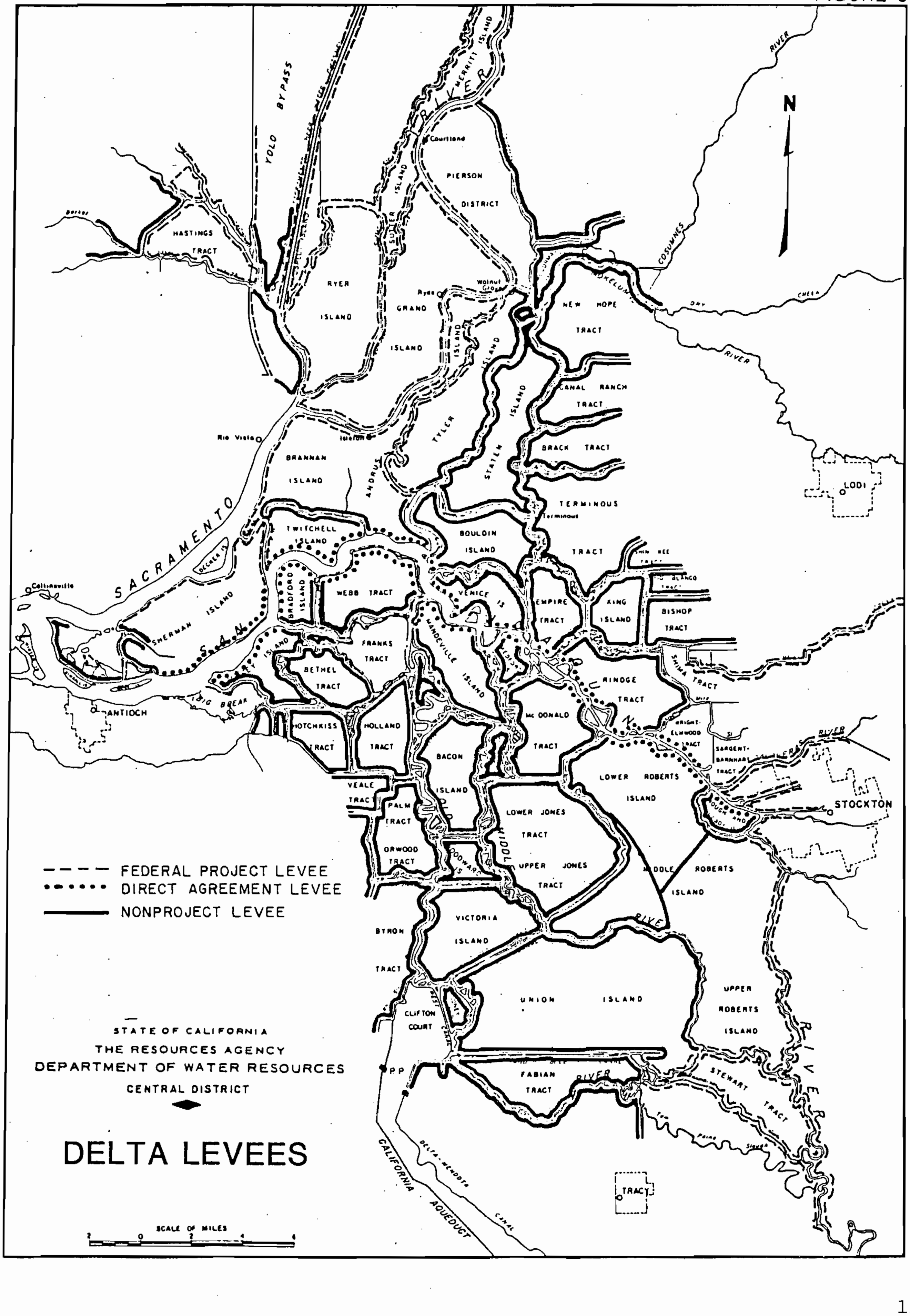
Structural failures are often preceded by a partial failure involving 200 to 1,000 feet of levee. Partial failures include settlement of levee materials and formation of cracks and sinkholes in the landward levee slope. A number of factors are involved in this type of failure: water level, levee height, levee slope, levee composition, presence of rodent holes, and foundation conditions. Lack of adequate maintenance to correct some of these problems on a regular basis also contributes to levee instability.

Delta levees are also susceptible to structural failure from earthquake shaking. This failure results when the static and earthquake induced loads exceed the soil strengths of the levee or foundation. This type of failure should not be confused with liquefaction.

Subsidence. Today, much of the Delta has subsided to below sea level elevations. Subsidence occurs generally in peat and other organic soils throughout the central Delta. The greatest amounts of subsidence since the time of island reclamation, ranging from about 12 to 21 feet, occur on 10 islands and tracts. At least 11 other islands and tracts have experienced 10 feet of subsidence since initial reclamation.

Seepage. The elevation difference between the higher water surface in the channel and the ground surface of many Delta islands causes continual seepage of water through the levees from the channels to the interior of the islands. Seepage tends to increase with time as land subsidence lowers the ground surface. This seepage can result in levee instability.

FIGURE 3



FEDERAL PROJECT LEVEE
DIRECT AGREEMENT LEVEE
NONPROJECT LEVEE
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
CENTRAL DISTRICT
DELTA LEVEES
SCALE OF MILES
N
SACRAMENTO
SAN JOAQUIN
RIVER
YOLO BYPASS
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
PIERSON DISTRICT
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
TERMINOUS TRACT
STATEN ISLAND
TYLER ISLAND
BRANNAN ISLAND
TWITCHELL ISLAND
SHERMAN ISLAND
BOULDIN ISLAND
WEBB TRACT
BRADFORD ISLAND
VENICE IS
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
FRANKS TRACT
BETHEL TRACT
MANDEVILLE ISLAND
RINDGE TRACT
MC DONALD TRACT
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
LOWER ROBERTS ISLAND
LOWER JONES TRACT
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
VEALE TRACT
PALM TRACT
ORWOOD TRACT
VICTORIA ISLAND
BYRON TRACT
UNION ISLAND
UPPER ROBERTS ISLAND
CLIFTON COURT
FABIAN TRACT
STEWART TRACT
SHIMA TRACT
COSUMNES
MOKELUMNE
DRY CREEK
STOCKTON
LODI
TRACY
ANTIOCH
Rio Vista
Isleton
Courtland
Walnut Grove
Ryde
Terminous
Collinsville
BIG BREAK
CALIFORNIA AQUEDUCT
DELTA-MENDOTA CANAL

Erosion. The waterside slopes of Delta levees are subjected to varying erosional effects from channel flows, tidal action, wind generated waves, and boat wakes. An increase in recreational use by boaters, anglers, and water skiers appears to have intensified the erosion problem in the Delta. Erosion reduces the cross sectional area of a levee and thereby increases the potential for stability failure.

Rodent Burrows. Rodents abound in marshlands, berms, and levees throughout the Delta. Their burrows, particularly those of beavers and muskrats, threaten the integrity of the levees. Burrows in the levees weaken the levee section or foundation and contribute to levee failure by increasing the potential for "piping" -- the washing away of levee material by seepage through or under the levee.

Liquefaction

Liquefaction is a phenomenon whereby, during shaking from an earthquake, saturated sands lose strength and flow like a liquid. In some situations, it is similar to quicksand.

Much of this information on liquefaction is based on a report, Partial Technical Background Data for the Mokelumne Aqueduct Security Plan (December 1981), prepared by Converse, Ward, Davis, Dixon, Incorporated, Geotechnical Consultants for East Bay Municipal Utility District. The report examines the extent of sand under the levees for islands traversed by the Mokelumne Aqueduct that would be subject to liquefaction under seismic motion.

The report identified 12 faults near enough to the Delta to cause significant ground accelerations near the Mokelumne Aqueduct (see Figure 4). These would have maximum credible earthquakes with magnitudes ranging from 6 to 8 on the Richter scale, with peak accelerations at the Mokelumne Aqueduct ranging from 0.07 to 0.27 of the acceleration of gravity and duration of shaking ranging from 5 to 23 seconds (see Table 1).

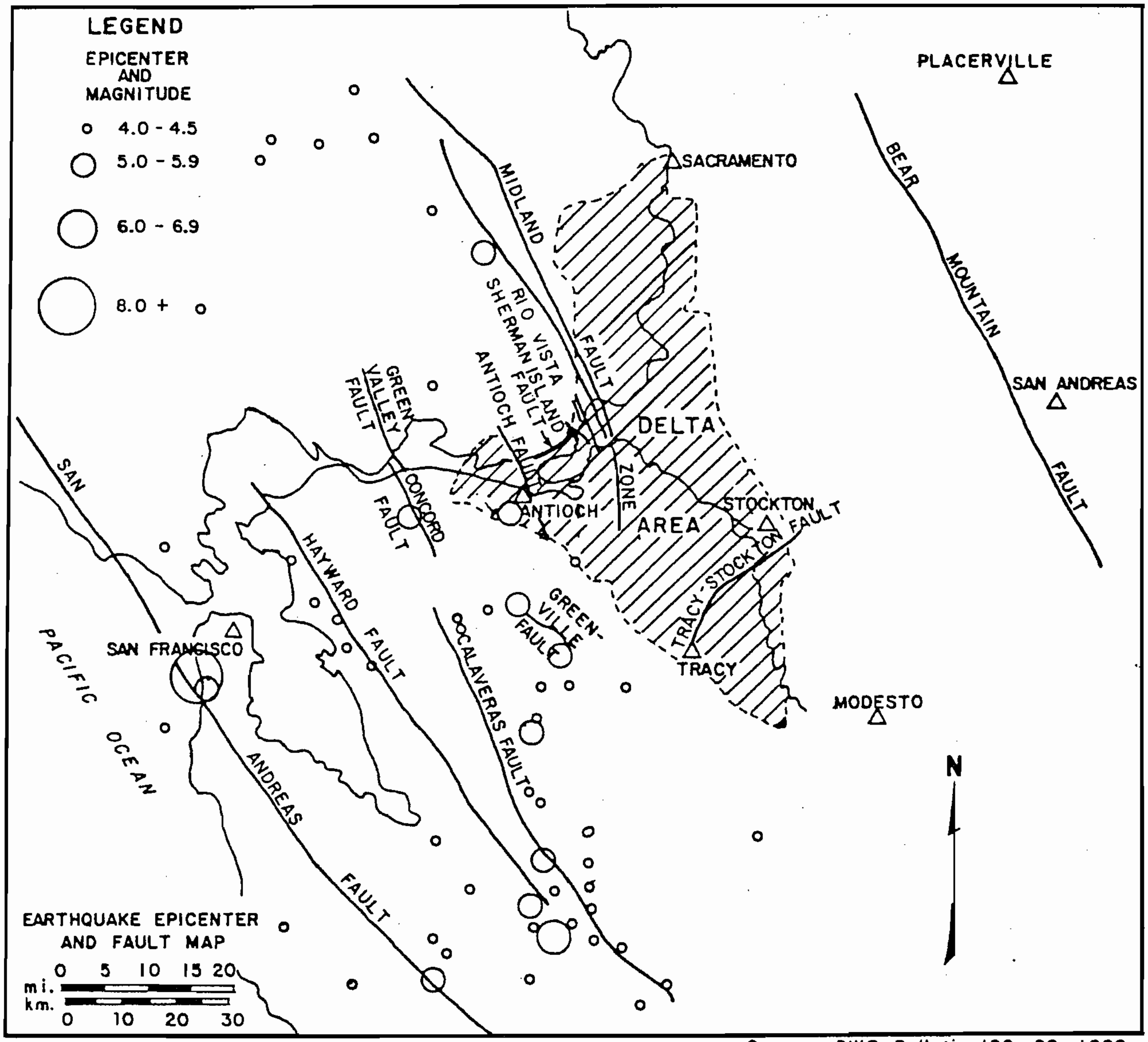
Using data developed by the Department of Water Resources and others from borings under or adjacent to levees, it was shown that sections of levees are founded on potentially liquefiable sands. The acceleration required for liquefaction ranged from 0.10 to 0.20g. There might be less serious effects on some of the sands from even smaller accelerations.

