Plan Formulation Appendix

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PLAN FORMULATION APPENDIX

PLAN FORMULATION APPENDIX

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35	PESCADERO TRACT
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PLAN FORMULATION APPENDIX

INTRODUCTION

1. This appendix explains the plan formulation analysis conducted to select, from viable alternatives, candidate plans to resolve the problems and realize the opportunities in the study area. The major features of the Plan Formulation Appendix are identified below.

- Technical studies conducted to support plan formulation
- Basis of economic analysis
- Formulation and evaluation criteria
- Measures evaluated
- Formulation of flood control/water quality alternatives
- Formulation of recreation and environmental quality alternatives
- Description of candidate plans

TECHNICAL STUDIES

INTRODUCTION

1. Numerous technical studies were conducted during this investigation to provide a basis for formulating a plan of improvement which would reduce the frequency of flooding in the Delta. The results of those studies are summarized in this section.

HYDROLOGIC STUDIES

INTRODUCTION

2. The hydrologic studies for this investigation included an analysis of historical stage data and higher-high stage profiles (the higher of the two high waters of any tidal day), and the development of higher-high annual stage-frequency relationships for 24 stations within the Delta.

TIDAL STAGES

3. The Sacramento-San Joaquin Delta is a complex hydraulic system because of tidal action, the variability of the Delta inflows, Federal, State, and local pumping withdrawals, and many interconnecting channels. These elements are continually interacting, resulting in a constant change in water surface elevation throughout the Delta. The major factors influencing Delta stages are tidal actions, weather, and tributary basin runoff.

4. The tidal stage records of 24 gages were analyzed to develop the stage-frequency relationships for this study. The locations of the gages are shown in Figure 1. Table 1 shows the 50-year and 100-year higher-high stages associated with each gage.

5. An analysis of the tidal stage records indicated that generally the high stages were caused by a combination of high inflows, winds, and high tides. Historically, the highest stages have usually occurred during December through February. The high stages on the eastern periphery of the Delta are caused by high inflows the majority of the time.

6. Classically, in a given reach of leveed stream channel where the water is moving steadily in one direction and no tidal effects exist, the hydraulic gradient has a uniform slope. In the Delta, this uniform relationship does not occur. As the incoming tide moves up the Delta, the water surface gradient changes slope and the channel flow, in many instances, reverses direction.

7. An extreme stage, such as a once in 100-year event, can occur at one point, while at the same time a stage of different frequency can be occurring at other locations in the Delta. This tidal rise, or high stage timing difference, is caused by the tidal current movement. In order to develop a 100-year (or any other frequency) higher-high stage profile for a defined channel reach, the locus, or surface line, of 100-year higher-high stages has to be determined for the entire reach. This profile is obtained by extrapolation of higher-high stages at each gage and at channel confluences.

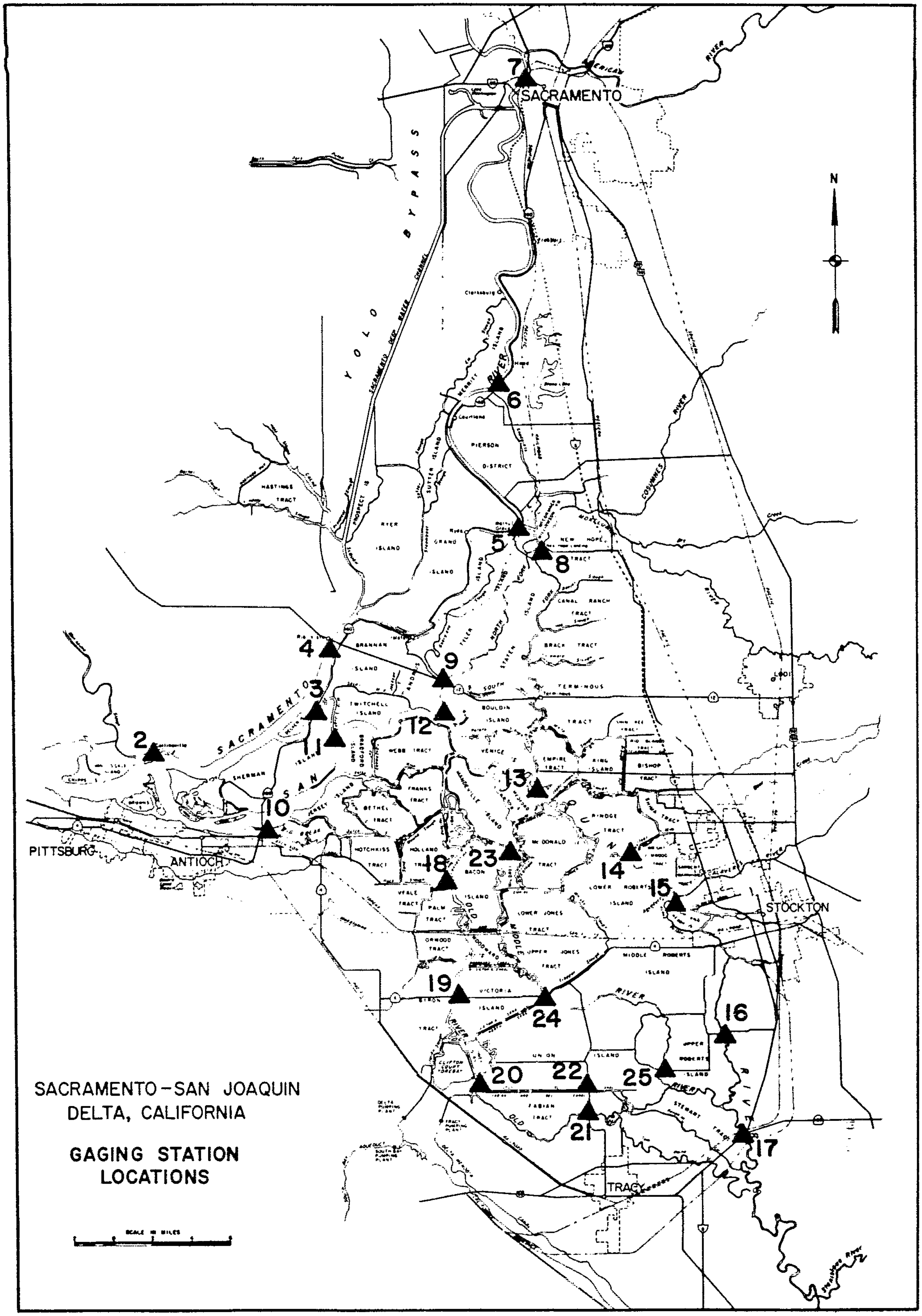
SACRAMENTO
YOLO BYPASS
SACRAMENTO DEEP WATER CHANNEL
PIERSON DISTRICT
HASTINGS TRACT
RYER ISLAND
GRAND ISLAND
NEW HOPE TRACT
CANAL RANCH TRACT
BRACK TRACT
BRANNAN ISLAND
TWITCHELL ISLAND
BOULDIN ISLAND
WEBB TRACT
VENICE
EMPIRE TRACT
KING ISLAND
BISHOP TRACT
BETHEL TRACT
FRANKS TRACT
RINDGE TRACT
McDONALD TRACT
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
LOWER ROBERTS ISLAND
PALM TRACT
LOWER JONES TRACT
ORWOOD TRACT
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
VICTORIA ISLAND
UNION ISLAND
UPPER ROBERTS ISLAND
FABIAN TRACT
PITTSBURG
ANTIOCH
STOCKTON
TRACY
LODI
N
SACRAMENTO-SAN JOAQUIN
DELTA, CALIFORNIA
GAGING STATION
LOCATIONS
SCALE IN MILES
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FIGURE 1

TABLE 1

50- AND 100-YEAR STAGES
SACRAMENTO-SAN JOAQUIN DELTA

(Stages are in feet above mean sea level)

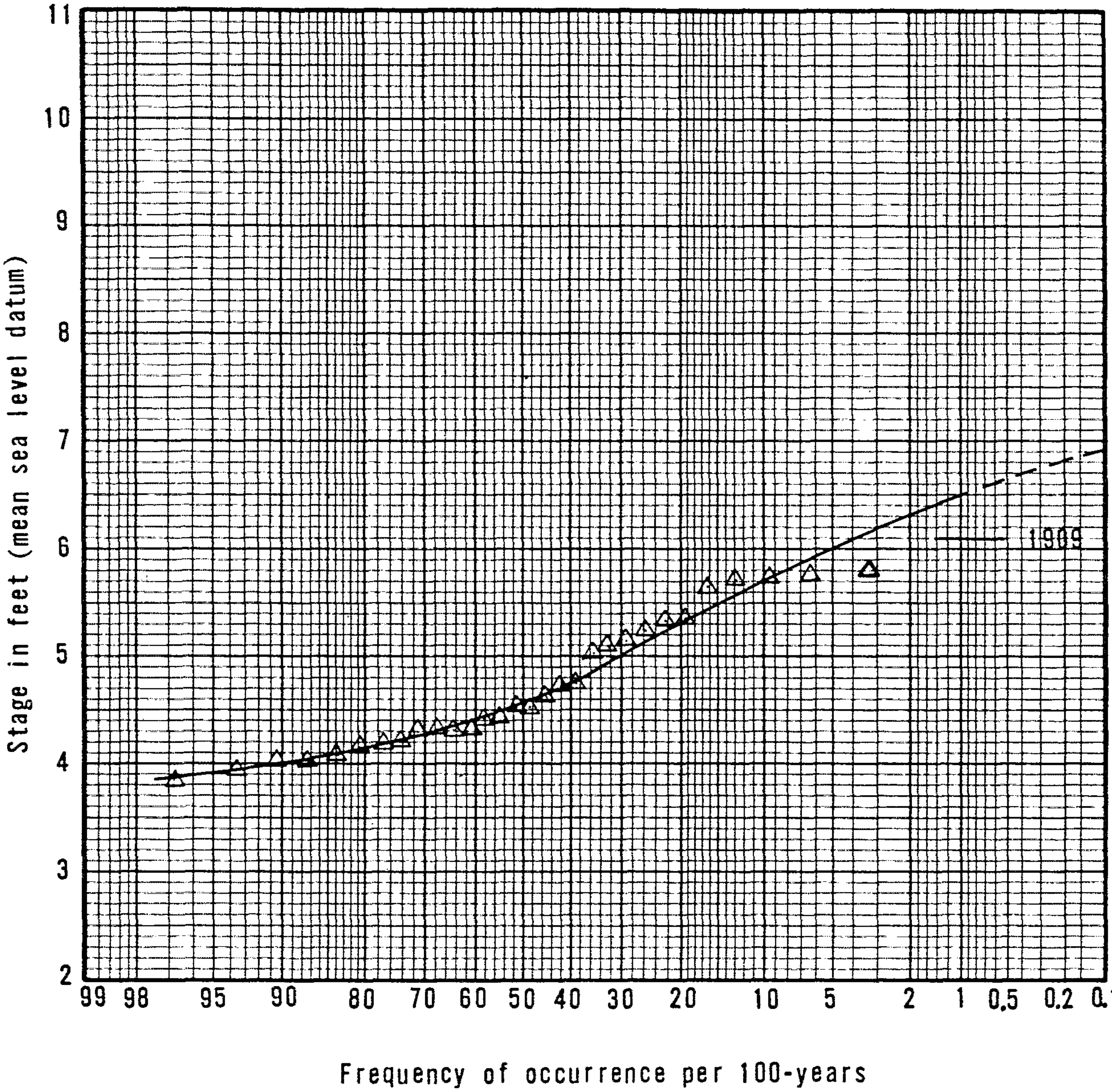
GAGE NO. (FIGURE 1)	GAGING STATION	50-YEAR	100-YEAR
	SACRAMENTO RIVER SYSTEM		
2	Collinsville	6.3	6.5
3	Threemile Slough	7.0	7.2
4	Rio Vista	7.0	7.2
5	Walnut Grove	13.0	13.3
6	Snodgrass Slough	18.2	18.5
7	Sacramento "I" Street Bridge	30.3	30.7
	SAN JOAQUIN RIVER SYSTEM		
10	Antioch	6.3	6.5
11	Threemile Slough	6.2	6.4
12	San Andreas Landing	6.7	7.0
13	Venice Island	7.1	7.4
14	Rindge Pump	7.1	7.4
15	Burns Cutoff	7.2	7.5
16	Brandt Bridge	14.0	14.7
17	Mossdale	25.5	27.5
	OLD RIVER SYSTEM		
18	Rock Slough	6.9	7.2
19	Byron Tract	7.3	7.6
20	Clifton Court	7.5	7.8
21	Tracy Bridge	8.6	8.9
	MIDDLE RIVER SYSTEM		
23	Bacon Island	7.0	7.2
24	Borden Highway	7.3	7.6
25	Mowry Bridge	12.5	13.2
	OTHER STATIONS		
22	Grant Line Canal at Tracy Bridge	8.6	8.9
8	Mokelumne River at New Hope Bridge	14.2	15.0
9	Georgiana Slough at Mokelumne River	6.9	7.2

STAGE-FREQUENCY ANALYSIS

8. The period 1945 to 1974 was chosen to be a representative sample for analyzing the higher-high stage data statistically. This period is subsequent to construction of Shasta Dam and covers the maximum length of record for the majority of the gages. Also, the Delta hydraulic system has not significantly changed in this period of time.

9. The stages from each recording station were compared with data from neighboring gaging stations and adjusted, when necessary, to obtain consistency in data. These data were statistically analyzed using the Pearson Type III distribution. The computed statistical curves for the gages on each major river in the Delta were reviewed for consistency in mean stage, standard deviation, and skew. From this review it was noted that (1) the computed statistical parameters were inconsistent from gage to gage along the same watercourse and (2) the statistically computed curves did not reflect levee overtopping or large areal inundation due to a levee break.

10. The recent history of Delta island flooding reveals that levee failure occurs before the water reaches the levee crown elevation. Therefore, the shape of the stage frequency curves was developed graphically to reflect levee failure and resultant areal inundation. This resulted in a negative skew in the upper end of the curves. Figure 2 illustrates a typical stage-frequency curve that was developed for each gaging station.



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

HIGHER-HIGH STAGE-FREQUENCY
RELATIONSHIP
SACRAMENTO RIVER AT COLLINSVILLE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

FIGURE 2

C-103014

GEOLOGY OF THE DELTA

GENERAL

11. The Delta was formed in the Sacramento Basin, a structural and topographic basin. The basin contains sedimentary rocks that range in age from Jurassic to Holocene. The deepest part of the Sacramento Basin is at the junction of the San Joaquin and Sacramento Rivers where an estimated 37,000 feet of Mesozoic and Cenozoic sediments have accumulated. Regional subsidence and deposition in a marine environment ended in late Eocene time. During middle and late Eocene time the margins of the basin experienced mild uplift, folding, and faulting. The basin received continental fluviatile deposits from late Eocene to Pleistocene time. Volcanic debris was carried into the valley from the Sierra and Coast Ranges. Tectonic subsidence in the Delta and the Sacramento Basin ended in Quaternary time. Channel and fan material were deposited in the Delta area and graded to a eustatically lower base level in Pleistocene time. At the end of the Pleistocene time the sea level began to rise, and peat and detrital sediments accumulated.

STRUCTURE

12. The Sacramento Basin is elongate and asymmetrical with the axis on the west side of the valley. Mesozoic and Cenozoic strata on the western limb of the basin dip steeply to the east along the east flank of the Coast Range. Gentle westward dips of the Cenozoic sediments along the east side of the basin parallel the western margin of the foothill belt.

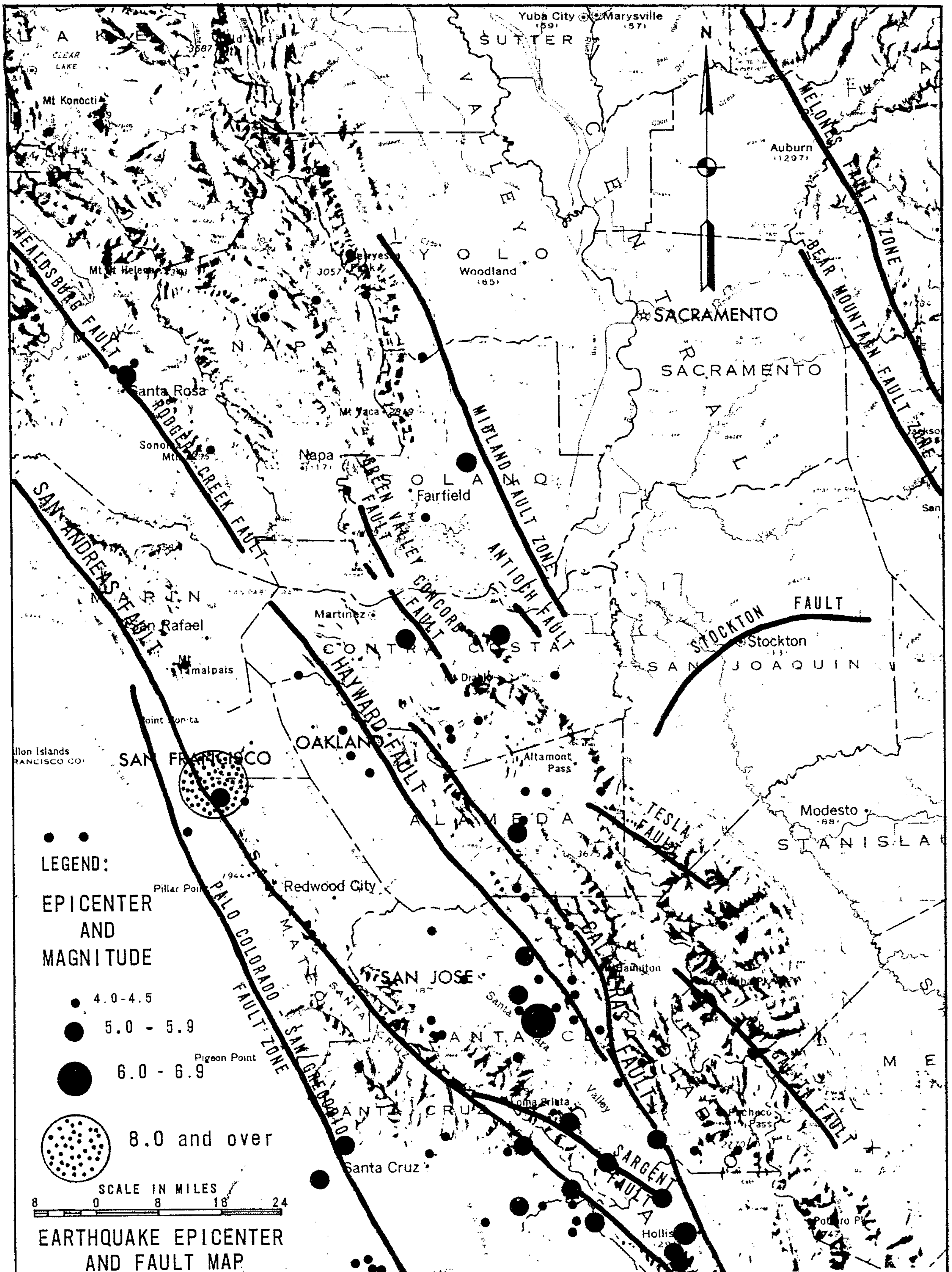
13. As shown on Figure 3 the major structural element in the Delta is the northwest trending Midland fault zone. Its dip is near vertical with the down-thrown block to the west. The Midland fault zone in the Delta parallels the axis of the West Valley Monocline that lies along the western margin of the valley. Inference of the possible relationship between the West Valley Monocline and the Midland fault indicates the latest movement along the fault to be as recent as Pleistocene time. However, drill hole logs from gas fields restrict the latest movement to late Eocene time. Also located in the Delta is the Tracy (Stockton) fault. It is a northeast trending fault that has a near vertical dip with the down-thrown block to the north and separates the Sacramento Basin from the San Joaquin Basin.

14. The latest strata offset by the Tracy (Stockton) fault zone are nonmarine Miocene beds. No surface displacement has been observed in the Quaternary sediments overlying the inferred trace of the fault.

15. A review of the geologic structures within and adjacent to the Delta area indicates that there has been no movement along the Midland fault or associated faults since Pleistocene time. There appears to have been no tectonic subsidence in the Delta since Pleistocene time.

DELTA PEAT

16. Radiocarbon dating indicates that peat began to accumulate in the Delta about 10,700 years ago. This age approximates the Pleistocene-Holocene boundary in this part of California and correlates fairly well with a worldwide rapid rise in sea level generally regarded as the end of the Pleistocene epoch. Since that time the Delta has gradually expanded

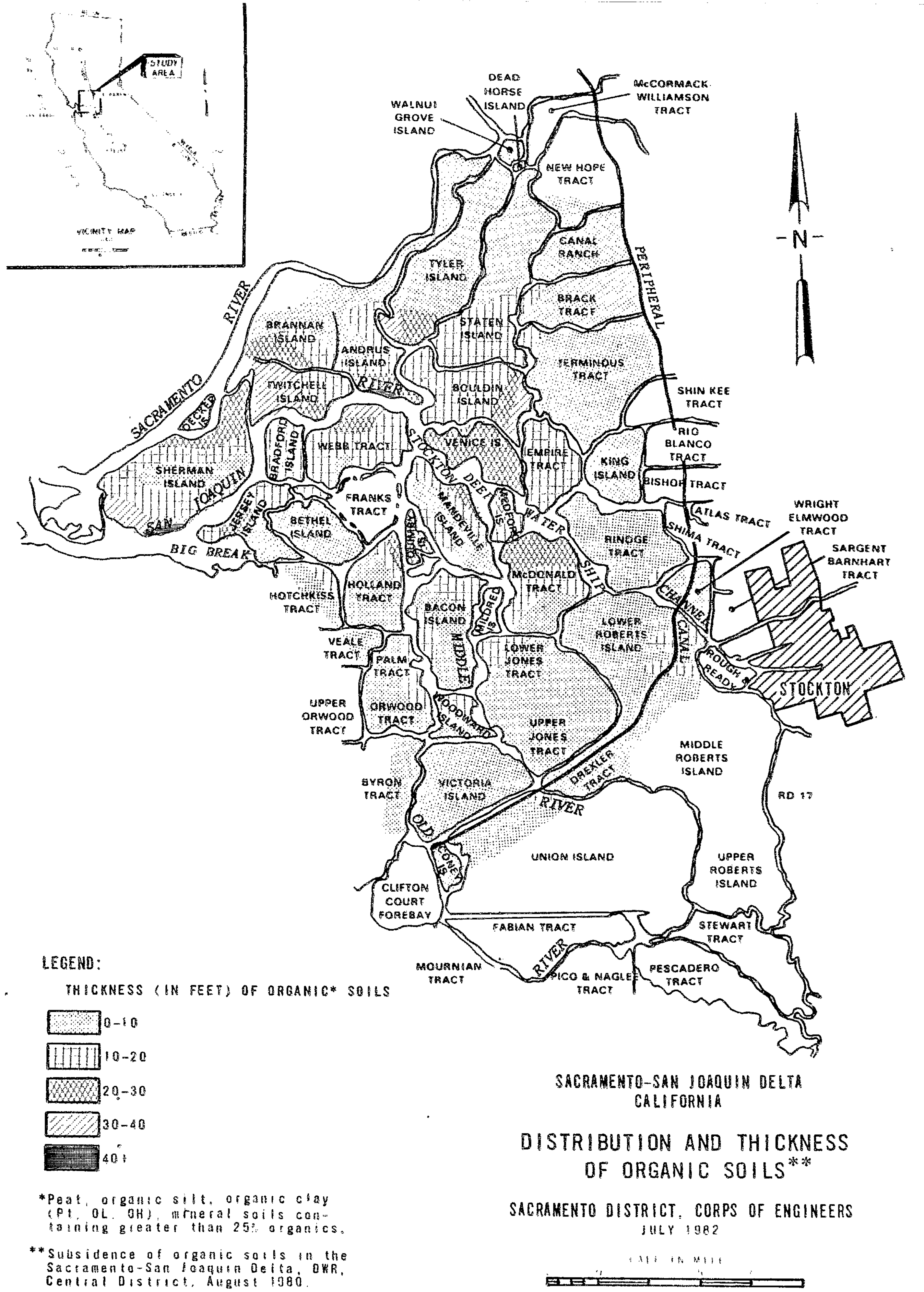


EARTHQUAKE EPICENTER AND FAULT MAP

FIGURE 3

"headward" to its approximate present area. The deepest known peat in the Delta underlies part of Sherman Island and extends to about 60 feet below sea level. Although generally thinning eastward, reentrants of mixed peat and mineral sediments, 40 to 50 feet thick, extend upstream generally underlying the modern Sacramento, San Joaquin, and Mokelumne Rivers, as shown in Figure 4. Tules, reeds, and other fibrous aquatic plants growing at water level were preserved as peat beds when postglacial sea levels slowly rose and inundated the present Delta. Minor fluctuations in sea level accompanied this general rise in sea level. Most of the peat beds in the Delta are less than 4 or 5 feet thick and separated by fine grained sediments. The peat probably formed in inter-distributary basins (now islands) in a freshwater environment close to sea level. These basins under natural conditions received fine detritus during river floods, and the deltaic sedimentary section generally contained intercalated silt, clay, and plant remains.

17. The thickness of peat growth is largely determined by the water level. The presence and composition of water regulates the rate of plant decay. Peat beds form when a gradual rise of water level occurs. If this water level remains long enough, marsh plants will adapt to the new environment and grow in place. A continued rise in water level allows time for decay of the existing plants and the accumulation of peat. Rapid drawdown or failure of the water level to rise terminates further building up of the deposit. A too rapid rise of freshwater drowns the flora. This interrupts peat formation and permits wash of other sediments. Plant decay is greater with warm water and less with cold. Agitation of water increases the supply of oxygen, whereas drainage or flushing causes a decrease in humic derivatives. Concentration of humic products is needed to retard and arrest biochemical



LEGEND:

THICKNESS (IN FEET) OF ORGANIC* SOILS

0-10

10-20

20-30

30-40

40+

*Peat, organic silt, organic clay (Pt, OL, OH), mineral soils containing greater than 25% organics.

**Subsidence of organic soils in the Sacramento-San Joaquin Delta, DWR, Central District, August 1980.

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

DISTRIBUTION AND THICKNESS OF ORGANIC SOILS**

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
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decomposition. Below the zone of bacterial activity the surviving organic debris is not subjected to further biochemical decomposition.

18. The Delta area prior to reclamation contained about 15 major islands, numerous channel islands, and the surrounding low lands. The area was marshy and at or near sea level. Partial inundation of the lands occurred during high tide and flood stages. The high ground water table and surface water kept the peat wet and supported the marsh plants and shrubs. The water and plant life protected the peat from wasting by oxidation, shrinkage, and deflation.

19. The distribution of the Delta peat, as reflected in the thickness, infers a "T" configuration with the top part parallel to the Sacramento River and a leg along the present San Joaquin River. Minor spurs coincide with Old River and the Mokelumne River. Assuming no Holocene tectonic movement, these thicker sections could be construed to be deposited in broad channels developed on a Pleistocene fan formed by these rivers. The channels appear to have been 20 to 30 feet below the fan surface.

PRESENT CONDITION

20. The division of the original islands and land tracts into smaller parcels for agricultural purposes changed the static environment necessary to maintain the peat. Dewatering by pumping to maintain arable lands enhances the flushing action and speeds up the wasting of peat. Commonly called "subsidence," the lowering of Delta island surfaces by as much as 20 feet is due to several factors including surficial compaction of the peat, oxidation, shrinkage, burning, and wind erosion. Land usage has lowered the ground

Subsidence at Cable Anchor, Mandeville Island
Circa 1950

Subsidence at pile cap EBMUD aqueduct
Lower Jones Tract 1981

surface of the interior portion of the islands an average of 3 inches a year, giving an appearance of land subsidence by tectonic action.

FUTURE CONDITION

21. The lowering of the water table on the islands and the subsequent wasting of the peat will continue to cause a lowering of the land surface of the islands. Estimated depletion times for some of the islands were published by DWR in its 1980 report "Subsidence of Organic Soils in the Sacramento - San Joaquin Delta." Figure 5 shows the relation between the depletion to date and the time left for complete depletion.

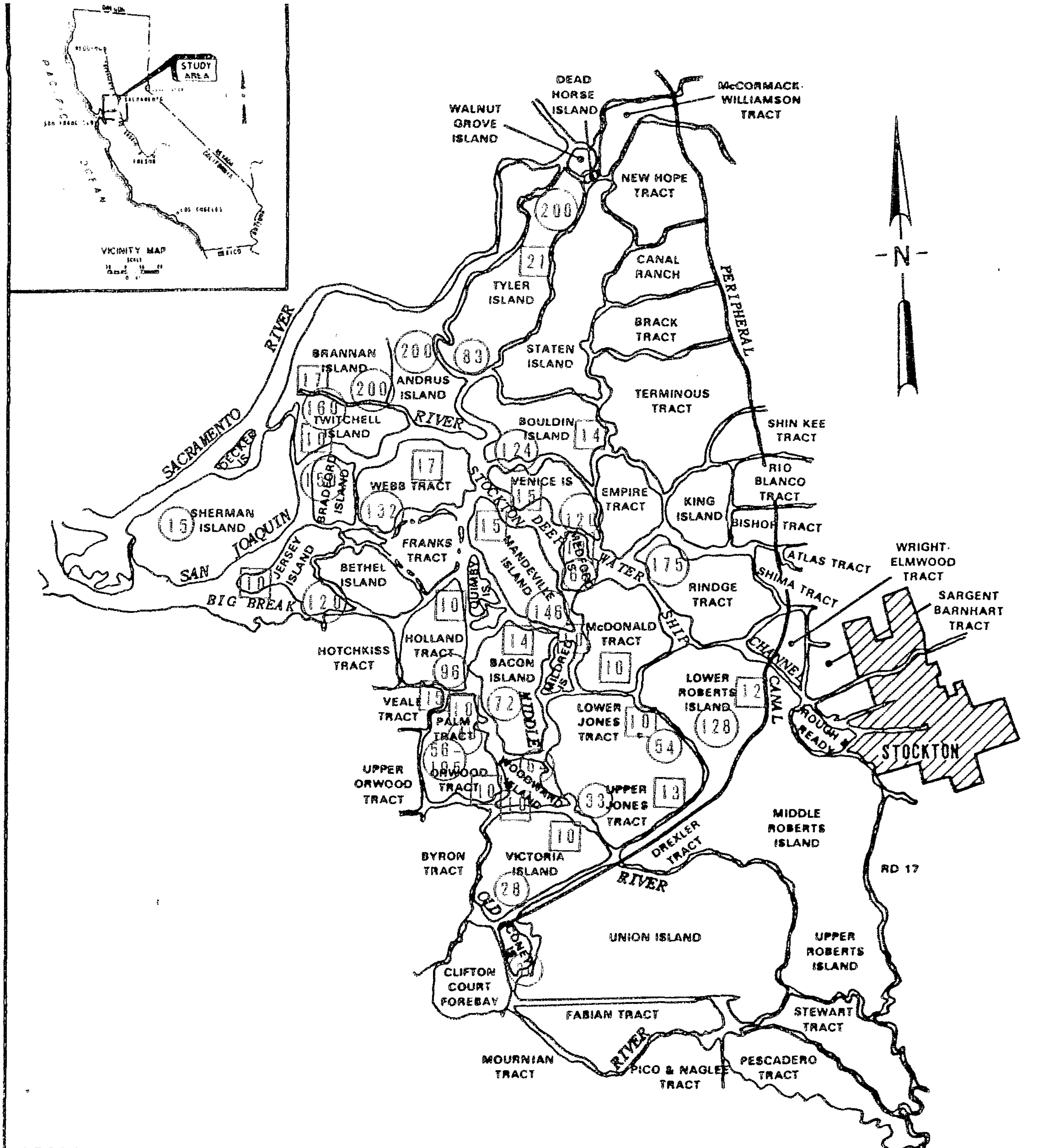
GROUND WATER CONDITION

22. In some of the islands the ground water level has dropped from at or near mean sea level to 20 feet below sea level. This has been caused by the construction of levees, drainage ditches, and dewatering by pumping. Water now enters the islands by seeping through the levees, passing under them, or by seeping through the peat and soils that surface the islands. As the island surface is lowered, additional seepage can be expected.

DESIGN DATA BASE

GENERAL

23. The basic data developed to support the basis of levee design is discussed in this section. Much of the data for this study was developed with the cooperation of personnel of DWR.



LEGEND:

(84) EXPECTED LIFE OF PEAT (YEARS)

[17] THICKNESS OF PEAT DEPLETED (FEET)

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CALIFORNIA

PEAT DEPLETION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
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SCALE IN MILES
2 0 2 4 6 8

SURVEYS

24. Nearly all the survey data was provided by DWR. The DWR surveys were conducted in 1978 and 1979. These surveys were supplemented in 1981 by the Corps surveys of Project levees in the southern Delta. The surveys consisted of a Fourth Order traverse along the existing levee crown with cross-sectioning at approximately 1,000-foot stations. Levee elevations were measured to the nearest 0.1 foot.

EXPLORATIONS

25. Some degree of subsurface data is available for practically every Delta island or tract. Since 1955 more than 1,000 exploration holes have been drilled by various public and private agencies. Exploration methods used included power auger, hand auger, pits, push and drive samplers, and Swedish Foil sampling. Hole depths ranged from less than 10 feet to about 200 feet. The majority of the exploration holes were located on the levee crowns and backslopes. Some holes were located in the central portions of the islands and a few were located in the existing channels.

SOILS

26. Except in the peripheral areas or along the main channels of the Sacramento and San Joaquin Rivers, foundation soils in the Delta are predominantly peats and organic silts and clays. The peats, either fibrous or decomposed to clayey peats, are found in the centers of the islands at or near the ground surface. They extend to depths nearly 60 feet below mean sea level in some locations. Generally, a thin stratum of organic silts and

clays overlies the peat deposits; however, in some cases these strata are located below the peats. Underlying the peat and organic clay deposits are earlier formations of sand and gravel or firm clays. The foundation soils under the existing levees have been modified substantially by the construction and reconstruction of the levees over a long period of time. The peats and organic clays have either consolidated or been displaced by the superimposed loads. As a result, the thickness of peats and organic soil layers under the levees are less than those encountered in the central portions of the islands. Some of the silts, clays, and sands used in the early stages of levee construction are now located below the elevation of the adjacent lands. Figure 6 shows a typical soil condition under an existing levee in the Delta. The existing levees were constructed by clamshell dredging operations using materials in the adjacent channels and rivers. Consequently, the levees consist of material ranging from peats to sands. The sands used in early stages of levee construction sometimes serve as seepage paths since they are now located below the elevation of the adjacent lands.

SOIL TESTS

27. Numerous tests have been conducted on the soils in the Delta. Field tests consisted of field vane shear tests. Laboratory tests included classification tests, Atterberg limits, moisture content, organic content, specific gravity, unconfined compression, permeability, triaxial shear, and consolidation.

SACRAMENTO-SAN JOAQUIN DELTA
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TYPICAL EXISTING LEVEE
CROSS SECTION

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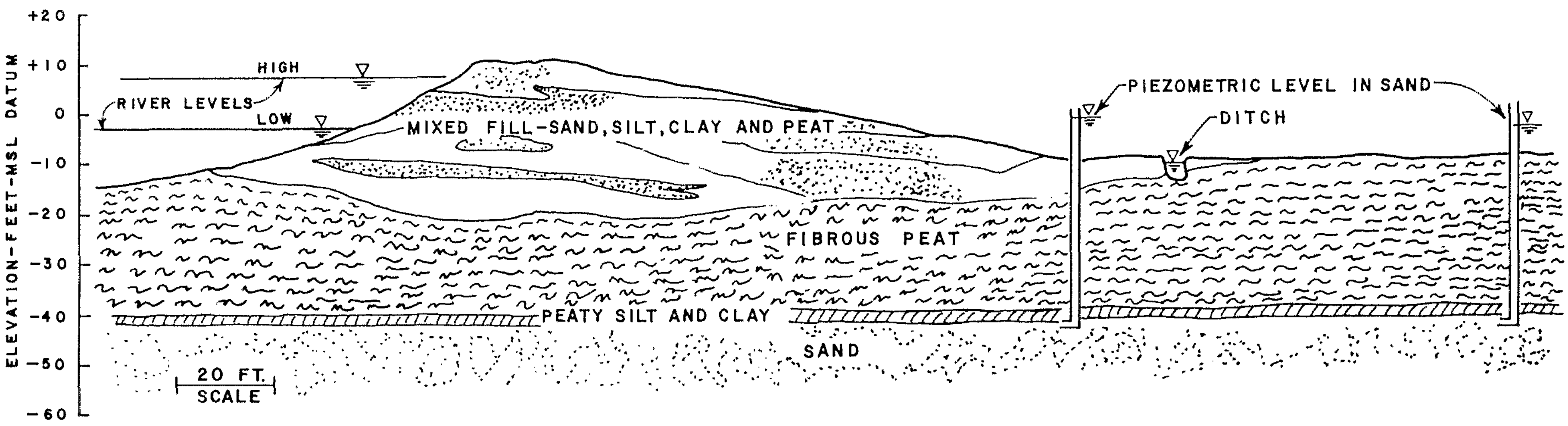


Typical levee subsurface conditions in the Central Delta compiled from Department Of Water Resources and Corps Of Engineers Data.

FIGURE 6

C-103026

CONSTRUCTION MATERIALS

28. DWR conducted a study of potential levee embankment borrow sites within a 50-mile radius of the Delta. The suggested borrow sites were selected based on their proximity to the Delta, availability of material, material type, volume of material, present site use, transportation routes, and environmental impacts. Table 2 lists the estimated quantity and type of material available at each site. The locations of these sites are shown on Figure 7.

29. It may be advantageous to procure and stockpile levee embankment material at the beginning of the project to insure its availability throughout the extended period of levee stage construction. An economic analysis would be conducted during post-authorization studies to determine the viability of this approach. Secure, centrally located stockpile areas, protected from vandalism and misuse, would be required. One or more of the islands designated for development of a non-Federal Wildlife Management Area described later in this appendix would be ideal for stockpiling borrow material. These islands are centrally located with respect to the islands included in the selected plan of improvement. Public access to the Wildlife Management Area would be controlled. This would insure the security of the stockpiled materials. Most significantly, it may be possible to stockpile the material in a manner that would bolster the levees on the Wildlife Management Area islands, thereby foregoing the need for improvement of these levees.

30. Erosion control materials are available from various commercial rock sources in the Coast Range and the Sierra Nevada foothills. These sources are 30 to 60 miles from the Delta.

C-103027

TABLE 2

POTENTIAL BORROW AREAS FOR EMBANKMENT MATERIAL

SITE	VOLUME (MILLION CUBIC YARDS)	MATERIAL TYPE
Peripheral Canal	12	Granular (no peat)
Peripheral Canal Intake Facilities	5	
Peripheral Canal - North of Lambert Road	2.8	Granular (no peat)
Franks Tract	Unknown	Channel deposits and organics
Los Vaqueros Reservoir and Kellogg Forebay	15.7 1/	Lean sandy clay and lean clay
Delta Pumping Plant Intake Canal	13	Unconsolidated alluvium
California Aqueduct	1.7	Sandstone Siltstone Claystone
Montezuma Hills #1	60 2/	Sand, silt, and gravel
Montezuma Hills #2	60 2/	Sand, silt, and gravel
Tracy Pumping Plant Intake Canal	5	Clay Clay sand Clay silt
Contra Costa County (various locations)	2.1	Primarily Sands
Portrero Hills Ditch	1.1	Quality Embankment Material
Sacramento River	Unknown 3/	Primarily Channel Deposits
San Joaquin River	Unknown 3/	Primarily Channel Deposits
Sacramento River Deep Water Ship Channel	Unknown 3/	Primarily Channel Deposits
Stockton Ship Channel	Unknown 3/	Primarily Channel Deposits

1/ About 30 percent of this volume is lean sandy clay.
2/ Montezuma Hills #1 and #2 borrow sites were chosen on the best probability of available material, close proximity to the Delta, and convenience to existing transportation systems.
3/ Channel dredging to obtain embankment material is not proposed. Embankment material would be obtained from dredged material disposal areas established for channel maintenance or improvement.

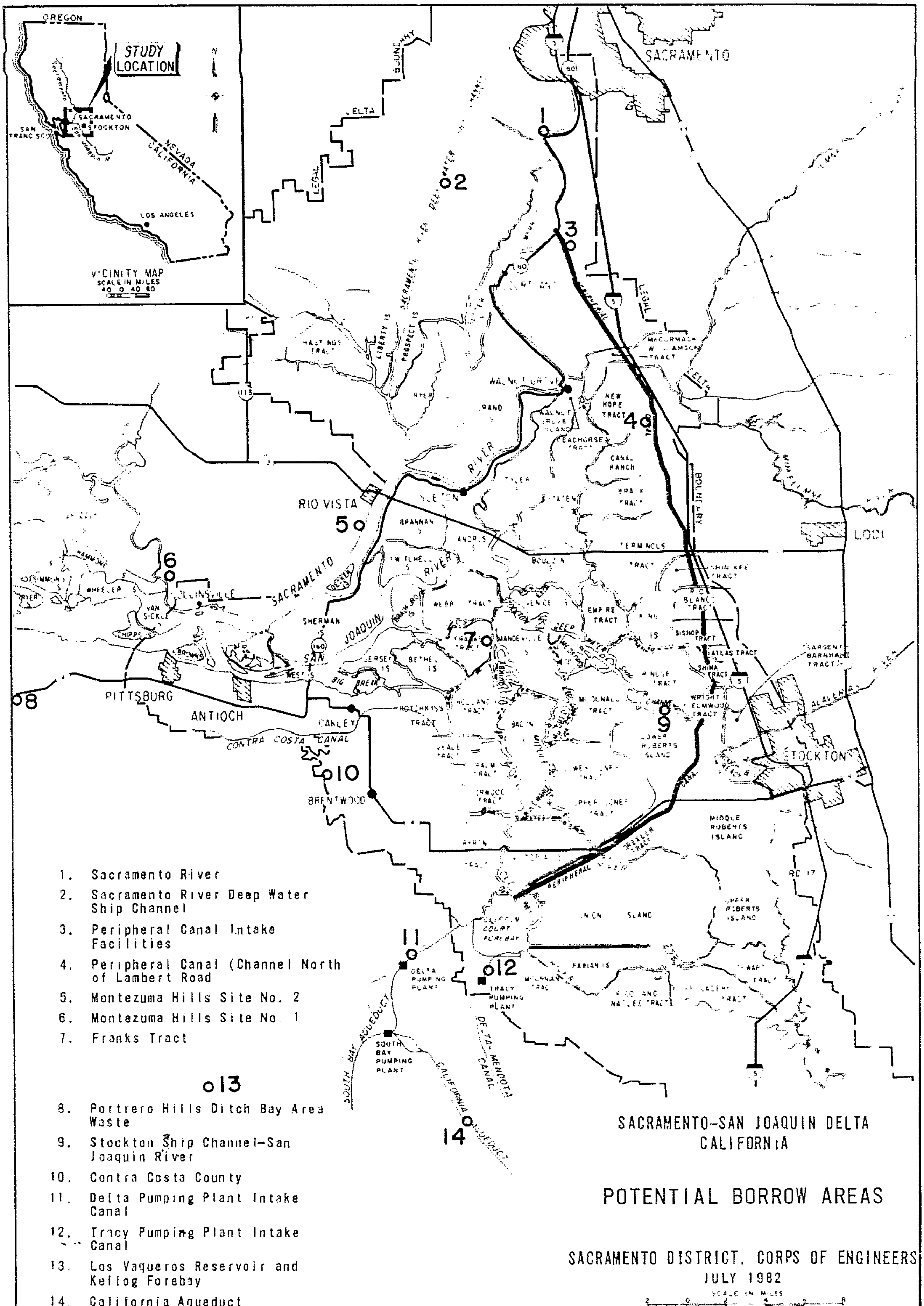


FIGURE 7

C-103029

LEVEE DESIGN AND CONSTRUCTION

GENERAL

31. The following design and construction parameters and considerations were determined during the investigation:

a. The placement of fill on top of an existing Delta levee involves some degree of risk. The additional weight increases the driving force on the critical failure surface.

b. Fill placed on a peat foundation causes consolidation. Primary consolidation occurs in a short period (a few weeks to a few months). Primary consolidation can equal the height of fill placed. Secondary consolidation continues indefinitely and the rate of consolidation decreases with time. This consolidation is a function of the height of fill, the thickness of the peat, and elapsed time.

c. Levee stability is a function of the underlying peat layer thickness.

d. Effective and total stress shear tests show an increase in peat strength due to consolidation.

e. Permeability is high for the natural fibrous peats but decreases rapidly due to consolidation.

f. Water temperature measurements indicate seepage passes through the levee and peat foundation rather than through the underlying sand layer. However, artesian pressures have been recorded in some of the sand layers underlying the peat.

g. Pore pressures in peat in the field are not critical under low loading increments. Gas in the peat is apparently dissolved into the pore water so there is no buildup of pore water pressures.

h. Any construction activity which disturbs the surface crust of the soil reduces embankment stability.

i. Sand drains, whether vertical or horizontal, are not very effective.

j. Any material dredged from the channels, including sands, cannot be reworked until the material has dried. Depending on the material, drying takes 2 weeks to 3 months. Shrinkage of dredged materials ranges from 10 percent for sand and silts to 50 percent for organic soils.

k. Depositing fill to depths of about 3 feet uniformly over extensive natural peat areas does not induce landside slide failures.

l. The pseudostatic method of analysis using 0.15g lateral force indicates that for earthquake stability, extremely flat landside slopes are required.

m. Lenses of loose silts and sand in the levee embankment and foundation are susceptible to liquefaction resulting from a major earthquake in the Bay Area on the San Andreas Fault. The construction of a landside berm does not provide protection against such an event.

n. The organic silts, rather than the fibrous peat, are in general the lowest strength materials.

o. Oxidation of the peat will occur to the greatest extent at the center of the island and will be less at the periphery.

MINIMUM FREEBOARD

32. A 1.5-foot minimum freeboard value was adopted for agricultural levees along with a 3-foot minimum freeboard for urban levees.

CROWN ELEVATION ALLOWANCES

33. Field conditions during flood events indicate the need for additional allowances in levee crown height at selected locations when determining design elevations. The following allowances were made:

a. The effective fetch method was used in calculating wave heights and wave runup. The effective fetch method is considered proper since boundary effects (high levees) of the Delta are important. The calculations indicate maximum wave heights are about 4 feet in Franks Tract and at other locations where the fetch is about 4,000-6,000 feet. Channels with fetches in the range of 2,000-4,000 feet have wave heights of about 2 feet. Except for the islands around Franks Tract, most fetches in the Delta are generally less than 2,000 feet.

b. Wind setup was accounted for in the stage-frequency hydrology.

c. Additional design elevation allowances were included in the design according to ship distance from shore. The allowances were based on a ship velocity of 8 knots and the ship to shore distance. If the ship to shore distance was greater than 100 feet but less than 500 feet, an allowance of 1.0 foot was used; otherwise, a 0.5-foot allowance was used. An allowance of 0.5-foot was used for recreation boat generated waves where shore to shore distances were less than 500 feet.

d. Allowances for additional design elevation in certain locations near bridges, drainage structures, and other constricted areas were also provided. An additional allowance of 0.5 foot was used within 200 feet upstream and downstream of bridges and other constricted areas.

EROSION CONTROL

34. Wind and recreation boat generated waves are the major cause of bank erosion in the Delta. Many existing levees have been given erosion protection by placement of stone on the levee slopes. Stone protection is the predominant erosion control method used. All alternative levee designs studied assume the placement of some type of erosion control at selected locations on each island and tract. Not all alternative levee designs require placement of erosion control features on all levees. Many levees are currently provided protection because of their location in sheltered areas.

Some of these areas have less recreational boat traffic than larger more popular waterways. For purposes of the stability analysis, it was assumed that stone would be used to protect the slopes from erosion.

SEISMICITY

35. California is one of the most active seismic areas in the continental United States. There are numerous active faults in the State capable of producing potentially damaging earthquakes. (In general, an earthquake with a Richter magnitude of 5 or greater is a potentially damaging earthquake.) There is no record of any Delta levee failure due to seismic activity. The most intense ground shaking in recent history occurred during the 1906 San Francisco earthquake. At that time, the few levees in existence were of low height. Subsequent earthquakes have been too small or too far away to cause any evident stress. The most recent significant seismic activity occurred near Livermore on the Greenville Fault. On 24 January 1980, a magnitude 5.5 earthquake occurred 2 miles north of Livermore. On 26 January 1980, a magnitude 5.2 earthquake occurred 1 mile northeast of Livermore. There was no known levee damage in the Delta attributable to these earthquakes.

36. Because of the short historical record of earthquake activity in California, the probability of recurrence of an earthquake is still not known with any degree of reliability. Statistical data have been developed giving the frequency of occurrence of earthquakes of various magnitudes. These are general and not site specific. The frequency of occurrence of an earthquake of significant magnitude is still a subjective estimate based on experience and judgment. The design parameters shown in Table 3 were used in the selection of basic rock motions used in the evaluation of Delta levees.

LEVEE MONITORING PROGRAM

37. A basic design and construction consideration for the Delta is monitoring levee settlement, island subsidence, and horizontal movement of levees. This requires maintaining a horizontal and vertical control system. A levee monitoring network would be a project feature for each island or tract included in the selected plan of improvement. Measurements of pore water pressure, levee settlement, horizontal levee movement, and density of levee fill will be included in the monitoring program.

TABLE 3

SEISMIC DESIGN PARAMETERS - SACRAMENTO-SAN JOAQUIN DELTA

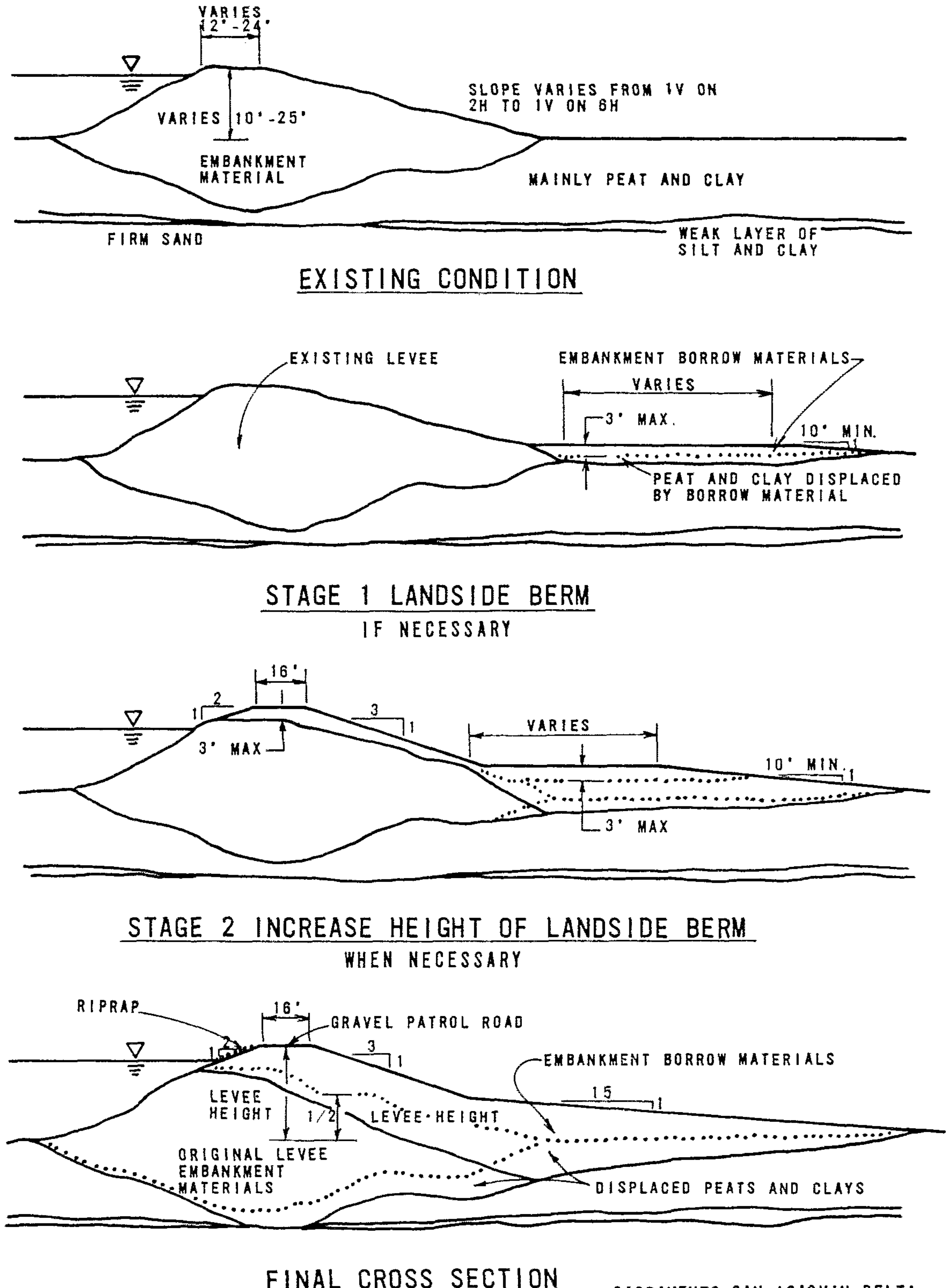
FAULT ZONE	MAXIMUM MAGNITUDE	LIQUEFACTION RADIUS, MILES	*	ANTIOCH	STOCKTON	SACRAMENTO
San Andreas	8-1/4	93	Distance, miles	44	65	79
			Max. accel. g's	0.25	0.2	0.18
			Period, sec.	0.5	0.6	0.7
			Duration, sec.	20	7	3
Hayward	7	31	Distance, miles	25	47	62
			Max. accel, g's	0.25	0.25	0.9
			Period, sec.	0.3	0.4	0.4
			Duration, sec.	23	10	4
Calaveras	6-3/4	20	Distance, miles	18	39	59
			Max. accel. g's	0.25	0.1	0.07
			Period, sec.	0.3	0.4	0.4
			Duration, sec.	20	12	3
Green Valley	6	5	Distance, miles	15	44	44
			Max. accel. g's	0.25	0.06	0.06
			Period, sec.	0.2	0.3	0.3
			Duration, sec.	9	2	2
Concord	6	5	Distance, miles	12	39	49
			Max. accel. g's	0.27	0.07	0.05
			Period, sec.	0.2	0.3	0.3
			Duration, sec.	10	2	1
Bear Mountain	6	5	Distance, miles	56	31	22
			Max. accel. g's	0.05	0.12	0.16
			Period, sec.	0.3	0.3	0.3
			Duration, sec.	1	3	7
Greenville	5-1/2	2	Distance, miles	26	14	56
			Max. accel. g's	0.1	0.18	0.04
			Period, sec.	0.2	0.2	0.3
			Duration, sec.	3	5	-
Antioch	5	1	Distance, miles	1	28	43
			Max. accel. g's	0.2	0.02	0.01
			Period, sec.	0.2	0.2	0.2
			Duration, sec.	4	-	-

*The distance shown is the shortest distance to the fault zone. Duration shown is the bracketed duration of 0.05g or greater.

LEVEE DESIGN ALTERNATIVES

38. Three levee design alternatives were considered for rehabilitating the Delta levees. The methods were: stage construction (on existing levee alignments), setback levees (on new levee alignments), and steel sheet piles. The stage construction method provides for the rehabilitation of existing levees by constructing a new design levee section on the existing levee alignment (Figure 8). This method requires frequent raising of the levee crown to accommodate expected levee settlement. For stability purposes, some levees would require construction of landside berms. The setback levee alternative provides for construction of a new levee along an alignment located landward of the existing levee (Figure 9). The sheet pile method consists of placing steel sheet piles at the waterside levee crown of the existing levees (Figure 10). A portion of the sheet pile would be left exposed to act as a floodwall.

39. A comparison of the annual costs of using each of the levee rehabilitation alternatives on each island in the study area revealed that in nearly every case the stage construction alternative was the least costly method of levee improvement. Therefore, stage construction was adopted as the predominant method of levee rehabilitation. The sheet pile alternative was used on Bethel Island and Hotchkiss Tract to avoid extensive relocation of houses and other improvements that encroach on the existing levees. The setback levee alternative was considered in the development of fish and wildlife enhancement elements to preserve trees and other significant vegetation on and adjacent to the existing levees.



SACRAMENTO-SAN JOAQUIN DELTA
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STAGE CONSTRUCTION
SEQUENCE OF CONSTRUCTION

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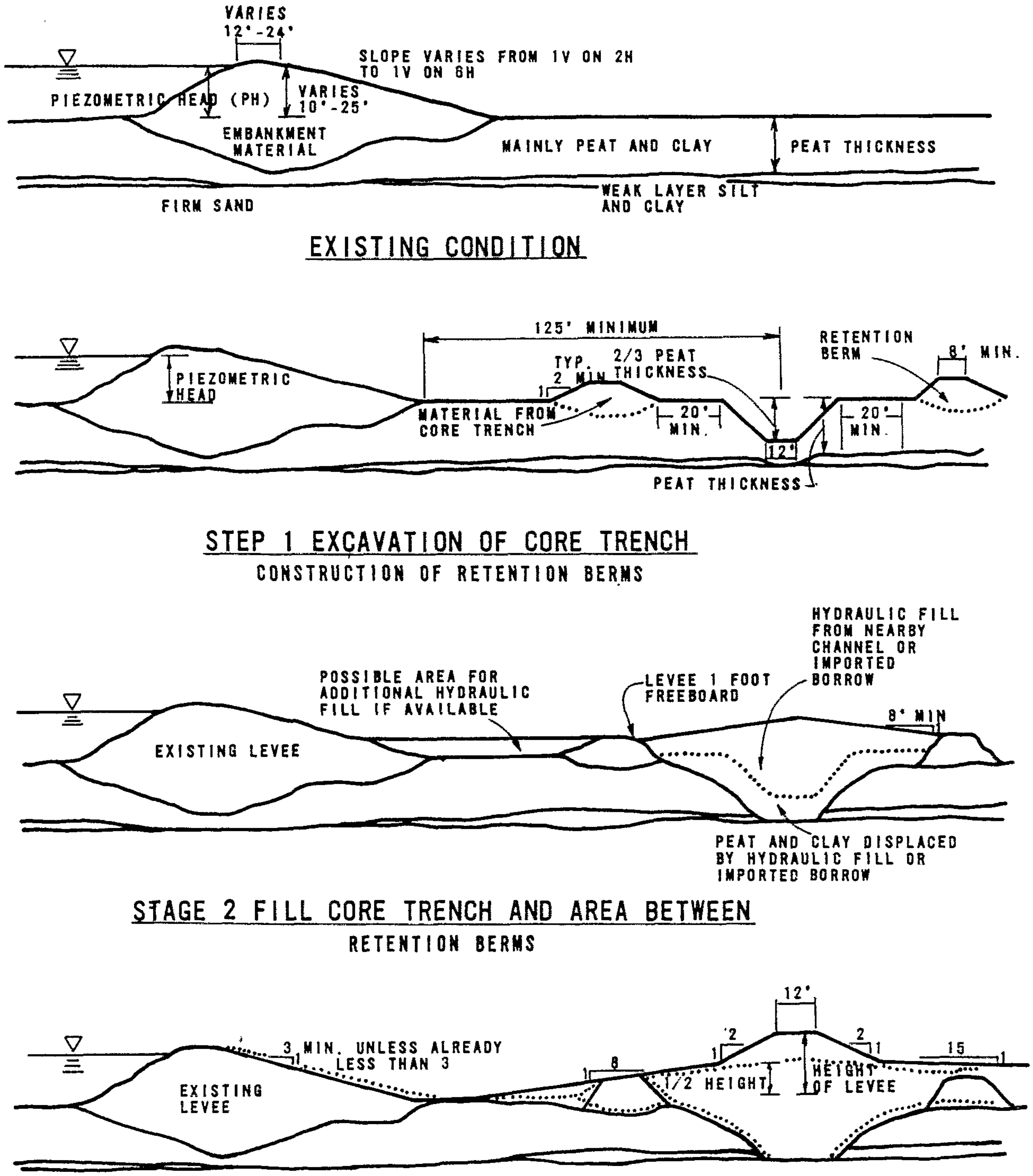
FIGURE 8



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SETBACK LEVEE ALTERNATIVE SEQUENCE OF CONSTRUCTION

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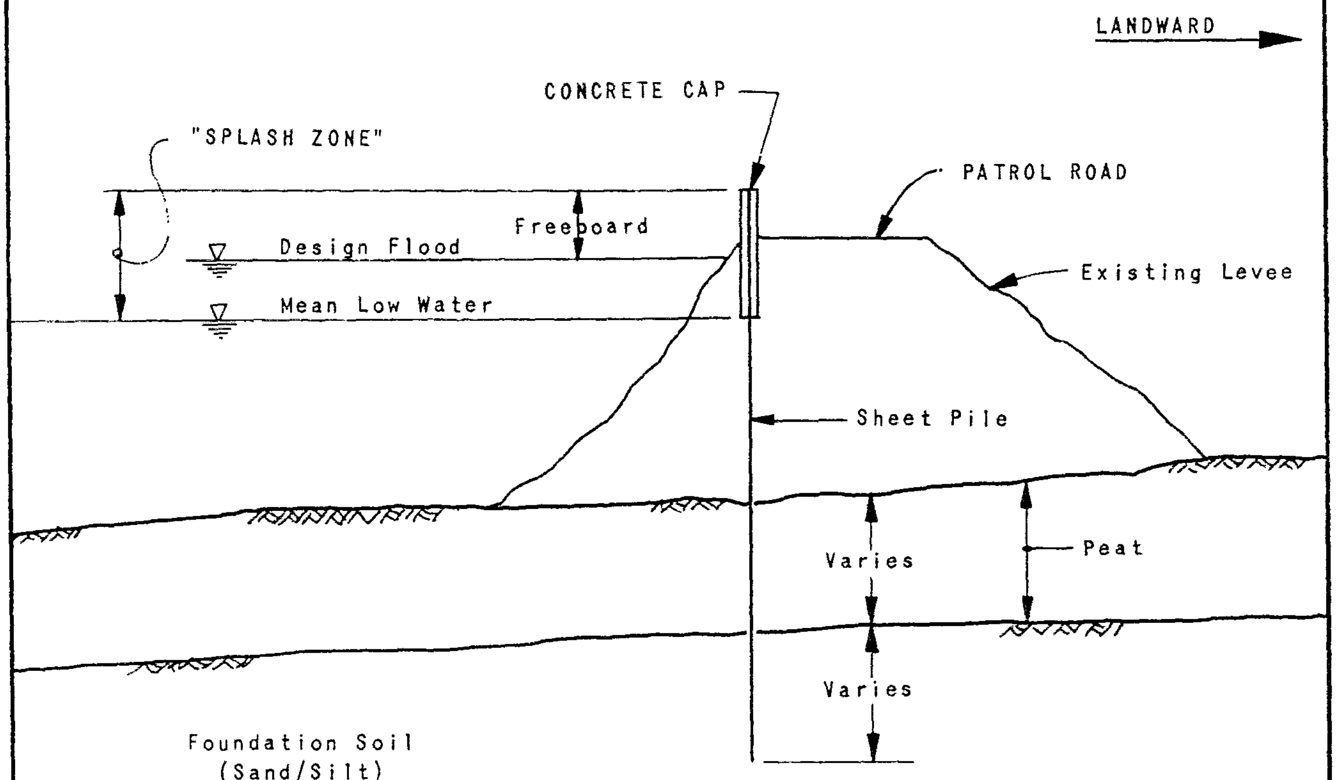
FIGURE 9



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

SHEET-PILING ALTERNATIVE

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
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FIGURE 10

BASIS OF ECONOMIC ANALYSIS

PROBABILITY OF LEVEE FAILURE

OVERTOPPING FAILURE

1. The probability of levee overtopping on each island was determined by comparing the low levee crown elevation on each island with the appropriate stage frequency curve. The probability of overtopping for each island in the study area is shown in Table 4.

STABILITY FAILURE

2. A mathematical model was developed to determine the probability of stability failure for each island. The probability theory on which the model is based and methodology developed are described below.

Probability Theory

3. The methodology developed for computing the probability of levee stability failure was based on an assumption that each island would behave as a separate entity, and the passing of 1 year was assumed to be a test or "trial" with only two possible outcomes: (1) a levee failure somewhere on the island or (2) no levee failure. This assumption corresponds to the "Bernoulli Trial" with probability of failure set equal to p and the probability of no failure equal to (1-p). It was also assumed that each passing year the probability of failure remained constant and equal to p.

4. Under the assumption of independence, the series of Bernoulli trials can be represented by the binomial distribution. The binomial distribution is a discrete probability distribution which is denoted by B(n,p) where n is the number of repetitions of the trial and p is the probability of failure. In equation form the distribution is given by:

$$\left\{\begin{array}{l}\text{Probability that the} \\ \text{total number of} \\ \text{failures equals some} \\ \text{specific value y}\end{array}\right\} = p\left\{Y=y\right\} = \binom{n}{y} p^y (1-p)^{n-y} \tag{1}$$

where

Y = symbol used for the number of failures

y = a specific value for Y

n = total number of repetitions of the Bernoulli trial

$\binom{n}{y} = n!/(y!(n-y)!)$

p = probability of failure

5. The "expected value" or average value for Y should also be noted. By an elementary theorem of probability the expected value of Y, the number of failures, may be computed as

$$E[Y] = np \tag{2}$$

6. The primary usefulness of the expected value of Y is that it provides a convenient means of using the record of past failures to estimate p. For example, suppose the probability of failure for each of the islands was assumed to be the same, p_{ave}. Then the total number of trials, n, could be set equal to the product of the number of islands times the number of years over which failures were observed. A total of 12 stability failures have been observed in the last 31 years, or since 1950; 1950 is the approximate year that Delta inflows began to be controlled.[1/] The Delta hydrologic

1/ The 23 August 1982 levee failure on McDonald Island occurred after the probability of stability failure analysis had been completed.

regime has been relatively unchanged since that time. The total number of islands within or partially within the zero peat thickness contour must be assigned somewhat arbitrarily. Nevertheless, the total number can be reasonably approximated as 53. Thus,

$$n = 53 \times 31 = 1643$$

7. The best estimate of p_{ave} is obtained by setting the observed number of failures, 12, equal to the expected number of failures, np_{ave}.

$$np_{ave} \cong 1643 \qquad p_{ave} = 12$$

or

$$p_{ave} = 12/1643 = 0.0073$$

8. Thus $p_{ave} = 0.0073$ is the best estimate of the average probability of stability failure for the levees of a single island in 1 year.

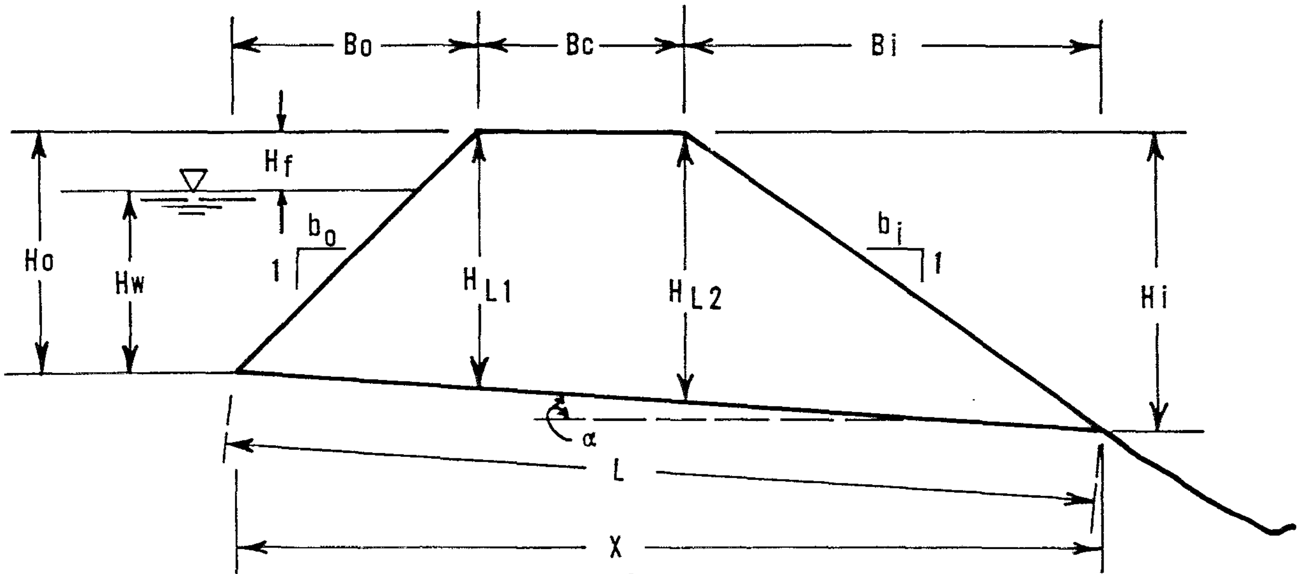
9. The preceding estimate of the probability of stability failure must be considered only a gross approximation of p for each island because in deriving the estimate no consideration was given to differences between individual islands. It was determined that peat thickness, for example, has a very strong effect on the probability of stability failure. Peat thickness intervals were therefore established and a correlation between peat thickness and the number of failures per unit length of levee in each peat thickness interval was developed. The number of failures per unit length of levee was then assumed to be proportional to the probability of failure in each peat thickness interval.

10. Using the additional assumption that the number of islands in each peat thickness interval was proportional to the estimated total length of levee in each peat thickness interval, it was possible to compute the number of failures per unit length of levee for each peat thickness interval and the relative probability of stability failure for each thickness interval.

11. Consideration of the effect of peat thickness on probability of levee stability failure resulted in significant improvement over the first estimate described earlier in which all islands were assumed to have identical probabilities of failure. Further improvement in the methodology was made by considering such factors as levee height, crest width, side slopes, freeboard, and shear strength of the levee embankment.

12. The computation of a "Factor of Safety Index" was chosen as the means for evaluating differences between the probabilities of stability failure for islands within a given peat thickness interval. The Factor of Safety Index (FSI) was calculated using the geometry and the equation given in Figure 11.

13. The term "Factor of Safety Index" was used rather than the actual factor of safety of the levee due to the simplifying assumptions and approximations that were required for its computation. The FSI may differ significantly from the actual levee factor of safety. Nevertheless, it is expected to be essentially proportional to the actual factor of safety and thus serves as a rational basis for assignment of probability of stability failure to individual islands.



Factor of Safety Index = FSI = $\dfrac{C'L + \tan\Phi' \,(W\cos\alpha - U_b - U_h\sin\alpha)}{W\sin\alpha + U_h\cos\alpha}$

Where

c' = cohesion of levee material, effective stress

Φ = friction angle of levee material, effective stress

W = weight of levee = f (γ_ℓ)

γ_ℓ = unit weight of levee material

U_h = 1/2 γ_ℓ w Hw L = horizontal water force

P = seepage parameter representing water pressure distribution on slip surface. For 'normal' seepage, P = 1.

DEFINITION OF FACTOR OF SAFETY INDEX

FIGURE 11

Methodology

14. The major steps in the methodology are summarized as follows:

a. Use the binomial distribution (Equation (1)) to represent the occurrence and nonoccurrence of Delta levee stability failures. Compute the average probability of failure for the levees of a single island in one year, p_{ave}, by utilizing the total number of observed failures.

b. Divide the Delta islands into groups according to original peat thickness in the foundation and establish a correlation between peat thickness and the number of failures per unit length of levee in the peat thickness intervals.

c. Compute the relative probability of stability failure for each group of islands.

d. Compute average probabilities of stability failure for each group of islands. These average values of probability must be consistent with both the relative probabilities computed in step c and the observed total number of failures for all the islands.

e. Use the FSI to compute probability of stability failure, p_j, for each individual island in each group. Satisfy the requirements that the procedure used to compute p_j from FSI is both rational and consistent and that the values of p_j yield a total number of expected failures for all islands within the group that is consistent with the total number of expected failures for each group computed in step d.

15. The specific steps in the procedure for computing the probability of stability failure, p_j, for each island in each group using the FSI are listed below.

a. For each island compute the FSI using a high (flood) water level in the channel for various cross sections along the levees.

b. Choose the lowest FSI section and assume it to be the most critical.

c. For the critical sections, gather stage-frequency data and treat the water level as a random variable.

d. Treat the ϕ' as a parameter with variability, but assume the same mean and variance for all levees due to lack of data to differentiate levees.

e. Treat all other parameters affecting the FSI as deterministic; that is, assign constant values.

f. Compute the FSI for the critical section of each island for a range of water levels and a range of ϕ' values.

g. Compute the probability that the FSI for the island falls below some critical value, $FSI_{critical}$. Use the same $FSI_{critical}$ for every island within the group.

h. Assume that the probability of failure is proportional to the probability that FSI is $FSI_{critical}$.

i. Adjust each of these probabilities by a factor which is proportional to the length of levee on the island or tract. (The probabilities obtained in this step are only relative probabilities of failure. Although the relative values are of interest, it was necessary to proceed to absolute values in order to produce expected numbers of failures.)

j. At this step it was immaterial that just relative values of probability of failure had been obtained because the absolute value of p_{ave} for each group had already been obtained. Thus the final step consisted of adjusting the probabilities within each group so that the average is equal to the expected number of failures and so that the values are in the same proportion as obtained in step i.

EFFECT OF SUBSIDENCE ON STABILITY FAILURE

16. The effect of island subsidence on the probability of stability failure was evaluated by utilizing an average rate of subsidence of 3 inches per year. This value is consistent with subsidence observations made by DWR.

17. Three inches per year corresponds to 10 feet for 40 years. The greatest subsidence would occur at the center of an island. After 40 years the average island floor elevation near the levee would be about 5 feet lower. The new cross section after subsidence was constructed by simply extending the inboard levee slope to reach a new island floor elevation 5 feet lower.

The probability that FSI would be less than the critical FSI, $p\left\{FSI < FSI_{crit}\right\}$, for this new configuration was then computed. The ratio of the new probability to the old probability was computed as

$$\text{Ratio} = \begin{array}{l}\text{adjustment "factor"}\\ \text{for subsidence}\end{array} = \frac{p\left\{FSI < FSI_{crit} \text{ new section after subsidence}\right\}}{p\left\{FSI < FSI_{crit} \text{ existing section}\right\}}$$

Using this procedure probabilities of stability failure were computed for periods 20, 40, 60, and 80 years into the future.

STABILITY FAILURE ADJUSTED TO CURRENT CONDITIONS

18. The value of p_{ave} computed earlier is of interest, but it is only the average probability of stability failure during the last 31 years. It is not the current probability of stability failure for the Delta which is needed for the benefit analysis. The procedure described above for computing the probability of stability failure assumed that the expected number of failures was equal to the historical number of failures.

19. In the Delta the assumption that past history is relatively unchanged from the present is generally true with regard to hydrology and other important factors except one -- island subsidence. Because of higher island floor elevations, the Delta levees of 1950 were more stable than the current levees. Therefore, it is reasonable that the number of failures which occurred between 1950 and the present would have been significantly higher if the hydrologic record for this period was repeated under existing levee conditions. For example, if the existing levees were subjected to the large 1955 flood, it is likely that more failures would occur than in 1955.

Therefore, it is evident that the methodology underestimates the probability of stability failure for current conditions.

20. The methodology was modified by setting the number of expected failures equal to the number of historical failures times a factor to account for the greater probability of stability failure at current conditions.

21. The procedure used to estimate "how much better" the 1950 levees were in relation to existing conditions is essentially the same as the procedure used to estimate the effect of island subsidence. The only difference is that the subsidence was reversed and projected back to 1950 conditions. The ratio of relative probability for the 1950 critical cross section to the relative probability for the current critical cross section was computed for each island and was found to vary over a wide range. The average value of the ratio indicated that the 1950 island levee conditions were at least 3.8 times safer than the existing levees.

22. It was assumed this ratio from 1950 to the present decreased from 3.8 to 1 by a straight line relationship. The expected number of failures, if the hydrologic record of the last 31 years repeated itself under today's levee conditions, was found to be 28 failures.

23. Therefore, all Delta levees stability failure rates were adjusted uniformly to reflect these projected 28 failures (i.e., multiplied by 28/12 = 2.3). Since many island critical cross sections were 5 to 100 times less likely to fail in 1950 than under current conditions, this adjustment still reflects a conservative estimate of levee stability failure rates.

24. The probability of stability failure for each island adjusted for current conditions is shown in Table 4.

PROBABILITY OF OVERTOPPING OR STABILITY FAILURE

25. Discrete probabilities of stability and overtopping failure were computed as described in the two preceding sections. Since Delta levees can fail by either overtopping or stability, the probability of occurrence of either mode of failure was determined. These failure frequencies formed the basis of the without-project flood control and water quality damages. The method adopted for computing the probability of some kind of levee failure is described below.

26. As a first approximation, the probability of a levee failure of some kind is simply the sum of the two types of failure:

$$p\left\{\begin{matrix}\text{levee}\\ \text{failure}\end{matrix}\right\} = p\left\{\begin{matrix}\text{overtopping}\\ \text{failure}\end{matrix}\right\} + p\left\{\begin{matrix}\text{stability}\\ \text{failure}\end{matrix}\right\}$$

This is an excellent approximation as long as both probabilities are small. If they become large, however, it is desirable to use the more rigorous expression:

$$p\left\{\begin{matrix}\text{levee}\\ \text{failure}\end{matrix}\right\} = p\left\{\text{overtopping}\right\} + p\left\{\begin{matrix}\text{stability}\\ \text{failure}\end{matrix}\right\} - p\left\{\begin{matrix}\text{both types of}\\ \text{failure occur}\\ \text{simultaneously}\end{matrix}\right\}$$

27. Because it is generally consistent with the past history of failures, it was assumed that the probabilities of stability failure computed in this study are the probabilities of stability failure given that overtopping has not previously occurred. The last two terms of the above expression can therefore be written as:

TABLE 4

PROBABILITY OF OVERTOPPING AND STABILITY FAILURE - CURRENT CONDITIONS

ISLAND	PROBABILITY OF STABILITY FAILURE					PROBABILITY OF OVERTOPPING FAILURE
	EXISTING	AFTER 20 YEARS	AFTER 40 YEARS	AFTER 60 YEARS	AFTER 80 YEARS	
(WITHOUT PERIPHERAL CANAL)						
ANDRUS-BRANNAN	0.0434	0.0651	0.0669	0.0671	0.0671	0.0030
ATLAS	NEG	0.0001	0.0005	0.0014	0.0030	0.0065
BACON	0.0113	0.0275	0.0427	0.0559	0.0669	0.0450
BETHEL	0.0020	0.0086	0.0191	0.0340	0.0429	NEG
BISHOP	0.0117	0.0154	0.0173	0.0176	0.0179	0.0450
BOULDIN	0.0382	0.0382	0.0382	0.0382	0.0382	0.1500
BRACK	0.0400	0.0425	0.0444	0.0448	0.0451	0.0900
BRADFORD	0.0200	0.0292	0.0329	0.0353	0.0359	0.0300
BYRON	0.0013	0.0046	0.0102	0.0165	0.0251	NEG
CANAL RANCH	0.0172	0.0300	0.0363	0.0407	0.0429	0.0350
CONEY	0.0112	0.0157	0.0213	0.0246	0.0259	0.0030
DEAD HORSE	0.0008	0.0012	0.0028	0.0044	0.0063	0.0500
EMPIRE	0.0081	0.0292	0.0379	0.0432	0.0467	0.1150
FABIAN	NEG	NEG	NEG	0.0001	0.0020	NEG
HOLLAND	0.0067	0.0218	0.0439	0.0562	0.0632	0.0350
HOTCHKISS	0.0110	0.0207	0.0276	0.0356	0.0389	0.0170
JERSEY	0.0349	0.0572	0.0730	0.0822	0.0880	-
JONES, ROBERTS, DREXLER	0.0115	0.0255	0.0318	0.0371	0.0386	0.0550
KING	0.0141	0.0238	0.0319	0.0379	0.0399	0.0250
MANDEVILLE	0.0135	0.0454	0.0586	0.0611	0.0615	0.0550
McCORMACK-WILLIAMSON	0.0053	0.0069	0.0101	0.0145	0.0201	0.0455
MCDONALD	0.0395	0.0612	0.0734	0.0783	0.0812	0.0370
MEDFORD	0.0224	0.0239	0.0244	0.0244	0.0244	0.1500
MILDRED	0.0156	0.0231	0.0284	0.0306	0.0318	0.0250
NEW HOPE	0.0082	0.0141	0.0244	0.0372	0.0445	0.0100
ORWOOD	0.0016	0.0069	0.0119	0.0211	0.0307	NEG
ORWOOD, UPPER	0.0094	0.0140	0.0180	0.0213	0.0246	0.1094
PALM	0.0070	0.0317	0.0357	0.0376	0.0380	0.0070
PESCADERO, PICO/NAGLEE, MOURNIAN	0.0094	0.0140	0.0180	0.0213	0.0246	NEG
QUIMBY	0.0034	0.0131	0.0232	0.0320	0.0371	0.0250
RINDGE	0.0264	0.0506	0.0697	0.0794	0.0851	0.0450
RIO BLANCO	0.0002	0.0019	0.0051	0.0089	0.0121	0.0350
SARGENT-BARNHART	0.0001	0.0006	0.0019	0.0042	0.0065	0.0130
SHERMAN	0.0054	0.0433	0.0616	0.0626	0.0626	0.0100
SHIMA	0.0121	0.0271	0.0399	0.0438	0.0470	0.0100
SHIN KEE	0.0009	0.0020	0.0037	0.0052	0.0064	0.1300
STATEN	0.0119	0.0333	0.0644	0.0950	0.1099	0.0100
STEWART	0.0094	0.0140	0.0180	0.0213	0.0246	NEG
TERMINOUS	0.0640	0.0779	0.0819	0.0841	0.0879	0.0900
TWITCHELL	0.0245	0.0436	0.0451	0.0453	0.0453	0.0040
TYLER	0.0347	0.0424	0.0467	0.0509	0.0521	0.0170
UNION	NEG	0.0002	0.0010	0.0030	0.0073	NEG
VEALE	0.0107	0.0159	0.0194	0.0212	0.0217	0.1200
VENICE	0.0394	0.0463	0.0463	0.0463	0.0463	0.1300
VICTORIA	0.0092	0.0167	0.0283	0.0418	0.0498	0.0030
WALNUT GROVE	NEG	0.0003	0.0006	0.0010	0.0013	NEG
WEBB	0.0531	0.0579	0.0579	0.0579	0.0579	0.0350
WOODWARD	0.0236	0.0312	0.0343	0.0366	0.0384	0.0450
WRIGHT-ELMWOOD	0.0091	0.0174	0.0253	0.0296	0.0318	0.0040
(WITH PERIPHERAL CANAL)						
BISHOP WEST	0.0117	0.0154	0.0173	0.0176	0.0179	0.0450
BRACK WEST	0.0400	0.0425	0.0444	0.0448	0.0451	0.0090
CANAL RANCH WEST	0.0172	0.0300	0.0363	0.0407	0.0429	0.0350
CONEY EAST	0.0112	0.0157	0.0213	0.0246	0.0259	NEG
JONES, LOWER ROBERTS WEST	0.0115	0.0255	0.0318	0.0371	0.0386	0.0550
NEW HOPE WEST	0.0082	0.0141	0.0244	0.0372	0.0445	0.0100
ROBERTS, UPPER AND MIDDLE, AND DREXLER	0.0014	0.0069	0.0170	0.0311	0.0453	0.0015
SHIMA WEST	0.0121	0.0271	0.0399	0.0438	0.0470	0.0100
SHIN KEE WEST	0.0009	0.0020	0.0037	0.0052	0.0064	0.1300
TERMINOUS WEST	0.0640	0.0779	0.0819	0.0841	0.0879	0.0900
WRIGHT-ELMWOOD EAST	0.0091	0.0174	0.0253	0.0296	0.0318	0.0040
WRIGHT-ELMWOOD WEST	0.0091	0.0174	0.0253	0.0296	0.0318	0.0020

$$p\begin{Bmatrix}\text{stability}\\\text{failure}\end{Bmatrix}\left[1-p\begin{Bmatrix}\text{overtopping}\\\text{failure}\end{Bmatrix}\right]$$

The probability of some type of levee failure was then expressed as:

$$p\begin{Bmatrix}\text{levee}\\\text{failure}\end{Bmatrix} = \begin{Bmatrix}\text{overtopping}\\\text{failure}\end{Bmatrix} + p\begin{Bmatrix}\text{stability}\\\text{failure}\end{Bmatrix}\left[1 - \begin{Bmatrix}p\ \text{overtopping}\\\text{failure}\end{Bmatrix}\right]$$

28. The probability of failure for all islands in the study area is shown in Table 5.

ECONOMIC ANALYSIS OF LEVEE FAILURE

29. It is imperative for the purpose of economic analysis that the with- and without-project conditions be evaluated on the same basis. The adopted method of economic analysis follows this precept and is described below.

30. Using information developed in the previous section, the probability of levee failure for the without project condition can be expressed as follows:

$$P_f = P_o + P_s\ (1 - P_o)$$

where,

P_f = the without-project probability of either an overtopping or stability failure

P_o = the without-project probability of an overtopping failure

P_s = the without-project probability of a stability failure

$P_s\ (1 - P_o)$ = the without-project probability of a stability failure given that an overtopping failure has not previously occurred

TABLE 5

PROBABILITY OF LEVEE FAILURE

ISLAND	EXISTING	AFTER 20 YEARS	AFTER 40 YEARS	AFTER 60 YEARS	AFTER 80 YEARS
(WITHOUT PERIPHERAL CANAL)					
ANDRUS-BRANNAN	0.0464	0.0681	0.0699	0.0701	0.0701
ATLAS	0.0065	0.0066	0.0070	0.0079	0.0094
BACON	0.0563	0.0725	0.0877	0.1009	0.1119
BETHEL	0.0020	0.0086	0.0191	0.0340	0.0429
BISHOP	0.0567	0.0604	0.0623	0.0626	0.0629
BOULDIN	0.1825	0.1825	0.1825	0.1825	0.1825
BRACK	0.1300	0.1325	0.1344	0.1348	0.1351
BRADFORD	0.0500	0.0592	0.0629	0.0653	0.0659
BYRON	0.0013	0.0046	0.0102	0.0165	0.0251
CANAL RANCH	0.0522	0.0650	0.0713	0.0757	0.0779
CONEY	0.0142	0.0187	0.0243	0.0276	0.0289
DEAD HORSE	0.0508	0.0512	0.0528	0.0544	0.0563
EMPIRE	0.1222	0.1408	0.1485	0.1532	0.1563
FABIAN	NEG	NEG	NEG	0.0001	0.0020
HOLLAND	0.0417	0.0568	0.0789	0.0912	0.0982
HOTCHKISS	0.0280	0.0377	0.0446	0.0526	0.0559
JERSEY	0.0349	0.0572	0.0730	0.0822	0.0880
JONES, ROBERTS, DREXLER	0.0665	0.0805	0.0868	0.0921	0.0936
KING	0.0391	0.0488	0.0569	0.0629	0.0649
MANDEVILLE	0.0685	0.1004	0.1136	0.1161	0.1165
McCORMACK-WILLIAMSON	0.0503	0.0519	0.0551	0.0595	0.0651
McDONALD	0.0765	0.0982	0.1104	0.1153	0.1182
MEDFORD	0.1690	0.1703	0.1707	0.1707	0.1707
MILDRED	0.0406	0.0481	0.0534	0.0556	0.0568
NEW HOPE	0.0182	0.0241	0.0344	0.0472	0.0545
ORWOOD	0.0016	0.0069	0.0119	0.0211	0.0307
ORWOOD, UPPER	0.1178	0.1219	0.1254	0.1284	0.1313
PALM	0.0387	0.0427	0.0446	0.0450	0.0456
PESCADERO, MOURNIAN & PICO/NAGLEE	0.0094	0.0140	0.0180	0.0213	0.0246
QUIMBY	0.0284	0.0381	0.0482	0.0570	0.0621
RINDGE	0.0714	0.0956	0.1147	0.1244	0.1301
RIO BLANCO	0.0352	0.0369	0.0401	0.0439	0.0471
SARGENT-BARNHART	0.0130	0.0136	0.0149	0.0172	0.0195
SHERMAN	0.0154	0.0533	0.0716	0.0726	0.0726
SHIMA	0.0221	0.0371	0.0499	0.0538	0.0570
SHIN KEE	0.1308	0.1317	0.1332	0.1345	0.1356
STATEN	0.0219	0.0433	0.0744	0.1050	0.1199
STEWART	0.0094	0.0140	0.0180	0.0213	0.0246
TERMINOUS	0.1540	0.1679	0.1719	0.1741	0.1779
TWITCHELL	0.0285	0.0476	0.0491	0.0493	0.0493
TYLER	0.0517	0.0594	0.0637	0.0679	0.0691
UNION	NEG	0.0002	0.0009	0.0030	0.0073
VEALE	0.1209	0.1340	0.1371	0.1387	0.1391
VENICE	0.1643	0.1703	0.1703	0.1703	0.1703
VICTORIA	0.0122	0.0197	0.0313	0.0448	0.0528
WALNUT GROVE	0.0002	0.0003	0.0006	0.0010	0.0013
WEBB	0.0881	0.0929	0.0929	0.0929	0.0929
WOODWARD	0.0686	0.0762	0.0793	0.0816	0.0834
WRIGHT-ELMWOOD	0.0131	0.0214	0.0293	0.0336	0.0358
(WITH PERIPHERAL CANAL)					
BISHOP WEST	0.0567	0.0604	0.0623	0.0626	0.0629
BRACK WEST	0.1300	0.1325	0.1344	0.1348	0.1351
CANAL RANCH WEST	0.0522	0.0650	0.0713	0.0757	0.0779
CONEY EAST	0.0112	0.0157	0.0213	0.0246	0.0259
JONES, LOWER ROBERTS WEST	0.0665	0.0805	0.0888	0.0921	0.0936
NEW HOPE WEST	0.0182	0.0241	0.0344	0.0472	0.0545
ROBERTS, UPPER AND MIDDLE AND DREXLER	0.0029	0.0084	0.0185	0.0325	0.0467
SHIMA WEST	0.0221	0.0371	0.0499	0.0538	0.0570
SHIN KEE WEST	0.1009	0.1020	0.1037	0.1052	0.1064
TERMINOUS WEST	0.1540	0.1679	0.1719	0.1741	0.1779
WRIGHT-ELMWOOD EAST	0.0131	0.0214	0.0293	0.0336	0.0358
WRIGHT-ELMWOOD WEST	0.0112	0.0195	0.0273	0.0317	0.0340

31. In order to maintain consistency in the economic analysis the probability of levee failure for project conditions was determined and expressed as:

$$P'_f = P'_o + P'_s\ (1 - P'_o)$$

where,

P'_f = the probability of either an overtopping or stability failure of a project levee

P'_o = the probability of overtopping of a project levee

P'_s = the probability of stability failure of a project levee

$P'_s\ (1 - P'_o)$ = the probability of a stability failure under project conditions given that an overtopping failure has not previously occurred

32. The probability of overtopping for the with-project condition was determined by relating the levee crown elevation (not the design flood elevation) to the appropriate stage-frequency curve. The minimum freeboard used for project conditions was 1.5 feet. This value was used for most islands; however, values of 3 to 6 feet were used in some instances as dictated by design conditions. Therefore, the probability of overtopping for with-project conditions was the frequency associated with a stage equal to the design flood stage plus the minimum freeboard for a given island. In cases where such a stage exceeded the limits of the stage-frequency curve, the probability of overtopping was limited to the upper limit of the stage-frequency curve (0.001).

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33. The probability of stability failure for project conditions was determined by using the methodology described earlier. This was done by modifying input data to represent the project levee geometric cross section and design flood stages.

34. The benefits developed under the adopted method were compared to benefits computed using the assumption that the benefits attributable to the levee freeboard were equal to 50 percent of the benefits accruing between the design flood elevation and the crown of the levee for five randomly selected islands. This is described as the "alternate method" in Table 6. The adopted method of analysis tends to provide more benefits for 50- and 100-year flood protection levels than the "alternate method." However, for the 300-year flood protection level, the two methods of economic analysis produce nearly identical results. The 300-year flood protection level maximizes net economic benefits and was the adopted level of flood protection for design conditions.

FLOOD DAMAGE REDUCTION BENEFITS

35. Inundation reduction benefits were estimated by evaluating damages with and without the project. Primary tangible flood damage reduction benefits for the plans equal the difference between the equivalent average annual flood losses without the project and the residual average annual losses with the project.

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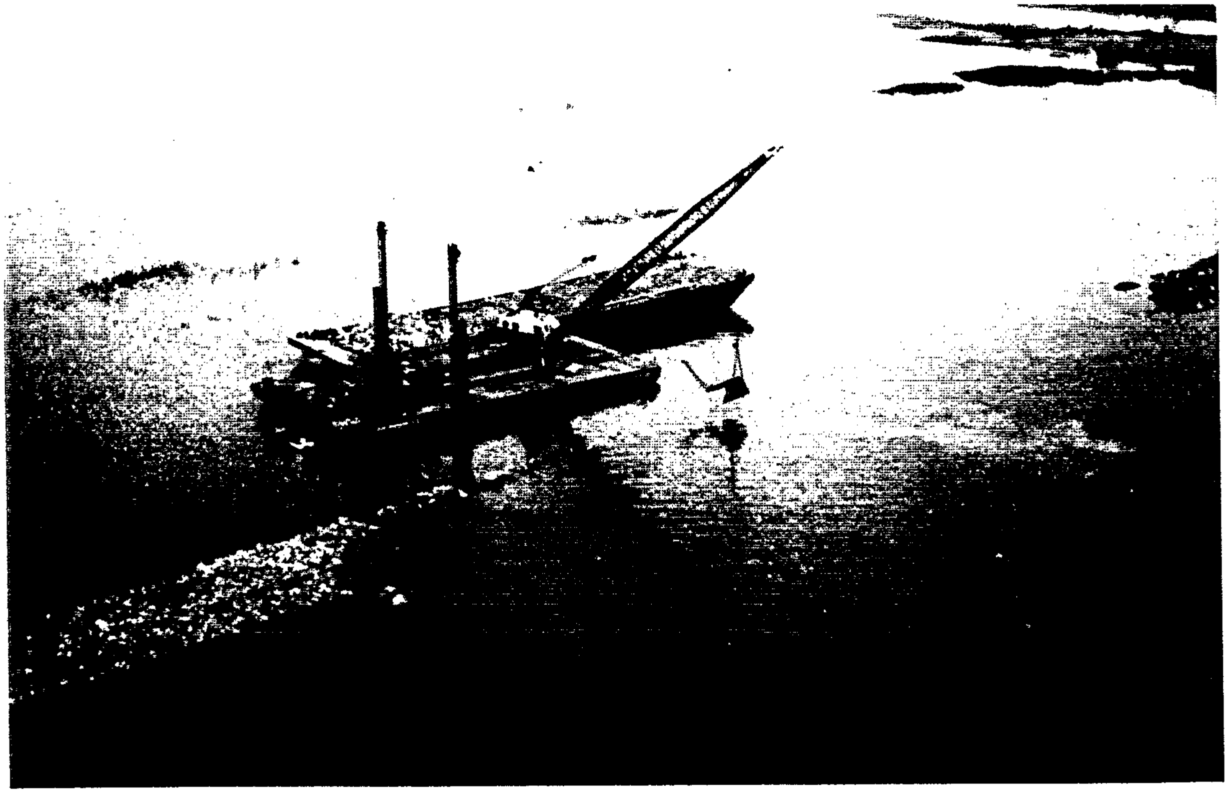
TABLE 6
COMPARISON OF METHODS OF ECONOMIC ANALYSIS OF LEVEE FAILURE
AVERAGE ANNUAL FLOOD CONTROL BENEFITS
($1,000)

	50-YEAR FLOOD PROTECTION		100-YEAR FLOOD PROTECTION		300-YEAR FLOOD PROTECTION	
ISLAND	ADOPTED METHOD	ALTERNATE METHOD	ADOPTED METHOD	ALTERNATE METHOD	ADOPTED METHOD	ALTERNATE METHOD
BACON	1510	1229	1524	1445	1624	1603
HOLLAND	438	314	438	395	449	446
MEDFORD	288	254	288	279	288	285
SHIMA	171	87	171	139	172	173
TYLER	1238	975	1300	1234	1367	1403

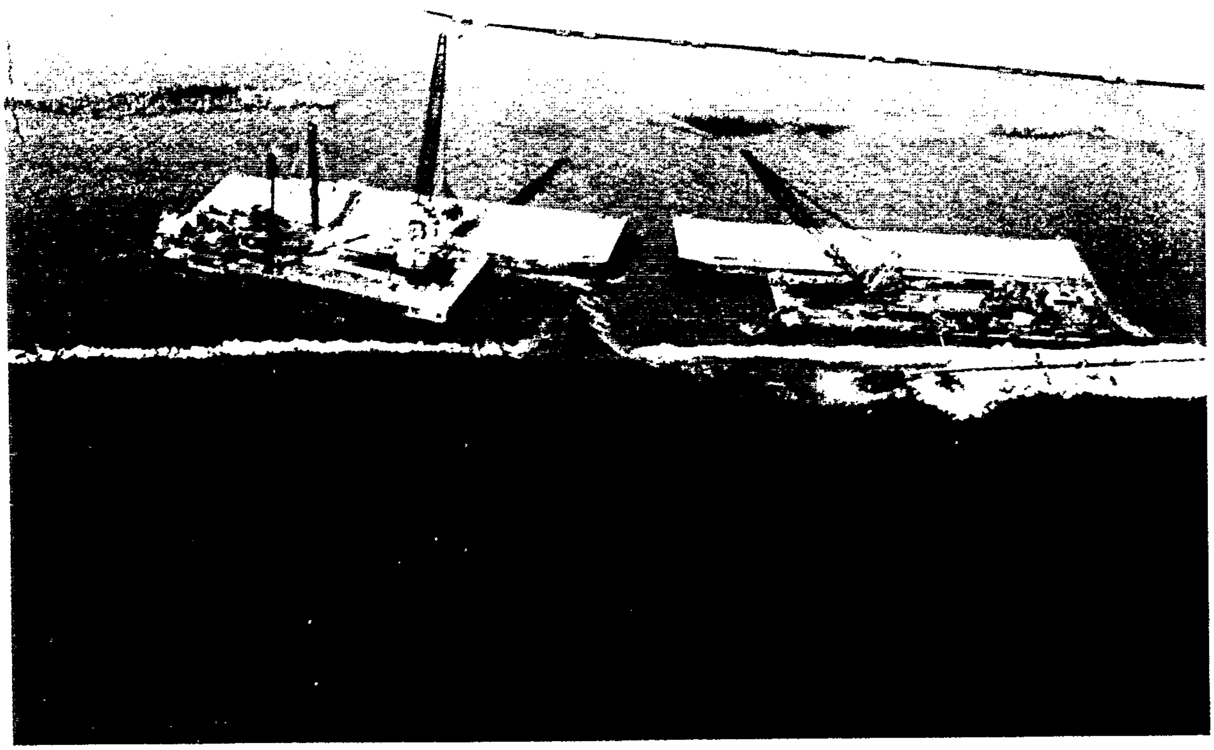
LEVEE REPAIR AND ISLAND RESTORATION BENEFITS

36. Flood control benefits attributable to levee repair and island restoration following a levee failure are significant and warrant further explanation.

