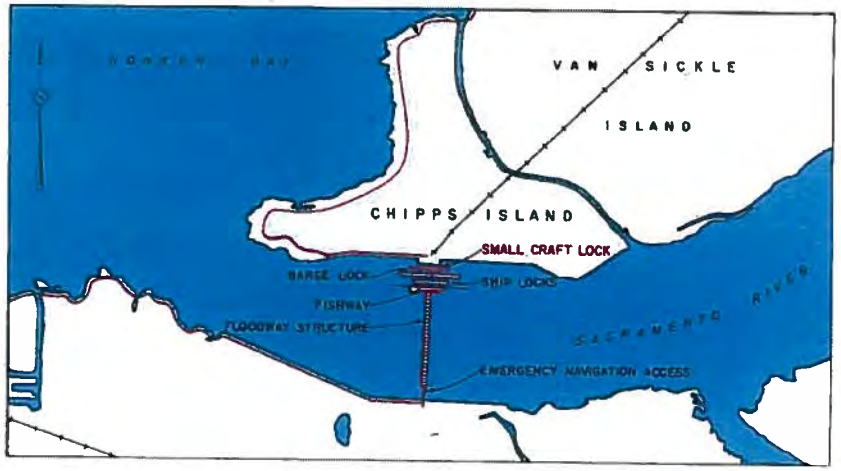
would be required for the two principal power plants which would discharge warm water into the barrier pool.

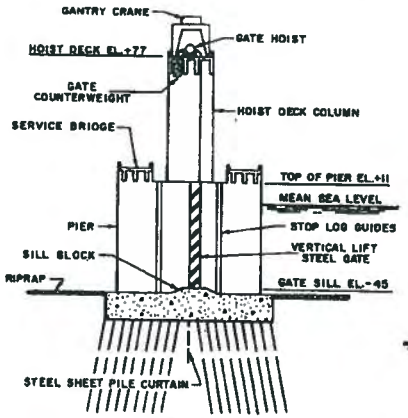
The type and design of the facilities described in this report incorporate results of preliminary designs and quantity estimates of the Corps of Engineers in current work on barriers in the San Francisco Bay system. Estimates of the capital cost of the facilities were based on construction costs prevailing in 1960, plus 15 percent for contingencies and 15 percent for engineering and overhead. The anticipated schedule of construction of the facilities is indicated in the tabulation of estimated capital costs.

SUMMARY OF ESTIMATED CAPITAL COSTS
CHIPPS ISLAND BARRIER PROJECT

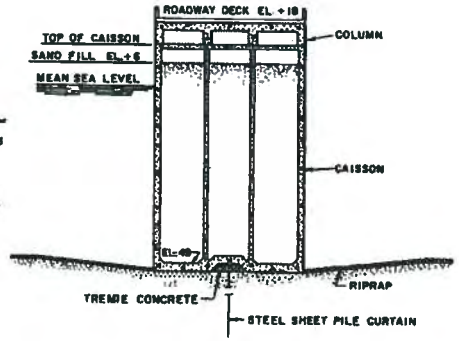
Feature and date of construction	Capital cost
On Site Features	
Floodway structure (1964-70)	$44,119,000
Locks (1964-70)	74,278,000
Salt-scavenging system (1968-70)	3,768,000
Emergency navigation access (1964-66)	6,092,000
South abutment and access facilities (1964-65)	723,000
Fishway (1969)	79,000
Buildings and miscellaneous (1966)	2,062,000
Montezuma Slough closure and barge lock (1968-70)	3,492,000
Subtotal, On Site Features	$134,613,000
Off Site Features	
Waste disposal facilities (1967-70)	$26,914,000
Extension San Joaquin Valley drain (1967-70)	17,356,000
Suisun Bay levee system (1964-73)	21,608,000
Shoreline facilities and dredging (1968-70)	1,481,000
Subtotal, Off Site Features	$67,359,000
TOTAL CAPITAL COST, CHIPPS ISLAND BARRIER PROJECT	$201,972,000



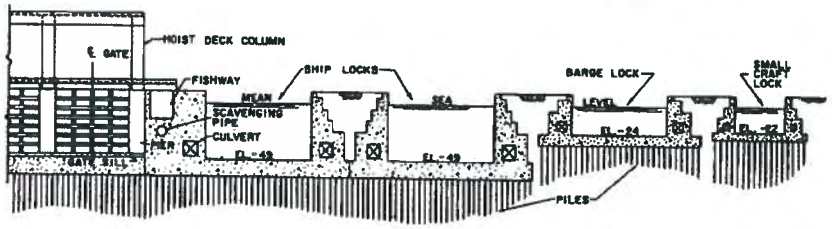
CHIPPS ISLAND BARRIER SITE



TYPICAL SECTION
FLOODWAY STRUCTURE



TYPICAL SECTION
EMERGENCY NAVIGATION ACCESS



TYPICAL SECTION OF FISHWAY AND LOCKS

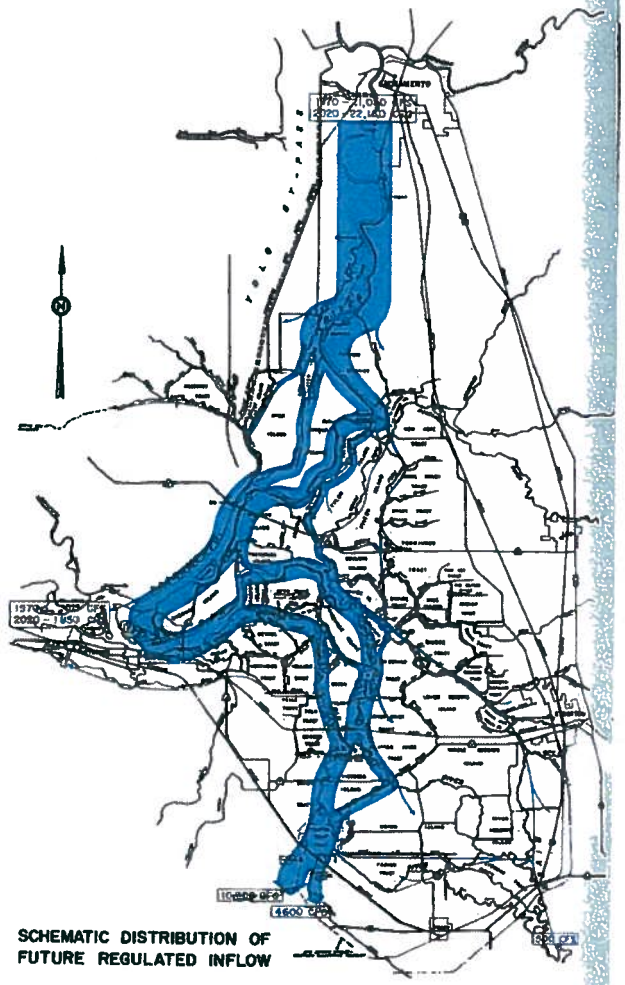
Chipps Island Barrier Project — operation

A barrier at Chipps Island would provide a definite separation between saline water in the Bay system and fresh water in the Delta channels, thereby preventing salinity incursion and assuring adequate water supplies in the Delta. However, there would be attendant operating problems, and the barrier and appurtenances would not provide flood control and related benefits to the Delta.

With the floodway gates closed, the inflow to the Delta to supply local uses and export pumping plants would be distributed in the channels as shown in the schematic diagram. Large quantities of water would be directed through channels in the western Delta to remove heat wastes and maintain satisfactory water quality conditions. Storage in the channels could be utilized to achieve a limited amount of regulation. However, navigation requirements would prevent controlling the water level lower than one foot below mean sea level, without additional dredging. Seepage and levee stability problems would limit the maximum level for sustained storage to about two feet above mean sea level. Economic analyses of various operating ranges indicate that a three-foot range in water levels for conservation of flood water would be most economical.

Electric analog model studies reveal that the barrier would increase the tidal amplitudes downstream from the structure. An unusually large amplitude of 6.3 feet at Chipps Island under present conditions would be increased to about 12 feet by a barrier. Changes indicated on the electric analog model were generally confirmed by preliminary tests by the U. S. Corps of Engineers on a hydraulic model which indicated slightly smaller increases in tidal amplitudes and a slight decrease in the mean tide level. The lower low water would seriously affect navigation depths, and the higher high water would seriously affect levees along the downstream bays and municipal, industrial, and military installations along the shore lines. Remedial measures would be necessary.

Disposal of cooling water from power plants and other industries would cause an increase in temperature in the nearly quiescent barrier pool. This increase in temperature would reduce the efficiency of cooling equipment and adversely affect fish, and could cause significantly increased corrosion in equipment exposed to the warmer water. The monetary magnitude of these effects would be dependent upon the amount of heat energy dissipated in the pool by existing and future industries, and many other factors which cannot be fully evaluated at this time. Satisfactory conditions could probably be achieved by passing cool-



SCHEMATIC DISTRIBUTION OF FUTURE REGULATED INFLOW

ing water from the principal power plants over cooling towers.

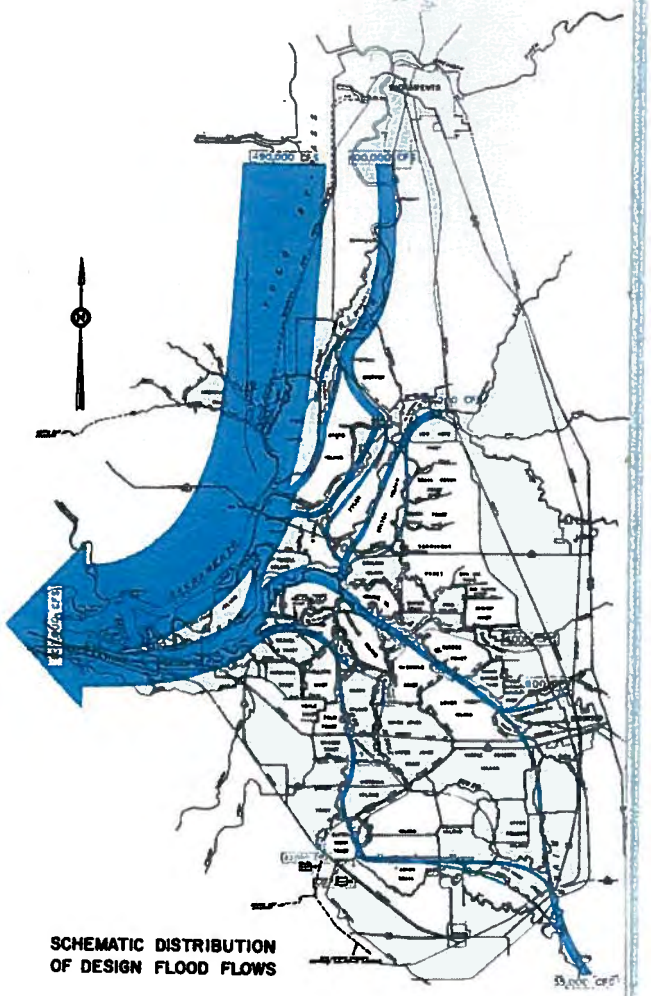
To maintain satisfactory water quality conditions in the barrier pool, it would be necessary to convey industrial and municipal wastes to tidal water. Drainage water from the San Joaquin Valley would also have to be discharged into tidal water.

Saline water entering the pool through the locks would be allowed to settle in a sump from which it would be pumped by a salt-scavenging system. Operation of locks would cause delays of about 35 minutes per transit for deep-draft vessels and 20 minutes for tugs and smaller vessels. Assistance would have to be provided to maneuver deep-draft ships through the locks. A tug and operating crew for this purpose would be necessary at all times.

National defense aspects dictate that an emergency navigation access be incorporated in the barrier. This access would consist of concrete bins filled with sand in a section of the barrier. In an emergency, the sand would be pumped out and the bins towed out of the channel.

Anadromous fish would be passed through a vertical baffle fishway, comprising a series of baffles with vertical slots extending to the bottom to provide passages for water and fish. The baffles would dissipate the energy of the water and create a series of bays with a slightly lower water level in each adjacent downstream bay. The bays would provide resting areas for the fish after passing through short distances of high velocity water in the slots. During high tides downstream from the barrier, the fishway would be closed by a gate to prevent saline water from entering the pool.

During flood conditions the gates in the barrier floodway would be opened. Flood stages in the Delta would be essentially the same as under present conditions for comparable flood flows. Since master levees in the Delta are not incorporated in this plan, high flood water would occur in all the channels. Although the flood stages would not be changed, levee stability problems would increase. Tidal fluctuations presently keep the levees saturated a few feet above the mean tide elevation, but under barrier conditions the peat levees would dry out and crack when water levels would be drawn down to about one foot below sea level. Should a sudden flood occur the open barrier gates would permit tidal fluctuations throughout the Delta and sections of some dried-out levees might become unstable and fail as the water levels rapidly rise and fall. Remedial work would be required as problems develop. Allowances for cost of this as yet undefined work are not included in the cost estimate.