These studies suggest that damage to Delta levees due to liquefaction of underlying sands can be expected at some time in the future with probable earthquakes on one or more of the adjacent faults. Such effects may have occurred in 1906 from the magnitude 8 earthquake on the San Andreas Fault. However, at that time Delta levees were low and were subjected to small effective hydraulic heads, and no record of damage was found. Many of the levees now have hydraulic heads against them of 20 feet or more.

While the study done for East Bay MUD was concerned only with the vicinity of the Mokelumne Aqueduct as it traverses the southern Delta, the data obtained from borings by the Department of Water Resources cover the major islands throughout the Delta and, for the most part, show sand lenses of various thicknesses underlying the levees. A Corps of Engineers study of the liquefaction potential of the sands described from these borings indicates that a situation similar to that found in the East Bay MUD study exists under Andrus Island.

In summary, long reaches of the Delta levees are underlain by sand lenses that could liquefy and cause failure of the levees at ground accelerations of 0.10 to 0.20 of gravity.

FIGURE 4



Source: DWR Bulletin 192-82, 1982.

Table 1

ESTIMATED MAXIMUM CREDIBLE EARTHQUAKES AND HORIZONTAL GROUND MOTION PARAMETERS, MOKELUMNE AQUEDUCT

Fault Name	Minimum Distance to Site (km)	Maximum Credible Magnitude Earthquake (Richter M)	Ground Motion Parameters: Peak Acceleration (g)	Ground Motion Parameters: Duration (Seconds)
Antioch-Montezuma Hills	17	6-1/2	0.27	17
Rio Vista	26	6	0.16	9
Telsa-Stand	28	6-1/2	0.19	15
Livermore Valley	35	6-1/4	0.13	10
Concord	37	6-1/4	0.13	10
Pleasanton	39	6	0.10	5
Calaveras	41	7	0.18	23
Green Valley-Cedar Roughs	47	6-1/2	0.11	10
Hayward	54	7	0.13	22
Cordelia-Wragg Canyon	57	6-1/2	0.09	10
San Andreas (Northern)	83	8 +	0.13	15
Bear Mountain and Melones	70	6-1/2	0.07	5

Source: Converse Ward Davis Dixon, December 1981.

Levees Critical for Maintenance of Export Water Quality

Levee failures can affect Delta water quality. Whether the effects are short- or long-term depends on the hydraulics during failure and the size and location of the flooded island. This report is concerned with quickly restoring potable water and, therefore, should identify levees that create a short-term or immediate impact on water quality. In evaluating the many studies that touch upon the subject, some contradictions become apparent.

The Corps of Engineers made extensive studies for the Federal Emergency Management Agency of the quality impacts of flooding Delta islands and combinations of islands through levee failure. The results, which can be interpreted as long-term effects, were reported in 1984. Long-term effects are those occurring when the hydraulic conditions have stabilized and the flooded island acts as another Delta channel. The Corps of Engineers considered both single-point and multiple-point failures of levees at various locations and, in addition, the simultaneous failure of 19 levees. The studies were made with some variation in Delta outflow and in quantities of export through the major pumping plants.

The studies, which were done on the Corps' physical model of San Francisco Bay and the Delta, indicate that, in general, a flooded island in the western Delta or in the eastern Delta tended to have similar adverse long-term effects on water quality when Delta outflow and export pumping were at a minimum, and considerably less effect when either the outflow or pumping is larger.

Prototype information of short-term impacts is available from islands that have flooded during summer since the Central Valley Project and State Water Project began operation. The first and most dramatic was the Brannan-Andrus Island flood in 1972. This brought large quantities of salt water into the Delta and created severe problems for the Central Valley Project, including the Contra Costa Canal, and for the State Water Project. Two other islands in the eastern Delta have flooded during summer: Jones Tract in September 1980, and McDonald Tract in August 1982. The water quality effect of flooding McDonald Tract was negligible. Exports were promptly curtailed when Lower Jones Tract flooded. There was no salt water inflow to the Delta. These events suggest that the combination of island location in the eastern Delta and the higher level of Delta outflow maintained under Decision 1485 tend to reduce the effect of flooding.

An economic analysis by the Department of Water Resources to evaluate water quality benefits that would result from restoring flooded islands suggests that there is little effect on water quality of the State Water Project. This analysis cannot be classified as short-term or long-term.

Appendix B of this report contains a methodology for evaluating short-term salinity intrusion potential. This is a gross approximation, but it does identify which island or combination of islands are critical. This methodology is based on determining when minimum Delta outflows cannot be maintained due to flows into an island or islands.

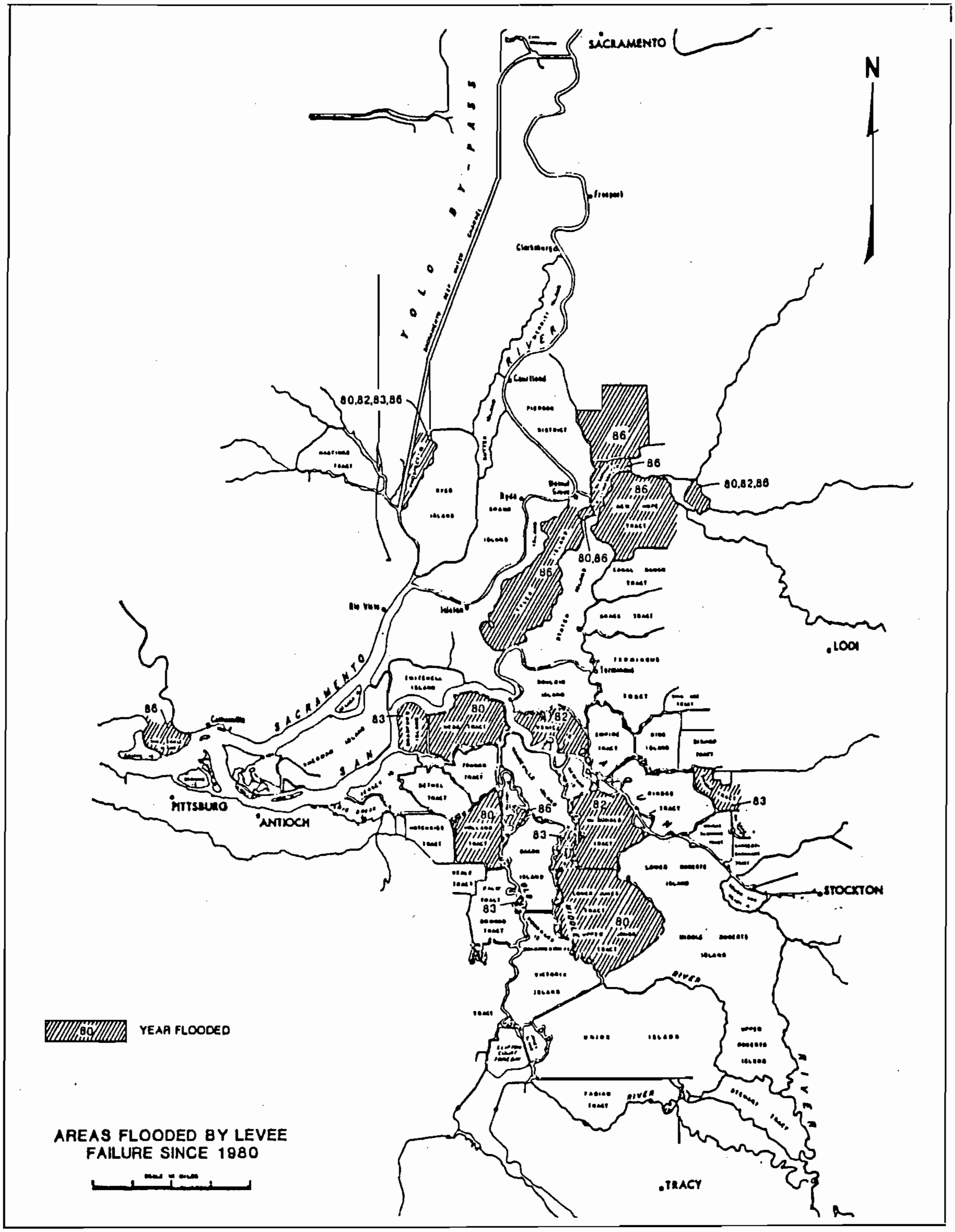
Which islands' levees are critical may be of little consequence, since the response to failure of the levees on one or more islands will be governed in large measure by the impact on water quality of that failure. However, as levees are improved, protection for Delta water quality will be increased.

Historical Frequency of Failure

Maintaining the fragile Delta levees has been a continuing problem since they were first built to reclaim the fertile Delta soils for farming. Since original reclamation, most of the 70 islands and tracts in the Delta have been flooded at least once. Even since 1980 some islands have flooded more than once, as shown in Figure 5.

Most flooded islands have been restored. Exceptions are Big Break, Franks Tract, Little Franks Tract, Lower Sherman Island, Donlon Island, and Mildred Island.

FIGURE 5



Levels of Risk for Critical Levees

In its 1982 draft feasibility report, Sacramento-San Joaquin Delta, California, the Corps of Engineers describes the results of a detailed 1978 study of probability of failure of Delta islands due to overtopping or instability. A consulting engineering firm assisted in the study, which was statistical and empirical and used data through 1976. Table 2 shows failure probability for the islands with critical levees and adjacent islands.

During the severe storms of February 1986, the largest Delta island to be inundated was Tyler Island. Extremely high stages in the Sacramento River, Cosumnes River, and Dry Creek resulted in overtopping on the eastern levee of the island. Parts or all of four other islands were also flooded. With a record high stage of 12.4 feet at Rio Vista, experience would suggest a large number of islands could have been inundated.

It seems probable that the improvement of Delta levees in recent years by the State's subventions program and Natural Disaster Assistance Act, along with the emergency repairs and restoration of levees by the Corps of Engineers and Federal Emergency Management Agency, resulted in the remaining islands and tracts weathering the extreme conditions of February 1986 without levee failure. This suggests that it has been possible to accomplish a significant degree of additional protection for the Delta lands with large expenditures for rehabilitation of the levees and that this same level of expenditure before an emergency would provide an even greater benefit.