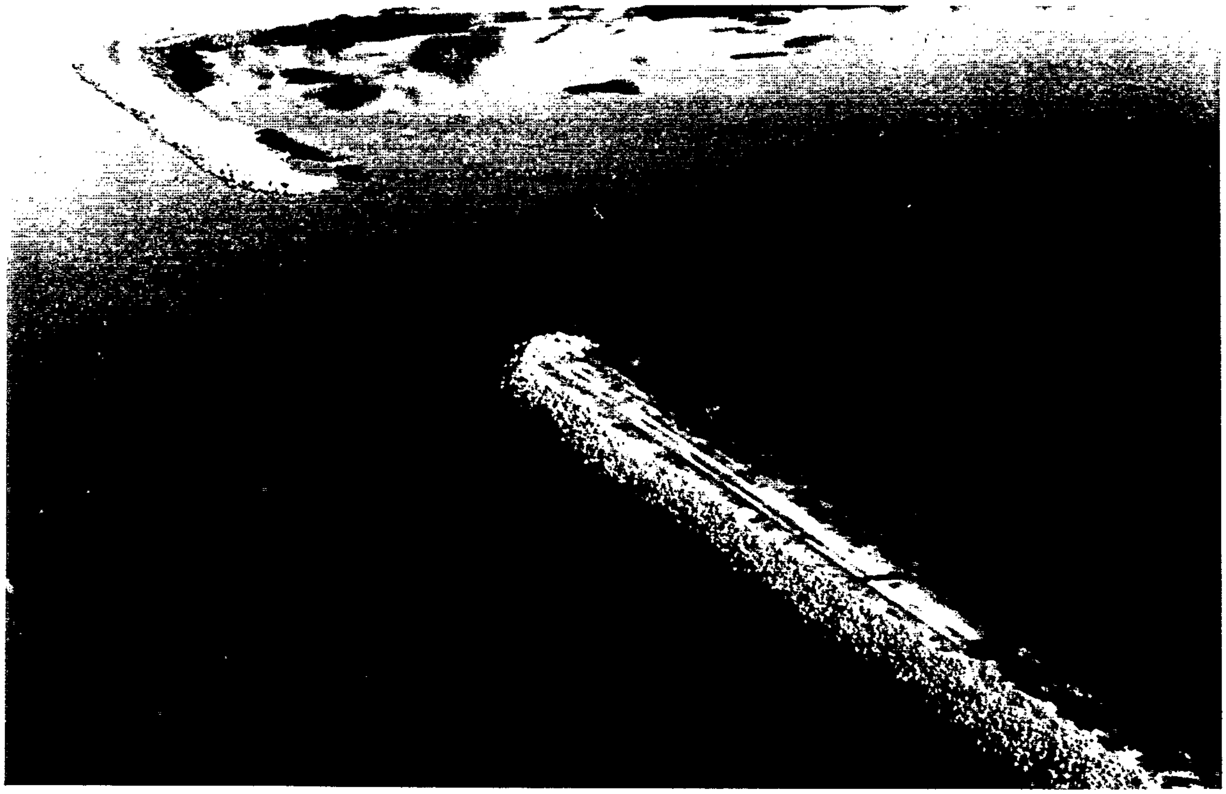
37. When a Delta levee fails, the subsequent flow of water into the island interior damages the levee primarily in two ways. First, and most apparent, is the horizontal length of levee that is displaced at the time of failure and the subsequent widening of the breach which is caused by the erosive effects of the water flowing into the island. Second, is the vertical scouring of the foundation material below the breach. The extent of erosion is basically a function of the volume of an island at m.s.l. and the type of foundation material at the location of the breach. On a large volume island more water rushes through a break for a longer period of time at greater velocities with more effective than on a small island. Also foundation areas composed of peat suffer more erosion than areas composed of other materials. Other factors which may affect the volume of scour may be the time of year.



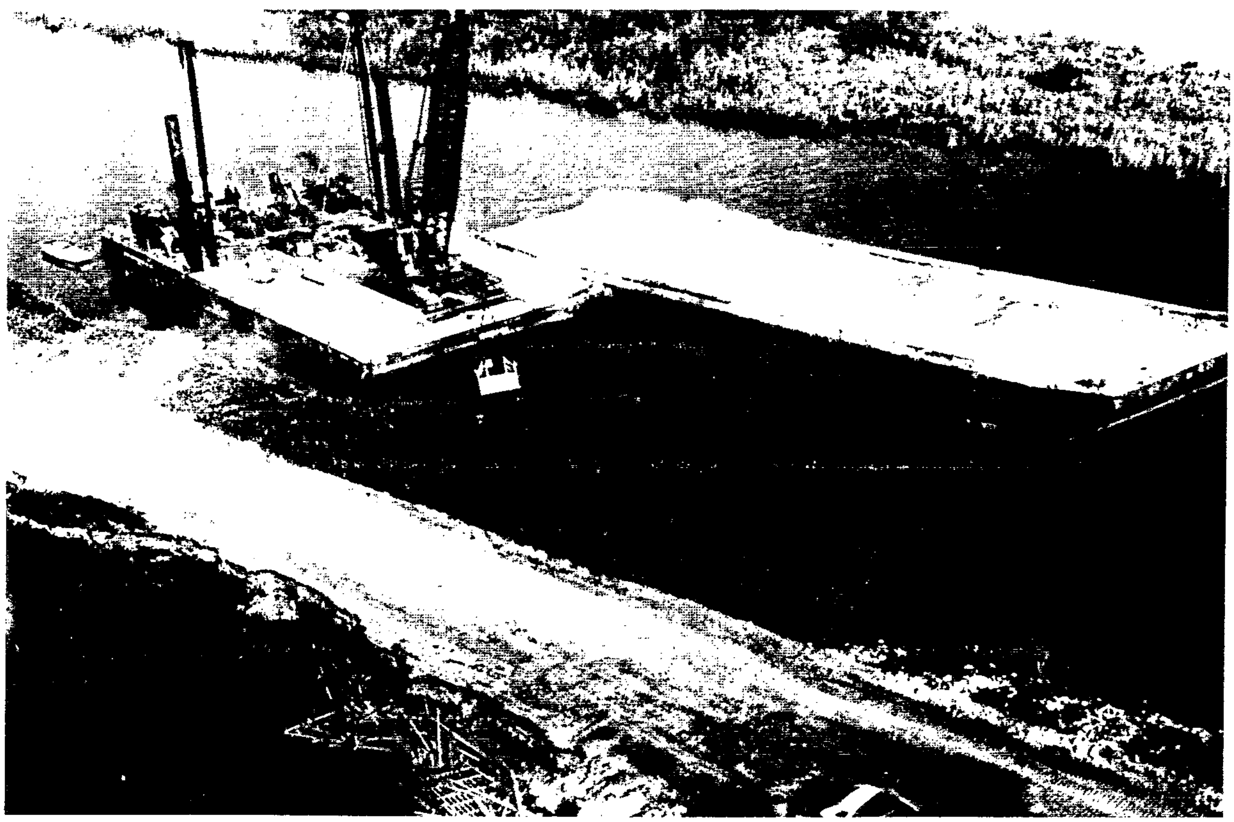
Holland Tract closure — 1980



Holland Tract closure — 1980



Holland Tract — 1980



Levee repair, Webb Tract — 1980

That is, more damage would be expected from a failure occurring during high winter flows than during low summer flows. The location of a break with respect to channels and sloughs may be influential. Recent levee failures have occurred along the main channels of the Delta. More erosion could be expected at these locations than at smaller cuts or dead end sloughs.

38. Since both the depth of vertical scour and the length of the break are primarily functions of island volume and the cost to repair a break is a function of the quantity of material that must be used to fill the eroded area, it follows that the cost to close a break may be expressed as a function of island volume.

39. The costs of closing and sealing the levee breaks that occurred in 1980 were calculated as a function of the volume of the flooded island at m.s.l. and were used as the basis for estimating the damage associated with this category. The recent experience of the 1980 Delta floods were also used as the basis for computing island dewatering costs.

WATER QUALITY BENEFITS

40. Maintenance of water quality in the Delta is of statewide as well as local importance. The Delta is a pool through which export water must be transported for use in water-deficient areas of California. The Delta channels also serve as a common source of water for Delta agriculture, industrial, urban, recreation, and fish and wildlife uses, as well as an outlet to the Pacific Ocean for water that originates in the Sacramento and San Joaquin Valleys.

41. The Delta is subject to the intrusion of saltwater by tidal action through the San Francisco Bay. Salinity intrusion is presently controlled by Delta outflow augmented as necessary by additional SWP and CVP reservoir releases during low flow periods. Under the State Water Resources Control Board Decision 1485, Delta water requirements must be met before any water is exported. If a Delta island floods during low flow periods, additional water from SWP and CVP reservoirs would be released and export pumping stopped or decreased to maintain Delta water quality standards. All water released to repel salinity intrusion would represent a damage (lost sales) which could have otherwise been recouped by CVP or SWP deliveries. Water quality benefits are therefore based on the difference in the quantity (value) of water released from upstream reservoirs for salinity repulsion under with- and without-project conditions.

Methodology

42. The procedure developed to compute water quality benefits required an analysis of the following items:

a. The quantity of water released to maintain Delta water quality if any particular island flooded.

b. The unit value of the water released.

c. The without-project frequency of levee stability failure during a low flow period.

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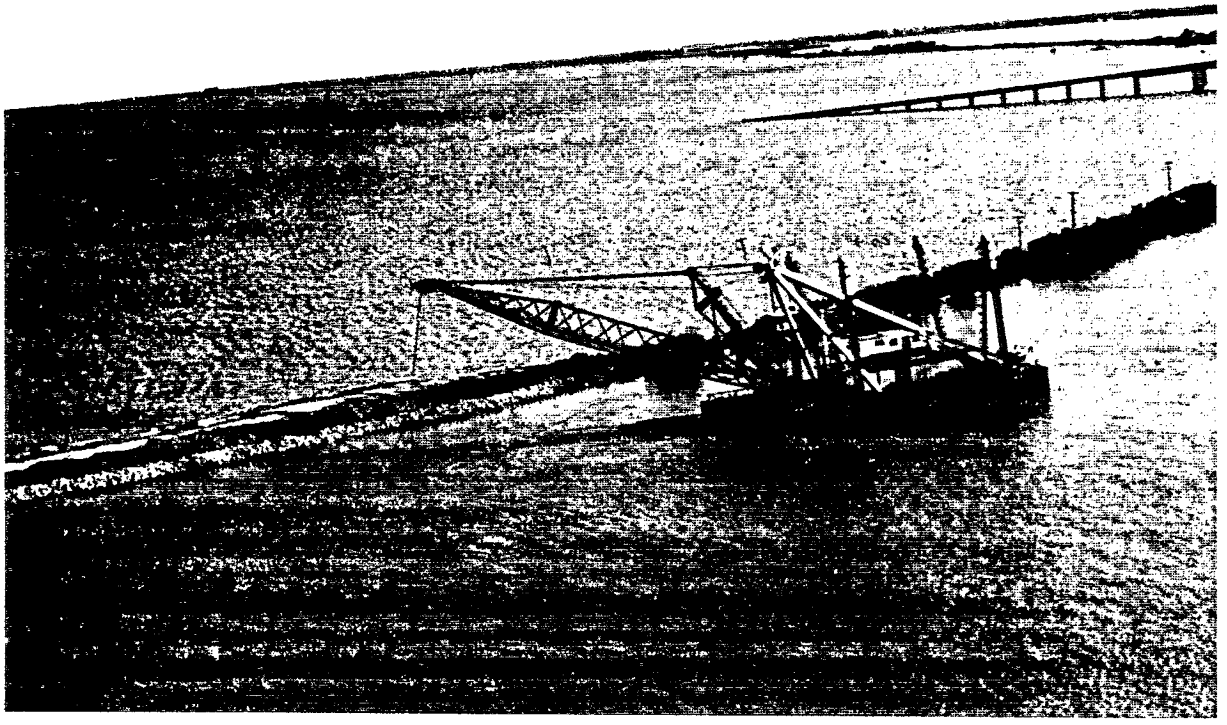
d. The with-project frequency of levee stability failure during a low flow period.

43. The volume of water required to prevent salinity intrusion was based on the experience from the 1972 Andrus-Brannan flood. Surveys conducted at that time estimated about 164,000 acre-feet of water poured through the levee break at mean sea level elevation. During the period of high salinity from 21 June to 10 August 1972, about 294,000 acre-feet of water was utilized to restore water quality to normal levels. This value represents a combination of reduced export pumping and increased releases from upstream reservoirs. Using this data, the ratio of the volume of restoration water to the volume of water that intruded the island was formed $\frac{294,000}{164,000} = 1.8$. It was assumed that the volume of water intruding into an island was equal to the volume of the island at m.s.l. The volume of each island was computed using U.S.G.S. quadrangles. Knowing the volume of each island and the ratio of the quantity of intrusion to the quantity of restoration water, the required restoration quantities were determined for each island. This provided the required restoration quantities for existing conditions assuming salinity intrusion for all islands would be similar to Andrus-Brannan.

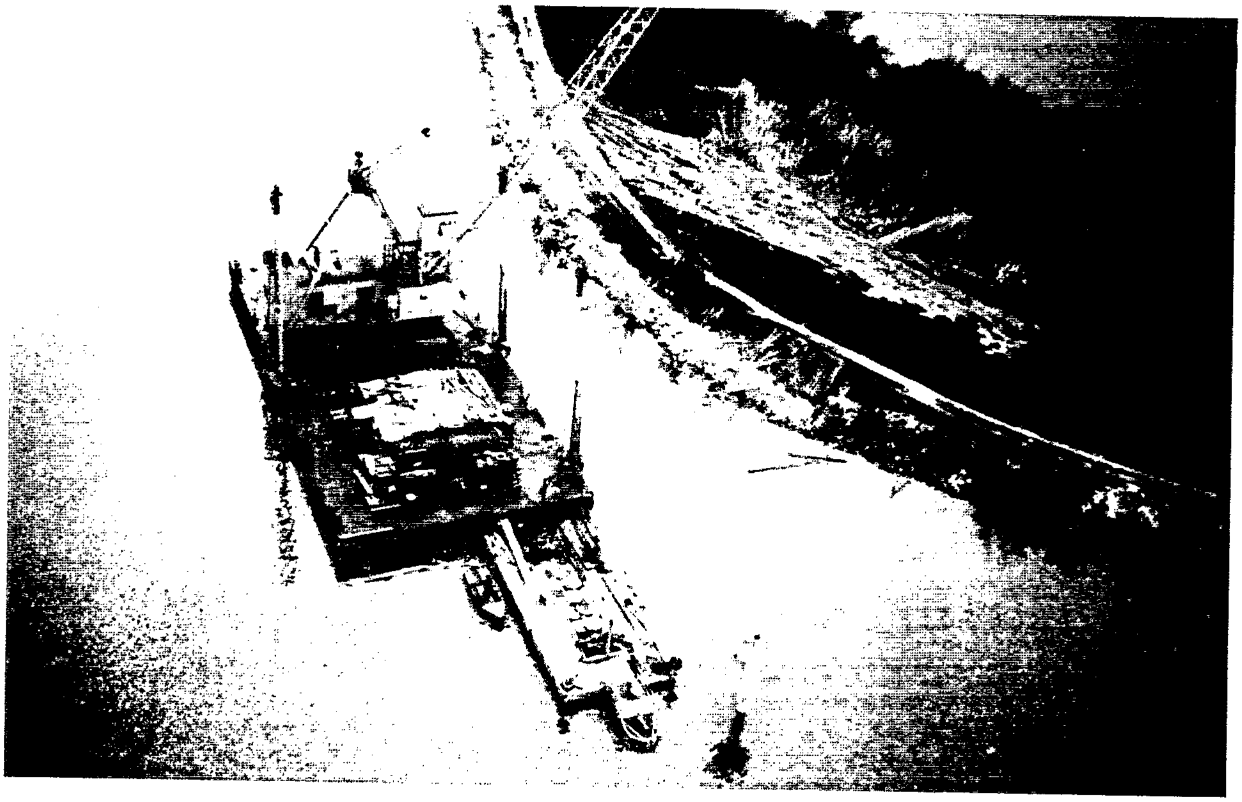
44. Future restoration volumes were computed by assuming island subsidence would continue at 3 inches per year. The historical ratio of 1.8 was assumed to remain constant over time.

45. The restoration quantities calculated in the manner described above were representative of a without-Peripheral Canal condition. DWR roughly estimated that with the Peripheral Canal in place the quantity of restoration could have

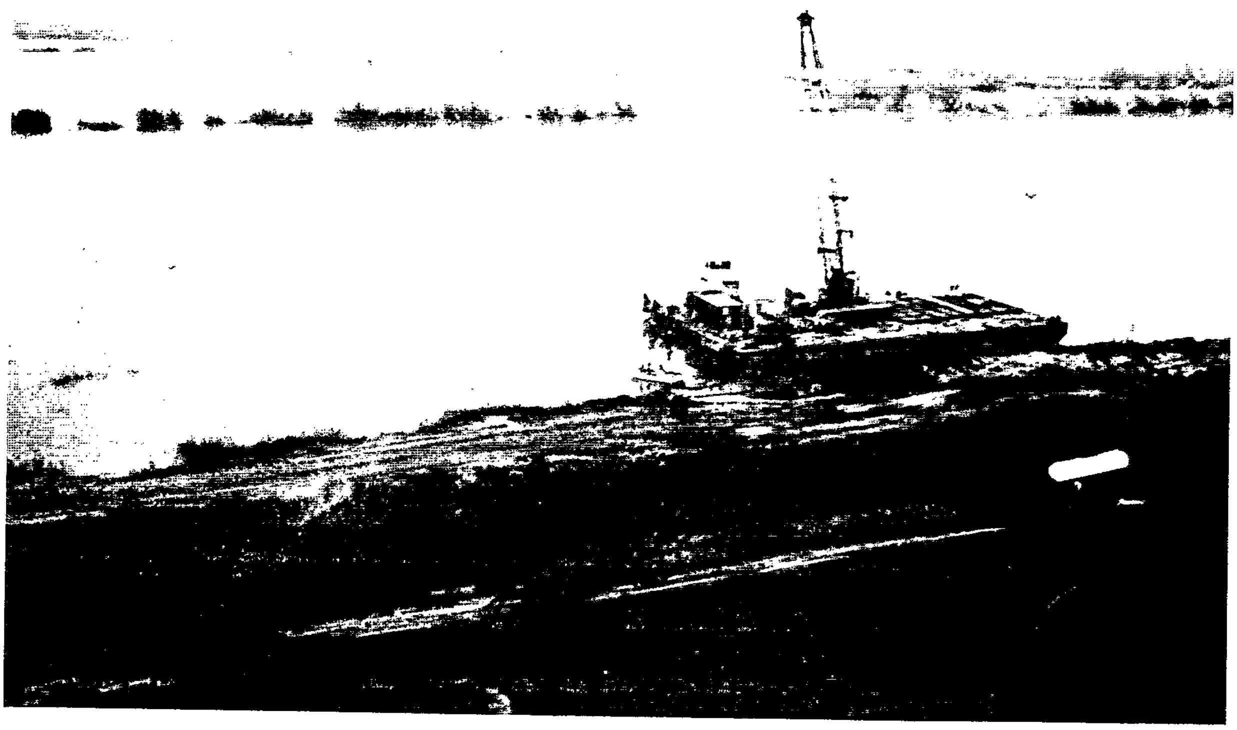


Sherman Island — 1969

Mildred Island — 1969



Levee repair, Mandeville Island — 1980



Levee repair, Medford Island — 1980

been reduced by about 40,000 acre-feet for the Andrus-Brannan incident. The with-Peripheral Canal water quality benefits were adjusted accordingly.

46. In order to compute monetary water quality benefits it was necessary to establish the unit value of releases from upstream reservoirs to maintain water quality in the Delta in the event of levee failure. DWR indicated that this value was at least as high as the cost allocated to water supply of new DWR storage facilities which are now under consideration to provide additional water to the Delta. Using October 1981 price levels and a 7-5/8 percent interest rate, a unit value of $285 per acre-foot was established.

47. The next step in the calculation of water quality benefits involved determining the frequency of levee failure for low flow summer conditions. Peak annual stage frequency curves could not be used in the analysis since normal winter/spring flows would be sufficient to repel salinity intrusion should any Delta levee fail during that period. Additional releases from upstream reservoirs would not need to be made in the winter, and there would be no associated water quality benefits.

48. As previously discussed, the two modes of Delta levee failure are overtopping and instability. Since overtopping failure would be unlikely to occur during low flow summer conditions, analysis of water quality benefits involved determining the probability of a stability failure during low flow conditions.

49. Since 1950, 3 of the 12 stability failures have occurred during the low outflow period. These events were: Webb, June 1950; Andrus-Brannan, June

1972; and Lower Jones, September 1980.[1/] Based on the historical record, 3 of 12, or 25 percent, of the stability failures have occurred during the normal low outflow period. This historical ratio was then applied to the probabilities of stability failure for peak flow conditions to determine the probability of stability failure for low flow conditions.

50. The probability of a stability failure during low flow conditions for project conditions is negligible. Therefore, it was assumed that the project condition would eliminate the occurrence of water quality damages and the project water quality benefits would be equal to the without-project damages.

SENSITIVITY ANALYSIS

INTRODUCTION

51. The sensitivity analysis conducted for this investigation consisted primarily of determining the impact of the alternative without-project conditions on costs and benefits of the flood control features. The adopted without-project condition assumed that the State-authorized Peripheral Canal was in place and operating, and that subsequent to a levee failure, a flooded island would be restored to preflood conditions. The alternative without-project conditions addressed included the following:

a. Peripheral Canal not in place; flooded island restored;

b. Peripheral Canal in place; flooded island not restored; and,

c. Peripheral Canal not in place; flooded island not restored.

1/ This analysis was completed prior to the 23 August 1982 levee failure on McDonald Island.

PERIPHERAL CANAL CONDITION

52. The Peripheral Canal assumption affects both the cost and benefit sides of the economic analysis equation. The Peripheral Canal would act as a barrier which would limit the area of inundation on tracts on the eastern side of the Delta (New Hope, Canal Ranch, Brack, Terminous, Shin Kee, Rio Blanco, Bishop, and Shima). Nonproject levees were considered to be improved on the west side of the Peripheral Canal for the islands identified above. Levees on these east tracts of the Peripheral Canal were not improved. Flooding on the east side of the canal on these islands was assumed to be a local drainage problem which would be addressed by DWR as part of its Peripheral Canal studies.

53. The canal would occupy about 3,600 acres on the islands that it traverses. As explained above, the canal would also limit the area of flooding on certain islands. Therefore, there would be less damagable property under the with-Peripheral Canal condition. Water quality damages would also be reduced under the with-Peripheral Canal condition. DWR roughly estimated approximately 14 percent less water would have to be released to restore water quality following a low flow levee failure if the canal was in place.

54. The Peripheral Canal essentially bisects two flood plains, Wright-Elmwood and Jones-Roberts, creating, in effect, an additional island in each case. Each island created in this manner had a unique probability of levee failure. The large Jones-Roberts flood plain was most significant in this regard. Without the Peripheral Canal, Jones Tract, Drexler Tract, and Roberts Island act as a single flood plain. A levee failure on any of these islands would

eventually inundate the remaining islands, assuming the break was not closed quickly and there was an unlimited quantity of water available, which would be the case in the Delta. Low interior levees on these islands would retard flooding until they were overtopped. Water would then spill over into the adjacent island. Flooding would continue incrementally until the entire flood plain was filled. The Santa Fe Railroad embankment separating Upper and Lower Jones Tracts was assumed to be in a post-1980 flood condition. That is, the breach in the embankment was assumed to be open and unrepaired allowing floodwaters to pass between Upper and Lower Jones Tracts. The controlling probability of failure for the Jones-Roberts flood plain is located on Lower Jones Tract.

NO RESTORATION CONDITION

55. Perhaps the easiest way to understand this scenario is to consider the damages that would occur if an island were not restored following a levee failure. Three damage categories were identified:

a. Inundation damages. - Inundation damages would occur to lands, crops, improvements, and contents. These damages would occur only once since flooding would be permanent. This contrasts to the scenario that assumes island restoration subsequent to flooding. Under that scenario, inundation damages would be experienced with each subsequent levee failure.

b. Evaporation losses. - Flooding of a Delta island would increase the surface area subject to evaporation. In order to maintain mandated Delta water quality standards, it was assumed that water would be released from SWP and/or CVP reservoirs to replace that lost to evaporation. Once an island is flooded, the evaporation losses would occur annually and the firm yield of the SWP and CVP would be reduced. (Firm yield is based on critically dry years. Although additional water would not be released in wet or normal years, additional releases would be required during dry and critically dry years and firm yield would therefore be reduced.)

c. Levee upgrade and increased maintenance costs. - Permanent island inundation would increase the fetch and expose islands contiguous to the flooded island to increased wind-wave erosion. This damage category accounts for the cost of levee improvements that would have to be made on contiguous islands to protect them from the increased height of wind-driven waves. An increased annual maintenance cost was also included to maintain the improved levee. It was assumed that the adjacent islands were not already flooded. This was considered to be a conservation assumption. If an adjacent island were flooded, the combined effect of adjacent flooded islands would geometrically escalate the improvement and maintenance costs to the remaining unflooded islands.

FORMULATION AND EVALUATION CRITERIA

1. Two coequal national objectives have been established to serve as a basis for justifying Federal participation in planning water and related land resources projects:

a. Promotion of national economic development (NED). This objective is achieved by increasing the value of the national output of goods and services.

b. Protection and enhancement of environmental quality (EQ). This objective is met by making favorable changes in the ecological, cultural, and esthetic attributes of natural and cultural resources that sustain and enrich human life.

2. Water and related land resource plans are to be formulated to alleviate problems and take advantage of opportunities that occur at the national, State, and local levels in ways that contribute to the NED and EQ objectives.

3. The additional considerations of Regional Economic Development (RED) and Other Social Effects (OSE) are also evaluated. The contributions to the RED account are determined by establishing the effect of a proposal on the regional aspects of income, employment, population distribution, economic base, environment, social development, and other factors. Contributions to the OSE account are determined by establishing the beneficial effects of a proposal on real income, security of life, health and safety, education, cultural and recreational opportunities, and emergency preparedness.

4. Because of the broad nature of these objectives and accounts, they have been redefined in terms of criteria relating to the problems and opportunities being investigated. These criteria provide for an objective and consistent formulation and evaluation of all alternatives.

TECHNICAL CRITERIA

5. The following technical criteria were utilized in developing the plans:

FLOOD CONTROL

a. All plans should be consistent with Federal laws, policies, and standards, and be cognizant of State and local ordinances, and county and city land use zoning and planning and development criteria.

b. Any urban island that is provided flood protection should be protected against a rare flood (300-year flood).

c. Plans should comply with the provisions of the National Flood Insurance Program.

d. Levees that provide a specified degree of flood protection should:

(1) Have a crown elevation equal to or greater than the design flood elevation plus freeboard,

(2) Be of sufficient cross section to preclude failure by sliding, sloughing, or some other form of structural failure,

(3) Have a foundation of satisfactory density and permeability to preclude a failure from foundation instability,

(4) Be composed of material of sufficient strength to withstand the hydraulic and live loads imposed on the levee, and

(5) Be operated and maintained to insure that the specified degree of flood protection is provided at all times.

e. Water quality in the Delta channels or sloughs should not be allowed to deteriorate due to inundation of Delta islands.

RECREATION

a. Recreation plans should complement State and local plans.

b. Recreation plans should be compatible with private recreation development in the study area.

c. Recreation facilities should be planned to satisfy a selected portion of the projected development needs in the study area.

d. Recreation plans should be compatible with and supported by non-Federal capabilities for sharing project costs and assuming operation and maintenance responsibilities.

e. Plans should be compatible with the flood control, water quality, fish and wildlife, environmental, and other objectives.

WATER QUALITY

a. Alternative plans should not detrimentally affect Delta water quality.

b. The Bureau of Reclamation's Central Valley Project (CVP) and the State Water Project (SWP) are dependent on Delta water quality, and their operation should not be hampered by projects constructed in the Delta.

ECONOMIC CRITERIA

6. Economic criteria for the formulation of the plans are summarized as follows:

a. Each separable feature of a plan should provide benefits at least equal to cost.

b. Benefits and costs should be expressed in comparable terms. All evaluations of alternatives should be based on October 1981 price levels, an interest rate of 7-5/8 percent, and 50-year project life.

c. Size of the flood control project selected should be based on providing the maximum net benefits; however, environmental quality and intangible considerations desired and supported by the public could dictate a project larger or smaller in size which would forego some of the net tangible benefits.

d. Project benefits should be based on an analysis of conditions without and with a project.

e. Each separable unit of a plan should provide benefits at least equal to costs.

ENVIRONMENTAL CRITERIA

7. The following environmental criteria are applicable to the formulation and evaluation of plans:

a. Plans should be formulated to protect, preserve, and enhance the quality of the natural environment. Attention should be focused on fish and wildlife, vegetation, land, air, water, open-space, and scenic and esthetic values.

b. Each alternative considered in detail must have total beneficial NED and EQ effects that outweigh combined adverse NED and EQ effects.

c. Detrimental environmental effects should be avoided where possible, and feasible mitigation for unavoidable effects should be included.

d. The relationship of the proposed action to land use plans should be analyzed, and the environmental impact of any proposed action evaluated.

e. The following should be considered if any proposed plan is to be implemented: any adverse environmental effects which cannot be avoided; the relationship between local short-term uses and the maintenance or enhancement of long-term productivity; and any irreversible and irretrievable commitment of resources.

SOCIOECONOMIC CRITERIA

8. The following socioeconomic criteria are applicable to this study:

a. Consideration should be given to safety, health, community cohesion, and social well-being.

b. Consideration should be given to evaluating and preserving historical, archeological, and other cultural resources.

c. Displacement of people should be minimized to the extent practicable.

d. Improvement of leisure activities and public facilities should be evaluated.

e. Effects of a project on regional economic development, including income, employment, business and industrial activity, population distribution, and desirable community growth, should be assessed.

f. General public acceptance of possible plans should be determined by coordination with interested Federal and non-Federal agencies, various local groups, and individuals by means of public meetings, field inspections, informal meetings, letters, and other public involvement procedures.

g. Plans should be workable within the constraints of present and potential governmental structure, function, relationships, and associations in the study area.

h. Public acceptability of proposed improvements and the ability and willingness of non-Federal interests to meet local cooperation requirements are essential considerations.

INSTITUTIONAL CRITERIA

9. The following institutional criteria were considered in the formulation and evaluation of alternative plans.

a. In 1973 the California State Legislature adopted Senate Bill 541 which delineated the State's policy concerning the Delta and the State's interest in the Delta levees. Senate Bill 541 is quoted in part from the State Water Code as follows:

> 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, recreation assets, and wildlife environment, the physical characteristics of the Delta should be preserved essentially in their present form, and that the key to preserving the Delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands.
>
> 12982. The Legislature further finds and declares that while most of the Delta's levees are privately owned and maintained they are being subjected to varied multiple uses and serve to benefit many varied segments and

interests of the public at large, and that as a result of the varied multiple uses of such levees, added maintenance costs are being borne by adjacent landowners.

12983. The Legislature further finds and declares that there is an urgent need for a higher degree of levee maintenance and rehabilitation generally throughout the Delta and that the state has an interest in providing technical and financial assistance for Delta levee maintenance and rehabilitation.

b. Beneficial water uses in the Delta and Suisun Marsh have been classified historically under three broad categories: (1) fish and wildlife, (2) agriculture, and (3) municipal and industrial. Water quality standards have been established for each of these broad categories of use to insure that each is protected in its own right. The underlying principle of these standards is that water quality in the Delta should be at least as good as those levels which would have been available had the State and Federal projects not been constructed, as limited by the constitutional mandate of reasonable use. The standards include adjustments in the levels of protection to reflect changes in hydrologic conditions experienced under different water year types (State of California, State Water Resources Control Board).

c. The Delta and Suisun Marsh comprise a highly productive and immensely valuable ecosystem which must be managed and protected as a matter of statewide public interest. The effect of the Delta Plan and this decision (State Water Resources Control Board Decision 1485) is that water quality standards in the Delta must be satisfied prior to any export from the Delta to other areas for any purpose. These standards must be maintained as first priority operating criteria for any and all projects or parts thereof that may be constructed and operated under the permits considered in this decision (State of California, State Water Resources Control Board).

MEASURES EVALUATED

INTRODUCTION

1. The measures evaluated in this investigation to address the flood control, water quality, recreation, and environmental planning objectives are discussed in this section.

NO ACTION MEASURE

2. Under this measure the Federal Government would take no action in the Delta as a result of this investigation to reduce the existing flood hazard; to prevent salinity intrusion associated with levee failures that occur during periods of low Delta outflow; to improve recreation opportunities; or to preserve and enhance environmental resources. Existing fish and wildlife habitat would not be affected, except when changed by flooding or natural processes or lost as a result of development or levee maintenance activities. No action means that levee failures would continue to occur. PL 84-99 funds would not be available to repair most nonproject Delta levees. Also, it is uncertain whether the Federal Emergency Management Agency (FEMA) would support future declarations of emergency in the Delta. Therefore, the repair of future levee failures and the restoration of flooded islands would be the responsibility of non-Federal interests. No action also means there would continue to be a lack of public recreation facilities in the Delta and land-based recreationists would continue to experience difficulty in gaining access to the public waterways. The no action measure was considered in order to compare the effect of the alternative plans to conditions expected

to occur with no Federal participation and is synonymous with the without-project condition.

FLOOD CONTROL AND WATER QUALITY MEASURES

3. The objective of the flood control measures is to reduce flood damages in the Delta. The objective of the water quality measures is to reduce the frequency of salinity intrusion into the Delta attributable to levee failures which occur during periods of low Delta outflow. Flood control and water quality measures are discussed together because both are related to levee failure.

Nonstructural measures included:

- o Flood proofing
- o Land use management (zoning)
- o Evacuation of the flood plain
- o Flood preparedness and forecasting
- o Flood insurance

Structural measures included:

- o Levee rehabilitation

- o Construction of barriers

- o Construction of upstream dams

RECREATION MEASURES

4. The recreation objectives are to develop public recreation facilities and additional access to public waterways for land-based recreationists. Recreation measures developed to satisfy these objectives included:

- o Land-based facilities

- o Water-based facilities

- o Day use facilities

- o Overnight use facilities

ENVIRONMENTAL MEASURES

5. The environmental objectives include the preservation of scenic values and the maintenance and enhancement of environmental resources.

Environmental measures considered were:

- o Acquisition of public interest in lands

- o Selective construction and management measures

- Development of wetland areas

- Establishment of a National Wildlife Refuge or similar State-managed area

- Recreation measures which would provide public access to fish and wildlife and environmental enhancement areas

NO ACTION PLAN

1. Under the No Action Plan the Federal Government would take no action to alleviate flood problems in the Delta. It was assumed that a comprehensive levee rehabilitation program would not be undertaken and that existing levees would be maintained at their current level of repair. Island interiors are expected to continue to lower with a resultant increase in the probability of levee failure. In compliance with the plan formulation criteria, it was assumed that failed levees would be repaired and that flooded islands would be restored in order to preserve the physical characteristics of the Delta in their present form. However, it should be noted that as the frequency of levee failure increases and as levee repair and island restoration costs increase, flooded islands may eventually not be restored to preflood conditions. The future availability of public funds may dictate whether flooded islands will be restored. Events following the 1980 Delta floods suggest that public funds may be provided in the future only in limited instances. Since the without-project assumption is subject to change, a sensitivity analysis was conducted on each of the candidate plans formulated hereinafter to determine the effect of the without-project assumptions on plan economics.

2. The equivalent average annual flood and water quality damages expected to occur with the No Action Plan are $54 million. This value was computed on the two assumptions that the authorized Peripheral Canal was in place and flooded islands would be restored.

C-103082

NONSTRUCTURAL ALTERNATIVES

INTRODUCTION

3. Nonstructural flood damage reduction measures are those which reduce or avoid flood damages without significantly altering either the nature or the extent of flooding. The nonstructural alternatives considered included flood insurance, land use management (zoning), flood forecasting and preparedness, flood proofing structures, and flood plain acquisition. Formulation of alternative plans was not limited to those which the Corps of Engineers could implement under current authorities. Plans which could be implemented by local, State, and other agencies were also considered.

4. During the formulation of nonstructural alternatives it was determined that several traditional nonstructural alternatives have been successfully implemented in the Delta by non-Federal interests. These included a flood insurance program, a flood preparedness and forecasting system, and land use regulation. These existing programs are described in subsequent paragraphs and were not further developed as nonstructural alternatives.

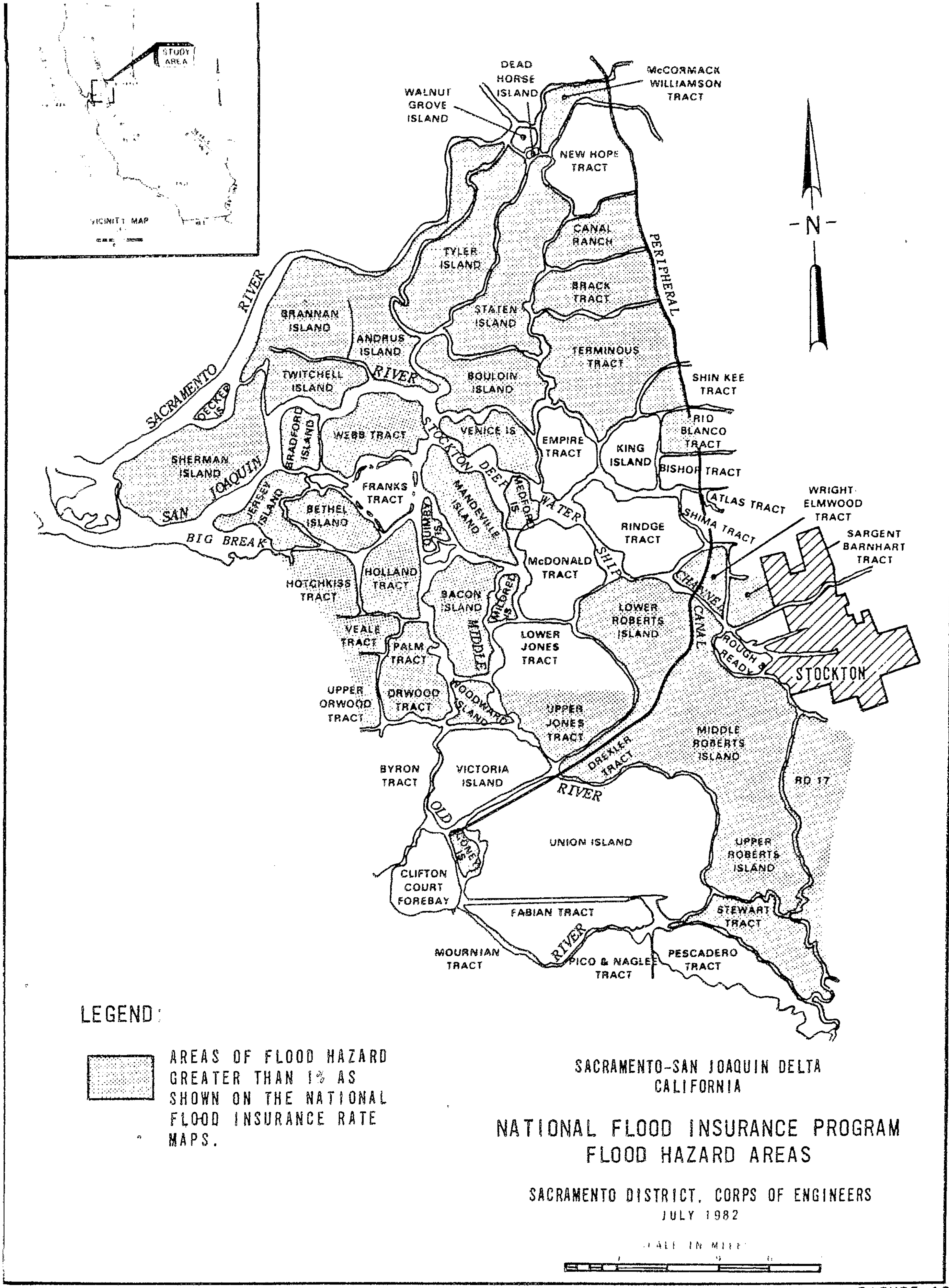
5. Flood proofing of structures and public acquisition of Delta lands were considered as additional nonstructural alternatives. Each alternative was evaluated with respect to completeness, effectiveness, efficiency, and acceptability. None of the alternatives would satisfactorily meet the four evaluation criteria, and a nonstructural alternative was not selected for detailed studies. However, land use management (zoning) was included as a feature of each candidate plan to prevent project-induced urban development on agricultural islands. Similarly, each candidate plan features limited use of

the flood plain acquisition alternative to develop a Wildlife Management Area and to preserve natural resource areas.

FLOOD INSURANCE

6. The flood insurance plan consists of a multiple-purpose program to indemnify policy holders for financial losses suffered during a flood and to reduce the damage potential in flood plains through regulatory action. To participate in the program, a community would have to require that all new construction and substantial improvements in identified areas of special flood hazard be elevated or flood proofed to the level of a base flood. The National Flood Insurance Program which was authorized in 1968 satisfies the requirements of the flood insurance plan. All of the Delta counties are participating in the National Flood Insurance Program which allows the county residents to obtain insurance against structure and content damage, but does not cover land and crop damages.

7. In the development of a flood insurance plan a Flood Insurance Rate Map is usually prepared following an engineering study. The map provides flood information necessary for a community's participation in the program. The study and map define the boundary lines of a community's special flood hazard areas and reflect the flood elevations in most of these areas that would occur during a flood with a 1 percent chance of occurrence in any given year (100-year flood). The actuarial or nonsubsidized premium rates reflecting the degree of flood risk to which developments are exposed are determined from these data. Figure 12 shows the areas of flood hazard in the Delta as identified by the Flood Insurance Rate Maps.



STUDY AREA
VICINITY MAP
DEAD HORSE ISLAND
McCORMACK WILLIAMSON TRACT
WALNUT GROVE ISLAND
NEW HOPE TRACT
N
CANAL RANCH
TYLER ISLAND
PERIPHERAL
BRACK TRACT
SACRAMENTO RIVER
BRANNAN ISLAND
STATEN ISLAND
ANDRUS ISLAND
TERMINOUS TRACT
TWITCHELL ISLAND
RIVER
BOULDIN ISLAND
SHIN KEE TRACT
DECKER IS
BRADFORD ISLAND
WEBB TRACT
VENICE IS
EMPIRE TRACT
KING ISLAND
RIO BLANCO TRACT
SHERMAN ISLAND
SAN JOAQUIN
STOCKTON DEEP WATER SHIP CHANNEL
BISHOP TRACT
ATLAS TRACT
WRIGHT ELMWOOD TRACT
JERSEY ISLAND
BETHEL ISLAND
FRANKS TRACT
MANDEVILLE ISLAND
MEDFORD IS
RINDGE TRACT
SHIMA TRACT
SARGENT BARNHART TRACT
BIG BREAK
QUIMBY IS
McDONALD TRACT
HOTCHKISS TRACT
HOLLAND TRACT
BACON ISLAND
MILDRED IS
LOWER ROBERTS ISLAND
CANAL
VEALE TRACT
MIDDLE
LOWER JONES TRACT
ROUGH & READY
STOCKTON
PALM TRACT
UPPER ORWOOD TRACT
ORWOOD TRACT
WOODWARD ISLAND
UPPER JONES TRACT
MIDDLE ROBERTS ISLAND
BYRON TRACT
VICTORIA ISLAND
DREXLER TRACT
RIVER
RD 17
OLD
UNION ISLAND
CONEY IS
UPPER ROBERTS ISLAND
CLIFTON COURT FOREBAY
FABIAN TRACT
STEWART TRACT
RIVER
MOURNIAN TRACT
PICO & NAGLEE TRACT
PESCADERO TRACT
LEGEND:
AREAS OF FLOOD HAZARD GREATER THAN 1% AS SHOWN ON THE NATIONAL FLOOD INSURANCE RATE MAPS.
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
NATIONAL FLOOD INSURANCE PROGRAM
FLOOD HAZARD AREAS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

FIGURE 12

8. Many of the Delta flood insurance engineering studies were conducted by the Corps of Engineers using "approximate" methods. Detailed field engineering studies such as levee surveys and hydrologic analyses were Not conducted. The 100-year flood elevations and/or 100-year flood boundaries were estimated, and U.S.G.S. quadrangles were used to determine levee elevations. It is important to note that these studies were based on the assumption that the Delta levees would only fail by overtopping. Levee stability failure was not considered in the analysis. Therefore, islands that are shown as being inundated represent areas where levee failure results from overtopping of the levees.

9. With respect to the published Flood Insurance Rate Maps and the minimum Flood Insurance Administration (FIA) flood plain management requirements, new structures in the Delta may be constructed below sea level as long as the levees surrounding the structures are shown as providing 100-year flood protection.

10. Since all of the Delta counties are participating in the National Flood Insurance Program, the flood insurance alternative was not considered for additional study. It is important that the local communities recognize the limitations of the existing flood insurance studies and the impact that stability failures may have on the location and extent of flood hazard areas in the Delta. It is suggested that the levee failure rates developed for this investigation be used to define more accurately the locations of flood hazard areas.

C-103086

LAND USE MANAGEMENT (ZONING)

11. This alternative would create land use regulations to manage the use of the Delta islands in a manner that is compatible with the severity of the flood hazard. Several means of regulation are available including zoning ordinances, subdivision regulations, and building and housing codes. Such regulations could reduce flood losses in the Delta by controlling future use, and restricting changes in existing use.

12. The Delta counties have determined that further development of the Delta flood plain will not take place unless the lowest floors of buildings are elevated to the 100-year level or flood proofed to that level.

13. With this measure flood damage to future structures would be reduced or eliminated, but no additional flood protection would be provided for the majority of the Delta. For this reason, no additional consideration was given to this alternative except as a measure to prevent undesirable urban growth induced by a structural flood control plan.

FLOOD PREPAREDNESS AND FORECASTING

14. This alternative would provide for the development of a flood preparedness program for the Delta. Included in the program would be a flood forecast center which would warn Delta inhabitants of imminent flooding so that the flood plain could be evacuated and flood fight activities could be initiated. Legislative authorities would also be developed to provide for public assistance in conducting flood emergency operations and restoration activities. This alternative was not pursued since it was determined that

flood preparedness in the Delta is highly developed, as described in the following paragraphs.

15. DWR is the State agency responsible for coordinating flood preparedness, flood forecasting, and emergency operations in the study area. DWR maintains a comprehensive Flood Operations Center in the Resources Building in Sacramento. This is primarily a hydrological data collecting and disseminating unit, but it also has the capability to respond to flood-related emergencies. The Center's basic responsibility during a major storm or at other flood periods is to provide the necessary data and staff to serve as an around-the-clock river surveillance and flood fight coordination team. The National Weather Service and the Federal-State River Forecast Center are conveniently located on the same floor of the Resources Building.

16. As major storm systems begin sweeping across California, the operations of the Flood Center are changed from a "Normal" status to a "Flood Monitoring" status. Current weather conditions, extended forecasts, and streamflows are reviewed and evaluated to keep pace with changing conditions. As the possibility of flooding increases and related problems appear imminent or actually exist, the Center advances to a "Flood Alert" condition. Under the Flood Alert status, with approval of the DWR Director, limited General Funds can be made available to assist in mobilizing a flood fight. The Center may use these funds to extend its operating hours and to provide a communication and coordinating flood center, on a 24-hour basis if necessary, and dispatch area teams to investigate flood damage reports. Under certain conditions, the Center may also arrange for levee patrols or provide initial wave wash protection to levees of critical statewide and public interest, or take measures immediately required for protection of levees and property. In

carrying out such work, the Center may enlist the aid of DWR employees or perform the work through or in cooperation with other State or local agencies. Funds are not available to the Flood Center for advance work before a flood. Also, funds are not available for maintenance of flood control facilities or for restoration work after a flood.

17. The operation and maintenance of sophisticated data collection equipment are a basic part of the Center's operation. The Center's personnel also locate and install, or supervise the installation of, permanent or experimental hydrological metering instruments.

18. Because of its flood fight coordinating responsibilities, the Center takes numerous preparatory steps during the course of the year to enhance its effectiveness during flood periods. One of the most important preparatory measures is the sponsoring of a flood fight training school for key personnel of local flood control and other emergency agencies. The schools are normally scheduled every 2 years, but more frequently when the need arises. At the school, field conditions are simulated for training in the control of "boils," prevention of levee overtopping, and combating levee wave wash erosion.

19. The Center also maintains a Directory of Officials. The Directory of Officials contains the names, addresses, telephone numbers, and titles of Flood Control, Reclamation, Levee, Drainage Districts, and Municipal officials.

20. Another publication prepared and distributed by the Flood Operations Center is the Flood Emergency Operations Manual. The purpose of this Manual is to inform public officials and agencies of the structure and operations

procedures of the State-Federal Flood Operations Center and to guide public officials seeking assistance during flood periods.

21. The Manual describes the functions of the Center during flood emergencies and the ways in which DWR, Federal, local, and other State agencies cooperate in meeting flood crises. The Manual also contains directories of DWR's Flood Operations personnel, other public agencies that assist in flood disaster operations, and sources of equipment and materials used in actual flood fighting. The Flood Operations Manual is updated each year.

22. The Center also maintains a list of people, local districts, and agencies to be notified in high water events. Based on information contained in River Forecast Bulletins issued by the joint Federal-State River Forecast Center, a designated staff member is responsible for notifying specific officials of various districts when and to what extent warning or flood stages are expected. The date, time, person contacted, and conditions are logged in the "Notification Register" as a permanent record. This service offers public officials and landowners advance warning and the opportunity to remove livestock and equipment located within a flood plain, or take appropriate steps to protect lives and property.

23. Flood preparedness is enhanced by the California Office of Emergency Services (OAS) which coordinates local civil defense/emergency operations efforts and works closely with the Federal Emergency Management Agency (FEMA). Law enforcement agencies provide traffic control, communications, and evacuation assistance. The Delta reclamation districts are responsible for monitoring levee conditions, and local governmental agencies are responsible for ordering evacuation from flood threatened areas. Manpower for flood

fighting is available from the California Department of Forestry, the California National Guard, and the California Conservation Corps. Assistance is also available from the U.S. Army Corps of Engineers.

FLOOD PROOFING

24. Flood proofing consists of adjusting a structure or its contents, or both, so that water is kept from the structure, or the damaging effects of water entry are eliminated or reduced. Permanent flood proofing measures are those that do not depend on judgment, flood forecast, or warning to put the protection into effect. Examples of permanent flood proofing measures are elevation of structures above flood levels; site protection using dikes or floodwalls; and structure protection using anchorage to resist buoyancy, sump pumps, sealing floors or basements, and increasing the structural strength of buildings to withstand hydrostatic pressure.

25. Contingent or partial flood proofing measures are those that are put into effect upon receipt of warning of impending flooding. Examples of contingent measures include structure protection through provision of closures for openings below the design flood elevation; utility backup protection using valves; and intentional flooding with clean water or floodwater to equalize hydrostatic pressures.

26. Emergency or temporary flood proofing measures are those that, upon receipt of warning, are either improvised just prior to or during a flood, or carried out according to an established plan of action. Emergency measures include site and structure protection using sandbags, and protection of structure contents by removal to higher elevations.

27. The Federal-State River Forecast Center and the DWR Flood Operations Center, which are described in the Flood Preparedness and Forecasting alternative in this section, generally provide sufficient warning of impending flood danger in the Delta. This allows implementation of the contingent or emergency flood proofing measures. However, these measures do not offer permanent flood protection. Furthermore, they would not provide adequate protection against inundation levels that can be expected in the Delta. Therefore, it was concluded that a permanent flood proofing measure consisting of structure elevation is the most appropriate flood proofing measure for the Delta. Structural protection measures using dikes or walls were discounted because of the need to provide access openings which would have to be closed and sealed before a flood to prevent damage.

28. Typical structures found in the Delta include one- and two-story wood frame residences of approximately 1,000 to 1,500 square feet living area with the first floor located above a crawl space; mobile homes; and small commercial and institutional structures, some of which are of masonry construction with concrete slab floors. In terms of physical feasiblity, most of the structures found in the Delta can be elevated in place using conventional equipment and construction methods. Certain commercial or industrial buildings founded on concrete slabs or constructed of heavy materials could also be elevated, but special equipment would be required and the additional expense would be considerable.

29. The cost of elevating structures was estimated for four Delta islands having some urban development: Andrus-Brannan, Bethel, Hotchkiss, and New Hope.

30. Residential structures only were considered for elevating for ease of analysis. All houses were considered to be 1,500 square feet wood frame and on a conventional foundation. Costs to elevate the structures in place were taken from the Corps Hydrologic Engineering Center report entitled "Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures," 1978, and are indicated below:

Elevation Feet	Cost of Raising In Place (Sound Condition)	Cost of Raising In Place (Deteriorated Condition)
1	$4,300	$10,320
2	$5,160	$12,040
3	$6,020	$13,760
4	$6,880	$14,620
5	$8,170	$15,480
6	$9,030	$17,200

31. As indicated in Table 7, flood proofing residential structures would not be economically feasible. Furthermore, flood proofing would not satisfy the evaluation criteria of being complete, effective, efficient, or acceptable. Flood proofing is not a complete or effective solution since damage to ground level facilities, utilities, and other improvements would continue to occur.

Most significantly, flood proofing would not reduce the majority of the flood damages in the Delta which include crop losses, levee repair and island restoration costs, and expenditures for flood emergency activities. For these reasons the flood proofing alternative was not investigated further as a nonstructural alternative.

TABLE 7

COST AND BENEFITS FOR ELEVATING RESIDENTIAL STRUCTURES
ON FOUR ISLANDS (all structures assumed to be 1,500 ft^2)

PARAMETER	ANDRUS-BRANNAN*	BETHEL	HOTCHKISS	NEW HOPE
Range in probability of flooding (next 50 years)	.0464 - .0699	.0020 - .0191	.0280 - .0446	.0182 - .0344
Estimated number of structures	209	544	261	189
Annual cost to raise in place to 300 year event flood stage	$646,849	$1,061,441	$433,363	$271,685
Expected reduction in annual flood damage ($)	$565,408	$280,659	$430,650	$184,193
Estimated B/C ratio	0.9	0.3	0.99	0.7

*Does not include City of Isleton.

PUBLIC ACQUISITION

32. This plan would provide for the removal of existing uses from the flood plain by fee simple acquisition of lands and improvements. The first step in formulating this alternative involved determining which of the Delta islands should be considered for acquisition. It was determined that 10 agricultural islands with at least 50-year flood protection were adequately protected and should not be acquired. These islands included Atlas, Fabian, Mournian, Orwood, Pescadero, Pico/Naglee, Sargent-Barnhart, Stewart, Union, and Walnut Grove. Urban islands (Andrus-Brannan, Bethel, Byron, Hotchkiss, and New Hope), were also excluded from acquisition in favor of structural improvements to avoid significant acquisition and relocation costs and the social impacts associated with relocating people.

33. The 41 remaining agricultural islands were then considered for acquisition. The improvements on these islands that would not be acquired would include the Santa Fe Railroad line, the State highways (4, 12, and 160) traversing the Delta, the Pacific Gas and Electric (PG&E) natural gas storage facilities on McDonald Island, the natural gas wellheads scattered throughout the Delta, the Mokelumne Aqueduct which supplies municipal and industrial water to the East Bay Municipal Utility District (EBMUD), and various utility pipelines connecting the East Bay area and Stockton. The McDonald Island facilities are flood proofed and the Mokelumne Aqueduct is constructed on pile bents partially above flood levels. Similarly, the Santa Fe Railroad tracks are located on an embankment above the flood plain.

34. The second stage in the plan formulation process involved assessing the most likely future use of the flood plain lands assuming no additional flood protection would be provided (i.e., the most likely future condition without a project). The adopted without-project condition for the Delta Investigation assumes that if an island floods, it would always be restored. With very few exceptions, this has proven to be the case in the Delta. Therefore, if flooded islands continue to be restored, it is reasonable to expect that the primary existing use (agriculture) would continue in the future. The experience of the most recent floods in the Delta suggest that a careful examination of the future uses of the Delta islands is warranted. Levee repair and island restoration work performed after the 1980 floods were accomplished largely with public funds. Prior to 1980, Federal flood emergency funds were available under the authority of PL 84-99 or as the result of a Presidential declaration of an emergency. Subsequent to the 1980 Delta floods, it was determined that PL 84-99 funds would be limited to flood fight activities and could not be used for levee repair or island restoration

work in most of the Delta. Similarly, FEMA indicated it may not support future declarations of emergency in the Delta. Therefore, the probability of not restoring flooded islands appears to be increasing. If this scenario should prove to be true, then there is doubt whether non-Federal interests would be able to finance the restoration of flooded islands. In this case the flooded islands would probably be abandoned. Areas similar to Franks Tract, which last flooded in 1938 and was not restored, would probably result.

35. The next step in formulating the acquisition plan involved determining the highest and best use of the evacuated flood plain. Alternative uses considered included downstream storage reservoirs, dredged material disposal, solid waste disposal, recreation, and fish and wildlife enhancement. Recreation and fish and wildlife enhancement were determined to be the highest and best use of the evacuated flood plain. The selection of these uses allows the acquisition plan to satisfy two of the objectives of the investigation. The removal of the existing agricultural use on islands to be acquired would reduce the conflict that would be created by integrating recreation with the existing agriculture.

36. The recreation plan selected for the flood plain acquisition alternative would be identical to that developed for the structural alternatives described later in this appendix. A larger scale recreation plan could be considered for the acquisition alternative, but this would have the potential for creating a conflict with the use of the remaining agricultural lands. Another consideration for using the recreation plan as formulated is that it was developed to be consistent with the desires and cost-sharing capabilities of potential non-Federal sponsors.

37. The fish and wildlife enhancement features would include all the enhancement measures identified in the Recreation and Environmental Quality Plan Formulation Section of this appendix except the setback levee measures.

38. The remainder of the acquired islands would be allowed to return to natural vegetation, and ground water levels would be allowed to rise to form marshes. The vegetation would enhance wildlife values by providing cover and food. The cessation of farming, combined with the growth of natural vegetation and the higher ground water levels or marsh conditions, would retard the island subsidence problem that currently exists. The reduction of the subsidence would in turn contribute to slowing the rate at which levee stability failures occur.

39. In order to provide some assurance that the configuration of the Delta channels would be maintained, a maintenance program would be implemented on the levees of the acquired islands. The level of maintenance would be equal to that required for the Flood Hazard Mitigation Program proposed under the structural alternatives. The maintenance program would not significantly reduce the frequency of flooding, and levee failures would still occur periodically. Therefore, the cost to repair a future levee break was also included in this plan. The levee break would be closed to avoid the creation of open bodies of water from which evaporation would occur, but flooded islands would remain flooded. Only one failure was assumed to occur since the flooding would have some stabilizing effect on the levees. Costs were also included for erosion protection material placed on the interior levee slopes to provide protection from wave wash erosion.

40. The remaining costs of this alternative would include flood control improvements for five urban islands (no improvements would be required for RD-17), the cost of the recreation improvements, land and acquisition costs for 41 islands and fish and wildlife enhancement areas, and development costs for a Wildlife Management Area. The Wildlife Management Area development costs would include levee improvements to provide minimum flood protection to the Wildlife Management Area.

41. The benefits of this alternative would include flood control benefits accruing from improvements provided to the urban islands. Recreation benefits and tangible fish and wildlife enhancement benefits would also be included. Benefits attributable to island acquisition would include the reduction of emergency flood fight and dewatering costs.

42. The first costs of this alternative are summarized in Table 8. Annual costs and benefits are presented in Table 9.

43. The advantages of this alternative include establishing an alternative use for those agricultural islands that generally have levees with the highest probability of failure. This avoids the need to continue spending large sums of money during flood emergencies. Some funds would continue to be spent to close future breaks. However, the closures effected for the proposed uses of the acquired islands would not have to provide the full control against seepage that is presently required to reestablish agricultural operations. Another significant advantage is that the proposed uses of the islands would provide some measure of control of land subsidence and thereby mitigate the existing levee stability problems.

TABLE 8

PUBLIC ACQUISITION FIRST COST
OCTOBER 1981 PRICE LEVEL
($1,000)

FEATURE	LEVEES	RECREATION FACILITIES	INTERIOR EROSION PROTECTION	LEVEE CLOSURE	LANDS AND RELOCATIONS	TOTAL
Flood Control & Water Quality						
Andrus Island	6,298				7,999	14,297
Bethel Island	28,521				1,514	30,035
Brannan Island	7,412				849	8,261
Bryon Island	5,806				3,488	9,294
Hotchkiss Tract	8,874				194	9,068
New Hope Tract	9,754				1,342	11,096
Recreation		33,783			6,783	40,566
Fish & Wildlife Enhancement						
Enhancement Areas					6,962	6,962
Wildlife Management Area	32,000				9,290	41,290
Flood Plain Acquisition (38 Islands)1/			24,498	84,984	737,591	847,073
TOTAL	98,665	33,783	24,498	84,984	776,012	1,017,942

1/ Medford, Mildred, and Quimby would be acquired as part of the Wildlife Management Area.

TABLE 9

PUBLIC ACQUISITION ANNUAL COST AND BENEFITS1/
($1,000)

FEATURE	ANNUAL COST: AMORTIZED FIRST COST	ANNUAL COST: MAINTENANCE AND OPERATION	ANNUAL COST: TOTAL	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
Flood Control & Water Quality						
Andrus/Brannan	2,272	76	2,348	5,791	3,443	2.5
Bethel	2,377	236	2,613	1,259	-1354	0.5
Byron	728	37	765	583	-182	0.8
Hotchkiss	710	64	774	2,441	1,667	3.2
New Hope	763	137	900	889	-11	0.99
Recreation	3,069	966	4,035	13,058	9,023	3.2
Fish & Wildlife Enhancement	2,844	340	3,184	8,124	4,940	2.6
Enhancement Areas	(542)	-	(542)			
Wildlife Management Area	(2,302)	(340)	(2,642)			
Flood Plain Acquisition (38 Islands)	66,267	-	66,267	6,623	-59,644	0.1
TOTAL	79,030	1,856	80,886	38,768	-42,118	0.5

1/ 7-5/8 percent interest; 50-year amortization

44. There are numerous disadvantages to this plan. Most significantly, about 182,000 acres would be permanently taken out of agricultural production. Institutional, social, and political opposition to public acquisition of such a large area of productive agricultural land could be expected. Major transportation routes crossing islands acquired under this alternative would be adversely impacted since the islands would not be restored if they flood. Utility lines crossing these islands could be similarly affected. This alternative was not economically justified; it was not carried forward in the planning process in its entirety. Public acquisition was included in each of the candidate plans as a means of implementing the recreation and fish and wildlife enhancement features.

SCREENING AND EVALUATION

45. The Delta islands and tracts are reclaimed lands protected by earthfill levees. Island interior elevations generally are below mean sea level. The failure of a levee and the resultant flooding of an island or tract is permanent unless the levee is repaired and the use of the land is restored by removal of the floodwaters. The use of traditional nonstructural solutions to reduce flood damage in the Delta is not as effective as compared to a flood plain which is subject to ephemeral flooding.

46. The nonstructural measures of flood forecasting and preparedness, land use management (zoning), and flood insurance have been successfully implemented in the Delta. These programs are complete and independent, effective in reducing flood damage, efficient, and have been readily implemented.

47. Flood proofing of new structures is currently required by local ordinance on all Delta lands having a flood hazard greater than 1 percent, as indicated on Figure 12. A nonstructural alternative of flood proofing existing structures was investigated but found to be economically infeasible and was not developed further.

48. Public acquisition of lands was identified as a nonstructural alternative. Islands and tracts would be purchased to forego further flood damage. This alternative was neither economically feasible nor socially acceptable.

49. The five nonstructural alternatives reviewed or formulated are evaluated in Table 10. Each was evaluated with respect to completeness, effectiveness, efficiency, and acceptability. Flood insurance, land management, and flood forecast preparedness met the four evaluation criteria and have been previously implemented in the study area. Flood proofing of existing structures and public acquisition of islands did not meet the evaluation criteria and were not further developed as independent plans.

TABLE 10

EVALUATION OF NONSTRUCTURAL ALTERNATIVES

ALTERNATIVE	COMPLETENESS	EFFECTIVENESS	EFFICIENCY	ACCEPTABILITY	COMMENT
Flood Insurance Program	Complete independent program program capable of standing alone.	Indemnifies participants against damage; does not reduce frequency of flooding.	Very efficient; available to all; cost proportionate to hazard.	Implemented across study area.	Implemented.
Land Use Management	Complete independent program implemented as requirement of flood insurance program.	Effective, identifies area of high hazard; requires new construction in such areas to be floodproofed.	Efficient; easily implemented and enforced.	Implemented across study area.	Implemented.
Flood Preparedness and Forecasting	Complete independent program.	Provides time and means for mobilization, evacuation and floodfighting very effective.	Efficient; capability annually demonstrated.	Implemented by State of California.	Implemented.
Floodproofing of existing structures	Complete independent program.	Provides a reduction in damages to structures; does not reduce frequency of flooding.	Not efficient; economically infeasible.	Acceptable, many structures are currently flood-proofed.	Not selected.
Public Acquisition	Complete independent program.	Reduces some damages. Preserves Delta in existing configuration.	Not economically efficient. Low benefit/cost ratio.	Not politically or socially acceptable.	Not selected.

C-103102

STRUCTURAL ALTERNATIVES

INTRODUCTION

1. Three types of structural alternatives were considered for alleviating the Delta's flood problems: Levee rehabilitation, construction of barriers, and the construction of upstream dams. Levee rehabilitation was determined to be the most effective structural measure. Three means of levee rehabilitation were evaluated: Stage construction, setback levee, and sheet piles. As indicated earlier, stage construction was determined to be the most economical form of levee rehabilitation for nearly every island. The stage construction method was therefore selected as the basis for formulating the levee rehabilitation flood control alternatives. Setback levees were considered in the development of fish and wildlife enhancement measures to preserve riparian habitat along existing levees and channels. Sheet pile floodwalls were used on islands where the relocation costs of structures adjacent to the existing levees would be cost prohibitive.

CONSTRUCTION OF DOWNSTREAM BARRIERS

Introduction

2. The concept of barriers, originating with the necessity for flood control and later for salinity control in the lower reaches of the Sacramento and San Joaquin Rivers, dominated much of the early thinking relative to the development problems of the Bay Area and the Delta.

3. References to barrier studies center around two distinct periods and involve different objectives and areas of interest.

a. The first period began in the 1860's with proposals for a barrier at some point below the confluence of the Sacramento and San Joaquin Rivers and ended in the 1930's with the decision to insure salinity control in the Delta using releases from upstream storage. The principal concerns during that period were flood control and salinity control to maintain a water supply of usable quality in the upper San Francisco Bay (above Carquinez Strait) and in the Delta channels.

b. The second period of barrier proposals began about 1941 and developed momentum after World War II. The imminent large expenditures for an additional vehicular crossing of San Francisco Bay included consideration of barriers as alternative multiple-purpose works offering benefits beyond a single-purpose transportation facility. None of the proposals, several vast in proportion and scope, were accompanied by comprehensive engineering and economic analyses. As a consequence, references to the findings of these earlier engineering investigations were mostly inapplicable and made desirable a comprehensive engineering investigation.

Earlier Comprehensive Barrier Studies

4. In response to Section 110 of the River and Harbor Act of 1950 (Public Law 516, 81st Congress, 2d Session) the San Francisco District Engineer conducted a comprehensive water resources survey of San Francisco Bay and tributaries. The scope of the survey included consideration of the existing

and potential requirements of navigation, flood control, transportation, water supply, land reclamation, recreation, national defense, and allied subjects.

5. As a part of the comprehensive investigation a Technical Report on Barriers was published in July 1963. Eight barrier plans were investigated. Five plans had as their major objective the prevention of intrusion of saltwater into the Sacramento-San Joaquin Delta and conservation of water otherwise required for this purpose. Three plans provided for flood control and land enhancement through reduction of tidal elevations, and for use as highway crossings. The water conservation barriers considered were for three locations in the North Bay. The flood control barriers, all in the South Bay would have had no water conservation features.

The Current Investigation

6. For purposes of flood and tidal intrusion control in the Delta, a barrier could be constructed at a narrow point in the estuary downstream of the Delta. Locations which have been considered in the past include Chipps Island in Suisun Bay, Dillon Point in Carquinez Strait, and Point San Pablo near Richmond. The barrier would prevent high tidal stages from entering the Delta, thus reducing the maximum water level in the Delta channels. The barrier would also separate the freshwater in the Delta from the saltwater which intrudes from the ocean. This would make additional freshwater available for agricultural, municipal, and industrial purposes.

Findings

7. The findings of the earlier studies as to the relative merits of the various barrier plans were presented in the Technical Report on Barriers, July 1963, and are therefore only summarized in this report.

8. Effects of Barriers on Regimen and Uses of the Bay. - A barrier would affect, to a degree depending on location, the ecology and development of the Bay Area and the Delta. The tidal prism would be altered, bringing about changes in tidal currents, tidal phasing and salinity concentrations. These primary effects would induce secondary effects notably with respect to sedimentation, shoaling, and water temperatures. The physical changes would then alter the biological environment and bring about adaptations or complete changes in the fauna and flora of the region such as freshwater fish replacing saltwater fish in the created reservoirs.

9. Tidal Prism. - In general terms the volume in an estuary between the planes of high and low water is regarded as the tidal prism, the volume that is swept into and emptied out of the estuary under the tidal impulse. Barriers at Chipps Island and Dillon Point would cause increases in the tidal prism. These changes would come about from a complex of hydraulic and tidal phasing phenomena. Barriers at Point San Pablo would reduce the tidal prism.

10. Tidal Velocities and Ranges. - Tidal currents and ranges, in conjunction with tidal phase variations, have critical influence on the estuarine conditions of the Bay System. Commencing at the Golden Gate, tidal phases proceed progressively with distance with little evidence of distortion. To the contrary, the corresponding velocities show marked distortion. Barriers,

however, would tend to eliminate phase differences, causing a more rapid transmission of velocities throughout the system.

11. When barriers are placed, the induced changes in tidal velocities and ranges would be considerable. Immediately downstream from the barrier a stagnant velocity condition would exist accompanied by a considerable increase in tidal range. In conjunction with altered salinity patterns, the changed velocities would affect sedimentation and shoaling patterns, potential reclamation, and environmental conditions in general.

12. Salinity. - Ocean salinity concentrations practically prevail in the lower Bay, brackish in Suisun Bay and brackish to fresh in the lower Delta. The studies indicated that saltwater wedges penetrate all local streams debouching into the system and into the Delta complex as far as Sherman Island. Thus, in the lower Delta with much of the ground surface below mean sea level, seepage of saline water is a present problem. Upon constructing a barrier, there would occur marked changes in saline concentrations in the reservoirs created and at considerable distances downbay from the actual barrier location. A barrier at Chipps Island would materially increase salinity concentrations in Suisun Bay with the maximum effect occurring immediately below the barrier. However, while the concentration at the barrier would increase substantially, it would still be well below ocean salinity. To a lesser degree, a barrier at Dillon Point in Carquinez Strait would increase salinity throughout the system.

13. Flood Control. - The Technical Report on Barriers found that water surface elevations would not be reduced upstream of the barriers. Barriers, therefore, would not improve flood protection in the Delta.

14. Water Conservation. - It was also found that the barriers would conserve various amounts of freshwater, depending on the quantity of water released for salinity control without the barriers.

15. Commercial Navigation. - The Technical Report on Barriers also reported that barriers would have adverse effects on commercial navigation. The negative effect on commercial navigation would be due to delays which would be encountered by ships using the navigation locks. Delays were estimated to range between 35 and 55 minutes per lockage, depending on the size of the ship using the lock.

16. Fish and Wildlife. - A barrier would adversely affect fish and wildlife by removing the gradual transition between saltwater in the ocean and freshwater inland. If this transition were removed, certain anadromous species of fish could be prevented from migrating upstream to spawn. Also, the water temperature in the reservoir (the Delta) upstream of the barrier would rise by about 10 degrees F (5.5 degrees C) in the summer, resulting in proliferation of aquatic vegetation and nongame fish such as carp. The barrier would also disrupt sediment transport and distribution within the estuary and cause increased light penetration, increased phytoplankton production, and decreased dissolved oxygen levels. Also, the area of primary productivity of opossum shrimp in the estuary would be impacted, thus affecting the production of higher order species which are dependent on shrimp for their food. This area of productivity is often referred to as the "null zone." It is located in the area where river currents and tidal intrusion merge to create a significant biologically productive area. A barrier could adversely affect this area.

17. Public Health. Public health would be affected since there are many municipal and industrial waste discharges upstream of the barrier sites. If these wastes were discharged to the reservoir behind the barrier, harmful constituents could become concentrated, thus causing a public health hazard. To prevent this problem, all waste discharges would have to be collected and transported downstream of the barrier for discharge.

Conclusion

18. The Technical Report on Barriers recommended that the Chipps Island and Dillon Point Barrier concepts be evaluated as potential elements of the California Water Plan. These concepts were subsequently evaluated by the State of California as an alternative to the Peripheral Canal but were rejected in favor of the canal.

19. Since downstream barriers provided no flood control benefits and the State rejected barriers as a water conservation and water quality measure, this alternative for flood protection and water quality improvement in the Delta was not pursued further in this investigation.

CONSTRUCTION OF INTERIOR DELTA BARRIERS

20. Under this concept, barriers distributed throughout the Delta at strategic locations would be installed to repel salinity and reduce salinity levels in certain Delta channels. This concept was studied by DWR in the 1960's as a single-purpose water quality measure. The alternative as formulated would consist of control structures on the Sacramento, San Joaquin, and Mokelumne Rivers. Gated openings for discharging floodflows, fish screens

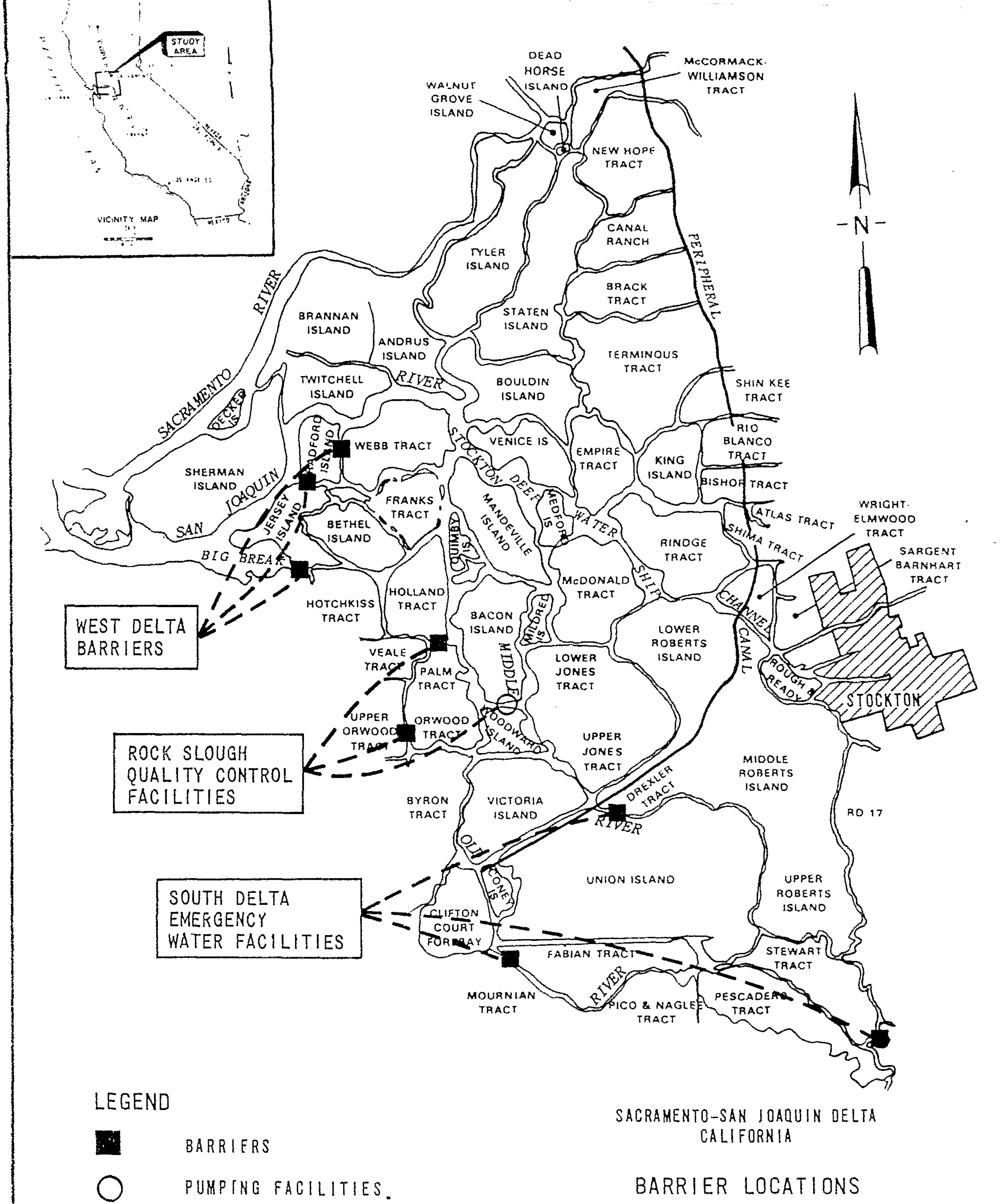
in some structures, and extensions of water supply facilities (additions to the Mokelumne River) were also included in the plan. In the preliminary edition of Bulletin 76, Delta Water Facilities, DWR recommended that this single-purpose alternative be incorporated as an integral part of the State Water Resources Development System. This alternative was subsequently rejected in later studies in favor of the Peripheral Canal.

21. More recently, DWR utilized the interior Delta barrier concept to cope with the effects of the 1976-77 drought. They considered at least three barrier plans including (1) West Delta Barriers, (2) Rock Slough Quality Control Facilities, and (3) South Delta Emergency Water Facilities.

West Delta Barriers

22. The West Delta barriers proposed by DWR consisted of three temporary rock barriers in the Western Delta; one each in Dutch Slough, False River, and Fisherman's Cut as shown on Figure 13. The barriers in Dutch Slough and False River would be rockfill structures incorporating siphons with flap gates to allow ebb flows only. The barrier in Fisherman's Cut would be rockfill without siphons.

23. The purpose of the barriers would be to prevent salinity intrusion by blocking the passage of saltwater in the channels in which they were installed and improve the effectiveness of the hydraulic barrier. In the Environmental Impact Report prepared on the three-barrier proposal, DWR estimated salinity concentrations would increase less than 10 percent west of the barrier and decrease as much as 65 percent east of the barriers. Reduction in flow of 300



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

BARRIER LOCATIONS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

FIGURE 13

C-103111

cfs with the barriers in place, however, could cause increases west of the barriers as much as 20 percent.

24. Water savings for the three western barriers was estimated to be 150,000 to 200,000 acre-feet of water in Oroville Reservoir if the drought continued through 1978. Because the drought ended, the False River and Fisherman's Cut barriers were not constructed and therefore most of the water savings were never realized.

25. Detrimental effects associated with these barriers would include buildup of salt in soils west of the barriers, restriction of navigation, interruption of the normal migrations of fish, change of fish habitat upstream of the barriers, possible hydraulic scour in the open channel, and pollution and sewage problems. Since DWR proposed these structures on a temporary basis, none of these problems were expected to be major. However, if the barriers were installed on a permanent or semi-permanent basis, many of the detrimental effects noted above would likely become significant.

Rock Slough Quality Control Facilities

26. Rockfill barriers were installed in Indian Slough at Orwood Crossing with culverts and tidegates to provide one-way flow north. In Rock Slough, between Holland and Palm Tracts, siphons and tidegates were installed to permit emergency east-to-west flows. A pumping plant was installed in Middle River (utilizing four DWR-owned pumps) and connected to the East Bay Municipal Utility District's Mokelumne Aqueduct No. 1. A discharge valve was installed in that aqueduct to discharge into the pool behind the two barriers. The purpose of these facilities was to provide water quality protection in Rock

Slough, the intake of the Central Valley Project's Contra Costa Canal. This was in lieu of the hydraulic protection provided by Delta outflow which had been reduced to conserve water in upstream storage. The Rock Slough barrier would prevent direct inflow from Old River, which is high in chlorides. The Indian Slough barrier permitted inflow from Old River but only after Old River had intercepted better quality water from Middle River through Railroad Cut and Woodward-Victoria North Canal. The Middle River Pumping Plant provided 100 cfs of better quality Middle River water to further enhance the Rock Slough quality. Together, the facilities were able to meet the emergency quality criteria established by the State Water Resources Control Board (SWRCB), a maximum of 300 mg/l at the intake of the Contra Costa Canal; i.e., in Rock Slough "behind" the barriers.

27. Detrimental effects associated with the Rock Slough facilities include interruption of normal fish migration, restriction of recreational boating activities, and change in fish habitat upstream of the barriers.

South Delta Barriers

28. This plan was developed because low freshwater inflows from the San Joaquin River and its tributaries caused a stagnant water condition in the South Delta. The South Delta barrier proposal consisted of three rock barriers and a small amount of channel dredging to improve water circulation in southern Delta channels and to provide a diversion pool on the San Joaquin River. The barriers in Old River and the San Joaquin River were constructed and became operational on 22 July and 8 August 1977, respectively, and were removed when the drought ended. The Middle River barrier was not constructed.

The dredging work was not done since its effectiveness depended on barrier operation.

29. The barrier in Old River, east of the Central Valley Project's Tracy Pumping Plant, was a rock barrier with culverts and flap gates to allow west to east flow only. Its purpose was to tidal pump water upriver and east toward Middle River eliminating a stagnant condition and dispersing the poor quality water. The barrier in the San Joaquin River, 1/2-mile downstream of Paradise Dam, was a rockfill barrier with culverts and flap gates to allow north-to-south flow only. Its function was to tidal pump water south; that is, upstream to form a pool for diversion by local water users.

30. The purpose of facilities for Middle River, a rock barrier with culverts and flap gates on Middle River 1 mile west of Tracy Road and dredging of the southern 2 to 3 miles of the river channel, was to have tidal-pumped water upstream toward Old River to eliminate a stagnant condition and improve water levels in Middle River.

31. Although changes before and after construction could not be directly compared because of the varying outflow entering the channel, results from installation of the barriers in Old River and the San Joaquin River indicated that the barriers had only a very small effect on reducing salinity. Furthermore, there were adverse impacts on navigation, fish movement, and fish habitat upstream of the barriers.

32. The measures proposed in response to the drought and described above were designated as temporary facilities. Conceivably, a permanent installation of interior Delta barriers could be designed with removable gates. However, a

permanent installation has signficant drawbacks over temporary facilities. Costs would increase substantially. Previous DWR studies concluded that temporary facilities in response to a specific need would be more economical and more responsive. Such barriers would have serious detrimental effects on recreational boat traffic, would interrupt the normal migration of fish, and would change fish habitat. Inevitably, lawsuits arising from operation (or nonoperation) of the structures would pose additional problems. Also, this waterway control concept (in addition to downstream barriers) was thoroughly examined by DWR as an alternative to the proposed Peripheral Canal and rejected.

33. Since a permanent waterway control barrier would seriously affect recreation, fish, and wildlife; would be less efficient economically than temporary barriers; and has previously been rejected by the State of California, it was not studied further.

CONSTRUCTION OF UPSTREAM DAMS

34. The construction of additional flood control structures on tributaries to the Delta system may alleviate the flood threat in the Delta by reducing flood stages. However, the threat of high stages due to extreme tidal and meteorologic conditions would not be reduced. This would be particularly significant in the western Delta where the tide is the major influence on water surface elevation. The western Delta is also the area of greatest peat thickness, and levees in this region experience significant stability problems. This alternative would not significantly reduce the risk of levee failure due to structural instability, such as that which caused the Andrus

Island levee failure in June 1972, and the Webb, Holland, and Lower Jones Tract floods in 1980.

35. Due to the limited degree of flood protection provided to the Delta by upstream dams and the limited economic and environmental justification for such structures, this alternative was eliminated from further consideration as an alternative flood control measure for the Delta.

LEVEE REHABILITATION

36. The levee rehabilitation measure was developed into a number of alternative plans, which were distinguished from each other on the basis of economic approach. The economic approach is related to two potential points of view of the Delta which can result in a system approach or an incremental approach to the economic analysis. The system approach views the Delta as a system of interdependent islands with feasibility justified on the basis of a total unit rather than on an island-by-island basis. The incremental approach views the Delta as a grouping of islands with widely varying characteristics. Under the incremental approach the islands are considered to be independent, with feasibility justified on an incremental, or island-by-island basis.

Alternative flood control plans were formulated using both the "system" and "incremental" philosophies. These plans are described in this section.

System Flood Control Alternative

37. The System Flood Control Alternative considers the Delta to be a system of interdependent islands. The economic justification for this plan was

determined on the basis that all the islands in the study area act in concert as a system or unit rather than individually. Under this concept, the System Alternative would be economically justified if the total annual benefits accruing from the flood control improvements for all islands in the system exceed the total annual costs of the flood control improvements.

38. The evaluation of the Delta as a system is supported by the interrelationships that exist among the islands. A flooded island, if not restored to preflood conditions, creates an open body of water which makes the levees on adjacent islands more vulnerable to wind-wave erosion and subsequent failure. Wind-driven waves from Franks Tract contributed to the levee failure on Holland Tract in 1980. Also, it has been observed that levees on islands surrounding Franks Tract have required above average maintenance. Another element in the interdependence equation is that increased seepage occurs on islands adjacent to a flooded island. In addition, when a levee fails, the water level at nearby islands is temporarily lowered, thus reducing the hydrostatic pressure on those levees.

39. The system concept is also supported in the State Water Code Section 12981 " . . . the physical characteristics of the Delta should be preserved essentially in their present form, and the key to preserving the Delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands." Furthermore, one of the most frequently expressed views at public meetings held throughout the State by DWR for their Bulletin 192 studies was that the character of the Delta including its channel configurations should be preserved essentially as it exists.

40. Three levels of flood protection were considered for the System Alternative: 50-year, 100-year, and 300-year. The complex Delta hydrologic system precluded the determination of a Standard Project Flood (SPF) which is normally evaluated in conventional flood plains. However, the 300-year event falls within the range of an SPF.

41. In compliance with the plan formulation criteria, urban islands (Andrus-Brannan, Bethel, Byron, Hotchkiss, and New Hope) were evaluated using only 300-year protection. The remaining agricultural islands were evaluated at each of the three levels of flood protection designated above. The following array of flood protection levels was thus formed for the system plan:

a. Flood Protection Level 1 - 300-year protection to urban islands and 50-year protection to agricultural islands;

b. Flood Protection Level 2 - 300-year protection to urban islands and 100-year protection to agricultural islands; and,

c. Flood Protection Level 3 - 300-year protection to all islands.

42. The economic analyses of the above plans are shown in Table 11.

TABLE 11
SYSTEM FLOOD CONTROL ALTERNATIVE ECONOMICS
7-5/8 PERCENT INTEREST; 50-YEAR AMORTIZATION
1 OCTOBER 1981 PRICE LEVEL
($1,000)

FLOOD PROTECTION LEVEL	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
1	876,966	58,322	50,229	-8,093	0.9
2	885,599	58,999	50,902	-8,097	0.9
3	898,917	60,046	51,901	-8,145	0.9

43. Though not economically justified, Level 3 was carried forward in the planning process and developed into a candidate plan because it provided the most potential for maintaining the configuration of the Delta channels in their present condition. The System Alternative also provided the most potential for the formulation of an EQ Plan because it would reduce the frequency of flooding and the adverse environmental impacts associated with flooding over the entire Delta.

Modified System Flood Control Alternative

44. The objective of the Modified System Alternative is to modify the previously formulated System Alternative so that levee improvements would be confined to an area that has actually experienced flooding and to islands that have an unacceptably high probability of levee failure.

45. Historically, flooding has occurred predominantly in the central and western regions of the Delta. Levee stability analyses conducted for this investigation revealed that islands in the central and western Delta have the

highest probability of levee failure. Those studies established a correlation between the depth of organic soils and the probability of stability failure. The deepest deposits of peat soils are found in the central and western Delta while shallow organic deposits or mineral soils are found in the southern Delta and along the periphery of the Delta. Therefore, it is not surprising that flooding has occurred frequently in the central and western areas of the Delta and that the probability of levee failure is relatively high there.

46. It was determined that 50-year flood protection was adequate for agricultural islands. Therefore, all agricultural islands that had a probability of levee failure less than 0.02 (greater than 50-year protection) throughout the period of economic analysis (50 years) were eliminated from the previously formulated System Alternative. Thirteen agricultural islands (Atlas, Drexler, Fabian, Mournian, Orwood, Pescadero, Pico/Naglee, Upper and Middle Roberts, Sargent-Barnhart, Stewart, Union, and Walnut Grove) were found to have an existing probability of failure less than 0.02 for the next 50 years and were eliminated from the system. The remaining islands were retained in the Modified System Alternative.

47. After eliminating islands which had an acceptable level of flood protection from the full Delta system, the economic feasibility of the remaining system (the modified system) was reviewed. The modified system was also found not to be economically feasible. Therefore, the formulation process was refined so that an economically feasible system could be formulated. This was accomplished by eliminating islands with the largest negative net benefits until an economically feasible modified system was formed. Eight islands (Bethel, Jersey, Mildred, Medford, Quimby, Sherman, Twitchell, and Venice) were eliminated in this iteration. The economics of

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the Modified System Flood Control Alternative are summarized in Table 12. Flood Protection Level 1 provides 300-year flood protection to urban islands and 50-year flood protection to agricultural islands. The flood protection associated with Level 2 is 300-year protection for urban islands and 100-year protection for agricultural islands. Level 3 provides 300-year protection to all islands.

TABLE 12
MODIFIED SYSTEM FLOOD CONTROL ALTERNATIVE ECONOMICS
7-5/8 PERCENT INTEREST; 50-YEAR AMORTIZATION
1 OCTOBER 1981 PRICE LEVEL
($1,000)

FLOOD PROTECTION LEVEL	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
1	586,096	38,130	41,704	3,574	1.09
2	593,744	38,728	42,639	3,911	1.1
3	600,975	39,297	43,900	4,603	1.1

48. The economic realities which dictated that the eight islands identified above be eliminated in the second iteration are tempered by the following considerations. As indicated in the Environmental Quality Plan Formulation section of this appendix, three of the islands (Medford, Mildred, and Quimby) were considered for the development of a Wildlife Management Area. Sherman and Twitchell Islands currently are partially afforded a high level of flood protection by existing Federal project levees. Landowners on Jersey Island have frequently voiced opposition to being included in a Federal project. The existing probability of failure for Bethel Island is acceptable; however, the probability of failure would rise to an undesirable level for an urban island within the next 50 years. Net benefits were optimized at the highest level of flood protection (Level 3), and that level was carried forward for development into a candidate plan.

49. The Modified System Flood Control Alternative would express a limited Federal interest in flood control in the Delta. To encourage flood control improvements by non-Federal interests on islands where a Federal interest is not identified, a Flood Hazard Mitigation Program would be included as a feature of the Modified System Flood Control Alternative. Under the Flood Hazard Mitigation Program, nonproject levees would be considered eligible for emergency assistance under the provisions of Public Law 84-99 provided the levees are upgraded and maintained to a Federal standard by non-Federal interests prior to need for assistance.

50. The Corps of Engineers provides flood emergency assistance under the authority of Public Law 84-99 and as directed by FEMA following a Presidential declaration of disaster. PL 84-99 is the most important of the two means of providing flood emergency assistance, for it allows the Corps to respond immediately to requests for assistance.

51. Public Law 84-99 authorizes the Corps of Engineers to engage in flood emergency activities including advance preparation, flood fighting, rescue work, and repair or restoration of flood control works threatened or destroyed by floods.

52. During and following floods in 1980, numerous requests for assistance under the PL 84-99 authority were submitted to the Corps of Engineers. At that time the following decisions were made regarding the Delta levees and the appropriateness of using the PL 84-99 authority in the Delta:

a. Some of the Delta levees were built for tidal control and not flood control;

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b. The design of the levees was considerably below Corps of Engineers standards of construction;

c. The past maintenance quality of the Delta levees was poor; and

d. A permanent solution to the flood problem should be vigorously pursued.

Therefore, the Corps of Engineers denied levee rehabilitation and flood restoration assistance to most of the Delta under the PL 84-99 authority. The Chief of Engineers clarified that Corps assistance in the Delta in the administration of PL 84-99 would be limited to supplementing local flood fight activities to save lives and prevent or mitigate property damage, and to restore flood preventative structures.

