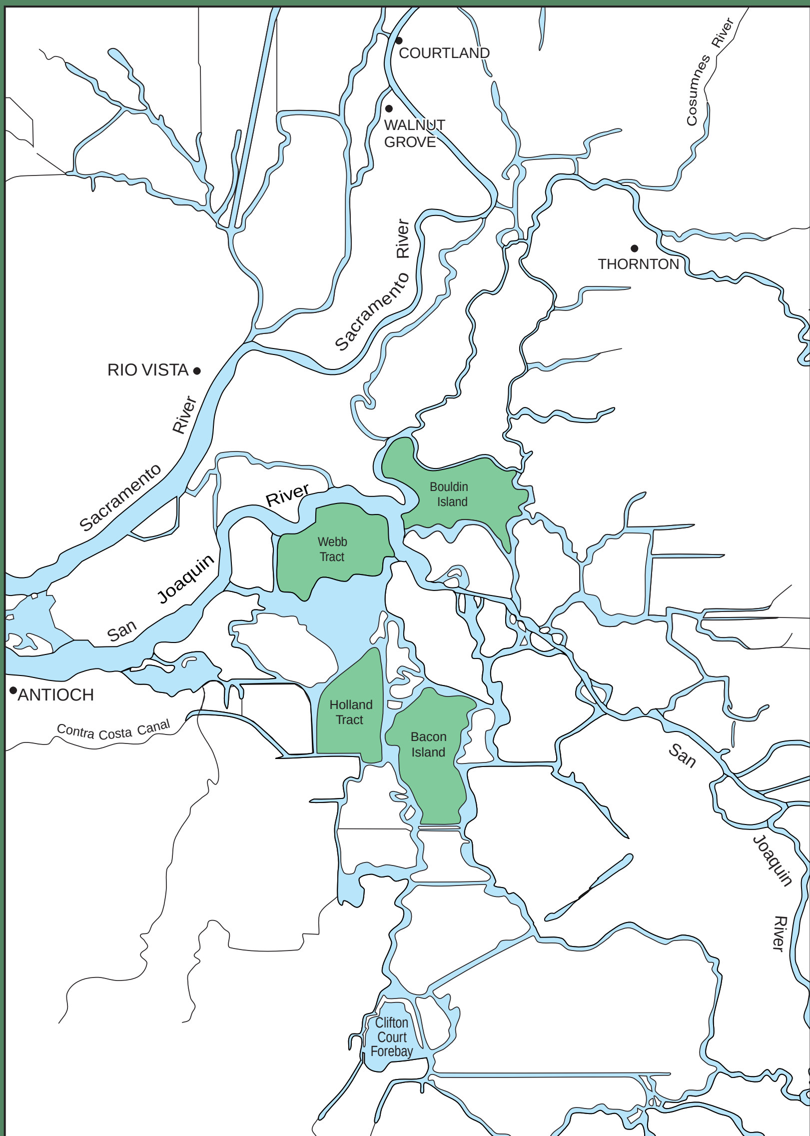
Final
Environmental Impact Statement



July 2001

Delta Wetlands Project

Volume 1

Prepared for:

U.S. Army Corps of Engineers
Sacramento District

Prepared by:

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Final
Environmental Impact Statement
for the Delta Wetlands Project

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Final
Environmental Impact Statement
for the Delta Wetlands Project

Lead Agency:	U.S. Army Corps of Engineers Sacramento District Sacramento, California
Proposed Action:	Delta Wetlands proposes to divert and store water on two Sacramento-San Joaquin Delta islands (Bacon Island and Webb Tract, or "reservoir islands") for later discharge for export or to meet outflow or environmental requirements for the San Francisco Bay/Sacramento-San Joaquin Delta estuary; and to divert water seasonally to create and manage wetlands and wildlife habitat on two Delta islands (Bouldin Island and most of Holland Tract, or "habitat islands").
Location:	Contra Costa and San Joaquin Counties, California
Document:	This Final Environmental Impact Statement (FEIS) is prepared in compliance with the National Environmental Quality Act (NEPA). The FEIS analyzes the impacts of the proposed project alternatives. The impact areas evaluated include water supply and water project operations; hydrodynamics; water quality; flood control; utilities and highways; fishery resources; vegetation and wetlands; wildlife; land use and agriculture; recreation and visual resources; economic conditions and effects; traffic and navigation; cultural resources; mosquitos and public health; and air quality.
For Further Information:	Mr. Mike Finan U.S. Army Corps of Engineers Regulatory Branch Sacramento District 1325 J Street, Room 1480 Sacramento, CA 95814 (916) 557-5324 mfinan@spk.usace.army.mil
Dates:	A permit decision will occur no earlier than 30 days from the date of the *Federal Register* notice of availability and circulation of the FEIS.

Summary

Summary

INTRODUCTION

This Final Environmental Impact Statement (FEIS) for the Delta Wetlands Project has been prepared under the direction of the U.S. Army Corps of Engineers (USACE, or Corps) in accordance with the requirements of the National Environmental Policy Act (NEPA). The environmental impacts of the Delta Wetlands Project (also referred to as the "DW project") were analyzed in the 1995 Delta Wetlands Project Draft Environmental Impact Report and Environmental Impact Statement (1995 DEIR/EIS) (Jones & Stokes Associates 1995) and the 2000 Revised Draft Environmental Impact Report and Environmental Impact Statement for the Delta Wetlands Project (2000 REIR/EIS) (Jones & Stokes 2000). These documents were prepared jointly by the California State Water Resources Control Board (SWRCB) and USACE in compliance with the California Environmental Quality Act (CEQA) and NEPA, respectively.

The Delta is part of an interconnected system that includes Suisun Marsh, San Francisco Bay, and the Sacramento and San Joaquin Rivers. The Bay-Delta estuary is one of the most important and complex estuaries on the Pacific Coast, providing important aquatic and terrestrial habitat for fish, waterfowl, and other wildlife. Water that flows through the Delta supplies a portion of the domestic water supply for over two-thirds of the state's population and irrigates several million acres of farmland.

The purpose of the Delta Wetlands Project is to divert surplus Delta inflows, transferred water, or banked water for later sale and/or release for Delta export or to meet water quality or flow requirements for the Bay-Delta estuary. Additionally, the Delta Wetlands Project would provide managed wetlands and wildlife habitat areas and recreational uses.

The applicant's proposed project, as evaluated in this document, would involve the following major components:

- diverting and storing water on two Sacramento-San Joaquin Delta (Delta) islands (Bacon Island and Webb Tract, or "reservoir islands") for later discharge for export or to meet outflow or environmental requirements for the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) estuary; and

- diverting water seasonally to create and enhance wetlands and to manage wildlife habitat on two Delta islands (Bouldin Island and most of Holland Tract, or "habitat islands").

To operate its project, Delta Wetlands would improve and strengthen levees on all four islands and install additional siphons and water pumps on the perimeters of the reservoir islands. Delta Wetlands would operate the habitat islands under a habitat management plan (HMP) to compensate for impacts on, and promote the recovery of, state-listed threatened or endangered wildlife species and other special-status species, and to provide other wetlands and wildlife habitat in the Delta.

In the 1995 DEIR/EIS, Delta Wetlands proposed to construct recreation facilities along the perimeter levees on all four Delta Wetlands Project islands. These facilities were included as part of the project description when Delta Wetlands submitted its application for water rights to the SWRCB and applied to USACE for authorization under the Clean Water Act (CWA) and Rivers and Harbors Act of 1899. Both the 1995 DEIR/EIS and the 2000 REIR/EIS provided conceptual descriptions of the recreation facilities and analyzed the effects that facility construction and operation would have on the environment. The water right permit issued by the SWRCB and the biological opinions issued by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and California Department of Fish and Game (DFG) for the proposed project include terms and conditions governing construction and operation of these facilities.

In May 2001, however, Delta Wetlands removed construction of recreation facilities from its CWA and

Rivers and Harbors Act permit applications; therefore, USACE will not include construction or operation of such facilities in any permit issued pursuant to Delta Wetlands' current application. Nevertheless, as information for the reader, this FEIS includes the conceptual descriptions of the recreation facilities, the analysis of their environmental effects, and responses to comments on the 1995 DEIR/EIS and 2000 REIR/EIS about the facilities. Delta Wetlands may subsequently apply for CWA and Rivers and Harbors Act permits for some or all of these recreation facilities; in such a case, separate environmental analysis would be required. The information developed in this EIS may be used in any subsequent environmental assessment as appropriate.

CEQA/NEPA PROCESS

The purposes of this document are to analyze and disclose the environmental effects of Delta Wetlands' project, to identify ways to reduce or avoid potential adverse environmental impacts resulting from the project, and to identify and assess alternatives to the proposed action.

CEQA and NEPA require environmental analyses for local, state, and federal permitting processes. Delta Wetlands has applied to USACE for a permit under Section 404 of the CWA and Section 10 of the Rivers and Harbors Act of 1899 to discharge dredged or fill material into waters of the United States and for other project activities in navigable waters. Delta Wetlands also has applied to the SWRCB's Division of Water Rights for the necessary permits to divert water and store it on the Delta Wetlands Project islands for discharge into Delta channels for export or to meet Bay-Delta estuary outflow requirements.

Because of Delta Wetlands' applications to USACE and the SWRCB, USACE is deemed the lead agency under NEPA and the SWRCB is deemed the lead agency under CEQA.

The SWRCB prepared a separate Final Environmental Impact Report (FEIR) in January 2001 to respond to public and agency comments on the 1995 DEIR/EIS and the 2000 REIR/EIS. USACE has prepared this FEIS to respond to agency and public comments received on those documents to provide a rewritten version of the EIS as required by NEPA. This FEIS includes the analysis of project effects presented in the 1995 DEIR/EIS and 2000 REIR/EIS and reflects information that has changed or been updated since those documents were published.

Department of the Army Permit Application Process

Section 404 of the CWA prohibits the discharge of dredged or fill material into waters of the United States, including wetlands, unless a permit is obtained from USACE. Section 10 of the Rivers and Harbors Act of 1899 prohibits work affecting the course, location, conditions or capacity of navigable waters of the United States without a permit from USACE. Delta Wetlands is required to obtain a permit from USACE for Delta Wetlands Project fill activities associated with perimeter and interior levee work on the reservoir islands; habitat enhancement activities on the habitat islands; and construction of boat docks, pumps, and siphons in Delta channels. As part of compliance with the CWA, Section 401 requires SWRCB certification that the proposed discharge complies with state water quality standards.

Water Right and Permit Application Process

Delta Wetlands has applied for new appropriative water rights for direct diversion and storage of surplus Delta inflows for later discharge for export or to meet Bay-Delta estuary water quality or flow requirements. The SWRCB would have to provide separate authorization if proposals were made for use of the Delta Wetlands Project islands for diversion and discharge of transferred or banked water. The SWRCB adopted Water Right Decision 1643 for the Delta Wetlands Project on February 15, 2001.

PURPOSE OF THE FINAL ENVIRONMENTAL IMPACT STATEMENT AND REQUIREMENTS FOR ADOPTION

The FEIS analyzes and discloses the environmental effects of the Delta Wetlands Project, identifies ways to reduce or avoid potential adverse environmental effects of the project, and identifies and assesses alternatives to the proposed action. Under

NEPA, after a lead agency has completed a draft EIS, it must consult with and obtain comments from public agencies that have legal jurisdiction with respect to the proposed project, and must provide the general public with opportunities to comment on the draft document (40 CFR 1503.1). A FEIS is prepared to respond to those comments and to present the text of the EIS with revisions and updates incorporated.

USACE will circulate this FEIS for 30 days before it makes a decision on the proposal. If USACE determines that the FEIS meets NEPA requirements, it will adopt the document. When it decides on Delta Wetlands' Section 404 and Section 10 permit applications, USACE will prepare a record of decision regarding its determination, the alternatives analyzed, the mitigation measures required as a condition of permit approval, and monitoring and enforcement of the required mitigation measures.

PROJECT ALTERNATIVES

Three project alternatives and the No-Project Alternative, described below, were selected to represent the range of project operations for purposes of determining environmental impacts; all alternatives are designed to operate within the objectives of the SWRCB's 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP):

Alternative 1 consists of operation of two reservoir islands and two habitat islands and implementation of a habitat management plan (HMP). Under Alternative 1, Delta Wetlands discharges would be subject to "percent of inflow" export limits specified in the 1995 WQCP.

Alternative 2 consists of operation of two reservoir islands and two habitat islands and implementation of an HMP. Under Alternative 2, Delta Wetlands discharges for export would not be subject to strict interpretation of the 1995 WQCP "percent of inflow" export limits.

Alternative 3 consists of operation of four reservoir islands, with limited compensation habitat provided in the North Bouldin Habitat Area (NBHA) on Bouldin Island. Under Alternative 3, discharges for export would not be subject to strict interpretation of the 1995 WQCP "percent of inflow" export limits.

The No-Project Alternative consists of intensified agricultural production on all four Delta Wetlands Project islands.

Alternatives 1 and 2

Alternatives 1 and 2 entail the potential year-round diversion and storage of water on Bacon Island and Webb Tract, and wetland and wildlife habitat creation and management on Bouldin Island and Holland Tract. Alternatives 1 and 2 include construction of recreation facilities along the perimeter levees of all four islands; however, as described above, Delta Wetlands has removed construction of these facilities from its USACE permit application.

To operate Alternative 1 or 2, Delta Wetlands would improve levees on the perimeters of the reservoir islands and install additional siphons and water pumps. Inner levee systems (i.e., berms) would also be constructed on both the reservoir and habitat islands for shallow-water management.

Under Alternative 1 or 2, during periods of availability throughout the year, water would be diverted onto the reservoir islands to be stored for later sale or release and would be discharged from the islands into Delta channels for sale for beneficial uses for export or for Bay-Delta estuary needs during periods of demand. Discharges from the islands would be subject to state and federal regulatory standards, endangered species protection measures, and Delta export pumping capacities. Storage capacity on the reservoir islands would total an estimated 238 thousand acre-feet (TAF), allocated between Bacon Island and Webb Tract as 118 TAF and 120 TAF, respectively. Water would be diverted onto the habitat islands to be used for creation and management of wetlands and wildlife habitat during periods of availability and need.

Portions of the habitat islands and the reservoir islands would support recreational activities. Up to 38 private recreation facilities may be located on the perimeter levees of all four islands. These recreation facilities, with up to 40 bedrooms each, would include boat docks in adjacent channels, with 30 boat berths, and boat docks on the island interiors, with up to 36 boat berths, that may be operated year round. Subject to restrictions in the HMP, waterfowl hunting would be allowed on all four Delta Wetlands Project islands.

Delta Wetlands would operate a private airstrip on Bouldin Island for maintenance and recreational use. Use of the airstrip would be restricted by the HMP during the waterfowl season to minimize disturbance to wildlife. No restrictions would apply during other times of the year.

Alternative 3

Under Alternative 3, all four Delta Wetlands Project islands would be managed for year-round diversion and storage of water. This alternative represents the maximum water appropriations that would be achieved under all Delta Wetlands' water right applications. It also represents the maximum amount of water storage that would be feasible on the four project islands based on levee height and internal elevation. Storage capacity under Alternative 3 would total an estimated 406 TAF. Project operations under this alternative would be the same as those under Alternative 2 with respect to diversion, discharge, and recreation operations and construction of recreation facilities. Water storage operations would require substantial investments in internal levee construction on Bouldin Island. A habitat reserve would be created north of State Route (SR) 12 on Bouldin Island to compensate for some of the wildlife and wetland impacts associated with water storage operations. Additional offsite wildlife habitat and wetland compensation would be required for this alternative.

No-Project Alternative

The No-Project Alternative entails Delta Wetlands implementing intensive agricultural operations on the four project islands or selling the property to another entity that would likely implement intensive agriculture. The No-Project Alternative is based on the assumption that intensified agricultural conditions represent the most realistic scenario for the Delta Wetlands Project islands if permit applications are denied. It is assumed that no new Delta Wetlands recreation facilities would be built.

CHANGES MADE TO THE PROPOSED PROJECT FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The project description and the treatment of project alternatives were modified in the 2000 REIR/EIS. USFWS and NMFS issued no-jeopardy biological opinions in 1997 regarding effects of the Delta Wetlands Project on federally listed fish species, and DFG issued a no-jeopardy opinion in 1998 on project effects on state-listed fish, wildlife, and plant species. USFWS and NMFS also issued no-jeopardy biological opinions in 2000 for these fish species and designated critical habitats that were listed after the 1997 opinions were issued. The findings of no jeopardy were based on incorporation into the proposed project of the detailed project operating parameters referred to as the Delta Wetlands "final operations criteria" (FOC). The FOC were developed by the SWRCB, USACE, NMFS, USFWS, and DFG as part of the formal consultation process for listed fish species. The biological opinions and the FOC were developed for the proposed two-reservoir-island project. The descriptions of Alternatives 1 and 2 provided in the 1995 DEIR/EIS were therefore revised in the 2000 REIR/EIS to incorporate these restrictions. These revisions are reflected in this FEIS.

The description of the proposed project as revised includes construction and operation of recreation facilities on all four project islands. In May 2001, however, Delta Wetlands removed construction of these facilities from its CWA and Rivers and Harbors Act permit applications. The conceptual descriptions of the recreation facilities remain largely unchanged from those included in the 1995 DEIR/EIS; they are presented in this FEIS for informational purposes. Also included are the analyses of the environmental effects of facility construction and operation, and responses to comments on the 1995 DEIR/EIS and 2000 REIR/EIS about the recreation facilities.

IMPACT ASSESSMENT OF ALTERNATIVES

Approach to Impact Analysis

The impact analysis for each resource topic in this document identifies and compares the probable impacts of each alternative specific to the resource topic. These comparative analyses highlight differences and similarities in predicted impacts between the alternatives.

For those chapters not addressing water resources, impacts were addressed through comparison between expected conditions associated with the Delta Wetlands Project alternatives and existing conditions. For those chapters assessing water resource effects of the Delta Wetlands Project (Chapter 3A, "Water Supply and Water Project Operations"; Chapter 3B, "Hydrodynamics"; Chapter 3C, "Water Quality"; and Chapter 3F, "Fishery Resources"), impacts were assessed through comparison between simulated (modeled) conditions associated with each alternative and with the No-Project Alternative as described below.

Evaluating Environmental Changes and Effects on Water Resources

Simulated effects of Delta Wetlands Project operations on the Delta cannot be directly compared with the historical record of Delta operations for purposes of impact assessment because historical Delta operations did not include current operating criteria; facilities; and conditions, such as upstream and export demands for water. To provide a point of reference for assessing the impacts of simulated operations of the Delta Wetlands Project alternatives, it was therefore necessary to also simulate a baseline condition consisting of the same operating conditions but without operations of the Delta Wetlands Project. This point of reference is the simulated No-Project Alternative.

Levels of Impacts Considered

The impact analysis used in the resource chapters was designed to comply with NEPA and CEQA guidelines. For each resource topic, three levels of impacts were considered:

direct impacts on the Delta Wetlands Project islands and on adjacent Delta channels;

indirect impacts on the project vicinity, including the Delta, Suisun Marsh, San Francisco Bay and, in some cases, upstream areas, induced by direct project-related changes in the environment; and

cumulative impacts.

The study area for analysis of direct project impact consists of the four project islands, surrounding channels, and adjacent islands. The study area for analysis of indirect impacts is the vicinity of the statutory Delta, as defined by Section 12220 of the California Water Code, and the hydrologically related Suisun Marsh and San Francisco Bay. In some cases, upstream areas are included in the study area for indirect impacts. The study area for cumulative impact analysis consists of the combination of the direct and indirect impact areas.

Where uncertainty exists in predicting the extent of project construction and operations, the impact analysis is based on "worst-case" conditions. For example, because Delta Wetlands is not certain of the size of the various recreation facilities, the impact analysis is based on the assumption that the largest possible facility would be built at all locations, even though it may not be realistic to have a facility of this size at every location.

Mitigation Measures

Where the Delta Wetlands Project alternatives are predicted to cause significant impacts, mitigation measures are identified. In accordance with NEPA and CEQA guidelines, measures are proposed that would avoid, minimize, rectify, reduce, or compensate for the predicted impacts.

The feasibility and effectiveness of the mitigation measures are described to the extent possible. Mitigation measures include modifying the project design or operations to reduce predicted impacts to less-than-significant levels wherever feasible. Mitigation measures are presented for effects of the No-Project Alternative to provide information regarding measures that would reduce effects of the No-Project Alternative. These measures would not be required under the No-Project Alternative; however, this information will allow for a more realistic comparison of the Delta Wetlands Project alternatives.

Comparison of Impacts of Alternatives

Results of impact analyses for each alternative are summarized in Table S-1. This table shows impacts by resource topics, level of significance without mitigation, mitigation measures to reduce impacts, and level of significance with mitigation. The sequence of resource topics in the table conforms to the sequence of chapters in the document.

SUMMARY OF PROJECT EFFECTS ON WATERS OF THE UNITED STATES

The Delta Wetlands Project would affect waters of the United States (waters of the U.S.), including wetlands, that are regulated by USACE under Section 404 of the CWA on the project island interiors and under Section 10 of the Rivers and Harbors Act for work in channels adjacent to the project islands. Activities that would result in the dredge or fill of waters of the U.S. on island interiors include the placement of new pumps and siphons on the reservoir islands, levee improvements, grading activity for habitat construction on the habitat islands, and water storage operations (i.e., inundation) on the reservoir islands. Activities in the channels adjacent to the project islands include the placement of new pump and siphon stations on the reservoir islands, removal of some existing siphon stations, and installation of fish screens on existing siphon stations. Construction of boat docks associated with the recreation facilities would also result in fill or dredge activities; however, as described above, Delta Wetlands has removed construction of these facilities from its CWA and Rivers and Harbors Act permit applications.

In December 1994 and January 1995, USACE and the Natural Resource Conservation Service (NRCS), respectively, verified a delineation of waters of the U.S., including wetlands, on the Delta Wetlands project islands. The verifications expired 5 years after they were issued. Delta Wetlands is currently working with USACE and Jones & Stokes to update the delineation to reflect current conditions on the project islands. The updated delineation will identify waters of the U.S., including wetlands, on the project islands and in channels where project facilities (e.g., pump and siphon stations) would be located. USACE will verify the new delineation before it issues a decision on the project.

Table S-2 summarizes the estimated effects of the applicant's proposed project on waters of the U.S. based on the delineation verified in 1994 and 1995 and on preliminary investigations. Before issuing a permit under the CWA and Rivers and Harbors Act, USACE will revise these estimates based on more detailed investigations conducted to update the existing delineation. Because farming conditions on the project islands have not substantially changed since 1994, the estimated acreage of wetland impacts presented in Table S-2 is not expected to change significantly.

Project effects on Section 404 jurisdictional wetlands on the island interiors are further described in Chapter 3G, "Vegetation and Wetlands" of this FEIS volume and in Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation" of the 1995 DEIR/EIS. To offset impacts on jurisdictional wetlands, mitigation wetlands would be constructed on the habitat islands as described in the HMP. For activities in the adjacent channels, areas of temporary (construction-related) effects are distinguished in Table S-2 from the amount of permanent fill associated with placement of structures in the channels. The biological opinions from the USFWS, NMFS, and DFG identify mitigation measures for project activities in the channels; these measures are discussed in Chapter 3F, "Fisheries", of this FEIS volume.

PERMIT AND ENVIRONMENTAL REVIEW AND CONSULTATION REQUIREMENTS

In addition to the entitlements required by the SWRCB and USACE, the Delta Wetlands Project requires compliance with other state and federal laws, including the Endangered Species Act, the Fish and Wildlife Coordination Act, the National Historic Preservation Act, and the California Endangered Species Act. Permits and other authorizations may also be required from regional and local agencies, including the Bay Area Air Quality Management District, San Joaquin Valley Unified Air Pollution Control District, Contra Costa and San Joaquin County planning and public works departments, State Division of

Aeronautics, and reclamation districts. Chapter 4, "Permit and Environmental Review and Consultation Requirements", describes these requirements.

IMPACT CONCLUSIONS

In accordance with NEPA and CEQA, this document focuses on the predictable changes in the environment for each of the project alternatives. The changes in the environment analyzed in this document encompass water resources and the aquatic ecosystem; vegetation, wetlands, and wildlife resources; flood control; public services and health; land uses; cultural resources; traffic and air quality; and economic issues.

This document analyzes the environmental effects of Delta Wetlands' project, identifies ways to reduce or avoid potential environmental impacts resulting from the project, and identifies and assesses alternatives to the proposed action. The following sections identify the environmentally superior alternative, the irreversible or irretrievable commitments of resources, growth inducement, and areas of controversy regarding the proposed project.

Environmentally Superior Alternative

The alternatives selected for analysis comply with the NEPA and CEQA requirement to analyze a reasonable range of alternatives and with the U.S. Environmental Protection Agency's (EPA's) Section 404(b)(1) guidelines requirement for USACE to demonstrate that it is issuing a permit under Section 404 of the CWA to the least environmentally damaging practicable alternative. The EIR/EIS lead agencies initially considered a broad range of actions that potentially could have been considered as alternatives to the proposed project. This list of alternatives was then narrowed to those analyzed in this document to include only those reasonably foreseeable alternatives that could meet the overall project purpose, given considerations of cost, existing technology, and logistics. The Section 404(b)(1) Alternatives Analysis for the Delta Wetlands Project, prepared under a separate cover for submittal to EPA and included as Appendix 4 of the 1995 DEIR/EIS, presents the alternatives analysis leading up to the selection of alternatives for assessment in this document. The environmental impact assessment, in combination with the Section 404(b)(1) alternatives analysis, presents the EIR/EIS lead agencies' process for determining the environmentally superior alternative for CEQA and NEPA purposes and the least environmentally damaging practicable alternative for Section 404(b)(1) purposes.

All the alternatives, including the No-Project Alternative, would cause significant and unavoidable environmental impacts. Although no mitigation measures would be implemented if USACE and the SWRCB denied approval of the Delta Wetlands Project and "adopted" the No-Project Alternative, it could be argued that because the No-Project Alternative would not involve any significant water operations, it would cause the least severe environmental impacts. However, the No-Project Alternative was eliminated from consideration as a practicable alternative to the proposed project because it would not meet the project purpose. It is analyzed in this document to satisfy the requirements of CEQA and NEPA.

Among those alternatives considered practicable, Alternative 3 would cause the most severe environmental impacts (see Table S-1). All impacts associated with reservoir island water operations under Alternatives 1 and 2 would occur with implementation of Alternative 3, but would be greater because Alternative 3 would generally have twice the storage capacity of Alternative 1 or 2. Alternative 3 would affect resources through water storage operations on Bouldin Island and Holland Tract that would not occur under Alternatives 1 and 2. Additionally, Alternative 3 would not have the benefits associated with implementation of the HMP that would occur with Alternatives 1 and 2.

The environmental effects of Alternative 1 and 2 are nearly identical. The project descriptions of the two alternatives differ only with regard to discharges of stored water. As stated above, it was assumed that under Alternative 2, discharges from storage would not be subject to strict interpretation of the 1995 WQCP "percent of inflow" export limit and would therefore be slightly more frequent than discharges under Alternative 1. Alternative 2 would allow more frequent discharges from the Delta Wetlands reservoir islands for export at the Central Valley Project (CVP) and State Water Project (SWP) pumping plants and would have a slightly larger potential to increase the supply of water for export from the Delta. However, the period of discharge may be shorter for Alternative 2.

Therefore, the monthly average changes in export simulated for Alternatives 1 and 2 were very similar.

The biological opinions and protest dismissal agreements that have been adopted since the 1995 DEIR/EIS was issued specify numerous restrictions on project operations; with these restrictions incorporated into project operations, there would be little difference between the environmental effects of Alternatives 1 and 2. Therefore, the applicant's proposed project, as mitigated by the biological opinions and other project limits, is considered the environmentally superior alternative.

Preferred Alternative

The applicant's preferred alternative is the proposed project as represented by Alternative 2 (as modified by incorporation of the biological opinions, FOC, and protest dismissal agreements). As reported in the 1995 DEIR/EIS, Alternative 2, with a higher amount of discharge pumping than Alternative 1, would have the maximum effect on fisheries associated with the proposed project. Alternative 2 was therefore used to represent the proposed project in the biological assessment for fish species (see Appendix F2). The terms and conditions of the DFG, USFWS, and NMFS biological opinions are based on this alternative.

This FEIS describes the changes made to the proposed project as part of the biological opinions and protest dismissal agreements. With these conditions and modifications in place, the environmental effects of the proposed project would be less than those reported in the 1995 DEIR/EIS.

Irreversible or Irretrievable Commitments of Resources

Irretrievable commitment of resources would occur as a result of implementation of the proposed project. The resources that would be irretrievably committed are associated with construction, operation, and maintenance of the project facilities and include building materials, fossil fuels, labor, energy resources, and land converted from its present uses. However, most of the land converted for water storage and wetland and wildlife habitat creation could physically be converted back to existing land uses, although project permit conditions would make this unlikely.

Growth Inducement

The proposed project is considered growth inducing because it either would add water directly for export to municipal water supplies or agricultural production to support growth, or would be used for water quality or environmental requirements in substitution for other water that could be used to support growth. The additional water supply that could be provided by the Delta Wetlands Project may induce growth in areas south of the Delta, resulting in secondary environmental impacts. More farmland could also be brought into production if water supplies expanded or became more reliable as a result of Delta Wetlands Project implementation.

The environmental documentation prepared by local, state, and federal agencies that approve and provide permits for residential, commercial, and industrial projects in the SWP and CVP service areas would identify site- and resource-specific growth inducement impacts resulting from the provision of Delta Wetlands Project water. Mitigation measures implemented by agencies with jurisdiction over urban development projects would address many of the secondary impacts associated with the growth induced by the Delta Wetlands Project. A detailed analysis of potential growth-inducing effects of the Delta Wetlands Project is provided in Chapter 2, "Master Responses: Discussions of Recurring Themes", in Volume 2 of this FEIS.

Areas of Known Controversy

Several areas of controversy regarding potential Delta Wetlands Project effects were discussed in comments on the 1995 DEIR/EIS and were the subject of conflicting water right hearing testimony. Most of the issues that were related to project effects on protected fish species have since been resolved by incorporation into the project of the FOC and reasonable and prudent measures (RPM) described in the state and federal biological opinions. Other controversial issues—project effects on dissolved organic carbon (DOC) and THM formation, levee stability, seepage, and Pacific Gas and Electric (PG&E)

maintenance of gas lines—were addressed in the 2000 REIR/EIS.

The following sections summarize the specific areas of controversy that remained after the 2000 REIR/EIS was released. Many of these issues are addressed further in Chapter 2, "Master Responses: Discussions of Recurring Themes", of Volume 2 of this FEIS.

Integration of the Delta Wetlands Project with Federal and State Water Project Operations

For purposes of this analysis, the Delta Wetlands Project is analyzed as a stand-alone water storage facility, operated independently of the SWP and the CVP and without regard to the specific entities to which the water could be sold. It is reasonable to assume that Delta Wetlands Project operations could be integrated in the future with operation of the SWP and CVP or other facilities to benefit the environment in addition to the water supply.

Several potential opportunities exist to operate the Delta Wetlands Project in conjunction with the CVP and SWP or in coordination with the CALFED Bay-Delta Program (CALFED). Recently, the U.S. Bureau of Reclamation and California Department of Water Resources have begun to evaluate the potential for lease or purchase of the Delta Wetlands Project. However, no specific proposals have been made for which the lead agencies could reasonably assess the environmental effects. Therefore, discussion of such arrangements would be speculative. When integrated project operations are proposed that would require additional permits or authorizations, additional environmental documentation would be needed to address the environmental effects of those operations.

The Delta Wetlands Project islands also could be used for interim storage of water being transferred through the Delta from sellers upstream to buyers served by Delta exports, or to buyers who would use the water to meet Bay-Delta estuary outflow or environmental requirements (water transfers).

Another option would be to use the islands to temporarily store water owned by parties other than Delta Wetlands for later use to meet scheduled Bay-Delta estuary outflow or environmental requirements or for export (water banking). Environmental effects that may be associated with uses under a third party's water rights are not analyzed in this document. The effects caused by this type of use of the Delta Wetlands Project are unknown; if this type of use were proposed by some party in the future, a separate environmental analysis would be required. Because no proposals exist for these types of uses of the project island facilities, this analysis considers the water supply yield and environmental impacts of the project based only on water stored under Delta Wetlands' own appropriative water right permits and later conveyed to Delta channels.

Potential Project Effects on Dissolved Organic Carbon Levels in Delta Exports

There is much disagreement among experts regarding the amount of DOC loading to stored water that would occur under Delta Wetlands' proposed reservoir storage operations. Because substantial disagreement remains regarding the appropriate levels of DOC loading to use in estimates of Delta Wetlands Project effects, the analysis in this document evaluates effects for a wide range of DOC loading estimates. The range encompasses the loading rates observed in Delta agricultural drainage and in field and laboratory studies of DOC loading from Delta island peat soil.

Relationship of Dissolved Organic Carbon and Bromide in Exports to Disinfection Byproduct Concentrations in Treated Water

Commenters on the 1995 DEIR/EIS and the 2000 REIR/EIS and parties to the water right hearing disputed the accuracy of the methods for determining the formation of disinfection byproducts (DBPs), including trihalomethanes (THMs), as a function of export salinity (Br^-) and DOC concentration. Methods for predicting the relationship between DOC and salinity levels and the formation of THMs and other DBPs at municipal water treatment plants were discussed in the 2000 REIR/EIS. The accuracy of these methods remains an area of controversy.

Appropriateness of the Significance Criteria Used in the Impact Analysis for Water Quality

Several parties to the water right hearing and commenters on the 1995 DEIR/EIS questioned the adequacy of the significance thresholds used in the impact analysis for water quality, arguing that these thresholds would not ensure the protection of all beneficial uses, most notably municipal water uses. The challenges are based on the concern that natural variability differs among water quality constituents and that for certain constituents, any change may constitute an unacceptable degradation of resources that are already impaired.

Several commenters did not recognize the distinction between the CEQA/NEPA significance criteria and the mitigation requirements that the SWRCB would apply in water right permit terms. The significance criteria are used to develop mitigation measures on a monthly time step in an evaluation based on monthly model results; in actual practice, the Delta Wetlands Project would be required to adjust operations each day in response to daily monitoring of actual Delta conditions and the quality of water stored on the Delta Wetlands islands. The mitigation performance requirements used to trigger changes in project operations under the terms and conditions of a water right permit and Section 404 permit, therefore, may differ from the significance criteria used in the impact analysis.

Potential for Increased Municipal Water Treatment Costs Resulting from Project Operations

Some commenters on the 1995 DEIR/EIS and 2000 REIR/EIS and parties to the water right hearing have argued that economic effects on treatment plant operators (i.e., increases in treatment costs) that could result from project-related increases in salinity and DOC concentrations should be considered significant impacts. They requested that the significance criteria for evaluating project effects on total organic compounds (TOC) be adjusted to account for increased treatment plant costs associated with TOC removal requirements and higher disinfectant doses.

Although this document acknowledges that the Delta Wetlands Project may have an effect on the water treatment costs for downstream water users, the economic effect alone is not treated as a significant environmental effect and does not require separate mitigation. Even without considering economic effects, the environmental impact of the Delta Wetlands Project on water quality degradation is deemed significant, and mitigation has been proposed.

Significance Criteria for the Evaluation of Effects on Levee Stability and Regulatory Standards to Be Applied to the Delta Wetlands Project Levees

Parties to the water right hearing have argued that USACE and the SWRCB should identify the levee standards, such as factors of safety (FSs), that would be applied to the Delta Wetlands Project's final levee design. The purpose of the environmental impact assessment is to determine the difference in levee stability between existing conditions and with-project conditions. The relative change in the FSs between the project and existing conditions is used as the basis for evaluating the impact of the proposed project. Because the analysis evaluates the change in levee conditions, a given FS standard cannot be used to determine the significance of the change. However, these standards will be considered during project approval and final design. For example, if the levees are determined to be "dams" as defined by the California Water Code (Sections 6002 through 6008), Delta Wetlands would be required to meet the Division of Safety of Dams' (DSOD's) standards and design review requirements. The determination of which standards apply to the project levees will depend on the final project design.

Effects on Pacific Gas and Electric Company's Ability to Use Its Bacon Island Easements

During the Delta Wetlands water right hearing, PG&E presented testimony regarding its easements and natural gas pipelines that cross Bacon Island. The testimony focused on the ways in which proposed Delta Wetlands water storage operations could adversely affect PG&E's ability to use its easements, decrease the useful life of the pipeline, increase the threat of pipeline damage, and affect pipeline maintenance.

The future use of PG&E's easement is a private property right dispute that will be resolved independent of the USACE and SWRCB approval process; it is not addressed in this evaluation. Issues related to the operation and maintenance of the pipeline on Bacon Island and the possibility of impacts on regional natural gas service are considered potential environmental effects (Table S-1).

Viability of the Project Given the Lack of Identified Purchasers of Delta Wetlands Water

Several commenters on the 1995 DEIR/EIS and the 2000 REIR/EIS, and parties to the water right hearing have questioned the viability of the proposed project, arguing that without identified purchasers of project water, the proposed project is financially infeasible and, therefore, should not be approved by the lead agencies.

Identification of beneficial uses of project water and financial feasibility of the project are water right and public interest issues. These issues are beyond the scope of CEQA and NEPA requirements and the EIR/EIS process, and were not addressed in the 2000 REIR/EIS or the 1995 DEIR/EIS.

CITATIONS

Jones & Stokes Associates, Inc. 1990. Draft EIR/EIS for the Delta islands project of Delta Wetlands, a California Corporation. December. (JSA 87-119.) Sacramento, CA. Prepared for California State Water Resources Control Board, Division of Water Rights, and U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA.

__________. 1995. Environmental impact report and environmental impact statement for the Delta Wetlands Project. Draft. September 11, 1995. Prepared for California State Water Resources Control Board, Division of Water Rights, and U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA. (JSA 87-119.) Sacramento, CA.

Jones & Stokes. 2000. Revised draft environmental impact report and environmental impact statement for the Delta Wetlands Project. May. (J&S 99-162.) Sacramento, CA. Prepared for the California State Water Resources Control Board and the U.S. Army Corps of Engineers, Sacramento, CA.

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
CHAPTER 3A. WATER SUPPLY AND WATER PROJECT OPERATIONS			
Impact A-1: Increase in Delta Consumptive Use (LTS) C No mitigation is required.	**Impact A-2**: Reduction in Delta Consumptive Use (B) C No mitigation is required.	**Impact A-3**: Increase in Delta Consumptive Use (SU) C No mitigation is available.	
Cumulative Impacts			
Impact A-4: Reduction in Delta Consumptive Use under Cumulative Conditions (B) C No mitigation is required.	The cumulative impact listed for Alternative 1 is the same for Alternative 2.	The cumulative impact listed for Alternative 1 is the same for Alternative 3.	
CHAPTER 3B. HYDRODYNAMICS			
Impact B-1: Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Diversions (LTS) C No mitigation is required. **Impact B-2**: Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Discharges (LTS) C No mitigation is required. **Impact B-3**: Hydrodynamic Effects on Net Channel Flows (LTS) C No mitigation is required.	The impacts listed for Alternative 1 are the same for Alternative 2.	**Impact B-4**: Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Diversions (LTS) C No mitigation is required. **Impact B-5**: Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Discharges (LTS) C No mitigation is required. **Impact B-6**: Hydrodynamic Effects on Net Channel Flows (LTS) C No mitigation is required.	
Cumulative Impacts			
Impact B-7: Cumulative Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Diversions (LTS) C No mitigation is required. **Impact B-8:** Cumulative Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Discharges (LTS) C No mitigation is required.	The cumulative impacts listed for Alternative 1 are the same for Alternative 2.	The cumulative impacts listed for Alternative 1 are the same for Alternative 3.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact B-9: Cumulative Hydrodynamic Effects on Net Channel Flows (S) C **Mitigation Measure B-1:** Operate the DW Project to Prevent Unacceptable Hydrodynamic Effects in the Middle River and Old River Channels during Flows That Are Higher Than Historical Flows (LTS)			
CHAPTER 3C. WATER QUALITY			
Impact C-1: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives (LTS) C **Mitigation Measure C-1**: Restrict DW Diversions to Limit EC Increases at Chipps Island (LTS) **Impact C-2**: Salinity (EC) Increase at Emmaton (S) C **Mitigation Measure C-2**: Restrict DW Diversions to Limit EC Increases at Emmaton (LTS) **Impact C-3**: Salinity (EC) Increase at Jersey Point (S) C **Mitigation Measure C-3**: Restrict DW Diversions to Limit EC Increases at Jersey Point (LTS) **Impact C-4**: Salinity (Chloride) Increase in Delta Exports (LTS) C **Mitigation Measure C-4**: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports (LTS) **Impact C-5**: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) (S) C **Mitigation Measure C-5**: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports (LTS)	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact C-9**: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives (S) C **Mitigation Measure C-1**: Restrict DW Diversions to Limit EC Increases at Chipps Island (LTS) **Impact C-10**: Salinity (EC) Increase at Emmaton during April-August (S) C **Mitigation Measure C-2**: Restrict DW Diversions to Limit EC Increases at Emmaton (LTS) **Impact C-11**: Salinity (EC) Increase at Jersey Point during April-August (S) C **Mitigation Measure C-3**: Restrict DW Diversions to Limit EC Increases at Jersey Point (LTS) **Impact C-12**: Salinity (Chloride) Increase in Delta Exports (S) C **Mitigation Measure C-4**: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports (LTS) **Impact C-13**: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) (S) C **Mitigation Measure C-5**: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports (LTS)	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact C-6: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) (S)		**Impact C-14**: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) (S)	
C **Mitigation Measure C-6**: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater than 72 Fg/l in Treated Delta Export Water (LTS)		C **Mitigation Measure C-6**: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater than 72 Fg/l in Treated Delta Export Water (LTS)	
Impact C-7: Changes in Other Water Quality Variables in Delta Channel Receiving Waters (S)		**Impact C-15**: Changes in Other Water Quality Variables in Delta Channel Receiving Waters (S)	
C **Mitigation Measure C-7**: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality (LTS)		C **Mitigation Measure C-7**: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality (LTS)	
Impact C-8: Potential Contamination of Stored Water by Pollutant Residues (S)		**Impact C-16**: Potential Contamination of Stored Water by Pollutant Residues (S)	
C **Mitigation Measure C-8**: Conduct Assessments of Potential Contamination Sites and Remediate as Necessary (LTS)		C **Mitigation Measure C-8**: Conduct Assessments of Potential Contamination Sites and Remediate as Necessary (LTS)	
Cumulative Impacts			
Impact C-17: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives under Cumulative Conditions (LTS)	The cumulative impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact C-25:** Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives under Cumulative Conditions (S)	
C **Mitigation Measure C-1:** Restrict DW Diversions to Limit EC Increases at Chipps Island (LTS)		C **Mitigation Measure C-1:** Restrict DW Diversions to Limit EC Increases at Chipps Island (LTS)	
Impact C-18: Salinity (EC) Increase at Emmaton under Cumulative Conditions (S)		**Impact C-26:** Salinity (EC) Increase at Emmaton under Cumulative Conditions (S)	
C **Mitigation Measure C-2**: Restrict DW Diversions to Limit EC Increases at Emmaton (LTS)		C **Mitigation Measure C-2**: Restrict DW Diversions to Limit EC Increases at Emmaton (LTS)	
Impact C-19: Salinity (EC) Increase at Jersey Point under Cumulative Conditions (S)		**Impact C-27:** Salinity (EC) Increase at Jersey Point under Cumulative Conditions (S)	
C **Mitigation Measure C-3**: Restrict DW Diversions to Limit EC Increases at Jersey Point (LTS)		C **Mitigation Measure C-3**: Restrict DW Diversions to Limit EC Increases at Jersey Point (LTS)	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact C-20: Salinity (Chloride) Increase in Delta Exports under Cumulative Conditions (LTS)		**Impact C-28:** Salinity (Chloride) Increase in Delta Exports under Cumulative Conditions (S)	
C **Mitigation Measure C-4**: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports (LTS)		C **Mitigation Measure C-4**: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports (LTS)	
Impact C-21: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions (S)		**Impact C-29:** Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions (S)	
C **Mitigation Measure C-5**: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports (LTS)		C **Mitigation Measure C-5**: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports (LTS)	
Impact C-22: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions (S)		**Impact C-30:** Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions (S)	
C **Mitigation Measure C-6**: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater than 72 Fg/l in Treated Delta Export Water (LTS)		C **Mitigation Measure C-6**: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater than 72 Fg/l in Treated Delta Export Water (LTS)	
Impact C-23: Changes in Other Water Quality Variables in Delta Channel Receiving Waters under Cumulative Conditions (S)		**Impact C-31:** Changes in Other Water Quality Variables in Delta Channel Receiving Waters under Cumulative Conditions (S)	
C **Mitigation Measure C-7**: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality (LTS)		C **Mitigation Measure C-7**: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality (LTS)	
Impact C-24: Increase in Pollutant Loading in Delta Channels (SU) *		**Impact C-32:** Increase in Pollutant Loading in Delta Channels (SU)	
C **Mitigation Measure C-9**: Clearly Post Waste Discharge Requirements, Provide Waste Collection Facilities, and Educate Recreationists regarding Illegal Discharges of Waste		C **Mitigation Measure C-9**: Clearly Post Waste Discharge Requirements, Provide Waste Collection Facilities, and Educate Recreationists regarding Illegal Discharges of Waste	
C **Mitigation Measure RJ-1:** Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)		C **Mitigation Measure RJ-1:** Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
CHAPTER 3D. FLOOD CONTROL			
Impact D-1: Change in Long-Term Levee Stability on Reservoir Islands (S) C **Mitigation Measure RD-1:** Adopt Final Levee Design That Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure (LTS) **Impact D-2**: Potential for Seepage from Reservoir Islands to Adjacent Islands (S) C **Mitigation Measure RD-2:** Modify Seepage Monitoring Program and Seepage Performance Standards (LTS) **Impact D-3**: Potential for Wind and Wave Erosion on Reservoir Islands (LTS) C No mitigation is required. **Impact D-4**: Potential for Erosion of Levee Toe Berms at Pump Stations and Siphon Stations on Reservoir Islands (LTS) C No mitigation is required. **Impact D-5**: Change in Potential for Levee Failure on DW Project Islands during Seismic Activity (S) C **Mitigation Measure RD-1:** Adopt Final Levee Design That Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure (LTS) **Impact D-6**: Increase in Long-Term Levee Stability on Habitat Islands (B) C No mitigation is required.	The impacts listed for Alternative 1 are the same for Alternative 2.	**Impact D-7**: Change in Long-Term Levee Stability on Reservoir Islands (S) C **Mitigation Measure RD-1:** Adopt Final Levee Design That Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure (LTS) **Impact D-8**: Potential for Seepage from Reservoir Islands to Adjacent Islands (S) C **Mitigation Measure RD-2:** Modify Seepage Monitoring Program and Seepage Performance Standards (LTS) **Impact D-9**: Potential for Wind and Wave Erosion on Reservoir Islands (LTS) C No mitigation is required. **Impact D-10**: Potential for Erosion of Levee Toe Berms at Pump Stations and Siphon Stations on Reservoir Islands (LTS) C No mitigation is required. **Impact D-11**: Change in Potential for Levee Failure on DW Project Islands during Seismic Activity (S) C **Mitigation Measure RD-1:** Adopt Final Levee Design That Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure (LTS)	Decrease in Long-Term Levee Stability C Buttress Perimeter Levees Increase in Potential for Seepage onto Project Islands Increase in Potential for Levee Failure during Seismic Activity

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Cumulative Impacts			
Impact D-12: Decrease in Cumulative Flood Hazard in the Delta (B) C No mitigation is required. **Impact D-13**: Decrease in the Need for Public Financing of Levee Maintenance and Repair on the DW Project Islands (B) C No mitigation is required.	The cumulative impacts listed for Alternative 1 are the same for Alternative 2.	The cumulative impacts listed for Alternative 1 are the same for Alternative 3.	
CHAPTER 3E. UTILITIES AND HIGHWAYS			
Impact E-1: Increase in the Structural Integrity of County Roads (B) C No mitigation is required. **Impact E-2**: Reduction in Ferry Traffic from Jersey Island to Webb Tract (LTS) * C No mitigation is required. **Impact E-3**: Increase in the Risk to Gas Lines Crossing Exterior Levees on Bacon Island Resulting from Levee Improvements (S) C **Mitigation Measure RE-1:** Monitor Locations Where Gas Pipelines Cross Bacon Island Levees during and after Levee Construction C **Mitigation Measure RE-2:** Implement Corrective Measures to Reduce Risk of Pipeline Failure during Levee Construction (LTS) **Impact E-4**: Increase in PG&E Response Time to Repair a Gas Line Failure on Bacon Island C No significance conclusion is made and no mitigation is identified for this potential economic effect on PG&E's operation. **Impact RE-1**: Increase in the Risk to Line 57-A from Island Inundation (S) C **Mitigation Measure RE-3**: Securely Anchor Line 57-A before Bacon Island Flooding (LTS)	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2	**Impact E-13**: Increase in the Structural Integrity of County Roads (B) C No mitigation is required. **Impact E-14:** Increase in the Risk of Structural Failure of SR 12 (LTS) C **Mitigation Measure E-8:** Coordinate Design and Construction of Wilkerson Dam with Caltrans and DSOD (LTS) **Impact E-15**: Increase in the Fog Hazard on SR 12 (SU) C No mitigation is available. **Impact E-16**: Reduction in Ferry Traffic from Jersey Island to Webb Tract (LTS) C No mitigation is required. **Impact E-17**: Increase in the Risk to Gas Lines Crossing Exterior Levees on Bacon Island Resulting from Levee Improvements (S) C **Mitigation Measure RE-1**: Monitor Locations Where Gas Pipelines Cross Bacon Island Levees during and after Levee Construction C **Mitigation Measure RE-2**: Implement Corrective Measures to Reduce Risk of Pipeline Failure during Levee Construction (LTS)	Increase in the Risk of Road Failure and Maintenance and Repair Needs C Buttress Perimeter Levees Increase in Maintenance Requirements for Gas Lines on Bacon Island Increase in the Risk of Structural Failure and Increase in Maintenance Requirements for Existing Distribution Utilities C Buttress Perimeter Levees

Table S-1. Continued

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact RE-2: Potential Interference with Pipeline Inspection Procedures (S) C **Mitigation Measure RE-4**: Provide Adequate Facilities on Bacon Island for Annual Pipeline Inspection C **Mitigation Measure RE-5**: Relocate Cathodic Protection Test Stations before Bacon Island Flooding (LTS) **Impact E-5**: Inundation of Electrical Distribution Utilities on the Reservoir Islands (S) C **Mitigation Measure E-1**: Relocate Electrical Distribution Lines to the Perimeter Levee around Webb Tract (LTS) **Impact E-6**: Possible Need to Increase Capacity of the Existing Electrical Distribution Lines on the DW Project Islands (LTS) * C No mitigation is required. **Impact E-7**: Possible Need to Expand the Existing Electrical Distribution Lines on Webb Tract, Bouldin Island, and Holland Tract to Serve a Proposed Siphon Station and Recreation Facilities (S) * C **Mitigation Measure E-2**: Extend Electrical Distribution Lines to Serve New Siphon and Pump Stations and Recreation Facilities (LTS) **Impact E-8:** Increase in Demand for Police Services on the DW Project Islands (S) * C **Mitigation Measure E-3:** Provide Adequate Lighting in and around Buildings, Walkways, Parking Areas, and Boat Berths C **Mitigation Measure E-4:** Provide Private Security Services for Recreation Facilities and Boat Docks (LTS)		**Impact E-18**: Increase in PG&E Response Time to Repair a Gas Line Failure on Bacon Island C No significance conclusion is made and no mitigation is identified for this potential economic effect on PG&E's operation. **Impact RE-3**: Increase in the Risk to Line 57-A from Island Inundation (S) C **Mitigation Measure RE-3**: Securely Anchor Line 57-A before Bacon Island Flooding (LTS) **Impact RE-4**: Potential Interference with Pipeline Inspection Procedures (S) C **Mitigation Measure RE-4**: Provide Adequate Facilities on Bacon Island for Annual Pipeline Inspection C **Mitigation Measure RE-5**: Relocate Cathodic Protection Test Stations before Bacon Island Flooding (LTS) **Impact E-19**: Inundation of Electrical Distribution Utilities on the Reservoir Islands (S) C **Mitigation Measure E-9**: Relocate Electrical Distribution Lines to the Perimeter Levees around Webb and Holland Tracts and Bouldin Island (LTS) **Impact E-20:** Possible Need to Increase Capacity of the Existing Electrical Distribution Lines on the Reservoir Islands (LTS) C No mitigation is required. **Impact E-21**: Possible Need to Expand the Existing Electrical Distribution Lines on Webb Tract, Bouldin Island, and Holland Tract to Serve Proposed Siphon and Pump Stations and Recreation Facilities (S) C **Mitigation Measure E-2**: Extend Electrical Distribution Lines to Serve New Siphon and Pump Stations and Recreation Facilities (LTS)	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact E-9: Increase in Demand for Fire Protection Services on the DW Project Islands (S) * C **Mitigation Measure E-5:** Incorporate Fire Protection Features into Recreation Facility Design C **Mitigation Measure E-6:** Provide Fire Protection Services to Webb Tract and Bacon Island (LTS) **Impact E-10:** Increase in Demand for Water Supply Services (LTS) * C **Mitigation Measure E-7:** Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities (LTS) **Impact E-11**: Increase in Demand for Sewage Disposal Services (LTS) * C **Mitigation Measure E-7:** Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities (LTS) **Impact E-12:** Increase in Demand for Solid Waste Removal (LTS) * C **Mitigation Measure E-7:** Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities (LTS)		**Impact E-22:** Increase in Demand for Police Services on the DW Project Islands (S) C **Mitigation Measure E-3:** Provide Adequate Lighting in and around Buildings, Walkways, Parking Areas, and Boat Berths C **Mitigation Measure E-4:** Provide Private Security Services for Recreation Facilities and Boat Docks (LTS) **Impact E-23:** Increase in Demand for Fire Protection Services on the DW Project Islands (S) C **Mitigation Measure E-5:** Incorporate Fire Protection Features into Recreation Facility Design C **Mitigation Measure E-6:** Provide Fire Protection Services to Webb Tract and Bacon Island (LTS) **Impact E-24:** Increase in Demand for Water Supply Services (LTS) C **Mitigation Measure E-7:** Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities (LTS) **Impact E-25:** Increase in Demand for Sewage Disposal Services (LTS) C **Mitigation Measure E-7:** Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities (LTS) **Impact E-26:** Increase in Demand for Solid Waste Removal (LTS) C **Mitigation Measure E-7:** Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities (LTS)	
Cumulative Impacts			
Impact E-27: Cumulative Decrease in the Risk of Structural Failure of Roadways and Utilities (B) C No mitigation is required.	The cumulative impact listed for Alternative 1 is the same for Alternative 2.	The cumulative impact listed for Alternative 1 is the same for Alternative 3.	Cumulative Increase in the Risk of Structural Failure of Roadways and Utilities C Buttress Perimeter Levees

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
CHAPTER 3F. FISHERY RESOURCES			
Impact F-1: Alteration of Habitat (LTS) * C No mitigation is required. **Impact F-2**: Increase in Temperature-Related Mortality of Juvenile Chinook Salmon (LTS) C No mitigation is required. **Impact F-3:** Potential Increase in Accidental Spills of Fuel and Other Materials (LTS) * C No mitigation is required. **Impact F-4:** Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of DW Project Diversions and Discharges on Flows (LTS) C No mitigation is required. **Impact F-5**: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae (LTS) C No mitigation is required. **Impact F-6**: Change in Area of Optimal Salinity Habitat (LTS) C No mitigation is required. **Impact F-7**: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt (LTS) C No mitigation is required. **Impact F-8**: Increase in Entrainment Loss of Juvenile American Shad and Other Species (LTS) C No mitigation is required.	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact F-9**: Alteration of Habitat (S) C **Mitigation Measure F-1**: Implement Fish Habitat Management Actions (LTS) **Impact F-10**: Increase in Temperature-Related Mortality of Juvenile Chinook Salmon (S) C **Mitigation Measure F-2**: Monitor the Water Temperature of DW Discharges and Reduce DW Discharges to Avoid Producing Any Increase in Channel Water Temperature Greater than 1ºF (LTS) **Impact F-11:** Potential Increase in Accidental Spills of Fuel and Other Materials (LTS) C No mitigation is required. **Impact F-12**: Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of DW Project Diversions and Discharges on Flows (S) C **Mitigation Measure F-3:** Operate the DW Project under Operations Objectives That Would Minimize Changes in Cross-Delta Flow Conditions during Peak Out-Migration of Mokelumne and San Joaquin River Chinook Salmon (LTS) **Impact F-13**: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae (S) C **Mitigation Measure F-4**: Operate the DW Project under Operations Objectives That Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt (LTS) **Impact F-14**: Change in Area of Optimal Salinity Habitat (LTS) C No mitigation is required.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
		Impact F-15: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt (S) C **Mitigation Measure F-5**: Operate the DW Project under Operations Objectives That Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt (LTS) **Impact F-16**: Increase in Entrainment Loss of Juvenile American Shad and Other Species (LTS) C No mitigation is required.	
Cumulative Impacts			
Impact F-17: Alteration of Habitat under Cumulative Conditions (LTS) * C No mitigation is required. **Impact F-18:** Potential Increase in Accidental Spills of Fuel and Other Materials under Cumulative Conditions (LTS) * C No mitigation is required. **Impact F-19:** Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of DW Project Diversions and Discharges on Flows under Cumulative Conditions (LTS) C No mitigation is required. **Impact F-20:** Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae under Cumulative Conditions (LTS) C No mitigation is required. **Impact F-21:** Change in Area of Optimal Salinity Habitat under Cumulative Conditions (LTS) C No mitigation is required.	The cumulative impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact F-24:** Alteration of Habitat under Cumulative Conditions (LTS) C No mitigation is required. **Impact F-25:** Potential Increase in Accidental Spills of Fuel and Other Materials under Cumulative Conditions (LTS) C No mitigation is required. **Impact F-26:** Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of DW Project Diversions and Discharges on Flows under Cumulative Conditions (S) C **Mitigation Measure F-3:** Operate the DW Project under Operations Objectives That Would Minimize Changes in Cross-Delta Flow Conditions during Peak Out-Migration of Mokelumne and San Joaquin River Chinook Salmon (LTS) **Impact F-27:** Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae under Cumulative Conditions (S) C **Mitigation Measure F-4:** Operate the DW Project under Operations Objectives That Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt (LTS)	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact F-22: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt under Cumulative Conditions (LTS) C No mitigation is required. **Impact F-23:** Increase in Entrainment Loss of Juvenile American Shad and Other Species under Cumulative Conditions (LTS) C No mitigation is required.		**Impact F-28:** Change in Area of Optimal Salinity Habitat under Cumulative Conditions (LTS) C No mitigation is required. **Impact F-29:** Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt under Cumulative Conditions (S) C **Mitigation Measure F-5:** Operate the DW Project under Operations Objectives That Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt (LTS) **Impact F-30:** Increase in Entrainment Loss of Juvenile American Shad and Other Species under Cumulative Conditions (LTS) C No mitigation is required.	
CHAPTER 3G. VEGETATION AND WETLANDS			
Impact G-1: Increase in Freshwater Marsh and Exotic Marsh Habitats (B) C No mitigation is required. **Impact G-2**: Loss of Riparian and Permanent Pond Habitats (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required. **Impact G-3**: Loss of Upland and Agricultural Habitats (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required.	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact G-5**: Loss of Jurisdictional Wetlands on Reservoir Islands (S) C **Mitigation Measure G-4**: Develop and Implement an Offsite Mitigation Plan (LTS) **Impact G-6**: Loss of Special-Status Plants (S) C **Mitigation Measure G-1**: Site Project Facilities to Avoid Special-Status Plant Populations C **Mitigation Measure G-2**: Protect Special-Status Plant Populations from Construction and Recreational Activities C **Mitigation Measure G-3**: Develop and Implement a Special-Status Plant Species Mitigation Plan (LTS)	Loss of Special-Status Plants C Protect Special-Status Plant Populations from Levee Maintenance Activities C Develop and Implement a Special-Status Plant Species Mitigation Plan

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact G-4: Loss of Special-Status Plants (S) * C **Mitigation Measure G-1**: Site Project Facilities to Avoid Special-Status Plant Populations C **Mitigation Measure G-2**: Protect Special-Status Plant Populations from Construction and Recreational Activities C **Mitigation Measure G-3**: Develop and Implement a Special-Status Plant Species Mitigation Plan (LTS)			
Cumulative Impacts			
Impact G-7: Increase in Wetland and Riparian Habitats in the Delta (B) C No mitigation is required.	The cumulative impact listed for Alternative 1 is the same for Alternative 2.	**Impact G-8:** Cumulative Loss of Section 404 Jurisdictional Emergent Wetland and Riparian Habitats (LTS) C No mitigation is required.	
CHAPTER 3H. WILDLIFE			
Impact H-1: Loss of Upland Habitats (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required. **Impact H-2**: Increase in Suitable Wetland Habitats for Nongame Water and Wading Birds (B) C No mitigation is required. **Impact H-3**: Loss of Foraging Habitats for Wintering Waterfowl (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required. **Impact H-4**: Increase in Suitable Breeding Habitats for Waterfowl (B) C No mitigation is required.	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact H-23**: Loss of Upland Habitats (S) C **Mitigation Measure H-4**: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan (LTS) **Impact H-24**: Loss of Foraging Habitats for Wintering Waterfowl (S) C **Mitigation Measure H-4**: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan (LTS) **Impact H-25:** Increase in Suitable Breeding Habitats for Waterfowl (B) C No mitigation is required. **Impact H-26:** Loss of Habitats for Upland Game Species (S) C **Mitigation Measure H-4**: Develop and Implement an Offsite Wildlife Habitat Management Plan (LTS)	Loss of Riparian and Wetland Habitats C Develop and Implement an Offsite Wildlife Habitat Mitigation Plan Loss of Northern Harrier Nesting Habitat C Develop and Implement an Offsite Wildlife Habitat Mitigation Plan Loss of Potential Swainson's Hawk Foraging Habitat C Develop and Implement an Offsite Wildlife Habitat Mitigation Plan

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact H-5: Loss of Habitats for Upland Game Species (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required. **Impact H-6**: Increase in Suitable Foraging Habitat for Greater Sandhill Crane (B) C No mitigation is required. **Impact H-7**: Increase in Suitable Roosting Habitat for Greater Sandhill Crane (B) C No mitigation is required. **Impact H-8**: Increase in Suitable Foraging Habitat for Swainson's Hawk (B) C No mitigation is required. **Impact H-9**: Increase in Suitable Nesting Habitat for Swainson's Hawk (B) C No mitigation is required. **Impact H-10**: Loss of Foraging Habitat for Aleutian Canada Goose (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required. **Impact H-11**: Increase in Suitable Nesting Habitat for Northern Harrier (B) C No mitigation is required. **Impact H-12**: Loss of Wintering Habitat for Tricolored Blackbird (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required.		**Impact H-27**: Loss of Foraging Habitat for Greater Sandhill Crane (S) C **Mitigation Measure H-4**: Develop and Implement an Offsite Wildlife Habitat Management Plan (LTS) **Impact H-28:** Loss of Foraging Habitat for Swainson's Hawk (S) C **Mitigation Measure H-4**: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan (LTS) **Impact H-29**: Loss of Foraging Habitat for Aleutian Canada Goose (LTS) C No mitigation is required. **Impact H-30**: Loss of Nesting Habitat for Northern Harrier (S) C **Mitigation Measure H-4**: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan (LTS) **Impact H-31**: Loss of Wintering Habitat for Tricolored Blackbird (LTS) C No mitigation is required. **Impact H-32:** Temporary Construction Impacts on State-Listed Species (S) C **Mitigation Measure H-1:** Develop and Implement a Construction Mitigation Plan for the Reservoir Islands (LTS) **Impact H-33:** Potential for Increased Incidence of Waterfowl Diseases (S) C **Mitigation Measure H-3**: Monitor Waterfowl Populations for Incidence of Disease and Implement Actions to Reduce Waterfowl Mortality (LTS) **Impact H-34**: Potential Disruption of Waterfowl Use as a Result of Increased Hunting (LTS) C No mitigation is required.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact H-13: Increase in Suitable Nesting Habitat for Tricolored Blackbird (B) C No mitigation is required. **Impact H-14**: Increase in Suitable Habitats for Special-Status Wildlife Species (B) C No mitigation is required. **Impact H-15:** Temporary Construction Impacts on State-Listed Species (S) * C **Mitigation Measure H-1:** Develop and Implement a Construction Mitigation Plan for the Reservoir Islands (LTS) **Impact H-16:** Disturbance to Greater Sandhill Cranes and Wintering Waterfowl from Aircraft Operation (S) * C **Mitigation Measure H-2:** Monitor Effects of Aircraft Flights on Greater Sandhill Cranes and Wintering Waterfowl and Implement Actions to Reduce Aircraft Disturbances of Wildlife (LTS) **Impact H-17**: Potential for Increased Incidence of Waterfowl Diseases (S) C **Mitigation Measure H-3**: Monitor Waterfowl Populations for Incidence of Disease and Implement Actions to Reduce Waterfowl Mortality (LTS) **Impact H-18**: Potential Disruption of Waterfowl Use as a Result of Increased Hunting (LTS) C No mitigation is required. **Impact H-19**: Potential Disruption of Greater Sandhill Crane Use of the Habitat Islands as a Result of Increased Hunting (LTS) C No mitigation is required. **Impact H-20**: Increase in Waterfowl Harvest Mortality (LTS) C No mitigation is required.		**Impact H-35**: Increase in Waterfowl Harvest Mortality (LTS) C No mitigation is required. **Impact H-36**: Potential Changes in Local and Regional Waterfowl Use Patterns (LTS) C No mitigation is required. **Impact H-37**: Potential Effects on Wildlife and Wildlife Habitats Resulting from Delta Outflow Changes (LTS) C No mitigation is required.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact H-21: Potential Changes in Local and Regional Waterfowl Use Patterns (LTS) C No mitigation is required. **Impact H-22**: Potential Effects on Wildlife and Wildlife Habitats Resulting from Delta Outflow Changes (LTS) C No mitigation is required.			
Cumulative Impacts			
Impact H-38: Cumulative Increase in Foraging Habitat for Wintering Waterfowl in the Delta (B) C No mitigation is required. **Impact H-39:** Cumulative Loss of Herbaceous Habitats in the Delta (LTS) C No mitigation is required. **Impact H-40:** Cumulative Temporary Loss of Riparian Habitat in the Delta (LTS) C No mitigation is required.	The cumulative impacts listed for Alternative 1 are the same for Alternative 2.	**Impact H-41:** Cumulative Loss of Foraging Habitat for Wintering Waterfowl in the Delta (LTS) C No mitigation is required. **Impact H-42:** Cumulative Loss of Herbaceous Habitats in the Delta (LTS) C No mitigation is required. **Impact H-43:** Cumulative Loss of Wetland and Riparian Habitats in the Delta (LTS) C No mitigation is required.	
CHAPTER 3I. LAND USE AND AGRICULTURE			
Impact I-1: Displacement of Residences and Structures on Reservoir Islands (LTS) C No mitigation is required. **Impact I-2**: Displacement of Property Owners on Habitat Islands (LTS) C No mitigation is required. **Impact I-3**: Inconsistency with Contra Costa County General Plan Policy for Agricultural Lands and Delta Protection Commission Land Use Plan Principles for Agriculture and Recreation (SU) * C No mitigation is available. **Impact I-4**: Direct Conversion of Agricultural Land (SU) C No mitigation is available.	The impacts listed for Alternative 1 are the same for Alternative 2.	**Impact I-5**: Displacement of Residences and Structures on Reservoir Islands (LTS) C No mitigation is required. **Impact I-6**: Inconsistency with Contra Costa County General Plan Policy for Agricultural Lands and Delta Protection Commission Land Use Plan Principles for Agriculture and Recreation (SU) C No mitigation is available. **Impact I-7**: Direct Conversion of Agricultural Land (SU) C No mitigation is available.	Increase in Cultivated Acreage and Agricultural Production on the DW Project Islands

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Cumulative Impacts			
Impact I-8: Cumulative Conversion of Agricultural Land (SU) C No mitigation is available.	The cumulative impact listed for Alternative 1 is the same for Alternative 2.	The cumulative impact listed for Alternative 1 is the same for Alternative 3.	
CHAPTER 3J. RECREATION AND VISUAL RESOURCES			
Impact J-1: Increase in Recreation Use-Days for Hunting in the Delta (B) * C No mitigation is required. **Impact J-2**: Change in Regional Hunter Success outside the Project Area (LTS) C No mitigation is required. **Impact J-3**: Increase in Recreation Use-Days for Boating in the Delta (B) * C No mitigation is required. **Impact J-4:** Change in the Quality of the Recreational Boating Experience in Delta Channels (SU) * C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU) **Impact J-5:** Increase in Recreation Use-Days for Other Recreational Uses in the Delta (B) * C No mitigation is required. **Impact J-6**: Reduction in the Quality of Views of the Reservoir Island Interiors from Island Levees (LTS) C No mitigation is required. **Impact J-7**: Potential Conflict with the Scenic Designation for Bacon Island Road (LTS) C No mitigation is required.	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact J-12**: Increase in Recreation Use-Days for Hunting in the Delta (B) C No mitigation is required. **Impact J-13**: Increase in Recreation Use-Days for Boating in the Delta (B) C No mitigation is required. **Impact J-14:** Change in the Quality of the Recreational Boating Experience in Delta Channels (SU) C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU) **Impact J-15:** Increase in Recreation Use-Days for Other Recreational Uses in the Delta (B) C No mitigation is required. **Impact J-16**: Reduction in the Quality of Views of Bacon Island and Webb Tract Interiors from Island Levees (LTS) C No mitigation is required. **Impact J-17**: Potential Conflict with the Scenic Designation for Bacon Island Road (LTS) C No mitigation is required.	Increase in Recreation Use-Days for Hunting in the Delta

Table S-1. Continued

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact J-8: Reduction in the Quality of Views of the Reservoir Islands from Adjacent Waterways and from the Santa Fe Railways Amtrak Line (SU) * C **Mitigation Measure J-1**: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas C **Mitigation Measure J-2**: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)		**Impact J-18**: Reduction in the Quality of Views of Bacon Island and Webb Tract from Adjacent Waterways and from the Santa Fe Railways Amtrak Line (SU) C **Mitigation Measure J-1**: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas C **Mitigation Measure J-2**: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)	
Impact J-9: Enhanced Views of Bouldin Island from SR 12 (B) C No mitigation is required.		**Impact J-19**: Change in Views Southward from SR 12 (LTS) C No mitigation is required.	
Impact J-10: Reduction in the Quality of Views of the Habitat Islands from Adjacent Waterways (S) * C **Mitigation Measure J-1**: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas C **Mitigation Measure J-2**: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (LTS)		**Impact J-20**: Reduction in the Quality of Views of Holland Tract from the Island Levee (LTS) C No mitigation is required. **Impact J-21**: Reduction in the Quality of Views of Bouldin Island and Holland Tract from Adjacent Waterways (SU) C **Mitigation Measure J-1**: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas C **Mitigation Measure J-2**: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)	
Impact J-11: Increase in Viewing Opportunities and the Quality of Views of Island Interiors and the DW Project Vicinity for Recreation Facility Members (B) * C No mitigation is required.		**Impact J-22**: Increase in Opportunities for Recreation Facility Members to View Reservoir Island Interiors and Other Areas in the DW Project Vicinity (B) C No mitigation is required.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Cumulative Impacts			
Impact J-23: Increase in Recreation Opportunities in the Delta (B) * C No mitigation is required.	The cumulative impacts listed for Alternative 1 are the same for Alternative 2.	The cumulative impacts listed for Alternative 1 are the same for Alternative 3.	
Impact J-24: Enhancement of Waterfowl Populations and Increased Hunter Success in the Delta (B) C No mitigation is required.			

CHAPTER 3K. ECONOMIC CONDITIONS AND EFFECTS

Because economic effects are not considered environmental impacts under CEQA and NEPA, no conclusions are made regarding the significance of economic effects.