The 1983 and 1986 levee failures have provided significant information that was not available at the time of the Corps' 1978 failure probability analysis. Since the calculated probability is highly dependent on past

Table 2

PROBABILITY OF OVERTOPPING OR STABILITY FAILURE OF SELECTED DELTA ISLANDS

Island/Tract	Probability of Failure	Return Period (In years)
Bacon	> 0.040	< 1 in 25
Bishop		
Bouldin		
Brack		
Bradford		
Brannan-Andrus		
Canal Ranch		
Dead Horse		
Drexler		
Empire		
Holland		
Jones		
Mandeville		
McCormack-Williamson		
McDonald		
Medford		
Orwood (Upper)		
Rindge		
Roberts		
Shin Kee		
Terminous		
Tyler		
Veale		
Venice		
Webb		
Woodward		
Hotchkiss	0.020-0.040	1 in 25 to 1 in 50
Jersey		
King		
Palm		
Quimby		
Rio Blanco		
Shima		
Staten		
Twitchell		
Coney	0.010-0.020	1 in 50 to 1 in 100
New Hope		
Sargent-Barnhart		
Sherman		
Victoria		
Wright-Elmwood		
Atlas	< 0.010	> 1 in 100
Bethel		
Byron		
Orwood		
Pescadero		
Stewart		
Walnut Grove		

failures, the estimates should be updated to include this new information.

Patterns of Island Flooding

Experience has shown that when a Delta levee fails, the small islands flood in about one day and the larger islands flood in about two days. The time required to fill an island in most cases depends on the size of the break rather than on the capacity of adjacent channels. The foundation scouring is often far larger than the area of levee washed out. The water pours into the island at such high velocity that it can erode the break as deep as 80 feet and extend some distance into the island. This accounts for the rapidity with which the island fills and, in part, for the high cost of closing the break, since a new foundation has to be built below the levee.

Dispersion of Salt

After the first in-rush of salt water following a levee failure, the movement of water back and forth in the channels with the ebb and flood of the tides is the major means by which salt water is dispersed. In addition, there is some dispersion through the smaller, connecting channels. High tides and low tides do not occur at quite the same time at the two ends of the small channels, resulting in some net movement of the saline water through the channels. This same action can be expected within any island that has two widely separated breaches in its levee, because the flooded island will act as another Delta channel.

Tidal Prism

Some investigators have hypothesized that if an island were to flood, there would be an increase in the tidal prism (the difference in volume between high and low tides) and oscillating tidal flows in and out of the Delta, thereby increasing the potential for salinity intrusion and the need for higher outflows to control it. While it is true that with a flooded island a greater surface area is covered with water, the tidal amplitude actually lessens so that the tidal prism remains essentially constant. The reason the tidal amplitude in the Delta decreases after an island is flooded is that it is controlled by the tidal energy or tidal amplitude at the Golden Gate, which remains constant.

This effect has been observed not only on an analog model developed by the Department of Water Resources and the hydraulic model constructed by the Corps of Engineers, but also in the Delta itself. After the Brannan-Andrus Island flood, there was no change in tidal range at Collinsville, and there was a 0.7-foot decrease at Venice Island.

Chapter 4. USER CURTAILMENT

Saline degradation of Delta water could make the export water unusable for an extended period. This chapter discusses limits of full or partial curtailment of export that could be tolerated by each water supply facility.

State Water Project

The Delta intake structure for the State Water Project is Clifton Court Forebay, a shallow reservoir on Old River formed by constructing a low dam inside the levees of Clifton Court Tract. The forebay is in the southeast corner of Contra Costa County, about 10 miles northwest of Tracy. A 1980 analysis indicates that the forebay statically and seismically meets Department stability criteria. Therefore it can be assumed that the forebay levees will not fail.

Impacts on the State Water Project would result from excess salinity in the channels leading to the forebay. Given the worst-case situation of terminating inflow to the forebay until channel salinity is reduced to acceptable levels, there is sufficient storage south of the Delta to meet existing demands for about 45 days, depending on storage at Del Valle, Clifton Court, and San Luis, and on demands at the time of failure.

Central Valley Project

The Central Valley Project is served by Tracy Pumping Plant, which consists of an inlet channel, pumping plant, and discharge pipes. Assuming the pumping plant stays operational, the most significant impact would be salinity levels in the inlet channel that might require that pumping be reduced or stopped. Central Valley Project tolerance of a major curtailment in pumping would depend on the time of year, the amount of water in storage in San Luis Reservoir, the upstream storage and forecast for runoff into Central Valley Project reservoirs, and the demand for water at the time of the emergency. Another key factor could be the availability of State Water Project wheeling after the emergency to replace exports foregone.

Contra Costa Water District

Contra Costa Canal diverts from the southwestern Delta at Rock Slough. This diversion is the first and most severely impacted of the export facilities when salt water is drawn into the Delta. The initial diversion capacity is 350 cubic feet per second. The only storage facility is Contra Loma Reservoir, which has less than 2,000 acre-feet of storage.

If unusable salinity levels in Rock Slough forced curtailment of pumping into Contra Costa Canal, an estimated 10-day termination could be tolerated, depending on many variables that control the demand for water from the canal. However, water to Oakley municipal and industrial users near the head of the canal would be terminated immediately.

East Bay Municipal Utility District

The 15-mile section of the Mokelumne Aqueduct that crosses the Delta is vulnerable to flooding and earthquake damage, either:

- Caused directly by levee failure, which may produce scouring of soil around the aqueduct support system, or

- Independent of levee failure, which includes liquefaction and damage to or failure of the aqueduct support system resulting from an earthquake.

If the Mokelumne Aqueduct pipelines are near a levee break, the scour resulting from water rushing in to fill the island could erode soils around the aqueduct supports, causing damage or failure of the pipelines. This nearly occurred in 1980, when the Lower Jones Tract levee failed and subsequently the Santa Fe Railroad embankment failed, flooding Upper Jones Tract and eroding the soil from all but a few feet of the piles supporting one of the aqueducts.

The pipelines are also vulnerable to damage or failure as a result of seismically induced liquefaction of foundation soils along the aqueduct alignment. Liquefaction results in loss of strength of supportive and surrounding soils. Loss of lateral support reduces the capacity of the supports to survive lateral seismic loading or buckling of long unsupported piles resulting from gravity loads. In addition, lack of support might topple the pipelines or cause differential settlement and excessive deformation.

East Bay MUD has estimated that a single aqueduct failure, as might result from a levee failure, would take months to repair. However, a serious earthquake could result in extensive damage and a supply outage of several months.

East Bay MUD currently maintains about 120 days of emergency standby supply in its terminal reservoirs in the East Bay hills. Loss of the Mokelumne water supply for a longer period would necessitate water rationing or finding alternative water supplies. East Bay MUD is reevaluating the security of critical facilities within the water supply system and emergency standby criteria.

Local Use

Agriculture, the main local use of Delta water, uses about 1.6 million acre-feet per year. In the event of a levee failure, local use would be impacted in one of the following ways.

- The island could be flooded, and need for agricultural water would not exist. However, annual evaporation from a flooded island exceeds water used for agriculture by about 2 acre-feet per acre.

- Available water may not be of acceptable quality for agriculture.

- Available water may still be of acceptable quality for agriculture, but it may become necessary to temporarily suspend local Delta diversions to facilitate restoring suitable quality in the Delta for urban uses.

Chapter 5. PREVIOUS LEVEE FAILURES

Historical failures were reviewed to help develop the emergency actions contained in this plan. The failures are discussed in two sections: those that did not result in salinity intrusion and those that did result in salinity intrusion.

Failures Resulting in No Salinity Intrusion

Four levee breaks are examined in this section to illustrate their effects on water quality and potential impacts on the export water projects. The first two breaks discussed were in winter, and the other two were in summer.

The Sherman Island levee failed on January 20, 1969. Flow in the Sacramento River at Sacramento at the time was 68,500 cubic feet per second, increasing to 93,500 cubic feet per second while the island filled, which required about 140,000 acre-feet. This large inflow to the Delta resulted in no measurable change in chlorides in the channels near Sherman Island.

The Mildred Island levee failed on January 27, 1983. Flow past Sacramento was over 100,000 cubic feet per second. Again, there was no measurable change in salinity during the period of filling, which required 13,000 acre-feet. There was no impact on the export of water from the Delta.

The McDonald Island levee failed on August 23, 1982, when flow past Sacramento was 22,600 cubic feet per second. The flooding caused an immediate, although moderate, increase in electrical conductivity and chlorides measured at Jersey Point, Antioch, and Chipps Island. No water quality standards were exceeded, however, due to the relatively high Delta outflow that summer. No special operations were required by the State Water Project or Central Valley Project to protect Delta water quality following the flooding.

The Lower Jones Tract levee failed on September 26, 1980. The potential impact of this failure was substantial, with a flow of 14,800 cubic feet per second past Sacramento and a requirement of 79,000 acre-feet to fill the island. The gates on Clifton Court Forebay were closed, eliminating export by the State Water Project. Pumping at the Tracy Pumping Plant was reduced to one unit, and releases from Folsom Lake were increased. These measures resulted in an increase of 47 percent in the Delta outflow index and no appreciable seawater intrusion. On September 30, normal export was resumed. No change was registered in the chloride content at Contra Costa Canal intake. At the Antioch Water Works intake, chlorides were 220 milligrams per liter on September 26, 456 mg/L on September 28, and 270 mg/L on September 29. Although salinity intrusion did occur, it was so minor as to be classified as a failure resulting in no salinity intrusion.

These examples show that under many flow conditions, failure of a levee on a single Delta island may have little or no impact on export of water from the Delta. Under those summer flow conditions where such failure may have an impact, special operations such as taken for the Jones Tract flooding may be able to prevent salinity intrusion that would affect export from the Delta.

Failure Resulting in Salinity Intrusion

The south levee of Andrus Island broke on June 21, 1972. This levee break, the most serious in terms of water supply, required interruption in service from the State Water Project and the Central Valley Project export facilities.

Over the 2-day period while Brannan and Andrus islands filled, a breach about 500 feet wide and 75 feet deep was carved by the water flowing into the islands. An estimated 150,000 acre-feet passed through the break and flooded about 13,000 acres to depths of 8 to 14 feet. It has been calculated that 123,000 acre-feet of this water was from the San Francisco Bay system and the remainder was fresh water from Delta tributaries.

The chloride content of the Sacramento River at Emmaton went from 260 milligrams per liter (mg/L) on June 20 to 1,150 on June 25. (At 250 mg/L most people can taste the salt.) At Jersey Point on the San Joaquin River, the chloride content climbed from 300 mg/L on June 20 to 1,410 mg/L on June 23. The chloride content of the water in the lake formed on Brannan-Andrus Island was measured at 375 mg/L on July 17.

The State Water Project stopped taking water into Clifton Court Forebay, and the Central Valley Project decreased its pumping through the Tracy Pumping Plant from 4,200 to 900 cubic feet per second within two days. At the time of the break, Sacramento River flow at Sacramento was 13,500 cubic feet per second. Reservoir releases were increased, with Shasta going from 12,000 to 13,000 cfs, Folsom from 2,000 to 3,000 cfs, and Oroville from 3,000 to 3,500 cfs. On June 26, releases were increased further to provide additional inflow; Shasta releases were increased to 14,000 cfs, Folsom to 5,000 cfs, and Oroville to 4,000 cfs.

Most heavily impacted by the inflow of salt water was Contra Costa Canal. Contra Costa Water District had stored water for emergencies in the small Contra Loma Reservoir and, in addition, immediately embarked on a program to connect to the Mokelumne Aqueduct. East Bay MUD supplied 40 million gallons a day through the intertie, which kept the chloride content to a maximum of 120 mg/L downstream from the intertie. Upstream, however, 70,000 people and some industries received water with a peak chloride content of about 440 mg/L. This required some of the industries to cease operation.