53. The Flood Hazard Mitigation Program would propose the application of the PL 84-99 authority in the Delta according to the following criteria:

a. Nonproject levees authorized for flood control improvements as a result of this investigation would be considered flood control structures irrespective of earlier determinations and therefore eligible for consideration for assistance under the PL 84-99 authority.

b. Nonproject levees not authorized for flood control improvements would be considered eligible for PL 84-99 assistance if non-Federal interests improve and maintain the levees to a Federal standard.

54. The minimum standards for the Flood Hazard Mitigation Program are described below. The minimum levee crown elevation would equal the 50-year flood stage elevation plus a 1.5-foot minimum freeboard where the levee protects agricultural lands. Where the levee provides protection to urban areas, the minimum elevation of the levee crown would be based on the 100-year flood stage plus a 3.0-foot minimum freeboard. The minimum levee section used in raising the existing levees should have a crown width of not less than 12 feet and side slopes of 1 vertical on 2 horizontal or flatter. The levee crown would be required to have an all weather surface for vehicular access and flood patrols.

55. Continuous maintenance and inspection of the levees would be required. The maintenance program would include but not be limited to the following:

(1) Shaping the levee crown and patrol and access roads to drain properly;

(2) Repair of any slip outs, erosion, subsidence, or other voids of the levee section, including raising the levee to maintain grade and section (for this purpose, a profile survey of the levee crown would be required at least every third year);

(3) Installation of revetment where needed to prevent erosion and the repair of revetment work which has been displaced or damaged;

(4) Cutting, removing, or trimming vegetative growth to inspect the levee and maintain the levee integrity. The basic levee structure must not be penetrated by roots of such vegetation;

(5) During periods of high water, the levees would be patrolled continuously and immediate steps would be taken to control any condition which endangers the levee.

56. The cost to implement the Flood Hazard Mitigation Program would not be assessed to the project.

Incremental Flood Control Alternative

57. The Incremental Flood Control Alternative was formulated on the philosophy that each increment of the plan should be economically justified. In the case of the Delta, this means that in order for an island to be included in this alternative, the benefits accruing from the flood control improvements must exceed the costs of the improvements. The Incremental Alternative recognizes that the characteristics of each Delta island, such as the conditions of the levees and maintenance practices, types of improvements, and agricultural production, can vary widely and each island should be evaluated on an individual basis.

58. The Incremental Flood Control Alternative would limit levee improvements to those islands previously identified in the System Flood Control Alternative as being economically feasible on an individual or incremental basis. The economics of the Incremental Alternative for the three levels of flood protection studied are presented in Table 13. Net benefits were optimized at the highest level of flood protection (Level 3), and this plan was considered in further planning studies as a candidate plan.

TABLE 13
INCREMENTAL FLOOD CONTROL ALTERNATIVE ECONOMICS
7-5/8 PERCENT INTEREST; 50-Year AMORTIZATION
1 OCTOBER 1981 PRICE LEVEL
($1,000)

FLOOD PROTECTION LEVEL	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
1	267,959	16,932	27,528	10,596	1.6
2	292,506	18,759	29,920	11,161	1.6
3	323,593	20,707	32,619	11,912	1.6

59. A Flood Hazard Mitigation Program identical to that described for the Modified System Flood Control Alternative would be established as a feature of the Incremental Flood Control Alternative. This program would allow levees on islands or tracts not included in the Federal plan of improvement to be considered eligible for emergency assistance under the provisions of PL 84-99 if non-Federal interests upgrade and maintain the levees to a Federal standard.

Polder Flood Control Alternative

60. In the Delta, polders can be formed by linking individual islands together with master levees. The objective of formulating a flood control plan which includes polders is to reduce the number of miles of levee that would have to be rehabilitated. Channels and sloughs within the master levee would be permanently closed off by rockfill closure structures. There would be no circulation of water by direct connection with Delta waterways in these channels. Therefore, there would be no requirement to maintain or improve the interior levees for flood control purposes.

61. The following considerations were made in developing the polders for the with-Peripheral Canal condition:

a. Polders should not interfere with or adversely impact the operation of the Peripheral Canal. The Peripheral Canal would release water into the sloughs on the eastern side of the Delta for water quality purposes. For this reason, no sloughs or channels into which such water quality releases are made would be closed by polders.

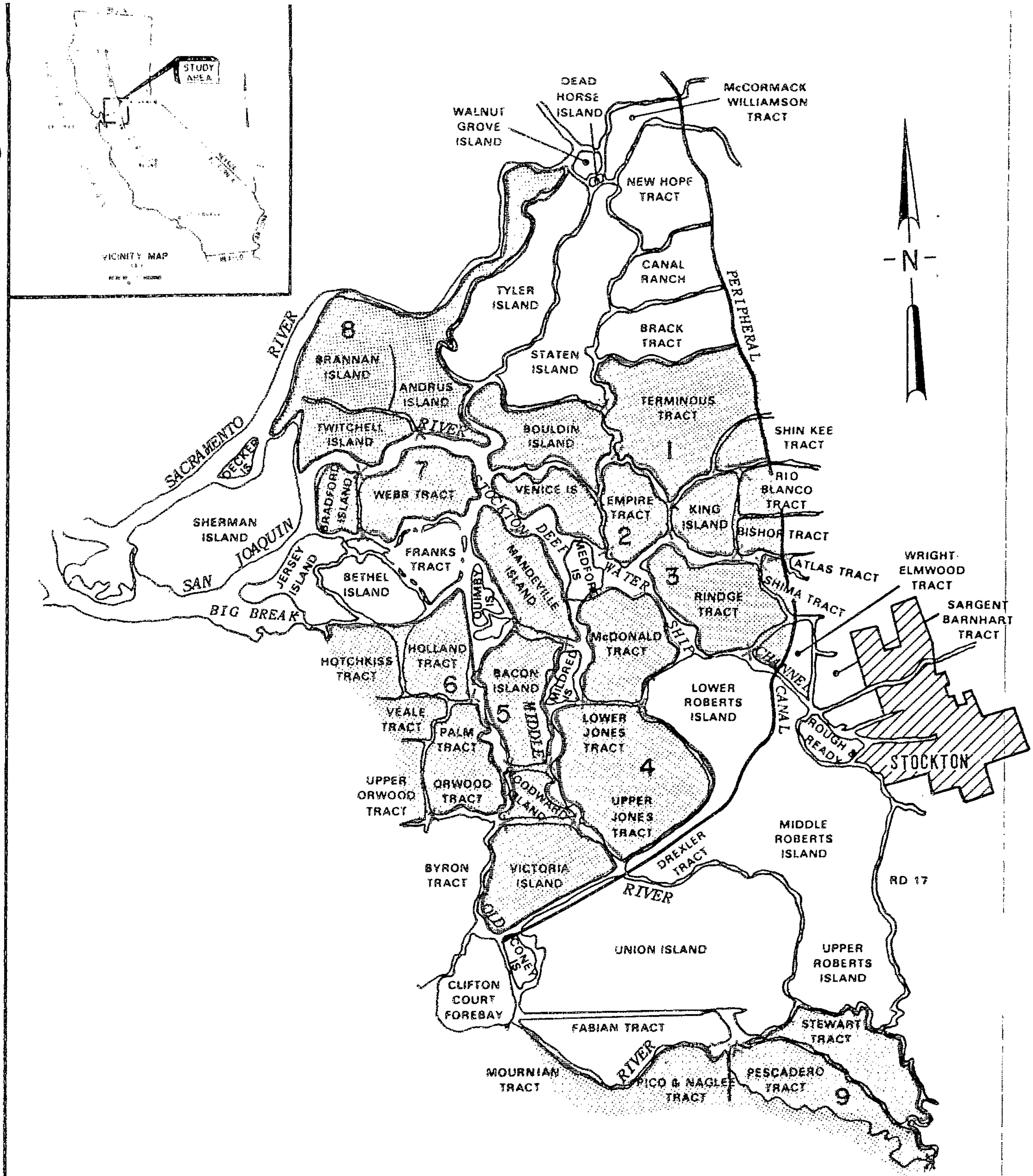
b. The Contra Costa Canal intake was assumed to be relocated to Clifton Court Forebay. This allowed the formation of a large polder on the west side of the Delta.

c. The flow of principal Delta streams such as the Mokelumne, San Joaquin, and Sacramento Rivers should not be altered or impacted.

d. Sloughs and channels experiencing significant local navigation traffic, such as Taylor, Dutch, and Sand Mound Slough in the vicinity of Bethel Island and Indian Slough leading to the Discovery Bay development on Byron Tract, should not be closed by polders.

e. Polders should not interfere with or adversely impact the operation of the CVP or SWP.

62. Nine polders were formed as shown in Figure 14. The polders would close about 60 miles of channels and sloughs; 200 miles of master levee would be constructed using the stage construction levee rehabilitation method previously described.



LEGEND:

X CHANNEL CLOSURE STRUCTURE.

POLDER LEVEE.

POLDER.

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

POLDERS
(WITH PERIPHERAL CANAL CONDITION)

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

FIGURE

C—103128

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63. Three flood control alternatives featuring polders were formulated. The first alternative was designated as the Polder System Flood Control Alternative and would provide improved flood protection to all islands in the study area. The Polder System Alternative included 9 polders protecting 33 islands. The remaining 21 islands in the system would be protected individually. The second polder alternative was designated as the Polder Incremental Flood Control Alternative and included only polders or individual islands that were economically feasible. The number of polders and individual islands included in this alternative varies with the level of flood protection provided. The objective of the third polder alternative was to maximize net NED benefits by selecting the optimum combination of economically feasible islands and polders. This was accomplished by comparing the net NED benefits of a polder to the net NED benefits of the islands within a polder if the islands were protected individually. Although some polders may be economically feasible, they may contain some economically infeasible islands. Therefore, greater net NED benefits could be obtained for a plan by eliminating the infeasible islands from a polder or by protecting the economically feasible islands within a polder individually rather than collectively. This alternative was designated as the Polder NED Flood Control Alternative. Each of the polder alternatives was evaluated at the three levels of flood protection previously described.

64. The Peripheral Canal significantly influenced polder configerations. The following considerations were made in developing polders for the without-Peripheral Canal condition:

a. Polders should not interfere with or adversely impact the operation of the CVP or SWP.

b. The flow of principal Delta streams such as the Mokelumne, San Joaquin, and Sacramento Rivers should not be altered or impacted.

c. The Contra Costa Canal was assumed to be in its existing location.

d. Sloughs and channels subject to high levels of recreational boat traffic should not be closed.

65. Nine polders were formed for the without-Peripheral Canal condition as shown in Figure 15. The polders would close about 86 miles of channels and sloughs; 240 miles of master levee would be constructed using the stage construction levee rehabilitation method previously described.

Polder System Flood Control Alternative

66. This alternative includes 9 polders protecting 35 islands and 19 individual islands. A total of 330 miles of levee would be rehabilitated with this plan; 200 miles of the total would be master levees included in the polders. The polders would close off about 60 miles of existing channels. The economics for each level of flood protection analyzed are indicated in Table 14.

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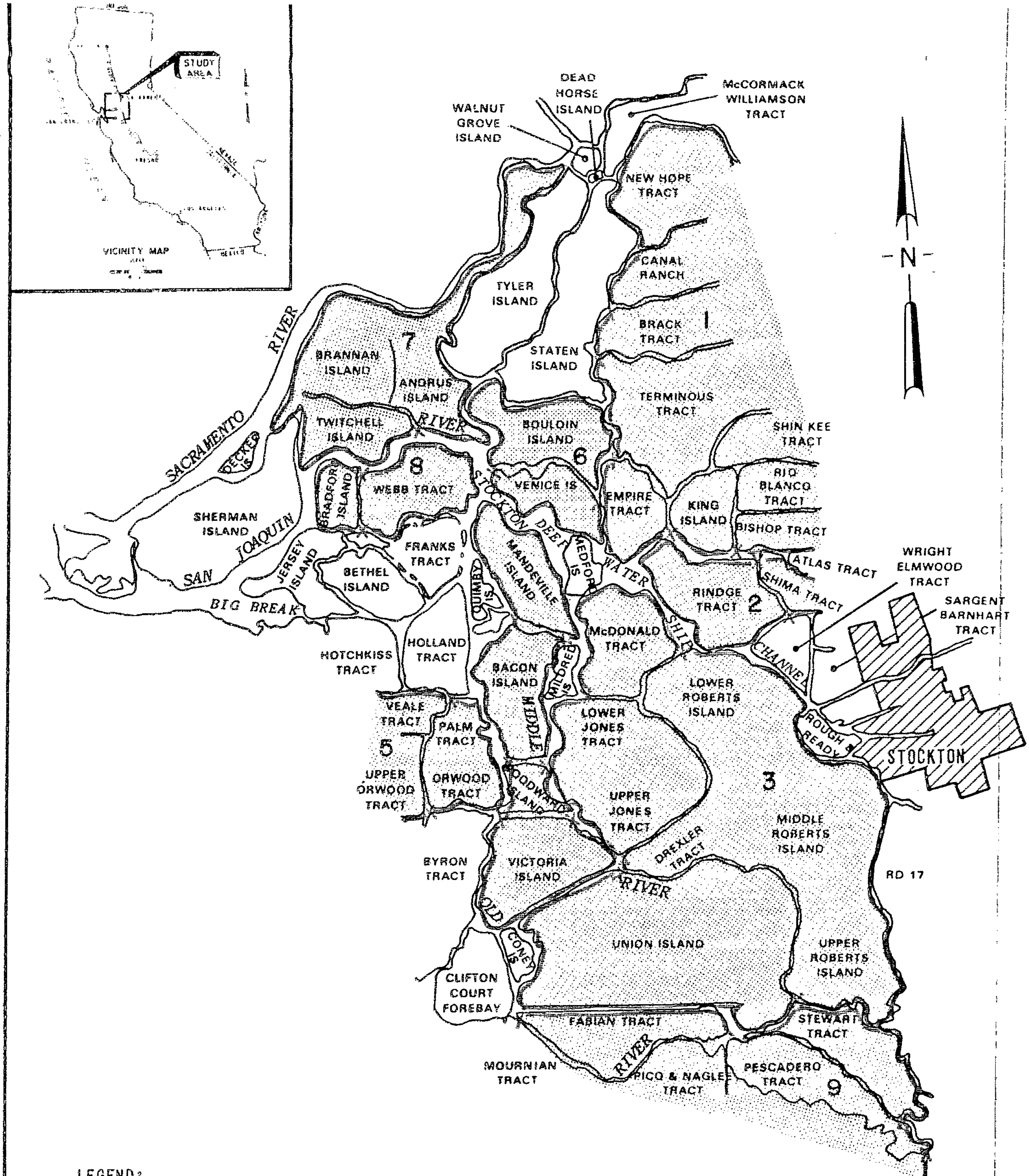
TABLE 14
POLDER SYSTEM FLOOD CONTROL ALTERNATIVE ECONOMICS
7-5/8 PERCENT INTEREST; 50-YEAR AMORTIZATION
1 OCTOBER 1981 PRICE LEVEL
($1,000)

FLOOD PROTECTION LEVEL	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
1	879,025	57,685	49,618	-8,067	0.9
2	880,370	57,789	50,600	-7,189	0.9
3	889,992	58,547	51,960	-6,587	0.9

67. A polder system alternative formulated on the basis of a without-Peripheral Canal condition to provide 300-year flood protection would have a first cost of $810,138,000, annual costs of $61,232,000, annual benefits of $53,669,000, and benefit-cost ratio of 1.1. This alternative would feature 9 polders protecting 42 islands with 240 miles of master levee; 12 islands would be protected individually. The polders would close about 86 miles of existing channel.

Polder Incremental Flood Control Alternative

68. This alternative would provide flood protection to 5 polders and 2 individual islands. The economics for each level of flood protection are presented in Table 15. A non-Federally implemented Flood Hazard Mitigation Program would be a part of this alternative to address flood control needs on islands not included in the alternative.



LEGEND:

X CHANNEL CLOSURE STRUCTURE.

POLDER LEVEE.

POLDER.

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

POLDERS
(WITHOUT PERIPHERAL CANAL CONDITION)

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN MILES

FIGURE

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TABLE 15
POLDER INCREMENTAL FLOOD CONTROL ALTERNATIVE ECONOMICS
7-5/8 PERCENT INTEREST; 50-YEAR AMORTIZATION
1 OCTOBER 1981 PRICE LEVEL
($1,000)

FLOOD PROTECTION LEVEL	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
1	233,309	15,289	21,261	5,972	1.4
2	371,239	22,772	29,538	6,766	1.3
3	402,010	25,009	32,622	7,613	1.3

69. A polder incremental flood control alternative formulated to provide 300-year flood protection for the without-Peripheral Canal condition would feature 5 polders and 1 individual island. The first cost would be $439,330,000. Annual costs would equal $27,258,000, annual benefits would equal $43,909,000, and the benefit-cost ratio would be 1.6.

Polder NED Flood Control Alternative

70. This alternative was formulated by selecting that combination of polders and individual islands that would maximize net NED benefits. To be considered for this alternative, a polder or island had to be economically feasible. Since some economically feasible polders included economically infeasible islands, the infeasible islands had to be eliminated from the polders in order to maximize net NED benefits. For example, Twitchell Island was eliminated from the Andrus-Brannan-Twitchell polder and Andrus-Brannan was included in the plan as an individual island. Similarly, Woodward Island was eliminated from the Mandeville-Bacon-Woodward polder. The economics of each level of flood protection analyzed are summarized in Table 16.

TABLE 16
POLDER NET BENEFIT FLOOD CONTROL ALTERNATIVE ECONOMICS
7-5/8 PERCENT INTEREST; 50-YEAR AMORTIZATION
1 OCTOBER 1981 PRICE LEVEL
($1,000)

FLOOD PROTECTION LEVEL	FIRST COST	ANNUAL COST	ANNUAL BENEFIT	NET BENEFIT	B/C RATIO
1	304,439	19,424	31,639	12,215	1.6
2	305,807	19,530	32,130	12,600	1.6
3	307,897	19,686	32,619	12,933	1.6

71. With 300-year flood protection 2 polders and 10 islands would be provided protection. About 160 miles of levee would be improved with this plan. The polders would eliminate 4 miles of channel. Islands not included in this alternative would be considered eligible for PL 84-99 emergency flood assistance if their levees are upgraded and maintained to Federal standards in compliance with the requirements of the previously described Flood Hazard Mitigation Program.

72. A polder NED plan formulated to provide 300-year flood protection for the without-Peripheral Canal condition would include three polders and seven individual islands. The first cost would be $403,637,000, with annual costs equal to $26,320,000, annual benefits of $46,346,000, and a benefit-cost ratio of 1.8.

73. Among the three polder alternatives, the Polder NED Alternative provides the most net NED benefits. For this reason it was nominated as a candidate plan and carried forward in the planning process for further study.

SCREENING AND EVALUATION

74. Structural flood control alternatives are evaluated in Table 17. Four levee rehabilitation alternatives were designated for further consideration as candidate plans.

TABLE 17

EVALUATION OF STRUCTURAL ALTERNATIVES

ALTERNATIVE	B/C RATIO	PLANNING OBJECTIVE FULFILLMENT	COMPLETENESS	EFFECTIVENESS	EFFICIENCY	ACCEPTABILITY	STATUS
Construction of Upstream Dams	<1:1	Fair	Incomplete. Levee rehabilitation would still be required to provide significant flood protection.	Ineffective. Would not significantly reduce flood or water quality damages.	Inefficient. Levee rehabilitation is more cost effective.	Unacceptable.	Deleted.
Construction of Barriers	<1:1	Fair	Incomplete. Levee rehabilitation would still be required to provide significant flood protection.	Ineffective. Would not significantly reduce flood damages. Partially effective with respect to water quality.	Inefficient. Levee rehabilitation is more cost effective.	Unacceptable. Permanent barriers would adversely impact fisheries, navigation, and recreation pursuits.	Deleted.
Levee Rehabilitation System Alternative	<1:1	Excellent	Complete, independent solution.	Effective. Significant reduction in flood and water quality damages.	Inefficient with respect to NED. Most efficient alternative when the combined NED and EQ effects are considered.	Acceptable. Public and institutional goals of maintaining the Delta in its existing condition would be satisfied.	Retained as a candidate plan (EQ plan).
Modified System Alternative	>1:1	Excellent	Complete, independent solution. Provides less protection than the System Alternative.	Effective. Significant reduction in flood and water quality damages but less than the System Alternative.	Efficient. Less net NED benefits than the Incremental Alternative.	Acceptable. Would maintain a significant portion of the Delta in its existing condition.	Retained as a candidate plan.
Incremental Alternative	>1:1	Excellent	Complete, independent solution. Provides less protection than the Modified System Alternative.	Effective. Flood and water quality damages would be reduced but to a lesser extent than for the Modified System Alternative.	Efficient. Maximizes net NED benefits.	Acceptable. Would maintain part of the Delta in its existing condition.	Retained as a candidate plan (NED plan).
Polder System Alternative	<1:1	Excellent	Complete, independent solution. Provides same amount of protection as the System Alternative.	Effective. Significant reduction in flood and water quality damages. Same as System Alternative.	Efficient. Less net NED benefits than the Incremental Alternative.	Unacceptable. Significant adverse environmental impacts. Fisheries and navigation adversely affected.	Deleted.
Polder Incremental Alternative	>1:1	Excellent	Complete, independent solution. Provides less protection than the Polder System Alternative.	Effective. Flood and water quality damages would be reduced but to a lesser extent than for the Polder System Alternative.	Efficient. More net NED benefits than the Polder System Alternative.	Possibly acceptable. Significant adverse environmental impacts. Some noncommercial navigation would be adversely affected.	Deleted.
Polder NED Alternative	>1:1	Excellent	Complete, independent solution. Provides less protection than the Polder Incremental Alternative. Provides protection to the same islands included in the Incremental Alternative.	Effective. Flood and water quality damages would be reduced but to a lesser extent than for the Polder Incremental Alternative.	Most efficient polder alternative. Net NED benefits are nearly the same as for the Incremental Alternative.	Acceptable. Among the polder alternatives this alternative would have the least adverse environmental impacts.	Retained as a candidate plan.

PLAN FORMULATION

RECREATION AND ENVIRONMENTAL QUALITY

INTRODUCTION

1. Recreation and environmental quality plan formulation are discussed together because of the close relationship of these subjects and the Congressional authorization which specifically asked the Corps of Engineers to investigate means to preserve scenic values and preserve and enhance recreation and related opportunities. Further, the Federal Water Project Recreation Act of 1965 reiterated that recreation and fish and wildlife enhancement opportunities should receive full consideration in Federal water resource development. Also, as a result of the Fish and Wildlife Coordination Act and the National Environmental Policy Act of 1969, careful attention is focused on fish and wildlife and other environmental aspects of water resources development.

PURPOSE AND SCOPE

2. This section presents plans for recreation and fish and wildlife developments that would best serve the public within the scope of the authorization cited above.

3. Available data from various sources were gathered to analyze recreation participation trends, use of existing facilities, fish and wildlife needs, and the socioeconomic composition of the population in the recreation market area for the project. The recreation plan formulated attempts to satisfy estimated demand in a manner that is compatible with the flood control features and

consistent with the desire and capability of the non-Federal sponsors. Natural resources data were obtained and plans of others for environmental quality improvement were analyzed, and detailed coordination was carried out to develop fish and wildlife enhancement measures and plans.

BACKGROUND

4. As part of their continuing study, DWR prepared three reports on Delta recreation. The first, "Delta Outdoor Recreation Survey" (Cajucom and Associates, March 1980) presents the results of a user survey for the Delta. The second report, "Sacramento-San Joaquin Delta Recreation Concept Plan" (Geidel and Moore, 1981), identified potential public recreation facilities and sites in the Delta based on the outdoor recreation survey results. The final report, the Delta Outdoor Recreation Implementation Plan (Moore and Geidel, 1981), discussed cost-benefit analysis and implementation strategies for the facilities identified in the concept plan.

5. Several other studies and reports are of significance to Delta recreation. The State of California Delta Master Recreation Plan Task Force produced the "Delta Master Recreation Plan" (DMRP) with editions in 1966, 1973, and 1976. This plan recognizes that the State has a responsibility to protect and enhance the environmental and economic attributes of the Delta and provides a guide to State, Federal, and local agencies and the public for the protection and development of the Delta's recreation, scenic, and wildlife resources.

6. The Delta Advisory Planning Council (DAPC) was formed in October 1972 by a joint exercise of powers agreement between the five Delta Counties --

Sacramento, San Joaquin, Solano, Yolo, and Contra Costa. DAPC was formed to develop a comprehensive plan for the Delta and to strengthen local government's role in State and Federal planning for the area. DAPC authorized a cooperative agreement with the Sacramento Regional Area Planning Commission to carry out the studies. A series of seven reports dealing with various aspects of the Delta was produced. In July 1976 DAPC adopted the "Delta Action Plan," a compilation of all policies and recommendations which evolved from the seven technical reports, which was intended as a planning guide for all levels of government.

7. The Corps of Engineers published the Sacramento-San Joaquin Delta Environmental Atlas in July 1979. The Atlas describes the natural resources of the Delta and delineates these resources on small scale maps and aerial

Snodgrass Slough — Delta Meadows

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photos. Using the Atlas as a companion document, the California Department of Fish and Game (DFG) and the U.S. Fish and Wildlife Service (FWS) produced the Sacramento-San Joaquin Delta Wildlife Habitat Protection and Restoration Plan in 1980. This plan discusses the value of the natural resources of the Delta and describes potential methods for protecting, enhancing, and restoring the Delta fish and wildlife and their habitat.

POTENTIAL FOR DEVELOPMENT

8. The Federal Water Project Recreation Act emphasizes the role of non-Federal agencies in Federal plans for recreation and fish and wildlife enhancement. Federal recreation development is predicated upon non-Federal agencies assuring participation and providing 50 percent of development costs and all operation and maintenance. Federal fish and wildlife enhancement opportunities are also considered. Such enhancement takes two forms: providing access for fishing and boating, in which non-Federal participation is the same as for general recreation; and providing for improved habitat, in which the Federal share of cost is increased to 75 percent of development costs. If a separate Federal purpose is served, such as migratory waterfowl conservation, and if another Federal agency such as FWS agrees to administer the development, then 100 percent of the development and operation and maintenance costs may be borne by the Federal Government. Similarly, environmental quality improvements would require support by other non-Federal or Federal agencies. The Delta contains an abundance of fish and wildlife and other natural resources which could be significantly enhanced. There are several Public Laws which express Congressional intent for enhancement of fish and wildlife and improvement of environmental quality.

- To encourage fish and wildlife enhancement at water resources projects, Congress amended the Federal Water Project Recreation Act in 1974 to provide Federal participation in habitat enhancement of 75 percent of first costs rather than the 50 percent provided for recreation developments authorized in the original 1965 Act. The Act also provides that all costs may be Federal costs if the fish and wildlife enhancement is undertaken as a part of another separately authorized Federal program for the conservation of fish and wildlife (e.g., migratory waterfowl and anadromous fish).

- All Federal agencies were directed by the Estuary Protection Act of 1968, Public Law 90-454, to give consideration to estuaries and their natural resources in planning for the use and development of water and land resources. Reports affecting estuaries are to contain a specific discussion by the Secretary of Interior on estuary resources and the effects of any project thereon.

- In the Anadromous Fish Conservation Act of 1970, Public Law 91-249, Congress provided a nationwide program for development, conservation, and enhancement of anadromous fish resources.

- In the Endangered Species Act of 1973, Public Law 93-205, Congress provided for the conservation of endangered and threatened species and the ecosystems upon which they depend.

- The National Migratory Bird Conservation Act of 1929, 16 USC 715, provides for a system of national wildlife refuges, developments, and operations entirely at Federal cost for conservation of migratory birds.

- Section 150 of the Water Resources Development Act of 1976, Public Law 94-587, directs that reports on water resources development projects of the Corps of Engineers shall include, where appropriate, consideration of the establishment of wetland areas entirely at Federal expense.

- In the Environmental Quality Improvement Act of 1970, Public Law 91-224, Congress declared there is a national policy for the environment which provides for the enhancement of environmental quality. Congress declared a national policy of restoring and maintaining environmental quality in the National Environmental Policy Act of 1969, Public Law 91-190.

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Delta Meadows

ADHERENCE TO PUBLIC LAWS AND REGULATIONS

9. The fish and wildlife and environmental quality measures identified in this report were developed in coordination with FWS, the National Marine Fishery Service (NMFS), and DFG as required by the Fish and Wildlife Coordination Act and the National Environmental Policy Act of 1969.

10. The policy of the Department of the Army for recreation facilities at local flood protection projects states that all recreation developments will be provided within the lands acquired by local interests for the basic flood control project, except as may be required for access, parking, potable water, sanitation, and related developments for health, safety, and public access. The policy further states that non-Federal share of recreation development costs shall at least equal 50 percent of the total first cost and that

non-Federal interests must agree to operate and maintain the areas without expense to the Federal Government. In addition, the estimated Federal cost for recreation is limited to 10 percent of the Federal cost of the project.

11. All of the facilities described in the plan, except the Bouldin Island, Connection Slough, and Holland Tract recreation areas, would be constructed on lands acquired by local interests for the flood control project or are necessary to provide access so that the recreation potential of the project can be realized. The Bouldin Island, Connection Slough, and Holland Tract recreation areas are included to provide a Delta-wide comprehensive recreation plan to satisfy the Congressional authorization.

EXISTING RECREATION

GENERAL

12. The Delta is a major recreation resource in California, and the existing recreation activities are significant to the Delta's economy. There are several factors which contribute to the Delta's constantly growing popularity as a recreation area. These include: One of the largest recreation waterways in the western United States; a temperate year-around climate; close proximity of the San Francisco, Sacramento, and Stockton metropolitan areas; an excellent sport fishery; and an esthetically pleasant environment.

ATTENDANCE

13. A survey conducted for DWR in 1977-79 (Cajucom, March 1980) determined that nearly one-third of the Delta recreationists originate from Contra Costa

County. About 94 percent of the visitors to the Delta originate from 14 counties. The remainder come from the other California counties and out of state. Table 18 shows the origin of all visitors by county.

TABLE 18
ORIGIN OF VISITORS BY COUNTY

ORIGIN		PERCENT
Contra Costa		29.4
San Joaquin		16.7
Sacramento		16.0
Alameda		10.4
Santa Clara		6.0
Solano		4.8
San Mateo		2.4
San Francisco		2.0
Stanislaus		1.3
Yolo		1.0
Sonoma		1.0
Marin		1.0
Napa		0.7
Los Angeles		1.0
25 Other California Counties (varying from 0.5 to 0.1)		4.7
Out of State		0.1
Origin Not Known		1.5
	TOTAL	100.0

14. The projected population for the 14-county market area is shown in Table 19. Sacramento, San Joaquin, Yolo, and Solano Counties are expected to experience a rapid growth rate with their populations increasing nearly three times their current population by 2020. The San Francisco Bay complex is expected to continue steady growth with the most rapid expansion occurring in Alameda, Contra Costa, Marin, and Santa Clara Counties. The remainder of the counties are expected to grow at a slow to moderate pace through the year 2020.

TABLE 19
MARKET AREA POPULATION ESTIMATES 1/

YEAR	POPULATION (MILLIONS) 2/
1980	14.21
1990	16.38
2000	16.97
2010	17.93
2020	19.24
2030	21.16

1/ Market area includes Alameda, Contra Costa, Los Angeles, Marin, Napa, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Solano, Sonoma, Stanislaus, and Yolo Counties. (Los Angeles was included here to recognize that the 1 percent-use origin could be an important contribution to recreation value considering the distances traveled.)

2/ Population projections for 1980-2020 extracted from the California Department of Finance, E-150 Series, April 1981. Population for 2030 calculated as a 10 percent increase over 2020.

EXISTING USE

15. Recreation use of the Delta is almost totally water dependent which reflects a lack of facilities for land-based users. The DWR survey (Cajucom, 1980) showed that fishing and boating were the most popular recreation activities in the Delta. About 70 percent of the residents in the Delta and approximately half of the visitors indicated that they participated in fishing and boating. Column 1 of Table 20 shows the percent of visitors who participated in a given activity. Column 1 totals more than 100 percent because visitors commonly participated in more than one activity in a day. Column 2 shows the percent of days each activity represents based on total recreation days.

TABLE 20

RECREATION PARTICIPATION IN DELTA ACTIVITIES

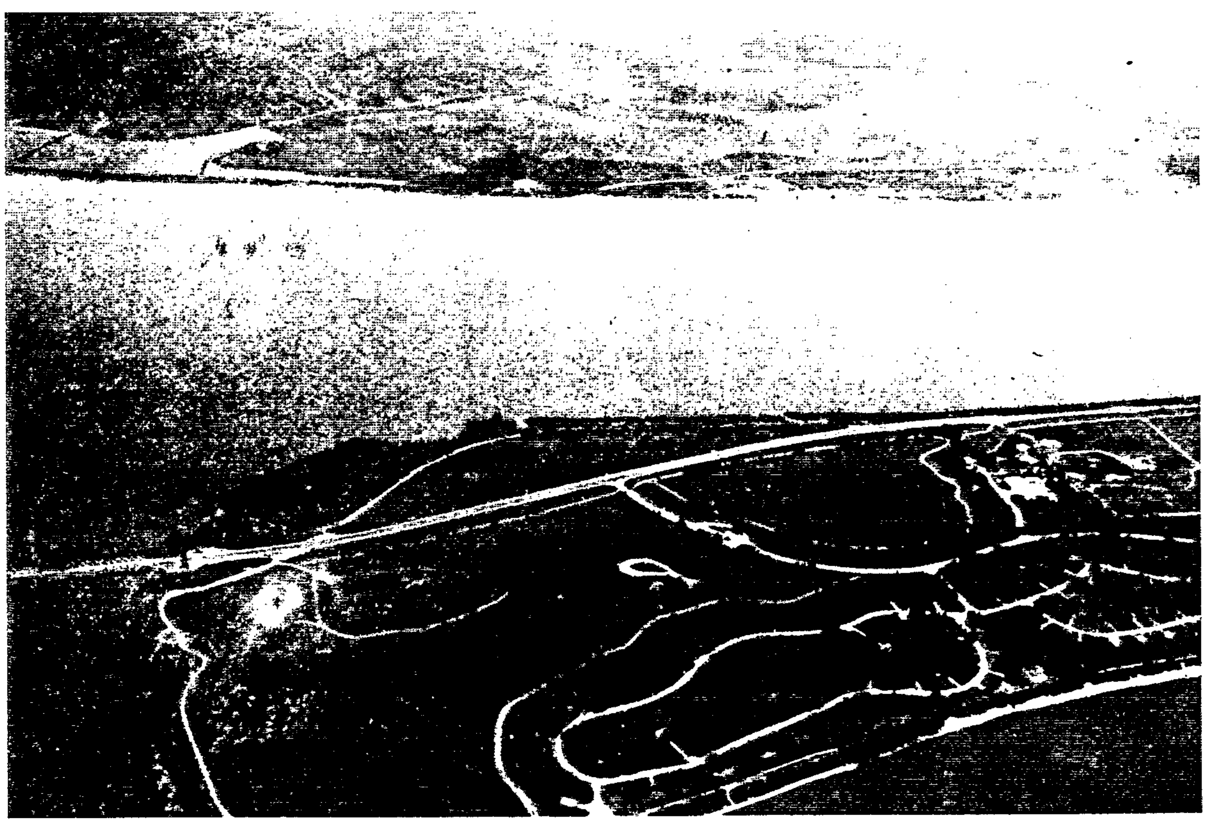
ACTIVITY	PERCENT PARTICIPATION BY INDIVIDUALS	PERCENT PARTICIPATION BY VISITATION
Motor Boating	47.6	15.2
Fishing	47.5	15.1
Relaxing	38.6	12.2
Driving for Pleasure	36.2	11.5
Sightseeing	33.1	10.5
Overnight Camping	26.2	8.3
Picnicking	22.9	7.3
Swimming	21.1	6.7
Water Skiing	14.7	4.7
Photography	10.1	3.2
Sailing	4.2	1.3
Bicycling	3.6	1.2
Canoe-Kayak-Rowing	2.5	0.8
Dirt Bike	2.5	0.8
Hunting	2.0	0.6
Snorkling or Scuba	0.9	0.3
Flying	0.9	0.3
TOTAL		100.0

Results of the DWR survey (Cajucom, March 1980) also indicate that more than 75 percent of the Delta users recreate in the portion of the Delta west of Old River and northwest of the Mokelumne River.

EXISTING FACILITIES

16. The Delta Recreation Concept Plan (Geidel and Moore, 1981) includes an inventory of existing commercial recreation facilities in the Delta. There are 116 commercial recreation facilities in the Delta: 107 commercial marinas, 3 commercial restaurants with guest docks, 1 retail store with guest docks, 1 commercial community development, 1 commercial boatyard, 1 trailer court with berths, 1 recreation vehicle park, and 1 community dock. Table 21 lists the numbers and types of existing commercial facilities. Table 22 lists existing public facilities in the Delta, and Table 23 describes proposed commercial and public recreation facilities in the Delta.

Hogback Island



Brannan Island State Recreation Area

TABLE 21
EXISTING COMMERCIAL RECREATION FACILITIES

FACILITY	NUMBER	FACILITY	NUMBER
Berths		Campsites	2,713
Covered	6,453	Picnic Tables	298
Open	2,081		
Docks		Sanitary Facilities	
Overnight	4	Restrooms	21
Day-Use	115	Restroom/w/shower	62
		Pumpout Stations	19
Launch Facilities		Parking	
Ramps	27	Paved	4,636
Lanes	41	Unpaved	4,180
Mechanical Devices	18		

TABLE 22
EXISTING PUBLIC RECREATION FACILITIES

Clarksburg Fishing Access (Yolo Co.)
Hogback Island Fishing Access (Sacramento Co.)
Cliff House Fishing Access (Sacramento Co.)
Georgiana Slough Fishing Access (Sacramento Co.)
Rio Vista Riverbank/Pier (City of Rio Vista)
Rio Vista Public Launch Ramp (City of Rio Vista)
Rio Vista Sandy Beach Park (Solano Co.)
Brannan Island State Recreation Area (State of California, Parks and Recreation)
Lower Sherman Island Fishing Access (Sacramento Co.)
Franks Tract State Recreation Area (State of California, Parks and Recreation)
Antioch Fishing Pier (City of Antioch)
Antioch Pier Park (City of Antioch)
I-5 Borrow Ponds (State of California)
Oak Grove County Park (San Joaquin Co.)
Buckley Cove Park Marina (City of Stockton)
Fritz Grupe Park (City of Stockton)
Mandeville Tip Park (Port of Stockton)
South Spud Island Park (San Joaquin Co.)
Channel I-5 Boat Ramp Park (City of Stockton)
Louis Park (City of Stockton)
Dos Reis County Park (San Joaquin Co.)
Mossdale Crossing Park (San Joaquin Co.)
Westgate Landing Fish Access (San Joaquin Co.)
Clifton Court Forebay (State of California, Department of Water Resources)
Antioch Dunes Endangered Species Refuge (U.S. Fish and Wildlife Service)

TABLE 23
PROPOSED COMMERCIAL AND PUBLIC
RECREATION FACILITIES

Commercial
- Collinsville Marina
- Marina De Playa
- Prince Harbor
- Discovery Bay Marina and Golf Course

Public
- Delta Meadows (State of California, Parks and Recreation)
- Browns Island (East Bay Regional Park District)
- Roberts Island (Corps of Engineers)
- Rio Vista Sandy Beach Park Addition (Corps of Engineers)

ALTERNATIVE WATER-ORIENTED RECREATION AREAS

17. Because of the Delta's unique physiographic and ecological composition, there are no comparable alternative areas where people from the 14-county market area and others could go for similar recreation opportunities. Clear Lake with an annual use of 2.4 million recreation days, Lake Berryessa with an annual use of 2.4 million recreation days, and Folsom Lake with an annual use of 4.6 million recreation days are the closest large bodies of flatwater supplying some alternative activities for many of the users in the market area. Anderson, Del Valle, and Kellogg Reservoirs are smaller bodies of water that are available to the users in the market area. These nearby partial alternatives supply beaches, picnicking, camping, and boat launching facilities where public lands, roads, parking, and other facilities furnish ready access. The Delta is a considerably larger recreation resource and already supports considerably more recreation use than these alternative sources. The estimates of potential use presented in this report reflect the effect of competition from these alternatives.

RECREATION DEMAND AND NEED

18. Recreation use of the Delta has increased steadily since the mid-1940's. The major recreation season occurs from June through August with peak use occurring on weekends and holidays. Camping facilities are typically used to capacity on weekends with a substantial number of persons turned away. Potential use is considerably greater than current use because use is constrained by poor access and few facilities.

19. The extent to which future recreation demand exceeds actual facilities is termed "latent demand" and is shown in Table 24. The recreation demand, as reported in the Delta Master Recreation Plan (Delta Master Recreation Plan Task Force, 1976) represents the recreation which would occur in the Delta if sufficient facilities were provided. The amount of actual recreation use estimated is based on an extrapolation of the results of the recreation survey conducted for DWR (Geidel and Moore, 1981) using population projections and known planned future facilities. The difference between these two figures represents the latent recreation demand above the capacity of the present and planned future facilities.

TABLE 24
RECREATION DEMAND
(MILLIONS OF RECREATION DAYS)1/

	PREDICTED FUTURE		
YEAR	WITH SUFFICIENT FACILITIES	ACTUAL USE	LATENT DEMAND
1980	21.7 2/	12.3 3/	9.4
1990	28.8	13.6	15.2
2000	39.8	14.1	25.7

1/ Recreation day=participation in any activity(ies) for any portion of a 24-hour period.
2/ Delta Master Recreation Plan Task Force, 1976. Delta Master Recreation Plan.
3/ Actual use survey and projection from Geidel and Moore, 1981.

PROJECT CAPABILITY

20. A levee rehabilitation project would provide important opportunities for development of public recreation. Boaters need increased access, parking, launching, and boater destination areas for day use, boat access, camping, and overnight moorage. Land-based users need facilities for day and overnight use. Both types of facilities could be provided as an integral part of levee rehabilitation to utilize the levees and other portions of the potential project to support overall Delta recreation needs. Despite large demand for added recreation use and added facilities, however, the levee rehabilitation project can supply only a limited part of the demand. The levee structure and associated potential project areas -- waterside berms adjacent to levees are examples of such areas -- front almost all of the waterways of the Delta. These areas are absolutely necessary for support of added recreation use. It is recognized that the linear and narrow extent of the levee areas will constrain the type of facilities and the extent of use. Another constraint is the capability and desire of the Federal and non-Federal governments to allocate limited financial resources for the recreation purpose and other purposes including fish and wildlife and environmental quality enhancement. The extent of financial commitment for these purposes in comparison to other societal needs requires a balancing of desire and prudence for project planning. Based on a level of use that maintains environmental qualities and observed tolerance to crowding, the proposed recreation plan could accommodate about 2.4 million recreation days annually. This would add about one-tenth more to present Delta use and would represent about one-tenth of latent demand for future increase in use. Existing recreation use is supported by a mixture of public and commercial facilities, and this mixture will continue to be important as future use increases.

RECREATION PLANNING CRITERIA

PATTERNS OF USE

21. Because of its temperate climate, the Delta receives significant recreation use from March to October with the peak use months being June, July, and August. Recreation use is concentrated on weekends and holidays. There is significant weekday use which is attributed to camping and overnight use of boats, particularly houseboats. In the future, with increased weekend crowding of available facilities, more diversity in days people have off, and trends toward a 4-day work week, weekday use of facilities will increase. With this anticipated pattern of use, facilities would be more efficiently used, and more persons would use the available facilities thereby resulting in greater annual use.

ESTIMATING USE

22. Estimates of annual use are based on the Delta Outdoor Recreation Survey published by DWR (Cajucom, 1980) which included information on the capacity of existing and proposed facilities, characteristics of recreation users, and current trends in distribution of recreation use in the Delta.

23. The carrying capacity for each recreation site was developed by calculating the number of individuals that could be reasonably supported by the proposed facilities. For day use facilities this was determined to be the product of the number of picnic sites (or parking spaces, whichever is greater), the number of persons per vehicle (4.0), and a turnover rate of two. For launching facilities it was the product of the number of car-boat

trailer parking spaces, the number of persons per vehicle, and a turnover rate of 1.5. For camping and overnight moorage it was the product of the number of sites and the number of persons per site (3.5). For the trail system it was the number of persons per mile of trail (20) and a turnover rate of 2. The sum of the carrying capacities of each site established the design day load, which is the maximum use that could be supported by the proposed facilities if used to their fullest extent for a 1-day period.

24. Analysis of the 2 years of survey data collected by DWR shows that 23 percent of the annual use occurs in each month from June through August and about 50 percent of summer use occurs on weekends. Substituting this information into the Corps standard recreation use estimating formula yields an estimate of initial annual attendance.

$$\text{Annual Attendance} = \frac{\text{design day load} \times \text{weekend days per month}}{\%\ \text{peak month use} \times \%\ \text{weekend use}}$$

where: weekend days per month = 9
% peak month use = 23
% weekend use = 50

25. Considering the significant latent demand for public recreation facilities in the project area and attendance patterns at other water-oriented recreation areas, design day use of facilities is anticipated within 3 years after the recreation areas are opened for public use. In the future, use of the recreation areas will increase when users find facilities full on popular days such as weekends and holidays. They will then redistribute their use to weekdays and other months besides the peak month. Larger amounts of use will then occur more frequently on weekdays. This will cause the weekend use to drop to 45 percent and the peak month use to drop to 22 percent, which will result in an increase in total annual use without the need for increasing facilities.

26. Table 25 shows the design day load and initial and future attendance for the proposed recreation sites in the Delta. It is expected that the full future attendance will be reached within 50 years. Thus, the total anticipated and potential use is as follows:

ANNUAL ATTENDANCE

YEAR	PROJECTED ATTENDANCE (1,000)
1985	2,090
1995	2,158
2005	2,226
2015	2,293
2025	2,361
2035	2,430
2045	2,430
2055	2,430
2065	2,430
2075	2,430
2085	2,430

Comparing this to the latent recreation demand of 25.7 million, the proposed plan, although comprehensive in nature, will only supply approximately 10 percent of the total latent demand.

RECREATION ACTIVITIES

27. Opportunities would be provided for the shore-based activities of picnicking, swimming, outdoor sports and games, bank fishing, camping, hiking, bicycling, horseback riding, and sightseeing. Provision for water dependent activities at the project would include opportunities for boating, fishing, water skiing, boat access, picnicking, boat access shore camping, and overnight mooring and docking facilities for large boats and houseboats.

TABLE 25

PROJECTED RECREATION ATTENDANCE
FOR PROPOSED FACILITIES

NO.	SITE	TYPE OF FACILITY 1/	DESIGN DAY LOAD	INITIAL ANNUAL VISITATION	FUTURE ANNUAL VISITATION
1.	Andrus Island	FAS	213	16,700	19,400
2.	Bacon Island	FAS	213	16,700	19,400
3.	Benson Ferry Bridge	FAS	229	18,000	20,800
4.	Blackbird	FAS	189	14,800	17,200
5.	Black Slough	FAS	189	14,800	17,200
6.	Bouldin Island	RA	1,225	95,900	111,400
7.	Brannan Is State Park	RA	1,580	123,700	143,600
8.	Canal Ranch	FAS	189	14,800	17,200
9.	Channel Island	BDS	100	7,800	9,100
10.	Clifton Court Forebay	FAS	378	29,600	34,400
11.	Connection Slough	RA	822	64,300	74,700
12.	Correia Road	FAS	189	14,800	17,200
13.	Decker Island	RA	205	16,000	18,600
14.	Delta Meadows	RA	710	55,600	64,500
15.	Donlon Island	BDS	100	7,800	9,100
16.	El Pescadero	FAS	189	14,800	17,200
17.	Fabian	FAS	189	14,800	17,200
18.	Franks Tract	BDS	100	7,800	9,100
29.	Grand Island	RA	3,028	237,000	275,300
20.	Grant Line Canal	RA	153	12,000	13,900
21.	Holland Tract	RA	3,440	269,200	312,700
22.	Highway 4	FAS	189	14,800	17,200
23.	Hog Slough	FAS	189	14,800	17,200
24.	Light 11	RA	822	64,300	74,700
25.	Little Mandeville	BDS	100	7,800	9,100
26.	Lower Jones	FAS	213	16,700	19,400
27.	Middle River	RA	1,102	86,250	100,200
28.	Old River Island	BDS	100	7,800	9,100
29.	Oulton Point	RA	1,225	95,900	111,400
30.	Paradise	FAS	229	18,000	20,800
31.	Pixley Slough	FAS	229	18,000	20,800
32.	Quimby Island	BDS	100	7,800	9,100
33.	Rio Vista	FAS	189	14,800	17,200
34.	Rock Slough	FAS	213	16,700	19,400
35.	Sacramento River	FAS	189	14,800	17,200
36.	Seven Mile Slough	FAS	189	14,800	17,200
37.	Shin Kee	RA	1,145	89,600	104,100
38.	South Fork Mokelumne	FAS	189	14,800	17,200
39.	Staten Island	FAS	213	16,700	19,400
40.	Tippy Canoe	RA	115	9,000	10,500
41.	Trapper Slough	FAS	189	14,800	17,200
42.	Turner Cut	FAS	213	16,700	19,400
43.	Tule Island	BDS	100	7,800	9,100
44.	Venice Cut	BDS	100	7,800	9,100
45.	Widdows Island	RA	153	12,000	13,900
	145 miles of trails		5,400	422,000	490,000
			26,725	2,091,350	2,429,100

1/FAS - FISHING ACCESS SITE, RA - RECREATION AREA, BDS - BOATER DESTINATION SITE

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BASIS OF SITE SELECTION

28. The Delta Recreation Concept Plan (Geidel and Moore, 1981), prepared for DWR, identified 56 potential public recreation sites/areas and a potential trail system. The Concept Plan served as a base from which the more limited proposed plan was developed. The sites identified in the Concept Plan were developed from recommendations of concerned public agencies, past Delta studies and plans, and a current inventory of recreation presently offered to the public. Specific facilities and sites for the Concept Plan were determined using information obtained from the Delta Outdoor Recreation Survey (Cajucom, 1980) which identified activities and needs of the Delta recreationists including demographic information on the users and the locations of use.

29. The recreation plan described in this appendix was developed to specifically include those facilities identified in the Concept Plan as presently lacking in the Delta; to meet the goals of providing a comprehensive recreation plan for the Delta as a whole; and to provide for approximately 2.4 million recreation days.

30. The selection of sites and facilities was made by applying the following criteria to the recreation sites described in the Concept Plan. The site should:

- o conform to the waterways use program identified in the Delta Master Recreation Plan.
- o minimize conflicts with existing recreation areas/facilities/services open to the public in the local vicinity.

- minimize competition with private enterprise.
- meet identified deficiencies and needs in local area.
- minimize impacts to Delta resources including endangered species, significant fish and wildlife habitat areas, historic and archeological resources, industrial areas, and areas of scenic quality.
- complement rather than duplicate existing recreation activities in the local vicinity.
- selected sites should be accessible to the physically handicapped.
- minimize utilization of productive agricultural land, avoiding where possible conflicts with landowners activities.
- be dispersed throughout the Delta according to existing use and future needs.
- complement known proposed recreation plans to be developed in the future within and adjacent to the Delta.

Ccoordination with many agencies, organizations, and individuals was important in selecting the sites and facilities as explained below in the coordination discussion.

RECREATION PLAN

DESCRIPTION OF FACILITIES

31. The recreation plan is composed of a mix of three basic types of recreation sites: recreation areas, fishing access sites, and boater destination sites. In addition, approximately 145 miles of trails (bicycling, hiking, canoeing, and equestrian) would link recreation sites with other sites

or continue trail access from outside the Delta. Approximately 70 miles of trails would be on existing roads. In the recreation areas, parking facilities, picnic sites; boat launching ramps; fishing sites; boat access campsites, shoreside docks, and restroom facilities with showers would be provided. The fishing access sites would provide access to the Delta waterways and would have picnic tables, restrooms, and parking facilities. Some of the sites would provide car top launching facilities, whereas others, depending on their location, would offer trailered boat launching facilities. The boater destination sites would provide access to small channel islands and areas accessible by boat only and contain a day-use dock or mooring buoy and some sanitary facilities, depending on the sites. Figure 16 shows the location of the recreation sites and the proposed trail system. Table 26 lists the individual facilities for all of the sites. Detailed site locations are shown on Plates 2 through 37.

RECREATION COSTS

32. Cost estimates have been prepared for the interest to be acquired in the lands to be utilized for public recreation and for construction and operation of the recreation facility developments. Costs are summarized for the individual sites, and the annual costs are reported for all 45 sites and the approximately 145 miles of trails. First costs are shown in Table 27 and annual costs are shown in Table 28. The cost estimates shown in Tables 27 and 28 are representative of a recreation plan that could be combined with either the Incremental Flood Control Alternative or the Polder Flood Control Alternative. The costs of a recreation plan that could be combined with either the System Flood Control Alternative and the Modified System Flood Control Alternative would be slightly less. This is primarily due to a

portion of the interest to be acquired in the lands for Fishing Access Sites and trails being furnished as part of the flood control feature.

RECREATION BENEFITS

33. The estimated annual recreation use previously discussed is based on the capacity of the proposed facilities. It is widely acknowledged that current and future demand for recreation in the Delta is greatly in excess of existing facilities and is constrained by a lack of facilities. Recreation facilities constructed as part of the project will provide for a net increase in recreation use rather than a redistribution of existing or future use.

34. Recreation benefits were computed in accordance with the Water Resources Council's National Economic Development Evaluation Procedures: Recreation (Subpart k of 18 CRF Part 713, 14 December 1979). Subpart k describes the Travel Cost Method (TCM), the Contingent Valuation Method (CVM), and the Unit Day Value Method (UDV) for estimating recreation benefits. For proposed projects where the annual visitation is expected to exceed 500,000, the TCM or CVM must be used to calculate recreation benefits.

35. Recreation benefits shown below were calculated using the TCM. Recreation user surveys conducted from 1977 to 1979 by DWR (Delta Outdoor Recreation Survey, Cajucom and Associates, March 1980) were used to develop a regional model for the Delta, and served as input to the TCM.

The equivalent average annual benefits for recreation use, based on a 7-5/8 percent interest rate and 50-year project economic life, are estimated at $20.86 million.

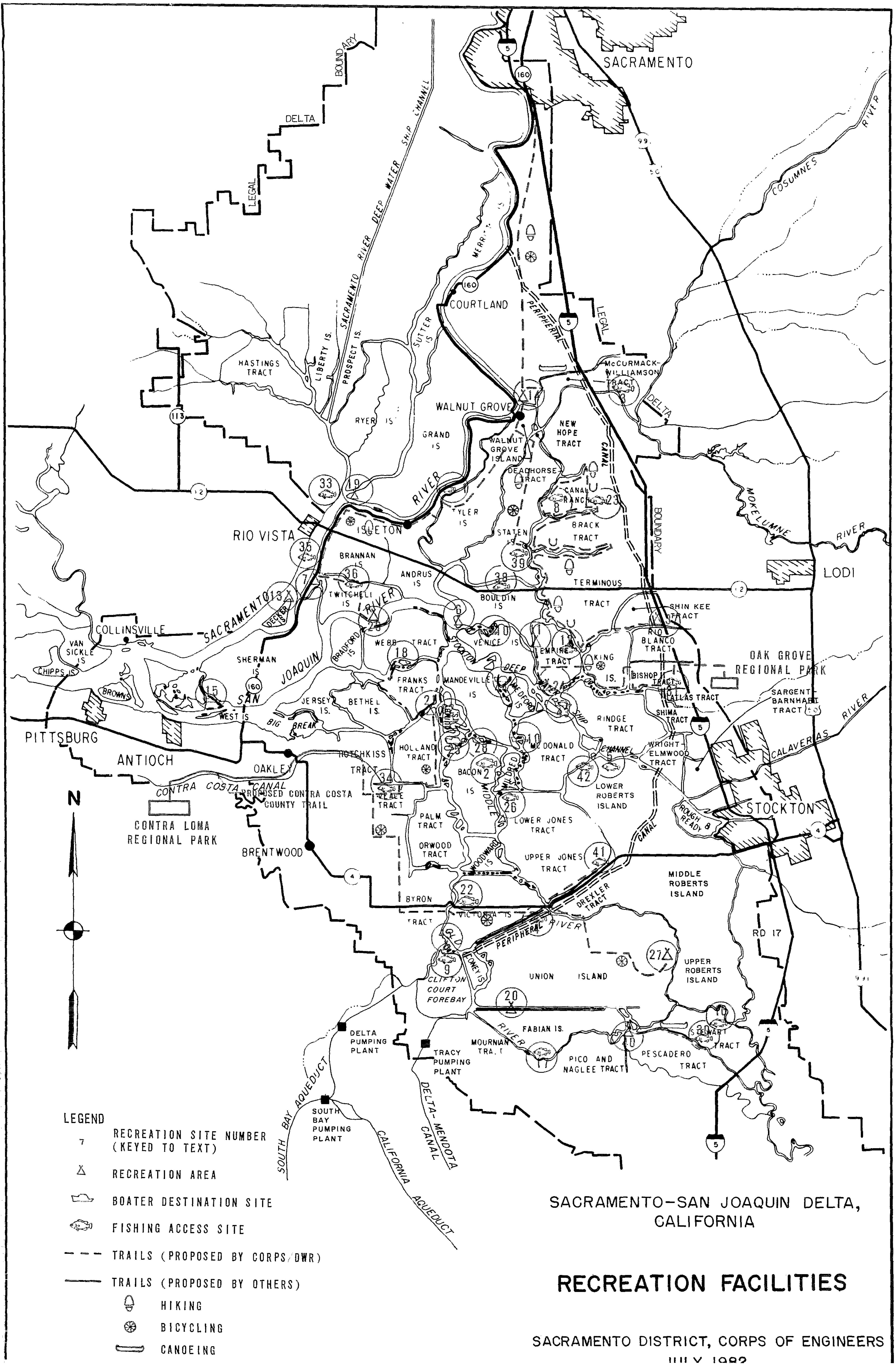

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TABLE 26

RECREATION FACILITIES

NO.	NAME	ACCESS	LANDS (AC.)	ACTIVITIES	FACILITIES
1	Andrus Island Fishing Access	Isleton Road	15	1-Mile Bank Fishing Picnicking Nature Trail	Parking - Auto (25 Spaces) 1 Fishing Pier 8 Picnic Sites 4 Chemical Toilets
2	Bacon Island Fishing Access	Bacon Island Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 1 Fishing Pier 8 Picnic Sites 4 Chemical Toilets
3	Benson Ferry Fishing Access	Levee road off Franklin Blvd.	20	1-Mile Bank Fishing Picnicking Canoeing	Parking - Auto (25 Spaces) 8 Picnic Sites Boat Launch-Car Top 2 Chemical Toilets
4	Blackbird Fishing Access	Klein Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
5	Blackslough Fishing Access	Holt Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
6	Bouldin Island Recreation Area	Levee road south from Highway 12	50	Bank Fishing Picnicking Camping Boat Launching Hiking	Administration Building Storage & Maintenance Building Service Yard Entrance Station Parking - Auto (100 Spaces) - Boat (50 Spaces) 3 Restrooms 1 Boat Dump Station 1 Trailer Dump Station Boat Launch Ramp (2 Lanes) 2 Day-Use Docks Finger Piers for 20 Houseboats Berths for 20 Boats 1 Service Dock 50 Campsites 30 Picnic Sites 1 Picnic Group Shelter 2-Mile Hiking Trail
7	Brannan Island Recreation Area Extension	Highway 160	75	Bank Fishing Picnicking Camping Hiking	Parking - Auto (200 Spaces) 2 Restrooms 1 Trailer Dump Station 2 Day-Use Docks Berths for 20 Boats 1 Service Dock 100 Campsites 30 Picnic Sites 1 Picnic Group Shelter 1-Mile Hiking Trail
8	Canal Ranch Fishing Access	West off Blossom Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
9	Clifton Court Forebay Fishing Access	Byron Highway	135	Bank Fishing Picnicking	Parking - Auto (50 Spaces) 16 Picnic Sites 4 Chemical Toilets
10	Channel Island Boater Destination Site	Water Access Only - Dissappointment Slough		Fishing Picnicking Nature Study	1 Day-Use Dock 2 Chemical Toilets 2-Mile Hiking Trail
11	Connection Slough Recreation Area	Empire Tract Road	20	Fishing Picnicking Camping Swimming Hiking	Storage & Maintenance Building Entrance Station Parking - Auto (125 Spaces) - Boat (25 Spaces) 2 Restrooms 1 Day-Use Dock Berths for 10 Boats Finger Piers for 10 Houseboats 20 Campsites 24 Picnic Sites - Family 1-Mile Hiking Trail
12	Correia Fishing Access	Correia Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets

TABLE 26 (Continued)

RECREATION FACILITIES

NO.	NAME	ACCESS	LANDS (AC.)	ACTIVITIES	FACILITIES
13	Decker Island Recreation Area	Water Access Only - Sacramento River	75	Bank Fishing Picnicking Camping Swimming	4 Chemical Toilets 10 Boat-In Campsites
14	Delta Meadows Recreation Area	Auto - River Road Boat - Snodgrass Slough	50	Fishing Picnicking Camping Hiking	Administration Building & Interpretive Center Storage & Maintenance Building Service Yard 4 Restrooms 1 Boat Dump Station 2 Day-Use Docks 1 Service Dock Berths for 40 Boats Finger Piers for 40 Houseboats 100 Campsites (Bicycling, Hiking, Boat-In) 30 Picnic Sites 2-Mile Hiking Trail
15	Donlon Island Boater Destination Site	Water Access Only - San Joaquin River	Will Depend on State ownership findings.	Fishing Hiking Birdwatching Nature Study	1 Day-Use Dock 2 Chemical Toilets 2-Mile Trail
16	El Pescadero Fishing Access	San Joaquin Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
17	Fabian Fishing Access	Finck Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
18	Franks Tract Boater Destination Site	Water Access Only - Franks Tract Create islands out of old levees for boater destination sites.	10	Fishing Picnicking Swimming	1 Day-Use Dock 2 Chemical Toilets
19	Grand Island Recreation Area	Grand Island Road	100	Fishing Picnicking Camping Swimming Boat Launching Hiking	Administration Building Storage & Maintenance Building Service Yard Entrance Station Parking - Auto (200 Spaces) - Boat (200 Spaces) 4 Restrooms 1 Boat Dump Station 1 Trailer Dump Station Boat Launch Ramp (6 Lanes) 2 Day-Use Docks Berths for 40 Boats Finger Piers for 40 Houseboats 2 Fishing Piers 1 Service Dock 100 Campsites 50 Picnic Sites - Family 2 Picnic Group Shelters 2-Mile Hiking Trail
20	Grant Line Canal Recreation Area	Water Access Only - Grant Line Canal	50	Fishing Picnicking Camping Swimming Hiking	1 Day-Use Dock 15 Boat-In Campsites 10 Picnic Sites 4 Chemical Toilets 1-Mile Hiking Trail
21	Holland Tract Recreation Area	Holland Tract Road	100	Fishing Picnicking Camping Boat Launching Hiking Bicycling	Administration Building Storage & Maintenance Buiding Service Yard Entrance Station Parking - Auto (300 Spaces) - Boat (200 Spaces) 4 Restrooms 1 Boat Dump Station 1 Trailer Dump Station Boat Launch Ramp (4 Lanes) 4 Day-Use Docks 1 Service Dock Campsites - Auto (70 Sites) - Boat (20 Sites) - Bicycle (10 Sites) 50 Picnic Sites 2 Picnic Group Shelters 1-Mile Hiking Trail

TABLE 26 (Continued)

RECREATION FACILITIES

NO.	NAME	ACCESS	LANDS (AC.)	ACTIVITIES	FACILITIES
22	Highway 4 Fishing Access	Highway 4	2	1-Mile Bank Fishing	Parking - Auto (25 Spaces) 2 Chemical Toilets
23	Hog Slough Fishing Access	Woodbridge Road North	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets 1-Mile Hiking Trail
24	Eight 11 Recreation Area	Empire Tract Road	20	Fishing Picnicking Camping Hikng	Storage & Maintenance Building Entrance Station Parking - Auto (125 Spaces) - Boat (25 Spaces) 2 Restrooms Berths for 10 Boats Finger Piers for 10 Houseboats 1 Day-Use Dock 20 Campsites 24 Picnic Sites 1-Mile Hiking Trail
25	Little Mandeville Boater Destination Site	Water Access Only - Connection Slough	Will depend on State ownership findings.	Fishing Picnicking Nature Study	1 Day-Use Dock 2 Chemical Toilets 2-Mile Hiking Trail
26	Lower Jones Fishing Access	Lower Jones Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 1 Fishing Pier 8 Picnic Sites 4 Chemical Toilets
27	Middle River Recreation Area	Wing Levee Road	45	Fishing Picnicking Camping Hiking	Storage/Maintenance Building Entrance Station Parking - Auto (125 Spaces) 2 Restrooms Boat Launch - Car Top 20 Campsites 24 Picnic Sites 2-Mile Hiking Trail
28	Old River Boater Destination Site	Water Access Only - Connection Slough	Will depend on State ownership findings.	Fishing Picnicking Nature Study	1 Day-Use Dock 2 Chemical Toilets 2-Mile Hiking Trail
29	Oulton Point Recreation Area	Levee road from Twitchell Island Rd.	50	Fishing Picnicking Camping Hiking	Administration Building Storage/Maintenance Bulding/Service Yard Parking - Auto (100 Spaces) - Boat (50 Spaces) 2 Restrooms 1 Boat Dump Station 1 Trailer Dump Station Boat Launch Ramp (2 Lanes) Berths for 20 Boats Finger Piers for 20 Houseboats 2 Day-Use Docks 1 Service Dock 50 Campsites 30 Picnic Sites 1 Picnic Group Site 1-Mile Hiking Trail
30	Paradise Fishing Access	Paradise Road	2	Fishing Picnicking Canoeing	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets Boat Launch - Car Top
31	Pixley Slough Fishing Access	Eight Mile Road to Frontage Road	2	1-Mile Bank Fishing Picnicking Canoe	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets Boat Launch - Car Top
32	Quimby Island Boater Destination Site	Water Access Only - Old River	50	Fishing Picnicking Swimming Hiking	1 Day-Use Dock 2 Chemical Toilets 2-Mile Hiking Trail
33	Rio Vista Fishing Access	Ryer Island Ferry Road	12	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets

TABLE 26 (Continued)

RECREATION FACILITIES

NO.	NAME	ACCESS	LANDS (AC.)	ACTIVITIES	FACILITIES
34	Rock Slough Fishing Access	Delta Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 1 Fishing Pier 8 Picnic Sites 4 Chemical Toilets
35	Sacramento River Fishing Access	Highway 160	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
36	Sevenmile Slough Fishing Access	Twitchell Island Rd.	20	1-Mile Bank Fishing Picnicking Boating	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets Boat Launch - Car Top
37	Shin Kee Recreation Area	Highway 12	50	Fishing Picnicking Camping Hiking Horseback Riding	Administration Building Storage & Maintenance Building Service Yard Entrance Station Parking - Auto (100 Spaces) - Horse Trailer (65 Spaces) 4 Restrooms 1 Trailer Dump Station 100 Campsites 30 Picnic Sites 1 Picnic Group Shelter 3-Mile Hiking Trail
38	South Fork Mokelumne Fishing Access	Highway 12	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
39	Staten Island Fishing Access	Staten Island Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 1 Fishing Pier 8 Picnic Sites 2 Chemical Toilets
40	Tippy Canoe Recreation Area	Water Access Only - Paradise Cut	25	Fishing Camping Canoeing	10 Campsites - Canoe In 4 Chemical Toilets
41	Trapper Slough Fishing Access Site	Highway 4 - Bacon Island Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 8 Picnic Sites 2 Chemical Toilets
42	Turner Cut Fishing Access	Neugerbauer Road	2	1-Mile Bank Fishing Picnicking	Parking - Auto (25 Spaces) 1 Fishing Pier 8 Picnic Sites 4 Chemical Toilets
43	Tule Island Boater Destination Site	Water Access Only - San Joaquin River	50	Fishing Picnicking Swimming Hiking	1 Day-Use Dock 2 Chemical Toilets 2-Mile Hiking Trail
44	Venice Cut Boater Destination	Water Access Only - San Joaquin River	Will depend on State ownership	Fishing Picnicking Nature Study	1 Day-Use Dock 2 Chemical Toilets 2-Mile Hiking Trail
45	Widdows Island Recreation Area	Water Access Only-Old River	50	Fishing Picnicking Camping Hiking	1 Day-Use Dock 15 Campsites - Boat-In 10 Picnic Sites 4 Chemical Toilets 1-Mile Hiking Trail

Proposed Bacon Island Fishing Access Site

Proposed Burns Cutoff Fishing Access Site

Proposed Turner Cut Fishing Access Site

Proposed Sacramento River Fishing Access Site

C-103165

TABLE 27

FIRST COST
RECREATION PLAN

RECREATION FACILITIES	FEDERAL Recreation Facilities	Engineering and Design	Supervision and Administration	Total Federal	NON-FEDERAL Lands and Damages	TOTAL FIRST COST
ANDRUS ISLAND FISHING ACCESS	44,000	5,300	3,700	53,000	110,000	163,000
BACON ISLAND FISHING ACCESS	44,000	5,300	3,700	53,000	-	53,000
BENSON FERRY BRIDGE FISHING ACCESS	32,000	3,800	2,200	38,000	65,000	103,000
BLACKBIRD FISHING ACCESS	32,000	3,800	2,200	38,000	11,000	49,000
BLACK SLOUGH FISHING ACCESS	32,000	3,800	2,200	38,000	10,000	48,000
BOULDIN ISLAND RECREATION AREA	2,669,000	320,000	214,000	3,203,000	150,000	3,353,000
BRANNAN ISLAND STATE PARK RECREATION AREA	1,956,000	235,000	156,000	2,347,000	220,000	2,567,000
CANAL RANCH FISHING ACCESS	30,000	3,600	2,400	36,000	10,000	46,000
CHANNEL ISLAND BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	-	20,000
CLIFTON COURT FOREBAY FISHING ACCESS	72,000	8,600	7,400	88,000	410,000	498,000
CONNECTION SLOUGH RECREATION AREA	1,293,000	155,000	103,000	1,551,000	80,000	1,631,000
CORREIA ROAD FISHING ACCESS	32,000	3,800	2,200	38,000	-	38,000
DECKER ISLAND RECREATION AREA	16,000	2,000	1,000	19,000	190,000	209,000
DELTA MEADOWS RECREATION AREA	1,440,000	173,000	115,000	1,728,000	150,000	1,878,000
DONLON ISLAND BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	-	20,000
EL PESCADERO FISHING ACCESS	32,000	3,800	2,200	38,000	11,000	49,000
FABIAN FISHING ACCESS	32,000	3,800	2,200	38,000	20,000	58,000
FRANKS TRACT BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	6,000	26,000
GRAND ISLAND RECREATION AREA	4,333,000	520,000	347,000	5,200,000	-	5,200,000
GRANT LINE CANAL RECREATION AREA	46,000	5,500	3,500	55,000	179,000	234,000
HIGHWAY 4 FISHING ACCESS	22,000	2,600	1,400	26,000	10,000	36,000
HOG SLOUGH FISHING ACCESS	34,000	6,800	2,200	43,000	-	43,000
HOLLAND TRACT RECREATION AREA	4,070,000	488,000	326,000	4,884,000	290,000	5,174,000
LIGHT 11 RECREATION AREA	1,268,000	152,000	101,000	1,521,000	80,000	1,601,000
LITTLE MANDEVILLE BOATER DESTINATION	17,000	2,000	1,000	20,000	-	20,000
LOWER JONES FISHING ACCESS	44,000	5,300	3,700	53,000	-	53,000
MIDDLE RIVER RECREATION AREA	1,196,000	143,500	95,500	1,435,000	-	1,435,000
OLD RIVER ISLAND BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	-	20,000
OULTON POINT RECREATION AREA	2,399,000	288,000	192,000	2,879,000	160,000	3,039,000
PARADISE FISHING ACCESS	32,000	3,800	2,200	38,000	10,000	48,000
PIXLEY SLOUGH FISHING ACCESS	32,000	3,800	2,200	38,000	12,000	50,000
QUIMBY ISLAND BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	-	20,000
RIO VISTA FISHING ACCESS	32,000	3,800	2,200	38,000	55,000	93,000
ROCK SLOUGH FISHING ACCESS	44,000	5,300	3,700	53,000	10,000	63,000
SACRAMENTO RIVER FISHING ACCESS	32,000	3,800	2,200	38,000	12,000	50,000
SEVEN MILE SLOUGH FISHING ACCESS	32,000	3,800	2,200	38,000	-	38,000
SHIN KEE RECREATION AREA	3,433,000	412,000	275,000	4,120,000	-	4,120,000
SOUTH FORK MOKELUMNE FISHING ACCESS	32,000	3,800	2,200	38,000	10,000	48,000
STATEN ISLAND FISHING ACCESS	44,000	5,300	3,700	53,000	10,000	63,000
TIPPY CANOE RECREATION AREA	16,000	2,000	1,000	19,000	-	19,000
TRAPPER SLOUGH FISHING ACCESS	32,000	3,800	2,200	38,000	-	38,000
TULE ISLAND BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	-	20,000
TURNER CUT FISHING ACCESS	44,000	5,300	3,700	53,000	10,000	63,000
VENICE CUT BOATER DESTINATION SITE	17,000	2,000	1,000	20,000	-	20,000
WIDDOWS ISLAND RECREATION AREA	53,000	6,200	4,800	64,000	-	64,000
SUBTOTAL RECREATION FACILITIES	25,162,000	3,021,000	2,007,000	30,190,000	2,291,000	32,481,000

TABLE 27

FIRST COST
RECREATION PLAN (Continued)

RECREATION FACILITIES	FEDERAL Recreation Facilities	Engineering and Design	Supervision and Administration	Total Federal	NON-FEDERAL Lands and Damages	TOTAL FIRST COST
TRAIL SYSTEM						
ANDRUS-BRANNAN ISLAND TRAIL	244,000	29,000	20,000	293,000	-	293,000
BISHOP TRACT TRAIL	107,000	13,000	9,000	129,000	-	129,000
BRACK TRACT TRAIL	156,000	19,000	12,000	187,000	-	187,000
BYRON TRACT TRAIL	103,000	12,000	8,000	123,000	-	123,000
CANAL RANCH TRAIL	156,000	19,000	12,000	187,000	88,000	275,000
DELTA MEADOWS CANOE TRAIL	59,000	7,000	5,000	71,000	-	71,000
DREXLER TRACT TRAIL	48,000	5,800	4,200	58,000	28,000	86,000
EMPIRE TRACT TRAIL	80,000	9,600	6,400	96,000	-	96,000
HOLLAND TRACT TRAIL	155,000	18,600	12,400	186,000	-	186,000
HOTCHKISS TRACT TRAIL	40,000	4,800	3,200	48,000	-	48,000
KING ISLAND TRAIL	80,000	9,600	6,400	96,000	34,000	130,000
PARADISE CANOE TRAIL	125,000	15,000	10,000	150,000	-	150,000
SACRAMENTO TO WALNUT GROVE TRAIL	376,000	45,000	30,000	451,000	2,870,000	3,321,000
SHIN KEE TRACT TRAIL	27,000	3,000	2,000	32,000	-	32,000
STATEN ISLAND TRAIL	147,000	17,600	11,400	176,000	-	176,000
TERMINOUS TRACT TRAIL	234,000	28,000	19,000	281,000	-	281,000
TWITCHELL ISLAND TRAIL	97,000	11,600	7,400	116,000	-	116,000
TYLER ISLAND TRAIL	147,000	17,600	11,400	176,000	1,158,000	1,334,000
UNION ISLAND TRAIL	262,000	31,000	21,000	314,000	109,000	423,000
UPPER JONES TRACT TRAIL	88,000	10,500	7,500	106,000	39,000	145,000
UPPER ORWOOD TRACT TRAIL	71,000	8,500	5,500	85,000	-	85,000
VEALE TRACT TRAIL	80,000	9,600	6,400	96,000	-	96,000
VICTORIA ISLAND TRAIL	97,000	11,200	7,800	116,000	-	116,000
WALNUT GROVE TRAIL	17,000	2,000	1,000	20,000	166,000	186,000
SUBTOTAL TRAIL SYSTEM	2,996,000	358,000	239,000	3,593,000	4,492,000	8,085,000
TOTAL	28,158,000	3,379,000	2,246,000	33,783,000	6,783,000	40,566,000

TABLE 28

ANNUAL COST 1/
RECREATION PLAN

RECREATION FACILITIES	FEDERAL Amortized First Cost	NON-FEDERAL Amortized First Cost	NON-FEDERAL Maintenance and Operation	NON-FEDERAL Total	TOTAL ANNUAL COST
ANDRUS ISLAND FISHING ACCESS	4,100	8,600	9,200	17,800	21,900
BACON ISLAND FISHING ACCESS	900	800	9,200	10,000	10,900
BENSON FERRY BRIDGE FISHING ACCESS	3,000	5,100	9,900	15,000	18,000
BLACKBIRD FISHING ACCESS	3,000	800	8,100	8,900	11,900
BLACK SLOUGH FISHING ACCESS	3,000	800	8,100	8,900	11,900
BOULDIN ISLAND RECREATION AREA	250,500	11,700	52,700	64,400	314,900
BRANNAN ISLAND STATE PARK RECREATION AREA	183,600	17,200	68,000	85,200	268,800
CANAL RANCH FISHING ACCESS	2,800	800	8,100	8,900	11,700
CHANNEL ISLAND BOATER DESTINATION SITE	1,500	-	4,300	4,300	5,800
CLIFTON COURT FOREBAY FISHING ACCESS	6,900	32,100	16,300	48,400	55,300
CONNECTION SLOUGH RECREATION AREA	118,000	6,300	35,400	41,700	159,700
CORREIA ROAD FISHING ACCESS	3,000	800	8,100	8,900	11,900
DECKER ISLAND RECREATION AREA	1,400	14,900	8,800	23,700	25,100
DELTA MEADOWS RECREATION AREA	112,700	11,700	30,600	42,300	155,000
DONLON ISLAND BOATER DESTINATION SITE	1,500	-	4,300	4,300	5,800
EL PESCADERO FISHING ACCESS SITE	3,000	800	8,100	8,900	11,900
FABIAN FISHING ACCESS SITE	3,000	1,500	8,100	9,600	12,600
FRANKS TRACT BOATER DESTINATION SITE	1,500	500	4,300	4,800	6,300
GRAND ISLAND RECREATION AREA	406,800	-	130,400	130,400	537,200
GRANT LINE CANAL RECREATION AREA	4,300	14,000	6,600	20,600	24,900
HOLLAND TRACT RECREATION AREA	382,500	23,200	148,200	171,400	553,900
HIGHWAY 4 FISHING ACCESS	2,100	800	8,100	8,900	11,000
HOG SLOUGH FISHING ACCESS	3,400	-	8,100	8,100	11,500
LIGHT 11 RECREATION AREA	118,400	6,300	35,400	41,700	160,100
LITTLE MANDEVILLE BOATER DESTINATION SITE	1,500	-	4,300	4,300	5,800
LOWER JONES FISHING ACCESS	4,100	700	9,200	9,900	14,000
MIDDLE RIVER RECREATION AREA	112,200	-	47,400	47,400	159,600
OLD RIVER ISLAND BOATER DESTINATION SITE	1,500	-	4,300	4,300	5,800
OULTON POINT RECREATION AREA	225,200	12,500	52,700	65,200	290,400
PARADISE FISHING ACCESS	3,000	800	9,900	10,700	13,700
PIXLEY SLOUGH FISHING ACCESS	3,000	900	9,900	10,800	13,800
QUIMBY ISLAND BOATER DESTINATION SITE	1,500	-	4,300	4,300	5,800
RIO VISTA FISHING ACCESS	3,000	4,300	8,100	12,400	15,400
ROCK SLOUGH FISHING ACCESS	4,100	800	9,200	10,000	14,100
SACRAMENTO RIVER FISHING ACCESS	3,000	900	8,100	9,000	12,000
SEVEN MILE SLOUGH FISHING ACCESS	3,000	-	8,100	8,100	11,100
SHIN KEE RECREATION AREA	322,400	-	49,300	49,300	371,700
SOUTH FORK MOKELUMNE FISHING ACCESS	3,000	800	8,100	8,900	11,900
STATEN ISLAND FISHING ACCESS	4,100	800	9,200	10,000	14,100
TIPPY CANOE RECREATION AREA	1,400	-	5,000	5,000	6,400
TRAPPER SLOUGH FISHING ACCESS	3,000	-	8,100	8,100	11,100
TURNER CUT FISHING ACCESS	4,100	800	9,200	10,000	14,100
TULE ISLAND BOATER DESTINATION	1,500	-	4,300	4,300	5,800
VENICE CUT BOATER DESTINATION	1,500	-	4,300	4,300	5,800
WIDDOWS ISLAND RECREATION AREA	5,000	-	6,600	6,600	11,600
SUBTOTAL RECREATION FACILITIES	2,332,000	182,000	918,000	1,100,000	3,432,000

TABLE 28

ANNUAL COST 1/
RECREATION PLAN (Continued)

RECREATION FACILITIES	FEDERAL Amortized First Cost	NON-FEDERAL Amortized First Cost	NON-FEDERAL Maintenance and Operation	NON-FEDERAL Total	TOTAL ANNUAL COST
TRAIL SYSTEM					
ANDRUS-BRANNAN ISLAND TRAIL	22,900	-	15,000	15,000	37,900
BISHOP TRACT TRAIL	10,100		600	600	10,700
BRACK TRACT TRAIL	14,700	14,300	900	15,200	29,900
BYRON TRACT TRAIL	9,600	-	600	600	10,200
CANAL RANCH TRAIL	14,700	6,900	900	7,800	22,500
DELTA MEADOWS CANOE TRAIL	5,500	-	400	400	5,900
DREXLER TRACT TRAIL	3,800	2,200	400	2,600	6,400
EMPIRE TRACT TRAIL	7,500	-	500	500	8,000
HOLLAND TRACT TRAIL	14,600	-	900	900	15,500
HOTCHKISS TRACT TRAIL	4,100	-	200	200	4,300
KING ISLAND TRAIL	7,500	2,700	700	3,400	10,900
PARADISE CUT CANOE TRAIL	11,700	-	800	800	12,500
SACRAMENTO TO WALNUT GROVE TRAIL	34,900	224,300	16,900	241,200	276,100
SHIN KEE TRACT TRAIL	2,500	-	200	200	2,700
STATEN ISLAND TRAIL	13,700	-	900	900	14,600
TERMINOUS TRACT TRAIL	22,000	-	1,400	1,400	23,400
TWITCHELL ISLAND TRAIL	9,000	-	600	600	9,600
TYLER ISLAND TRAIL	13,700	-	900	900	14,600
UNION ISLAND TRAIL	24,500	8,500	2,100	10,600	35,100
UPPER JONES TRACT TRAIL	8,300	3,100	700	3,800	12,100
UPPER ORWOOD TRACT TRAIL	6,700	-	400	400	7,100
VEALE TRACT TRAIL	7,500	-	500	500	8,000
VICTORIA ISLAND TRAIL	9,000	-	600	600	9,600
WALNUT GROVE TRAIL	1,500	13,000	900	13,900	15,400
SUBTOTAL TRAIL SYSTEM	280,000	275,000	48,000	323,000	603,000
TOTAL	2,612,000	457,000	966,000	1,423,000	4,035,000

1/ 7-5/8 Percent Interest, 50-Year Amortization

ENVIRONMENTAL QUALITY PLANNING

INTRODUCTION

36. The objective of the environmental quality (EQ) plan is the management, conservation, preservation, creation, restoration, or improvement of natural and cultural resources while meeting the other objectives of the project to the greatest extent practicable.

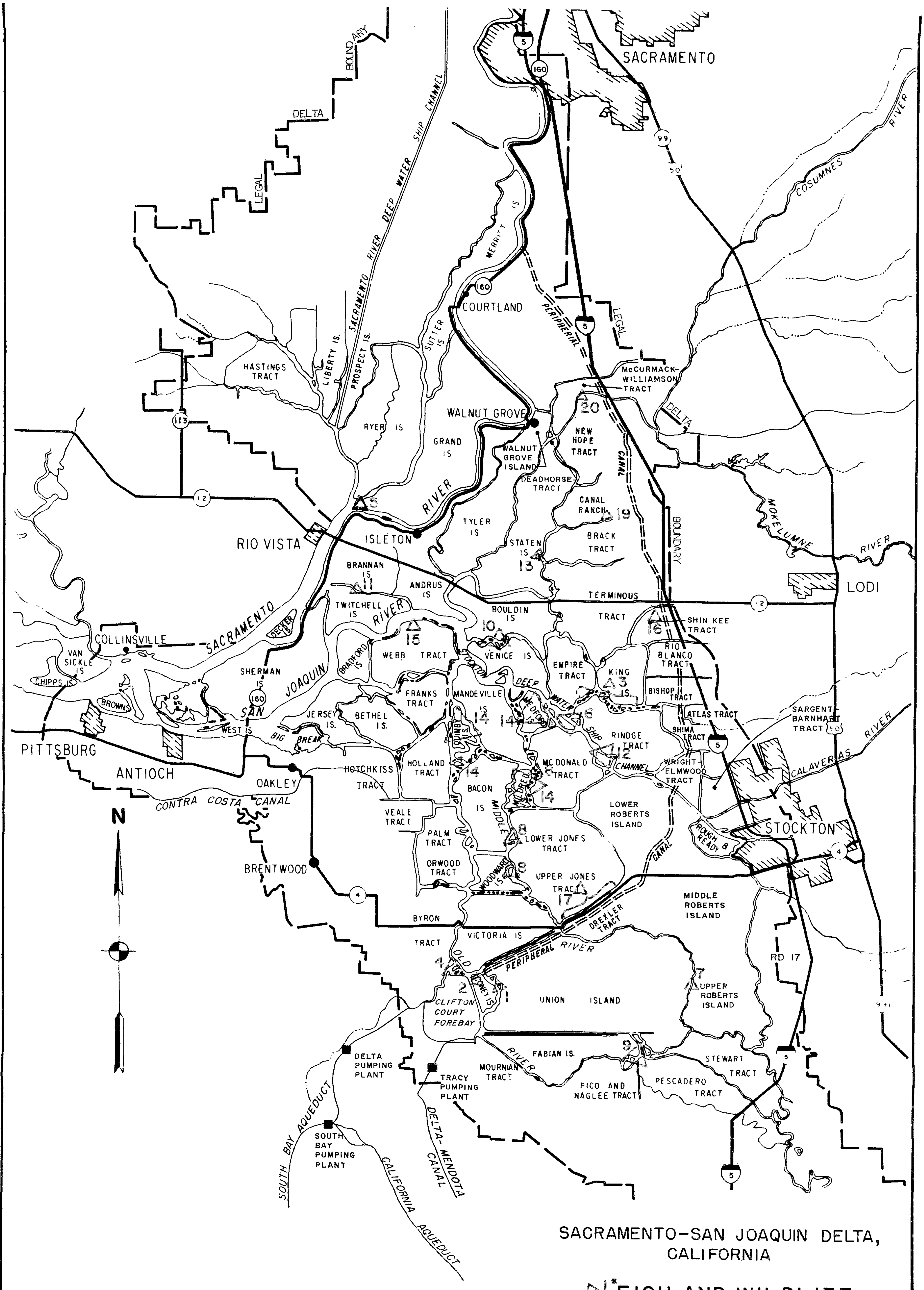
PLAN FORMULATION

37. The initial step in developing the EQ Plan was to determine the environmental desires and objectives of the State and local governments from available land use and other planning documents. A list of potential actions was developed which would meet these objectives and allow fulfillment of the flood control and recreation purposes. The third and most important step was to meet with interested agencies and the public to discuss the potential measures developed and obtain ideas and suggestions for other measures and to insure that all local desires were included. The final list of measures was developed with the cooperation of the California Department of Fish and Game (DFG), the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS) and the Department of Water Resources (DWR). In addition, these measures were presented to various local entities and organizations at a meeting held in October 1981 by DWR. Once the measures were selected, they were considered for inclusion in each flood control candidate plan, and those measures which were feasible were included. Each candidate plan was then evaluated, and the plan which best met the environmental objectives was designated as the EQ plan.

FISH AND WILDLIFE ENHANCEMENT MEASURES

38. The fish and wildlife enhancement measures desired to meet the environmental quality goals of preserving and enhancing the natural resources of the Delta included acquisition of a public interest in lands containing significant fish and wildlife habitat to insure its protection. In some cases, environmental easements or agreements may be suitable. Some recreation facilities are located in some enhancement areas to provide public access and to insure proper use of the enhancement lands. For this reason, the description of these areas also includes a description of the recreation facilities that would be located in these areas. The recreation development would be planned to avoid existing sensitive natural resources and fish and wildlife habitat and to provide controlled access. Existing inappropriate development, which could reduce the quality of the habitat at many enhancement areas, would be removed from the area and planned recreation facilities would be placed in the previously disturbed locations.

39. The following is a description of the fish and wildlife enhancement measures included in the Environmental Quality Plan. The locations of the fish and wildlife areas are shown on Figure 17. More detailed plates showing the location of the areas are located at the end of this appendix.



SACRAMENTO–SAN JOAQUIN DELTA,
CALIFORNIA

1* FISH AND WILDLIFE
ENHANCEMENT AREAS

*Keyed to text

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

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FIGUR

FISH AND WILDLIFE ENHANCEMENT MEASURES

1. Bonetti Island. - Purchase entire island, 33 acres, referred to in "Delta Wildlife Habitat Protection and Restoration Plan" as an island in Old River. The area has significant upland habitat, and is designated a natural area by Delta Master Recreation Plan, February 1976.

2. Coney Island. - Purchase two berm islands totaling 50 acres which are relatively undisturbed, and have important riparian habitat which is relatively limited in the southern portion of the Delta.

3. Disappointment Slough - Channel Islands. - Purchase approximately 300+1/ acres of tidal tule islands from the San Joaquin River to Fourteenmile Slough. The area is important habitat for wintering ducks, and for the State-designated rare black rail. There is also a DFG identified heron rookery in this area (DFG, 1979). At one of the islands, a boater destination site would be developed which would consist of one day-use dock and two chemical toilets. To minimize impacts, this site could be situated at an already disturbed area.

4. Eucalyptus and Widdows Islands. - Purchase entire islands consisting of 120 acres. Eucalyptus Island has significant upland habitat which has been designated a natural area by DMRP. Widdows Island is a small island currently used for agricultural purposes and the island will be allowed to revert to native vegetation and be managed for wildlife. A portion of the island would be developed for recreation with 15 campsites, 10 picnic sites, and 4 chemical toilets.

5. Grand Island. - Preserve 100 acres of Grand Island currently used as a dredged material disposal site. This site has been proposed as critical habitat for the Federally designated threatened Sacramento anthicid beetle, and has significant mature riparian habitat. A major recreation area would be developed on this island which would include 100 campsites, 50 picnic sites, and a boat launch ramp and day-use dock. These sites would be developed in nonsensitive areas to minimize impacts to the anthicid beetle and significant vegetation.

6. Headreach, Fern, Lost Lake, and Tule Islands. - Purchase all four islands totaling 300+ acres. These islands provide a diverse mix of upland and marsh habitats. The freshwater marsh and open water complex provide valuable wintering areas for ducks. The rare black rail is also found in this habitat type. At Headreach Island, a boater destination site would be developed which would consist of a dav-use dock and two chemical toilets.

7. Middle River. - Purchase 45 acres in fee on Union Island which has approximately 25 acres of significant remnant riparian vegetation and 20 acres of fallow agricultural lands. A recreation area including 20 campsites and 24 picnic sites will be constructed on the 20-acre portion to avoid impacts on the natural habitat.

8. Middle River and Latham Slough Channel Islands. - Purchase 290 acres of channel tule islands with some riparian habitat. This area was designated a natural area by DMRP. A boater destination site will be located on one of these islands. It would be placed in an area which has already been impacted by previous developments.

1/ Acreage of some islands in this report was estimated to the nearest 10 acres.

9. Old River. - Purchase islands near the junction of Old River and Tom Paine Slough totaling approximately 220 acres. The upland islands have well-developed oak-riparian habitat unique from other riparian habitats in the Delta. A canoe-in campground consisting of 10 primitive sites would be placed on one of the channel islands.

10. Potato Slough Channel Islands. - Purchase in fee, from the San Joaquin River to and including Little Potato Slough, channel islands totaling 200 acres. Important marsh habitat designated natural and scenic areas by DMRP.

11. Sevenmile Slough. - Purchase 20-acre island with riparian-marshland habitat. The slough was designated a natural area by DMRP. A fishing access site would be located along this slough adjacent to the island which would include a car-top boat launching ramp, 8 picnic sites, and 25 parking spaces.

12. Spud and Hog Islands. - Purchase Spud Island (115 acres) and Hog Island (180 acres) which are predominantly upland habitat and freshwater marsh. Designated a natural area by DMRP.

13. South Fork of Mokelumne River. - Purchase entire 10-acre island, located near the mouth of Sycamore Slough. The area has diverse vegetation which may be a remnant example of an original Delta vegetational community. It is designated a natural area by DMRP.

14. Quimby, Little Mandeville (including Old River Islands), Rhode, Mildred, and Medford Islands. - Purchase in fee these islands totaling 3,454 acres (Quimby, 769 acres; Little Mandeville, 376 acres; Rhode Island, 92 acres; Medford, 1,219 acres; Mildred, 998 acres). These islands provide excellent wildlife habitat because of the diverse mix of upland, agricultural, riparian, marsh, and tule islands. Old River Islands and Rhode Island are designed scenic areas by DMRP. Quimby, Little Mandeville, Mildred, and Medford and Rhode Islands would be developed into a wildlife refuge. Medford and Mildred Islands are currently used for agricultural purposes and would be managed to provide a food source for waterfowl. On Mildred Island a boater destination site would be developed and a 50-acre riparian grove will be preserved.

15. Webb Tract. - Purchase 230 acres on northside of Webb Tract including an existing lake to preserve riparian and wetland habitat.

16. Shin Kee Tract. - Purchase 50 acres at the headwater of White Slough to protect approximately 25 acres of significant freshwater marsh area and some riparian vegetation. Also, two State-designated rare animals (giant garter snake and California black rail) have been sighted in the vicinity (DFG, 1979). The marsh areas and islands are designated as natural areas and the sloughs as scenic areas by DMRP. A recreation area would be developed on the remaining 25 acres adjacent to the marsh which would include 100 campsites and 30 picnic sites.

17. Trapper Slough. - Acquire public interest on 100 acres. This freshwater marsh supports muskrats, a wide variety of birds, as well as a highly productive fishery. Trapper Slough is a designated natural area by DMRP.

18. Beaver Slough. - East of Blossom Road, construct setback levees with no bank protection on waterside and acquire public interest in approximately 50 acres to protect riparian habitat. This area has extensive riparian vegetation with many snags in the water making it inaccessible to all but small, slow boats, thus preserving the wildlife habitat. The area is also surrounded by agricultural land which is an important winter habitat for the sandhill crane.