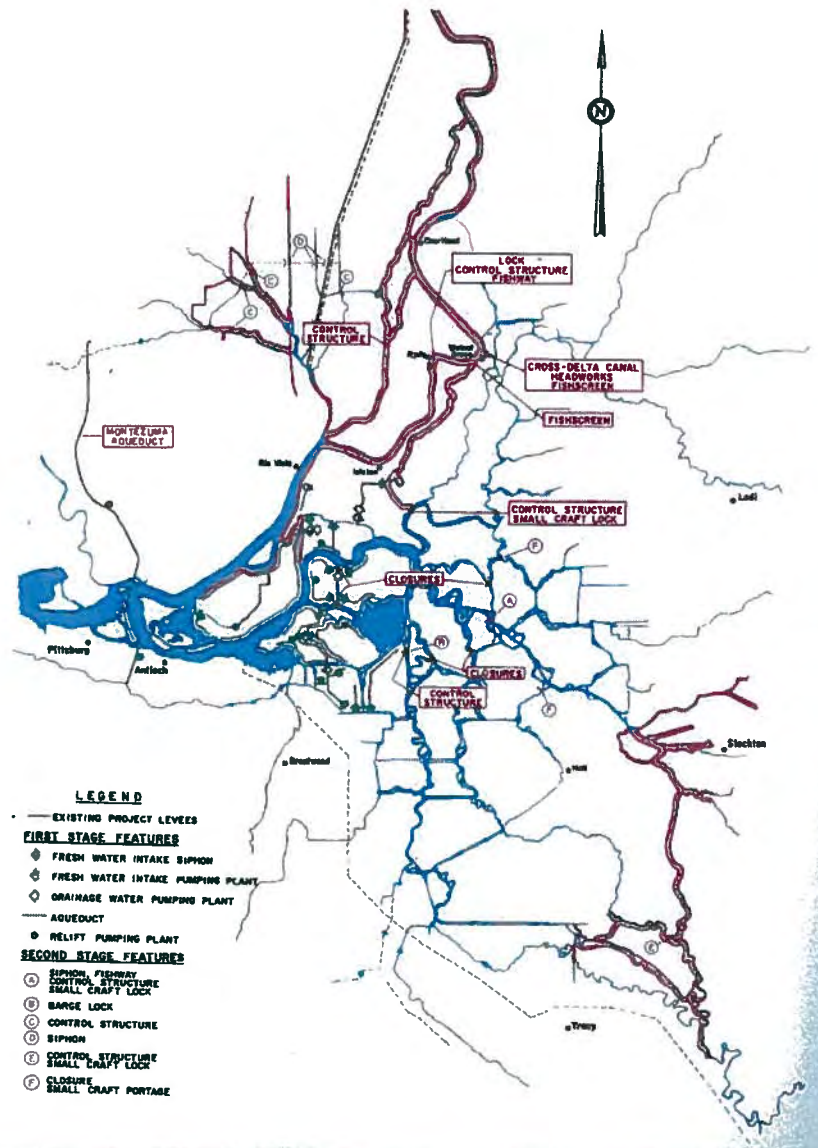
SCHEMATIC DISTRIBUTION OF DESIGN FLOOD FLOWS

Single Purpose Delta Water Project—physical works

This system of works would accomplish essentially the same results as a barrier at Chipps Island, that is, adequate water supplies for the Delta and for export therefrom, but would not necessitate costly remedial works. Good quality water supplies for the Delta and export pumps would be separated from saline water by control structures operated with a relatively small rate of fresh water outflow. Water would be supplied in the western Delta area through new supply facilities, and in the rest of the Delta existing irrigation and drainage works would continue in operation. There are no flood control features in this plan.

Control structures with gated openings for discharging flood flows would be located on channels of the Sacramento, Mokelumne, and San Joaquin Rivers. A barge lock and fishway would be incorporated in the Sacramento River control structure. Earth fill channel closures would be constructed at four locations. In 1980-82, additional gates would be constructed at the existing headworks of the Delta Cross Channel of the Central Valley Project. Small craft locks and portage facilities would be incorporated in certain control structures and channel closures. Vertical louver fish screens would be constructed at the head of Georgiana Slough and at the Delta Cross Channel near Walnut Grove, and rotary drum fish screens would be constructed at other diversions.

Water supply facilities would serve areas in the western Delta. The Montezuma Aqueduct would be constructed in about 1968-71 and in subsequent stages to serve water to potential industrial land and some agriculture in central southern Solano County, and to supplement supplies in Contra Costa County. Works would also be included to remedy detrimental effects of project operation, such as seepage alleviation along the Sacramento River channels and modifications to existing irrigation and drainage works made necessary by the project.



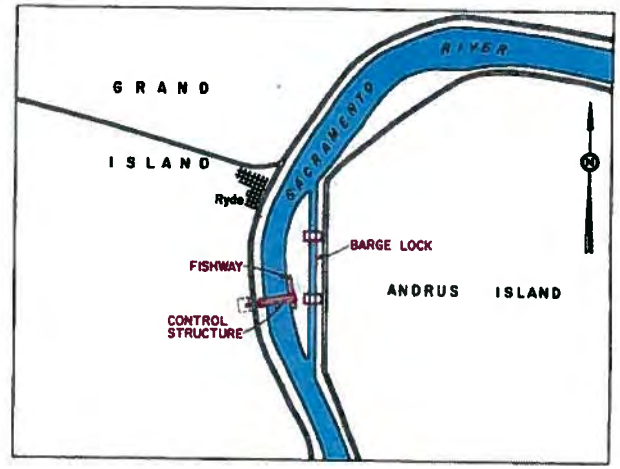
About 1,900 acres of land in the Delta, mostly small unreclaimed islands, would be used for disposal of excess dredged material. Many of these areas would be available and desirable for development as recreation areas.

Additional water could be salvaged by completely separating good quality cross-Delta flows from tidal water, and thereby reducing the amount of fresh water outflow needed for salinity repulsion. These second stage features would include a siphon under the San Joaquin River, additional channel closures, control structures and appurtenances, and water supply facilities. These works may be indefinitely deferred, depending on their need.

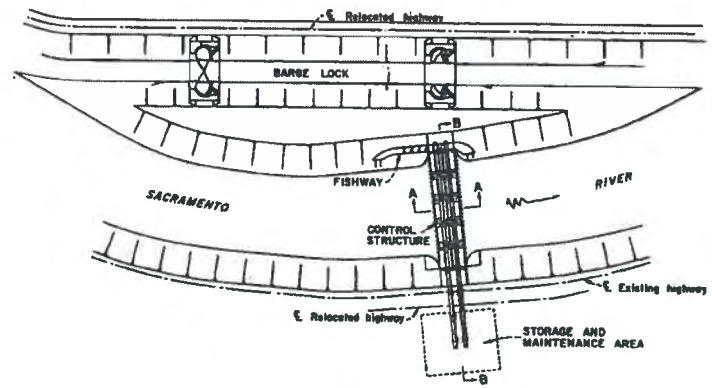
Estimates of the capital costs reflect 1960 construction costs, plus 15 percent for contingencies and 15 percent for engineering and overhead. The anticipated construction schedule is indicated in the following tabulation:

SUMMARY OF ESTIMATED CAPITAL COSTS
SINGLE PURPOSE DELTA WATER PROJECT

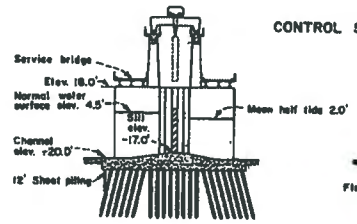
Feature and date of construction	Capital cost
Steamboat Slough control structure (1968-70)	$2,943,000
Miner Slough closure (1970)	108,000
Ryde control structure, barge lock, and fishway (1968-71)	5,653,000
Holland Cut control structure (1973-75)	2,761,000
Mokelumne River control structure and small craft lock (1973-75)	1,951,000
Cross-Delta Canal headworks (1980-82)	1,223,000
Fish screens: Cross-Delta Canal and Georgiana Slough (1968-70)	3,500,000
Closures: Potato Slough, Old River, and Middle River (1974-76)	404,000
Fishermans Cut closures (2) (1964)	133,000
Agricultural water facilities (1963-65)	4,300,000
Municipal and industrial water facilities (1968-71, 1980, 1995, 2010)	13,952,000
Channel dredging (1974-78)	7,154,000
Bank protection (1976-78)	1,880,000
Seepage alleviation facilities (1971)	593,000
TOTAL CAPITAL COST, FIRST STAGE FEATURES	$46,555,000
TOTAL CAPITAL COST, SECOND STAGE FEATURES	$23,765,000



RYDE STRUCTURE SITE



PLAN
CONTROL STRUCTURE, FISHWAY AND LOCK



SECTION A-A
CONTROL STRUCTURE

SECTION B-B
CONTROL STRUCTURE AND FISHWAY

Single Purpose Delta Water Project—operation

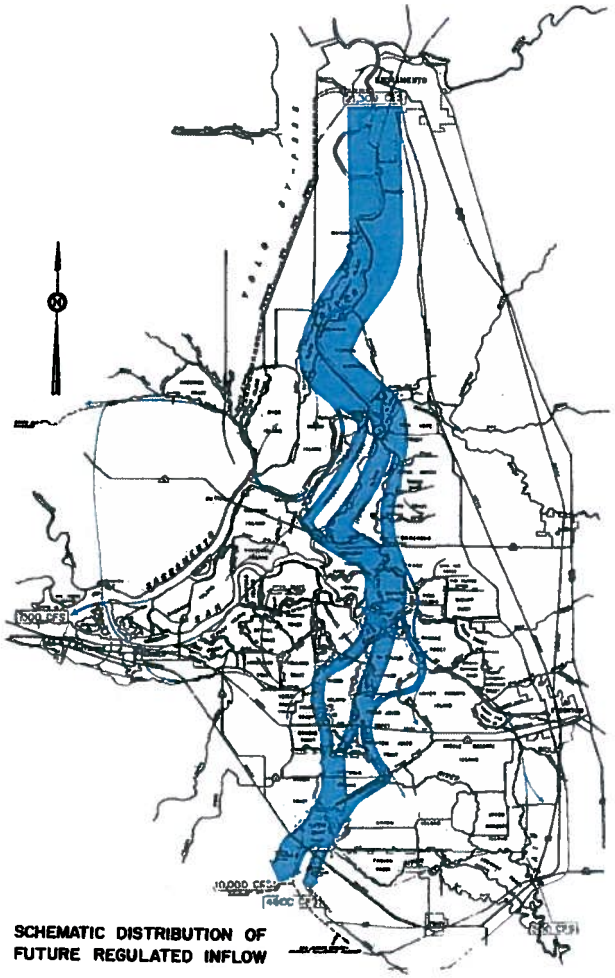
A Single Purpose Delta Water Project would salvage water otherwise wasted to Suisun Bay for salinity control, and would provide water supplies for the Delta and for export and use in areas of deficiency. The project would allow salinity to encroach somewhat farther into the Delta than under present operations; however, the area affected by this controlled incursion would be supplied water by new facilities. Certain aspects of operation described in the following paragraphs would also apply to other variations of the Delta Water Project.

Control structures on the Sacramento River system would divert water southward toward the center of the Delta. Control structures and closures on channels east of Franks Tract would cause the water to flow toward the export pumping plants in channels in the center of the Delta. With this type of operation, it would be necessary to prevent brackish saline water from mixing with fresh water in the center of the Delta. This control could be accomplished by providing fresh water outflow in the Sacramento and San Joaquin Rivers.

The salinity control line, with control to a mean concentration of 1,000 parts of chlorides per million parts of water (1,000 ppm), would be maintained in the San Joaquin River near the mouth of False River, about 7 miles upstream from Antioch and in the Sacramento River at Decker Island, about 1½ miles below Threemile Slough. Salinity control at these locations could be accomplished by maintaining an outflow from the Delta of 1,000 second-feet, of which about 60 percent would be released through the San Joaquin River and the remainder through the Sacramento River.

Good quality water from the cross-Delta flows would be available in existing channels throughout 90 percent of the Delta lowlands. Water would be provided to all agricultural lands downstream of the line of *maximum* salinity encroachment of 500 ppm of chlorides. The mean concentration of chlorides would be about 250 ppm at locations on this line. Research studies by the University of California indicate that seepage of any brackish water from the channels into the Delta islands can be controlled below the plant root zone by application of good quality water on the surface. The supplies diverted from the cross-Delta flows would normally contain between 20 and 80 ppm of chlorides.

Water would also be provided to municipalities and for certain industrial uses in the western Delta area. Most of the required industrial cooling water could be supplied from the adjacent channels. The Contra



SCHEMATIC DISTRIBUTION OF FUTURE REGULATED INFLOW

Costa Canal could serve the projected industrial requirements in its service area until about 1970, and significant industrial development in southeastern Solano County is not anticipated before 1980. The Montezuma Aqueduct would be constructed to convey supplemental water from the proposed North Bay Aqueduct and would be linked to the Contra Costa Canal near Pittsburg in 1980. The capacity of the Contra Costa Canal would then be utilized primarily between the Delta and the connection with the Montezuma Aqueduct. The estimated quality of the water would be very good, with a chloride content generally ranging between 15 and 80 ppm, total dissolved solids ranging between 125 and 300 ppm, and with total hardness of between 40 and 160 ppm.

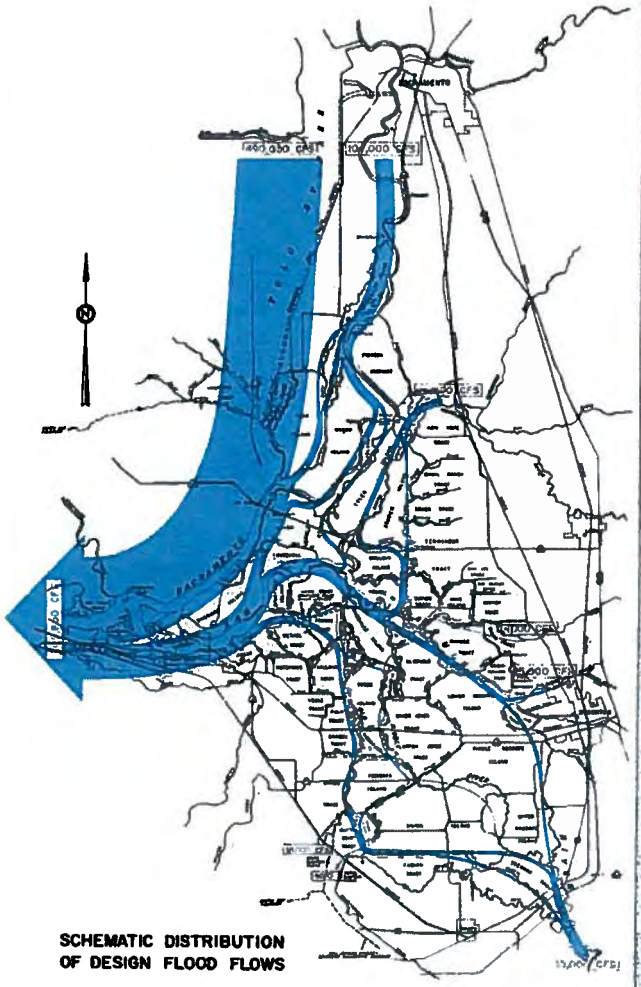
Existing irrigation water supply facilities throughout most of the Delta would not be affected by operation of the export pumps, but the average water level in the southern portion of the Delta would be lowered slightly. Irrigation facilities affected thereby would be modified under the project.