The increased inflow of fresh water in the Sacramento River was effective in flushing the salt water out of the northern Delta. However, about 30 percent of the Sacramento River increased flow entered the eastern Delta through the Delta Cross Channel and Georgiana Slough. This was not sufficient to clear the salt water out of the Delta. In addition, a large block of saline water was trapped south of the San Joaquin River. The southern Delta could only be cleared by the projects pumping water out or allowing the San Joaquin River (which had relatively low flows) to flush the saline water out to the bay. The saline water was pumped out.

The Central Valley Project and State Water Project both used water stored in San Luis Reservoir to maintain deliveries south of that reservoir. The State used Clifton Court Forebay and Del Valle Reservoir water for its customers on the South Bay Aqueduct. The Bureau of Reclamation decided to export the salt water from the southern Delta through Tracy Pumping Plant to restore suitable quality. It increased diversions at a rate that permitted maximum possible dilution, and was able to clear the salt out of the southern Delta while maintaining a maximum concentration at its pumping plant of 165 mg/L chlorides, which did not exceed its contractual obligation to customers. It is estimated that this higher chloride concentration resulted in an additional 53,000 tons of salt being exported to users of water from the southern Delta.

Two things have happened since 1972 that would decrease the impact of the Brannan-Andrus flooding if it were to take place now.

First, the State Water Resources Control Board has set more rigorous water quality standards under Decision 1485 than were in effect in 1972 under Decision 1379. As a result, salinity in the channel between Sherman Island and Antioch is held at much lower levels in all but dry or critical years. Consequently, less salt would be expected to enter the Delta with a repetition of the Brannan-Andrus flooding.

Second, completion of New Melones Reservoir on the Stanislaus River makes it possible to release water from that reservoir to move salt out or dilute it in the southern Delta, similar to the way the salt was flushed out of the northern Delta by releases down the Sacramento River in 1972.

Chapter 6. EXISTING AGENCY PLANS FOR RESTORING WATER SERVICE

It appears that none of the agencies mentioned in Assembly Bill 955 has an emergency plan for quickly restoring water service in the event of a levee failure that causes saline water intrusion. However, related emergency plans or precautions do exist. Additionally, much experience has been gained by the agencies from levee failures such as those described in Chapter 5.

Department of Water Resources

Emergency plans prepared by the Department of Water Resources relate primarily to operating and maintaining the State Water Project north and south of the Delta. Typical emergency situations considered are fire, civil disturbance, earthquake, and structural failure. The emergency plans that pertain to this report are:

- Emergency Handbook for Water Supply Managers: This handbook is designed to serve during the first hours and days after a major disaster has damaged or destroyed a water distribution system.

- Developing an Emergency Response Plan -- Supplement to Emergency Handbook for Water Supply Managers: This publication completes the goal set for the "Emergency Handbook for Water Supply Managers". It emphasizes activities that should be performed to develop the emergency response plan before the disaster occurs.

- Flood Emergency Operations Manual: This manual describes responsibilities of the Department of Water Resources during periods of flooding. The Department maintains a permanent staff skilled in flood control and forecasting activities. During flood alert periods, the staff is temporarily expanded. The Department's Flood Center works closely with the National Weather Service during both routine and emergency activities. During flood alerts, the Department also works closely with the U. S. Army Corps of Engineers and the Office of Emergency Services.

- Contingency Plan -- State Water Project: This plan defines operation of the State Water Project under various types of emergencies. It discusses step-by-step procedures to assist personnel during an emergency. The water quality emergency procedures relate to point source contamination and do not discuss the type of emergency addressed in this report.

- State Flood Hazard Mitigation Plan for the Sacramento-San Joaquin Delta: The purpose of this plan is to evaluate natural hazards of an area and take mitigating action. Flood hazard mitigation is a management strategy in which current actions and expenditures to reduce the occurrence or severity of flood disasters are balanced with potential losses from future floods. Flood hazard mitigation can reduce the severity of the effects of floods on people and property by reducing the cause or occurrence of the hazard, reducing exposure to the hazard, or reducing the effects through preparedness, response, and recovery measures.

- State of California Emergency Plan: This plan contains emergency preparedness and response concepts that serve as a basis for conducting emergency operations by all jurisdictions throughout the State. The plan is in accordance with the Constitution and statutes of California, and the Director of the Office of Emergency Services is charged with the responsibility to execute the plan under emergency conditions and continue its development as experience and changing conditions require.

U. S. Bureau of Reclamation

In the event of a Delta emergency, the Bureau of Reclamation would want to resume normal project operations with a minimum of disruption, via measures intended to reduce any prolonged effect on the Central Valley Project's ability to deliver water, power, and acceptable water quality.

Specific response to any emergency would depend strongly on the circumstances of the emergency, the status of Central Valley Project water supplies, and the nature of existing demands for water and power. Coordination of Central Valley Project and State Water Project operations would be guided by provisions of the Coordinated Operation Agreement. However, emergency conditions would probably require special coordination and agreement on such issues as the use of New Melones storage or temporary deviation from Decision 1485 water quality standards.

The Bureau of Reclamation has in the past reduced pumping at the Tracy Pumping Plant following a levee failure. In most foreseeable conditions, the Bureau could reduce pumping at Tracy temporarily without major adverse effect on project operation. Delivery of water through Tracy Pumping Plant would need to continue to at least those contractors with no other water supply. In any situation, the following considerations must be taken into account.

Water Delivery Considerations

Assuming an adequate supply of water is stored in San Luis Reservoir, pumping at Tracy could be reduced to an amount just sufficient to meet demands in the northern reaches (Pools 1-13) of the Delta-Mendota Canal. Pools 1-13 are those upstream of O'Neill pump-generating plant. It may be possible to reverse the direction of flow in Pools 11-12-13, so that water could be delivered from O'Neill Forebay to the northern reaches.

If water available in the Delta for pumping at Tracy was of adequate quality for agricultural use, it may be assumed that the Bureau would, at a minimum, continue to pump enough to meet demands in Pools 1-10. This might be from 50 to 900 cubic feet per second, depending on the season, and could likely be met with only one pump at Tracy. It should be noted that these rates are well within the summer release rates and channel capacities for water from New Melones Reservoir.

Water Quality Considerations

Decision 1485 requires Delta-Mendota Canal water quality of no higher than 250 mg/L chloride. Contractual requirements are for total dissolved solids (TDS in mg/L) of no higher than: daily, 800; monthly, 600; annual, 450; 5-year, 400.

The most critical of the standards is probably the 800 mg/L daily TDS for delivery of water to Mendota Pool under the Bureau's water contracts. For a situation of one month duration, water quality requirements for 600 mg/L TDS suggest that dilution water from San Luis Reservoir might be required to be mixed with Delta water delivered to Mendota Pool.

As an example, during the June 1972 Brannan-Andrus Levee break, the chloride concentration at the Tracy Pumping Plant reached 165 mg/L. That quality water was acceptable based on the daily TDS standard, but would not have been acceptable for the monthly standard without dilution. Shortly after the break, pumping was curtailed at Tracy. Export was reduced from 4,200 cfs to 900 cfs over three days. The Bureau maintained pumping of 900 to 1,000 cfs for six days, then gradually increased to 4,300 cfs over four days. Because demands were high in Mendota Pool at that time, Delta water was diluted by water delivered from San Luis Reservoir to make up the shortage resulting from the reduction in Tracy pumping.

U. S. Army Corps of Engineers

Executive Order 490 directs the Corps of Engineers to develop a national emergency water plan for a catastrophic domestic emergency. This undertaking started in 1986. The first phase report, scheduled for release in 1987, will include a listing of water supplies conveyance facilities, users, and other information necessary to inventory the water and water support system.

East Bay Municipal Utility District

East Bay MUD has taken a number of precautions to protect against levee and aqueduct failure and to reduce outage time in the event the Mokelumne Aqueduct does fail. Included in these precautions is the stockpiling of 1,500 feet of 69-inch diameter pipe and other materials that would help speed repair of any of the aqueducts.

Following the Jones Tract Flood in 1980, East Bay MUD constructed the foundation and piping for a 90 MGD emergency pumping plant that could pump water from the western edge of the Delta near Bixler. Pumps and controls would only be installed in the event of severe damage to the pipelines and would remain in operation only until an adequate Mokelumne supply was restored. It is estimated that 90 days would be required to make the pumping plant operational. This water supply would extend water available to customers; however, depending on the severity of damage to the pipelines, water demand reduction may still be necessary.

Each island's levees are the responsibility of a local Reclamation District, and although East Bay MUD has no direct authority over Delta levees, it voluntarily patrols and inspects the levees regularly in coordination with the Reclamation Districts. During high tides or other high water level situations, patrols are increased. East Bay MUD has no agreement with any agency regarding emergency levee repairs. However, during critical situations East Bay MUD cooperates with island Reclamation Districts.

Chapter 7. ACTIONS AND SERVICES AVAILABLE TO RESTORE SERVICE

The immediate results of a levee break in the Delta could be twofold: (1) a greater tendency for salinity intrusion into the central Delta and project water supplies, and (2) corresponding increases in Delta outflow required to control that salinity. This chapter discusses how to minimize salinity intrusion and increase Delta outflow.

Flushing

To minimize damage from salinity intrusion following a levee break, a hydraulic barrier must be reestablished to prevent the tides from pushing sea water upstream into the Delta. This could be accomplished by increasing freshwater inflow. During controlled hydrologic conditions, large amounts of additional water would have to be released from project reservoirs to flow through the Delta for salinity control and flushing. Water supply availability will be a major factor in determining if reservoir releases will be used in an emergency.

Project reservoirs that could supply additional Delta outflow and approximate travel times for water released from these reservoirs to reach the Delta are:

Lake Shasta	3-5 days
Folsom Lake	1 day
New Melones Reservoir	0.5-1 day
Lake Oroville	2-3 days

Another means to provide flushing flows is to reduce Delta use and exports. This has the advantage of providing an immediate effect, as opposed to a half-day to 3-day lag time. Project exports that could be reduced or halted include diversions into the Delta-Mendota Canal and the California Aqueduct.

Barriers

Massive salt water intrusion into the Delta may make it necessary to temporarily alter the distribution of flow in Delta channels to flush as much salt as possible back to Suisun Bay. This would decrease the amount of salt that would need to be taken out of the Delta through the State Water Project, Central Valley Project, and other diversions.

Barriers in Steamboat Slough and in the Sacramento River downstream from Georgiana Slough may increase the amount of Sacramento River water that will move through the Delta Cross Channel and Georgiana Slough into the central Delta. Under normal summer conditions about 30 percent plus 2,000 cubic feet per second of the water going down the Sacramento River follows this route. Barriers in these two channels could be rock fill, similar to temporary barriers constructed in several Delta channels in the past. It may be possible to complete a barrier more quickly by sinking barges in the channels, with provisions to refloat the barges when need for barriers has passed. Advance design studies would be desirable to determine the best barrier design and operations.

A rock barrier on the San Joaquin River at the upstream end of Rough and Ready Island, with flap gates for tidal pumping upstream, would contribute to moving fresh water into the southern Delta to help flush salt water trapped in that area out to Suisun Bay. This barrier probably would need to be rock, with pipes under it to convey the water upstream on floodtides. Advance design studies would be desirable.

Levee Reconstruction

Levees on flooded islands should be repaired quickly to minimize adverse impacts on water project operations. This includes placing riprap on the ends of the break, placing wave protection on the inside of the levee, and/or closing the break.