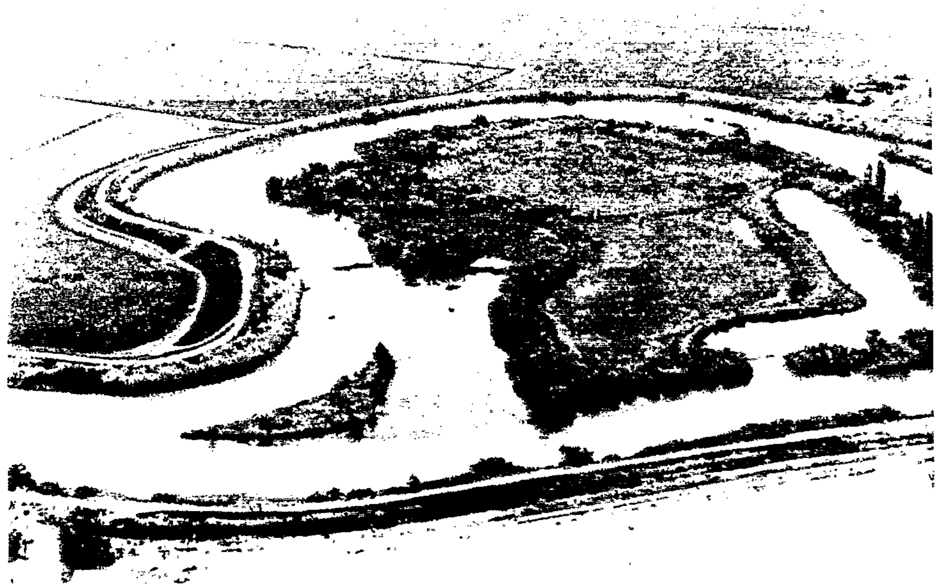
19. Hog Slough. - Along entire slough, construct setback levees with no bank protection on waterside and acquire public interest on 100 acres to protect riparian habitat. The California hibiscus, a Federal candidate species, has been found here. In the agricultural fields, on either side of the slough, is important winter habitat for the sandhill crane which has been designated by DFG as a significant habitat. This area has been designated a scenic area by DMRP.

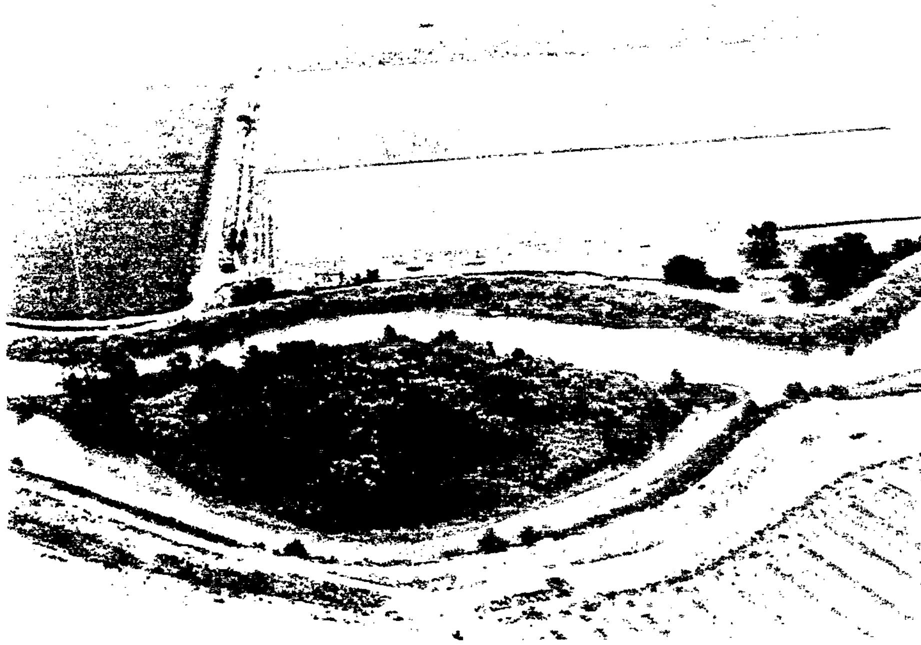
20. Mokelumne River. - Acquire public interest on 125 acres and construct setback levees from New Hope Landing to Interstate 5. The river has marsh, riparian, and upland habitat and is an important ecological area. The area is habitat for the State-listed rare giant garter snake and is designated a natural area by DMRP.

40. All the fish and wildlife enhancement measures except the use of setback levees (numbers 18, 19, and 20) were included in each of the candidate plans. The three measures which proposed the use of setback levees were incorporated into the System and Modified System flood control candidate plans. For the Incremental and Polder flood control candidate plans, setback levees would only be used on Brack Tract along Hog Slough. This is due to the fact that the remaining tracts where setback levees could be used were economically infeasible and therefore did not qualify for the Incremental or Polder Plans.

WILDLIFE REFUGE

41. Measure 14 proposes the development of a wildlife refuge on Little Mandeville, Medford, Mildred, Quimby, and Rhode Islands. The wildlife refuge could be included in the National Refuge System if the FWS determines that the refuge would be consistent with the National Migratory Bird Management Program and agrees to administer the refuge. At the time this report was prepared,

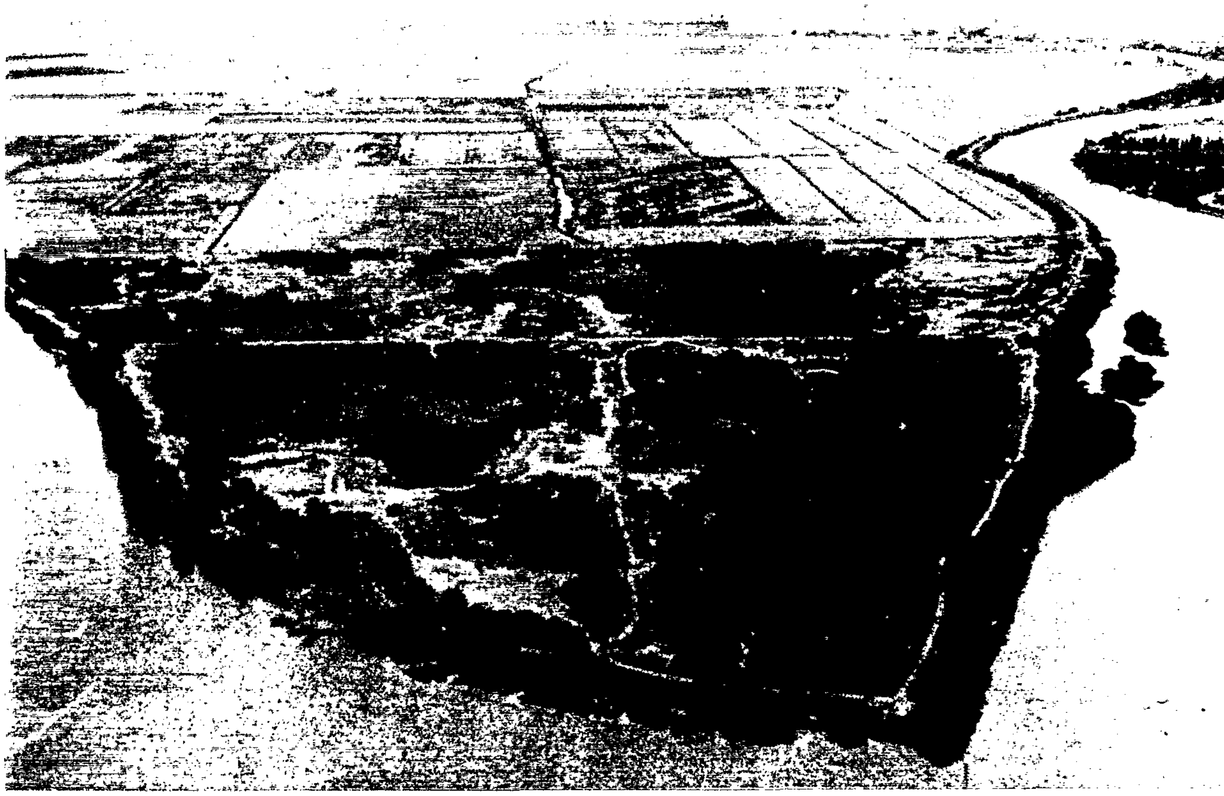




Measure 2 — Berm Islands near Coney Island

C-103176

Measure 4 — Widdows Island



Measure 5 — Grand Island

DFG Photo

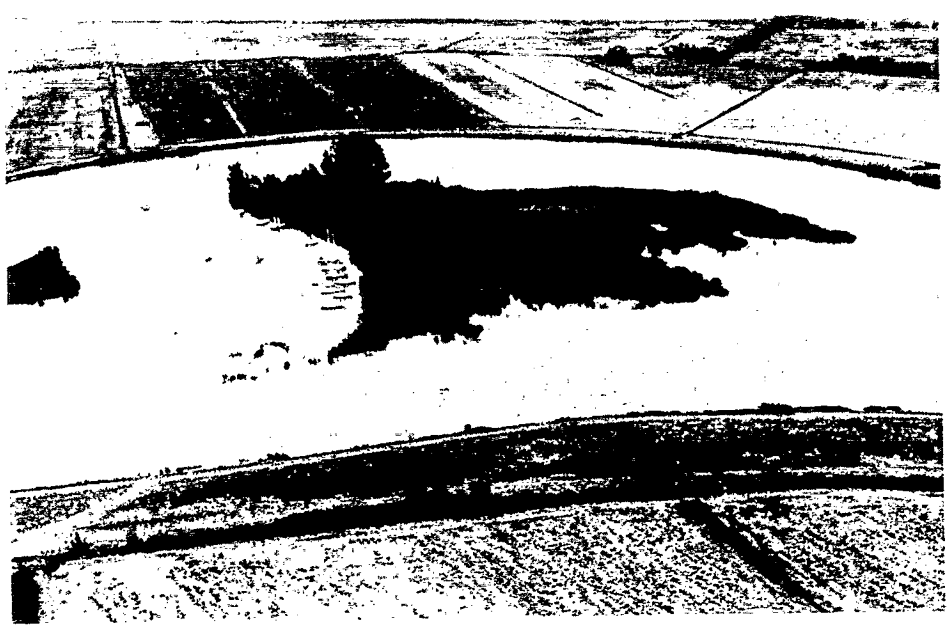
Measure 3 —
Disappointment Slough
Channel Islands

Measure 6 — Fern Island

Measure 8 — Latham Slough Channel Islands

**Measure 8 —
Middle River
Channel Islands**

C-103180



Measure 10 — Potato Slough Channel Islands

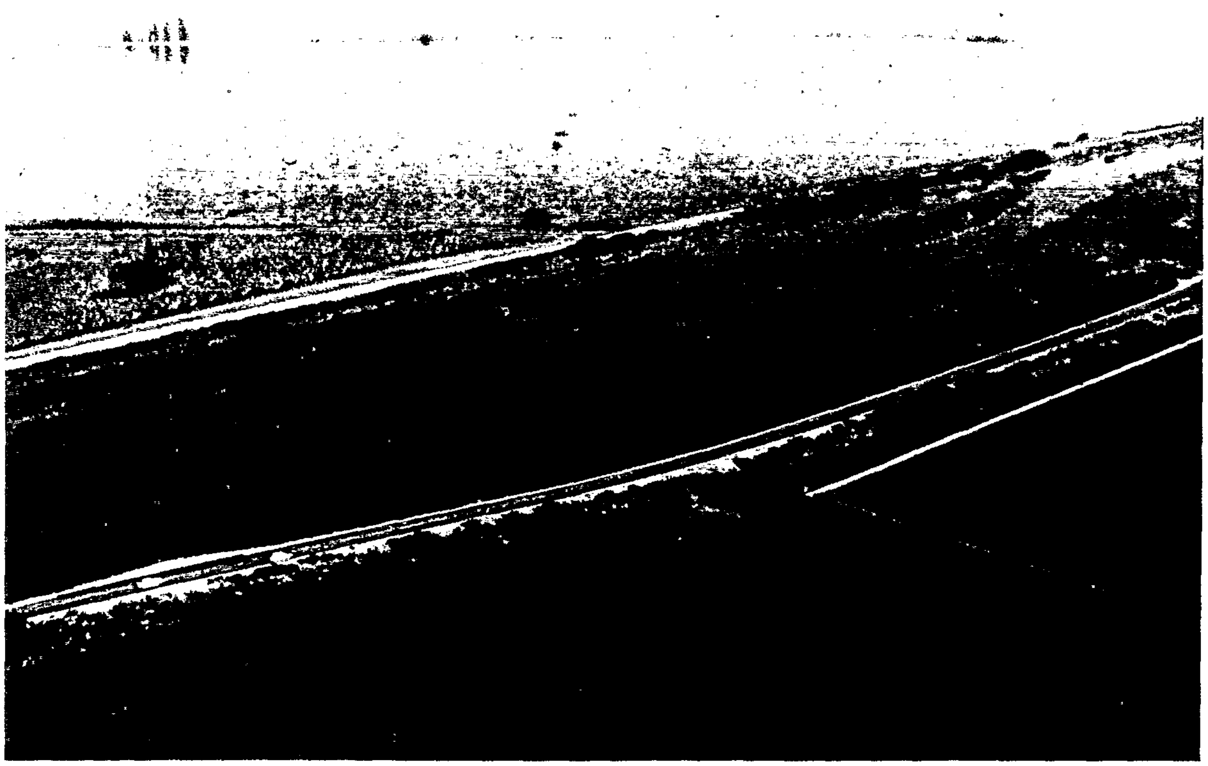
C-103181

Measure 12 — Spud Island

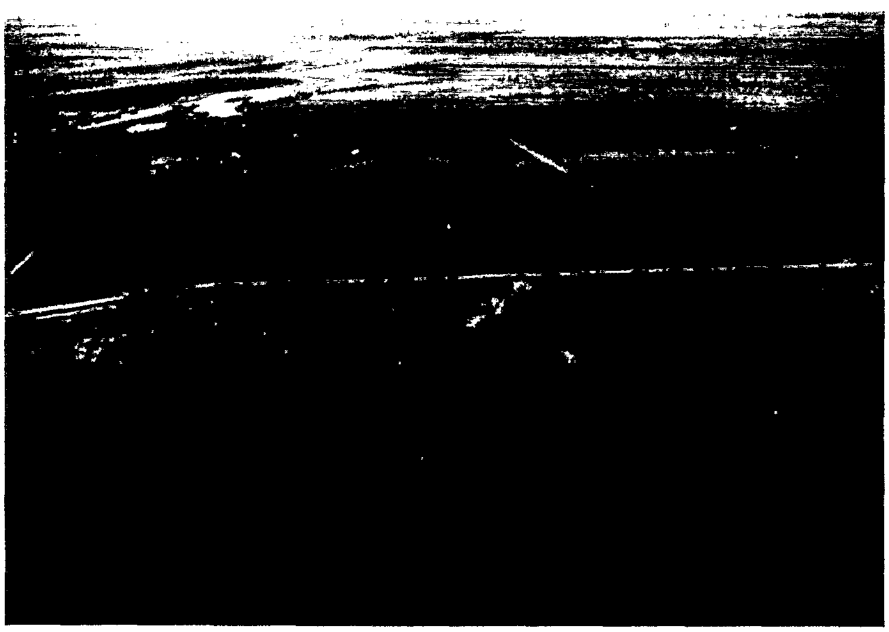
Measure 12 — Hog Island

C-103182

Measure 14 — Quimby Island



Measure 17 — Trapper Slough



Measure 16 — Shin Kee Tract

Measure 18 — Beaver Slough

FWS had not provided an unqualified statement regarding the administration of the refuge. Coordination will continue with FWS during the review of the draft report to determine the appropriate extent of Federal participation in the refuge. For the purpose of this draft report it was assumed that the islands designated for the refuge would be developed as a Wildlife Management Area to be cost-shared and operated and maintained by non-Federal interests.

42. Several scenarios were considered for developing and operating the wildlife area. One method of operating the wildlife area would be to lease the acquired lands back to agricultural interests and allow farming operations to continue. Only certain crops would be allowed, and portions of the crops would not be harvested but would be left as a food source for wildlife. This development strategy would require some minimum levee improvements to protect the investment in the wildlife area. It was assumed that levee improvements would conform to the standards described for the Flood Hazard Mitigation Program described earlier in this appendix. The levee improvements would be made using imported embankment material.

43. Depending on economics, environmental impacts, and the source of borrow material for levee rehabilitation for the project flood control features of the selected plan, it is conceivable that the wildlife area islands could be used as temporary storage areas for embankment material designated for future stage construction. If this were the case, it may be possible to stockpile the embankment material in a manner that would bolster the levees of the wildlife area islands. This may preclude the need to otherwise improve the levees. This alternative is recommended for authorization and would be in detail during continuing studies. This approach would be selected in lieu of the levee improvement alternative if it can be demonstrated that it is clearly advantageous considering both tangible and intangible costs and benefits.

44. Another alternative for developing the wildlife area would be to fill the interior of the designated islands to near mean sea level to create a wetland area. Select material would not be required for filling the islands, and dredged material from adjacent channels or Franks Tract could be used. The environmental effects of dredging and the availability and cost of fill materials at the time of construction would be important factors. This alternative is also recommended for authorization and would be studied during continuing planning. It would be implemented if advantages clearly outweigh disadvantages when all tangible and intangible costs and benefits are considered. Levee improvements would not be required for this alternative.

45. The cost estimates for developing and maintaining the Wildlife Management Area were based on the first alternative with levee improvements conforming to Flood Hazard Mitigation standards. Coordination with FWS and non-Federal interests during continuing planning, if a project is authorized, would determine if one of the other development and management scenarios should be adopted.

ENVIRONMENTAL QUALITY MANAGEMENT MEASURES

46. Additional environmental quality management measures that would be implemented are described below.

47. Recreation features. - Vegetative plantings of native species or other compatible species would be planted and maintained in the recreation areas of the project to provide shade, shelter from wind, and an esthetically pleasing setting for recreation use. Buffer zones between recreation areas and dredged disposal sites not used for agriculture would be planted with a vegetative cover that would provide food and shelter for indigenous wildlife.

48. All recreation areas and facilities would be designed to be compatible with the Delta's natural environment. All buildings and structures located in the proposed public use areas would be designed to be in harmony with the Delta setting. The buildings would be sited away from the edge of the shorelines and would be landscaped utilizing appropriate plant materials to blend them into the project area.

49. Adequate provisions would be made for the collection and disposal of sanitary and solid wastes. Vault toilets with periodic pumping-out and transport of effluents to an appropriate disposal site would be utilized where waterborne facilities are impractical. Those recreation areas with overnight docking accommodations would have sanitary dumping stations for use by boats with holding tanks or centralized convenient sanitary dumping stations would be provided. Where practicable, flush restrooms would be utilized. Solid waste would be collected periodically from the recreation areas and transported for disposal at approved facilities.

50. Off-road vehicle use of the natural areas would be prohibited and provisions for concentrating public access would be made by providing walkways and other suitable facilities placed in appropriate locations. Selected project areas, such as portions of isolated existing levees and berms developed by the levee setbacks constructed for the project, would be allowed to naturally vegetate with riparian growth. Environmental quality features incorporated into the project would be preserved and protected for the purposes intended, and public uses would be generally less intensive than the areas selected primarily for support of recreation.

51. <u>Flood control features</u>. - Vegetation on project levees would be limited to grass and small shrubs to facilitate inspection and maintenance.

FISH AND WILDLIFE ENHANCEMENT COSTS

52. First and annual costs for the fish and wildlife enhancement features are shown in Tables 29 and 30, respectively. First costs are based on October 1981 price level, and annual costs are reported for a 50-year project life at 7-5/8 percent interest rate.

53. The cost estimates shown in Tables 29 and 30 are representative of the enhancement features that would be included with the System and Modified System alternatives. Canal Ranch, McCormack-Williamson, and New Hope Tracts are economically infeasible and would not be included in the Incremental or Polder NED alternatives. Therefore, setback levees for these tracts would be deleted from the fish and wildlife features that would be included with the Incremental or Polder NED alternatives.

FISH AND WILDLIFE ENHANCEMENT BENEFITS

54. The benefits attributable to the Sacramento-San Joaquin Delta Investigation fish and wildlife enhancement measures can be divided into monetary and nonmonetary benefits. Tangible monetary benefits are calculated on the basis of recreation use of facilities provided as part of the recreation plan and benefits to sport and commercial fisheries and hunting of game birds as part of the fish and wildlife enhancement measures. These benefits are included in the benefit analysis of those accounts. However, there are certain intangible benefits in which monetary values cannot be

TABLE 29
FIRST COST
FISH AND WILDLIFE ENHANCEMENT
($1000)

SUB NO.	DESCRIPTION	FEDERAL				NON-FEDERAL					TOTAL FIRST COST
		LEVEES	E & D	S & A	TOTAL	LANDS	RELOCATIONS	E & D	S & A	TOTAL	
	ENHANCEMENT AREAS										
1.	Bonetti Island					83				83	83
2.	Coney Island Berm Islands					125				125	125
3.	Disappointment Slough					750				750	750
4.	Eucalyptus and Widdows Islands					367				367	367
5.	Grand Island					250				250	250
6.	Headreach, Fern, Lost Lake and Tule Islands					750				750	750
7.	Middle River (Union Island)					155				155	155
8.	Middle River Channel Islands					726				726	726
9.	Old River Channel Islands					549				549	549
10.	Potato Slough Channel Islands					500				500	500
11.	Sevenmile Slough					52				52	52
12.	Spud and Hog Islands					738				738	738
13.	South Fork Mokelumne River					28				28	28
15.	Webb Tract					639				639	639
16.	Shin Kee Tract					162				162	162
17.	Trapper Slough					250				250	250
18.	Beaver Slough					125				125	125
19.	Hog Slough					317				317	317
20.	Mokelumne River					396				396	396
	Total - Enhancement Areas					6,962				6,962	6,962
14.	WILDLIFE MANAGEMENT AREA										
	Levees-Initial Construction	13,000	1,560	1,040	15,600	9,123	34	4	4	9,165	24,765
	Levees-Stage Construction	13,671	1,641	1,088	16,400	-	105	12	8	125	16,525
	Total - Wildlife Management Area	26,671	3,201	2,158	32,000	9,123	139	16	12	9,290	41,290
18., 19., 20.	SETBACK LEVEES*										
	Brack Tract	102	12	9	123	302	-	-	-	302	425
	Canal Ranch	333	40	26	399	135	-	-	-	135	534
	McCormack-Williamson	1,835	220	147	2,202	600	-	-	-	600	2,802
	New Hope	3,428	413	275	4,116	521	-	-	-	521	4,647
	Total - Setback Levees	5,698	685	457	6,840	1,558				1,558	8,398
	Total - Fish and Wildlife Enhancement	32,369	3,886	2,585	38,840	17,643	139	16	12	17,810	56,650

*Net cost increase as a result of using setback levees

TABLE 30
ANNUAL COST
FISH AND WILDLIFE ENHANCEMENT
($1000)

MEASURE NO.	DESCRIPTION	FEDERAL INTEREST	FEDERAL AMORTIZATION	FEDERAL TOTAL	NON-FEDERAL INTEREST	NON-FEDERAL AMORTIZATION	NON-FEDERAL M&O LEVEES	NON-FEDERAL M&O WILDLIFE AREA	NON-FEDERAL TOTAL	TOTAL ANNUAL COST
	ENHANCEMENT AREAS									
1.	Bonetti Island				6	-			6	6
2.	Coney Island Berm Islands				10	-			10	10
3.	Disappointment Slough				57	1			58	58
4.	Eucalyptus and Widdows Islands				28	1			29	29
5.	Grand Island				19	1			20	20
6.	Headreach, Fern, Lost Lake and Tule Islands				57	1			58	58
7.	Middle River (Union Island)				12	-			12	12
8.	Middle River Channel Islands				55	1			56	56
9.	Old River Channel Islands				42	1			43	43
10.	Potato Slough Channel Islands				38	1			39	39
11.	Sevenmile Slough				4	-			4	4
12.	Spud and Hog Islands				56	1			57	57
13.	South Fork Mokelumne River				2	-			2	2
15.	Webb Tract				49	1			50	50
16.	Shin Kee Tract				12	-			12	12
17.	Trapper Slough				19	1			20	20
18.	Beaver Slough				10	-			10	10
19.	Hog Slough				24	1			25	25
20.	Mokelumne River				30	1			31	31
	Total - Enhancement Areas				530	12			542	542
14.	WILDLIFE MANAGEMENT AREA									
	Initial Construction	1,190	30	1,220	698	18	99	241	1,056	2,276
	Stage Construction	358	8	366	-	-	-	-	-	366
	Total - Wildlife Management Area	1,548	38	1,586	698	18	99	241	1,056	2,642
18., 19., 20.	SETBACK LEVEES*									
	Brack Tract	9	1	10	23	1	-	-	24	34
	Canal Ranch	30	1	31	10	-	-	-	10	41
	McCormack-Williamson	168	4	172	46	1	-	-	47	219
	New Hope	315	8	323	40	1	-	-	41	364
	Total - Setback Levees	522	14	536	119	3	-	-	122	658
TOTAL		2,070	52	2,122	1,347	33	99	241	1,720	3,842

*Net cost increase as a result of using setback levees.

C-103191

assigned but which have significant value. Many of these benefits would occur in areas that have been identified as significant natural areas by FWS and DFG in their Delta Wildlife Habitat Protection and Restoration Plan; Delta Master Recreation Plan (DMRP), the Resource Agency; Delta Action Plan, Delta Planning Council (DAPC); and Environmental Atlas, July 1979, U.S. Army Corps of Engineers.

Intangible Benefits

55. A wetland serves as a "nutrient trap" which holds onto entering nutrients. This can be a major contributor to the food web, because nutrients such as nitrates can be exported from wetlands through water outflow as well as contribute to productivity within the wetland. Also, this storage function can be used for tertiary treatment of human sewage (National Symposium on Wetlands, November 1978).

56. Qualitative research in the north Pacific coast has established the importance of shoreline wetlands to fish and shellfish populations in associated waters. The wetlands in the Delta adjacent to open waters provide significant nursery habitats for many species of fish including important commercial and game fish. For many species of wildlife, wetlands provide food, breeding grounds, nesting materials or sites, molting grounds, resting areas, protection from weather, and cover. In addition, seasonally flooded wetlands are valuable to wintering waterfowl which depend on the invertebrate populations to obtain the necessary protein for egg laying. According to the DFG (1979) ". . . less than 10 percent of the more than 5 million acres (of wetlands) which originally occurred in the state remain today." The remaining wetland habitat is highly important to numerous wildlife species. In the

Delta there are approximately 12,000 acres of marshlands and 7,000 acres of riparian habitat; of this figure, the EQ Plan would protect 1,500 acres of marshland and 500 acres of riparian habitat. DFG (1979) reports that "Riparian habitat supports a greater variety of wildlife than any other type. The continuing loss of this habitat type is of special concern to the Department of Fish and Game."

57. Five species of birds, two mammals, one reptile, two insects and fifteen plants that may be found in the Delta area are listed as rare, threatened, or endangered, or are listed as candidate species by the DFG and FWS. The greater the variety of organisms in an ecosystem, the more stable the system. All native species (and varieties) in the Delta must be considered important contributors to the stability and predictability of the Delta ecosystem. The Delta Wildlife Habitat Protection and Restoration Plan (Madrone Associates, 1980) explains, "The value of preserving these species is based on the premise that once lost, a particular genetic combination is gone forever, along with its role in ecosystem function, its scientific interest and its potential for human use or enjoyment."

58. The rate at which species are becoming extinct in the world is rapidly accelerating. The world's gene pool is a resource that is being depleted before all its uses are known (in agriculture, medicine, ecological stability, etc.). Maintaining the Delta's diversity is important to the Delta ecosystem and the world's gene pool.

59. The Delta Wildlife Habitat Protection and Restoration Plan (Madrone, 1980) explains the Delta's importance to endangered species, "The reduction of tule marshes to remnants has probably contributed to the gradual reduction or

extinction of many native fish species such as thick-tail chub, Sacramento perch, hitch, and tule perch.

60. Freshwater marshes are essential habitat for two animals listed by the DFG as rare, the California black rail and the giant garter snake. Five species of plants that are considered rare or species of concern by the California Fish and Game Commission grow in marshlands of the Delta.

TANGIBLE BENEFITS

61. The tangible monetary benefits of the fish and wildlife enhancement areas were primarily based on the percentage of total recreation benefits that the fish and wildlife enhancement areas would support. This was considered justified since total recreation is composed of general recreation activities (picnicking, boating, camping, hiking, etc.) and fish and wildlife activities (fishing, hunting, bird watching, nature walks, etc.). FWS determined from survey data obtained by DWR (Cajucom and Associates, 1980) that approximately 37 percent of the visitors to the Delta participate in fish and wildlife activities dependent on the fish and wildlife resources. Assuming that these visitors have the same point of origin characteristics as the Delta users, then 37 percent of the total recreation benefits would be attributable to fish and wildlife resources. This percentage was applied to the total annual recreation benefits of $20,860,000 to obtain annual benefits of $7,802,000 which were considered to be the primary tangible monetary benefits of the fish and wildlife enhancement areas. Additional fish and wildlife benefits were based on reduced waterfowl losses due to disease, habitat improvement, and other contributions to the National Waterfowl Management Program, reduced crop depredation, and hunting and visitation at the Wildlife Management Area.

These average annual benefits were estimated at least $322,000. Total average annual fish and wildlife enhancement benefits equaled $8,124,000.

COORDINATION

GENERAL

62. During these studies, the Corps of Engineers maintained coordination with Federal and non-Federal agencies with possible interest in the recreation, fish and wildlife, and environmental quality enhancement potential of the project. Information was solicited regarding the various agencies' current and future plans for recreation development and needs within the project area. In addition, meetings were held with the Delta reclamation districts and private landowners. The following paragraphs identify the agencies and organizations contacted and contain a synopsis of their position.

FEDERAL

63. U.S. Fish and Wildlife Service (FWS). - FWS has expressed an interest in the development of a National Wildlife Refuge in the Delta and favors recreation developments which afford access to fishing, hunting, and other uses of fish and wildlife resources. FWS is also concerned about impacts of recreation users on the Delta's resources. FWS recognizes the need for careful recreation planning. FWS input was used to modify the recreation plan to minimize impacts and to maximize the opportunities for mitigation and enhancement.

STATE

64. California Department of Water Resources (DWR). - The recreation, fish and wildlife enhancement, and environmental quality plans have been developed quite closely with DWR. The recreation plan was prepared based on information collected by DWR surveys of existing use and demand (Cajucom, 1981) and on the potential recreation sites proposed in DWR's Delta Recreation Concept Plan (Geidel and Moore, 1980).

65. California Department of Fish and Game (DFG). - The recreation plan was coordinated with DFG and changes were made to the recreation plan to minimize impacts to the Delta's natural resources. DFG is in general agreement with the proposed plan and changes made as a result of the coordination. Like FWS, DFG saw ample opportunity for mitigation and potential enhancement on lands proposed for recreation sites. In addition, the DFG and FWS report "Sacramento-San Joaquin Delta Wildlife Habitat Protection and Restoration Plan" (December, 1980) was reviewed and an attempt made to avoid conflicts with the Plan. In fact, many of the recreation and fish and wildlife features of the proposed plan were selected to meet guidelines described in the Plan. These guidelines include:

1. The most valuable channel islands should be secured through easements, purchase, or other arrangements, using public funds to protect these important wildlife areas.
2. Restoration of areas of riparian forest should be encouraged through dedication of land which can be subjected to occasional seasonal flooding.
3. Public funds or private land trust funds should be used to acquire marginal farmlands. These areas would be managed by a responsible public agency such as FWS or DFG for wildlife habitat.

66. Other State Agencies. - During coordination with DWR, meetings were held with the California Department of Parks and Recreation, California Department of Boating and Waterways, California Department of Transporation, and the State Lands Commission. All agencies recognized the need for increased public access for the Delta. The State Lands Commission indicated a willingness to trade State lands in the Delta for lands required for recreation.

LOCAL

67. San Joaquin County. - Several meetings were held with representatives of the San Joaquin County Planning Department, Parks and Recreation Department, County Board of Supervisors, and the County Parks and Recreation Commission during which information was gathered on potential recreation sites, areas of heavy use, and areas of interest to San Joaquin County. The plan was presented to the county; and the county's initial major desires were as follows: Limit construction of new access roads which would require future county maintenance; minimize, where possible, conflicts with agriculture; and insure selected sites were compatible with existing and future recreation facilities.

68. Solano County. - Solano County expressed interest in specifically participating in the development of the Rio Vista fishing access site as this had been identified by the county as a desired development.

69. Contra Costa County (East Bay Regional Park District). - This agency expressed an interest in the need for recreation in the Delta. Specific comments were considered in the development of this plan.

70. Delta Advisory Planning Council. - Comments were received on the recreation plan and were considered in the final formulation.

71. Local Landowners and Delta Reclamation Districts. - Meetings were held on 27 May, 19 June, and 23 July 1981 with local interests to discuss various aspects of the proposed project including recreation. In general the comments received reflected the concerns of the landowners and reclamation districts over opening new areas to public access which would result in increased conflicts with agricultural operations, increased vandalism, and threats to public safety due to heavy seasonal agricultural traffic and spraying. Changes were made to locations of recreation sites and the proposed trail system in response to the constructive comments received at these meetings and subsequent letters to minimize potential conflicts. The establishment of new recreation areas which include overnight camping appear to be of greatest concern, because of potential vandalism problems as a result of the intrusion of recreationists into new areas of the Delta and because of the extended length of stay. However, it was recognized that the increased opportunity for control afforded by concentrated use at campgrounds, picnic sites, and fishing access sites may actually reduce vandalism caused by the present indiscriminate use throughout the Delta.

FUTURE COORDINATION

72. Coordination with appropriate Federal and non-Federal entities will continue to insure that the needs and desires of all interested parties are evaluated. Additional coordination will be conducted on the recreation plan and fish and wildlife enhancement with the National Marine Fisheries Service, which has reviewed other aspects of the study; National Park Service and State

Historic Preservation Office; and the State Water Resources Control Board. Refinements to the recreation, fish and wildlife, and environmental quality plans will be made when necessary as a result of this continued coordination.

SPECIAL PROBLEMS AND RECOMMENDED SOLUTIONS

73. In view of the concerns of local interests over increased trespass and vandalism potential and considering the size and complexity of the Delta, special consideration should be given to insure adequate enforcement patrol. One solution to the problem would include contracting with local enforcement agencies by the project sponsor(s) responsible for operation and maintenance to secure additional personnel to provide the necessary patrol capability.

74. One comment that was received from virtually all potential non-Federal sponsors was that the cost of operation and maintenance may prohibit participation in future recreation development. One recurring suggested solution is the institution of user and recreation fees to cover the cost of operation and maintenance. Such fees would be permitted, and specific schedules of fees would be determined during coordination of continuing planning activities.

MANAGEMENT AND COST SHARING

FEDERAL

75. Federal (Corps of Engineers) responsibility for the recreation, fish and wildlife, and environmental quality features of the proposed project includes coordination and preparation of preliminary conceptual plans as described

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herein; preparation of more detailed conceptual plans for the development if a project is authorized, including guidelines for administration, operation, and maintenance; and preparation of plans and specifications and supervision of construction. The Corps of Engineers would provide one-half the separable cost of recreation development and construct the recreation developments. The Corps would also provide 100 percent of the cost for Federally administered fish and wildlife developments (i.e., anadromous fish, migratory birds, and endangered species) and up to 75 percent of the cost of other fish and wildlife habitat improvement. A contract would be developed between the non-Federal agencies sponsoring recreation, fish and wildlife, and environmental quality, and the Corps and would include these local cooperation requirements. For Federally administered fish and wildlife enhancement areas, the FWS would advise on the need and agree to administer the completed developments. All of this activity would be closely coordinated with other Federal and non-Federal interests to insure that all applicable requirements are included.

NON-FEDERAL

76. Non-Federal responsibilities for the recreation, fish and wildlife enhancement, and environmental quality features of the project include the provision of lands for the recreation development, contribution of not less than one-half the cost of recreation development (not less than one-fourth the cost of fish and wildlife habitat improvement), and assumption of all administration, operation, and maintenance of the completed developments, except for Federally administered fish and wildlife developments. For those recreation sites which would be developed on berms and levees for which construction and maintenance easements would be obtained, additional rights in

the lands could be required to permit public use of these areas. A letter of intent is required from the non-Federal sponsoring public agencies indicating their interest, support, and intent to participate if a project is authorized. This letter or letters would accompany the Corps final feasibility report when forwarded to Congress recommending authorization of a project. A formal contract for cost sharing, administration, operation, and maintenance by non-Federal agencies must be entered into with the Corps of Engineers prior to construction.

THE CANDIDATE PLANS

1. This section contains a comprehensive discussion of the candidate plans which were identified and analyzed in the preceding sections. The plans are described under the headings: No Action Plan; System Flood Control Plan; Modified System Flood Control Plan; Incremental Flood Control Plan; and Polder Flood Control Plan. The purpose of this section is to present adequate information so that the overall scope of each plan may be readily understood and visualized. Included are generalized descriptions of plan components; their functions and interrelationships; and significant design, construction, and operation and maintenance aspects. The accomplishments and the costs and benefits of each plan are also presented. A sensitivity analysis discusses the impact on costs and benefits of the without-project assumptions regarding the Peripheral Canal and the restoration of flooded islands. Environmental, cultural, social, and economic effects of the candidate plans are discussed in detail in the EIS and summarized in Tables 8 through 11 of the main report.

NO ACTION PLAN

PLAN DESCRIPTION

2. The No Action Plan means that no Federal interest would be expressed for providing improvements to reduce the frequency of flooding and salinity intrusion in the Delta. Similarly, there would be no Federal interest in preserving scenic values, preserving and enhancing recreational opportunities, or providing measures for fish and wildlife enhancement. Under the No Action

Plan there would be no comprehensive plan of improvement for flood control, recreation, or fish and wildlife enhancement.

3. The No Action Plan represents conditions expected to exist in the Delta in the future in the absence of a plan of improvement which would address the identified water resource problems and opportunities. The No Action Plan serves as a basis against which alternative plans can be compared to determine the effects of those plans and is synonymous with the without-project condition. The adopted without-project condition assumes that the Peripheral Canal would be constructed and placed in operation and that islands that flood in the future would be restored.

PLAN ACCOMPLISHMENTS

4. Flood Control. - No Federal action would be taken to reduce flood damages in the Delta. The frequency of flooding would probably increase over time without significant non-Federal mitigative efforts. Increased frequency of flooding would be expected because the continual lowering of Delta island surfaces results in less stable levees. The repair of future levee failures and island restoration would probably have to be accomplished by non-Federal interests. Equivalent average annual flood damages expected to occur with the No Action Plan are presented in Table 31.

5. Recreation. - No Federal action would be taken to alleviate recreation problems. There would continue to be a lack of public recreation facilities. Land-based recreationists would continue to have difficulty gaining access to Delta waterways.

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TABLE 31

AVERAGE ANNUAL EQUIVALENT WITHOUT-PROJECT DAMAGES [1]
(WITH PERIPHERAL CANAL)
($1,000)

ISLAND	FLOOD DAMAGES	WATER QUALITY DAMAGES	TOTAL
ANDRUS-BRANNAN	5,178	1,209	6,387
ATLAS	4	-	4
BACON	1,671	233	1,904
BETHEL	1,241	32	1,273
BISHOP-WEST	226	14	240
BOULDIN	3,155	938	4,093
BRACK WEST	1,422	135	1,557
BRADFORD	357	90	447
BYRON	643	24	667
CANAL RANCH WEST	303	35	338
CONEY EAST	22	10	32
DEAD HORSE	49	-	49
EMPIRE	1,242	130	1,372
FABIAN	-	-	-
HOLLAND	470	128	598
HOTCHKISS	2,511	36	2,547
JERSEY	365	202	567
JONES, LOWER ROBERTS WEST	3,500	374	3,874
KING	473	79	552
MANDEVILLE	1,579	306	1,885
McCORMACK-WILLIAMSON	182	6	188
MCDONALD	1,554	491	2,045
MEDFORD	302	39	341
MILDRED	119	31	150
NEW HOPE WEST	186	1	187
ORWOOD	407	10	417
ORWOOD UPPER	150	14	164
PALM	256	89	345
PESCADERO	340	11	351
QUIMBY	37	12	49
RINDGE	1,590	432	2,022
RIO BLANCO	56	1	57
ROBERTS, UPPER AND MIDDLE AND DREXLER	954	40	994
SARGENT-BARNHART	74	-	74
SHERMAN	1,471	451	1,922
SHIMA WEST	62	13	75
SHIN KEE WEST	240	2	242
STATEN	1,331	515	1,846
STEWART	159	7	166
TERMINOUS WEST	5,874	794	6,668
TWITCHELL	484	191	675
TYLER	1,480	368	1,848
UNION	-	-	-
VEALE	326	12	338
VENICE	1,370	251	1,621
VICTORIA	459	164	623
WALNUT GROVE	-	-	-
WEBB	1,243	522	1,765
WOODWARD	587	65	652
WRIGHT-ELMWOOD WEST	22	6	28
WRIGHT ELMWOOD EAST	42	14	56
TOTAL	45,768	8,527	54,295

[1] 7-5/8 percent interest, 50-year amortization.

6. Fish and Wildlife. - No Federal action would be taken to preserve scenic values or to enhance fish and wildlife resources.

EFFECTS OF THE PLAN ON THE ENVIRONMENT

7. Water Quality. - Maintenance of water quality in the Delta is considered of prime importance and is reflected in the State Water Resources Control Board's Water Quality Plan for the Sacramento-San Joaquin Delta and Suisun Marsh. Suisun Marsh is located north of Suisun Bay immediately west of the Delta and is the largest brackish, contiguous marsh in the United States. Its productivity is dependent on a delicate balance between freshwater and saltwater. Reduction in Delta outflow caused by increased water diversion would result in the marsh becoming more saline in time (USFWS, May 1978). With no Federal action, levee failures would continue to occur. If failures occur during periods of low Delta outflow (summer), saline water would intrude into the Delta and threaten the marsh. These factors would result in a reduced carrying capacity for waterfowl due to elimination of many of their important food items.

8. Maintenance of water quality would contribute to protection and preservation of the numerous fish and wildlife species dependent on the freshwater marsh and Delta habitat; some of these species, such as the giant garter snake and California black rail, are on the Federal and/or State threatened, rare, and endangered lists. The Delta habitat for waterfowl is essentially limited to natural islands and large blocks of flooded grain fields, primarily corn. The quality of this habitat is dependent on good water quality. Increased salinity could cause agricultural crops to shift to

more salt-tolerant crops which generally are less valuable to waterfowl and reduce waterfowl carrying capacity (USFWS, May 1978).

9. Maintenance of Delta water quality would serve to protect the phytoplankton and zooplankton populations on which the neomysis and, ultimately, striped bass and many other fish species are dependent.

10. Waterfowl. - Flooding of the interior of an island would result in the loss of food source and habitat for waterfowl. The magnitude of these losses would depend on the season and duration of island flooding and therefore are difficult to accurately assess. The Delta is ranked second and Suisun marsh third for biological importance in the entire State of California (USFWS, 1978). Also, the Concept Plan for Waterfowl Wintering Habitat Preservation (USFWS, 1977) describes the Delta as "the most important whistling swan area in the Pacific flyway." The Delta also received high desirability/potential value and high feasibility for waterfowl refuge development by FWS. The DFG designated virtually the entire Delta as key Waterfowl Winter Habitat and Limited Habitat (Wetlands). "Limited Habitat" is "Habitat type that has been significantly reduced from its historical distribution and is of special importance in meeting the general life requirements of a diversity of wildlife species" (DFG, 1979).

11. Fish. - The king salmon runs in the Sacramento-San Joaquin River system support 75 percent of California's commercial catch, in addition to being an important sport fishery. The fish and wildlife agencies have indicated that flooded tracts have little or no advantages for salmon. No specific problems are known, however.

12. Striped bass is a very important sport fish in California with DFG population estimates ranging from 1.6 million to 1.9 million adult fish (State Water Project Agencies, September 1979). Adult bass enter the Delta in the fall or winter. The San Joaquin River and adjacent sloughs, from approximately Antioch upstream to Venice Island in the Central Delta, provide the major spawning areas. Inundated tracts do not appear to offer advantages for striped bass, although sport fishing is often popular and successful for this species on the permanently flooded Franks Tract. Larval bass are not motile and tend to drift with the water currents near the bottom. Therefore, striped bass recruitment could be reduced with a levee failure, when larval bass are drawn into the break area.

13. Other fish species would be impacted due to associated loss of riparian and marsh habitat at the break site. Also, less habitat would be available due to a change from slow moving sloughs to an open-bodied lake. Dead end sloughs such as Beaver, Sycamore, and Hog are habitat for most of the principal resident game fish, such as white catfish, brown bullhead, black crappie, bluegill, and largemouth bass. These sloughs also provide important spawning grounds for the Sacramento splittail and Delta smelt, two native fish species whose range has declined in recent years.

14. Other Birds and Mammals. - There are many upland game species which utilize the Delta islands and would be impacted by a levee failure. Unflooded wheat, corn, and sugar beet fields and pasturelands provide habitat for the ring-necked pheasant, California quail, and mourning dove. The abundance of these species on agricultural lands increases by the proximity to riparian habitat (Rollins, 1977; from FWS/DFG, Dec 1980). In 1977, 80,000 to 90,000

pheasant, 35,000 quail, and 110,000 doves were taken by Delta hunters (FWS/DFG, Dec 1980).

15. Wetlands. - In the Delta there are approximately 12,000 acres of wetland habitat. Flooding can be a major detriment to the wetlands, since it affects the chemical and physical conditions of wetland soils and subsequently the vigor and net primary productivity of wetland plants. With a levee failure, there would be a temporary loss of wetland habitat, since the interior of most islands would be too deep for wetland maintenance when inundated. The associated benefits of wetlands described above would be lost until the island is restored.

16. Esthetics. - The esthetic value of the Delta contributes to all its recreation uses. Beautiful scenery makes all outdoor activities more enjoyable and provides another reason to spend leisure time in the Delta. Wildlife, particularly birds, adds to the Delta's esthetics and brings bird watchers to the area. The Delta scenery and the presence of wildlife provide a recreation opportunity for photographers. The overall enjoyment by the Delta recreation users would deteriorate if flooding continues.

17. Threatened and Endangered Species. - Five species of birds, two mammals, one reptile, three insects, and twelve plants that may be found in the Delta area are listed as rare, threatened, or endangered, or are listed as candidate species by DFG and FWS. These species would continue to be adversely impacted under the No Action Plan.

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SENSITIVITY ANALYSIS

18. Equivalent average annual damages expected under the four alternative without-project conditions are presented in Table 32.

SYSTEM FLOOD CONTROL PLAN (EQ PLAN)

PLAN DESCRIPTION

19. Flood Control Features. - The System Flood Control Plan would provide 300-year flood protection to 54 islands and tracts. Approximately 610 miles of levees on 47 islands would be improved using the stage construction method of levee improvement. Fifteen miles of sheet pile floodwalls would be used on Bethel Island and part of Hotchkiss Tract to avoid the relocation of existing development along the levees on those islands. Setback levees would be used on Canal Ranch and Brack Tract along Hog and Beaver Sloughs to protect existing riparian habitat along those sloughs. Setback levees would be used for the same reason on McCormack-Williamson and New Hope Tracts along the Mokelumne River between New Hope Landing and Interstate 5. Levee improvements on seven islands or tracts (Fabian, Mournian, Pescadero, Pico-Naglee, Stewart, Union, and Walnut Grove) would be limited to shaping the existing levees, which generally conform to project levee cross section requirements, and constructing patrol roads and placing erosion protection. One island in the study area, RD-17, currently complies with the project design criteria. The specific locations of the various types of levee improvements are shown on Plates 2 through 37.

TABLE 32

SENSITIVITY ANALYSIS
NO ACTION PLAN

Without-Project Condition	Flood Damages	Water Quality Damages ($1000)	Total Damages
With Peripheral Canal With Island Restoration (Adopted Condition)	45,768	8,527	54,295
Without Peripheral Canal With Island Restoration	54,315	10,842	65,157
With Peripheral Canal Without Island Restoration	75,292	-	75,292
Without Peripheral Canal Without Island Restoration	90,395	-	90,395

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20. <u>Land Use Regulations</u>. - Land use management would be a required feature of this plan to insure that adverse impacts are prevented or minimized and that the natural and beneficial flood plain values are preserved. This feature would include the enactment and enforcement of zoning regulations which would prevent project-induced urban growth on agricultural islands. Development on urban islands would be required to be consistent with city and county General Plans and the California Environmental Quality Act and would be limited to areas incapable of sustained economic agricultural production. This feature would be a legal requirement of non-Federal interests. It is anticipated that the State would provide the necessary non-Federal assurances for satisfying this requirement.

21. <u>Recreation Features</u>. - Recreation features would consist of 14 recreation areas, 23 fishing access sites, and 8 boater destination sites. In addition, approximately 145 miles of trails would be provided for bicycling, hiking, canoeing, and equestrian use. The trails would link recreation sites together or continue trail access outside the Delta. Approximately 70 miles of trails would be on existing roads. Facilities included in the recreation areas would include picnic sites, boat launching ramps, fishing and boat access, camping, boat docks, and restrooms with showers. The fishing access sites would provide access to the Delta waterways and would have picnic tables, restrooms, and parking facilities. Some of the sites would provide car top launching facilities, whereas others, depending on their location, would offer trailered boat launching facilities. The boater destination sites would provide access to small channel islands and areas accessible only by boat. These sites would have a day-use dock or mooring buoy and some sanitary facilities, depending on the sites. Figure 16 shows the location of the recreation sites and the

proposed trail system. Table 26 lists facilities provided for all of the sites. Detailed site locations are shown on Plates 2 through 37.

22. Fish and Wildlife Enhancement Features. - Fish and wildlife enhancement features would include the acquisition in fee or environmental easement of the areas shown below. These acquisitions would be made to preserve scenic values and to preserve and enhance fish and wildlife resources. Recreation facilities would be established at many of the sites to provide the public with the opportunity to access and enjoy the resources. A Wildlife Management Area would be developed on Little Mandeville, Medford, Mildred, Quimby, and Rhode Islands to enhance waterfowl resources. Levee improvements on the islands in the Wildlife Management Area would be similar to those that would be accomplished under the Flood Hazard Mitigation Program described earlier in this appendix. Such improvements would provide protection from overtopping of a stage expected once in 50 years (50-year flood protection).

23. Alternative means of levee improvement and management of the Wildlife Management Area islands would be studied during continuing planning activities. This would include using the islands as stockpile areas for embankment materials required for future stage construction of the project flood control features. With this alternative, materials would be stockpiled in a manner to bolster the levees of the Wildlife Management Area islands. Material in excess of the needs of the flood control features would be left in place to forego the need for other levee improvements. An alternative management method consisting of raising the island floor elevations to near mean sea level to create wetlands would also be studied. One of these alternatives may be adopted if the tangible and intangible benefits can be shown to exceed the costs.

	Fish and Wildlife Enhancement Feature	Area (Acres)
1.	Bonetti Island	33
2.	Coney Island	50
3.	Channel Islands Disappointment Slough	300
4.	Eucalyptus and Widows Islands	120
5.	Grand Island	100
6.	Headreach, Fern, Lost Lake Tule Islands	300
7.	Middle River Union Island	45
8.	Middle River and Lathan Slough Channel Islands	290
9.	Old River Islands	220
10.	Potato Slough Channel Islands	200
11.	Sevenmile Slough Island	20
12.	Spud and Hog Islands	295
13.	South Fork Mokelumne Island	10
14.	Quimby, Little Mandeville, Rhode, Mildred, Medford Islands	3,454
15.	Webb Island	230
16.	Shin Kee Tract	50
17.	Trapper Slough	100
18.	Beaver Slough	50
19.	Hog Slough	100
20.	Mokelumne River	125
	Total	6,092

24. Mitigation Features. - Coordination with FWS has resulted in the identification of alternative mitigation measures. FWS has indicated that the most significant environmental impact resulting from levee rehabilitation would be the loss of riparian habitat. FWS indicates that full compensation is both reasonable and feasible and can be accomplished through the improvement of habitat values to offset project-induced losses.

25. One suggested approach to mitigation involves the development of riparian forest vegetation on existing agricultural land adjacent to the levee improvements. Conversion could occur naturally or under intensified management. The sites, to be no smaller than 15 acres in size and approximately circular, would be evenly distributed among the islands receiving levee improvements. The other suggested approach would be to provide at least one-half the mitigation on agricultural lands, as described

above, with the remainder of the mitigation to be derived from the management of selected lands included in the fish and wildlife enhancement features.

26. For the purposes of this draft report, mitigation costs were based upon the acquisition of agricultural lands which would be allowed to revegetate naturally. This natural process of development into a mature riparian habitat is expected to take about 40 years. Based on compensation requirements developed by FWS for the Incremental Flood Control Plan, it is estimated that about 3,165 acres of agricultural land would be required for mitigation of impacts resulting from construction of the System Flood Control Plan. If only half of the mitigation is accomplished on agricultural lands, these land requirements would be reduced to about 1,600 acres with an equal amount placed elsewhere on other types of lands in the Delta such as the lands acquired for fish and wildlife enhancement.

PLAN ACCOMPLISHMENTS

27. Flood Control. - The System Flood Control Plan would provide 300-year protection to all the major Delta islands and tracts in the study area. Equivalent average annual damages would be reduced from about $54 million to about $2 million.

28. Recreation. - The potential for recreational use of the Delta would be enhanced. Present recreational use is predominantly waterborne activities with limited water access. Current annual recreation use amounts to 12.3 million visitor days. The recreation plan would provide for 2.4 million additional recreation days annually, which is about one-tenth of the latent demand forecast for the year 2000.

29. Fish and Wildlife. - The system plan would reduce the periodic damages to wildlife habitat due to island flooding. Approximately 6,000 acres of wetlands and wildlife habitat would be purchased and preserved, thus insuring the availability of habitat for the propagation of fish and wildlife indigenous to the Delta.

EFFECTS OF THE PLAN ON THE ENVIRONMENT

30. The primary impact of the System Plan would be the loss of riparian, agricultural, and upland habitat due to the rehabilitation of the existing levees. Table 3.3 of the EIS lists the amount of land that would be affected. Upland habitat would increase by about 4,700 acres as grasses and shrubs are reestablished on the project levees. There would be 720 acres of emergent vegetation removed during construction, and 80 percent is expected to recover in time. The major adverse impacts to wildlife resources would primarily result from the loss of about 1,900 acres of riparian habitat, although a mitigation (compensation) plan as previously discussed would completely offset this. An additional discussion of impacts is presented in the EIS.

DESIGN

31. With the exception of the polder candidate plan, the design characteristics of the candidate plans are similar and only vary in the number of islands improved. Under the System Flood Control Plan, nonproject levee improvements would primarily be confined to the landside of existing levees.

32. Hydrology. - The System Flood Control Plan would not significantly change the hydraulic regime of the Delta. Channel cross sections would not be reduced as the levee improvements would primarily be confined to the landside of existing levees.

33. Foundations and Materials. - The levee rehabilitation was designed to account for the weak and permeable soils in the Delta. As discussed in the technical studies section, the foundation soils are predominantly peats and organic silts and clays. The thickness of the peats varies up to 60 about feet. Generally, a thin stratum of organic silts and clays overlies the peat deposits. The foundation soils beneath the existing levees have been partially consolidated or displaced by the construction and maintenance of the existing levees.

34. Levees. - Levees would be enlarged with imported borrow material. Erosion protection would be placed on the channel side levee slopes to suppress the erosive effects of flood and tidal flows, wind-driven waves, and recreational boat traffic. Levee slopes would be 1 vertical on 2 horizontal on channelside slopes, and 1 vertical on 3 horizontal on landside slopes. Levee crown width would be 16 feet. A landside berm would be used to enhance levee stability in locations where the depth of organic soils exceeds 20 feet and levee height is greater than 20 feet. The berm would have a final slope of 1 vertical on 15 horizontal. Minimum levee freeboard would be 1.5 feet on agricultural islands and 3.0 feet on urban islands.

RIGHTS-OF-WAY

35. Rights-of-way would be required for all levee improvements, recreation features, and fish and wildlife enhancement features. Lands on which the public would be allowed would be acquired in fee. Construction and maintenance easements could be acquired for levee improvements where the public would be denied access. Minimum rights-of-way requirements for the levee improvements are summarized in Table 33. Environmental easements would be acquired on fish and wildlife enhancement lands that would not be open to the public. Rights-of-way would be provided by non-Federal interests.

RELOCATIONS

36. Facilities relocated at Federal expense would be a railroad bridge on New Hope Tract and railroad tracks on Orwood, Upper Orwood, and Veale Tracts. Non-Federal interests would be responsible for the relocation of a highway bridge on New Hope Tract as well as all roads, powerlines, siphons, pumps, gaging stations, and irrigation ditches.

CONSTRUCTION

37. Stage construction was adopted as the primary method of improving the Delta levees. This procedure involves an initial phase of construction which is estimated to be completed in less than 2 years for any given island. Consolidation of foundation soils would take place following the initial construction period. The stage construction method anticipates this action. Therefore, following initial construction, a series of construction periods would ensue to raise or maintain levee cross sections to project design

standards. The number of stages varies with location and foundation conditions, and ranges from 1 to more than 10 stages. Construction quantities for initial construction are summarized in Tables 33 and 34. Stage construction quantities are presented in Table 35. An instrumentation network would be established on each island to monitor levee movement, island subsidence, pore water pressures, and seepage.

38. The construction of recreation facilities located on islands receiving levee improvements would be coordinated with initial levee construction. The construction of all other recreation facilities could commence at the same time as the levee improvement work.

OPERATION AND MAINTENANCE

39. Operation of the flood control, recreation, and fish and wildlife mitigation and enhancement facilities would be a non-Federal responsibility. Flood control improvements would be operated and maintained in conformance with a maintenance manual developed by the Corps in coordination with non-Federal interests. The maintenance manual would carefully distinguish non-Federal maintenance responsibilities and Federal stage construction obligations. Operation and maintenance of the flood control features would conform to the requirements of the Code of Federal Regulations (CFR) Title 33 Chapter 208.10.

ECONOMICS

40. First costs of the flood control features for the System Plan are listed in Tables 36 and 37. Annual costs are presented in Table 38. An economic summary of the System Flood Control Plan flood control features is shown in Table 39. The economics of all features of the plan are summarized in Table 40.

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TABLE 33

SYSTEM FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	LANDS AND DAMAGES			RELOCATIONS								
	PERMANENT EASEMENTS		TEMPORARY EASEMENT	ROADS	BRIDGES	UTILITIES						
	AGRI- CULTURE (Acre)	COMMER- CIAL (Acre)	(Acre)	(LF)	(LS) $	TOWERS (LS) $	POWER- LINES & CABLES (LF)	SIPHONS (LF)	PUMP HOUSES (LS) $	GAGING STATIONS (LS) $	WIND- MILLS (LS) $	IRRI- GATION DITCH (LF)
ANDRUS	144	35	9	0	0	0	10,000	250	18,000	1,000	0	0
ATLAS	32	0	3	0	0	0	0	0	0	0	0	0
BACON	231	0	17	0	0	15,000	10,600	180	29,000	1,000	0	0
BETHEL	42	0	5	13,000	0	0	0	0	0	0	0	0
BISHOP WEST	75	3	1	23,000	0	0	2,000	120	9,000	0	0	0
BOULDIN	495	0	22	0	0	0	8,000	1,250	2,000	0	0	5,000
BRACK WEST	130	0	13	0	0	0	0	360	2,000	0	0	0
BRADFORD	83	7	9	6,500	0	0	4,000	0	2,000	0	3,000	0
BRANNAN	91	0	4	17,000	0	0	0	0	9,000	0	0	3,000
BYRON	141	16	13	0	0	15,000	0	780	7,000	0	0	0
CANAL RANCH WEST	89	0	10	0	0	0	0	240	14,000	0	0	3,000
CONEY EAST	55	0	6	0	0	0	0	0	0	0	0	0
DEAD HORSE	34	0	3	0	0	0	0	0	0	0	0	0
DREXLER	88	0	8	0	0	0	0	0	0	0	0	0
EMPIRE	100	7	13	32,000	0	30,000	7,000	600	5,000	0	0	37,000
FABIAN	32	3	35	21,000	0	0	8,000	0	5,000	0	0	8,000
HOLLAND	159	0	13	35,000	0	0	4,000	840	5,000	1,000	0	20,000
HOTCHKISS	71	19	11	0	0	0	5,000	0	0	0	0	0
JERSEY	51	0	23	18,000	0	0	0	0	0	0	0	0
JONES	299	5	22	61,500	0	0	3,000	1,080	0	0	0	20,000
KING	108	0	11	0	0	0	3,000	960	0	0	0	0
MANDEVILLE	272	0	17	0	0	0	2,000	720	0	0	0	0
McCORMACK-WILLIAMSON	118	0	11	13,500	0	0	0	0	0	0	0	0
McDONALD	271	0	16	0	0	0	1,000	1,080	0	0	0	10,000
NEW HOPE WEST	119	4	13	0	120,000	0	0	240	5,000	0	0	16,000
ORWOOD	82	0	9	0	0	15,000	0	0	0	0	0	0
ORWOOD (UPPER)	45	0	6	0	0	0	0	0	0	0	0	0
PALM	140	0	13	0	0	15,000	0	960	0	0	0	0
PESCADERO	0	0	0	0	0	0	0	600	10,000	0	0	0
RINDGE	287	13	19	0	0	15,000	0	240	9,000	1,000	0	0
RIO BLANCO	28	0	3	3,600	0	0	0	0	0	0	0	0
ROBERTS-UPPER	201	12	22	6,000	0	0	2,000	0	7,000	1,000	0	0
ROBERTS-MIDDLE EAST	164	16	18	0	0	0	2,000	0	11,000	1,000	0	0
ROBERTS-MIDDLE WEST	15	2	2	2,000	0	0	0	0	0	0	0	0
ROBERTS-LOWER EAST	84	8	7	0	0	0	1,500	200	0	0	0	0
ROBERTS-LOWER WEST	136	16	14	22,000	0	0	2,500	400	0	0	0	0
SARGENT-BARNHART	34	0	3	0	0	0	0	0	0	0	0	0
SHERMAN	579	16	24	29,600	0	0	0	0	0	0	0	0
SHIMA WEST	50	0	4	0	0	0	2,000	60	10,000	0	0	0
SHIN KEE	46	0	5	0	0	0	0	0	0	0	0	0
STATEN	309	0	31	8,000	0	0	0	240	10,000	0	0	20,000
STEWART	0	0	0	4,000	0	0	0	660	11,000	0	0	0
TERMINOUS WEST	332	8	22	34,000	0	0	0	0	10,000	0	0	0
TWITCHELL	314	0	15	18,000	0	0	2,000	0	5,000	0	0	30,000
TYLER	299	8	28	38,000	0	0	0	0	10,000	0	0	0
UNION	350	0	35	0	0	0	0	0	51,000	2,000	0	0
VEALE	51	0	51	0	0	15,000	0	240	7,000	0	0	0
VENICE	266	0	15	0	0	0	0	900	11,000	0	0	0
VICTORIA	184	0	19	0	0	0	0	1,560	0	2,000	0	0
WALNUT GROVE	17	1	0	0	0	0	0	0	0	0	0	0
WEBB	233	0	16	0	0	15,000	0	0	5,000	0	0	0
WOODWARD	119	0	11	0	0	15,000	0	1,560	0	0	0	0
WRIGHT-ELMWOOD EAST	17	0	2	8,500	0	15,000	0	110	0	0	0	0
WRIGHT-ELMWOOD WEST	35	0	4	1,500	0	0	0	220	0	0	0	0
TOTAL	7,747	199	706	415,700	120,000	165,000	79,600	16,650	279,000	9,000	3,000	172,000

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TABLE 34

SYSTEM FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	RELOCATIONS		LEVEES						
	TRACKS (LF)	BRIDGES (LS)	CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	INSTRU-MENTATION (LS) $
ANDRUS	0	0	154	337,700	36,000	12,500	179	58,700	20,000
ATLAS	0	0	24	62,000	13,800	4,800	28	3,700	20,000
BACON	0	0	205	964,000	75,300	26,000	231	57,900	20,000
BETHEL	0	0	38	130,300	60,800	21,000	38	7,900	20,000
BISHOP WEST	0	0	73	279,000	29,000	10,400	78	16,700	20,000
BOULDIN	0	0	435	3,256,000	94,000	32,500	495	196,000	20,000
BRACK WEST	0	0	122	1,024,000	53,600	18,700	129	61,400	20,000
BRADFORD	0	0	82	472,000	39,000	13,500	90	28,300	20,000
BRANNAN	0	0	86	622,000	17,200	6,000	91	37,300	20,000
BYRON	0	0	152	170,000	57,000	19,700	157	10,200	20,000
CANAL RANCH WEST	0	0	81	622,000	38,500	13,400	89	37,300	20,000
CONEY EAST	0	0	50	92,000	23,800	8,200	55	5,500	20,000
DEAD HORSE	0	0	32	269,000	13,000	4,500	34	16,100	20,000
DREXLER	0	0	88	276,000	33,000	11,400	91	16,600	20,000
EMPIRE	0	0	128	454,000	55,100	19,100	137	27,300	20,000
FABIAN	0	0	70	0	99,800	34,500	70	0	20,000
HOLLAND	0	0	179	720,300	57,700	20,000	190	43,300	20,000
HOTCHKISS	0	0	67	163,500	27,600	9,600	71	11,700	20,000
JERSEY	0	0	149	1,330,000	82,100	28,400	113	79,800	20,000
JONES	0	0	289	1,449,000	95,400	33,000	304	86,900	20,000
KING	0	0	98	565,000	46,800	16,200	108	33,900	20,000
MANDEVILLE	0	0	213	1,010,000	74,100	85,600	272	60,600	20,000
McCORMACK-WILLIAMSON	0	0	112	506,000	46,000	15,900	118	30,400	20,000
McDONALD	0	0	252	1,049,000	70,000	24,200	271	62,900	20,000
NEW HOPE WEST	0	800,000	116	540,000	47,000	23,000	135	32,400	20,000
ORWOOD	2,000	0	74	349,000	35,400	12,300	82	20,900	20,000
ORWOOD (UPPER)	3,000	0	37	161,000	24,500	8,500	45	9,700	20,000
PALM	0	0	132	463,000	54,300	18,700	140	27,800	20,000
PESCADERO	0	0	152	0	132,200	45,700	152	0	20,000
RINDGE	0	0	279	1,085,000	81,100	28,100	300	65,100	20,000
RIO BLANCO	0	0	28	146,000	17,100	5,900	31	8,000	20,000
ROBERTS - UPPER	0	0	194	678,000	92,800	32,100	213	40,900	20,000
ROBERTS - MIDDLE EAST	0	0	164	320,000	75,800	26,200	181	19,200	20,000
ROBERTS - MIDDLE WEST	0	0	15	15,000	7,200	2,500	16	900	0
ROBERTS - LOWER EAST	0	0	90	100,000	33,300	11,700	93	6,000	10,000
ROBERTS - LOWER WEST	0	0	146	51,000	55,100	19,100	151	3,100	10,000
SARGANT-BARNHART	0	0	26	248,000	12,300	4,300	34	14,900	20,000
SHERMAN	0	0	548	3,942,000	101,000	35,000	595	236,500	20,000
SHIMA WEST	0	0	48	215,000	19,500	6,800	50	12,900	10,000
SHIN KEE WEST	0	0	42	202,000	20,000	6,900	46	12,100	20,000
STATEN	0	0	231	1,331,000	134,600	46,600	309	79,900	20,000
STEWART	0	0	98	0	85,300	29,500	98	0	20,000
TERMINOUS WEST	0	0	319	1,797,000	95,000	32,900	340	107,800	20,000
TWITCHELL	0	0	270	2,042,000	63,200	21,900	314	122,500	20,000
TYLER	0	0	137	992,000	119,300	41,300	144	59,500	20,000
UNION	0	0	175	0	152,000	52,600	0	0	20,000
VEALE	4,000	0	51	189,000	29,200	10,100	62	11,300	20,000
VENICE	0	0	223	1,430,000	65,300	22,600	226	85,800	20,000
VICTORIA	0	0	168	423,000	80,000	27,700	184	25,400	20,000
WALNUT GROVE	0	0	14	0	15,500	0	0	0	20,000
WEBB	0	0	200	1,018,000	67,700	23,400	223	61,100	20,000
WOODWARD	0	0	113	410,000	46,300	16,000	119	24,600	20,000
WRIGHT-ELMWOOD EAST	0	0	18	25,000	8,500	2,900	20	1,500	10,000
WRIGHT-ELMWOOD WEST	0	0	36	148,000	17,000	5,900	39	8,900	10,000
TOTAL	9,000	800,000	7,323	31,675,800	3,026,100	1,109,300	7,781	2,089,100	1,010,000

ISLAND/TRACT	FLOODWALLS					
	CONCRETE (CY)	CEMENT (Ton)	REINFORCING STEEL (Lbs)	SHEET-PILING (SF)	WATER STOP (LF)	JOINT FILLER (LF)
BETHEL	15,900	5,800	2,544,000	855,000	42,800	42,800
HOTCHKISS	5,100	1,300	816,000	144,000	18,000	18,000
TOTAL	21,000	7,100	3,360,000	999,000	60,800	60,800

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TABLE 35

SYSTEM FLOOD CONTROL PLAN
STAGE CONSTRUCTION QUANTITIES 300-YEAR DESIGN
(With Peripheral Canal)

ISLAND/TRACT	STAGE YEAR	LEVEES						UTILITIES	
		CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	SIPHONS (LF)	GAGING STATIONS (LS)
ANDRUS	4	76	105,000	33,000	11,400	76	6,300	0	0
	8	100	139,000	43,400	15,000	100	8,400	0	0
	12	126	162,000	54,900	19,000	126	9,700	0	0
	20	126	176,000	54,900	19,000	126	10,600	0	0
	30	86	120,000	37,300	12,900	86	7,200	0	0
	40	76	105,000	32,700	11,300	76	6,300	0	0
	60	96	134,000	41,600	14,400	96	8,000	0	0
BACON	6	104	320,200	45,200	15,700	104	19,200	180	1,000
	17	173	532,500	75,200	26,000	173	32,000	180	1,000
	40	23	2,900	10,000	3,500	23	200	180	1,000
	60	81	10,000	35,200	12,200	81	600	180	1,000
BETHEL	20	16	41,100	27,000	9,400	16	2,500	0	0
BISHOP WEST	17	10	168,400	3,800	1,300	10	10,100	120	0
BOULDIN	5	162	499,300	70,500	24,400	162	30,000	1,250	0
	10	149	459,400	65,000	22,500	149	27,600	1,250	0
	20	171	526,000	74,300	25,700	171	31,600	1,250	0
	35	216	665,700	94,000	32,500	216	39,900	1,250	0
	80	55	166,500	23,700	8,200	55	10,000	1,250	0
BRACK WEST	8	8	165,000	3,100	1,100	8	9,900	360	0
BRADFORD	10	90	205,000	39,000	13,500	90	12,300	0	0
	20	90	205,000	39,000	13,500	90	12,300	0	0
	40	90	205,000	39,000	13,500	90	12,300	0	0
	80	90	205,000	39,000	13,500	90	12,300	0	0
BRANNAN	1	23	63,000	9,800	3,400	23	3,800	0	0
	6	23	63,000	9,800	3,400	23	3,800	0	0
	12	33	92,000	14,200	4,900	33	5,500	0	0
	26	23	63,000	9,800	3,400	23	3,800	0	0
	60	23	63,000	9,800	3,400	23	3,800	0	0
CANAL RANCH WEST	25	17	55,600	7,100	2,500	17	3,400	240	0
DEAD HORSE	4	7	500	3,000	1,000	7	30	0	0
	10	7	500	3,000	1,000	7	30	0	0
	20	30	2,200	13,000	4,500	30	130	0	0
	30	7	500	3,000	1,000	7	30	0	0
	70	7	500	3,000	1,000	7	30	0	0
DREXLER	3	76	178,900	33,000	11,400	76	10,700	0	0
	10	51	119,000	22,200	7,700	51	7,100	0	0
	32	76	178,900	33,000	11,400	76	10,700	0	0
EMPIRE	4	12	19,700	5,200	1,800	12	1,200	600	0
	8	17	26,400	7,200	2,500	17	1,600	600	0
	16	127	204,300	55,100	19,100	127	12,300	600	0
	29	32	50,900	13,900	4,800	32	3,100	600	0
	54	12	19,100	5,200	1,800	12	1,200	600	0
HOLLAND	4	44	28,000	19,100	6,600	44	1,700	840	1,000
	8	44	28,000	19,100	6,600	44	1,700	840	1,000
	20	119	76,300	51,700	17,900	119	4,600	840	1,000
	30	44	28,000	19,100	6,600	44	1,700	840	1,000
	55	44	28,000	19,100	6,600	44	1,700	840	1,000
HOTCHKISS	30	35	21,800	15,200	5,300	35	1,300	0	0
JONES	18	121	279,000	52,800	18,300	121	16,700	1,080	0
KING	20	2	35,100	800	300	2	2,100	1,080	0
MANDEVILLE	10	110	295,000	48,300	16,700	110	1,700	720	0
	15	44	117,000	19,200	6,700	44	7,100	720	0
	30	74	197,000	32,200	11,100	74	11,800	720	0
	45	36	98,000	15,600	5,400	36	5,900	720	0
McCORMACK-WILLIAMSON	50	46	27,100	20,000	6,900	46	17,000	0	0
McDONALD	4	108	128,400	46,800	16,200	108	7,700	1,080	0
	8	93	110,200	40,200	13,900	93	6,600	1,080	0
	16	118	138,800	50,900	17,600	118	8,300	1,080	0
	24	112	131,900	48,300	16,700	112	7,900	1,080	0
	38	89	105,300	38,400	13,300	89	6,300	1,080	0
	80	67	78,900	28,900	10,000	67	4,700	1,080	0
ORWOOD	30	21	86,100	9,000	3,100	21	5,200	0	0

TABLE 35 (Continued)

SYSTEM FLOOD CONTROL PLAN
STAGE CONSTRUCTION QUANTITIES 300-YEAR DESIGN
(With Peripheral Canal)

ISLAND/TRACT	STAGE YEAR	LEVEES: CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	UTILITIES: SIPHONS (LF)	GAGING STATIONS (LS)
PALM	20	59	186,700	25,700	8,900	59	11,200	960	0
RINDGE	8	20	11,700	8,800	3,000	20	700	240	1,000
	15	17	10,000	7,500	2,600	17	600	240	1,000
	25	50	29,400	22,100	7,700	50	1,800	240	1,000
	42	51	29,900	22,500	7,800	51	5,400	240	1,000
RIO BLANCO	31	1	2,200	300	100	1	100	0	0
ROBERTS-UPPER	1	20	15,400	8,700	3,000	20	900	0	1,000
SARGENT-BARNHART	10	9	19,500	3,600	1,300	9	1,200	0	0
	60	9	19,500	3,600	1,300	9	1,200	0	0
SHIMA WEST	18	11	11,400	4,700	1,600	11	700	0	0
STATEN	9	40	97,900	17,300	6,000	40	5,900	240	0
	20	194	383,000	84,000	29,000	194	23,000	240	0
	45	115	226,000	49,500	17,200	115	13,600	240	0
TERMINOUS WEST	4	36	103,200	15,700	5,400	36	6,200	360	0
	8	101	289,000	44,000	15,200	101	17,400	360	0
	15	149	425,700	64,800	22,400	149	25,600	360	0
	25	115	328,500	50,000	17,300	115	19,700	360	0
	40	119	340,300	51,800	17,900	119	20,400	360	0
	70	35	98,000	15,000	5,200	35	6,700	360	0
TWITCHELL	8	93	431,000	40,500	14,000	93	25,900	0	0
	20	93	431,000	40,500	14,000	93	25,900	0	0
	36	27	123,600	11,500	4,000	27	7,400	0	0
TYLER	20	112	103,000	48,900	16,900	112	6,200	0	0
VENICE	2	150	324,000	65,300	22,600	150	19,500	900	0
	4	150	324,000	65,300	22,600	150	19,500	900	0
	6	150	324,000	65,300	22,600	150	19,500	900	0
	8	150	324,000	65,300	22,600	150	19,500	900	0
	12	150	324,000	65,300	22,600	150	19,500	900	0
	16	150	324,000	65,300	22,600	150	19,500	900	0
	20	150	324,000	65,300	22,600	150	19,500	900	0
	25	150	324,000	65,300	22,600	150	19,500	900	0
	30	150	324,000	65,300	22,600	150	19,500	900	0
	40	150	324,000	65,300	22,600	150	19,500	900	0
	70	150	324,000	65,300	22,600	150	19,500	900	0
	90	150	324,000	65,300	22,600	150	19,500	900	0
VICTORIA	25	46	70,000	20,000	6,900	46	4,200	1,560	2,000
WEBB	4	64	145,500	27,800	9,600	64	8,700	0	0
	9	156	358,500	67,700	23,400	156	21,500	0	0
	27	156	358,500	67,700	23,400	156	21,500	0	0
	45	64	145,500	27,800	9,600	64	8,700	0	0
	80	49	111,300	21,100	7,300	49	6,700	0	0
WOODWARD	1	78	146,300	33,600	11,600	78	8,800	0	0
	8	28	146,300	33,600	11,600	78	8,800	0	0
	26	107	202,600	46,300	11,600	107	12,200	0	0
WRIGHT-ELMWOOD EAST	17	9	3,400	3,700	1,300	9	200	110	0
WRIGHT-ELMWOOD WEST	17	17	6,800	7,300	2,500	17	400	230	0
TOTAL		8,238	17,855,500	3,617,000	1,247,100	8,288	1,076,650	43,910	16,000

ISLAND/TRACT	FLOODWALLS: CONCRETE (CY)	CEMENT (Ton)	REBAR (Lbs)	SHEET-PILING (Ton)	WATER STOP (LF)	JOINT FILLER (LF)
BETHEL	800	207	128,000	0	20,000	20,000
HOTCHKISS	250	47	41,000	0	8,400	8,400
TOTAL	1,050	254	169,000	0	28,400	28,400

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TABLE 36

SYSTEM FLOOD CONTROL PLAN
FIRST COST INITIAL CONSTRUCTION ONLY*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL						NON-FEDERAL					
ISLAND-TRACT	LEVEE LENGTH (MILES)	RELO-CATIONS	LEVEES	FLOOD-WALLS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL FEDERAL	LANDS+ DAMAGES	RELO-CATIONS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
ANDRUS	6.9	0	5248	0	630	420	6298	7849	125	15	10	7999	14297
ATLAS	3.1	0	1342	0	161	107	1610	911	0	0	0	911	2521
BACON	14.3	0	12412	0	1489	993	14894	2323	160	19	13	2515	17409
BETHEL	11.5	0	4554	19214	2852	1901	28521	1140	312	37	25	1514	30035
BISHOP W	5.0	0	4037	0	484	323	4844	356	585	70	47	1058	5902
BOULDIN	18.0	0	32458	0	3895	2597	38950	2050	127	15	10	2202	41152
BRACK W	10.8	0	11544	0	1385	924	13853	719	11	1	1	732	14585
BRADFORD	7.4	0	6178	0	741	494	7413	1959	208	25	17	2209	9622
BRANNAN	3.2	0	6177	0	741	494	7412	333	430	52	34	849	8261
BYRON	9.5	0	4838	0	581	387	5806	12722	45	5	4	12776	18582
CANAL R-W	9.5	0	7368	0	884	589	8841	542	33	4	3	582	9423
CONEY EAST	5.0	0	2187	0	262	175	2624	414	0	0	0	414	3038
DEAD HORSE	2.5	0	2989	0	359	239	3587	273	0	0	0	273	3860
DREXLER	8.0	0	4254	0	510	340	5104	780	0	0	0	780	5884
EMPIRE	10.3	0	7007	0	841	561	8409	701	1025	123	82	1931	10340
FABIAN	18.8	0	5734	0	688	459	6881	1100	616	74	49	1839	8720
HOLLAND	10.9	0	9395	0	1127	752	11274	712	978	117	78	1885	13159
HOTCHKISS	8.4	0	3007	4388	887	592	8874	194	0	0	0	194	9068
JERSEY	15.6	0	15636	0	1876	1251	18763	324	432	52	35	843	19606
JONES L+U	17.8	0	17599	0	2112	1408	21119	1860	1603	192	128	3783	24902
KING	9.0	0	7398	0	888	592	8878	709	52	6	4	771	9649
MANDEVILLE	14.3	0	13548	0	1626	1084	16258	1050	36	4	3	1093	17351
MCCORM-WLM	8.7	0	6891	0	827	551	8269	441	324	39	26	830	9099
MCDONALD	13.7	0	12870	0	1544	1030	15444	974	72	9	6	1061	16505
NEW HOPE W	9.0	960	7329	0	879	586	9754	1086	213	26	17	1342	11096
ORWOOD	6.4	50	4965	0	596	397	6008	1372	18	2	1	1393	7401
ORWOOD-UP	4.5	76	2770	0	332	222	3400	754	0	0	0	754	4154
PALM	7.8	0	7038	0	845	563	8446	558	41	5	3	607	9053
PESCADERO	8.3	0	7677	0	921	614	9212	0	26	3	2	31	9243
RINDGE	15.7	0	13829	0	1659	1106	16594	2029	36	4	3	2072	18666
RIO BLANCO	3.2	0	2218	0	266	177	2661	212	86	10	7	315	2976
ROB-LOW E	6.0	0	2834	0	340	227	3401	957	19	2	2	980	4381
ROB-LOW W	10.0	0	3745	0	449	300	4494	1608	562	67	45	2282	6776
ROB-MID E	1.0	0	7140	0	857	571	8568	1896	34	4	3	1937	10505
ROB-MID W	1.0	0	550	0	66	44	660	203	48	6	4	261	921
ROB-UP	4.2	0	11051	0	1326	884	13261	2097	173	21	14	2305	15566
SARG-BARNH	2.5	0	2776	0	333	222	3331	360	0	0	0	360	3691
SHERMAN	9.8	0	38581	0	4630	3086	46297	3232	710	85	57	4084	50381
SHIMA W	4.0	0	2928	0	351	234	3513	186	33	4	3	226	3739
SHIN KEE W	1.9	0	2854	0	342	228	3424	164	0	0	0	164	3588
STATEN	25.5	0	18805	0	2257	1504	22566	1424	282	34	23	1763	24329
STEWART	0.0	0	4962	0	595	397	5954	0	125	15	10	150	6104
TERMIN W	16.1	0	20454	0	2454	1636	24544	2336	828	99	66	3329	27873
TWITCHELL	9.5	0	20603	0	2472	1648	24723	2116	565	68	45	2794	27517
TYLER	10.7	0	14995	0	1799	1200	17994	1570	924	111	74	2679	20673
UNION	24.6	0	235	0	28	19	282	1686	61	7	0	1754	2036
VEALE	5.7	101	3284	0	394	263	4042	226	32	4	3	265	4307
VENICE	12.3	0	15646	0	1878	1252	18776	1772	35	4	3	1814	20590
VICTORIA	15.1	0	8219	0	986	657	9862	977	40	5	3	1025	10887
WALNUT GR	2.0	0	834	0	100	67	1001	248	0	0	0	248	1249
WEBB	12.8	0	12414	0	1490	993	14897	892	24	3	2	921	15818
WOODWARD	8.7	0	6129	0	736	490	7355	432	55	7	4	498	7853
WRIT-ELM E	2.0	0	721	0	86	58	865	88	225	27	18	358	1223
WRIT-ELM W	3.0	0	2226	0	267	178	2671	181	41	5	3	230	2901
TOTAL	485.5	1187	452483	23602	57124	38086	572482	71098	12410	1487	990	85985	658467

*OCTOBER 1981 PRICE LEVEL

TABLE 37

SYSTEM FLOOD CONTROL PLAN
FIRST COST STAGE CONSTRUCTION*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

ISLAND-TRACT	LEVEE LENGTH (MILES)	FEDERAL RELO-CATIONS	LEVEES	FLOOD-WALLS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL FEDERAL	NON-FEDERAL LANDS + DAMAGES	RELO-CATIONS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
ANDRUS	6.9	0	11916	0	1430	953	14299	0	0	0	0	0	14299
ATLAS	3.1	0	0	0	0	0	0	0	0	0	0	0	0
BACON	14.3	0	9680	0	1162	774	11616	0	17	2	1	20	11636
BETHEL	11.5	0	830	411	149	99	1489	0	0	0	0	0	1489
BISHOP W	5.0	0	1449	0	174	116	1739	0	3	0	0	3	1742
BOULDIN	18.0	0	23824	0	2859	1906	28589	0	120	14	10	144	28733
BRACK W	10.8	0	1407	0	169	113	1689	0	9	1	1	11	1700
BRADFORD	7.4	0	7445	0	893	596	8934	0	0	0	0	0	8934
BRANNAN	3.2	0	2706	0	325	217	3248	0	0	0	0	0	3248
BYRON	9.5	0	0	0	0	0	0	0	0	0	0	0	0
CANAL R-W	9.5	0	602	0	72	48	722	0	6	1	0	7	729
CONEY EAST	5.0	0	0	0	0	0	0	0	0	0	0	0	0
DEAD HORSE	2.5	0	450	0	54	36	540	0	0	0	0	0	540
DREXLER	8.0	0	5718	0	686	457	6861	0	0	0	0	0	6861
EMPIRE	10.3	0	4153	0	498	332	4983	0	58	7	5	70	5053
FABIAN	18.8	0	0	0	0	0	0	0	0	0	0	0	0
HOLLAND	10.9	0	3583	0	430	287	4300	0	85	10	7	102	4402
HOTCHKISS	8.4	0	0	0	0	0	0	0	0	0	0	0	0
JERSEY	15.6	0	0	0	0	0	0	0	0	0	0	0	0
JONES L+U	17.8	0	3371	0	404	270	4045	0	26	3	2	31	4076
KING	9.0	0	302	0	36	24	362	0	26	3	2	31	393
MANDEVILLE	14.3	0	8154	0	978	652	9784	0	69	8	6	83	9867
MCCORM-WLM	8.7	0	639	0	77	51	767	0	0	0	0	0	767
MCDONALD	13.7	0	9696	0	1163	776	11635	0	130	16	10	156	11791
NEW HOPE W	9.0	0	0	0	0	0	0	0	0	0	0	0	0
ORWOOD	6.4	0	888	0	107	71	1066	0	0	0	0	0	1066
ORWOOD-UP	4.5	0	0	0	0	0	0	0	0	0	0	0	0
PALM	7.8	0	2054	0	247	164	2465	0	23	3	2	28	2493
PESCADERO	8.3	0	0	0	0	0	0	0	0	0	0	0	0
RINDGE	15.7	0	1909	0	229	153	2291	0	28	3	2	33	2324
RIO BLANCO	3.2	0	39	0	5	3	47	0	0	0	0	0	47
ROB-LOW E	6.0	0	0	0	0	0	0	0	0	0	0	0	0
ROB-LOW W	10.0	0	0	0	0	0	0	0	0	0	0	0	0
ROB-MID E	1.0	0	0	0	0	0	0	0	0	0	0	0	0
ROB-MID W	1.0	0	0	0	0	0	0	0	0	0	0	0	0
ROB-UP	4.2	0	307	0	37	25	369	0	1	0	0	1	370
SARG-BARNH	2.5	0	236	0	28	19	283	0	0	0	0	0	283
SHERMAN	9.8	0	0	0	0	0	0	0	0	0	0	0	0
SHIMA W	4.0	0	191	0	23	15	229	0	0	0	0	0	229
SHIN KEE W	1.9	0	0	0	0	0	0	0	0	0	0	0	0
STATEN	25.5	0	8901	0	1068	712	10681	0	17	2	1	20	10701
STEWART	0.0	0	0	0	0	0	0	0	0	0	0	0	0
TERMIN W	16.1	0	16810	0	2017	1345	20172	0	43	5	3	51	20223
TWITCHELL	9.5	0	9943	0	1193	795	11931	0	0	0	0	0	11931
TYLER	10.7	0	1859	0	223	149	2231	0	0	0	0	0	2231
UNION	24.6	0	0	0	0	0	0	0	0	0	0	0	0
VEALE	5.7	0	0	0	0	0	0	0	0	0	0	0	0
VENICE	12.3	0	39982	0	4798	3199	47979	0	216	26	17	259	48238
VICTORIA	15.1	0	987	0	118	79	1184	0	40	5	3	48	1232
WALNUT GR	2.0	0	0	0	0	0	0	0	0	0	0	0	0
WEBB	12.8	0	12184	0	1462	975	14621	0	0	0	0	0	14621
WOODWARD	8.7	0	6400	0	768	512	7680	0	112	13	9	134	7814
WRIT-ELM E	2.0	0	106	0	13	8	127	0	3	0	0	3	130
WRIT-ELM W	3.0	0	208	0	25	17	250	0	6	1	0	7	257
TOTAL	485.5	0	198929	411	23920	15948	239208	0	1038	123	81	1242	240450

*OCTOBER 1981 PRICE LEVEL

TABLE 38

SYSTEM FLOOD CONTROL PLAN
ANNUAL COST*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL				NON-FEDERAL						
ISLAND-TRACT	LEVEE LENGTH (MILES)	INTEREST	AMORTI-ZATION	STAGE CONST	TOTAL FEDERAL	INTEREST	AMORTI-ZATION	STAGE CONST	MAIN. + OPER.	MAJOR REPL	TOTAL NON-FED	TOTAL ANNUAL COST
ANDRUS	6.9	480	13	392	885	610	16	0	23	0	649	1534
ATLAS	3.1	123	3	0	126	69	2	0	10	0	81	207
BACON	14.3	1136	30	374	1540	192	5	1	49	0	247	1787
BETHEL	11.5	2175	57	27	2259	115	3	0	231	0	349	2608
BISHOP W	5.0	369	10	39	418	81	2	0	17	0	100	518
BOULDIN	18.0	2970	77	768	3815	168	4	4	61	0	237	4052
BRACK W	10.8	1056	27	73	1156	56	1	0	37	0	94	1250
BRADFORD	7.4	565	15	178	758	168	4	0	25	0	197	955
BRANNAN	3.2	565	15	114	694	65	2	0	11	0	78	772
BYRON	9.5	443	12	0	455	974	25	0	33	0	1032	1487
CANAL R-W	9.5	674	18	9	701	44	1	0	31	0	76	777
CONEY EAST	5.0	200	5	0	205	32	1	0	17	0	50	255
DEAD HORSE	2.5	273	7	13	293	21	1	0	8	0	30	323
DREXLER	8.0	389	10	245	644	59	2	0	27	0	88	732
EMPIRE	10.3	641	17	127	785	147	4	2	35	0	188	973
FABIAN	18.8	525	14	0	539	140	4	0	64	0	208	747
HOLLAND	10.9	860	22	120	1002	144	4	3	37	0	188	1190
HOTCHKISS	8.4	677	18	0	695	15	0	0	71	0	86	781
JERSEY	15.6	1431	37	0	1468	64	2	0	53	0	119	1587
JONES L+U	17.8	1610	42	84	1736	288	8	1	61	0	358	2094
KING	9.0	677	18	7	702	59	2	1	31	0	93	795
MANDEVILLE	14.3	1240	32	223	1495	83	2	2	62	0	149	1644
MCCORM-WLM	8.7	631	16	2	649	63	2	0	30	0	95	744
MCDONALD	13.7	1178	31	339	1548	81	2	4	46	0	133	1681
NEW HOPE W	9.0	744	19	0	763	102	3	0	32	0	137	900
ORWOOD	6.4	458	12	9	479	106	3	0	22	0	131	610
ORWOOD-UP	4.5	259	7	0	266	57	1	0	21	0	79	345
PALM	7.8	644	17	44	705	46	1	0	28	0	75	780
PESCADERO	8.3	702	18	0	720	2	0	0	80	0	82	802
RINDGE	15.7	1265	33	33	1331	158	4	1	53	0	216	1547
RIO BLANCO	3.2	203	5	0	208	24	1	0	11	0	36	244
ROB-LOW E	6.0	259	7	0	266	75	2	0	21	0	98	364
ROB-LOW W	10.0	343	9	0	352	174	5	0	22	0	201	553
ROB-MID E	1.0	653	17	0	670	148	4	0	9	0	161	831
ROB-MID W	1.0	50	1	0	51	20	1	0	4	0	25	76
ROB-UP	4.2	1011	26	27	1064	176	5	0	20	0	201	1265
SARG-BARNH	2.5	254	7	11	272	27	1	0	8	0	36	308
SHERMAN	9.8	3530	92	0	3622	311	8	0	37	0	356	3978
SHIMA W	4.0	268	7	5	280	17	0	0	13	0	30	310
SHIN KEE W	1.9	261	7	0	268	13	0	0	7	0	20	288
STATEN	25.5	1721	45	171	1937	134	3	0	87	0	224	2161
STEWART	0.0	454	12	0	466	11	0	0	6	0	17	483
TERMIN W	16.1	1872	49	477	2398	254	7	1	56	0	318	2716
TWITCHELL	9.5	1885	49	329	2263	213	6	0	33	0	252	2515
TYLER	10.7	1372	36	40	1448	204	5	0	41	0	250	1698
UNION	24.6	22	1	0	23	134	3	0	74	0	211	234
VEALE	5.7	308	8	0	316	20	1	0	19	0	40	356
VENICE	12.3	1432	37	1532	3001	138	4	8	42	0	192	3193
VICTORIA	15.1	752	20	15	787	78	2	1	51	0	132	919
WALNUT GR	2.0	76	2	0	78	19	0	0	6	0	25	103
WEBB	12.8	1136	30	395	1561	70	2	0	44	0	116	1677
WOODWARD	8.7	561	15	300	876	38	1	6	30	0	75	951
WRIT-ELM E	2.0	66	2	3	71	27	1	0	7	0	35	106
WRIT-ELM W	3.0	204	5	6	215	18	0	0	7	0	25	240
TOTAL	485.5	43653	1141	6531	51325	6552	173	35	1961	0	8721	60046

*OCTOBER 1981 PRICE LEVEL, 7.625 PERCENT INTEREST RATE, 50 YEAR AMORTIZATION

TABLE 39

SYSTEM FLOOD CONTROL PLAN
AVERAGE ANNUAL COSTS AND BENEFITS

($1000)

ISLAND	FLOOD PROTECTION LEVEL	AVERAGE ANNUAL COSTS	AVERAGE ANNUAL BENEFITS FLOOD CONTROL	WATER QUALITY	TOTAL	NET BENEFITS	B/C RATIO
ANDRUS-BRANNAN ISLAND	300	2306	4742	1209	5951	3645	2.58
ATLAS TRACT	300	207	4	0	4	-203	.02
BACON ISLAND	300	1787	1624	233	1857	70	1.04
BETHEL ISLAND	300	2608	1223	32	1255	-1353	.48
BISHOP TRACT WEST	300	518	215	14	229	-289	.44
BOULDIN ISLAND	300	4052	2995	938	3933	-119	.97
BRACK TRACT WEST	300	1250	1356	135	1491	241	1.19
BRADFORD ISLAND	300	955	334	90	424	-531	.44
BYRON ISLAND	300	1487	558	24	582	-905	.39
CANAL RANCH WEST	300	777	286	35	321	-456	.41
CONEY ISLAND EAST	300	255	19	10	29	-226	.11
DEAD HORSE ISLAND	300	323	49	0	49	-274	.15
EMPIRE TRACT	300	973	1211	130	1341	368	1.38
FABIAN TRACT	300	747	0	0	0	-747	0.00
HOLLAND TRACT	300	1190	449	128	577	-613	.48
HOTCHKISS TRACT	300	781	2400	36	2436	1655	3.12
JERSEY ISLAND	300	1587	339	202	541	-1046	.34
JONES/L.ROBERTS WEST	300	2647	3377	492	3869	1222	1.46
KING ISLAND	300	795	449	79	528	-267	.66
MANDEVILLE ISLAND	300	1644	1535	306	1841	197	1.12
MC CORMACK-WILLIAMSON	300	744	177	6	183	-561	.25
MCDONALD TRACT	300	1681	1471	491	1962	281	1.17
NEW HOPE TRACT WEST	300	900	179	1	180	-720	.20
ORWOOD TRACT	300	610	398	10	408	-202	.67
UPPER ORWOOD TRACT	300	345	146	14	160	-185	.46
PALM TRACT	300	780	231	89	320	-460	.41
PESCADERO ISLAND	300	802	314	11	325	-477	.41
RINDGE TRACT	300	1547	1530	432	1962	415	1.27
RIO BLANCO	300	244	54	1	55	-189	.23
ROBERTS-L,U,M,DREX	300	3268	865	225	1090	-2178	.33
SARGENT-BARNHART	300	308	67	0	67	-241	.22
SHERMAN ISLAND	300	3978	1419	451	1870	-2108	.47
SHIMA TRACT WEST	300	310	57	13	70	-240	.23
SHIN KEE TRACT WEST	300	288	238	2	240	-48	.83
STATEN ISLAND	300	2161	1297	515	1812	-349	.84
STEWART ISLAND	300	483	148	7	155	-328	.32
TERMINOUS TRACT WEST	300	2716	5639	794	6433	3717	2.37
TWITCHELL ISLAND	300	2515	472	191	663	-1852	.26
TYLER ISLAND	300	1698	1367	368	1735	37	1.02
UNION ISLAND	300	234	0	0	0	-234	0.00
VEALE TRACT	300	356	315	12	327	-29	.92
VENICE ISLAND	300	3193	1324	251	1575	-1618	.49
VICTORIA ISLAND	300	919	421	164	585	-334	.64
WALNUT GROVE ISLAND	300	103	0	0	0	-103	0.00
WEBB TRACT	300	1677	1219	522	1741	64	1.04
WOODWARD ISLAND	300	951	583	65	648	-303	.68
WRIGHT-ELMWOOD TRACT EAST	300	106	37	14	51	-55	.48
WRIGHT-ELMWOOD TRACT WEST	300	240	20	6	26	-214	.11
T O T A L		60046	43153	8748	51901	-8145	.86

1 WITH PERIPHERAL CANAL, WITH ISLAND RESTORATION

2 7.625 PERCENT INTEREST RATE   50 YEAR AMORTIZATION   OCTOBER 1981 PRICE LEVEL

Table 40

SYSTEM FLOOD CONTROL PLAN
ECONOMIC SUMMARY
(1 October 1981 prices; 1990-2040 project conditions; 7-5/8 percent discount rate)

FIRST COST1/			$1,007,000,000
Flood Control and Water Quality		$910,000,000	
Initial Construction2/	$670,000,000		
Stage Construction	240,000,000		
Recreation		40,000,000	
Fish and Wildlife Enhancement		57,000,000	
ANNUAL COST			$68,800,000
Flood Control and Water Quality		$60,900,000	
Interest and Amortization	$58,900,000		
Operation and Maintenance	2,000,000		
Recreation		$4,000,000	
Interest and Amortization	$3,000,000		
Operation and Maintenance	1,000,000		
Fish and Wildlife Enhancement		$3,900,000	
Interest and Amortization	$3,500,000		
Operation and Maintenance	400,000		
ANNUAL BENEFITS			$73,100,000
Flood Control and Water Quality		$51,900,000	
Recreation		13,100,000	
Fish and Wildlife Enhancement		8,100,000	
BENEFIT-COST RATIOS - Total Project			1.1:1
Flood Control and Water Quality		0.9:1	
Recreation		3.3:1	
Fish and Wildlife Enhancement		2.1:1	
NET BENEFITS (excess of benefits over costs)			$4,300,000

1/ Rounded to nearest $1,000,000
2/ Includes $11,000,000 in fish and wildlife mitigation costs.