Small increases in tidal amplitudes of about 1.5 feet would occur at the Sacramento River and Steamboat Slough control structure sites, but the mean water level would not significantly change. The effects would be very minor at Rio Vista.

The average water level upstream from the control structures would be gradually raised to a maximum of about 2.5 feet under full project operation in about 30 years. The increase would occur during summer months, and any resultant increased seepage from the channels would be fully consumed by crops on adjoining lands without damage.

During flood periods, the control structures would be opened and flood stages throughout the Delta would be similar to those under present conditions. Flood stages on the Sacramento River would be slightly higher for longer periods due to closing of Miner Slough. This effect would tend to increase seepage conditions during a critical crop planting time, and might necessitate installation of seepage alleviation works. Such works would also alleviate existing seepage problems.

The future value of water and quality considerations might justify construction of the second stage features to permit further reduction in the fresh water outflow from the Delta. The outflow could be reduced to the amount of unavoidable losses, or about 750 second-feet. The value of the additionally salvaged water would probably not justify construction of these works before 1990.



SCHEMATIC DISTRIBUTION OF DESIGN FLOOD FLOWS

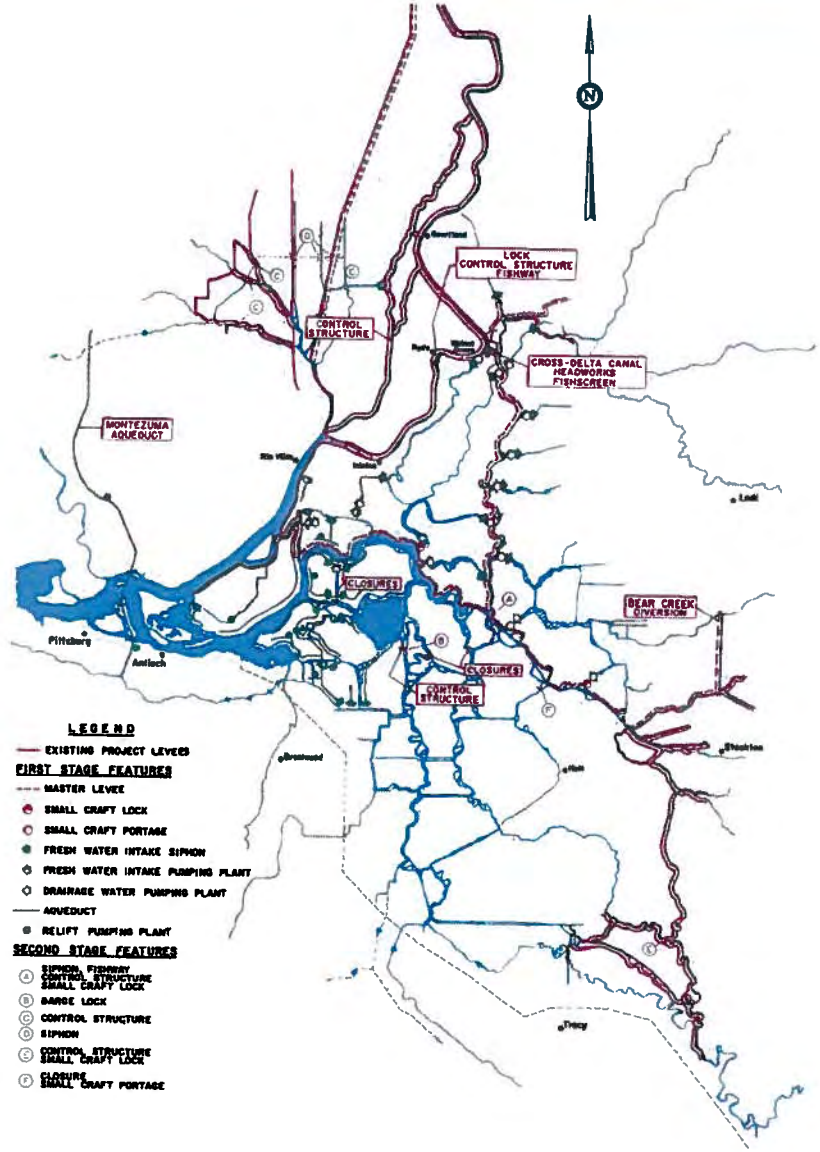
Typical Alternative Delta Water Project — physical works

Several additional features can be added to the basic Single Purpose Delta Water Project to provide varying degrees of local benefits, in addition to adequate water supplies. These additional features would be for flood and seepage control, transportation, and recreation. While the economics of construction and operation factors would dictate grouping certain islands within encircling master levee systems, flood protection for any one or more of several groups of islands could be undertaken.

The Typical Alternative Delta Water Project, one of several alternative plans, would include flood protection for the islands in the north central portion of the Delta around Isleton, and for the northeastern islands in the vicinity of Lodi. Fourteen channel closures would be required in addition to those incorporated in the Single Purpose Delta Water Project. Minor modifications and additions would be made in the irrigation water supply and drainage facilities. Rotary drum fish screens would be incorporated where required in all water supply works, and a vertical louver screen would be constructed at the headworks of the Cross-Delta Canal at Walnut Grove. Bear Creek would be diverted into the Calaveras River.

The master levee system would include existing levees of the Sacramento River Flood Control Project. Other existing levees would be improved by constructing a berm on the landward side, and by raising the levee crown where necessary to increase the freeboard. Public roads would be relocated from levee crowns to the berms. A service and maintenance road would be placed on the crown of the levees.

Small craft locks would be constructed at certain channel closures. At locations where rapid transits of boats under 25 feet long would be necessary, a tank elevator boat portage would be installed.



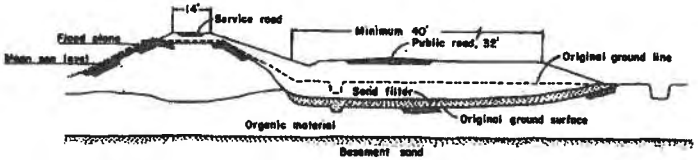
About 1,900 acres of Delta land would be filled with excess dredged material, and most of this land would be available for recreational development. The additional gates on the Cross-Delta Canal headworks and the extensions of the adjacent highway and railroad bridges would be constructed with about 16 feet of clearance above the present average water level to improve small craft access between the Sacramento River and channels of the Mokelumne River system.

The second stage features of this project would be similar to those contemplated for the Single Purpose Delta Water Project.

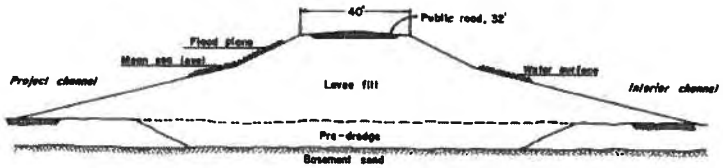
Estimates of capital cost were based on 1960 construction costs plus 15 percent for contingencies and 15 percent for engineering and overhead.

SUMMARY OF ESTIMATED CAPITAL COSTS
TYPICAL ALTERNATIVE DELTA WATER PROJECT

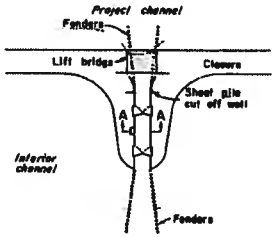
Feature and date of construction	Capital cost
Steamboat Slough control structure (1968-70)	$2,943,000
Miner Slough closure (1970)	108,000
Ryde control structure, barge lock, and fishway (1967-70)	5,653,000
Holland Cut control structure (1973-75)	2,761,000
Cross-Delta Canal headworks (1975-77)	1,998,000
Cross-Delta Canal fish screen (1968-70)	3,500,000
Old River and Middle River closures (1975)	258,000
Fishermans Cut closures (2) (1964)	133,000
Agricultural water facilities (1963-65)	4,282,000
Municipal and industrial water facilities (1968-71, 1980, 1995, 2010)	13,952,000
Channel dredging (1974-78)	7,224,000
Master levee system (small craft locks and portages, irrigation and drainage works)	
Isleton island-group (1964-80)	12,610,000
Lodi island-group (1964-81)	11,439,000
Bear Creek diversion (1967-70)	670,000
TOTAL CAPITAL COST, FIRST STAGE FEATURES	$67,531,000
TOTAL CAPITAL COST, SECOND STAGE FEATURES	$23,635,000



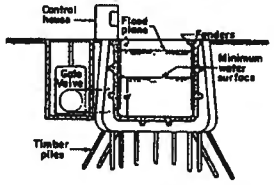
TYPICAL SECTION OF MASTER LEVEE



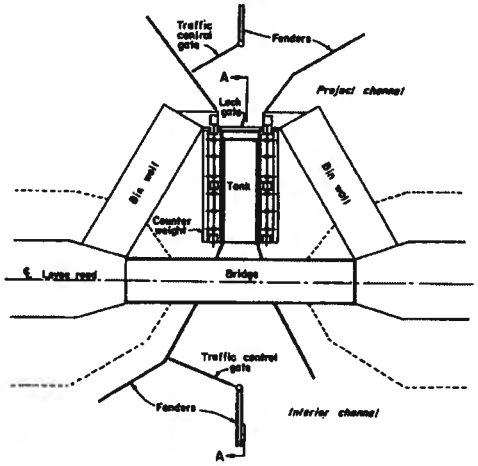
TYPICAL SECTION OF CHANNEL CLOSURE



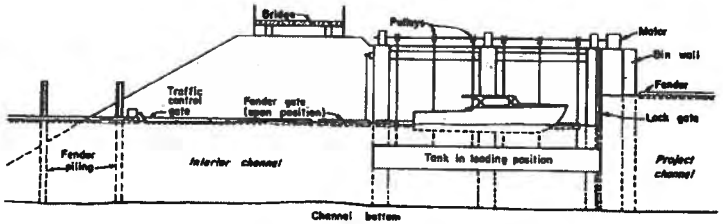
SMALL CRAFT LOCK SITE



SECTION A-A
SMALL CRAFT LOCK



PLAN OF SMALL CRAFT PORTAGE



SECTION A-A OF SMALL CRAFT PORTAGE

Typical Alternative Delta Water Project — operation

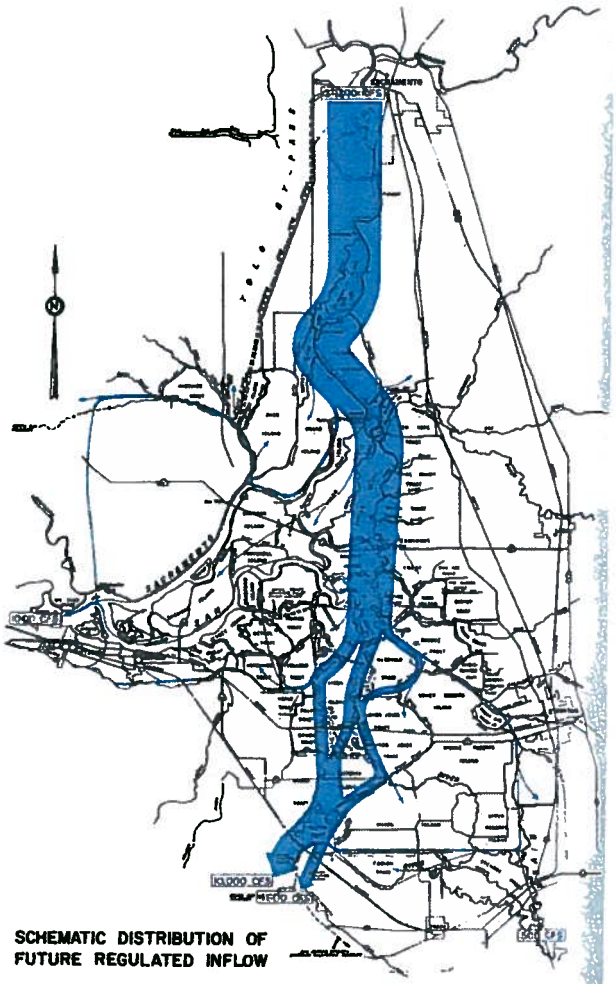
Operation of the Typical Alternative Delta Water Project would be basically the same as with the Single Purpose Delta Water Project. Good quality water would be transferred directly across the Delta and degradation in water quality from salinity incursion would be prevented by limited releases of fresh water with the same degree of control as under the Single Purpose Delta Water Project. Water supplies for the Delta would be distributed from the cross-Delta flows.

Irrigation water for the Isleton island-group and the Lodi island-group would be diverted through siphons from the Cross-Delta Canal into interior channels. Existing diversion works out of the Cross-Delta Canal, which would be rebuilt during construction of the master levees, and diversion works out of the interior channels would continue in operation. Drainage pumping plants at channel closures would have capacity to remove all water pumped from the islands into the interior channels. Under all alternative plans for the Delta Water Project, the irrigation and drainage works would be managed by local districts. Adjustments in costs of operation and maintenance would be made with the districts to reflect costs allocated to interests other than the local districts. Water supply facilities serving several districts or agencies would be operated by the State or by an appropriate master district or agency.

Flood flows would be contained in principal project channels in those portions of the Delta protected by the master levee system, and levees along interior channels would no longer be subject to high flood stages. Levees on interior channels would not need to be as high as for present conditions, and could be allowed to settle. Experience has shown that Delta levees reach a state of equilibrium if they are allowed to settle a limited amount. Thus much of the periodic reconstruction of the interior levees would no longer be necessary. Bank erosion problems due to flood flows also would be eliminated on interior levees.

Storm runoff from upland areas surrounding the Delta would be pumped into flood channels, except in the case of Bear Creek which would be diverted into flood channels.