Pumping

Emergency pumping has been used to help maintain water supplies. For example, following the Jones Tract flood in 1980, East Bay Municipal Utility District constructed the foundations and piping for a 90 million gallon per day emergency pumping plant that could pump water from the western edge of the Delta near Bixler.

Water Quality Monitoring Sites

More than 40 salinity observation stations in the Delta are monitored by the Department of Water Resources and the U. S. Bureau of Reclamation (see Figure 6). The Department of Water Resources' six multiparameter water quality stations, with telemetry systems to be completely installed by late 1987, will provide direct and timely Delta water quality information during a levee failure. Most of the salinity stations are also telemetered. Other salinity stations can be personally monitored and that information sent via telephone. In addition, the Department's water quality monitoring vessel, the San Carlos, can be used for concentrated sampling in critical areas.

Computer Modeling

The Fischer Delta model, a computer model of the Delta Region, is available for use by the Department of Water Resources. The model was specifically designed to simulate salinity changes that result from changes in geometry and hydrology. The model can simulate a full year or more of hydrology, and it includes mechanisms for simulating levee breaks, installation of tidal barriers and other control structures, dredging, diking, and dike failures. The model can simulate multiple breaks on one or more islands and can simulate a specific break location and length.

Salinity intrusion can be computed on 15-minute time intervals. Therefore, this model would be valuable in predicting salinity intrusion in the event of levee failure.

To make this program useful during the initial critical hours of a levee failure, predevelopment work would be required to develop the program and data so that when a levee failure does occur, salinity intrusion information can be projected within one working day. In addition, it would be advantageous to link the continuous monitoring salinity stations directly to the computer to allow immediate access to salinity information.

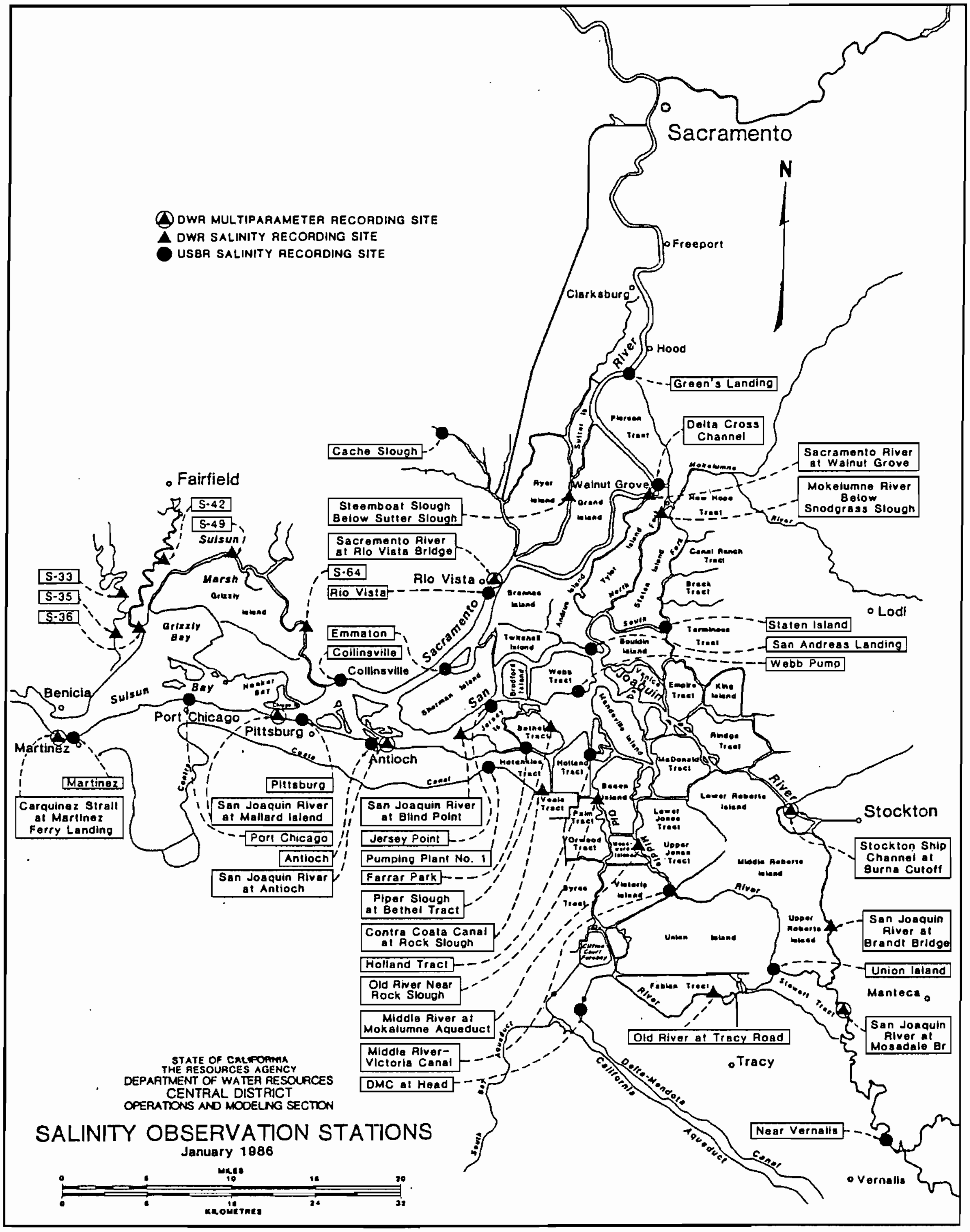
The computer model would also allow simulations of possible corrective actions. Due to the many input variables that must be known at the time of a break and the nearly infinite number of possible failure scenarios, it would not be cost effective to try to develop specific emergency plans until a failure actually occurs.

Health Limits

The Department of Health Services has established maximum contaminant levels for secondary drinking water. These are contained in the California Administrative Code, Title 22, Section 64473, Table 7. The maximum contaminant levels listed may be objectionable to an appreciable number of people but it is not generally considered to be hazardous to health. The short-term, upper, and recommended maximum contaminant levels for chlorides are 600, 500, and 250 milligrams per liter, respectively.

For municipal and industrial purposes, the water quality standard set by Decision 1485 was in general 250 milligrams per liter maximum mean daily chlorides. This compares to the secondary drinking water standards as established by the Department of Health Services. Relaxing these health limits or any other water quality standards may have to be considered during an emergency.

FIGURE 6



Chapter 8. DELTA EMERGENCY PLANS

The variables that determine the severity of an emergency caused by levee failure in the Sacramento-San Joaquin Delta, the many possible combinations of levee failure, and the impact a levee failure will have on the water supply facilities are nearly infinite in number, but can be described in three categories.

- Structural damage to water supply facilities.
- Salt water intrusion, the effect of which would be greater during periods of low flow.
- Increased salt dispersion (mixing) into the Delta if western island levees fail.

While all emergencies in the Delta can be expected to have elements in common, there would also be great diversity, requiring several plans that depend on conditions at the time of the failure. For this reason, the report does not endeavor to indicate time periods required to restore service. Additionally, the time necessary to implement an appropriate plan and restore service may vary greatly depending on the resources available and the priority of this emergency compared to other emergencies outside the Delta.

The responses listed are recommendations only, and should not be construed as binding commitments or required actions by the participants. When possible, the recommended responses are expected to be performed immediately and simultaneously.

Some of the possible actions, such as placing temporary barriers in the Sacramento River, will have significant impacts. In such cases, the actions should be implemented only if absolutely necessary and after thorough discussion with all affected parties. It is expected that those impacts and others will be addressed through the implementation process (discussed in this chapter) before the actual need for barriers occurs.

Emergency Plans

Following are four emergencies illustrating the scenario, the consequence, and the possible actions that could be taken in response to such an emergency. The four emergencies have been selected to represent the spectrum of possibilities. It is, therefore, likely that when an actual emergency occurs, it can be represented by one or a combination of the following four emergencies. To facilitate comparison, the plans are summarized on Plate 1.

Emergency I

Scenario: Failure of a large island in the western Delta in the summer, similar to the 1972 flooding of Brannan-Andrus Islands.

Consequence: Movement of saline water from Suisun Bay upstream into the Delta.

Response:

- Immediately stop pumping into the California Aqueduct and the Delta-Mendota Canal except for essential requirements in the reach to San Luis Reservoir.
- Fill Clifton Court Forebay on the next high tide.

- Increase release from Folsom Lake by 5,000 cfs.

- Increase release from Lake Oroville by 3,000 cfs.

- Increase release from Shasta Lake by 4,000 cfs.

- Increase release from New Melones Reservoir by 2,000 cfs after salt dispersion in channels has stabilized (releases should be increased simultaneously from Tullock and New Melones Reservoirs).

- Request Delta farmers to stop irrigation until flooded islands fill.

- Connect Contra Costa Canal to Mokelumne Aqueduct (East Bay MUD) to decrease salinity in Contra Costa Canal.

- Place riprap on ends of break to stop loss of levee and install wave erosion protection on interior of levee to avoid additional breaks that would increase salt dispersion.

- Close levee break.

- Monitor salt content of channels; decrease reservoir releases and resume pumping as salt content permits.

Emergency II

Scenario: Failure of the Middle River levee on Upper Jones Tract at the Mokelumne Aqueduct crossing.

Consequence: Possible failure of the Mokelumne Aqueduct due to erosion, and salinity intrusion into the central Delta (at low Delta outflow).

Response:

- Immediately stop pumping into the California Aqueduct and the Delta-Mendota Canal except for essential requirements in the reach to San Luis Reservoir.

- Monitor salt movement into the Delta and evaluate need for increased reservoir releases.

- Install pumps at East Bay MUD's Bixler emergency pumping plant near Indian Slough.

- Reestablish the 1977 water transfer from South Bay Aqueduct to San Antonio Reservoir (City of San Francisco) to East Bay MUD at Hayward.

- Install pumps (if needed) to reverse flow, and reinstall a pipeline on Richmond-San Rafael Bridge to bring water from Marin County to East Bay MUD.

- Connect Contra Costa Canal to Mokelumne Aqueduct, with pumps to move water from the Delta to East Bay MUD (if salinity at Rock Slough intake permits).

- Place pipeline on Carquinez Bridge to bring North Bay Aqueduct-Vallejo water or Solano Project water to East Bay MUD.

- Place pipeline on Benicia Bridge to bring North Bay Aqueduct-Benicia water to Contra Costa Water District for exchange to East Bay MUD.

- Place riprap on the ends of the break on the Upper Jones Tract levee.

- Place wave erosion protection on interior of levees.

- Close break and dewater Upper and Lower Jones Tracts to prevent further damage to Mokelumne Aqueduct.

- Replace damaged section of Mokelumne Aqueduct.

Emergency III

Scenario: Severe earth movement due to an earthquake during winter.

Consequence: Loss of several miles of levee on several Delta islands.

Response:

° Dispatch airplane to determine which islands are flooding.

° Compute acre-feet necessary to fill islands in a 2-day period and compare with Delta outflow to see if a net reversal of flow from west of the Delta will occur that will move salt water into the Delta. If net reversal occurs, continue with response actions.

° Immediately stop pumping into the California Aqueduct and the Delta-Mendota Canal except essential requirements in the reach to San Luis Reservoir.

° Fill Clifton Court Forebay on next high tide.