DESIGNATION AS THE EQ PLAN

41. The objective of the Environmental Quality (EQ) plan is the management, conservation, preservation, creation, restoration, or improvement of natural and cultural resources and ecological systems while meeting the other objectives of the investigation to the greatest extent practicable. Although plans formulated to maximize Environmental Quality are not necessarily constrained by monetary or cost-sharing requirments, they should be reasonable and viable plans and should assist other Federal, State, or local environmental objectives.

42. The System Flood Control Plan was designated as the EQ Plan. Among the candidate plans, the System Plan would most nearly satisfy the State Legislature's desire that the physical characteristics of the Delta be preserved in their present form. The System Plan also has the most potential for reducing the adverse impact of flooding in the study area on water quality, fish and wildlife, wetlands, esthetics, and threatened and endangered species. The impacts of flooding on these resources were described under the No Action Plan.

43. Actions taken to meet the EQ objectives include: The improvement of about 600 miles of levee to reduce the frequency of flooding, the acquisition of environmental easements to preserve existing natural habitat and esthetic values, the establishment of recreation facilities and public access sites, and the use of specific management procedures. Land would be purchased at various locations along and adjacent to the levees and channels to provide public access for fishing and to provide sites for picnicking, camping, and to preserve wildlife habitat. Permanent environmental easements would be

acquired at various locations to limit land uses to those compatible with wildlife habitat preservation and enhancement. Environmental management and improvement measures would include preserving wetlands, acquiring channel islands to preserve and enhance the last remaining remnants of original Delta riparian habitat, and using of setback levees to preserve stands of riparian vegetation along existing levees. A Wildlife Management Area would be established on five islands to enhance waterfowl and wildlife resources. The Wildlife Management Area would improve waterfowl distribution and decrease disease loss and crop depredation. This area would contribute to recreational consumptive uses such as hunting and fishing and nonconsumptive uses such as increasing the opportunity for environmental education. One method of operating the Wildlife Management Area would be that of "crop-sharing." This method allows farming operations to continue with a portion of the crops left unharvested for use by wildlife. This practice is traditional in many wildlife refuges in the Sacramento Basin and has successfully enhanced other wildlife refuge operations.

SENSITIVITY ANALYSIS

44. The sensitivity analysis consists of evaluating the impact of three alternative without-project conditions on project costs and benefits. The adopted without-project condition and the three alternative conditions are identified below:

a. The Peripheral Canal is assumed to be in place and operating and a flooded island is assumed to be restored following a levee failure (this is the adopted without-project condition).

b. The Peripheral Canal is assumed not to be implemented and a flooded island would be restored following a levee failure.

c. The Peripheral Canal is assumed to be in place and operating but a flooded island would not be restored following a levee failure.

d. The Peripheral Canal is assumed not to be constructed and a flooded island would not be restored following flooding.

The results of the sensitivity analysis are shown in Table 41.

MODIFIED SYSTEM FLOOD CONTROL PLAN

PLAN DESCRIPTION

45. Flood Control Features. - The Modified System Flood Control Plan would provide 300-year flood protection to 36 islands and tracts. Approximately 480 miles of nonproject levees would be included in this plan. The majority of the levees would be improved using stage construction. About 3-1/2 miles of sheet pile floodwalls would be employed on Hotchkiss Tract to avoid the relocation of existing development along the existing levee. Along Beaver and Hog Sloughs on Canal Ranch and Brack Tract, setback levees would be used to avoid riparian habitat. Setback levees would also be used on McCormack-Williamson and New Hope Tracts along the Mokelumne River to avoid removal of riparian growth. Detailed locations of levee improvements for the islands included in this plan may be found on Plates 2 through 37.

TABLE 41

SENSITIVITY ANALYSIS
SYSTEM FLOOD CONTROL PLAN

Without-Project Condition	Project Feature	Annual 1/ Cost	Annual Benefit ($1000)	Net Benefit	B/C Ratio	No. of Islands In Plan
With Peripheral Canal With Island Restoration (Adopted Condition)	Flood Control	60,046	51,901	-8,145	0.9	54
	Recreation	4,013	13,058	9,045	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	67,901	73,083	5,182	1.08	
Without Peripheral Canal With Island Restoration	Flood Control	62,039	62,271	232	1.00	54
	Recreation	4,013	13,058	9,045	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	69,894	83,453	13,559	1.2	
With Peripheral Canal Without Island Restoration	Flood Control	60,046	70,234	10,188	1.2	54
	Recreation	4,013	13,058	9,045	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	67,901	91,416	23,515	1.3	
Without Peripheral Canal Without Island Restoration	Flood Control	62,039	86,857	24,818	1.4	54
	Recreation	4,013	13,058	9,045	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	69,894	108,039	38,145	1.5	

1/ Does not include mitigation costs

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46. The Modified System Flood Control Plan generally confines levee improvements to locations where the probability of levee failure is high and where flooding has been prevalent historically. The Modified System Flood Control Plan was formed by eliminating from the System Flood Control Plan agricultural islands that were estimated to currently have 50-year flood protection and would continue to have that protection for some time into the future. Islands in this category included Atlas, Drexler, Fabian, Mournian, Orwood, Pescadero, Pico-Naglee, Upper and Middle Roberts, Sargent-Barnhart, Stewart, Union, and Walnut Grove.

47. The system of islands remaining after the first iteration of the plan formulation process remained economically infeasible. Another iteration was made to form an economically feasible system-type plan which would justify Federal participation.

48. Eight additional islands with large negative net benefits (excess of costs over benefits) were eliminated from the System Flood Control Plan to create an economically viable system-type plan which was designated the Modified System Flood Control Plan. The islands eliminated in the second iteration included Bethel, Jersey, Medford, Mildred, Quimby, Sherman, Twitchell, and Venice. Other factors, in addition to poor economics, were considered in selecting this group of islands. As indicated in the Recreation and Environmental Quality Plan Formulation section of this appendix, Medford, Mildred, and Quimby Islands were identified as being candidates for development into a Wildlife Management Area. Jersey Island was excluded from the plan because representatives of that island have often expressed a desire not to be included in any Federal plan of improvement. Sherman and Twitchell Islands are partially protected by Federal project levees which provide a high degree of flood protection. Bethel Island, which was designated as an urban

island, currently has a high degree of flood protection. Probability of failure estimates developed for this investigation indicate this protection would deteriorate to about 50-year flood protection in about 50 years. However, it was determined that non-Federal interests should be encouraged to institute a vigorous maintenance program to maintain the existing high level of flood protection on Bethel Island. Poor foundation conditions on Venice Island require a lengthy and costly rehabilitation program to improve those levees to Federal standards. Design studies indicate that stage construction would have to be performed on the average at 5-year intervals to maintain Federal project standards on Venice Island.

49. Land Use Regulations. - Land use management would be a required feature of this plan to prevent project-induced development. This feature would include the enactment and enforcement of zoning regulations which would prevent project-induced urban development on agricultural islands. Future development of urban islands would be limited to areas incapable of sustained economic agricultural production and be consistent with city and county General Plans. This feature would be a legal requirement of non-Federal interests. It is anticipated that the State would provide the necessary non-Federal assurances for satisfying this requirement.

50. Recreation Features. - The recreation features included in the Modified System Flood Control Plan would be identical to those included in the System Flood Control Plan. These would include 14 recreation sites, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails. Detailed site locations are shown on Plates 2 through 37.

51. Fish and Wildlife Enhancement Features. - The fish and wildlife enhancement features included in this plan would be identical to those described for the System Flood Control Plan.

52. Flood Hazard Mitigation Program. - The Modified System Flood Control Plan would express a limited Federal interest in flood control in the Delta. To encourage flood control improvements by non-Federal interests on islands where a Federal interest is not expressed, a Flood Hazard Mitigation Program would be included as a feature of the Modified System Flood Control Plan. Under the Flood Hazard Mitigation Program, nonproject levees would be considered eligible for emergency assistance under the provisions of Public Law 84-99, providing the levees are upgraded and maintained to a Federal standard by non-Federal interests. The costs of upgrading and maintaining the levees would be a non-Federal responsibility and would not be included in the costs of the Modified System Flood Control Plan.

53. Mitigation Features. - Alternative mitigation measures were identified in the System Flood Control Plan. For the purpose of establishing mitigation costs, the mitigation measure which proposes the acquisition of agricultural land on each project island was tentatively adopted. These parcels would be allowed to revegetate naturally. Based on compensation requirements developed by FWS for the Incremental Flood Control Plan, it is estimated that about 1,935 acres of agricultural land would be required for mitigation of impacts resulting from construction of the Modified System Flood Control Plan.

PLAN ACCOMPLISHMENTS

54. Flood Control. - The Modified System Flood Control Plan would provide 300-year flood protection to 36 islands. Equivalent average annual damages on those islands and tracts included in the plan would be reduced from about $46 million to about $2 million. About $8 million in equivalent average annual damages would still occur on islands not included in the plan.

55. Recreation. - The recreation improvements would expand the number of public recreation facilities in the Delta and improve access to the rivers and channels. The plan would accommodate 2.4 million recreation days annually.

56. Fish and Wildlife. - Approximately 6,000 acres of marshes, wildlife habitat, or agricultural land would be acquired or developed to preserve or enhance fish and wildlife resources indigenous to the Delta.

EFFECTS OF THE PLAN ON THE ENVIRONMENT

57. The primary impact of the Modified System Plan would be the loss of riparian, agricultural, and upland habitat due to the rehabilitation of the existing levees. Table 3.3 of the EIS lists the amount of land that would be affected. Upland habitat would increase by about 3,000 acres as grasses and shrubs reestablish on the project levees. There would be 365 acres of emergent vegetation removed during construction, and 80 percent is expected to recover in time. The major adverse impact to wildlife resources would primarily result from the loss of about 1,150 acres of riparian habitat. Mitigation (compensation) as previously discussed would be provided. The EIS discusses additional impacts of the plan.

DESIGN

58. With the exception of the polder candidate plan, the design characteristics of the candidate plans are similar and only vary in the number of island levees improved. Refer to the System Flood Control Plan for a discussion of design considerations.

RIGHTS-OF-WAY

59. Non-Federal interests would be required to provide all required project lands and to bear the costs of any associated damages. Rights-of-way would be required for all levee, recreation, and fish and wildlife improvements. Lands open to public access could be acquired in fee. Temporary construction and permanent maintenance easements could be acquired for levees not open to the public. Permanent environmental easements would be acquired on those fish and wildlife enhancement lands on which public access would be denied. Minimum rights-of-way requirements for the levee improvements are shown in Table 42.

RELOCATIONS

60. Relocation quantities are shown in Table 42. Non-Federal interests would be responsible for all relocations except those involving railroad tracks and bridges.

CONSTRUCTION

61. Levee improvements would be constructed using the stage construction method which was described in the System Flood Control Plan. Construction

TABLE 42

MODIFIED SYSTEM FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	LANDS AND DAMAGES			RELOCATIONS								
	PERMANENT EASEMENTS		TEMPORARY EASEMENT	ROADS	BRIDGES	UTILITIES						
	AGRICULTURE (Acre)	COMMERCIAL (Acre)	(Acre)	(LF)	(LS) $	TOWERS (LS) $	POWER-LINES & CABLES (LF)	SIPHONS (LF)	PUMP HOUSES (LS) $	GAGING STATIONS (LS) $	WIND-MILLS (LS) $	IRRIGATION DITCH (LF)
ANDRUS	144	35	9	0	0	0	10,000	250	18,000	1,000	0	0
BACON	231	0	17	0	0	15,000	10,600	180	29,000	1,000	0	0
BISHOP WEST	75	3	1	23,000	0	0	2,000	120	9,000	0	0	0
BOULDIN	495	0	22	0	0	0	8,000	1,250	2,000	0	0	5,000
BRACK WEST	130	0	13	0	0	0	0	360	2,000	0	0	0
BRADFORD	83	7	9	6,500	0	0	4,000	0	2,000	0	3,000	0
BRANNAN	91	0	4	17,000	0	0	0	0	9,000	0	0	3,000
BYRON	141	16	13	0	0	15,000	0	780	7,000	0	0	0
CANAL RANCH WEST	89	0	10	0	0	0	0	240	14,000	0	0	3,000
CONEY EAST	55	0	6	0	0	0	0	0	0	0	0	0
DEAD HORSE	34	0	3	0	0	0	0	0	0	0	0	0
EMPIRE	100	7	13	32,000	0	30,000	7,000	600	5,000	0	0	37,000
HOLLAND	159	0	13	35,000	0	0	4,000	840	5,000	1,000	0	20,000
HOTCHKISS	71	19	11	0	0	0	5,000	0	0	0	0	0
JONES	299	5	22	61,500	0	0	3,000	1,080	0	0	0	20,000
KING	108	0	11	0	0	0	3,000	960	0	0	0	0
MANDEVILLE	272	0	17	0	0	0	2,000	720	0	0	0	0
McCORMACK-WILLIAMSON	118	0	11	13,500	0	0	0	0	0	0	0	0
McDONALD	271	0	16	0	0	0	1,000	1,080	0	0	0	10,000
NEW HOPE WEST	119	4	13	0	120,000	0	0	240	5,000	0	0	16,000
ORWOOD (UPPER)	45	0	6	0	0	0	0	0	0	0	0	0
PALM	140	0	13	0	0	15,000	0	960	0	0	0	0
RINDGE	287	13	19	0	0	15,000	0	240	9,000	1,000	0	0
RIO BLANCO	28	0	3	3,600	0	0	0	0	0	0	0	0
ROBERTS-LOWER WEST	136	16	14	22,000	0	0	2,500	400	0	0	0	0
SHIMA WEST	50	0	4	0	0	0	2,000	60	10,000	0	0	0
SHIN KEE	46	0	5	0	0	0	0	0	0	0	0	0
STATEN	390	0	31	8,000	0	0	0	240	10,000	0	0	20,000
TERMINOUS WEST	332	8	22	34,000	0	0	0	0	10,000	0	0	0
TYLER	299	8	28	38,000	0	0	0	0	10,000	0	0	0
VEALE	51	0	51	0	0	15,000	0	240	7,000	0	0	0
VICTORIA	184	0	19	0	0	0	0	1,560	0	2,000	0	0
WEBB	233	0	16	0	0	15,000	0	0	5,000	0	0	0
WOODWARD	119	0	11	0	0	15,000	0	1,560	0	0	0	0
WRIGHT-ELMWOOD WEST	35	0	4	1,500	0	0	0	220	0	0	0	0
TOTAL	5,460	141	480	295,600	120,000	135,000	64,100	14,180	168,000	6,000	3,000	134,000

quantities for the Modified System Flood Control Plan for initial and stage construction are summarized in Tables 42 and 43. Stage construction quantities are shown in Table 44. Initial levee construction and stage construction would be a Federal responsibility. An instrumentation network would be established on each island to monitor levee movement, island subsidence, pore water pressure, and seepage.

OPERATION AND MAINTENANCE

62. Flood control, recreation, and fish and wildlife enhancement facilities would be operated and maintained by non-Federal interests. A levee maintenance manual would be developed by the Corps in coordination with non-Federal interests to carefully distinguish non-Federal maintenance requirements from Federal stage construction work. Levee maintenance and operation would conform to the requirements of CFR Title 33 Chapter 208.10.

ECONOMICS

63. First costs of the flood control features for the Modified System Flood Control Plan are listed in Tables 45 and 46. Annual costs are presented in Table 47. An economic summary of the flood control features is presented in Table 48. Table 49 summarizes the economics of all features of the plan.

SENSITIVITY ANALYSIS

64. The alternative without-project conditions considered in the sensitivity analysis were described in the System Flood Control Plan. The results of the sensitivity analysis are shown in Table 50. The modified system of islands

TABLE 43

MODIFIED SYSTEM FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	RELOCATIONS		LEVEES						
	TRACKS (LF)	BRIDGES (LS)	CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	INSTRU-MENTATION (LS) $
ANDRUS	0	0	154	337,700	36,000	12,500	179	58,700	20,000
BACON	0	0	205	964,000	75,300	26,000	231	37,900	20,000
BISHOP WEST	0	0	73	279,000	29,000	10,400	78	16,700	20,000
BOULDIN	0	0	435	3,256,000	94,000	32,500	495	196,000	20,000
BRACK WEST	0	0	122	1,024,000	53,600	18,700	129	61,400	20,000
BRADFORD	0	0	82	472,000	39,000	13,500	90	28,300	20,000
BRANNAN	0	0	86	622,000	17,200	6,000	91	37,300	20,000
BYRON	0	0	152	170,000	57,000	19,700	157	10,200	20,000
CANAL RANCH WEST	0	0	81	622,000	38,500	13,400	89	37,300	20,000
CONEY EAST	0	0	50	92,000	23,800	8,200	55	5,500	20,000
DEAD HORSE	0	0	32	269,000	13,000	4,500	34	16,100	20,000
EMPIRE	0	0	128	454,000	55,100	19,100	137	27,300	20,000
HOLLAND	0	0	179	720,300	57,700	20,000	190	43,300	20,000
HOTCHKISS	0	0	67	194,600	27,600	9,600	71	11,700	20,000
JONES	0	0	289	1,449,000	95,400	33,000	304	86,900	20,000
KING	0	0	98	565,000	46,800	16,200	108	33,900	20,000
MANDEVILLE	0	0	213	1,010,000	74,100	85,600	272	60,600	20,000
McCORMACK-WILLIAMSON	0	0	112	506,000	46,000	15,900	118	30,400	20,000
McDONALD	0	0	252	1,049,000	70,000	24,200	271	62,900	20,000
NEW HOPE WEST	0	800,000	116	540,000	47,000	23,000	135	32,400	20,000
ORWOOD (UPPER)	3,000	0	37	161,000	24,500	8,500	45	9,700	20,000
PALM	0	0	132	463,000	54,300	18,700	140	27,800	20,000
RINDGE	0	0	279	1,085,000	81,100	28,100	300	65,100	20,000
RIO BLANCO	0	0	28	146,000	17,100	5,900	31	8,000	20,000
ROBERTS - LOWER WEST	0	0	146	51,000	55,100	19,100	151	3,100	10,000
SHIMA WEST	0	0	48	215,000	19,500	6,800	50	12,900	10,000
SHIN KEE WEST	0	0	42	202,000	20,000	6,900	46	12,100	20,000
STATEN	0	0	231	1,331,000	134,600	46,600	309	79,900	20,000
TERMINOUS WEST	0	0	319	1,797,000	95,000	32,900	340	107,800	20,000
TYLER	0	0	137	992,000	119,300	41,300	144	59,500	20,000
VEALE	4,000	0	51	189,000	29,200	10,100	62	11,300	20,000
VICTORIA	0	0	168	423,000	80,000	27,700	184	25,400	20,000
WEBB	0	0	200	1,018,000	67,700	23,400	223	61,100	20,000
WOODWARD	0	0	113	410,000	46,300	16,000	119	24,600	20,000
WRIGHT-ELMWOOD WEST	0	0	36	148,000	17,000	5,900	39	8,900	10,000
TOTAL	7,000	800,000	4,893	20,759,600	1,856,800	709,900	5,417	1,412,000	670,000

ISLAND/TRACT	FLOODWALLS					
	CONCRETE (CY)	CEMENT (Ton)	REINFORCING STEEL (Lbs)	SHEET-PILING (SF)	WATER STOP (LF)	JOINT FILLER (LF)
HOTCHKISS	5,100	1,300	816,000	144,000	18,000	18,000

TABLE 44

MODIFIED SYSTEM FLOOD CONTROL PLAN
STAGE CONSTRUCTION QUANTITIES 300-YEAR DESIGN
(With Peripheral Canal)

ISLAND/TRACT	STAGE YEAR	LEVEES: CLEARING & GRUBBING (Acre)	LEVEES: EMBANKMENT (CY)	LEVEES: EROSION PROTECTION (LF)	LEVEES: PATROL ROAD (Ton)	LEVEES: SEEDING (Acre)	LEVEES: WATER (M-Gal)	UTILITIES: SIPHONS (LF)	UTILITIES: GAGING STATIONS (LS)
ANDRUS	4	76	105,000	33,000	11,400	76	6,300	0	0
	8	100	139,000	43,400	15,000	100	8,400	0	0
	12	126	162,000	54,900	19,000	126	9,700	0	0
	20	126	176,000	54,900	19,000	126	10,600	0	0
	30	86	120,000	37,300	12,900	86	7,200	0	0
	40	76	105,000	32,700	11,300	76	6,300	0	0
	60	96	134,000	41,600	14,400	96	8,000	0	0
BACON	6	104	320,200	45,200	15,700	104	19,200	180	1,000
	17	173	532,500	75,200	26,000	173	32,000	180	1,000
	40	23	2,900	10,000	3,500	23	200	180	1,000
	60	81	10,000	35,200	12,200	81	600	180	1,000
BISHOP WEST	17	10	168,400	3,800	1,300	10	10,100	120	0
BOULDIN	5	162	499,300	70,500	24,400	162	30,000	1,250	0
	10	149	459,400	65,000	22,500	149	27,600	1,250	0
	20	171	526,000	74,300	25,700	171	31,600	1,250	0
	35	216	665,700	94,000	32,500	216	39,900	1,250	0
	80	55	166,500	23,700	8,200	55	10,000	1,250	0
BRACK WEST	8	8	165,000	3,100	1,100	8	9,900	360	0
BRADFORD	10	90	205,000	39,000	13,500	90	12,300	0	0
	20	90	205,000	39,000	13,500	90	12,300	0	0
	40	90	205,000	39,000	13,500	90	12,300	0	0
	80	90	205,000	39,000	13,500	90	12,300	0	0
BRANNAN	1	23	63,000	9,800	3,400	23	3,800	0	0
	6	23	63,000	9,800	3,400	23	3,800	0	0
	12	33	92,000	14,200	4,900	33	5,500	0	0
	26	23	63,000	9,800	3,400	23	3,800	0	0
	60	23	63,000	9,800	3,400	23	3,800	0	0
CANAL RANCH WEST	25	17	55,600	7,100	2,500	17	3,400	240	0
DEAD HORSE	4	7	500	3,000	1,000	7	30	0	0
	10	7	500	3,000	1,000	7	30	0	0
	20	30	2,200	13,000	4,500	30	130	0	0
	30	7	500	3,000	1,000	7	30	0	0
	70	7	500	3,000	1,000	7	30	0	0
EMPIRE	4	12	19,700	5,200	1,800	12	1,200	600	0
	8	17	26,400	7,200	2,500	17	1,600	600	0
	16	127	204,300	55,100	19,100	127	12,300	600	0
	29	32	50,900	13,900	4,800	32	3,100	600	0
	54	12	19,100	5,200	1,800	12	1,200	600	0
HOLLAND	4	44	28,000	19,100	6,600	44	1,700	840	1,000
	3	44	28,000	19,100	6,600	44	1,700	840	1,000
	20	119	76,300	51,700	17,900	119	4,600	840	1,000
	30	44	28,000	19,100	6,600	44	1,700	840	1,000
	55	44	28,000	19,100	6,600	44	1,700	840	1,000
HOTCHKISS	30	35	21,800	15,200	5,300	35	1,300	0	0
JONES	18	121	279,000	52,800	18,300	121	16,700	1,080	0
KING	20	2	35,100	800	300	2	2,100	1,080	0
MANDEVILLE	10	110	295,000	48,300	16,700	110	1,700	720	0
	15	44	117,000	19,200	6,700	44	7,100	720	0
	30	74	197,000	32,200	11,100	74	11,800	720	0
	45	36	98,000	15,600	5,400	36	5,900	720	0
McCORMACK-WILLIAMSON	50	46	27,100	20,000	6,900	46	17,000	0	0
McDONALD	4	108	128,400	46,800	16,200	108	7,700	1,080	0
	8	93	110,200	40,200	13,900	93	6,600	1,080	0
	16	118	138,800	50,900	17,600	118	8,300	1,080	0
	24	112	131,900	48,300	16,700	112	7,900	1,080	0
	38	89	105,300	38,400	13,300	89	6,300	1,080	0
	80	67	78,900	28,900	10,000	67	4,700	1,080	0
PALM	20	59	186,700	25,700	8,900	59	11,200	960	0
RINDGE	8	20	11,700	8,800	3,000	20	700	240	1,000
	15	17	10,000	7,500	2,600	17	600	240	1,000
	25	50	29,400	22,100	7,700	50	1,800	240	1,000
	42	51	29,900	22,500	7,800	51	5,400	240	1,000
RIO BLANCO	31	1	2,200	300	100	1	100	0	0
SHIMA WEST	18	11	11,400	4,700	1,600	11	700	0	0
STATEN	9	40	97,900	17,300	6,000	40	5,900	240	0
	20	194	383,000	84,000	29,000	194	23,000	240	0
	45	115	226,000	49,500	17,200	115	13,600	240	0

TABLE 44 (Continued)

MODIFIED SYSTEM FLOOD CONTROL PLAN
STAGE CONSTRUCTION QUANTITIES 300-YEAR DESIGN
(With Peripheral Canal)

ISLAND/TRACT	STAGE YEAR	LEVEES						UTILITIES	
		CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	SIPHONS (LF)	GAGING STATIONS (LS)
TERMINOUS WEST	4	36	103,200	15,700	5,400	36	6,200	360	0
	8	101	289,000	44,000	15,200	101	17,400	360	0
	15	149	425,700	64,800	22,400	149	25,600	360	0
	25	115	328,500	50,000	17,300	115	19,700	360	0
	40	119	340,300	51,800	17,900	119	20,400	360	0
	70	35	98,000	15,000	5,200	35	6,700	360	0
TYLER	20	112	103,000	48,900	16,900	112	6,200	0	0
VICTORIA	25	46	70,000	20,000	6,900	46	4,200	1,560	2,000
WEBB	4	64	145,500	27,800	9,600	64	8,700	0	0
	9	156	358,500	67,700	23,400	156	21,500	0	0
	27	156	358,500	67,700	23,400	156	21,500	0	0
	45	64	145,500	27,800	9,600	64	8,700	0	0
	80	49	111,300	21,100	7,300	49	6,700	0	0
WOODWARD	1	78	146,300	33,600	11,600	78	8,800	0	0
	8	28	146,300	33,600	11,600	78	8,800	0	0
	26	107	202,600	46,300	11,600	107	12,200	0	6
WRIGHT-ELMWOOD WEST	17	17	6,800	7,300	2,500	17	400	230	0
TOTAL	262	877	1,794,300	401,800	134,400	927	107,700	1,790	2,006

ISLAND/TRACT	FLOODWALLS					
	CONCRETE (CY)	CEMENT (Ton)	REBAR (Lbs)	SHEET-PILING (Ton)	WATER STOP (LF)	JOINT FILLER (LF)
HOTCHKISS	250	47	41,000	0	8,400	8,400

TABLE 45

MODIFIED SYSTEM FLOOD CONTROL PLAN
FIRST COST INITIAL CONSTRUCTION ONLY*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL						NON-FEDERAL					
ISLAND-TRACT	LEVEE LENGTH (MILES)	RELO-CATIONS	LEVEES	FLOOD-WALLS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL FEDERAL	LANDS+ DAMAGES	RELO-CATIONS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
ANDRUS	6.9	0	5248	0	630	420	6298	7849	125	15	10	7999	14297
BACON	14.3	0	12412	0	1489	993	14894	2323	160	19	13	2515	17409
BISHOP W	5.0	0	4037	0	484	323	4844	356	585	70	47	1058	5902
BOULDIN	18.0	0	32458	0	3895	2597	38950	2050	127	15	10	2202	41152
BRACK W	10.8	0	11544	0	1385	924	13853	719	11	1	1	732	14585
BRADFORD	7.4	0	6178	0	741	494	7413	1959	208	25	17	2209	9622
BRANNAN	3.2	0	6177	0	741	494	7412	333	430	52	34	849	8261
BYRON	9.5	0	4838	0	581	387	5806	12722	45	5	4	12776	18582
CANAL R-W	9.5	0	7368	0	884	589	8841	542	33	4	3	582	9423
CONEY EAST	5.0	0	2187	0	262	175	2624	414	0	0	0	414	3038
DEAD HORSE	2.5	0	2989	0	359	239	3587	273	0	0	0	273	3860
EMPIRE	10.3	0	7007	0	841	561	8409	701	1025	123	82	1931	10340
HOLLAND	10.9	0	9395	0	1127	752	11274	712	978	117	78	1885	13159
HOTCHKISS	8.4	0	3007	4388	887	592	8874	194	0	0	0	194	9068
JONES L+U	17.8	0	17599	0	2112	1408	21119	1860	1603	192	128	3783	24902
KING	9.0	0	7398	0	888	592	8878	709	52	6	4	771	9649
MANDEVILLE	14.3	0	13548	0	1626	1084	16258	1050	36	4	3	1093	17351
MCCORM-WLM	8.7	0	6891	0	827	551	8269	441	324	39	26	830	9099
MCDONALD	13.7	0	12870	0	1544	1030	15444	974	72	9	6	1061	16505
NEW HOPE W	9.0	960	7329	0	879	586	9754	1086	213	26	17	1342	11096
ORWOOD-UP	4.5	76	2770	0	332	222	3400	754	0	0	0	754	4154
PALM	7.8	0	7038	0	845	563	8446	558	41	5	3	607	9053
RINDGE	15.7	0	13829	0	1659	1106	16594	2029	36	4	3	2072	18666
RIO BLANCO	3.2	0	2218	0	266	177	2661	212	86	10	7	315	2976
ROB-LOW W	10.0	0	3745	0	449	300	4494	1608	562	67	45	2282	6776
SHIMA W	4.0	0	2928	0	351	234	3513	186	33	4	3	226	3739
SHIN KEE W	1.9	0	2854	0	342	228	3424	164	0	0	0	164	3588
STATEN	25.5	0	18805	0	2257	1504	22566	1424	282	34	23	1763	24329
TERMIN W	16.1	0	20454	0	2454	1636	24544	2336	828	99	66	3329	27873
TYLER	10.7	0	14995	0	1799	1200	17994	1570	924	111	74	2679	20673
VEALE	5.7	101	3284	0	394	263	4042	226	32	4	3	265	4307
VICTORIA	15.1	0	8219	0	986	657	9862	977	40	5	3	1025	10887
WEBB	12.8	0	12414	0	1490	993	14897	892	24	3	2	921	15818
WOODWARD	8.7	0	6129	0	736	490	7355	432	55	7	4	498	7853
WRIT-ELM W	3.0	0	2226	0	267	178	2671	181	41	5	3	230	2901
TOTAL	338.9	1137	302388	4388	36809	24542	369264	50816	9011	1080	722	61629	430893

*OCTOBER 1981 PRICE LEVEL

TABLE 46

MODIFIED SYSTEM FLOOD CONTROL PLAN
FIRST COST STAGE CONSTRUCTION*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL						NON-FEDERAL					
ISLAND-TRACT	LEVEE LENGTH (MILES)	RELO-CATIONS	LEVEES	FLOOD-WALLS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL FEDERAL	LANDS + DAMAGES	RELO-CATIONS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
ANDRUS	6.9	0	11916	0	1430	953	14299	0	0	0	0	0	14299
BACON	14.3	0	9680	0	1162	774	11616	0	17	2	1	20	11636
BISHOP W	5.0	0	1449	0	174	116	1739	0	3	0	0	3	1742
BOULDIN	18.0	0	23824	0	2859	1906	28589	0	120	14	10	144	28733
BRACK W	10.8	0	1407	0	169	113	1689	0	9	1	1	11	1700
BRADFORD	7.4	0	7445	0	893	596	8934	0	0	0	0	0	8934
BRANNAN	3.2	0	2706	0	325	217	3248	0	0	0	0	0	3248
BYRON	9.5	0	0	0	0	0	0	0	0	0	0	0	0
CANAL R-W	9.5	0	602	0	72	48	722	0	6	1	0	7	729
CONEY EAST	5.0	0	0	0	0	0	0	0	0	0	0	0	0
DEAD HORSE	2.5	0	450	0	54	36	540	0	0	0	0	0	540
EMPIRE	10.3	0	4153	0	498	332	4983	0	58	7	5	70	5053
HOLLAND	10.9	0	3583	0	430	287	4300	0	85	10	7	102	4402
HOTCHKISS	8.4	0	0	0	0	0	0	0	0	0	0	0	0
JONES L+U	17.8	0	3371	0	404	270	4045	0	26	3	2	31	4076
KING	9.0	0	302	0	36	24	362	0	26	3	2	31	393
MANDEVILLE	14.3	0	8154	0	978	652	9784	0	69	8	6	83	9867
MCCORM-WLM	8.7	0	639	0	77	51	767	0	0	0	0	0	767
MCDONALD	13.7	0	9696	0	1163	776	11635	0	130	16	10	156	11791
NEW HOPE W	9.0	0	0	0	0	0	0	0	0	0	0	0	0
ORWOOD-UP	4.5	0	0	0	0	0	0	0	0	0	0	0	0
PALM	7.8	0	2054	0	247	164	2465	0	23	3	2	28	2493
RINDGE	15.7	0	1909	0	229	153	2291	0	28	3	2	33	2324
RIO BLANCO	3.2	0	39	0	5	3	47	0	0	0	0	0	47
ROB-LOW W	10.0	0	0	0	0	0	0	0	0	0	0	0	0
SHIMA W	4.0	0	191	0	23	15	229	0	0	0	0	0	229
SHIN KEE W	1.9	0	0	0	0	0	0	0	0	0	0	0	0
STATEN	25.5	0	8901	0	1068	712	10681	0	17	2	1	20	10701
TERMIN W	16.1	0	16810	0	2017	1345	20172	0	43	5	3	51	20223
TYLER	10.7	0	1859	0	223	149	2231	0	0	0	0	0	2231
VEALE	5.7	0	0	0	0	0	0	0	0	0	0	0	0
VICTORIA	15.1	0	987	0	118	79	1184	0	40	5	3	48	1232
WEBB	12.8	0	12184	0	1462	975	14621	0	0	0	0	0	14621
WOODWARD	8.7	0	6400	0	768	512	7680	0	112	13	9	134	7814
WRIT-ELM W	3.0	0	208	0	25	17	250	0	6	1	0	7	257
TOTAL	338.9	0	140919	0	16909	11275	169103	0	818	97	64	979	170082

*OCTOBER 1981 PRICE LEVEL

TABLE 47

MODIFIED SYSTEM FLOOD CONTROL PLAN
ANNUAL COST*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL				NON-FEDERAL						
ISLAND-TRACT	LEVEE LENGTH (MILES)	INTEREST	AMORTI-ZATION	STAGE CONST	TOTAL FEDERAL	INTEREST	AMORTI-ZATION	STAGE CONST	MAIN. + OPER.	MAJOR REPL	TOTAL NON-FED	TOTAL ANNUAL COST
ANDRUS	6.9	480	13	392	885	610	16	0	23	0	649	1534
BACON	14.3	1136	30	374	1540	192	5	1	49	0	247	1787
BISHOP W	5.0	369	10	39	418	81	2	0	17	0	100	518
BOULDIN	18.0	2970	77	768	3815	168	4	4	61	0	237	4052
BRACK W	10.8	1056	27	73	1156	56	1	0	37	0	94	1250
BRADFORD	7.4	565	15	178	758	168	4	0	25	0	197	955
BRANNAN	3.2	565	15	114	694	65	2	0	11	0	78	772
BYRON	9.5	443	12	0	455	974	25	0	33	0	1032	1487
CANAL R-W	9.5	674	18	9	701	44	1	0	31	0	76	777
CONEY EAST	5.0	200	5	0	205	32	1	0	17	0	50	255
DEAD HORSE	2.5	273	7	13	293	21	1	0	8	0	30	323
EMPIRE	10.3	641	17	127	785	147	4	2	35	0	188	973
HOLLAND	10.9	860	22	120	1002	144	4	3	37	0	188	1190
HOTCHKISS	8.4	677	18	0	695	15	0	0	71	0	86	781
JONES L+U	17.8	1610	42	84	1736	288	8	1	61	0	358	2094
KING	9.0	677	18	7	702	59	2	1	31	0	93	795
MANDEVILLE	14.3	1240	32	223	1495	83	2	2	62	0	149	1644
MCCORM-WLM	8.7	631	16	2	649	63	2	0	30	0	95	744
MCDONALD	13.7	1178	31	339	1548	81	2	4	46	0	133	1681
NEW HOPE W	9.0	744	19	0	763	102	3	0	32	0	137	900
ORWOOD-UP	4.5	259	7	0	266	57	1	0	21	0	79	345
PALM	7.8	644	17	44	705	46	1	0	28	0	75	780
RINDGE	15.7	1265	33	33	1331	158	4	1	53	0	216	1547
RIO BLANCO	3.2	203	5	0	208	24	1	0	11	0	36	244
ROB-LOW W	10.0	343	9	0	352	174	5	0	22	0	201	553
SHIMA W	4.0	268	7	5	280	17	0	0	13	0	30	310
SHIN KEE W	1.9	261	7	0	268	13	0	0	7	0	20	288
STATEN	25.5	1721	45	171	1937	134	3	0	87	0	224	2161
TERMIN W	16.1	1872	49	477	2398	254	7	1	56	0	318	2716
TYLER	10.7	1372	36	40	1448	204	5	0	41	0	250	1698
VEALE	5.7	308	8	0	316	20	1	0	19	0	40	356
VICTORIA	15.1	752	20	15	787	78	2	1	51	0	132	919
WEBB	12.8	1136	30	395	1561	70	2	0	44	0	116	1677
WOODWARD	8.7	561	15	300	876	38	1	6	30	0	75	951
WRIT-ELM W	3.0	204	5	6	215	18	0	0	7	0	25	240
TOTAL	338.9	28158	737	4348	33243	4698	122	27	1207	0	6054	39297

*OCTOBER 1981 PRICE LEVEL, 7.625 PERCENT INTEREST RATE, 50 YEAR AMORTIZATION

TABLE 48

MODIFIED SYSTEM FLOOD CONTROL PLAN
AVERAGE ANNUAL COSTS AND BENEFITS
($1000)

ISLAND	FLOOD PROTECTION LEVEL	AVERAGE ANNUAL COSTS	AVERAGE ANNUAL BENEFITS FLOOD CONTROL	WATER QUALITY	TOTAL	NET BENEFITS	B/C RATIO
ANDRUS-BRANNAN ISLAND	300	2306	4742	1209	5951	3645	2.58
BACON ISLAND	300	1787	1624	233	1857	70	1.04
BISHOP TRACT WEST	300	518	215	14	229	-289	.44
BOULDIN ISLAND	300	4052	2995	938	3933	-119	.97
BRACK TRACT WEST	300	1250	1356	135	1491	241	1.19
BRADFORD ISLAND	300	955	334	90	424	-531	.44
BYRON ISLAND	300	1487	558	27	585	-902	.39
CANAL RANCH WEST	300	777	286	35	321	-456	.41
CONEY ISLAND EAST	300	255	19	10	29	-226	.11
DEAD HORSE ISLAND	300	323	49	0	49	-274	.15
EMPIRE TRACT	300	973	1211	130	1341	368	1.38
HOLLAND TRACT	300	1190	449	128	577	-613	.48
HOTCHKISS TRACT	300	781	2400	36	2436	1655	3.12
JONES/L.ROBERTS WEST	300	2647	3377	492	3869	1222	1.46
KING ISLAND	300	795	449	79	528	-267	.66
MANDEVILLE ISLAND	300	1644	1535	306	1841	197	1.12
MC CORMACK-WILLIAMSON	300	744	177	6	183	-561	.25
MCDONALD TRACT	300	1681	1471	491	1962	281	1.17
NEW HOPE TRACT WEST	300	900	179	1	180	-720	.20
UPPER ORWOOD TRACT	300	345	146	14	160	-185	.46
PALM TRACT	300	780	231	89	320	-460	.41
RINDGE TRACT	300	1547	1530	432	1962	415	1.27
RIO BLANCO	300	244	54	1	55	-189	.23
SHIMA TRACT WEST	300	310	57	13	70	-240	.23
SHIN KEE TRACT WEST	300	288	238	2	240	-48	.83
STATEN ISLAND	300	2161	1297	515	1812	-349	.84
TERMINOUS TRACT WEST	300	2716	5639	794	6433	3717	2.37
TYLER ISLAND	300	1698	1367	368	1735	37	1.02
VEALE TRACT	300	356	315	12	327	-29	.92
VICTORIA ISLAND	300	919	421	164	585	-334	.64
WEBB TRACT	300	1677	1219	522	1741	64	1.04
WOODWARD ISLAND	300	951	583	65	648	-303	.68
WRIGHT-ELMWOOD TRACT WEST	300	240	20	6	26	-214	.11
TOTAL		39297	36543	7357	43900	4603	1.12

1 WITH PERIPHERAL CANAL, WITH ISLAND RESTORATION

2 7.625 PERCENT INTEREST RATE   50 YEAR AMORTIZATION   OCTOBER 1981 PRICE LEVEL

TABLE 49

MODIFIED SYSTEM FLOOD CONTROL PLAN
ECONOMIC SUMMARY
(1 October 1981 prices; 1990-2040 project conditions;
7-5/8 percent discount rate)

FIRST COST 1/			$705,000,000
Flood Control and Water Quality		$608,000,000	
Initial Construction 2/	$438,000,000		
Stage Construction	170,000,000		
Recreation		40,000,000	
Fish and Wildlife Enhancement		57,000,000	
ANNUAL COST			$47,700,000
Flood Control and Water Quality		$39,800,000	
Interest and Amortization	$38,600,000		
Operation and Maintenance	1,200,000		
Recreation		$4,000,000	
Interest and Amortization	$3,000,000		
Operation and Maintenance	1,000,000		
Fish and Wildlife Enhancement		$3,900,000	
Interest and Amortization	$3,500,000		
Operation and Maintenance	400,000		
ANNUAL BENEFITS			$65,100,000
Flood Control and Water Quality		$43,900,000	
Recreation		13,100,000	
Fish and Wildlife Enhancement		8,100,000	
BENEFIT-COST RATIOS - Total Project			1.4:1
Flood Control and Water Quality		1.1:1	
Recreation		3.3:1	
Fish and Wildlife Enhancement		2.1:1	
NET BENEFITS (excess of benefits over costs)			$17,400,000

1/ Rounded to nearest $1,000,000
2/ Includes $7,000,000 in fish and wildlife mitigation costs.

TABLE 50

SENSITIVITY ANALYSIS
MODIFIED SYSTEM FLOOD CONTROL PLAN

Without-Project Condition	Project Feature	Annual 1/ Cost	Annual Benefit ($1000)	Net Benefit	B/C Ratio	No. of Islands In Plan
With Peripheral Canal	Flood Control	39,297	43,900	4,603	1.1	36
With Island Restoration	Recreation	4,016	13,058	9,042	3.3	
(Adopted Condition)	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	47,155	65,082	17,927	1.4	
Without Peripheral Canal	Flood Control	48,841	57,063	8,222	1.2	41
With Island Restoration	Recreation	4,016	13,058	9,042	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	56,699	78,245	21,546	1.4	
With Peripheral Canal	Flood Control	39,297	59,109	19,812	1.5	36
Without Island Restoration	Recreation	4,016	13,058	9,042	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	47,155	80,291	33,136	1.7	
Without Peripheral Canal	Flood Control	48,841	81,106	32,265	1.7	41
Without Island Restoration	Recreation	4,016	13,058	9,042	3.3	
	Fish and Wildlife	3,842	8,124	4,282	2.1	
	Total	56,699	102,288	45,589	1.8	

1/ Does not include mitigation costs

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was not reformulated during the sensitivity analysis with respect to the reclamation versus no reclamation assumption. The sensitivity analysis showed that more positive net benefits were available under the alternative scenarios than under the adopted scenario. Bethel, Drexler, Jersey, and Upper and Middle Roberts were added to the without-Peripheral Canal scenario.

INCREMENTAL FLOOD CONTROL PLAN (NED PLAN AND SELECTED PLAN))

PLAN DESCRIPTION

65. Flood Control Features. - The Incremental Flood Control Plan includes only the islands and tracts identified in the System Flood Control Plan as being economically feasible. Approximately 165 miles of nonproject levees on 15 islands would be improved to provide 300-year flood protection. Stage construction would be the predominant method of levee improvement although about 3-1/2 miles of sheet pile floodwall would be built on Hotchkiss Tract to avoid removing extensive improvements along the levee on that tract. Setback levees would be used on Brack Tract along Hog Slough to avoid the removal of a significant stand of riparian forest. Detailed locations of levee improvements for the islands included in this plan are shown in the applicable plates located at the end of this appendix.

66. Land Use Regulations. - Land use regulation requirements are identical for all candidate plans. Non-Federal interests would be required to provide assurances that zoning regulations would be enacted and enforced to prevent project-induced urban development on agricultural islands. Development on urban islands would be restricted to areas incapable of sustained economic

agricultural production and would be consistent with city and county General Plans.

67. Recreation Features. - The recreation features of each candidate plan are identical and would consist of 14 recreation sites, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails. The locations of recreation sites are shown on Plates 2 through 37.

68. Fish and Wildlife Enhancement Features. - The fish and wildlife enhancement features of the Incremental Flood Control Plan would be identical to those of the System and Modified System Plans with the exception of the use of setback levees on Canal Ranch, McCormack-Williamson, and New Hope Tracts. These tracts are economically infeasible and not included in the Incremental Plan.

69. Flood Hazard Mitigation Plan. - Flood control improvements on 42 islands and tracts in the study area proved to be economically infeasible. These islands and tracts were therefore excluded from the Incremental Plan. It should not be construed that flood control improvements are not needed in those locations. At this time, the cost of flood control improvements to Federal standards cannot be economically justified by the benefits that would be derived. Therefore, a Flood Hazard Mitigation Program would be included in the Incremental Plan to encourage non-Federal interests to improve flood protection on islands not a part of the Federal plan of improvement. If this were accomplished, some measure of protection would be provided to the entire system of islands either by Federal or non-Federal interests. The Flood Hazard Mitigation Program would declare nonproject levees to be flood control structures if they are improved and maintained to a Federal standard by

non-Federal interests. The improvement and maintenance costs would not be included in the costs of the Incremental Flood Control Plan.

70. Mitigation Features. - Alternative mitigation measures were identified in the System Flood Control Plan. For the purpose of establishing mitigation costs, the mitigation measure which proposes the acquisition of agricultural land on each project island was tentatively adopted. Six hundred fifty acres of mitigation lands would be equally distributed to the islands included in the plan.

PLAN ACCOMPLISHMENTS

71. Flood Control. - The Incremental Flood Control Plan would provide 300-year flood protection to about 80,000 acres of primarily agricultural lands on 15 islands and tracts. Equivalent average annual flood damages in these locations would be reduced from about $34 million to about $1 million. About $20 million in equivalent average annual damages would continue to occur on islands not included in the plan.

72. Recreation. - The number of public recreation facilities would be increased and public access to Delta channels would be improved with the proposed recreation improvements; 2.4 million annual recreation days would be provided by the recreation plan.

73. Fish and Wildlife. - A total of about 6,000 acres of freshwater marshes, channel islands with native vegetation, and agricultural lands would be acquired or developed to preserve or enhance fish and wildlife resources. The Wildlife Management Area developed on Little Mandeville, Medford, Mildred,

Quimby, and Rhode Islands would improve waterfowl distribution and decrease disease loss and crop depredation. Recreation consumptive uses such as hunting and fishing as well as non-consumptive uses such as environmental education would increase.

EFFECTS OF THE PLAN OF THE ENVIRONMENT

74. The primary impact of the Incremental Flood Control Plan would result from the clearing of riparian, agricultural, and upland habitat to rehabilitate the existing levees. Table 3.3 of the EIS lists the amount of land that would be affected. Upland habitat would increase by about 1,500 acres as grasses and shrubs cover the project levees. During construction, 160 acres of emergent vegetation would be removed, and 80 percent is expected to recover in time. The major adverse impact to wildlife resources would result from the loss of about 390 acres of riparian habitat. A mitigation (compensation) plan would be included to completely offset the vegetation losses. The impacts of the Incremental Flood Control Plan are discussed in more detail in the EIS.

DESIGN

75. With the exception of the polder candidate plan, the design characteristics of the candidate plans are similar and only vary in the number of island levees improved. Refer to the System Flood Control Plan for a discussion of design considerations.

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RIGHTS-OF-WAY

76. Non-Federal interests would be required to provide all required project lands and absorb all claims for damages. Rights-of-way would be required for all levee, recreation, and fish and wildlife improvements. Fee acquisition would be required for all lands open to the public. Temporary construction and permanent maintenance easements could be acquired for levees not open to the public. Permanent environmental easements could be acquired to preserve those fish and wildlife lands closed to the public. Table 51 summarizes rights-of-way requirements for levee improvements.

RELOCATIONS

77. Facilities to be relocated are identified in Table 51. Non-Federal interests would be responsible for all relocations costs.

CONSTRUCTION

78. Nearly all levee improvements proposed in the Incremental Flood Control Plan would be accomplished using the stage-construction method. This method was described in the System Flood Control Plan. Initial and stage construction would be a Federal responsibility. An instrumentation network would be established on each island to monitor levee movement, island subsidence, pore water pressure, and seepage. Construction quantities for the Incremental Flood Control Plan are summarized in Tables 51 and 52 for initial

TABLE 51

INCREMENTAL FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	LANDS AND DAMAGES: PERMANENT EASEMENTS AGRI-CULTURE (Acre)	LANDS AND DAMAGES: PERMANENT EASEMENTS COMMER-CIAL (Acre)	LANDS AND DAMAGES: TEMPORARY EASEMENT (Acre)	RELOCATIONS: ROADS (LF)	RELOCATIONS: BRIDGES (LS) $	RELOCATIONS: UTILITIES TOWERS (LS) $	UTILITIES POWER-LINES & CABLES (LF)	UTILITIES SIPHONS (LF)	UTILITIES PUMP HOUSES (LS) $	UTILITIES GAGING STATIONS (LS) $	UTILITIES WIND-MILLS (LS) $	UTILITIES IRRI-GATION DITCH (LF)
ANDRUS	144	35	9	0	0	0	10,000	250	18,000	1,000	0	0
BACON	231	0	17	0	0	15,000	10,600	180	29,000	1,000	0	0
BRACK WEST	130	0	13	0	0	0	0	360	2,000	0	0	0
BRANNAN	91	0	4	17,000	0	0	0	0	9,000	0	0	3,000
EMPIRE	100	7	13	32,000	0	30,000	7,000	600	5,000	0	0	37,000
HOTCHKISS	98	19	11	0	0	0	5,000	0	0	0	0	0
JONES	299	5	22	0	0	0	3,000	1,080	0	0	0	20,000
MANDEVILLE	272	0	17	0	0	0	2,000	720	0	0	0	0
McDONALD	271	0	16	0	0	0	1,000	1,080	0	0	0	10,000
RINDGE	287	13	19	0	0	15,000	0	240	9,000	1,000	0	0
ROBERTS-LOWER (WEST)	136	16	14	22,000	0	0	2,500	400	0	0	0	0
TERMINOUS WEST	332	8	22	34,000	0	0	0	0	10,000	0	0	0
TYLER	299	8	28	38,000	0	0	0	0	10,000	0	0	0
WEBB	233	0	16	0	0	15,000	0	0	5,000	0	0	0
TOTAL	2,923	111	221	143,000		75,000	41,100	4,910	97,000	3,000		70,000

TABLE 52

INCREMENTAL FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	RELOCATIONS: TRACKS (LF)	RELOCATIONS: BRIDGES (LS)	LEVEES: CLEARING & GRUBBING (Acre)	LEVEES: EMBANKMENT (CY)	LEVEES: EROSION PROTECTION (LF)	LEVEES: PATROL ROAD (Ton)	LEVEES: SEEDING (Acre)	LEVEES: WATER (M-Gal)	LEVEES: INSTRU-MENTATION (LS) $
ANDRUS	0	0	154	337,700	36,000	12,500	179	58,700	20,000
BACON	0	0	205	964,000	75,300	26,000	231	87,900	20,000
BRACK WEST	0	0	122	1,024,000	53,600	18,700	129	61,400	20,000
BRANNAN	0	0	86	622,000	17,200	6,000	91	37,300	20,000
EMPIRE	0	0	128	454,000	55,100	19,100	137	27,300	20,000
HOTCHKISS	0	0	111	366,000	45,600	15,800	117	22,000	20,000
JONES	0	0	289	1,449,000	95,400	33,000	304	86,900	20,000
MANDEVILLE	0	0	213	1,010,000	74,700	85,600	272	60,600	20,000
McDONALD	0	0	252	1,049,000	70,000	24,200	271	62,900	20,000
RINDGE	0	0	279	1,085,000	81,100	28,100	300	65,100	20,000
ROBERTS - LOWER (WEST)	0	0	146	51,000	55,100	19,100	151	3,100	10,000
TERMINOUS WEST	0	0	319	1,797,000	95,000	32,900	340	107,800	20,000
TYLER	0	0	291	992,000	119,300	41,300	307	59,500	20,000
WEBB	0	0	200	1,018,000	67,700	23,400	223	61,100	20,000
TOTAL	0	0	2,795	10,769,700	941,100	385,700	3,052	801,600	270,000

ISLAND/TRACT	FLOODWALLS: CONCRETE (CY)	FLOODWALLS: CEMENT (Ton)	FLOODWALLS: REINFORCING STEEL (Lbs)	FLOODWALLS: SHEET-PILING (SF)	FLOODWALLS: WATER STOP (LF)	FLOODWALLS: JOINT FILLER (LF)
HOTCHKISS	5,100	1,300	816,000	144,000	18,000	18,000

TABLE 53

INCREMENTAL FLOOD CONTROL PLAN
STAGE CONSTRUCTION QUANTITIES 300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	STAGE YEAR	LEVEES: CLEARING & GRUBBING (Acre)	LEVEES: EMBANKMENT (CY)	LEVEES: EROSION PROTECTION (LF)	LEVEES: PATROL ROAD (Ton)	LEVEES: SEEDING (Acre)	LEVEES: WATER (M-Gal)	UTILITIES: SIPHONS (LF)	UTILITIES: GAGING STATIONS (LS)
ANDRUS	4	76	105,000	33,000	11,400	76	6,300	0	0
	8	100	139,000	43,400	15,000	100	8,400	0	0
	12	126	162,000	54,900	19,000	126	9,700	0	0
	20	126	176,000	54,900	19,000	126	10,600	0	0
	30	86	120,000	37,300	12,900	86	7,200	0	0
	40	76	105,000	32,700	11,300	76	6,300	0	0
	60	96	134,000	41,600	14,400	96	8,000	0	0
BACON	6	104	320,200	45,200	15,700	104	19,200	180	1,000
	17	173	532,500	75,200	26,000	173	32,000	180	1,000
	40	23	2,900	10,000	3,500	23	200	180	1,000
	60	81	10,000	35,200	12,200	81	600	180	1,000
BRACK	8	8	165,000	3,100	1,100	8	9,900	360	0
BRANNAN	1	23	63,000	9,800	3,400	23	3,800	0	0
	6	23	63,000	9,800	3,400	23	3,800	0	0
	12	33	92,000	14,200	4,900	33	5,500	0	0
	26	23	63,000	9,800	3,400	23	3,800	0	0
	60	23	63,000	9,800	3,400	23	3,800	0	0
EMPIRE	4	12	19,700	5,200	1,800	12	1,200	600	0
	8	17	26,400	7,200	2,500	17	1,600	600	0
	16	127	204,300	55,100	19,100	127	12,300	600	0
	29	32	50,900	13,900	4,800	32	3,100	600	0
	54	12	19,100	5,200	1,800	12	1,200	600	0
HOTCHKISS	30	35	21,800	15,200	5,300	35	1,300	0	0
JONES	18	121	279,000	52,800	18,300	121	16,700	1,080	0
MANDEVILLE	10	110	295,000	48,300	16,700	110	17,700	720	0
	15	44	117,000	19,200	6,700	44	7,100	720	0
	30	74	197,000	32,200	11,100	74	11,800	720	0
	45	36	98,000	15,600	5,400	36	5,900	720	0
McDONALD	4	108	128,400	46,800	16,200	108	7,700	1,080	0
	8	93	110,200	40,200	13,900	93	6,600	1,080	0
	16	118	138,800	50,900	17,600	118	8,300	1,080	0
	24	112	131,900	48,300	16,700	112	7,900	1,080	0
	38	89	105,300	38,400	13,300	89	6,300	1,080	0
	80	67	78,900	28,900	10,000	67	4,700	1,080	0
RINDGE	8	20	11,700	8,800	3,000	20	700	240	1,000
	15	17	10,000	7,500	2,600	17	600	240	1,000
	25	50	29,400	22,100	7,700	50	1,800	240	1,000
	42	51	29,900	22,500	7,800	51	5,400	240	1,000
TERMINOUS	4	36	103,200	15,700	5,400	36	6,200	360	0
	8	101	289,000	44,000	15,200	101	17,400	360	0
	15	149	425,700	64,800	22,400	149	25,600	360	0
	25	115	328,500	50,000	17,300	115	19,700	360	0
	40	119	340,300	51,800	17,900	119	20,400	360	0
	70	35	98,000	15,000	5,200	35	6,700	360	0
TYLER	20	112	103,000	48,900	16,900	112	6,200	0	0
WEBB	4	64	145,500	27,800	9,600	64	8,700	0	0
	9	156	358,500	67,700	23,400	156	21,500	0	0
	27	156	358,500	67,700	23,400	156	21,500	0	0
	45	64	145,500	27,800	9,600	64	8,700	0	0
	60	49	111,300	21,100	7,300	49	6,700	0	0
TOTAL		3,701	7,225,300	1,606,500	555,900	3,701	438,300	17,640	8,000

ISLAND/TRACT	FLOODWALLS: CONCRETE (CY)	FLOODWALLS: CEMENT (Ton)	FLOODWALLS: REBAR (Lbs)	FLOODWALLS: SHEET-PILING (Ton)	FLOODWALLS: WATER STOP (LF)	FLOODWALLS: JOINT FILLER (LF)
HOTCHKISS	250	47	41,000	0	8,400	8,400

construction and Table 53 for stage construction. The construction of recreation facilities located on project islands would be coordinated with levee construction.

OPERATION AND MAINTENANCE

79. Flood control, recreation, and fish and wildlife enhancement features would be operated and maintained by non-Federal interests. A levee maintenance manual would be developed by the Corps in conjunction with non-Federal interests to carefully distinguish non-Federal maintenance requirements from Federal stage construction work. Levee maintenance and operation would conform to the requirements of CFR Title 33 Chapter 208.10.

ECONOMICS

80. First costs of the flood control features for the Incremental Flood Control Plan are listed in Tables 54 and 55. Annual costs are shown in Table 56. An economic summary of the flood control features is shown in Table 57. The economics of all features of the plan are shown in Table 58.

DESIGNATION AS THE NED PLAN

81. The NED Plan is the plan that addresses the planning objectives while reasonably maximizing net economic benefits (excess of benefits over costs) to the national economy. The Incremental Flood Control Plan was designated as the NED Plan since it is the candidate plan with the largest positive net benefits.

TABLE 54

INCREMENTAL FLOOD CONTROL PLAN
FIRST COST INITIAL CONSTRUCTION ONLY*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL						NON-FEDERAL					
ISLAND-TRACT	LEVEE LENGTH (MILES)	RELO-CATIONS	LEVEES	FLOOD-WALLS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL FEDERAL	LANDS+ DAMAGES	RELO-CATIONS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
ANDRUS	6.9	0	5248	0	630	420	6298	7849	125	15	10	7999	14297
BACON	14.3	0	12412	0	1489	993	14894	2323	160	19	13	2515	17409
BRACK W	10.8	0	11544	0	1385	924	13853	719	11	1	1	732	14585
BRANNAN	3.2	0	6177	0	741	494	7412	333	430	52	34	849	8261
EMPIRE	10.3	0	7007	0	841	561	8409	701	1025	123	82	1931	10340
HOTCHKISS	8.4	0	3007	4388	887	592	8874	194	0	0	0	194	9068
JONES L+U	17.8	0	17599	0	2112	1408	21119	1860	1603	192	128	3783	24902
MANDEVILLE	14.3	0	13548	0	1626	1084	16258	1050	36	4	3	1093	17351
MCDONALD	13.7	0	12870	0	1544	1030	15444	974	72	9	6	1061	16505
RINDGE	15.7	0	13829	0	1659	1106	16594	2029	36	4	3	2072	18666
ROB-LOW W	10.0	0	3745	0	449	300	4494	1608	562	67	45	2282	6776
TERMIN W	16.1	0	20454	0	2454	1636	24544	2336	828	99	66	3329	27873
TYLER	10.7	0	14995	0	1799	1200	17994	1570	924	111	74	2679	20673
WEBB	12.8	0	12414	0	1490	993	14897	892	24	3	2	921	15818
TOTAL	165.0	0	154849	4388	19106	12741	191084	24438	5836	699	467	31440	222524

*OCTOBER 1981 PRICE LEVEL

TABLE 55

INCREMENTAL FLOOD CONTROL PLAN
FIRST COST STAGE CONSTRUCTION*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

ISLAND-TRACT	LEVEE LENGTH (MILES)	FEDERAL RELO-CATIONS	FEDERAL LEVEES	FEDERAL FLOOD-WALLS	FEDERAL ENGR + DESIGN	FEDERAL SUPER-VISION + ADMIN	TOTAL FEDERAL	NON-FEDERAL LANDS + DAMAGES	NON-FEDERAL RELO-CATIONS	NON-FEDERAL ENGR + DESIGN	NON-FEDERAL SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
ANDRUS	6.9	0	11916	0	1430	953	14299	0	0	0	0	0	14299
BACON	14.3	0	9680	0	1162	774	11616	0	17	2	1	20	11636
BRACK W	10.8	0	1407	0	169	113	1689	0	9	1	1	11	1700
BRANNAN	3.2	0	2706	0	325	217	3248	0	0	0	0	0	3248
EMPIRE	10.3	0	4153	0	498	332	4983	0	58	7	5	70	5053
HOTCHKISS	8.4	0	0	0	0	0	0	0	0	0	0	0	0
JONES L+U	17.8	0	3371	0	404	270	4045	0	26	3	2	31	4076
MANDEVILLE	14.3	0	8154	0	978	652	9784	0	69	8	6	83	9867
MCDONALD	13.7	0	9696	0	1163	776	11635	0	130	16	10	156	11791
RINDGE	15.7	0	1909	0	229	153	2291	0	28	3	2	33	2324
ROB-LOW W	10.0	0	0	0	0	0	0	0	0	0	0	0	0
TERMIN W	16.1	0	16810	0	2017	1345	20172	0	43	5	3	51	20223
TYLER	10.7	0	1859	0	223	149	2231	0	0	0	0	0	2231
WEBB	12.8	0	12184	0	1462	975	14621	0	0	0	0	0	14621
TOTAL	165.0	0	83845	0	10060	6709	100614	0	380	45	30	455	101069

*OCTOBER 1981 PRICE LEVEL

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TABLE 56

INCREMENTAL FLOOD CONTROL PLAN
ANNUAL COST*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

ISLAND-TRACT	LEVEE LENGTH (MILES)	FEDERAL				NON-FEDERAL						TOTAL ANNUAL COST
		INTEREST	AMORTI-ZATION	STAGE CONST	TOTAL FEDERAL	INTEREST	AMORTI-ZATION	STAGE CONST	MAIN. + OPER.	MAJOR REPL	TOTAL NON-FED	
ANDRUS	6.9	480	13	392	885	610	16	0	23	0	649	1534
BACON	14.3	1136	30	374	1540	192	5	1	49	0	247	1787
BRACK W	10.8	1056	27	73	1156	56	1	0	37	0	94	1250
BRANNAN	3.2	565	15	114	694	65	2	0	11	0	78	772
EMPIRE	10.3	641	17	127	785	147	4	2	35	0	188	973
HOTCHKISS	8.4	677	18	0	695	15	0	0	71	0	86	781
JONES L+U	17.8	1610	42	84	1736	288	8	1	61	0	358	2094
MANDEVILLE	14.3	1240	32	223	1495	83	2	2	62	0	149	1644
MCDONALD	13.7	1178	31	339	1548	81	2	4	46	0	133	1681
RINDGE	15.7	1265	33	33	1331	158	4	1	53	0	216	1547
ROB-LOW W	10.0	343	9	0	352	174	5	0	22	0	201	553
TERMIN W	16.1	1872	49	477	2398	254	7	1	56	0	318	2716
TYLER	10.7	1372	36	40	1448	204	5	0	41	0	250	1698
WEBB	12.8	1 36	30	395	1561	70	2	0	44	0	116	1677
TOTAL	165.0	14571	382	2671	17624	2397	63	12	611	0	3083	20707

*OCTOBER 1981 PRICE LEVEL, 7.625 PERCENT INTEREST RATE, 50 YEAR AMORTIZATION

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TABLE 57

INCREMENTAL FLOOD CONTROL PLAN
AVERAGE ANNUAL COSTS AND BENEFITS
($1000)

ISLAND	FLOOD PROTECTION LEVEL	AVERAGE ANNUAL COSTS	AVERAGE ANNUAL BENEFITS FLOOD CONTROL	WATER QUALITY	TOTAL	NET BENEFITS	B/C RATIO
ANDRUS-BRANNAN ISLAND	300	2306	4742	1209	5951	3645	2.58
BACON ISLAND	300	1787	1624	233	1857	70	1.04
BRACK TRACT WEST	300	1250	1356	135	1491	241	1.19
EMPIRE TRACT	300	973	1211	130	1341	368	1.38 marginal
HOTCHKISS TRACT	300	781	2400	36	2436	1655	3.12
JONES/L.ROBERTS WEST	300	2647	3377	492	3869	1222	1.46 marginal
MANDEVILLE ISLAND	300	1644	1535	306	1841	197	1.12
MCDONALD TRACT	300	1681	1471	491	1962	281	1.17
RINDGE TRACT	300	1547	1530	432	1962	415	1.27
TERMINOUS TRACT WEST	300	2716	5639	794	6433	3717	2.37
TYLER ISLAND	300	1698	1367	368	1735	37	1.02
WEBB TRACT	300	1677	1219	522	1741	64	1.04
TOTAL		20707	27471	5148	32619	11912	1.58

1 WITH PERIPHERAL CANAL, WITH ISLAND RESTORATION

2 7.625 PERCENT INTEREST RATE   50 YEAR AMORTIZATION   OCTOBER 1981 PRICE LEVEL

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TABLE 58

INCREMENTAL FLOOD CONTROL PLAN
ECONOMIC SUMMARY
(1 October 1981 prices; 1990-2040 project conditions;
7-5/8 percent discount rate)

FIRST COST1/			$415,000,000
Flood Control and Water Quality		$326,000,000	
Initial Construction2/	$225,000,000		
Stage Construction	101,000,000		
Recreation		40,000,000	
Fish and Wildlife Enhancement		49,000,000	
ANNUAL COST			$28,100,000
Flood Control and Water Quality		$20,900,000	
Interest and Amortization	$20,300,000		
Operation and Maintenance	600,000		
Recreation		$4,000,000	
Interest and Amortization	$3,000,000		
Operation and Maintenance	1,000,000		
Fish and Wildlife Enhancement		$3,200,000	
Interest and Amortization	$2,900,000		
Operation and Maintenance	300,000		
ANNUAL BENEFITS			$53,800,000
Flood Control and Water Quality		$32,600,000	
Recreation		13,100,000	
Fish and Wildlife Enhancement		8,100,000	
BENEFIT-COST RATIOS - Total Project			1.9:1
Flood Control and Water Quality		1.6:1	
Recreation		3.3:1	
Fish and Wildlife Enhancement		2.5:1	
NET BENEFITS (excess of benefits over costs)			$25,700,000

1/ Rounded to nearest $1,000,000
2/ Includes $2,000,000 in fish and wildlife mitigation costs.

SENSITIVITY ANALYSIS

82. The alternative without-project conditions considered in the sensitivity analysis were described in the System Flood Control Plan. The results of the sensitivity analysis are shown in Table 59. Annual costs and benefits varied with the without-project condition. More islands were economically justified under the alternative scenarios than under the adopted scenario. The number of economically feasible islands associated with each scenario is also indicated in Table 59.

POLDER FLOOD CONTROL PLAN

PLAN DESCRIPTION

83. Flood Control Features. - The objective of formulating the Polder Flood Control Plan was to find the combination of islands and polders that would maximize net NED benefits. Given this objective, economically infeasible islands or polders were automatically discarded. Since some economically feasible polders contained economically infeasible islands, an examination of these polders was made to determine how optimum NED benefits could be obtained. This required modifying the original polders to exclude the infeasible islands. The net benefits accruing from the remaining modified polders were compared to the net benefits derived from protecting the islands within the modified polders individually.

84. The resulting Polder Flood Control Plan consisted of 2 polders and 10 islands that would be protected individually. The lands protected by the Polder Flood Control Plan are identical to those protected by the Incremental

TABLE 59

SENSITIVITY ANALYSIS
INCREMENTAL FLOOD CONTROL PLAN

Without-Project Condition	Project Feature	Annual Cost 1/	Annual Benefit ($1000)	Net Benefit	B/C Ratio	No. of Islands In Plan
With Peripheral Canal	Flood Control	20,707	32,619	11,912	1.6	15
With Island Restoration	Recreation	4,035	13,058	9,023	3.3	
(Adopted Condition)	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	27,960	53,801	25,841	1.9	
Without Peripheral Canal	Flood Control	28,607	46,346	17,739	1.6	19
With Island Restoration	Recreation	4,035	13,058	9,023	3.3	
	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	35,860	67,528	31,668	1.9	
With Peripheral Canal	Flood Control	29,269	53,573	24,304	1.8	27
Without Island Restoration	Recreation	4,035	13,058	9,023	3.3	
	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	36,522	74,755	38,233	2.0	
Without Peripheral Canal	Flood Control	31,540	68,703	37,163	2.2	27
Without Island Restoration	Recreation	4,035	13,058	9,023	3.3	
	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	38,793	89,885	51,092	2.3	

1/ Does not include mitigation costs.

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Flood Control Plan. The only difference is that McDonald and Upper and Lower Jones Tracts, and Mandeville and Bacon Islands are included in polders in the Polder Flood Control Plan. The Polder Plan is attractive from the standpoint that it maximizes the area of land provided flood protection per mile of improved levee. The economic trade-off made when considering polders involves the cost of channel closure structures compared to the cost of levee improvements foregone for those levees located inside the polder.

85. With the Polder Plan, about 155 miles of nonproject levees would be improved to provide 300-year flood protection. Rockfill closure structures would close Empire Cut between McDonald and Lower Jones Tracts. Similarly, Connection Slough between Mandeville and Bacon Islands would be closed. The closure structures would provide positive channel closure and no water would enter the channels. Four miles of channels would be lost. Levees along the closed channels would not be improved.

86. Stage construction would be used to improve the majority of the levees. Sheet pile floodwalls would be used on about 3-1/2 miles of existing Hotchkiss Tract levee where development along the levee prohibits the use of stage construction. Setback levees would be used on Brack Tract along Hog Slough to avoid removing significant riparian habitat.

87. Land Use Regulations. - Land use regulation requirements are identical for all candidate plans. Non-Federal interests would be required to provide assurances that zoning regulations would be enacted and enforced to limit development on agricultural islands to a level consistent and compatible with the continued use of those islands for agricultural purposes. Development on

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urban islands would be restricted to areas incapable of sustained economic agricultural production and be consistent with city and county General Plans.

88. Recreation Features. - Recreation features would include 14 recreation sites, 23 fishing access sites, 8 boater destination sites, and 145 miles of trails. A detailed description of the facilities provided at these sites appears in the Recreation and Environmental Quality Plan Formulation section of this appendix.

89. Fish and Wildlife Enhancement Features. - The fish and wildlife enhancement features would be identical to those of the System and Modified System Flood Control Plans except that the setback levee provisions for Canal Ranch, McCormack-Williamson, and New Hope Tracts would be omitted since those tracts are economically infeasible and not included in the plan.

90. Flood Hazard Mitigation Program. - As with the Modified System and Incremental Flood Control Plans, a Flood Hazard Mitigation Program would be an integral part of the Polder Plan. This program would encourage non-Federal interests to improve and maintain levees not included in the Polder Plan to a Federal standard. In return, such levees would be declared to be flood control structures. They would thus be eligible for consideration to receive flood emergency assistance under the authority of PL 84-99 in the event of future floods.

91. Mitigation Features. - Mitigation features would involve the acquisition of about 650 acres of agricultural land on project islands and the development of three recreation areas near Empire Cut and Connection Slough.

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PLAN ACCOMPLISHMENTS

92. Flood Control. - The Polder Flood Control Plan would provide 300-year flood protection to about 80,000 acres of primarily agricultural lands on 14 islands and tracts. Equivalent average annual flood damages in these locations would be reduced from about $34 million to $1 million. About $20 million in equivalent average annual damages would occur on islands not included in the plan.

93. Recreation. - On an annual basis, 2.4 million recreation days would be provided by the recreation improvements.

94. Fish and Wildlife. - Fish and wildlife resources would be preserved or enhanced through the acquisition and management of about 6,000 acres of freshwater marshes, channel islands with native vegetation, and agricultural lands. A Wildlife Management Area would be developed on Little Mandeville, Medford, Mildred, Quimby, and Rhode Islands. This area would improve waterfowl distribution and decrease disease loss and crop depredation. Opportunities would be provided for fishing and hunting and environmental education.

EFFECTS OF THE PLAN ON THE ENVIRONMENT

95. A significant impact of the polder plan would be the clearing of riparian, agricultural, and upland habitat for rehabilitation of the existing levees. Table 3.3 of the EIS lists the lands that would be affected. Upland habitat would increase by approximately 1,370 acres, as grasses and shrubs cover the project levees. About 160 acres of emergent vegetation would be

removed during construction, and 80 percent would recover in time. The major adverse impacts would result from the loss of about 390 acres of riparian habitat. An additional significant impact would result from the closing of two major waterway connections, Connection Slough, which joins Old River to Middle River, and Empire Cut, which connects Middle River to Turner Cut and the San Joaquin River. Approximately 4 miles of channel would be closed. This would affect recreational boating, fishing, the fishery, and flow patterns. Permanent relocation of irrigation and drainage facilities located along the channels would be required.

96. No technical studies were conducted to determine the effects of the two polders on hydrodynamic and salinity conditions. Earlier studies were conducted to determine the effects of imposing nine polders on the Delta. The polders were similar in configuration to those shown in Figure 18. DWR's tidal hydrodynamics mathematical model and salinity mathematical model were used to conduct the studies. The tidal hydrodynamics model output used the average tidal-cycle flowrates predicted over prescribed steady-state Delta hydrologic and operational conditions. For historic 1968 conditions it was assumed that 21 steady-state periods should be used. These average tidal-cycle flowrates over each steady-state period were input to the salinity model which predicts continuous salinity concentrations over the year, accounting for both ocean-derived and land-derived salts.

97. The nine-polder plan was found to have no effect upon hydrodynamics in Suisun Bay, in net Delta outflows, nor in reverse flow at Antioch. The reduction in flowrate possible through Fisherman's Cut would slightly reduce reverse flow into the main-stem San Joaquin River and slightly increase reverse flow into False River and Dutch Slough. The polders would result in a

more direct routing of Sacramento River water to the export pumps, thereby increasing the flowrates in the northerly reaches of Old and Middle Rivers due to a reduction in the westward flowrate possible through Empire Cut. This tends to decrease reverse flow in the San Joaquin River north of McDonald Island, but not south of Turner Cut. The reduction in the flowrates possible through Bacon and Woodward Canal would reduce the cross-transfer of water between Middle and Old Rivers. The reduction in the flowrate possible through Indian Slough would increase the flowrate in Old River east of Palm-Orwood tracts. Channel velocities would be both increased and decreased in various reaches of Old and Middle Rivers.

98. The nine-polder plan was found to have no effect upon salinity in Suisun Bay or the Sacramento River. Salinities would be reduced slightly in the main-stem San Joaquin River, and increased slightly in False River and Dutch Slough.

99. In Old and Middle Rivers, there would be no increase in salinity at Holland Tract, a small increase in the Contra Costa Canal (resulting from flowrate reduction in Indian Slough), a small decrease at Victoria Canal (resulting from the reduction in cross-transfer of Sacramento River water out of Middle River), and no change at Clifton Court Forebay.

100. Channel detention times would increase in some channels and decrease in others. However, there would be no change in the San Joaquin River near Stockton. Thus, the polders would neither alleviate nor worsen the alleged dissolved oxygen sag occurring there.

101. The polders would have no effect upon the poor quality San Joaquin River water in the southern Delta as it flows into the Old River bifurcation and on to the pumps for exportation.

102. The polders would have no negative effect upon the duration of Sacramento River water in the southern Delta, and in fact may increase outflow in portions of the San Joaquin River or result in a lesser amount of outflow required past Stockton to produce an outward flow north of McDonald Island. However, as reverse flows in the San Joaquin River into Empire Cut are decreased, simultaneous increases in flowrates occur in northern Middle and Old Rivers, which may increase the adverse effects that export pumps have in drawing fish eggs southward to the export pumps.

103. The polders should produce no effect upon already undesirable reverse salinity gradients in the Delta.

DESIGN

104. Polders would be constructed by rehabilitating existing levees and closing channels between islands within the polders with rockfill stuctures.

105. Hydrology. - The Polder Plan would alter the hydraulic regime of the Delta by closing off Connection Slough between Bacon and Mandeville Islands and Empire Cut between McDonald Island and Lower Jones Tract. The impact of the closure on adjacent waterflows, stages, and water quality was not evaluated for the polders adopted for this plan. Refer to the System Flood Control Plan for a discussion of levee design aspects.

RIGHTS-OF-WAY

106. Non-Federal interests would be required to provide all project lands and absorb all claims for damages. Rights-of-way would be required for all levee, recreation, and fish and wildlife improvements. Fee acquisition would be required for all lands open to the public. Temporary construction easements and permanent maintenance easements could be acquired for levees not open to the public. Permanent environmental easements would be acquired to preserve those fish and wildlife lands closed to the public. Table 60 summarizes the minimum right-of-way requirements for levee improvements.

RELOCATIONS

107. Facility relocation quantities are shown in Table 60. Irrigation and drainage structures located along the closed channels would be permanently relocted. Relocation costs would be borne by non-Federal interests.

CONSTRUCTION

108. Levees. - As indicated in the description of the flood control features of this plan, nearly all the levees would be improved using the stage construction method. The stage construction method was described in the System Flood Control Plan. Initial and stage construction would be a Federal responsibility. An instrumentation network would be established on each island to monitor levee movement, island subsidence, and seepage. Construction quantities for initial construction are shown in Tables 60 and 61. Stage construction quantities are shown in Table 62. Recreation facility

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TABLE 60

POLDER FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	LANDS AND DAMAGES			RELOCATIONS								
	PERMANENT EASEMENTS		TEMPORARY EASEMENT	ROADS	BRIDGES	UTILITIES						
	AGRI-CULTURE (Acre)	COMMER-CIAL (Acre)	(Acre)	(LF)	(LS) $	TOWERS (LS) $	POWER-LINES & CABLES (LF)	SIPHONS (LF)	PUMP HOUSES (LS) $	GAGING STATIONS (LS) $	WIND-MILLS (LS) $	IRRI-GATION DITCH (LF)
ANDRUS	144	35	15	63,000	0	0	10,000	250	18,000	1,000	0	0
BACON-MANDEVILLE POLDER	565	0	32	0	0	15,000	12,600	900	29,000	1,000	0	0
BRACK	130	0	13	0	0	0	0	360	2,000	0	0	0
BRANNAN	91	0	4	17,000	0	0	0	0	9,000	0	0	3,000
EMPIRE	100	7	13	32,000	0	30,000	7,000	600	5,000	0	0	37,000
HOTCHKISS	98	19	11	0	0	0	5,000	0	0	0	0	0
JONES-McDONALD POLDER	497	4	31	0	0	0	4,000	2,000	0	0	0	24,000
RINDGE	287	13	19	0	0	15,000	0	240	9,000	1,000	0	0
ROBERTS-LOWER (WEST)	136	16	14	22,000	0	0	2,500	400	0	0	0	0
TERMINOUS	332	8	22	34,000	0	0	0	0	10,000	0	0	0
TYLER	299	8	28	38,000	0	0	0	0	10,000	0	0	0
WEBB	233	0	16	0	0	15,000	0	0	5,000	0	0	0
TOTAL	2,912	110	218	206,000		75,000	41,100	4,750	97,000	3,000		64,000

TABLE 61

POLDER FLOOD CONTROL PLAN
INITIAL CONSTRUCTION QUANTITIES
300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	RELOCATIONS		LEVEES							FLOOD CONTROL STRUCTURES		
	TRACKS (LF)	BRIDGES (LS)	CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	INSTRU-MENTATION (LS) $	EMBANK-MENT (CY)	EROSION PROTECTION (LF)	STONE FILL (Ton)
ANDRUS	0	0	154	337,700	36,000	12,500	179	58,700	20,000			
BACON-MANDEVILLE POLDER	0	0	464	2,727,000	135,000	99,900	573	152,600	20,000	143,400	1,500	90,000
BRACK WEST	0	0	122	1,024,000	53,600	18,700	129	61,400	20,000			
BRANNAN	0	0	86	622,000	17,200	6,000	91	37,300	20,000			
EMPIRE	0	0	128	454,000	55,100	19,100	137	27,300	20,000			
HOTCHKISS	0	0	111	366,000	45,600	15,800	117	22,000	20,000			
JONES-McDONALD POLDER	0	0	467	2,233,000	136,200	47,500	504	134,000	40,000	47,600	1,000	106,000
RINDGE	0	0	279	1,085,000	81,100	28,100	300	65,100	20,000			
ROBERTS - LOWER (WEST)	0	0	146	51,000	55,100	19,100	151	3,100	10,000			
TERMINOUS WEST	0	0	319	1,797,000	95,000	32,900	340	107,800	20,000			
TYLER	0	0	291	992,000	119,300	41,300	307	59,500	20,000			
WEBB	0	0	200	1,018,000	67,700	23,400	223	61,100	20,000			
TOTAL	0	0	2,767	12,706,700	896,900	364,300	3,051	789,900	250,000	191,000	2,500	196,000

ISLAND/TRACT	FLOODWALLS					
	CONCRETE (CY)	CEMENT (Ton)	REINFORCING STEEL (Lbs)	SHEET-PILING (SF)	WATER STOP (LF)	JOINT FILLER (LF)
HOTCHKISS	5,100	1,300	816,000	144,000	18,000	18,000

TABLE 62

POLDER FLOOD CONTROL PLAN
STAGE CONSTRUCTION QUANTITIES 300-YEAR FLOOD PROTECTION
(With Peripheral Canal)

ISLAND/TRACT	STAGE YEAR	LEVEES						UTILITIES	
		CLEARING & GRUBBING (Acre)	EMBANKMENT (CY)	EROSION PROTECTION (LF)	PATROL ROAD (Ton)	SEEDING (Acre)	WATER (M-Gal)	SIPHONS (LF)	GAGING STATIONS (LS)
ANDRUS	4	76	105,000	33,000	11,400	76	6,300	0	0
	8	100	139,000	43,400	15,000	100	8,400	0	0
	12	126	162,000	54,900	19,000	126	9,700	0	0
	20	126	176,000	54,900	19,000	126	10,600	0	0
	30	86	120,000	37,300	12,900	86	7,200	0	0
	40	76	105,000	32,700	11,300	76	6,300	0	0
	60	96	134,000	41,600	14,400	96	8,000	0	0
BACON (BACON-MANDEVILLE POLDER)	6	104	320,200	45,200	15,700	104	19,200	180	1,000
	17	173	532,500	75,200	26,000	173	32,000	180	1,000
	40	23	2,900	10,000	3,500	23	200	180	1,000
	60	81	10,000	35,200	12,200	81	600	180	1,000
BRACK	8	8	165,000	3,100	1,100	8	9,900	360	0
BRANNAN	1	23	63,000	9,800	3,400	23	3,800	0	0
	6	23	63,000	9,800	3,400	23	3,800	0	0
	12	33	92,000	14,200	4,900	33	5,500	0	0
	26	23	63,000	9,800	3,400	23	3,800	0	0
	60	23	63,000	9,800	3,400	23	3,800	0	0
EMPIRE	4	12	19,700	5,200	1,800	12	1,200	600	0
	8	17	26,400	7,200	2,500	17	1,600	600	0
	16	127	204,300	55,100	19,100	127	12,300	600	0
	29	32	50,900	13,900	4,800	32	3,100	600	0
	54	12	19,100	5,200	1,800	12	1,200	600	0
HOTCHKISS	30	35	21,800	15,200	5,300	35	1,300	0	0
JONES (JONES-McDONALD POLDER)	18	121	279,000	52,800	18,300	121	16,700	1,080	0
MANDEVILLE (BACON-MANDEVILLE POLDER)	10	110	295,000	48,300	16,700	110	17,700	720	0
	15	44	117,000	19,200	6,700	44	7,100	720	0
	30	74	197,000	32,200	11,100	74	11,800	720	0
	45	36	98,000	15,600	5,400	36	5,900	720	0
McDONALD (JONES-McDONALD POLDER)	4	108	128,400	46,800	16,200	108	7,700	1,080	0
	8	93	110,200	40,200	13,900	93	6,600	1,080	0
	16	118	138,800	50,900	17,600	118	8,300	1,080	0
	24	112	131,900	48,300	16,700	112	7,900	1,080	0
	38	89	105,300	38,400	13,300	89	6,300	1,080	0
	80	67	78,900	28,900	10,000	67	4,700	1,080	0
RINDGE	8	20	11,700	8,800	3,000	20	700	240	1,000
	15	17	10,000	7,500	2,600	17	600	240	1,000
	25	50	29,400	22,100	7,700	50	1,800	240	1,000
	42	51	29,900	22,500	7,800	51	5,400	240	1,000
TERMINOUS	4	36	103,200	15,700	5,400	36	6,200	360	0
	8	101	289,000	44,000	15,200	101	17,400	360	0
	15	149	425,700	64,800	22,400	149	25,600	360	0
	25	115	328,500	50,000	17,300	115	19,700	360	0
	40	119	340,300	51,800	17,900	119	20,400	360	0
	70	35	98,000	15,000	5,200	35	6,700	360	0
TYLER	20	112	103,000	48,900	16,900	112	6,200	0	0
WEBB	4	64	145,500	27,800	9,600	64	8,700	0	0
	9	156	358,500	67,700	23,400	156	21,500	0	0
	27	156	358,500	67,700	23,400	156	21,500	0	0
	45	64	145,500	27,800	9,600	64	8,700	0	0
	80	49	111,300	21,100	7,300	49	6,700	0	0
TOTAL		3,701	7,225,300	1,606,500	555,900	3,701	438,300	17,640	8,000

ISLAND/TRACT	FLOODWALLS					
	CONCRETE (CY)	CEMENT (Ton)	REBAR (Lbs)	SHEET-PILING (Ton)	WATER STOP (LF)	JOINT FILLER (LF)
HOTCHKISS	250	47	41,000	0	8,400	8,400

construction would have to be coordinated with levee construction on project islands. On nonproject islands recreation construction could commence at the time levee construction begins on project islands.

109. Closure Structures. - Channel closure structures would be constructed of quarry waste material. Although no information is available on foundation conditions at the channel closure sites, it can be inferred from available data along the levees that the channel deposits probably consist of peats, soft clays and silts, organic silts and clays, and sand. Generally, the subsoils decrease in organic material and increase in strength with depth. With this type of foundation condition, fill material would either sink bodily into the subsoil or, together with the layer of soil on which it rests, it may spread on an underlying stratum of soft clay or on partings of sand and silt containing water under pressure. To accelerate the penetration of the fill material and to shorten the subsequent period of settlement, the fill would be overbuilt to a height of 15 to 20 feet above final grade. Excess material would be removed after settlement is completed.

OPERATION AND MAINTENANCE

110. Flood control, recreation, and fish and wildlife enhancement features would be operated and maintained by non-Federal interests. A levee maintenance manual would be developed by the Corps in cooperation with non-Federal interests to carefully distinguish non-Federal maintenance requirements from stage construction operations conducted by Federal interests. Levee maintenance and operation requirements would conform to the requirements of CFR Title 33 Chapter 208.10.

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ECONOMICS

111. First costs for the Polder Flood Control Plan are listed in Tables 63 and 64. Annual costs are shown in Table 65. Annual costs and benefits are shown in Table 66. An economic summary appears in Table 67.

SENSITIVITY ANALYSIS

112. The alternative without-project conditions considered in the sensitivity analysis were described in the System Flood Control Plan. The results of the sensitivity analysis are summarized in Table 68.

TABLE 63

POLDER FLOOD CONTROL PLAN
FIRST COST INITIAL CONSTRUCTION ONLY
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

ISLAND-TRACT	LEVEE LENGTH (MILES)	FEDERAL RELO-CATIONS	FEDERAL LEVEES	FEDERAL FLOOD-WALLS2	FEDERAL ENGR + DESIGN	FEDERAL SUPER-VISION + ADMIN	TOTAL FEDERAL	NON-FEDERAL LANDS+ DAMAGES	NON-FEDERAL RELO-CATIONS	NON-FEDERAL ENGR + DESIGN	NON-FEDERAL SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
POLDER 4	25.8	0	26758	2331	3491	2327	34907	2384	173	21	14	2592	37499
POLDER 5	41.6	0	18123	2816	2513	1675	25127	2879	40	5	3	2927	28054
ANDRUS	6.9	0	5248	0	630	420	6298	7849	125	15	10	7999	14297
BRACK	3.2	0	11544	0	1385	924	13853	719	11	1	1	732	14585
BRANNAN	3.2	0	6177	0	741	494	7412	333	430	52	34	849	8261
EMPIRE	10.3	0	7007	0	841	561	8409	701	1025	123	82	1931	10340
HOTCHKISS	8.4	0	3007	4388	887	592	8874	194	0	0	0	194	9068
RINDGE	15.7	0	13829	0	1659	1106	16594	2029	36	4	3	2072	18666
ROB-LOW W	10.0	0	3745	0	449	300	4494	1608	562	67	45	2282	6776
TERMIN W	16.1	0	20454	0	2454	1636	24544	2336	828	99	66	3329	27873
TYLER	10.7	0	14995	0	1799	1200	17994	1570	924	111	74	2679	20673
WEBB	12.8	0	12414	0	1490	993	14897	892	24	3	2	921	15818
TOTAL	164.7	0	143301	9535	18339	12228	183403	23494	4178	501	334	28507	211910

1OCTOBER 1981 PRICE LEVEL
2FLOODWALLS INCLUDE CLOSURE STRUCTURES

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TABLE 64

POLDER FLOOD CONTROL PLAN
FIRST COST STAGE CONSTRUCTION*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL						NON-FEDERAL					
ISLAND-TRACT	LEVEE LENGTH (MILES)	RELO-CATIONS	LEVEES	FLOOD-WALLS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL FEDERAL	LANDS + DAMAGES	RELO-CATIONS	ENGR + DESIGN	SUPER-VISION + ADMIN	TOTAL NON-FED	TOTAL PROJECT
POLDER 4	25.8	0	11810	0	1417	945	14172	0	48	6	4	58	14230
POLDER 5	41.6	0	12379	0	1486	990	14855	0	2669	320	214	3203	18058
ANDRUS	6.9	0	11916	0	1430	953	14299	0	0	0	0	0	14299
BRACK	3.2	0	1407	0	169	113	1689	0	9	1	1	11	1700
BRANNAN	3.2	0	2706	0	325	217	3248	0	0	0	0	0	3248
EMPIRE	10.3	0	4153	0	498	332	4983	0	58	7	5	70	5053
HOTCHKISS	8.4	0	0	0	0	0	0	0	0	0	0	0	0
RINDGE	15.7	0	1909	0	229	153	2291	0	28	3	2	33	2324
ROB-LOW W	10.0	0	0	0	0	0	0	0	0	0	0	0	0
TERMIN W	16.1	0	16810	0	2017	1345	20172	0	43	5	3	51	20223
TYLER	10.7	0	1859	0	223	149	2231	0	0	0	0	0	2231
WEBB	12.8	0	12184	0	1462	975	14621	0	0	0	0	0	14621
TOTAL	164.7	0	77133	0	9256	6172	92561	0	2855	342	229	3426	95987

*OCTOBER 1981 PRICE LEVEL

TABLE 65

POLDER FLOOD CONTROL PLAN
ANNUAL COST*
WITH PERIPHERAL CANAL
WITH ISLAND RESTORATION
300-YEAR FLOOD PROTECTION
($1000)

		FEDERAL				NON-FEDERAL						
ISLAND-TRACT	LEVEE LENGTH (MILES)	INTEREST	AMORTI-ZATION	STAGE CONST	TOTAL FEDERAL	INTEREST	AMORTI-ZATION	STAGE CONST	MAIN. + OPER.	MAJOR REPL	TOTAL NON-FED	TOTAL ANNUAL COST
POLDER 4	25.8	2662	69	383	3114	198	5	2	88	0	293	3407
POLDER 5	41.6	1916	50	384	2350	223	6	118	81	0	428	2778
ANDRUS	6.9	480	13	392	885	610	16	0	23	0	649	1534
BRACK	3.2	1056	27	73	1156	56	1	0	37	0	94	1250
BRANNAN	3.2	565	15	114	694	65	2	0	11	0	78	772
EMPIRE	10.3	641	17	127	785	147	4	2	35	0	188	973
HOTCHKISS	8.4	677	18	0	695	15	0	0	71	0	86	781
RINDGE	15.7	1265	33	33	1331	158	4	1	53	0	216	1547
ROB-LOW W	10.0	343	9	0	352	174	5	0	22	0	201	553
TERMIN W	16.1	1872	49	477	2398	254	7	1	56	0	318	2716
TYLER	10.7	1372	36	40	1448	204	5	0	41	0	250	1698
WEBB	12.8	1136	30	395	1561	70	2	0	44	0	116	1677
TOTAL	164.7	13985	366	2418	16769	2174	57	124	562	0	2917	19686

*OCTOBER 1981 PRICE LEVEL, 7.625 PERCENT INTEREST RATE, 50 YEAR AMORTIZATION

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TABLE 66
POLDER FLOOD CONTROL PLAN
AVERAGE ANNUAL COSTS AND BENEFITS
($1000)

ISLAND	FLOOD PROTECTION LEVEL	AVERAGE ANNUAL COSTS	AVERAGE ANNUAL BENEFITS FLOOD CONTROL	WATER QUALITY	TOTAL	NET BENEFITS	B/C RATIO
POLDER 4	300	3407	3362	805	4167	760	1.22
POLDER 5	300	2778	3159	539	3698	920	1.33
ANDRUS-BRANNAN ISLAND	300	2306	4742	1209	5951	3645	2.58
BRACK TRACT WEST	300	1250	1356	135	1491	241	1.19
EMPIRE TRACT	300	973	1211	130	1341	368	1.38
HOTCHKISS TRACT	300	781	2400	36	2436	1655	3.12
RINDGE TRACT	300	1547	1530	432	1962	415	1.27
ROBERTS-LOWER WEST TRACT	300	553	1486	178	1664	1111	3.01
TERMINOUS TRACT WEST	300	2716	5639	794	6433	3717	2.37
TYLER ISLAND	300	1698	1367	368	1735	37	1.02
WEBB TRACT	300	1677	1219	522	1741	64	1.04
TOTAL		19686	27471	5148	32619	12933	1.66

1 WITH PERIPHERAL CANAL, WITH ISLAND RESTORATION

2 7.625 PERCENT INTEREST RATE 50 YEAR AMORTIZATION OCTOBER 1981 PRICE LEVEL

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TABLE 67

POLDER FLOOD CONTROL PLAN

ECONOMIC SUMMARY

(1 October 1981 prices; 1990-2040 project conditions;

7-5/8 percent discount rate)

FIRST COST1/			$415,000,000
Flood Control and Water Quality		$326,000,000	
Initial Construction2/	$230,000,000		
Stage Construction	96,000,000		
Recreation		40,000,000	
Fish and Wildlife Enhancement		49,000,000	
ANNUAL COST			$28,300,000
Flood Control and Water Quality		$21,100,000	
Interest and Amortization	$20,500,000		
Operation and Maintenance	600,000		
Recreation		$4,000,000	
Interest and Amortization	$3,000,000		
Operation and Maintenance	1,000,000		
Fish and Wildlife Enhancement		$3,200,000	
Interest and Amortization	$2,900,000		
Operation and Maintenance	300,000		
ANNUAL BENEFITS			$53,800,000
Flood Control and Water Quality		$32,600,000	
Recreation		13,100,000	
Fish and Wildlife Enhancement		8,100,000	
BENEFIT-COST RATIOS - Total Project			1.9:1
Flood Control and Water Quality		1.5:1	
Recreation		3.3:1	
Fish and Wildlife Enhancement		2.5:1	
NET BENEFITS (excess of benefits over costs)			$25,500,000

1/ Rounded to nearest $1,000,000
2/ Includes $18,000,000 in fish and wildlife mitigation costs.