Water levels in the interior channels could be lowered to achieve reductions in the amount of seepage into the islands. In



SCHEMATIC DISTRIBUTION OF FUTURE REGULATED INFLOW

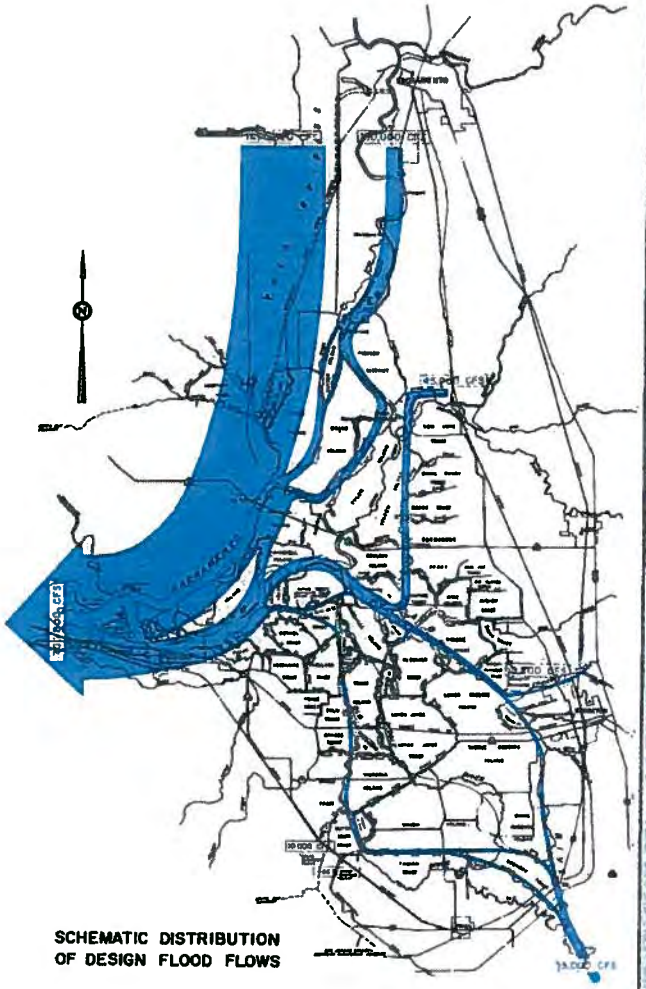
practically all channels the level could be five feet lower than the present average level, or about three feet below sea level, without causing maneuvering problems for small craft. Any resultant shallow depths in specific locations could be increased by dredging.

Small craft locks and portage facilities would be operated without cost to the boating public as the costs would be allocated to beneficiaries of the master levee system. The locks would be operated in a standard manner with pumps for filling and draining. The boat portages would be tank elevators with a gate at one end. The tank would be lowered below the hull of the boat, and the boat would then move between guides over the tank. The counterweighted tank would then be raised to the higher water level and the gate opened to permit the boat to move out under its own power. The time for operation after positioning of the boat over the tank would be less than one minute. The boat would be in the water at all times and there would be no contact with the bottom of the hull.

The operation and maintenance of public roads located on the berm of the master levees would be less costly than for existing roads, which must be periodically reconstructed due to levee settlement and levee rebuilding. Maintenance of the public roads would be by local agencies. Closures in the master levee system of this plan would eliminate the need for continued operation of four ferries.

Reduction of the water surface area under tidal influence would cause limited increases in tidal amplitudes in the Delta, but no significant changes in the average water levels. Such changes on the Sacramento River and Steamboat Slough would be similar to those under the Single Purpose Delta Water Project, and amplitude changes in the San Joaquin River in the heart of the Delta would be less than one foot. However, dredging would be necessary in some navigable channels.

Small islands in bends and side channels, which would be reclaimed and raised by filling, would be available for recreational development after the areas are no longer needed for disposal areas. It is contemplated that arrangements would be made with local governmental agencies for recreational development of the lands, either by direct means or by leasing to concessionaires.



SCHEMATIC DISTRIBUTION OF DESIGN FLOOD FLOWS

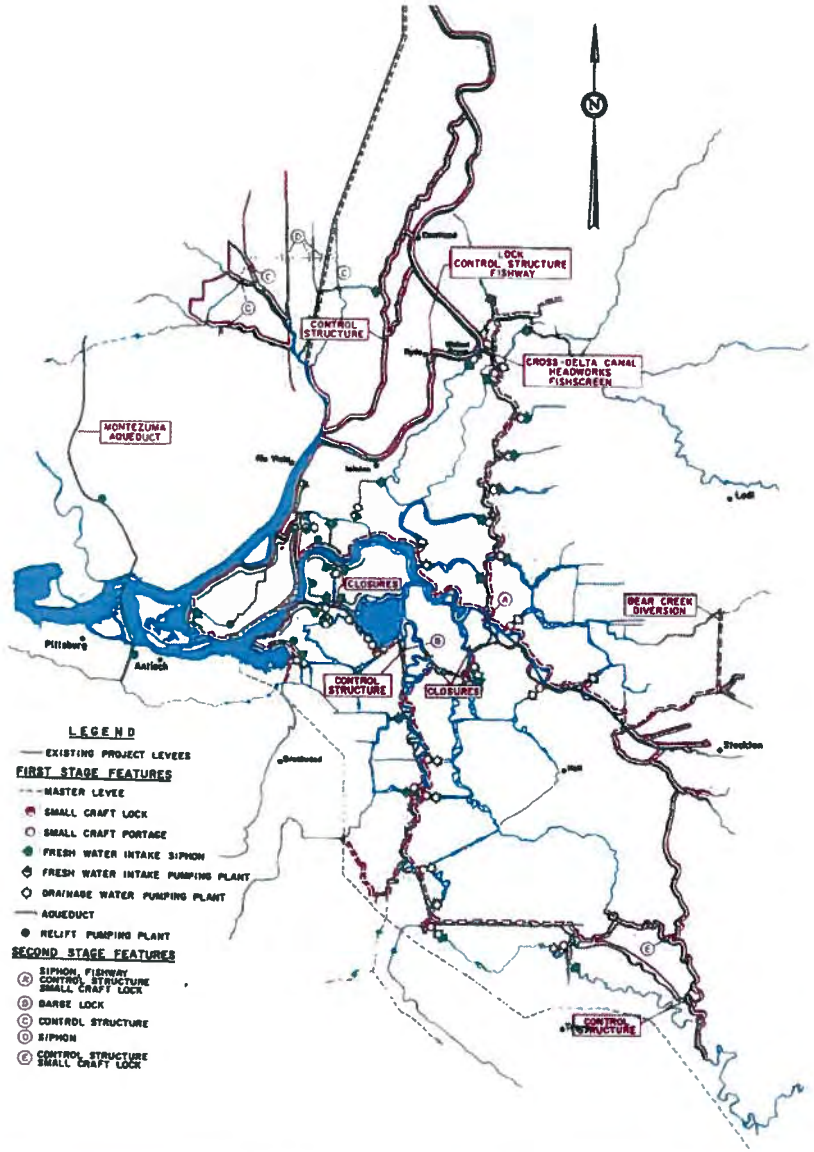
Comprehensive Delta Water Project—physical works

The Comprehensive Delta Water Project would salvage water otherwise needed for salinity control and provide water for the Delta. In addition, the project would provide flood and seepage control, transportation, and recreation benefits for most of the Delta. New master levees would encompass five principal groups of islands and Sherman Island. Works for water supply and drainage in the Delta would include those of the Typical Alternative Delta Water Project, with some modifications, plus other works to serve the newly formed island-groups. Additional small craft facilities would also be constructed.

Flood waters of the San Joaquin River would be divided between the main channel and an improved chain of distributary channels to the west, the two branches coming together in the western Delta. Improved channels of the Lower San Joaquin River Tributaries Flood Control Project would be incorporated.

The master levee along Piper Slough east of Bethel Island would be constructed on old levees on Franks Tract to minimize interference with existing developments on the Bethel Island levee.

The additional interior channels created by the project in northeastern Contra Costa County would contain good quality water, and would serve as a fresh water distribution system for the adjacent islands. Intensive small craft traffic in the vicinity of Bethel Island would necessitate the construction of four small craft portage facilities in adjacent channels and one small craft lock at Sand Mound Slough.

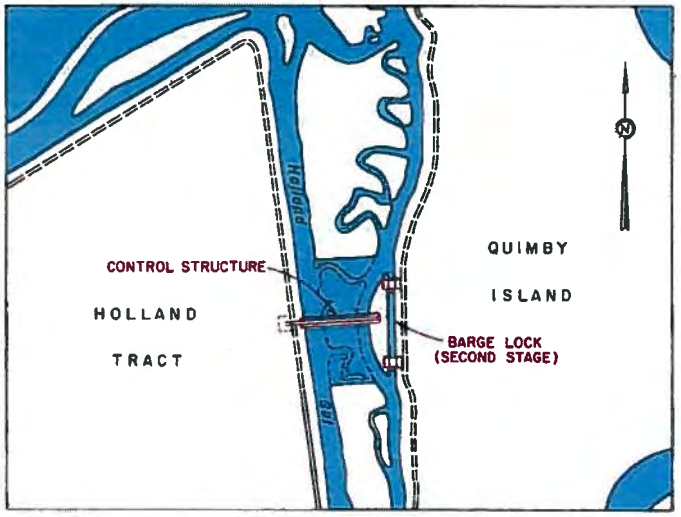


The second stage features of the Comprehensive Delta Water Project would be similar to those in other variations of the Delta Water Project.

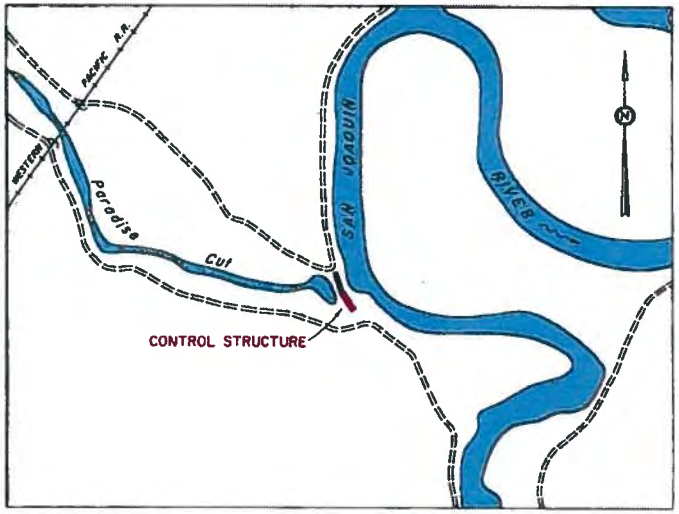
Estimates of the capital costs reflect 1960 construction costs, plus 15 percent for contingencies and 15 percent for engineering and overhead.

SUMMARY OF ESTIMATED CAPITAL COSTS COMPREHENSIVE DELTA WATER PROJECT

Feature and date of construction	Capital cost
Steamboat Slough control structure (1968-70)	$2,943,000
Miner Slough closure (1970)	108,000
Ryde control structure, barge lock and fishway (1967-70)	5,653,000
Holland Cut control structure (1973-75)	2,761,000
Cross-Delta Canal headworks (1975-77)	1,998,000
Cross-Delta Canal fish screen (1968-70)	3,500,000
Old River and Middle River closures (1975)	258,000
Fishermans Cut closures (2) (1964)	133,000
Agricultural water facilities (1963-65)	2,520,000
Municipal and industrial water facilities (1968-71, 1980, 1995, 2010)	13,952,000
Channel dredging (1968-78)	8,950,000
Master levee system (small craft locks and portages, irrigation and drainage works)	
Isleton island-group (1964-80)	12,610,000
Lodi island-group (1964-81)	11,439,000
Holt island-group (1964-80)	13,810,000
Tracy island-group (1968-74)	4,722,000
Brentwood island-group (1964-79)	9,802,000
Sherman Island (1964-79)	2,030,000
Paradise Cut control structure (1969-71)	121,000
Bear Creek diversion (1967-70)	670,000
Kellogg Creek diversion (1971)	79,000
TOTAL CAPITAL COST, FIRST STAGE FEATURES	$98,059,000
TOTAL CAPITAL COST, SECOND STAGE FEATURES	$21,560,000



HOLLAND CUT STRUCTURE SITE



PARADISE CUT STRUCTURE SITE

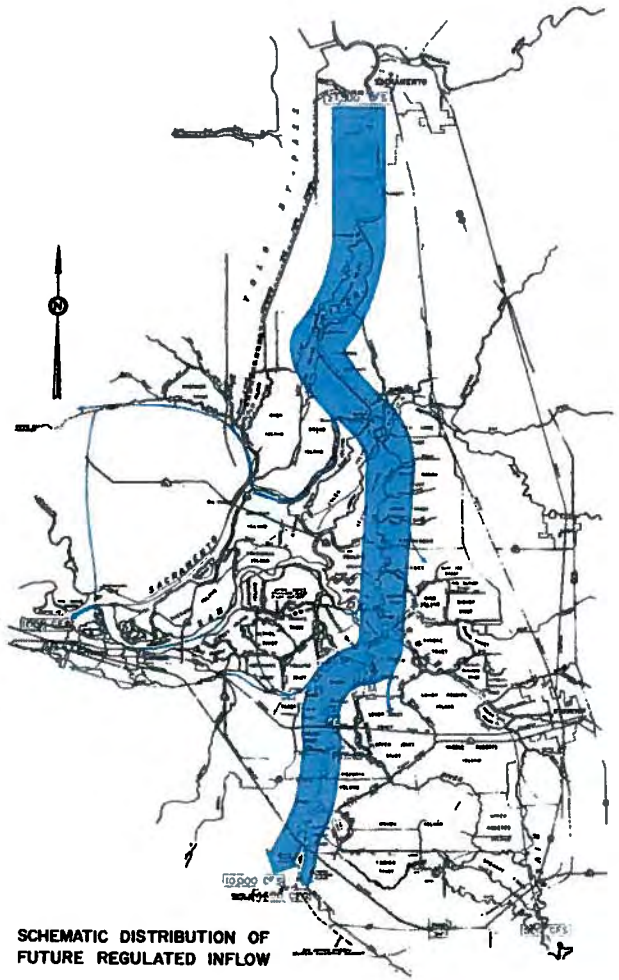
Comprehensive Delta Water Project—operation

Integrated operation of the multipurpose facilities of the Comprehensive Delta Water Project would enhance all principal phases of the Delta's economy, salvage water otherwise needed for salinity control, and provide very good quality water throughout the Delta. Although the project would have some adverse effects on certain segments of the Delta's economy, such as recreation and navigation, the multipurpose works would afford opportunity for enhancement of these same segments in other ways.