CHAPTER 3L. TRAFFIC AND NAVIGATION

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact L-1: Increase in Traffic on Delta Roadways during Project Construction (LTS) * C No mitigation is required.	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact L-11**: Increase in Traffic on Delta Roadways during Project Construction (LTS) C No mitigation is required.	Increase in Traffic on Delta Roadways Creation of Safety Conflicts on Delta Roadways
Impact L-2: Increase in Traffic on Delta Roadways during Project Operation (SU) * C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)		**Impact L-12**: Increase in Traffic on Delta Roadways during Project Operation (SU) C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)	C Clearly Mark Intersections with Poor Visibility in the Vicinity of Agricultural Operations Decrease in Circulation on Delta Roadways C Restrict Agricultural Vehicle Operators from Using Delta Highways during Peak Hours
Impact L-3: Creation of Safety Conflicts on Delta Roadways during Project Construction (S) C **Mitigation Measure L-1**: Clearly Mark Intersections with Poor Visibility in the DW Project Vicinity (LTS)		**Impact L-13**: Creation of Safety Conflicts on Delta Roadways during Project Construction (S) C **Mitigation Measure L-1**: Clearly Mark Intersections with Poor Visibility in the DW Project Vicinity (LTS)	
Impact L-4: Reduction in Safety Conflicts on Delta Roadways during Project Operation (B) * C No mitigation is required.		**Impact L-14**: Reduction in Safety Conflicts on Delta Roadways during Project Operation (B) C No mitigation is required.	
Impact L-5: Change in Circulation on or Access to Delta Roadways during DW Project Construction (LTS) C No mitigation is required.		**Impact L-15**: Change in Circulation on or Access to Delta Roadways during DW Project Construction (LTS) C No mitigation is required.	
Impact L-6: Change in Circulation on Delta Roadways during DW Project Operation (LTS) * C No mitigation is required.		**Impact L-16**: Change in Circulation on Delta Roadways during DW Project Operation (LTS) C No mitigation is required.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact L-7: Increase in Boat Traffic and Congestion on Delta Waterways during DW Project Operation (SU) *		**Impact L-17:** Increase in Boat Traffic and Congestion on Delta Waterways during DW Project Operation (SU)	
C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)		C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)	
Impact L-8: Change in Navigation Conditions on Delta Waterways Surrounding the DW Project Islands during Project Operation (LTS) *		**Impact L-18:** Change in Navigation Conditions on Delta Waterways Surrounding the DW Project Islands during Project Operation (LTS)	
C No mitigation is required.		C No mitigation is required.	
Impact L-9: Creation of Safety Conflicts on Delta Waterways during DW Project Construction (S)		**Impact L-19**: Creation of Safety Conflicts on Delta Waterways during DW Project Construction (S)	
C **Mitigation Measure L-2**: Clearly Mark the Barge and Notify the U.S. Coast Guard of Construction Activities (LTS)		C **Mitigation Measure L-2**: Clearly Mark the Barge and Notify the U.S. Coast Guard of Construction Activities (LTS)	
Impact L-10: Increase in the Potential for Safety Problems on Waterways Surrounding the DW Project Islands (S) *		**Impact L-20:** Increase in the Potential for Safety Problems on Waterways Surrounding the DW Project Islands (S)	
C **Mitigation Measure L-3:** Clearly Post Waterway Intersections, Speed Zones, and Potential Hazards in the DW Project Vicinity (LTS)		C **Mitigation Measure L-3:** Clearly Post Waterway Intersections, Speed Zones, and Potential Hazards in the DW Project Vicinity (LTS)	
Cumulative Impacts			
Impact L-21: Increase in Traffic on Delta Roadways during Operation of Future Projects, Including the DW Project (S) *	The cumulative impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	The cumulative impacts and mitigation measures listed for Alternative 1 are the same for Alternative 3.	Increase in Traffic on Delta Roadways during Operation of Future Projects, Including the No-Project Alternative
C **Mitigation Measure L-4**: Implement Caltrans' Route Concepts for SR 4 and SR 12			C Implement Caltrans' Route Concepts for SR 4 and SR 12
C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (LTS)			Creation of Safety Conflicts on Delta Roadways during Operation of Future Projects, Including the No-Project Alternative
Impact L-22: Reduction in Safety Conflicts on Delta Roadways during Operation of Future Projects, Including the DW Project (B)			C Clearly Mark Intersections with Poor Visibility in the Vicinity of Agricultural Operations
C No mitigation is required.			

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact L-23: Cumulative Increase in Safety Problems on Delta Waterways (SU) * C **Mitigation Measure L-5**: Develop and Enforce a Boater Safety Program for DW Private Boat Users C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities (SU)			
CHAPTER 3M. CULTURAL RESOURCES			
Impact M-1: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Webb Tract (S) C **Mitigation Measure M-1**: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract (LTS) **Impact M-2**: Disturbance of Intact Burials at CA-CCo-593 (If Present) on Holland Tract (S) C **Mitigation Measure M-2**: Design Habitat Management and Enhancement Activities to Prevent Disturbance of CA-CCo-593 on Holland Tract (LTS) **Impact M-3**: Disturbance of Intact Burials in CA-CCo-593 (If Present) Resulting from Vandalism on Holland Tract (S) C **Mitigation Measure M-3**: Prepare an HPMP to Address Disturbance of Human Remains at CA-CCo-593 on Holland Tract (LTS) **Impact M-4**: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Holland Tract (S) C **Mitigation Measure M-4**: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Holland Tract (LTS)	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact M-7:** Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Webb Tract (S) C **Mitigation Measure M-1**: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract (LTS) **Impact M-8**: Damage or Destruction of Known Archaeological Sites Resulting from Inundation, Wave Action and Erosion, or Vandalism on Holland Tract (SU) C **Mitigation Measure M-10**: Prepare an HPMP and Conduct Data Recovery Excavations (Only Appropriate for CA-CCo-147) for Archaeological Materials on Holland Tract C **Mitigation Measure M-11**: Cap Archaeological Sites on Holland Tract C **Mitigation Measure M-12**: Construct Fencing or Other Barriers to Prevent Site Access on Holland Tract C **Mitigation Measure M-13**: Construct Levees or Beach Slopes around Archaeological Sites to Decrease Wave Action and Erosion on Holland Tract (SU) C **Mitigation Measure M-14**: Prepare an HPMP to Provide for the Long-Term Monitoring of Known Archaeological Sites on Holland Tract (SU)	Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Webb Tract as a Result of Agricultural Activities C Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract Damage to Known and Unknown Prehistoric Sites Resulting from Agricultural Activities on Holland Tract C Prepare an HPMP to Provide for the Long-Term Monitoring of Known and Unknown Archaeological Sites on Holland Tract Damage to Historic Structures Resulting from Agricultural Practices on Bacon Island C Prepare an HPMP to Provide for the Long-Term Maintenance and Protection of Historic Properties on Bacon Island

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact M-5: Demolition of the NRHP-Eligible Historic District on Bacon Island (SU) C **Mitigation Measure M-5**: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island C **Mitigation Measure M-6:** Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island C **Mitigation Measure M-7:** Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools C **Mitigation Measure M-8**: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island (SU) **Impact M-6**: Disturbance of Archaeological Site CA-SJo-208H on Bouldin Island (S) C **Mitigation Measure M-9**: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bouldin Island (LTS)		**Impact M-9**: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Holland Tract (S) C **Mitigation Measure M-4**: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Holland Tract (LTS) **Impact M-10**: Disturbance of Unknown Resources on Unsurveyed Portions of Holland Tract (S) C **Mitigation Measure M-15**: Survey Unsurveyed Portions of Holland Tract and Determine Eligibility for NRHP Listing and Appropriate Treatment (LTS) **Impact M-11:** Demolition of the NRHP-Eligible Historic District on Bacon Island (SU) C **Mitigation Measure M-5**: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island C **Mitigation Measure M-6:** Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island C **Mitigation Measure M-7:** Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools C **Mitigation Measure M-8**: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island (SU) **Impact M-12**: Disturbance of Archaeological Site CA-SJo-208H on Bouldin Island (S) C **Mitigation Measure M-9**: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bouldin Island (LTS)	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Cumulative Impacts			
Impact M-13: Destruction of or Damage to Prehistoric Archaeological Sites in the Delta (LTS) C No mitigation is required. **Impact M-14**: Destruction of or Damage to the NRHP-Eligible Historic Districts Representing Agricultural Labor Camp Systems in the Delta (SU) C **Mitigation Measure M-5**: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island C **Mitigation Measure M-6**: Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island C **Mitigation Measure M-7**: Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools C **Mitigation Measure M-8**: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island (SU)	The cumulative impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2	**Impact M-15**: Destruction of or Damage to Prehistoric Archaeological Sites in the Delta (SU) C **Mitigation Measure M-4**: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Holland Tract C **Mitigation Measure M-11**: Cap Archaeological Sites on Holland Tract C **Mitigation Measure M-12**: Construct Fencing or Other Barriers to Prevent Site Access on Holland Tract C **Mitigation Measure M-13**: Construct Levees or Beach Slopes around Archaeological Sites to Decrease Wave Action and Erosion on Holland Tract C **Mitigation Measure M-14**: Prepare an HPMP to Provide for the Long-Term Monitoring of Known Archaeological Sites on Holland Tract C **Mitigation Measure M-15**: Survey Unsurveyed Portions of Holland Tract and Determine Eligibility for NRHP Listing and Appropriate Treatment (SU) **Impact M-16**: Destruction of or Damage to the NRHP-Eligible Historic Districts Representing Agricultural Labor Camp Systems in the Delta (SU) C **Mitigation Measure M-5**: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island C **Mitigation Measure M-6**: Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island C **Mitigation Measure M-7**: Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools C **Mitigation Measure M-8**: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island (SU)	Destruction of or Damage to Prehistoric Archaeological Sites and Historic Resources in the Delta C Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract C Prepare an HPMP to Provide for the Long-Term Monitoring of Known and Unknown Archaeological Sites on Holland Tract C Prepare an HPMP to Provide for the Long-Term Maintenance and Protection of Historic Properties on Bacon Island

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
CHAPTER 3N. MOSQUITOS AND PUBLIC HEALTH			
Impact N-1: Reduction or Elimination of Mosquito Abatement Activities during Full-Storage Periods on the Reservoir Islands (B) C No mitigation is required. **Impact N-2**: Increase in Abatement Levels on the Habitat Islands and during Partial-Storage, Shallow-Storage, or Shallow-Water Wetland Periods on the Reservoir Islands (S) C **Mitigation Measure N-1**: Coordinate Project Activities with SJCMAD and CCMAD (LTS) **Impact N-3:** Increase in Potential Exposure of People to Wildlife Species That Transmit Diseases (LTS) * C No mitigation is required.	The impacts and mitigation measure listed for Alternative 1 are the same for Alternative 2.	**Impact N-4**: Reduction or Elimination of Mosquito Abatement Activities during Full-Storage Periods on the Reservoir Islands (B) C No mitigation is required. **Impact N-5**: Increase in Abatement Levels during Partial-Storage, Shallow-Storage, or Shallow-Water Wetland Periods on the Reservoir Islands and in the NBHA (S) C **Mitigation Measure N-1**: Coordinate Project Activities with SJCMAD and CCMAD (LTS)	Reduction in Mosquito Abatement Activities on the DW Project Islands Increase in Mosquito Production Levels as a Result of Increased Corn Production C Coordinate Project Activities with SJCMAD and CCMAD
Cumulative Impacts			
Impact N-6: Increase in Abatement Levels during Partial-Storage, Shallow-Storage, or Shallow-Water Wetland Periods on the Reservoir Islands under Cumulative Conditions (S) C **Mitigation Measure N-1:** Coordinate Project Activities with SJCMAD and CCMAD (LTS) **Impact N-7:** Cumulative Increase in Mosquito Abatement Needs Resulting from Implementation of Future Projects, Including the DW Project (SU) * C No mitigation is available.	The cumulative impacts and mitigation measure listed for Alternative 1 are the same for Alternative 2.	The cumulative impacts and mitigation measure listed for Alternative 1 are the same for Alternative 3.	Cumulative Increase in Mosquito Abatement Needs Resulting from Implementation of Future Projects, Including the No-Project Alternative

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
		CHAPTER 3O. AIR QUALITY	
Impact O-1: Increase in CO Emissions on the DW Project Islands during Construction (LTS) C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines (LTS) **Impact O-2**: Increase in CO Emissions on the DW Project Islands during Project Operation (LTS) * C No mitigation is required. **Impact O-3**: Increase in ROG Emissions on the DW Project Islands during Construction (SU) C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines (SU) **Impact O-4**: Increase in NOx Emissions on the DW Project Islands during Construction (SU) C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines (SU)	The impacts and mitigation measures listed for Alternative 1 are the same for Alternative 2.	**Impact O-9**: Increase in CO Emissions on the DW Project Islands during Construction (LTS) C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines (LTS) **Impact O-10**: Increase in CO Emissions on the DW Project Islands during Project Operation (LTS) C No mitigation is required. **Impact O-11**: Increase in ROG Emissions on the DW Project Islands during Construction (SU) C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines (SU) **Impact O-12**: Increase in NOx Emissions on the DW Project Islands during Construction (SU) C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines (SU)	Increase in CO Emissions on the DW Project Islands Increase in ROG Emissions on the DW Project Islands. Increase in NOx Emissions on the DW Project Islands Increase in PM10 Emissions on the DW Project Islands

Table S-1. Continued

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Impact O-5: Increase in ROG Emissions on the DW Project Islands during Project Operation (SU) *		**Impact O-13**: Increase in ROG Emissions on the DW Project Islands during Project Operation (SU)	
C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities		C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities	
C **Mitigation Measure O-4:** Coordinate with Local Air Districts to Reduce or Offset Emissions (SU)		C **Mitigation Measure O-4:** Coordinate with Local Air Districts to Reduce or Offset Emissions (SU)	
Impact O-6: Increase in NOx Emissions on the DW Project Islands during Project Operation (SU) *		**Impact O-14**: Increase in NOx Emissions on the DW Project Islands during Project Operation (SU)	
C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities		C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities	
C **Mitigation Measure O-4:** Coordinate with Local Air Districts to Reduce or Offset Emissions (SU)		C **Mitigation Measure O-4:** Coordinate with Local Air Districts to Reduce or Offset Emissions (SU)	
Impact O-7: Increase in PM10 Emissions on the DW Project Islands during Construction (SU)		**Impact O-15**: Increase in PM10 Emissions on the DW Project Islands during Construction (SU)	
C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment		C **Mitigation Measure O-1**: Perform Routine Maintenance of Construction Equipment	
C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations		C **Mitigation Measure O-2**: Choose Borrow Sites Close to Fill Locations	
C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines		C **Mitigation Measure O-3**: Prohibit Unnecessary Idling of Construction Equipment Engines	
C **Mitigation Measure O-5**: Implement Construction Practices That Reduce Generation of Particulate Matter (SU)		C **Mitigation Measure O-5**: Implement Construction Practices That Reduce Generation of Particulate Matter (SU)	
Impact O-8: Decrease in PM10 Emissions on the DW Project Islands during Project Operation (B)		**Impact O-16**: Decrease in PM10 Emissions on the DW Project Islands during Project Operation (B)	
C No mitigation is required.		C No mitigation is required.	

Alternative 1	Alternative 2	Alternative 3	No-Project Alternative
Cumulative Impacts			
Impact O-17: Increase in Cumulative Production of Ozone Precursors and CO in the Delta (SU) * C **Mitigation Measure RJ-1**: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities C **Mitigation Measure O-4:** Coordinate with Local Air Districts to Reduce or Offset Emissions (SU)	The cumulative impact and mitigation measure listed for Alternative 1 are the same for Alternative 2.	The cumulative impact and mitigation measure listed for Alternative 1 are the same for Alternative 3.	Increase in Cumulative Production of Ozone Precursors, CO, and PM10 in the Delta

* Although DW has removed the construction of recreation facilities from its CWA and Rivers and Harbors Act permit applications for the proposed project, this impact conclusion assumes that the recreation facilities would be constructed and operated.

Key:

LTS = Less than significant.
S = Significant.
SU = Significant and unavoidable.
B = Beneficial.

Table S-2. Summary of Estimated Impacts of the Delta Wetlands Project on Waters of the United States

	Temporary Impacts			Permanent Impacts		
Project Feature	Type of Waters	Cause of Impact	Acreage	Type of Waters	Cause of Impact	Acreage
BACON ISLAND						
Project Construction and Operation *				Riparian, willow scrub	Island inundation and project structures on island interior	2.4
				Freshwater marsh		1.0
				Exotic marsh		2.0
				Open water, canal/ditch		17.8
				Open water, permanent pond		0.8
Pump Station 700+00	Other waters of the U.S.	Construction and access for placement of pipes, riprap, and docks in adjacent channels	1.63	Other waters of the U.S.	Pipe, riprap, docks, and associated support piles	0.68
Siphon Station 180+00	Other waters of the U.S.	Construction and access for placement of pipes, riprap, and docks in adjacent channels	1.04	Other waters of the U.S.	Pipe, riprap, docks, and associated support piles	0.49
Siphon Station 360+00	Other waters of the U.S.	Construction and access for placement of pipes, riprap, and docks in adjacent channels	1.04	Other waters of the U.S.	Pipe, riprap, docks, and associated support piles	0.49
Existing Siphons	Other waters of the U.S.	Construction and access for installing fish screens	0.15	Other waters of the U.S.	New fish screens on existing siphons	0.15
	Total—Bacon Island		**3.86**	**Total—Bacon Island**		**25.81**

Table S-2. Continued

Project Feature	Temporary Impacts: Type of Waters	Temporary Impacts: Cause of Impact	Temporary Impacts: Acreage	Permanent Impacts: Type of Waters	Permanent Impacts: Cause of Impact	Permanent Impacts: Acreage
WEBB TRACT						
Project Construction and Operation *				Riparian, cottonwood-willow woodland	Island inundation and project structures on island interior	47.5
				Riparian, willow scrub		56.2
				Freshwater marsh		24.7
				Exotic marsh		66.9
				Annual grassland		17.0
				Exotic perennial grassland		16.6
				Agricultural wetland		2.6
				Open water, canal/ditch		19.1
				Open water, permanent pond		97.7
				Other		21.3
Pump Station 190+00	Other waters of the U.S.	Construction and access for placement of pipes, riprap, and docks in adjacent channels	1.35	Other waters of the U.S.	Pipe, riprap, docks, and associated support piles	0.64
Siphon Station 200+00	Other waters of the U.S.	Construction and access for placement of pipes, riprap, and docks in adjacent channels	1.22	Other waters of the U.S.	Pipe, riprap, docks, and associated support piles	0.49

Table S-2. Continued

Project Feature	Temporary Impacts: Type of Waters	Temporary Impacts: Cause of Impact	Temporary Impacts: Acreage	Permanent Impacts: Type of Waters	Permanent Impacts: Cause of Impact	Permanent Impacts: Acreage
WEBB TRACT (Continued)						
Siphon Station 330+00	Other waters of the U.S.	Construction and access for placement of pipes, riprap, and docks in adjacent channels	0.85	Other waters of the U.S.	Pipe, riprap, docks, and associated support piles	0.49
Existing Siphons	Other waters of the U.S.	Construction and access for installing fish screens	0.04	Other waters of the U.S.	New fish screens on existing siphons	0.04
		Removal of existing siphons in adjacent channels	0.02			
	Total—Webb Tract		**3.48**	**Total—Webb Tract**		**371.26**
BOULDIN ISLAND						
Establishment and Management of Habitat *	Freshwater marsh	Grading and excavation for habitat creation	0.8			
	Exotic marsh		65.3			
	Annual grassland		93.1			
Existing Siphons	Other waters of the U.S.	Construction and access for installing fish screens	0.04	Other waters of the U.S.	New fish screens on existing siphons	0.08
		Removal of existing siphons in adjacent channels	0.02			
	Total—Bouldin Island		**159.26**	**Total—Bouldin Island**		0.08

Table S-2. Continued

Project Feature	Temporary Impacts: Type of Waters	Temporary Impacts: Cause of Impact	Temporary Impacts: Acreage	Permanent Impacts: Type of Waters	Permanent Impacts: Cause of Impact	Permanent Impacts: Acreage
HOLLAND TRACT						
Establishment and Management of Habitat *	Riparian, willow scrub	Grading and excavation for habitat creation	2.4			
	Freshwater marsh		0.7			
	Exotic marsh		12.9			
Existing Siphons	Other waters of the U.S.	Construction and access for installing fish screens	0.04	Other waters of the U.S.	New fish screens on existing siphons	0.04
	Total—Holland Tract		**16.04**	**Total—Holland Tract**		**0.04**

* The description of wetlands on the island interiors is based on Section 404 Jurisdiction Map, November 4, 1994; see also Appendix G5, “Summary of Jurisdictional Wetland Impacts and Mitigation”, in the 1995 DEIR/EIS.

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List of Acronyms

1995 DEIR/EIS	1995 Delta Wetlands Project Draft Environmental Impact Report and Environmental Impact Statement
1995 WQCP	1995 Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary
2000 REIR/EIS	2000 Revised Draft Environmental Impact Report and Environmental Impact Statement for the Delta Wetlands Project
Fg/l	micrograms per liter
FS	microsiemens
FS/cm	microsiemens per centimeter
af	acre-foot
AFRP	Anadromous Fish Restoration Program
CALFED	CALFED Bay-Delta Program
Caltrans	California Department of Transportation
CCMAD	Contra Costa Mosquito Abatement District
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
cfs	cubic feet per second
COTP	California-Oregon Transmission Project
CPUC	California Public Utilities Commission
CUWA	California Urban Water Agencies
CVOCO	Central Valley Operations Coordinating Office
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
DBP	disinfection byproduct
DCC	Delta Cross Channel
D/DBP	Disinfection/Disinfection Byproducts
Delta	Sacramento-San Joaquin Delta
DeltaSOQ	Delta Standards, Operations, and Quality model
DeltaSOS	Delta Standards and Operations Simulation model
DFG	California Department of Fish and Game
DO	dissolved oxygen
DOC	dissolved organic carbon
DOT	U.S. Department of Transportation
DRB	design review board
DSOD	Division of Safety of Dams
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
EC	electrical conductivity

E/I	export/inflow
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
EWA	Environmental Water Account
FDM	Fischer Delta Model
FEIR	final environmental impact report
FEIS	final environmental impact statement
FMWT	fall midwater trawl
FOC	final operations criteria
fps	feet per second
FS	factor of safety for slope stability
g/m^2	grams per square meter
HEP	habitat evaluation procedures
HLA	Harding Lawson Associates
HMAC	Habitat Management Advisory Committee
HMP	habitat management plan
IEP	Interagency Ecological Program
ISI	Integrated Storage Investigation
km	kilometer
LAFCO	Local Agency Formation Commission
LOS	level of service
MAB	Reservoir Island Monitoring and Action Board
MAF	million acre-feet
MCL	maximum contaminant level
mg/l	milligrams per liter
msl	mean sea level
MWD	Metropolitan Water District of Southern California
MWQI	Municipal Water Quality Investigations
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PG&E	Pacific Gas and Electric Company
ppt	parts per thousand
psi	pounds per square inch
RMA	Resource Management Associates
ROW	right-of-way
RPM	reasonable and prudent measure
RWQCB	regional water quality control board
SB	Senate Bill
SJCMAD	San Joaquin County Mosquito Abatement District
SLC	State Lands Commission
SMARTS	Special Multipurpose Applied Research Technology Station

SR	State Route
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TAF/yr	thousand acre-feet per year
TDS	total dissolved solids
THM	trihalomethane
THMFP	trihalomethane formation potential
TOC	total organic carbon
TTHM	total trihalomethane
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UVA	ultraviolet absorbance
VAMP	Vernalis Adaptive Management Plan
WQMP	Delta Wetlands Water Quality Management Plan
WTP	water treatment plant

Chapter 1. Introduction

Chapter 1. Introduction

This Final Environmental Impact Statement (FEIS) for the Delta Wetlands Project has been prepared under the direction of the U.S. Army Corps of Engineers (USACE, or Corps) in accordance with the requirements of the National Environmental Policy Act (NEPA). The environmental impacts of the Delta Wetlands Project (also referred to as the "DW project") were analyzed in the 1995 Delta Wetlands Project Draft Environmental Impact Report and Environmental Impact Statement (1995 DEIR/EIS) (Jones & Stokes Associates 1995) and the 2000 Revised Draft Environmental Impact Report and Environmental Impact Statement for the Delta Wetlands Project (2000 REIR/EIS) (Jones & Stokes 2000). These documents were prepared jointly by the California State Water Resources Control Board (SWRCB) and USACE in compliance with the California Environmental Quality Act (CEQA) and NEPA, respectively. The SWRCB prepared a separate Final Environmental Impact Report (FEIR) in January 2001 to respond to public and agency comments on these documents. USACE has prepared this FEIS to respond to agency and public comments received on the 1995 DEIR/EIS and the 2000 REIR/EIS and to provide a rewritten version of the EIS as required by NEPA. This FEIS includes the analysis of project effects presented in the 1995 DEIR/EIS and 2000 REIR/EIS and reflects information that has changed or been updated since those documents were published.

PROJECT OVERVIEW

Description of the Proposed Project

Delta Wetlands proposes a water storage project on four islands in the Sacramento-San Joaquin Delta (Delta) (Figure 1-1). The project would involve diverting and storing water on two of the islands (Bacon Island and Webb Tract, or "reservoir islands") for later discharge for export or to meet outflow or environmental requirements for the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) estuary. In addition, the project would involve diverting water seasonally to create and enhance wetlands and to manage wildlife habitat on the other two islands (Bouldin Island and most of Holland Tract, or "habitat islands") (Figure 1-2).

The description of the proposed project as revised includes construction and operation of recreation facilities on all four project islands. In May 2001, however, Delta Wetlands removed construction of these facilities from its CWA and Rivers and Harbors Act permit applications. The conceptual descriptions of the recreation facilities remain largely unchanged from those included in the 1995 DEIR/EIS; they are presented in this FEIS for informational purposes. Also included are the analyses of the environmental effects of facility construction and operation, and responses to comments on the 1995 DEIR/EIS and 2000 REIR/EIS about the recreation facilities.

The project islands are owned either wholly or partially by Delta Wetlands. To operate its project, Delta Wetlands would improve and strengthen levees on all four islands and would install additional siphons and water pumps on the perimeters of the reservoir islands. Delta Wetlands would operate the habitat islands under a habitat management plan (HMP) to compensate for impacts on, and promote the recovery of, state-listed threatened or endangered wildlife species and other special-status species, and to provide additional wetlands and wildlife habitat in the Delta.

In this document, as in the 1995 DEIR/EIS and 2000 REIR/EIS, the Delta Wetlands Project is analyzed as a stand-alone water storage facility, operated independently of the State Water Project (SWP) and the Central Valley Project (CVP), and without regard to the specific entities to which the water could be sold. Environmental effects that may be associated with the delivery of purchased Delta Wetlands water or the storage of water under a third party's water rights are not analyzed because the identity of the end user of the Delta Wetlands water remains speculative.

The Delta Wetlands Project islands could also be used for interim storage of water being transferred through the Delta from sellers upstream to buyers served by Delta exports or to meet Bay-Delta estuary outflow requirements (water transfers). In addition, it could be used for interim storage of water owned by parties other than Delta Wetlands for use to meet scheduled Bay-Delta estuary outflow requirements or for export (water banking). This analysis considers the environmental impacts and water supply yield of the Delta Wetlands Project based only on water stored under Delta Wetlands' own appropriative permits and subsequently conveyed to Delta channels.

A separate entity purchasing Delta Wetlands water could divert that water from Delta channels to storage on the Delta Wetlands islands and discharge it, probably through CVP or SWP facilities, for direct use or to increase groundwater or surface storage; or it could use water for estuarine or Delta beneficial uses (increased outflow). The purchasing entity would affect SWP or CVP operations to the same extent as would any entity that diverts, stores, and discharges water under California Water Code provisions and contracts authorized by those provisions.

This document also does not analyze how state or federal facilities may be operated in the future in coordination with the Delta Wetlands Project, although the impact analysis does estimate the effects of project operations on operation of the SWP and CVP pumping facilities. Several potential opportunities exist to operate the Delta Wetlands Project in conjunction with the CVP and the SWP or in coordination with the CALFED Bay-Delta Program (CALFED); however, no proposals have been made for which USACE and the SWRCB could reasonably assess the environmental effects, and discussion of such arrangements remains speculative.

Project Permit Requirements

Department of the Army Permit Application

Section 404 of the Clean Water Act (CWA) prohibits the discharge of dredged or fill material into waters of the United States, including wetlands, unless a permit is obtained from USACE. Section 10 of the Rivers and Harbors Act of 1899 prohibits work affecting the course, location, conditions or capacity of navigable waters of the United States without a permit from USACE.

Delta Wetlands is required to obtain a permit from USACE under Section 404 because Delta Wetlands Project fill activities associated with perimeter and interior levee work on the reservoir islands; habitat enhancement activities on the habitat islands; and construction of boat docks, pumps, and siphons in Delta channels involve discharges of dredged or fill material into waters of the United States. As part of the review process for issuance of a permit for the Delta Wetlands Project's fill and discharge activities, USACE is using the information in this FEIS to comply with the requirements of the U.S. Environmental Protection Agency's (EPA's) Section 404(b)(1) guidelines. Before Delta Wetlands can be issued a permit under Section 404, it must obtain a water quality certification from the SWRCB under Section 401 of the CWA. Section 401 certification ensures that discharge of dredged or fill material into waters of the United States will not violate state water quality standards. The Section 401 certification would be appended to the Section 404 permit and incorporated by reference.

In addition to the Section 404 requirements, Delta Wetlands would be required to comply with Section 10 of the Rivers and Harbors Act because it proposes to construct docks and install siphons and pumps in navigable waters. Activities conducted below the ordinary high-water mark in navigable waters are authorized under Section 10 through issuance of a Department of the Army permit. Section 10 and Section 404 requirements are considered concurrently in Department of the Army permit applications (U.S. Army Corps of Engineers 1977).

Delta Wetlands has applied to USACE for a permit under Section 404 of the CWA for the discharge of dredged or fill materials into waters of the United States and under Section 10 of the Rivers and Harbors Act of 1899 for other project activities in navigable waters.

Water Right Applications

The State of California recognizes riparian and appropriative surface water rights. Riparian rights are correlative entitlements to water that are held by owners of land that borders natural watercourses. California requires a statement of diversion and use of natural flows on adjacent riparian land under a riparian right.

Water is currently being used for agriculture on the Delta Wetlands Project islands under riparian and existing appropriative water rights. However, because water obtained under riparian rights cannot be stored and cannot be sold, Delta Wetlands must apply for new appropriative water rights to divert and store water for later sale on the reservoir and habitat islands. A distinct appropriative water right permit would apply to each island.

The SWRCB has authority to issue permits to grant appropriative water rights. Appropriative water rights allow the diversion of a specified amount of water from a source for reasonable and beneficial use during all or a portion of the year. In California, previously issued appropriative water rights are superior to and take precedence over newly granted rights.

When an appropriative water right application is filed with the SWRCB, the application is given a number and priority date. Applications determined by the SWRCB to be complete are published to inform the public about them and to allow for protests to be filed against them. Most protests are based on suspected interference with existing water rights or harm to the environment. After a 40-to-60-day protest period, the applicant may negotiate with those filing protests to attempt to reach agreements for protest dismissal. If the SWRCB issues permits, the permittee must subsequently establish that the water is being put to a reasonable and beneficial use before the right is made permanent through licensing.

Delta Wetlands applied to the SWRCB, Division of Water Rights, for new appropriative water rights to divert water and store it on the project islands for later discharge to Delta channels for export or to meet Bay-Delta estuary outflow or environmental requirements. The SWRCB issued Water Right Decision 1643 for the Delta Wetlands Project on February 15, 2001.

When the holder of a post-1914 appropriative water right proposes to park water (transferred or intended for banking) on Delta Wetlands' reservoir islands, the SWRCB would have to separately authorize the diversion of the water to Delta Wetlands storage. The SWRCB's authorization for diversions would change the transfer right holder's place of use or point of diversion and could require further environmental documentation.

REGULATORY COMPLIANCE HISTORY

Because the Delta Wetlands Project requires discretionary approvals from USACE and the SWRCB, the project must comply with both NEPA and CEQA, with USACE serving as the lead agency for NEPA compliance and the SWRCB as the lead agency for CEQA compliance. Compliance with Section 7 of the federal Endangered Species Act (ESA), Section 106 of the National Historic Preservation Act, and other regulations is also required before USACE may issue a permit. Compliance with the California ESA is a required part of the SWRCB permitting process. Various other permits and consultations are also required, as discussed in Chapter 4, "Permit and Environmental Review and Consultation Requirements". See Chapter 4 for more information on the USACE permitting process and Appendix 1 of the 1995 DEIR/EIS for details on Delta Wetlands' water right applications and the SWRCB water right process.

Table 1-1 shows an overview of the steps in the Delta Wetlands Project's regulatory compliance history, which are described below in roughly chronological order.

Delta Wetlands' 1987 Project Proposal

Delta Wetlands applied to the SWRCB in 1987 for water rights to store water seasonally on all four of its project islands. Delta Wetlands also applied to USACE for a permit under Section 404 of the CWA for the discharge of dredged or fill materials into waters of the United States and under Section 10 of the Rivers and Harbors Act of 1899 for other project activities in navigable waters. The SWRCB originally issued the notice of applications prepared by Delta Wetlands to appropriate water on December 4, 1987 (Application Nos. 29061, 29062, 29063, and 29066) (see Appendix 1 of the 1995 DEIR/EIS).

After Delta Wetlands submitted its applications, USACE and the SWRCB determined that the project could have significant environmental impacts. A notice of intent (NOI) for the preparation of an environmental impact report/environmental impact statement (EIR/EIS) for the project was published in the Federal Register on January 6, 1988. A notice of preparation (NOP) for an EIR/EIS was distributed in February 1988; 40 days were allowed for submission of comments.

A scoping meeting was held on February 11, 1988. Thirty-five scoping comment letters were received by USACE and the SWRCB. A scoping report on the project was published on September 20, 1988. The report summarized the comments received during the scoping period and the issues raised in water right protests, and described the kind and extent of analyses to be performed for the EIR/EIS (Jones & Stokes Associates 1988).

In December 1990, the lead agencies released a draft EIR/EIS analyzing the Delta Wetlands Project as it was originally proposed (Jones & Stokes Associates 1990). The 1990 EIR/EIS was never finalized because the project changed substantially as described below.

Delta Wetlands' 1993 Project Proposal and the 1995 Draft EIR/EIS

In 1993, Delta Wetlands submitted new water right applications based on a revised project description that proposed two reservoir islands and two habitat islands. Delta Wetlands' new water right applications requested new appropriative water rights for direct diversion to and storage on the project reservoir islands. The SWRCB issued the notice for Delta Wetlands' revised water right applications and new applications on August 6, 1993 (new Application Nos. 30267, 30268, 30269, and 30270) (see Appendix 1 of the 1995 DEIR/EIS).

The SWRCB and USACE, acting as the lead agencies under CEQA and NEPA, determined that Delta Wetlands' revised water right applications in 1993 did not trigger the need to issue an additional NOP/NOI. The information submitted in response to the original NOP/NOI and the comments received on the 1990 draft EIR/EIS assisted the lead agencies in defining the kind and extent of analyses to be performed for a new EIR/EIS. The lead agencies directed that the 1995 DEIR/EIS be prepared to assess the environmental effects of the Delta Wetlands Project based on the 1993 project description.

Based on the initial scoping process, public and agency comments received on the December 1990 draft EIR/EIS, and other correspondence with state and federal agencies, the lead agencies determined that the following issue areas would be addressed in the 1995 DEIR/EIS:

water supply,
hydrodynamics,
water quality,
flood control,
utilities and highways,
fishery resources,
vegetation and wetlands,
wildlife,
land use and agriculture,
recreation and visual resources,
economic issues,
traffic,
cultural resources,
mosquitos and public health, and
air quality.

The USACE and SWRCB distributed the 1995 DEIR/EIS for public review and comment in September 1995. They also held a public meeting on October 11, 1995, to receive comments on the document; a court reporter was in attendance and a transcript was prepared for the administrative record.

The lead agencies received numerous comment letters during the public review period, which ended on December 21, 1995. Many commenters expressed concerns about levee stability and seepage potential and project effects on fisheries and water quality.

Consultation on Listed Fish Species and the Federal and State 1997 and 1998 Biological Opinions

At the same time that the 1995 DEIR/EIS was being prepared, the SWRCB and USACE prepared biological assessments that evaluated potential effects of the Delta Wetlands Project on fish and wildlife species listed or proposed for listing under the California and federal ESAs. The biological assessment for fish species concluded that the project could adversely affect several fish species that were listed or proposed for listing.

Pursuant to the federal ESA, USACE began formal consultation with the U.S. Fish and Wildlife Service (USFWS) about project effects on delta smelt and Sacramento splittail, and with the National Marine Fisheries Service (NMFS) about project effects on winter-run chinook salmon and steelhead. The SWRCB began consultation with the California Department of Fish and Game (DFG) pursuant to the

California ESA about project effects on delta smelt and winter-run chinook salmon.

As part of the consultation process, the SWRCB, USACE, USFWS, NMFS, DFG, and Delta Wetlands held a series of meetings to cooperatively develop operating parameters for the Delta Wetlands Project that would protect these species. The outcome of the meetings was agreement on a set of "final operations criteria" (FOC) for the project.

In 1997, the USFWS and NMFS issued no-jeopardy biological opinions regarding effects of the Delta Wetlands Project on federally listed fish species. DFG issued a no-jeopardy opinion in 1998 on project effects on state-listed fish, wildlife, and plant species. The findings of no jeopardy were based on the incorporation of the FOC into the proposed project. The biological opinions all included "reasonable and prudent measures" (RPMs) to be implemented by Delta Wetlands to minimize the effects of incidental take of listed species. Copies of the final biological opinions are included in Appendices C, D, and E of the 2000 REIR/EIS.

The State Water Resources Control Board's 1997 Water Right Hearing

Also in 1997, the SWRCB convened a water right hearing to consider Delta Wetlands' petitions for new water rights and changes to existing water rights. Eighteen parties filed protests with the SWRCB against Delta Wetlands' water right applications. Delta Wetlands entered into stipulated agreements with five of these protestants. Four of the stipulated agreements affirm the seniority of the protesting parties' water rights; to preclude interference with those senior water rights, they outline general conditions under which the Delta Wetlands Project would operate. The fifth precludes Delta Wetlands' interference with the protesting party's ability to meet water quality criteria for salinity. These agreements are described in Appendix A of the 2000 REIR/EIS.

A substantial amount of testimony was presented at the 1997 water right hearing. Much of the testimony concerned the stability of the levees under the proposed design and project operations, seepage from the project reservoir islands to neighboring islands, and the effects of the project on salinity and concentrations of dissolved organic carbon (DOC) in Delta exports and the resulting effects of this increased salinity and DOC loading on treatment plant operations.

Additionally, Pacific Gas and Electric Company (PG&E) presented evidence to show that the Delta Wetlands Project could affect PG&E's ability to maintain its gas line across Bacon Island. The East Bay Municipal Utility District (EBMUD) and DFG raised questions about potential project effects on Mokelumne River salmon and predation of protected fish species at Delta Wetlands Project boat docks and other project facilities. (Other issues raised by DFG were subsequently addressed in DFG's biological opinion, which was included as Appendix C of the 2000 REIR/EIS.) A broad range of assumptions and conclusions on these issues is reflected in the SWRCB's and USACE's administrative record.

2000 Revised Draft EIR/EIS

Substantial controversy remained regarding some of the potential effects of the project following the 1997 water right hearing; as a result, the SWRCB and USACE believed that it would be prudent to identify available new information on certain issues and to consider the relevance of this information to the analysis of potential project effects. The 2000 REIR/EIS was prepared, therefore, to allow for recirculation of parts of the environmental analysis and to provide for additional public review of, and comment on, this information.

The Council of Environmental Quality's (CEQ's) NEPA Regulations (40 CFR 1502.9[c]) direct that agencies "[s]hall prepare supplements to either draft or final environmental impact statements if . . . [t]here are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts". They further direct that agencies "[m]ay also prepare supplements when the agency determines that the purposes of [NEPA] will be furthered by doing so".

The CEQA Guidelines (Section 15088.5) include the following guidance on recirculation of a draft EIR or portions of a draft EIR:

> [A] lead agency is required to recirculate an EIR when significant new information is added to the EIR after public notice is given of the availability of the draft EIR for public

review under Section 15087 but before certification. ... [T]he term "information" can include changes in the project or environmental setting as well as additional data or other information. New information added to an EIR is not "significant" unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement. ... Recirculation is not required where the new information added to the EIR merely clarifies or amplifies or makes insignificant modifications in an adequate EIR. ... If the revision is limited to a few chapters or portions of the EIR, the lead agency need only recirculate the chapters or portions that have been modified.

Pursuant to Section 1502.9 of the CEQ NEPA Regulations (33 CFR 230) and Section 15088.5 of the CEQA Guidelines, USACE and the SWRCB recirculated those parts of the CEQA/NEPA analysis for the project for which significant information had been developed since the 1995 DEIR/EIS was published. These parts are the analyses of levee stability, seepage, water quality, and natural gas facilities and transmission pipelines.

The two lead agencies directed that a revised, quantitative analysis of geotechnical (levee stability and seepage) issues be developed to provide information to supplement the discussion of flood control features included in the 1995 DEIR/EIS. The evaluation of water quality effects is based in part on the estimated timing and volumes of Delta Wetlands Project diversions and discharges. Therefore, the modeling of water supply and operations was also updated for the 2000 REIR/EIS, and the results of the modeling were presented for comparison with those of the 1995 DEIR/EIS. In addition, the fisheries assessment was updated with the most recent information available to address issues raised after the 1995 DEIR/EIS was published.

The 2000 REIR/EIS therefore included information on the following subjects to supplement the evaluations presented in the 1995 DEIR/EIS:

- water supply and operations,
- water quality,
- fisheries,
- levee stability and seepage, and
- natural gas facilities and pipelines.

The 2000 REIR/EIS was issued for public review on May 31, 2000. Several comment letters were received during the public review period, which ended on July 31, 2000.

Listings of Fish Species Since 1997

After the issuance of the biological opinions discussed above, splittail, steelhead (Central Valley Evolutionarily Significant Unit [ESU]), and spring-run chinook salmon were listed as threatened under the federal ESA, and spring-run chinook salmon was also listed as threatened under the California ESA. In addition, the Delta has been designated critical habitat for steelhead and spring-run chinook salmon under the federal ESA. Also, the requirements of Section 2090 of the California ESA have expired, resulting in the need to convert DFG's biological opinion to a take permit under the current requirements of the California ESA.

Splittail and Steelhead

The USFWS and NMFS biological opinions included conference opinions on splittail and steelhead, respectively, because these species were proposed for listing at the time when the opinions were issued. The conference opinions found that the Delta Wetlands Project, as modified by the FOC, would not jeopardize the continued existence of these species. USFWS formally adopted the conference opinion as its biological opinion on splittail for the Delta Wetlands Project in April 2000. USFWS's letter notifying USACE of the adoption was included in Appendix E of the 2000 REIR/EIS. NMFS formally adopted the conference opinion as its biological opinion on steelhead for the project in May 2000. NMFS's letter notifying USACE of the adoption is included in the Appendix to the Responses to Comments volume of this FEIS.

Spring-Run Chinook Salmon

As stated above, spring-run chinook salmon was listed as threatened under the federal and California ESAs in 1999. To address potential project effects on

Central Valley spring-run chinook salmon ESU, USACE requested consultation with NMFS in accordance with Section 7 of the federal ESA in 1999. USACE noted that the protective measures included in the biological opinions for previously listed species cover the period when spring-run chinook salmon occur in the Delta; USACE concluded that these measures therefore would also minimize adverse effects of the project on spring-run chinook salmon.

NMFS concurred with this conclusion; in August 2000, NMFS issued a biological opinion that states that the project is not likely to jeopardize the continued existence of spring-run chinook salmon or result in the adverse modification of its critical habitat or that of Central Valley steelhead ESU. NMFS's biological opinion on spring-run chinook salmon is included in the Appendix to Volume 2 of this FEIS.

DFG's biological opinion on project effects on delta smelt and winter-run chinook salmon also assessed Delta Wetlands' impacts on spring-run chinook salmon, but it made no conclusions about effects on this species because the species was not listed at the time. The RPMs were indicated as minimizing adverse impacts of the incidental taking of spring-run chinook salmon and of the fish species that were then listed. In accordance with Section 2081 of the California Fish and Game Code, Delta Wetlands has requested concurrence directly from DFG that the protective measures in the existing biological opinion adequately address potential project effects on spring-run chinook salmon.

Resumption of the Water Right Hearing and Completion of the Final EIR and Final EIS

The SWRCB's hearing on Delta Wetlands' water right applications was resumed and completed in October 2000. Delta Wetlands and California Urban Water Agencies (CUWA) submitted to the SWRCB an agreement that Delta Wetlands would operate according to the terms of the Delta Wetlands Project Water Quality Management Plan (WQMP) negotiated by Delta Wetlands and CUWA. During the October 2000 hearing, CUWA stated that it will withdraw its opposition to the Delta Wetlands water right permits based on the inclusion of the WQMP as a permit term or condition.

EBMUD and Contra Costa Water District (CCWD) also entered into protest dismissal agreements with Delta Wetlands and submitted these to the SWRCB. The agreements include programs to ensure the stability of project island levees, protections against seepage from the reservoir islands to neighboring islands, and limits on the project's water quality effects. Copies of these agreements are included in the Appendix to Volume 2 of this FEIS.

In January 2001, the SWRCB issued a FEIR to respond to comments on the 1995 DEIR/EIS and the 2000 REIR/EIS. The SWRCB certified the FEIR and approved Delta Wetlands' water right permit applications on February 15, 2001.

This FEIS has been prepared to respond to agency and public comments received on the 1995 DEIR/EIS and 2000 REIR/EIS. The NEPA requirements for a FEIS are described in the next section.

PURPOSE OF THE FINAL EIS AND REQUIREMENTS FOR ADOPTION

The FEIS analyzes and discloses the environmental effects of the Delta Wetlands Project, identifies ways to reduce or avoid potential adverse environmental effects of the project, and identifies and assesses alternatives to the proposed action. Under NEPA, after a lead agency has completed a draft EIS, it must consult with and obtain comments from public agencies that have legal jurisdiction with respect to the proposed project, and must provide the general public with opportunities to comment on the draft document (40 CFR 1503.1). An FEIS is prepared to respond to those comments and to present the text of the EIS with revisions and updates incorporated.

Information presented in this FEIS will be used by USACE in its evaluation of Delta Wetlands' permit applications. The FEIS may be used by other agencies for compliance with NEPA and CEQA for other approvals needed for project implementation. Chapter 4, "Permit and Environmental Review and Consultation Requirements", describes the other approvals that may be needed.

USACE will circulate this FEIS for public review before making a decision on the proposal. If USACE determines that the FEIS meets NEPA requirements, it will adopt the document. When it decides on Delta Wetlands' Section 404 and Section 10 permit applications, USACE will prepare a record of decision regarding its determination, the alternatives analyzed, the mitigation measures required as a condition of permit approval, mitigation measures presented but not required, and monitoring and enforcement of the required mitigation measures.

ORGANIZATION AND FORMAT OF THE FINAL EIS

According to the CEQ NEPA Regulations, an FEIS must include:

comments and recommendations received on the draft EIS, either verbatim or in summary;

the responses of the lead agency to significant environmental points raised in the review and consultation process (40 CFR 1503.4[b]);

a rewritten version of the draft EIS that reflects changes to the text resulting from the responses to comments as well as information that has been changed or updated since the original publication of the document; and

a list of persons, organizations, and public agencies commenting on the draft EIS.

The FEIS is divided into two volumes. Volume 1 consists of a combined rewritten version of the 1995 DEIR/EIS and the 2000 REIR/EIS. The organization of chapters in this volume is the same as that of the 1995 DEIR/EIS. As described above, the 2000 REIR/EIS updated the analyses for only some of the subjects covered by the 1995 DEIR/EIS. Therefore, for those subject areas of the 1995 DEIR/EIS that were addressed again in the 2000 REIR/EIS, the chapter of this FEIS includes the text of the 1995 DEIR/EIS followed by the text of the corresponding 2000 REIR/EIS chapter. The other chapters in this volume (those that cover subject areas that were not updated in the 2000 REIR/EIS) include only the 1995 DEIR/EIS analysis as revised in response to comments.

All the chapters have been revised to reflect changes made in response to comments received on the 1995 DEIR/EIS and the 2000 REIR/EIS and to incorporate updates of other information contained in those chapters. The chapters that include material from the 1995 DEIR/EIS and the 2000 REIR/EIS also have been modified to enhance readability; for example, cross-referencing has been added between the 1995 DEIR/EIS and 2000 REIR/EIS sections.

Volume 1 is organized as follows:

"Summary" provides a comparison of environmental effects between the alternatives and a summary of impact determinations, as required by CEQA and NEPA. Unavoidable impacts are identified, as are irreversible commitments of resources and cumulative impacts of this project in combination with other actions in the region.

Chapter 2, "Delta Wetlands Project Alternatives", identifies the purpose of and need for the project and describes the features of the Delta Wetlands Project alternatives considered in this FEIS.

Chapter 3, "Affected Environment and Environmental Consequences", is presented as a series of chapters (3A through 3O), each devoted to an issue area listed under "Delta Wetlands' 1993 Project Proposal and the 1995 Draft EIR/EIS" above. Each of these chapters describes the affected environment and environmental impacts of the Delta Wetlands Project alternatives, and methods of mitigating significant impacts.

Chapter 4, "Permit and Environmental Review and Consultation Requirements", summarizes the environmental review, consultation, and permitting requirements that must be satisfied before the Delta Wetlands Project can proceed.

Chapter 5, "List of Preparers", lists the individuals involved in preparing the FEIS.

Chapter 6, "Glossary of Technical Terms", provides definitions of technical terms used in this report.

Chapter 7, "Distribution List", lists all the agencies, organizations, and individuals that have received copies of the FEIS.

References are listed at the end of each chapter in which they are cited.

Volume 2 consists of responses to comments.

Chapter 1 of Volume 2, "Introduction to the Responses to Comments", describes the organization of that volume.

The technical appendices to the 1995 DEIR/EIS and the 2000 REIR/EIS contain background information for the resource chapters and data compiled for the impact assessments. Table 1-2 lists the appendices from both documents. These appendices are hereby incorporated by reference.

Volumes 1 and 2 of this document and the technical appendices incorporated by reference constitute the FEIS. Copies of the 1995 DEIR/EIS, the 2000 REIR/EIS, the FEIR, and this FEIS are available for public review at public libraries located in the following cities in California:

- Antioch,
- Concord,
- Vallejo,
- Lodi,
- Martinez,
- Oakland,
- Rio Vista,
- Fairfield,
- Stockton,
- Tracy, and
- Sacramento (the main public library and the California State Library).

Additional copies of the NEPA and CEQA documents for the Delta Wetlands Project are available for review during normal business hours Monday through Friday, excluding holidays, at the following locations:

U.S. Army Corps of Engineers
Regulatory Branch, Sacramento District
1325 J Street, Room 1480
Sacramento, CA 95814

California State Water Resources Control Board
Division of Water Rights
1001 I Street
Sacramento, CA 95814

CITATIONS

Jones & Stokes Associates, Inc. 1988. Final scoping report for the EIR/EIS on the Bedford Properties Delta Islands project. (JSA 87-119.) Sacramento, CA. Prepared for California State Water Resources Control Board, Division of Water Rights, and U.S. Army Corps of Engineers, Sacramento District, Regulatory Section, Sacramento, CA.

__________. 1990. Draft EIR/EIS for the Delta islands project of Delta Wetlands, a California Corporation. December. (JSA 87-119.) Sacramento, CA. Prepared for California State Water Resources Control Board, Division of Water Rights, and U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA.

__________. 1995. Environmental impact report and environmental impact statement for the Delta Wetlands Project. Draft. September 11, 1995. (JSA 87-119.) Sacramento, CA. Prepared for California State Water Resources Control Board, Division of Water Rights, and U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA.

Jones & Stokes. 2000. Revised draft environmental impact report and environmental impact statement for the Delta Wetlands Project. May. (J&S 99-162.) Sacramento, CA. Prepared for the California State Water Resources Control Board and the U.S. Army Corps of Engineers, Sacramento, CA.

U.S. Army Corps of Engineers. 1977. Regulatory program applicant information. (EP-1145-2-1.) Washington, DC.

Table 1-1. Timeline of the Delta Wetlands Project

Year	CEQA/NEPA Process	Water Right Process	Section 404/Section 10 Process	Endangered Species Act (ESA) Process
1987		Water right applications filed with the SWRCB for storage of water on four islands		
1988			Department of Army application filed with USACE for discharge of dredged or fill material into waters of the United States and for effects on navigable waters of the United States	
1990	Draft EIR/EIS released (December)			
1993		New water right applications submitted for storage of water on two islands and creation of habitat on two islands		
1995	1995 DEIR/EIS released (September)			Biological assessment of project effects on state-listed and federally listed fish and wildlife species prepared
				California ESA consultation initiated by the SWRCB with DFG
				Federal ESA consultation initiated by USACE with USFWS and NMFS
1996	Comments received on 1995 DEIR/EIS			State and federal ESA consultation continues
1997		SWRCB water right hearing conducted to receive input on water right applications		No-jeopardy biological opinions issued by USFWS and NMFS
1998			SWRCB denies Section 401 certification without prejudice	Final no-jeopardy biological opinion issued by DFG

Table 1-1. Continued

Year	CEQA/NEPA Process	Water Right Process	Section 404/Section 10 Process	Endangered Species Act (ESA) Process
1999	The SWRCB and USACE determine that an REIR/EIS is required to present new information and to describe changes to the project resulting from the water right hearing and ESA consultations	Parties to the water right hearing invited to attend status meetings conducted by the SWRCB	USACE suspends processing of application due to the SWRCB's denial of Section 401 certification USACE resumes processing application with commencement of preparation of FEIS	USACE consults with USFWS and NMFS about newly listed species; Delta Wetlands coordinates with DFG about newly listed species and changes to California ESA
2000	2000 REIR/EIS issued for public review and comment (May)	After comments are received on the 2000 REIR/EIS, water right hearing proceedings concluded by the SWRCB (October)		USFWS adopts conference opinion on splittail as biological opinion. NMFS adopts conference opinion on steelhead as biological opinion; NMFS confirms that its authorization applies to spring-run chinook salmon
2001	FEIR prepared, responding to comments received on the 2000 REIR/EIS and 1995 DEIR/EIS (January) The SWRCB certifies the FEIR and adopts findings of fact and statement of overriding considerations for all significant and unavoidable impacts (February) USACE circulates FEIS for public review (July) *USACE issues a record of decision (ROD)*	After FEIR is prepared, the SWRCB releases a draft water right decision and receives comments on draft decision (January) The SWRCB approves the water right permits under Water Right Decision 1643 (February)	*After FEIS is adopted, USACE confirms compliance with ESA, the National Historic Preservation Act, and Section 401* *After issuing a ROD, USACE decides whether to issue Department of Army permit*	*DFG converts biological opinion to a 2081 agreement, and confirms that its authorization applies to spring-run chinook salmon.*

Note: *Italic type* indicates anticipated future actions.

Table 1-2. Appendices in the 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS

Appendix	Title
	1995 DEIR/EIS
1	SWRCB Public Notice for the Delta Wetlands Water Right Applications
2	Supplemental Description of the Delta Wetlands Project Alternatives
A1	Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project
A2	DeltaSOS: Delta Standards and Operations Simulation Model
A3	DeltaSOS Simulations of the Delta Wetlands Project
A4	Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments
B1	Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project
B2	Salt Transport Modeling Methods and Results for the Delta Wetlands Project
C1	Analysis of Delta Inflow and Export Water Quality Data
C2	Analysis of Delta Agricultural Drainage Water Quality Data
C3	Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project
C4	DeltaDWQ: Delta Drainage Water Quality Model
C5	Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water
C6	Assessment of Potential Water Contaminants on the Delta Wetlands Project Islands
D1	Annotated List of Geotechnical Reports Prepared for the Delta Wetlands Project
E1	Design and Construction of Wilkerson Dam South of SR 12 on Bouldin Island
F1	Supplemental Information on the Affected Environment for Fisheries
F2	Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species
G1	Plant Species Nomenclature
G2	Prediction of Vegetation on the Delta Wetlands Reservoir Islands
G3	Habitat Management Plan for the Delta Wetlands Habitat Islands
G4	Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives

Table 1-2. Continued

Appendix	Title
G5	Summary of Jurisdictional Wetland Impacts and Mitigation
H1	Wildlife Species Nomenclature
H2	Wildlife Inventory Methods and Results
H3	Federal Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Wildlife Species
H4	California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane
H5	Agency Correspondence regarding the Federal and California Endangered Species Acts
L1	Estimated Trip Generation
M1	Cultural Context of the Delta Wetlands Project Islands
M2	Cultural Resource Survey Information for the Delta Wetlands Project Islands
M3	Programmatic Agreement
O1	Air Quality Monitoring Data and Pollutant Emissions under Existing Conditions and the Delta Wetlands Project Alternatives
4	Section 404(b)(1) Alternatives Analysis for the Delta Wetlands Project
	2000 REIR/EIS
A	Summary of Stipulated Agreements between Delta Wetlands and Parties to the Hearing on Delta Wetlands' Water Rights Applications
B	Delta Wetlands Project Final Operations Criteria
C	California Department of Fish and Game Biological Opinion
D	National Marine Fisheries Service Biological Opinion
E	U.S. Fish and Wildlife Service Biological Opinion
F	Daily Simulations of Delta Wetlands Project Operations
G	Water Quality Assessment Methods
H	Levee Stability and Seepage Technical Report
I	Distribution List for the Revised Draft EIR/EIS

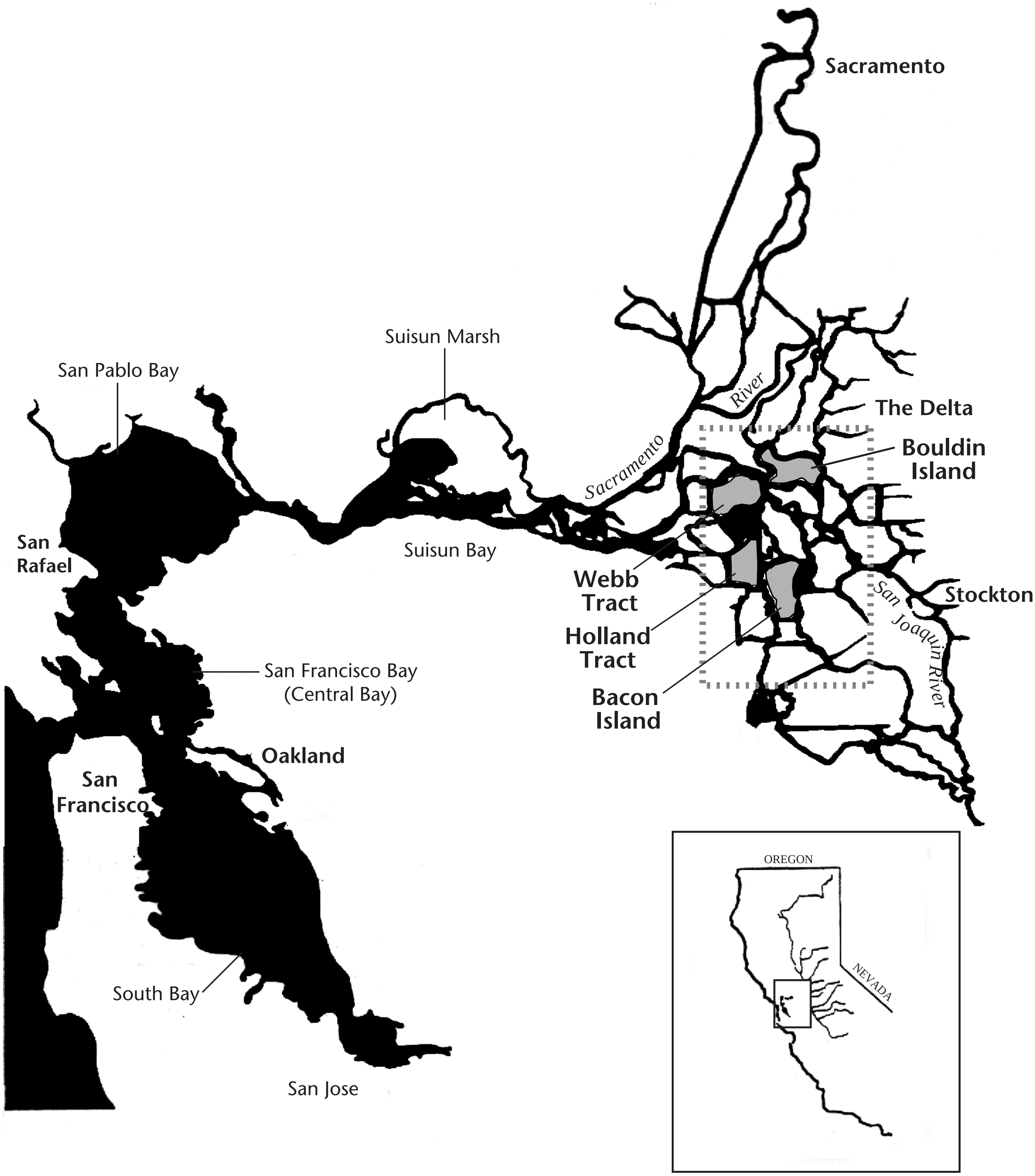

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Figure 1-1
Delta Wetlands Project Location

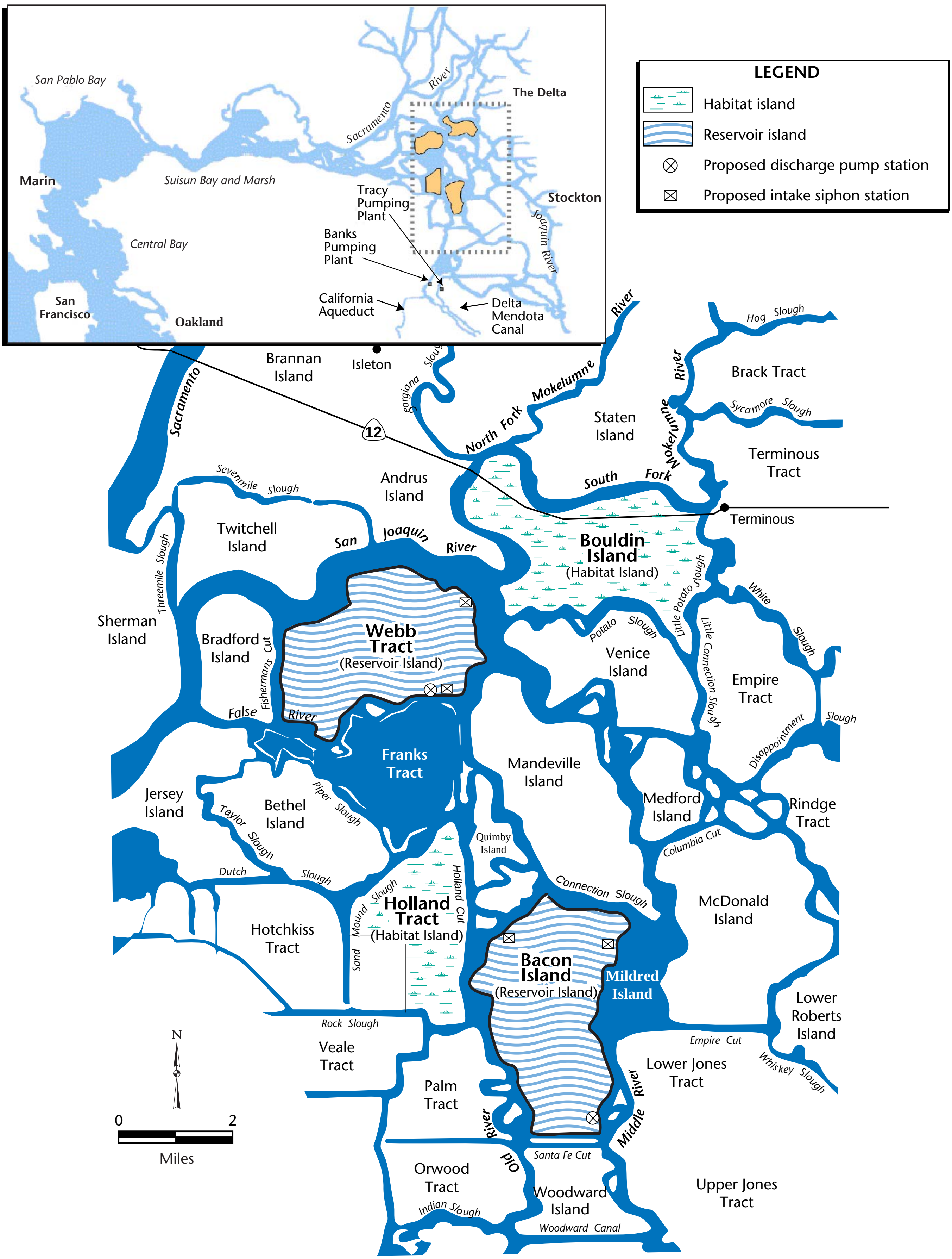

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Figure 1-2
Delta Wetlands Project Islands

Chapter 2. Delta Wetlands Project Alternatives

Chapter 2. Delta Wetlands Project Alternatives

DW PROJECT PURPOSE AND NEED

The purpose of the DW project is to divert surplus Delta inflows, transferred water, or banked water for later sale and/or release for Delta export or to meet water quality or flow requirements for the Bay-Delta estuary. Additionally, the DW project will provide managed wetlands and wildlife habitat areas.

The DW project would increase the availability of high-quality water in the Delta for export or outflow by storing water on two reservoir islands, and would compensate for wetland and wildlife effects of the water storage operations on the reservoir islands by implementing a habitat management plan (HMP) on two habitat islands.

The DW project also includes construction of recreation facilities along the perimeter levees on all four DW project islands; operation of a private airstrip on Bouldin Island; and, during periods of nonstorage, management of shallow water within an inner levee system on the reservoir islands. In May 2001, however, DW removed construction of recreation facilities from its CWA and Rivers and Harbors Act permit applications. The conceptual descriptions of those facilities remain largely unchanged from those included in the 1995 DEIR/EIS; they are presented in this chapter for informational purposes.

The following discussions describe Delta export demands, Delta water quality needs, and environmental flow requirements that DW project water could be used to satisfy.

Delta Export Demands

It is the project applicant's intent that DW project operations would help satisfy Delta export demands by augmenting water supply for exports.

Water sent from northern California to central and southern California or to the Bay Area by the SWP, operated by DWR, and the CVP, operated by the U.S. Bureau of Reclamation (Reclamation, or USBR), must pass through the Delta. Water is diverted from the Delta by the CVP and the SWP; agricultural users of water from approximately 1,800 local irrigation diversions; and cities such as Antioch and Concord to supply the domestic needs of two-thirds of the state's population and irrigate several million acres of farmlands (DWR 1994). Destinations for DW project water could include the SWP, the CVP, and third-party buyers that use the SWP or CVP facilities for transport of water (a process often referred to as "wheeling").

As described in DWR's 1994 California Water Plan Update (Bulletin 160-93), demands for water in California are estimated to exceed dependable supplies. Assuming the levels of Delta water supply availability under improved water management, existing SWP facilities, and SWRCB Water Right Decision 1485 (D-1485), issued in 1978, DWR estimated that California would have an annual deficit in dependable supplies of 2.9-4.9 million acre-feet (MAF) of water by 2020. (DWR 1994.)

Delta Water Quality Needs

It is the project applicant's intent that DW project discharges would increase the supply of high-quality water and freshwater releases for outflow from the Delta.

Water quality considerations have a direct bearing on the quantity of Delta water available for use. Delta waters provide a rich habitat for fish and wildlife and are a major source of supply for uses throughout the state. Drinking water for about 20 million Californians flows through the Delta. Water quality parameters such as temperature; turbidity; and oxygen, mineral, dissolved metal, organic, and nutrient content all affect the usability of water and therefore affect the total quantity available for specific uses and the overall availability of water supplies in California. Urban water supplies diverted from the south Delta, for example, face the threat of increasing water quality degradation resulting from both salinity intrusion and the presence of organic substances and salinity originating in agricultural drainage from Delta islands or tributary streams. The pressures of a steadily growing population, additional requirements for water to meet environmental needs, and potentially more frequent water shortages pose serious water management and risk management problems for California (DWR 1994).

SWRCB has established specific water quality objectives to protect the uses of water in the Bay-Delta. Many of these objectives relate to salinity. The SWP and the CVP are required to release sufficient fresh water to meet these Delta salinity objectives. However, DWR estimates that increasingly stringent water quality standards for public health protection will affect the continued availability and cost of water supplies (DWR 1994).

Environmental Flow Requirements

DW project water could be used to increase water available to meet environmental flow needs, including fishery flow needs, water needs of freshwater wetlands (and Suisun Marsh), and outflow requirements to meet estuarine salinity objectives.

The Bay-Delta estuarine system has long been an important resource to California. More than 100 species of fish use the Bay-Delta system. Some, such as delta smelt and catfish, are year-round residents and others, such as American shad, are in the estuary for only a few months. Some of the species can live only in relatively fresh water and others can survive only in the more saline parts of the Bay. There are also several fish with intermediate salinity tolerance; these are the true estuarine species.

The health of populations of estuarine species is closely linked to the condition of the estuarine environment. The recurrence of drought (both in 1976-1977 and 1987-1992), combined with increasing human demands on water supply, has shown that fish populations and wetland areas require a water supply that is more dependable than that managed now. As a result of natural and human factors, three runs (or races) of chinook salmon in the Central Valley and Klamath/Trinity River system have shown severe population declines in recent years. Five fish species that use the Bay-Delta estuary—winter-run chinook salmon, spring-run chinook salmon, Central Valley steelhead, splittail, and delta smelt—are at such low abundance levels that they are listed under the federal ESA. Additionally, spring-run and winter-run chinook salmon and delta smelt are also listed as threatened under the California ESA.

Among the many factors affecting the estuarine environment are the rate and timing of freshwater inflow to the estuary; the quantities of fresh water reaching it seasonally, annually, and over a series of years; and diversions from the estuary for both local and export uses. In the past 50 years, developments in the vicinity of the Bay-Delta estuary, along with numerous local, state, and federal water developments on Central Valley tributary streams, caused changes in the timing and amounts of Delta inflows and outflows during most years.

Water-related factors having the greatest effect on the Bay-Delta estuary are:

Delta inflow,

flows from the Sacramento River through the Delta Cross Channel (DCC),

reverse flows,

water project diversions and local agricultural diversions,

agricultural return flows, and

Delta outflow and salinity.

SWRCB, through its water right process, provides the principal forum for establishing the Bay-Delta's environmental flow requirements. SWRCB reserves jurisdiction in water right permits and periodically holds water right hearings in which interested agencies and parties provide evidence supporting their views regarding the water right, public interest, or public trust impacts of a permitted use. SWRCB then sets objectives and operating criteria to provide balanced protection to all recognized beneficial uses.

DWR calculates that environmental demands for water in California are currently at 28.4 MAF and could increase to 28.8 MAF by 2020 (DWR 1994). The flows that may ultimately be required to meet Bay-Delta environmental needs are influenced by many of the decision-making processes that affect the operation of the state and federal water projects (see discussion of CVP and SWP requirements in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives").

SELECTION PROCESS FOR THE DW PROJECT ALTERNATIVES

The DW project alternatives (Alternatives 1, 2, and 3) and the No-Project Alternative were selected to represent a range of project operations for purposes of determining environmental impacts. All alternatives are designed to operate within the objectives of SWRCB's 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 WQCP), adopted May 22, 1995. If the DW project is approved by the SWRCB and Corps, actual project operations should be within the range of impacts analyzed in this EIR/EIS.

The project applicant's proposed project consists of storage of water on two reservoir islands and implementation of an HMP on two habitat islands. The operational scenarios presented below as Alternatives 1 and 2 both represent DW's proposed project and differ only with regard to operating criteria for discharge of stored water. Analysis of the proposed project as represented by these two alternatives allows potential impacts of DW's proposed project to be evaluated for the full range of likely DW operations. An additional operational scenario, Alternative 3, consists of use of all four of the DW project islands as reservoirs and provision of limited compensation habitat on Bouldin Island. Table 2-1 presents an overview of the differences between water storage operations under Alternatives 1, 2, and 3 as simulated for the 1995 DEIR/EIS. The "seasonal wetlands" operation of diverting and storing water for discharge to export during winter through summer and creating wetland habitat in fall, as originally proposed in the 1990 EIR/EIS, no longer applies to any of the alternatives.