° Increase releases from Folsom, Oroville, New Melones, and Shasta reservoirs to move salt water out of Delta channels.

° Open Delta Cross Channel gates as necessary to assist Mokelumne River system in flushing central Delta.

° Connect Contra Costa Canal to Mokelumne Aqueduct to decrease salinity in Contra Costa Canal.

° Monitor salt content of channels, decrease reservoir releases, close cross channel gates, and resume pumping as salt content permits.

° Repair damaged levees on western Delta islands.

Emergency IV

Scenario: Severe earth movement due to an earthquake during summer.

Consequence: Loss of several miles of levee on several Delta islands, including four western Delta islands. Intrusion of a large amount of salt water into the western and central Delta.

Response:

° Curtail export pumping.

° Fill Clifton Court Forebay at next high tide.

° Dispatch airplane to determine which islands are flooding.

° Increase releases from upstream reservoirs by the following amounts: Folsom, 5,000 cfs; Oroville, 3,000 cfs; Shasta, 4,000 cfs; New Melones, 2,000 cfs (after salt dispersion has stabilized).

° Request Delta farmers to stop irrigation until flooded islands fill.

° Request diverters from Sacramento and San Joaquin rivers and valley floor tributaries to temporarily stop diversions.

° Request substantial downstream releases from reservoirs tributary to the San Joaquin River until Delta salinity is reduced to a usable salt concentration.

° Connect Contra Costa Canal to Mokelumne Aqueduct to decrease salinity in Contra Costa Canal.

° Place pipeline on Benicia Bridge to bring North Bay Aqueduct-Benicia water to Contra Costa Water District.

° Place pipeline on Carquinez Bridge to bring North Bay Aqueduct-Vallejo water or Solano Project water to Contra Costa Water District.

° Place pumps at one or more checks in the California Aqueduct to move water upstream for South Bay Aqueduct.

° Place temporary barriers in the Sacramento River below Georgiana Slough and in Steamboat Slough to increase head and flow through the Delta Cross Channel and Georgiana Slough.

° Place a temporary rock barrier in the San Joaquin River at upstream end of Rough and Ready Island, with flap gates for tidal pumping upstream.

° Monitor salt content of Delta channels; cut back reservoir releases and resume export pumping as water quality permits.

° Rebuild damaged levees, with western Delta islands the first priority (to reduce salt dispersion).

° Remove temporary barriers.

Responsibility

Numerous measures can be taken in advance of an emergency to facilitate implementation of the actions proposed in the emergency plans. Lead responsibility for protecting the water supply as described in this report shall be assigned to the Department of Water Resources.

The Department will assign responsibility within its organization for pursuing implementation measures contained in this chapter and for updating the plans and measures for implementation. It will also train key personnel so they are familiar with the plans and the implementation measures.

The U. S. Bureau of Reclamation, East Bay Municipal Utility District, and Contra Costa Water District should take similar action to facilitate effective use of the plans.

The Director of the Department of Water Resources is specifically empowered to act on water-related emergencies. This authority is provided in Section 128, Article 1, Chapter 2, Division 1 of the Water Code. More specifically, this section allows the Department to perform work during times of extraordinary stress "...to immediately avert, alleviate, repair, or restore damage or destruction .... to protect the health, safety, convenience, and welfare of the general public of the state."

The Governor's emergency powers are contained in Article 3, Chapter 7, Division 1, Title 2 of the Government Code, the State Emergency Services Act. That authority, which is much broader than that of the Director, allows the Governor to make, amend, and rescind orders and regulations necessary to carry out the California Emergency Services Act (Chapter 7). The Act also provides the Governor with the authority to use private property or personnel to react to the emergency.

Based on the powers of the Director and the Governor, it appears that most actions in the emergency plans can be performed under existing law.

Implementation Measures

Listed below are some measures that will help implement the plan in an emergency.

° Create a roster of organizations and individuals who will have a role in implementing the "responses" given in the plans. This will include the water agencies, county and state offices of Emergency Services, U. S. Army Corps of Engineers, and California Department of Forestry.

- Develop coordination between agencies that would need water during an emergency and the agencies that would supply the water.
- Prepare a preliminary design for temporary structural measures described. (This would be prepared by the benefiting agency.)
- Consider advance installation of pipelines that interconnect water systems.
- Identify permits and licenses (or amendments) that will be required and complete as much as possible in advance.
- Complete environmental documentation where required.
- Consider expansion of this plan into an approved Emergency Plan as defined by Section 8560(a) of the California Emergency Services Act, Government Code, Title 2, Division 1, Chapter 7, Article 2.
- Continue to develop the actions and services described in Chapter 7 (i.e. computer modeling, salinity monitoring) to increase their usefulness during an emergency.
- Conduct model studies to better define salinity intrusion if one or more islands fail.
- Conduct model studies to evaluate the effectiveness and impacts of the proposed temporary physical works.

REFERENCES

California Department of Health Services. California Domestic Water Quality and Monitoring Regulations. Sanitary Engineering Section. 1977.

California Department of Public Works. Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay. Division of Water Resources. Bulletin 27. 1931.

California Department of Water Resources. Developing an Emergency Response Plan, Supplement to Emergency Handbook for Water Supply Managers. Southern District. May 1985.

_______. Emergency Handbook for Water Supply Managers. Southern District. June 30, 1984.

_______. Alternatives for Delta Water Transfer. November 1983.

_______. Flood Emergency Operations Manual. Division of Flood Management. October 1984.

_______. Flood Hazard Mitigation Plan for the Sacramento-San Joaquin Delta. September 15, 1983.

_______. Delta Levees Investigation. Bulletin 192-82. October 1982.

_______. Safety Evaluation of Clifton Court Forebay Dam and Reservoir. Division of Design and Construction. Memorandum Report. July 1980.

_______. California Flood Management - An Evaluation of Flood Damage Prevention Programs. Bulletin 199. September 1980.

_______. The California Drought 1976-77. Contingency Plans for Rationing by California Communities Pursuant to Sections 350-358 of the Water Code. February 1977, August 1977, May 1978.

_______. Delta Water Facilities. Bulletin 76. July 1978.

_______. Performance of the Oroville Dam and Related Facilities During the August 1, 1975 Earthquake. Bulletin 203. April 1977.

_______. California High Water. Bulletin 69. Annual.

_______. Contingency Plan - State Water Project. Division of Operation and Maintenance. Civil Maintenance Branch. Annual.

_______. The California State Water Project, Water Operations in the Sacramento-San Joaquin Delta. Bulletin 132, Appendix E. Annual.

California Office of Emergency Services. State of California Emergency Plan. 1984.

Converse, Ward, Davis, Dixon, Inc. Partial Technical Background Data for the Mokelumne Aqueduct Security Plan, for East Bay Municipal Utility District. December 1981.

Dames and Moore. McDonald Island Levee Stability Study, McDonald Island, California, for Pacific Gas and Electric Company. January 1985.

Houston, W. N., and J. M. Duncan. Probability of Failure of Levees in the Sacramento-San Joaquin Delta, California. February 1978.

U. S. Army Corps of Engineers. Draft Feasibility Report and Draft Environmental Impact Statement, Sacramento-San Joaquin Delta, California. Sacramento District. October 1982.

_______. Hydraulic Model Study for the Salinity Impact of Levee Failure Flooding, Sacramento-San Joaquin Delta Islands. San Francisco District. June 1984.

Appendix A

ASSEMBLY BILL NO. 955

-- C O P Y --

Assembly Bill No. 955

CHAPTER 1271

An act to amend Section 12981 of the Water Code, relating to water resources.

[Approved by Governor September 30, 1985. Filed with Secretary of State September 30, 1985.]

LEGISLATIVE COUNSEL'S DIGEST

AB 955, Peace. Delta levee failure plan.

(1) Existing law provides for the design, construction, operation, and maintenance by the Department of Water Resources of specified water development facilities as part of the state water project. The federal government also operates certain water development facilities as part of the Central Valley Project.

This bill would require the department to prepare an emergency plan which will allow the federal Central Valley Project and the state water project to continue exporting, or quickly resume exporting, usable water from the Sacramento-San Joaquin Delta in the event of the failure of one or more levees in the delta, and allow the East Bay Municipal Utility District and the Contra Costa Water District to continue delivering, or quickly resume delivering, usable water. The bill would require the emergency plan to include specified matters and would require the recommended emergency plan to be submitted to the Legislature by January 1, 1987, for consideration. The bill would make legislative findings and declarations in this connection.

(2) Existing law makes various legislative findings concerning the delta, including that the physical characteristics of the delta should be preserved essentially in their present form.

This bill would include findings that the Legislature recognizes that it may not be economically justifiable to maintain all delta islands and would revise other findings.

The people of the State of California do enact as follows:

SECTION 1. The Legislature finds and declares all of the following concerning the levees in the Sacramento-San Joaquin Delta:

(a) Some delta levees are becoming more and more unstable because (1) they were never built to proper engineering standards, (2) they are substantially undersized, (3) the underlying peat is a very poor foundation material for what are now large and heavy levees, and (4) subsidence is causing increased hydrostatic pressure against the levees.

(b) The United States Army Corps of Engineers has estimated that the probability of failure for some of the delta levees is greater than 10 failures over a 110-year period.

(c) The federal Central Valley Project and the state water project use the natural delta channels to carry water from the Sacramento River system across the delta to the export pumps in the south delta, thereby supplying about 20 percent of the water used in the state.

(d) The East Bay Municipal Utility District's water pipelines cross the delta, and the Contra Costa Water District diverts water directly from the delta.

(e) Depending on hydrologic conditions, the failure of one or more critical levees in the delta could draw salt water into the delta from the Carquinez Straits and San Francisco Bay, thereby contaminating the water in the delta.

(f) The contamination of the water in the delta could make the export water unusable for an extended period of time, with substantial economic and social effects upon the areas that are dependent on that water.

(g) In order to protect this water supply and thereby the state's economy, it is only prudent that the state have an emergency plan to respond to the failure of one or more critical levees in the delta.

SEC. 2. The Department of Water Resources shall prepare an emergency plan which will allow the federal Central Valley Project and the State Water Resources Development System to continue exporting, or quickly resume exporting, usable water from the Sacramento-San Joaquin Delta in the event of the failure of one or more levees in the delta as the result of levee overtoppings, levee foundation failure, liquefaction of levees due to an earthquake, or other failure modes. The emergency plan shall also allow the East Bay Municipal Utility District and the Contra Costa Water District to continue delivering, or quickly resume delivering, usable water.

The emergency plan shall also include consideration of a catastrophic failure of a large number of levees that might occur with a strong earthquake on the San Andreas Fault. The emergency plan shall designate which levees are critical for the maintenance of export water quality and shall evaluate the levels of risk for failure for those critical levees. The emergency plan shall be designed to respond to short-term consequences of levee failure and shall not be designed to respond to long-term delta water transfer issues or to long-term levee reconstruction issues.

The recommended emergency plan, including alternative plans, shall be submitted to the Legislature on or before January 1, 1987, for consideration.

This section does not authorize the construction of physical works of any kind, including, but not limited to, any peripheral canal or through-delta channel plan.