Operation of the water supply and transfer facilities during summer months would be similar to that described for the Single Purpose and Typical Alternative plans. Where representative districts or agencies are organized, the facilities could be locally operated and maintained, and appropriate adjustments in costs thereof could be made to achieve equitable distribution of costs to all beneficiaries.

Creation of interior and project channels in the southern portion of the Delta would separate irrigation water supplies from drainage water originating on lands east of the San Joaquin River. Good quality water from cross-Delta flows would be available throughout most of the southern Delta. Lands adjacent to the San Joaquin River upstream from Stockton would continue to divert from the river, but the quality of the water in this area could be improved by upstream flow in the San Joaquin River past Stockton induced by the pumping plants. A small net upstream flow occurs during summer months under present conditions. The quality of water in Paradise Cut could also be improved with circulation induced by pumping from the upper end into the San Joaquin River. Diversions from the river in this vicinity might be affected by operation of a San Joaquin Valley waste conduit. If current studies indicate that substitute supplies would then be necessary, or if further improvement of the quality of the supplies is desired even in the absence of adverse effects of a waste conduit, such supplies could be readily diverted from Delta channels without affecting works described herein.

Lands in the Holt island-group in the south central portion of the Delta range in elevation from several feet below sea level to a few feet above sea level. Irrigation water for the higher islands is pumped from the channels, while siphons are utilized for the lower islands. To achieve seepage control benefits for the lower islands, water



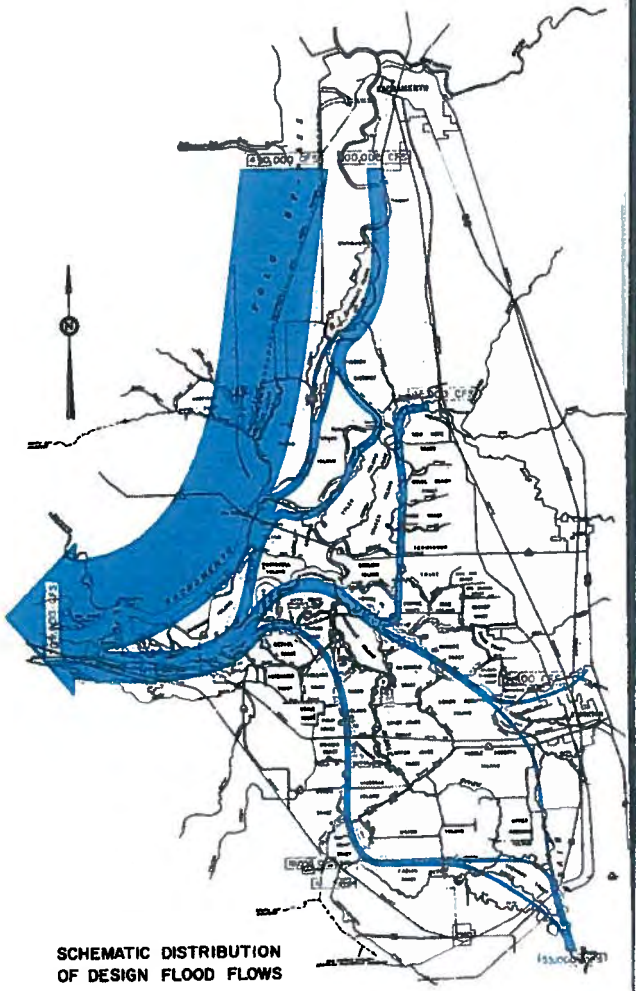
SCHEMATIC DISTRIBUTION OF FUTURE REGULATED INFLOW

levels in the channels could be lowered. This could be accomplished locally without detriment to the higher lands by constructing low dams with pumping plants in the channels and maintaining different water levels in the interior channel system.

Large volumes of small craft and fishing boats move between marinas and resorts in the Bethel Island area and Franks Tract or more distant points in the Delta and San Francisco Bay system. Peak small boat traffic would be served by three small craft portages on Piper Slough, and by one small craft lock on Sand Mound Slough. Lock or portage service for small craft would be provided at various other locations in the Delta when dictated by construction of channel closures. It should be recognized that subsequent developments and changes in patterns of use may necessitate revisions in the planned local service. While the lock and portages would cause some inconvenience to recreationists, creation of interior channels not subject to flood and tidal stages would benefit shore line installations. An expected great increase in boating in the future would intensify problems of patrolling and safety enforcement. Opportunities would be available to local public agencies to designate certain waterways for specific uses, and problems of regulation would be reduced under controlled access.

Master levees of the project in the southern half of the Delta would cause increased tidal amplitudes in the project channels. The maximum increase in the San Joaquin River system would be about one foot at Stockton. There would be no significant change in the mean water level. Some dredging in navigation channels would be necessary.

Tug and barge shipments into the southern Delta would be limited to the Cross-Delta Canal. Most of the present traffic involves beet shipments to a sugar refinery near Tracy, and the Holland Cut channel east of Franks Tract is generally used. The Cross-Delta Canal would be open to the San Joaquin River, and a barge lock at the Holland Cut control structure would not be economically justified. Although a slightly greater travel distance from northern and western Delta points would be involved under the project, the channel to the vicinity of the sugar refinery would be dredged. This would permit use of larger barges, which are presently precluded by shallow channel depths.



SCHEMATIC DISTRIBUTION OF DESIGN FLOOD FLOWS

Project Accomplishments—Delta water supply

Over 90 percent of the Delta lowlands now has adequate water supplies during summer months due in part to operation of the Central Valley Project. However, ten percent of the Delta in the western portion, including lands occupied by large water-using industries and municipalities, does not have adequate good quality water supplies at all times. Moreover, additional regulation and use of water in areas tributary to the Delta, exclusive of Delta exports, will lengthen the average period each year when salinity incursion from the Bay causes increased operating costs, plant shutdowns, and decreased farm production. The concentrations of dissolved minerals in water from the Contra Costa Canal now approach upper limits of acceptable quality during several months of most years, and significant sums of money are expended by industries for demineralization and water softening.

Under any of the foregoing projects, water of very good quality would continue to be supplied to about 90 percent of the Delta lowlands through existing facilities. It is estimated that the mineral quality of the supplies would generally range between about 15 to 80 parts of chlorides and between 100 and 350 parts of total dissolved solids per million parts water. The quality of water in the southern portion of the Delta would be improved.

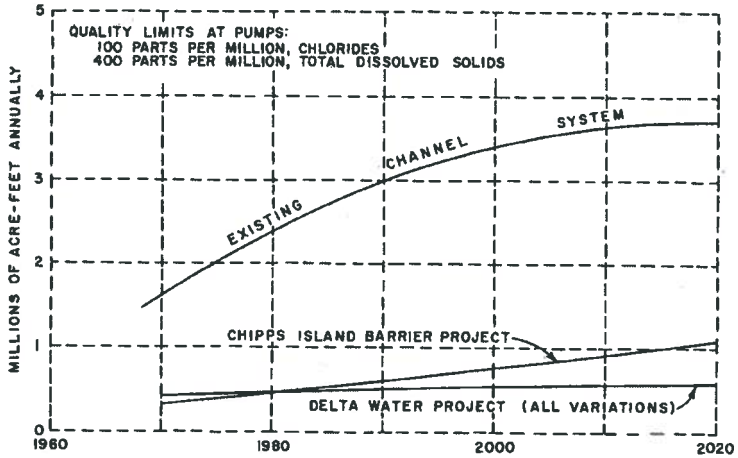
The quality of water in the Pittsburg-Antioch area with the Chipps Island Barrier Project in operation would be uncertain. Although downstream disposal of local municipal and industrial wastes and drainage from the San Joaquin Valley would eliminate the majority of the mineral pollutants, the effects of cooling water and mineral and organic wastes of the Delta might result in water supplies of questionable quality, particularly during critical dry periods. Elimination of the tidal effects in this area by construction of the barrier would also reduce the supply of dissolved oxygen in the water, which is now partly replenished from Suisun Bay.

All of the alternative plans for the Delta Water Project would involve dual water supplies with different water quality characteristics. While the concentrations of minerals in water in certain western channels would increase due to greater ocean salinity incursion, the quality of water from the Contra Costa Canal and from proposed water supply facilities would be excellent. It is estimated that substitute industrial water supplies would generally contain between 15 and 80 parts of chlorides per million parts of water. Similarly, the total dissolved solids would generally range between 125 and 300 parts per million. Irrigation water supplies would be of similar quality. The Contra Costa Canal would annually supply about 195,000 acre-feet of water, including some substitute water in northeastern Contra Costa County. All additionally required supplemental and substitute water would be supplied from the Montezuma Aqueduct. This annual quantity would amount to about 120,000 acre-feet in 1990 and 330,000 acre-feet in 2020. Brackish water supplies in the western Delta channels would vary in quality with location. The mean quality would be about 3,000 parts of chlorides per million parts water at Antioch during summer months. Water containing this much salinity is not necessarily damaging to cooling equipment involving alloy metals. A composite of several factors, most of which would not be modified by alternative plans for the Delta Water Project, controls the rate of corrosion of cooling equipment.

Project Accomplishments—water salvage

Unless physical works are constructed in the Delta to prevent salinity incursion from the Bay system, or to channelize fresh water directly across the Delta channels, it will be necessary to release increasingly greater amounts of fresh water from upstream storage to maintain satisfactory quality conditions. Greater rates of fresh water outflow will be necessary as the rate of export pumping from the Delta increases, and greater quantities of stored water will have to be released as the amount of surplus water for outflow is reduced by upstream depletions and export from the Delta. If Delta works are not constructed, the yield of other features of the State Water Facilities would be reduced and subsequent features for importation of water from north coastal sources would be needed at an earlier date. Any such modifications in the program would increase the cost of water in the Delta.

With any of the plans for the Delta water facilities, the amount of outflow from the Delta otherwise necessary for salinity control would be greatly reduced. It would still be necessary to dispose of municipal and industrial wastes from the western Delta, and drainage from the San Joaquin Valley, into channels downstream from points of usable good quality water. All of the plans are comparable in this respect, except that these wastes would aid in repulsion of ocean salinity incursion with any of the alternatives of the Delta Water Project. Fresh water required for operation of locks and the fishway would be lost with a barrier at Chipps Island, but would be available for use downstream of the control structures with any of the alternatives of the Delta Water Project. A small amount of conservation yield could be obtained from limited storage in Delta channels with a barrier at Chipps Island, but alternatives of the Delta Water Project would not provide conservation storage.



UPSTREAM STORAGE RELEASES FOR PROJECT OPERATION

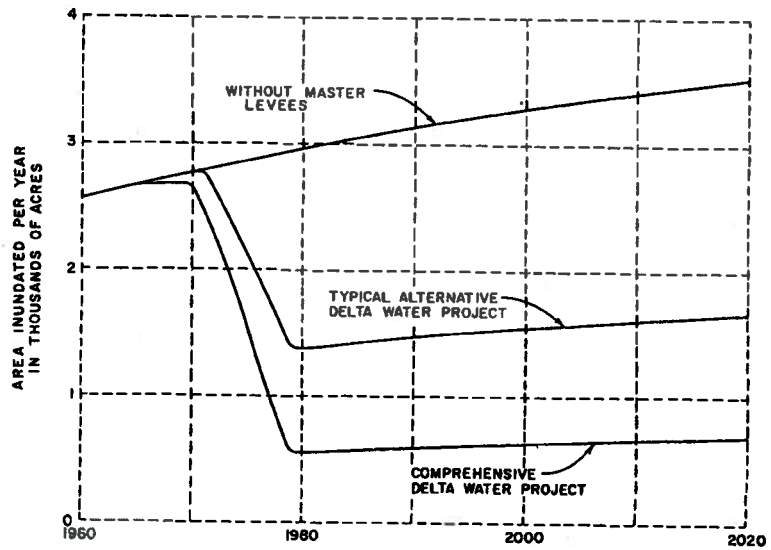
The amount of water otherwise necessary for salinity control which could be salvaged by Delta water facilities would vary with time, as indicated by the above graph. The amount of salvaged water would be the difference between demands on upstream storage for outflow without any works in the Delta, and demands with such works in operation. The estimated average annual salvage during the next 60 years would be 1,900,000 acre-feet with the Chipps Island Barrier Project, and 2,050,000 acre-feet with any of the alternative plans for the Delta Water Project.

Project Accomplishments — flood and seepage control

Only the Typical Alternative Delta Water Project and the Comprehensive Delta Water Project would provide flood and seepage control benefits to the Delta. However, all plans would include remedial works made necessary by adverse effects of flood or tidal water stages changed by project operation. These would be particularly necessary with the Chipps Island Barrier Project.

Project flood control benefits would result from reduction in the frequency of flooding, and from reductions in costs of maintaining Delta levees. It is emphasized that complete flood protection could not be assured, as the inflow to the Delta could exceed the designed capacity of the channels. Furthermore, although the stability of the master levees would be significantly greater than the stability of existing levees, the character of organic foundation soils is such that unforeseen stability problems might develop in some areas. For these reasons, emphasis should be given to zoning Delta lands lying below flood levels for uses involving low-value improvements such as farming, and precluding residential development. While complete flood protection for the Delta lands could not be assured under project conditions, there would be a marked improvement in protection over existing conditions which will worsen as land elevations in the Delta continue to subside.

About 103,000 acres would be benefited by master levees included in the Typical Alternative Delta Water Project, and about 143 miles of levees along interior channels would no longer require costly maintenance for high flood stages. The estimated average annual benefit of reduced flooding and operation and maintenance costs would be about $4.65 per acre. Master levees of the Comprehensive Delta Water Project would benefit about 252,000 acres and would reduce expensive maintenance on 295 miles of interior channel levees. The estimate of average annual flood control benefits is about $3.60 per acre.