The alternatives are described in detail in the following sections of this chapter. The section "Alternatives Considered but Not Selected for Detailed Evaluation" presents those alternatives that were first considered during development of the range of project alternatives to meet the requirements of both EPA's Section 404(b)(1) guidelines and NEPA. The alternatives analyzed in detail in this document represent further refinement of the reasonable range of alternatives. The project must constitute the least environmentally damaging practicable alternative in compliance with Section 404(b)(1) guidelines of the Clean Water Act (CWA) to be permitted by the Corps.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The project description and the treatment of project alternatives were modified in the 2000 REIR/EIS. As described in Chapter 1, USFWS and NMFS issued no-jeopardy biological opinions in 1997 regarding effects of the DW project on federally listed fish species, and DFG issued a no-jeopardy opinion in 1998 on project effects on state-listed fish, wildlife, and plant species. The findings of no jeopardy were based on incorporation into the proposed project of the detailed project operating parameters referred to as the DW "final operations criteria" (FOC). The FOC were developed by the SWRCB, the Corps, NMFS, USFWS, and DFG as part of the formal consultation process for listed fish species. The biological opinions and the FOC were developed for the proposed two-reservoir-island project. The description of Alternatives 1 and 2 provided in the 1995 DEIR/EIS were therefore revised in the 2000 REIR/EIS to incorporate these restrictions.

This chapter includes both the 1995 DEIR/EIS description of project alternatives and the discussion of modifications and differences between the proposed project as described in the 1995 DEIR/EIS and the 2000 REIR/EIS. Additionally, minor text changes were made to update information in response to comments received on the 1995 DEIR/EIS and 2000 REIR/EIS.

The description of the proposed project as revised includes construction and operation of recreation facilities on all four project islands. In May 2001, however, DW removed construction of these facilities from its CWA and Rivers and Harbors Act permit applications. The conceptual descriptions of the recreation facilities remain largely unchanged from those included in the 1995 DEIR/EIS; they are presented in this FEIS for informational purposes. Also included are the analyses of the environmental effects of facility construction and operation, and responses to comments on the 1995 DEIR/EIS and 2000 REIR/EIS about the recreation facilities.

DESCRIPTION OF ALTERNATIVES 1 AND 2

Overview

Alternatives 1 and 2 entail the potential year-round diversion and storage of water on two Delta islands owned by DW (Bacon Island and Webb Tract) and wetland and wildlife habitat creation and management, with the incidental sale of the water used for wetland and wildlife habitat creation, on two Delta islands owned primarily by DW (Bouldin Island and Holland Tract) (Figure 2-1). All the land required for the DW project is currently owned by DW or controlled under an option agreement. The reservoir island operations may include shallow-water management during periods of nonstorage at the discretion of DW and incidental to the proposed project. To operate Alternative 1 or 2, DW would improve levees on the perimeters of the reservoir islands and install additional siphons and water pumps. Inner levee systems would also be constructed on both the reservoir and habitat islands for shallow-water management.

Under Alternative 1 or 2, during specified periods of availability throughout the year, water would be diverted onto the reservoir islands to be stored for later sale or release. Water would be discharged from the islands into Delta channels for sale for beneficial uses for export or for Bay-Delta estuary needs during periods of demand, subject to state and federal regulatory standards and the terms of the DW project FOC, biological opinions, and stipulated agreements between DW and other parties to the SWRCB's water right hearing. Water discharged into the Delta channels under proposed project operations would mix with Delta inflows from the Sacramento and San Joaquin Rivers and other tributary rivers and would be available as either export water or Delta outflow (e.g., outflow necessary to satisfy 1995 WQCP objectives or other state or federal standards). DW project operations would be adjusted on a daily basis according to hydrologic information and information on fish abundance and location obtained through monitoring.

The DW project islands could also be used for interim storage of water being transferred through the Delta from sellers upstream to buyers served by Delta exports or to meet Bay-Delta estuary outflow requirements (water transfers), or for interim storage of water owned by parties other than DW for use to meet scheduled Bay-Delta estuary outflow requirements or for export (water banking). Such uses could occur only after the transferrers or bankers of the water applied to SWRCB for rights to new points of diversion or rediversion onto the DW project islands. The frequency and magnitude of these transfer/banking activities is uncertain at this time; each would require separate authorization and may require further environmental documentation beyond that provided for the DW project.

During periods of nonstorage, DW could choose to divert water onto the reservoir islands under riparian claim or senior appropriative water rights for wetland habitat management; typically, diversion would begin after September 1, after an appropriate dry period to allow for growth of wetland plants of value to wintering waterfowl as forage and cover. Wetland habitat created on the reservoir islands would be flooded as storage water becomes available. The inner levee system constructed on each reservoir island would manage shallow-water circulation during nonstorage periods.

Water would be diverted onto the habitat islands to be used for wetland and wildlife habitat creation and management during periods of availability and need. Most likely, the water diversions for wetland management would begin in September and water would be circulated throughout winter. Except for small areas of permanent water, water used on the habitat islands would be discharged on a schedule related to wetland and wildlife values, with drawdown typically by May to promote vegetation growth. In the 1995 DEIR/EIS, the sale of water released from the habitat islands was proposed as an incidental operation of the habitat islands. In response to comments received on the 1995 DEIR/EIS and discussion with resource agency staff during the ESA consultation process, the SWRCB, the Corps, and the project applicant removed the incidental sale of water released from the habitat islands from the description of the proposed project.

Portions of the habitat islands and the reservoir islands would support recreational activities. Waterfowl hunting would be allowed on all four DW project islands; upland bird hunting would be allowed on the reservoir islands and in specific areas on the habitat islands. In the 1995 DEIR/EIS, DW proposed to construct private recreation facilities, including as many as 30 boat berths per facility in adjacent channels and 36 boat berths per facility on the island interiors, vehicle access and parking, and living accommodations, along the perimeter levees on all four DW islands. In May 2001, however, DW removed construction of recreation facilities from its CWA and Rivers and Harbors Act permit applications; therefore, USACE will not approve construction of such facilities when it issues its record of decision. Nevertheless, as information for the reader, the conceptual descriptions of the recreation facilities are provided below. As many as 38 private recreation facilities on the four islands could be developed over the life of the project, and each facility may accommodate up to 40 bedrooms. The recreation facilities on all four islands may be operated to support year-round use of the boat docks. Recreational use and location of the recreation facilities on the habitat islands would be subject to restrictions of the HMP; recreational use on the reservoir islands would depend on water storage operations.

A private airstrip located on Bouldin Island would be operated to support DW recreational and maintenance activities. The airstrip is currently used for agricultural operations.

The following sections describe DW's proposed project in detail and describe the differences between the two operational scenarios for the proposed project presented as Alternatives 1 and 2. Details of DW's existing and applied-for water rights and the proposed uses for these rights are provided later in this chapter under "DW's Existing and Pending Water Rights".

Reservoir Islands

Bacon Island and Webb Tract would be managed for water storage under Alternatives 1 and 2. Facilities that would be needed for the proposed water storage operations include intake siphon stations with auxiliary pumps to divert water onto the reservoir islands and pump stations to discharge stored water from the islands. DW proposes to construct two intake siphon stations on each reservoir island with 16 new siphons each, for a total of 64 siphons. One discharge pump station with 32 new pumps would be installed on Webb Tract and a pump station with 40 pumps would be installed on Bacon Island, for a total of 72 new pumps. Where possible, existing siphons and pumps would be modified or upgraded (e.g., by installation of fish screens on siphons) and reused for water operations. Figures 2-2 and 2-3 show the proposed locations of siphon and pump stations and recreation facilities on Bacon Island and Webb Tract, respectively. DW has proposed locations for these facilities; flexibility exists to choose other locations for the siphon and pump stations before initial construction if the EIR/EIS lead agencies determine that different locations are desirable because of channel hydraulics or environmental, water quality, or other considerations. For example, the location of the discharge station on Bacon Island has been changed from Old River to Middle River since the 1995 DEIR/EIS was issued. Figure 2-4 depicts conceptual cross sections of reservoir islands for full-storage and nonstorage operations. Reservoir island operations and features are described below.

Water Storage Operations

Storage Capacity. The reservoir islands would be designed for water storage levels up to a maximum pool elevation of +6 feet relative to mean sea level (based on National Geodetic Vertical Datum data) providing a total estimated initial capacity of 238 thousand acre-feet (TAF), allocated between Bacon Island and Webb Tract as 118 TAF and 120 TAF, respectively. Water availability, permit conditions, and requirements of the DWR Division of Safety of Dams (DSOD) may limit storage capacities and may result in a final storage elevation of less than +6 feet.

The total physical storage capacity of the reservoir islands may increase over the life of the project as a result of soil subsidence (local or regional sinking, mainly resulting from the oxidation of peat soil in the Delta). Subsidence on the reservoir islands is currently estimated to average 2-3 inches per year and is thought to be caused mostly by agricultural operations. With water storage operations replacing agricultural operations, the rate of subsidence on the reservoir islands is expected to be greatly reduced, although some subsidence may still occur. No method currently exists to predict the rate of subsidence on a Delta island used for water storage operations. DW estimates, however, that the reservoir islands could subside at a rate of approximately 0.5 inch per year, even with the cessation of agricultural operations and possible sedimentation during filling and storage. Under this hypothetical scenario for subsidence on the reservoir islands, the storage capacity of the reservoir islands could increase by as much as 9% in 50 years, increasing total storage capacity of the reservoir islands to 260 TAF.

Multiple Storage. DW has applied for permission to allow reservoir islands to be filled, drawn down, and refilled again in years when water availability and demands were appropriate. These years are classified as multiple-storage years. Multiple storage would generally occur during years of moderate rainfall. This management scenario depends on the availability of surplus water early in the year and a demand for the water to allow an early discharge of the reservoir followed by another period of available surplus water.

Carry-Over Storage. During years of low water demand, water would remain in the reservoirs at the end of the water year (i.e., September 30). DW has applied for permission to allow water to remain on a reservoir island for release in subsequent years. Carry-over storage would generally occur during wet years with low demand.

Siphon Station Design. Two new siphon stations for water diversions would be installed along the perimeter of each reservoir island (Figures 2-2 and 2-3). Each siphon station would consist of 16 siphon pipes 36 inches in diameter. Fish screens to prevent entrainment of fish in DW diversions would be installed around the intake end of each existing and new siphon pipe as specified in the FOC and the biological opinions. The individual siphons would be placed as close together as possible but would be spaced at least 40 feet apart to incorporate fish screen requirements. DW could use the existing reservoir island siphons for diversions to create shallow-water wetland habitat. In-line booster pumps would be available on the reservoir islands to supplement the siphon capacity during final stages of reservoir filling. Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", includes a detailed description of the siphon unit design.

Pump Station Design. One discharge pump station would be located on each reservoir island (Figures 2-2 and 2-3). The pump stations would have 32 new pumps (on Webb Tract) or 40 new pumps (on Bacon Island) with 36-inch-diameter pipes discharging to adjacent Delta channels. Typical spacing for the pumps would be 25 feet on center. An assortment of axial-flow and mixed-flow pumps would be used to accommodate a variety of head conditions throughout drawdown. Actual rates of discharge of each pump would vary with the remaining pool elevations. As water levels decrease on the islands, the discharge rate of each pump also would decrease. Existing pump stations on the islands may be modified and used when appropriate to help with dewatering or for water circulation for water quality purposes. Appendix 2 includes a detailed description of the pump unit design.

Diversion and Discharge Operations. The DW project alternatives are designed to operate within the objectives of the 1995 WQCP and consistently with Corps requirements for maximum SWP exports. The following discussions define terms used to describe DW project operations in the context of Delta operations criteria; explain the criteria for diversions under Alternatives 1 and 2; describe the assumed operating criteria for discharges under Alternative 1; and describe the assumed criteria for discharges under Alternative 2, contrasting them with those for Alternative 1.

Definition of Terms. Following are definitions of several terms used below to describe the manner in which the project alternatives would operate relative to 1995 WQCP requirements and other conditions:

Export limits. The 1995 WQCP specifies that Delta exports are limited to a percentage of total Delta inflow (generally 35% during February-June and 65% during July-January).

Outflow requirements. The 1995 WQCP specifies Delta outflow requirements that encompass water quality protection for agricultural and municipal and industrial uses, Suisun Marsh, and fish habitat. In standard DWR calculations of Delta operations (using the water balance model known as "DWRSIM"), "outflow" represents the difference between inflow and exports; the outflow term used in this chapter therefore includes in-Delta consumptive use.

Available water. Under the 1995 WQCP, available water is total Delta inflow less Delta outflow requirements.

Allowable export. Water allowable for export under the 1995 WQCP is the lesser of the amount specified by the export limits (i.e., percentage of total Delta inflow) and the amount remaining after outflow requirements are met (i.e., available water).

Physical export pumping capacity. The SWP export pumps have a maximum physical pumping capacity of 10,300 cubic feet per second (cfs) and the CVP export pumps have a maximum physical pumping capacity of 4,600 cfs, for a combined physical export pumping capacity of 14,900 cfs. At times, the canal capacity for the CVP is reduced to 4,200 cfs, reducing the combined physical export pumping capacity to 14,500 cfs.

Permitted pumping rate. The Corps would require a new permit for SWP export pumping under Section 404 of the CWA if SWP export pumping were to exceed a maximum 3-day average rate of 6,680 cfs. Therefore, the maximum combined export pumping rate that does not require a new Corps permit is 11,280 cfs (6,680 cfs for the SWP pumps and 4,600 cfs for the CVP pumps). The restrictions for the period of December 15 to March 15, as interpreted by DWR, allow a combined rate of 11,700 cfs in December and March and a combined maximum 3-day average rate of 12,700 cfs in January and February. For assessment of the DW project alternatives, it is assumed that the SWP and CVP pumps will always pump the maximum amount allowable (i.e., the lesser of available water and the amount specified by the export limits) within the limits of the permitted pumping rate.

Future permitted export pumping capacity. In the future, new permit conditions may be established for the SWP, thereby allowing the permitted export pumping rate of the SWP pumps to be increased to the physical export pumping capacity of 10,300 cfs. If that occurs, the combined permitted export pumping rate of the SWP and CVP pumps could then equal up to 14,900 cfs or 14,500 cfs.

Actual exports. Actual exports are the least of the following: the amount specified by the export limits (i.e., as percentage of inflow), available water (i.e., water available after outflow requirements are met), and permitted export pumping rate.

DW discharge for export. DW may sell its stored and discharged water to buyers south or west of the Delta who would arrange to have the purchased water transported to areas of use through either the SWP or CVP aqueducts. The term “wheeling” is often applied to this process of transporting water owned by the purchasing entity through the SWP or CVP aqueducts.

Diversions under Alternatives 1 and 2. Under Alternatives 1 and 2, DW diversions are treated consistently with the 1995 WQCP objectives for Delta exports at the SWP and CVP pumping plants. That is, DW diversions are considered to be the same as SWP and CVP exports in complying with the WQCP objectives, although DW’s applied-for water rights for diversions would have a lower priority than the SWP and CVP water rights and those of other senior water right holders in the Delta.

DW diversions would occur only when the volume of allowable water for export (i.e., the lesser of the amount specified by the export limits and the amount of available water) is greater than the permitted pumping rate of the export pumps. As defined in the 1995 DEIR/EIS, this would occur when two conditions are met: 1) when all Delta outflow requirements are met and 2) when the export limit is greater than the permitted pumping rate, so that water that is allowable for export is not being exported by the SWP and CVP pumps. Situations may exist, however, in which the SWP and CVP may not be pumping at capacity because of low demands during winter, maintenance activities, or other circumstances, but DW would still be able to divert water for storage.

Since the 1995 DEIR/EIS was released, new restrictions have been added that limit the timing and the rate at which diversions may occur on the reservoir islands under Alternatives 1 and 2. These restrictions are described in detail in the FOC, biological opinions, and stipulated agreements between DW and other parties to the SWRCB’s water right hearing. Additional information about these restrictions is provided in the section from the 2000 REIR/EIS below entitled "Revisions to the Project Description from the 2000 Revised Draft EIR/EIS".

Figure 2-5 shows two examples of months with opportunities for DW diversion to storage. The panel on the left shows a month with 40,000 cfs of total Delta inflow when the export limit is 35% of inflow and when required outflow is 7,000 cfs. The permitted pumping rate of 11,280 cfs limits CVP and SWP exports to less than the export limit of 14,000 cfs (35% of 40,000 cfs), providing an opportunity for DW diversions of 2,720 cfs (14,000 cfs - 11,280 cfs).

The panel on the right in Figure 2-5 illustrates a month with total inflow of 20,000 cfs when the export limit is 65% of inflow (13,000 cfs) and when required outflow is 4,000 cfs. In this month also, CVP and SWP exports are limited by permitted pumping rate, so that DW has an opportunity to divert 1,720 cfs, the difference between the export limit and the permitted pumping rate (13,000 cfs - 11,280 cfs).

Current and applied-for water rights for the reservoir islands and their proposed uses are discussed below under "DW's Existing and Pending Water Rights".

Discharges under Alternative 1. For Alternative 1, the 1995 DEIR/EIS analysis assumed that discharges of water from the DW islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and strict interpretation of the export limits (percentage of total Delta inflow, or "percent inflow") specified in the 1995 WQCP does not prevent use of that capacity. Such unused capacity could exist when the amount of available water (i.e., total inflow less Delta outflow requirements) is less than the amount specified by the export limits.

Since the 1995 DEIR/EIS was released, new restrictions have been added that further limit discharges from reservoir islands. These restrictions are described in detail in the FOC, biological opinions, and stipulated agreements between DW and other parties to the SWRCB's water right hearing, which are included in Appendices A through E in the 2000 REIR/EIS. Additional information about modifications to project operations as a result of these restrictions is provided in the section from the 2000 REIR/EIS below entitled "Revisions to the Project Description from the 2000 Revised Draft EIR/EIS".

Figure 2-6 presents an example of DW discharges for export under this alternative as analyzed in the 1995 DEIR/EIS. In the example, total Delta inflow is 20,000 cfs in a month with an export limit of 35% of inflow, or 7,000 cfs. The outflow requirement is 14,000 cfs, leaving only 6,000 cfs of available water (20,000 cfs - 14,000 cfs). The difference between the 35% export limit and the available water (7,000 - 6,000 = 1,000 cfs) could present an opportunity for export of DW releases.

Under this alternative, DW discharges would be treated as additions to total Delta inflow. Export of DW discharges thus would be limited to the lesser of the permitted export pumping capacity and the amount calculated under the "percent inflow" export limit, based on the adjusted inflow amount (20,000 cfs + DW additions to inflow). For example, if DW water is released and exported at the DW maximum monthly average discharge rate of 4,000 cfs, the adjusted total Delta inflow would be 24,000 cfs and the adjusted export limit would be 8,400 cfs (35% of 24,000 cfs). With this adjusted export limit, the opportunity for DW discharge for export would be 2,400 cfs (8,400-cfs export limit - 6,000 cfs of available water). The remainder of the 4,000-cfs DW discharge (1,600 cfs) would be added to Delta outflow.

Under Alternative 1, DW has two choices regarding allocation of discharges. If DW chooses to discharge at the maximum DW discharge rate, some of the releases must be used to increase Delta outflow while the balance is exported, as shown in this example. Alternatively, DW could choose to limit discharges so that no allocation to Delta outflow is needed. In this same example, if DW were to release only 1,500 cfs, the adjusted inflow would be 21,500 cfs and the adjusted export limit would be 7,525 cfs (35% of 21,500 cfs), allowing the 1,500-cfs DW discharge to be exported, along with the 6,000 cfs of available water, without an allocation to Delta outflow.

Discharges under Alternative 2. Under Alternative 2 in the 1995 DEIR/EIS, it is assumed that releases of water from the DW islands would be exported by the SWP and CVP pumps during any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps. DW discharges would be allowed to be exported in any month when such capacity exists and would not be subject to strict interpretation of the export limits (percentage of total Delta inflow). It is assumed that Alternative 2, like Alternative 1, would operate in the context of current Delta facilities, demand for export, and operating constraints. Under this alternative, it is assumed that export of DW discharges is limited by the 1995 WQCP Delta outflow requirements and the permitted combined pumping rate of the export pumps but is not subject to strict interpretation of the 1995 WQCP "percent of inflow" export limit.

Figure 2-6 shows an example of an opportunity for DW discharge for export under this alternative as analyzed in the 1995 DEIR/EIS. For the example month, total Delta inflow is 20,000 cfs when the export limit is 35% of inflow and when required outflow is 14,000 cfs. Total inflow less required outflow would leave 6,000 cfs available for export by the CVP and SWP. Maximum DW discharge of 4,000 cfs could be exported under this alternative, for a total Delta export of 10,000 cfs. The export limit of 7,000 cfs (35% of 20,000 cfs) would not limit export of the DW discharge.

Timing and Rate of Diversions onto the Reservoir Islands. The timing and volume of diversions onto the reservoir islands would depend on how much water flowing through the Delta is not put to reasonable beneficial use by senior water right holders or required for environmental protection and would be subject to operational terms and conditions of project approval. DW proposes to develop a procedure to coordinate DW project diversions with SWP and CVP operations on a daily basis to ensure that DW diversions capture only available Delta flows, satisfy 1995 WQCP water quality objectives, and maximize efficiency of the DW water storage operations. See also the summary of DW's stipulated agreements with DWR and Reclamation presented in the section from the 2000 REIR/EIS below entitled "Revisions to the Project Description".

Diversion rates of water onto the reservoir islands would vary with pool elevation and water availability. The maximum daily average rate of diversions onto either Webb Tract or Bacon Island would be 4,500 cfs (9 TAF per day) at the time diversions begin (i.e., when head differential [the pressure created by water within a given volume] between channel water elevation and the island bottom is greatest). The diversion rate would be reduced as the reservoirs fill and the head differentials diminish. Booster pumps would be used to complete the filling process. The combined maximum daily average rate of diversion for all the islands (including diversions to habitat islands, described below) would not exceed 9,000 cfs. The combined maximum monthly average diversion rate would be 4,000 cfs; at this average rate, both reservoir islands could be filled in approximately one month provided that all terms and conditions set forth by DW's water rights, the FOC, biological opinions, and stipulated agreements are satisfied; see the section from the 2000 REIR/EIS below entitled "Revisions to the Project Description from the 2000 Revised Draft EIR/EIS".

Estimated mean monthly diversions under Alternatives 1 and 2 simulated for the 1995 DEIR/EIS are shown in Table 2-2. This table presents an overview of estimated DW project operations but does not show the pattern of estimated operations, which includes values that vary widely from the average values. Appendix 2 presents monthly percentiles of diversions under Alternatives 1 and 2 simulated for the 1995 DEIR/EIS. Chapter 3A, "Water Supply and Water Project Operations", includes the results of the 2000 REIR/EIS simulations of proposed project diversions.

Timing and Rate of Discharges from the Reservoir Islands. DW proposes to discharge stored water from the reservoir islands during periods of demand, subject to Delta regulatory limitations, export pumping capacities, and restrictions imposed by the FOC, biological opinions, and DW's stipulated agreements with other parties to the SWRCB's water right hearing. Discharges would be pumped at a combined maximum daily average rate of 6,000 cfs. The combined monthly average discharge rate of the reservoir islands, however, would not exceed 4,000 cfs; at this average rate, both reservoir islands could be emptied in approximately one month. The pump station pipes would discharge underwater to adjacent Delta channels.

Estimated mean monthly discharges from the reservoir islands under Alternatives 1 and 2 simulated for the 1995 DEIR/EIS are shown in Table 2-2. Appendix 2 presents monthly percentiles showing simulated patterns of operations under the DW project alternatives. Chapter 3A, "Water Supply and Water Project Operations", includes the results of the 2000 REIR/EIS simulations of proposed project discharges.

Levee Improvements and Maintenance

For operation of Alternatives 1 and 2, the perimeter levees on the DW reservoir islands would be improved to bear the stresses and erosion potential of interior island water storage and drawdown. DW would raise and widen the perimeter levees on the reservoir islands to hold water at a maximum elevation of +6 feet. Levee improvements would be designed to meet or exceed state-recommended criteria for levees outlined in DWR Bulletin 192-82 (DWR 1982). Levee design would address control of wind and wave erosion through placement of rock revetment on the inside slopes of the perimeter levees and control of project-related seepage through an extensive monitoring and control system.

DW would implement a monitoring and maintenance plan for the improved perimeter levees on the reservoir islands. During project operation, the perimeter levees would be inspected weekly to indicate any erosion, cracking, or seepage problems. Ongoing maintenance activities on the levees would include, but are not limited to, placement of fill material, placement or installation of erosion protection material, reshaping or grading of fill material, herbicide application, selective burning, and regrading or patching of the levee road surface.

Shallow-Water Management on the Reservoir Islands

Incidental to project operations, Alternatives 1 and 2 could include shallow-water management on Bacon Island and Webb Tract to enhance forage and cover for wintering waterfowl when water would not be stored on the reservoir islands. As discussed in Chapters 3G, "Vegetation and Wetlands", and 3H, "Wildlife", DW would not be required to create wetland habitat on the reservoir islands to compensate for impacts on wildlife or wetland resources resulting from water storage operations; compensation habitat is provided on the habitat islands under the HMP (see "Summary of the Habitat Management Plan" below). Creation of wetland habitat on the reservoir islands would be implemented at DW's discretion.

DW would construct and maintain an inner levee system on the bottoms of the reservoir islands. The system would consist of a series of low-height levees and connecting waterways and would manage shallow water during periods of nonstorage. The inner levees would be broad earthen structures large enough to serve as roadways during nonstorage and shallow-water wetland conditions and similar to the structures currently in place on existing farm fields. The inner levee system and associated water control structures would be designed to allow at least 65% of each reservoir island to be flooded to create shallow-water wetlands. At least 50% of the flooded area would be managed to provide an average water depth of 12 inches, and up to 15% of the area would be flooded to a depth of 24 inches or more. Water control structures would be installed to manage water to contain outbreaks of wildlife disease and mosquito production. Appendix 2 includes details on levee design and borrow sites for levee improvement materials. More detail regarding levee design and maintenance is presented in Chapter 3D, "Flood Control".

When water is not being stored on the reservoir islands, the islands could be flooded to shallow depths (approximately 1 acre-foot of water per acre of wetland) for creation of wetland habitat, typically 60 days after reservoir drawdown. During years of late reservoir drawdown, additional time may be necessary before shallow flooding begins to allow seed crops to reach maturity. Once shallow flooding for wetland management occurred, water would be circulated through the system of inner levees until deep flooding occurred or through April or May. If the reservoir islands were not deeply flooded by April or May, water in seasonal wetlands would be drawn down in May, and if no water were available for storage, the island bottoms would remain dry until September, when the cycle would potentially repeat. Incidental to the shallow-water management, DW could potentially sell that water when it was drawn down in April or May. DW's current and applied-for water rights for the reservoir islands and their proposed uses under Alternatives 1 and 2 are described below under "DW's Existing and Pending Water Rights".

Recreation Facilities

Water storage operations on Bacon Island and Webb Tract would not preclude recreation on those islands. DW has proposed to construct a maximum of 11 recreation facilities on each of these islands along the perimeter levees, as shown in Figures 2-2 and 2-3. Each recreation facility would be constructed on approximately 5 acres and would include living quarters with a maximum of 40 bedrooms, a 30-berth floating dock with a gangway that provides access from neighboring water channels, a 36-berth floating dock on the interior of the island to provide small-boat access to hunting areas, and a 40-car parking lot located along the levee crest access road. Appendix 2 describes the proposed recreation facilities in more detail. In May 2001, however, DW removed construction of recreation facilities from its CWA and Rivers and Harbors Act permit applications; therefore, USACE will not include construction or operation of such facilities in any permit issued pursuant to Delta Wetlands' current application. Nevertheless, as information for the reader, the conceptual descriptions of the recreation facilities are provided below.

DW Environmental Research Fund

The DW project, once operating, would contribute $2 per acre-foot of water sold for Delta export to a research fund established to sponsor related research work. No monies from the fund will be allocated to fulfill project permit requirements. Rather, it is intended that the fund pay for research in those areas that may be affected by the DW project and in other areas in the Delta.

The fund would be administered by DW, and an invited committee would be established to decide how research funds would be allocated. The committee will likely include representatives from the California Department of Fish and Game (DFG), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), SWRCB, DW, fishery-oriented and waterfowl-oriented organizations, and one general environmental organization.

Operations and Maintenance

Operation and maintenance activities for the reservoir islands under Alternatives 1 and 2 would include:

- operation of onsite siphons and pumps during water diversions and discharges;
- inspections and maintenance of perimeter levees, including placement of fill and rock revetment as needed;
- maintenance of inner levees for shallow-water management and management of reservoir bottoms;
- maintenance and monitoring of siphon units and fish screens;
- inspections and maintenance of pump and siphon stations; and
- maintenance and operation of recreation facilities performed by seasonal employees.

Other operation and maintenance measures required by water rights, the FOC, biological opinions, stipulated agreements, and other permit requirements (including proposed mitigation measures) are described for each resource area in Chapters 3A through 3O.

Habitat Islands

Bouldin Island and Holland Tract would be managed for wetlands and wildlife habitat under Alternatives 1 and 2 (Figures 2-7 and 2-8).

The primary function of the habitat islands, as described in the HMP, is to offset the effects of water storage operations on state-listed threatened and endangered species, waters of the United States (including wetlands) pursuant to Section 404 of the CWA and Section 10 of the Rivers and Harbors Act of 1899, other wildlife habitat areas, and wintering waterfowl. The habitat islands would be developed and managed to provide breeding and foraging habitat for special-status wildlife species and other important wildlife species groups. The amounts and types of wetlands and other habitats developed on the habitat islands would compensate for the impacts of project facility construction and water storage operations on the reservoir islands and any impacts associated with construction and operation of the habitat islands.

Wetland management on the habitat islands would require grading areas, revegetating, and diverting water. As part of Alternatives 1 and 2, improvements would be made to existing siphon and pump facilities and to perimeter levees, including levee buttressing to meet DWR's recommended standards for levee stability and flood control. Figure 2-9 depicts conceptual cross sections of Bouldin Island and Holland Tract under fall management conditions when seasonal wetlands are flooded. No new siphon or discharge pump stations would be constructed on the habitat islands. Recreation facilities would be constructed on the habitat island perimeter levees, and the Bouldin Island airstrip would be operated to support maintenance and recreational activities on the DW project islands. As described above, DW removed construction of these facilities from its CWA permit applications.

Summary of the Habitat Management Plan

The HMP was developed to describe how the habitat islands will be managed to provide for wetlands and wildlife habitat to offset acreage affected by operation of the DW project. Also incorporated into the HMP were provisions for best land management practices to benefit wildlife species other than those special-status target species specifically addressed by the HMP. The HMP specifically describes goals and objectives for wildlife habitat management, habitat design and function, guidelines for habitat and recreation management, and procedures for ensuring short- and long-term success of project compensation. Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", contains detailed descriptions of the components of the HMP.

The HMP was developed by a team consisting of representatives of DFG, SWRCB, and JSA, in consultation with the Corps and USFWS. DW worked with the HMP team prior to preparation of the 1995 DEIR/EIS to incorporate the HMP into DW's proposed project. The HMP team designed island habitats, habitat juxtaposition, and habitat management guidelines to achieve the following goals, which are listed in order of descending priority:

Compensation goals: compensate for water storage operation effects on Swainson's hawk and greater sandhill crane, species listed as threatened or endangered under the California Endangered Species Act; wintering waterfowl habitat; and wetlands, as regulated by the Corps, pursuant to Section 404 of the CWA.

Species goals: without compromising compensation goals, implement best land management practices to benefit upland wildlife species; enhance waterfowl breeding habitat, greater sandhill crane roosting habitat, and Swainson's hawk nesting habitat; and provide habitats for other special-status species.

Other important goals: propose best land management practices that do not detract from compensation and priority species goals to enhance habitat conditions for other important species or species groups, such as migratory shorebirds, nongame water birds, and species associated with riparian habitats.

See Chapter 3G, "Vegetation and Wetlands"; Chapter 3H, "Wildlife"; and associated appendices for more information on the HMP and on the effects of water storage operations.

Habitat Island Diversions and Discharges

Bouldin Island and Holland Tract would be managed for improvement and maintenance of wetland and wildlife values. The timing and volumes of diversions onto the habitat islands would depend on the needs of wetlands and wildlife habitat. Wetland diversions would typically begin in September and water would be circulated through winter. Existing siphons would be used for diversions to the habitat islands. Fish screens would be installed on all siphons used for diversions.

The maximum rate of proposed diversions onto Holland Tract and Bouldin Island would be 200 cfs per island. Diversions onto the habitat islands would not cause the combined maximum daily average diversion rate of 9,000 cfs for all four DW project islands to be exceeded. The estimated water budget for the habitat islands is presented in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project". Water would be applied to the habitat islands in each month for management of acreages of open water and perennial wetlands, flooded seasonal wetlands, and irrigated croplands specified in the HMP. Approximately 19 TAF would be diverted annually onto the habitat islands.

Water would be discharged from the habitat islands based on wetland and wildlife management needs. Typically, water would be drawn down by May and the habitat islands would remain dry until September, except for permanent water areas and other areas kept wet because of vegetation needs. Existing pumps would be used for discharges and for water circulation on the habitat islands. The maximum rate of proposed discharges from Bouldin Island and Holland Tract would be 200 cfs per island.

Levee Improvements and Maintenance

Levee improvements on the habitat islands would be designed, at a minimum, to meet criteria for levees outlined in DWR Bulletin 192-82 (DWR 1982). Routine maintenance activities on habitat island perimeter levees would not differ from current practices and would include replenishing riprap, placing fill material, placing gravel, reshaping fill material, grading, disking, mowing, selectively burning, controlling rodents, and installing rock revetment. Interior slopes of perimeter levees on the habitat islands would be planted with grass to resist erosion from rainfall and would be maintained according to current practices. In accord with the HMP, borrow material for levee improvement and maintenance would be extracted at designated locations from the island interiors before the beginning of habitat development and intermittently as needed thereafter. More detail regarding levee design and maintenance is presented in Chapter 3D, "Flood Control".

Water Management Facilities for Habitat Creation

Water would be diverted to and discharged from the habitat islands with existing facilities, with newly installed fish screens on the siphons for diversions (Figures 2-7 and 2-8). See Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species", and Appendices B through E from the 2000 REIR/EIS for details on fish screen design.

Recreation Facilities

Recreation facilities on the habitat islands would be similar to those described above for the reservoir islands. Consistent with the HMP, DW would construct up to 10 new recreation facilities on Bouldin Island and six new recreation facilities on Holland Tract. As described above, DW removed construction of these facilities from its CWA permit applications.

The HMP designates open hunting areas for waterfowl and upland hunting, as well as closed zones where hunting is prohibited. The HMP allows for waterfowl hunting in areas consisting of approximately 50% free-roam hunting zones (average of one hunter per 60 acres) and 50% spaced-blind hunting zones (one fixed-location blind with a maximum occupancy of four hunters per 50 acres). No waterfowl or upland bird hunting or other human disturbance (e.g., birdwatching or dog training), except monitoring, maintenance, and other activities consistent with implementation of the HMP, would be permitted in designated closed zones.

Waterfowl hunting would be permitted only on Saturdays, Sundays, and Wednesdays and on two additional days (subject to the restriction that, in any event, hunting would not be permitted on more than 3 consecutive days) to be designated by the hunting program manager prior to the opening of waterfowl season. Hunting of upland birds (i.e., pheasants and doves) would be permitted on Saturdays, Sundays, and Wednesdays during waterfowl season and during the break between the first and second halves of the waterfowl season. No hunting beyond that described above and in Chapter 3J, "Recreation and Visual Resources", would be permitted on the DW project islands.

The Bouldin Island airstrip will be available for use by hunters and other recreationists to fly to the island. To reduce disturbances to wildlife, restrictions specified in the HMP have been placed on operation of fixed-wing aircraft and helicopters in the habitat island areas. From September 1 through March 31, use of the airstrip for flights related to habitat management activities would be limited to 4 days per week. During the waterfowl hunting season (generally October 1 through January 2), use of the airstrip for habitat management activities would be limited to nonhunt days. During this season, use of the airstrip by fixed-wing aircraft for purposes other than habitat management (e.g., recreational use) would be limited to 100 landings and takeoffs (a landing and a takeoff in combination are counted as one). On hunt days, these flights would be allowed only between 12:00 p.m. and 2:00 p.m. Helicopters would be permitted to land on perimeter levees in the recreation areas and would be required to approach the landing areas from outside the island; helicopters would not be permitted to fly over the habitat islands. No restrictions on use of the airstrip would be required during other times of the year.

Operations and Maintenance

Operation and maintenance activities for the habitat islands under Alternatives 1 and 2 would include:

- operation and routine maintenance of the siphon and pump units;
- management of habitat areas, including, but not limited to, the control of undesirable plant

species, agricultural plantings and irrigation, and the maintenance or modification of inner levees, circulation ditches, canals, open water, and water control structures to facilitate flooding and drainage;

maintenance and monitoring of fish screens during water diversions for habitat maintenance;

wildlife and habitat monitoring for the HMP;

inspections and maintenance of perimeter levees;

use of the Bouldin Island airstrip for seed dispersal and application of herbicides and other pesticides;

operation of recreation facilities; and

monitoring and enforcement of hunting restrictions.

Other operation and maintenance measures required to mitigate impacts associated with the DW project are described for each resource area in Chapters 3A through 3O.

DW's Existing and Pending Water Rights

Current Water Rights

DW has existing appropriative water rights for each of the four DW project islands for direct diversion from March 1 through November 1 annually. These rights have a priority date of July 28, 1922, and have been licensed. These appropriative rights are the primary basis of right to divert and use water for the current agricultural activities on each of the islands.

DW also claims riparian rights, which may be used when there is riparian water available in the Delta and there is need to divert water outside the season of diversion specified for the existing appropriative water rights or for uses other than irrigation. Riparian rights have been used as a secondary basis of right on all four DW project islands for many years. Tables 2-3 and 2-4 provide a detailed summary of these existing water rights and pending water right applications for the DW project.

Under the DW project, these rights could not be used independently to fill the reservoir islands.

Proposed Uses of Water

The following section describes the proposed uses of water on the two reservoir islands (Webb Tract and Bacon Island) and the two habitat islands (Bouldin Island and Holland Tract) under DW's existing and applied-for water rights. The description applies to Alternatives 1 and 2, DW's proposed project.

Reservoir Islands (Webb Tract and Bacon Island). The primary basis of water rights for DW's proposed reservoir operations will be storage and direct diversion rights under Applications 29062 and 30268 for Webb Tract and Applications 29066 and 30270 for Bacon Island.

The existing licensed rights may be used for irrigation of habitat cover crops on the reservoir islands, particularly during drier years, when water may be available under the terms of the existing licenses and not under those of the new applications. Also, when water is available for use under riparian rights, riparian claims could be exercised for seasonal wetland habitat use on the reservoir islands, for irrigation, or for diversions for other legal uses outside the licensed season. To allow for the sale of water previously diverted onto the reservoir islands under existing rights, DW filed petitions to add additional points of diversions under Applications 30268 and 30270 at the location(s) on the islands where water otherwise would be discharged during reservoir operations. Approval of the petitions would allow the reappropriation of water already on the reservoir islands at the rate(s) up to the discharge pump capacities. If the petitions are approved, DW could appropriate seepage, return flow from cover crop irrigation under Licenses 1572 and 1321 (Applications 2952 and 2954), and surplus wetland water diverted under riparian claim when surplus water is available under Applications 30268 and 30270. The existing licenses or riparian claims could be used in dry years for on-island beneficial uses until sufficient surplus is available for normal reservoir storage operations or until water transfer parking options develop later in a dry year.

DW has applied for both storage and direct diversion rights under the applications filed in 1987 and 1993 for both reservoir islands. The quantities, purpose(s) of use, and seasons of diversion are shown in Table 2-3. The quantities are sufficient to allow multiple filling and emptying of the reservoir islands when there is sufficient available water. Any permits issued will include special terms and conditions and specify the required accounting procedure(s) needed to identify the timing of appropriations and amount of water allowed to be appropriated under the applications.

Habitat Islands (Bouldin Island and Holland Tract). Table 2-4 shows current and proposed water rights for Bouldin Island and Holland Tract. The licensed appropriative water rights will continue to be the primary basis of right for irrigation of habitat cover crops on the DW project islands. Riparian claim will be exercised as the basis of right for wetland habitat use and when irrigation or diversions for other legal uses are required outside the licensed season. Both types of right will be needed under the HMP, which calls for irrigation of cover crops and sequential flooding of seasonal wetland habitat ponds beginning in September and continuing through December. Supplemental water will be added as required to replenish water lost through evaporation, evapotranspiration (ET), and seepage. The HMP requires that seasonal wetlands be drained each year for forage crops to be grown.

At the time the 1995 DEIR/EIS was prepared, DW had requested that water diverted onto the habitat islands be available for later sale if consistent with HMP requirements. This incidental use of the habitat islands cannot occur under the existing water rights. Therefore, DW filed petitions to add additional points of diversion under Applications 30267 and 30269. Approval of the petitions would allow the reappropriation of water on the habitat islands at the rate(s) at which, and the locations where, seepage or return flows would otherwise be discharged from the islands. If the additional points of diversion were approved, DW could appropriate seepage, return flow from cover crop irrigation under Licenses 1405 and 1571 (Applications 2948 and 2951), and surplus wetland water diverted under riparian claim when surplus water is available in the Delta under Applications 30267 and 30269. Although DW requested that SWRCB approve the petitions along with the pending applications, the sale of water released from the habitat islands is no longer an element of the proposed project.

DESCRIPTION OF ALTERNATIVE 3

Under Alternative 3, all four DW project islands would be managed for year-round diversion and storage of water. This alternative represents the maximum water appropriations that would be achieved under all of DW's water right applications. This alternative also represents the maximum amount of water storage that would be feasible on the four project islands based on levee height and internal elevation. Project operations under this alternative would be the same as those described above for Alternative 2 with respect to diversion and discharge operations (except for diversion and discharge rates) and construction and operation of recreation facilities; however, this alternative would allow year-round water diversions on all four DW project islands and would require substantially greater investments in internal levee construction to protect State Route (SR) 12 on Bouldin Island.

Operations on Bacon Island and Webb Tract would be the same as those described above for Alternative 2 and shown in Figures 2-2 and 2-3. Bouldin Island and Holland Tract would be operated for water storage similar to Webb Tract and Bacon Island, rather than for wetland habitat creation; proposed locations for water storage facilities on Bouldin Island and Holland Tract are shown in Figures 2-10 and 2-11. Alternative 3 would include the area on Holland Tract excluded from the project area under Alternatives 1 and 2 but would not preclude the operation of the marinas located on the channel side of Holland Tract's southern perimeter levee. According to DW, landowners of the Holland Tract area not now owned by DW have been contacted, and DW would be able to purchase the area if Alternative 3 were implemented. Under Alternative 3, a habitat reserve (the North Bouldin Habitat Area [NBHA]) would be created north of SR 12 on Bouldin Island to compensate for some of the impacts associated with water storage operations. Additional offsite wildlife habitat and wetland compensation would be required for this alternative.

Water Storage Operations

The four reservoir islands would be designed for water storage levels up to a maximum pool elevation of +6 feet relative to mean sea level (based on National Geodetic Vertical Datum data), with a total initial capacity of 406 TAF allocated among the reservoir islands as follows: Bacon Island, 117 TAF; Webb Tract, 119 TAF; Bouldin Island, 98 TAF; and Holland Tract, 72 TAF. Water availability, permit conditions, and DSOD requirements may limit storage capacities and may result in a final storage elevation of less than +6 feet.

As described for Alternatives 1 and 2, the total physical storage capacity of the reservoir islands may increase over the life of the project as a result of subsidence. Based on an estimated 0.5 inch of subsidence per year, it is estimated that the total storage capacity of the four reservoir islands after 50 years could be as much as 448 TAF.

The siphon and pump station designs for all four DW project islands would be the same as those described for the reservoir islands (Bacon Island and Webb Tract) under Alternatives 1 and 2. DW proposes to construct two intake siphon stations on each reservoir island with 16 new siphons each on Bacon Island and Webb Tract and 12 new siphons each on Bouldin Island and Holland Tract, for a total of 112 new siphons. One discharge pump station would be installed on each reservoir island, with 40 new pumps at both the Bacon Island and Webb Tract stations and 30 new pumps at both the Bouldin Island and Holland Tract stations, for a total of 140 new pumps. Locations of the proposed siphon and pump stations under Alternative 3 are shown in Figures 2-2, 2-3, 2-10, and 2-11.

The perimeter levees of all four reservoir islands would be buttressed and improved as described for Webb Tract and Bacon Island under Alternatives 1 and 2. Alternative 3 would require construction of a large interior levee across Bouldin Island along the south side of SR 12. Water storage operations south of SR 12 would require that the south-side levee, also known as Wilkerson Dam, be designed and constructed in accordance with DSOD standards where water would be stored in excess of +6 feet in elevation. Wilkerson Dam is described in Chapter 3E, “Utilities and Highways”, and Appendix E1, “Design and Construction of Wilkerson Dam South of SR 12 on Bouldin Island”.

Chapter 3A, “Water Supply and Water Project Operations”, and Appendix A3, “DeltaSOS Simulations of the Delta Wetlands Project Alternatives”, describe the water budget for diversions, storage, and exports under Alternative 3 simulated for the 1995 DEIR/EIS.

Diversions onto the Reservoir Islands

The maximum daily average rate of proposed DW project diversions onto either Webb Tract or Bacon Island would be 4,500 cfs (9 TAF/day) and onto either Bouldin Island or Holland Tract would be 3,000 cfs (6 TAF/day) at the time diversions begin. If water were being diverted to multiple reservoir islands at the same time, the combined maximum daily average diversion rate of the islands would not exceed 9,000 cfs. The maximum monthly average diversion rate would be approximately 6,000 cfs, which would fill the four reservoir islands in one month. Estimated mean monthly diversions onto the reservoir islands under Alternative 3 simulated for the 1995 DEIR/EIS are shown in Table 2-2.

Discharges from the Reservoir Islands

Discharge pumping would occur at a maximum rate of 4,000 cfs from Bacon Island and Webb Tract and 2,000 cfs from Bouldin Island and Holland Tract. The discharge rate for Bacon Island and Webb Tract would be greater than the rate for the other islands to allow - rapid discharge from those islands. The maximum combined monthly average discharge rate of the reservoir islands, however, would depend on available export capacity but would be less than 6,000 cfs because the reservoir islands could be emptied in one month at this rate. The maximum daily average discharge rate is assumed to be 12,000 cfs. Estimated mean monthly discharges from the reservoir islands under Alternative 3 simulated for the 1995 DEIR/EIS are shown in Table 2-2.

Habitat Management

Shallow-Water Management

Incidental to project operations, Alternative 3 could include shallow-water management to enhance forage and cover for wintering waterfowl when water would not be stored on the reservoir islands because of limits to water availability and increased demand for discharge. Each of the four reservoir islands would have an inner levee system for shallow-water management. Shallow-water management for Alternative 3 would be similar to that described for the reservoir islands under Alternatives 1 and 2.

North Bouldin Habitat Area

The portion of Bouldin Island north of SR 12 would be managed as the NBHA, a year-round riparian and wetland habitat area (Figure 2-10). The ground within the NBHA would be dredged and reshaped to provide year-round and seasonal water for habitat management. The NBHA would be bounded by a new interior levee north of SR 12 and by the island's perimeter levees. The north-side interior levee would not be subject to design review by DSOD. A new pump would be constructed in the NBHA for water discharges, and fish screens would be installed on existing siphons for water diversions.

Following are acreages of habitat types (totaling 875 acres) proposed for the NBHA:

- corn = 170 acres,
- perennial pond = 50 acres,
- riparian woodland = 200 acres,
- seasonal managed wetland = 313 acres,
- ditch = 17 acres,
- annual grassland = 29 acres, and
- fallow levee slope = 96 acres.

Additional offsite wildlife habitat compensation would be required for this alternative.

Recreation Facilities

Recreation facilities on Bacon Island and Webb Tract would be the same as those described for the reservoir islands under Alternatives 1 and 2. DW would construct up to ten and eight recreation facilities on Bouldin Island and Holland Tract, respectively, as shown in Figures 2-10 and 2-11. Operation and design of the recreation facilities for Alternative 3 would be similar to those described for the reservoir islands under Alternatives 1 and 2. No airstrip would be maintained under Alternative 3.

Operations and Maintenance

Operation and maintenance activities for the islands under Alternative 3 would be similar to those described for the reservoir islands under Alternatives 1 and 2. The NBHA would be managed similar to the habitat islands under Alternatives 1 and 2, but on a smaller scale.

DESCRIPTION OF THE NO-PROJECT ALTERNATIVE

If Corps permit applications or SWRCB water right permit applications for the DW project are denied, DW would implement intensive agricultural operations on the four project islands or sell the property to another entity that would likely implement intensive agriculture. The No-Project Alternative is based on the assumption that intensified agricultural conditions represent the most realistic scenario for the DW project islands if permit applications are denied. It is assumed that no new recreation facilities would be built.

Changes in project island operations under the No-Project Alternative would be limited to those farming activities that increase cropping intensity and could be implemented without a permit issued by the Corps or SWRCB. The No-Project Alternative would entail implementing more efficient drainage and weed management practices on Holland and Webb Tracts and shifting some crop types on Bacon and Bouldin Islands.

The DW island water budget terms for the No-Project Alternative are assumed to be approximately 50% higher than water budget terms under existing conditions, reflecting more extensive agricultural use of the islands; however, for modeling of water operations, this difference is not discernible and no distinction is made between the water budgets for existing conditions and the No-Project Alternative. The water budget for the No-Project Alternative, as simulated for the 1995 DEIR/EIS, is shown in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project". Average monthly diversions for combined irrigation and salt leaching under the 1995 DEIR/EIS analysis of the No-Project Alternative are shown in Table 2-2. Currently existing siphon facilities on the islands, which are unscreened, would not be modified under the No-Project Alternative.

WATER BUDGETS FOR THE DW ALTERNATIVES

By converting conventional agricultural land use to a combination of water storage and wildlife habitat management, the DW project would modify Delta water budgets. Table 2-1 summarizes differences in diversions, storage capacity, and discharges between the DW project alternatives as simulated for the 1995 DEIR/EIS. Table 2-2 shows the estimated mean monthly diversions from Delta channels to the DW project islands under Alternatives 1, 2, and 3 and the No-Project Alternative and mean monthly discharges for export or outflow from the DW project islands under Alternatives 1, 2, and 3 as simulated for the 1995 DEIR/EIS.

These tables present an overview of general differences between alternatives but do not show the detailed patterns of DW project operations, which include values that vary widely from the average values. Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", provides a more detailed comparison of water storage operations under Alternatives 1, 2, and 3 in the form of monthly percentiles showing simulated diversions, end-of-month storage, and discharge amounts. Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", show details of the Delta water budget simulated under DW project operations as monthly percentiles and annual totals for each of the alternatives.

The 2000 REIR/EIS included revised simulations of water budgets under No-Project and proposed project (Alternatives 1 and 2) conditions. Results of the revised simulations are presented in Chapter 3A, "Water Supply and Water Project Operations". Appendix 2 shows that the pattern of water storage operations is generally characterized by large diversions and export amounts in small percentages of years. This conclusion is confirmed by the simulations of water storage operations presented in the 2000 REIR/EIS.

COORDINATION WITH WATER RIGHTS, DELTA STANDARDS, AND FISH TAKE LIMITS

The project's permits, if granted by SWRCB and the Corps, would contain terms and conditions to protect prior water right holders and the public interest and public trust. All existing and any future Delta standards regarding water quality, flows, and diversions would be applicable to the DW project alternatives as appropriate. The project permits would require that project diversions not interfere with the diversion and use of water by any other user with riparian or prior appropriative rights. This requirement is reflected in the stipulated agreements between DW and other parties to the SWRCB's water right hearing. Additional information about these agreements is presented in the section from the 2000 REIR/EIS below entitled "Revisions to the Project Description from the 2000 Revised Draft EIR/EIS".

Coordination Regarding Senior Water Rights

Most holders of riparian and senior appropriative water rights are located upstream of the Delta in the Sacramento or San Joaquin River Basins. Many holders of riparian rights are located in the Delta, and senior appropriative water rights are also held in the Delta by the SWP and the CVP, as well as Contra Costa Water District (CCWD) and several smaller diverters. The DW project would not interfere with diversions by these senior water right holders.

The DWR Division of Operations and Maintenance and Reclamation's Central Valley Operations Coordinating Office (CVOCO) maintain the official daily water budget estimates for the Delta and designate the Delta condition each day as being "in balance" or "in excess" relative to all SWRCB objectives and water right terms and conditions. The term "in balance" indicates that all Delta inflow is required to meet Delta objectives and satisfy diversions by CCWD, the CVP, the SWP, and Delta riparian and senior appropriative water users. Under all circumstances, when the Delta condition is designated to be in balance, no additional water would be available for diversion by the DW project under new water rights.

When DWR and CVOCO determine the Delta condition to be in excess and other terms and conditions are met, the DW project would be allowed to divert available excess water for storage on the designated reservoir islands under new appropriative water rights. DW diversions under existing riparian and senior appropriative rights may be permitted for shallow-water management, subject to applicable water right laws, even when the Delta is not determined to be in excess. The daily quantity of available excess water would be estimated according to DWR's normal accounting procedures. To provide extra protection for compliance with the 1995 WQCP, SWRCB can establish requirements for amounts of water within the designated excess water (i.e., buffers) that would not be available for DW diversions, or other measures to protect Delta objectives, existing water right holders, and public trust values. Nevertheless, during major runoff events, excess Delta inflow will likely be available for diversion by the DW project (see Chapter 3A, "Water Supply and Water Project Operations").

Coordination Regarding Water Quality Standards

All existing and any future Delta water quality standards adopted by SWRCB or other regulatory agencies would be applicable to the proposed project operations. Project operations for water storage would not be allowed to violate applicable Delta water quality objectives and public trust values or interfere with the ability of other projects to meet the objectives.

The DW project permits would contain terms and conditions that specify the allowable project operations for a variety of possible Delta conditions related to water quality or fish and wildlife requirements. SWRCB terms and conditions for the requested DW water rights specify DW operational rules and guidelines related to meeting applicable Delta objectives.

Coordination Regarding Endangered Species

As described in Chapter 1, the lead agencies concluded formal consultation with DFG, NMFS, and USFWS on the effects of the DW project on listed fish species after they issued the 1995 DEIR/EIS. As part of the consultation process for compliance with the federal and California ESAs, the Corps, the SWRCB, NMFS, USFWS, DFG, and DW agreed on the project operating parameters referred to as the FOC, which have been incorporated into the proposed project.

DFG subsequently issued a no-jeopardy biological opinion regarding project effects on delta smelt and winter-run chinook salmon; NMFS issued no-jeopardy biological opinions regarding project effects on winter-run chinook salmon, Central Valley steelhead ESU, and Central Valley spring-run chinook salmon ESU and their habitats; and USFWS issued no-jeopardy biological opinions regarding project effects on delta smelt and splittail and their habitats. The biological opinions include RPMs to reduce or compensate for the incidental take of listed species and identify DW project operational criteria, take limits, and facility design (i.e., fish screen criteria) for listed species.

Project permits issued by the Corps and SWRCB would require that project operations fully comply with any applicable ESA conditions and allowable take limits as specified in the biological opinions. Water exported from the DW reservoir islands also will be subject to all applicable biological opinion requirements at the SWP and CVP export facilities.

CHANGES TO THE PROJECT DESCRIPTION, ALTERNATIVES ANALYZED, AND FUTURE CONDITIONS CONSIDERED IN THE 2000 REVISED DRAFT EIR/EIS

The following sections of this chapter include a description of the revisions made to the project description and alternatives after issuance of the 1995 DEIR/EIS. This information was presented as Chapter 2, "Changes to the Project Description, Alternatives Analyzed, and Future Conditions Considered", in the 2000 REIR/EIS.

Some differences exist between the DW project as analyzed in the 2000 REIR/EIS and as analyzed in the 1995 DEIR/EIS. The following section explains and summarizes those differences. The following are described below:

- the revisions to the project description since publication of the 1995 DEIR/EIS,
- the treatment of project alternatives in the 2000 REIR/EIS, and

future conditions as analyzed in the 2000 REIR/EIS.

The latter discussion also describes the potential future relationship between the DW project and CALFED, as requested by several parties in comments on the 1995 DEIR/EIS and at the SWRCB hearing on DW's water right applications in 1997. The information from the 2000 REIR/EIS is followed by a description from the 1995 DEIR/EIS of alternatives considered but not selected for detailed evaluation.

REVISIONS TO THE PROJECT DESCRIPTION FROM THE 2000 REVISED DRAFT EIR/EIS

Table 2-5 provides a summary comparison of the proposed project as evaluated in the 1995 DEIR/EIS and as evaluated in the 2000 REIR/EIS. As shown in Table 2-5, the major elements of the proposed project have not changed.

Two types of modifications to the DW project as described in previous sections of this chapter have been incorporated into the proposed project description:

Project operations would be restricted to ensure the protection of endangered and threatened fish species as described in terms set forth in the following, which were developed as a result of consultation pursuant to the California and federal ESAs:

- DW FOC, also referred to as the DW Operating Criteria and Plan (OCAP); and
- RPMs in the DFG, NMFS, and UFSWS biological opinions for the protection of fish species listed as threatened or endangered.

Operations also would be restricted as specified in the stipulated agreements entered into by DW and the following parties to the SWRCB's water right hearing for the DW project:

- Reclamation,
- DWR,
- Amador County,
- the City of Stockton, and
- North Delta Water Agency.

The terms of the FOC, biological opinions, and stipulated agreements limit potential project operations to increase protection of fisheries, affirm the senior water rights of other parties, or protect another party's ability to meet specific water quality criteria. These changes are generally considered to reduce environmental impacts, primarily because they may limit the timing and amounts of diversions and discharges to export. They therefore are considered beneficial and did not trigger the need to recirculate the EIR/EIS analysis. They were included in the discussions in the 2000 REIR/EIS, however, to present reviewers with an updated assessment of the possible range of allowable project operations.

Other changes in conditions and assessment methods that have emerged since publication of the 1995 DEIR/EIS and that pertain to the evaluation of DW project effects are described in the resource evaluation chapters (3A through 30) rather than in this chapter. Examples of such changes include new listings of fish species under the California and federal ESAs, and updated assumptions about the Delta water budget that pertain to water supply and water quality modeling. These changes represent modifications to existing conditions rather than changes to the proposed project; they are presented as revisions to the affected environment, the setting within which the potential impacts of the project are analyzed.

Restrictions on Project Operations to Ensure the Protection of Fish

The FOC and biological opinion measures were developed in response to anticipated impacts of the proposed project, as analyzed in the 1995 DEIR/EIS, on fish species protected under the California and federal ESAs. Therefore, as described in Chapter 3F, "Fishery Resources", some of these measures supersede mitigation measures proposed in the 1995 DEIR/EIS.

As discussed under "Regulatory Compliance History" in Chapter 1, DW, the SWRCB, the Corps, DFG, NMFS, and USFWS, as part of the formal consultation process on the DW project's effects on protected fish species, cooperatively developed operating parameters (referred to as the FOC) for the project to ensure the protection of these species. The FOC terms include many specific measures that define the flow and water quality conditions under which project diversions and discharges would be allowed, and describe mitigation that DW has agreed to incorporate into the proposed project. Table 2-6 summarizes the timing of restrictions on diversions and discharges specified in the FOC. Chapter 3A, "Water Supply and Water Project Operations", describes the incorporation of FOC and biological opinion terms into the modeling of DW project operations. All the restrictions and mitigation measures included in the FOC and the biological opinions have been considered in the updated analysis of impacts on fisheries presented in Chapter 3F, "Fishery Resources".

The full text of the FOC is provided in Appendix B of the 2000 REIR/EIS. The biological opinions are included in Appendices C, D, and E of the 2000 REIR/EIS.

Stipulated Agreements

DW entered into stipulated agreements with Reclamation, DWR, Amador County, the City of Stockton, and North Delta Water Agency. The agreements affirm the seniority of these parties' water rights; they also outline general conditions under which the DW project would operate to preclude interference with those water rights or with a party's ability to meet particular water quality criteria. For example, the agreement between DW and DWR includes three terms:

- Term 1, generally speaking, prohibits DW diversions when the Delta is determined to be in "balanced conditions"—that is, when all Delta inflow is required to meet Delta objectives and satisfy diversions by Contra Costa Water District (CCWD), the CVP, the SWP, and Delta riparian and senior appropriative water users.

- Term 2 limits the amount of water DW can take under "excess Delta conditions" to the amount by which the Delta is in excess as reasonably determined by DWR and Reclamation. This will be the amount of water that DW may divert "without putting the Delta back into balanced conditions".

- Term 3 requires DW to stop or reduce any reservoir releases if, as a result of these releases, the SWP or the CVP would have to modify operations to meet a legal requirement (e.g., ESA requirements, water rights terms and conditions such as export limits and salinity standards for exported water, or Corps requirements).

The terms of the stipulated agreements explicitly confirm the assumption of DW and the EIR/EIS lead agencies that the DW project would not be allowed to interfere with other parties' senior water rights and with SWP and CVP operations. Because this assumption has been part of the description of the proposed project, the agreements do not substantially change the project description or affect the analysis of project effects.

Appendix A of the 2000 REIR/EIS summarizes the terms of the stipulated agreements entered into by DW and other parties to the water right hearing.

CONSIDERATION OF PROJECT ALTERNATIVES IN THE 2000 REVISED DRAFT EIR/EIS

As described above, the 1995 DEIR/EIS analyzed three project alternatives and a No-Project Alternative in an equal level of detail. Alternatives 1 and 2 both represent DW's proposed project, consisting of water storage on two reservoir islands and implementation of an HMP on two habitat islands, but these alternatives offer two different scenarios for the discharge of stored water. Alternatives 1 and 2 feature identical project components and operations for diversion onto the reservoir islands; however, they have different operating criteria for discharge of stored water (i.e., frequency and volume of discharges) from the reservoir islands as described above in the section entitled "Description of Alternatives 1 and 2". Under Alternative 3, all four DW project islands would be used as reservoirs and limited compensation wetland habitat would be provided on Bouldin Island.

Alternative 2, with the highest amount of discharge pumping, would have the maximum effect on fisheries associated with project discharges. Alternative 2 was therefore used to represent the proposed project in the biological assessment for fish species (see Appendix F2 of the 1995 DEIR/EIS). The terms and conditions of the DFG, USFWS, and NMFS biological opinions are based on this alternative. Therefore, the proposed project simulated in the 2000 REIR/EIS is Alternative 2, as modified by the changes to the proposed project description adopted since issuance of the 1995 DEIR/EIS. Incorporating the restrictions from the FOC and biological opinion RPMs into the proposed project operations under Alternative 1 and 2 results in little difference between the environmental effects of Alternative 1 and the effects of Alternative 2.

The 2000 REIR/EIS analysis was performed to confirm the results of the 1995 DEIR/EIS analysis and to provide revised impact assessments and new or revised mitigation measures where necessary. Generally, the 2000 REIR/EIS evaluates the proposed project as represented by Alternative 2 (as modified) and describes any changes in the evaluation of the other alternatives from the 1995 DEIR/EIS.

FUTURE CONDITIONS AND RELATIONSHIP OF THE DW PROJECT TO OTHER PROJECTS

As noted in Chapter 1, for purposes of the 1995 DEIR/EIS and the 2000 REIR/EIS, the DW project is analyzed as a stand-alone water storage facility, operated independently of the SWP and the CVP and without regard to the specific entities to which the water could be sold. Several potential opportunities exist to operate the DW project in conjunction with the CVP and the SWP or in coordination with CALFED; however, no proposals have been made for which the SWRCB and the Corps could reasonably assess the environmental effects, so discussion of such arrangements would be speculative.

The cumulative future scenario assumed in the 2000 REIR/EIS analysis of water supply and operations is based on the same assumptions as the cumulative future analysis presented in the 1995 DEIR/EIS. Full pumping capacity at Harvey O. Banks Pumping Plant (10,300 cfs), although not presently permitted by USACE, is assumed to represent reasonably foreseeable future conditions. Demand for CVP/SWP water, however, is assumed to remain at the 1995 level in the 2000 REIR/EIS analysis.

The provision of new surface and groundwater storage has been identified as a possible action to be included in CALFED (CALFED Bay-Delta Program 1996, 1998). CALFED has identified the possibility of using in-Delta storage for diversions and to manage Delta flows; water would be stored or diverted at times when fish would not be adversely affected and pumping would be shifted to less sensitive periods. CALFED has identified 230 TAF of in-Delta storage on Delta islands as one of 14 possibilities for providing water supply, flood control, water quality, and ecosystem benefits (CALFED Bay-Delta Program 1998). The DW project could be included as part of the CALFED in-Delta storage element.

As part of its water management strategy, CALFED has undertaken an Integrated Storage Investigation (ISI) to evaluate various types of water storage projects and the possible role in overall water management that may be fulfilled by in-Delta, onstream, and offstream water storage projects. The DW project may be one option for in-Delta storage and is a candidate for consideration by the ISI. The ISI will identify those projects that warrant further study and conduct feasibility studies for 1 to 2 years after it identifies these projects for possible inclusion in CALFED's program. Some of the information presented in the 1995 DEIR/EIS and the 2000 REIR/EIS may be used by the ISI to determine whether the DW project could be included in this program. However, assumed project operations under this program would differ from the independent operations analyzed in the 1995 DEIR/EIS and the 2000 REIR/EIS; therefore, CALFED would need to analyze the project separately.

In 1999, CALFED completed a draft programmatic environmental impact statement/environmental impact report (CALFED Bay-Delta Program 1999), which provides a broad overview of the potential actions that the CALFED program could take. The document does not specifically address in-Delta storage in any detail. It broadly describes the environmental consequences of proposed actions and enables decision making regarding program direction and content. Subsequent actions, including implementation of in-Delta storage projects, will be subject to alternative analysis, environmental review, and permitting decisions before they can be implemented.

ALTERNATIVES CONSIDERED BUT NOT SELECTED FOR DETAILED EVALUATION

EPA's Section 404(b)(1) guidelines prohibit discharges of dredged or fill material into waters of the United States if a practicable alternative exists that would have less adverse impacts on the aquatic ecosystem and that would not have significant adverse impacts on other biological resources. To comply with EPA's Section 404(b)(1) guidelines, the lead agencies initially considered a broad range of project alternatives that would meet the project purpose. This range was then narrowed to include only those alternatives that are reasonably foreseeable and technically and financially practicable for the applicant. The permitted project will constitute the least environmentally damaging practicable alternative for purposes of complying with Section 404 of the CWA. The 404(b)(1) alternatives analysis, provided in Appendix 4, gives additional detail.

This section describes alternatives considered for the project but not selected for detailed evaluation. The alternatives that were considered were not limited to water storage facilities in the Delta and included non-structural and structural projects. Nonstructural alternatives are those that do not require construction of major new facilities. Structural alternatives are those that require construction of new facilities onsite or offsite.

Certain Delta programs and studies are not considered as alternatives to the DW project. These programs and studies relate to environmental conditions in the Delta and to the quantity and quality of available water supply in the Delta and therefore demonstrate the general public need for and benefit of additional water supply in the Delta. The related programs and studies are discussed in Appendix 2.

Reoperation of the CVP and the SWP

Under this alternative, DWR and Reclamation would further integrate and consolidate operations of the CVP and the SWP. Currently, the federal and state water projects operate their systems under different sets of rules. Integrating the CVP and the SWP would facilitate greater operational flexibility of the two systems and could facilitate improved water management throughout California's water system. A more efficient water system could result from better coordination of groundwater and surface water supplies and deliveries, and easier implementation of water conservation techniques, market-based water transfers, and groundwater management.

Reoperation of the CVP and the SWP, as described above, would require combined management of the CVP and the SWP to increase the operational flexibility of the two projects and therefore result in a more efficient water storage and delivery system.

This alternative could increase the supply of water in the Delta for sale for export south of the Delta or as Delta outflow to San Francisco Bay. However, this alternative has not been sufficiently defined to determine whether it could achieve the project purpose of increasing the supply of high-quality water in the Delta. It is presently impossible to estimate how much the combined management of the CVP and the SWP would contribute to increasing the quantity of water in the Delta.

Reoperation of the CVP and the SWP is not an available alternative to the project proponent. No role exists for a private participant in the management of an integrated CVP and SWP system. Financial implications of the reoperation of the CVP and the SWP are uncertain. The alternative could require substantial financial investments to evaluate, negotiate, plan, and implement CVP transfer and coordinated management of the two systems.

For the reasons stated above, reoperation of the CVP and the SWP was eliminated from further evaluation as a practicable alternative.

Water Conservation Alternative

Under this alternative, an entity (presumably governmental) would implement a water conservation program that would result in increased supplies of water in the Delta. Conservation measures for residential developments include retrofitting existing residences and constructing new developments with low-flow fixtures and appliances, relandscaping existing developments and landscaping new developments with drought-tolerant plants, and installing drip irrigation systems. Conservation measures for commercial and industrial uses include landscaping with drought-tolerant plants to reduce irrigation to a minimum, retrofitting existing structures, constructing new developments with low-flow fixtures, recycling water, and repairing leaks. Conservation measures for agriculture include furrow irrigation techniques, irrigation management, and irrigation system assessment.

DWR (1994) estimated that urban and agricultural water conservation programs might achieve 3 MAF of demand reduction statewide by 2020. This demand reduction was accounted for in the DWR (1994) projections for long-term California water demand. It is not possible to estimate the extent to which a reduction in California water demand would reduce demand in the Delta watershed, or how a reduction in demand in the Delta might contribute to increased Delta water supply. Therefore, the water conservation alternative cannot be defined sufficiently to support the conclusion that it would be able to satisfy the project purpose.

Water conservation, on a very small scale, is available to the project applicant. DW could implement water conservation efforts for intensified agricultural uses on its four Delta islands, but these efforts would not generate a measurable supply of water for sale for export or outflow. Conservation on a scale broad enough to have the potential to supply a minimum amount of water would require public, institutional, local agency, private industry, and agricultural community participation and would therefore be unavailable as a project alternative to DW.

For the reasons stated above, the water conservation alternative was eliminated from further evaluation as a practicable alternative.

Water Transfers Alternative

The water transfers alternative would consist of voluntary, market-based temporary and long-term water transfers directly using the Delta. The voluntary transfer of water has the potential to be an important means of achieving better water management in California. The California Legislature has declared that the established policy of the state is to facilitate voluntary water transfers and has directed DWR, SWRCB, and all other state agencies to encourage voluntary water transfers (California Water Code Sections 109 and 475).

Voluntary, market-based temporary and long-term water transfers directly using the Delta could increase the supply of high-quality water in the Delta for sale for export and/or outflow. Although DW could act as a type of broker for potential suppliers and buyers of market water, the feasibility of this role is highly speculative. The role DW would play in this alternative is not defined clearly enough to allow proper evaluation of the financial feasibility of DW being a broker in the water transfer market. A broker may not have a financially feasiblely role in the water transfer market if suppliers and buyers contract directly with each other without the aid of a broker.

Water transfers can be short term (1 year or less) or long term. Many short-term water transfers were implemented through the State Drought Water Bank in 1991 and 1992 (DWR 1994). Short-term transfers are typically based on fallowing of irrigable agricultural land for short periods or on temporary shifts of supplies not needed by the seller on an interim basis. Long-term transfers that could increase water supply to the Delta are not sufficiently definable to be considered a practicable alternative to meet the project purpose. Because of the temporary or interim nature of these transfers, they cannot achieve the basic project purpose of providing a long-term increase in Delta water supply.

As stated above, the water transfers alternative was eliminated from further evaluation as a practicable alternative because:

it would not realistically be available to the project proponent,

it is not definable as a program of long-term transfers to increase Delta water supply,

temporary transfers cannot meet the long-term project purpose, and

the alternative may have limited financial feasibility for DW as a participant.

Non-Delta Water Storage or Conjunctive Use

Non-Delta water storage entails the construction of storage facilities with the capacity to store high-quality water for uses compatible with the DW project purpose. Such storage facilities could include surface water storage reservoirs or groundwater storage basins. Such facilities also could be operated conjunctively to improve overall supply reliability.

Agencies that are responsible for municipal, regional, state, and federal water systems are presently considering non-Delta options for offstream storage between the Delta and places of use (e.g., Los Banos Grandes Reservoir, Kern Water Bank, and Diamond Valley Reservoir). These entities are also pursuing several options for conjunctive use of groundwater basins to produce drought-year water supplies. (DWR 1994.)

Under this alternative, a water storage facility could be constructed and operated to increase the long-term supply of water in the Delta. Similarly, a conjunctive use program could be developed to increase Delta water supplies in drought years.

Conjunctive use programs require sponsorship and direction by regional water districts that coordinate management of large areas of irrigated farmland and defined groundwater basins in combination with centralized points for surface water diversions. Therefore, a conjunctive use water management program does not appear to be available to the project proponent. Furthermore, a conjunctive use program upstream of the Delta would not increase Delta water supplies over the long term but could increase Delta inflows in dry years.

As stated above, this alternative was eliminated from further evaluation as a practicable alternative for the following reasons:

- definable options that might be implemented under this alternative by 2020 are not available to the project proponent,
- other options require extensive investigation to determine their financial feasibility or their compatibility with a long-term Delta solution and thus are not currently definable, and
- conjunctive use programs might increase Delta water supplies only in drought years and are not available to the project proponent.