SEC. 3. Section 12981 of the Water Code is amended to read:

12981. The Legislature hereby finds and declares that the delta is endowed with many invaluable and unique resources and that these resources are of major statewide significance. The Legislature further finds and declares that the delta's uniqueness is particularly characterized by its hundreds of miles of meandering waterways and the many islands adjacent thereto; that, in order to preserve the delta's invaluable resources, which include highly productive agriculture, recreational assets, fisheries, and wildlife environment, the physical characteristics of the delta should be preserved essentially in their present form; and that the key to preserving the delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands. However, the Legislature recognizes that it may not be economically justifiable to maintain all delta islands.

Appendix B

SALINITY INTRUSION POTENTIAL IN THE EVENT OF A LEVEE FAILURE

SALINITY INTRUSION POTENTIAL IN THE EVENT OF A LEVEE FAILURE

When a levee fails, an island will flood, possibly resulting in salinity intrusion into the Delta. The actual effect could be modeled with the Department's computer model. However, decisions need to be made immediately, and at this time the computer model is not capable of providing immediate results. Therefore, a two phased methodology was developed that may aid the operator in making immediate decisions. Phase 1 allows identification of an island or combination of islands that potentially could cause salinity intrusion during dry summer conditions. These islands would be considered critical for maintaining water quality. Phase 2 goes one step farther, by determining the distance that possible salinity intrusion extends into the Delta. This methodology should be considered only as a gross approximation as it does not reflect the true delta hydraulics.

Phase 1: Each island was evaluated to determine its individual effect on salinity intrusion. The following assumptions were made:

Dry Summer Conditions
Inflow to Delta = 19,000 cfs
Delta Consumptive Use = 5,000 cfs
Minimum Outflow without Salinity Intrusion = 4,000 cfs
Number of Days to Flood = 1 if 5,000 acres or less; 2 if more than 5,000 acres

An inflow rate was estimated for each island (Table B-1) by dividing the volume of the island by the estimated time it would take to fill the island if the levee failed. For example, Medford Island with about 1,219 acres would flood in one day (since 1,219 $\leq$ 5,000 acres). The volume of Medford Island is about 14,100 acre-feet. Dividing the volume by the time (14,100 acre-feet divided by 24 hours) yields an estimated inflow rate of 7,100 cfs.

Under the assumed conditions, the maximum available export is 10,000 cfs (19,000 - 5,000 - 4,000 cfs). Since the amount of export can be controlled, if a levee failed, exports can be reduced to compensate for the island inflow. That is, the island inflow rate could be up to 10,000 cfs (which would mean curtailing all exports), and the 4,000 cfs outflow would still be maintained. Therefore, the maximum island inflow rate without effect on salinity is 10,000 cfs.

If the levee failed on Medford Island, its estimated inflow rate is about 7,100 cfs. Since 7,100 cfs is less than 10,000 cfs, exports could be decreased by 7,100 cfs and the outflow would not be affected. Hence, there probably would not be any salinity intrusion. But for Twitchell Island, the estimated inflow rate is 26,300 cfs, which is greater than 10,000 cfs. So even if all exports are curtailed, the minimum outflow cannot be maintained. Salinity intrusion probably would occur. The results for each island are tabulated in Table B-1, Column 3.

The estimated inflow rates can also be used for combinations of failures. For example, Medford Island (7,100 cfs) and Quimby Island (4,300 cfs), if flooded independently, would have no effect on salinity intrusion (since 7,100 cfs is less than 10,000 cfs and 4,300 cfs is less than 10,000 cfs); however, if both islands flood concurrently, the combined estimated inflow rate is 11,400 cfs

(7,100 + 4,300 cfs) which is greater than 10,000 cfs. Therefore, their combined failures would cause salinity intrusion while their independent failures would not.

Phase 2: Selected locations in Suisun Bay and the Sacramento-San Joaquin Delta are identified in Figure B-1. Their corresponding channel volumes are shown on Figure B-2. Figure B-2 may be used to determine the distance that possible salinity intrusion extends into the Delta immediately after an island or combination of islands flood.

For example, if McDonald Island floods (93,800 acre-feet, Table B-1) the level and location of critical salinity before the flooding is determined to be 600 mg/L at Jersey Point. On Figure B-2, move upstream the volume of the flooded island or 93,800 acre-feet. The location of the critical salinity level of 600 mg/L immediately after the island floods will potentially be at the Mokelumne River on the San Joaquin River.

This process may be used for any island or combination of islands that flood to determine the distance that salinity may be expected to intrude into the Delta.

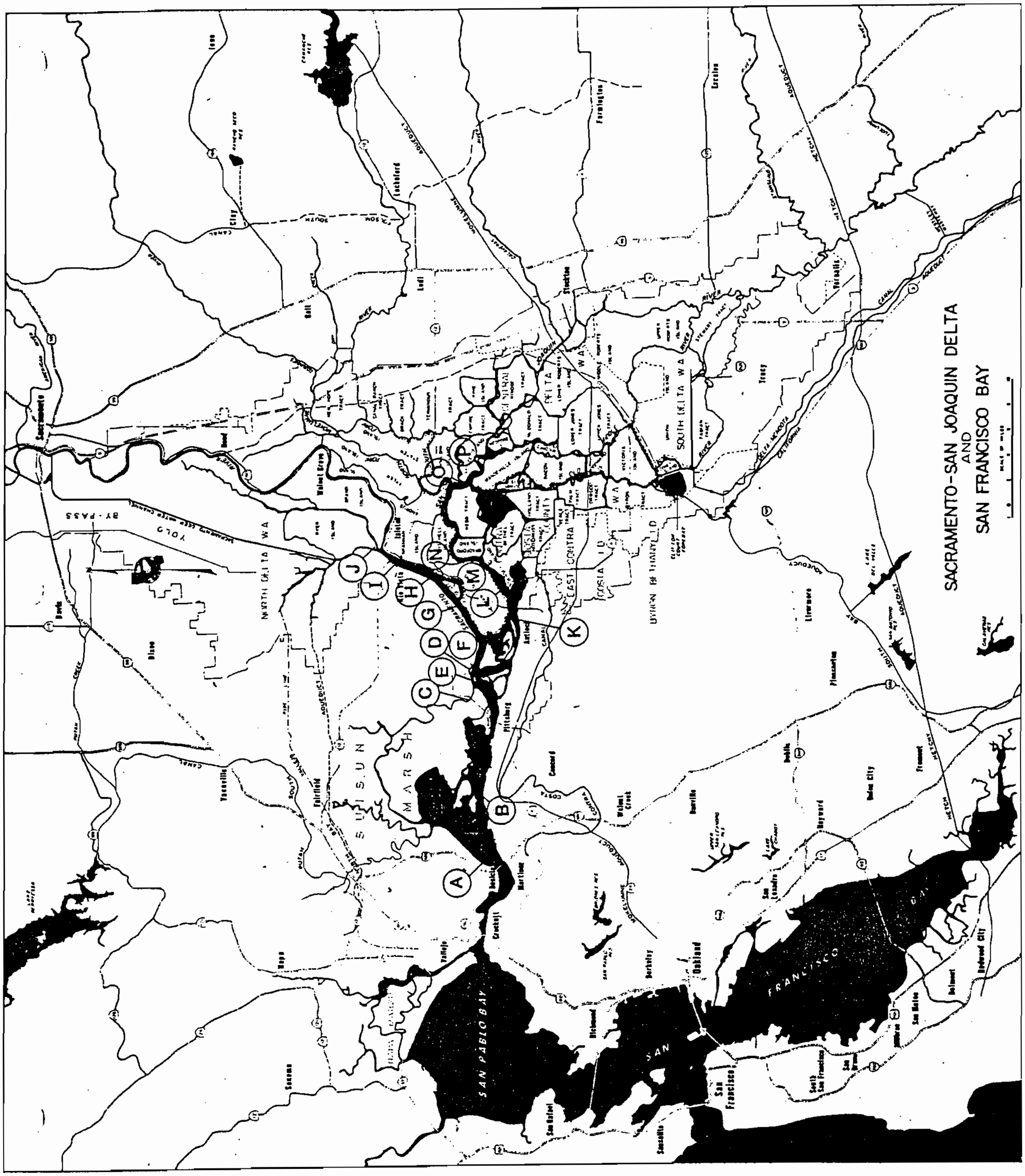
TABLE B-1
POTENTIAL SALINITY INTRUSION IN THE
EVENT OF A LEVEE FAILURE

Island or Tract	Volume of Flooded Island (Acre-Feet)	Estimated Inflow Rate During Flooding (cfs)
Atlas	1,000	500
Bacon	87,800	22,100
Bethel	31,700	16,000
Bishop	13,000	6,600
Bouldin	94,000	23,700
Brack	48,000	24,200
Bradford	29,000	14,600
Brannan-Andrus	195,000	49,200
Byron	51,500	13,000
Canal Ranch	28,900	14,600
Coney	8,800	4,400
Deadhorse	1,400	700
Drexler	21,400	10,800
Empire	56,200	28,300
Fabian	29,100	7,300
Holland	49,800	25,100
Hotchkiss	18,900	9,500
Jersey	40,600	20,500
Jones, Lower	79,100	19,900
Jones, Upper	71,700	18,000
King	37,000	18,700
Mandeville	81,900	20,600
McCormack-Williamson	8,500	4,300
McDonald	93,800	23,600
Medford	14,100	7,100
Mildred	13,200	6,700
New Hope	46,600	11,700
Orwood	16,300	8,200
Orwood, Upper	11,400	5,700
Palm	28,900	14,600
Quimby	8,600	4,300
Rindge	89,500	22,600
Rio Blanco	3,000	1,500
Roberts	248,200	62,600
Sargent-Barnhart	3,500	1,800
Sherman	136,800	34,500
Shima	13,200	6,700
Shin Kee	5,900	3,000
Staten	122,200	30,800
Terminous	116,400	29,300
Twitchell	52,200	26,300
Tyler	101,400	25,600

Island or Tract	Volume of Flooded Island (Acre-Feet)	Estimated Inflow Rate During Flooding (cfs)
Union	122,100	30,800
Veale	8,000	4,000
Venice	50,600	25,500
Victoria	95,700	24,100
Walnut Grove	3,500	1,800
Webb	87,700	22,100
Woodward	24,500	12,400
Wright-Elmwood	18,500	9,300

If combined estimated inflow rate of one or more failed islands exceeds 10,000 cfs, there is potential for salinity intrusion. These islands would be identified as critical for maintaining water quality.