PROJECTED AVERAGE ANNUAL AREA OF FLOODING

Seepage control benefits would be made available by lowering water levels in interior channels created by the Typical Alternative Delta Water Project or by the Comprehensive Delta Water Project. In addition, lower water levels would prolong the economic life of certain islands. These benefits and the extent of increased economic life would depend upon lowering average water levels in the interior channels. A general lowering of five feet could be made without adversely affecting depths for small craft, except in isolated locations, or the majority of water supply siphons. Based upon a five-foot lowering of water levels, seepage control benefits, averaging an estimated $0.50 per acre for 103,000 acres, would be available with the Typical Alternative Delta Water Project. The Comprehensive Delta Water Project would afford seepage benefits to 252,000 acres, and the estimated average annual benefit would be $0.45 per acre.

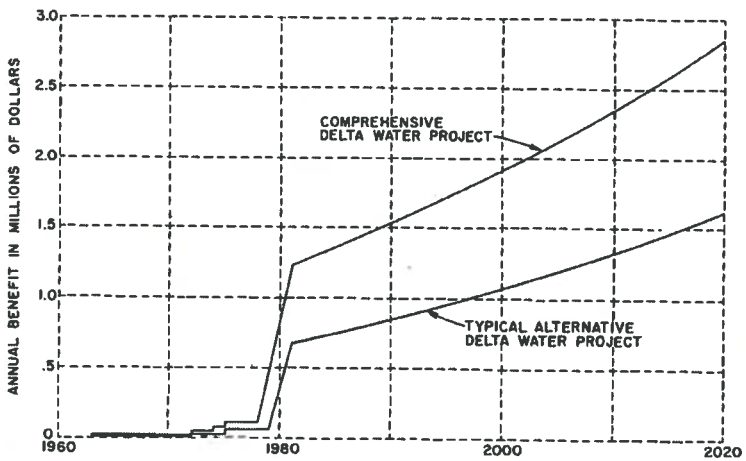
Project Accomplishments—vehicular transportation

The two basic problems of the existing road system in the Delta are (1) inadequate channel crossings and circuitous routes, with resultant excessive travel times, and (2) disproportionately high costs of maintenance. Projects involving master levees for flood control in the Delta would afford means for reducing both of these problems. However, the Chipps Island Barrier Project would provide no benefits to vehicular transportation, and the Single Purpose Delta Water Project would provide only incidental benefits of this kind.

The master levee system of the Typical Alternative Delta Water Project would include twenty-two channel closures upon which roads could be placed, and operation of four existing ferries could be terminated. The Comprehensive Delta Water Project would include thirty-nine channel closures providing new access and would eliminate the need for six ferries.

Roads on the landward berms of the master levees would be more stable and less difficult to maintain than existing roads on levee crowns. Driving on present levee roads is hazardous, as evidenced by frequent drownings when vehicles run off levees into adjacent channels. Passing clearance is often limited by parked vehicles. In addition to improved safety with roads on the levee berms, there would be ample width for parking off the roadways.

To realize the anticipated and needed development of recreation in the Delta, it will be necessary to greatly improve vehicular access. Realization of about 7,000,000 recreation-days each year by 1990, and almost 14,000,000 by 2020 will, in large degree, be dependent upon the improved vehicular access that could be provided by multipurpose use of the master flood control levees.



BENEFITS OF VEHICULAR TRANSPORTATION IMPROVEMENTS

The project benefits from enhancement of the road system would be a combination of savings in maintenance costs and savings in costs to Delta traffic associated with farming and to the recreationists. Savings to Delta interests reflect reduced costs of general travel and produce shipments through decreased travel times and distances. Savings to the recreationists were based upon projected recreation use and decreased travel times and distances.

Project Accomplishments—recreation

While some detriments to recreation are inherent in construction of any facilities in the Delta, substantial benefits would also be achieved. As has been stated, improvements in the road network would make more of the Delta accessible to recreationists. Land areas reclaimed by spoiling material from dredging of channels onto small islands would afford space for development of recreation service facilities and picnic areas. Project works at the head of the Cross-Delta Canal would be constructed to provide clearance for the majority of pleasure craft, thereby connecting the Sacramento and Mokelumne River systems. Elimination of flood and tidal effects from interior channels would make it possible to control water levels in those channels, reducing costs of maintaining waterfront recreation facilities. Furthermore, costs of new facilities would be less than for present conditions. The safety of the boating public is becoming a significant problem, and the incompatibility of high-speed boating, cruising, and skiing with fishing and swimming creates related safety problems. Local authorities will find it desirable and even necessary to designate certain Delta channels for specified types of recreation use. The interior project channels would lend themselves to this type of zoning and also to simplified enforcement.

Planning and construction of recreational developments in the Delta should involve local governmental agencies. Most project channel closures would not be constructed for eight or more years, and changing recreation patterns should be considered in future selection of remedial and enhancement facilities. Needs for small craft locks and boat portages should be re-evaluated at the time closures are constructed.

The most important form of recreation in the Delta is fishing. In terms of recreation-days, fishing is three times as important as the next most popular sport—cruising. A project which would cause a major reduction in fish populations might also cause very adverse effects on the recreation. In this connection the Chipps Island Barrier Project would result in losses of striped bass several times as great as those anticipated with any of the alternative plans for the Delta Water Project.

It is recognized that cruising, sailing, and water skiing are rapidly gaining in popularity in the Delta, and that construction of master flood control levees and channel closures would interfere with unrestricted boating access to certain channels. However, access would be provided through small craft locks or portage facilities at many of the channel closures, thus reducing the detriment primarily to short delays. Studies in other areas indicate that lockage delays are not too important to the majority of pleasure boatmen.

The following tabulation summarizes physical features of the several alternative projects which would affect recreational activity and growth in the Delta.

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Control structures	1	4	3	4
Channel closures	1	10	23	41
New master levees (miles)	0	0	90	185
Fishways	1	1	1	1
Principal fish screens	0	2	1	1
Barge locks	1	1	1	1
Small craft locks	0	0	2	5
Small craft portage facilities	0	0	5	17
Open navigable area (acres)	49,500	49,400	45,800	42,600
Navigable interior area (acres)	0	100	3,700	6,900
Open navigable channels (miles)	700	695	590	450
Navigable interior channels (miles)	0	5	110	250
Project roads (miles)				
Paved	0	0	33	70
Graveled	0	1	47	109
State and county levee roads (miles)	295	295	279	265
New inter-island accesses (closures)	0	6	22	39
New public waterfront land (acres)				
From master levees	0	0	1,900	3,600
From dredge spoils	0	1,900	1,900	2,300
Normal overhead clearance through Delta Cross Channel (feet)	6	16	16	16

Project Accomplishments—fish and wildlife

Any Delta water facilities would affect the habitat of fish in the Delta, but would have little effect, if any, on Delta wildlife. While it is known that the Delta plays an important role in the life cycle of migratory fish, and also supports resident sport fish, insufficient biological information is available with which to clearly define the potential effects of Delta water facilities. Nevertheless, relative comparisons of the alternative projects can be made.

Studies of effects of the Delta water facilities and export pumping plants were made by the California Department of Fish and Game in co-operation with the Department of Water Resources. Cooperative experiments with a full-scale vertical baffle fishway indicate that all migratory species would use this type of fishway. The conclusions of the Department of Fish and Game regarding the alternative projects are as follows:

"Chipps Island Barrier

"This project would be the most damaging of the four studied. It would probably cause a disastrous reduction of almost all species of fish found in the Delta. These losses would be brought about by the rapid salinity and temperature change across the barrier, loss of current in the fresh-water pool for migration direction, striped bass spawning eliminated due to lack of current behind the barrier, loss of important food items, and a threefold increase in pumping of water at Tracy. The amount of Sacramento River water being drawn around the tip of Sherman Island to the pumping plant would be greatly increased. Downstream migrants of the Sacramento River would be diverted to the pumps in large numbers. These fish would have to be screened at the pumps and returned to the river channel below the influence of this current. This condition would be a serious detriment to all fish using the Delta.

"Single Purpose Delta Water Project

"This project would be the least detrimental of the four projects studied. The reversal of flow around Sherman Island would be eliminated. Major fish screens would be installed at the Cross-Delta Canal headworks and at the head of Georgiana Slough. Therefore, downstream migrants in the Sacramento River would be guided down the western side of the Delta out of the influence of the pumps. In general, fish and eggs in the western portion of the Delta would no longer be affected by the pumps. The replacement of the hundreds of existing small irrigation siphons in the western Delta by screened irrigation supply systems would further reduce losses of small fish. In these respects conditions for fish in the Delta would be improved.

"Fish habitat would not be reduced in the Delta. The one channel that would be isolated under this project would be insignificant. An important effect of the project would be the increased reversal of flow in the San Joaquin River above the Cross-Delta Canal crossing. This reversal of flow would occur during an average of seven months of the year under full project operation. We were unable to evaluate the effect of the reversal. However, it could result in serious losses to salmon that now spawn in San Joaquin River tributaries south of the Mokelumne River. Most seriously affected would be upstream migrating salmon. The amount of water pumped from the Delta would be increased threefold. This increased withdrawal of water would divert proportionately more fish than is presently being diverted.

"Typical Alternative Delta Water Project

"This project would be the second least detrimental. Losses would be expected to be greater than the Single Purpose Project because of the reduction of 8 percent of the fish habitat through channel closures, and partial channelization of the Cross-Delta Canal. The channelization would cause a detriment by channeling the fish toward the pumps by a more direct route. Water diversions into isolated channels would be screened and loss of fish would be reduced. However, loss of eggs and fry would be unavoidable. Other project conditions would be the same as the Single Purpose Project.

"Comprehensive Delta Water Project

"This project would be the third least detrimental. It would cause greater loss than the Typical Alternative Project because of the reduction of 14 percent of the fish habitat, and the complete channelization of the Cross-Delta Canal. This would channel the fish directly to the pumps. Other project conditions would be the same as in the Single Purpose Project.

"From the foregoing, if one of the above-named projects is to be built in the Delta, the Department of Fish and Game would favor the Single Purpose Delta Water Project. However, all projects will cause serious fisheries problems and an intensive study would be required to solve these problems."

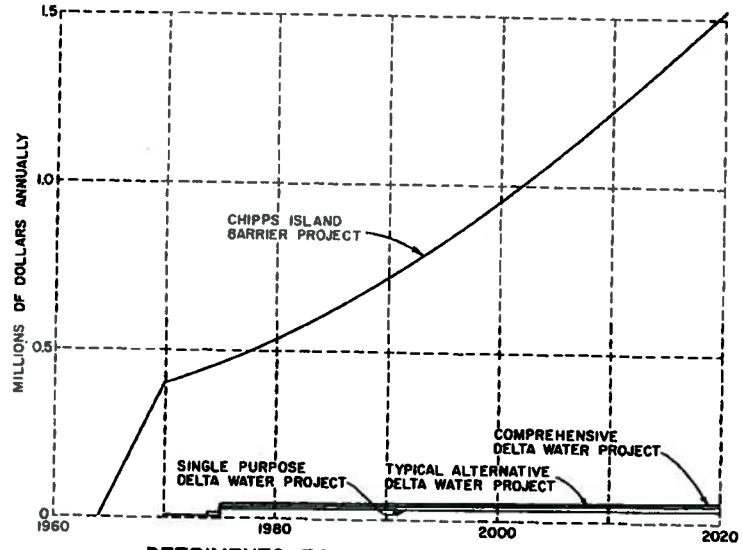
Formulation of project plans reflects comments and recommendations of the Department of Fish and Game. Fish screens would be installed at the heads of channels diverting water southward from the Sacramento River. Such screens would reduce the present rates of fish losses at the Tracy Pumping Plant and in numerous other diversions in the Delta. Project pumping plants would also be screened. Hundreds of diversion siphons and pumping plants in the Delta are not screened at this time. However, project diversions into interior channels would be screened, and the fish populations enhanced thereby.

Project Accomplishments—navigation

Commercial and military navigation in the Delta would be adversely affected in varying degrees by any Delta water facilities, but some potential benefits would also be realized through increases in channel depths and widths.

The Chipps Island Barrier Project would cause the greatest detrimental effect to navigation, since all traffic between the San Francisco Bay system and Delta points would have to pass through locks. At present, an average of about 570 deep-draft commercial vessels, and 10,300 tug and barge tows and small vessels pass Chipps Island each year. It is estimated the annual transits would increase to 2,800 and 40,000, respectively, by 2020. The volume of future military traffic cannot be realistically estimated, nor is it possible to place a reasonable value on its lost time. The increased tidal amplitude downstream from a barrier at Chipps Island would necessitate additional dredging in some areas to provide the required minimum navigation depth. This increased depth might cause additional maintenance dredging which frequently results from deepening navigation channels.

Completion of the Sacramento Deep Water Channel will divert most of the tug and barge traffic away from the Sacramento River between the vicinities of Rio Vista and Sacramento. The traffic which would pass the site of the Sacramento River control structure would generally be limited to that originating from or destined to points of call downstream from the vicinity of Freeport. It is anticipated that the volume of this traffic would increase from 600 transits per year after completion of the Sacramento Deep Water Channel to about 900 transits per year by 2020.



DETRIMENTS TO COMMERCIAL NAVIGATION

Construction of control structures and closures on channels south of the San Joaquin River in the heart of the Delta would increase time and distance for tug and barge travel to a sugar refinery near Tracy. However, channel improvements would permit use of larger barges, if shipping concerns should elect to do so. As this advantage would be subject to many factors in an operator's business which cannot be readily predicted, benefits were not claimed for possible use of larger barges.

Construction of a master levee system would necessitate relocation of some sugar beet loading docks in the Delta. However, improved roads would tend to compensate for increased hauls to relocated docks.

Economic Aspects—benefits, detriments, and costs

Only direct, tangible benefits and detriments to the initial recipient were evaluated for comparison with direct costs. However, it must be recognized that direct, intangible benefits and detriments would also result from project operation. The ratios of benefits to costs provide a guide to project selection, but consideration should also be given to the net benefits in making the final project selection. Although variations in benefit-cost ratios can result from different basic economic premises, the relative comparison of alternative projects would not change.