Water Storage on Other Delta Islands

This alternative could include using any number of the islands in the Delta other than DW's Bacon and Bouldin Islands and Holland and Webb Tracts to provide water storage for later sale for export or outflow. The facilities and operations used for this alternative would be similar to those described for Alternatives 1 and 2. However, because operation of the islands is, to some extent, a function of their geographic location, operations and facilities on other Delta islands may be very different from those proposed under Alternative 1, 2, or 3.

Although this alternative was generally available to the project proponent at the time of initial project planning, specific islands were unavailable and certain factors particular to each Delta island affect the financial feasibility of using an island as a potential site for water storage. Therefore, this alternative was eliminated from evaluation as a practicable alternative. See Appendix 4 for more detailed information about the evaluation of other Delta islands for water storage.

CITATIONS

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California. Department of Water Resources. 1982. Delta levees investigation. December. (Bulletin 192-82.) Sacramento, CA.

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Table 2-1. Comparison of Alternative Delta Wetlands Project Operations

Alternative	Combined Reservoir Storage Capacity (TAF)	Mean Annual Diversion (TAF)	Limits to Discharges	Mean Annual Discharge (TAF)
1	238	222	1995 WQCP Delta outflow requirements; permitted combined SWP and CVP pumping rate; 1995 WQCP export limits as "percentage of total Delta inflow diverted"	188
2	238	225	1995 WQCP Delta outflow requirements; permitted combined SWP and CVP pumping rate	202
3	406	356	1995 WQCP Delta outflow requirements; permitted combined SWP and CVP pumping rate	302

Notes: TAF = thousand acre-feet.

Mean annual diversion and discharge values are derived from 1995 DEIR/EIS simulations of DW project operations based on the historical hydrologic record for 1922-1991 and assuming current Delta standards (see Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives"). Mean annual diversion and discharge quantities do not include the small amounts of incidental water storage available from the habitat islands, estimated to be approximately 17 TAF annually. The 2000 REIR/EIS simulations of DW project operations under Alternatives 1 and 2 and the resulting mean annual diversions and discharges are less than those presented in this table; see Chapter 3A, "Water Supply and Water Project Operations", for results of the new analysis.

Table 2-2. Estimated Mean Monthly Diversions and Discharges under the Delta Wetlands Project Alternatives (TAF), as Simulated for the 1995 Draft EIR/EIS

	October	November	December	January	February	March	April	May	June	July	August	September	Annual
	October	November	December	January	February	March	April	May	June	July	August	September	Annual
Diversions													
Alternative 1	39	41	31	42	24	13	1	2	1	3	1	22	222
Alternative 2	39	41	31	40	24	14	5	2	1	3	1	22	225
Alternative 3	61	68	59	60	42	20	7	3	1	5	1	26	356
No-Project Alternative	2	0	3	3	3	0	0	3	13	16	12	6	60
Existing conditions	1	0	1.5	1.5	1.5	0	0	1.5	6.5	8	6	3	30
Discharges													
Alternative 1	0	1	13	2	10	5	12	16	8	56	49	18	188
Alternative 2	0	1	11	3	37	27	5	17	46	30	18	5	202
Alternative 3	0	1	11	4	43	42	5	17	70	48	48	11	302

Notes: Values for Alternatives 1, 2, and 3 are derived from 1995 DEIR/EIS simulations of DW project diversions to reservoir storage based on the historical hydrologic record for 1922-1991 and assuming current Delta standards (see Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives"). Habitat island diversions are not included.

Values for the No-Project Alternative represent average combined diversions for irrigation and salt leaching estimated for intensified agricultural use of the DW project islands (see Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project").

The annual simulated patterns of DW project operations vary widely from these average values. See Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", for monthly percentiles.

Annual values may not total correctly because of rounding.

Table 2-3. Existing and Proposed Delta Wetlands Water Rights for Reservoir Islands

Island/Tract	Water Right Type	Nature of Right	Application No./ Priority	Permit No.	License No.	Current Use	Proposed Fugure Use	Season of Diversion	Quantity[a]	Comments
Webb Tract	Appropriative	Direct diversion	2952 1922 priority	1416	1572	I	I	March 1- November 1	63.94 cfs	Primary right
	Riparian	Direct diversion	N/A	N/A	N/A	Ag	Ag/FWPE	N/A	Undefined	Secondary right
	Appropriative	Storage	29062 1987 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	December 15- May 1	106,900 af	
	Appropriative	Direct diversion	30268 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	3,000 cfs[b] 262,000 af[c]	
	Appropriative	Storage	30268 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	155,000 af	Petition to add on-island point of diversion for storage pending
Bacon Island	Appropriative	Direct diversion	2954 1922 priority	1418	1321	I	I	March 1- November 1	60.16 cfs	Primary right
	Riparian	Direct diversion	N/A	N/A	N/A	Ag	Ag/FWPE	N/A	Undefined	Secondary right
	Appropriate	Storage	29066 1987 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	December 15- May 1	110,570 af	
	Appropriative	Direct diversion	30270 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	3,000 cfs[b] 258,000 af[c]	
	Appropriative	Storage	30270 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	147,000 af	Petition to add on-island point of diversion for storage pending

Notes:
Ag = agricultural.
D = domestic.
I = irrigation.
M&I = municipal and industrial.
FWPE = fish and wildlife preservation and enhancement.
WQ = water quality.
af = acre-feet.
cfs = cubic feet per second.
N/A = not applicable.

[a] The maximum potential annual diversion for each island is the sum of the 1987 priority and the 1993 priority (see Appendix 1, "SWRCB Public Notice for the Delta Wetlands Water Right Applications"); the actual diversions for the project would likely be substantially less than the maximum amount.

[b] 30-day average rate of diversion.

[c] Annual maximum amount.

Table 2-4. Existing and Proposed Delta Wetlands Water Rights for Habitat Islands

Island/Tract	Water Right Type	Nature of Right	Application No./ Priority	Permit No.	License No.	Current Use	Proposed Future Use	Season of Diversion	Quantity[a]	Comments
Bouldin Island	Appropriative	Direct diversion	2948 1922 priority	1412	1405	I	I	March 1- November 1	71.56 cfs	Primary right
	Riparian	Direct diversion	N/A	N/A	N/A	Ag	Ag/FWPE	N/A	Undefined	Secondary right
	Appropriative	Storage	29061 1987 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	December 15- May 1	96,070 af	
	Appropriative	Direct diversion	30267 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	2,500 cfs[b] 216,000 af[c]	
	Appropriative	Storage	30267 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	110,000 af	Petition to add on-island points of diversion for storage pending
Holland Tract	Appropriative	Direct diversion	2951 1922 priority	1415	1571	I	I	March 1- November 1	49.25 cfs	Primary right
	Riparian	Direct diversion	N/A	N/A	N/A	Ag	Ag/FWPE	N/A	Undefined	Secondary right
	Appropriative	Storage	29063 1987 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	December 15- May 1	69,050 af	
	Appropriative	Direct diversion	30269 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	2,500 cfs[b] 160,000 af[c]	
	Appropriative	Storage	30269 1993 priority	Pending	N/A	N/A	I/D/M&I/ FWPE/WQ	January 1- December 31	90,000 af	Petition to add on-island points of diversion for storage pending

Notes:
Ag = agricultural.
D = domestic.
I = irrigation.
M&I = municipal and industrial.
FWPE = fish and wildlife preservation and enhancement.
WQ = water quality.
af = acre-feet.
cfs = cubic feet per second.

a The maximum potential annual diversion for each island is the sum of the 1987 priority and the 1993 priority (see Appendix 1, "SWRCB Public Notice for the Delta Wetlands Water Right Applications"); the actual diversions for the project would likely be substantially less than the maximum amount.

b 30-day average rate of diversion.

c Annual maximum amount.

N/A = not applicable.

Table 2-5. Comparison of the Proposed Delta Wetlands Project Features as Evaluated in the 1995 Draft EIR/EIS and in the 2000 Revised Draft EIR/EIS

Project Feature	Proposed Project, as Evaluated in the 1995 DEIR/EIS	Proposed Project, as Evaluated in the 2000 REIR/EIS
Purpose	Potential year-round diversion and storage of water on Bacon Island and Webb Tract (reservoir islands) and wetland and wildlife habitat creation and management on Bouldin Island and most of Holland Tract (habitat islands). During periods of availability throughout the year, water would be diverted onto the reservoir islands to be stored for later sale or release. Incidental shallow-water management on reservoir islands to enhance forage and cover for waterfowl during nonstorage periods.	Same as in 1995 DEIR/EIS.
Diversion and discharge timing	1995 Water Quality Control Plan outflow requirements and objectives, permitted combined SWP and CVP pumping rate, and endangered species protection measures.	Same as in 1995 DEIR/EIS, plus terms of the Delta Wetlands final operations criteria (FOC) (see Table 2-2), biological opinions, and stipulated agreements between Delta Wetlands and other parties to the SWRCB's water right hearing.
Reservoir storage capacity[a]	Bacon Island: 118 thousand acre-feet (TAF). Webb Tract: 120 TAF.	Same as in 1995 DEIR/EIS, but the discharge station on Bacon Island has been relocated from Old River to Middle River.
Multiple storage utilized (multiple fillings and drawdown in one year, if possible)?	Yes.	Yes.
Pump station design	One discharge pump station on each reservoir island, with 40 new pumps (on Bacon Island) or 32 new pumps (on Webb Tract) with 36-inch-diameter pipes discharging to adjacent Delta channels. Typical spacing would be 25 feet on center. An assortment of axial-flow and mixed-flow pumps would be used.	Same as in 1995 DEIR/EIS.
Siphon station design	Two new stations for diversions installed along the perimeter of each reservoir island, each with 16 siphon pipes 36 inches in diameter and with fish screens to prevent entrainment of fish in diversions. Stations would be spaced at least 40 feet apart.	Same as in 1995 DEIR/EIS, with fish screen measures included in the FOC and biological opinions.

Table 2-5. Continued

Project Feature	Proposed Project, as Evaluated in the 1995 DEIR/EIS	Proposed Project, as Evaluated in the 2000 REIR/EIS
Diversion rate	Either reservoir island: maximum of 4,500 cubic feet per second (cfs) (9 TAF per day). Either habitat island: maximum of 200 cfs. Combined maximum daily average (all islands): 9,000 cfs. Combined maximum monthly average: 4,000 cfs (allowing for filling of both reservoir islands in one month).	Same as in 1995 DEIR/EIS, with restrictions specified in the FOC (see Table 2-2), biological opinions, and stipulated agreements.
Discharge rate	Either habitat island: maximum of 200 cfs. Combined maximum daily average (all islands): 6,000 cfs. Combined maximum monthly average: 4,000 cfs (allowing for emptying of both reservoir islands in one month).	Same as in 1995 DEIR/EIS, with restrictions specified in the FOC (see Table 2-2), biological opinions, and stipulated agreements.
Levee improvements	Perimeter levees raised and widened on reservoir islands to hold water at a maximum elevation of 6 feet above mean sea level. Levee improvements on all four Delta Wetlands Project islands designed to meet or exceed recommended standards for levees outlined in DWR Bulletin 192-82. Weekly inspections and ongoing maintenance.	Same as in 1995 DEIR/EIS.
Wetlands management	Wetlands and wildlife habitat created and managed year round on Bouldin Island and Holland Tract under a habitat management plan to offset the effects of water storage operations on wetlands and wildlife habitat.	Same as in 1995 DEIR/EIS.
Maximum number of recreation facilities[b]	Bacon Island: 11. Webb Tract: 11. Bouldin Island: 10. Holland Tract: 6.	Same as in 1995 DEIR/EIS.

Notes:

[a] Assuming a maximum pool elevation of 6 feet above mean sea level (based on National Geodetic Vertical Datum data).

[b] Each recreation facility would be constructed on approximately 5 acres along a perimeter levee and would include vehicle and boat access.

Table 2-6. Summary of Final Operations Criteria for the Delta Wetlands Project

Final Operations Criteria	Applicable Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Annual export of Delta Wetlands stored water will not exceed 250,000 acre-feet *(Applies on an annual basis)*	■	■	■	■	■	■	■	■	■	■	■	■
Diversion Measures												
Maximum X2 value limits start of diversions									■	■	■	
Maximum X2 value limits magnitude of diversions	■	■	■						■	■	■	■
Diversions limited by a maximum allowable change in X2	■	■	■							■	■	■
Diversions to storage limited by QWEST (California Endangered Species Act)			■									
No diversion				■	■							
No diversion if delta smelt fall midwater trawl index <239		■	■	■	■	■						
Diversions limited to a percentage of Delta surplus	■	■	■			■	■	■	■	■	■	■
Diversions limited to a percentage of Delta outflow	■	■	■			■	■	■	■	■	■	■
Diversions limited to a percentage of San Joaquin River inflow	■	■	■									■
Diversions reduced when monitoring detects presence of delta smelt	■	■	■	■	■	■	■	■				■
Diversions limited if Delta Cross Channel is closed for fish protection	■										■	■
Topping-off diversions for evaporation limited						■	■	■	■	■		
Discharge Measures												
Bacon Island discharges for export limited to 50% of San Joaquin River inflow				■	■	■						
No Webb Tract discharges for export allowed	■	■	■	■	■	■						
No discharges for export or rediversion from habitat islands (Bouldin Island, Holland Tract) allowed	■	■	■	■	■	■	■	■	■	■	■	■
Discharges limited to a percentage of available unused export capacity		■	■	■	■	■	■					
Environmental water set aside and provided as a percentage of discharge		■	■	■	■	■						
Discharges reduced when monitoring detects presence of delta smelt				■	■	■	■	■				

Notes: QWEST = a calculated flow parameter representing net flow between the central and western Delta.
Shading represents periods when criterion applies.

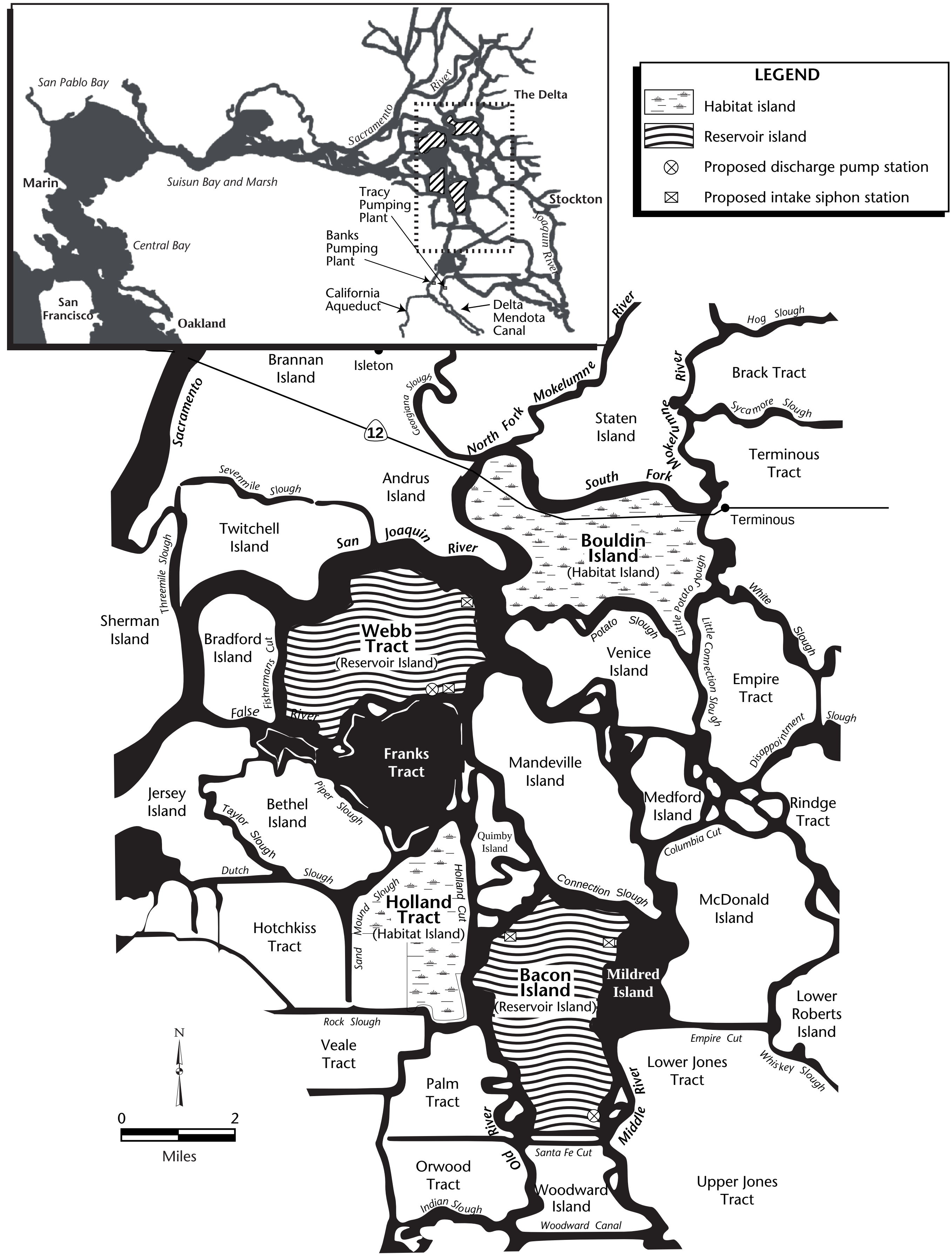

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Figure 2-1
Delta Wetlands Project Islands

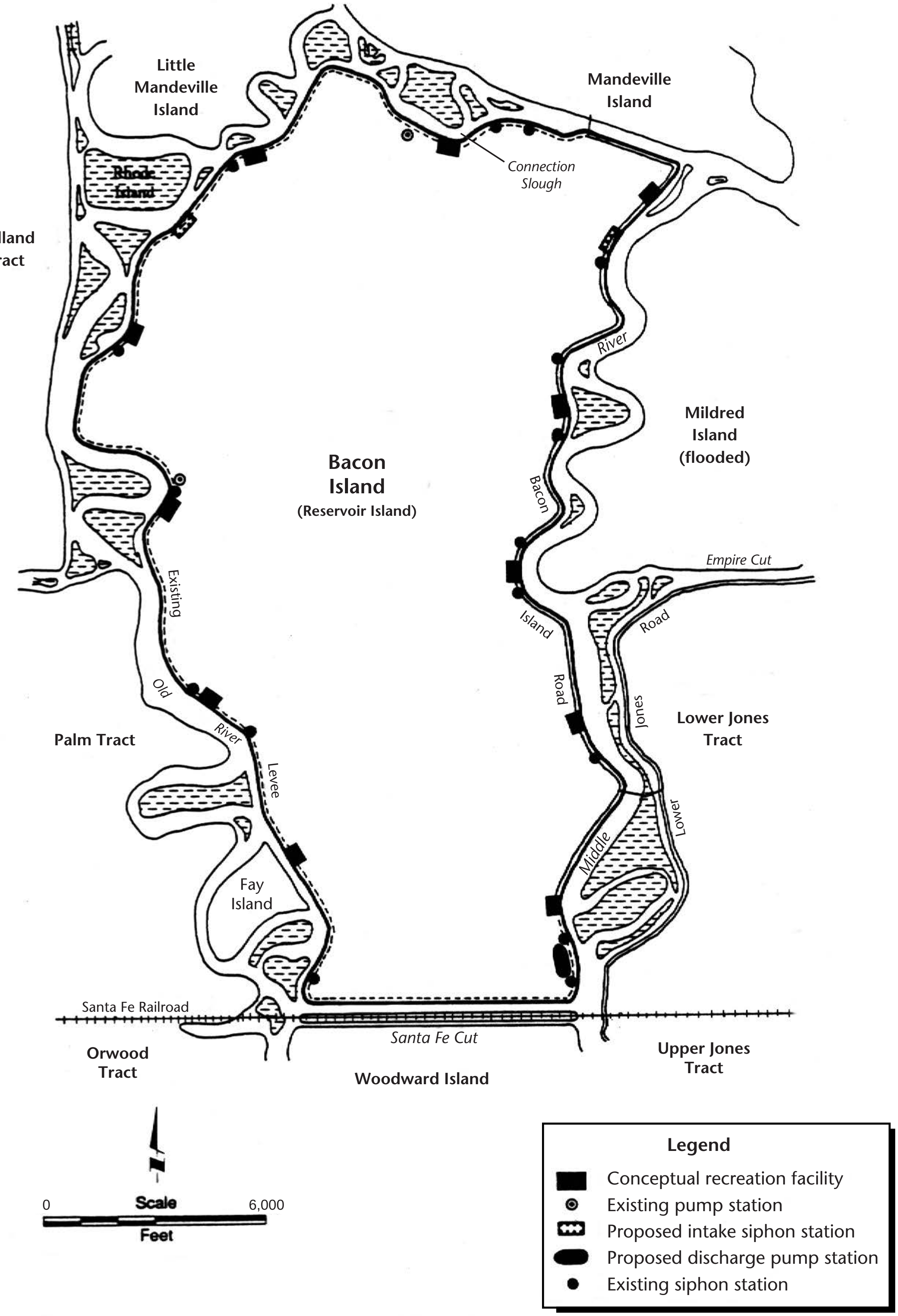

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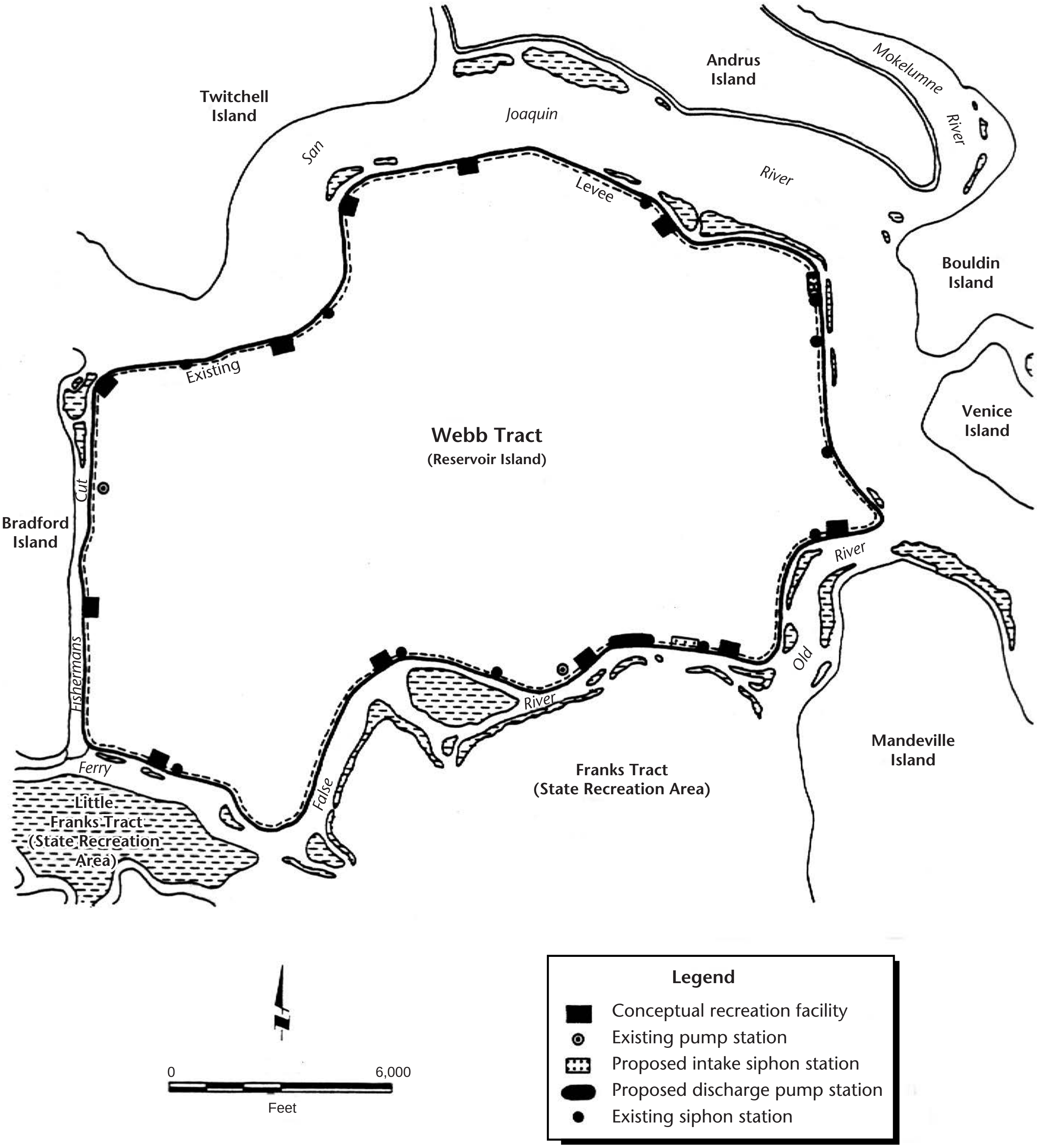
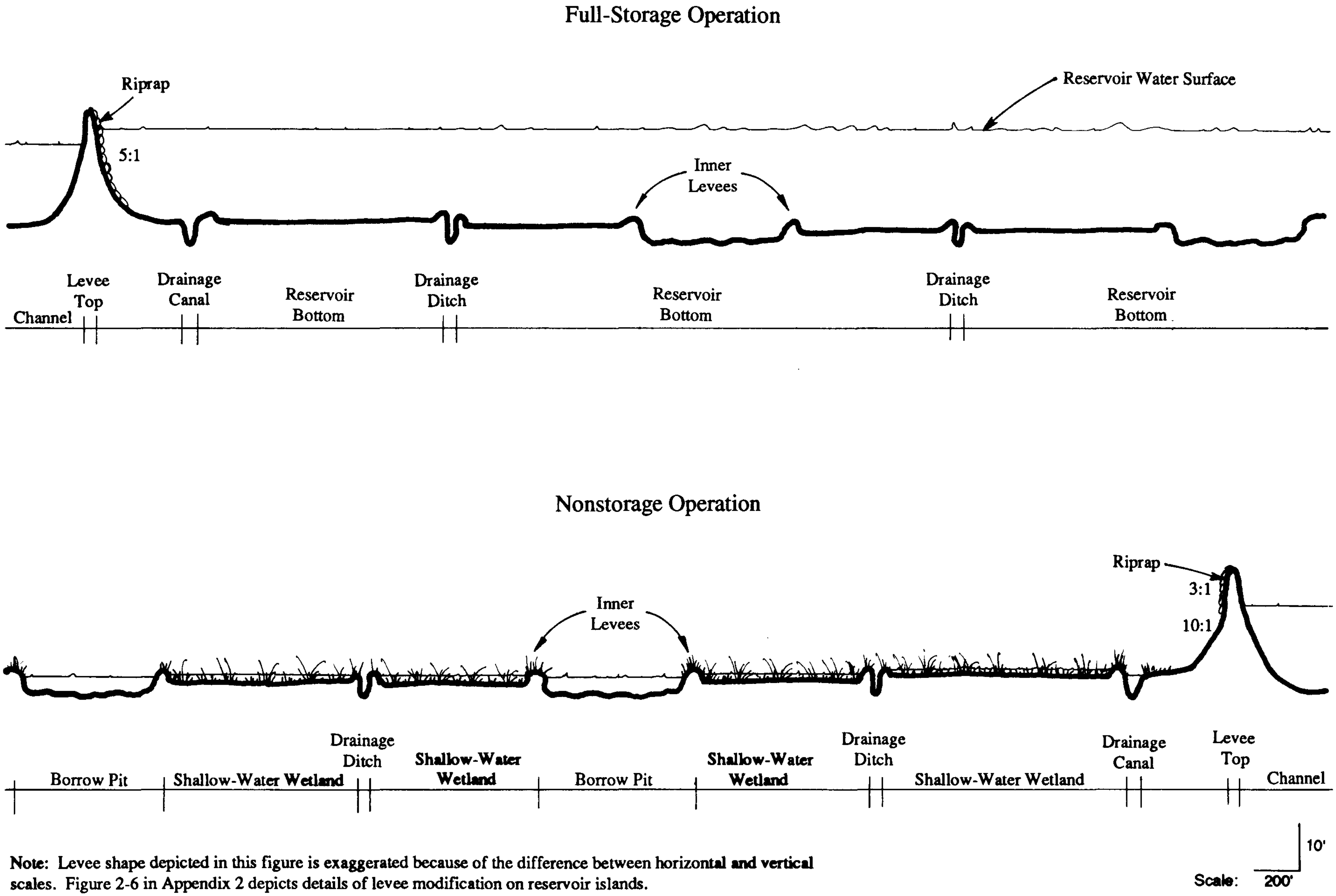
Figure 2-2
Delta Wetlands Project Facilities for Bacon Island under Alternatives 1, 2, and 3



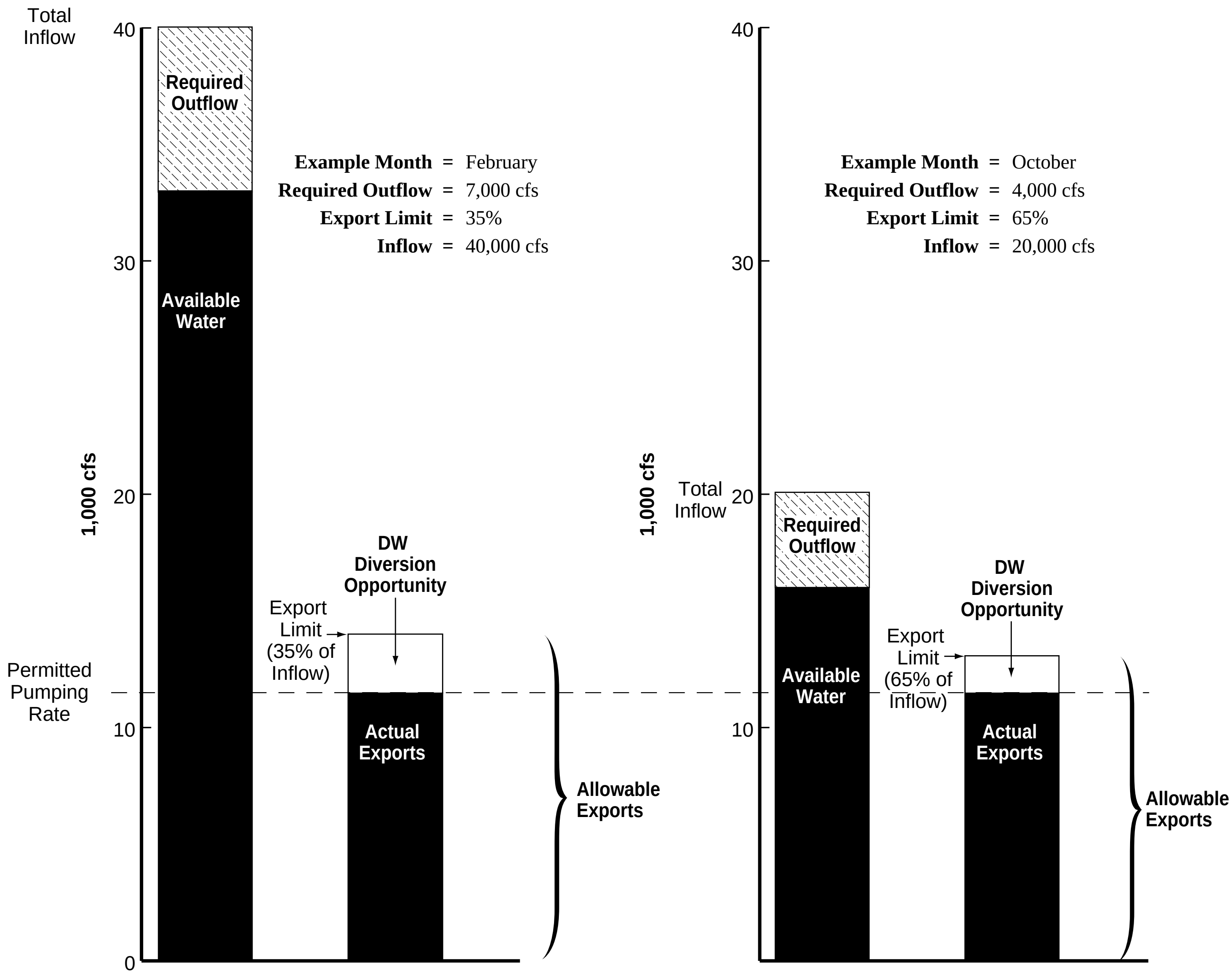
Jones & Stokes

Figure 2-3
Delta Wetlands Project Facilities for Webb Tract under Alternatives 1, 2, and 3



Note: Levee shape depicted in this figure is exaggerated because of the difference between horizontal and vertical scales. Figure 2-6 in Appendix 2 depicts details of levee modification on reservoir islands.

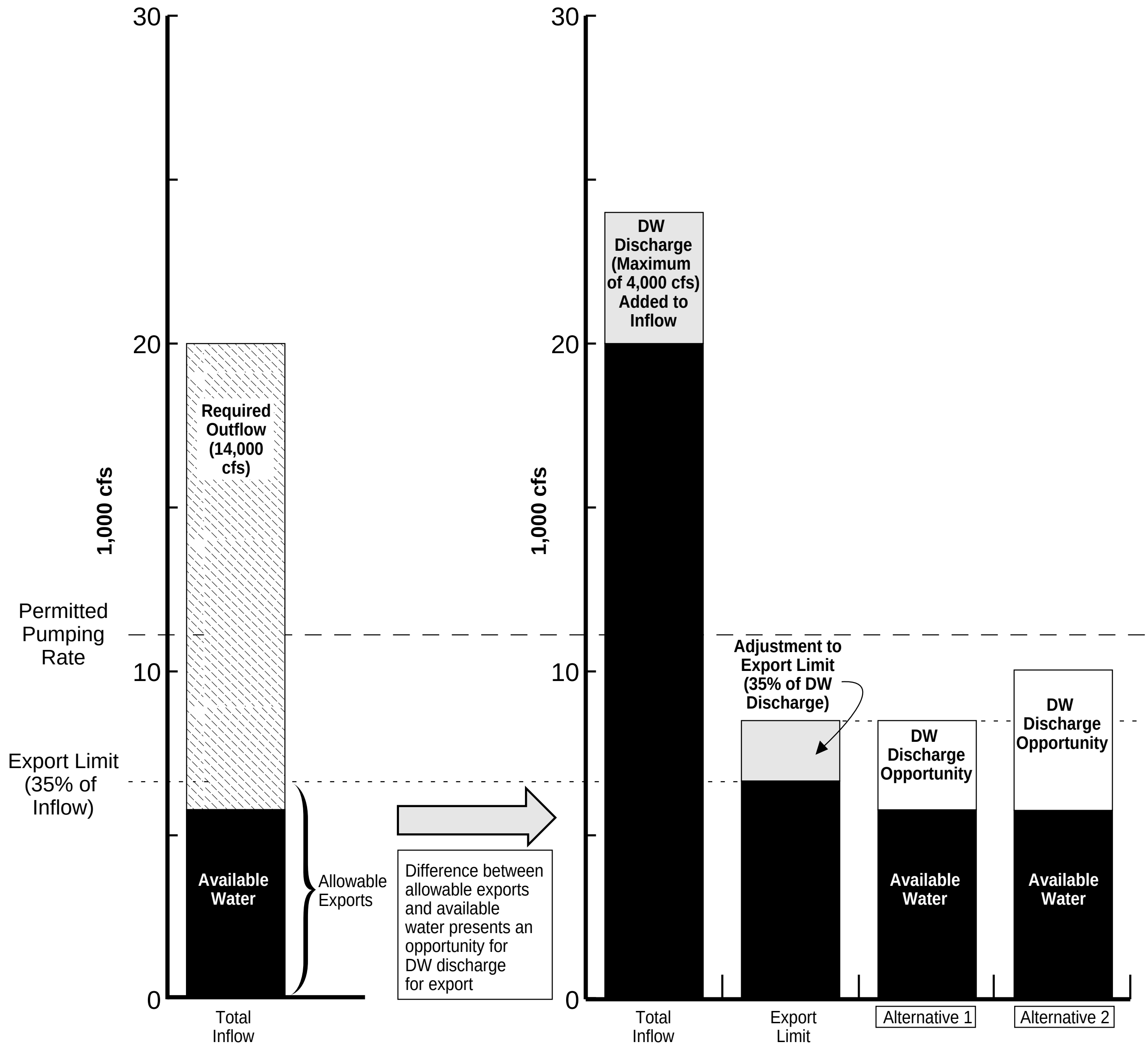
Figure 2-4
Conceptual Cross Section of Reservoir Islands



DW diversion opportunity = export limit - actual exports (actual exports limited by permitted pumping rate)

Figure 2-5
Examples of Delta Wetlands Diversion Opportunities

Required Outflow = 14,000 cfs
Export Limit = 35%
Inflow = 20,000 cfs



Alternative 1: DW discharge subject to the (adjusted) export limit

Alternative 2: DW discharge not subject to the export limit. The amount of DW discharge added to inflow and to the export limit are not relevant to this alternative. DW discharges for export would be allowed up to the permitted pumping rate as long as outflow requirements are met.

Figure 2-6
Examples of Delta Wetlands Discharge Export Opportunities

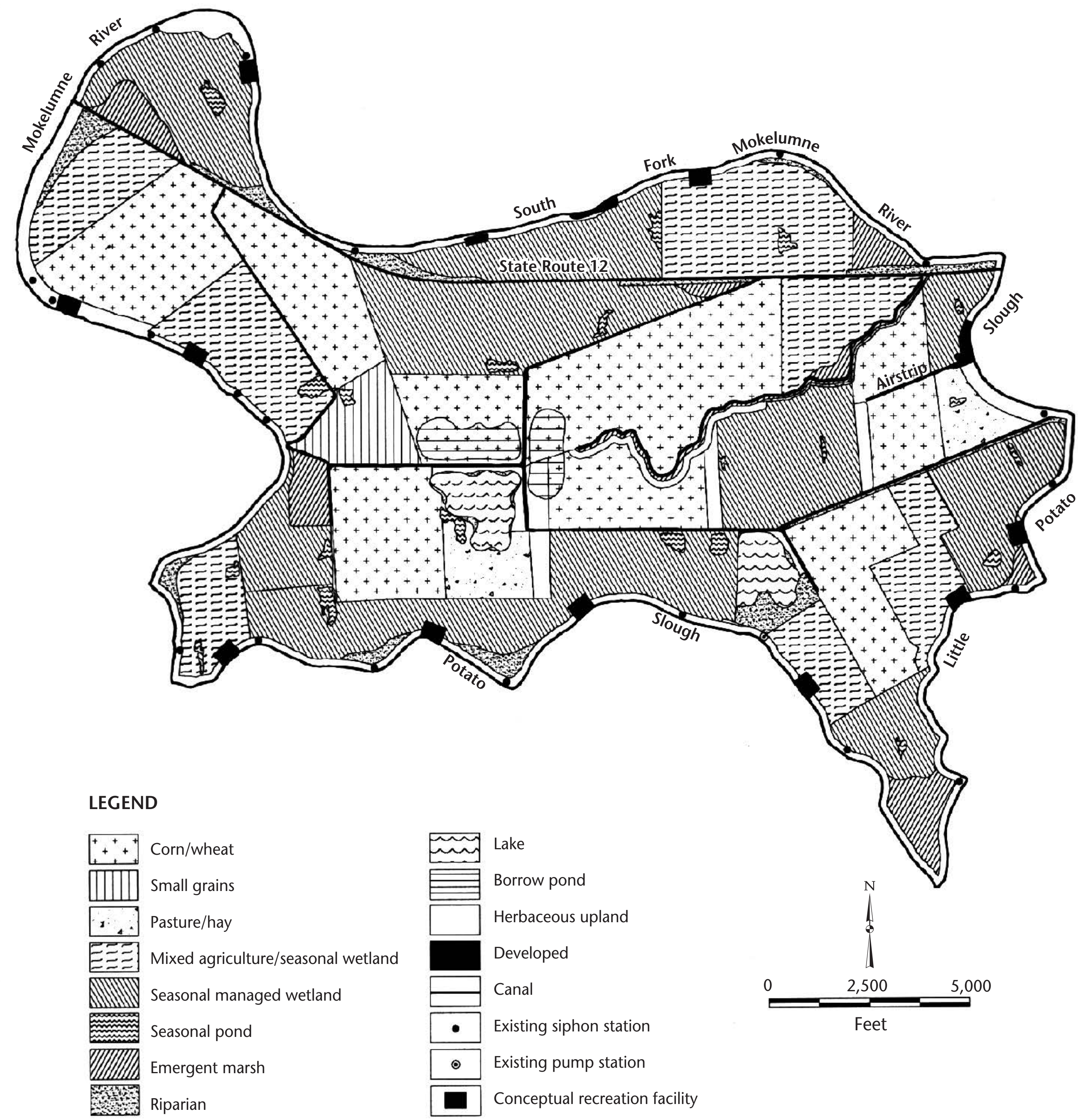


Figure 2-7
Delta Wetlands Project Facilities and Habitats for Bouldin Island under Alternatives 1 and 2

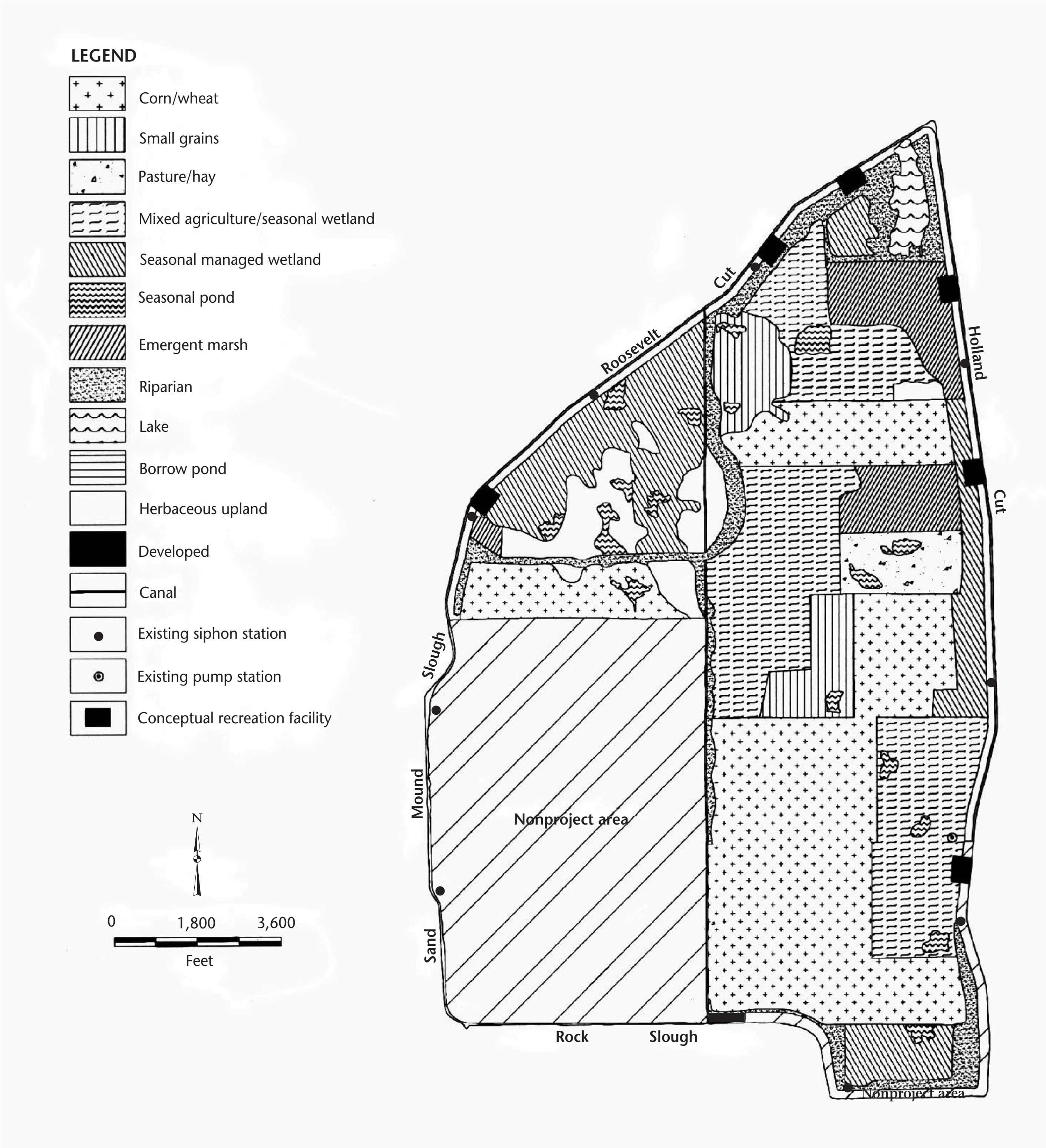
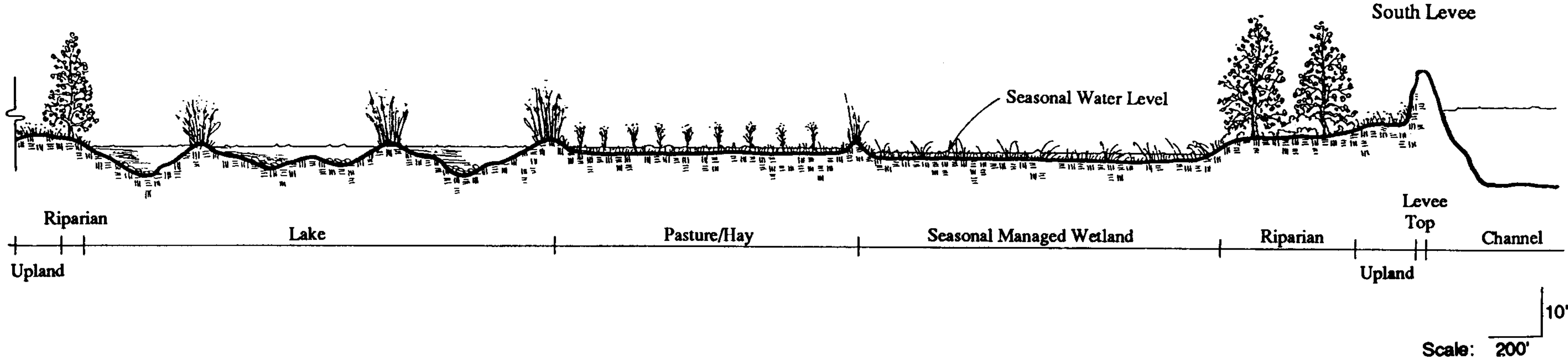
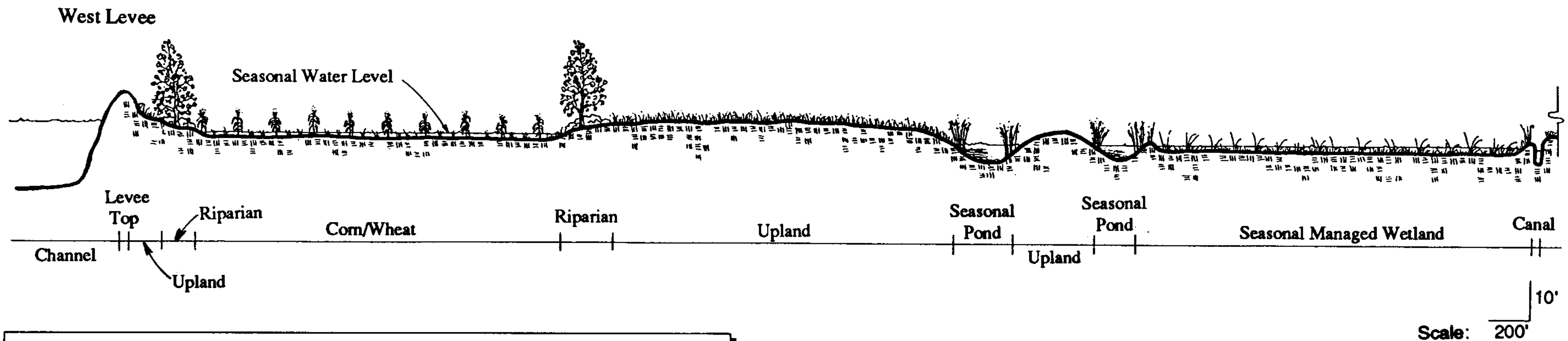


Figure 2-8
Delta Wetlands Project Facilities and Habitats for Holland Tract under Alternatives 1 and 2

Bouldin Island



Holland Tract



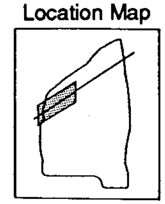
LEGEND	
Corn/Wheat	= Partially harvested, fields of corn rotated with wheat
Seasonal Managed Wetland	= Watergrass- and smartweed-dominated wetlands
Seasonal Pond	= Small ponds supporting emergent vegetation
Pasture/Hay	= Partially harvested, grass and forb fields
Riparian	= Habitats dominated by cottonwood and willow trees
Lake	= Large, open water areas supporting shoreline riparian and emergent vegetation
Upland	= Grasses and forbs

Notes:

Average interior levee slope is 3:1.

Levee shape depicted in this figure is exaggerated because of the difference between horizontal and vertical scales.

Holland Tract Cross Section Location Map



Bouldin Island Cross Section Location Map

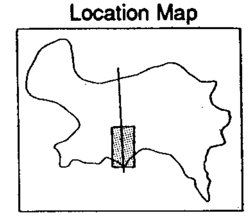
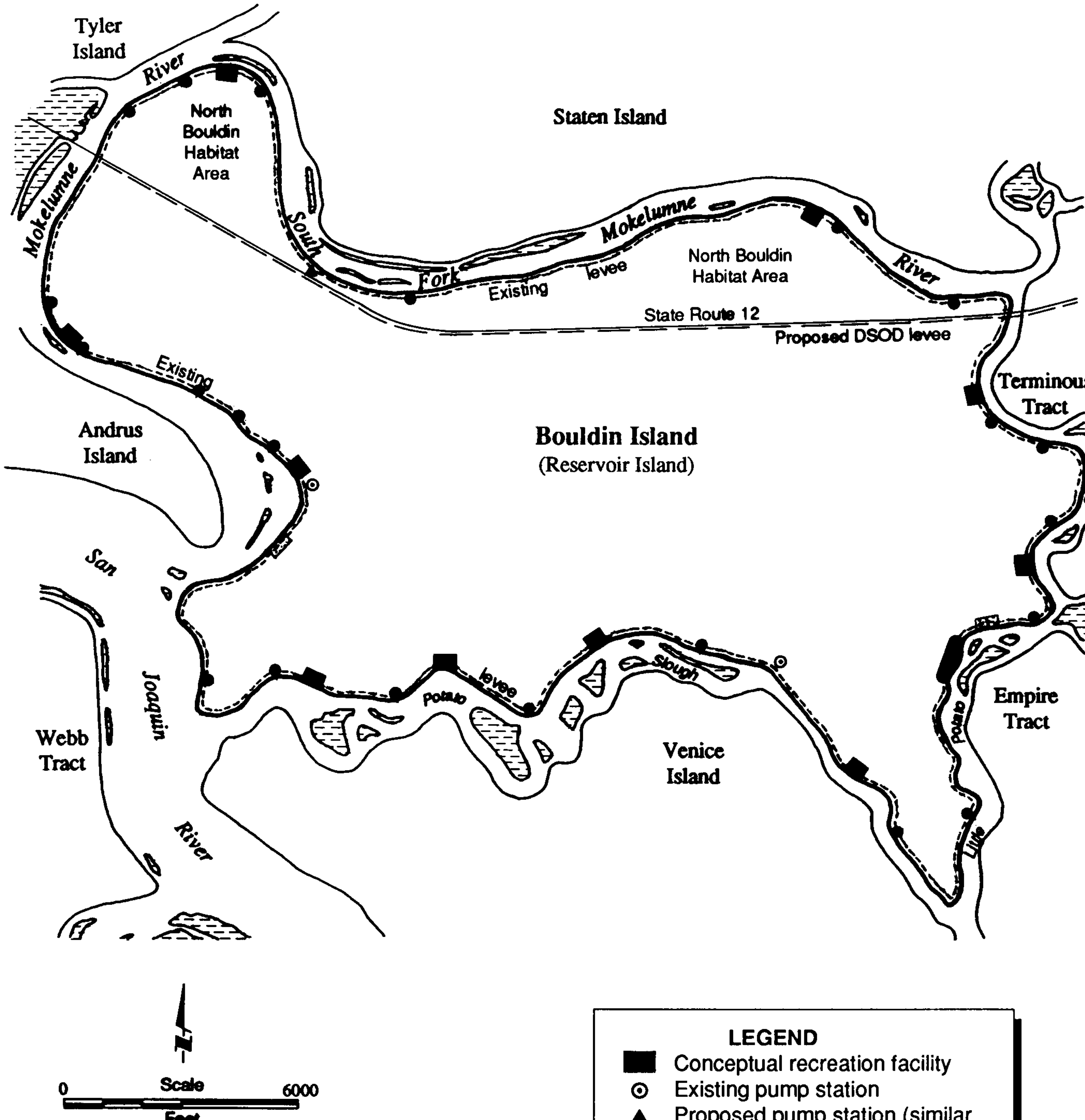
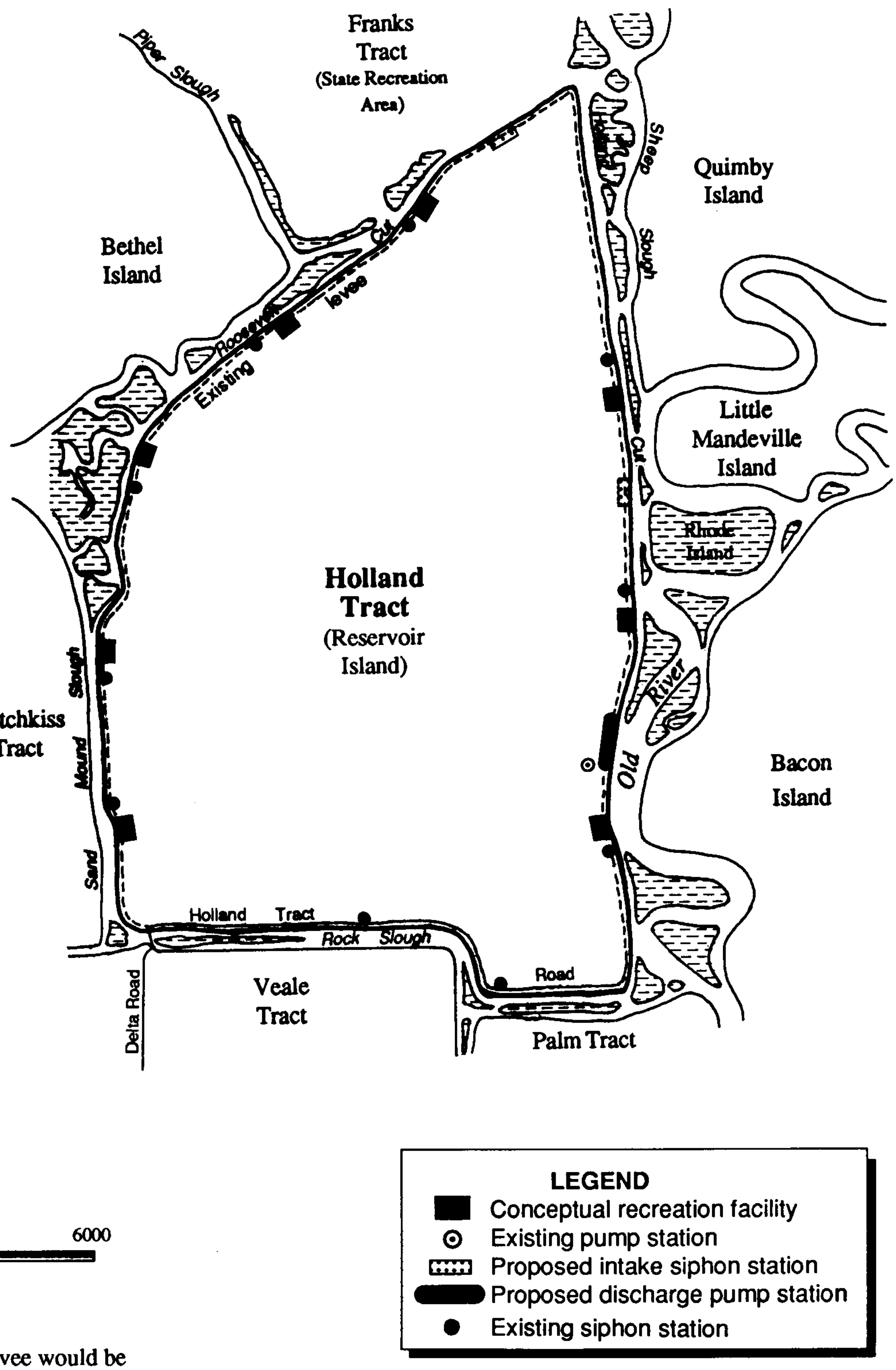


Figure 2-9
Conceptual Cross Section of Habitat Islands under Fall Management Conditions



Note: The existing levee would be improved as described in Chapter 3D, "Flood Control".

Figure 2-10
Delta Wetlands Project Facilities for Bouldin Island under Alternative 3



Note: The existing levee would be improved as described in Chapter 3D, "Flood Control".

Figure 2-11
Delta Wetlands Project Facilities for Holland Tract under Alternative 3

Chapter 3. Affected Environment and Environmental Consequences - Overview of Impact Analysis Approach

Chapter 3. Affected Environment and Environmental Consequences - Overview of Impact Analysis Approach

The following chapters, 3A-3O, describe the affected environments and analyze the environmental impacts of the DW project alternatives in the following 15 resource topics:

- water supply and water project operations,
- hydrodynamics,
- water quality,
- flood control,
- utilities and highways,
- fishery resources,
- vegetation and wetlands,
- wildlife,
- land use and agriculture,
- recreation and visual resources,
- economic conditions and effects,
- traffic,
- cultural resources,
- mosquitos and public health, and
- air quality.

As described in Chapter 1, this selection of topics is based on the issues raised in scoping comment letters, comment letters on the 1990 draft EIR/EIS, water right protests submitted to SWRCB, and issues raised during revision of the 1990 draft EIR/EIS. Evaluations of environmental effects were presented in the 1995 DEIR/EIS for each of these resource topics.

As described in Chapter 1, the 2000 REIR/EIS was prepared to supplement some of these evaluations. Chapters 3 through 7 of the 2000 REIR/EIS addressed the following issues:

- water supply and operations;

- water quality, including project effects on DOC, trihalomethanes (THMs), and salinity;

- fisheries, including Mokelumne River anadromous fish, spring-run chinook salmon, and predation at boat docks and other project facilities;

- levee design and stability, and seepage and proposed seepage control measures; and

- PG&E's gas lines on Bacon Island.

For those subject areas of the 1995 DEIR/EIS that were updated by these additional evaluations, the chapter of this FEIS includes the information from both the 1995 DEIR/EIS and the 2000 REIR/EIS. The following chapters of this document contain information from both these documents:

- # Chapter 3A, "Water Supply and Water Project Operations" (incorporates Chapter 3, "Water Supply and Operations", of the 2000 REIR/EIS);
- # Chapter 3C, "Water Quality" (incorporates Chapter 4, "Water Quality", of the 2000 REIR/EIS);
- # Chapter 3D, "Flood Control" (incorporates Chapter 6, "Levee Stability and Seepage", of the 2000 REIR/EIS);
- # Chapter 3E, "Utilities and Highways" (incorporates Chapter 7, "Natural Gas Facilities and Pipelines", of the 2000 REIR/EIS); and
- # Chapter 3F, "Fishery Resources" (incorporates Chapter 5, "Fisheries", of the 2000 REIR/EIS).

The format of these chapters is described below in the section entitled "Format of Chapters 3A through 3O".

Supplementary information for the resource chapters was included in technical appendices accompanying the 1995 DEIR/EIS and 2000 REIR/EIS chapters. As indicated in Chapter 1, these appendices are incorporated by reference in this FEIS. A complete list of the appendices is provided in Table 1-2 of Chapter 1.

AFFECTED ENVIRONMENT

The "Affected Environment" section of each resource chapter describes the environmental setting and the sources of environmental setting information for the chapter. The environmental settings provide a point of reference (or baseline) for comparing the environmental impacts of the various project alternatives.

General

The environmental setting information for the DW project depends on the conditions particular to each resource topic. Conditions on the DW project islands may have changed since the project was first proposed and since the 1990 draft EIR/EIS was prepared. Certain changes may have occurred because of environmental factors or land use management decisions made in response to agricultural needs (limited to activities that do not require any state or federal agency discretionary approval). For example, portions of the island that were fallow in 1989 may now be in agricultural production or vice versa. The Affected Environment" section of each resource chapter in the 1995 DEIR/EIS analysis was based on one of the following:

- # **Information presented in the 1990 draft EIR/EIS (conditions existing between 1987 and 1990)**. For certain resource topics, because of land management activities occurring since 1987 (e.g., reduction in acreage of crop production), the "1987 point of reference" provided the most reliable description of the affected environment.
- # **Information updated for the 1995 DEIR/EIS (conditions existing between 1991 and 1994)**. In resource areas for which information was not obtained for preparation of the 1990 draft EIR/EIS or factors outside the control of the project applicant altered the setting, the "1994 point of reference" provided the appropriate description of the affected environment.

In those chapters that have been updated with information from the 2000 REIR/EIS, the environmental setting information that was presented in the 1995 DEIR/EIS has been augmented with new data and other information that has been provided to the lead agencies since 1995.

Water Operations

Since the DW project was first proposed in 1987, there has been uncertainty regarding the standards applying to the management of water in the Bay/Delta estuary and, therefore, the standards defining existing conditions for water operations to be used as a baseline for comparing the environmental effects of the proposed DW project alternatives. For those chapters in the EIR/EIS analyzing water operations, the analysis is based on the most likely regulatory constraints that will exist when the DW project is implemented.

The most likely regulatory scenario consists of implementation of SWRCB's 1995 WQCP, which incorporates the protection measures from the NMFS 1993 biological opinion for CVP and SWP operational effects on winter-run chinook salmon and 1995 amendments, and the USFWS 1995 biological opinion for CVP and SWP operational effects on delta smelt. This scenario includes existing Corps requirements for SWP exports at Banks Pumping Plant. The assumptions regarding this regulatory scenario are presented in Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives".

In addition to this overall Delta regulatory scenario, the scenario for the 2000 REIR/EIS evaluation of water operations and effects on fisheries under the proposed project included the restrictions incorporated into the proposed project by the FOC, biological opinions, and stipulated agreements between DW and other parties to the SWRCB's water right hearing (see Chapters 2 and 3A).

IMPACT ASSESSMENT METHODOLOGY

General

The "Impact Assessment Methodology" section of each resource chapter:

- describes the methodology for the impact analysis for the specific resource topic;
- presents the reasons for the selection of the impact assessment variables for the specific resource topic; and
- describes the basis for determining whether the impacts of the project alternatives for the specific resource topic are less than significant, significant, or beneficial.

Resources Affected by Water Operations

For those chapters involving assessment of how the Delta would be affected by water operations of the DW project, impact analysis based purely on survey results is not possible. Various models were used to analyze the effects of water operations of the DW project described in Chapters 3A, 3B, 3C, and 3F. The models developed to analyze Delta operations and effects of DW project water operations are based on the best available tools for water resource impact assessment. Figure 3-1 presents an overview of conditions analyzed for these chapters, model inputs, models, and data sets generated for these analyses in the 1995 DEIR/EIS. The analyses are described in detail in these chapters and related appendices. The modeling of water supply and water quality for the 2000 REIR/EIS included some years of input data beyond those shown in Figure 3-1.

The hydrologic record for the Delta is the best description of likely future Delta hydrologic conditions. Future Delta operations were therefore modeled based on this record. The simulations of DW project operations for the 1995 DEIR/EIS and the 2000 REIR/EIS were based on estimates of water that would be available for diversion and discharge under hydrologic conditions replicating those of the 70-year record of 1922-1991 and the 73-year record of 1922-1994, respectively. All data and modeling results are presented in water years rather than calendar years (i.e., beginning in October of the previous calendar year and ending in September of the specified year).

The hydrologic record alone, however, will not provide an accurate estimate of future operating conditions. The modeling must also be based on anticipated regulatory standards, facilities, and demand for exports, rather than those conditions that existed during the years of the hydrologic record. As described above, the simulations of the DW project alternatives were based on an assumed regulatory scenario consisting of implementation of the 1995 WQCP; the simulations also assumed current Delta operations, facilities, and demand for exports.

Model simulations of Delta operations and effects of DW project water operations are considered adequate for impact analysis if they follow general patterns of data (e.g., peaks and trends) and indicate expected responses to changes in the model inputs (i.e., sensitivity) comparable to changes observed in available measurements. The simulation results are presented graphically, rather than in statistical summaries, to better demonstrate the correspondence to the general patterns of data. Although simulation results are shown corresponding to years of the hydrologic record (e.g., water years 1922-1991), it must be remembered that these results represent operations that would have occurred in those corresponding years only if current standards, facilities, and upstream and export demands for water had been in place.

The DW project as proposed would operate under a range of Delta restrictions. This document analyzes the environmental effects of DW operations within this range. Generally, the DW project would divert water during wet periods when high flow conditions exist in the Delta and would discharge water during drier periods when unused export capacity exists.

Simulated effects of DW project operations on the Delta cannot be directly compared with the historical record of Delta operations for purposes of impact assessment because historical Delta operations did not include current operating criteria; facilities; and conditions, such as upstream and export demands for water. To provide a point of reference for assessing the impacts of simulated operations of the DW project alternatives, it was therefore necessary to also simulate a baseline condition consisting of the same operating conditions but without operations of the DW project. This point of reference is the simulated No-Project Alternative (see below). As with the DW project alternatives, simulation results for the No-Project Alternative are shown corresponding to the hydrologic record; these simulation results, however, do not correspond to historical Delta operations and should not be confused with actual Delta operating conditions for these years. They represent Delta operations, based on monthly averages, that would likely have occurred under the hydrologic conditions of those water years with a regulatory scenario consisting of the 1995 WQCP and with current facilities and upstream and export demands for water. It should be noted that actual daily Delta operations may vary from the monthly averages.

Reservoir Island Storage Capacity

Impacts of the water storage operations of the DW project alternatives are assessed based on the assumption that reservoir capacity at the time of project implementation will be 238 TAF for Alternatives 1 and 2 and 406 TAF for Alternative 3. The total storage capacity of the reservoir islands under the DW project alternatives may increase over the life of the project because of subsidence. No method currently exists to predict the rate of subsidence on a Delta island used for water storage operations or, therefore, to predict the increase in the storage capacity. According to DW's estimate for subsidence under water storage operations, the reservoir islands could subside at a rate of approximately 0.5 inch per year. At this rate of subsidence, the storage capacity of the reservoir islands could increase by as much as 9% over the life of the project (50 years).

An increase in water storage capacity over the life of the project would not alter the impact analysis for this FEIS. The impact analysis for the DW project alternatives is based on the assumption that water operations may, in any year, include several periods of diversion to storage, followed by subsequent discharges for export or Delta outflow augmentation. The total reservoir storage capacity in any period of water storage is not the primary factor controlling the total volume of water diverted and discharged. The primary factors controlling the total volumes of water diverted for storage and discharged for export or outflow are the capacities of the siphons and pumps and durations of periods when the DW project would be allowed to divert and discharge water. These factors, rather than physical storage capacity, are the primary variables for assessing the impacts of project operations.

If the reservoir island storage capacities increase because of subsidence above the levels assumed at project implementation, the monthly DW diversion and discharge volumes, when averaged over a year, could be greater than simulated amounts. The possibility exists that larger annual volumes could be diverted or discharged when sufficient water is available to fill the reservoir islands above the initial storage capacity, or when export capacity is available to completely empty the reservoir islands filled beyond the initial storage capacity, provided that all project operating restrictions are met. The periods for permitted diversions and discharges and the maximum diversion and discharge rates would not change, however. Therefore, the conclusions of the impact assessment of water operations of the DW project alternatives also would likely not change. Although specific impacts may increase incrementally, the change would not alter the significance conclusions in this FEIS.

IMPACTS AND MITIGATION MEASURES OF THE DW PROJECT ALTERNATIVES

Comparison of Alternatives

The impact analysis for each resource topic in the 1995 DEIR/EIS identified and compared the probable impacts of each alternative specific to the resource topic. These comparative analyses highlight differences or similarities in predicted impacts between the alternatives. Each resource chapter analyzes the following project alternatives, which were described in Chapter 2:

- Alternative 1, consisting of two reservoir islands and two habitat islands, implementation of an HMP, and DW discharges for export subject to strict interpretation of the 1995 WQCP export limits;
- Alternative 2, consisting of two reservoir islands and two habitat islands, implementation of an HMP, and DW discharges for export not subject to strict interpretation of the 1995 WQCP export limits;
- Alternative 3, consisting of four reservoir islands, limited compensation habitat provided in the NBHA on Bouldin Island, and discharges for export not subject to strict interpretation of the 1995 WQCP export limits; and
- the No-Project Alternative, consisting of intensified agricultural production on all four DW project islands (see below).

Where the DW project alternatives are predicted to cause significant impacts, mitigation measures are identified. In accordance with NEPA and CEQA guidelines, measures are proposed that would avoid, minimize, rectify, reduce, or compensate for the predicted impacts, thereby reducing them to less-than-significant levels. The feasibility and effectiveness of the mitigation measures are described to the extent possible. Mitigation measures may include modifying the project design or operations to reduce predicted impacts to less-than-significant levels wherever feasible.

The 2000 REIR/EIS analysis was performed to confirm the results of the 1995 DEIR/EIS analysis and to provide revised impact assessments and new or revised mitigation measures where necessary. The updated evaluations of water supply and operations, water quality, and fisheries included project operations as modified by incorporation of the FOC, biological opinion RPMs, and stipulated agreements between DW and other parties to the SWRCB's water right hearing.

The biological opinions and the FOC were developed based on the proposal for a two-reservoir-island project (represented by Alternatives 1 and 2), with Alternative 2 representing the greatest fishery impacts. Therefore, the 2000 REIR/EIS text generally presents an updated evaluation of the proposed project as represented by Alternative 2 (as modified) and describes how the updated information may change the evaluation of the other alternatives presented in the 1995 DEIR/EIS.

No-Project Alternative

The No-Project Alternative (intensified agriculture) is discussed as a separate DW project alternative. It represents DW project island operations that do not require state or federal agency discretionary approvals and would be implemented if the lead agencies denied approval of all other alternatives. The project applicant would not be required to implement mitigation measures if the No-Project Alternative were "selected" by the lead agencies (i.e., if the lead agencies denied approval of all other alternatives). However, mitigation measures are presented for effects of the No-Project Alternative to provide information to the reviewing agencies regarding measures that would reduce effects of the No-Project Alternative. This information will allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Impact Assessment

The impact analysis used in the resource chapters was designed to comply with NEPA and CEQA guidelines. For each resource topic, three levels of impacts were considered:

- direct impacts on the DW project islands and on adjacent Delta channels;

indirect impacts on the project vicinity, including the Delta, Suisun Marsh, and San Francisco Bay, and in some cases upstream areas, induced by direct project-related changes in the environment; and

cumulative impacts.

The study area for analysis of direct project impacts consists of the four project islands, surrounding channels, and adjacent islands. The study area for analysis of indirect impacts is the vicinity of the statutory Delta, as defined by Section 12220 of the California Water Code; the hydrologically related Suisun Marsh and San Francisco Bay; and, in some cases, upstream areas. The study area for analysis of cumulative impacts consists of the combination of the direct and indirect impact areas.

Where uncertainty exists in predicting the extent of project construction and operations, the impact analysis is based on "worst-case" conditions. For example, the impact assessments for water supply, hydrodynamics, water quality, and fishery resources are based on the assumption that DW project operations include the maximum diversion and discharge rates for the entire storage cycle, although these rates would not be maintained during the actual operation of the project. However, the impact assessment of project operations was based on modeling of monthly averages of Delta operations; estimated impacts could be greater if based on daily simulations. Also, because DW is not certain of the size of the various recreation facilities, the impact analysis is based on the assumption that the largest possible facility would be built at all locations, even though it may not be realistic to have a facility of this size at every location.

Direct Impacts

Direct impacts may be of two types: construction impacts and operational impacts. Construction impacts are those caused directly by construction activities, such as siting of project facilities. Operational impacts are those that result directly from project operations, such as flooding of project islands and discharge of stored water to adjacent channels.

Indirect Impacts

Indirect impacts are those that can be reasonably expected to occur in the project vicinity. Project diversions and discharges, for example, may indirectly affect water operations and flows in other areas of the Delta and in areas upstream of the Delta.