TABLE 68

SENSITIVITY ANALYSIS
POLDER FLOOD CONTROL PLAN

Without-Project Condition	Project Feature	Annual Cost 1/ ($1,000)	Annual Benefit ($1,000)	Net Benefit ($1,000)	B/C Ratio	No. of Islands In Plan
With Peripheral Canal	Flood Control	19,686	32,619	12,933	1.7	15
With Island Restoration	Recreation	4,035	13,058	9,023	3.3	
(Adopted Condition)	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	26,939	53,801	26,862	2.0	
Without Peripheral Canal	Flood Control	26,320	46,346	20,026	1.8	18
With Island Restoration	Recreation	4,035	13,058	9,023	3.3	
	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	33,573	67,528	33,955	2.0	
With Peripheral Canal	Flood Control	28,248	53,573	25,325	1.9	27
Without Island Restoration	Recreation	4,035	13,058	9,023	3.3	
	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	35,501	74,755	39,254	2.1	
Without Peripheral Canal	Flood Control	29,253	68,703	39,450	2.3	27
Without Island Restoration	Recreation	4,035	13,058	9,023	3.3	
	Fish and Wildlife	3,218	8,124	4,906	2.5	
	Total	36,506	89,885	53,379	2.5	

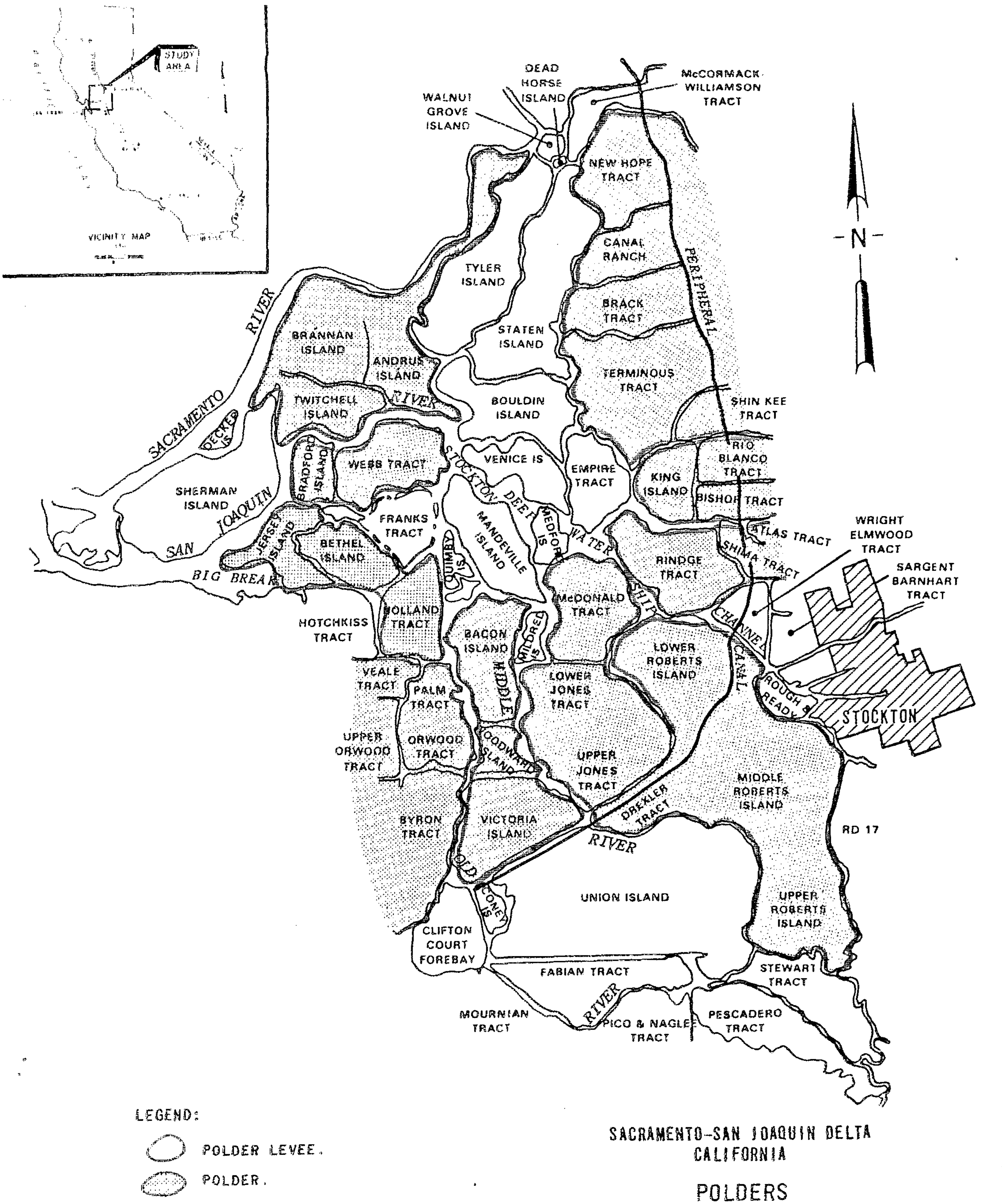
1/ Does not include mitigation costs

C-103280

113. If the additional mitigation costs for the polder plan were taken into account the net benefits and benifit-cost ratio would be reduced by the following amounts.

Without Project Condition	Net Benefit ($1,000)	B/C Ratio
With Peripheral Canal With Island Restoration	25,458	1.9
Without Peripheral Canal With Island Restoration	29,930	1.8
With Peripheral Canal Without Island Restoration	37,460	2.0
Without Peripheral Canal Without Island Restoration	45,729	2.0

114. The without-project condition regarding the Peripheral Canal had a significant impact on formulating a plan involving polders. With the Peripheral Canal, polders were formed to allow a generally east-to-west movement of water. Without the Peripheral Canal, polders were formed to allow water to be transported across the Delta from Walnut Grove in the north to the CVP and SWP pumping plants located near Tracy in the south. Figure 15 shows polders developed for the without-Peripheral Canal condition. Annual costs and benefits of a polder plan formulated to maximize net NED benefits for this scenario are shown in Table 68.



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

POLDERS
EARLIER STUDIES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

FIGURE 18

C-103282

C-103282

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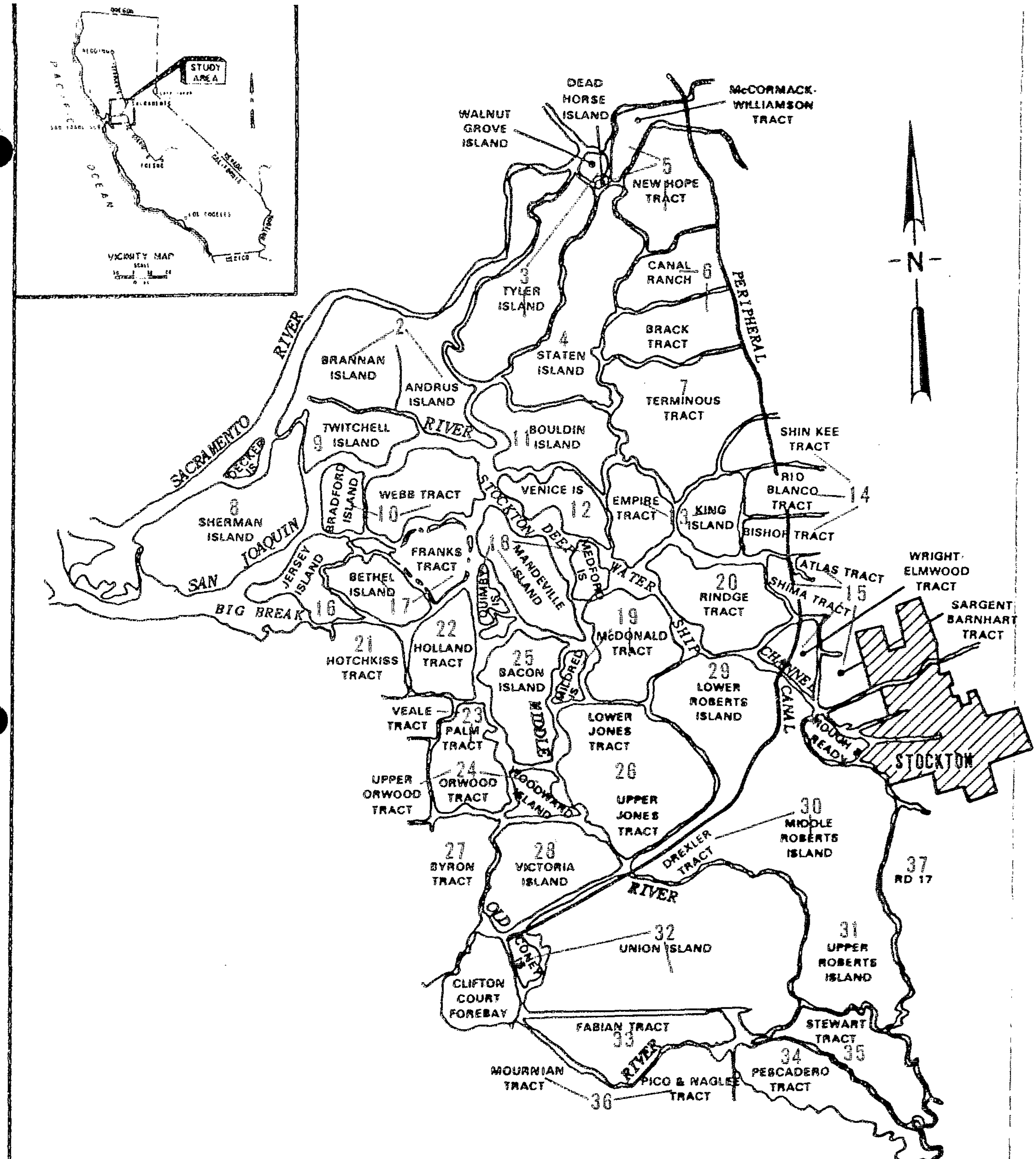


SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

PLATE KEY

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN MILES
2 0 2 4 6 8

PLATE

C-103285

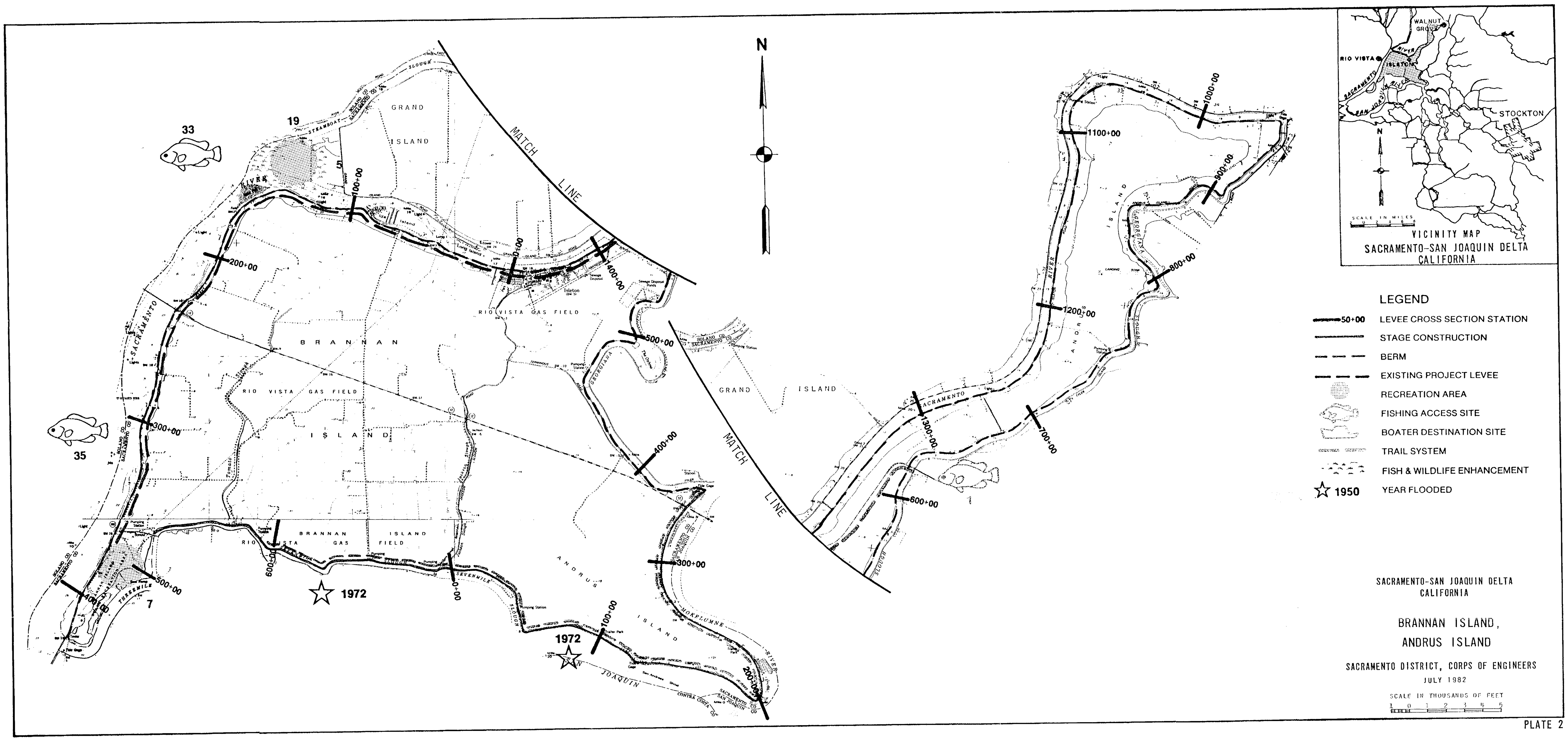
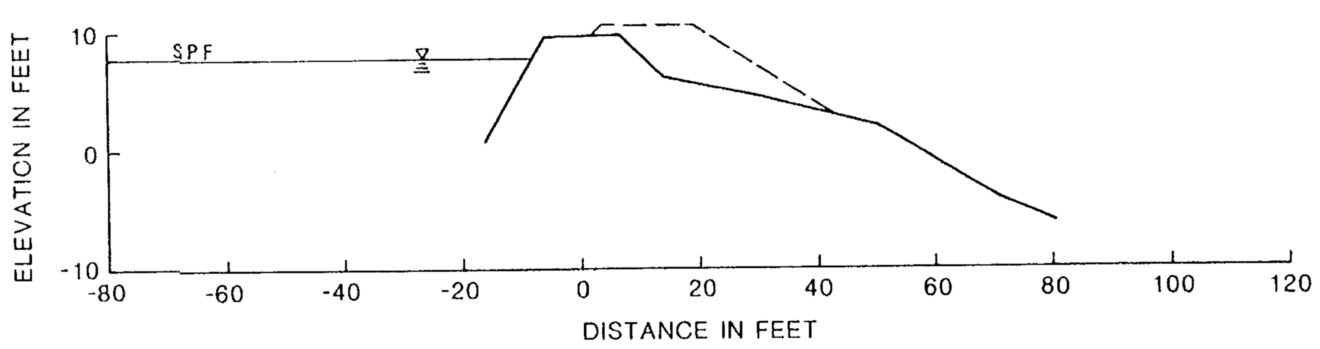


PLATE 2

C-103286



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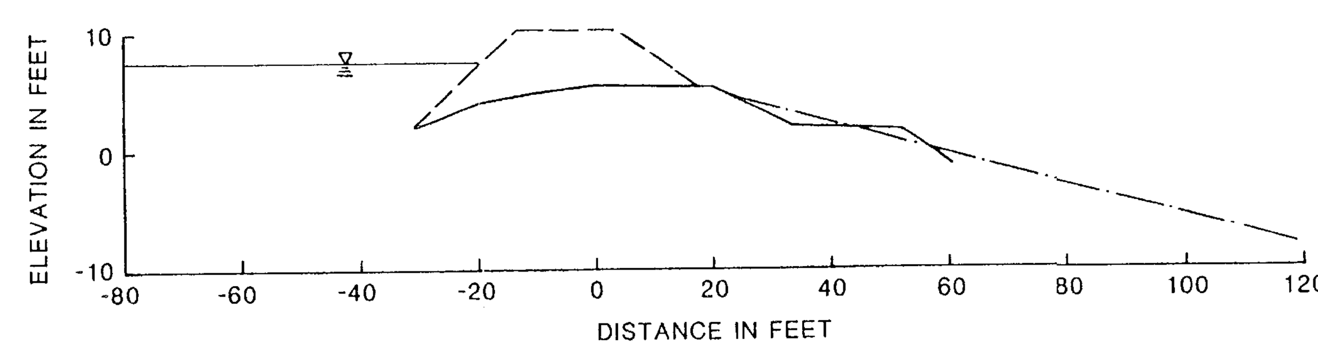

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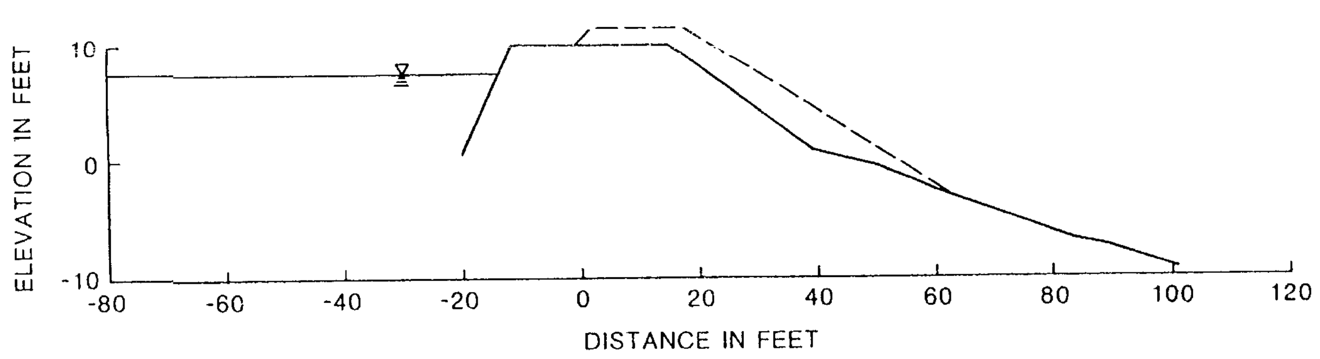

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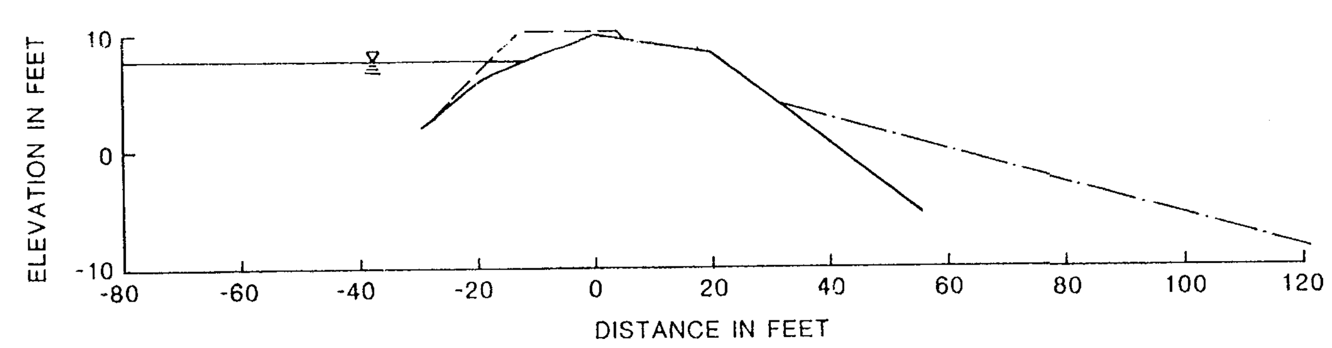

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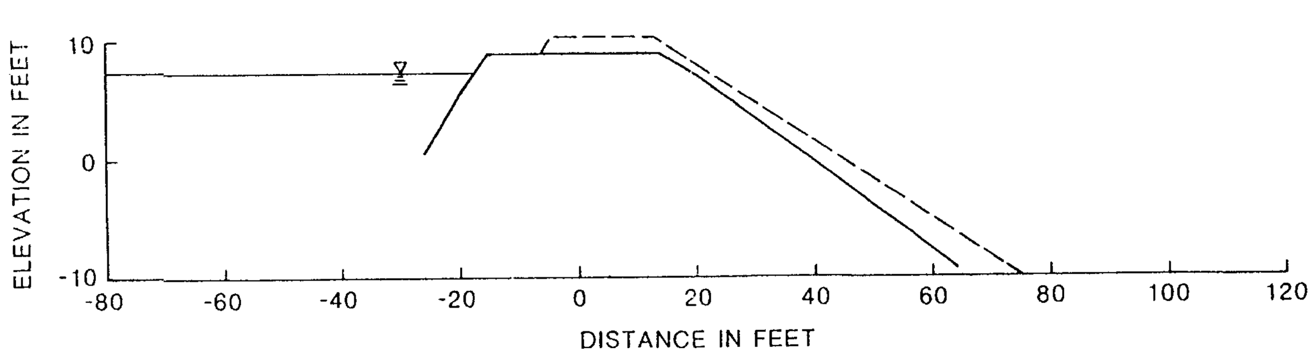

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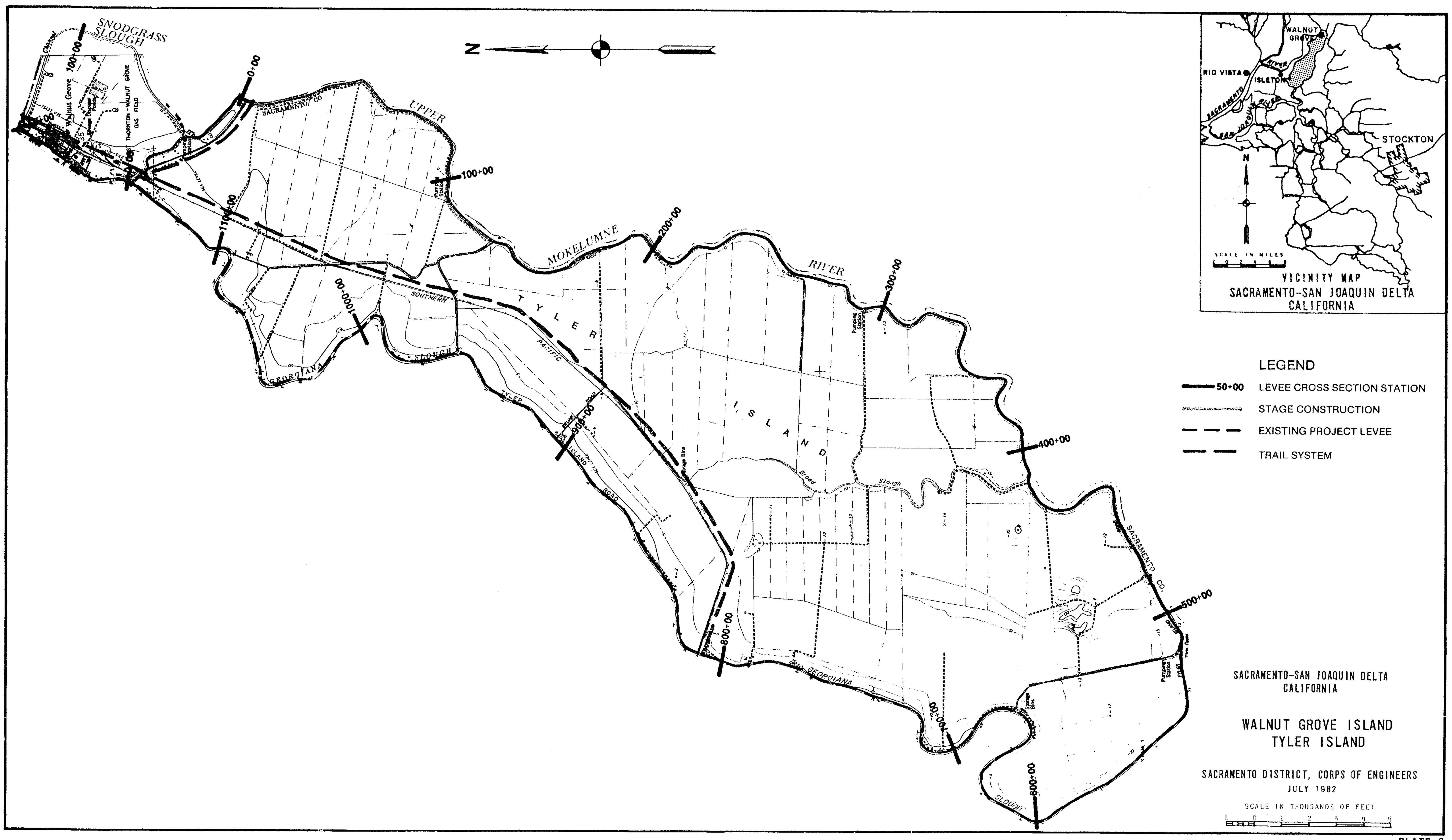
LEGEND

EXISTING LEVEE SECTION
PROPOSED DESIGN CROWN
PROPOSED BERM

BRANNAN ISLAND

C-103287



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

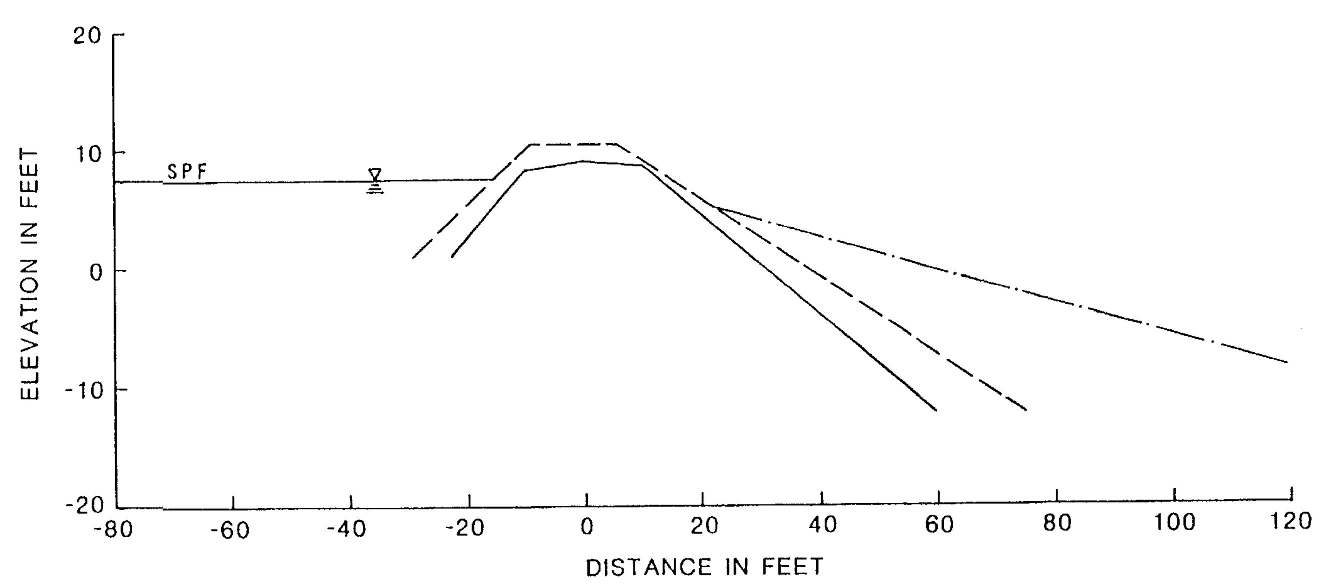
WALNUT GROVE ISLAND
TYLER ISLAND

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN THOUSANDS OF FEET

PLATE 3

C-103288



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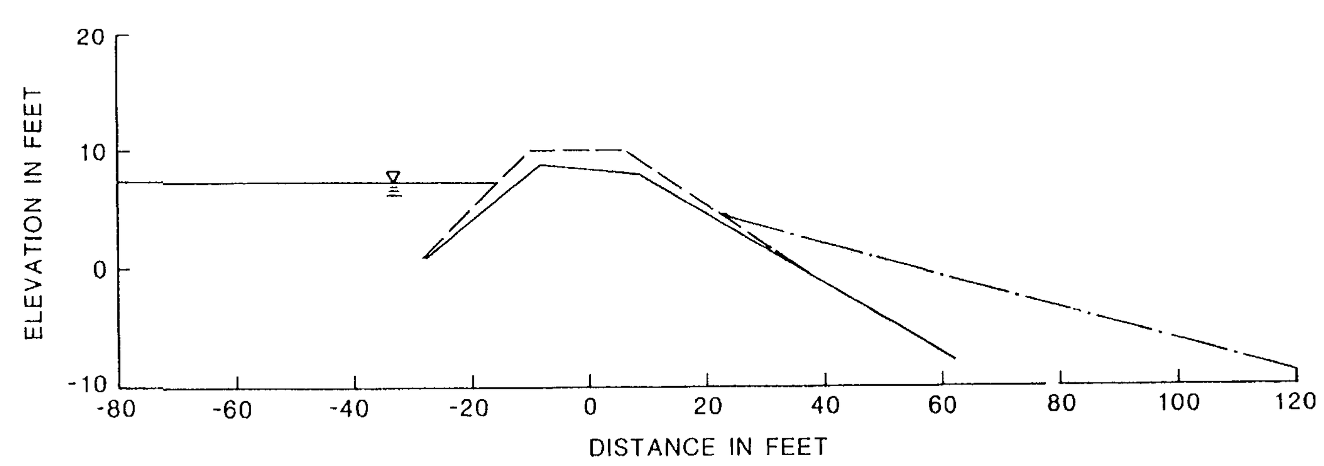

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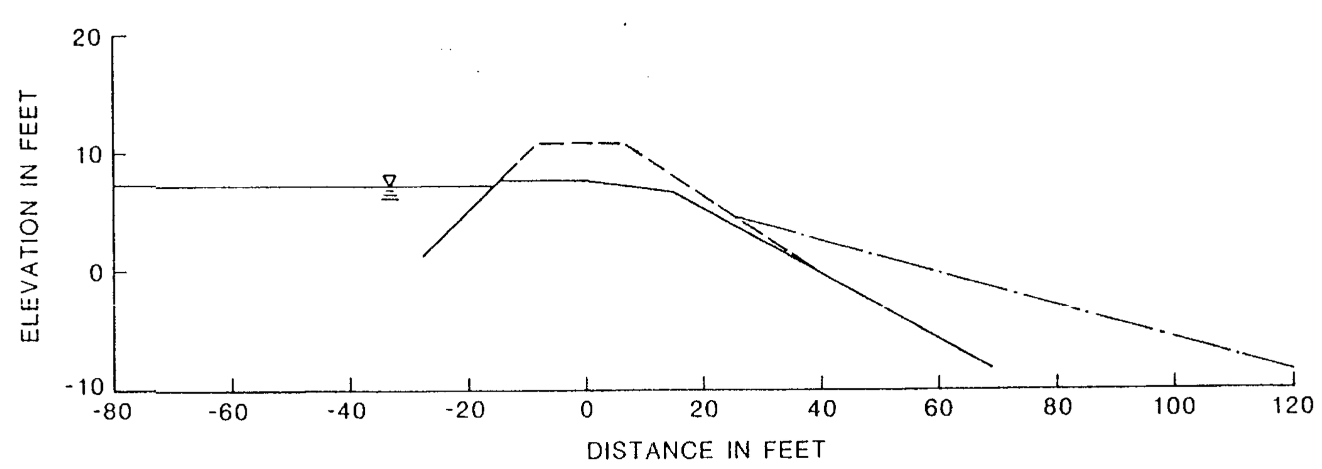

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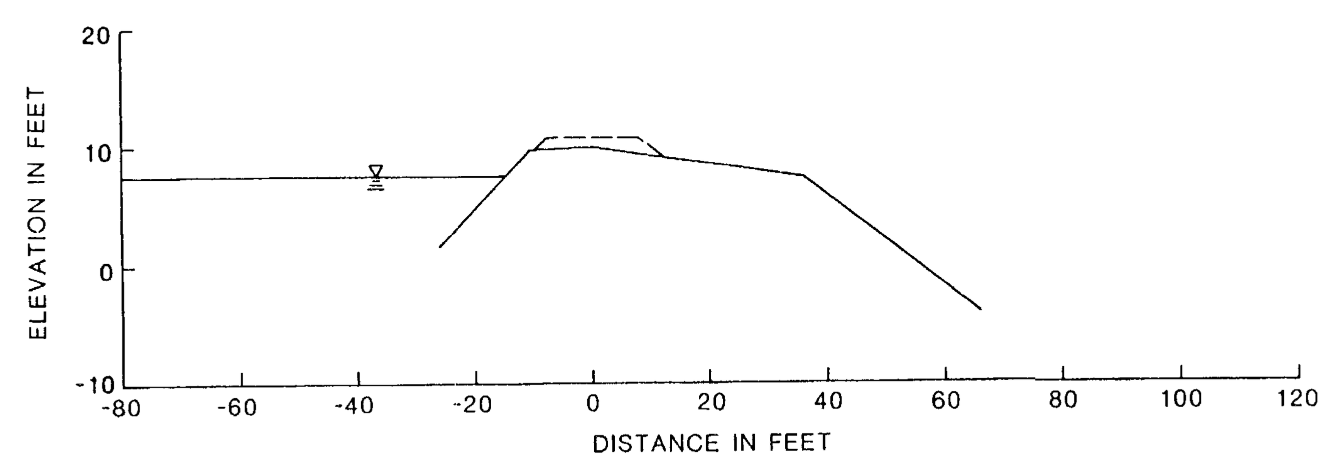

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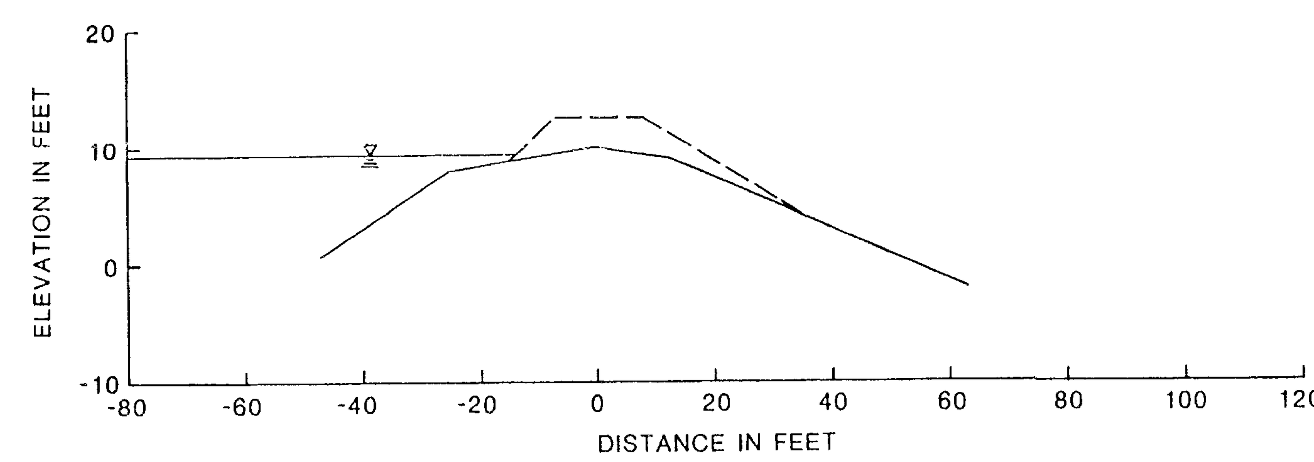

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LEGEND

- EXISTING LEVEE SECTION
- PROPOSED DESIGN CROWN
- PROPOSED BERM

ANDRUS ISLAND

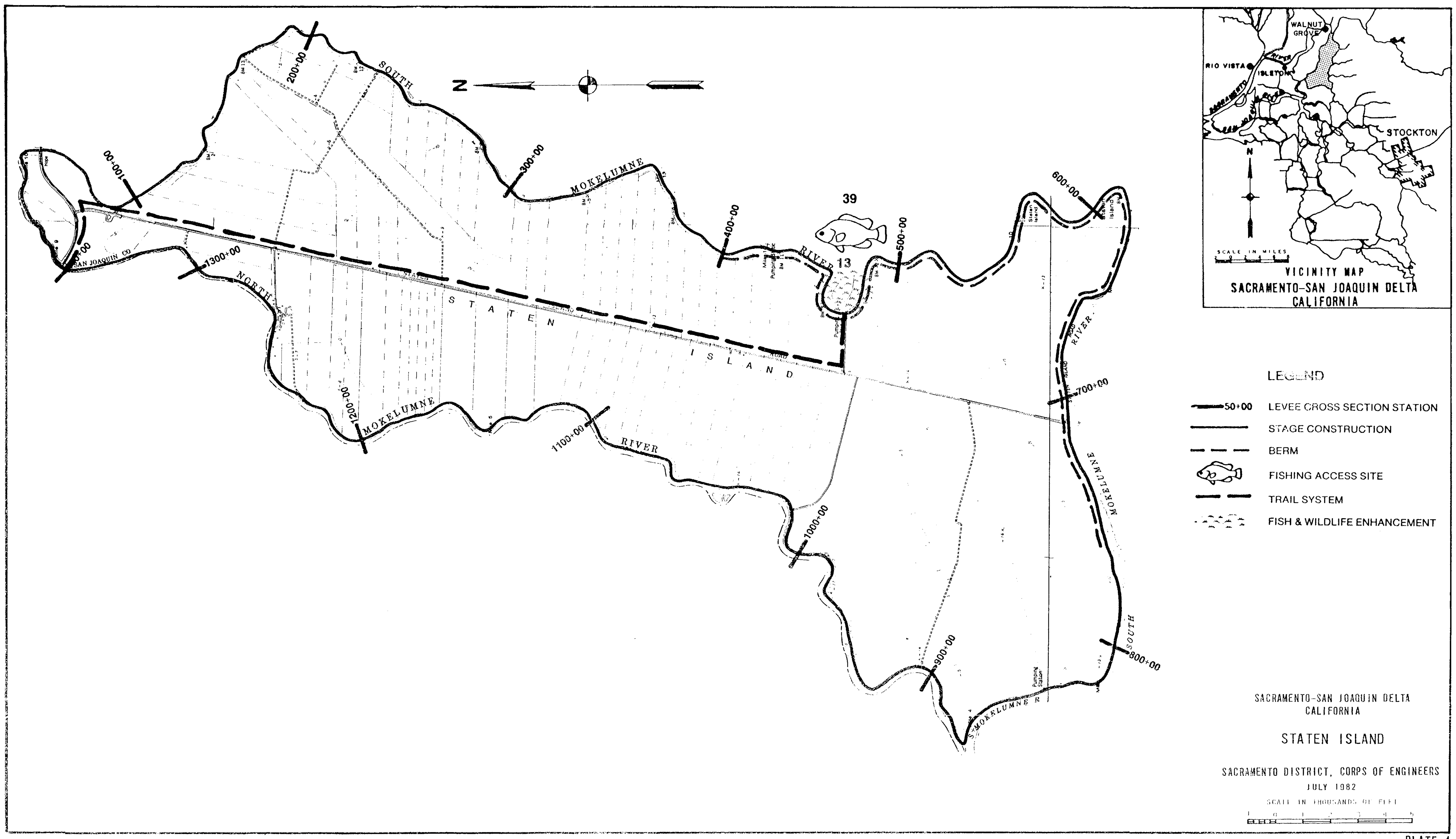
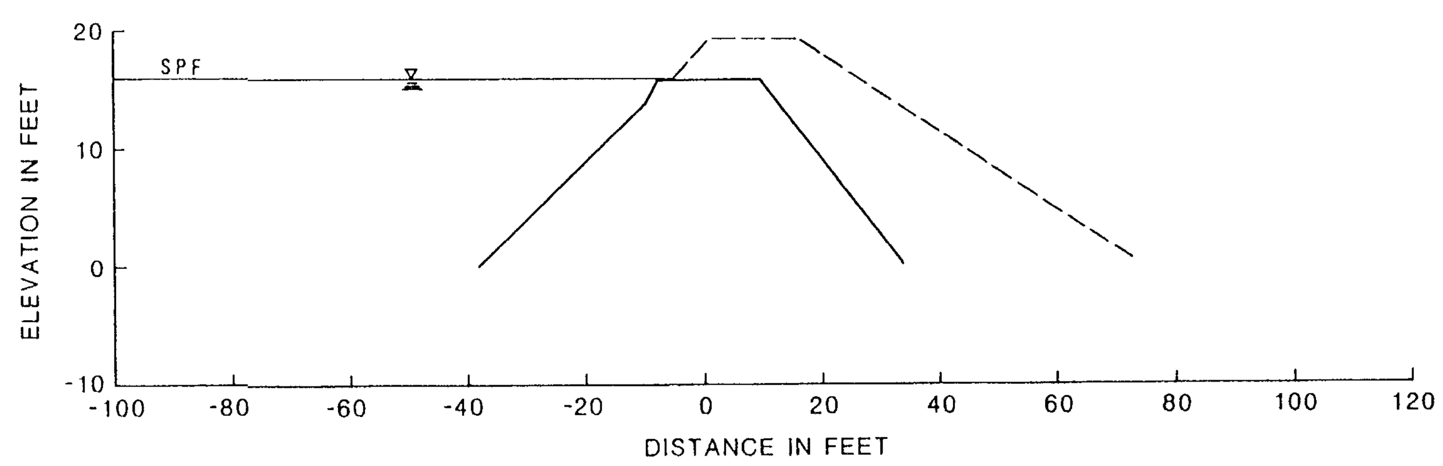


PLATE 4

C-103290



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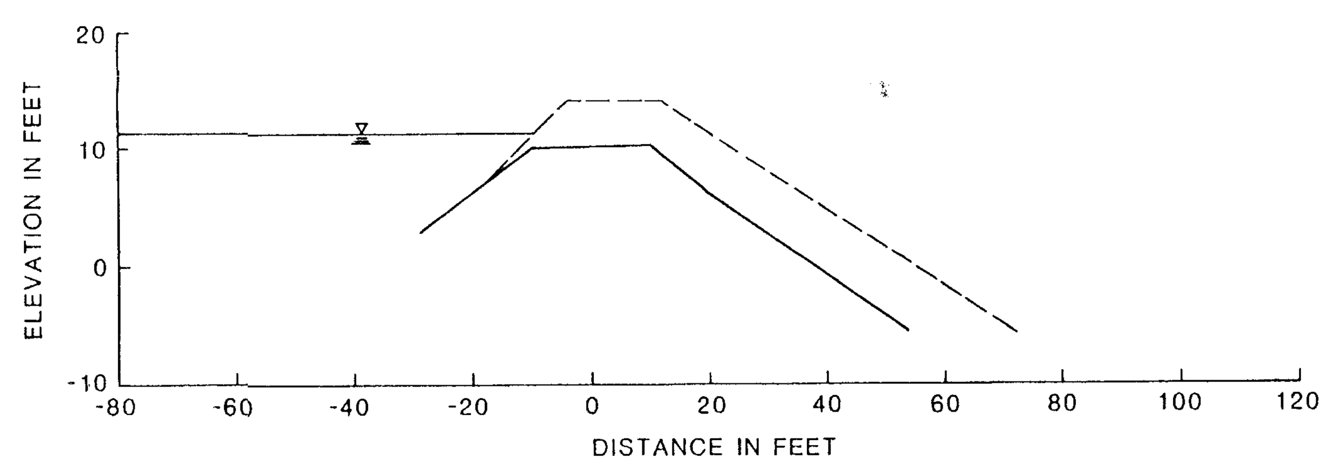

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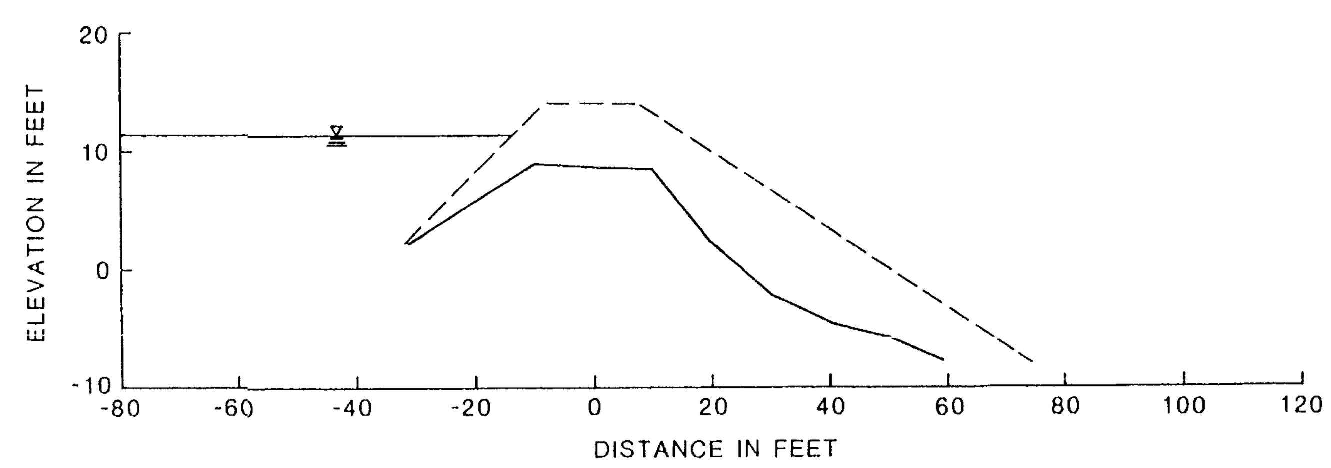

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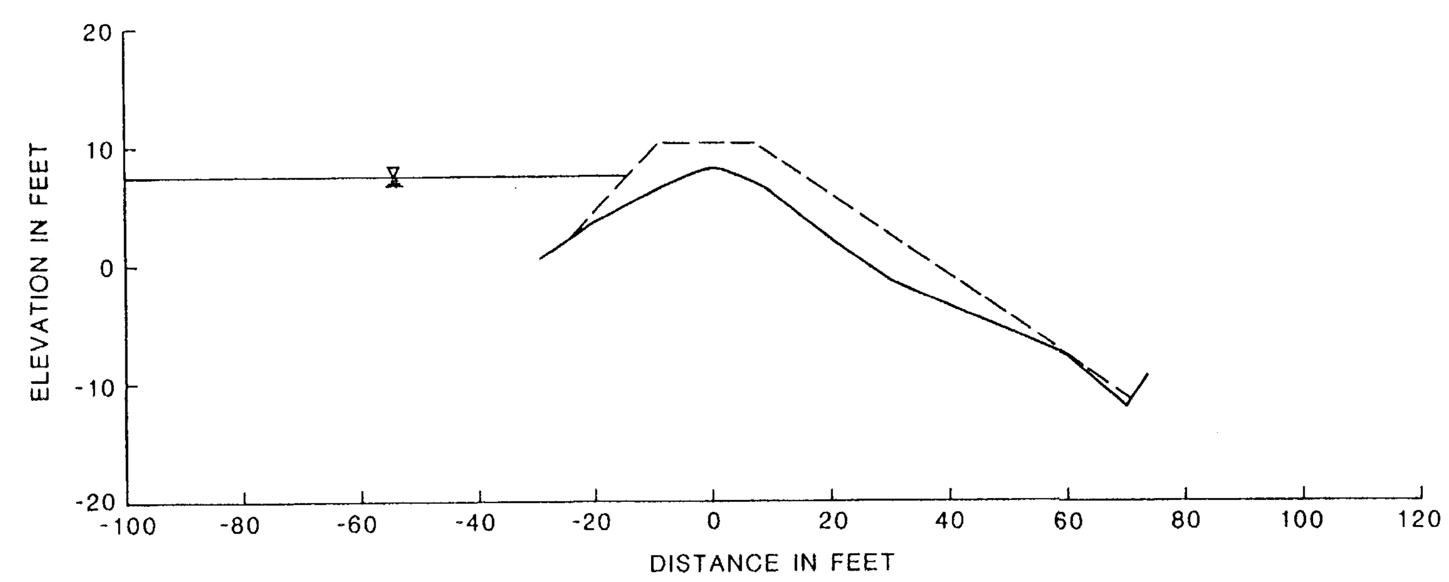

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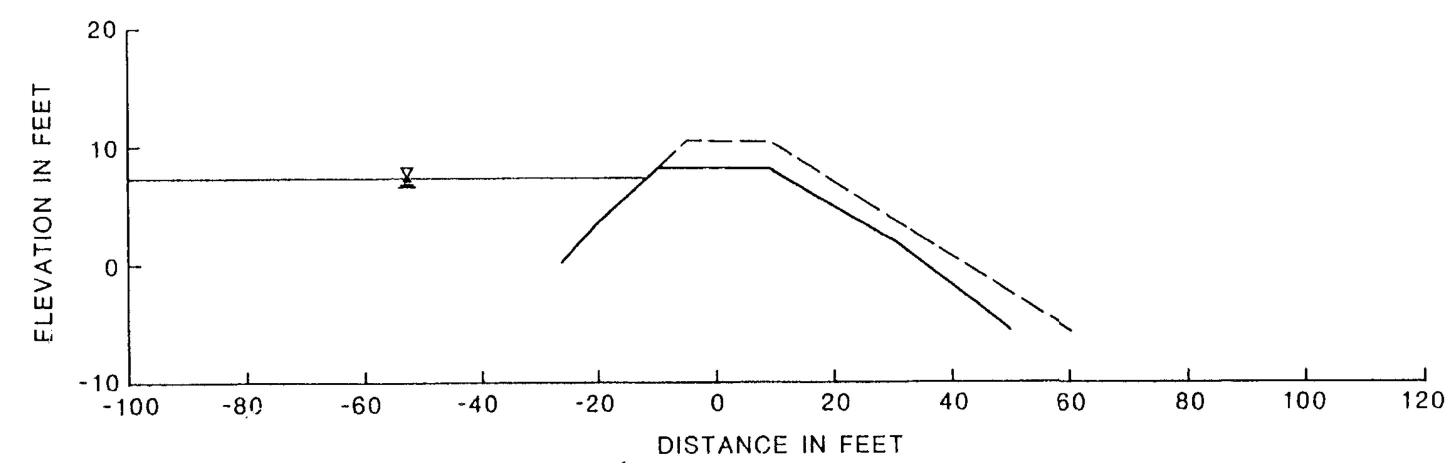

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LEGEND

——— EXISTING LEVEE SECTION
– – – – PROPOSED DESIGN CROWN

TYLER ISLAND

PLATE 3A

C-103291

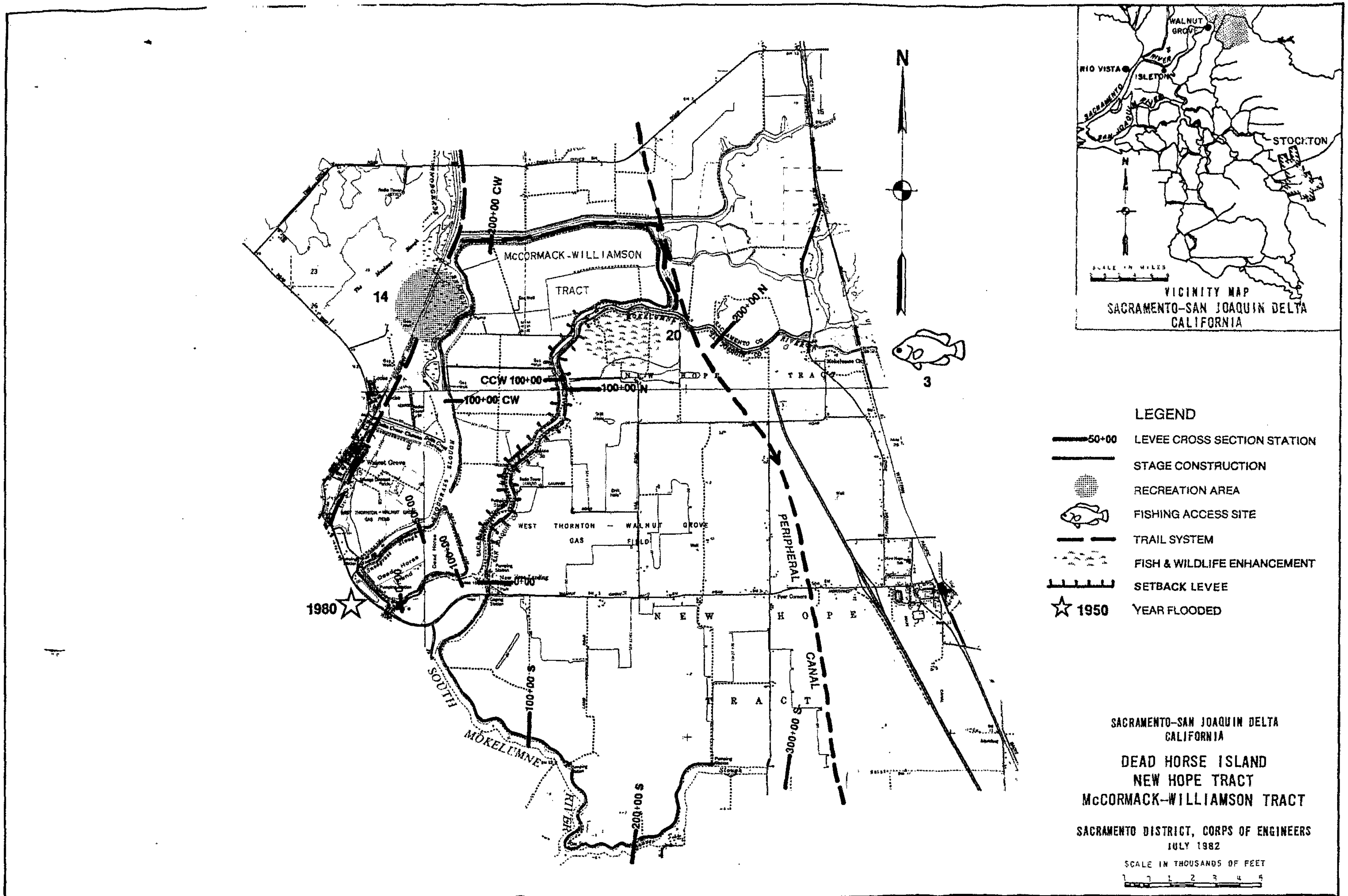
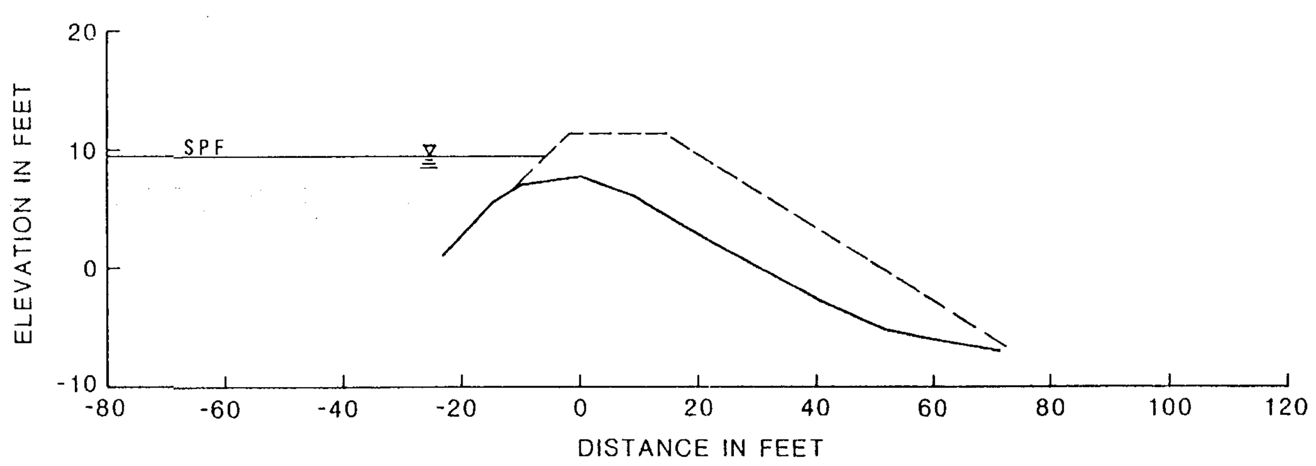


PLATE 5

C-103292

C-103292



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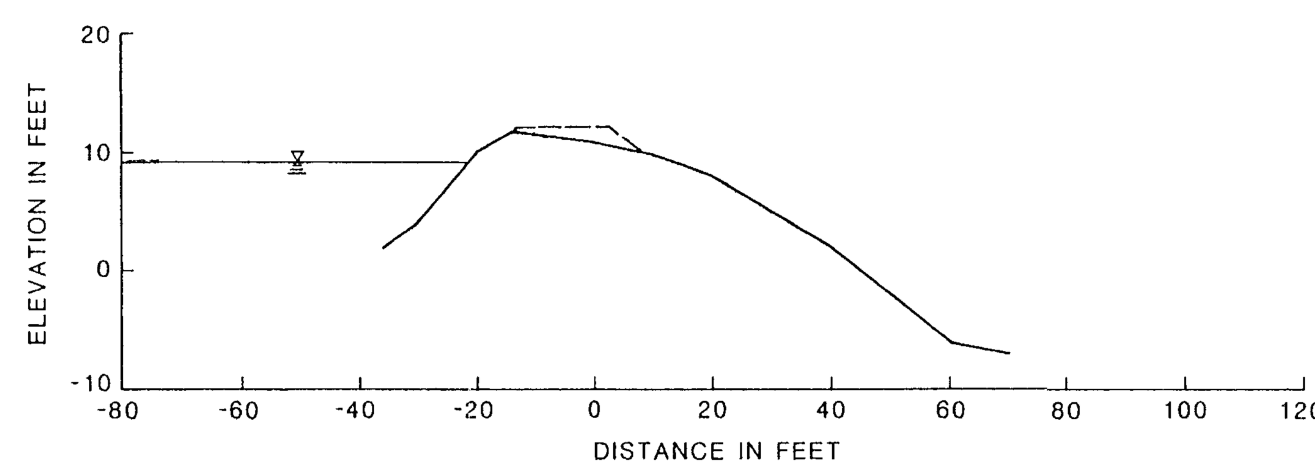

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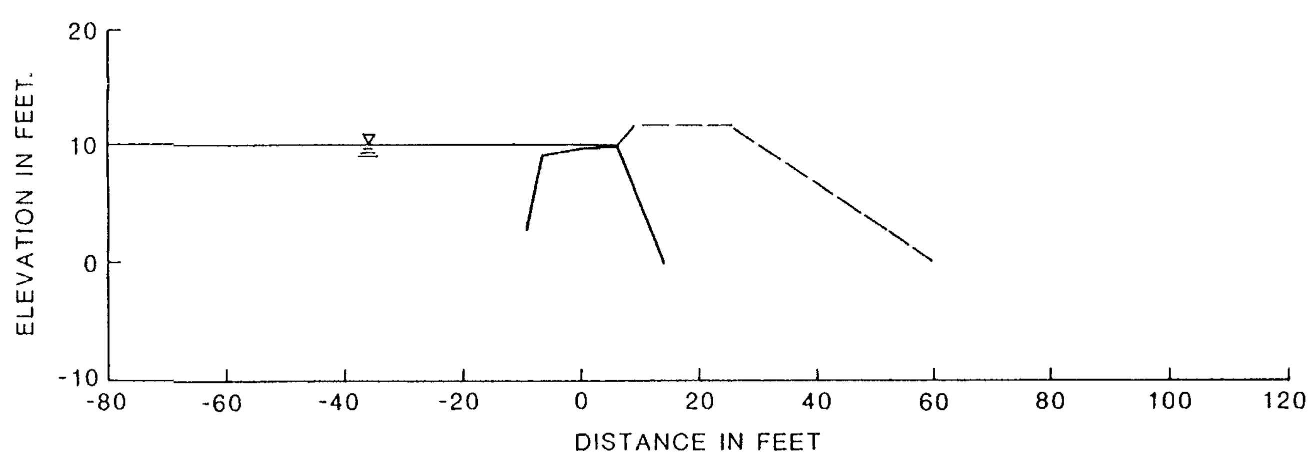

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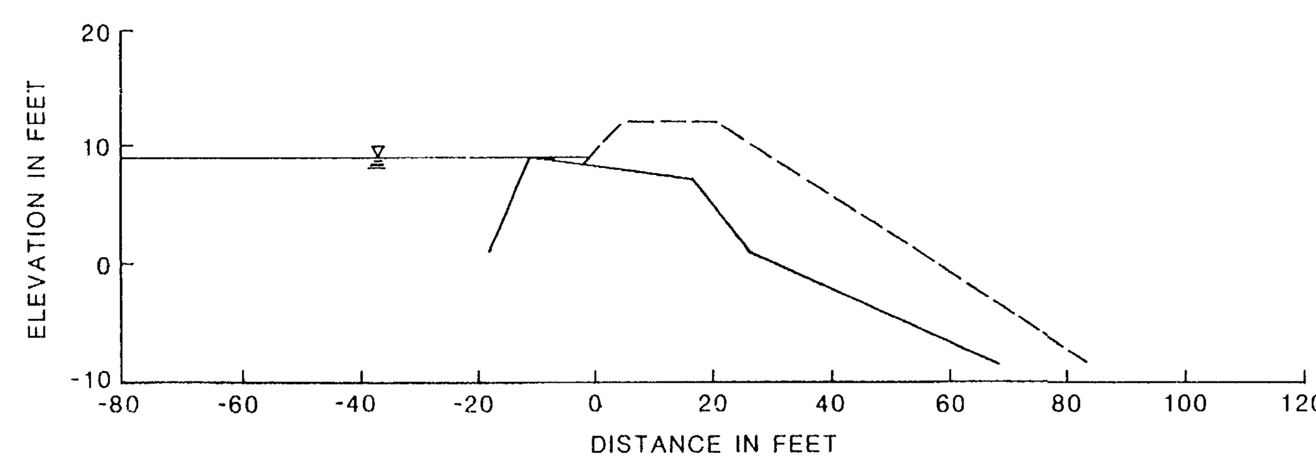

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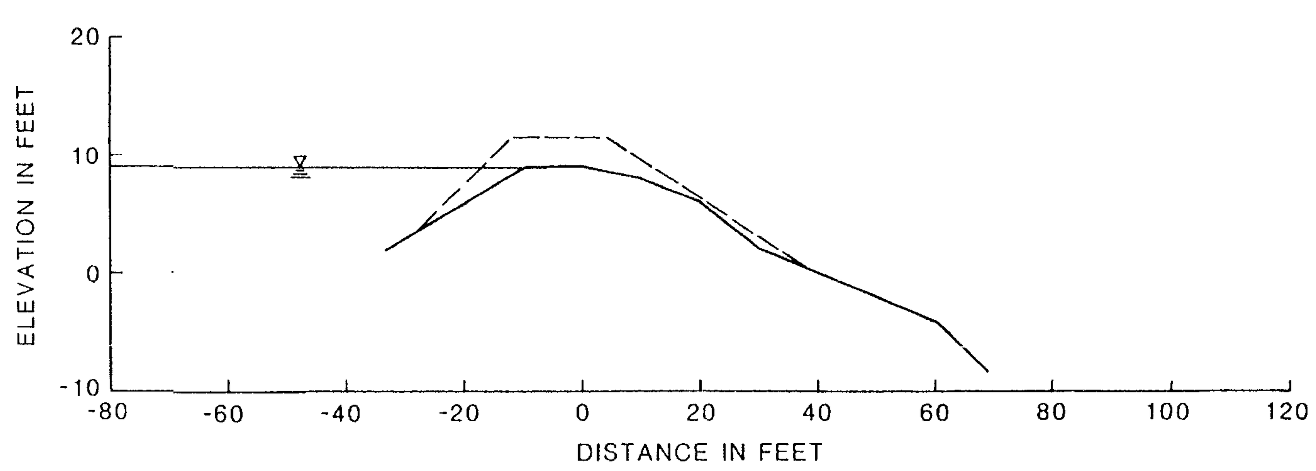

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SOUTH

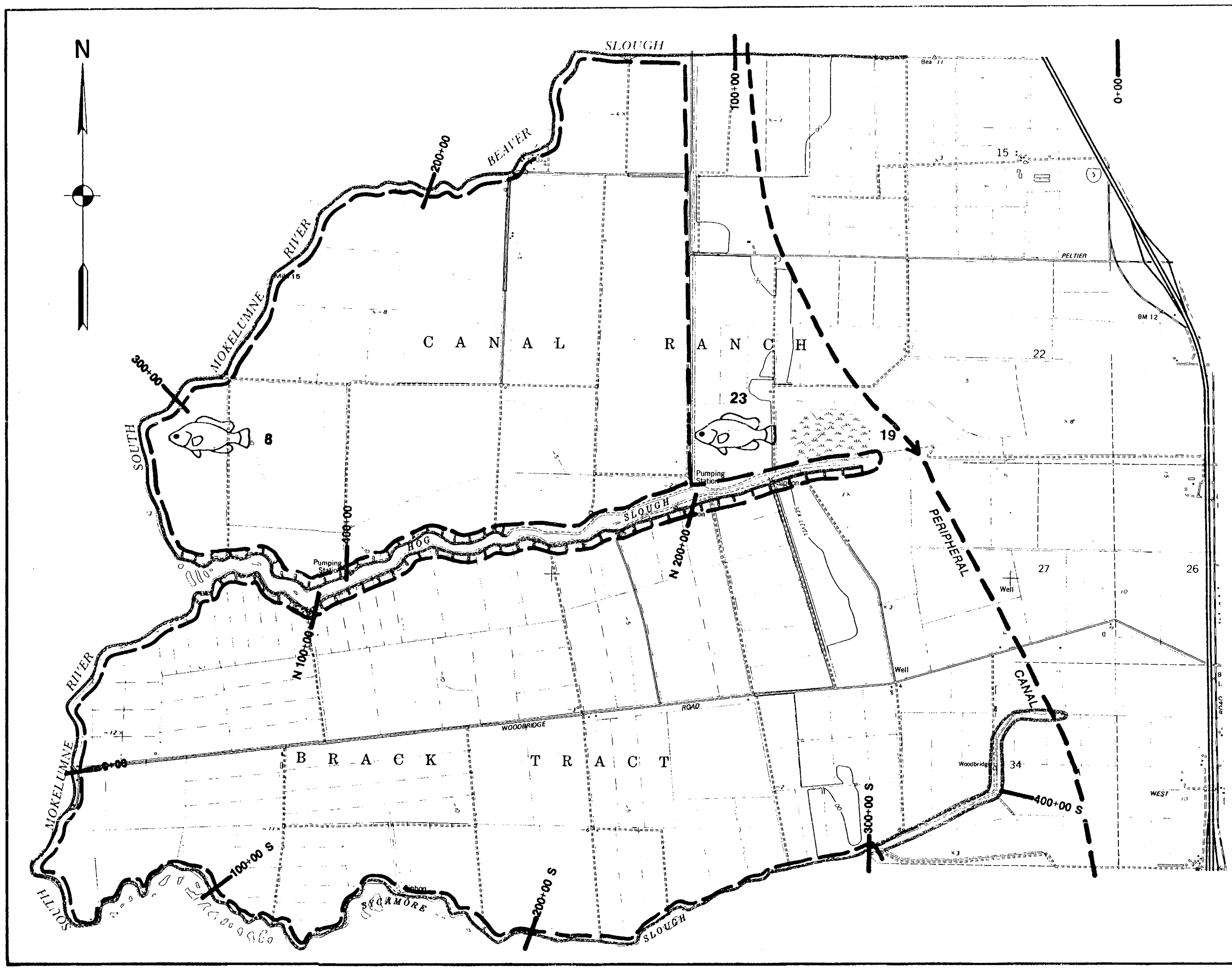
LEGEND

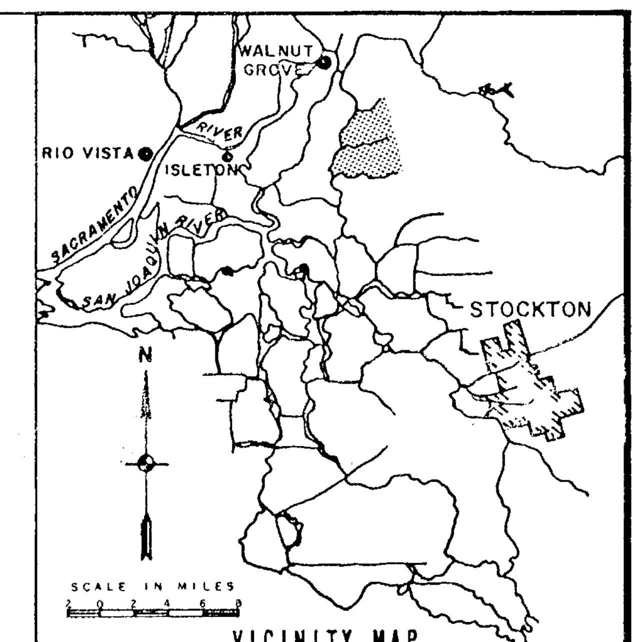
——— **EXISTING LEVEE SECTION**
– – – **PROPOSED DESIGN CROWN**

BRACK TRACT

PLATE 6A

C-103293





VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

LEGEND

50+00 LEVEE CROSS SECTION STATION
STAGE CONSTRUCTION
FISHING ACCESS SITE
TRAIL SYSTEM
FISH & WILDLIFE ENHANCEMENT
SETBACK LEVEE

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

CANAL RANCH,
BRACK TRACT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN THOUSANDS OF FEET
1 0 1 2 3 4 5

PLATE 6

C-103294

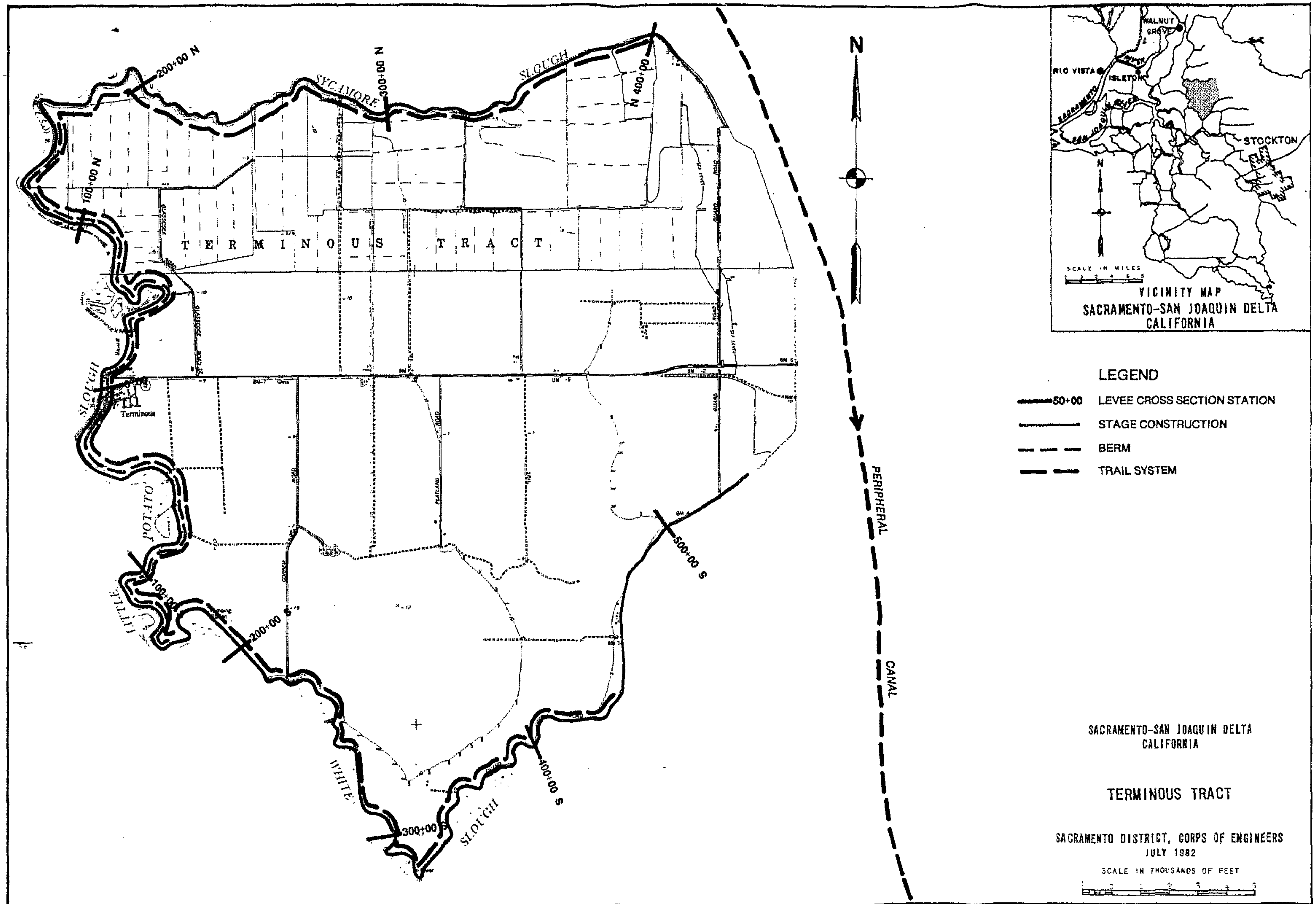


PLATE 7

C-103295

C—103295

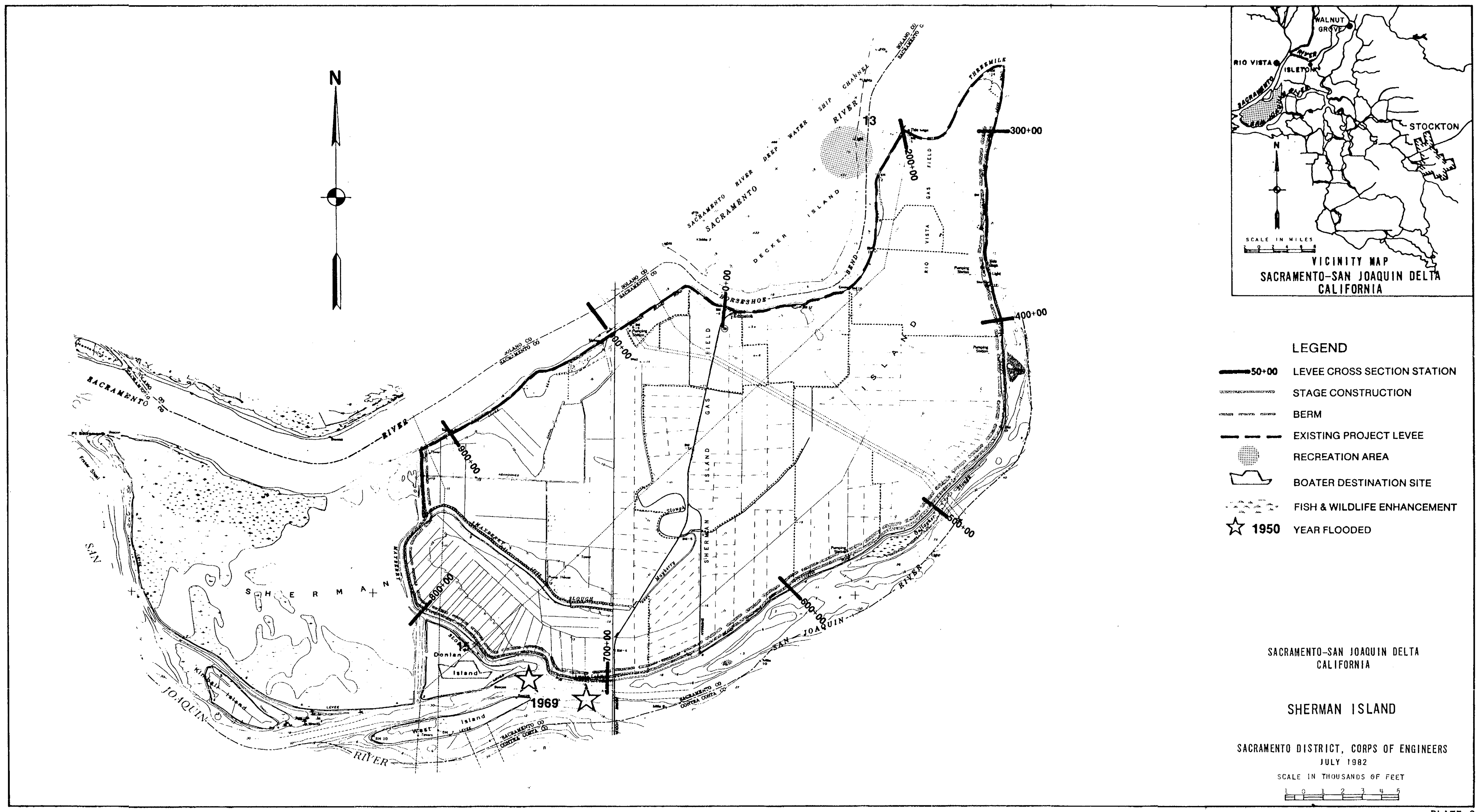
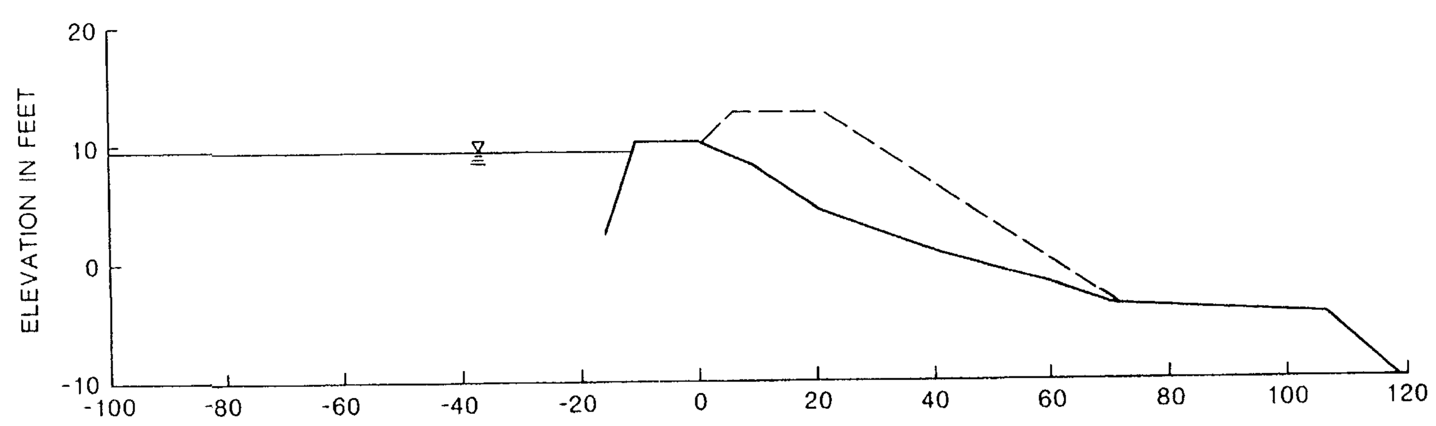


PLATE 8

C-103296



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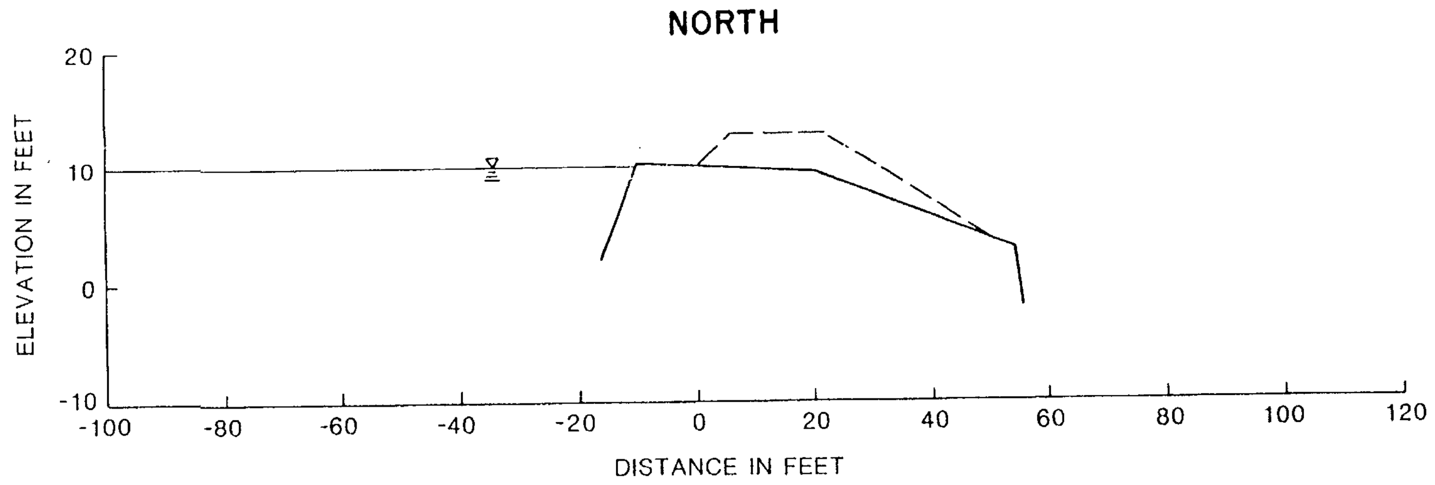

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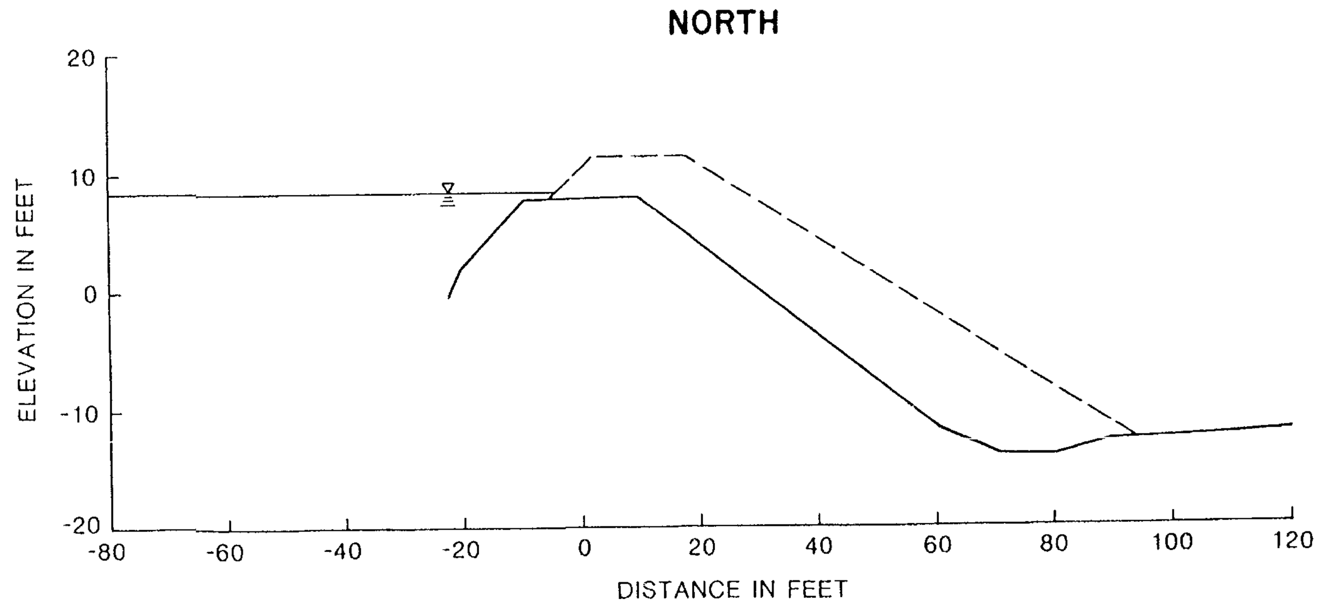

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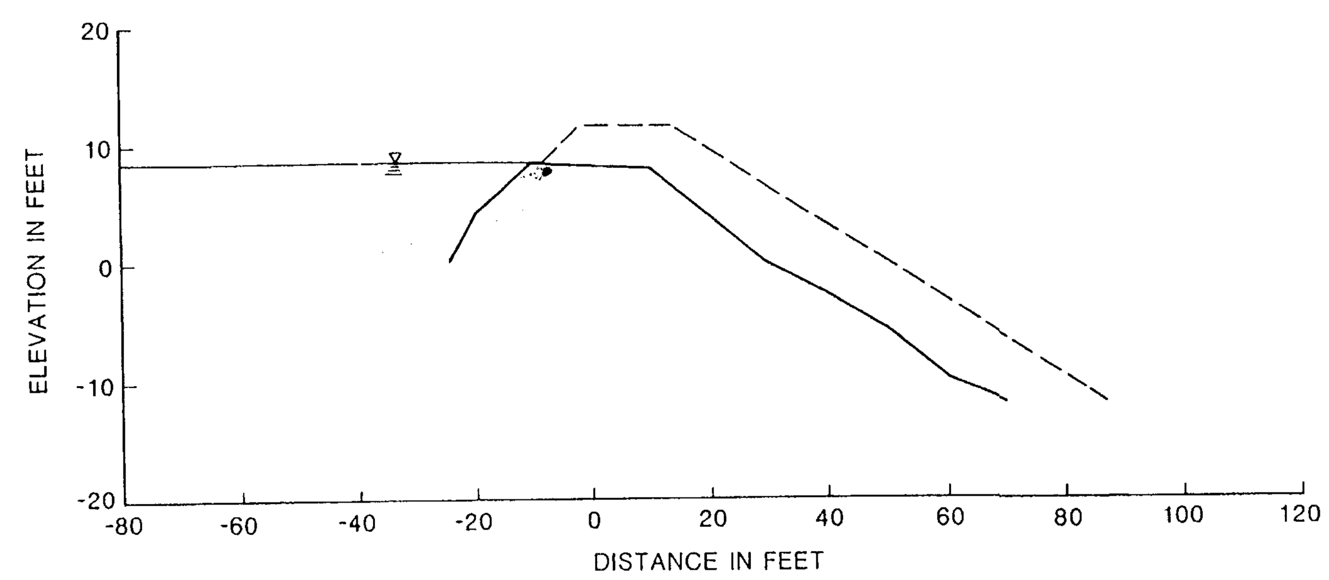

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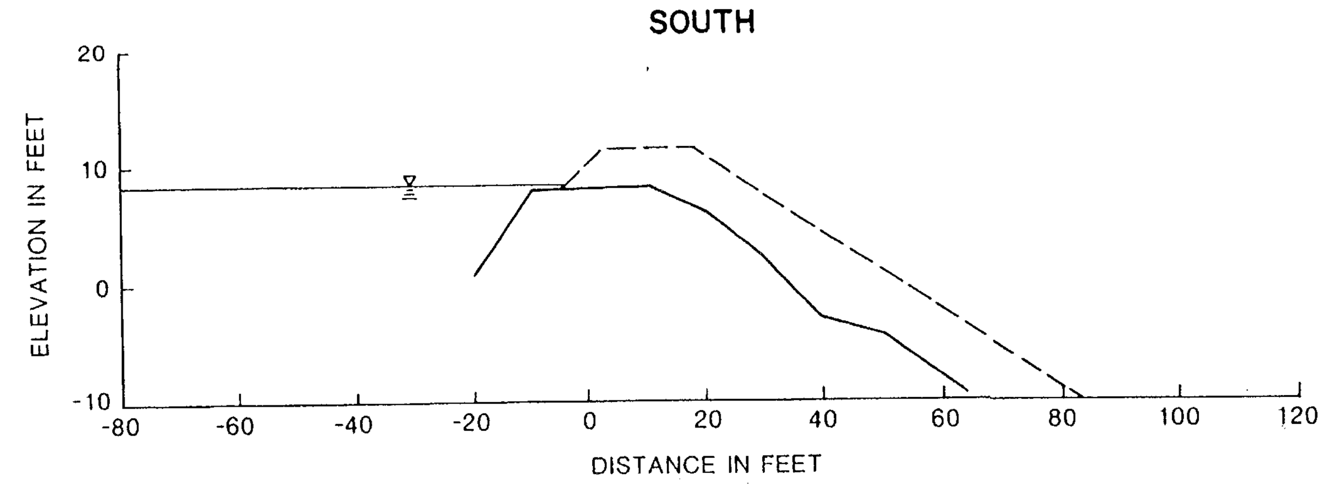

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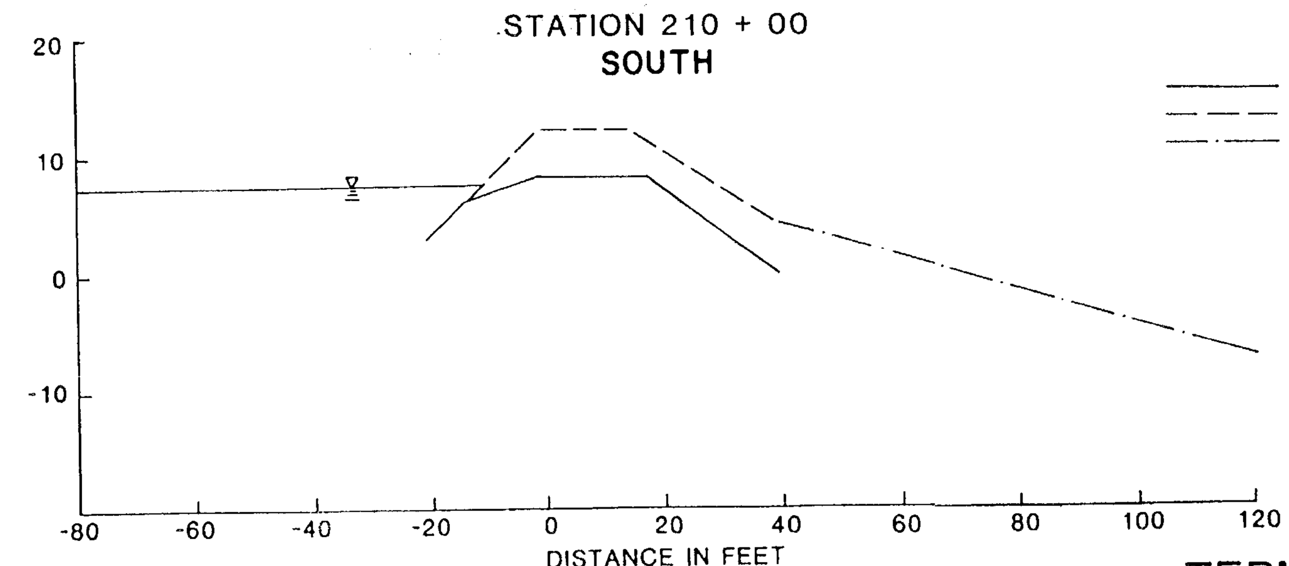