Certain significant benefits and detriments were not evaluated. All alternative plans would improve the quality of water exported to the San Joaquin Valley and reduce the drainage problems there. Only direct benefits of flood protection to agriculture were evaluated, but this protection would also benefit principal highways and urban developments. The estimated recreation benefits from land made available for development were considered to be equivalent to the value of the land. Intangible benefits would also accrue to recreation, and intangible detriments would result from reduced convenience of access into some channels. Only detriments to commercial fishing are shown, but intangible detriments to sport fishing would also accrue.

All estimates of benefits, detriments, and costs, including amortization, operation, and maintenance, reflect annual equivalent values for the period 1960-2020. An interest rate of four percent per annum was used in the analysis.

Attention is invited to the net benefits of the Comprehensive Delta Water Project which are less than the net benefits of the Typical Alternative Delta Water Project. This condition results from inclusion of economically unjustified flood control for large areas south of the San Joaquin River wherein the direct benefits would be less than the costs. However, flood control for some of the critical areas south of the San Joaquin River warrants further study.

ESTIMATED ANNUAL BENEFITS, DETRIMENTS, AND COSTS
(In thousands of dollars)

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Benefits				
Water salvage (for export)	8,337	8,963	8,963	8,963
Improved water quality—municipal, industrial, and irrigation	880	880	880	880
Supplemental municipal and industrial water supply	503	1,343	1,343	1,343
Flood and seepage control	—	—	530	1,022
Vehicular transportation	—	—	410	734
Recreation	—	19	37	58
Total Benefits	9,720	11,205	12,163	13,000
Detriments				
Commercial navigation	617	18	24	27
Commercial fisheries	844	203	254	287
Total Detriments	1,461	221	278	314
BENEFITS MINUS DETRIMENTS	8,259	10,984	11,885	12,686
Costs				
Capital amortization	6,825	1,358	1,965	2,846
Annual operation and maintenance	2,077	691	884	1,136
Total Costs	8,902	2,049	2,849	3,982
NET BENEFITS	–643	8,935	9,036	8,704
BENEFIT–COST RATIO	0.93:1	5.36:1	4.17:1	3.19:1

Economic Aspects—allocation of costs

The capital and operational costs of each of the alternative projects were allocated among the project functions by the Separable Costs-Remaining Benefits method. In this method, all costs assignable to single functions are identified, and the remaining multipurpose costs are distributed among the functions in proportion to the benefits provided by the project, or in proportion to the lowest cost alternative means of providing equivalent benefits. The lowest value of either the benefits or alternative means is used as a limit.

The basic allocations were made in terms of present worth values (1960) of all costs and benefits. This procedure properly accounts for the time-value of money (interest) and the wide variation in dates of expenditure of money and realization of benefits. Allocations of the capital and operational costs in terms of actual expenditures, rather than present worth, are indicated in the accompanying tabulations to permit convenient comparisons with total amounts of these costs.

Attention is invited to the allocated costs of the Chipps Island Barrier Project. The costs which would be allocated to water salvage and western Delta water supply were limited by the lowest cost alternative means of providing equivalent benefits, which would be the Single Purpose Delta Water Project. The values

ALLOCATION OF ESTIMATED CAPITAL COSTS
(In thousands)

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Water salvage (for export)	$38,384	$38,444	$38,662	$41,655
Western Delta water supply [1]	8,098	8,111	8,156	8,788
Flood and seepage control	none	none	11,900	25,159
Vehicular transportation	none	none	8,132	18,083
Recreation land	none	none	681	1,429
Unassigned local costs	155,490	none	none	2,945
TOTALS	$201,972	$46,555	$67,531	$98,059

[1] For improvement in quality and supplemental water supplies. Allocated costs include portions properly attributable to upstream water users for future effects on the western Delta area due to increased water use in areas tributary to the Delta. Definite values attributable to upstream water users would be dependent upon resolution, negotiated or otherwise, of water rights problems.

shown for the Chipps Island Barrier Project are slightly less than those for the lowest cost alternative, since the funds for the former would be expended at an earlier date. The allocations to both projects in present worth values would be the same. As the costs which may be properly allocated to water salvage and western Delta water supply are less than the total cost, a portion of the costs of the Chipps Island Barrier Project are shown as unassigned local costs. If these costs are not repaid from sources other than water users, the Chipps Island Barrier Project would be financially infeasible.

Attention is also invited to the allocated costs of the Comprehensive Delta Water Project which indicate certain unassigned local costs. In this case the costs of flood and seepage control in areas south of the San Joaquin River exceed the direct benefits of flood and seepage control in these areas. Therefore, the allocation to flood and seepage control for these areas was limited to the benefits. These flood and seepage control features of the Comprehensive Delta Water Project are not economically justified.

After the costs were allocated to principal project functions, it was necessary to make suballocations among particular groups of beneficiaries. These suballocations, which are indicated on the following pages, were also made by the Separable Costs-Remaining Benefits method and were the basis for computing the average annual costs to beneficiaries throughout a 60-year period. In the adjoining tabulations the amounts allocated to vehicular transportation include some costs which would be suballocated to recreation access to reflect the benefits to the public for improved access to recreation areas of the Delta. It is estimated that about $7,075,000 of the capital costs and $92,000 of the annual operational costs for vehicular transportation under the Typical Alternative Delta Water Project would be suballocated to recreation access. Under the Comprehensive Delta Water Project these respective amounts would be $15,123,000 and $176,000. These foregoing amounts would be in addition to the basic allocation to recreation land, which reflects the value of lands made available for recreational development.

ALLOCATION OF ESTIMATED AVERAGE ANNUAL OPERATIONAL COSTS
(In thousands)

Item	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Water salvage (for export)	$395	$571	$506	$483
Western Delta water supply [1]	83	120	107	102
Flood and seepage control	none	none	156	292
Vehicular transportation	none	none	106	210
Recreation land	none	none	9	16
Unassigned local costs	1,599	none	none	34
TOTALS	$2,077	$691	$884	$1,137

[1] For improvement in quality and supplemental water supplies. Allocated costs include portions properly attributable to upstream water users for future effects on the western Delta area due to increased water use in areas tributary to the Delta. Definite values attributable to upstream water users would be dependent upon resolution, negotiated or otherwise, of water rights problems.

Economic Aspects—costs of project services

It was assumed that all project costs not specifically declared nonreimbursable would be repaid by all beneficiaries of project functions. In accordance with the contracting principles established for water service under the State Water Resources Development System, the conservation features of the Delta water facilities will be financially integrated with other conservation features of the system. The cost of supplemental water required by Delta water users will include the Delta Water Charge and an allocated transportation charge.

Estimates of present and future costs of water supply in the western Delta area were predicated on continuation of current federal salinity control policy, which limits the minimum regulated outflow from the Delta to 1,500 second-feet, considered necessary to afford satisfactory quality control at the Central Valley Project pumping plants. Estimates of increased future costs without the State Water Facilities reflect continued upstream depletion of surplus water in the Delta, and represent average costs during the next 60 years. Estimates of costs shown for project conditions also reflect average costs during the next 60 years. It is emphasized that the estimates are comparative average annual *costs* during a 60-year period and do not reflect estimates of year by year *prices* which may be established.

The amounts allocated for repayment were limited by the lowest cost alternative means of accomplishing equivalent benefits. It may be noted that the costs of water supply in the western Delta area would be the same for the Chipps Island Barrier Project, Single Purpose Delta Water Project, and Comprehensive Delta Water Project. The Single Purpose Delta Water Project would be the lowest cost alternative means of providing water supplies and it limits the amount which may be allocated under the other two projects.

The costs of the Typical Alternative Delta Water Project allocated to water salvage would amount to an average of $0.64

COMPARATIVE SUMMARY OF ESTIMATED AVERAGE ANNUAL COSTS OF WATER SUPPLY IN WESTERN DELTA AREA WITH AND WITHOUT STATE WATER FACILITIES DURING 1960-2020 [1]

Item	Future cost without State Water Facilities	Chipps Island Barrier Project	Single Purpose Delta Water Project	Typical Alternative Delta Water Project	Comprehensive Delta Water Project
Contra Costa Canal service, $/acre-foot [2]	14.52 [3]	11.66	11.66	11.64	11.66
Substitute municipal and industrial water supply, $/acre-foot	[4]	[4]	3.45	3.33	3.45
Supplemental water supply [5]					
Contra Costa County, $/acre-foot	15.20	9.06	9.06	8.92	9.06
Solano County, $/acre-foot	17.00	8.82	8.82	8.68	8.82
Agricultural water supply, $/acre [6]	7.91 [7]	1.50	1.50	1.45	1.50

[1] Average of estimated costs during a 60-year period. Values do not necessarily reflect *prices* for project services.
[2] For all municipal and industrial water served from the Contra Costa Canal. All costs include $11 per acre-foot for water from the canal. Allocated costs reflect benefits from improved quality.
[3] Includes estimated excess water treatment due to salinity degradation.
[4] Estimated future cost of high quality water from Delta channels will vary between $2.00 and $5.00 per acre-foot, depending upon plant locations and operations.
[5] All supplemental project water available through operation of the Montezuma Aqueduct.
[6] Costs reflect average for about 34,000 acres in the western Delta lowlands.
[7] Cost expressed as loss per acre due to salinity incursion.

per acre-foot for all water exported from the Delta by the State Water Facilities. Similar costs with the other projects would be about $0.66 per acre-foot.

It is anticipated that a federal contribution would be provided for flood and seepage control. This contribution, tentatively estimated at $10,123,000 for the Typical Alternative Delta Water Project and $16,020,000 for the Comprehensive Delta Water Project, would probably reflect current federal policy for allocation of costs of levee improvements, and would be based on reduced flood damages and net savings from reduced levee maintenance costs. Local costs of maintaining existing levees incorporated in the master levee system probably would not be directly met by local districts. Maintenance would be included in the total project costs, and a portion of these costs would be allocated to local beneficiaries.

The total project costs allocated to vehicular transportation were suballocated to the benefited counties and to the general public. The allocation to the general public reflects enhancement of recreation, and was considered nonreimbursable.

COMPARATIVE SUMMARY OF ESTIMATED ANNUAL COSTS OF FLOOD AND SEEPAGE CONTROL WITH AND WITHOUT DELTA WATER FACILITIES DURING 1960-2020 [1]

(Per acre)

Item	Island-group					
	Isleton	Lodi	Holt	Tracy	Brentwood	Sherman
Present control cost	$8.00	$8.00	$7.50	$6.50	$7.50	$9.00
Future control cost without a project	10.85	10.29	9.16	7.50	8.83	13.10
Annual damage savings with a project	2.80	1.65	0.35	0.20	1.32	3.12
Typical Alternative Delta Water Project						
Allocated project cost	2.04	2.17				
Interior levees and pumping cost	7.96	7.34				
Total control cost	$10.00	$9.51				
Net savings	3.65	2.43				
Comprehensive Delta Water Project						
Allocated project cost	2.15	2.29	2.09	2.29	2.38	2.53
Interior levees and pumping cost	7.96	7.34	6.66	4.97	6.04	10.57
Total control cost	$10.11	$9.63	$8.75	$7.26	$8.42	$13.10
Net savings	3.54	2.31	0.76	0.44	1.73	3.12

[1] Average of estimated costs during a 60-year period. Values do not necessarily reflect prices for project services.

COMPARATIVE SUMMARY OF ESTIMATED ANNUAL COSTS AND SAVINGS WITH VEHICULAR TRANSPORTATION IMPROVEMENTS DURING 1960-2020 [1]

Item	Contra Costa County	San Joaquin County	Sacramento County
Typical Alternative Delta Water Project			
Allocated project cost	$—	$41,400	$4,500
Operational savings to present road system	—	38,500	1,100
Savings to road users	—	265,700	105,200
Net savings	—	268,800	101,800
Comprehensive Delta Water Project			
Allocated project cost	13,300	95,700	11,200
Operational savings to present road system	2,900	59,300	5,000
Savings to road users	82,000	465,600	119,700
Net savings	71,600	429,200	113,500

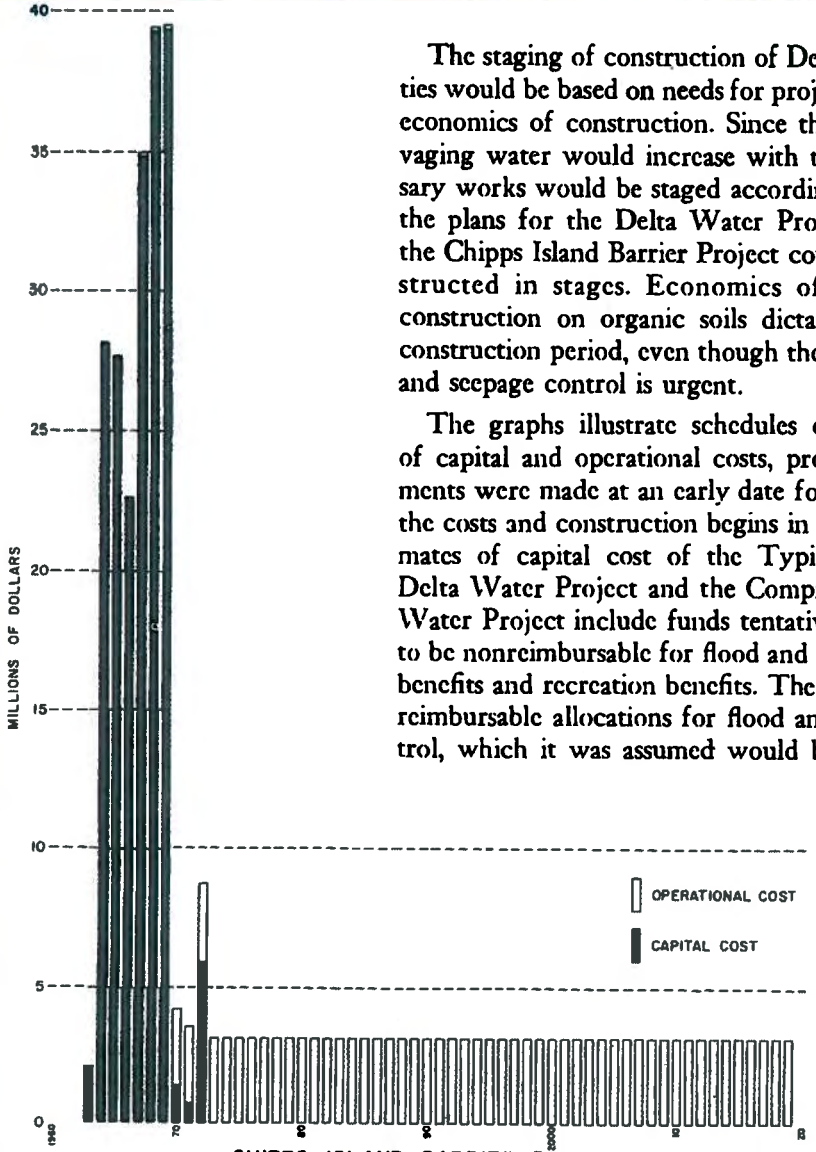
[1] Average of estimated costs during a 60-year period. Values do not necessarily reflect prices for project services.
NOTE: There would not be any vehicular transportation improvements in portions of other counties within the Delta.