Cumulative Impacts

General. Cumulative impacts, discussed in the last section of each resource chapter, are the direct and indirect impacts of the DW project alternatives considered in combination with the impacts of past projects, other current projects, and reasonably foreseeable future projects. Criteria for selecting related projects for the cumulative impact analysis are the following:

the project must be sufficiently related to the proposed project either by location in the general Delta study area or by production of similar types of impacts on similar resources (e.g., land use conversion of agricultural lands),

the project must be reasonably foreseeable,

the specifics of project design or operation must be known or predictable, and

the project must produce additional impacts beyond those already considered under implementation of the DW project alternatives.

Resources Affected by Water Operations. DWR recently installed four additional pumping units at SWP's Banks Pumping Plant. These units increase total pumping capacity from 6,400 cfs to 10,300 cfs. These pumps provide DWR with standby capacity and allow DWR to pump the quantity of water specified under Corps restrictions over a shorter period. The current pumping level is limited to a daily average of 6,680 cfs by the requirement for a Corps permit for exceedance of this rate. (The restrictions for the period of December 15 to March 15, as interpreted by DWR, allow a combined rate of 11,700 cfs in December and March and a combined rate of 12,700 cfs in January and February.)

For those resources affected by water operations, the cumulative impact analysis is based on the assumption that the 1995 WQCP will be in effect and that the maximum SWP pumping rate will be increased to equal full physical export pumping capacity (increased from 6,680 cfs to 10,300 cfs at Banks Pumping Plant). Such an increase may require additional facilities in the Delta, such as Interim South

Delta Program facilities, but these facilities are not specified in the analysis.

FORMAT OF CHAPTERS 3A THROUGH 3O

A section has been added to each of the resource chapters (3A through 3O) that describes how the text has been changed since it was originally published. This section, entitled "Changes Made to This Chapter for the Final Environmental Impact Statement", follows the summary at the beginning of each of these chapters.

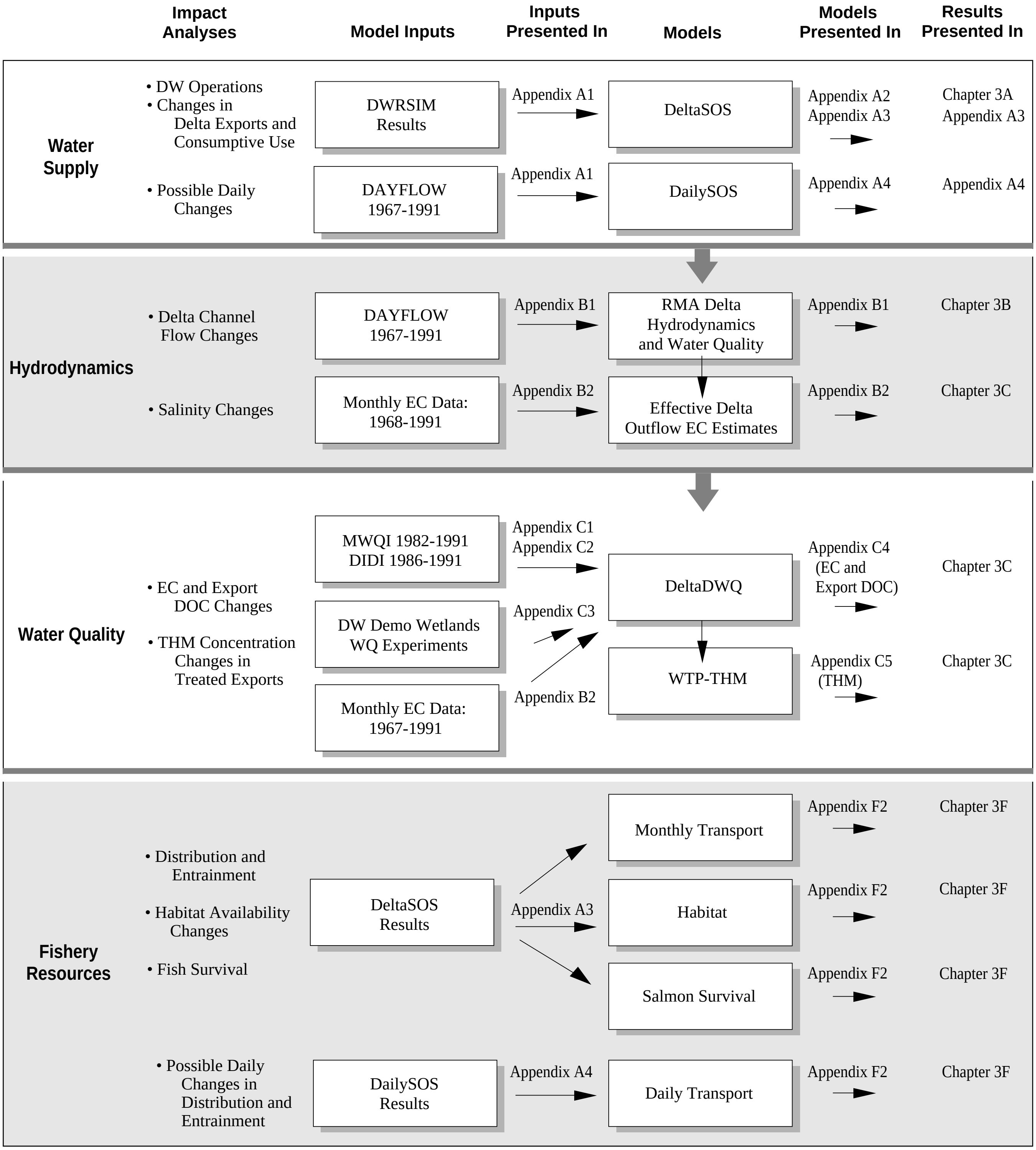
As described above, the 2000 REIR/EIS was prepared to supplement some of the evaluations that were presented in the 1995 DEIR/EIS; the information from the 2000 REIR/EIS has been added to Chapter 3A and Chapters 3C through 3F. These chapters of the FEIS consist of the text of the 1995 DEIR/EIS followed by the text of the corresponding 2000 REIR/EIS chapter.

The impact statements, conclusions, and mitigation measures presented in these chapters have been updated by information and analyses from the 2000 REIR/EIS and this FEIS. In the impact analyses, the impacts and mitigation measures identified for each resource topic are numbered according to the chapter designation for that topic. Mitigation measures are numbered sequentially as they are identified in the chapter; therefore, mitigation numbers do not necessarily correspond to impact numbers. For example, the impacts identified for Alternative 1 in Chapter 3N, "Mosquitos and Public Health", are numbered N-1, N-2, and N-3. Impact N-2 is the first impact in the chapter that requires mitigation; therefore, its mitigation measure is numbered N-1.

Some impacts and mitigation measures were added in the 2000 REIR/EIS, and one mitigation measure has been added in this FEIS. Impacts and mitigation measures that have been added since the 1995 DEIR/EIS was published are designated with a number that begins with the letter "R". For example, for Alternative 1 in Chapter 3D, "Flood Control", mitigation measures recommended in the 2000 REIR/EIS are designated as Mitigation Measures RD-1 and RD-2.

The text of both the 1995 DEIR/EIS and 2000 REIR/EIS sections of these chapters has been modified in response to comments on the 1995 DEIR/EIS and the 2000 REIR/EIS and to incorporate updates of other information. The text also has been modified to enhance readability; for example, cross-referencing has been added between the 1995 DEIR/EIS and 2000 REIR/EIS sections. Otherwise, each section is presented as it appeared in the separate original documents. For example, the 1995 DEIR/EIS text is presented in two-column format as it was in 1995, while the 2000 REIR/EIS is not. There are also some differences between the treatment of acronyms and abbreviations in the sections from the 1995 DEIR/EIS and those from the 2000 REIR/EIS; readers are referred to the list of acronyms and abbreviations that follows the table of contents of this volume.

Chapter 3B and Chapters 3G through 3O address subject areas that were not re-evaluated in the 2000 REIR/EIS. These chapters of the FEIS therefore include only the 1995 DEIR/EIS analysis, as revised in response to comments. They are presented in the (two-column) format of the 1995 DEIR/EIS. These chapters also have been revised to reflect changes made in response to comments received on the 1995 DEIR/EIS and the 2000 REIR/EIS and to incorporate updates of other information they contain.



EC = electrical conductivity
DOC = dissolved organic carbon
THM = trihalomethane

Figure 3-1
Summary of Delta Wetlands Impact Assessment for Water Supply, Hydrodynamics, Water Quality, and Fishery Resources

Chapter 3A. Affected Environment and Environmental Consequences - Water Supply and Water Project Operations

Chapter 3A. Affected Environment and Environmental Consequences - Water Supply and Water Project Operations

SUMMARY

This chapter describes Delta conditions related to water supply and consumptive use in the Delta. Delta island consumptive use is the water supplied by rainfall and channel depletion that is lost from Delta islands through crop ET and open-water evaporation. The chapter provides an overview of historical Delta water supply conditions, describes the water budget for the DW project islands, discusses possible effects of the DW project on water available for export, and describes potential impacts of the DW project alternatives on consumptive use.

Possible effects of DW project operations on water supply were assessed by comparison between simulated conditions associated with the DW project alternatives and those associated with the No-Project Alternative. The Delta Standards and Operations Simulation (DeltaSOS) model was used to simulate water supply conditions; DeltaSOS modeling was based on the initial water budget developed from results of simulations performed by DWR using the operations planning model DWRSIM. The simulations for the 1995 DEIR/EIS were performed using the 70-year hydrologic record for the Delta tributaries but assumed that Delta operations would comply with 1995 WQCP objectives and existing SWP export limits and would operate according to DWR's estimated current level of demand. Cumulative conditions were simulated also with the 1995 WQCP objectives but included full SWP pumping capacity. Updated DeltaSOS simulations of proposed project operations were performed for the 2000 REIR/EIS based on a more recent DWRSIM initial water budget and reflecting the incorporation of the FOC, biological opinion RPMs, and stipulated agreements into the proposed project. The updated simulations were performed using a 73-year hydrologic record and the same basic assumptions that were used in the 1995 DEIR/EIS evaluation. Results of the DeltaSOS modeling discussed in this chapter were used as a basis for analysis of DW project effects on topics in other resource chapters of this document.

The DW project would be required to operate under all applicable standards for protection of Delta water quality, fish and wildlife uses, and other resources and would be precluded from interfering with the ability of those holding prior water rights to comply with Delta standards. Implementation of the DW project alternatives is expected to increase water available for annual Delta exports; however, changes in export water supply are not considered in themselves to be beneficial or adverse impacts, and these changes are described in this chapter but are not assessed for impact significance.

Implementation of Alternative 1 is expected to result in a less-than-significant increase in Delta consumptive use. Implementation of Alternative 2 is expected to result in a beneficial decrease in Delta consumptive use. Implementation of Alternative 3 is expected to result in a significant and unavoidable increase in Delta consumptive use. Under cumulative conditions, implementation of Alternative 1, 2, or 3 would result in a beneficial decrease in consumptive use.

Under the No-Project Alternative, consumptive use would increase, but not measurably so at the scale of monthly water supply modeling.

CHANGES MADE TO THIS CHAPTER
FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The evaluation of water supply and project operations under the proposed project (Alternative 1 or 2) was updated in the 2000 REIR/EIS with the results of new simulations performed using a revised version of DeltaSOS. This chapter consists of the 1995 DEIR/EIS discussion of water supply and project operations under Alternatives 1, 2, and 3 followed by the discussion of the updated simulations performed for the proposed project for the 2000 REIR/EIS. Additionally, minor changes were made to update information in this chapter in response to comments received on the 2000 REIR/EIS.

INTRODUCTION

This chapter discusses Delta conditions related to water supply (the amount of water available for beneficial uses) and the possible effects of DW project operations on water supply. Beneficial uses of Delta water include in-Delta use (e.g., crop irrigation) by other water right holders, maintenance of fish and wildlife habitat, and export to users receiving water from the CVP or the SWP. The "Affected Environment" section of this chapter discusses water rights; Delta objectives and requirements for protection of water quality and biological resources and the constraints placed on Delta water project operations by these objectives and requirements; and operations of the major water projects, the SWP and the CVP. The section also presents an overview of the historical Delta water budget (those hydrologic terms that represent the amounts of water entering and exiting the Delta).

The impact discussions of this chapter focus on potential DW project effects on consumptive use. This chapter does not quantify the effect of an increase of water available for beneficial uses. Direct effects of an increase of water available for annual Delta exports from the DW project alternatives are analyzed in subsequent chapters of this document. Chapter 3B, "Hydrodynamics", discusses potential DW project effects on channel flows and stages. Chapter 3C, "Water Quality", discusses potential DW project effects on outflow and resulting changes in water quality. Chapter 3F, "Fishery Resources", discusses the potential for fish habitat changes, increased entrainment, and other impacts resulting from project-related changes in outflow and export.

Following are definitions of the Delta boundary (systemwide) water budget terms as they are used in this document:

- # **Inflow**. The total rate (cfs) or volume (TAF) of streamflow entering the Delta from the Sacramento and San Joaquin Rivers, Yolo Bypass, and the eastside streams.
- # **Rainfall**. In-Delta precipitation.
- # **Channel depletion**. The water removed from Delta channels by diversions for irrigation and by open-water evaporation.
- # **Consumptive use**. Loss of water on the DW project islands and other Delta islands through crop ET and open-water evaporation and use for shallow-water management for wetlands and wildlife habitat. Rainfall and channel depletion supply the consumptive use water.
- # **Exports**. The water pumped from the Delta to south-of-Delta users by DWR at Banks Pumping Plant and by Reclamation at the CVP Tracy Pumping Plant, and the amount diverted by CCWD at its Rock Slough intake.
- # **Outflow**. The water flowing out of the Delta into San Francisco Bay.

The relationship between these water budget terms is described by the following equations:

Inflow + rainfall = consumptive use + exports + outflow

Channel depletion = consumptive use - rainfall

Additional definitions of terms are provided below in the section from the 2000 REIR/EIS entitled "Definition of Terms".

AFFECTED ENVIRONMENT

Numerous parties hold rights to divert water from the Delta and Delta tributaries. The reasonable beneficial requirements of existing riparian and senior appropriative users with regard to both water quantity and water quality must not be impaired by exercise of subsequent appropriative water rights. DWR's SWP and Reclamation's CVP and other users divert water from the Delta under appropriative rights. Additionally, approximately 1,800 siphons are used to divert water under riparian and appropriative rights from Delta channels to Delta islands for agricultural consumptive uses; most of these appropriative rights were applied for in the 1920s and are senior to those under which the SWP and CVP operate. DW project operations would be conducted under DW's existing riparian and appropriative water rights and new appropriative rights, as described in Chapter 2, "Delta Wetlands Project Alternatives".

Various water quality and flow objectives have been established to ensure that the quality of Delta water is sufficient to satisfy all designated uses; implementation of these objectives requires that limitations be placed on Delta water supply operations, particularly operations of the SWP and CVP, affecting amounts of fresh water and salinity levels in the Delta. The DW project would be prohibited from affecting the ability of those holding prior water rights, such as DWR and Reclamation, to exercise those rights, and the DW project would not be allowed to interfere with compliance with Delta water quality standards or protection of biological resources.

Sources of Information

Ongoing studies and analyses of the Bay-Delta served as important sources of information for this analysis. Studies and reports that were used include San Francisco Estuary Project (1993) and the estuarine standards proposed in December 1993 by EPA; Bay-Delta hearings and workshops sponsored by SWRCB; evaluations of effects of SWP and CVP operations on two federally listed endangered species, winter-run chinook salmon (NMFS 1993) and delta smelt (U.S. Fish and Wildlife Service [USFWS] 1995); and draft environmental documents for major water resource projects in or adjacent to the Delta, including the Los Vaqueros Project (CCWD and Reclamation 1993) and DWR's North Delta Program (DWR 1990a), South Delta Program (DWR 1990b), and Los Banos Grandes (DWR 1990c).

Major sources of data for this chapter were the "DAYFLOW" hydrologic database maintained by DWR's central district and simulation results from the monthly Delta operations planning models DWRSIM and DeltaSOS. DAYFLOW, DWRSIM, and DeltaSOS are described below under "Delta Water Supply Planning". DWRSIM and DeltaSOS are described further under "Analytical Approach and Impact Mechanisms" and in the sections below from the 2000 REIR/EIS entitled "Revised Delta Monthly Water Budget Simulated by DWRSIM" and "Revisions to DeltaSOS".

Other sources of information for this chapter are the environmental report prepared by SWRCB on the 1995 WQCP (SWRCB 1995) and the description and analysis of California water supply and water use demands provided in DWR Bulletin 160-93, California Water Plan Update (DWR 1994). Bulletin 160-93 describes the potential effects of environmental requirements, including Delta outflow and export limits to protect fish and wildlife species, on Delta water supply.

This chapter is also based on information presented in the following appendices:

- Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", describes historical monthly Delta inflows and exports and the monthly Delta inflows, exports, and outflows simulated using study 409 of the water supply planning model DWRSIM.

- Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model", describes the 1995 DEIR/EIS application of DeltaSOS, the water supply model developed by JSA for evaluating Delta water management operations for compliance with present and likely future Delta standards and for describing the potential effects of DW project operations on water supply.

- Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", presents results of DeltaSOS simulations of the DW project alternatives and the No-

Project Alternative performed for the 1995 DEIR/EIS and describes the use of DWRSIM simulation results as initial water budget terms for DeltaSOS modeling.

Appendix A4, “Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments”, compares daily hydrologic conditions with monthly average conditions in the Delta as simulated for the 1995 DEIR/EIS analysis. Results from the daily water supply planning model, DailySOS, are used to describe likely daily operations. The appendix discusses potential differences between impact assessment based on monthly average hydrologic conditions and impact assessment based on actual daily hydrologic conditions.

The reader is directed to these appendices for a more detailed explanation of the analytical methods and assumptions used in the 1995 DEIR/EIS for estimating water supply effects of DW project operations. Readers who are unfamiliar with Delta water supply planning issues may choose to review the appendices before reading this chapter.

The information in these appendices is supplemented by the following updated information that was presented in the 2000 REIR/EIS:

Differences between the DWRSIM initial water budgets used for the 1995 DEIR/EIS and the 2000 REIR/EIS are described later in this chapter in the section from the 2000 REIR/EIS entitled “Revised Delta Monthly Water Budget Simulated by DWRSIM”.

Revisions made to DeltaSOS for the 2000 REIR/EIS evaluation are described later in this chapter in the section from the 2000 REIR/EIS entitled “Revisions to DeltaSOS”.

Results of the updated simulations of proposed project operations performed for the 2000 REIR/EIS are described later in this chapter in the section from the 2000 REIR/EIS entitled “Revised Analysis of Water Supply and Operations under the Proposed Project”.

Updated DailySOS simulations of proposed project operations are described in Appendix F of the 2000 REIR/EIS.

Delta Water Rights

Riparian Water Rights

Riparian water rights are entitlements to water that are held by owners of land bordering natural flows of water. A landowner has the right to divert a portion of the natural flow for reasonable and beneficial use on his or her land within the same watershed. If natural flows are not sufficient to meet reasonable beneficial requirements of all riparian users on a stream, the users must share the available supply according to each owner’s reasonable requirements and uses (SWRCB 1989). Natural flows do not include return flows from use of groundwater (e.g., for irrigation), water seasonally stored and later released (e.g., by the SWP or the CVP for Delta export), or water diverted from another watershed.

Appropriative Water Rights

Appropriative rights are held in the form of conditional permits or licenses from SWRCB. These authorizations contain terms and conditions to protect prior water right holders, including Delta and upstream riparian water users, and to protect the public interest in fish and wildlife resources. To a varying degree, SWRCB reserves jurisdiction to establish or revise certain permit or license terms and conditions for salinity control, protection of fish and wildlife, protection of vested water rights, and coordination of terms and conditions between the major water supply projects.

Diversion and storage of water in upstream reservoirs by California’s two major water supply projects, DWR’s SWP and Reclamation’s CVP, and diversion and export of water from the Delta are authorized and regulated by SWRCB under appropriative water rights. The SWP and the CVP store and release water upstream of the Delta and export water from the Delta to areas generally south and west of the Delta. Reclamation diverts water from the Delta through its Tracy Pumping Plant to the Delta-Mendota Canal (DMC) and San Luis Canal, and DWR pumps for export through the California Aqueduct and South Bay

Aqueduct at its Banks Pumping Plant in Clifton Court Forebay (Figure 1-2 in Chapter 1). DWR also operates the North Bay Aqueduct, which diverts water at the Barker Slough Pumping Plant. SWRCB first issued water right permits to Reclamation for operation of the CVP in 1958 (Water Right Decision 893 [D-893]) and to DWR for operation of the SWP in 1967 (D-1275 and D-1291).

A third substantial diverter of Delta water is CCWD, which currently diverts water from Rock Slough under Reclamation's CVP water rights and will be diverting water from a second intake to be constructed on Old River (CCWD and Reclamation 1993). Several municipal users and many agricultural users also divert water from the Delta under riparian and appropriative rights.

Protection of Water Quality and Biological Resources

The Delta Protection Act of 1959 declared that the maintenance of an adequate water supply for agriculture, industry, urban use, and recreation in the Delta area and for export to areas of water deficiency was necessary for people of the state. Since issuing CVP's water right permit in 1958, SWRCB has established permit terms and conditions to protect beneficial uses of Delta water. SWRCB decisions and water quality control plans and other agency requirements and proposed standards for protection of Delta resources are described below.

D-1485 and the 1978 Water Quality Control Plan

In 1978, SWRCB adopted D-1485 and the Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (1978 Delta Plan). D-1485 modified the Reclamation and DWR permits to require the CVP and the SWP to meet water quality standards specified in the 1978 Delta Plan. The general goal of D-1485 standards was to protect Delta resources by maintaining them under conditions that would have occurred without CVP and SWP operations. D-1485 also required extensive monitoring and special studies of Delta aquatic resources.

D-1485 and the 1978 Delta Plan were challenged in litigation that was finally decided in the "Racanelli Decision" (*United States v. State Water Resources Control Board* 182 Cal. App. 3d 82 [1986]), which directed the state to revise its standards. Pursuant to that decision, SWRCB implemented a hearing process, known as the Bay-Delta hearings, to review and amend the 1978 Delta Plan.

Suisun Marsh Preservation Agreement

SWRCB's D-1485 directed Reclamation and DWR to develop a plan to protect Suisun Marsh resources. The Suisun Marsh Preservation and Restoration Act of 1979 authorized the Secretary of the Interior to enter into a cooperative agreement with the State of California to protect the marsh and specified the federal share of costs for water management facilities. An agreement between federal and state agencies was signed in 1987 with the goal to mitigate the effects of CVP and SWP operations and other upstream diversions on water quality in the marsh. A salinity control structure (tidal gate) was completed on Montezuma Slough in 1988. Additional facilities are being planned, and operation of the facilities will be governed by the 1995 WQCP objectives and monitoring results.

Draft D-1630 and the 1991 Water Quality Control Plan

Following a lengthy hearing process, SWRCB issued revised water quality objectives in the 1991 Delta Water Quality Control Plan for Salinity, Temperature and Dissolved Oxygen (1991 Delta Plan). In 1992, SWRCB proposed new interim water right terms and conditions in draft D-1630. Although subsequently withdrawn, draft D-1630 presented several new Delta water management concepts that have been partially adopted in other actions taken by SWRCB, DWR, Reclamation, fishery protection agencies, and other regulatory agencies. Because draft D-1630 was not adopted, the revised water quality objectives of the 1991 Delta Plan have not been implemented.

Endangered Fish Species

The federal Endangered Species Act requires assessment of the effect of water project operations on fish species listed under the Endangered Species Act as threatened or endangered. NMFS issued its biological opinion on the effects of SWP and CVP operations on winter-run chinook salmon in February 1993, and

USFWS issued a biological opinion on effects of SWP and CVP operations on delta smelt in March 1995. The biological opinions establish requirements to be met by the SWP and the CVP to protect these listed species. These include requirements for Delta inflow, Delta outflow, DCC gate closure, central Delta outflows (QWEST flows, described in Appendix A2), and reduced export pumping because of specified incidental "take" limits. (Take includes harassment of and harm to a species, entrainment, directly and indirectly caused mortality, and actions that adversely modify habitat.) These fish protection requirements impose important constraints on Delta water supply operations.

December 1994 Bay-Delta Framework Agreement and the 1995 WQCP

A Bay-Delta Framework Agreement was signed in June 1994 between the Federal Ecosystem Directorate and the Governor's Water Policy Council of the State of California to establish a comprehensive program for coordination and cooperation with respect to environmental protection and water supply dependability in the Bay-Delta estuary. The three major areas of agreement were:

- formulation of water quality objectives that incorporate EPA and SWRCB regulatory responsibilities,
- coordination of SWP and CVP operations that rapidly respond to environmental conditions in the Delta with an adaptive management approach, and
- evaluation and implementation of necessary facilities and operational controls to provide long-term Delta ecosystem management that integrates water supply and environmental protection objectives.

SWRCB's 1995 WQCP (adopted May 1995) and environmental appendix incorporated several elements of the EPA, NMFS, and USFWS regulatory objectives for salinity and endangered species protection. The 1995 WQCP objectives were used as the applicable Delta standards for simulating the DW project alternatives and the No-Project Alternative. Several of the specific objectives are discussed in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives".

Delta Water Project Operations

Coordinated Operations Agreement

Reclamation, DWR, and others have worked extensively to deal with the complexities of protecting Delta beneficial uses. For example, under interim agreements, DWR cooperatively exports ("wheels") CVP water from the Delta when excess SWP pumping capacity is available.

One product of direct negotiation between Reclamation and DWR is the Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project. The Coordinated Operations Agreement (COA) establishes the basis for cooperative CVP and SWP operations to satisfy SWRCB objectives and provides for periodic review of CVP and SWP operations to satisfy the COA. The 1994 Bay-Delta Framework Agreement further emphasizes the cooperative operations of CVP and SWP facilities.

CALFED Ops Group

The 1994 Bay-Delta Framework Agreement established the California-Federal Operations Group (referred to as the CALFED Ops Group) to coordinate SWP and CVP operations and recommend changes in combined Delta operations that might provide additional fish protection and allow Delta exports with reduced fishery impacts. The CALFED Ops Group was specifically charged with recommending operational changes based on real-time fish monitoring results to minimize incidental take and satisfy other requirements of Endangered Species Act biological opinions. The CALFED Ops Group is also charged with the exchange of information and the discussion of strategies to implement fish protection measures, satisfy 1995 WQCP water quality objectives, and cooperate with the Interagency Ecological Program (IEP) to determine factors affecting Delta habitat and the health of fisheries and to identify appropriate corrective measures for the CVP and the SWP. The CALFED Ops Group meets monthly.

Water Quality and Fishery Monitoring

DWR and Reclamation operate an extensive network of stations for monitoring Delta salinity conditions. Daily data on electrical conductivity (EC) are used to determine the response of Delta salinity conditions to changes in water supply operations and to demonstrate compliance with applicable water quality standards (see Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project"). EC is a general measure of dissolved salts in water and is the most commonly measured water quality variable in the Delta.

Reclamation and DWR operations staffs routinely coordinate monthly planning and daily Delta operations to meet Delta objectives for municipal and agricultural uses and the protection of fish and wildlife and satisfy export pumping demands. The CVP and the SWP are obligated to follow the directives of the "reasonable and prudent" alternatives that are recommended in the biological opinions for winter-run chinook salmon and delta smelt to minimize adverse effects of project operations on these species while still achieving the water supply purposes of the projects. Fish salvage records and IEP fish monitoring data are used to guide operations.

Provisions of the CVP Improvement Act of 1992

The Central Valley Project Improvement Act (CVPIA) dedicates 800 thousand acre-feet per year (TAF/yr) of water delivery for fish and wildlife recovery and mandates the acquisition of additional water for fish and wildlife purposes. Reclamation implemented interim changes in its Delta operations during 1993 and 1994, as recommended by USFWS, to dedicate the 800 TAF/yr. Long-term changes in CVP operations to satisfy the CVPIA were being evaluated by Reclamation and USFWS and had not yet been determined at the time that the assumptions for the 1995 DEIR/EIS were developed.

Additional Delta Operating Rules

Some changes in the standards and operating criteria that govern Delta water project operations have been made since the 1995 DEIR/EIS was published; most of these are related to AFRP recommendations for the use of CVP water under the CVPIA. These modifications are described below in the section from the 2000 REIR/EIS entitled "Revised Delta Standards".

Delta Water Supply Planning

A large proportion of California's water supply moves through the Delta to be exported to urban and agricultural water users in the San Joaquin Valley, San Francisco Bay Area, and Southern California. Therefore, statewide water supply planning must be based on an accurate description of Delta standards and operational constraints.

Water supply conditions in California and the Delta are commonly evaluated using DWR's operations planning model, DWRSIM, or Reclamation's operations planning model, PROSIM. DWR and Reclamation use these models to simulate possible effects of increased demands, new facilities, or new standards on SWP or CVP project operations. These models simulate monthly patterns of water storage, diversion, and export based on historical hydrologic data. Figure 3A-1 shows the upstream reservoirs that are simulated in the DWRSIM and PROSIM operations planning models.

DAYFLOW is a database of daily hydrologic conditions, including measured Delta inflows and exports, estimated consumptive use, and net Delta outflow (DWR 1986). The daily data have been compiled for each water year (October 1 to September 30) beginning with 1930 and are updated annually. U.S. Geological Survey (USGS) and DWR streamflow gages are the sources of inflow measurements for the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras Rivers. Yolo Bypass and several miscellaneous inflows between Sacramento and Stockton are also estimated from available streamflow gages. CVP and SWP operations records are the source of export pumping data. DAYFLOW provides an accounting of historical Delta boundary (systemwide) hydrology that is used for evaluating flow-related conditions in the Delta.

Results from DWR studies to evaluate flow requirements of the 1995 WQCP objectives using DWRSIM have been used along with results from the DeltaSOS model developed by JSA for this analysis to describe Delta conditions, standards, and water supply constraints as a basis for evaluating possible effects of DW operations.

Historical Delta Water Supply and Water Quality

Because of variable hydrologic conditions, seasonal demands for water diversions, and agricultural drainage flows, water supply and water quality conditions in the Delta exhibit considerable fluctuations. Periods of high inflows that result in low salinity alternate with periods of low inflow that allow greater salinity intrusion and may allow larger effects from agricultural drainage. A second source of variation in Delta water supply and water quality conditions is CVP and SWP project operations that may store water upstream for later release and export to supply south-of-Delta demands. Existing Delta water supply conditions as characterized for the 1995 DEIR/EIS are described in detail in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", and existing Delta salinity conditions as characterized for the 1995 DEIR/EIS are described in detail in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project".

Figure 3A-2 shows the historical annual pattern of Delta inflow and exports and estimated annual channel depletion resulting from Delta ET losses for the 1922-1991 period, based on DWR's DAYFLOW database (1930-1991) and DWR's estimates of unimpaired flow (natural tributary inflow without storage or diversions) (1922-1929). Delta inflow that is not lost to Delta ET or pumped as Delta export is calculated as Delta outflow.

Table 3A-1 gives annual values for the historical Delta water budget terms for water years 1922-1991 based on the DAYFLOW database (1930-1991) and unimpaired flow estimates (1922-1929). Historical Delta inflow averaged approximately 23.0 million acre-feet per year (MAF/yr) for 1922-1991. Consumptive use was estimated at 1.59 MAF/yr and rainfall averaged 0.82 MAF/yr, so net Delta channel depletion averaged about 0.77 MAF/yr. Historical exports increased from less than 0.1 MAF in 1950 (CCWD diversions) to about 6 MAF in 1989 and 1990 (see details in Appendix A1).

Figure 3A-3 shows DAYFLOW estimates of monthly historical Delta outflow for water years 1968-1991, corresponding to the period when most CVP and SWP facilities were constructed and operating. Delta outflow has fluctuated greatly during this historical period, with low-flow periods of less than 5,000 cfs common in fall, and high-flow periods of greater than 50,000 cfs in winter of 13 of the 24 years.

Figure 3A-4 shows historical monthly Delta EC patterns for 1968-1991 (from EPA's STORET database) measured at Pittsburg, just upstream of Chipps Island (see Appendix B2). By comparison of Figures 3A-3 and 3A-4, it can be seen that periods of low Delta outflow correspond with major salinity intrusion episodes at Pittsburg, and periods of high Delta outflow correspond with salinity being flushed from the Delta.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

DWRSIM and DeltaSOS

Possible water supply effects of alternative operations of the DW project were evaluated with the DeltaSOS model developed by JSA. For assessment purposes, operations under the DW project alternatives were simulated using DeltaSOS, and the No-Project Alternative was simulated with DeltaSOS to provide a baseline condition, including the same Delta operating conditions, with which DW operations under each alternative could be compared. The EIR/EIS lead agencies (SWRCB and the Corps) determined that the simulations for this assessment should be performed assuming implementation of the 1995 WQCP objectives as interpreted by DWR for modeling the Delta water supply effects of the WQCP using DWRSIM. The lead agencies consider the DWRSIM results to be the best available representation of likely future Delta conditions under the 1995 WQCP objectives.

As described in Chapter 3, "Affected Environment and Environmental Consequences - Overview of Impact Analysis Approach", the simulations were therefore performed based on the assumption that operations of the DW project and the No-Project Alternative would be within the 1995 WQCP objectives for Delta outflow and Delta export limits and would be consistent with current Corps limits on SWP pumping (6,680 cfs). For assessment of cumulative impacts, DeltaSOS simulations were also performed for operations that would be within the 1995 WQCP objectives, but allowing for SWP export pumping at the full physical capacity of 10,300 cfs for Banks Pumping Plant.

Because the hydrologic record for the Delta tributaries is the best available description of likely future hydrologic conditions, hydrologic data from this record serve as the basis of simulations of future Delta operations. The results of the simulations are therefore shown as corresponding to the water years of the hydrologic record (1922-1991 for the 1995 DEIR/EIS analysis and 1922-1994 for the 2000 REIR/EIS analysis)and represent estimates of operations under hydrologic conditions replicating those of this period of record.

DeltaSOS simulations require an initial Delta water budget, user-specified input parameters (switches) that govern simulated Delta operations, and specified matrices of Delta standards. As described below under "Simulated 1995 WQCP Objectives", simulation results from the DWRSIM monthly water supply planning model provided the initial water budget terms for the DeltaSOS simulations. DWR performed these simulations, referred to as DWRSIM study 1995-C6B-SWRCB-409, or Study 409, in January 1995 to represent the 1995 WQCP objectives. The specified model inputs for the DW project simulations based on DWRSIM Study 409 are described in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives". Selected results are presented in tables and graphs in Appendix A3 to compare each simulated DW alternative with the No-Project Alternative; results of the DWRSIM and DeltaSOS model studies are summarized in this chapter.

As described below in sections from the 2000 REIR/EIS, since the 1995 DEIR/EIS was published some assumptions used for establishing baseline conditions in the Delta have changed, and DWR has conducted new DWRSIM modeling studies to establish new simulated baseline conditions for the Delta under the 1995 WQCP. The results of one of these studies, Study 771, were used as the basis of the updated DeltaSOS simulations of proposed project operations performed for the evaluation presented in the 2000 REIR/EIS. (See the section from the 2000 REIR/EIS below entitled "Overview of the Evaluation Methods Used in the 2000 Revised Draft EIR/EIS: DeltaSOS, DWRSIM Water Budget, and Modeling Assumptions".)

Simulated 1995 WQCP Objectives

The DWRSIM simulation used for estimating the initial Delta water budget used in the DeltaSOS simulations (Study 409) represented the 1995 WQCP objectives based on assumptions summarized below. The DWRSIM modeling assumptions necessary to represent the 1995 WQCP objectives in a monthly water supply planning model have been described in detail in SWRCB (1995). More complete descriptions of these DWRSIM and DeltaSOS modeling assumptions are presented in Appendices A1, A2, and A3. Except where indicated, DWRSIM Study 771, which provided the initial water budget used in the DeltaSOS simulations for the 2000 REIR/EIS, was based on the same assumptions.

Following are major DWRSIM assumptions for the 1995 WQCP simulations:

- Upstream hydrology, depletions, and diversions were based on 1995 level of development, as presented in California Water Plan Update (DWR 1994). See Appendix A1 for more details.

- Water-year classification was based on the "40-30-30 Sacramento Valley Four-River Index" and the "60-20-20 San Joaquin Valley Four-River Index". The outflow requirements during February-June depend on the previous month's "Eight-River Index" runoff volume. These classification schemes are slightly different from those used for the standards specified in D-1485, which established the Delta operations criteria in effect until approval of the 1995 WQCP.

- Delta outflow requirements were the combination of fixed monthly requirements, estuarine habitat requirements (expressed in terms of "X2", the position of the 2-parts-per-thousand [2-ppt] salinity gradient), and requirements for additional outflow to protect the chloride objective of 250 milligrams per liter (mg/l) for Delta exports. Because the X2 requirements in the 1995 WQCP depend on the previous month's runoff, the required outflow must be calculated for each month. Minimum outflow objectives are maintained during low runoff periods.

The CVP Delta export demand in DWRSIM Study 409 was assumed to be 3.15 MAF/yr, including 145 TAF/yr for CCWD diversions. However, these CVP demands were not always satisfied in drier years in DWRSIM simulations. The SWP Delta export demands were assumed to vary with Kern River runoff and Los Angeles rainfall conditions. The range of possible SWP export demands was 2.6-3.6 MAF/yr, with an average of 2.85 MAF/yr. The maximum combined Delta export demand of 6.7 MAF/yr was specified in about 45% of the simulated years. The simulated average annual Delta export, based on these variable demands, was 5.7 MAF/yr, with 2.8 MAF/yr simulated as SWP and delivery and 2.9 MAF/yr as CVP delivery. See Appendix A3 for more details on assumptions about export demands in Study 409. (The revised assumptions for CVP export demand used in Study 771 are described below in the section from the 2000 REIR/EIS entitled "Overview of the Evaluation Methods used in the 2000 Revised Draft EIR/EIS: DeltaSOS, DWRSIM Water Budget, and Modeling Assumptions".)

San Joaquin River inflows, estimated with another DWR model called STANSIM, met the 1995 WQCP Vernalis water quality objectives (with a maximum of 70 TAF/yr), and the Vernalis pulse-flow objectives were satisfied with additional water from upstream tributaries (Tuolumne and Merced Rivers) when necessary. This additional San Joaquin River inflow averaged 72 TAF/yr but was required in only a few years. See Appendix A3 for more details. (This assumption was slightly modified in Study 771 because of Vernalis Adaptive Management Plan [VAMP] requirements; see the section from the 2000 REIR/EIS below entitled "Overview of the Evaluation Methods used in the 2000 Revised Draft EIR/EIS: DeltaSOS, DWRSIM Water Budget, and Modeling Assumptions".)

Combined SWP and CVP Delta exports were limited as specified in the 1995 WQCP to a percentage of the simulated Delta river inflow (which does not include rainfall). These percentages are 35% in February-June and 65% for the remainder of the year. The February percentage is 45% if the January Eight-River Index is less than 1.0 MAF. Export pumping during the pulse-flow period was limited to an amount equivalent to the pulse flow during half of April and half of May. See Appendix A2 for details.

Simulated Delta Water Supply Conditions

Possible effects of the DW project on Delta water supply conditions were assessed through comparison of simulated conditions under the DW project alternatives with those under the No-Project Alternative. Delta water supply under existing conditions, which include agricultural land uses on the DW project islands, is similar to water supply under the No-Project Alternative; the estimated changes in consumptive water use between the existing agricultural land uses and the intensified agricultural uses under the No-Project Alternative (estimated to be as much as 30 TAF/yr, as shown in Table 2-2 in Chapter 2) are not measurable at the scale of monthly water supply modeling. Therefore, rather than presenting two lists of the same values for existing Delta water supply conditions and the No-Project Alternative conditions, this section describes the simulation results for the No-Project Alternative.

Appendix A3 includes details of annual and monthly values for Delta conditions simulated by DeltaSOS for the No-Project Alternative for the 1995 DEIR/EIS. Annual values summarize annual variations but do not show monthly fluctuations. Monthly percentile tables in Appendix A3 provide an important seasonal summary of simulated Delta conditions for the No-Project Alternative.

Table 3A-2 summarizes average annual DW project operations under the No-Project Alternative as simulated for the 1995 DEIR/EIS, showing DeltaSOS-adjusted exports, required outflow, and effects on export and outflow and major channel flows. Tables 3A-3 and 3A-4 show DeltaSOS average simulation output for Delta exports and outflow under the No-Project Alternative. Selected simulation results from the 1995 DEIR/EIS are summarized in graphs in this chapter and are described below.

Monthly Simulation of Maximum SWP and CVP Exports. The only adjustment made in DeltaSOS to the initial DWRSIM results is to increase the combined CVP and SWP exports to the maximum possible within the constraints specified in the 1995 WQCP.

DeltaSOS simulations indicate that a considerable amount of Delta export would be possible in addition to that simulated by DWRSIM for its variable assumption of south-of-Delta demands (see Appendix A1). The additional simulated SWP and CVP exports average 442 TAF/yr. These additional exports are simulated in DeltaSOS to provide an appropriate basis for estimating potential water supply effects of the DW project. Only water that could not have been exported directly by the SWP or the CVP was simulated to be available for DW diversions. Only export pumping capacity that could not have been used by the CVP and the SWP because of the 1995 WQCP export limits was simulated to be available for export pumping (wheeling) of DW discharges.

The DeltaSOS adjustment of the initial DWRSIM Delta exports is fully described in Appendix A3. This assumption of maximum CVP and SWP exports within the export limits specified in the 1995 WQCP may result in more Delta export being simulated than could be fully used in some years. It seems likely that in the event that more water were needed for south-of-Delta beneficial uses than simulated with DWRSIM, SWP or CVP export pumping of available water in the Delta would occur prior to discharge from DW storage. Additional discussion of these SWP and CVP export adjustments can be found in Appendix A3. For information on the way that south-of-Delta demands were addressed in the 2000 REIR/EIS, see the section from the 2000 REIR/EIS below entitled "South-of-Delta Demands and Deficits".

Monthly Simulation Values for Outflow, Export, and Water Available for DW Diversions. Figure 3A-5 shows monthly Delta outflow and required Delta outflow under the No-Project Alternative for 1968-1991, as simulated by DeltaSOS for the 1995 DEIR/EIS. Simulated outflow values for 1922-1967 are shown in Figures A3-1A and A3-1B in Appendix A3. In many months of most years, a considerable portion of Delta outflow is represented by required Delta outflow, which includes DWRSIM estimates of X2 and requirements for "carriage water" (additional Delta outflow required to maintain acceptable chloride concentrations in export water as Delta exports are increased) (see details in Appendix A2).

Figure 3A-6 shows the monthly Delta export pumping for water years 1968-1991 for the No-Project Alternative, as simulated by DeltaSOS for the 1995 DEIR/EIS. The initial export values from DWRSIM were adjusted by DeltaSOS to estimate additional exports that could be made within specified monthly export limits and Delta outflow objectives (without considering south-of-Delta demands and storage capacity). In these simulations, DeltaSOS often simulated additional export in spring because DWRSIM-simulated exports were less than the maximum possible if demands are satisfied and San Luis Reservoir storage is full. Table 3A-4 presents monthly percentiles of the DeltaSOS simulations showing the monthly distribution of Delta exports for the 70-year simulation period for the No-Project Alternative. Monthly percentiles indicate the fraction of years that a cell value (export rate) would be less than that value. For example, the average October export was simulated to be below 11,280 cfs in 70% of years, and the minimum export rate was simulated to be 4,288 cfs.

Figure 3A-7 shows monthly values of water available for DW project diversions for the 1968-1991 period under the 1995 WQCP objectives, as simulated by DeltaSOS for the 1995 DEIR/EIS. The maximum monthly average diversion rate needed to fill the 238-TAF capacity of the two DW reservoir islands is 4,000 cfs. Because the monthly average flow of available water is often greater than 4,000 cfs, the DW project would divert only a small portion of the available water in most months.

Annual Simulation Values for Outflow and Export. Figure 3A-8 shows annual values for Delta outflow and required Delta outflow (in MAF) for the No-Project Alternative for water years 1922-1991, as simulated by DeltaSOS for the 1995 DEIR/EIS. Some years were simulated to have very little surplus Delta outflow, whereas other years were simulated to have several MAF of surplus outflow.

Figure 3A-9 shows the annual values for DWRSIM-simulated Delta exports (from DWRSIM results) and the DeltaSOS-adjusted Delta exports (that satisfy all standards and criteria but export all available water) for the No-Project Alternative for water years 1922-1991. The average annual adjusted CVP and SWP exports totaled 6.15 MAF. DeltaSOS simulated some years having no additional export pumping, whereas other years were simulated to have more than 1,000 TAF (1 MAF) of additional export beyond the amount simulated by DWRSIM. DeltaSOS simulated total possible export for most years to be less than 7 MAF; 1958, 1975, 1982, and 1983 were the only years with simulated adjusted exports of more than 7.5 MAF/yr. Each of the DW alternatives was simulated and compared with these DeltaSOS-adjusted Delta conditions simulated for the No-Project Alternative. The simulated values are shown in Figures 3A-10, 3A-11, and 3A-12, and comparisons are discussed below.

Measures of Potential Water Supply Effects and Criteria for Determining Impact Significance

Several issues related to potential water supply effects were considered as impact assessment variables. Some of these could be simulated with the water supply planning models, whereas others could only be qualitatively assessed.

Full evaluations of potential environmental impacts on hydrodynamics, water quality, and fisheries were performed using the 1995 DEIR/EIS simulated monthly changes in Delta conditions associated with the DW project. The results of these impact assessments are presented in Chapters 3B, 3C, and 3F, respectively.

For purposes of this document, the DW project is analyzed without consideration of subsequent environmental effects caused by the delivery of purchased DW water or by the storage of water under a third party's water rights because the identity of the end user of the DW water remains speculative. The DW project could be used for interim storage of water being transferred through the Delta from sellers upstream to buyers served by Delta exports or as interim storage for water owned by parties other than DW for use to meet scheduled outflow requirements (water transfers and water banking).

For this analysis, it was assumed that the DW project would yield a water supply based only on water stored under its own appropriative permits and subsequently conveyed to Delta channels. A separate entity purchasing DW water could divert that water from Delta channels and export it, probably through CVP or SWP facilities, for direct use or to increase groundwater or surface water storage, or could use water for estuarine or Delta beneficial uses (increased outflow). The purchasing entity would affect SWP or CVP operations to the same extent as would any entity that wheels water under California Water Code provisions and contracts authorized by those provisions. A number of opportunities exist to operate the DW project conjunctively with the CVP and SWP, but these arrangements remain speculative and are beyond the scope of this analysis. Delivery of purchased DW water or temporary storage of water being transferred through the Delta may be subject to further environmental review.

The actual purchaser of DW project water and actual contractual arrangements with major water supply project operators have not been identified. DW project operations could be adjusted as necessary to be integrated with any contractor-purchaser's operating criteria. The contractor-purchaser and associated operations might be changed from time to time, reflecting future water demands, Delta conditions, and Delta operating requirements. However, DW project effects on potential purchasers of DW project water were not used as criteria for assessing impact significance.

Delta Water Rights

Project permits granted by SWRCB would require that project diversions not interfere with the diversion and use of water by other users with riparian or prior (senior) appropriative rights. Many riparian and appropriative water right holders are located upstream of the Delta in the Sacramento River and San Joaquin River Basins. A large number of riparian water diversions are located in the Delta. DWR, Reclamation, CCWD, and several smaller diverters hold senior appropriative water rights.

DWR Division of Operations and Maintenance, in cooperation with Reclamation's CVOCO, maintains daily water budget estimates for the Delta and designates the Delta condition each day as being "in balance" or "in excess" relative to all SWRCB objectives and water right terms and conditions. When the Delta condition is designated by DWR (with possible review by the CALFED Ops Group) to be in balance, all Delta inflow is determined to be required to meet Delta objectives and satisfy diversions by CCWD, the CVP, the SWP, other senior water right holders, and Delta riparian water users. Therefore, when the Delta is in balance, additional water would not be available for diversion by the DW project.

When DWR determines the Delta condition to be in excess, the DW project could be allowed to divert available excess water for storage on the reservoir islands. The daily quantity of available excess water would be estimated by DWR according to DWR's normal accounting procedures. To provide extra protection for compliance with 1995 WQCP Delta objectives and for existing water right holders, SWRCB can establish requirements for amounts of water within the designated excess water (i.e., buffers) that would not be available for DW diversions. Nevertheless, excess Delta inflow would be available for diversion by the DW project during certain periods, especially major runoff events.

DW project operations would not be permitted to interfere with senior appropriative water right holders or Delta riparian users. Since the 1995 DEIR/EIS was published, DW has entered into stipulated agreements with Reclamation, DWR, Amador County, the City of Stockton, and North Delta Water Agency. These agreements affirm the seniority of these party's water rights; they also outline general conditions under which the DW project would operate to preclude interference with those water rights or with a party's ability to meet particular water quality criteria. Additional information about the terms of these agreements is available in the section entitled "Stipulated Agreements" in Chapter 2, "Delta Wetlands Project Alternatives".

Although any interference with other riparian or prior appropriative water rights by the DW project alternatives would be considered a significant impact, SWRCB terms and conditions for DW project operations would not allow such interference with other riparian or prior water rights. Because DeltaSOS simulations of the DW alternatives were constrained to preclude interference with any riparian or prior appropriative rights, it is presumed that the DW project would have no significant impacts related to interference with prior water rights. No criteria for determining impact significance were selected and potential effects of the DW project on prior water rights are not discussed further in the impact assessment.

Compliance with Delta Objectives and Requirements

Water Quality and Biological Resources. Existing and any future Delta water quality objectives or requirements for protection of fish and wildlife and other purposes, as adopted by SWRCB or other regulatory agencies, will be applicable to the DW project. DW project operations as conditioned and limited by permits would not be allowed to violate or interfere with compliance by others with applicable Delta water quality objectives or fish and wildlife requirements.

DeltaSOS simulations of the No-Project Alternative and the DW project alternatives accounted for constraints by all 1995 WQCP objectives and operations criteria that can be interpreted on a monthly basis. The DW project therefore would not adversely affect compliance of Delta water management operations with Delta objectives.

Although any violation of applicable Delta objectives caused by the DW project would be considered a significant impact, SWRCB terms and conditions for DW project operations would not allow violation of Delta objectives. Therefore, it is presumed that none of the DW project alternatives would result in significant impacts related to violating Delta objectives. Therefore, no criteria for determining impact significance were selected and compliance of the DW project with applicable Delta objectives is assumed and is not discussed further in the impact assessment.

Delta Outflow. A general effect of the DW project diversions would be to reduce Delta outflow during periods of surplus outflow (i.e., outflows greater than those required to satisfy applicable outflow objectives) for the period of several weeks when project diversions would occur. It is also possible that a purchaser of stored DW water could use the water to increase Delta outflow for fisheries or estuarine habitat management purposes. DW project diversions are potentially substantial (maximum monthly average of 4,000 cfs), and simulated reductions in Delta outflow during periods of DW diversions can be identified in the monthly planning model results.

The 1995 WQCP objectives specify monthly minimum Delta outflows, as flows necessary for fish transport, as flows necessary to prevent salinity intrusion at agricultural control locations during the irrigation season and at water supply intakes throughout the year, or as flows necessary to maintain the X2 salinity gradient location.

As discussed above, SWRCB terms and conditions for DW project operations would not allow violation of Delta outflow requirements. DW project effects on

Delta outflow were not used as criteria for assessing water supply impact significance because it was presumed that the specified 1995 WQCP objectives adequately protect beneficial uses related to outflow. Potential effects of augmenting Delta outflow with purchased DW water during periods of reduced flows are expected to be generally beneficial. Because outflow can affect water quality and estuarine fish habitat, these potential impacts are evaluated in Chapter 3C, "Water Quality", and Chapter 3F, "Fishery Resources".

Delta Water Project Operations

Upstream Reservoir Storage. DW operations may influence upstream reservoir storage by the CVP or the SWP if these projects purchase DW water as replacement for upstream reservoir releases. The general effect of using DW storage water as replacement for upstream reservoir releases would be to maintain slightly higher reservoir levels throughout the summer and fall when reservoirs typically draw down. Minimum streamflows below these reservoirs are regulated by instream flow requirements, and streamflows would not be reduced below these minimums by CVP or SWP use of DW water as replacement for upstream reservoir releases.

It is reasonable to assume that DW project operations could be integrated in the future with operation of the SWP and CVP or other facilities; however, no specific proposals have been made for which the environmental effects could reasonably be assessed, and discussion of such arrangements would be speculative. For purposes of this analysis, the project is analyzed as a stand-alone water storage facility, operated independently of the SWP and the CVP and without regard to the specific entities to which the water could be sold. Therefore, DW project effects on upstream reservoir storage were not used as a criterion for assessing impact significance.

Delta Exports. As described in Chapter 2, "Delta Wetlands Project Alternatives", the major purpose of the DW project is to divert surplus Delta inflows, transferred water, or banked water for later sale and/or release for Delta export or to meet water quality or flow requirements. Although one of the possible uses of DW project water could be augmenting Delta outflow, the more likely use is increasing the supply of Delta exports for beneficial use in the CVP and SWP service areas.

Potential increases in Delta exports were the major water supply effects evaluated using the DWRSIM and DeltaSOS models. Annual and seasonal effects on export water supply are described in this chapter. Related impacts on hydrodynamics, water quality, and fishery resources are evaluated in Chapters 3B, 3C, and 3F, respectively. Because the lead agencies do not consider the addition or reduction of export water supply, by itself, as a beneficial or adverse impact, no criteria can be established to assess the significance of the impact. Therefore, DW project effects on export water supply were not used as criteria for assessing impact significance.

Daily CVP and SWP Operations. The DW project would be operated in response to daily changes in hydrologic, water quality, and fishery conditions. The DW project is designed to operate once all applicable Delta objectives are satisfied. If CVP and SWP compliance with Delta objectives is based, however, on fixed-period or moving averages, DW diversions during storm-related flows might reduce allowable CVP and SWP export pumping following the storm. Terms and conditions for operating the DW project to address these daily operations issues and prevent DW operations from interfering with otherwise allowable CVP and SWP operations may be specified by SWRCB or decided by the CALFED Ops Group.

To assess the effects of short-term changes in Delta conditions on DW project operations, DeltaSOS was modified to simulate Delta conditions with a daily time step. A description of the daily model (DailySOS) and a discussion of the results from the 1995 DailySOS simulations are presented in Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments". The daily model was used for simulating project operations and water supply effects in response to short-term hydrologic fluctuations. Results of revised DailySOS simulations performed for the 2000 REIR/EIS analysis are described in Appendix F of the 2000 REIR/EIS and in the section from the 2000 REIR/EIS below entitled "Results: Daily Delta Wetlands Project Operations".

Potential impacts on water quality and fisheries were not directly simulated at a daily time step, however, because available information is not sufficient to allow accurate assessment of these potential daily effects. Therefore, DW project effects on daily Delta flows were not used as criteria for assessing impact significance. The magnitude of DW diversions and discharges simulated using the daily model were compared with the monthly model estimates to confirm that potential water quality and fishery impact estimates that were based on monthly model results are similar to likely daily estimates. While effects may be larger on particular days, the monthly average effect is likely to be similar to the estimates based on monthly average DW operations.

Delta Consumptive Use

The four DW project islands have existing riparian and appropriative water rights to use a reasonable quantity of water from Delta channels for agricultural and other beneficial purposes. As described in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", the water budget for continuing agricultural use of the DW islands under the No-Project Alternative was based on DWR estimates for riparian water use on Delta lowlands. Delta riparian water use is factored into simulations performed using the water supply planning models (DWRSIM and DeltaSOS). Estimates for the No-Project Alternative water budget consist of approximately 77 TAF of combined diverted and seepage water, 23 TAF of rainfall onto the four DW project islands, and approximately 56 TAF of drainage water off the DW project islands, with a net consumptive use of about 44 TAF (Table A1-8 in Appendix A1, Table 3A-5).

Under DW project operations, consumptive water use would generally shift from irrigation diversions and crop ET with minor amounts of open-water evaporation to open-water evaporation during periods of storage on the reservoir islands and the seasonally flooded portions of the habitat islands with minor amounts of irrigation diversions and crop ET.

A project alternative is assumed to have a significant detectable impact on Delta consumptive use if it would cause an increase in Delta lowland ET exceeding 1% of the No-Project Alternative ET from Delta lowlands (890 TAF/yr) (Table A1-7 in Appendix A1). This assumed significance criterion could also be expressed as a change of greater than 20% of the consumptive use on the DW islands (44 TAF/yr) because the DW islands represent about 5% of the area of the Delta lowlands (Table A1-8 in Appendix A1). A project is considered to have a beneficial effect on Delta consumptive use if it would cause a decrease in Delta lowland ET.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 was defined in the 1995 DEIR/EIS as involving potential year-round diversion and storage of surplus water on Bacon Island and Webb Tract (reservoir islands). Bouldin Island and Holland Tract (habitat islands) would be managed primarily as wildlife habitat.

Under Alternative 1 as defined for the 1995 DEIR/EIS analysis, DW diversions could occur in any month with surplus flows. In DeltaSOS modeling, it was assumed that discharges of water from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and strict interpretation of the 1995 WQCP "percent inflow" export limits do not prevent use of that capacity. Such unused capacity could exist when the amount of available water (i.e., total inflow less Delta channel depletion and Delta outflow requirements) is less than the amount specified by the export limits.

Water would be diverted to the reservoir islands (238-TAF water storage capacity) at a maximum monthly average diversion rate of 4,000 cfs, which would fill the two reservoir islands in one month. The maximum daily average diversion rate would be 9,000 cfs during several days when siphoning of water onto empty reservoirs begins; at this time, the maximum head differential would exist between island bottoms and channel water surfaces. The maximum daily average discharge rate would be 6,000 cfs, but the maximum monthly average discharge rate is assumed to be 4,000 cfs, allowing the two reservoir islands to empty in one month.

Water management on the habitat islands would be slightly different from irrigation and drainage practices under the No-Project Alternative. Table A1-8 (in Appendix A1) gives the estimated monthly water budget terms for the DW habitat islands. Maximum diversion would occur in July, with an estimated diversion flow of 60 cfs (3.6 TAF). Maximum drainage would occur in January, with an estimated drainage flow of 42 cfs (2.5 TAF), assuming average rainfall. These diversions and drainage flows would not substantially change the DeltaSOS-simulated operations of the DW reservoir islands as described in this chapter.

Chapter 2, "Delta Wetlands Project Alternatives", presents a more complete description of DW project facilities and operations. Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", presents monthly average approximations of DW project operations under Alternative 1 from the 1995 DEIR/EIS analysis.

Delta Water Supply Simulations

The 1995 DEIR/EIS presented detailed descriptions of the results of simulations of DW project operations under the project alternatives. As described in Chapter 1, however, after the USFWS, NMFS, and DFG biological opinions were issued, SWRCB and the Corps directed that new DeltaSOS simulations of operations under the proposed project (Alternatives 1 and 2) be performed for the 2000 REIR/EIS. These new simulations were to be based on the more recent DWRSIM baseline water budget (Study 771) and the revised project description for the proposed project. The revised project description included the restrictions on project operations specified in the FOC, biological opinion RPMs, and stipulated agreements.

The results of these updated simulations, which are presented later in this chapter (see "Revised Analysis of Water Supply and Operations under the Proposed Project"), supersede the results for Alternatives 1 and 2 presented in the 1995 DEIR/EIS. Therefore, the detailed descriptions of 1995 results for Alternative 1 have been removed from this text.

Several other analyses in the 1995 DEIR/EIS were based partially on the results of simulations of water diversion, storage, and discharge operations presented in that document. For this reason, and for purposes of comparison of the results for Alternative 3 with those for Alternative 1, the tables and figures that show results of the 1995 DEIR/EIS simulations have been retained in this chapter, and brief summaries of the results are provided.

Tables 3A-2 and 3A-6 summarize average annual DW project operations and Delta conditions under Alternative 1 as simulated for the 1995 DEIR/EIS. Average diversions were 222 TAF/yr and average discharges for export were 188 TAF/yr. In some years, the annual diversion for storage or discharge for export was simulated to be greater than the 238-TAF reservoir capacity because multiple diversion and discharge sequences occurred in the same year. Figure 3A-10 shows the simulated annual DW diversions and DW discharges for export. In many years, simulated diversions were slightly greater than discharges, reflecting evaporation losses. In other years, diversions were much greater than discharges, indicating carryover storage on reservoir islands. As discussed above under "Delta Outflow" in the section entitled "Measures of Potential Water Supply Effects and Criteria for Determining Impact Significance", DW project diversions would not cause violations of applicable Delta objectives.

Table 3A-7 gives the monthly percentiles of the DeltaSOS simulations for Alternative 1. The monthly distribution gives an overview of the expected DW operations in a particular calendar month. For example, as shown in the second panel, DW storage was simulated as being empty at the end of September and October in 80% of the years and 60% of the years, respectively. The mean in a panel for each month indicates the overall importance of that month in terms of the parameter shown.

Effects on Delta Consumptive Use

Under Alternative 1, land uses would change from irrigated agriculture to primarily water storage on the reservoir islands and to wildlife habitat on the habitat islands. These land use changes would reduce ET from a total of 44 TAF/yr to 14 TAF/yr (estimated ET from the habitat islands) for the four islands. Additionally, an average of approximately 34 TAF/yr of evaporation would be lost from stored water on the reservoir islands during periods of water storage (Table 3A-5). An unknown amount of ET from moist soil and possibly from seepage would continue to be lost on the reservoir islands directly after total drawdown. Also, an ET amount approximately equal to the ET for the habitat islands (14 TAF) would be lost during periods when the reservoir islands are in a shallow-water wetland condition.

Total consumptive use on the four DW project islands is expected to increase by approximately 4 TAF/yr compared with use under the No-Project Alternative as a long-term average.

The conclusion about changes in total consumptive use in the 2000 REIR/EIS was the same as this 1995

DEIR/EIS conclusion, as described below in the section from the 2000 REIR/EIS entitled "Results: Delta Consumptive Use".

Summary of Project Impacts and Recommended Mitigation Measures

Impact A-1: Increase in Delta Consumptive Use. Implementation of Alternative 1 would increase consumptive use by approximately 4 TAF/yr compared with consumptive use under the No-Project Alternative. This impact is considered less than significant for Delta water supply.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Alternative 2, as defined for the 1995 DEIR/EIS analysis, represents DW operations with two reservoir islands (Bacon Island and Webb Tract) and two habitat islands (Bouldin Island and Holland Tract).

Under Alternative 2, it was assumed that DW diversions could occur in any month with surplus flows, as under Alternative 1. In DeltaSOS modeling, it is assumed that discharges from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps. Under this alternative, it was assumed that DW discharges would be allowed to be exported in any month when such capacity exists and would not be subject to strict interpretation of the 1995 WQCP "percent inflow" export limits. Export of DW discharges would be limited by Delta outflow requirements and the permitted combined pumping rate of the export pumps but would not be subject to strict interpretation of the "percent inflow" export limit.

The maximum diversion and discharge rates for the reservoir islands and management of the habitat islands under Alternative 2 would be the same as described above for Alternative 1.

Delta Water Supply Simulations

As described above for Alternative 1, new DeltaSOS simulations of project operations were performed for the 2000 REIR/EIS. The results of these updated simulations, which are presented below under "Revised Analysis of Water Supply and Operations under the Proposed Project", supersede the results for Alternatives 1and 2 presented in the 1995 DEIR/EIS. The 1995 results of simulations for Alternative 2 are briefly summarized here, and the tables and figures have been retained for purposes of comparison of results for Alternative 3 with those for Alternative 2.

Tables 3A-2 and 3A-8 summarize simulated average annual DW project operations and Delta conditions under Alternative 2 as simulated for the 1995 DEIR/EIS. Average diversions were 225 TAF/yr and average discharges for export were 202 TAF/yr. Figure 3A-11 shows simulated annual diversions and discharges for export. The patterns of years of multiple reservoir island fillings, carryover storage years, and years with no diversions or discharges were similar to those for Alternative 1. Table 3A-9 shows the monthly percentiles of DW operations simulated for Alternative 2.

Effects on Delta Consumptive Use

Under Alternative 2, habitat island ET is estimated to average 14 TAF/yr, as under Alternative 1, and evaporation of stored water would average approximately 23 TAF/yr, somewhat less than for Alternative 1 because of decreases in storage duration (Table 3A-5). Total consumptive use under Alternative 2 is estimated to average approximately 7 TAF/yr less than under the No-Project Alternative.

The conclusion about changes in total consumptive use in the 2000 REIR/EIS was the same as this 1995 DEIR/EIS conclusion, as described below in the section from the 2000 REIR/EIS entitled "Results: Delta Consumptive Use".

Summary of Project Impacts and Recommended Mitigation Measures

Impact A-2: Reduction in Delta Consumptive Use. Implementation of Alternative 2 would decrease consumptive use by approximately 7 TAF compared with consumptive use for the No-Project Alternative. This impact is considered beneficial to Delta water supply and will result in reduced diversions during the irrigation season.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. Diversions to the reservoir islands (406-TAF capacity) would be allowed during any month with available surplus flows. The diversion and discharge operations for Alternative 3 would be the same as for Alternative 2, but the assumed diversion and discharge rates are higher. The maximum monthly average diversion rate would be about 6,000 cfs, which would fill the four reservoir islands in about one month (maximum daily average initial diversion rate of 9,000 cfs). The maximum monthly average discharge rate is assumed to be 6,000 cfs (maximum daily average discharge rate of 12,000 cfs).

Delta Water Supply Simulations

Table 3A-2 summarizes simulated average annual DW project operations under Alternative 3, showing DeltaSOS-adjusted exports; required outflow; DW diversions and discharges for export; and effects on export, outflow, and major Delta channel flows. Average annual reductions in Delta outflow associated with this alternative would be equivalent to the volume of diversions but would not cause violations of applicable outflow standards.

Table 3A-10 indicates that the average annual values for simulated DW operations for Alternative 3 were 356 TAF/yr of diversions and 302 TAF/yr of discharges for export. These values are much greater than for Alternative 1 or Alternative 2 because of the increased reservoir storage capacity on four project islands. Increased storage capacity allows increased DW diversions during years with plentiful surplus water but does not compensate for years of limited water availability. The greatest simulated annual DW diversion for Alternative 3 was 815 TAF/yr in 1982 (two complete DW reservoir fillings). It is unlikely that this volume of additional water supply would be needed in wet years. Table A3-13 in Appendix A3 gives the monthly results of simulations of Alternative 3.

Table 3A-11 shows the monthly percentiles of DW operations for Alternative 3. Diversions generally would occur early in the water year (October-February) and discharges would generally occur during early spring (February-March) or summer (June-August).

Figure 3A-12 shows the simulated annual DW diversions and DW discharges for Alternative 3. The patterns of years with no DW operation, years with large DW diversions and carryover DW storage, and years with reduced DW diversions because of carryover storage are similar to those of the other alternatives as simulated for the 1995 DEIR/EIS.

Appendix A3 presents detailed simulation results for Alternative 3. Appendix A4 discusses the possible differences between these monthly average simulations and likely daily DW operations.

Effects on Delta Consumptive Use

Under Alternative 3, evaporation of stored water from all four DW islands is estimated to average 54 TAF/yr (Table 3A-5). Because all four islands would be operated as reservoir islands, there would be essentially no habitat island ET as under Alternatives 1 and 2 except for ET from a small portion of Bouldin Island. Some ET would occur from intermittent wetlands during nonstorage periods on the four reservoir islands, but the extent of this ET is not predictable.

Total consumptive use under Alternative 3 is predicted to average 54 TAF/yr, approximately 10 TAF/yr greater than under the No-Project Alternative. This increase in Delta consumptive use represents about a 1% increase in Delta lowland consumptive use. The consumptive use under Alternative 3 would be supplied by DW project diversions, whereas the No-Project Alternative consumptive use would be supplied by irrigation diversions in summer.

Summary of Project Impacts and Recommended Mitigation Measures

Impact A-3: Increase in Delta Consumptive Use. Implementation of Alternative 3 would increase consumptive use by approximately 10 TAF compared with consumptive use under the No-Project Alternative. This increase represents about a 1% increase in Delta lowland consumptive use. Therefore, this impact is considered a significant and unavoidable impact of water storage operations. The reduced diversions during the irrigation season may still be considered a benefit to Delta water supply.

Mitigation. No mitigation is available to reduce this impact to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The No-Project Alternative (intensified agricultural use of the four DW project islands) represents Delta water supply conditions predicted under implementation of the 1995 WQCP.

The DeltaSOS results for the No-Project Alternative as simulated for the 1995 DEIR/EIS were described above under "Impact Assessment Methodology". Table 3A-2 summarizes the simulated average annual results, showing DeltaSOS-adjusted exports; required outflow; and export, outflow, and major Delta channel flows.

Delta exports for the No-Project Alternative in these simulations averaged 6.15 MAF/yr over the 70-year hydrologic record (Appendix A3). Delta exports under actual historical conditions totaled approximately 6 MAF in 1990 (Table 3A-1). The increased Delta consumptive use of 22 TAF can be attributed to variations in Delta agricultural use between drought and normal years.

Consumptive use of water to supply crop ET would be somewhat greater under the No-Project Alternative compared with historical agricultural land uses, but not measurably so at the scale of monthly water supply modeling (e.g., DWRSIM or DeltaSOS). Chapter 2, "Delta Wetlands Project Alternatives", describes the likely ET increase from existing (drought) conditions (i.e., 1988-1994) to intensive agricultural land use (No-Project Alternative) as 50% of the assumed consumptive use of 44 TAF/yr for the DW project islands. The lower estimated ET for the existing condition (22 TAF/yr) was caused by reduced agricultural use during the drought.

New simulations of water project operations under the No-Project Alternative were performed for the 2000 REIR/EIS using the results of DWRSIM Study 771 and updated assumptions about Delta standards and objectives that were incorporated into DeltaSOS. The differences between the no-project conditions estimated for the 1995 DEIR/EIS and those estimated for the 2000 REIR/EIS were minor, however (see the comparisons of results of DWRSIM Studies 409 and 771 below in sections from the 2000 REIR/EIS), and do not affect the consumptive-use estimates presented in the 1995 DEIR/EIS.

CUMULATIVE IMPACTS

Cumulative water supply effects were evaluated in the 1995 DEIR/EIS using DeltaSOS simulations of the DW project alternatives under the 1995 WQCP, but assuming SWP pumping permitted at full capacity of Banks Pumping Plant. This represents reasonably foreseeable future Delta conditions and regulatory standards (see description under "Impact Assessment Methodology" above). Cumulative water supply effects of the DW project alternatives are compared below with simulated monthly Delta water supply conditions for the No-Project Alternative under cumulative conditions.

The reservoir islands may have somewhat greater water storage capacity under cumulative conditions because of effects of continued peat soil oxidation and subsidence (see Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and

Trihalomethane Precursors for the Delta Wetlands Project"). DW estimates that average subsidence over the 50-year planning life of the project may average 0.5 inch per year over the 10,000 acres of the reservoir islands (Forkel pers. comm.). This average rate of subsidence would increase water storage capacity under cumulative conditions by approximately 20 TAF or 9% of the reservoir storage capacity. Therefore, possible average DW project diversions and discharges may be approximately 9% greater than those simulated by DeltaSOS.

Water Supply Conditions for the No-Project Alternative under Cumulative Conditions

Delta Water Supply Simulations

Appendix A3 presents complete results of the DeltaSOS simulations from the 1995 DEIR/EIS for cumulative Delta water supply conditions, represented as the No-Project Alternative under cumulative conditions. Selected variables are summarized in this chapter.

Figure 3A-13 shows the simulated monthly Delta outflow and the required Delta outflow for the No-Project Alternative under cumulative conditions for water years 1968-1991. The pattern of required Delta outflow is the same as for the No-Project Alternative.

Figure 3A-14 shows the simulated monthly Delta exports for the No-Project Alternative under cumulative conditions for water years 1968-1991 as simulated for the 1995 DEIR/EIS. The DWRSIM simulation of exports used as the initial Delta water budget did not assume use of the full SWP pumping capacity of 10,300 cfs. The DeltaSOS simulation of the No-Project Alternative under cumulative conditions indicated that a considerable amount of additional export pumping would be possible beyond that simulated by DWRSIM. However, DeltaSOS was not used to check for south-of-Delta demands on storage capacity or to change the DWRSIM estimates of carriage water (see Appendix A2). The DeltaSOS adjustment in exports for the cumulative No-Project Alternative averaged 1,018 TAF/yr (Table 3A-2).

Figure 3A-15 shows the simulated monthly pattern of water available for DW diversion for the cumulative No-Project Alternative for water years 1968-1991 as simulated for the 1995 DEIR/EIS. Tables 3A-12 and 3A-13 show the mean annual simulation output and monthly percentiles of simulations for exports under the No-Project Alternative.