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LEGEND

- EXISTING LEVEE SECTION
- PROPOSED DESIGN CROWN
- PROPOSED BERM

TERMINOUS TRACT

PLATE 7A

C-103297

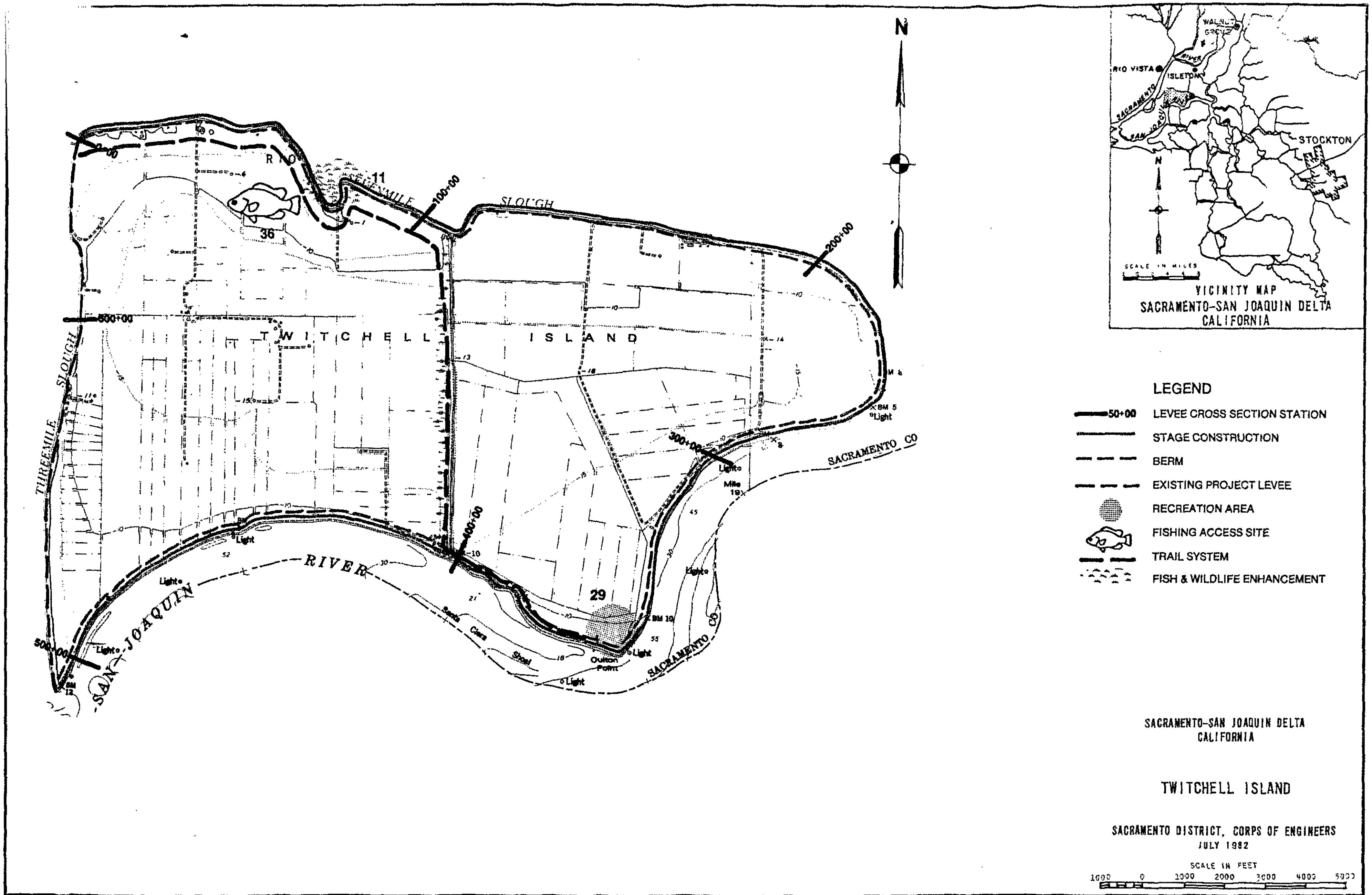
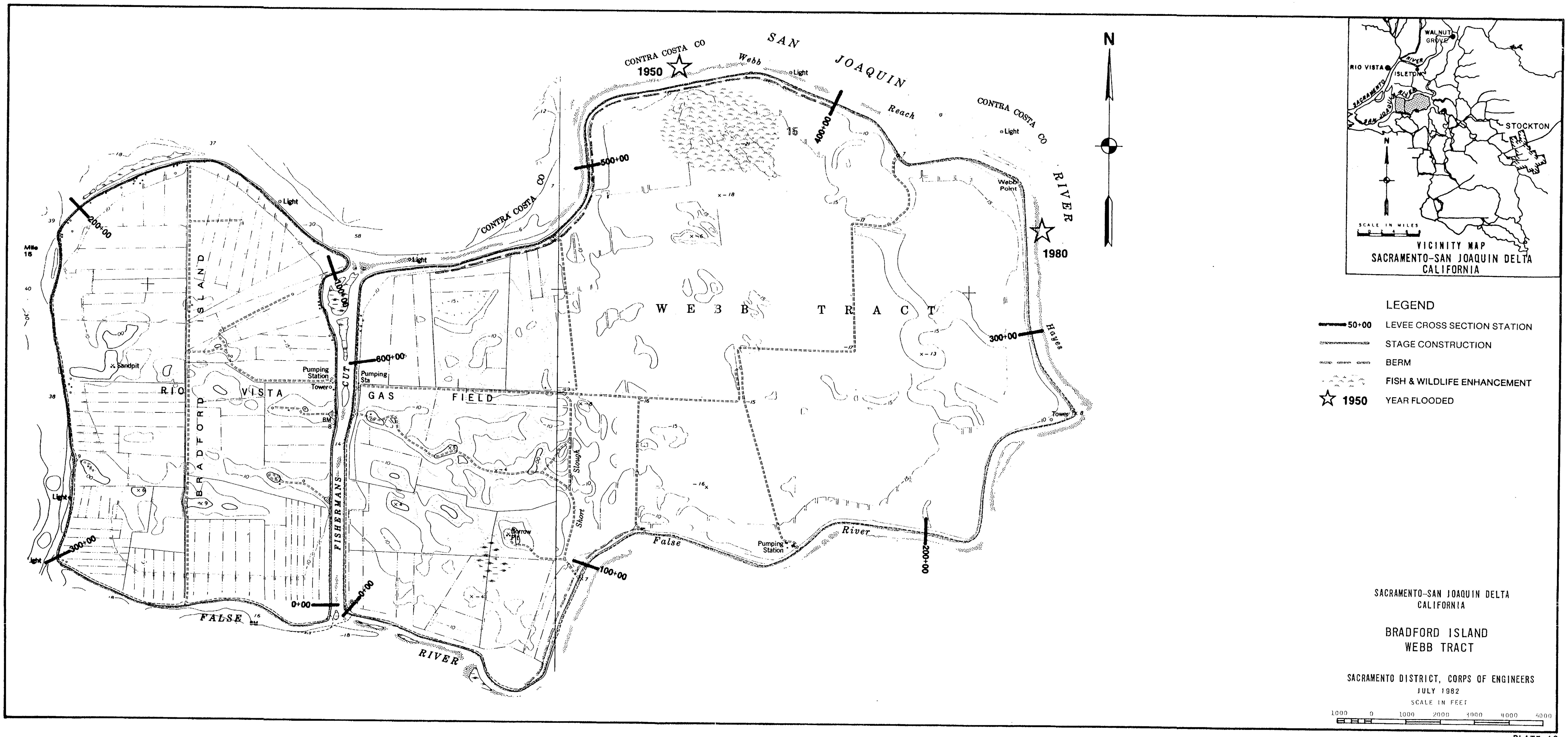

N
TWITCHELL ISLAND
THREEMILE SLOUGH
SEVENMILE SLOUGH
SAN JOAQUIN RIVER
SACRAMENTO CO
100+00
200+00
300+00
400+00
500+00
600+00
36
11
29
VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
WALNUT GROVE
RIO VISTA
ISLETON
STOCKTON
SCALE IN MILES
LEGEND
50+00 LEVEE CROSS SECTION STATION
STAGE CONSTRUCTION
BERM
EXISTING PROJECT LEVEE
RECREATION AREA
FISHING ACCESS SITE
TRAIL SYSTEM
FISH & WILDLIFE ENHANCEMENT
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
TWITCHELL ISLAND
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

PLATE 9

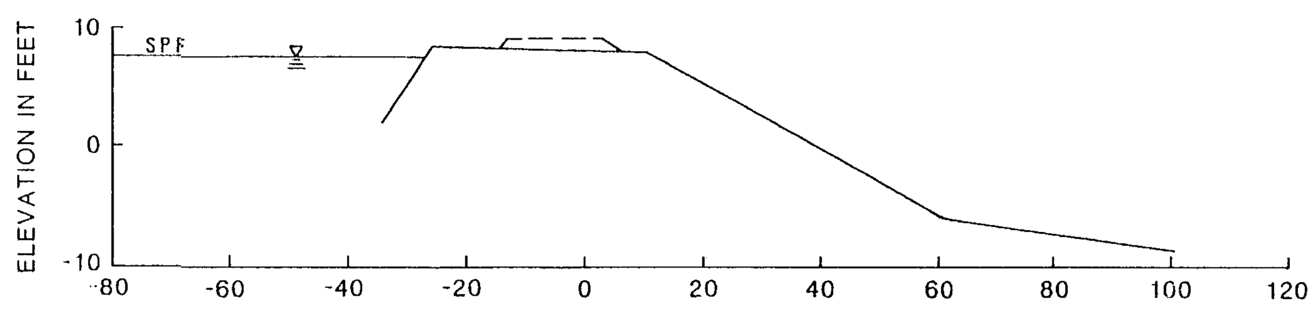


SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

BRADFORD ISLAND
WEBB TRACT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982
SCALE IN FEET

PLATE 10



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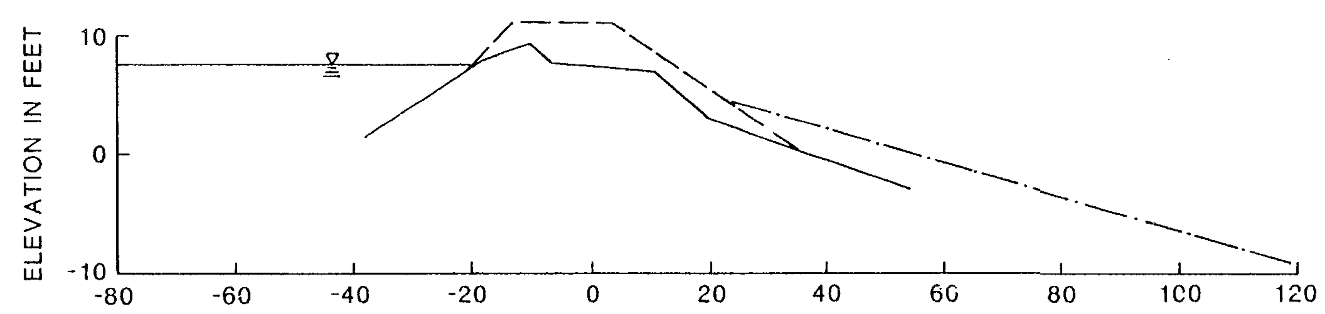

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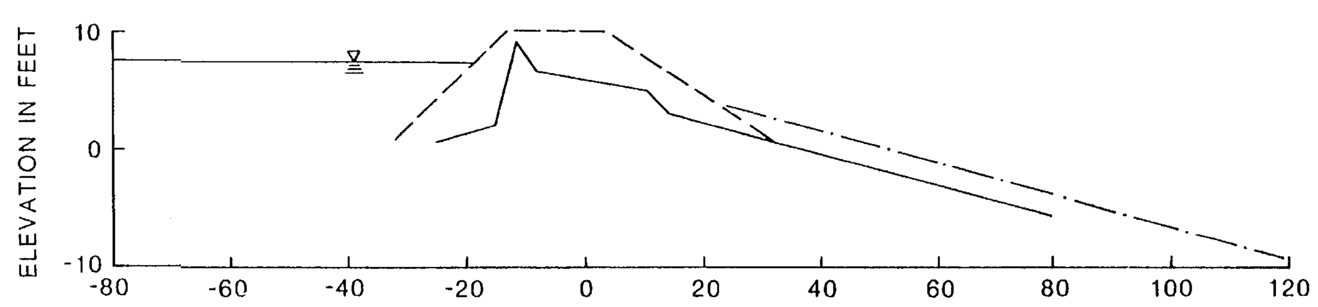

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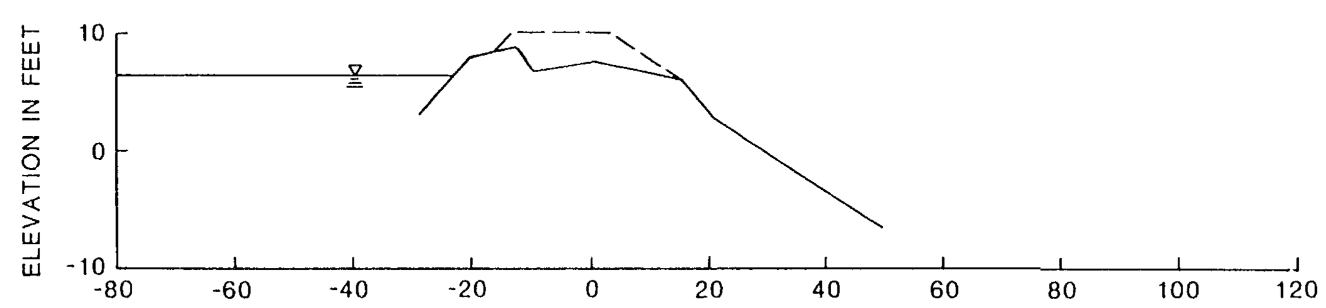

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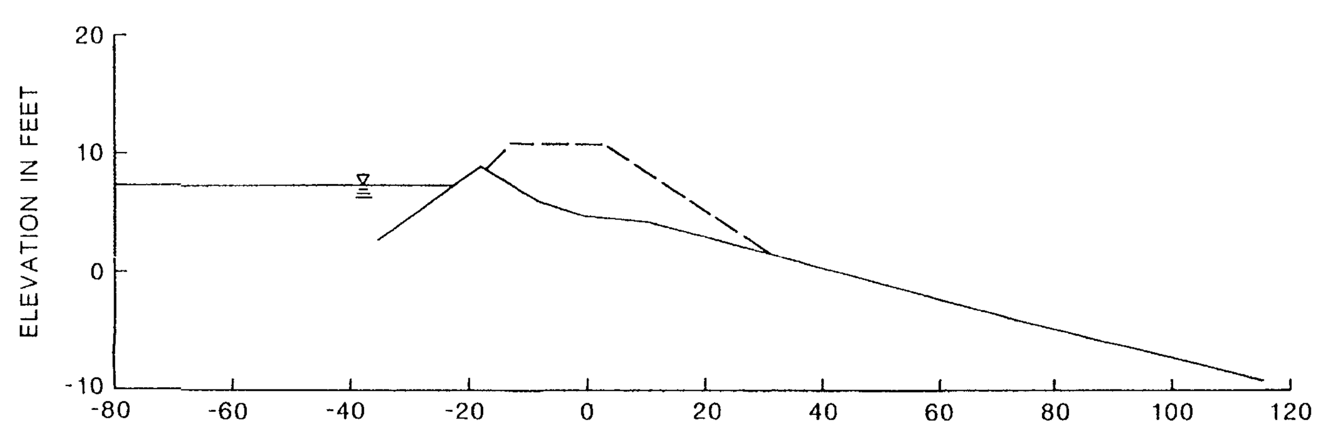


STATION 440 + 00

LEGEND

EXISTING LEVEE SECTION
PROPOSED DESIGN CROWN
PROPOSED BERM

WEBB TRACT

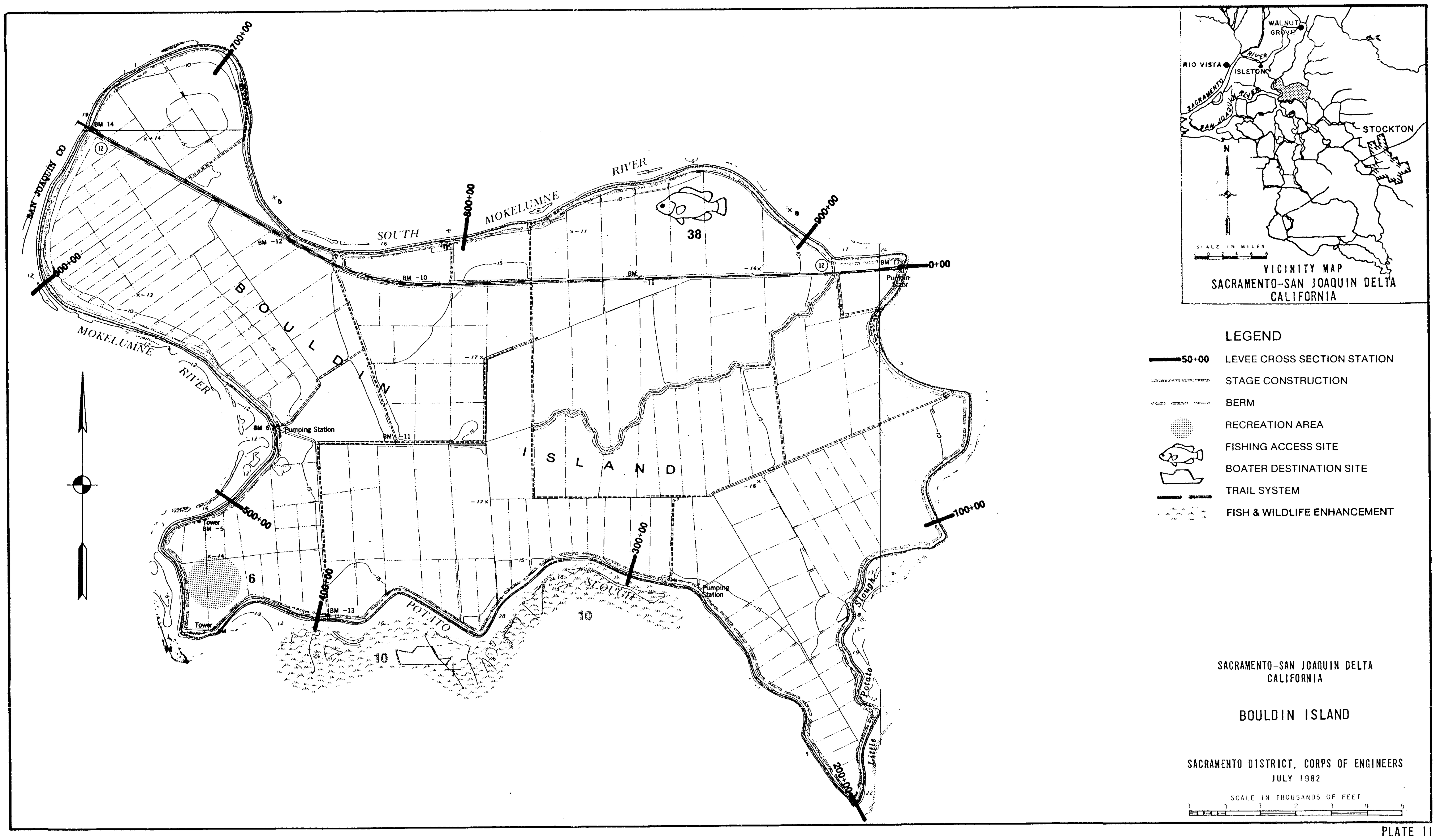


PLATE 11

C-103301

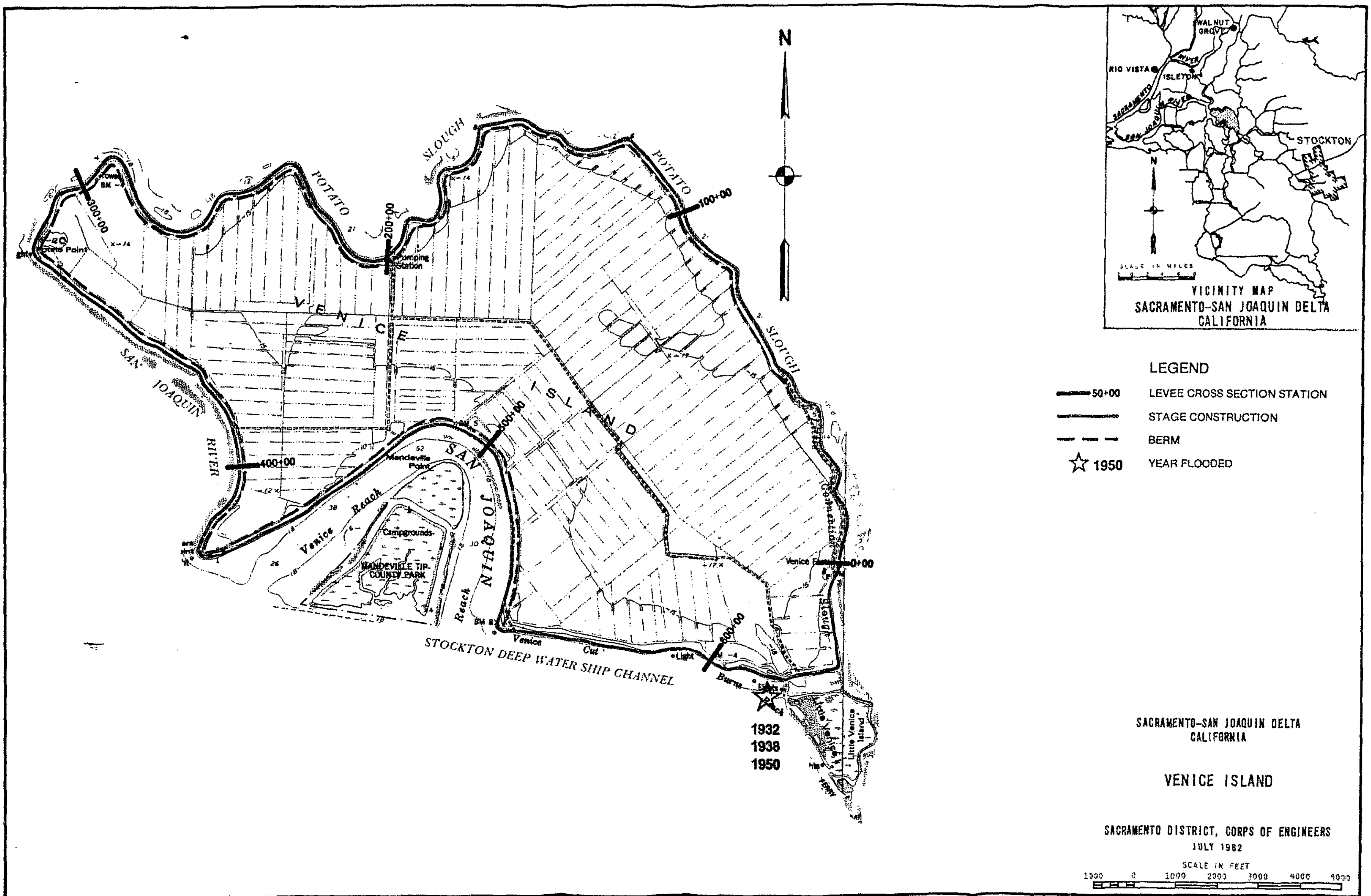


PLATE 12

C-103302

C—103302

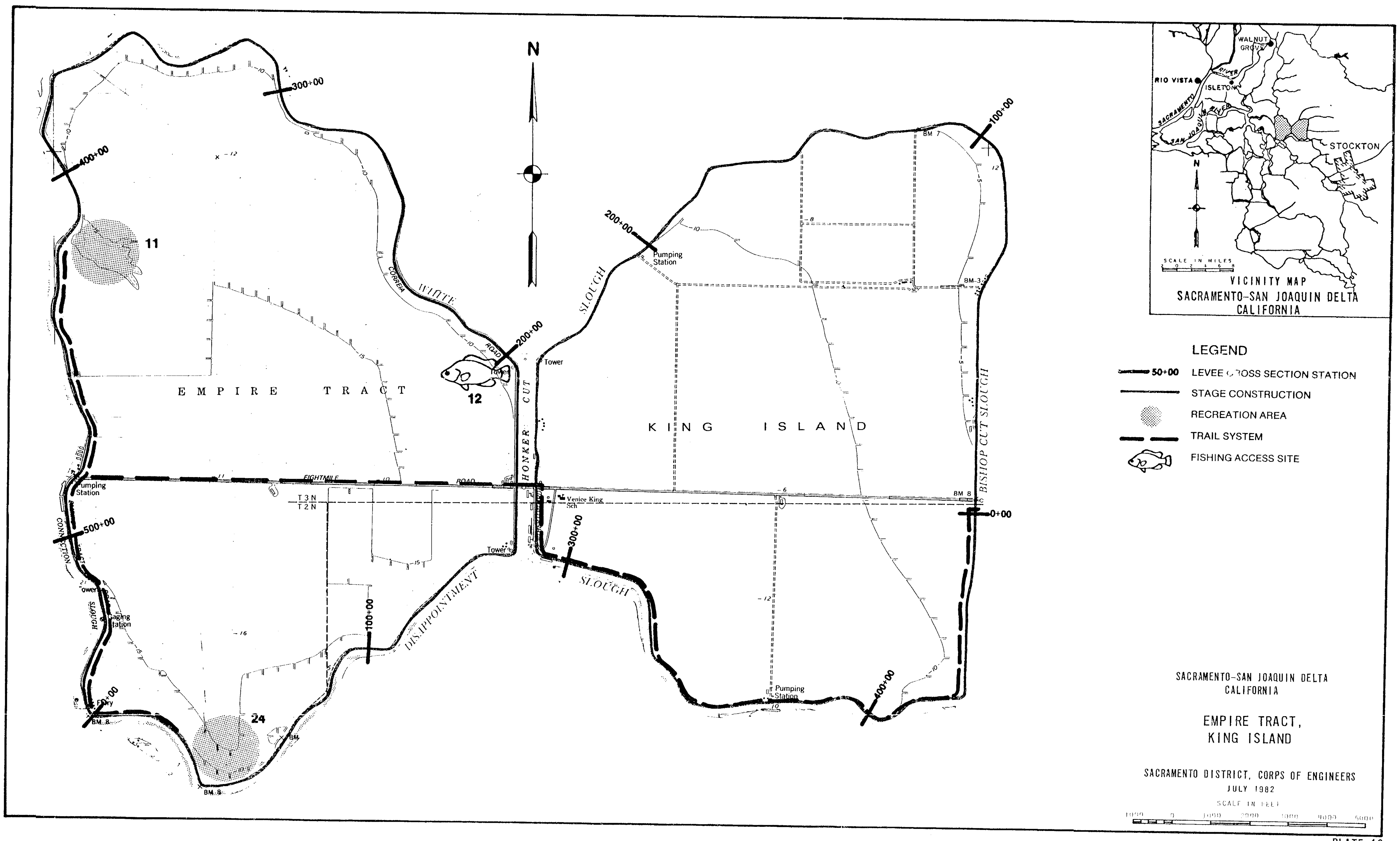
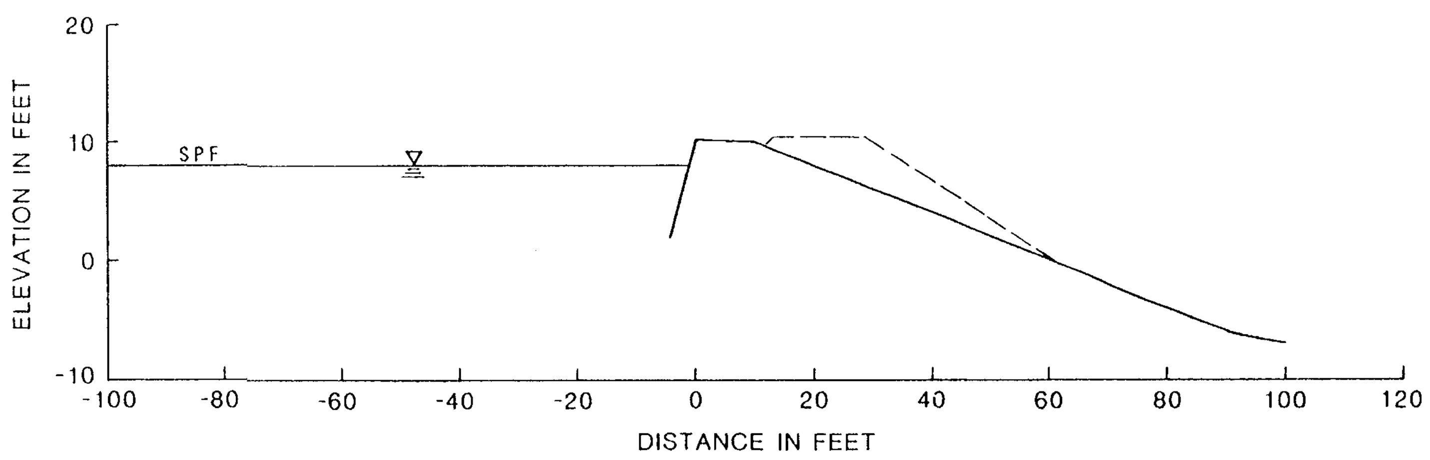
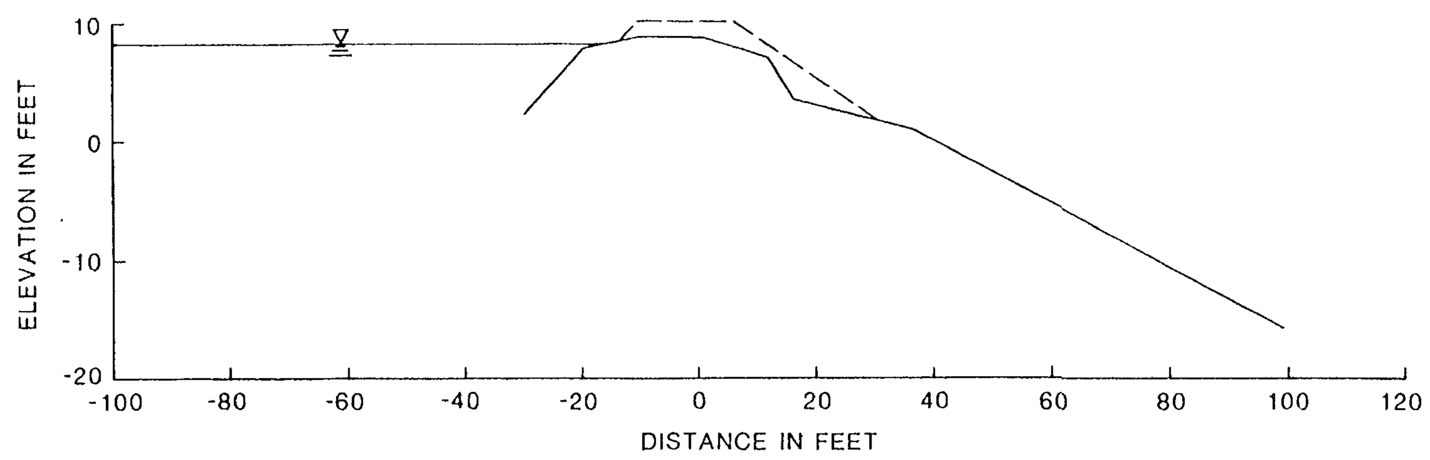


PLATE 13

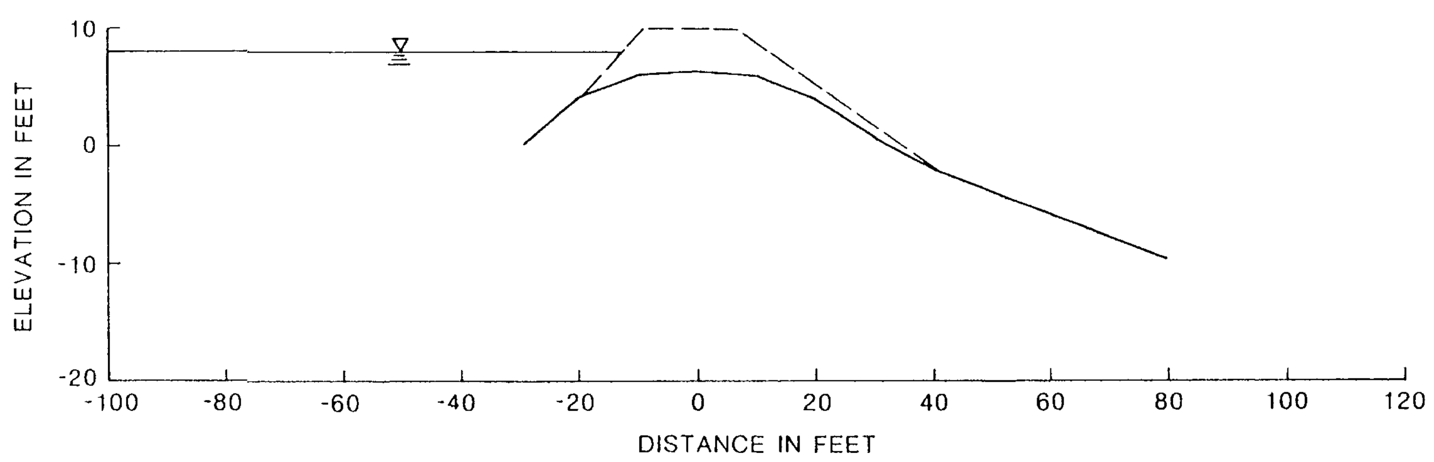
C-103303



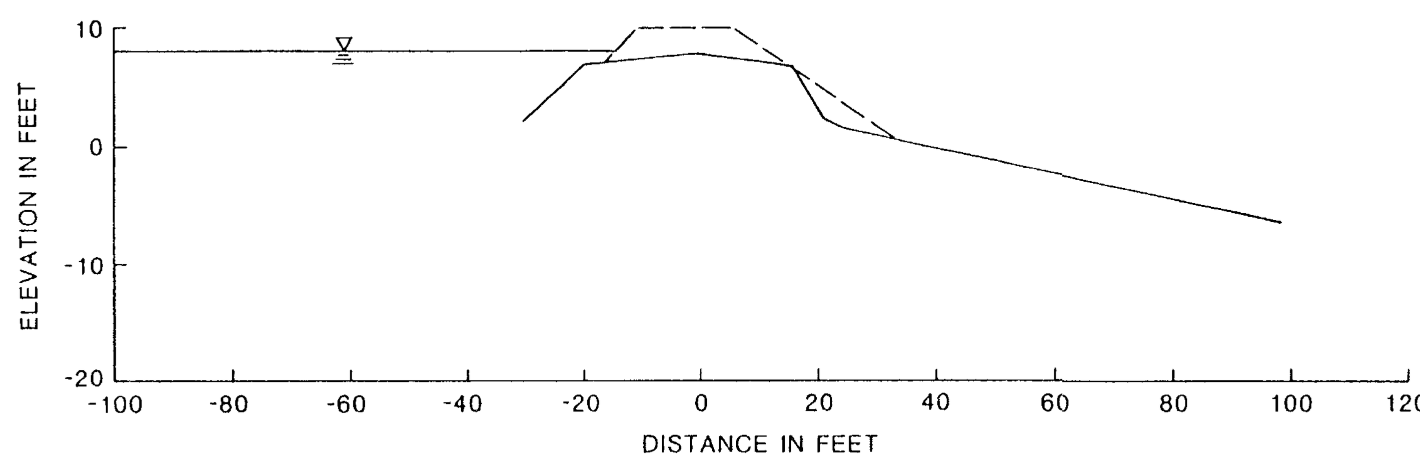
STATION 180 + 00



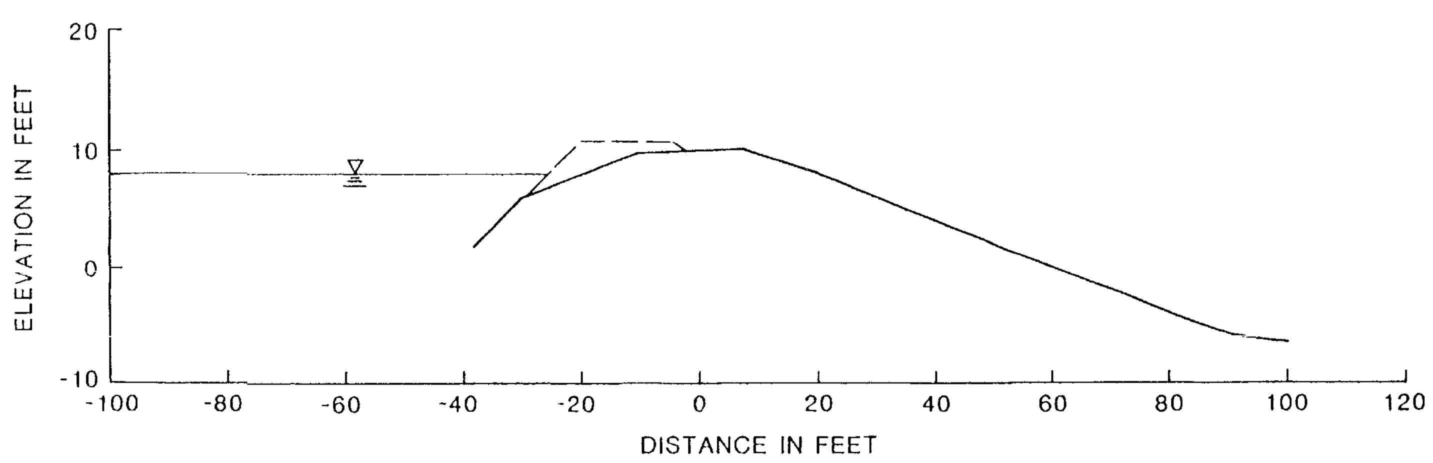
STATION 510 + 00



STATION 290 + 00



STATION 520 + 00



STATION 350 + 00

LEGEND

——— **EXISTING LEVEE SECTION**
— — — **PROPOSED DESIGN CROWN**

EMPIRE TRACT

PLATE 13A

C-103304

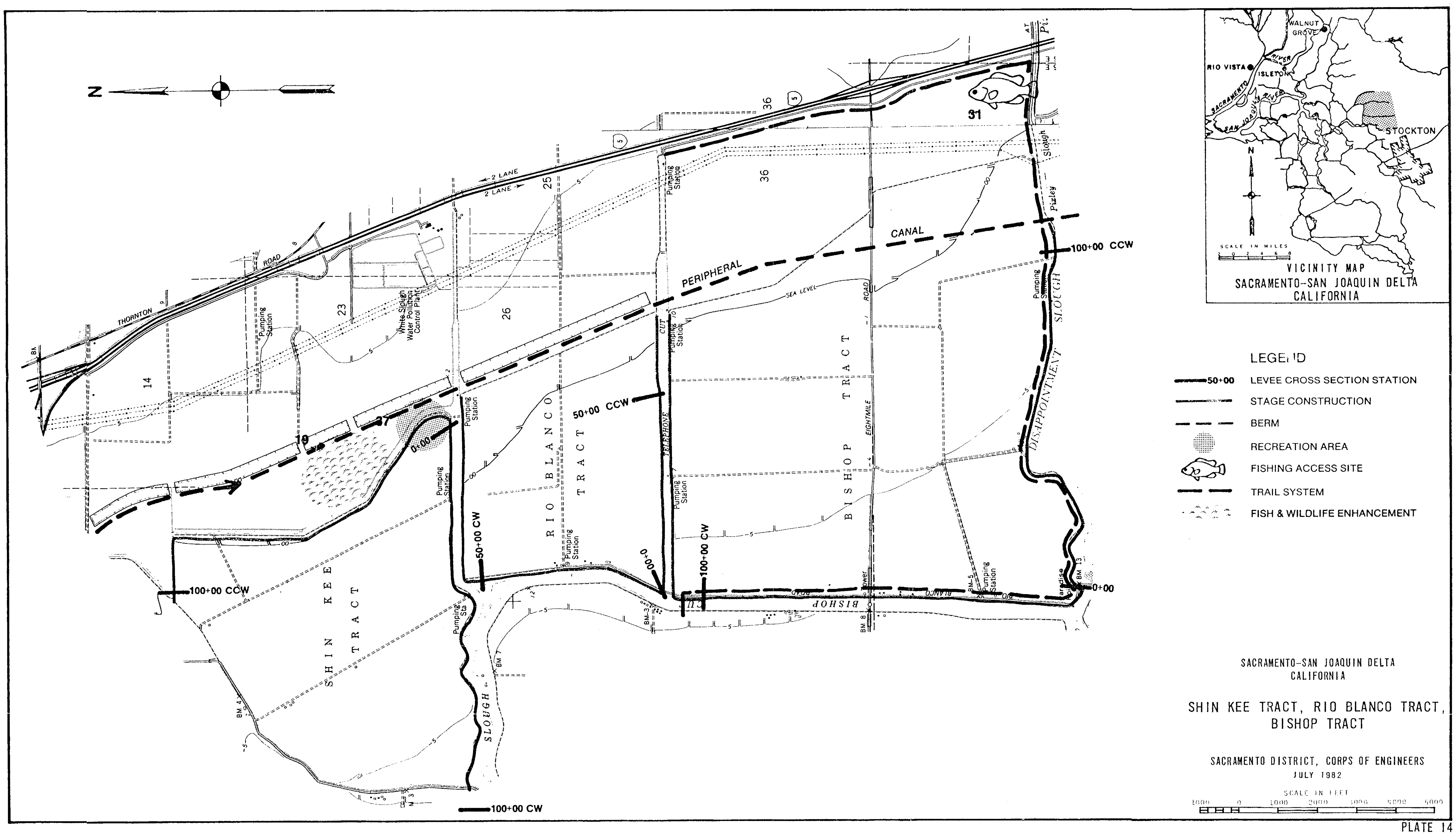


PLATE 14

C-103305

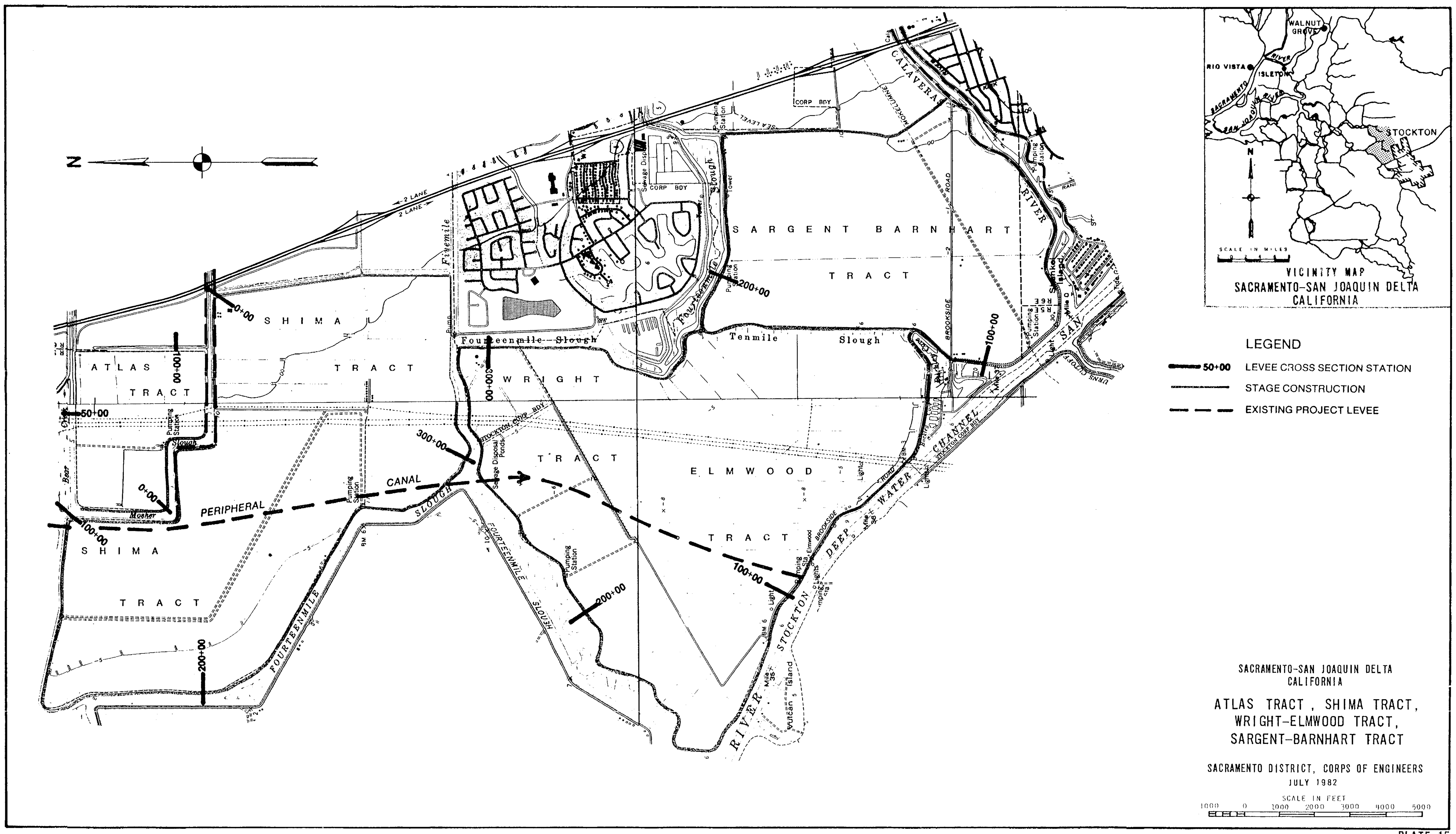

N
SHIMA TRACT
ATLAS TRACT
WRIGHT TRACT
ELMWOOD TRACT
SARGENT BARNHART TRACT
Fourteenmile Slough
Fivemile
Tenmile Slough
PERIPHERAL CANAL
FOURTEENMILE SLOUGH
STOCKTON DEEP WATER CHANNEL
SAN JOAQUIN RIVER
CALAVERAS RIVER
CORP BDY
Pumping Station
2 LANE
0+00
50+00
100+00
200+00
300+00
VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
WALNUT GROVE
RIO VISTA
ISLETON
STOCKTON
SCALE IN MILES
LEGEND
50+00 LEVEE CROSS SECTION STATION
STAGE CONSTRUCTION
EXISTING PROJECT LEVEE
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
ATLAS TRACT, SHIMA TRACT,
WRIGHT-ELMWOOD TRACT,
SARGENT-BARNHART TRACT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

PLATE 15

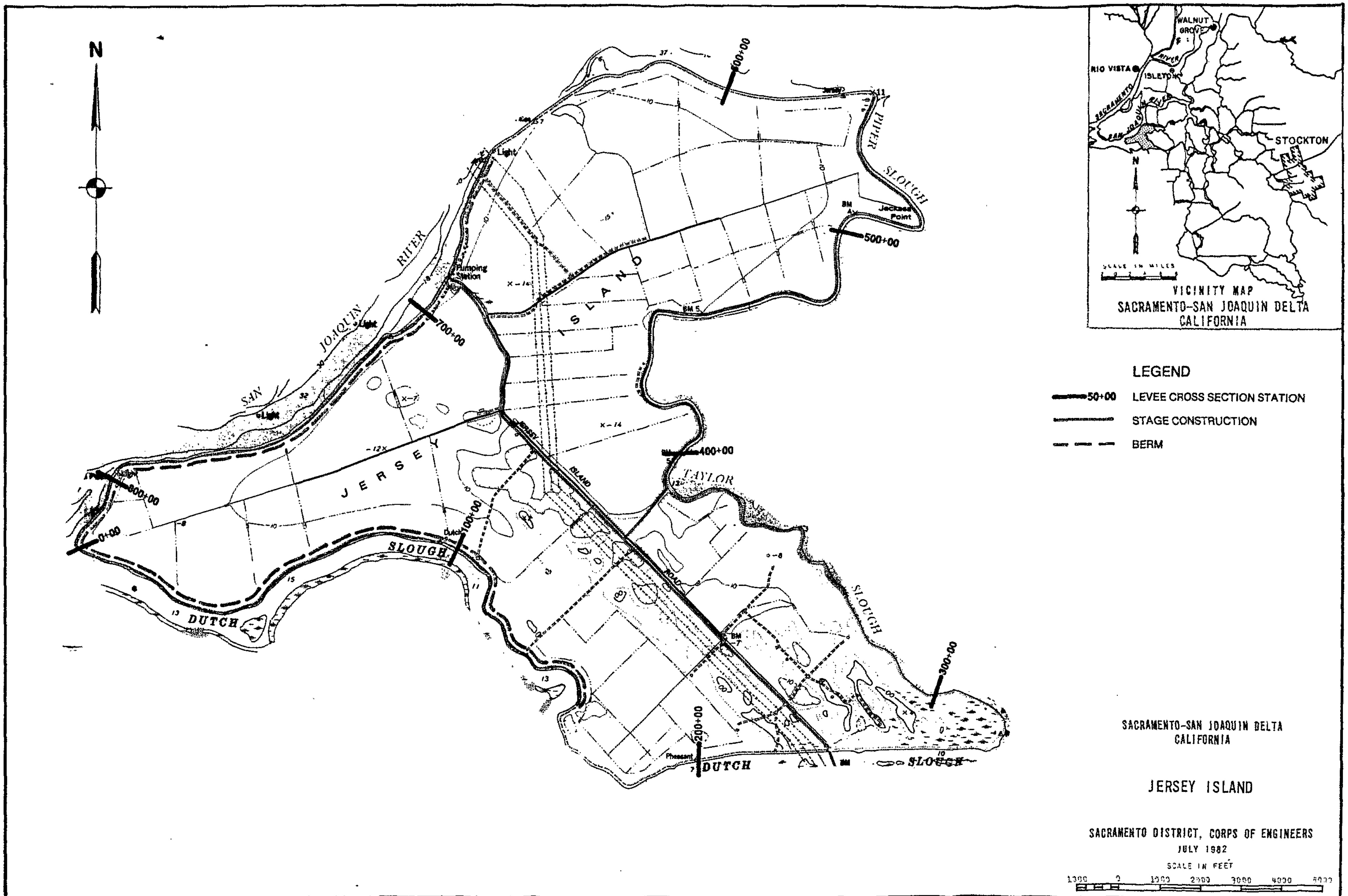

N
SAN JOAQUIN RIVER
PIPER SLOUGH
Jackass Point
500+00
600+00
700+00
800+00
0+00
100+00
200+00
300+00
400+00
Pumping Station
Light
JERSEY ISLAND
JERSEY ISLAND ROAD
TAYLOR SLOUGH
DUTCH SLOUGH
Pheasant
WALNUT GROVE
RIO VISTA
ISLETON
SACRAMENTO RIVER
SAN JOAQUIN RIVER
STOCKTON
VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
LEGEND
50+00 LEVEE CROSS SECTION STATION
STAGE CONSTRUCTION
BERM
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
JERSEY ISLAND
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982
SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

PLATE 16

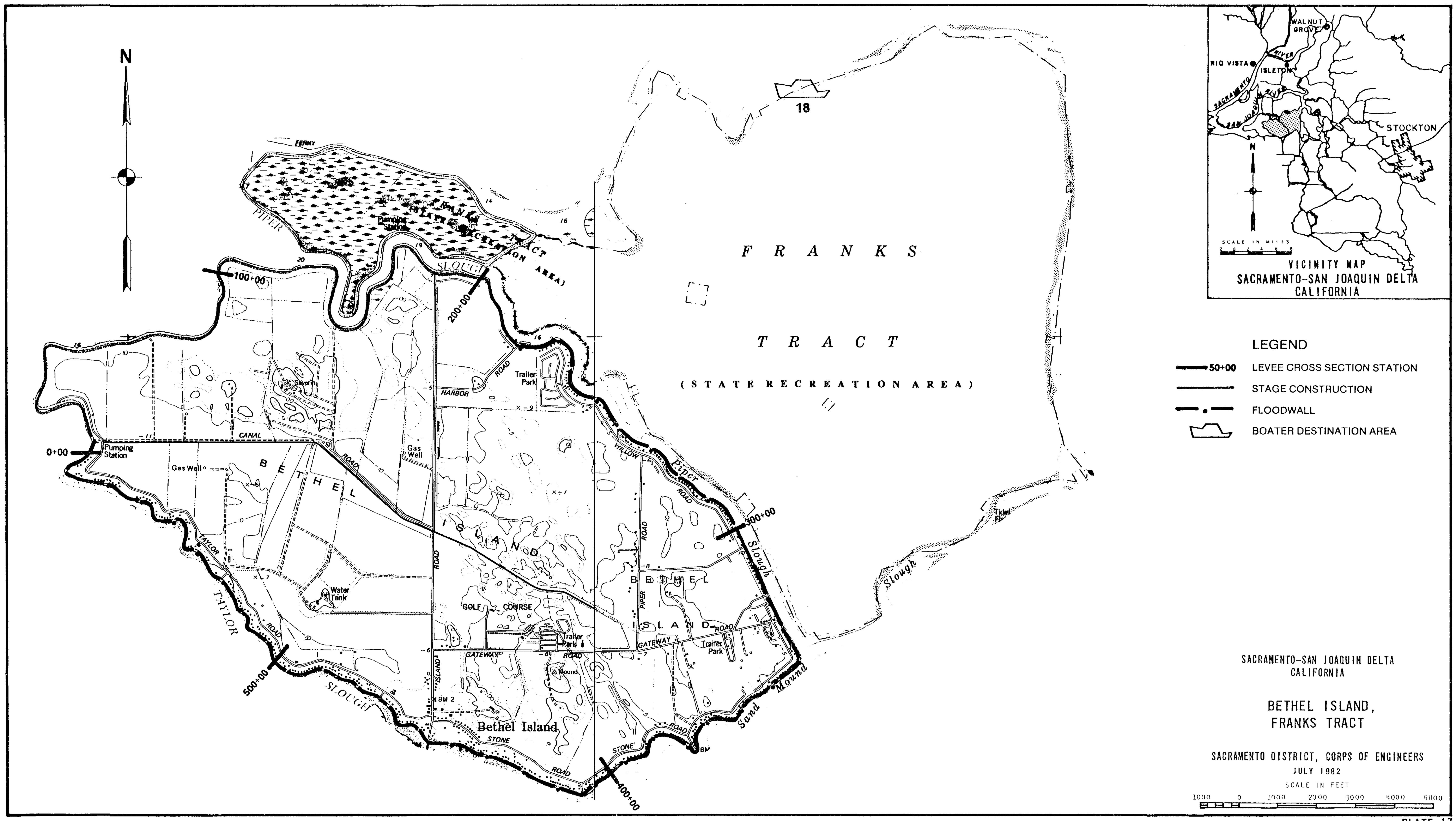


PLATE 17

C-103308

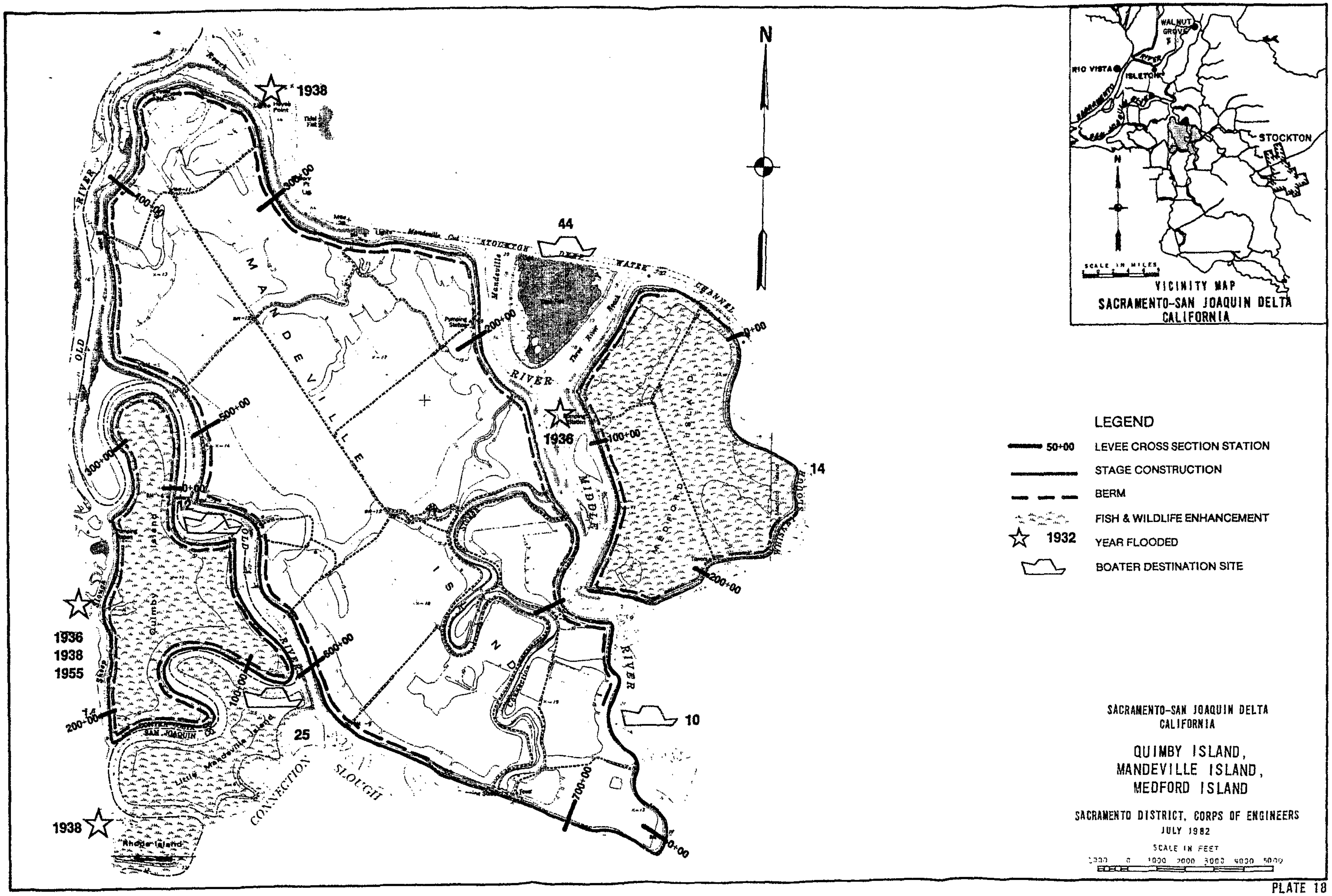


PLATE 18

C-103309

C—103309

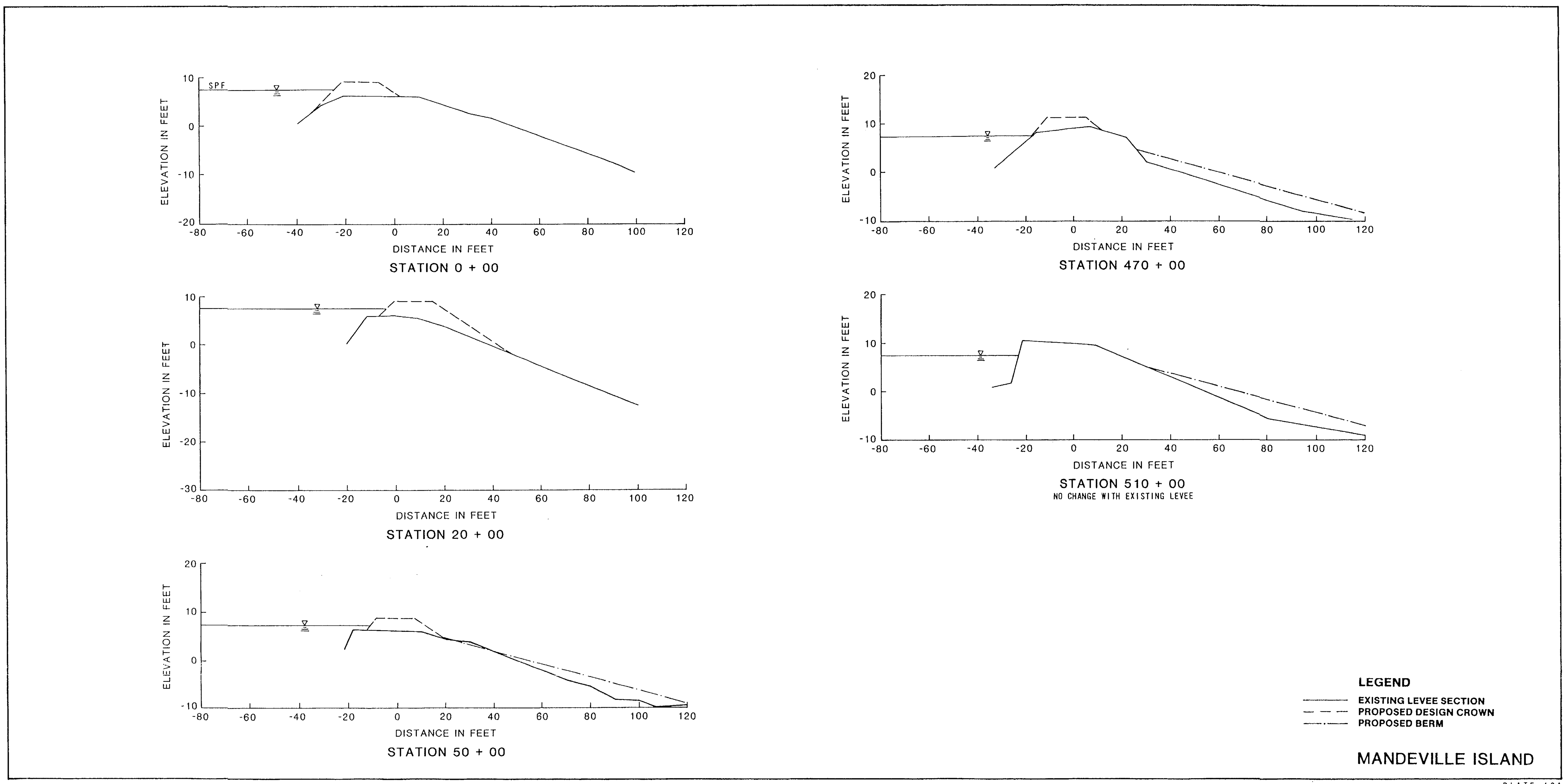


PLATE 18A

C-103310

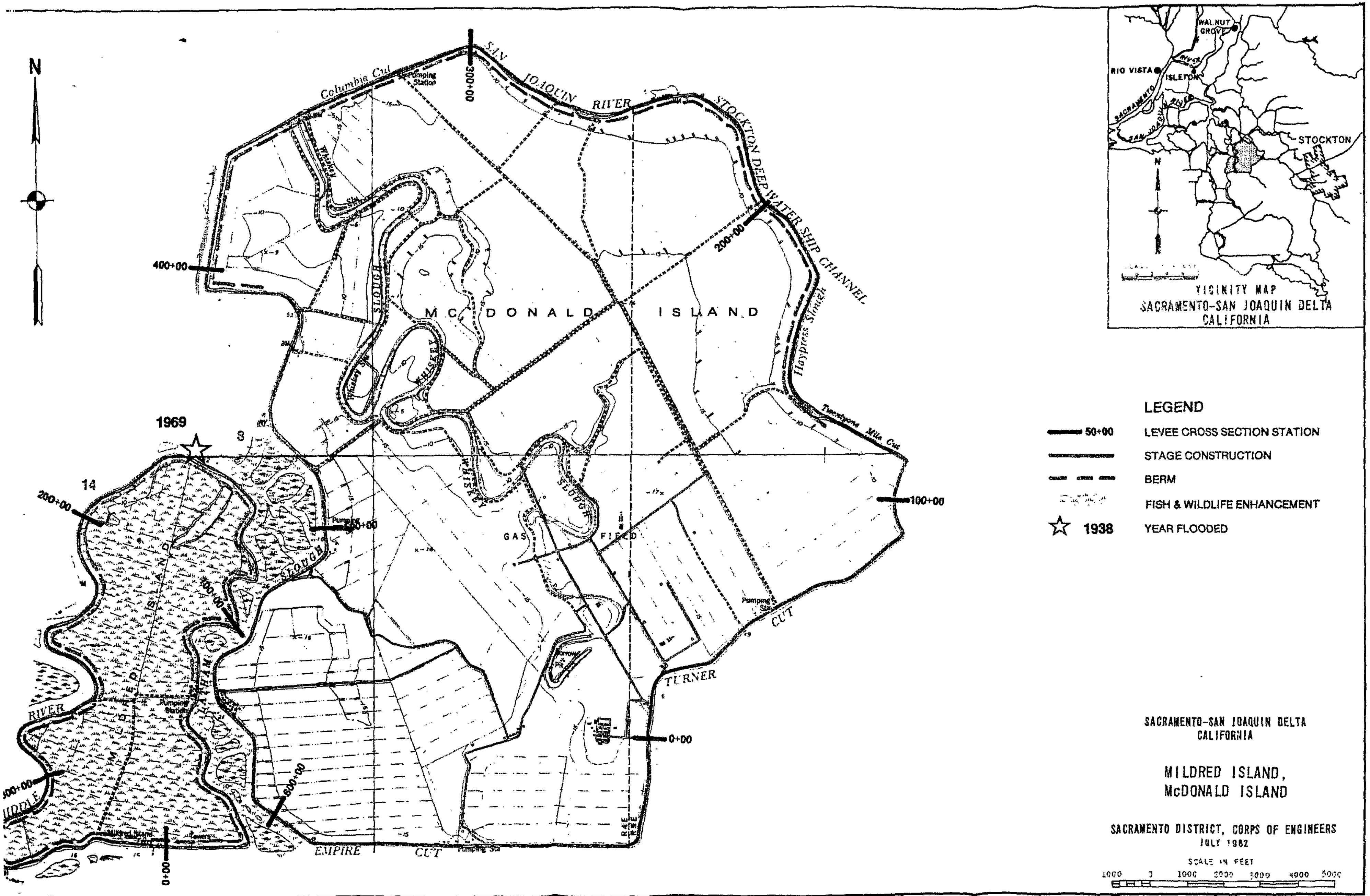
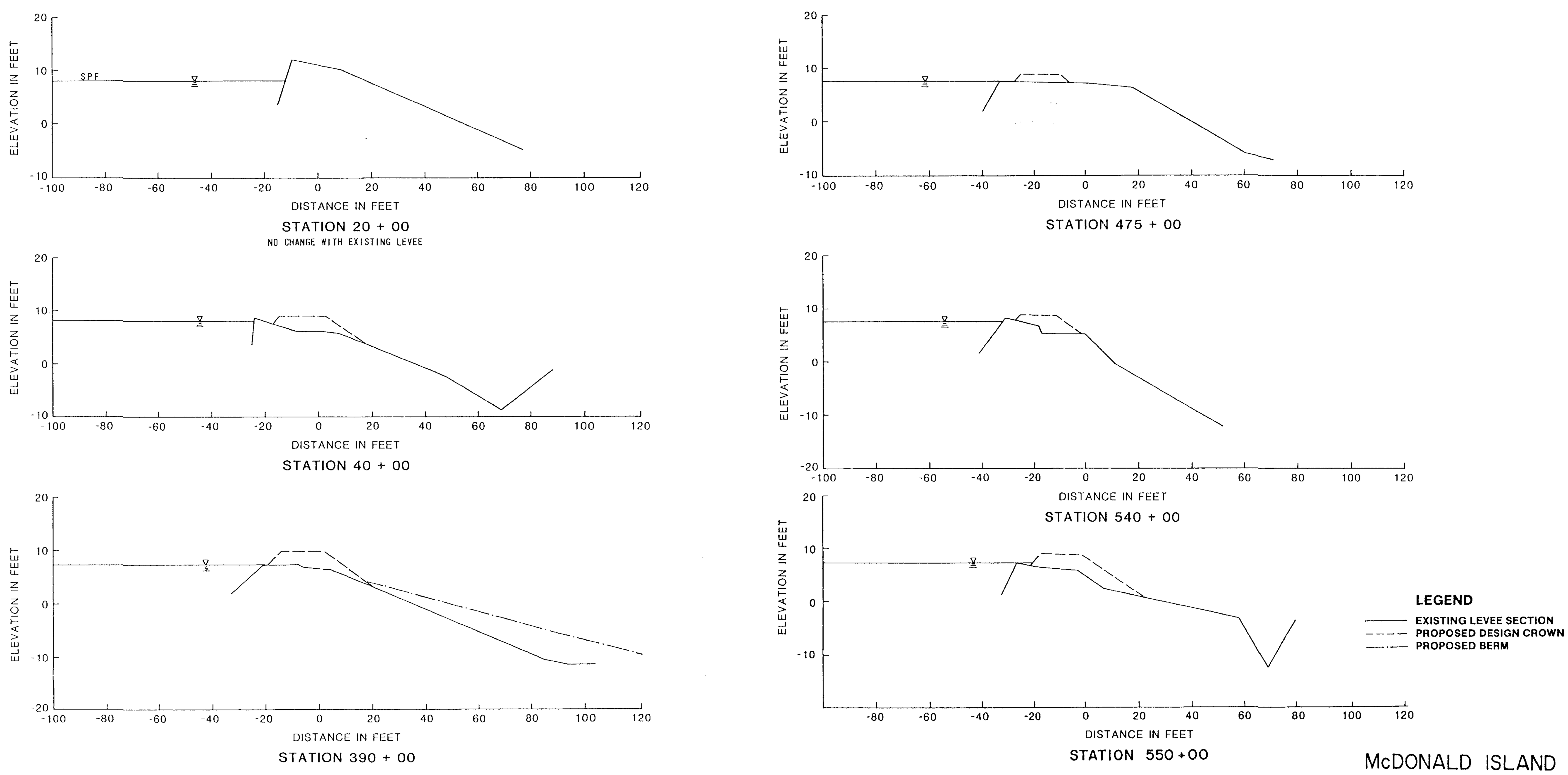


PLATE 19

C-103311

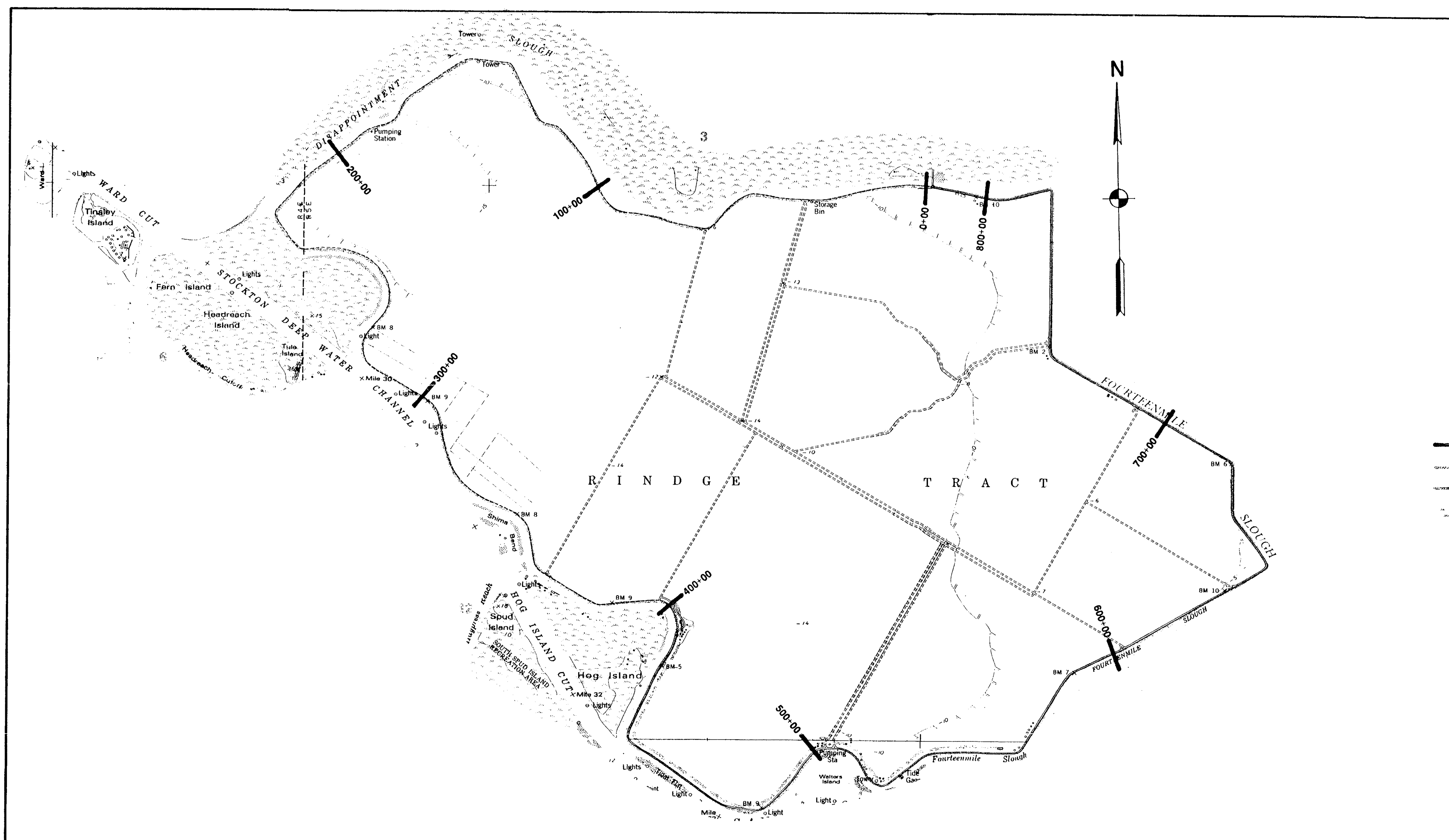
C—103311

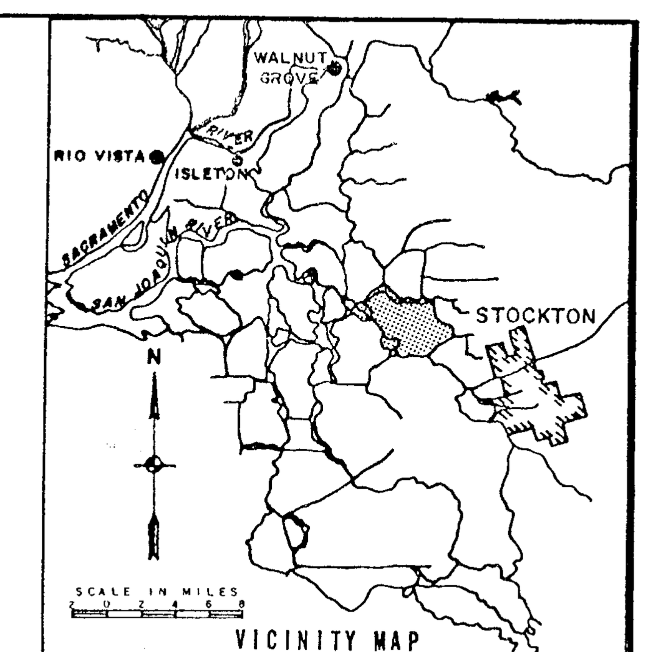


McDONALD ISLAND

PLATE 19A

C-103312





VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

LEGEND

- 50+00 LEVEE CROSS SECTION STATION
- STAGE CONSTRUCTION
- BERM
- FISH & WILDLIFE ENHANCEMENT

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

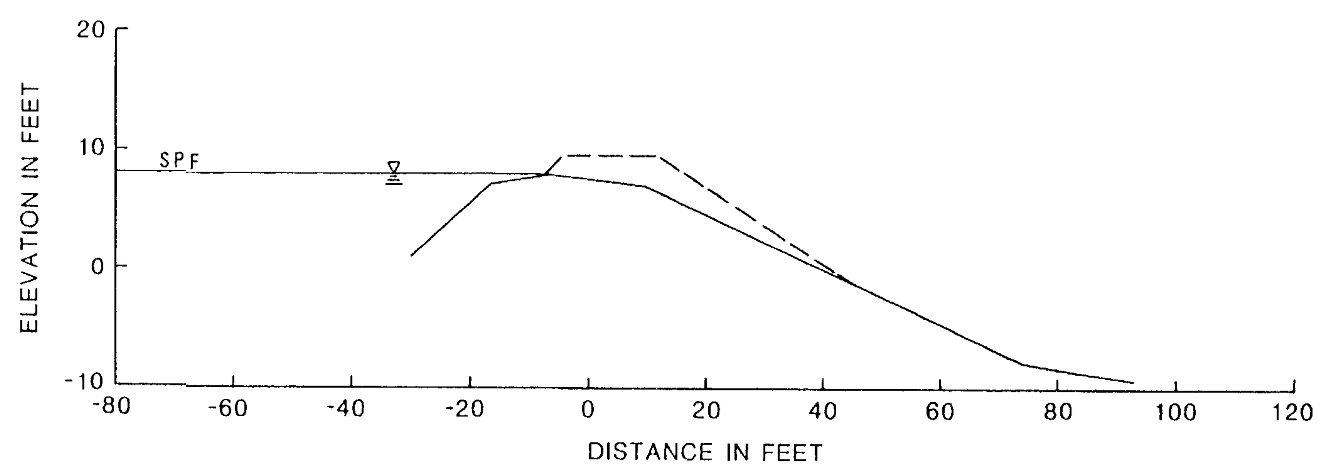
RINDGE TRACT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

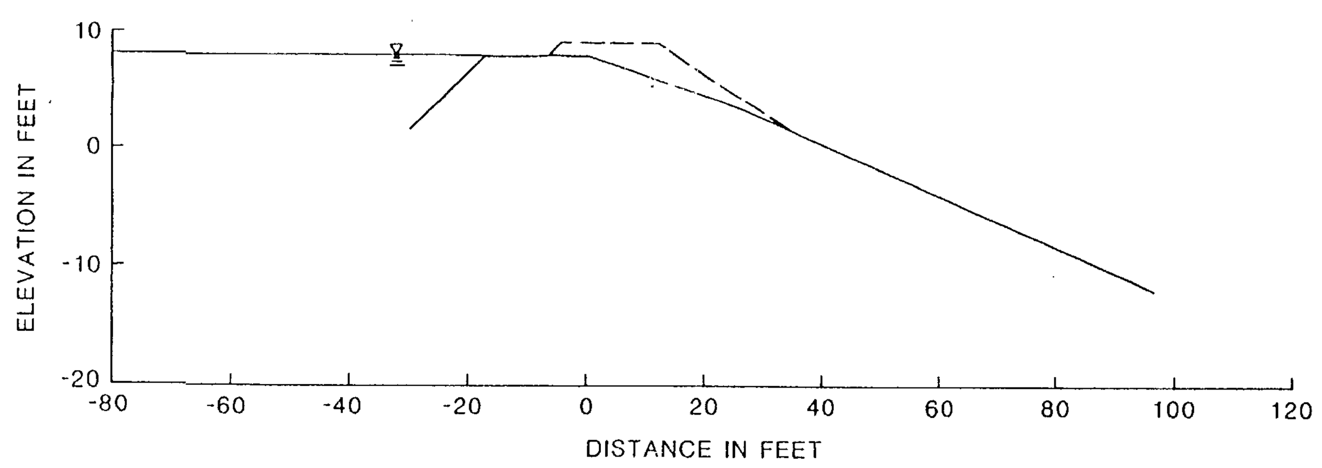
SCALE IN THOUSANDS OF FEET

PLATE 20

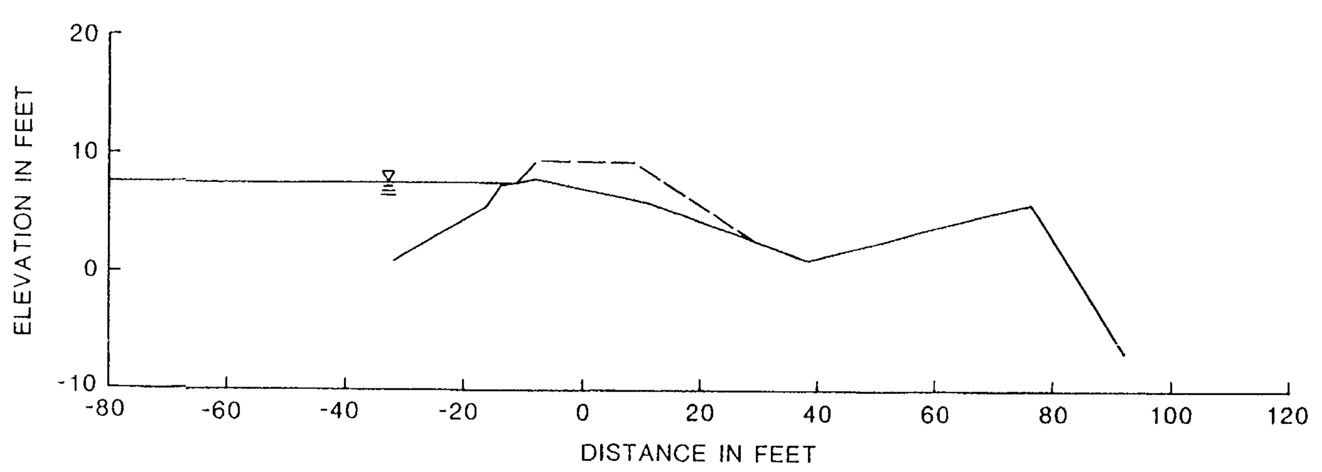
C-103313



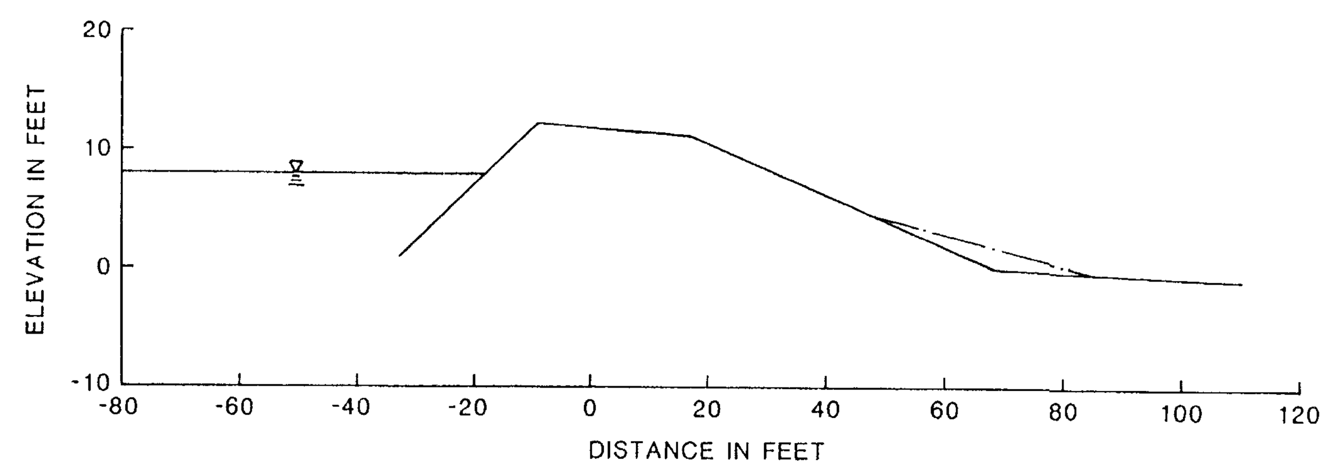
STATION 70 + 00



STATION 250 + 00

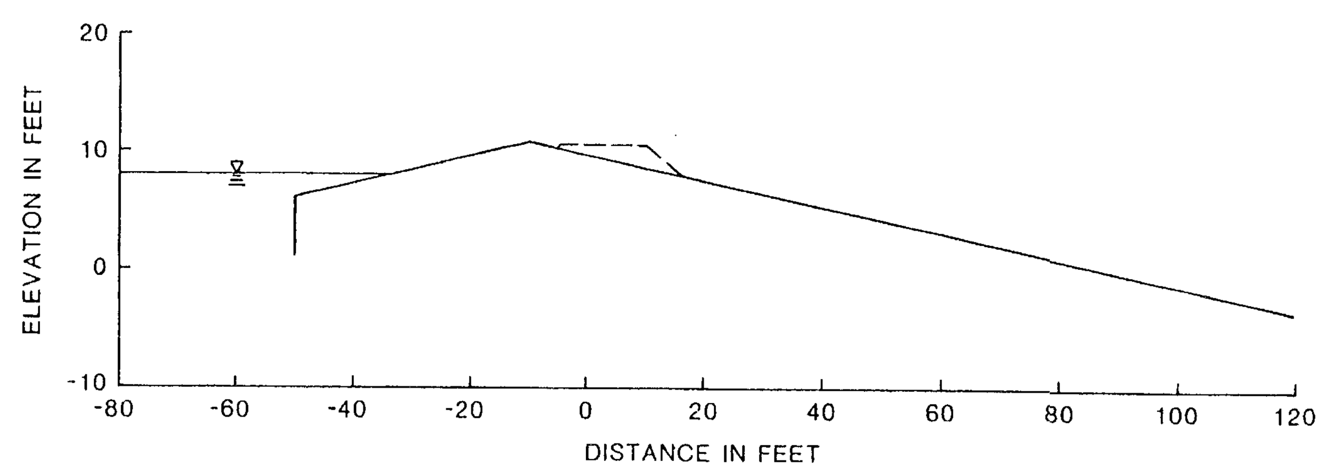


STATION 300 + 00



STATION 530 + 00

NO CHANGE WITH EXISTING LEVEE



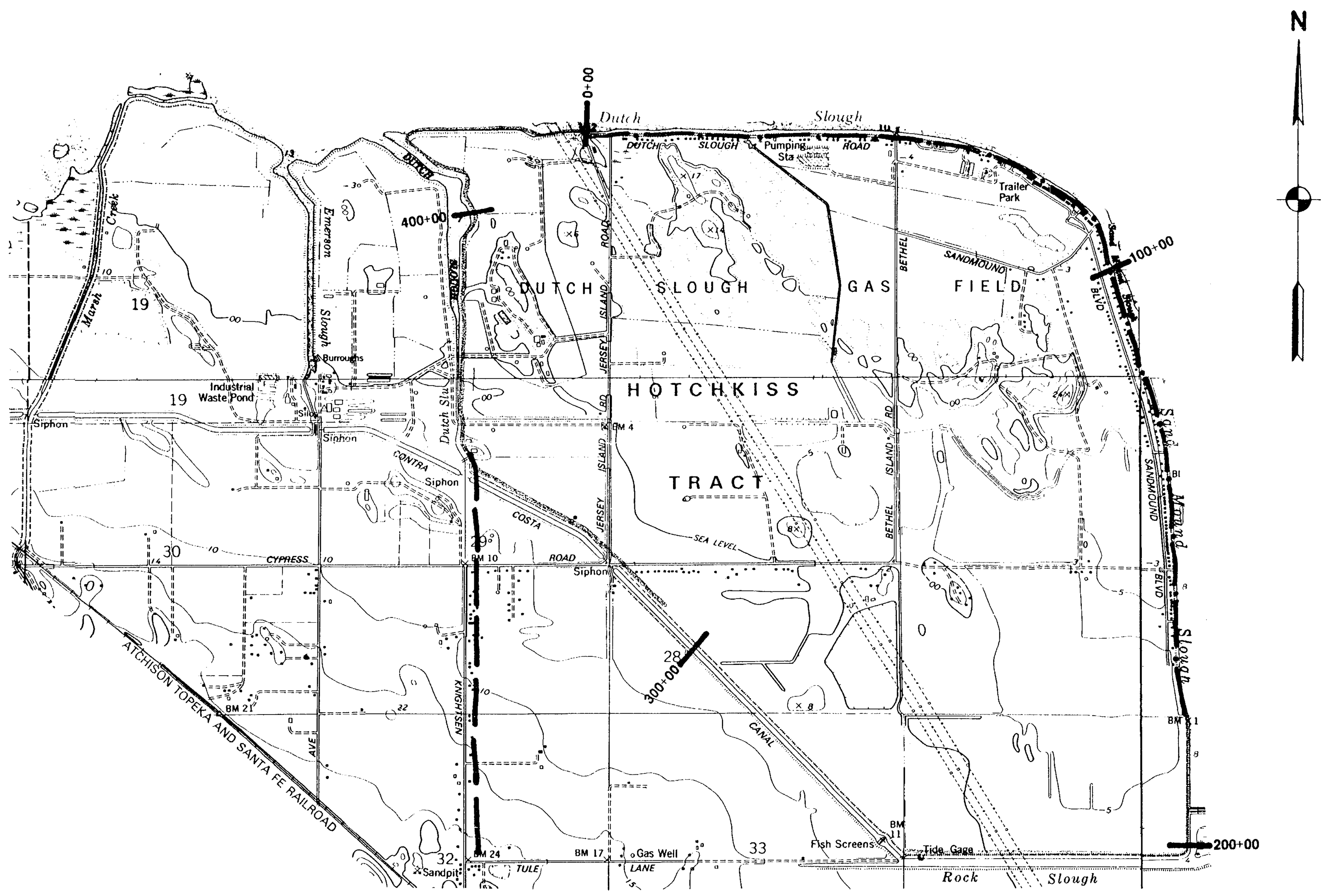
STATION 660 + 00

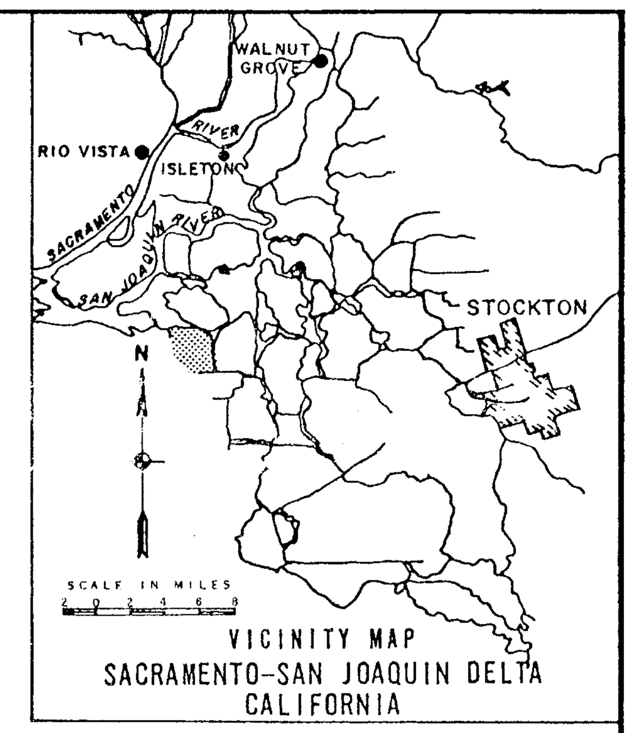
LEGEND

- EXISTING LEVEE SECTION
- PROPOSED DESIGN CROWN
- PROPOSED BERM

RINDGE TRACT

C-103314





LEGEND

- 50+00 LEVEE CROSS SECTION STATION
- STAGE CONSTRUCTION
- FLOODWALL
- TRAIL SYSTEM

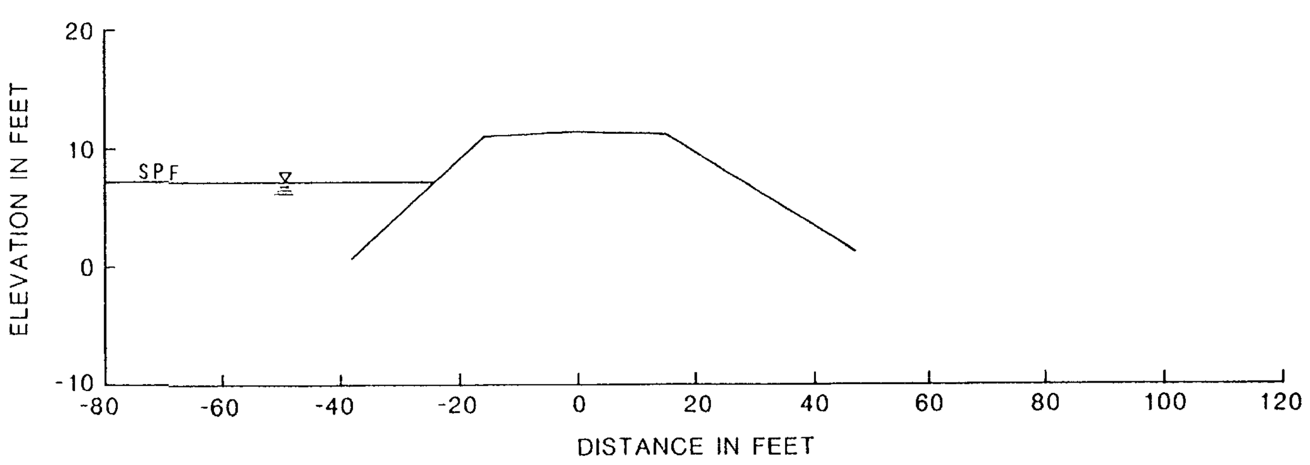
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

HOTCHKISS TRACT

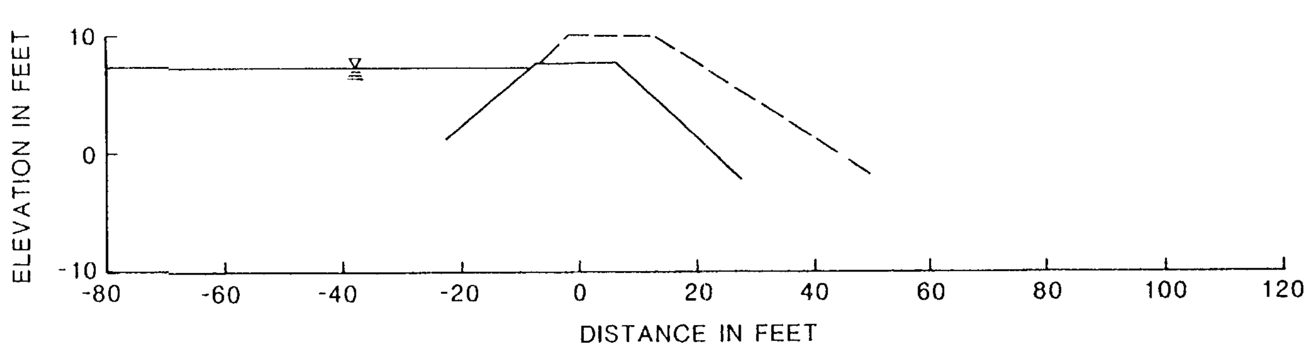
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

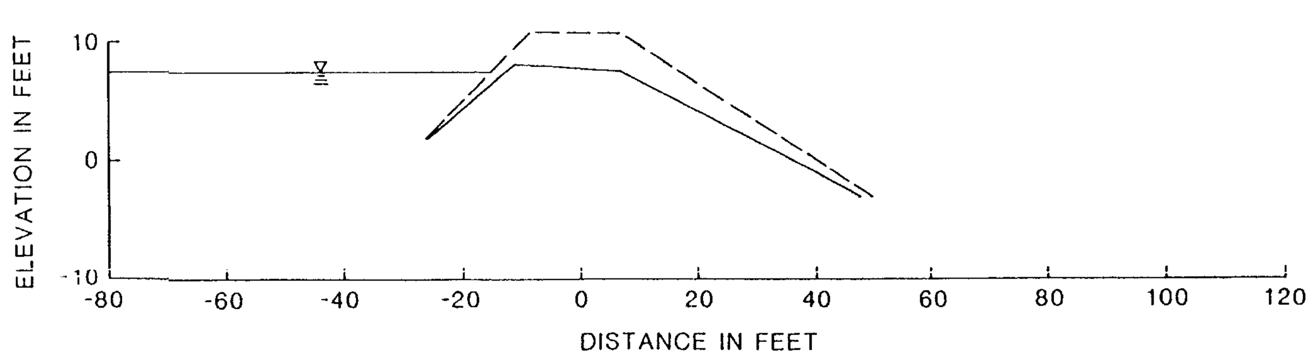
C-103315



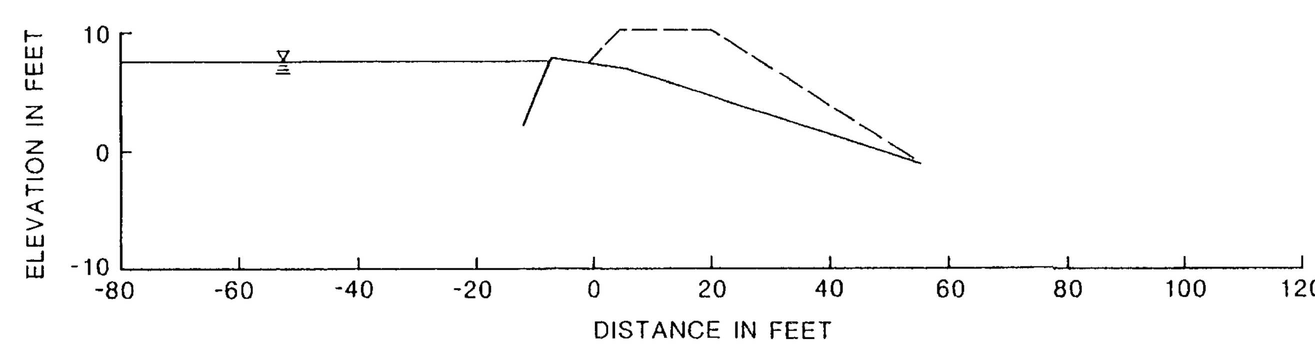
STATION 20 + 00
NO CHANGE WITH EXISTING LEVEE