Economic Aspects—repayment

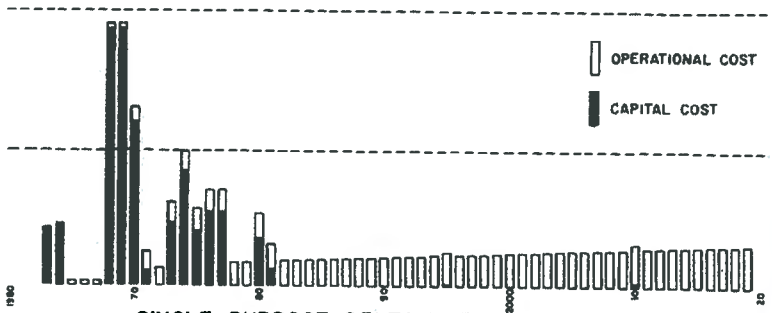
The staging of construction of Delta water facilities would be based on needs for project services and economics of construction. Since the need for salvaging water would increase with time, the necessary works would be staged accordingly for any of the plans for the Delta Water Project. However, the Chipps Island Barrier Project could not be constructed in stages. Economics of master levee construction on organic soils dictate an extended construction period, even though the need for flood and seepage control is urgent.

The graphs illustrate schedules of expenditures of capital and operational costs, provided arrangements were made at an early date for repayment of the costs and construction begins in 1963. The estimates of capital cost of the Typical Alternative Delta Water Project and the Comprehensive Delta Water Project include funds tentatively considered to be nonreimbursable for flood and seepage control benefits and recreation benefits. The estimated nonreimbursable allocations for flood and seepage control, which it was assumed would be provided by the Federal Government, amount to about $10,123,000 for the Typical Alternative Delta Water Project and $16,020,000 for the Comprehensive Delta Water Project. The estimated allocation of capital costs to recreation land and access would be $7,756,000 with the Typical Alternative Delta Water Project and $16,552,000 with the Comprehensive Delta Water Project. The corresponding allocations of annual operational costs would be $101,000 and $192,000, respectively. It was assumed that the allocated capital costs for recreation land and access would be nonreimbursable and be borne by the State of California. It was also assumed that the annual operational costs would be reimbursable from gas tax funds and nominal rental charges on land made available for recreation development.

The allocated reimbursable costs for water salvage and western Delta water supply would be repaid by water charges. The charges would be based on integrated repayment of other necessary State Water Facilities. The reimbursable costs of flood



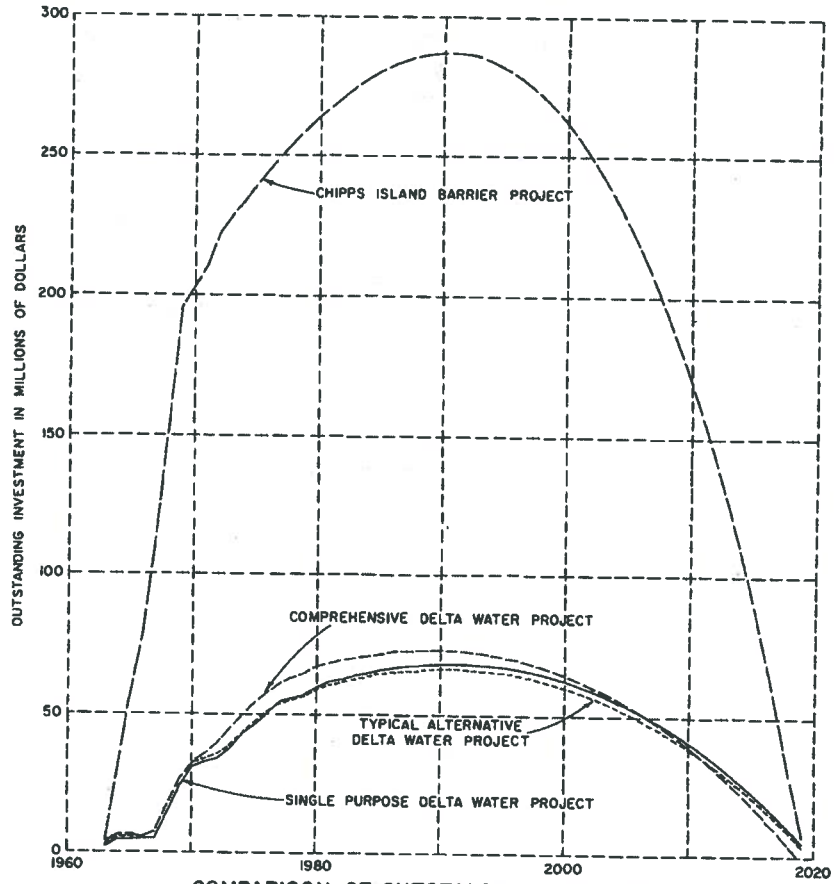
CHIPPS ISLAND BARRIER PROJECT



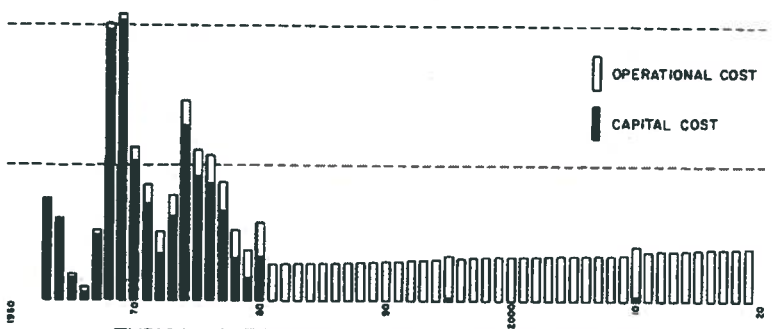
SINGLE PURPOSE DELTA WATER PROJECT

and seepage control and vehicular transportation improvements would be repaid by annual payments from the beneficiaries of flood and seepage control and from the counties, respectively. It was assumed that unassigned local costs of the Chipps Island Barrier Project would be recovered in annual payments in proportion to the projected industrial tax base. This assumed method of repayment would necessitate a rate of about $1.19 per $100 of assessed valuation throughout a 60-year period. It was also assumed that unassigned local costs of the Comprehensive Delta Water Project would be recovered in annual payments based upon the total acreage of land south of the San Joaquin River which would benefit from flood and seepage control. An annual payment of $0.86 per acre would be required.

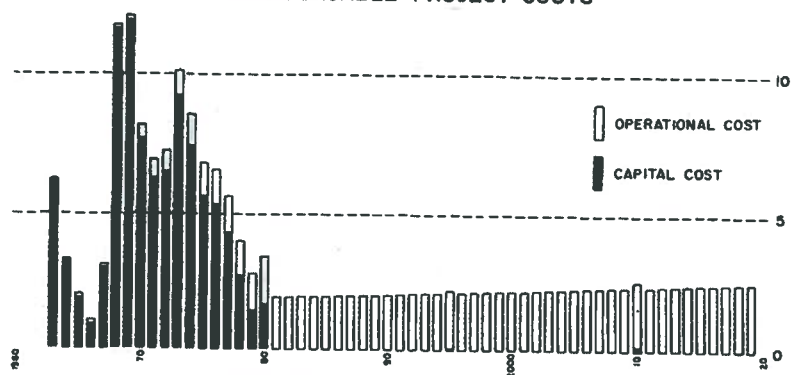
The comparative investment requirements for allocated reimbursable costs, including interest and operational costs, of the several projects are shown in the accompanying graph.



COMPARISON OF OUTSTANDING INVESTMENT
REIMBURSABLE PROJECT COSTS



TYPICAL ALTERNATIVE DELTA WATER PROJECT



COMPREHENSIVE DELTA WATER PROJECT

Conclusions and Recommendations

CONCLUSIONS

GENERAL

The plans for Delta water facilities described in this report are consistent with and would accomplish the water development purposes embraced in the California Water Resources Development Bond Act approved on November 8, 1960. Additional features could be incorporated to provide flood and seepage control, transportation, and recreation benefits.

WATER SUPPLY

Problems of water quality in the western portion of the Delta necessitate early construction of facilities to provide suitable water supplies for present and future uses.

WATER SALVAGE

Without physical control works in the Delta, increasingly greater quantities of fresh water from upstream storage will be required to repel ocean salinity and maintain good quality water for use within and export from the Delta. Water salvage will be dependent upon coordinated operation of regulatory storage, export works, and Delta water facilities.

FLOOD AND SEEPAGE CONTROL

The magnitude of flood damage and the costs of flood and seepage control will become increasingly greater as the land surface of many Delta islands continues to subside. A master levee system would reduce these costs. Early initiation of construction is necessary to economically provide stable levees.

VEHICULAR TRANSPORTATION AND RECREATION

Improvements to the road system in the Delta are needed to reduce costs of vehicular shipment and to develop the recreation potential to accommodate an estimated 7,000,000 recreation-days in 1990, and 14,000,000 recreation-days in 2020.

DELTA WATER FACILITIES

1. The Chipps Island Barrier Project would be functionally feasible, would provide adequate water supplies of acceptable quality for the Delta, and would salvage water otherwise needed for salinity control amounting to an estimated annual average of 1,900,000 acre-feet based on a 60-year period. However, the net benefits would be less than the project costs in a ratio of 0.93:1. Therefore, the project would not be economically justified. The project would not be financially feasible, unless revenues could be obtained from local taxes in addition to revenues derived from water sales.

2. The alternative plans of the Delta Water Project would be functionally feasible, would permit export of full water demands on the State Water Facilities, and would provide adequate water supplies, both in quality and quantity, for the Delta. The project would salvage water otherwise needed for salinity control amounting to an estimated annual average of 2,050,000 acre-feet based on a 60-year period.

3. The Chipps Island Barrier Project would probably cause disastrous reductions in the fisheries resource of the Delta. The Single Purpose Delta Water Project would be the least detrimental of all projects and would reduce some losses of fish and

Advanced Planning, Design, and Operation Studies

It is anticipated that the results of the planning studies summarized in this bulletin and described in detail in the supporting office reports will be the basis for selection of a general plan for the Delta Water Project. However, it is recognized that definite plans, designs, and operation programs will be dependent upon further studies and negotiations on certain aspects of the project plans.

LOCAL ACTION

Early consideration should be given by local agencies to the extent of their interest in facilities which could be constructed to provide local benefits. Acute water supply problems in the western Delta, particularly in the agricultural lowlands, warrant early resolution of interest in plans for water supply facilities. Consideration should be given to creation of master districts to represent related areas of interest in flood and seepage control benefits.

UNITED STATES CORPS OF ENGINEERS

Studies for flood and seepage control benefits and estimates of the federal contribution were based on methods and preliminary studies of the Corps of Engineers. Conditions in the Delta do not precisely fit standard procedures, and it will be necessary for the Corps of Engineers to make a detailed review of these studies to determine the extent of federal interest.

UNITED STATES BUREAU OF RECLAMATION

The Delta Water Project would enhance the operation of the Federal Central Valley Project by improving and insuring the quality of water exported from the Delta and by providing good quality water in the western Delta area in lieu of salinity control. The extent of federal interest in these benefits should be jointly analyzed by the Bureau of Reclamation and the Department of Water Resources.

HIGHWAYS

The channel closures and wide landward berms of the master levee system offer excellent opportunities for enhancing the road network in the Delta. Studies should be made by the State Division of Highways and county highway departments of transportation enhancement features, such as better road surfacing and connecting roads, which might be incorporated in the project plans.

FISHERY RESOURCES

To more definitely predict the anticipated project effects on fisheries and to design the fish screens and other remedial measures, it will be necessary to study certain biological aspects of the Delta fisheries. Joint studies of the anticipated project effects should be undertaken by the Department of Fish and Game and the Department of Water Resources.

OTHER STUDIES

Advance planning studies of flow distribution, salinity incursion, water quality, and sedimentation should continue throughout the design and early operation phases of project construction.

Test levee construction now being conducted pursuant to legislative directives will be continued to determine the most economical and efficient means of construction to provide an adequate levee system.

A general plan for remedial recreation facilities and recreation enhancement has been developed. Specific plans for facilities and development of land which can be made available for recreation uses should be prepared by county agencies, the Department of Water Resources, and other appropriate state agencies.

Acknowledgments

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COOPERATIVE STUDIES

U. S. Corps of Engineers
Sacramento District—flood control and navigation aspects
San Francisco District—preliminary designs, Chipps Island Barrier Project

U. S. Coast and Geodetic Survey—subsidence surveying

California Department of Fish and Game—fish and game studies

Contra Costa County Water Agency—industrial water use studies

University of California
Berkeley—electric analog model of Delta channels
Davis—organic soil salination research

Stanford University—salinity incursion analyses

Parsons, Brinckerhoff, Hall and Macdonald—recreation studies

WESTERN DELTA ADVISORY COMMITTEE

A special Western Delta Advisory Committee was established at the suggestion of the Director of Water Resources to advise the department, primarily on studies of water requirements and plans in the western Delta. Committee membership, which has not endorsed all aspects of this report, included:

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San Joaquin County

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