Figure 3A-16 shows annual Delta outflow and required Delta outflow for the No-Project Alternative under cumulative conditions for water years 1922-1991. Table A3-14 in Appendix A3 shows the annual DeltaSOS adjustments in initial Delta exports (DWRSIM results) and the DeltaSOS-adjusted Delta exports (that satisfy standards while exporting all available water) for the No-Project Alternative under cumulative conditions. Monthly DeltaSOS adjustment to DWRSIM-simulated exports are shown in Table A3-16 in Appendix A3. In some years, no additional export pumping was simulated by DeltaSOS, whereas in other years more than 3 MAF of additional export was simulated beyond the DWRSIM results (1983 and 1984). The total adjusted export for 13 out of 70 years was greater than 8 MAF/yr (i.e., in wet years) because of the greater assumed Delta permitted pumping rate. Some of these potential exports may not be required for south-of-Delta beneficial uses.

Each of the DW alternatives was simulated under cumulative conditions and compared with the DeltaSOS simulation results for the No-Project Alternative under cumulative conditions to determine cumulative water supply effects.

Delta Consumptive Use

Net consumptive use on the DW project islands under the No-Project Alternative is estimated to be 44 TAF/yr under cumulative conditions.

Cumulative Impacts, Including Impacts of Alternative 1

Delta Water Supply Simulations

Tables 3A-2 and 3A-14 summarize simulated average annual DW project operations and Delta conditions under Alternative 1 cumulative conditions as simulated for the 1995 DEIR/EIS. Average diversions were 191 TAF/yr and average discharges for export were 166 TAF/yr. Alternative 1 was simulated as operating in fewer years under cumulative conditions than under existing conditions because of limited availability of water for diversions. Because of the greater export pumping capacity, however, more DW discharges for export were simulated in several years. Figure 3A-17 shows simulated annual diversions and discharges for export. Table 3A-15 shows the monthly percentiles of DW operations simulated for Alternative 1 under cumulative conditions. Table A3-19 in Appendix A3 gives the full monthly simulation results.

See the section from the 2000 REIR/EIS below entitled "Results: Cumulative Water Supply Conditions" for results of the updated simulations of cumulative water supply conditions under the proposed project.

Effects on Delta Consumptive Use

Because of differences in periods of DW diversions and discharges, consumptive use from evaporation under Alternative 1 would be reduced by 9 TAF/yr (from 48 TAF/yr to 39 TAF/yr) under cumulative future conditions (Table 3A-5). The consumptive use of 39 TAF/yr represents a decrease of 5 TAF/yr from consumptive use under the No-Project Alternative. This conclusion was not changed by the updated simulations in the 2000 REIR/EIS.

Impact A-4: Reduction in Delta Consumptive Use under Cumulative Conditions. Under cumulative conditions, implementation of Alternative 1 would decrease Delta consumptive use from consumptive use estimated for the No-Project Alternative. This impact is considered beneficial.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of Alternative 2

Delta Water Supply Simulations

Tables 3A-2 and 3A-16 summarize simulated average annual DW project operations and Delta conditions under Alternative 2 cumulative conditions as simulated for the 1995 DEIR/EIS. Average diversions were 211 TAF/yr and average discharges for export were 197 TAF/yr. Figure 3A-18 shows simulated annual diversions and discharges for export. Table 3A-17 shows the monthly percentiles of DW operations simulated for Alternative 1 under cumulative conditions. Table A3-22 in Appendix A3 gives the full monthly simulation results.

See the section from the 2000 REIR/EIS below entitled "Results: Cumulative Water Supply Conditions" for results of the updated simulations of cumulative water supply conditions under the proposed project.

Effects on Delta Consumptive Use

Consumptive use from evaporation under Alternative 2 would be reduced by 9 TAF/yr (from 37 TAF/yr to 28 TAF/yr) under cumulative future conditions (Table 3A-5). The consumptive use of 28 TAF/yr represents a decrease of 16 TAF/yr from consumptive use under the No-Project Alternative.

Under cumulative conditions, Alternative 2 would have the same impact on consumptive use as described above for Alternative 1 under cumulative conditions. This conclusion was not changed by the updated simulations in the 2000 REIR/EIS.

Cumulative Impacts, Including Impacts of Alternative 3

Delta Water Supply Simulations

Table 3A-2 summarizes simulated average annual DW project operations for Alternative 3 under cumulative conditions, showing DeltaSOS-adjusted exports; required outflow; DW diversions and discharges for export; and effects on export, outflow, and major Delta channel flows. Average annual reductions in Delta outflow associated with this alternative would be equivalent to the volume of diversions (minus No-Project Alternative consumptive use) but would not cause violations of applicable outflow standards.

Table 3A-18 indicates that the average annual simulated DW operations for Alternative 3 under cumulative conditions were 314 TAF/yr of diversions and 282 TAF/yr of discharges for export.

Table 3A-19 shows the monthly percentiles of DW operations for Alternative 3 under cumulative conditions and Table A3-25 in Appendix A3 gives the monthly results.

Figure 3A-19 shows simulated annual DW diversions and DW discharges for Alternative 3 under cumulative conditions for water years 1922-1991. DW discharges for export were 7% less under cumulative conditions (Table 3A-2). No significant cumulative water supply impacts are identified.

Effects on Delta Consumptive Use

Consumptive use under Alternative 3 would be reduced by 22 TAF/yr (from 54 TAF/yr to 32 TAF/yr) under cumulative conditions (Table 3A-5). The consumptive use of 32 TAF/yr represents a decrease of 12 TAF/yr from consumptive use under the No-Project Alternative.

Under cumulative conditions, Alternative 3 would have the same impact on consumptive use as described above for Alternative 1 under cumulative conditions.

Cumulative Impacts, Including Impacts of the No-Project Alternative

The No-Project Alternative would not contribute measurably to cumulative effects on consumptive use in the Delta.

ASSESSMENT OF WATER SUPPLY AND OPERATIONS FROM THE 2000 REVISED DRAFT EIR/EIS

The remainder of this chapter includes the revised assessment of water supply and operations that was conducted for the 2000 REIR/EIS. This information, which was presented as Chapter 3, “Water Supply and Operations”, in the 2000 REIR/EIS, has been modified slightly from the 2000 REIR/EIS version in response to comments received on the 2000 REIR/EIS. However, those minor changes do not change the conclusions of the evaluation.

FOCUS OF THE 2000 REVISED DRAFT EIR/EIS ANALYSIS

This evaluation provides information on the potential range of diversion and discharge operations of the proposed project based on the updated project description (which includes the FOC and biological opinion RPMs and the stipulated agreements described in Chapter 2), current assumptions for modeling Delta water supply, current regulatory standards, and an updated baseline (no-project) water budget.

Summary of Issues Addressed in This Analysis

The analysis presented in the remainder of this chapter specifically addresses the following two questions, which represent the concerns expressed by stakeholders at the SWRCB water right hearing on the Delta Wetlands Project and in comments on the 1995 DEIR/EIS:

- What is the frequency, timing, and amount of water available to the Delta Wetlands Project, considering:
  - updated DWRSIM results from technical studies prepared in support of the CALFED no-action simulations;
  - upstream and in-Delta actions resulting from implementation of the CVPIA;
  - terms of the FOC and the USFWS, NMFS, and DFG biological opinions for the Delta Wetlands Project;
  - Delta Wetlands’ settlement agreements with Reclamation, DWR, Amador County, the City of Stockton, and North Delta Water Agency; and
  - the proposed X2 restriction to preserve CCWD senior water rights consistent with the X2 restriction on CCWD operations described in the 1993 USFWS biological opinion for Los Vaqueros Project effects on delta smelt?

What is the project's potential water supply, considering:

  - water availability (see above),
  - conveyance capacity for export water,
  - a range of south-of-Delta water demand assumptions, and
  - quality of water at the time of diversion and discharge?

The analysis presented below answers these questions by providing new estimates of monthly water availability and project yield using a revised DeltaSOS model. The updated DeltaSOS simulations themselves are based on a revised Delta water budget developed by DWR using its operations planning model, DWRSIM. The daily operations model DailySOS is used to confirm the adequacy of the DeltaSOS analysis. Results of the new simulations are compared with results presented in the 1995 DEIR/EIS. In addition, the impacts on consumptive use identified in the 1995 DEIR/EIS are reviewed in light of the updated information on project operations to determine whether there are any differences in severity of impacts.

Definition of Terms

The following are definitions of terms as they are used in this chapter:

Channel Depletion: The water removed from Delta channels by diversions for irrigation and by open-water evaporation.

Consumptive Use: Loss of water on the Delta Wetlands Project islands and other Delta islands through crop evapotranspiration (ET) and open-water evaporation and use for shallow-water management for wetlands and wildlife habitat. Rainfall and channel depletion supply the consumptive-use water.

Delta Exports: The water pumped from the Delta to south-of-Delta users by DWR at Banks Pumping Plant and by Reclamation at the CVP Tracy Pumping Plant, and the amount diverted by CCWD at its Rock Slough and Old River intakes.

Inflow: The total rate (cfs) or volume (TAF) of streamflow entering the Delta from the Sacramento and San Joaquin Rivers, Yolo Bypass, and the eastside streams.

Interruptible Demand: An assumed additional demand for SWP water above the specified monthly demands. Interruptible demand is simulated as 84 TAF/month for 5 months, or 1,400 cfs/month during November through March when San Luis Reservoir is full. DWRSIM assumes that additional SWP deliveries are made to meet interruptible demand when there is unused export capacity and available water in the Delta.

Local Water Supply: In the DWRSIM model, the assumed amount of captured rainfall in areas south of the Delta that can be used to satisfy CVP and SWP demands.

Outflow: The water flowing out of the Delta into San Francisco Bay.

Project Yield: Average annual water discharged for export from the Delta Wetlands Project islands. Reported in TAF per year (TAF/yr).

South-of-Delta Delivery Deficit: Unmet demand, that is, total demand for CVP and SWP water minus total CVP and SWP deliveries. Total deliveries are calculated based on water exported from the Delta and the change in San Luis Reservoir storage. (When San Luis Reservoir storage drops, that amount is added to Delta exports to determine total CVP and SWP deliveries. When San Luis Reservoir storage increases, that amount is subtracted from Delta exports to determine total CVP and SWP deliveries.)

Surplus Delta Outflow: Outflow in excess of the amount required to meet all monthly water demands, protect Delta salinity standards, and comply with the export/inflow objectives of the 1995 WQCP.

X2: The mean daily location in the Bay-Delta estuary of the 2–parts-per-thousand-(ppt)–total dissolved solids (TDS) isohaline 1 meter off the bottom; an isohaline is a line connecting all points of equal salinity.

Overview of the Evaluation Methods Used in the 2000 Revised Draft EIR/EIS: DeltaSOS, DWRSIM Water Budget, and Modeling Assumptions

DeltaSOS

As described previously in this chapter, the DeltaSOS model was developed to represent possible Delta Wetlands Project operations (diversions and discharges) under various scenarios for Delta inflow conditions and regulatory standards. DeltaSOS modeling of the No-Project Alternative and project operations is based on the initial water budget developed from the results of simulations performed by DWR using the operations planning model DWRSIM for the water years 1922-1994. DWRSIM represents systemwide hydrology, including upstream reservoirs; inflows to the Delta; and Delta channel depletions, exports, and outflow. DeltaSOS is used to simulate monthly project operations as controlled by the DWRSIM Delta inflows, by appropriate Delta objectives and requirements, and by operating criteria specific to Delta Wetlands.

DeltaSOS has been updated for this analysis through the incorporation, to the extent possible, of the following:

restrictions on project operations specified in the FOC, biological opinions, and stipulated agreements;

restrictions on Delta Wetlands Project operations when CCWD's diversions to Los Vaqueros Reservoir are restricted because X2 is upstream of Chipps Island; and

revised Delta standards resulting from implementation of the CVPIA.

These modifications are described below under "Revisions to DeltaSOS".

DWRSIM

DWRSIM simulates current conditions, including the operation of water storage facilities (reservoirs), regulatory standards (e.g., instream flow requirements), and assumed demand for exports, to estimate likely future Delta inflows, exports, and outflows under hydrologic conditions replicating those of the 73-year hydrologic record (water years 1922-1994).

Since publication of the 1995 DEIR/EIS, the implementation of state and federal programs has resulted in changes to the basic assumptions used for establishing baseline conditions in the Delta. The Anadromous Fish Restoration Program (AFRP) was implemented pursuant to the CVPIA, resulting in the establishment of several new Delta operating criteria and standards. Additionally, in response to the CALFED program, which state and federal agencies initiated in 1994 to resolve several Delta issues, and in response to other statewide planning efforts, DWR has conducted a series of DWRSIM modeling studies to establish new simulated baseline conditions for the Delta under the 1995 WQCP. These baseline conditions incorporate the new Delta operating criteria and standards established as a result of these programs. One of these studies, DWRSIM existing conditions study 1995-D06E-CALFED-771 (study 771 or run 771), completed in July 1998 for CALFED, is the currently accepted standard used by CALFED and other state water planners to represent baseline conditions. The results of study 771 are therefore used as the basis of the simulations of Delta Wetlands Project operations performed using DeltaSOS for the present evaluation. They replace the results of run 409, which provided the baseline water budget for the 1995 DEIR/EIS evaluation.

Similarities between DWRSIM Studies 409 and 771. DWRSIM study 771 is similar to study 409 in that both comply with the 1995 WQCP, use 1995 hydrology and demands, use south-of-Delta demands for SWP exports that vary according to Kern River flow and Los Angeles rainfall, and maintain minimum Trinity River flows below Lewiston Dam at 340 TAF/yr. Neither study provides for SWP pumping of water for the CVP.

Differences between DWRSIM Studies 409 and 771. The following assumptions were revised in DWRSIM study 771:

- A slightly different variable SWP demand is used, ranging from 2,644 to 3,529 TAF/yr.
- Maximum SWP interruptible demand is specified as 84 TAF/month for 5 months.
- New American River Water Forum demands have been added.
- South-of-Delta demands for CVP exports (including Level II refuge demand of 288 TAF/yr) are set at 3,433 TAF/yr.
- SWP export capacity from December through March is slightly higher than in DWRSIM study 409.

Many small changes in the FORTRAN code and parameters have also been made between studies 409 and 771 (362 different studies have been completed). In addition, three additional years of historical data (1992-1994) were added to the 70 years of data used in DWRSIM study 409.

The simulated Delta operating conditions of DWRSIM study 771 reflect new Delta operational objectives established for the AFRP, which is being implemented as part of the CVPIA. The adopted AFRP actions simulated in DWRSIM 771 include:

export reduction requirements for the Vernalis Adaptive Management Plan (VAMP),

the addition of days during the period from March through June when X2 must be at specified locations,

minimum flow requirements for the Sacramento River at Freeport,

required ramping of Delta exports in May,

Delta Cross Channel (DCC) closure from October through January, and

July export restrictions based on the X2 position in June.

These modifications are described in the next section.

REVISED DELTA MONTHLY WATER BUDGET SIMULATED BY DWRSIM

This section describes changes in the major DWRSIM input variables and simulated output between DWRSIM study 409, used for the 1995 DEIR/EIS, and DWRSIM study 771. The 25-year period of 1967-1991 was selected for comparison in the graphs referenced in this section because it represents a wide range of hydrologic year types, and because results covering this period are available from both studies.

The major hydrologic inputs for DWRSIM are the reservoir inflows and inflows from tributary streams. The Delta's two major tributary streams are the Sacramento and San Joaquin Rivers. DWRSIM simulates some, but not all, of the major tributary facilities. The simulation of upstream facility operations is important because some of these operations are controlled by Delta outflow requirements and export limits. The reservoir releases are also governed by flood control storage rules, instream flow requirements, power generation constraints, and upstream diversion targets.

Delta Inflows

Overview

Simulated Delta inflows consist of the combination of simulated upstream reservoir operations and local inflows, minus the simulated diversions along the upstream tributaries. Table 3A-20 presents annual values for the Sacramento River and Yolo Bypass, the San Joaquin River and eastside streams, CCWD diversions and net channel depletion, CVP and SWP Delta exports, Delta outflow, and required Delta outflow for water years 1922-1994. Some Sacramento River inflow is diverted into the Yolo Bypass during high-flow periods. The San Joaquin River inflow at Vernalis includes contributions from the Stanislaus, Tuolumne, and Merced Rivers. Eastside streams include the Cosumnes, Mokelumne, and Calaveras Rivers. Sacramento River runoff and San Joaquin River runoff vary considerably from one water year to the next. Local runoff from rainfall events in the Delta can provide substantial flow in some years.

Comparison of Results from Studies 409 and 771

In general, annual average inflows simulated in DWRSIM study 771 do not differ appreciably from those simulated in DWRSIM study 409 because no new upstream storage or conveyance facilities have been constructed since the 1995 DEIR/EIS was prepared, and no major changes in facility operations are simulated. However, the estimates of required Delta outflows changed substantially in some years (see "Delta Outflow" below). DWRSIM 771 has generally lower required Delta outflows, allowing for slightly higher exports for the same inflows.

Sacramento River and Yolo Bypass. Effects of local inflows, Sacramento Valley irrigation diversions, and other consumptive uses are aggregated in the combined Sacramento River and Yolo Bypass inflows. The combined average annual inflow for 1922-1991 was 18,141 TAF/yr in study 409 and 18,086 TAF/yr in study 771 (Table 3A-20). Figure 3A-20 shows the monthly Sacramento River flows simulated for studies 409 and 771 for the 1967-1991 period. Low-flow periods are generally similar for the two DWRSIM studies. Table 3A-21 provides the monthly Sacramento River and Yolo Bypass inflows for the 1967-1991 period for both DWRSIM studies; differences in the monthly and annual values are given for comparison purposes.

San Joaquin River and Eastside Streams. Fixed inputs are used for both the San Joaquin River and eastside streams in DWRSIM study 409, but the San Joaquin River tributary reservoir operations are simulated in study 771. The 70-year annual average inflow was 3,240 TAF in study 409 and 3,743 TAF in study 771 (Table 3A-20). Figure 3A-21 shows the simulated San Joaquin River flow at Vernalis for 1967-1991 in studies 409 and 771. Simulated flows during many of the peak- flow events are substantially larger in study 771 than in study 409. Summer flows in the two studies are generally similar. The magnitude of the simulated San Joaquin River changes is small relative to total Delta inflows. Table 3A-22 provides the monthly San Joaquin River and eastside stream inflows for the 1967-1991 period for both DWRSIM studies; differences in the monthly and annual values are given for comparison purposes.

Contra Costa Water District and Agricultural Diversions. The estimates of CCWD diversions and net channel depletions for agricultural diversions in the Delta were generally the same in studies 409 and 771. Table 3A-20 indicates that the 70-year average annual net Delta depletion with CCWD diversion was 1,079 TAF in study 409 and 1,140 TAF in study 771. The simulated depletion in dry water years was greater in study 771 than in study 409. For example, annual average simulated depletion was greater in study 771 than in study 409 by 68 TAF for the 1928-1934 dry-year period and by 108 TAF for the 1987-1991 dry-year period.

Delta Exports

Overview

DWRSIM simulates Delta exports and outflow after determining the amount of inflows needed for Delta channel depletion and required outflow. Delta export pumping and diversion occurs at five locations: CVP pumping at Tracy Pumping Plant, SWP pumping at Banks Pumping Plant, CCWD diversions at Rock Slough and Old River, and North Bay Aqueduct pumping at Barker Slough.

DWRSIM simulates Delta exports to meet downstream monthly demands and to fill San Luis Reservoir to meet seasonal demands, subject to 1995 WQCP and AFRP objectives for outflow and pumping limits. The magnitude of water supply demands is a major input assumption of DWRSIM that governs the amount of simulated Delta exports. Studies 409 and 771 both use simulated 1995 "level of development" for upstream diversions and estimated south-of-Delta demands.

Comparison of Results from Studies 409 and 771

DWRSIM-simulated demands range from 5.9 to 6.9 million acre-feet per year (MAF/yr) throughout the simulated period for study 409 and from 6.1 to 6.9 MAF/yr for study 771. Figure 3A-22 compares Delta exports at the CVP Tracy Pumping Plant and the SWP Banks Pumping Plant for 1967-1991 as simulated for DWRSIM studies 409 and 771. Minimum pumping in April and May is slightly less in study 771 because of the assumed VAMP restrictions on pumping during this period, with combined pumping at 1,500 cfs in most years.

DWRSIM study 409 included CVP Delta export demands of 3.15 MAF/yr, with 145 TAF/yr to satisfy CCWD diversions. However, these CVP demands were not always satisfied in drier years in DWRSIM simulations. The SWP variable Delta export demands ranged from 2.6 to 3.6 MAF/yr, with an average of 2.85 MAF/yr. The maximum combined Delta export demand of 6.9 MAF/yr was assumed to occur in about 45% of simulated years. Exports were divided almost equally between the CVP and the SWP.

Table 3A-23 lists the monthly combined CVP and SWP exports as simulated for studies 409 and 771; the monthly and annual differences between study 771 and study 409 values are shown for comparison. The combined exports are approximately 90 TAF higher on average in study 771 for the simulated 25-year period. Neither study 409 nor study 771 includes a joint point of diversion for the CVP to use the large pumps at Banks Pumping Plant to meet CVP demands and to fill the CVP share of San Luis Reservoir.

Delta Outflow

Overview

Figure 3A-23 shows monthly Delta outflow for 1967-1991, as simulated by DWRSIM for studies 409 and 771. Differences between the two scenarios can be attributed to differences between estimates of Delta inflows, exports, or required Delta outflow.

Comparison of Results from Studies 409 and 771

Table 3A-20 indicates an annual average simulated Delta outflow from 1922-1991 in study 771 of 15,102 TAF, 520 TAF greater than the 14,582 TAF average annual outflow simulated in study 409. Table 3A-24 lists the monthly Delta outflows simulated for studies 409 and 771; the monthly and annual differences between study 771 and study 409 values are shown for comparison.

As Table 3A-20 demonstrates, the estimated required Delta outflow for the two studies is similar, although study 409 and study 771 use somewhat different methods for estimating outflow requirements to satisfy Delta salinity objectives. The required Delta outflow under 1995 WQCP objectives is a combination of some fixed outflow objectives; salinity requirements at Emmaton, Jersey Point, and Rock Slough that are satisfied by equivalent outflow requirements; and X2 requirements that depend on the previous month's runoff.

DWRSIM estimates the minimum outflow necessary to satisfy these combined objectives. The flow necessary to satisfy the salinity objectives is now calculated using a monthly procedure that incorporates the effective outflow-salinity relationships proposed by CCWD (i.e., "G-model"). Table 3A-25 lists the monthly estimates of required Delta outflow for studies 409 and 771; the monthly and annual differences between study 771 and study 409 values are shown for comparison.

Surplus Outflow Available for Delta Wetlands Diversion

Overview

Surplus Delta outflow is outflow in excess of the amount required to meet all monthly water demands, protect Delta salinity standards, and comply with the export/inflow objectives of the 1995 WQCP. Not all surplus outflow may be available for Delta Wetlands Project diversions because such diversions are assumed to be subject to the 1995 WQCP "percent of inflow" export ratio limits (see Chapter 2, "Delta Wetlands Project Alternatives", for a thorough description of assumptions about Delta Wetlands diversions).

Comparison of Results from Studies 409 and 771

Figure 3A-24 shows the monthly pattern of available water for Delta Wetlands diversions. Because most of this surplus water is present during periods of relatively high flows, the estimates of water available for diversion by Delta Wetlands are similar for studies 409 and 771. (The monthly values for study 771 are listed in Table 3A-30, which is discussed below under "Results: Monthly Delta Wetlands Project Operations".)

The availability of surplus Delta water in a few months during relatively dry years is important for estimating the Delta Wetlands Project's water supply potential. Upstream reservoirs may be able to store more of this runoff during some years and reduce the surplus flows entering the Delta. This reduced inflow may reduce simulated Delta Wetlands monthly diversions in some dry years. However, because the project is located in the Delta, any excess runoff from Sacramento or San Joaquin River tributaries can be diverted if conditions in the Delta satisfy the Delta Wetlands FOC and senior water rights are satisfied. The ability of Delta Wetlands to modify project operations to respond to daily changes in Delta conditions (i.e., storm events) is explored below under "Results: Daily Delta Wetlands Operations". Changes in operations based on daily changes in conditions would generally increase the Delta Wetlands water supply potential.

San Luis Reservoir Operations

Overview

San Luis Reservoir provides offstream storage for surplus water (i.e., water in excess of monthly demands) pumped from the Delta to the California Aqueduct and Delta-Mendota Canal (DMC) during periods of high runoff in winter and spring. San Luis Reservoir provides a source of water during the summer peak-demand period to allow more deliveries than could be pumped directly from the SWP and CVP Delta pumping plants. San Luis Reservoir facilitates the coordinated wheeling (conveyance) of state and federal water supplies allowed under the Coordinated Operations Agreement (COA) between DWR and

Reclamation. However, neither study 409 nor study 771 includes any CVP wheeling (i.e., joint point of diversion).

San Luis Reservoir storage values were not evaluated for the 1995 DEIR/EIS because south-of-Delta water supply operations were not included in the DeltaSOS simulations. For the 1995 DEIR/EIS, water stored in Delta Wetlands facilities was simulated as being released for export if excess SWP and CVP export pumping and conveyance capacity was available within the specified export limits. This assumption allowed for estimation of the maximum potential environmental impacts caused by Delta Wetlands Project discharges. However, based on concerns raised at the water right hearing, south-of-Delta demands for water supply and storage in San Luis Reservoir were considered in the 2000 REIR/EIS as constraints to simulated Delta Wetlands discharges for export. The resulting project operations were simulated in the 2000 REIR/EIS analysis to provide reviewers with estimates of a range of potential project yields.

Comparison of Results from Studies 409 and 771

Figure 3A-25 shows end-of-month combined CVP and SWP San Luis Reservoir storage for 1967-1991 as simulated by DWRSIM for study 409 and study 771. Table 3A-26 compares monthly San Luis Reservoir storage values for these two studies during this same period. On average, end-of-month storage values in study 771 are lower than study 409 values, but this is not a consistent trend in all years. The largest differences occur in dry years. For example, simulated monthly San Luis Reservoir storage values in water year 1977 were 420 TAF less in study 771 than in study 409. In contrast, during the 1987 water year, the study 771 monthly values during the winter reservoir filling period (October to February) were 270 to 496 TAF greater than the study 409 values.

Table 3A-27 lists the monthly combined CVP and SWP deliveries that have been calculated from the results of DWRSIM studies 409 and 771. Total deliveries are a combination of water exported from the Delta and water delivered from south-of-Delta storage (i.e., San Luis Reservoir storage). These total deliveries are calculated simply as the combined CVP and SWP exports minus the change in combined CVP and SWP San Luis Reservoir storage. Therefore, when the change in storage is negative (i.e., water is removed from storage), the monthly deliveries consist of the storage volume added to the exports; when the change in storage is positive (water is added to storage), the deliveries consist of the storage volume subtracted from the exports.

Other factors that influence total deliveries in the simulated conditions include SWP interruptible demands, evaporation and seepage losses, and local diversions. These factors were not included in study 409, but have been included in study 771. Table 3A-28 lists the monthly deliveries for DWRSIM study 771 that were obtained by adjusting exports and San Luis Reservoir storage for these factors. The combined deliveries include SWP interruptible demands and the assumed evaporation and seepage losses from the canals and south-of-Delta reservoirs. In some wet years, some simulated demand for CVP deliveries is satisfied through San Joaquin River spills from Friant Dam (or from the Tulare Basin) and some simulated demand for SWP deliveries is met by means of diversions from the Kern River. The monthly deliveries shown in Table 3A-28 are generally less than the estimated CVP and SWP demands, which are assumed in DWRSIM study 771 to vary with Kern River and Los Angeles rainfall conditions (i.e., rainfall in these areas is assumed to reduce demand for CVP and SWP deliveries).

Combined CVP and SWP Delivery Deficits for Study 771

Table 3A-29 shows the monthly combined CVP and SWP delivery deficits (i.e., unmet demands) that resulted from the combination of hydrologic conditions, reservoir operations, and Delta objectives as simulated in DWRSIM study 771. Figure 3A-26 shows the monthly combined CVP and SWP demands, deliveries, and corresponding delivery deficits for study 771.

The annual combined CVP and SWP delivery deficits ranged from 102 TAF to 4,485 TAF, with an average deficit of 1,205 TAF per year. Some years have relatively small deficits, and a few have large deficits. This suggests that there is commonly a deficit in meeting combined CVP and SWP south-of-Delta demands that could be partially satisfied with water supply from the Delta Wetlands Project. Figure 3A-27 shows the annual demands, interruptible SWP supply, local inflow, and total combined CVP and SWP deliveries.

Because DWRSIM study 771 did not include any CVP wheeling export at the SWP Banks Pumping Plant, most of the simulated deficits were assigned to CVP contractors. DeltaSOS simulates only the combined exports and does not account for the distribution of deliveries and deficits to CVP and SWP contractors. DeltaSOS adjusts the DWRSIM results to simulate the export of all allowable water from the Delta for full CVP and SWP deliveries and storage of any surplus water in San Luis Reservoir. Exports may be reduced in subsequent months if San Luis Reservoir is filled under DeltaSOS simulations earlier than under DWRSIM simulations. These adjustments in combined exports increase deliveries, thereby reducing the original combined CVP and SWP deficits calculated by DWRSIM 771. The DeltaSOS adjustment in combined CVP and SWP exports ranged from 0 to 450 TAF per year and averaged about 110 TAF per year. This DeltaSOS adjustment is explained more fully under “South-of-Delta Demands and Deficits” in the section “Revisions to DeltaSOS”, below.

Summary of the Comparison between Results from DWRSIM Studies 409 and 771

This comparison of results from DWRSIM study 771 and study 409 indicates that both simulations of the Delta and upstream reservoir operations provide a reasonable framework for evaluating likely future Delta Wetlands Project operations and assessing their potential environmental impacts. Delta Wetlands Project operations and potential water supply benefits are not substantially different under study 409 and study 771 conditions. Most of the changes in simulated Delta Wetlands Project operations are the result of incorporation of the FOC terms into DeltaSOS, as described below under “Revisions to DeltaSOS”.

REVISED DELTA STANDARDS

Several of the Delta standards and operations criteria have been modified slightly since publication of the 1995 DEIR/EIS. Most of these modifications are AFRP recommendations for the use of CVP water under CVPIA Section (b)(2) for several Delta actions. Most of the adjustments to standards and criteria have been incorporated into DWRSIM study 771. Where necessary, DeltaSOS parameters were also modified to reflect these changes in regulatory operations of Delta water supply facilities and water quality protection standards. Adjustments made to DeltaSOS for consistency with the revised Delta criteria and standards are described below.

Minimum Sacramento River Flow at Freeport

The AFRP Delta actions include requiring Sacramento River flow at Freeport of 9,000 to 15,000 cfs in May. DWRSIM includes these specified Sacramento flows in its initial Delta water budget; therefore, further adjustment of the Sacramento River inflow values is not needed in DeltaSOS.

Delta Cross Channel and Georgiana Slough Operations

Operations of the DCC gates are controlled on a daily basis and may depend on either the Sacramento River inflow or Delta outflow at Chipps Island. Whenever Sacramento River inflow is greater than 25,000 cfs, the DCC is closed to protect the gate structure and downstream levees on the Mokelumne River. Original provisions of the 1995 WQCP called for the DCC to be closed 50% of the time from November through January and at all times from February through May. The revised AFRP rules call for the DCC to be closed from November through January. The DeltaSOS input matrix for DCC closure periods was modified accordingly to address this new standard. This modification does not change either the allowable SWP and CVP export pumping or the amount of water available for Delta Wetlands diversions.

X2 Position for Estuarine Habitat Protection

The 1995 WQCP includes a specified salinity standard to protect estuarine habitat in Suisun Bay. This standard is based on the location of X2, the mean daily bottom salinity gradient value of 2 ppt TDS, which is equivalent to approximately 3 mS/cm electrical conductivity (EC). During the February-through-June control period, X2 must be downstream of the confluence of the Sacramento and San Joaquin Rivers near Collinsville. In addition, for a certain number of days each month depending on runoff conditions, X2 must be downstream of Chipps Island and Roe Island. The AFRP action requires additional X2 days at Chipps Island from March through June. DWRSIM estimates the monthly minimum outflow necessary to satisfy the X2 standard. DeltaSOS uses the DWRSIM values for minimum Delta outflow.

Vernalis Adaptive Management Plan and Delta Export Pumping Restrictions

After the 1995 WQCP was put into effect, the VAMP was proposed and implemented to provide the April-through-May pulse-flow requirements for improving the migration of San Joaquin River chinook salmon juveniles. The VAMP flow requirement depends both on San Joaquin River flows during the pulse-flow period of April 15–May 15 and the current- and previous-water-year 60-20-20 index values; these pulse-flow requirements differ slightly from the flows specified in the 1995 WQCP.

One recommended AFRP Delta action during the VAMP period would limit combined CVP and SWP pumping to less than the San Joaquin River flow (as allowed under the 1995 WQCP). The combined pumping would be 1,500 cfs during most years, but it would increase to 2,250 cfs in some wet years and would alternate between 3,000 cfs and 1,500 cfs in years with VAMP flows of greater than 7,000 cfs. These VAMP flows and the associated pumping restrictions have been included in DWRSIM study 771.

Because DWRSIM uses split-month calculations to estimate the allowable exports during the first half of April and the second half of May but does not save the split-month calculations, it is not possible for DeltaSOS to check the DWRSIM values during April or May. Therefore, DeltaSOS does not adjust the DWRSIM exports during these two months.

As a result, DeltaSOS cannot determine whether any unused pumping capacity is available for Delta Wetlands exports in the first half of April or the second half of May. These export restrictions during the VAMP period generally increase the delivery deficits because there is usually no opportunity to increase pumping during the summer period. The possibility of allowing some Delta Wetlands exports during the VAMP period is discussed under "Additional Considerations for Proposed Project Operations and Water Supply Potential" in the results section below.

REVISIONS TO DELTASOS

This section describes modifications made to DeltaSOS to incorporate the quantifiable terms of the FOC; the USFWS, NMFS, and DFG biological opinions; and the stipulated agreements.

Restrictions for Fish Protection

Delta Wetlands Project Diversion Criteria

Numerous terms limiting Delta Wetlands Project diversion and discharge operations are specified in the FOC; some additional restrictions are specified as RPMs in DFG's biological opinion. Several of these terms have been simulated with the monthly DeltaSOS model. Other terms depend on fish monitoring and daily flow or salinity conditions, which can only be approximated in DeltaSOS modeling of Delta Wetlands Project operations.

The FOC terms include the following restrictions on Delta Wetlands diversions:

- Initial diversions may not be conducted from September through November unless the X2 position is downstream of Chipps Island. X2 must be downstream of Chipps Island for 10 days if the initial diversion is made in the period from December through March. This condition was simulated in DeltaSOS with a minimum Delta outflow requirement of 9,000 cfs for the months of September through January.

- Delta Wetlands may not divert to storage from September through March unless X2 is west (i.e., downstream) of Collinsville. This term was simulated with a minimum required outflow of 7,100 cfs. If the delta smelt fall midwater trawl (FMWT) index value is less than 239, diversions cannot be made unless X2 is 1.4 kilometers (km) downstream of Collinsville (assumed to correspond to an outflow of 8,500 cfs). However, because the delta smelt FMWT index value cannot be calculated, this additional set of restrictions has not been included in the DeltaSOS modeling.

Diversions may not cause the X2 position to move upstream more than 2.5 km from October through March. Because the relationship between X2 and outflow is logarithmic, this limitation has been simulated by limiting the Delta Wetlands diversions to be less than 25% of the outflow.

No water may be diverted in April or May because many delta smelt and other fish species are present during these months. This no-diversion period is extended from February 15 through June if the delta smelt FMWT index is less than 239. As noted above, the FMWT index cannot be calculated and therefore cannot be included in DeltaSOS modeling. "Additional Considerations for Proposed Project Operations and Water Supply Potential", in the results section below, discusses qualitatively the effects of this restriction on Delta Wetlands Project operations.

Diversions are limited to a specific fraction of Delta outflow, 25% from June through December and 15% from January through March.

Between November and January, the diversion rate is limited to 3,000 cfs (rather than 4,000 cfs) if the DCC is closed for fish protection and Delta inflow is less than 30,000 cfs. This limitation was simulated based on monthly average inflow.

Diversions are limited to a specified percentage of the total available water calculated from the 1995 WQCP objectives. Delta Wetlands may divert 90% of available surplus water during the months of August through January, 75% in February, and 50% in March. This provides a buffer of surplus water that may not be diverted by Delta Wetlands. These fractions are used in DeltaSOS calculations of maximum monthly diversions.

Another operations rule required by the DFG biological opinion limits Delta Wetlands Project diversions in March to a maximum rate of 550 cfs unless the previous day's QWEST is positive and is calculated to remain positive during the current day's diversions to storage. (QWEST is a calculated flow parameter that represents net flow between the central and western Delta.) A minimum QWEST flow in March is specified to minimize the upstream movement of juvenile fish life stages from the western Delta into the central Delta, where they would become vulnerable to potential entrainment losses at the export pumps and at Delta Wetlands' diversions. This rule effectively eliminates project diversions in March, except under very high flow conditions, because the DCC gates are closed for fish protection during this month and export capacity is high during this month; both of these factors reduce QWEST.

As described above, Delta Wetlands Project diversions are restricted on a daily basis by salinity conditions in the Delta (i.e., X2 and Delta outflow). The DeltaSOS monthly operations model is limited in its ability to represent daily salinity conditions and daily diversion restrictions. Additionally, Delta Wetlands discharges will be limited by the quality of water on the islands (see Chapter 4, "Water Quality"), so the quality of water at the Delta Wetlands diversion points would be a consideration for project operators. Diversion restrictions as a function of monthly modeled outflow (described above) usually result in low salinity (i.e., chloride [Cl^-]) levels in Delta channels during diversions. However, for monthly modeling purposes, diversions are also restricted until the previous month's Cl^- concentration is less than 150 milligrams per liter (mg/l). This criterion affects diversion activities in less than 5 of the simulated years (i.e., delaying diversions by one month). It is not a specific restriction in the FOC but is used as a tool in the monthly model to more closely represent daily project operations.

Delta Wetlands Project Discharge Criteria

The FOC terms prohibit Delta Wetlands Project discharges for export from Webb Tract from January through June. Delta Wetlands discharges from Bacon Island are limited by the FOC to 50% of San Joaquin River inflow during the period of April through June. Whether discharges from Bacon Island would be allowed during the VAMP export limitation period has not yet been determined. In addition, discharges from the Delta Wetlands reservoir islands are limited to 75% of the unused SWP and CVP pumping capacity in February and July and to 50% of the unused pumping capacity in March through June. Each of these monthly restrictions was specified in DeltaSOS.

Restrictions to Protect Other Parties' Senior Water Rights

Stipulated Agreements

As described in Chapter 2, Delta Wetlands entered into stipulated agreements with five parties protesting Delta Wetlands' water right applications; these agreements restrict Delta Wetlands diversion and discharge operations.

Agreements reached with DWR and Reclamation prevent diversions whenever DWR and Reclamation designate Delta conditions as being "in balance", meaning that all Delta inflow is required to meet Delta objectives and satisfy exports by the CVP and the SWP and diversions by CCWD and Delta riparian and senior appropriative water users. When Delta conditions are designated as being in balance, no additional water would be available for diversion by the Delta Wetlands Project under new water rights. When DWR and Reclamation determine that Delta conditions are "in excess" and when other terms and conditions are met, the Delta Wetlands Project would be allowed to divert available excess water for storage on the designated reservoir islands under new appropriative water rights.

Agreements with the City of Stockton and Amador County include narrative requirements that prevent Delta Wetlands operations from directly or indirectly depriving inhabitants of those jurisdictions of any water reasonably required for beneficial uses.

Delta Wetlands' agreement with North Delta Water Agency prohibits Delta Wetlands Project operations if the water quality criteria for salinity in effect pursuant to the "Contract Between State of California Department of Water Resources and North Delta Water Agency for the Assurance of a Dependable Water Supply of Suitable Quality" dated January 28, 1981, as amended, are not being met.

DeltaSOS simulates these agreements by allowing maximum possible CVP and SWP export pumping and fully satisfying in-Delta diversions by agricultural and senior appropriative water right users.

Contra Costa Water District

DeltaSOS was also modified to address the possibility that the SWRCB would restrict Delta Wetlands Project diversions to preserve CCWD's senior water rights, consistent with the X2 restriction on CCWD operations described in the 1993 USFWS biological opinion for Los Vaqueros Project effects on delta smelt.

To simulate this protection of CCWD's senior water rights, the minimum outflow in February and March is specified in DeltaSOS as 11,400 to maintain X2 downstream of Chipps Island so that Delta Wetlands diversions do not interfere with CCWD operations of Los Vaqueros Reservoir, which are limited by the biological opinion if X2 is upstream of Chipps Island.

South-of-Delta Demands and Deficits

For the 1995 DEIR/EIS, Delta Wetlands discharges for export were allowed whenever there was unused permitted pumping capacity at the SWP and CVP export pumping plants. In other words, in the DeltaSOS simulations of Delta Wetlands discharges for export, south-of-Delta demand was assumed to be unlimited.

The DeltaSOS simulation of maximum possible Delta exports was based on the assumption that all available water within the specified export pumping limits would be exported to satisfy combined CVP and SWP water demands or to serve as supplemental water supply that would be purchased by an existing SWP or CVP contractor. This assumption often resulted in additional exports that used the SWP pumping capacity to satisfy CVP demands and fill the CVP portion of San Luis Reservoir. This combined use of SWP pumping and CVP storage is sometimes referred to as "joint point of diversion" and has been approved by the SWRCB in Decision 1641 implementing the 1995 WQCP and the consolidated and conformed place of use (California State Water Resources Control Board 1999).

This assumption of maximum possible export pumping is similar to the SWP interruptible supply simulated in DWRSIM 771 as 84 TAF/month (i.e., 1,400 cfs). Interruptible delivery is made when the following conditions are met:

- there is surplus water in the Delta,
- Banks Pumping Plant has excess capacity, and
- San Luis Reservoir is full.

Because DWRSIM assumes that contractors will take this additional water whenever it is available during winter, it may be reasonably assumed that the Delta Wetlands Project water would be purchased when available.

DeltaSOS simulation of maximum possible Delta Wetlands Project discharges to export and the export of all available water by the combined CVP and SWP export pumps allows for estimation of the maximum environmental impacts that would result from discharge operations.

In response to comments on the 1995 DEIR/EIS analysis and questions raised in testimony at the SWRCB water right hearing, the lead agencies determined that presentation of a broader range of Delta Wetlands Project operations would be helpful. Delta Wetlands discharges to export could be assumed to be limited to the south-of-Delta delivery deficits simulated in DWRSIM (Figure 3A-26). Therefore, DeltaSOS was modified to allow Delta Wetlands discharges for export to be limited to south-of-Delta CVP and SWP delivery deficits. Under this option, available water may not be exported if the specified CVP and SWP demands have already been satisfied. These specified CVP and SWP demands reflect the current (i.e., 1995) level of demands and upstream development; projected future levels of demand and upstream development have not been evaluated. Actual demands for Delta Wetlands exports may vary with delivery forecasts and with other hydrologic and economic conditions.

To incorporate south-of-Delta SWP and CVP delivery deficits, the delivery deficit information was extracted from the DWRSIM results and the Delta Wetlands exports were limited to these monthly delivery deficits in the simulations. The combined CVP and SWP demands and deliveries reflect the local inflow from the San Joaquin River and Tulare Basin that satisfy CVP demands in some years and the Kern River flows that satisfy SWP demands in some years. The evaporation and seepage losses from the canals and reservoirs must also be included in these overall demand and delivery values.

Table 3A-28 lists the monthly deliveries (in cfs) and annual deliveries (in TAF) for the 1922-1994 period as simulated by DWRSIM study 771. The deliveries are generally highest in the summer months, but the monthly values vary greatly from one year to the next as governed by variable demands and the fluctuations in available water for CVP and SWP exports. Table 3A-29 shows the monthly and annual delivery deficits from DWRSIM study 771 that were used to limit potential Delta Wetlands exports, for comparison with the simulation of unlimited Delta Wetlands exports. Based on the DWRSIM 771 results, the annual deficits in south-of-Delta deliveries are relatively high, ranging from 102 TAF in the wettest year (1983) to more than 4,000 TAF in extremely dry years (e.g., 1977 and 1991).

DeltaSOS then adjusts the initial DWRSIM results to increase the combined CVP and SWP exports to the maximum extent possible and to fill San Luis Reservoir within the export limits specified by the 1995 WQCP. The combined CVP and SWP demands, deliveries, and deficits as adjusted by DeltaSOS for combined export pumping capacity under study 771 conditions for 1967-1991 are shown in Figure 3A-26.

Although the baseline DWRSIM 771 study did not simulate joint-point-of-diversion operations, water is often available for exports under a joint point of diversion to satisfy some of the CVP delivery deficits. Additional opportunities for delivery of CVP and SWP exports under a joint point of diversion were simulated by DeltaSOS; values ranged from 0 TAF to 450 TAF, with an average annual additional export of 110 TAF. Figure 3A-27 shows annual average combined demands and deliveries for DWRSIM study 771 as adjusted by DeltaSOS for a joint point of diversion. Deficits are the difference between the two. The interruptible SWP deliveries are shown at the bottom; values range from 0 TAF in dry years to a maximum of 420 TAF in wet years. Interruptible supply increases the annual demand and delivery values. The annual delivery achieved with local inflows is also shown at the bottom to range from 0 TAF in most years to a maximum of more than 1 MAF (in 1983). These local inflows reduce the annual demand and delivery values. As shown in the figure, even with a joint point of diversion, delivery deficits exist in almost all years.

REVISED ANALYSIS OF WATER SUPPLY AND OPERATIONS UNDER THE PROPOSED PROJECT

Two types of results for operations of the proposed project at a monthly time step are presented below. The first consists of the results of the updated DeltaSOS simulations, which show the potential range of water supply operations under the proposed project to provide information on the timing, frequency, and amount of project diversions and discharges. The second, based on these DeltaSOS simulation results, consists of results of the analysis of project impacts on Delta consumptive use.

These results are presented below following a description of the criteria for evaluating water supply effects and impact significance and an explanation of the scenarios evaluated in this updated analysis.

Measures of Potential Water Supply Effects and Criteria for Determining Impact Significance

Diversion and Discharge Operations and Water Supply

The following are the basic assumptions underlying the evaluation of the potential range of diversions and discharges and the resulting project yield of the proposed project:

- The Delta Wetlands Project would yield a water supply based only on water stored under its own appropriative permits and subsequently conveyed to Delta channels.

- The economic constraints of potential purchasers of Delta Wetlands Project water were not used as criteria for assessing impact significance.

- Permits granted by the SWRCB would specify that project diversions may not interfere with the diversion and use of water by other users with riparian or senior appropriative rights. Because DeltaSOS simulations of the Delta Wetlands alternatives were constrained to preclude interference with any riparian or senior appropriator, the Delta Wetlands Project presumably would have no significant impacts related to interference with senior water rights. Impacts on senior water rights were not used as criteria for assessing impact significance.

- DeltaSOS simulations of the No-Project Alternative and the proposed Delta Wetlands Project accounted for assumed constraints based on 1995 WQCP objectives, AFRP Delta actions, FOC and biological opinion terms, and terms of the stipulated agreements between Delta Wetlands and other parties that can be interpreted and simulated on a monthly basis. Delta Wetlands Project operations, as conditioned and limited by permits, would not be allowed to violate applicable Delta water quality objectives or fish and wildlife requirements or to interfere with other parties' compliance with these objectives and requirements.

- Delta Wetlands Project effects on Delta outflow were not used as criteria for assessing water supply impact significance; the specified 1995 WQCP objectives were presumed to adequately protect beneficial uses related to outflow. Potential effects of augmenting Delta outflow with purchased Delta Wetlands water during periods of reduced flows are assumed to be generally beneficial to the quality of the Delta water supply.

- Delta Wetlands Project effects on export water supply were not used as criteria for assessing impact significance because the addition or reduction of export water supply, by itself, is not a beneficial or adverse environmental impact.

- Potential impacts of the Delta Wetlands Project on water supply, water quality, and fisheries were not directly simulated at a daily time step because available information is not sufficient to allow accurate assessment of these potential daily effects. Therefore, Delta Wetlands Project effects on daily Delta flows were not used as criteria for assessing impact significance. Results of daily simulations are compared with monthly simulation results as part of the discussion and interpretation of the basic monthly findings.

An evaluation of DeltaSOS results is included here to provide useful information for document reviewers on the potential range of project operations. The estimates of diversions and discharges represented by these results are the basis for the updated analyses of effects of the proposed project on water quality (Chapter 3C), fisheries (Chapter 3F), and Delta consumptive water use (below).

Delta Consumptive Use

In addition to the Delta boundary water budget based on the results of DWRSIM study 771, the evaluation of likely effects of Delta Wetlands Project operations relies on a water budget that represents water use on the project islands under no-project conditions (agricultural operations). This second water budget consists of estimates for rainfall, water evaporation, crop ET, soil moisture, seepage, applied irrigation and salt leaching water, and drainage water. The water budgets for the Delta Wetlands Project islands are fully described in Appendix A1 of the 1995 DEIR/EIS.

As described in the results of the assessment of consumptive use from the 1995 DEIR/EIS, the estimated water budget for the four Delta Wetlands Project islands under the No-Project Alternative indicates a net consumptive use of about 44 TAF per year (see Table A1-8 in Appendix A1).

Under Delta Wetlands Project operations, consumptive water use would generally shift from irrigation diversions and crop ET, with minor amounts of open-water evaporation, to open-water evaporation during periods of storage on the reservoir islands and the seasonally flooded portions of the habitat islands, with minor amounts of irrigation diversions and crop ET.

A Delta Wetlands alternative is assumed to have a significant impact on Delta consumptive use if it would cause an increase in Delta lowland ET exceeding 1% of the No-Project Alternative ET from Delta lowlands (estimated as 890 TAF/yr). This assumed significance criterion could also be expressed as a change of greater than 20% of the consumptive use on the Delta Wetlands Project islands (i.e., 8.8 TAF/yr) because the project islands represent about 5% of the area of the Delta lowlands. A project alternative is considered to have a beneficial effect on Delta consumptive use if it would cause a decrease in Delta lowland ET.

Scenarios Evaluated in the Revised Analysis of Delta Wetlands Water Supply and Operations

This document evaluates three alternatives for Delta Wetlands operations, as described in Chapter 2. Alternatives 1 and 2 both represent Delta Wetlands' proposed project, consisting of water storage on two reservoir islands and implementation of an HMP on two habitat islands, but these alternatives offered two different scenarios for the discharge of stored water. Under Alternative 3, all four Delta Wetlands Project islands would be used as reservoirs and limited compensation wetland habitat would be provided on Bouldin Island. Alternative 2, with the largest amount of discharge pumping for export, would have the maximum effect on fisheries associated with project discharges. Therefore, Alternative 2 was used to represent the proposed project in the biological assessment for fish species and is the alternative on which the terms and conditions of the DFG, USFWS, and NMFS biological opinions are based. For this reason, the proposed project evaluated in the 2000 REIR/EIS is Alternative 2 from the 1995 DEIR/EIS, as modified by the changes to the project description summarized in Chapter 2.

The range of potential project operations under the proposed project, as described in the remainder of this chapter, can be affected by several factors that either depend on natural conditions that cannot be simulated (e.g., occurrence of fish species) or that would result from decisions made by the SWRCB about allowable Delta Wetlands Project operations during the water right approval process. For example, if the FMWT delta smelt index is low, Delta Wetlands operations are more restricted than if the FWMT index is high. Alternatively, if Delta Wetlands is allowed to discharge water from Bacon Island for export in April and May (i.e., during the VAMP period), potential project water supply benefits will increase.

Figure 3A-28 shows the relationship between the Delta Wetlands Project alternatives evaluated in the 1995 DEIR/EIS and the potential operations under the proposed project that were considered in the 2000 REIR/EIS evaluation. The 1995 DEIR/EIS considered three alternatives. The Delta inflows were taken from DWRSIM study 409, which incorporated the Delta objectives from the 1995 WQCP.

The proposed project in this analysis of water supply and operations is represented by 1995 DEIR/EIS Alternative 2 with the revisions described in Chapter 2. The most consequential revision is the addition of the FOC terms. Delta inflows and other parameters are taken from DWRSIM study 771 for the no-project and with-project simulations. The analysis addresses a range of potential discharge operations for the proposed project. DeltaSOS simulation results are presented for two operational scenarios for discharge to export:

1. Project discharges are assumed to be exported if pumping capacity exists and FOC and other operating rules are met (i.e., not limited by south-of-Delta delivery deficits).

2. Project discharges to export are limited by the simulated delivery deficits (total CVP and SWP deliveries minus combined CVP and SWP demands) in addition to export capacity, FOC, and other operating rules (i.e., limited by south-of-Delta delivery deficits).

Figure 3A-28 also illustrates other considerations or operating scenarios that would affect estimated project diversions, storage, and exports. These options are discussed qualitatively below.

Results: Monthly Delta Wetlands Project Operations

This section describes the results of the 2000 REIR/EIS DeltaSOS simulations of project diversion, storage, and discharge operations, and estimates project yield under different discharge scenarios.

Water Available for Diversion and Unused Pumping Capacity

The Delta Wetlands Project water supply simulation results can be described in two basic steps: determining the availability of water for Delta Wetlands diversion and determining the opportunities for Delta Wetlands discharge for export.

Water Available for Diversion. Table 3A-30 lists the monthly (in cfs) and annual (in TAF) quantities of water available for Delta Wetlands diversions, as constrained by 1995 WQCP outflow and "percent of inflow" objectives with DWRSIM study 771 inflows. Because Delta Wetlands diversions are most likely to occur from October through March, the annual total volume is calculated for the October-March period. The results in Table 3A-30 suggest that water will be available for diversion during at least one month in the majority of years. The annual amount of water available for Delta Wetlands diversions in the months of October through March ranges from 0 TAF in 10 dry years to more than 5,000 TAF in eight wet years. Under adjusted DWRSIM study 409, less than 100 TAF of water was available in 15 years out of 70. Table 3A-30 indicates that for DWRSIM study 771, less than 100 TAF of water was available for diversions in 17 of the 73 study years (i.e., 23%). The quantity and timing of available water simulated by DeltaSOS using DWRSIM study 771 inflows and outflow requirements is similar to the results shown in the simulations previously performed for the 1995 DEIR/EIS using the results of DWRSIM study 409.

The FOC terms impose several additional limits on the available water that may be diverted by the Delta Wetlands Project. No diversions are allowed in April or May. The project can divert only a variable percentage of the available water in the other months. These FOC diversion limits are described above under "Restrictions for Fish Protection" in the section entitled "Revisions to DeltaSOS".

Unused Pumping Capacity. Table 3A-31 shows the simulated monthly unused CVP and SWP combined permitted export capacity for adjusted DWRSIM study 771. (Unused pumping capacity in April and May cannot be determined from DWRSIM study 771 because DWRSIM uses split-month calculations.) Because Delta Wetlands exports are most likely to occur from June through September, the unused pumping capacity during this period has been summarized. Unused pumping capacity was not discussed in the 1995 DEIR/EIS but was similar in magnitude and seasonal pattern to the results presented here.

Generally, enough unused permitted pumping capacity is simulated, after all possible CVP and SWP exports have been made, to allow the full Delta Wetlands project capacity of 238 TAF to be exported in most years. However, less than 100 TAF of unused export capacity is simulated from June through September in 9 of the 73 study years (12%). These are not the same years as those when limited amounts of water are available for Delta Wetlands diversions (which represent 23% of the years simulated). Project water supply potential is therefore reduced in 35% of years in the simulations by limits on either available water or unused pumping capacity.

Project Diversions, Storage, and Exports with Unlimited Demand

Table 3A-32 shows the monthly simulated diversions for the proposed project with DWRSIM 771 inflows, net channel depletions, and required Delta outflow conditions. Table 3A-33 shows the monthly storage values and Table 3A-34 shows the discharges for export under the assumptions of maximum allowable Delta Wetlands exports for adjusted DWRSIM study 771, without limitation by south-of-Delta delivery deficits. (The table shows water years, but the 250-TAF annual export limit from the FOC is based on calendar years. Some years [e.g., 1971] in the table may appear to violate the FOC limit but do not on a calendar-year basis.)

This case represents the maximum potential Delta Wetlands operations under the proposed project, similar to the simulated Alternative 2 conditions described in the 1995 DEIR/EIS (see "Impacts and Mitigation Measures of Alternative 2" above), but as modified by the FOC and other operating rules. The annual average Delta Wetlands diversions would be 165 TAF (Table 3A-32), and the water supply potential would average about 138 TAF per year (Table 3A-34). The difference between simulated diversions and discharges for export provides an estimate of evaporation from the reservoir islands of 27 TAF. Table 3A-33 indicates that Delta Wetlands storage will not be emptied every year; the simulation results show 12 years with a carryover storage of more than 50 TAF, as indicated by October storage volume.

Figure 3A-29 shows the simulated annual Delta Wetlands diversions and discharges for export for the proposed project with exports unlimited by delivery deficits. In most years, diversions were slightly greater than discharges for export, reflecting evaporation losses during the storage period. The FOC terms limit the annual (January-December calendar year) discharge for export to less than 250 TAF. Years characterized by diversions that are much greater than discharges for export reflect carryover storage years.

Project Diversions, Storage, and Exports Limited by South-of-Delta Delivery Deficits

Tables 3A-35, 3A-36, and 3A-37 show the monthly simulated Delta Wetlands diversions, storage, and discharges for export under the assumption that Delta Wetlands exports are limited to remaining SWP and CVP delivery deficits for adjusted DWRSIM study 771. Delivery deficits are often smaller than the simulated Delta Wetlands discharges for export from June through September, causing Delta Wetlands exports to be delayed and/or reduced. For example, as shown in Table 3A-29, delivery deficits in June are less than 2,000 cfs (the maximum allowed Delta Wetlands discharge for export under the FOC terms) in many years. In these years, Delta Wetlands discharges for export are delayed with the delivery-deficit assumption, resulting in evaporative losses and reduced total discharges for export. (Table 3A-34 shows the discharges for export without the delivery-deficit limit.) The Delta Wetlands water supply operations are reduced in 22 of the 70 simulated years when compared to operations under unlimited-demand conditions. The annual average diversions would be 144 TAF, and the water supply potential would average about 114 TAF per year. Delta Wetlands carryover storage of more than 50 TAF is simulated in 16 years.

Figure 3A-30 shows the simulated annual Delta Wetlands diversions and discharges for export for the proposed project with exports limited by south-of-Delta delivery deficits. In most years, diversions were slightly greater than discharges for export, reflecting evaporation losses during the storage period. In other years, diversions were much greater than discharges, indicating carryover storage on the reservoir islands. Diversions in subsequent years were much less than discharges.

Additional Considerations for Proposed Project Operations and Water Supply Potential

Several different Delta conditions and Delta Wetlands operating choices may affect operations in particular years. Some of these conditions are listed in Figure 3A-28. Some conditions and operating choices would restrict diversions and reduce Delta Wetlands' water supply potential (i.e., yield) while others may increase potential water supply. The DeltaSOS monthly simulations described above are representative of the range of potential proposed project operations and provide the basis for evaluating environmental impacts resulting from the likely range of operations. However, several Delta conditions may necessitate adjustments in these monthly estimates of likely operations. Because most of these cannot be calculated, these additional considerations were not included in the DeltaSOS modeling.

Delta Smelt Fall Midwater Trawl Index Restriction. The Delta Wetlands FOC terms include several additional restrictions on diversions whenever the FMWT index value is less than 239. If the value is less than 239, diversions could not be made unless X2 is 1.4 km downstream of Collinsville (assumed to correspond to an outflow of 8,500 cfs), and diversions are restricted from February 15 through June. When these restrictions are in place, Delta Wetlands water supply potential would decrease.

Bacon Island Export under the Vernalis Adaptive Management Program. The possible discharge and export of Bacon Island water during April and May (the VAMP period) would increase the Delta Wetlands water supply potential. Whether VAMP rules would apply to Delta Wetlands Project exports has not been determined.

Top-Off Allowance for Evaporative Losses. The allowance for diversions to replace evaporation losses from June through October, as described in the Delta Wetlands FOC, has not been included in the DeltaSOS simulation. This "topping-off" allowance would increase the Delta Wetlands water supply potential. "Topping off" could not violate senior water rights or water quality and outflow requirements, however.

Delta Outflow Augmentation. For purposes of environmental impact assessment, Delta Wetlands Project operations modeling assumes that all Delta Wetlands water available for export would be exported. However, as indicated in the project purpose (see Chapter 2), Delta Wetlands Project water also may be released to improve Delta water quality and outflow benefits. For example, when Delta Wetlands exports are limited by export capacity or delivery deficits, the Delta Wetlands carryover storage could be reduced by the release of water during periods of relatively low Delta outflow to augment outflow or reduce salinity intrusion (i.e., through the CALFED Environmental Water Account). This could improve water quality and provide slightly improved estuarine habitat conditions. These Delta releases may reduce Delta Wetlands' water supply potential for exports (i.e., project yield) in some years compared to the simulated conditions because insufficient water may be available for diversions to refill the reservoir islands during the next winter. These Delta Wetlands releases for outflow are not assumed to replace the Delta outflow provided by CVP and SWP operations to satisfy the WQCP Delta outflow requirements.

Results: Daily Delta Wetlands Project Operations

Daily Delta Wetlands operations were evaluated in the 1995 DEIR/EIS using the DailySOS model, as described in Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments". The ability of Delta Wetlands to divert water to storage during periods of excess inflows and export during short periods of unused export pumping, while complying with the daily requirements established in the biological opinions, can be more realistically simulated with the daily model than with DeltaSOS. These daily simulations also provide a firm basis for the establishment of terms and conditions for allowable operation of the Delta Wetlands Project.

Appendix A4 of the 1995 DEIR/EIS compared the monthly and daily simulation results and determined that the monthly estimates of CVP and SWP exports were higher than the daily estimates because of inflow fluctuations resulting from storm events and because of the physical capacity of the pumping facilities. The daily Delta Wetlands Project operations were generally higher than the monthly estimates because there were short periods when diversions could be made during storm events and subsequent periods when Delta Wetlands exports could be made.

In this section, the daily rules for Delta Wetlands diversion and discharge are reviewed, and the daily results are compared with the monthly results for the case of exports not subject to limitation by delivery deficits. The 10-year period of 1985-1994 is used to illustrate the potential daily Delta Wetlands operations as constrained by the rules contained in the FOC. Appendix F of the 2000 REIR/EIS provides a narrative explanation of the DailySOS results for each year and represents the results graphically. The yearly results presented in Appendix F provide a more accurate picture of potential Delta Wetlands operations than the monthly model results; the yearly results can depict how project operations would respond to opportunities for diversions and discharges on a daily basis throughout the year.

Simulation Method

The FOC terms include rules that restrict the timing and magnitude of Delta Wetlands diversions to storage and discharges to export; those rules would be applied on a daily basis. In addition to the WQCP objectives that govern Delta exports (i.e., minimum required Delta outflow and maximum allowed exports as a percentage of inflow [E/I ratio]), several rules for Delta Wetlands diversions are applied. When more than one measure is applicable, the most restrictive is used. The FOC discharge measures differ for Bacon Island and Webb Tract, so the daily modeling simulated Bacon Island diversions, storage, and discharge separately from Webb Tract diversions, storage, and discharge. As simulated in the daily model, Bacon Island diversions would be made first, and diversions to Webb Tract would then be made using any remaining diversion capacity under the FOC rules. Several of the criteria are more restrictive if the FMWT delta smelt index is less than 239; however, because the FMWT index value cannot be calculated, the model assumes a FMWT index greater than 239 for the daily simulations. The Delta Wetlands diversion and discharge rules are described above under "Restrictions for Fish Protection" in the section entitled "Revisions to DeltaSOS". Table 3A-38 lists those rules and the ways in which they are applied in the daily operations model.

Daily Delta Wetlands operations were simulated using daily historical Delta inflows, CCWD diversions, and net channel depletions that were adjusted to match DWRSIM 771 simulated inflows, CCWD diversions, and net channel depletions. The daily pattern of inflows caused by storm events was preserved, but upstream adjustments in reservoir storage made by the monthly planning model were assumed to provide the most realistic future seasonal inflow pattern. Figure 3A-31 illustrates this adjustment for 1985 Sacramento and San Joaquin River inflows. The daily values have been adjusted to match the DWRSIM monthly average. Adjustments in the Sacramento River flows are typically less than 2,000 cfs, with adjustments resulting in increases as well as decreases from the historical values. Adjustments in San Joaquin River flows typically reduce the flows to below historical values, except during the pulse flow (i.e., VAMP) period of April and May. Adjustments in river inflows for the other years are similar to those presented for 1985.

Summary of Daily Results

The 10-year sequence of daily simulations using the FOC for Delta Wetlands operations provides the most accurate picture of potential operations of the proposed project under highly variable Delta inflow and export conditions. Table 3A-39 provides a summary comparison between the monthly and daily model results for Delta Wetlands diversions and Delta Wetlands exports for the 1985-1994 water year sequence. The daily model results confirm the monthly Delta Wetlands diversion and export values for moderately wet years (e.g., 1985, 1986, 1993). Like the monthly results, the daily simulations indicate that there are some years with very little or no available water for Delta Wetlands diversions (i.e., 1990, 1991, 1992). However, in 1989, the monthly model indicates no available water, but the daily model shows that there is some opportunity to divert during a limited major storm event once the X2 location is downstream of Chipps Island. The daily simulation of Delta Wetlands operations indicates that more Delta Wetlands exports could be made in some dry years (i.e., 1987, 1989, and 1994) than indicated by the monthly results. On the other hand, daily simulation of 1988 shows that X2 was not located downstream of Chipps Island for a sufficient length of time to allow Delta Wetlands diversions, so exports were much less in the daily results than the monthly results for that year.

Results: Cumulative Water Supply Conditions

For the 1995 DEIR/EIS, cumulative future conditions were simulated using DeltaSOS for each of the project alternatives, based on the assumption that the full SWP pumping capacity (10,300 cfs) was available in any month for combined CVP and SWP Delta exports. This availability of full pumping capacity is considered to be the most likely change in Delta facilities that would directly influence proposed Delta Wetlands operations. It may require approval and implementation of DWR's South Delta Project and a revised USACE permit for the SWP Banks Pumping Plant. This scenario represents the reasonably foreseeable future Delta conditions and regulatory standards. Results of the DeltaSOS simulations with

DWRSIM 771 inflows and demands adjusted to the full SWP pumping capacity of 10,300 cfs were used to represent the baseline for cumulative future conditions.

For the 2000 REIR/EIS analysis, cumulative future conditions for the proposed project were simulated using DeltaSOS in the same way. The DeltaSOS simulations used DWRSIM 771 results showing likely future Delta inflows, exports, and outflows under hydrologic conditions replicating those of the 73-year hydrologic record (water years 1922-1994). The 1995 level of development and demands used in DWRSIM 771 was used for the cumulative-conditions scenario. Assumptions for maximum Delta Wetlands discharges to export in addition to maximum CVP and SWP exports (i.e., future increased demands) are briefly described for comparison with the 1995 DEIR/EIS results for cumulative future conditions.

The annual combined CVP and SWP demands, deliveries, and deficits as adjusted by DeltaSOS for baseline DWRSIM 771 conditions, but with full SWP export pumping capacity under cumulative conditions, are shown in Figure 3A-32. Additional CVP and SWP exports as adjusted for cumulative conditions ranged from 0 TAF in dry years to more than 500 TAF in wet years, with an average of 220 TAF. The delivery deficits that Delta Wetlands water supply may satisfy are less under cumulative future conditions than under existing conditions because, with full use of SWP Banks pumping capacity, the combined CVP and SWP exports will be greater.

Table 3A-40 shows the monthly diversions under the proposed project as simulated for cumulative future conditions with full pumping capacity at Banks Pumping Plant and Delta Wetlands exports unlimited by delivery deficits. Average annual diversions would be 169 TAF. Table 3A-41 shows the monthly Delta Wetlands storage values for these assumed cumulative future conditions. Carryover storage of more than 50 TAF would occur in only 3 years. Table 3A-42 shows the monthly Delta Wetlands discharge for export for these cumulative future conditions. Average annual exports of 147 TAF are simulated.

These results indicate that Delta Wetlands would operate in fewer years under cumulative conditions than under existing conditions because of reduced availability of water for diversions in some years (24 years with diversions less than 100 TAF). However, because of the greater export pumping capacity, more Delta Wetlands exports were simulated in several of the years. Average Delta Wetlands discharges for export were simulated to be approximately 9 TAF/yr more (increase of 7%) under cumulative conditions than for the proposed project without south-of-Delta delivery deficit limitations.

The likely Delta Wetlands yield under cumulative future conditions might be slightly less when limited by simulated south-of-Delta delivery deficits. However, future south-of-Delta demands and delivery deficits are likely to be greater than the 1995 level of demand simulated in DWRSIM 771. The relative effects of limiting Delta Wetlands exports by south-of-Delta delivery deficits for cumulative conditions could be similar to those reported for project conditions. For example, project yield was 138 TAF under unlimited demand versus 114 TAF when limited by south-of-Delta delivery deficits. Similarly, under cumulative conditions, project yield was 147 TAF under unlimited demand, so project yield is estimated as 123 TAF when limited by south-of-Delta delivery deficits.

When compared to results presented in the 1995 DEIR/EIS, the potential yield from Delta Wetlands Project operations under cumulative conditions is reduced from an estimated average of 197 TAF to 147 TAF because the opportunities for Delta Wetlands diversions are reduced under DWRSIM study 771 conditions and because of limitations imposed by the FOC. However, the south-of-Delta water demands are expected to increase over time, and the project would provide an increment of storage that could be used to increase deliveries to CVP and SWP contractors.

Results: Delta Consumptive Use

Under the proposed project, land uses would change from irrigated agriculture to primarily water storage on the reservoir islands and to wildlife habitat on the habitat islands. These land use changes would reduce ET for the four islands from a total of 44 TAF/yr to 14 TAF/yr (estimated ET from the habitat islands). Additionally, an average of approximately 27 TAF/yr of evaporation would be lost from stored water on the reservoir islands during periods of water storage (i.e., Delta Wetlands diversions minus discharges for export). Therefore, total consumptive use for the proposed project is simulated to be about the same as under existing conditions. There is no change from the 1995 DEIR/EIS conclusion that the project would not have a significant impact on Delta consumptive use and that no mitigation is required.

Impact Evaluation of Project Alternatives from the 1995 Draft EIR/EIS

As described in Chapter 2, project operations under Alternative 1 in the 1995 DEIR/EIS were assumed to be the same as project operations under Alternative 2, except that discharges to export were assumed to be more restricted (i.e., by strict interpretation of the E/I ratio). As shown in the 1995 DEIR/EIS analysis, Alternative 1 operations provide fewer opportunities for Delta Wetlands discharges to export—potentially meaning a lower yield—than Alternative 2 operations (i.e., project yield was 14 TAF less under Alternative 1 than Alternative 2). Changes in simulated Alternative 1 project operations between the 1995 DEIR/EIS analysis and the 2000 REIR/EIS analysis are similar in magnitude and direction to the changes described above for the proposed project (i.e., Alternative 2). Therefore, Delta Wetlands discharges to exports under Alternative 1 would be less than previously reported in the 1995 DEIR/EIS, and the potential environmental impacts of Alternative 1 are slightly less than originally estimated. Based on the daily simulation of Delta Wetlands operations, the E/I export restriction would rarely limit Delta Wetlands discharges. The likely effect of applying the E/I export limit would be an increase in the period of Delta Wetlands discharges, resulting in increased evaporative losses on the Delta Wetlands islands. These evaporative losses are estimated to result in an average annual reduction in yield of less than 10 TAF compared with the Alternative 2 results.

Alternative 3, the four-reservoir-island alternative, has not changed since the 1995 DEIR/EIS was published. The FOC and biological opinion terms were developed for two-reservoir-island operations and are not applicable to a four-reservoir-island alternative. New simulations of Alternative 3, which are based on the Delta water budget developed from DWRSIM study 771 and include AFRP actions, would result in minor changes in project diversion, storage, and discharge operations. There is no change to the conclusions of the environmental impact analysis presented in the 1995 DEIR/EIS for Alternative 3. For the results of this evaluation, see the section above from the 1995 DEIR/EIS entitled "Impacts and Mitigation Measures of Alternative 3".