Figure B-1


SACRAMENTO-SAN JOAQUIN DELTA
AND
SAN FRANCISCO BAY
SUISUN MARSH
SAN PABLO BAY
SAN FRANCISCO BAY
NORTH DELTA WA
SOUTH DELTA WA
EAST CONTRA COSTA ID
BYRON BETHANY ID
YOLO BY-PASS
A
B
C
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E
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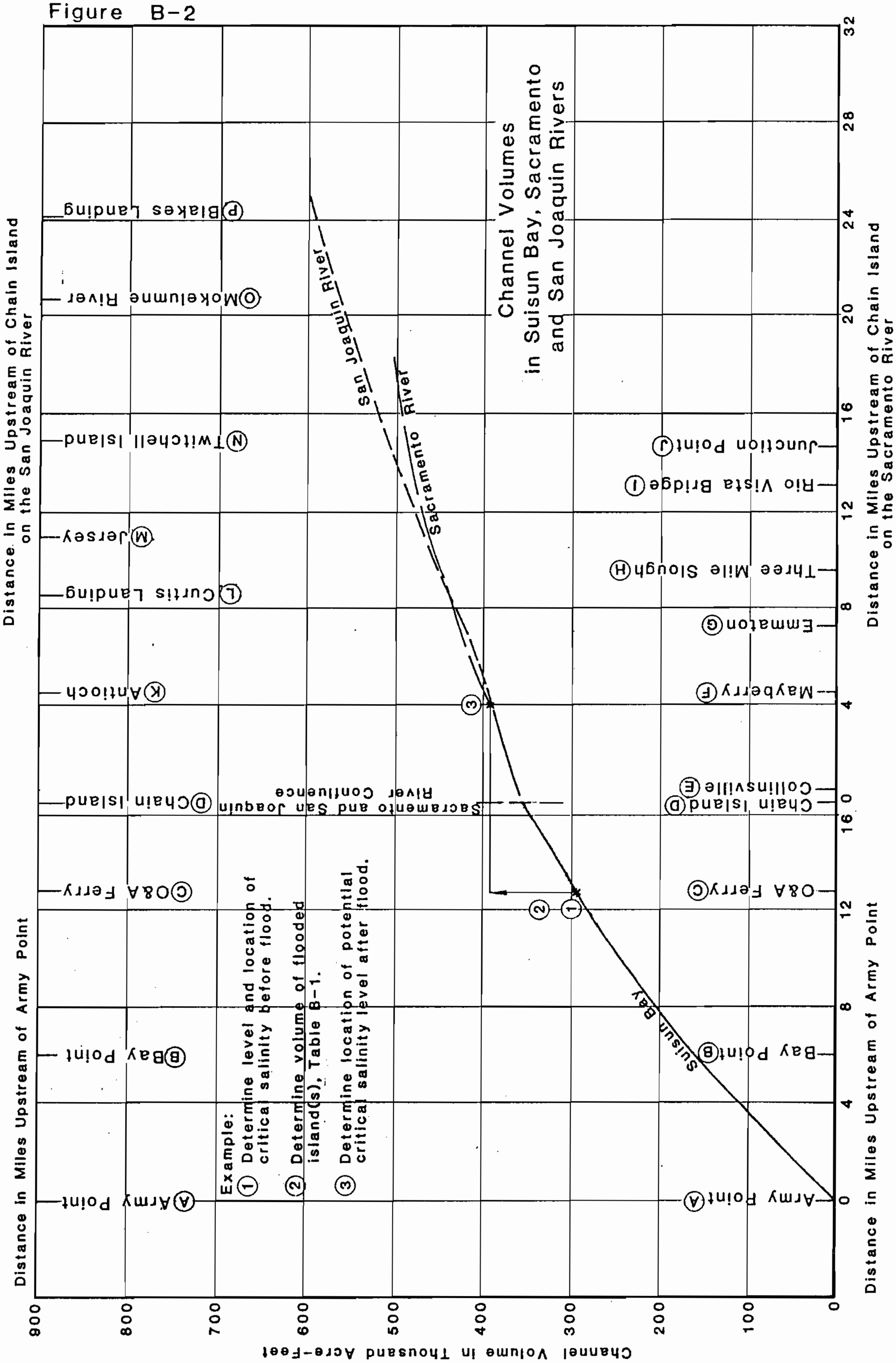
P

Figure B-2


Channel Volumes
in Suisun Bay, Sacramento
and San Joaquin Rivers
Distance in Miles Upstream of Chain Island
on the San Joaquin River
Distance in Miles Upstream of Army Point
Distance in Miles Upstream of Chain Island
on the Sacramento River
Distance in Miles Upstream of Army Point
Channel Volume in Thousand Acre-Feet
0
100
200
300
400
500
600
700
800
900
0
4
8
12
16
0
4
8
12
16
20
24
28
32
Ⓐ Army Point
Ⓑ Bay Point
Ⓒ O&A Ferry
Ⓓ Chain Island
Ⓚ Antioch
Ⓛ Curtis Landing
Ⓜ Jersey
Ⓝ Twitchell Island
Ⓞ Mokelumne River
Ⓟ Blakes Landing
Ⓔ Collinsville
Ⓕ Mayberry
Ⓖ Emmaton
Ⓗ Three Mile Slough
Ⓘ Rio Vista Bridge
Ⓙ Junction Point
Sacramento and San Joaquin River Confluence
Suisun Bay
Sacramento River
San Joaquin River
Example:
① Determine level and location of critical salinity before flood.
② Determine volume of flooded island(s), Table B-1.
③ Determine location of potential critical salinity level after flood.

EMERGENCY RESPONSE PLAN

RESPONSE	SCENARIO / EMERGENCY PLAN *	ONE OR TWO ISLANDS FLOODED (I)	EBMUD STRUCTURAL FAILURE (TEMPORARY SUPPLY) (II)	SEVERAL ISLANDS FLOODED WINTER (III)	SEVERAL ISLANDS FLOODED SUMMER (IV)	EMERGENCY: MASSIVE SALT MOVEMENT INTO DELTA	EMERGENCY: SERIOUS SALT MOVEMENT INTO DELTA	EMERGENCY: POSSIBLE SALT MOVEMENT INTO DELTA	EMERGENCY: CONTRA COSTA WATER DISTRICT (TEMPORARY SUPPLY)
• IMMEDIATELY STOP PUMPING INTO THE CALIFORNIA AQUEDUCT AND INTO THE DELTA-MENDOTA CANAL EXCEPT FOR ESSENTIAL REQUIREMENTS IN THE REACH TO SAN LUIS RESERVOIR.		X	X	(X)	X	X	X	(X)	
• FILL CLIFTON COURT FOREBAY ON THE NEXT HIGH TIDE.		X		(X)	X	X	X	X	
• INCREASE RELEASES FROM FOLSOM, ORIVILLE, AND SHASTA RESERVOIRS.		X		(X)	X	X	X		
• INCREASE RELEASE FROM NEW MELONES RESERVOIR AFTER SALT DISPERSION IN CHANNELS HAS STABILIZED.		X		(X)	X	X	X		
• REQUEST DELTA FARMERS TO STOP IRRIGATION UNTIL FLOODED ISLAND(S) FILLS.		X			X	X			
• CONNECT CONTRA COSTA CANAL TO EBMUD MOKELUMNE AQUEDUCT TO DECREASE SALINITY IN THE CONTRA COSTA CANAL.		X		(X)	X	X	X		X
• PLACE RIPRAP ON ENDS OF BREAK TO STOP LOSS OF LEVEE AND INSTALL WAVE EROSION PROTECTION ON INTERIOR OF LEVEE FOR WESTERN ISLANDS.		X					X	X	
• CLOSE LEVEE BREAK FOR WESTERN ISLANDS ONLY.		X			X		X		
• MONITOR SALT MOVEMENT INTO DELTA AND EVALUATE NEED FOR INCREASED RESERVOIR RELEASES.			X	X				X	
• MONITOR SALT CONTENT OF CHANNELS; DECREASE RESERVOIR RELEASES, CLOSE CROSS CHANNEL GATES (IF OPENED FOR THIS EMERGENCY) AND RESUME PUMPING AS SALT CONTENT PERMITS.		X		(X)	X	X	X	X	
• INSTALL PUMPS AT EBMUD'S BIXLER EMERGENCY PUMPING PLANT AT INDIAN SLOUGH.			X						
• REESTABLISH THE 1977 WATER TRANSFER FROM SOUTH BAY AQUEDUCT TO SAN ANTONIO RESERVOIR TO EBMUD AT HAYWARD.			X						
• INSTALL PUMPS (IF NEEDED) TO REVERSE FLOW, AND REINSTALL A PIPELINE ON RICHMOND-SAN RAFAEL BRIDGE TO BRING WATER FROM MARIN COUNTY TO EBMUD.			X						
• CONNECT CONTRA COSTA CANAL TO MOKELUMNE AQUEDUCT WITH PUMPS TO MOVE WATER FROM DELTA TO EBMUD.			X						
• PLACE PIPELINE ON CARQUINEZ BRIDGE TO BRING NORTH BAY AQUEDUCT-VALLEJO WATER OR SOLANO PROJECT WATER TO EBMUD.			X						
• PLACE PIPELINE ON BENICIA BRIDGE TO BRING NORTH BAY AQUEDUCT-BENICIA WATER TO CONTRA COSTA WATER DISTRICT FOR EXCHANGE TO EBMUD.			X						
• PLACE RIPRAP ON THE ENDS OF THE BREAK ON THE UPPER JONES TRACT LEVEE.			X						
• PLACE WAVE EROSION PROTECTION ON INTERIOR OF JONES TRACT LEVEES.			X						
• CLOSE BREAK AND DEWATER UPPER AND LOWER JONES TRACTS.			X						
• REPLACE DAMAGED SECTION OF MOKELUMNE AQUEDUCT.			X						
• COMPUTE ACRE-FEET TO FILL ISLANDS IN A TWO-DAY PERIOD AND COMPARE WITH DELTA OUTFLOW TO SEE IF A NET REVERSAL OF FLOW FROM WEST OF THE DELTA WILL OCCUR THAT WILL MOVE SALT WATER INTO THE DELTA. IF NET REVERSAL OCCURS, CONTINUE WITH RESPONSE ACTIONS.				X				X	
• DISPATCH AIRPLANE TO DETERMINE WHICH ISLANDS ARE FLOODING.				X	X	X	X	X	
• OPEN CROSS CHANNEL GATES FOR FLUSHING CENTRAL DELTA (IF NOT CURRENTLY OPEN).				(X)		X	X		
• REQUEST DIVERTERS FROM SACRAMENTO AND SAN JOAQUIN RIVERS AND VALLEY FLOOR TRIBUTARIES TO TEMPORARILY STOP DIVERSIONS.					X	X			
• REQUEST SUBSTANTIAL DOWNSTREAM RELEASES FROM RESERVOIRS TRIBUTARY TO THE SAN JOAQUIN RIVER UNTIL DELTA SALINITY IS REDUCED TO A USABLE SALT CONCENTRATION.					X	X			
• PLACE PIPELINE ACROSS BENICIA BRIDGE TO BRING NORTH BAY AQUEDUCT-BENICIA WATER TO CONTRA COSTA WATER DISTRICT.					X	X			X
• PLACE PIPELINE ON CARQUINEZ BRIDGE TO BRING NORTH BAY AQUEDUCT-VALLEJO WATER OR SOLANO PROJECT WATER TO CONTRA COSTA WATER DISTRICT.					X	X			X
• PLACE PUMPS AT ONE OR MORE CHECKS IN CALIFORNIA AQUEDUCT TO MOVE WATER UPSTREAM FOR SOUTH BAY AQUEDUCT.					X	X			
• PLACE TEMPORARY BARRIERS IN SACRAMENTO RIVER BELOW GEORGIANA SLOUGH AND IN STEAMBOAT SLOUGH TO INCREASE HEAD AND FLOW THROUGH THE DELTA CROSS CANAL AND GEORGIANA SLOUGH.					X	X			
• PLACE ROCK BARRIER ON SAN JOAQUIN RIVER AT UPSTREAM END OF ROUGH & READY ISLAND WITH FLAP GATES FOR TIDAL PUMPING UPSTREAM.					X	X			
• REBUILD DAMAGED LEVEES WITH WESTERN DELTA ISLANDS FIRST PRIORTY (TO REDUCE SALT DISPERSION).				X	X	X	X		

* SEE TEXT.

(X) RESPONSE NECESSARY ONLY IF SALT INTRUSION OCCURS.