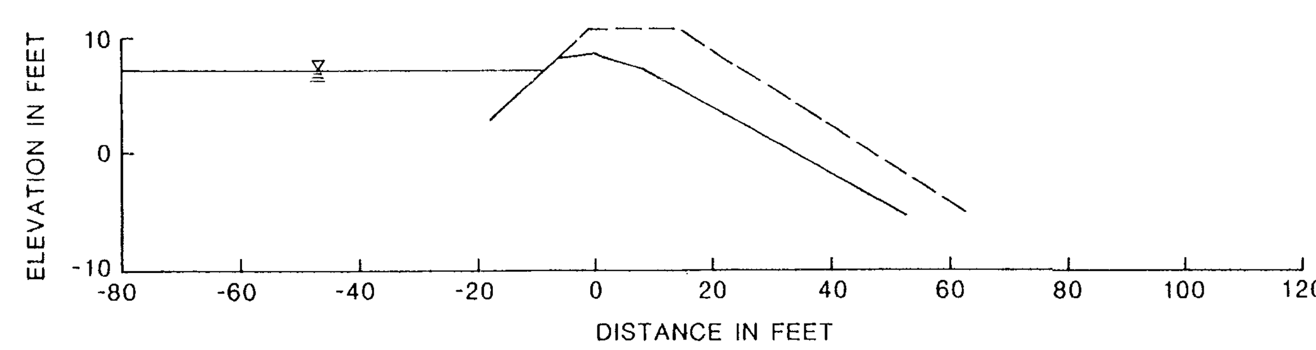
STATION 180 + 00



STATION 220 + 00



STATION 240 + 00



STATION 430 + 00

LEGEND

——— EXISTING LEVEE SECTION
– – – PROPOSED DESIGN CROWN

HOTCHKISS TRACT

C-103316

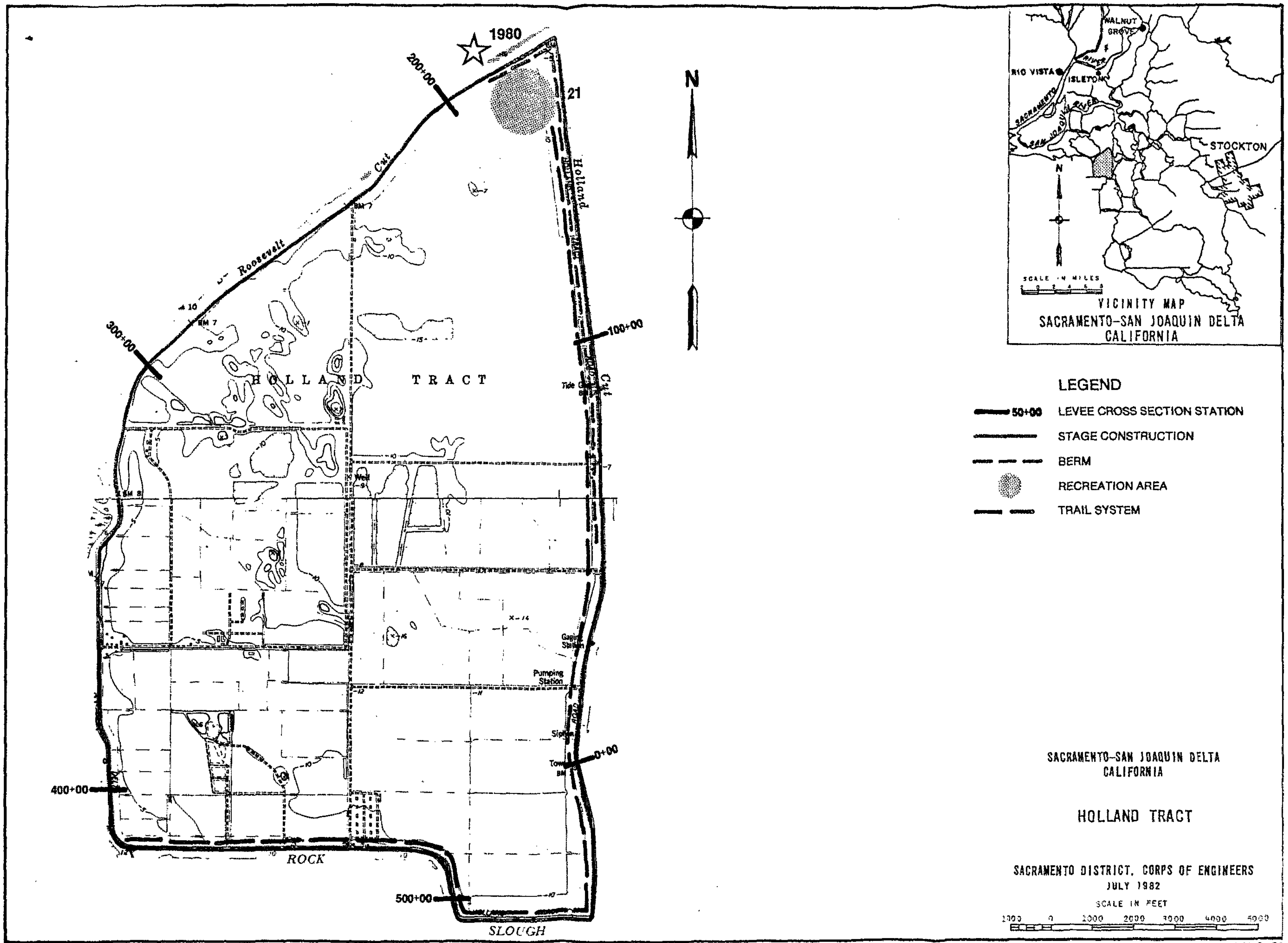


PLATE 22

C-103317

C—103317

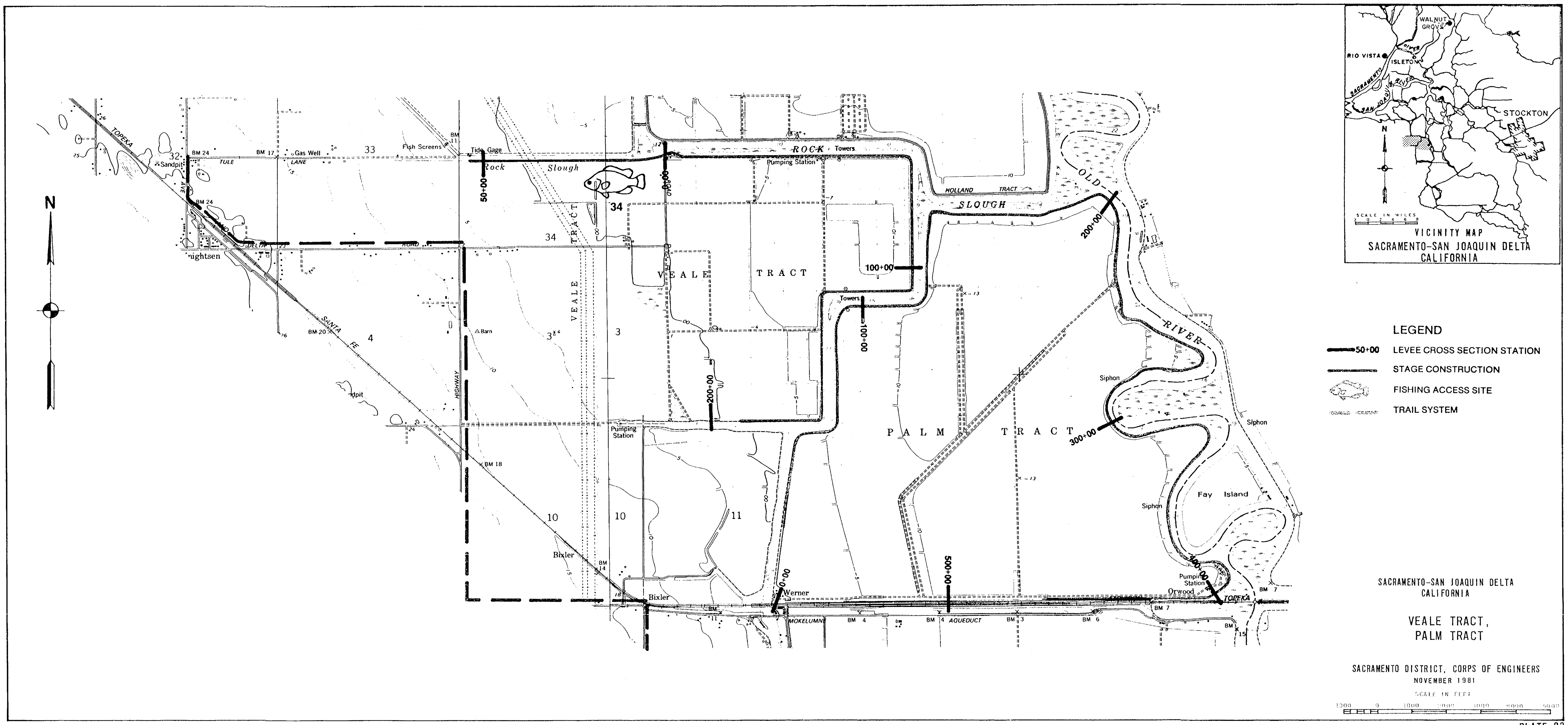


PLATE 23

C-103318

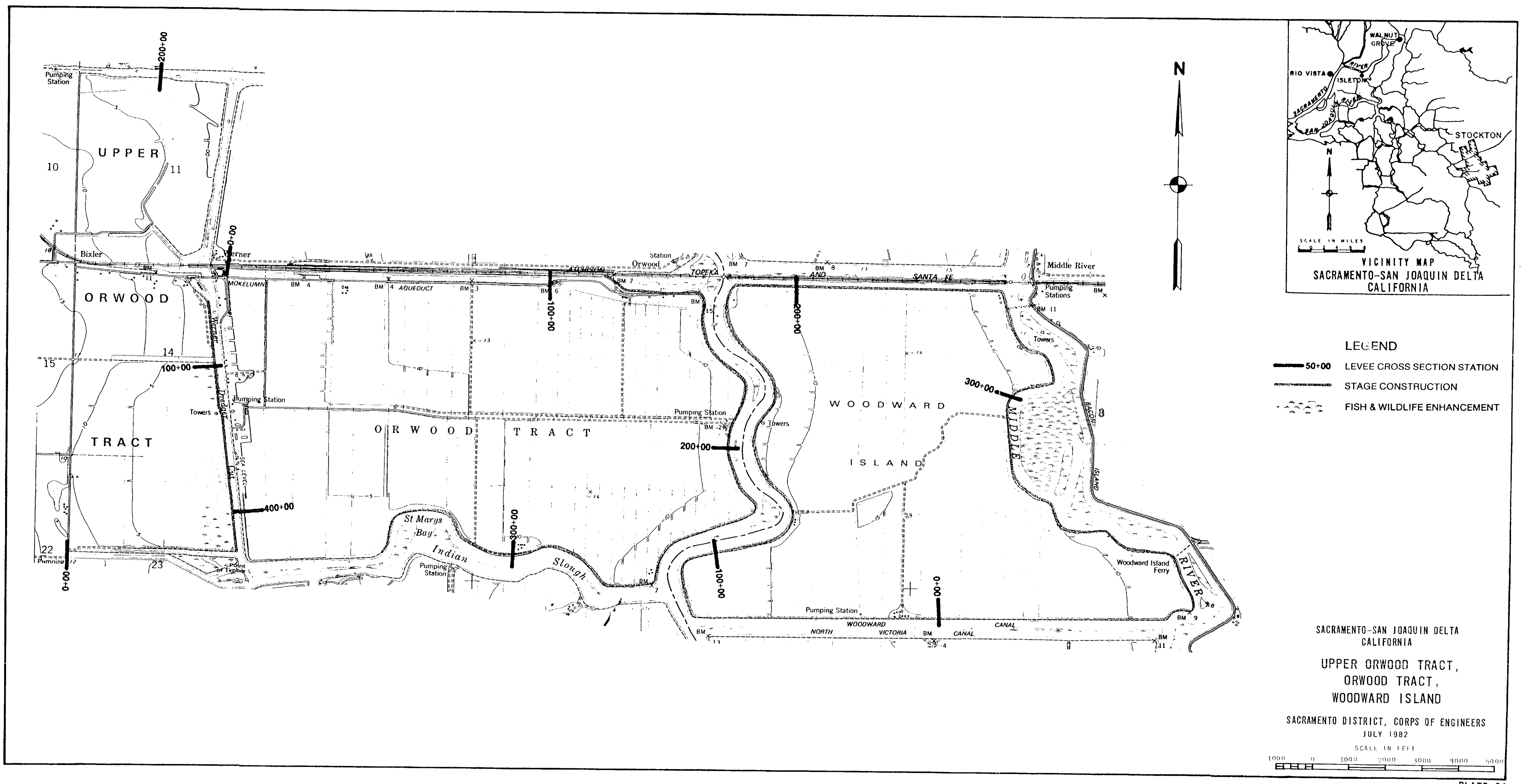
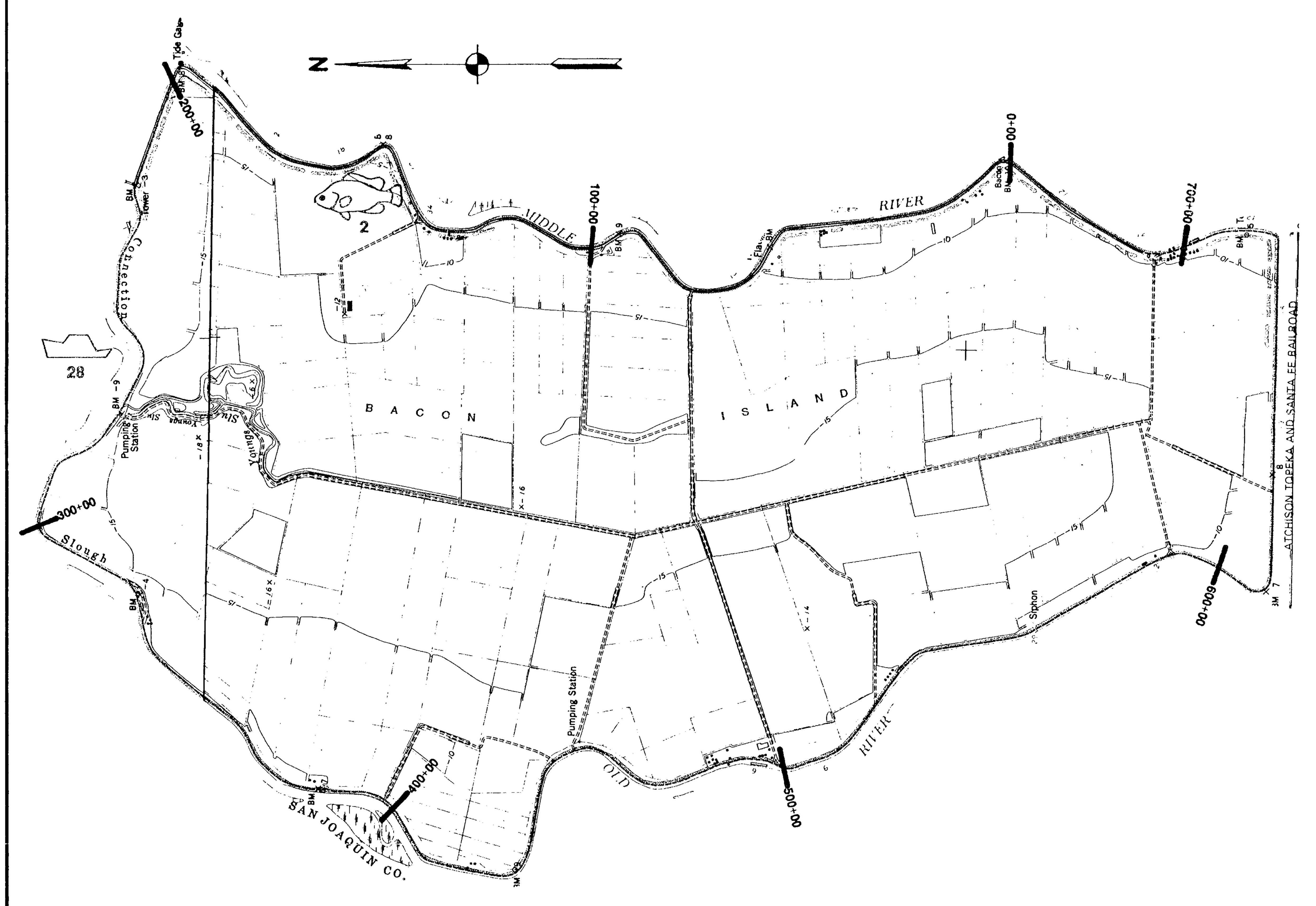
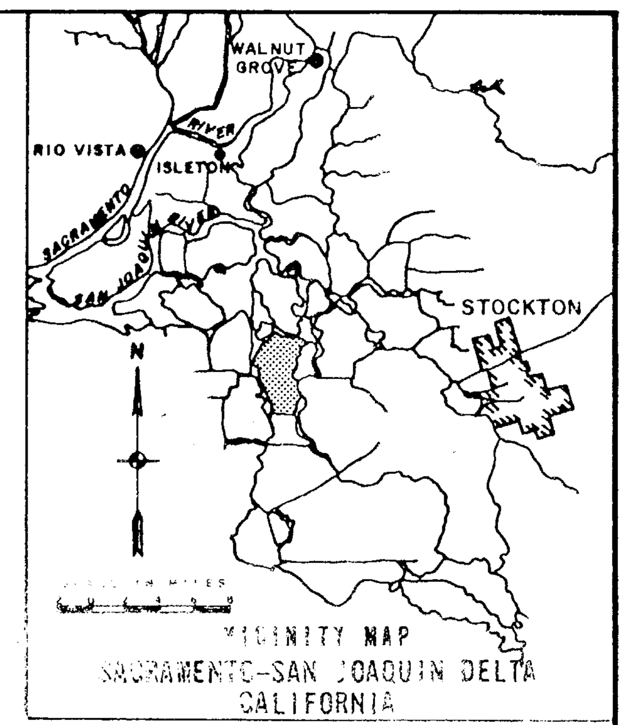


PLATE 24

C-103319





LEGEND

- 50+00 LEVEE CROSS SECTION STATION
- STAGE CONSTRUCTION
- BERM
- EXISTING PROJECT LEVEE
- FISHING ACCESS SITE
- BOATER DESTINATION SITE

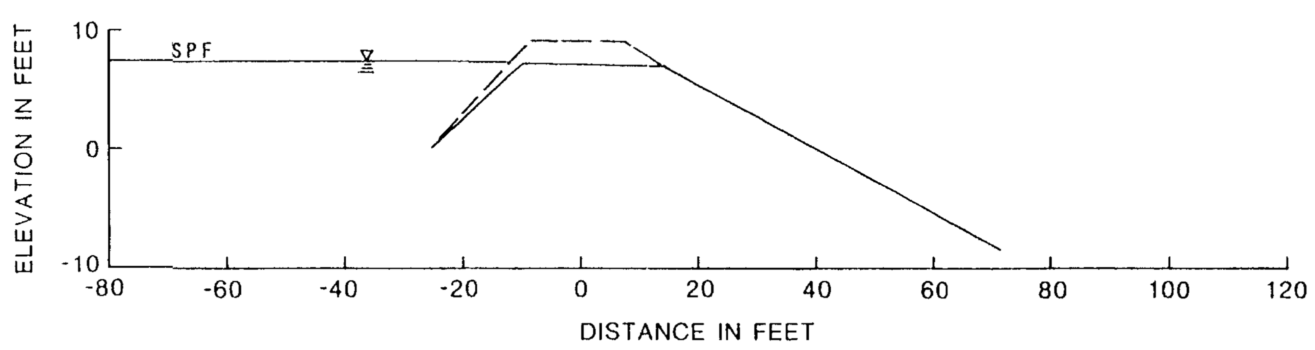
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

BACON ISLAND

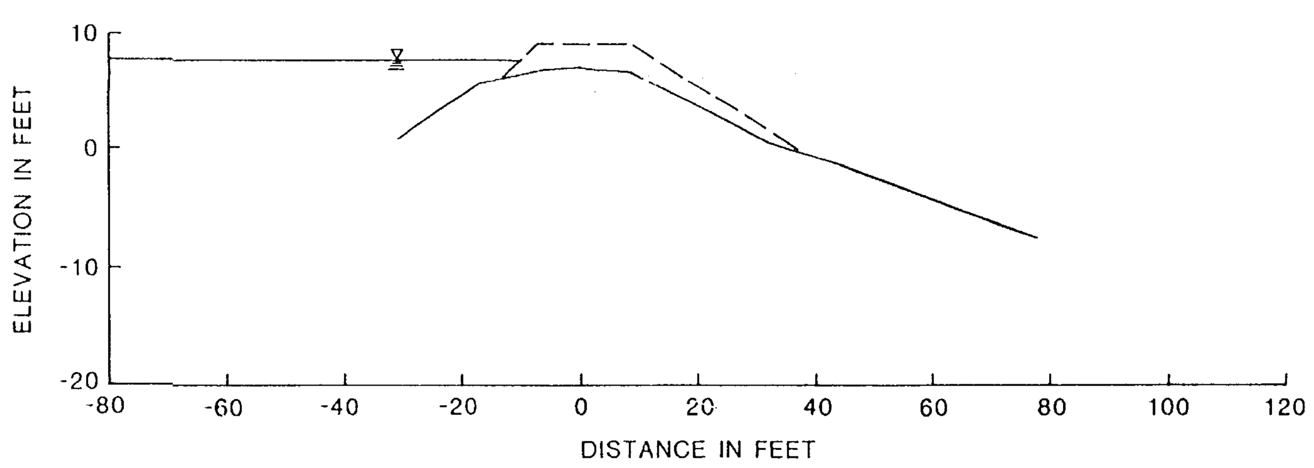
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

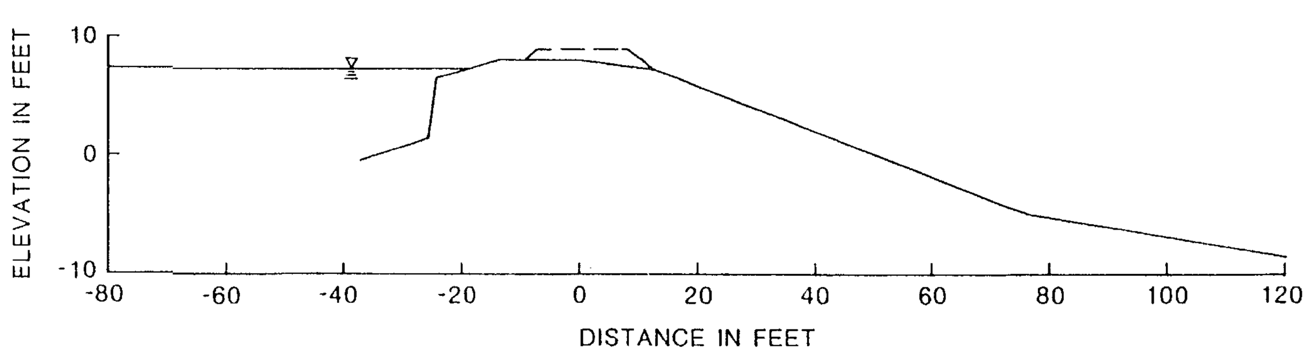
PLATE 25



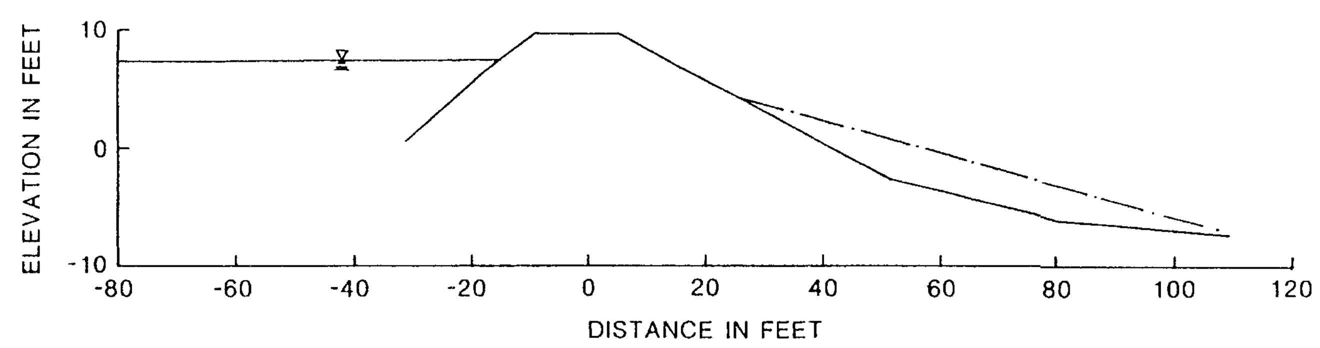
STATION 100 + 00



STATION 370 + 00

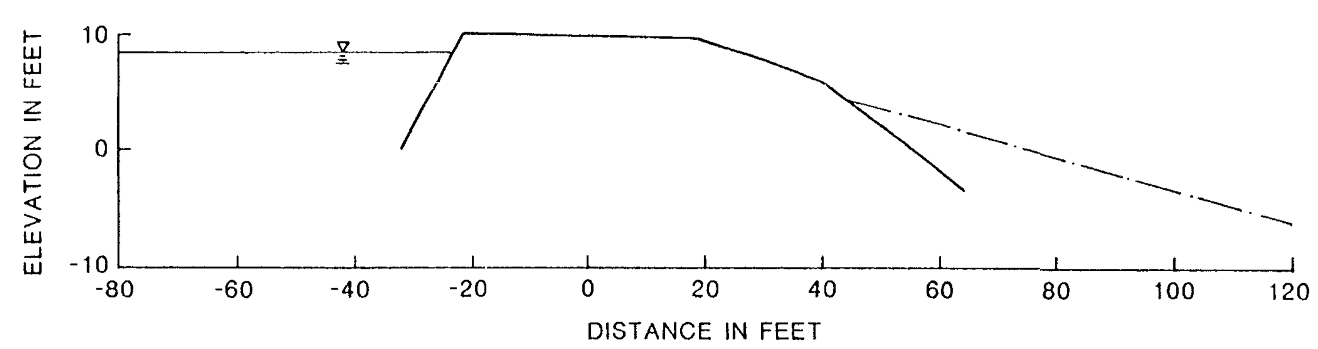


STATION 440 + 00



STATION 560 + 00

NO CHANGE WITH EXISTING LEVEE



STATION 590 + 00

NO CHANGE WITH EXISTING LEVEE

LEGEND

EXISTING LEVEE SECTION
PROPOSED DESIGN CROWN
PROPOSED BERM

BACON ISLAND

PLATE 25A

C-103321

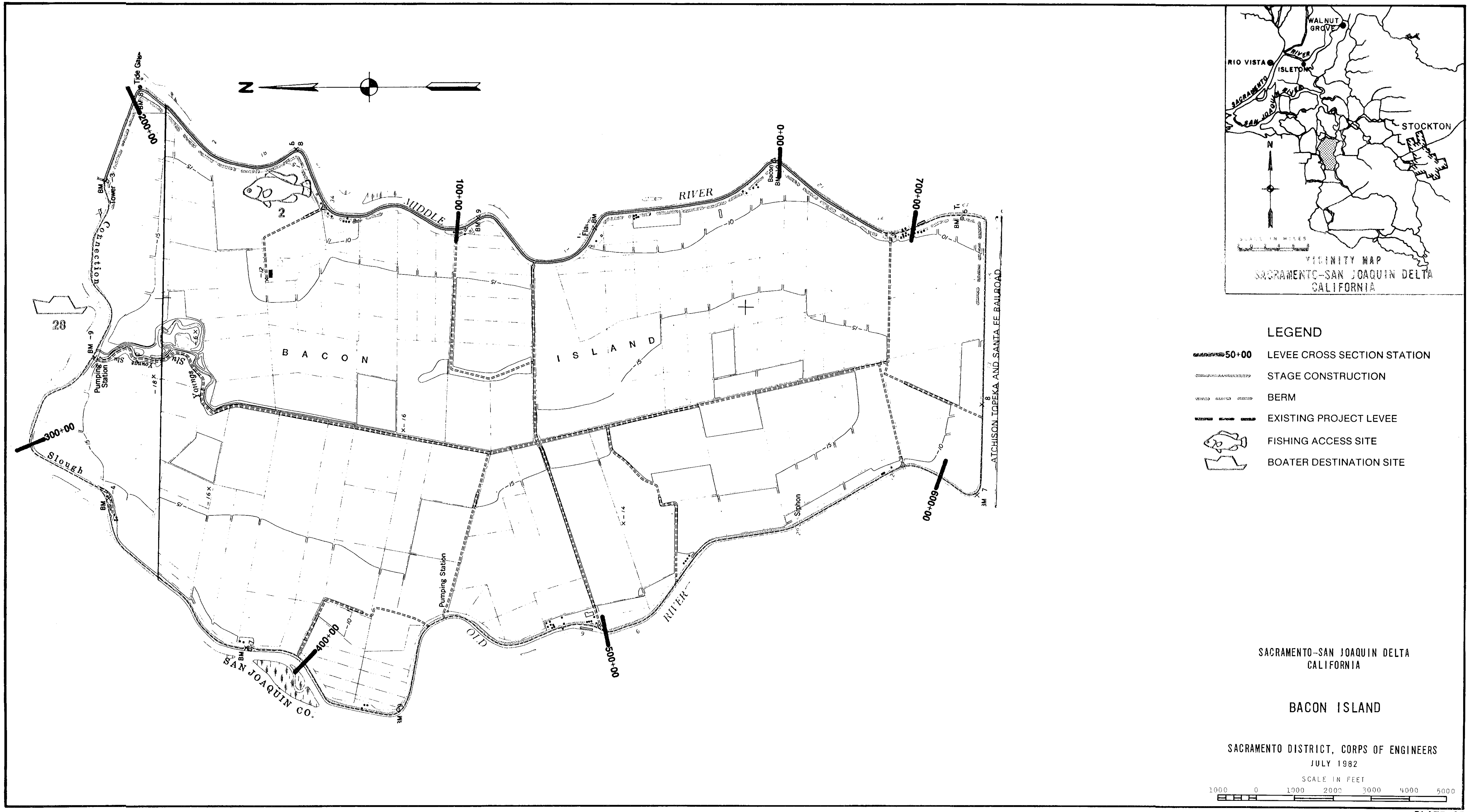


PLATE 25

C-103322

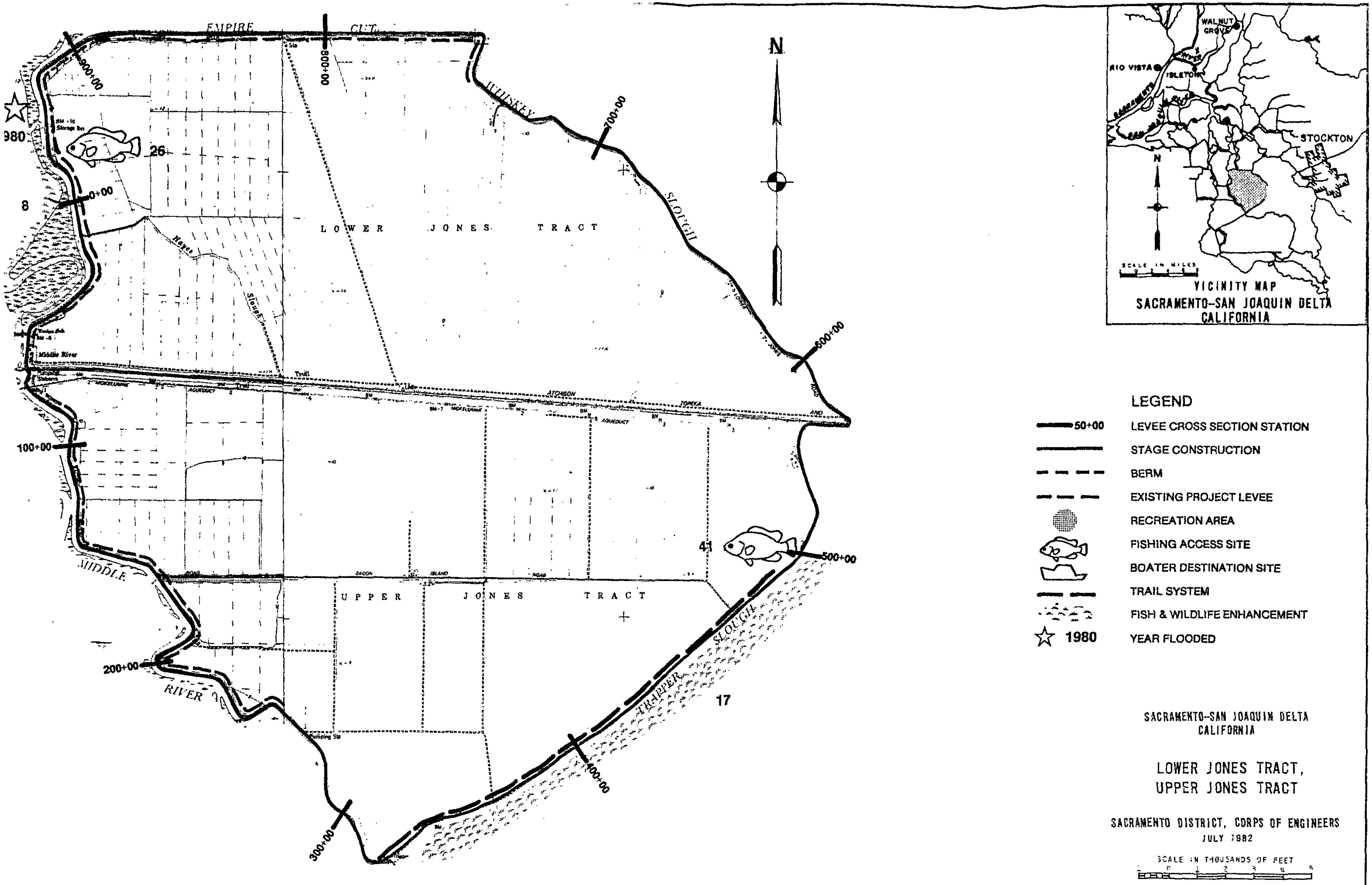
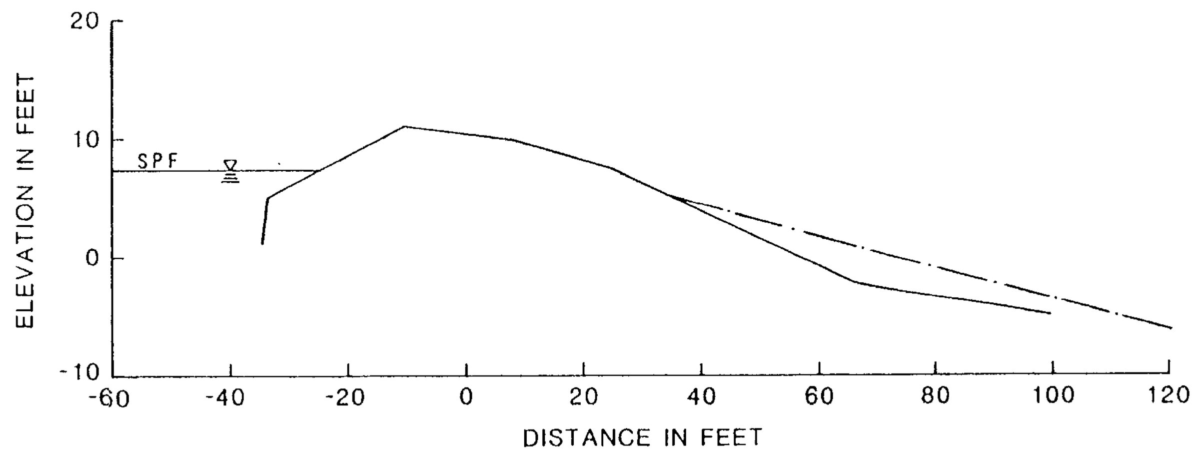
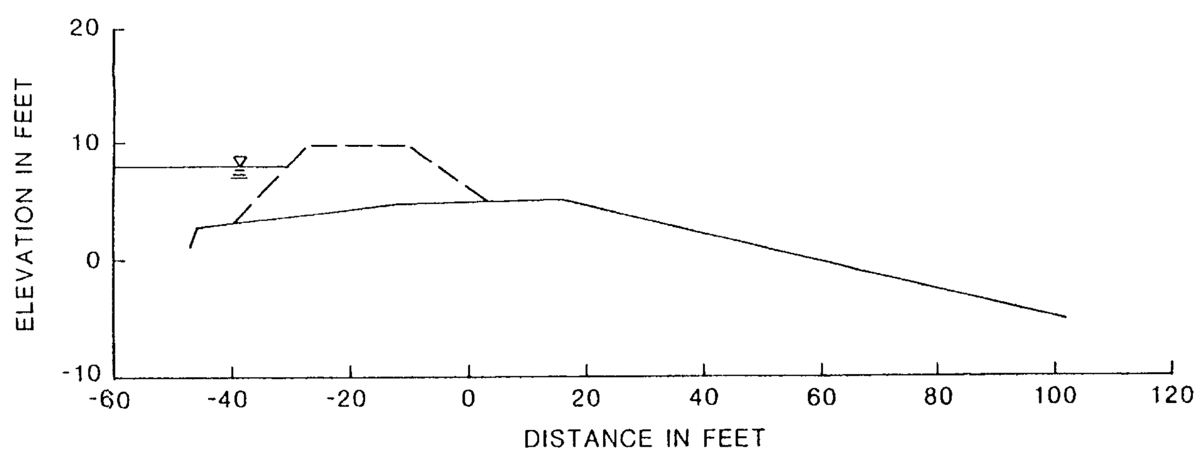

EMPIRE CUT
WHISKEY SLOUGH
LOWER JONES TRACT
UPPER JONES TRACT
MIDDLE RIVER
TRAPPER SLOUGH
N
980
8
26
41
17
800+00
900+00
700+00
600+00
500+00
400+00
300+00
200+00
100+00
VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
WALNUT GROVE
RIO VISTA
ISLETON
STOCKTON
LEGEND
50+00 LEVEE CROSS SECTION STATION
STAGE CONSTRUCTION
BERM
EXISTING PROJECT LEVEE
RECREATION AREA
FISHING ACCESS SITE
BOATER DESTINATION SITE
TRAIL SYSTEM
FISH & WILDLIFE ENHANCEMENT
1980 YEAR FLOODED
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
LOWER JONES TRACT,
UPPER JONES TRACT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982
SCALE IN THOUSANDS OF FEET

PLATE 26

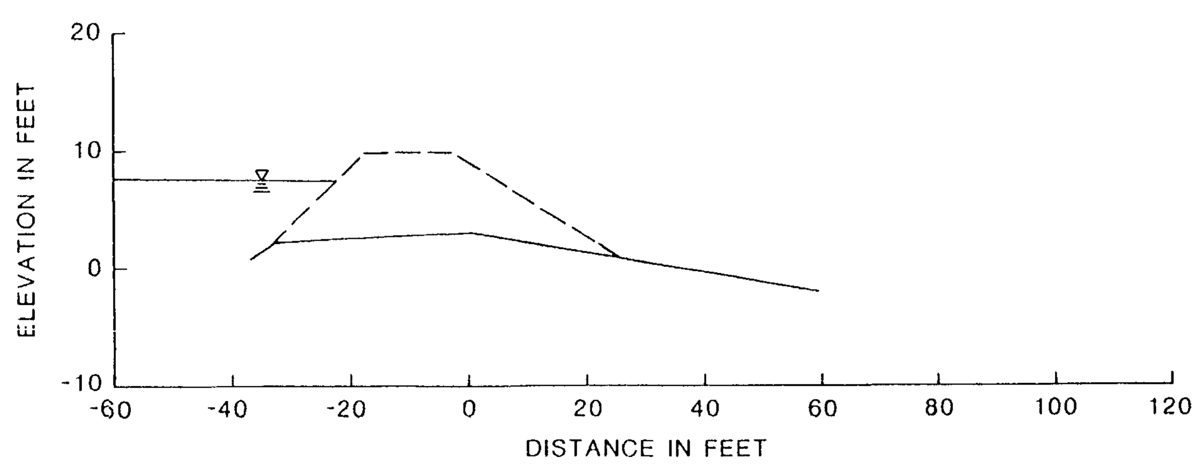


STATION 230 + 00

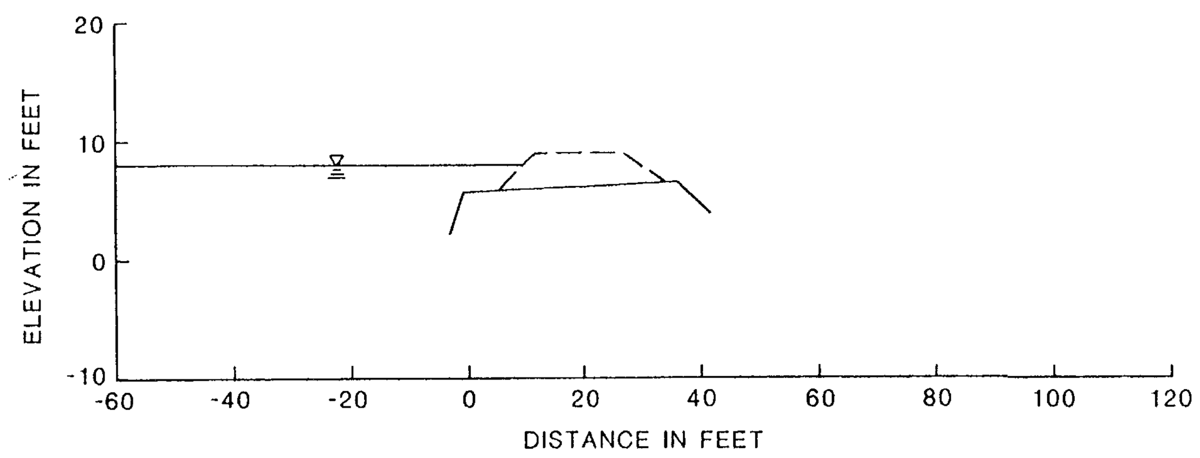
NO CHANGE WITH EXISTING LEVEE



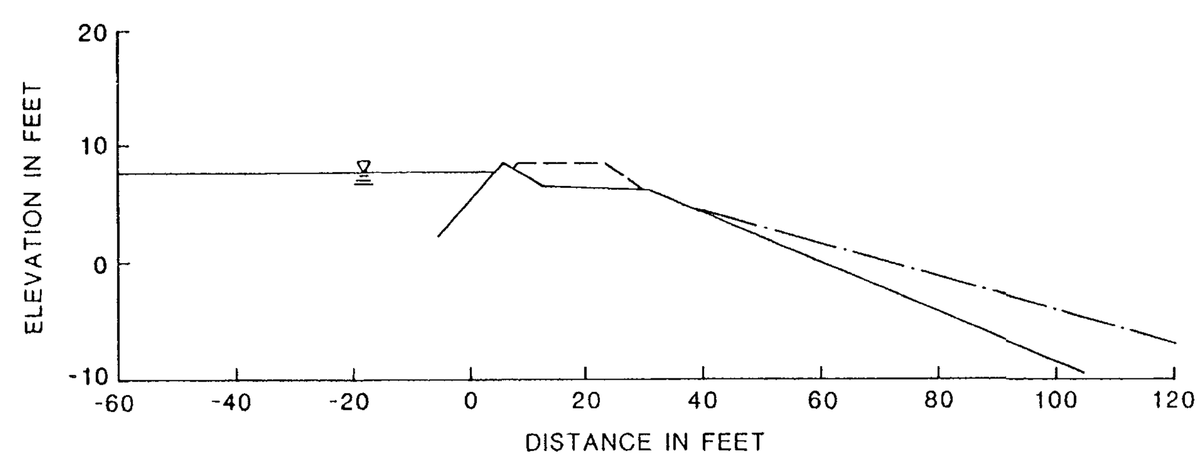
STATION 360 + 00



STATION 454 + 00



STATION 530 + 00



STATION 930 + 00

LEGEND

——— EXISTING LEVEE SECTION
— — — PROPOSED DESIGN CROWN
—·—·— PROPOSED BERM

UPPER AND LOWER JONES TRACT

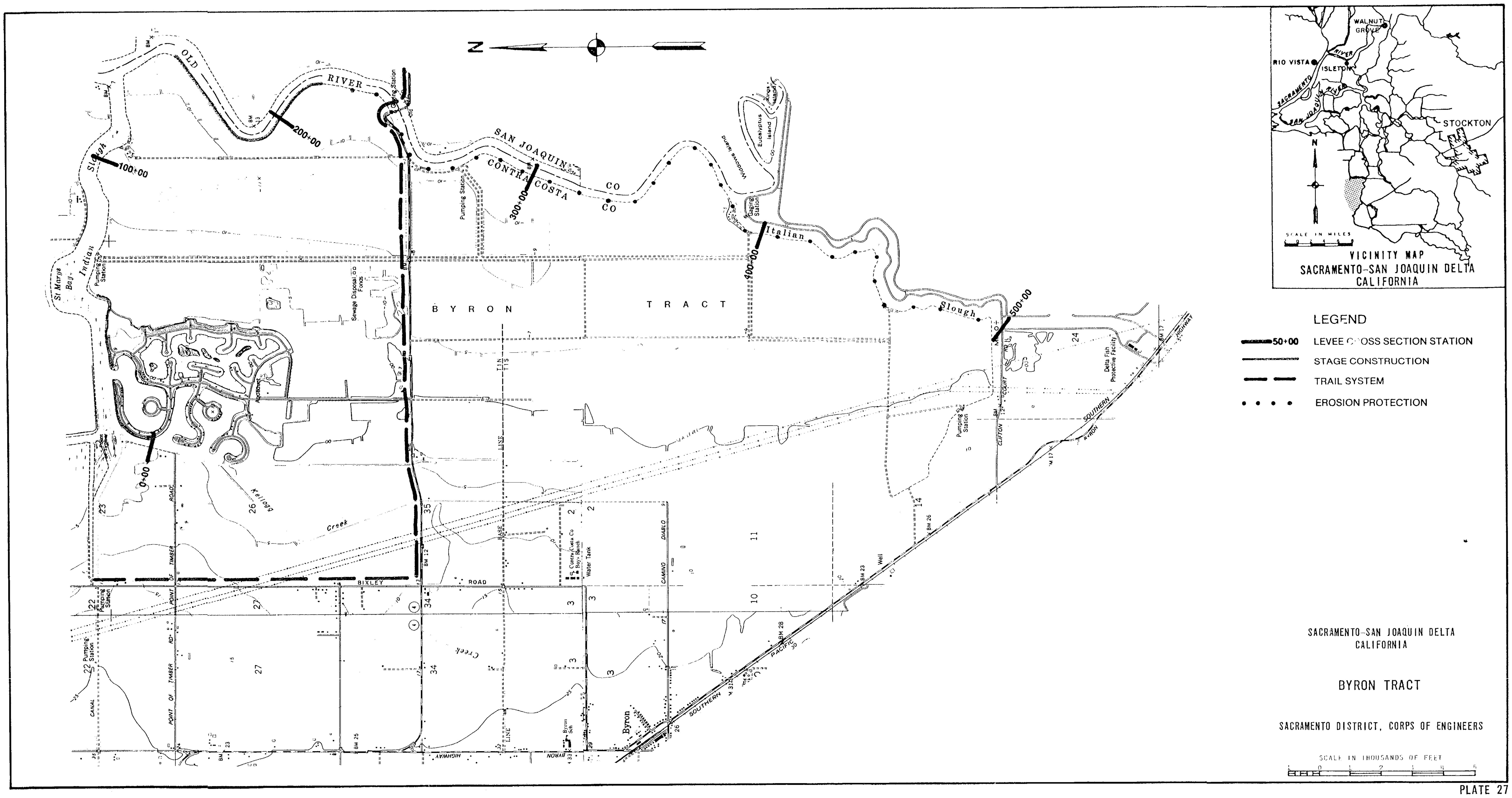


PLATE 27

C-103325

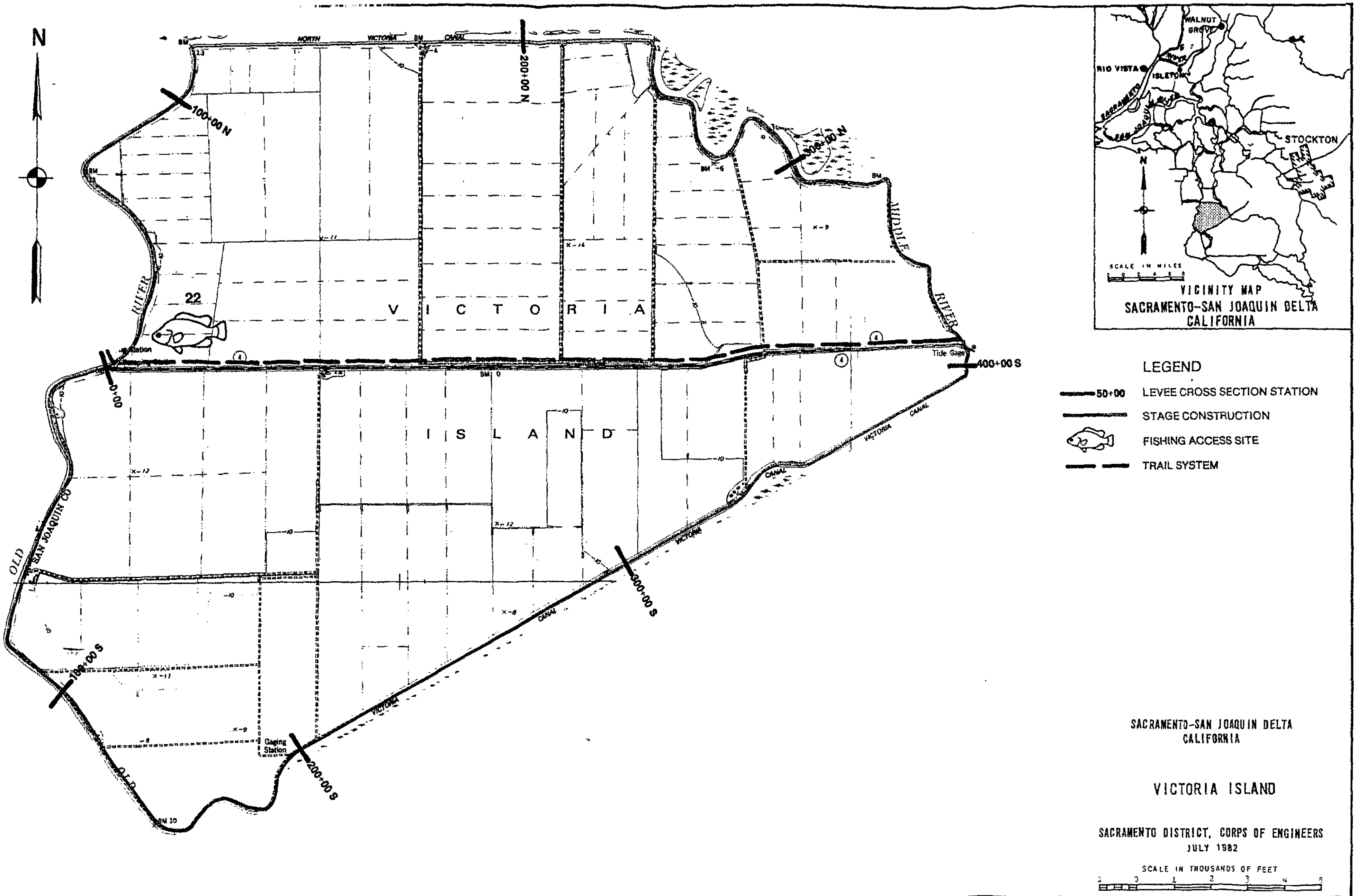


PLATE 28

C-103326

C—103326

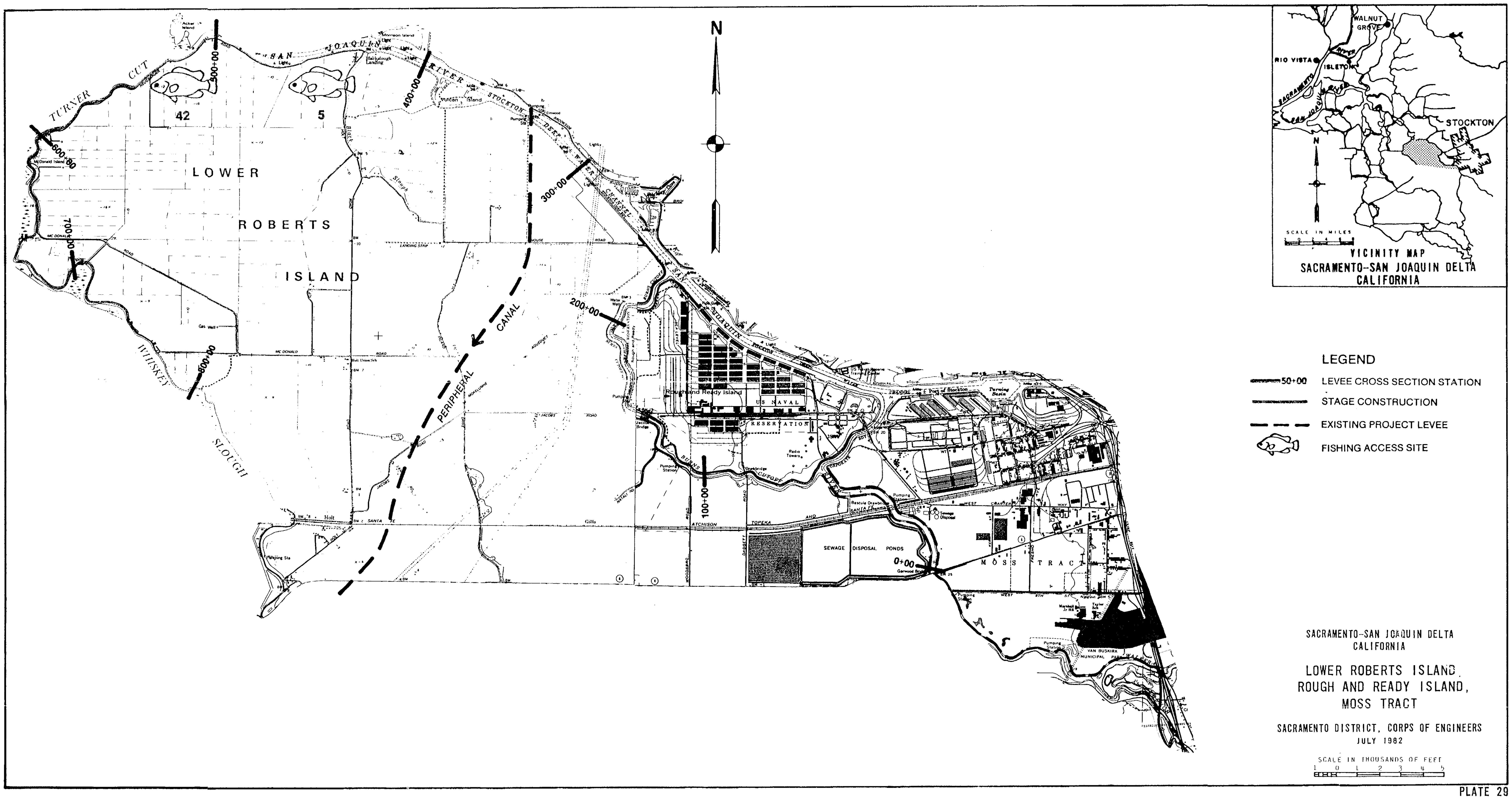
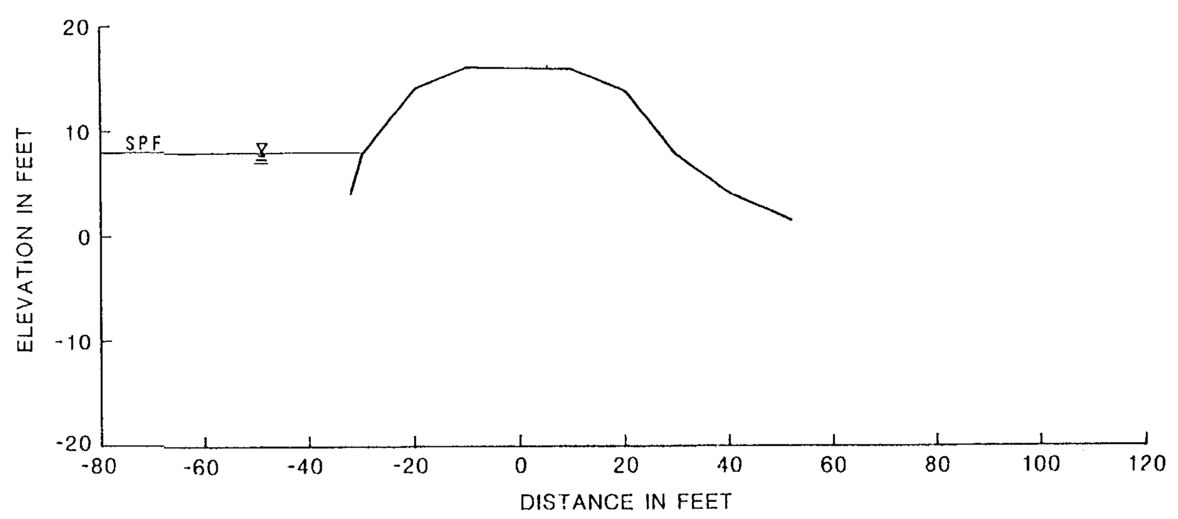
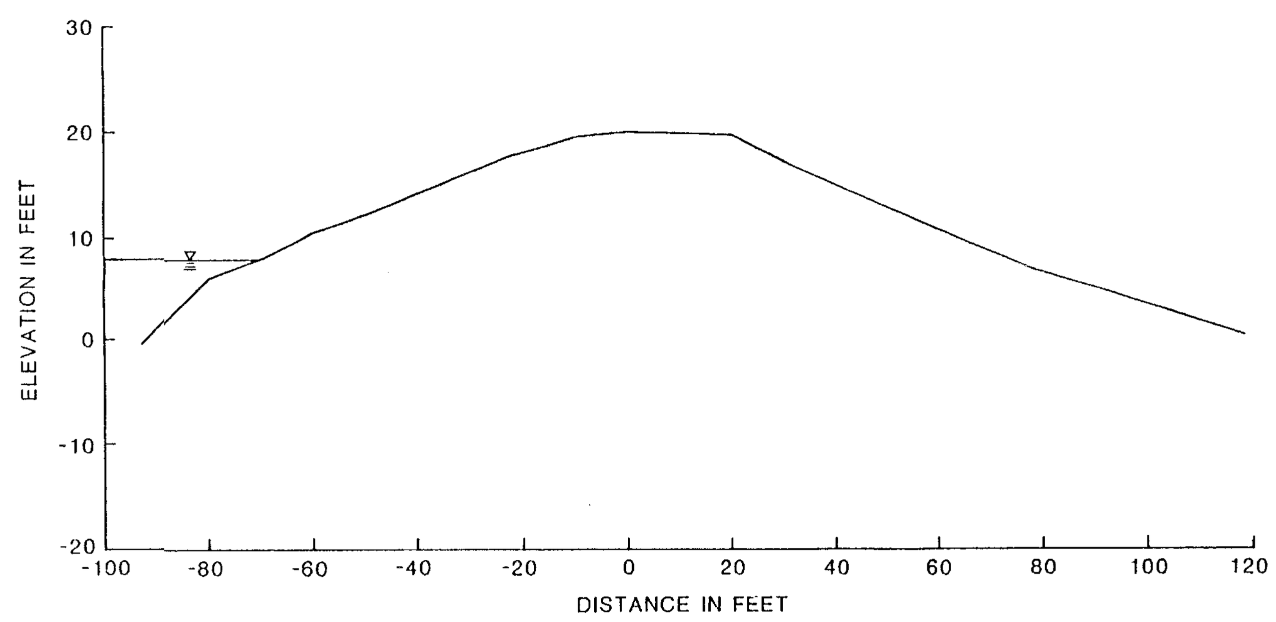


PLATE 29

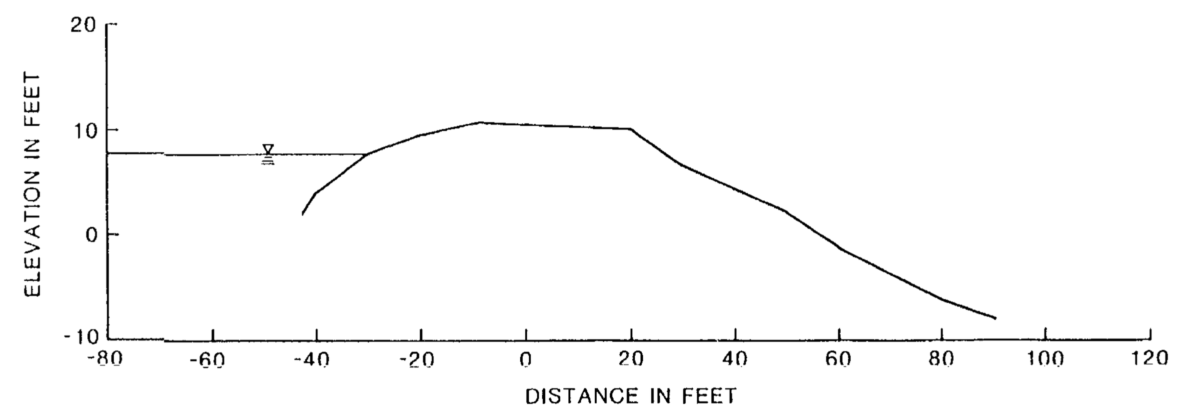
C-103327



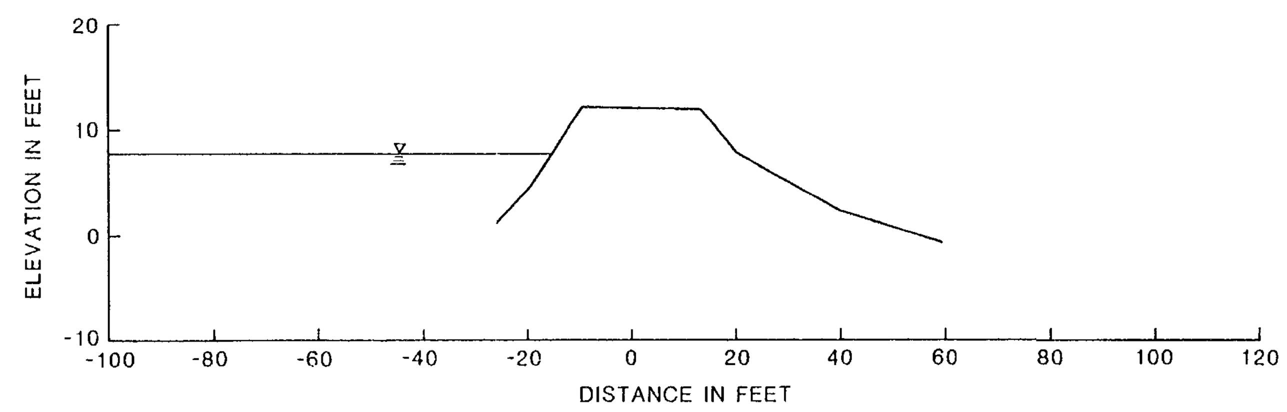
STATION 80 + 00
NO CHANGE WITH EXISTING LEVEE



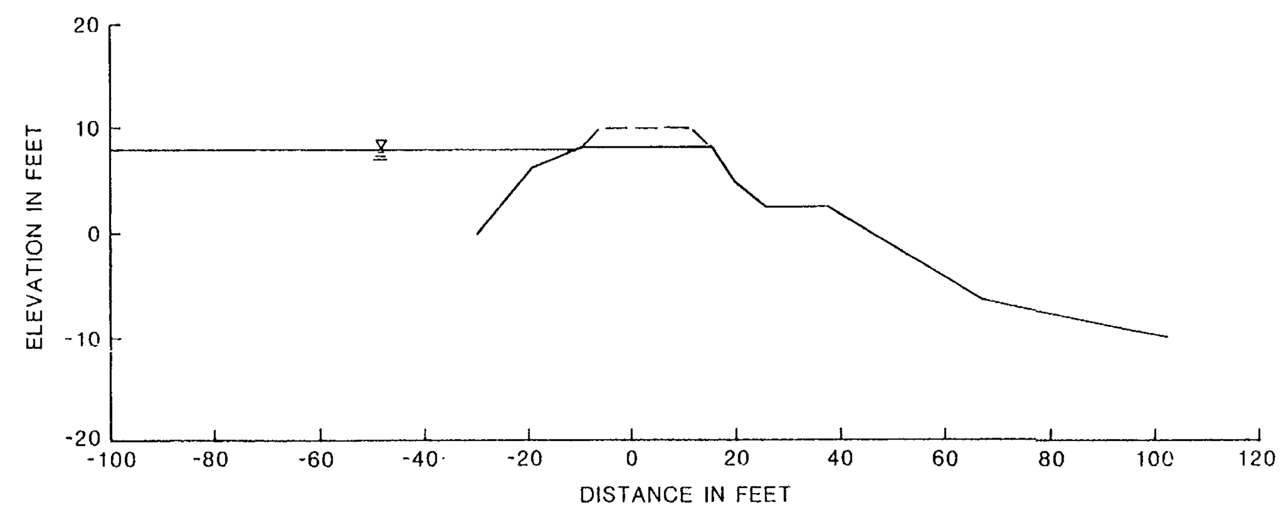
STATION 240 + 00
NO CHANGE WITH EXISTING LEVEE



STATION 343 + 00
NO CHANGE WITH EXISTING LEVEE



STATION 693 + 00
NO CHANGE WITH EXISTING LEVEE



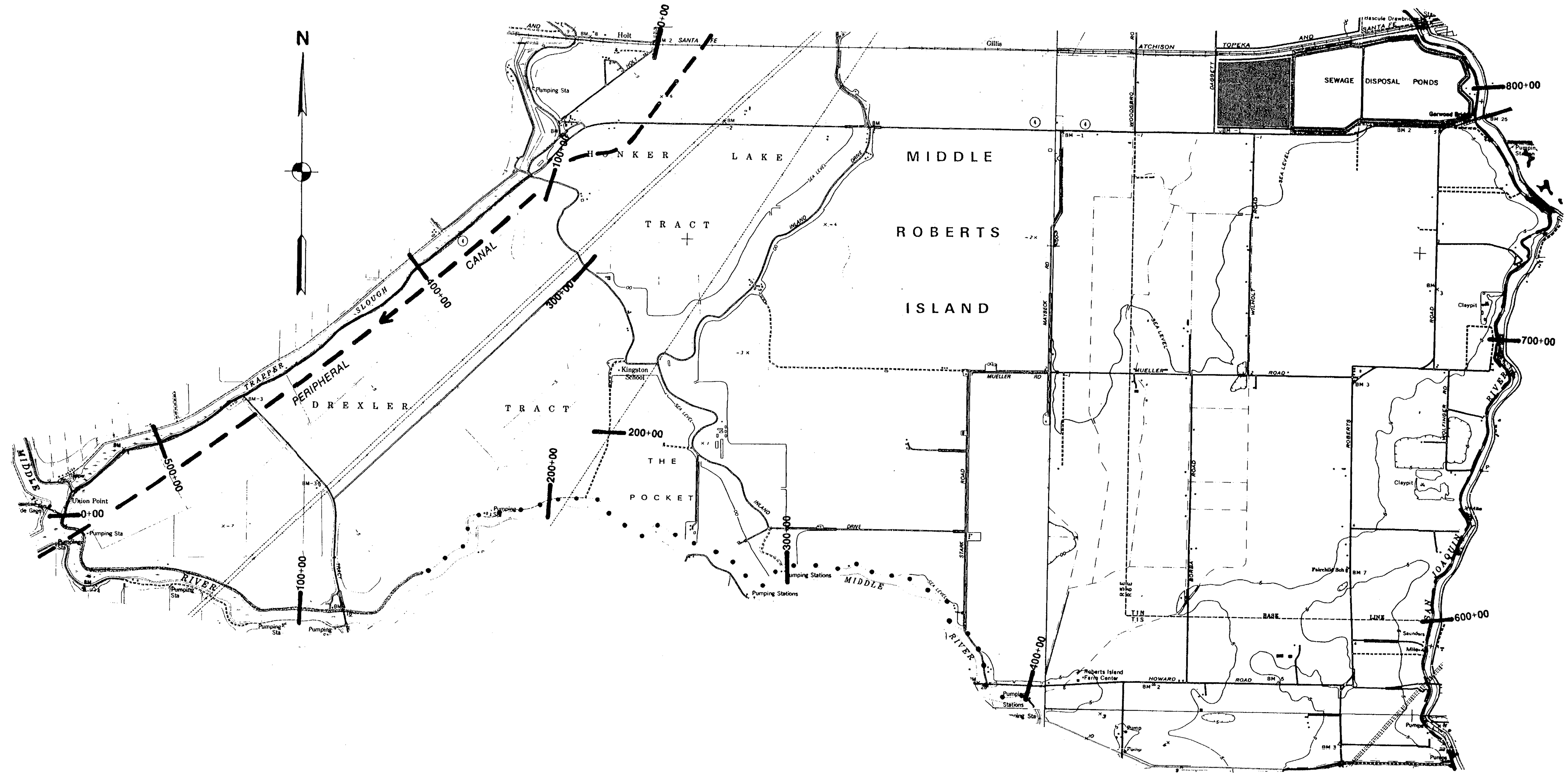
STATION 713 + 00

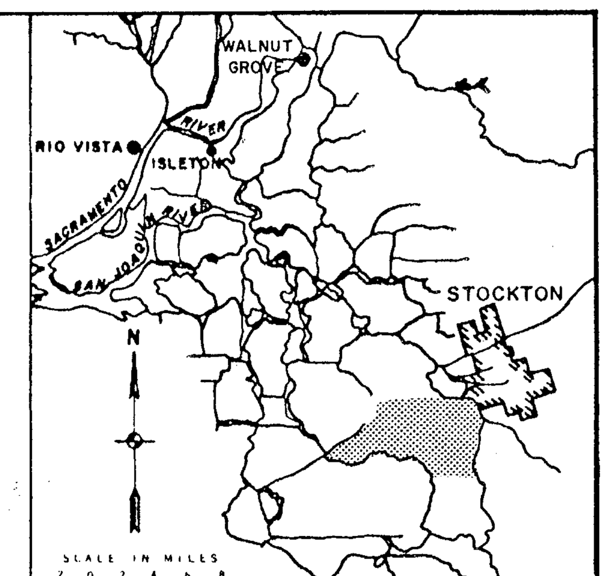
LEGEND
——— EXISTING LEVEE SECTION
– – – PROPOSED DESIGN CROWN

LOWER ROBERTS ISLAND

PLATE 29A

C-103328





VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

LEGEND

- 50+00 LEVEE CROSS SECTION STATION
- STAGE CONSTRUCTION
- EXISTING PROJECT LEVEE
- EROSION PROTECTION

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

DREXLER TRACT,
MIDDLE ROBERTS ISLAND

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN THOUSANDS OF FEET
1 0 1 2 3 4 5

PLATE 30

C-103329

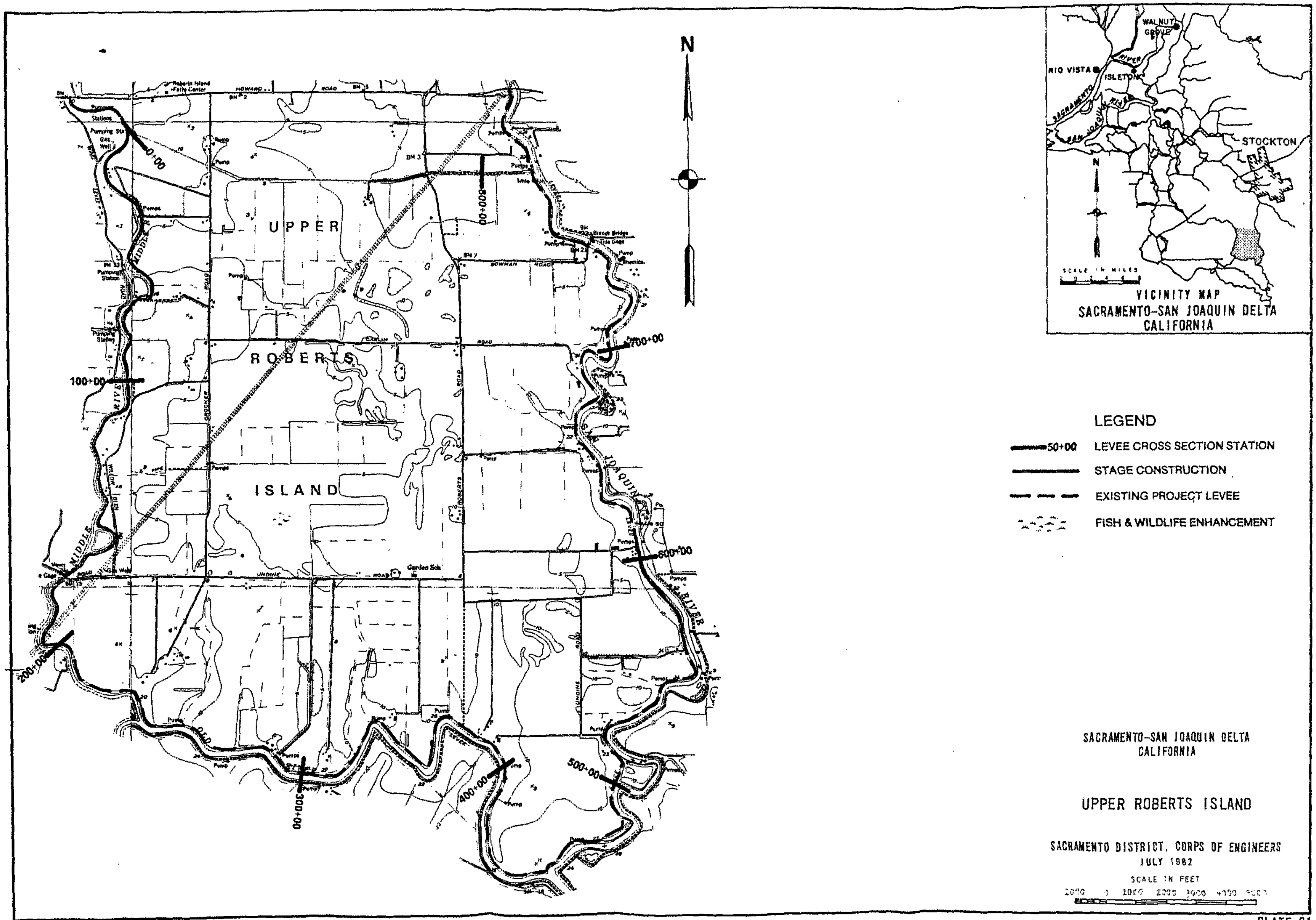


PLATE 31

C-103330

C—103330

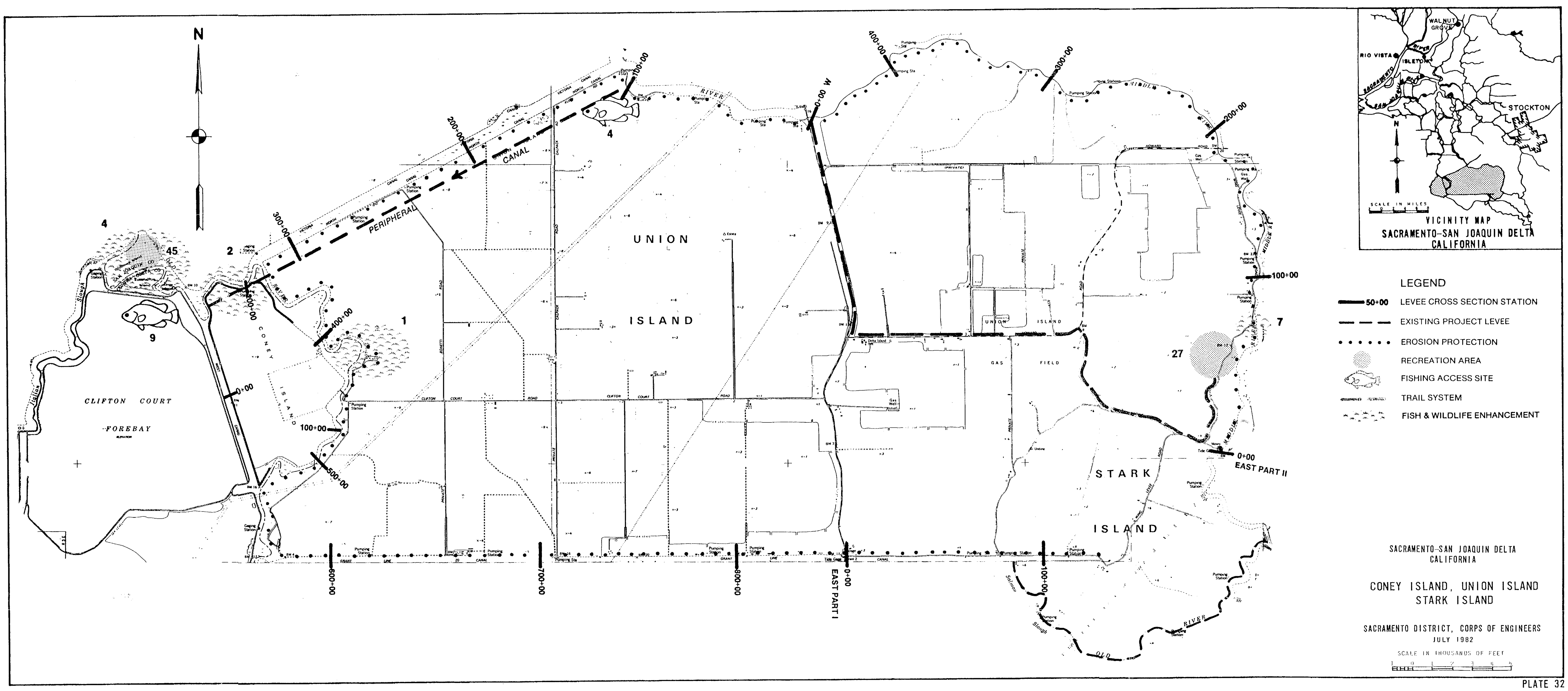
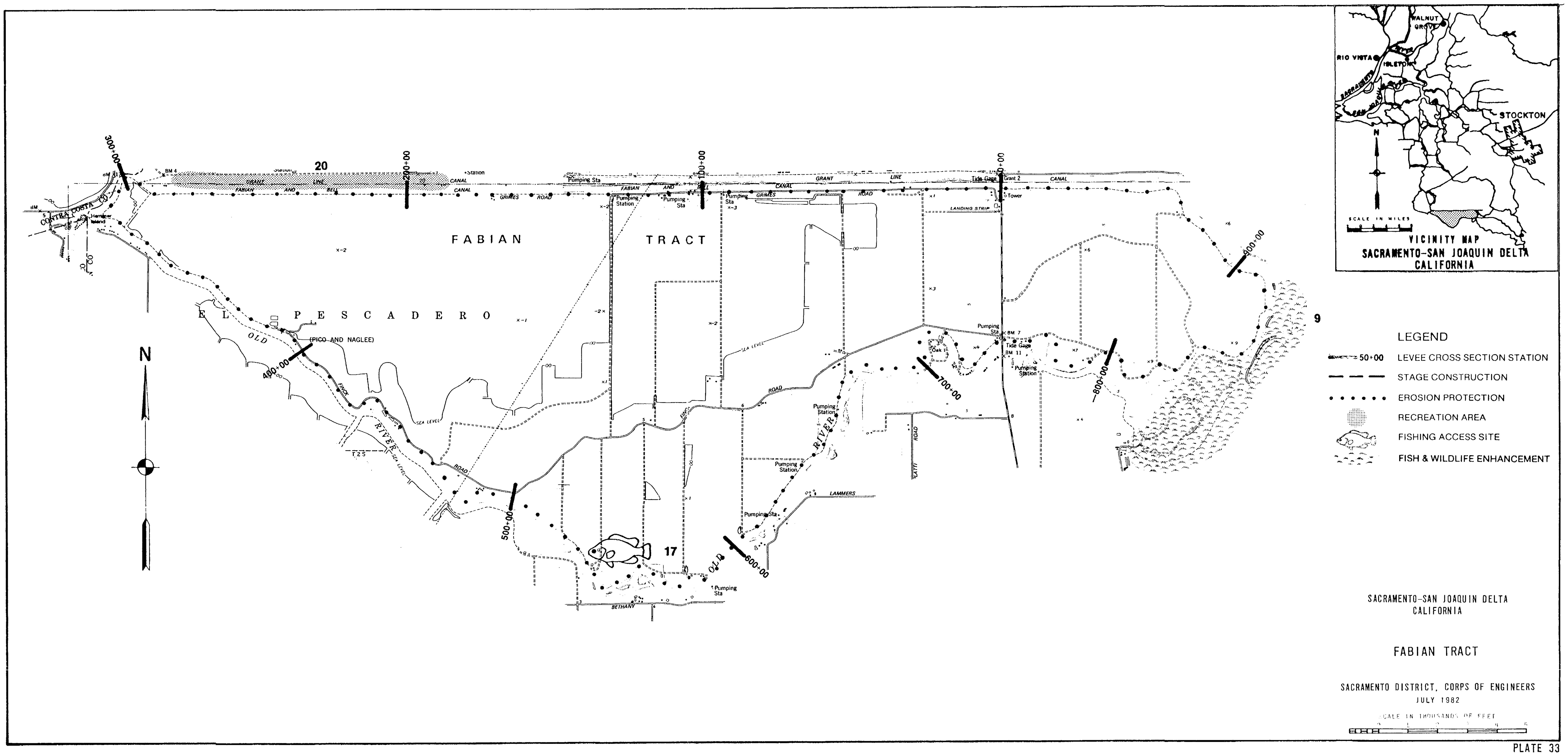


PLATE 32

C-103331



LEGEND

- 50+00 LEVEE CROSS SECTION STATION
- STAGE CONSTRUCTION
- EROSION PROTECTION
- RECREATION AREA
- FISHING ACCESS SITE
- FISH & WILDLIFE ENHANCEMENT

SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

FABIAN TRACT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN THOUSANDS OF FEET

PLATE 33

C-103332

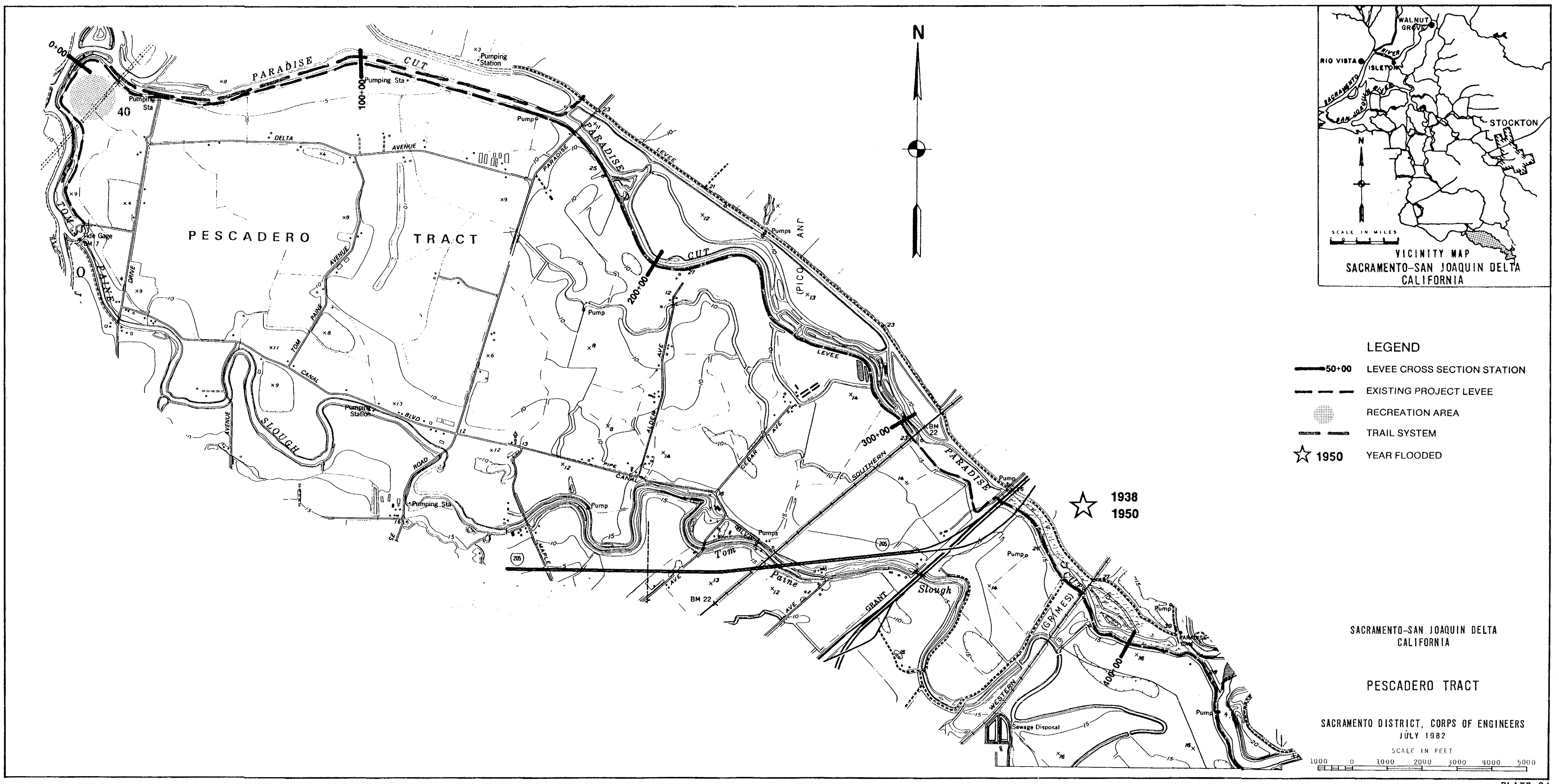
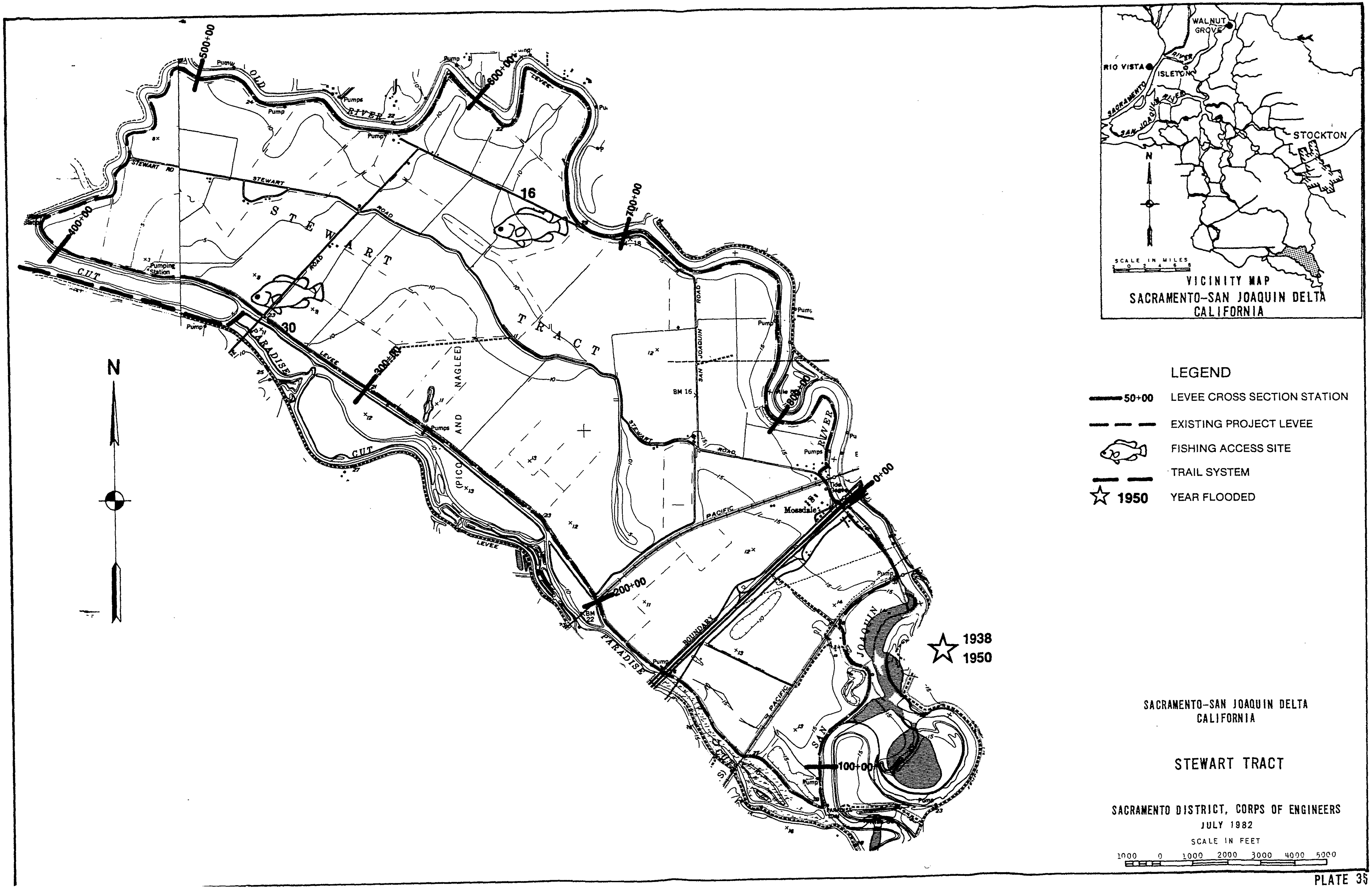
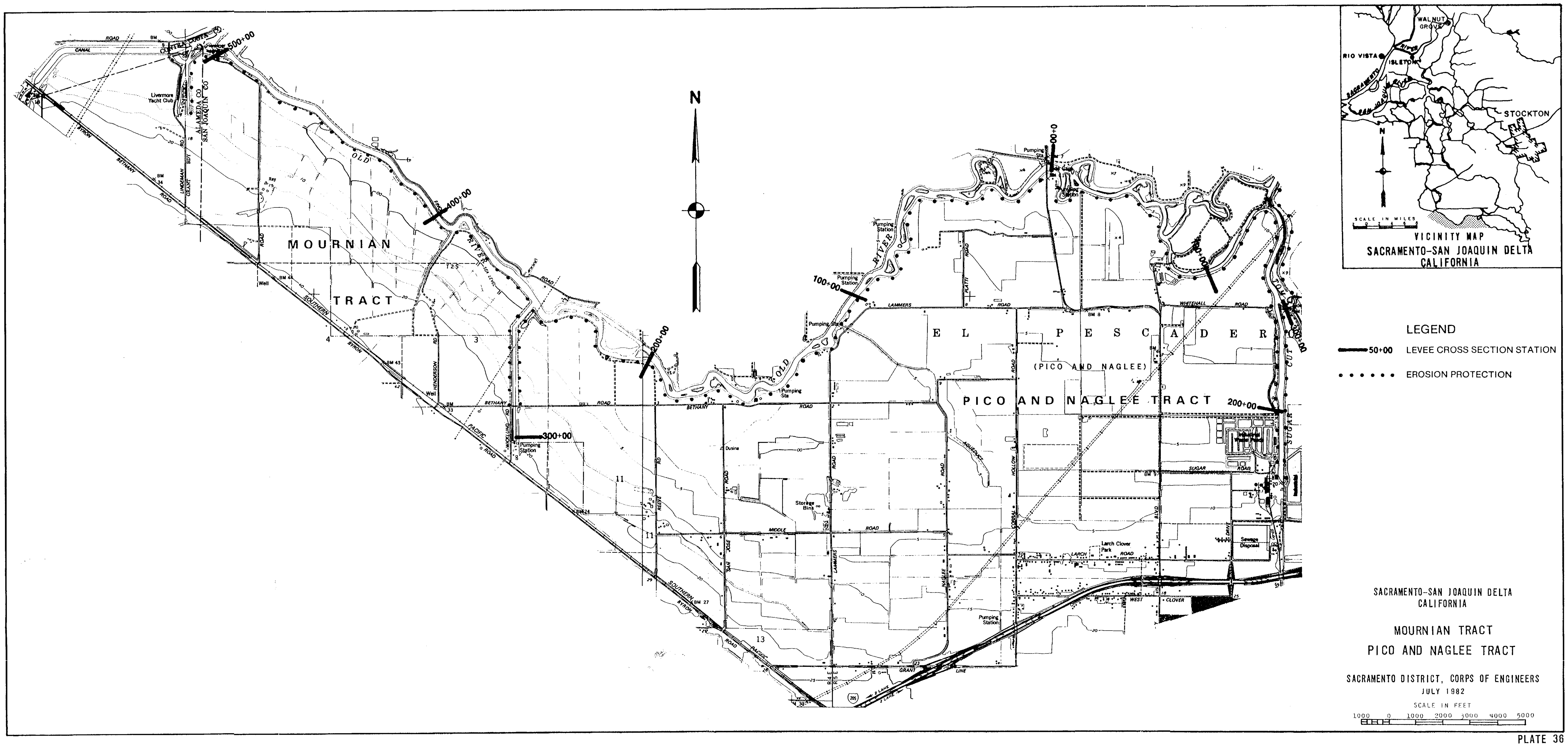


PLATE 34

C-103333


VICINITY MAP
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
WALNUT GROVE
RIO VISTA
ISLETON
STOCKTON
SCALE IN MILES
LEGEND
50+00 LEVEE CROSS SECTION STATION
EXISTING PROJECT LEVEE
FISHING ACCESS SITE
TRAIL SYSTEM
1950 YEAR FLOODED
STEWART TRACT
OLD RIVER
PARADISE CUT
SAN JOAQUIN RIVER
1938
1950
SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA
STEWART TRACT
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982
SCALE IN FEET
PLATE 35
C-103334



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

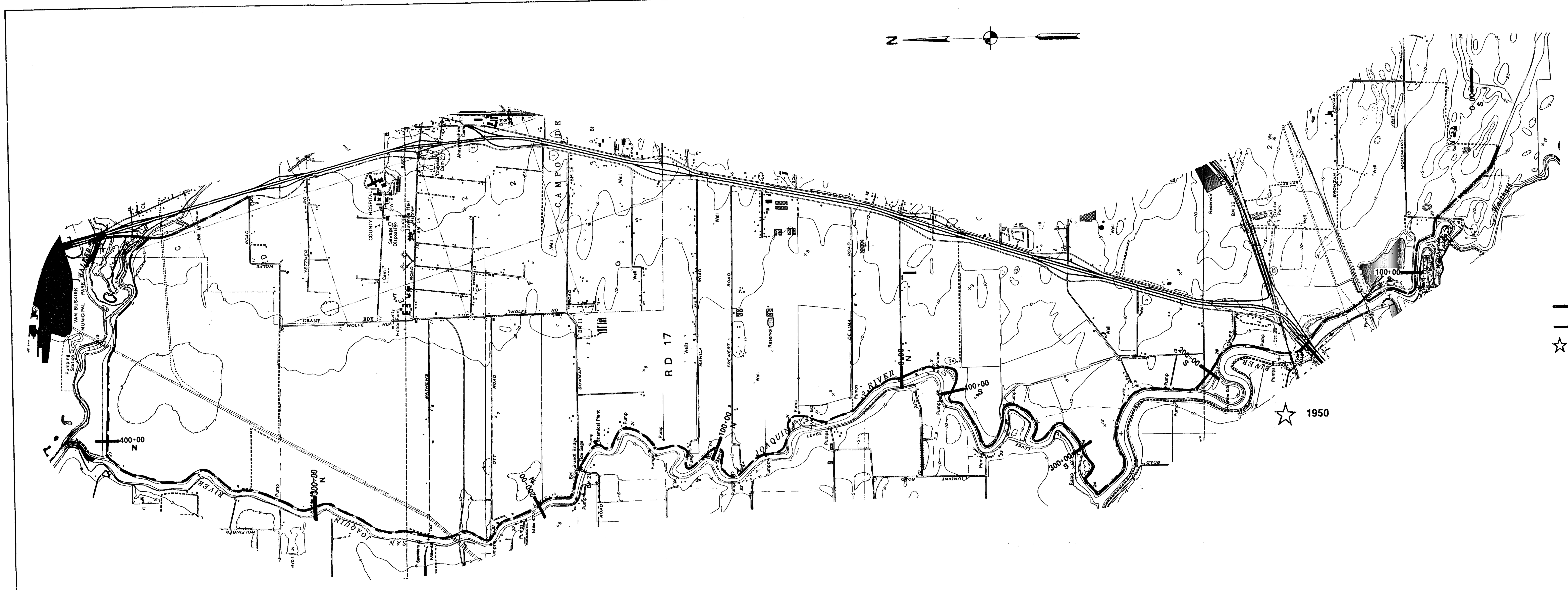
MOURNIAN TRACT
PICO AND NAGLEE TRACT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

PLATE 36

C-103335



SACRAMENTO-SAN JOAQUIN DELTA
CALIFORNIA

RD 17

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
JULY 1982

SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

PLATE 37

C-103336