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Table 3A–1. Annual Historical Delta Water Budget for 1922 – 1991

Water Year	Sac Basin Year Type [a]	SJR Basin Year Type [a]	Sac Inflow (TAF)	Yolo Bypass Flow (TAF)	Eastside Inflow (TAF)	SJR Basin Inflow (TAF)	Total Delta Inflow (TAF)	Delta Rain (TAF)	Delta Consumptive Use (TAF)	Delta Channel Depletion (TAF)	Delta Exports (TAF)	Delta Outflow (TAF)
1922	2	1	18,998	1,302	1,840	6,732	28,873	548	1,425	877	0	28,798
1923	3	2	13,989	0	1,440	4,043	19,471	562	1,425	863	0	19,471
1924	5	5	4,373	0	106	486	4,965	146	1,425	1,279	0	4,965
1925	4	3	15,363	2,485	1,474	3,749	23,071	626	1,425	799	0	23,071
1926	4	4	11,747	721	461	1,939	14,868	446	1,425	979	0	14,868
1927	1	2	23,001	5,200	1,641	5,076	34,918	599	1,425	826	0	34,918
1928	2	3	16,199	2,092	1,034	2,709	22,033	432	1,425	993	0	22,033
1929	5	5	7,472	0	266	937	8,675	288	1,425	1,137	0	8,675
1930	4	5	13,190	906	466	1,266	15,828	607	1,411	804	0	15,017
1931	5	5	5,148	36	159	678	6,021	523	1,405	881	0	5,132
1932	4	2	12,218	432	930	3,669	17,249	731	1,400	669	0	16,577
1933	5	4	7,722	64	418	1,383	9,587	531	1,399	868	0	8,706
1934	5	5	8,041	228	432	928	9,629	558	1,399	842	0	8,786
1935	3	2	16,043	2,072	1,043	4,034	23,192	765	1,398	633	0	22,551
1936	3	2	15,512	3,357	1,602	4,986	25,458	984	1,401	416	0	25,057
1937	3	1	13,670	1,228	1,231	5,510	21,640	958	1,400	443	0	21,206
1938	1	1	25,878	14,152	2,188	10,879	53,096	1,002	1,401	399	0	52,716
1939	4	4	7,080	170	422	1,714	9,386	581	1,413	831	0	8,551
1940	2	2	18,267	6,974	1,340	4,765	31,346	948	1,429	481	0	30,867
1941	1	1	23,698	11,510	1,292	7,310	43,810	1,026	1,442	417	0	43,400
1942	1	1	22,795	6,733	1,565	6,188	37,281	1,121	1,456	335	0	36,944
1943	1	1	19,660	3,145	1,826	6,079	30,710	1,044	1,472	428	0	30,287
1944	4	3	9,069	124	515	1,798	11,506	751	1,487	737	0	10,772
1945	3	2	13,155	735	1,185	4,446	19,521	837	1,523	686	0	18,843
1946	3	2	15,903	2,101	1,091	3,627	22,723	748	1,553	805	0	21,908
1947	4	4	9,491	72	369	1,334	11,266	510	1,580	1,071	0	10,189
1948	3	3	14,552	301	703	1,550	17,106	660	1,610	951	0	16,145
1949	4	3	11,793	260	613	1,242	13,909	636	1,626	991	0	12,597
1950	3	3	13,948	357	993	1,796	17,093	606	1,642	1,036	21	15,236
1951	2	2	21,766	3,445	2,321	4,735	32,268	927	1,644	718	192	30,552
1952	1	1	28,056	3,945	2,477	7,136	41,615	1,096	1,646	550	195	40,375
1953	1	3	18,121	2,752	859	1,893	23,626	660	1,623	963	821	22,362
1954	2	3	17,110	1,213	717	1,713	20,754	589	1,637	1,049	1,063	19,140
1955	4	4	10,591	76	557	978	12,203	788	1,637	848	1,175	10,040
1956	1	1	22,328	9,860	2,359	6,287	40,833	1,159	1,686	527	765	39,743
1957	2	3	13,150	778	684	1,440	16,052	759	1,684	925	1,233	13,920
1958	1	1	26,058	10,012	2,396	6,059	44,525	1,573	1,684	111	705	43,765
1959	3	4	12,059	635	366	1,249	14,308	794	1,684	890	1,404	12,039
1960	4	5	10,771	618	255	550	12,194	559	1,686	1,127	1,460	9,707
1961	4	5	11,488	169	103	438	12,198	713	1,684	971	1,561	9,687
1962	3	3	13,089	1,123	683	1,505	16,400	820	1,684	864	1,422	14,139
1963	1	2	20,422	4,170	1,334	2,839	28,766	1,247	1,684	437	1,400	26,969
1964	4	4	11,591	67	307	1,119	13,083	643	1,686	1,044	1,726	10,384
1965	1	1	14,965	6,193	1,644	3,803	31,604	926	1,684	759	1,539	29,347
1966	3	3	13,392	377	639	1,698	16,106	686	1,684	999	1,678	13,449
1967	1	1	24,233	3,661	1,723	5,559	35,177	1,294	1,684	390	1,323	33,515
1968	3	4	13,377	668	520	1,423	15,987	653	1,686	1,033	2,564	12,507
1969	1	1	23,362	6,281	2,391	10,168	42,202	1,260	1,684	424	2,953	38,883
1970	1	2	20,289	8,500	1,415	3,076	33,280	895	1,684	789	2,162	30,290
1971	1	3	22,811	1,306	902	1,779	26,797	941	1,684	743	2,905	23,191
1972	3	4	12,470	30	365	1,112	13,977	437	1,686	1,249	3,544	9,261
1973	2	2	20,758	3,887	1,429	2,392	28,466	1,244	1,684	440	3,457	24,609
1974	1	1	30,663	7,566	1,551	2,773	42,553	995	1,684	689	4,439	37,482
1975	1	1	19,941	951	1,125	2,826	24,842	828	1,684	856	3,983	20,043
1976	5	5	10,963	15	206	1,523	12,707	460	1,686	1,226	4,951	6,583
1977	5	5	5,497	1	30	416	5,944	445	1,684	1,239	2,177	2,539
1978	2	1	17,691	2,844	1,146	4,490	26,172	1,368	1,684	316	4,427	21,467
1979	3	2	13,034	154	1,020	2,625	16,832	941	1,684	743	4,561	11,555
1980	2	1	19,248	6,502	1,830	5,986	33,566	1,045	1,686	641	4,610	28,501
1981	4	4	11,499	126	286	1,763	13,675	725	1,684	960	4,829	7,908
1982	1	1	30,101	7,229	3,038	5,477	45,845	1,655	1,684	30	4,696	41,230
1983	1	1	34,049	14,962	4,557	15,438	69,006	1,713	1,684	(29)	4,479	64,643
1984	1	2	22,384	4,689	1,807	6,260	35,140	863	1,686	824	3,938	30,592
1985	4	4	12,192	172	470	2,101	14,935	743	1,684	941	5,584	8,453
1986	1	1	18,112	10,608	2,124	5,235	36,080	1,454	1,684	230	5,396	30,493
1987	4	5	10,031	35	384	1,808	12,257	683	1,684	1,001	5,174	6,105
1988	5	5	9,653	115	143	1,164	11,075	718	1,686	968	5,746	4,409
1989	4	5	12,244	44	221	1,057	13,566	795	1,684	889	6,101	6,599
1990	5	5	9,860	21	169	914	10,965	619	1,680	1,060	5,947	3,967
1991	5	5	7,540	75	221	655	8,491	847	1,681	834	3,286	4,371
Average			15,856	2,752	1,077	3,319	23,004	819	1,587	768	1,737	20,616

Notes: [a] 1 = wet, 2 = above normal, 3 = below normal, 4 = dry, 5 = critically dry.

Sources: The 1922–1929 data are from the UNIMPAIRED data set and the 1930–1991 data are from the DAYFLOW database, both maintained by DWR. See Appendix A1 for details.

Table 3A-2. Summary of 70-Year DeltaSOS Mean Annual Simulation Output for Channel Flows, Diversions, and Exports under the DW Project Alternatives and the No-Project Alternative (TAF)

Location	No-Project Alternative	Alternative 1	Alternative 2	Alternative 3	No-Project Alternative Cumulative	Alternative 1 Cumulative	Alternative 2 Cumulative	Alternative 3 Cumulative
Sutter & Steamboat Slough flow	5,091	5,091	5,091	5,091	5,091	5,091	5,091	5,091
Revised DCC diversion	1,347	1,347	1,347	1,347	1,347	1,347	1,347	1,347
Georgiana Slough flow	4,090	4,090	4,090	4,090	4,090	4,090	4,090	4,090
Rio Vista flow	13,793	13,793	13,793	13,793	13,793	13,793	13,793	13,793
Initial DWRSIM exports	5,712	5,712	5,712	5,712	5,712	5,712	5,712	5,712
Net export change	442	450	450	464	1,018	1,029	1,029	1,046
Adjusted total export	6,154	6,162	6,162	6,177	6,730	6,741	6,741	6,759
Required Delta outflow	5,802	5,802	5,802	5,802	5,802	5,802	5,802	5,802
Outflow deficit	0	0	0	0	0	0	0	0
Montezuma Slough flow	930	931	931	931	930	931	931	931
Head of Old River diversion	1,370	1,369	1,369	1,369	1,369	1,369	1,369	1,369
Available for DW diversion	2,572	2,575	2,575	2,579	1,995	1,996	1,996	1,996
DW storage diversions	0	222	225	356	0	191	211	314
DW storage exports	0	188	202	302	0	166	197	282
DW storage releases	0	0	0	0	0	0	0	0
Final total export	6,154	6,350	6,364	6,479	6,730	6,907	6,938	7,041
Final QWEST flow	420	215	212	92	(156)	(333)	(353)	(448)
Final Delta outflow	14,120	13,915	13,912	13,792	13,544	13,367	13,347	13,252
Final Antioch flow	3,504	3,363	3,361	3,363	3,108	2,987	2,973	2,908
Old & Middle River flow	(5,304)	(5,499)	(5,514)	(5,499)	(5,879)	(6,056)	(6,087)	(6,191)

Note: Negative values shown in parentheses.

Table 3A–3. DeltaSOS Mean Annual Simulation Output for the No–Project Alternative

Water Year	SJR Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)
1922	1	1,073	0	0	0	0	6,380	604	12,101	2,512	1,587	3,115
1923	2	2,231	0	0	0	0	6,491	140	10,478	2,386	1,369	2,526
1924	5	2	0	0	0	0	4,539	(1,152)	4,158	1,628	825	476
1925	3	770	0	0	0	0	5,796	(753)	8,206	2,343	852	1,590
1926	4	427	0	0	0	0	5,757	(1,085)	6,974	2,242	877	1,157
1927	2	2,854	0	0	0	0	6,604	(175)	17,268	4,140	1,038	3,966
1928	3	2,464	0	0	0	0	6,734	(706)	13,846	3,637	996	2,931
1929	5	0	0	0	0	0	4,564	(911)	4,548	1,585	851	673
1930	5	281	0	0	0	0	5,000	(1,037)	6,229	2,043	764	1,005
1931	5	0	0	0	0	0	3,327	(312)	3,677	1,054	831	743
1932	2	148	0	0	0	0	4,272	158	5,700	1,263	943	1,421
1933	4	0	0	0	0	0	3,678	(351)	4,288	1,218	853	867
1934	5	121	0	0	0	0	3,734	(445)	4,831	1,395	805	950
1935	2	612	0	0	0	0	5,986	(457)	9,392	2,459	1,131	2,002
1936	2	1,424	0	0	0	0	6,202	62	10,803	2,503	1,192	2,565
1937	1	934	0	0	0	0	5,890	768	9,629	1,842	1,494	2,610
1938	1	8,833	0	0	0	0	7,215	4,892	35,927	5,715	3,087	10,607
1939	4	548	0	0	0	0	5,781	(1,228)	5,635	2,013	995	785
1940	2	2,650	0	0	0	0	6,456	39	17,614	4,100	1,046	4,139
1941	1	5,967	0	0	0	0	6,660	2,540	30,118	5,644	2,157	8,185
1942	1	5,141	0	0	0	0	7,230	1,487	26,463	5,374	1,534	6,861
1943	1	4,699	0	0	0	0	6,712	2,090	19,572	3,441	1,611	5,531
1944	3	45	0	0	0	0	5,986	(1,246)	6,439	2,207	984	960
1945	2	880	0	0	0	0	6,487	(622)	8,286	2,294	1,254	1,672
1946	2	2,348	0	0	0	0	6,340	(139)	12,946	3,119	1,135	2,980
1947	4	1	0	0	0	0	6,032	(1,609)	5,559	2,202	958	594
1948	3	19	0	0	0	0	6,364	(1,517)	7,322	2,561	806	1,044
1949	3	449	0	0	0	0	5,709	(1,081)	7,100	2,272	842	1,191
1950	3	319	0	0	0	0	6,177	(1,212)	7,528	2,443	866	1,231
1951	2	5,184	0	0	0	0	7,131	1,567	19,847	3,789	1,430	5,356
1952	1	6,017	0	0	0	0	7,533	2,332	27,154	5,071	1,548	7,403
1953	3	2,568	0	0	0	0	6,801	(755)	15,854	4,132	1,084	3,377
1954	3	2,571	0	0	0	0	7,024	(1,203)	14,233	4,002	908	2,799
1955	4	701	0	0	0	0	6,077	(1,502)	6,170	2,283	844	781
1956	1	5,266	0	0	0	0	7,129	2,044	26,827	5,153	1,711	7,197
1957	3	931	0	0	0	0	6,761	(1,240)	9,695	2,963	964	1,723
1958	1	6,692	0	0	0	0	7,634	2,410	31,978	6,148	2,019	8,557
1959	4	1,805	0	0	0	0	6,103	(839)	9,803	2,770	997	1,931
1960	5	156	0	0	0	0	5,844	(1,661)	6,050	2,345	802	684
1961	5	222	0	0	0	0	5,768	(1,731)	6,003	2,371	763	640
1962	3	822	0	0	0	0	5,788	(967)	8,118	2,444	892	1,476
1963	2	3,051	0	0	0	0	7,129	(520)	18,205	4,546	1,021	4,025
1964	4	1,256	0	0	0	0	5,967	(1,447)	6,931	2,434	869	987
1965	1	3,152	0	0	0	0	6,732	652	19,806	4,282	1,246	4,935
1966	3	1,213	0	0	0	0	6,798	(1,380)	8,544	2,771	1,110	1,392
1967	1	4,457	0	0	0	0	7,625	1,162	21,014	4,278	1,729	5,440
1968	4	2,129	0	0	0	0	6,544	(1,080)	10,992	3,178	943	2,098
1969	1	6,435	0	0	0	0	7,306	4,789	28,667	4,081	3,097	8,870
1970	2	5,612	0	0	0	0	6,777	1,982	26,265	5,060	1,632	7,042
1971	3	2,998	0	0	0	0	6,965	(362)	16,462	4,058	993	3,696
1972	4	601	0	0	0	0	6,666	(1,896)	7,234	2,751	902	855
1973	2	4,137	0	0	0	0	6,919	660	19,041	4,090	1,204	4,750
1974	1	6,240	0	0	0	0	7,436	1,506	31,451	6,528	1,154	8,034
1975	1	2,723	0	0	0	0	7,596	(208)	15,848	3,831	1,176	3,623
1976	5	567	0	0	0	0	5,079	(1,367)	5,423	2,041	755	674
1977	5	0	0	0	0	0	3,053	(453)	3,657	1,129	676	676
1978	1	2,712	0	0	0	0	5,719	934	15,992	3,230	1,158	4,165
1979	2	1,050	0	0	0	0	6,485	(350)	9,570	2,443	1,220	2,093
1980	1	5,330	0	0	0	0	6,404	3,484	22,768	3,420	2,567	6,904
1981	4	777	0	0	0	0	6,477	(1,351)	7,698	2,559	1,068	1,208
1982	1	8,661	0	0	0	0	7,773	6,421	36,441	4,996	3,355	11,417
1983	1	21,445	0	0	0	0	8,377	18,602	61,152	4,091	9,324	22,693
1984	2	8,816	0	0	0	0	7,109	5,669	27,727	3,388	3,669	9,058
1985	4	1,574	0	0	0	0	6,239	(921)	8,171	2,431	1,103	1,511
1986	1	6,120	0	0	0	0	6,486	4,748	27,860	3,913	2,756	8,660
1987	5	67	0	0	0	0	5,844	(1,331)	5,852	2,119	919	788
1988	5	418	0	0	0	0	4,440	(980)	5,148	1,761	685	781
1989	5	228	0	0	0	0	5,296	(1,352)	6,626	2,310	646	957
1990	5	60	0	0	0	0	4,063	(835)	4,617	1,558	633	723
1991	5	4	0	0	0	0	3,804	(585)	4,857	1,478	634	892
Average		2,572	0	0	0	0	6,154	420	14,120	3,084	1,370	3,504

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A-4. Monthly Percentiles for DeltaSOS Simulations for the No-Project Alternative

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,288	3,326	5,072	4,844	4,073	3,147	2,791	2,395	1,076	1,818	537	3,271
10	5,125	5,385	7,368	8,686	6,384	4,525	3,571	3,114	5,464	3,427	3,448	3,592
20	6,854	6,640	7,842	10,935	7,285	6,095	3,789	3,538	5,568	6,446	4,730	5,890
30	7,992	7,372	9,922	11,372	9,184	7,956	4,189	3,928	5,766	7,379	5,083	6,051
40	8,500	8,383	10,868	11,428	11,137	10,191	5,623	4,859	5,923	8,865	5,864	6,359
50	9,055	10,670	11,176	11,562	11,633	11,268	6,573	5,685	6,313	10,505	6,324	6,518
60	9,710	11,280	11,246	11,732	12,009	11,323	7,380	6,754	6,543	11,280	7,174	6,685
70	11,280	11,280	11,298	11,849	12,462	11,461	8,476	7,487	7,026	11,280	7,966	7,409
80	11,280	11,280	11,393	12,266	12,700	11,499	9,203	8,673	8,448	11,280	9,615	10,062
90	11,280	11,280	11,503	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,965	9,107	10,138	11,205	10,487	9,420	6,697	6,209	6,974	8,952	6,847	7,147

Table 3A-5. Consumptive Water Use Estimated for the Delta Wetlands Project Alternatives

Alternative	Consumptive Water Use (TAF/yr)			Change in Consumptive Use in Relation to the No-Project Alternative
	Habitat Island ET[a]	Stored Water Evaporation	Total	
No-Project Alternative (17,500 irrigated acres)	44[b]	0	44	Not applicable
Alternative 1 (two reservoir and two habitat islands)	14	34	48	+4
Alternative 2 (two reservoir and two habitat islands)	14	23	37	-7
Alternative 3 (four reservoir islands)	0	54	54	+10
No-Project Alternative Cumulative	44[b]	0	44	Not applicable
Alternative 1 Cumulative	14	25	39	-5
Alternative 2 Cumulative	14	14	28	-16
Alternative 3 Cumulative	0	32	32	-12

[a] ET on habitat islands consists of ET from crops grown for habitat purposes plus ET from flooded wetlands.

[b] Represents total ET on all four Delta Wetlands Project islands under intensified agriculture; wildlife habitat is not specifically developed or managed under the No-Project Alternative.

Table 3A–6. DeltaSOS Mean Annual Simulation Output for Alternative 1

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	2	1,073	238	257	225	0	6,614	363	11,860	2,587	1,587	2,950	(5,526)
1923	3	2,239	238	246	241	0	6,726	(75)	10,263	2,454	1,369	2,379	(5,852)
1924	5	3	3	3	0	0	4,558	(1,149)	4,161	1,627	825	478	(4,391)
1925	4	774	222	246	183	0	5,987	(982)	7,977	2,415	852	1,433	(5,612)
1926	4	432	238	260	203	0	5,950	(1,309)	6,750	2,312	877	1,003	(5,610)
1927	1	2,854	238	277	239	0	6,857	(441)	17,003	4,224	1,038	3,783	(6,297)
1928	2	2,473	238	252	207	0	6,953	(946)	13,606	3,712	996	2,766	(6,504)
1929	5	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	4	281	238	238	203	0	5,218	(1,264)	6,002	2,114	764	850	(5,013)
1931	5	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	4	148	150	148	142	0	4,439	11	5,553	1,309	943	1,320	(4,009)
1933	5	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	5	121	123	121	92	0	3,849	(564)	4,712	1,432	805	868	(3,644)
1935	3	617	238	248	206	0	6,198	(686)	9,163	2,531	1,100	1,845	(5,596)
1936	3	1,433	238	243	208	0	6,392	(138)	10,603	2,566	1,192	2,428	(5,663)
1937	3	934	238	259	214	0	6,115	522	9,383	1,920	1,494	2,442	(5,066)
1938	1	8,837	238	431	225	0	7,448	4,478	35,514	5,845	3,087	10,323	(4,735)
1939	4	552	238	84	202	0	5,995	(1,299)	5,564	2,035	995	736	(5,626)
1940	2	2,660	238	248	209	0	6,676	(195)	17,381	4,173	1,046	3,978	(6,032)
1941	1	5,968	238	249	219	0	6,887	2,307	29,885	5,717	2,157	8,025	(5,077)
1942	1	5,142	238	252	219	0	7,459	1,251	26,227	5,448	1,534	6,698	(6,371)
1943	1	4,700	238	246	214	0	6,944	1,851	19,334	3,516	1,611	5,367	(5,831)
1944	4	50	43	50	36	0	6,031	(1,281)	6,405	2,217	984	936	(5,609)
1945	3	880	238	253	201	0	6,667	(829)	8,079	2,359	1,254	1,530	(5,947)
1946	3	2,353	238	247	242	0	6,558	(338)	12,747	3,181	1,139	2,843	(5,993)
1947	4	9	5	9	0	0	6,039	(1,599)	5,568	2,199	958	600	(5,693)
1948	3	27	18	27	0	0	6,364	(1,519)	7,320	2,562	806	1,043	(6,138)
1949	4	449	238	233	201	0	5,922	(1,301)	6,880	2,341	842	1,040	(5,669)
1950	3	327	238	248	208	0	6,388	(1,438)	7,302	2,514	866	1,076	(6,111)
1951	2	5,187	238	253	204	0	7,333	1,341	19,621	3,860	1,430	5,201	(6,376)
1952	1	6,016	238	506	224	0	7,765	1,842	26,665	5,224	1,548	7,067	(6,626)
1953	1	2,567	238	6	206	0	7,018	(747)	15,861	4,130	1,084	3,382	(6,489)
1954	2	2,577	238	315	271	0	7,307	(1,504)	13,931	4,097	908	2,592	(7,006)
1955	4	709	238	249	213	0	6,292	(1,729)	5,943	2,354	844	625	(6,003)
1956	1	5,267	238	262	212	0	7,339	1,809	26,592	5,226	1,711	7,035	(6,049)
1957	2	940	238	488	444	0	7,213	(1,711)	9,224	3,111	964	1,400	(6,828)
1958	1	6,698	238	493	225	0	7,868	1,933	31,501	6,297	2,019	8,230	(6,167)
1959	3	1,811	238	219	425	0	6,543	(1,048)	9,595	2,835	997	1,787	(6,138)
1960	4	159	145	159	116	0	5,971	(1,807)	5,903	2,390	802	583	(5,769)
1961	4	227	205	227	173	0	5,950	(1,942)	5,791	2,437	763	495	(5,773)
1962	3	827	222	246	190	0	5,989	(1,199)	7,886	2,516	892	1,318	(5,631)
1963	1	3,055	238	264	224	0	7,363	(770)	17,955	4,624	1,021	3,854	(6,786)
1964	4	1,263	238	337	294	0	6,270	(1,768)	6,610	2,534	869	766	(6,015)
1965	1	3,157	238	253	216	0	6,964	408	19,562	4,359	1,246	4,767	(6,237)
1966	3	1,218	238	248	199	0	7,006	(1,612)	8,312	2,844	1,110	1,232	(6,478)
1967	1	4,461	238	498	226	0	7,853	687	20,539	4,427	1,729	5,113	(6,515)
1968	3	2,134	238	23	208	0	6,763	(1,090)	10,982	3,181	943	2,091	(6,401)
1969	1	6,436	238	497	225	0	7,538	4,309	28,188	4,231	3,097	8,541	(4,853)
1970	1	5,616	238	16	207	0	6,995	1,978	26,262	5,062	1,632	7,040	(5,866)
1971	1	3,002	238	456	431	0	7,405	(802)	16,022	4,196	993	3,393	(6,939)
1972	3	609	238	273	235	0	6,908	(2,152)	6,978	2,832	902	679	(6,642)
1973	2	4,138	238	263	218	0	7,150	408	18,790	4,169	1,204	4,577	(6,293)
1974	1	6,244	238	433	206	0	7,649	1,091	31,036	6,658	1,154	7,749	(6,978)
1975	1	2,724	238	124	212	0	7,816	(316)	15,740	3,864	1,176	3,549	(7,174)
1976	5	567	238	195	232	0	5,326	(1,554)	5,237	2,099	755	546	(5,230)
1977	5	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2	2,713	238	243	213	0	5,941	708	15,765	3,301	1,158	4,009	(5,160)
1979	3	1,050	238	432	393	0	6,891	(770)	9,150	2,575	1,220	1,805	(6,180)
1980	2	5,331	238	246	210	0	6,594	3,282	22,566	3,483	2,567	6,766	(4,459)
1981	4	782	238	256	217	0	6,706	(1,592)	7,456	2,635	1,068	1,042	(6,237)
1982	1	8,660	238	522	235	0	8,016	5,916	35,935	5,154	3,355	11,070	(4,988)
1983	1	21,447	238	49	0	0	8,377	18,578	61,128	4,099	9,324	22,677	760
1984	1	8,815	238	11	201	0	7,280	5,714	27,771	3,374	3,669	9,088	(4,156)
1985	4	1,578	238	242	199	0	6,450	(1,150)	7,942	2,503	1,103	1,353	(5,888)
1986	1	6,120	238	250	213	0	6,707	4,514	27,626	3,986	2,756	8,500	(4,314)
1987	4	72	68	72	58	0	5,912	(1,389)	5,794	2,137	919	748	(5,606)
1988	5	417	237	234	205	0	4,660	(1,205)	4,923	1,831	685	626	(4,551)
1989	4	236	232	236	204	0	5,504	(1,567)	6,411	2,377	646	810	(5,451)
1990	5	60	61	60	46	0	4,123	(884)	4,568	1,573	633	690	(4,081)
1991	5	4	4	4	0	0	3,824	(585)	4,858	1,477	634	893	(3,788)
Average		2,575	198	222	188	0	6,350	215	13,915	3,148	1,370	3,363	(5,499)

Notes: Definitions of the categories are provided in Table A2–3 in Appendix 2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A-7. Monthly Percentiles for DeltaSOS Simulations for Alternative 1

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	15	0	0	0	0	0	0	0	0
50	0	0	13	15	30	49	0	0	0	0	0	0
60	0	25	13	15	31	49	0	0	0	85	0	0
70	53	25	13	222	31	49	0	0	0	86	0	0
80	1,020	906	384	1,065	31	49	76	99	0	86	0	0
90	3,019	4,000	1,744	3,326	2,465	76	76	99	37	86	67	734
100	3,871	4,000	3,871	3,871	4,000	3,871	192	297	118	130	115	4,000
Mean	641	698	502	691	438	216	24	29	12	43	10	379

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	(0)	0	0	(0)	(0)	0	(0)	(0)	(0)
10	0	0	0	0	0	0	0	0	0	(0)	(0)	(0)
20	0	0	0	0	14	56	7	0	0	0	0	0
30	0	0	0	61	174	218	151	110	86	0	0	0
40	0	0	2	236	233	232	196	148	131	5	0	0
50	0	0	148	238	236	235	229	176	155	34	0	0
60	0	196	225	238	238	238	234	209	185	88	0	0
70	39	238	238	238	238	238	234	227	194	138	0	0
80	201	238	238	238	238	238	238	232	225	161	6	0
90	238	238	238	238	238	238	238	238	233	183	80	164
100	238	238	238	238	238	238	238	238	238	238	238	238
Mean	65	105	122	162	175	181	167	148	135	75	23	26

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	433	0
70	0	0	0	0	0	0	0	411	0	1,141	987	0
80	0	0	0	0	0	0	616	480	136	2,614	1,888	0
90	0	0	352	0	0	0	768	827	586	3,291	2,679	1,195
100	0	515	3,335	2,708	4,000	2,691	1,332	1,843	2,822	3,741	3,755	3,379
Mean	0	12	215	39	174	78	204	259	130	910	796	304

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,075	4,123	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,351	9,055	6,407	4,723	3,810	3,327	5,500	6,208	3,607	3,617
20	6,844	6,628	8,569	11,036	7,754	6,095	4,662	3,956	5,568	7,611	4,790	5,966
30	7,982	7,360	10,426	11,372	9,746	8,217	4,975	4,464	5,804	10,052	5,143	6,100
40	8,490	8,371	11,114	11,428	11,320	10,191	5,753	5,424	6,202	11,280	6,824	6,405
50	9,045	10,658	11,281	11,562	11,663	11,268	6,573	6,064	6,595	11,280	8,279	6,626
60	9,700	11,280	11,315	11,732	12,097	11,340	7,380	6,581	6,968	11,280	9,116	7,589
70	11,280	11,280	11,399	11,849	12,506	11,461	8,428	7,882	7,148	11,280	10,296	9,087
80	11,280	11,280	11,472	12,266	12,700	11,499	9,203	9,437	8,756	11,280	11,280	10,268
90	11,280	11,280	11,658	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,958	9,113	10,343	11,247	10,664	9,506	6,886	6,484	7,125	9,902	7,694	7,472

Table 3A-8. DeltaSOS Mean Annual Simulation Output for Alternative 2

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3-Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	2	1,073	238	257	225	0	6,614	363	11,860	2,587	1,587	2,950	(5,526)
1923	3	2,239	238	246	252	0	6,737	(75)	10,263	2,454	1,369	2,379	(5,862)
1924	5	3	3	3	2	0	4,559	(1,149)	4,161	1,627	825	478	(4,393)
1925	4	774	222	246	200	0	6,003	(982)	7,977	2,415	852	1,433	(5,629)
1926	4	432	238	260	230	0	5,976	(1,309)	6,750	2,312	877	1,003	(5,637)
1927	1	2,854	238	261	237	0	6,854	(424)	17,019	4,219	1,038	3,794	(6,295)
1928	2	2,473	238	287	260	0	7,006	(981)	13,571	3,723	996	2,742	(6,557)
1929	5	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	4	281	238	244	259	0	5,273	(1,270)	5,996	2,116	764	845	(5,069)
1931	5	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	4	148	150	148	151	0	4,447	11	5,553	1,309	943	1,320	(4,018)
1933	5	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	5	121	123	121	132	0	3,889	(564)	4,712	1,432	805	868	(3,683)
1935	3	617	238	351	350	0	6,342	(789)	9,060	2,563	1,100	1,774	(5,740)
1936	3	1,433	238	243	222	0	6,407	(138)	10,603	2,566	1,192	2,428	(5,678)
1937	3	934	238	259	218	0	6,120	522	9,383	1,920	1,494	2,442	(5,071)
1938	1	8,837	238	431	225	0	7,448	4,478	35,514	5,845	3,087	10,323	(4,735)
1939	4	552	238	84	250	0	6,043	(1,299)	5,564	2,035	995	736	(5,674)
1940	2	2,660	238	248	227	0	6,694	(195)	17,381	4,173	1,046	3,978	(6,050)
1941	1	5,968	238	249	224	0	6,893	2,307	29,885	5,717	2,157	8,025	(5,083)
1942	1	5,142	238	260	227	0	7,467	1,242	26,218	5,450	1,534	6,692	(6,379)
1943	1	4,700	238	246	225	0	6,955	1,851	19,334	3,516	1,611	5,367	(5,841)
1944	4	50	43	50	39	0	6,034	(1,281)	6,405	2,217	984	936	(5,612)
1945	3	880	238	253	202	0	6,668	(829)	8,079	2,359	1,254	1,530	(5,948)
1946	3	2,353	238	247	252	0	6,568	(338)	12,747	3,181	1,139	2,843	(6,003)
1947	4	9	5	9	0	0	6,039	(1,599)	5,568	2,199	958	600	(5,693)
1948	3	27	18	27	7	0	6,370	(1,519)	7,320	2,562	806	1,043	(6,145)
1949	4	449	238	233	221	0	5,942	(1,301)	6,880	2,341	842	1,040	(5,689)
1950	3	327	238	248	203	0	6,383	(1,438)	7,302	2,514	866	1,076	(6,106)
1951	2	5,187	238	253	223	0	7,352	1,341	19,621	3,860	1,430	5,201	(6,396)
1952	1	6,016	238	503	220	0	7,761	1,846	26,669	5,223	1,548	7,070	(6,623)
1953	1	2,567	238	6	227	0	7,039	(747)	15,861	4,130	1,084	3,382	(6,511)
1954	2	2,577	238	289	264	0	7,300	(1,479)	13,956	4,089	908	2,610	(7,000)
1955	4	709	238	249	246	0	6,326	(1,729)	5,943	2,354	844	625	(6,037)
1956	1	5,267	238	270	220	0	7,348	1,800	26,583	5,229	1,711	7,029	(6,057)
1957	2	940	238	488	455	0	7,224	(1,711)	9,224	3,111	964	1,400	(6,839)
1958	1	6,698	238	493	225	0	7,868	1,933	31,501	6,297	2,019	8,230	(6,167)
1959	3	1,811	238	192	400	0	6,518	(1,021)	9,621	2,827	997	1,806	(6,113)
1960	4	159	145	159	141	0	5,996	(1,807)	5,903	2,390	802	583	(5,794)
1961	4	227	205	227	198	0	5,974	(1,942)	5,791	2,437	763	495	(5,798)
1962	3	827	222	246	201	0	6,000	(1,199)	7,886	2,516	892	1,318	(5,642)
1963	1	3,055	238	256	220	0	7,358	(761)	17,964	4,621	1,021	3,860	(6,782)
1964	4	1,263	238	312	306	0	6,281	(1,743)	6,635	2,526	869	784	(6,027)
1965	1	3,157	238	429	401	0	7,150	232	19,385	4,414	1,246	4,646	(6,423)
1966	3	1,218	238	248	202	0	7,009	(1,612)	8,312	2,844	1,110	1,232	(6,482)
1967	1	4,461	238	498	226	0	7,853	687	20,539	4,427	1,729	5,113	(6,515)
1968	3	2,134	238	23	207	0	6,763	(1,090)	10,982	3,181	943	2,091	(6,400)
1969	1	6,436	238	497	225	0	7,538	4,309	28,188	4,231	3,097	8,541	(4,853)
1970	1	5,616	238	16	207	0	6,996	1,978	26,262	5,062	1,632	7,040	(5,866)
1971	1	3,002	238	406	375	0	7,349	(752)	16,072	4,180	993	3,428	(6,884)
1972	3	609	238	322	289	0	6,962	(2,201)	6,929	2,847	902	646	(6,696)
1973	2	4,138	238	253	217	0	7,149	418	18,800	4,166	1,204	4,584	(6,292)
1974	1	6,244	238	433	217	0	7,661	1,091	31,036	6,658	1,154	7,749	(6,989)
1975	1	2,724	238	124	213	0	7,818	(316)	15,740	3,864	1,176	3,549	(7,176)
1976	5	567	238	195	231	0	5,326	(1,554)	5,237	2,099	755	546	(5,230)
1977	5	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2	2,713	238	243	228	0	5,955	708	15,765	3,301	1,158	4,009	(5,174)
1979	3	1,050	238	432	405	0	6,903	(770)	9,150	2,575	1,220	1,805	(6,192)
1980	2	5,331	238	246	220	0	6,605	3,283	22,567	3,483	2,567	6,766	(4,470)
1981	4	782	238	293	258	0	6,747	(1,630)	7,418	2,647	1,068	1,017	(6,278)
1982	1	8,660	238	509	221	0	8,002	5,930	35,949	5,150	3,355	11,080	(4,974)
1983	1	21,447	238	49	0	0	8,377	18,578	61,128	4,099	9,324	22,677	760
1984	1	8,815	238	11	201	0	7,280	5,714	27,771	3,374	3,669	9,088	(4,156)
1985	4	1,578	238	242	248	0	6,499	(1,150)	7,942	2,503	1,103	1,353	(5,937)
1986	1	6,120	238	250	227	0	6,722	4,514	27,626	3,986	2,756	8,500	(4,328)
1987	4	72	68	72	50	0	5,904	(1,389)	5,794	2,137	919	748	(5,598)
1988	5	417	237	234	244	0	4,700	(1,205)	4,923	1,831	685	626	(4,590)
1989	4	236	232	236	205	0	5,504	(1,567)	6,411	2,377	646	810	(5,452)
1990	5	60	61	60	64	0	4,141	(884)	4,568	1,573	633	690	(4,099)
1991	5	4	4	4	0	0	3,824	(585)	4,858	1,477	634	893	(3,788)
Average		2,575	198	225	202	0	6,364	212	13,912	3,149	1,370	3,361	(5,514)

Notes: Definitions of the categories are provided in Table A2-3 in Appendix 2.
Water-year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A-9. Monthly Percentiles for DeltaSOS Simulations for Alternative 2

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	15	0	0	0	0	0	0	0	0
50	0	0	13	15	30	49	0	0	0	0	0	0
60	0	25	13	15	31	49	0	0	0	85	0	0
70	53	25	13	90	31	49	0	0	0	86	0	0
80	1,020	906	384	990	31	49	76	99	0	86	0	0
90	3,019	4,000	1,744	3,326	2,465	657	76	99	37	86	67	734
100	3,871	4,000	3,871	3,871	4,000	3,871	3,125	312	118	130	115	4,000
Mean	641	698	502	658	438	236	92	31	12	43	10	379

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	(0)	(0)	(0)	0	0	(0)	(0)	(0)	(0)
10	0	0	0	0	0	0	0	0	(0)	0	(0)	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	61	14	0	0	0	0	0	0	0
40	0	0	2	226	145	15	30	8	0	0	0	0
50	0	0	174	238	222	226	200	99	0	5	0	0
60	0	196	233	238	238	238	225	169	0	5	0	0
70	39	238	238	238	238	238	234	204	62	5	0	0
80	201	238	238	238	238	238	238	232	147	28	0	0
90	238	238	238	238	238	238	238	238	233	137	4	164
100	238	238	238	238	238	238	238	238	238	238	238	238
Mean	65	105	125	161	147	133	130	111	61	30	9	26

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	266	114	0	0	0
80	0	0	0	0	1,065	181	0	457	2,228	443	0	0
90	0	0	123	0	3,353	2,309	414	880	3,283	2,614	933	0
100	0	515	3,335	2,721	4,000	3,822	1,053	3,771	3,780	3,741	3,755	2,861
Mean	0	12	176	54	667	437	81	283	783	497	293	79

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,090	3,469	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,351	9,055	7,140	4,750	3,622	3,174	5,500	4,447	3,508	3,617
20	6,844	6,628	8,569	11,101	9,758	6,363	3,840	3,781	5,568	6,887	4,790	5,915
30	7,982	7,360	10,426	11,380	11,332	10,265	4,414	4,296	5,804	8,729	5,143	6,076
40	8,490	8,371	11,114	11,444	11,633	11,268	5,623	5,362	6,321	10,396	6,183	6,393
50	9,045	10,658	11,265	11,568	11,941	11,268	6,573	6,047	7,001	11,280	7,118	6,568
60	9,700	11,280	11,280	11,768	12,048	11,461	7,380	7,176	8,380	11,280	7,889	6,822
70	11,280	11,280	11,295	11,873	12,462	11,461	8,476	8,380	9,733	11,280	9,116	8,100
80	11,280	11,280	11,393	12,266	12,700	11,499	9,203	9,410	10,551	11,280	10,293	10,087
90	11,280	11,280	11,503	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,958	9,113	10,304	11,261	11,156	9,864	6,764	6,508	7,778	9,489	7,192	7,248

Table 3A–10. DeltaSOS Mean Annual Simulation Output for Alternative 3

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	2	1,073	406	462	368	0	6,773	167	11,664	2,648	1,587	2,816	(5,685)
1923	3	2,247	406	426	424	0	6,916	(236)	10,101	2,504	1,369	2,268	(6,042)
1924	5	4	4	4	0	0	4,579	(1,144)	4,166	1,626	825	482	(4,412)
1925	4	779	333	371	289	0	6,110	(1,099)	7,861	2,452	852	1,353	(5,735)
1926	4	436	383	423	336	0	6,098	(1,463)	6,596	2,360	877	897	(5,759)
1927	1	2,857	406	437	374	0	7,009	(591)	16,852	4,271	1,038	3,680	(6,450)
1928	2	2,476	406	467	390	0	7,151	(1,150)	13,402	3,776	996	2,626	(6,702)
1929	5	0	0	0	0	0	4,604	(901)	4,558	1,581	851	681	(4,359)
1930	4	281	275	281	296	0	5,333	(1,303)	5,963	2,126	764	823	(5,128)
1931	5	0	0	0	0	0	3,363	(297)	3,692	1,050	831	753	(3,142)
1932	4	148	149	148	146	0	4,464	15	5,556	1,308	943	1,323	(4,035)
1933	5	0	0	0	0	0	3,722	(344)	4,295	1,216	853	872	(3,486)
1934	5	121	123	121	130	0	3,910	(560)	4,716	1,431	805	871	(3,704)
1935	3	621	369	484	457	0	6,465	(912)	8,937	2,602	1,100	1,690	(5,863)
1936	3	1,436	406	419	352	0	6,554	(306)	10,435	2,618	1,192	2,312	(5,825)
1937	3	934	406	439	371	0	6,294	347	9,208	1,974	1,494	2,321	(5,245)
1938	1	8,844	406	626	368	0	7,601	4,298	35,334	5,901	3,087	10,199	(4,888)
1939	4	559	406	255	412	0	6,215	(1,454)	5,409	2,084	995	629	(5,846)
1940	2	2,663	406	428	361	0	6,848	(370)	17,206	4,228	1,046	3,858	(6,204)
1941	1	5,971	406	430	374	0	7,058	2,136	29,714	5,771	2,157	7,907	(5,249)
1942	1	5,146	406	446	370	0	7,620	1,072	26,048	5,504	1,534	6,576	(6,532)
1943	1	4,700	406	424	382	0	7,128	1,682	19,165	3,569	1,611	5,251	(6,014)
1944	4	54	43	54	36	0	6,049	(1,277)	6,408	2,216	984	939	(5,627)
1945	3	880	406	441	335	0	6,819	(1,010)	7,898	2,416	1,254	1,406	(6,099)
1946	3	2,359	406	418	416	0	6,744	(495)	12,590	3,230	1,139	2,735	(6,180)
1947	4	17	10	17	0	0	6,053	(1,596)	5,572	2,198	958	603	(5,707)
1948	3	35	18	35	4	0	6,378	(1,512)	7,327	2,560	806	1,048	(6,153)
1949	4	449	369	362	336	0	6,077	(1,424)	6,757	2,379	842	955	(5,824)
1950	3	335	309	335	242	0	6,435	(1,511)	7,228	2,537	866	1,026	(6,158)
1951	2	5,197	406	432	353	0	7,495	1,174	19,455	3,912	1,430	5,087	(6,538)
1952	1	6,021	406	715	370	0	7,922	1,649	26,471	5,285	1,548	6,934	(6,783)
1953	1	2,569	406	154	345	0	7,169	(881)	15,728	4,172	1,084	3,291	(6,640)
1954	2	2,581	406	471	393	0	7,444	(1,649)	13,786	4,142	908	2,493	(7,143)
1955	4	719	406	423	404	0	6,488	(1,881)	5,790	2,402	839	521	(6,204)
1956	1	5,272	406	453	363	0	7,504	1,630	26,413	5,283	1,711	6,912	(6,214)
1957	2	947	406	711	624	0	7,405	(1,921)	9,014	3,176	964	1,256	(7,020)
1958	1	6,701	406	685	368	0	8,018	1,759	31,328	6,352	2,019	8,110	(6,318)
1959	3	1,815	406	367	531	0	6,660	(1,181)	9,461	2,877	997	1,696	(6,254)
1960	4	166	145	166	139	0	6,010	(1,803)	5,907	2,389	802	586	(5,807)
1961	4	231	205	231	195	0	5,989	(1,938)	5,795	2,436	763	498	(5,812)
1962	3	832	333	371	293	0	6,109	(1,315)	7,769	2,553	892	1,237	(5,752)
1963	1	3,057	406	440	363	0	7,512	(930)	17,795	4,674	1,021	3,744	(6,935)
1964	4	1,274	406	491	469	0	6,454	(1,905)	6,472	2,577	869	672	(6,199)
1965	1	3,163	406	594	522	0	7,287	77	19,230	4,463	1,246	4,539	(6,560)
1966	3	1,225	406	425	334	0	7,149	(1,772)	8,152	2,894	1,110	1,123	(6,622)
1967	1	4,468	406	694	316	0	7,952	508	20,360	4,483	1,729	4,991	(6,613)
1968	3	2,138	406	145	335	0	6,901	(1,196)	10,876	3,214	943	2,018	(6,538)
1969	1	6,436	406	806	368	0	7,694	4,013	27,892	4,324	3,097	8,337	(5,009)
1970	1	5,623	406	80	344	0	7,142	1,931	26,215	5,076	1,632	7,008	(6,013)
1971	1	3,009	406	593	498	0	7,484	(925)	15,899	4,234	993	3,309	(7,018)
1972	3	617	406	487	388	0	7,070	(2,349)	6,781	2,893	902	544	(6,805)
1973	2	4,138	406	427	371	0	7,321	253	18,634	4,218	1,204	4,470	(6,463)
1974	1	6,251	406	615	347	0	7,802	924	30,869	6,711	1,154	7,634	(7,130)
1975	1	2,727	406	310	356	0	7,968	(484)	15,572	3,917	1,176	3,433	(7,327)
1976	5	567	406	363	393	0	5,505	(1,712)	5,078	2,149	755	437	(5,408)
1977	5	0	0	0	0	0	3,103	(453)	3,657	1,129	676	676	(3,077)
1978	2	2,713	406	420	365	0	6,115	534	15,591	3,356	1,158	3,890	(5,334)
1979	3	1,052	406	607	531	0	7,045	(936)	8,984	2,627	1,220	1,691	(6,333)
1980	2	5,331	406	417	373	0	6,774	3,121	22,405	3,534	2,567	6,655	(4,639)
1981	4	786	406	467	384	0	6,884	(1,790)	7,258	2,697	1,068	906	(6,416)
1982	1	8,665	406	815	344	0	8,136	5,639	35,658	5,241	3,355	10,880	(5,108)
1983	1	21,455	406	136	0	0	8,377	18,517	61,067	4,118	9,324	22,635	760
1984	1	8,820	406	22	334	0	7,423	5,718	27,775	3,373	3,669	9,091	(4,299)
1985	4	1,584	406	419	407	0	6,668	(1,311)	7,781	2,553	1,103	1,243	(6,106)
1986	1	6,124	406	442	379	0	6,889	4,332	27,444	4,043	2,756	8,374	(4,495)
1987	4	76	68	76	46	0	5,915	(1,382)	5,801	2,135	919	753	(5,609)
1988	5	419	369	366	373	0	4,848	(1,331)	4,797	1,871	685	540	(4,738)
1989	4	244	232	244	174	0	5,487	(1,562)	6,416	2,375	646	813	(5,434)
1990	5	60	61	60	62	0	4,161	(880)	4,572	1,572	633	692	(4,119)
1991	5	4	4	4	0	0	3,848	(583)	4,859	1,477	634	894	(3,812)
Average		2,579	321	356	302	0	6,479	92	13,792	3,186	1,369	3,279	(5,628)

Notes: Definitions of the categories are provided in Table A2–3 in Appendix A2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A-11. Monthly Percentiles for DeltaSOS Simulations for Alternative 3

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	29	0	0	0	0	0	0	0	0
50	0	0	26	29	59	98	0	0	0	0	0	0
60	0	50	26	102	61	98	0	0	0	157	0	0
70	106	235	822	632	61	98	0	0	0	158	0	0
80	2,452	2,434	1,111	1,593	704	98	151	198	0	158	0	0
90	3,763	5,702	4,227	3,326	3,207	773	151	198	37	158	123	778
100	6,000	6,000	6,000	6,000	6,000	6,000	3,000	484	235	260	231	6,000
Mean	996	1,152	964	976	761	322	110	55	24	80	19	445

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	(0)	(0)	(0)	0	0	(0)	(0)	(0)	(0)
10	0	0	0	0	0	(0)	0	0	(0)	0	0	0
20	0	0	0	0	1	0	0	0	0	0	0	0
30	0	0	0	102	107	0	0	0	0	0	0	0
40	0	0	5	275	265	123	129	102	0	10	0	0
50	0	0	248	369	337	364	360	234	37	10	0	0
60	0	197	369	406	406	406	387	312	95	31	0	0
70	42	357	402	406	406	406	397	368	209	66	0	0
80	201	406	406	406	406	406	406	394	298	160	8	0
90	406	406	406	406	406	406	406	406	394	275	64	166
100	406	406	406	406	406	406	406	406	406	406	406	406
Mean	94	161	208	263	259	232	227	206	127	76	21	34

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	139	0	271	1,018	0	323	0
80	0	0	0	0	1,184	1,104	29	416	3,283	1,460	873	0
90	0	0	123	0	3,530	2,568	416	839	4,674	2,677	3,435	695
100	425	473	3,740	2,717	6,000	4,975	1,030	3,000	4,899	6,000	5,237	3,917
Mean	6	10	179	58	784	678	91	270	1,187	777	777	191

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,329	3,356	5,087	4,862	6,108	3,360	2,865	2,496	1,207	1,968	653	3,340
10	5,166	5,415	7,387	9,055	7,109	4,810	3,645	3,215	5,500	5,172	3,564	3,661
20	6,895	6,670	8,605	11,101	10,454	7,142	3,873	3,781	5,613	7,470	4,957	5,959
30	8,033	7,402	10,462	11,380	11,632	11,079	4,797	4,300	5,864	9,807	5,199	6,144
40	8,541	8,413	11,176	11,460	11,663	11,268	5,623	5,456	6,550	11,280	7,214	6,449
50	9,096	10,700	11,259	11,578	12,009	11,268	6,573	6,047	8,152	11,280	8,082	6,614
60	9,751	11,280	11,280	11,768	12,097	11,461	7,380	7,176	9,645	11,280	8,944	7,028
70	11,280	11,280	11,298	11,873	12,462	11,461	8,476	8,380	11,280	11,280	10,217	8,266
80	11,280	11,280	11,393	12,266	12,700	11,574	9,203	9,410	11,280	11,280	11,280	10,514
90	11,280	11,280	11,503	12,700	12,700	11,700	9,950	9,950	11,280	11,280	11,280	11,280
100	11,280	11,280	11,700	12,700	12,700	11,700	11,280	11,280	11,280	11,280	11,280	11,280
Mean	8,998	9,134	10,323	11,267	11,275	10,104	6,783	6,517	8,199	9,806	7,723	7,398

Table 3A-12. DeltaSOS Mean Annual Simulation Output for the No-Project Alternative under Cumulative Conditions

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3-Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)
1922	2	276	0	0	0	0	7,177	(193)	11,304	2,761	1,587	2,568
1923	3	1,512	0	0	0	0	7,210	(579)	9,759	2,612	1,369	2,033
1924	5	0	0	0	0	0	4,542	(1,154)	4,155	1,629	825	475
1925	4	597	0	0	0	0	5,969	(926)	8,033	2,398	852	1,471
1926	4	201	0	0	0	0	5,966	(1,294)	6,765	2,307	877	1,013
1927	1	1,964	0	0	0	0	7,494	(1,065)	16,379	4,419	1,038	3,355
1928	2	1,823	0	0	0	0	7,374	(1,347)	13,205	3,838	996	2,491
1929	5	0	0	0	0	0	4,564	(911)	4,548	1,585	851	673
1930	4	85	0	0	0	0	5,196	(1,233)	6,033	2,104	764	871
1931	5	0	0	0	0	0	3,327	(312)	3,677	1,054	831	743
1932	4	0	0	0	0	0	4,420	10	5,552	1,309	943	1,320
1933	5	0	0	0	0	0	3,678	(351)	4,288	1,218	853	867
1934	5	0	0	0	0	0	3,855	(566)	4,710	1,433	805	867
1935	3	335	0	0	0	0	6,263	(734)	9,115	2,546	1,100	1,812
1936	3	1,139	0	0	0	0	6,487	(223)	10,518	2,592	1,192	2,370
1937	3	657	0	0	0	0	6,167	491	9,352	1,929	1,494	2,420
1938	1	7,361	0	0	0	0	8,687	3,419	34,455	6,176	3,087	9,596
1939	4	203	0	0	0	0	6,127	(1,574)	5,289	2,121	995	547
1940	2	2,037	0	0	0	0	7,070	(575)	17,001	4,292	1,046	3,717
1941	1	5,154	0	0	0	0	7,473	1,727	29,305	5,899	2,157	7,627
1942	1	4,079	0	0	0	0	8,293	425	25,401	5,706	1,534	6,132
1943	1	3,663	0	0	0	0	7,749	1,053	18,536	3,766	1,611	4,819
1944	4	0	0	0	0	0	6,031	(1,292)	6,394	2,221	984	929
1945	3	656	0	0	0	0	6,712	(847)	8,062	2,365	1,254	1,518
1946	3	1,793	0	0	0	0	6,895	(695)	12,390	3,293	1,135	2,598
1947	4	0	0	0	0	0	6,033	(1,609)	5,558	2,203	958	593
1948	3	0	0	0	0	0	6,382	(1,536)	7,303	2,567	806	1,031
1949	4	254	0	0	0	0	5,903	(1,275)	6,906	2,333	842	1,057
1950	3	21	0	0	0	0	6,475	(1,509)	7,230	2,536	866	1,027
1951	2	4,503	0	0	0	0	7,812	886	19,166	4,003	1,430	4,889
1952	1	4,681	0	0	0	0	8,868	997	25,819	5,490	1,548	6,486
1953	1	1,918	0	0	0	0	7,451	(1,405)	15,204	4,336	1,084	2,931
1954	2	1,496	0	0	0	0	8,099	(2,278)	13,158	4,339	908	2,061
1955	4	319	0	0	0	0	6,459	(1,884)	5,788	2,403	839	519
1956	1	4,550	0	0	0	0	7,846	1,328	26,111	5,377	1,711	6,705
1957	2	361	0	0	0	0	7,332	(1,811)	9,125	3,142	964	1,331
1958	1	5,027	0	0	0	0	9,299	744	30,313	6,670	2,019	7,414
1959	3	1,191	0	0	0	0	6,717	(1,453)	9,189	2,962	997	1,509
1960	4	0	0	0	0	0	6,000	(1,817)	5,894	2,393	802	576
1961	4	45	0	0	0	0	5,945	(1,908)	5,825	2,427	763	518
1962	3	679	0	0	0	0	5,932	(1,111)	7,974	2,489	892	1,378
1963	1	2,088	0	0	0	0	8,092	(1,484)	17,242	4,847	1,021	3,364
1964	4	756	0	0	0	0	6,467	(1,947)	6,431	2,590	869	644
1965	1	2,633	0	0	0	0	7,252	133	19,286	4,445	1,246	4,578
1966	3	726	0	0	0	0	7,285	(1,867)	8,057	2,924	1,110	1,057
1967	1	3,092	0	0	0	0	8,990	(203)	19,649	4,706	1,729	4,503
1968	3	1,224	0	0	0	0	7,449	(1,985)	10,087	3,462	943	1,477
1969	1	5,106	0	0	0	0	8,636	3,459	27,337	4,498	3,097	7,957
1970	1	4,600	0	0	0	0	7,789	969	25,253	5,378	1,632	6,347
1971	1	2,192	0	0	0	0	7,771	(1,168)	15,656	4,310	993	3,142
1972	3	76	0	0	0	0	7,190	(2,421)	6,709	2,916	902	495
1973	2	3,238	0	0	0	0	7,818	(240)	18,142	4,372	1,204	4,132
1974	1	5,056	0	0	0	0	8,619	323	30,268	6,899	1,154	7,222
1975	1	1,805	0	0	0	0	8,513	(1,125)	14,930	4,118	1,176	2,993
1976	5	131	0	0	0	0	5,515	(1,803)	4,987	2,178	755	374
1977	5	0	0	0	0	0	3,053	(453)	3,657	1,129	676	676
1978	2	2,135	0	0	0	0	6,295	358	15,415	3,411	1,158	3,769
1979	3	488	0	0	0	0	7,047	(913)	9,007	2,620	1,220	1,707
1980	2	4,573	0	0	0	0	7,161	2,727	22,011	3,657	2,567	6,384
1981	4	271	0	0	0	0	6,984	(1,857)	7,191	2,718	1,068	861
1982	1	7,155	0	0	0	0	9,279	4,916	34,935	5,468	3,355	10,384
1983	1	19,190	0	0	0	0	10,631	16,348	58,898	4,798	9,324	21,146
1984	1	7,825	0	0	0	0	8,100	4,679	26,736	3,699	3,669	8,378
1985	4	1,002	0	0	0	0	6,811	(1,492)	7,600	2,610	1,103	1,118
1986	1	5,487	0	0	0	0	7,119	4,115	27,227	4,111	2,756	8,225
1987	4	0	0	0	0	0	5,911	(1,398)	5,785	2,140	919	742
1988	5	218	0	0	0	0	4,640	(1,180)	4,948	1,823	685	643
1989	4	24	0	0	0	0	5,500	(1,556)	6,422	2,374	646	817
1990	5	0	0	0	0	0	4,123	(894)	4,557	1,577	633	682
1991	5	0	0	0	0	0	3,808	(589)	4,853	1,479	634	890
Average		1,995	0	0	0	0	6,730	(156)	13,544	3,264	1,369	3,108

Notes: Definitions of the categories are provided in Table A2-3 in Appendix 2.
Water-year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A–13. Monthly Percentiles for DeltaSOS Simulations for the No–Project Alternative under Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,288	3,326	5,072	4,844	4,073	3,147	2,791	2,395	1,076	1,818	537	3,271
10	5,125	5,385	7,368	8,686	6,384	4,525	3,571	3,114	5,464	3,427	3,448	3,592
20	6,854	6,640	7,842	10,935	7,285	6,095	3,789	3,538	5,568	6,446	4,730	5,890
30	7,992	7,372	9,922	11,575	9,184	7,956	4,189	3,928	5,766	7,379	5,083	6,051
40	8,500	8,383	10,868	13,474	11,137	10,191	5,623	4,859	5,923	8,865	5,864	6,359
50	9,055	10,670	11,667	14,500	14,500	11,701	6,552	5,685	6,313	10,505	6,324	6,518
60	9,710	12,488	13,050	14,500	14,500	13,992	7,380	6,754	6,543	11,287	7,174	6,685
70	11,921	14,219	14,500	14,500	14,500	14,500	8,921	7,487	7,026	11,288	7,966	7,409
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	8,829	8,448	11,288	9,615	10,062
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	11,317	11,288	11,287	14,004
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,155	14,900
Mean	9,968	10,424	11,479	12,759	11,671	10,752	7,249	6,614	7,326	9,026	6,889	7,552

Table 3A–14. DeltaSOS Mean Annual Simulation Output for Alternative 1 under Cumulative Conditions

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3–Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	2	276	238	263	219	0	7,404	(440)	11,057	2,839	1,587	2,399	(6,316)
1923	3	1,512	238	238	241	0	7,453	(794)	9,544	2,679	1,369	1,885	(6,579)
1924	5	0	0	0	0	0	4,561	(1,149)	4,161	1,627	825	478	(4,395)
1925	4	597	222	241	190	0	6,171	(1,155)	7,804	2,469	852	1,315	(5,797)
1926	4	201	186	201	154	0	6,130	(1,481)	6,578	2,366	877	885	(5,791)
1927	1	1,965	238	274	243	0	7,749	(1,326)	16,118	4,501	1,038	3,175	(7,190)
1928	2	1,828	238	247	208	0	7,600	(1,587)	12,966	3,913	996	2,326	(7,151)
1929	5	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	4	85	86	85	72	0	5,282	(1,307)	5,959	2,127	764	820	(5,078)
1931	5	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	4	0	0	0	0	0	4,444	11	5,553	1,309	943	1,320	(4,014)
1933	5	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	5	0	0	0	0	0	3,878	(564)	4,712	1,432	805	868	(3,672)
1935	3	335	238	237	207	0	6,481	(957)	8,892	2,616	1,100	1,659	(5,879)
1936	3	1,139	238	235	206	0	6,685	(424)	10,317	2,655	1,192	2,231	(5,956)
1937	3	657	238	259	214	0	6,392	245	9,106	2,006	1,494	2,251	(5,343)
1938	1	7,363	238	265	225	0	8,922	3,170	34,205	6,255	3,087	9,424	(6,209)
1939	4	203	207	203	172	0	6,315	(1,767)	5,096	2,182	995	414	(5,946)
1940	2	2,041	238	242	214	0	7,299	(808)	16,768	4,365	1,046	3,558	(6,655)
1941	1	5,155	238	249	219	0	7,700	1,494	29,072	5,972	2,157	7,466	(5,890)
1942	1	4,080	238	247	213	0	8,515	193	25,169	5,779	1,534	5,972	(7,427)
1943	1	3,664	238	243	210	0	7,976	817	18,300	3,840	1,611	4,657	(6,863)
1944	4	0	0	0	0	0	6,045	(1,281)	6,405	2,217	984	936	(5,623)
1945	3	656	222	241	190	0	6,880	(1,041)	7,867	2,426	1,254	1,384	(6,160)
1946	3	1,792	238	234	242	0	7,118	(885)	12,200	3,353	1,139	2,468	(6,553)
1947	4	0	0	0	0	0	6,048	(1,599)	5,568	2,199	958	600	(5,702)
1948	3	0	0	0	0	0	6,390	(1,519)	7,320	2,562	806	1,043	(6,165)
1949	4	254	238	233	208	0	6,123	(1,495)	6,685	2,402	842	906	(5,870)
1950	3	21	22	21	6	0	6,492	(1,517)	7,223	2,539	866	1,022	(6,215)
1951	2	4,502	238	244	206	0	8,021	663	18,943	4,073	1,430	4,736	(7,065)
1952	1	4,681	238	303	225	0	9,100	711	25,534	5,579	1,548	6,290	(7,962)
1953	1	1,917	238	194	206	0	7,668	(1,585)	15,023	4,392	1,084	2,807	(7,139)
1954	2	1,497	238	419	383	0	8,498	(2,688)	12,747	4,468	908	1,780	(8,198)
1955	4	319	238	234	204	0	6,671	(2,102)	5,570	2,471	839	369	(6,387)
1956	1	4,549	238	249	219	0	8,064	1,103	25,887	5,447	1,711	6,551	(6,773)
1957	2	361	209	361	335	0	7,683	(2,163)	8,773	3,252	964	1,090	(7,298)
1958	1	5,034	238	271	225	0	9,532	491	30,060	6,749	2,019	7,240	(7,832)
1959	3	1,192	238	427	428	0	7,165	(1,875)	8,768	3,094	997	1,220	(6,759)
1960	4	0	0	0	0	0	6,015	(1,807)	5,903	2,390	802	583	(5,812)
1961	4	45	41	45	34	0	5,993	(1,942)	5,791	2,437	763	495	(5,817)
1962	3	679	222	241	192	0	6,139	(1,342)	7,743	2,561	892	1,219	(5,782)
1963	1	2,087	238	303	267	0	8,374	(1,776)	16,949	4,939	1,021	3,163	(7,797)
1964	4	756	238	435	397	0	6,879	(2,372)	6,006	2,724	849	352	(6,645)
1965	1	2,633	238	247	217	0	7,490	(110)	19,043	4,521	1,246	4,411	(6,763)
1966	3	726	238	243	204	0	7,501	(2,097)	7,826	2,996	1,110	899	(6,974)
1967	1	3,091	238	272	218	0	9,215	(457)	19,395	4,785	1,729	4,328	(7,877)
1968	3	1,224	238	226	206	0	7,672	(2,203)	9,869	3,530	943	1,327	(7,310)
1969	1	5,106	238	400	219	0	8,861	3,077	26,955	4,618	3,097	7,694	(6,176)
1970	1	4,599	238	98	208	0	8,014	879	25,163	5,406	1,632	6,285	(6,885)
1971	1	2,192	238	433	417	0	8,202	(1,590)	15,234	4,442	993	2,853	(7,737)
1972	3	76	78	76	61	0	7,268	(2,488)	6,642	2,937	902	449	(7,002)
1973	2	3,239	238	244	209	0	8,041	(472)	17,910	4,445	1,204	3,973	(7,184)
1974	1	5,060	238	252	213	0	8,841	86	30,032	6,973	1,154	7,060	(8,170)
1975	1	1,805	238	257	208	0	8,731	(1,368)	14,688	4,194	1,176	2,826	(8,090)
1976	5	131	132	131	128	0	5,659	(1,926)	4,864	2,216	755	290	(5,563)
1977	5	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2	2,136	238	243	213	0	6,517	131	15,188	3,482	1,158	3,613	(5,737)
1979	3	488	238	235	206	0	7,266	(1,135)	8,785	2,689	1,220	1,554	(6,555)
1980	2	4,574	238	239	209	0	7,350	2,533	21,817	3,718	2,567	6,251	(5,215)
1981	4	271	238	233	205	0	7,204	(2,081)	6,967	2,788	1,068	707	(6,736)
1982	1	7,154	238	492	219	0	9,505	4,441	34,460	5,617	3,355	10,057	(6,477)
1983	1	19,189	238	98	41	0	10,676	16,271	58,821	4,822	9,324	21,093	(1,539)
1984	1	7,824	238	11	208	0	8,277	4,723	26,780	3,685	3,669	8,408	(5,153)
1985	4	1,001	238	242	204	0	7,031	(1,726)	7,366	2,683	1,103	958	(6,469)
1986	1	5,489	238	259	208	0	7,335	3,873	26,985	4,187	2,756	8,059	(4,941)
1987	4	0	0	0	0	0	5,926	(1,389)	5,794	2,137	919	748	(5,620)
1988	5	218	223	218	190	0	4,844	(1,388)	4,740	1,889	685	501	(4,735)
1989	4	24	25	24	14	0	5,526	(1,567)	6,411	2,377	646	810	(5,473)
1990	5	0	0	0	0	0	4,137	(884)	4,568	1,573	633	690	(4,095)
1991	5	0	0	0	0	0	3,828	(585)	4,858	1,477	634	893	(3,792)
Average		1,996	173	191	166	0	6,907	(333)	13,367	3,320	1,369	2,987	(6,056)

Notes: Definitions of the categories are provided in Table A2–3 in Appendix 2.
Water–year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A–15. Monthly Percentiles for DeltaSOS Simulations for Alternative 1 under Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	15	30	0	0	0	0	0	0	0
60	0	0	0	15	31	0	0	0	0	0	0	0
70	0	0	13	15	31	49	0	0	0	0	0	0
80	0	517	839	620	31	49	76	0	0	0	0	0
90	1,815	4,000	3,871	3,871	2,790	49	76	99	0	0	0	0
100	3,871	4,000	3,871	3,871	4,000	3,871	1,068	1,572	118	130	0	3,888
Mean	415	613	617	702	443	173	35	36	8	2	0	123

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	(0)	0	0	0	(0)	(0)	0	(0)	(0)	0
10	0	0	0	0	0	0	0	0	0	(0)	0	0
20	0	0	0	0	0	0	0	0	0	(0)	0	0
30	0	0	0	0	29	70	12	0	0	(0)	0	0
40	0	0	0	77	186	183	153	110	86	0	0	0
50	0	0	0	238	222	229	207	147	132	0	0	0
60	0	0	83	238	236	235	231	198	182	0	0	0
70	0	124	238	238	238	238	234	224	193	0	0	0
80	0	204	238	238	238	238	238	232	220	0	0	0
90	203	238	238	238	238	238	238	238	231	0	0	0
100	238	238	238	238	238	238	238	238	238	238	189	238
Mean	35	69	96	139	153	157	147	130	118	5	3	10

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	1,079	0	0
50	0	0	0	0	0	0	0	0	0	2,000	0	0
60	0	0	0	0	0	0	0	0	0	2,302	0	0
70	0	0	0	0	0	0	0	52	0	2,977	0	0
80	0	0	0	0	0	0	0	456	136	3,378	0	0
90	0	0	0	0	0	0	637	703	586	3,627	0	0
100	0	2,543	3,313	0	4,000	2,691	1,332	2,428	2,822	3,741	1,379	0
Mean	0	45	171	0	169	71	140	236	130	1,759	29	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,075	3,220	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,347	8,701	6,407	4,525	3,672	3,267	5,500	6,208	3,508	3,617
20	6,844	6,628	7,821	10,950	7,754	6,095	4,071	3,691	5,568	7,611	4,790	5,915
30	7,982	7,360	10,347	11,590	9,746	8,217	4,908	4,375	5,804	9,978	5,143	6,076
40	8,490	8,371	11,155	13,474	11,320	10,191	5,753	5,424	6,202	11,365	5,924	6,384
50	9,045	10,658	12,309	14,500	14,500	12,287	6,573	6,047	6,595	11,366	6,699	6,543
60	9,700	12,910	13,448	14,500	14,500	13,992	7,380	6,581	6,968	12,180	7,367	6,710
70	11,911	14,219	14,500	14,500	14,500	14,500	8,921	7,882	7,148	12,880	8,026	7,434
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	9,632	8,756	13,530	9,675	10,087
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	11,317	14,202	11,347	14,029
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,900	14,900
Mean	9,962	10,461	11,640	12,762	11,842	10,832	7,379	6,866	7,476	10,862	6,979	7,575

Table 3A-16. DeltaSOS Mean Annual Simulation Output for Alternative 2 under Cumulative Conditions

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3-Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	2	276	220	276	232	0	7,417	(453)	11,044	2,843	1,587	2,390	(6,330)
1923	3	1,512	238	238	252	0	7,464	(794)	9,544	2,679	1,369	1,885	(6,589)
1924	5	0	0	0	0	0	4,561	(1,149)	4,161	1,627	825	478	(4,395)
1925	4	597	222	241	215	0	6,196	(1,155)	7,804	2,469	852	1,315	(5,821)
1926	4	201	186	201	179	0	6,155	(1,481)	6,578	2,366	877	885	(5,816)
1927	1	1,965	238	274	257	0	7,763	(1,326)	16,118	4,501	1,038	3,175	(7,204)
1928	2	1,828	238	558	546	0	7,937	(1,898)	12,654	4,010	996	2,113	(7,488)
1929	5	0	0	0	0	0	4,583	(906)	4,553	1,583	851	677	(4,338)
1930	4	85	86	85	92	0	5,302	(1,307)	5,959	2,127	764	820	(5,098)
1931	5	0	0	0	0	0	3,341	(301)	3,688	1,051	831	750	(3,120)
1932	4	0	0	0	0	0	4,444	11	5,553	1,309	943	1,320	(4,014)
1933	5	0	0	0	0	0	3,696	(344)	4,295	1,216	853	872	(3,461)
1934	5	0	0	0	0	0	3,878	(564)	4,712	1,432	805	868	(3,672)
1935	3	335	238	237	252	0	6,526	(957)	8,892	2,616	1,100	1,659	(5,924)
1936	3	1,139	238	235	214	0	6,692	(424)	10,317	2,655	1,192	2,231	(5,963)
1937	3	657	238	259	218	0	6,397	245	9,106	2,006	1,494	2,251	(5,348)
1938	1	7,363	238	265	225	0	8,922	3,170	34,205	6,255	3,087	9,424	(6,209)
1939	4	203	207	203	204	0	6,347	(1,767)	5,096	2,182	995	414	(5,977)
1940	2	2,041	238	242	227	0	7,312	(808)	16,768	4,365	1,046	3,558	(6,668)
1941	1	5,155	238	249	234	0	7,715	1,494	29,072	5,972	2,157	7,466	(5,906)
1942	1	4,080	238	375	338	0	8,640	65	25,041	5,819	1,534	5,884	(7,552)
1943	1	3,664	238	243	220	0	7,986	817	18,300	3,840	1,611	4,657	(6,873)
1944	4	0	0	0	0	0	6,045	(1,281)	6,405	2,217	984	936	(5,623)
1945	3	656	222	241	205	0	6,896	(1,041)	7,867	2,426	1,254	1,384	(6,175)
1946	3	1,792	238	234	252	0	7,128	(885)	12,200	3,353	1,139	2,468	(6,564)
1947	4	0	0	0	0	0	6,048	(1,599)	5,568	2,199	958	600	(5,702)
1948	3	0	0	0	0	0	6,390	(1,519)	7,320	2,562	806	1,043	(6,165)
1949	4	254	238	233	221	0	6,136	(1,495)	6,685	2,402	842	906	(5,884)
1950	3	21	22	21	22	0	6,507	(1,517)	7,223	2,539	866	1,022	(6,230)
1951	2	4,502	238	244	216	0	8,031	663	18,943	4,073	1,430	4,736	(7,075)
1952	1	4,681	238	303	225	0	9,100	711	25,534	5,579	1,548	6,290	(7,962)
1953	1	1,917	238	299	359	0	7,821	(1,690)	14,919	4,425	1,084	2,735	(7,293)
1954	2	1,497	238	419	397	0	8,512	(2,688)	12,747	4,468	908	1,780	(8,212)
1955	4	319	238	234	252	0	6,720	(2,102)	5,570	2,471	839	369	(6,436)
1956	1	4,549	238	258	231	0	8,076	1,095	25,878	5,450	1,711	6,545	(6,785)
1957	2	361	209	361	347	0	7,695	(2,163)	8,773	3,252	964	1,090	(7,310)
1958	1	5,034	238	271	225	0	9,532	491	30,060	6,749	2,019	7,240	(7,832)
1959	3	1,192	238	427	434	0	7,171	(1,875)	8,768	3,094	997	1,220	(6,766)
1960	4	0	0	0	0	0	6,015	(1,807)	5,903	2,390	802	583	(5,812)
1961	4	45	41	45	37	0	5,997	(1,942)	5,791	2,437	763	495	(5,820)
1962	3	679	222	241	215	0	6,162	(1,342)	7,743	2,561	892	1,219	(5,804)
1963	1	2,087	238	591	541	0	8,647	(2,064)	16,661	5,029	1,021	2,966	(8,071)
1964	4	756	238	474	477	0	6,958	(2,411)	5,967	2,736	849	325	(6,724)
1965	1	2,633	238	336	320	0	7,593	(199)	18,954	4,549	1,246	4,350	(6,866)
1966	3	726	238	334	340	0	7,638	(2,189)	7,735	3,025	1,110	836	(7,110)
1967	1	3,091	238	272	218	0	9,215	(457)	19,395	4,785	1,729	4,328	(7,877)
1968	3	1,224	238	422	406	0	7,872	(2,399)	9,673	3,591	943	1,192	(7,509)
1969	1	5,106	238	400	220	0	8,863	3,077	26,955	4,618	3,097	7,694	(6,177)
1970	1	4,599	238	98	209	0	8,015	879	25,163	5,406	1,632	6,285	(6,885)
1971	1	2,192	238	462	449	0	8,234	(1,619)	15,205	4,451	993	2,833	(7,769)
1972	3	76	78	76	74	0	7,281	(2,488)	6,642	2,937	902	449	(7,015)
1973	2	3,239	238	244	223	0	8,055	(472)	17,910	4,445	1,204	3,973	(7,198)
1974	1	5,060	238	252	228	0	8,856	86	30,032	6,973	1,154	7,060	(8,185)
1975	1	1,805	238	343	307	0	8,830	(1,454)	14,602	4,221	1,176	2,767	(8,189)
1976	5	131	132	131	128	0	5,659	(1,926)	4,864	2,216	755	290	(5,563)
1977	5	0	0	0	0	0	3,076	(452)	3,658	1,128	676	676	(3,050)
1978	2	2,136	238	243	228	0	6,532	131	15,188	3,482	1,158	3,613	(5,751)
1979	3	488	238	235	218	0	7,277	(1,135)	8,785	2,689	1,220	1,554	(6,566)
1980	2	4,574	238	239	220	0	7,361	2,533	21,817	3,718	2,567	6,251	(5,226)
1981	4	271	238	233	248	0	7,247	(2,081)	6,967	2,788	1,068	707	(6,779)
1982	1	7,154	238	492	225	0	9,512	4,441	34,460	5,617	3,355	10,057	(6,484)
1983	1	19,189	238	98	41	0	10,676	16,271	58,821	4,822	9,324	21,093	(1,539)
1984	1	7,824	238	11	208	0	8,277	4,723	26,780	3,685	3,669	8,408	(5,153)
1985	4	1,001	238	242	238	0	7,065	(1,726)	7,366	2,683	1,103	958	(6,503)
1986	1	5,489	238	259	223	0	7,349	3,873	26,985	4,187	2,756	8,059	(4,956)
1987	4	0	0	0	0	0	5,926	(1,389)	5,794	2,137	919	748	(5,620)
1988	5	218	223	218	231	0	4,886	(1,388)	4,740	1,889	685	501	(4,777)
1989	4	24	25	24	14	0	5,526	(1,567)	6,411	2,377	646	810	(5,473)
1990	5	0	0	0	0	0	4,137	(884)	4,568	1,573	633	690	(4,095)
1991	5	0	0	0	0	0	3,828	(585)	4,858	1,477	634	893	(3,792)
Average		1,996	173	211	197	0	6,938	(353)	13,347	3,326	1,369	2,973	(6,087)

Notes: Definitions of the categories are provided in Table A2-3 in Appendix 2.
Water-year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A-17. Monthly Percentiles for DeltaSOS Simulations for Alternative 2 under Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	15	30	0	0	0	0	0	0	0
60	0	0	0	15	31	0	0	0	0	0	0	0
70	0	0	13	15	31	49	0	0	0	0	0	0
80	0	517	1,260	1,676	31	49	76	0	0	0	0	0
90	1,815	4,000	3,871	3,871	2,899	307	76	99	0	0	0	0
100	3,871	4,000	3,871	3,871	4,000	3,871	2,795	1,791	118	130	0	3,888
Mean	415	613	644	811	501	226	111	41	8	2	0	123

DW Storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	(0)	0	(0)	(0)	0	(0)	(0)	(0)	(0)	0
10	0	0	0	0	0	0	0	0	(0)	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	14	0	0	0	0	0	0	0
50	0	0	0	238	56	0	9	0	0	0	0	0
60	0	0	0	238	222	121	169	99	0	0	0	0
70	0	86	238	238	238	238	230	169	0	0	0	0
80	0	150	238	238	238	238	234	227	18	0	0	0
90	203	238	238	238	238	238	238	238	190	0	0	0
100	238	238	238	238	238	238	238	238	238	238	189	238
Mean	35	62	86	129	120	100	102	88	37	5	3	10

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	52	0	0	494	0	0	0
80	0	0	0	0	360	508	0	67	2,152	0	0	0
90	0	0	1,387	0	3,840	2,726	139	664	3,414	2,268	0	0
100	0	2,543	3,858	2,703	4,000	3,822	562	3,698	3,882	3,741	1,379	0
Mean	0	160	254	90	651	507	45	212	817	500	29	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,278	3,314	5,051	4,859	6,075	3,220	2,842	2,455	1,145	1,896	597	3,296
10	5,115	5,373	7,347	8,701	6,836	4,706	3,622	3,174	5,500	4,447	3,508	3,617
20	6,844	6,628	7,821	10,950	8,462	6,276	3,840	3,598	5,568	6,832	4,790	5,915
30	7,982	7,360	9,901	11,590	10,331	9,000	4,240	4,033	5,804	8,143	5,143	6,076
40	8,490	8,371	11,134	14,147	13,939	11,285	5,623	4,976	6,267	9,710	5,924	6,384
50	9,045	10,658	12,749	14,500	14,500	13,755	6,573	5,858	6,976	11,365	6,699	6,543
60	9,700	13,308	14,106	14,500	14,500	14,500	7,380	7,176	7,467	11,365	7,367	6,710
70	11,911	14,900	14,500	14,500	14,500	14,500	8,921	8,416	9,632	11,366	8,026	7,434
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	9,437	10,590	11,366	9,675	10,087
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	14,900	11,367	11,347	14,029
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,900	14,900
Mean	9,962	10,577	11,723	12,852	12,324	11,268	7,284	6,842	8,164	9,603	6,979	7,575

Table 3A-18. DeltaSOS Mean Annual Simulation Output for Alternative 3 under Cumulative Conditions

Water Year	Sac Basin Year Type	Available for DW Diversion (TAF)	Delta Storage (TAF)	Delta Storage Diversion (TAF)	Delta Storage Export (TAF)	Delta Storage Outflow (TAF)	Final Total Export (TAF)	Final QWEST Flow (TAF)	Final Delta Outflow (TAF)	3-Mile Slough Flow (TAF)	Old River Diversion Flow (TAF)	Final Antioch Flow (TAF)	Old & Middle Flow (TAF)
1922	2	276	207	276	204	0	7,405	(443)	11,054	2,840	1,587	2,397	(6,317)
1923	3	1,512	406	405	424	0	7,651	(951)	9,387	2,728	1,369	1,778	(6,776)
1924	5	0	0	0	0	0	4,582	(1,144)	4,166	1,626	825	482	(4,416)
1925	4	597	333	362	321	0	6,324	(1,271)	7,688	2,506	852	1,234	(5,949)
1926	4	201	186	201	176	0	6,173	(1,476)	6,583	2,364	877	888	(5,834)
1927	1	1,966	406	452	397	0	7,922	(1,497)	15,946	4,555	1,038	3,058	(7,363)
1928	2	1,827	406	733	698	0	8,109	(2,066)	12,487	4,063	996	1,998	(7,660)
1929	5	0	0	0	0	0	4,604	(901)	4,558	1,581	851	681	(4,359)
1930	4	85	86	85	90	0	5,322	(1,303)	5,963	2,126	764	823	(5,118)
1931	5	0	0	0	0	0	3,363	(297)	3,692	1,050	831	753	(3,142)
1932	4	0	0	0	0	0	4,467	15	5,556	1,308	943	1,323	(4,037)
1933	5	0	0	0	0	0	3,722	(344)	4,295	1,216	853	872	(3,486)
1934	5	0	0	0	0	0	3,900	(560)	4,716	1,431	805	871	(3,695)
1935	3	335	338	335	362	0	6,656	(1,050)	8,799	2,645	1,100	1,595	(6,054)
1936	3	1,139	406	404	363	0	6,862	(588)	10,153	2,707	1,192	2,119	(6,133)
1937	3	657	406	439	371	0	6,571	70	8,931	2,061	1,494	2,131	(5,522)
1938	1	7,367	406	458	368	0	9,078	2,990	34,025	6,311	3,087	9,301	(6,365)
1939	4	203	207	203	201	0	6,361	(1,758)	5,105	2,179	995	421	(5,991)
1940	2	2,040	406	425	384	0	7,493	(989)	16,587	4,422	1,046	3,433	(6,849)
1941	1	5,158	406	430	380	0	7,877	1,323	28,901	6,026	2,157	7,349	(6,068)
1942	1	4,083	406	545	474	0	8,787	(89)	24,887	5,868	1,534	5,778	(7,699)
1943	1	3,664	406	419	373	0	8,155	651	18,133	3,892	1,611	4,543	(7,042)
1944	4	0	0	0	0	0	6,067	(1,277)	6,408	2,216	984	939	(5,645)
1945	3	656	333	362	272	0	6,980	(1,154)	7,754	2,461	1,254	1,307	(6,260)
1946	3	1,795	406	400	424	0	7,317	(1,041)	12,043	3,402	1,139	2,360	(6,752)
1947	4	0	0	0	0	0	6,070	(1,596)	5,572	2,198	958	603	(5,724)
1948	3	0	0	0	0	0	6,409	(1,512)	7,327	2,560	806	1,048	(6,183)
1949	4	254	259	254	225	0	6,161	(1,511)	6,670	2,407	842	895	(5,908)
1950	3	21	22	21	20	0	6,526	(1,511)	7,228	2,537	866	1,026	(6,249)
1951	2	4,506	406	417	366	0	8,198	500	18,780	4,124	1,430	4,624	(7,241)
1952	1	4,683	406	491	368	0	9,257	536	25,358	5,634	1,548	6,170	(8,118)
1953	1	1,920	406	470	519	0	7,992	(1,846)	14,762	4,474	1,084	2,628	(7,464)
1954	2	1,497	406	597	549	0	8,684	(2,859)	12,577	4,521	908	1,662	(8,383)
1955	4	319	324	319	338	0	6,821	(2,177)	5,495	2,495	839	318	(6,537)
1956	1	4,551	406	438	381	0	8,242	924	25,708	5,504	1,711	6,428	(6,951)
1957	2	361	206	361	325	0	7,693	(2,157)	8,778	3,250	964	1,093	(7,308)
1958	1	5,034	406	458	368	0	9,685	319	29,887	6,803	2,019	7,122	(7,985)
1959	3	1,192	406	597	582	0	7,334	(2,034)	8,608	3,145	997	1,110	(6,929)
1960	4	0	0	0	0	0	6,037	(1,803)	5,907	2,389	802	586	(5,834)
1961	4	45	41	45	34	0	6,016	(1,938)	5,795	2,436	763	498	(5,839)
1962	3	679	333	362	314	0	6,283	(1,459)	7,626	2,598	892	1,139	(5,925)
1963	1	2,090	406	769	686	0	8,801	(2,226)	16,500	5,080	1,021	2,854	(8,225)
1964	4	756	400	661	660	0	7,161	(2,591)	5,787	2,792	849	201	(6,927)
1965	1	2,635	406	502	467	0	7,761	(360)	18,794	4,599	1,246	4,240	(7,034)
1966	3	726	406	502	500	0	7,813	(2,347)	7,577	3,074	1,110	727	(7,286)
1967	1	3,093	406	460	368	0	9,379	(632)	19,219	4,840	1,729	4,208	(8,040)
1968	3	1,224	406	591	523	0	8,003	(2,556)	9,516	3,641	943	1,085	(7,641)
1969	1	5,107	406	581	370	0	9,026	2,908	26,787	4,670	3,097	7,579	(6,341)
1970	1	4,602	406	274	335	0	8,154	716	24,999	5,457	1,632	6,173	(7,025)
1971	1	2,194	406	704	655	0	8,455	(1,851)	14,973	4,524	993	2,673	(7,990)
1972	3	76	78	76	72	0	7,295	(2,479)	6,651	2,934	902	455	(7,029)
1973	2	3,239	406	415	362	0	8,210	(635)	17,747	4,496	1,204	3,861	(7,353)
1974	1	5,063	406	431	368	0	9,010	(81)	29,865	7,025	1,154	6,945	(8,339)
1975	1	1,805	406	522	438	0	8,971	(1,617)	14,438	4,272	1,176	2,655	(8,330)
1976	5	131	130	131	126	0	5,673	(1,917)	4,874	2,213	755	297	(5,577)
1977	5	0	0	0	0	0	3,103	(453)	3,657	1,129	676	676	(3,077)
1978	2	2,136	406	420	368	0	6,694	(43)	15,015	3,536	1,158	3,494	(5,913)
1979	3	488	406	411	367	0	7,445	(1,304)	8,616	2,742	1,220	1,438	(6,734)
1980	2	4,574	406	409	372	0	7,531	2,371	21,655	3,769	2,567	6,140	(5,396)
1981	4	271	276	271	280	0	7,297	(2,110)	6,939	2,797	1,068	687	(6,828)
1982	1	7,159	406	678	375	0	9,673	4,270	34,290	5,670	3,355	9,940	(6,645)
1983	1	19,194	406	308	38	0	10,676	16,083	58,633	4,881	9,324	20,964	(1,539)
1984	1	7,829	406	22	334	0	8,413	4,728	26,785	3,683	3,669	8,411	(5,289)
1985	4	1,004	406	411	417	0	7,259	(1,883)	7,209	2,733	1,103	850	(6,697)
1986	1	5,490	406	439	369	0	7,514	3,701	26,814	4,240	2,756	7,942	(5,120)
1987	4	0	0	0	0	0	5,945	(1,382)	5,801	2,135	919	753	(5,639)
1988	5	218	223	218	230	0	4,906	(1,384)	4,744	1,887	685	503	(4,797)
1989	4	24	25	24	3	0	5,536	(1,562)	6,416	2,375	646	813	(5,483)
1990	5	0	0	0	0	0	4,159	(880)	4,572	1,572	633	692	(4,117)
1991	5	0	0	0	0	0	3,852	(583)	4,859	1,477	634	894	(3,816)
Average		1,996	272	314	282	0	7,041	(448)	13,252	3,356	1,369	2,908	(6,191)

Notes: Definitions of the categories are provided in Table A2-3 in Appendix 2.
Water-year types: 1=wet, 2=above normal, 3=below normal, 4=dry, 5=critically dry.
Negative values shown in parentheses.

Table 3A–19. Monthly Percentiles for DeltaSOS Simulations for Alternative 3 under Cumulative Conditions

DW diversion (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	29	59	0	0	0	0	0	0	0
60	0	0	0	29	61	0	0	0	0	0	0	0
70	0	0	822	632	61	98	0	0	0	0	0	0
80	0	517	1,260	3,390	729	98	151	0	0	0	0	0
90	2,847	4,949	4,914	5,499	2,945	399	151	198	0	0	0	0
100	6,000	6,000	6,000	6,000	6,000	4,951	2,939	1,791	235	260	0	3,888
Mean	526	848	1,117	1,295	796	305	127	55	17	4	0	125

DW storage (TAF)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	(0)	0	(0)	(0)	(0)	0	(0)	(0)	(0)	0
10	0	0	0	0	0	(0)	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	52	0	0	0	0	0	0	0
50	0	0	0	276	189	31	16	0	0	0	0	0
60	0	0	52	369	333	240	266	207	0	0	0	0
70	0	81	278	406	406	406	389	315	14	0	0	0
80	0	149	406	406	406	406	397	385	179	0	0	0
90	200	357	406	406	406	406	406	406	330	21	0	0
100	406	406	406	406	406	406	406	406	406	406	353	406
Mean	44	84	137	210	205	175	174	159	72	15	5	12

DW discharge for export (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	683	0	0	0
80	0	0	0	0	329	1,031	0	67	3,583	1,454	0	0
90	0	0	1,296	0	3,851	2,922	167	636	5,878	3,463	112	0
100	0	2,518	4,215	2,703	6,000	6,000	895	3,000	6,000	6,000	3,938	0
Mean	0	159	255	90	841	732	61	204	1,352	861	127	0

DW discharge for outflow (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0	0	0	0	0

Final CVP Tracy and SWP Banks exports (cfs)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0	4,329	3,356	5,087	4,862	6,075	3,202	2,865	2,496	1,207	1,968	653	3,340
10	5,166	5,415	7,383	8,704	6,836	4,723	3,645	3,215	5,500	4,519	3,564	3,661
20	6,895	6,670	7,857	10,953	9,184	6,570	3,873	3,639	5,595	6,959	4,957	5,959
30	8,033	7,402	9,937	11,593	12,331	9,174	4,412	4,074	5,804	8,325	5,199	6,120
40	8,541	8,413	11,170	14,147	14,500	12,287	5,623	5,017	6,267	11,260	6,064	6,428
50	9,096	10,700	12,749	14,500	14,500	14,500	6,573	6,047	7,026	11,437	7,028	6,587
60	9,751	13,325	14,500	14,500	14,500	14,500	7,380	7,176	9,209	11,438	7,625	6,754
70	11,962	14,900	14,500	14,500	14,500	14,500	8,921	8,457	10,551	11,438	8,521	7,478
80	14,542	14,900	14,500	14,500	14,500	14,500	10,960	9,437	12,588	11,438	9,980	10,131
90	14,900	14,900	14,500	14,500	14,500	14,500	11,760	11,760	14,900	13,615	11,403	14,073
100	14,900	14,900	14,500	14,500	14,500	14,500	14,900	14,900	14,900	14,900	14,900	14,900
Mean	9,997	10,602	11,742	12,853	12,516	11,491	7,310	6,856	8,717	10,034	7,132	7,615

Table 3A-20. DeltaSOS Mean Annual Input Data from Historical Data, DWRSIM Study 409, and DWRSIM Study 771

	Historic Flows					DWRSIM Study 409 (1995 DW DEIR/EIS)						DWRSIM Study 771 (1999 DW REIR/EIS)					
Water Year	Sacramento + Yolo*	SJR + Eastside*	Depletion + CCWD	CVP+SWP Exports	Delta Outflow	Sacramento + Yolo	SJR + Eastside	Depletion + CCWD	CVP+SWP Exports	Delta Outflow	Required Outflow	Sacramento + Yolo	SJR + Eastside	Depletion + CCWD	CVP+SWP Exports	Delta Outflow	Required Outflow
1922	-	-	-	0	28,838	15,460	4,080	1,035	6,193	12,313	6,112	16,271	4,131	1,000	6,522	12,879	6,356
1923	-	-	-	0	19,498	14,704	3,311	1,022	6,199	10,793	5,841	14,266	3,551	942	5,938	10,943	5,653
1924	-	-	-	0	4,972	8,667	1,462	1,421	4,548	4,161	4,069	7,900	1,352	1,431	3,604	4,219	3,921
1925	-	-	-	0	23,103	12,891	2,095	965	5,743	8,278	5,202	12,639	2,275	853	4,445	9,626	5,866
1926	-	-	-	0	14,889	11,974	1,903	1,129	5,741	7,007	5,013	11,426	1,769	1,287	5,157	6,756	4,397
1927	-	-	-	0	34,966	22,268	2,619	981	6,251	17,655	6,990	23,331	3,076	1,009	6,308	19,095	6,830
1928	-	-	-	0	22,064	19,474	2,286	1,152	6,336	14,271	6,674	18,710	2,640	1,257	6,114	13,985	5,961
1929	-	-	-	0	8,687	8,808	1,605	1,288	4,570	4,554	4,424	8,618	1,406	1,306	4,315	4,406	3,931
1930	-	1,734	812	0	15,038	10,947	1,470	1,173	5,016	6,229	5,059	11,322	1,404	1,134	5,080	6,516	4,775
1931	-	838	890	0	5,140	6,852	1,462	1,300	3,332	3,682	3,662	7,586	1,084	1,449	3,397	3,831	3,760
1932	-	4,605	673	0	16,600	8,787	2,244	1,045	4,153	5,833	5,197	8,616	2,755	1,107	3,933	6,322	5,151
1933	-	1,804	882	0	8,719	7,629	1,654	1,306	3,683	4,294	4,055	7,305	1,504	1,372	3,227	4,204	3,821
1934	-	1,362	844	0	8,798	8,330	1,507	1,260	3,742	4,835	4,539	8,487	1,299	1,377	3,577	4,830	4,477
1935	-	4,995	637	0	22,582	13,725	2,692	1,018	5,934	9,466	6,464	13,490	2,864	1,082	5,528	9,748	6,168
1936	-	6,598	402	0	25,092	14,769	3,205	945	6,162	10,867	6,257	15,255	4,276	1,070	6,056	12,408	6,472
1937	-	6,751	434	0	21,235	12,689	3,750	898	5,887	9,654	5,294	12,679	4,713	992	5,506	10,892	5,578
1938	-	13,085	381	0	52,788	36,820	7,100	719	6,235	36,966	8,137	36,707	10,362	789	6,729	39,557	7,471
1939	-	2,139	836	0	8,563	10,796	1,984	1,348	5,096	6,337	4,363	10,917	2,338	1,490	4,889	6,887	4,013
1940	-	6,114	480	0	30,910	22,241	2,655	792	6,428	17,675	7,256	21,570	3,829	922	5,988	18,490	7,253
1941	-	8,614	410	0	43,460	32,989	4,492	652	6,283	30,546	7,020	33,977	5,600	711	6,507	32,363	7,096
1942	-	7,763	338	0	36,995	30,494	4,146	900	5,957	27,783	6,681	30,385	5,261	987	6,077	28,588	6,689
1943	-	7,916	423	0	30,329	22,643	4,707	1,030	5,566	20,755	7,319	22,235	6,555	1,129	5,686	21,982	7,181
1944	-	2,316	735	0	10,787	11,595	2,039	1,192	5,937	6,505	4,959	11,629	2,436	1,305	5,286	7,479	4,191
1945	-	5,638	678	0	18,869	12,920	2,993	1,119	6,142	8,651	5,284	13,398	3,584	1,250	5,910	9,823	6,141
1946	-	4,725	816	0	21,938	17,663	2,871	1,222	6,299	13,013	6,288	16,859	3,677	1,323	6,249	12,967	6,015
1947	-	1,705	1,079	0	10,203	11,073	1,850	1,316	6,042	5,566	5,079	10,915	1,778	1,427	5,888	5,379	4,445
1948	-	2,257	962	0	16,167	13,157	1,785	1,237	6,310	7,394	5,494	12,622	1,829	1,258	5,911	7,287	4,622
1949	12,070	1,858	1,005	0	12,615	12,203	1,881	1,258	5,700	7,127	4,928	12,199	1,890	1,303	6,041	6,747	4,428
1950	14,324	2,793	1,066	0	15,257	12,940	2,043	1,259	6,159	7,564	5,606	13,002	2,237	1,337	6,221	7,685	5,096
1951	25,246	7,066	755	163	30,594	23,605	4,379	969	6,775	20,240	6,335	23,879	5,487	1,006	6,601	21,762	6,331
1952	32,046	9,627	589	165	40,431	30,744	4,800	810	6,936	27,799	7,996	30,899	6,998	834	6,633	30,439	7,675
1953	20,902	2,756	1,014	788	22,393	21,360	2,501	1,175	5,312	17,374	6,088	21,115	3,099	1,213	5,772	17,232	6,004
1954	18,349	2,434	1,101	1,022	19,167	20,648	1,943	1,304	6,382	14,904	7,031	19,938	2,027	1,352	6,205	14,414	6,718
1955	10,682	1,538	906	1,129	10,054	11,635	1,802	1,174	6,025	6,239	5,058	11,371	1,738	1,186	5,494	6,429	4,304
1956	32,232	8,645	572	722	39,798	30,078	4,762	837	6,833	27,171	6,230	30,508	6,803	862	6,796	29,659	6,491
1957	13,947	2,126	978	1,181	13,939	15,512	2,200	1,233	6,295	10,185	5,669	15,133	2,455	1,293	6,334	9,964	5,257
1958	36,120	8,463	159	658	43,825	35,187	5,061	581	7,056	32,611	7,277	35,637	6,310	577	6,861	34,513	6,653
1959	12,712	1,616	958	1,338	12,056	15,120	2,074	1,265	5,184	10,745	5,301	14,192	2,334	1,393	4,971	10,164	5,066

Water Year	Historical Flows: Sacramento + Yolo*	SJR + Eastside*				DWRSIM Study 409 (1995 DEIR/EIS)						DWRSIM Study 771 (2000 REIR/EIS)					
1960	11,405	802	1,207	1,386	9,720	11,672	1,523	1,285	5,864	6,046	5,210	11,294	1,510	1,396	5,625	5,785	4,563
1961	11,673	542	1,048	1,485	9,700	11,682	1,357	1,252	5,784	6,003	5,104	11,866	1,172	1,298	5,735	6,001	4,312
1962	14,232	2,189	935	1,352	14,158	13,101	1,947	1,122	5,805	8,120	5,070	13,503	2,279	1,172	6,206	8,410	4,720
1963	24,626	4,177	499	1,339	27,006	23,586	2,679	897	6,661	18,708	7,339	23,549	3,008	857	7,187	18,510	6,855
1964	11,674	1,426	1,123	1,646	10,399	12,563	1,675	1,323	5,922	6,993	5,150	11,924	1,680	1,340	5,389	6,874	4,359
1965	26,194	5,451	830	1,469	29,388	24,106	3,550	1,082	6,660	19,914	6,680	24,487	4,774	1,065	7,068	21,130	6,857
1966	13,788	2,339	1,082	1,596	13,467	14,240	2,365	1,241	6,411	8,952	5,610	13,209	2,881	1,310	5,775	9,006	4,765
1967	27,933	7,289	461	1,254	33,561	24,830	4,609	760	6,875	21,804	7,564	25,998	6,632	745	7,084	24,807	7,639
1968	14,064	1,939	1,134	2,471	12,524	16,703	2,095	1,238	4,789	12,771	5,565	15,739	2,294	1,333	5,054	11,649	5,521
1969	29,684	12,572	502	2,879	38,936	29,451	7,387	814	6,439	29,584	7,978	30,183	11,340	865	6,435	34,229	7,478
1970	28,829	4,494	883	2,070	30,332	29,644	4,485	1,041	5,038	28,049	5,644	29,227	5,264	1,169	5,104	28,226	5,639
1971	24,150	2,682	818	2,834	23,223	22,122	2,443	1,105	6,822	16,637	7,103	22,062	2,787	1,132	6,763	16,959	7,051
1972	12,517	1,476	1,352	3,445	9,273	13,421	1,875	1,377	6,352	7,567	5,417	12,990	1,601	1,487	5,890	7,213	4,898
1973	24,679	3,824	532	3,369	24,643	23,309	3,340	653	6,618	19,378	6,830	23,318	4,043	724	6,879	19,762	6,804
1974	38,282	4,327	768	4,366	37,534	36,436	3,497	992	6,838	32,103	6,954	37,025	4,702	1,076	6,766	33,892	6,679
1975	20,920	3,954	934	3,910	20,070	21,389	3,209	1,122	6,503	16,973	6,636	21,026	4,091	1,186	6,773	17,168	6,653
1976	10,992	1,731	1,337	4,846	6,592	10,557	1,382	1,423	5,006	5,510	4,423	10,754	1,669	1,503	5,335	5,586	3,694
1977	5,506	446	1,337	2,081	2,542	6,939	1,167	1,387	3,057	3,662	3,662	6,825	1,290	1,453	2,695	3,965	3,965
1978	20,564	5,642	393	4,356	21,497	19,343	3,111	714	4,513	17,228	7,944	19,034	4,935	778	5,431	17,760	8,205
1979	13,206	3,648	834	4,476	11,571	14,143	2,993	1,059	5,813	10,264	5,852	14,134	3,854	1,123	5,651	11,219	5,816
1980	25,785	7,806	732	4,529	28,541	23,927	6,151	866	5,681	23,531	6,577	24,028	6,669	871	5,905	23,927	6,591
1981	11,641	2,052	1,066	4,728	7,919	13,220	2,258	1,284	5,595	8,599	5,116	12,865	2,198	1,404	4,767	8,891	4,618
1982	37,381	8,522	105	4,627	41,287	36,386	8,491	602	7,276	36,999	7,109	36,684	9,721	596	7,043	38,771	6,966
1983	49,079	20,014	51	4,405	64,732	49,206	20,669	249	5,421	64,201	6,206	49,309	19,397	239	5,294	63,181	6,413
1984	27,110	8,070	922	3,846	30,634	27,404	8,629	1,150	4,582	30,301	5,684	27,000	7,597	1,247	4,838	28,515	6,144
1985	12,381	2,574	1,053	5,478	8,465	13,248	2,321	1,139	5,942	8,488	5,075	12,721	1,919	1,229	5,716	7,700	4,502
1986	28,760	7,366	341	5,293	30,535	27,876	7,208	691	6,277	28,117	6,164	28,579	7,547	760	6,186	29,189	5,985
1987	10,079	2,194	1,131	5,050	6,113	11,045	1,985	1,318	5,816	5,896	4,826	10,887	1,695	1,421	5,054	6,111	4,206
1988	9,782	1,307	1,101	5,619	4,415	9,567	1,258	1,223	4,452	5,150	4,511	9,484	1,205	1,348	3,936	5,399	4,318
1989	12,306	1,279	1,023	5,975	6,608	11,878	1,330	1,270	5,285	6,653	4,823	11,593	1,279	1,377	4,871	6,657	4,374
1990	9,894	1,085	1,211	5,819	3,973	8,787	1,156	1,251	4,071	4,621	4,512	9,400	1,098	1,378	4,438	4,687	4,092
1991	7,626	877	941	3,185	4,377	8,700	1,228	1,256	3,813	4,860	4,094	8,334	1,179	1,335	2,666	5,510	4,055
1992	-	1,247	961	2,912	-	-	-	-	-	-	-	8,774	1,371	1,262	3,132	5,764	4,486
1993	-	-	-	-	-	-	-	-	-	-	-	19,349	3,523	625	6,157	16,090	8,402
1994	-	-	-	-	-	-	-	-	-	-	-	11,038	1,692	1,353	5,312	6,064	3,961
Avg ('22-'91	19,892	4,419	798	1,691	20,644	18,141	3,240	1,079	5,720	14,582	5,810	18,086	3,743	1,140	5,590	15,102	5,586

*Notes: Sacramento + Yolo = Sacramento River and Yolo Bypass
SJR + Eastside = San Joaquin River and eastside streams
Depletion + CCWD = Contra Costa Water Distric diversions and net channel depletion
See "Notes and Acronyms" at end of tables section

Table 3A-21. Comparison of Sacramento River + Yolo Bypass Flow (cfs) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
	DWRSIM Study 409 (1995 DEIR/EIS)												
1967	12680	15473	41319	46741	59682	56679	43818	46199	40864	15589	12698	19813	24830
1968	23643	18017	16207	29254	67429	37050	12293	10820	14760	21516	14177	11675	16703
1969	14078	12574	23151	111492	111153	52937	43896	44733	25335	13042	12083	23658	29451
1970	21939	18806	57778	184333	85637	36152	13232	10762	15238	23106	13363	10993	29644
1971	13723	22988	67713	53426	29159	52059	19441	31548	22990	23192	13662	16761	22122
1972	18865	16485	21278	18288	25382	32355	11592	10956	14603	21618	20089	10936	13421
1973	15127	23028	27877	72678	88679	56526	17416	17979	19696	22972	12753	11608	23309
1974	15026	66497	69975	127939	47112	106615	71375	24715	21434	18189	13856	21175	36436
1975	22724	17840	18043	16081	64541	83394	22644	32443	25262	20252	13015	18274	21389
1976	23074	20504	15689	13414	19069	15202	9873	10305	14737	16563	8650	7893	10557
1977	8183	11104	18131	8303	13468	10403	9127	6787	7009	9003	6316	7178	6939
1978	7179	6260	16102	58430	57316	64666	38711	19681	14350	13255	10870	13778	19343
1979	18469	15924	10638	25785	40922	30818	16689	15571	20572	17819	11205	10001	14143
1980	10623	18125	20806	100940	112793	51001	16691	14264	12647	13041	11215	14433	23927
1981	17286	14254	16319	25675	28599	32518	14686	10889	13654	20878	14221	10145	13220
1982	12801	35650	94683	73874	92720	67180	115305	36117	22606	15164	13851	23136	36386
1983	30060	41797	68882	78120	141232	200690	79835	59449	52097	23412	15591	24410	49206
1984	27521	69988	131698	60540	39887	33563	14220	12617	15445	21437	12186	15112	27404
1985	18599	35922	26287	14443	19838	17790	9859	13784	13489	20965	17901	10706	13248
1986	12711	10997	15940	18764	198107	122935	20232	11194	12479	16354	11426	10901	27876
1987	10638	12133	9495	12911	19356	32272	13457	11495	13656	21261	16142	10254	11045
1988	10369	9911	16405	26311	17146	12006	9207	9574	14318	15770	10258	7289	9567
1989	7179	9446	11759	12971	13986	39617	22383	14636	13464	21670	19283	10483	11878
1990	9151	8092	14263	17463	15935	11083	13102	7884	14643	16078	10380	7568	8787
1991	7159	7716	9364	10525	13924	29237	14113	8058	13814	12442	9529	8320	8700
	DWRSIM Study 771 (1999 REIR/EIS)												
1967	11270	19007	40723	51132	59437	57832	42904	46009	45274	21012	18085	18217	25998
1968	17353	13461	16361	31421	59786	39129	14335	12555	13730	15190	16101	11444	15739
1969	12149	14200	25110	110525	110357	52790	42534	48155	27678	18085	16832	21847	30183
1970	15938	14805	57149	183384	86985	38771	14604	13255	14016	18556	15531	11428	29227
1971	11921	23628	63492	54400	28647	52351	21360	29713	23746	21728	17190	17494	22062
1972	15336	13932	21402	20459	23730	33388	11781	14230	15276	16654	17076	12033	12990
1973	13108	21494	26200	76372	87526	56596	20099	15369	20318	21061	13791	14553	23318
1974	14051	64784	70485	126349	47571	109272	67288	27615	24216	22150	19435	20452	37025
1975	16475	13764	17743	18410	59833	83658	26922	27452	28048	20313	18101	17780	21026
1976	20589	15612	16702	16751	20079	17515	9680	9872	15831	13238	11287	11092	10754
1977	11108	8823	8977	8928	13342	8083	9999	7383	11058	8717	8847	7848	6825
1978	6164	6117	13027	59426	57114	59214	34837	20036	15108	14507	15515	14419	19034
1979	14393	12722	12604	27338	41827	32640	18234	12864	21796	17011	10815	12016	14134
1980	12929	15713	21402	93172	111367	51294	20015	15076	13461	13531	16231	14066	24028
1981	11775	10470	16979	29046	30033	30656	17746	12328	13999	13840	15678	10688	12865
1982	11335	40585	90521	71086	87454	74355	111117	37682	25208	20427	18036	20217	36684
1983	23045	35577	67346	80454	140714	195451	81405	58889	59289	27826	24037	23242	49309
1984	20882	64364	129146	61930	36282	36218	16251	14897	18839	20410	14539	13747	27000
1985	13287	31560	23956	17125	21697	21955	12906	13011	13814	13482	16117	11932	12721
1986	11563	12033	18133	22980	190014	126934	23309	14068	11579	16605	12149	14318	28579
1987	12604	11226	12311	15564	21697	28379	12554	10034	15579	14198	16393	9915	10887
1988	10327	8672	17450	28152	14064	15271	9327	9433	14217	12750	8506	9024	9484
1989	9075	9966	10165	13417	11794	41910	25914	13401	13226	14133	16767	12386	11593
1990	13515	10638	14686	19857	16205	13677	13612	9481	15058	10864	8928	9277	9400
1991	8701	8235	8164	7985	12244	32591	17158	9498	8503	7904	8213	8940	8334
	Change: DWRSIM 771 - DWRSIM 409												
1967	-1410	3534	-596	4391	-245	1153	-914	-190	4410	5423	5387	-1596	1167
1968	-6290	-4556	154	2167	-7643	2079	2042	1735	-1030	-6326	1924	-231	-964
1969	-1929	1626	1959	-967	-796	-147	-1362	3422	2343	5043	4749	-1811	732
1970	-6001	-4001	-629	-949	1348	2619	1372	2493	-1222	-4550	2168	435	-417
1971	-1802	640	-4221	974	-512	292	1919	-1835	756	-1464	3528	733	-60
1972	-3529	-2553	124	2171	-1652	1033	189	3274	673	-4964	-3013	1097	-431
1973	-2019	-1534	-1677	3694	-1153	70	2683	-2610	622	-1911	1038	2945	9
1974	-975	-1713	510	-1590	459	2657	-4087	2900	2782	3961	5579	-723	589
1975	-6249	-4076	-300	2329	-4708	264	4278	-4991	2786	61	5086	-494	-363
1976	-2485	-4892	1013	3337	1010	2313	-193	-433	1094	-3325	2637	3199	198
1977	2925	-2281	-9154	625	-126	-2320	872	596	4049	-286	2531	670	-114
1978	-1015	-143	-3075	996	-202	-5452	-3874	355	758	1252	4645	641	-309
1979	-4076	-3202	1966	1553	905	1822	1545	-2707	1224	-808	-390	2015	-9
1980	2306	-2412	596	-7768	-1426	293	3324	812	814	490	5016	-367	101
1981	-5511	-3784	660	3371	1434	-1862	3060	1439	345	-7038	1457	543	-355
1982	-1466	4935	-4162	-2788	-5266	7175	-4188	1565	2602	5263	4185	-2919	298
1983	-7015	-6220	-1536	2334	-518	-5239	1570	-560	7192	4414	8446	-1168	103
1984	-6639	-5624	-2552	1390	-3605	2655	2031	2280	3394	-1027	2353	-1365	-405
1985	-5312	-4362	-2331	2682	1859	4165	3047	-773	325	-7483	-1784	1226	-527
1986	-1148	1036	2193	4216	-8093	3999	3077	2874	-900	251	723	3417	703
1987	1966	-907	2816	2653	2341	-3893	-903	-1461	1923	-7063	251	-339	-158
1988	-42	-1239	1045	1841	-3082	3265	120	-141	-101	-3020	-1752	1735	-83
1989	1896	520	-1594	446	-2192	2293	3531	-1235	-238	-7537	-2516	1903	-285
1990	4364	2546	423	2394	270	2594	510	1597	415	-5214	-1452	1709	613
1991	1542	519	-1200	-2540	-1680	3354	3045	1440	-5311	-4538	-1316	620	-366

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-22. Comparison of San Joaquin River + Eastside Streams Flow (cfs) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
	DWRSIM Study 409 (1995 DEIR/EIS)												
1967	2163	2285	4607	6732	7039	5746	12312	9585	10645	9511	2251	3508	4609
1968	4058	2290	2802	3036	4613	3565	4291	3202	2163	2017	1330	1360	2095
1969	1641	2532	2555	13179	27970	11301	11590	24907	15284	6059	2298	3117	7387
1970	8283	4208	5047	21274	10411	6234	5998	4607	2667	2063	1983	1563	4485
1971	1851	3718	6567	3529	3145	3516	4980	4795	2802	2066	1999	1516	2443
1972	2260	2170	2968	2476	3109	2752	4459	3365	2165	2032	1298	2022	1875
1973	1606	3098	2270	6126	10661	10686	6603	6239	2551	2033	1953	1531	3340
1974	2566	4156	5710	8513	4286	7570	8363	7097	3893	2124	2078	1605	3497
1975	2335	3183	2918	1889	7839	8722	7741	7683	4565	2121	2068	2119	3209
1976	2569	3048	2381	1121	1340	2049	2398	2387	2111	1339	1099	1072	1382
1977	1721	1616	1189	1127	1382	1741	2430	2250	2109	1298	1204	1280	1167
1978	1779	1511	1873	6100	6865	6312	8783	7081	5196	2108	2186	1776	3111
1979	3530	2780	1772	4350	9098	7206	6301	6336	2568	2024	1930	1706	2993
1980	2354	3750	2793	16699	24189	24976	7187	6869	4739	2521	2241	3640	6151
1981	4478	4059	3295	3543	3567	4200	4106	3153	2156	2022	1441	1410	2258
1982	1537	2639	4246	11796	14264	20962	36202	24293	9727	5948	3354	5768	8491
1983	13458	12724	28435	31556	49188	62664	37426	32518	34260	20942	7553	11848	20669
1984	18450	18643	30960	28088	13948	9620	6721	4949	3592	2435	2676	2944	8629
1985	3399	4577	5682	3706	3700	3374	3598	3267	2166	2009	1446	1548	2321
1986	2130	2826	2817	2564	28698	36518	20598	9361	5580	2600	2647	3134	7208
1987	6669	3493	3918	2037	2329	2948	2543	2275	2154	1753	1303	1473	1985
1988	1643	1895	2110	1566	1053	1489	2410	2308	2159	1537	1297	1383	1258
1989	1989	1538	1554	1100	1205	2952	3178	2422	2249	1391	1327	1141	1330
1990	1570	1316	1083	1319	1421	1685	2528	2275	1939	1327	1259	1444	1156
1991	2008	1407	1258	857	1269	2599	2561	2487	2005	1288	1223	1397	1228
	DWRSIM Study 771 (1999 REIR/EIS)												
1967	2082	2252	3968	7416	5600	9156	21914	22394	17646	10311	2992	4185	6632
1968	5351	2302	2472	2651	5424	4342	5109	3480	1798	1740	1691	1664	2294
1969	2017	2000	2683	23695	40729	23793	26132	31160	20654	6570	4033	4487	11340
1970	5904	3378	4521	27469	12550	10506	6957	6001	3008	2212	2244	2504	5264
1971	2472	3126	6603	4017	3241	5123	6168	5529	2823	2326	2309	2454	2787
1972	2163	1983	2927	2179	2712	2196	3227	2862	1731	1464	1626	1462	1601
1973	1838	2168	2000	6944	13954	13515	8235	7530	3311	2505	2407	2605	4043
1974	3692	4470	6310	12571	6536	11710	11344	8262	4554	2781	2732	2975	4702
1975	3887	2487	2862	2635	8445	13791	8957	8392	7596	2944	2814	2991	4091
1976	4602	2353	2244	1984	2451	2212	2891	2716	1580	1578	1529	1529	1669
1977	3204	2386	1968	1529	1494	1464	2286	1952	1496	1138	1155	1311	1290
1978	1545	1529	1919	6473	9345	14003	18167	12490	7865	3350	2082	3025	4935
1979	4668	2353	2082	5757	12784	11677	7596	7026	2790	2358	2309	2487	3854
1980	2765	2218	2667	20719	27468	17483	8201	8896	8924	4879	2651	3664	6669
1981	5237	2269	2130	3123	3259	4716	5109	3741	1798	1643	1708	1697	2198
1982	1968	2806	3724	15824	25766	22768	40450	19939	12033	5481	3919	6436	9721
1983	9384	12789	28314	34754	50110	60727	26284	26964	40568	17483	4781	9344	19397
1984	8148	21007	32803	19060	12778	8001	7075	5920	3311	2505	2553	2756	7597
1985	2391	3361	2618	2130	3133	3253	4386	3692	1832	1626	1724	1664	1919
1986	1984	2201	2326	2830	40099	34868	11747	10457	10503	2683	2602	2790	7547
1987	3838	2252	2082	1984	2773	3090	2941	2700	1613	1610	1594	1613	1695
1988	1691	1832	2065	1838	1512	1447	2218	2049	1496	1138	1171	1512	1205
1989	1529	1529	1756	1366	1548	3041	2504	2212	1714	1236	1203	1563	1279
1990	1529	1529	1366	1529	1711	1756	2168	1773	1260	1041	1073	1462	1098
1991	1415	1311	1301	1106	1314	3757	2554	2082	1328	1041	1008	1328	1179
	Change: DWRSIM 771 - DWRSIM 409												
1967	-81	-33	-639	684	-1439	3410	9602	12809	7001	800	741	677	2023
1968	1293	12	-330	-385	811	777	818	278	-365	-277	361	304	199
1969	376	-532	128	10516	12759	12492	14542	6253	5370	511	1735	1370	3953
1970	-2379	-830	-526	6195	2139	4272	959	1394	341	149	261	941	779
1971	621	-592	36	488	96	1607	1188	734	21	260	310	938	344
1972	-97	-187	-41	-297	-397	-556	-1232	-503	-434	-568	328	-560	-274
1973	232	-930	-270	818	3293	2829	1632	1291	760	472	454	1074	703
1974	1126	314	600	4058	2250	4140	2981	1165	661	657	654	1370	1205
1975	1552	-696	-56	746	606	5069	1216	709	3031	823	746	872	882
1976	2033	-695	-137	863	1111	163	493	329	-531	239	430	457	287
1977	1483	770	779	402	112	-277	-144	-298	-613	-160	-49	31	123
1978	-234	18	46	373	2480	7691	9384	5409	2669	1242	-104	1249	1823
1979	1138	-427	310	1407	3686	4471	1295	690	222	334	379	781	862
1980	411	-1532	-126	4020	3279	-7493	1014	2027	4185	2358	410	24	517
1981	759	-1790	-1165	-420	-308	516	1003	588	-358	-379	267	287	-60
1982	431	167	-522	4028	11502	1806	4248	-4354	2306	-467	565	668	1230
1983	-4074	65	-121	3198	922	-1937	-11142	-5554	6308	-3459	-2772	-2504	-1271
1984	-10302	2364	1843	-9028	-1170	-1619	354	971	-281	70	-123	-188	-1032
1985	-1008	-1216	-3064	-1576	-567	-121	788	425	-334	-383	278	116	-402
1986	-146	-625	-491	266	11401	-1650	-8851	1096	4923	83	-45	-344	339
1987	-2831	-1241	-1836	-53	444	142	398	425	-541	-143	291	140	-290
1988	48	-63	-45	272	459	-42	-192	-259	-663	-399	-126	129	-53
1989	-460	-9	202	266	343	89	-674	-210	-535	-155	-124	422	-51
1990	-41	213	283	210	290	71	-360	-502	-679	-286	-186	18	-58
1991	-593	-96	43	249	45	1158	-7	-405	-677	-247	-215	-69	-49

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-23. Comparison of CVP + SWP Exports (cfs) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
	DWRSIM Study 409 (1995 DEIR/EIS)												
1967	8718	10672	11526	11916	10784	6352	7644	8128	10257	10775	5927	11243	6875
1968	9342	7641	6876	4239	4835	6480	4666	3870	5924	11287	7538	6684	4789
1969	9074	8547	11249	12373	11632	6647	6727	7690	9600	6578	5360	11243	6439
1970	11027	7887	7427	4700	4822	6543	5990	4706	6268	11287	6324	6526	5038
1971	9054	10941	11411	11618	9028	10190	6116	7704	9028	11287	6640	10061	6822
1972	11027	10941	11264	10891	8473	8443	4578	3924	5870	11287	11287	7294	6352
1973	10113	10941	11250	11573	12382	7836	6772	6930	7786	11110	6124	6866	6618
1974	10863	10941	11352	11037	8319	8492	8550	8701	8864	8065	6913	11243	6838
1975	11027	10941	9893	7640	6018	7644	8266	8756	10439	9670	6241	11243	6503
1976	11027	10941	10586	8462	8468	6038	3070	3268	5896	7623	3547	4042	5006
1977	5434	6433	11057	4844	6067	4197	2825	2394	1076	1817	941	3580	3057
1978	4415	3326	10812	10363	5453	5280	6313	6696	6613	2839	4473	8219	4513
1979	11027	10941	6331	10707	7836	8114	6604	6512	8100	8864	5187	6117	5813
1980	7828	10941	11332	12621	8081	6096	6262	6772	5681	3232	4873	10445	5681
1981	11027	10941	9165	7318	7774	7239	5026	3874	5534	11287	7551	6005	5595
1982	8382	10941	11217	12015	11725	8742	8607	9742	11277	8589	8123	11243	7276
1983	11027	8298	7936	6107	4628	4948	6594	6273	7679	7796	10177	8388	5421
1984	7062	5299	5242	3218	4144	6341	6270	5104	6664	10505	5856	10243	4582
1985	11027	10941	11708	7800	8028	7408	3696	4418	5480	11287	10258	6439	5942
1986	8726	7912	11320	11410	12821	10247	8347	7354	6322	6447	5051	8075	6277
1987	11027	8936	7785	9199	9758	10838	3800	3456	5534	11287	8755	6020	5816
1988	6587	6114	11175	11273	6370	4724	2964	3114	5768	7321	4885	3498	4452
1989	4627	5403	6928	8317	6836	11402	5466	4050	5500	11287	11287	6501	5285
1990	5470	3927	7841	11255	6076	4468	3620	2804	5804	7330	5021	3857	4071
1991	4665	3854	5073	6171	6384	11142	3790	2873	5453	5022	4228	4544	3813
	DWRSIM Study 771 (1999 REIR/EIS)												
1967	8067	11226	11547	12067	10893	7709	7041	5416	11612	11661	11693	11596	7272
1968	9172	8672	8164	7725	6884	7221	4336	3318	5781	5936	11384	8302	5243
1969	9026	10772	11401	12295	6230	6326	6235	4310	11612	11026	11010	9495	6621
1970	8018	7445	6668	7725	8481	7188	5126	4115	6302	8213	9237	9075	5285
1971	9270	11209	11466	11791	7292	9091	5697	4863	9646	11661	11693	11512	6950
1972	11466	10587	11368	8831	8779	9091	3411	2911	6302	7302	11693	9108	6085
1973	10002	11209	11319	11710	12910	8863	6403	4554	8621	11238	8798	11495	7066
1974	11433	11226	11579	8034	8805	8310	6235	4310	10419	11661	11693	11528	6952
1975	11466	10806	9059	8278	9057	8148	7041	5416	11612	11205	11693	11528	6957
1976	11466	11226	10311	8294	8675	7156	3059	2488	6403	6473	7871	8167	5526
1977	7611	6857	6554	5838	2287	2814	2958	699	1395	1464	4310	4773	2869
1978	960	3411	9904	12132	12946	7432	6235	4310	8403	5529	10213	11612	5616
1979	11563	9915	7058	7660	8373	8392	5966	4163	8957	8668	6456	9613	5839
1980	10490	11209	11417	8652	6606	5692	5395	3562	8184	6538	11693	11478	6089
1981	11352	7310	6082	5188	6086	7221	4924	3285	5882	6050	11026	7764	4958
1982	8473	11209	11368	12880	9795	9059	6235	4310	11612	11661	11693	11528	7229
1983	11466	11243	9725	3415	3241	4131	6184	4310	8772	8522	10750	9041	5478
1984	7660	6974	4261	5253	5441	7188	4571	3204	8100	10522	9042	11058	5024
1985	10474	11226	11319	8278	9057	8473	3697	2814	5815	5855	11693	9176	5905
1986	8424	9293	11368	11579	12874	9075	6235	3610	8083	7026	6603	11411	6370
1987	10961	8050	9042	8636	5870	6749	3479	2488	6352	6782	11677	6689	5235
1988	6863	5294	11287	11433	4242	4293	2806	2358	5092	5090	3757	5663	4113
1989	3789	7294	7758	9742	2413	11270	5613	2797	5563	5757	11677	9394	5012
1990	10034	6873	10604	11384	6752	5627	3580	2391	5663	3334	4131	5899	4602
1991	3432	5142	5139	4310	1152	11498	4218	2407	471	455	3497	5294	2837
	Change: DWRSIM 771 - DWRSIM 409												
1967	-651	554	21	151	109	1357	-603	-2712	1355	886	5766	353	397
1968	-170	1031	1288	3486	2049	741	-330	-552	-143	-5351	3846	1618	453
1969	-48	2225	152	-78	-5402	-321	-492	-3380	2012	4448	5650	-1748	182
1970	-3009	-442	-759	3025	3659	645	-864	-591	34	-3074	2913	2549	246
1971	216	268	55	173	-1736	-1099	-419	-2841	618	374	5053	1451	127
1972	439	-354	104	-2060	306	648	-1167	-1013	432	-3985	406	1814	-267
1973	-111	268	69	137	528	1027	-369	-2376	835	128	2674	4629	449
1974	570	285	227	-3003	486	-182	-2315	-4391	1555	3596	4780	285	114
1975	439	-135	-834	638	3039	504	-1225	-3340	1173	1535	5452	285	454
1976	439	285	-275	-168	207	1118	-11	-780	507	-1150	4324	4125	520
1977	2177	424	-4503	994	-3780	-1383	133	-1695	319	-353	3369	1193	-187
1978	-3455	85	-908	1769	7493	2152	-78	-2386	1790	2690	5740	3393	1103
1979	536	-1026	727	-3047	537	278	-638	-2349	857	-196	1269	3496	27
1980	2662	268	85	-3969	-1475	-404	-867	-3210	2503	3306	6820	1033	407
1981	325	-3631	-3083	-2130	-1688	-18	-102	-589	348	-5237	3475	1759	-638
1982	91	268	151	865	-1930	317	-2372	-5432	335	3072	3570	285	-47
1983	439	2945	1789	-2692	-1387	-817	-410	-1963	1093	726	573	653	57
1984	598	1675	-981	2035	1297	847	-1699	-1900	1436	17	3186	815	442
1985	-553	285	-389	478	1029	1065	1	-1604	335	-5432	1435	2737	-37
1986	-302	1381	48	169	53	-1172	-2112	-3744	1761	579	1552	3336	94
1987	-66	-886	1257	-563	-3888	-4089	-321	-968	818	-4505	2922	669	-580
1988	276	-820	112	160	-2128	-431	-158	-756	-676	-2231	-1128	2165	-339
1989	-838	1891	830	1425	-4423	-132	147	-1253	63	-5530	390	2893	-274
1990	4564	2946	2763	129	676	1159	-40	-413	-141	-3996	-890	2042	531
1991	-1233	1288	66	-1861	-5232	356	428	-466	-4982	-4567	-731	750	-976

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-23. Comparison of CVP + SWP Exports (cfs) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
DWRSIM Study 409 (1995 DEIR/EIS)													
1967	8718	10672	11526	11916	10784	6352	7644	8128	10257	10775	5927	11243	6875
1968	9342	7641	6876	4239	4835	6480	4666	3870	5924	11287	7538	6684	4789
1969	9074	8547	11249	12373	11632	6647	6727	7690	9600	6578	5360	11243	6439
1970	11027	7887	7427	4700	4822	6543	5990	4706	6268	11287	6324	6526	5038
1971	9054	10941	11411	11618	9028	10190	6116	7704	9028	11287	6640	10061	6822
1972	11027	10941	11264	10891	8473	8443	4578	3924	5870	11287	11287	7294	6352
1973	10113	10941	11250	11573	12382	7836	6772	6930	7786	11110	6124	6866	6618
1974	10863	10941	11352	11037	8319	8492	8550	8701	8864	8065	6913	11243	6838
1975	11027	10941	9893	7640	6018	7644	8266	8756	10439	9670	6241	11243	6503
1976	11027	10941	10586	8462	8468	6038	3070	3268	5896	7623	3547	4042	5006
1977	5434	6433	11057	4844	6067	4197	2825	2394	1076	1817	941	3580	3057
1978	4415	3326	10812	10363	5453	5280	6313	6696	6613	2839	4473	8219	4513
1979	11027	10941	6331	10707	7836	8114	6604	6512	8100	8864	5187	6117	5813
1980	7828	10941	11332	12621	8081	6096	6262	6772	5681	3232	4873	10445	5681
1981	11027	10941	9165	7318	7774	7239	5026	3874	5534	11287	7551	6005	5595
1982	8382	10941	11217	12015	11725	8742	8607	9742	11277	8589	8123	11243	7276
1983	11027	8298	7936	6107	4628	4948	6594	6273	7679	7796	10177	8388	5421
1984	7062	5299	5242	3218	4144	6341	6270	5104	6664	10505	5856	10243	4582
1985	11027	10941	11708	7800	8028	7408	3696	4418	5480	11287	10258	6439	5942
1986	8726	7912	11320	11410	12821	10247	8347	7354	6322	6447	5051	8075	6277
1987	11027	8936	7785	9199	9758	10838	3800	3456	5534	11287	8755	6020	5816
1988	6587	6114	11175	11273	6370	4724	2964	3114	5768	7321	4885	3498	4452
1989	4627	5403	6928	8317	6836	11402	5466	4050	5500	11287	11287	6501	5285
1990	5470	3927	7841	11255	6076	4468	3620	2804	5804	7330	5021	3857	4071
1991	4665	3854	5073	6171	6384	11142	3790	2873	5453	5022	4228	4544	3813
DWRSIM Study 771 (1999 REIR/EIS)													
1967	8067	11226	11547	12067	10893	7709	7041	5416	11612	11661	11693	11596	7272
1968	9172	8672	8164	7725	6884	7221	4336	3318	5781	5936	11384	8302	5243
1969	9026	10772	11401	12295	6230	6326	6235	4310	11612	11026	11010	9495	6621
1970	8018	7445	6668	7725	8481	7188	5126	4115	6302	8213	9237	9075	5285
1971	9270	11209	11466	11791	7292	9091	5697	4863	9646	11661	11693	11512	6950
1972	11466	10587	11368	8831	8779	9091	3411	2911	6302	7302	11693	9108	6085
1973	10002	11209	11319	11710	12910	8863	6403	4554	8621	11238	8798	11495	7066
1974	11433	11226	11579	8034	8805	8310	6235	4310	10419	11661	11693	11528	6952
1975	11466	10806	9059	8278	9057	8148	7041	5416	11612	11205	11693	11528	6957
1976	11466	11226	10311	8294	8675	7156	3059	2488	6403	6473	7871	8167	5526
1977	7611	6857	6554	5838	2287	2814	2958	699	1395	1464	4310	4773	2869
1978	960	3411	9904	12132	12946	7432	6235	4310	8403	5529	10213	11612	5616
1979	11563	9915	7058	7660	8373	8392	5966	4163	8957	8668	6456	9613	5839
1980	10490	11209	11417	8652	6606	5692	5395	3562	8184	6538	11693	11478	6089
1981	11352	7310	6082	5188	6086	7221	4924	3285	5882	6050	11026	7764	4958
1982	8473	11209	11368	12880	9795	9059	6235	4310	11612	11661	11693	11528	7229
1983	11466	11243	9725	3415	3241	4131	6184	4310	8772	8522	10750	9041	5478
1984	7660	6974	4261	5253	5441	7188	4571	3204	8100	10522	9042	11058	5024
1985	10474	11226	11319	8278	9057	8473	3697	2814	5815	5855	11693	9176	5905
1986	8424	9293	11368	11579	12874	9075	6235	3610	8083	7026	6603	11411	6370
1987	10961	8050	9042	8636	5870	6749	3479	2488	6352	6782	11677	6689	5235
1988	6863	5294	11287	11433	4242	4293	2806	2358	5092	5090	3757	5663	4113
1989	3789	7294	7758	9742	2413	11270	5613	2797	5563	5757	11677	9394	5012
1990	10034	6873	10604	11384	6752	5627	3580	2391	5663	3334	4131	5899	4602
1991	3432	5142	5139	4310	1152	11498	4218	2407	471	455	3497	5294	2837
Change: DWRSIM 771 - DWRSIM 409													
1967	-651	554	21	151	109	1357	-603	-2712	1355	886	5766	353	397
1968	-170	1031	1288	3486	2049	741	-330	-552	-143	-5351	3846	1618	453
1969	-48	2225	152	-78	-5402	-321	-492	-3380	2012	4448	5650	-1748	182
1970	-3009	-442	-759	3025	3659	645	-864	-591	34	-3074	2913	2549	246
1971	216	268	55	173	-1736	-1099	-419	-2841	618	374	5053	1451	127
1972	439	-354	104	-2060	306	648	-1167	-1013	432	-3985	406	1814	-267
1973	-111	268	69	137	528	1027	-369	-2376	835	128	2674	4629	449
1974	570	285	227	-3003	486	-182	-2315	-4391	1555	3596	4780	285	114
1975	439	-135	-834	638	3039	504	-1225	-3340	1173	1535	5452	285	454
1976	439	285	-275	-168	207	1118	-11	-780	507	-1150	4324	4125	520
1977	2177	424	-4503	994	-3780	-1383	133	-1695	319	-353	3369	1193	-187
1978	-3455	85	-908	1769	7493	2152	-78	-2386	1790	2690	5740	3393	1103
1979	536	-1026	727	-3047	537	278	-638	-2349	857	-196	1269	3496	27
1980	2662	268	85	-3969	-1475	-404	-867	-3210	2503	3306	6820	1033	407
1981	325	-3631	-3083	-2130	-1688	-18	-102	-589	348	-5237	3475	1759	-638
1982	91	268	151	865	-1930	317	-2372	-5432	335	3072	3570	285	-47
1983	439	2945	1789	-2692	-1387	-817	-410	-1963	1093	726	573	653	57
1984	598	1675	-981	2035	1297	847	-1699	-1900	1436	17	3186	815	442
1985	-553	285	-389	478	1029	1065	1	-1604	335	-5432	1435	2737	-37
1986	-302	1381	48	169	53	-1172	-2112	-3744	1761	579	1552	3336	94
1987	-66	-886	1257	-563	-3888	-4089	-321	-968	818	-4505	2922	669	-580
1988	276	-820	112	160	-2128	-431	-158	-756	-676	-2231	-1128	2165	-339
1989	-838	1891	830	1425	-4423	-132	147	-1253	63	-5530	390	2893	-274
1990	4564	2946	2763	129	676	1159	-40	-413	-141	-3996	-890	2042	531
1991	-1233	1288	66	-1861	-5232	356	428	-466	-4982	-4567	-731	750	-976

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-24. Comparison of Delta Outflow (cfs) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
	DWRSIM Study 409 (1995 DEIR/EIS)												
1967	4506	6538	34816	46682	55505	56651	48507	45279	37462	9803	5741	9902	21804
1968	16772	11630	11134	28914	67389	33948	10325	7579	6840	7724	5259	4158	12771
1969	5157	5675	13929	116820	130914	56981	47434	59410	26877	8002	5741	13407	29584
1970	17934	14092	55147	205170	91229	35248	11579	7959	7579	9358	5741	3872	28049
1971	5063	15618	64439	45778	22775	44856	16812	26487	12689	9449	5741	6040	16637
1972	8528	6661	12423	9956	19716	25452	9811	7579	6840	7840	6820	3791	7567
1973	5618	15492	18954	72356	89859	59498	15653	14634	10301	9373	5302	4147	19378
1974	5615	59398	65122	126767	42649	106026	70318	20652	12454	8002	5741	9345	32103
1975	12707	9012	10182	10316	67661	85520	20861	28861	15245	8263	5741	6958	16973
1976	13567	11491	6355	5879	11385	9744	7475	6366	6897	5750	3415	3008	5510
1977	2992	5211	7186	4505	8083	6897	6897	4505	4000	4001	3415	3008	3662
1978	2992	3537	6832	59011	60344	67366	40512	17640	8774	8002	5302	5227	17228
1979	9352	6861	4984	21446	44456	29641	15028	12903	10882	6505	4668	3397	10264
1980	4001	9948	12113	107524	132325	69498	16291	12000	7579	8002	5302	5436	23531
1981	9134	6252	9481	22569	24089	29667	12223	7579	6117	7090	4831	3492	8599
1982	4793	26967	87982	77836	95820	82058	142617	48242	16998	8002	5801	16124	36999
1983	31393	46767	89976	107902	189090	262789	110435	83414	74552	32036	9719	26029	64201
1984	37420	83000	159165	85443	49713	36149	13094	9792	8231	8845	5741	5638	30301
1985	9792	29597	19994	10628	15513	14122	8185	10012	6117	7164	5807	3758	8488
1986	4675	5194	7089	11205	219765	150695	31242	10807	7579	8002	5741	4037	28117
1987	4677	5554	4598	5767	12344	24487	10473	7579	6117	7205	5409	3515	5896
1988	4001	4740	6877	17924	11400	7804	7300	6496	6897	5491	3415	3008	5150
1989	2992	4648	5565	5788	8175	31151	18361	10268	6117	7264	6120	3818	6653
1990	4001	4504	6416	7862	11400	7310	10251	5910	6897	5584	3447	3008	4621
1991	2992	4187	4532	5025	8258	21264	11259	5362	7037	4215	3415	3008	4860
	DWRSIM Study 771 (1999 REIR/EIS)												
1967	4033	10487	35486	46903	49408	58580	63154	62337	46147	12848	5595	8117	24320
1968	10392	6689	13043	30445	58465	36153	13293	12116	5126	6505	4342	3008	12041
1969	4033	4924	17841	125650	146746	70241	66163	73184	29527	8001	5757	11915	34027
1970	10018	10050	55083	206998	91181	41162	14721	12799	6604	8001	5578	3008	28067
1971	4033	16469	58791	45260	24650	46806	23981	30526	13764	8001	4911	3882	16958
1972	4050	4504	10880	16963	19714	25533	10655	12197	6218	6505	4180	3008	7506
1973	4342	16368	22004	77478	91469	55799	23780	15727	10234	8001	4586	3479	20107
1974	5432	56583	66533	131618	45608	113338	76229	31664	13646	8506	6668	9461	34106
1975	7725	4588	9010	15174	62930	89399	31880	29274	17108	8001	5952	5344	17279
1976	12051	5260	6700	10864	17420	14653	8218	7562	6285	4001	2992	3008	5974
1977	5302	3496	3497	4863	11668	6522	6773	6896	6873	4001	2992	3008	3975
1978	5416	3496	5253	57653	55151	71200	52416	27387	9579	8001	4521	3748	18331
1979	4017	4537	4505	24427	47715	35177	21309	13482	11024	6505	4001	3008	10842
1980	4342	5848	13076	98799	136419	64906	25830	20914	10638	8001	4456	3865	23958
1981	4163	4504	8766	26509	27315	27973	18620	10539	5277	4993	3497	3008	8758
1982	4033	31560	83414	74648	103569	89529	150239	55262	20452	8001	5595	11713	38494
1983	20085	39156	86390	115160	190824	257170	106865	83658	84816	31258	15125	21208	63454
1984	17532	78733	156940	73119	42732	36023	18671	15434	9646	8001	5269	3075	28066
1985	4375	24805	19565	14051	18042	19500	13780	10994	5344	4993	3497	3008	8564
1986	4033	4958	10978	20898	220786	153167	33644	21158	10066	8001	5188	4100	29984
1987	4017	4521	4977	9368	19878	23452	10050	7904	6218	4993	3497	3008	6147
1988	4033	4504	8701	20231	11022	11433	7596	7497	6436	4001	2992	3008	5518
1989	5464	3496	3497	5107	11146	36690	23410	9530	5310	4993	3497	3664	6987
1990	4017	4504	4521	11026	12802	9953	10218	7985	6134	4001	2992	3008	4897
1991	5481	3496	3497	4749	11974	29469	16520	7351	5865	4001	2992	3008	5937
	Change: DWRSIM 771 - DWRSIM 409												
1967	-473	3949	670	221	-6097	1929	14647	17058	8685	3045	-146	-1785	2516
1968	-6380	-4941	1909	1531	-8924	2205	2968	4537	-1714	-1219	-917	-1150	-730
1969	-1124	-751	3912	8830	15832	13260	18729	13774	2650	-1	16	-1492	4443
1970	-7916	-4042	-64	1828	-48	5914	3142	4840	-975	-1357	-163	-864	18
1971	-1030	851	-5648	-518	1875	1950	7169	4039	1075	-1448	-830	-2158	321
1972	-4478	-2157	-1543	7007	-2	81	844	4618	-622	-1335	-2640	-783	-61
1973	-1276	876	3050	5122	1610	-3699	8127	1093	-67	-1372	-716	-668	729
1974	-183	-2815	1411	4851	2959	7312	5911	11012	1192	504	927	116	2003
1975	-4982	-4424	-1172	4858	-4731	3879	11019	413	1863	-262	211	-1614	305
1976	-1516	-6231	345	4985	6035	4909	743	1196	-612	-1749	-423	0	464
1977	2310	-1715	-3689	358	3585	-375	-124	2391	2873	-0	-423	0	313
1978	2424	-41	-1579	-1358	-5193	3834	11904	9747	805	-1	-781	-1479	1103
1979	-5335	-2324	-479	2981	3259	5536	6281	579	142	0	-667	-389	578
1980	341	-4100	963	-8725	4094	-4592	9539	8914	3059	-1	-846	-1571	427
1981	-4971	-1748	-715	3940	3226	-1694	6397	2960	-840	-2097	-1334	-484	159
1982	-760	4593	-4568	-3188	7749	7471	7622	7020	3454	-1	-206	-4411	1495
1983	-11308	-7611	-3586	7258	1734	-5619	-3570	244	10264	-778	5406	-4821	-747
1984	-19888	-4267	-2225	-12324	-6981	-126	5577	5642	1415	-844	-472	-2563	-2236
1985	-5417	-4792	-429	3423	2529	5378	5595	982	-773	-2171	-2310	-750	76
1986	-642	-236	3889	9693	1021	2472	2402	10351	2487	-1	-553	63	1867
1987	-660	-1033	379	3601	7534	-1035	-423	325	101	-2212	-1912	-507	251
1988	32	-236	1824	2307	-378	3629	296	1001	-461	-1490	-423	0	368
1989	2472	-1152	-2068	-681	2971	5539	5049	-738	-807	-2271	-2623	-154	334
1990	16	-0	-1895	3164	1402	2643	-33	2075	-763	-1583	-455	0	276
1991	2489	-691	-1035	-276	3716	8205	5261	1989	-1172	-214	-423	0	1077

Note: See "Notes and Acronyms" at end of section.

Table 3A-25. Comparison of Required Delta Outflow (cfs) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
DWRSIM Study 409 (1995 DEIR/EIS)													
1967	4506	6538	7120	6001	24954	14889	15102	11288	15427	8002	5741	5795	7564
1968	4001	5464	4685	6001	9901	20302	10325	7579	6840	7724	5259	4158	5565
1969	5157	5675	6705	6001	22447	15373	10822	20587	19795	8002	5741	5921	7978
1970	4001	4562	4885	6001	16029	12369	11579	7579	7579	9358	5741	3872	5644
1971	5063	5876	5719	8484	22775	15023	16279	9466	7822	9449	5741	6040	7103
1972	5475	6485	6235	6103	11400	11400	9811	7579	6840	7840	6820	3791	5417
1973	5618	5947	7461	6001	23408	16464	10742	8440	10301	9373	5302	4147	6830
1974	5615	7269	6591	6001	17027	12241	16292	15365	8779	8002	5741	6333	6954
1975	5398	6266	5984	6001	11400	19282	15699	7722	12026	8263	5741	6212	6636
1976	5242	6313	6355	5865	8609	8007	7475	6366	6897	5750	3415	3008	4423
1977	2992	5211	7186	4505	8083	6897	6897	4505	4000	4001	3415	3008	3662
1978	2992	3537	6832	6001	28559	19427	21202	15808	8774	8002	5302	5227	7944
1979	5026	6316	4984	6294	11400	16369	13576	7579	10882	6505	4668	3397	5852
1980	4001	6096	6397	6001	23044	16110	11084	9962	7579	8002	5302	5436	6577
1981	4597	6062	5589	6001	11276	9935	12223	7579	6117	7090	4831	3492	5116
1982	4793	7477	7160	6001	18180	17080	13890	15768	9704	8002	5801	3975	7109
1983	4001	4504	4505	6001	16285	13554	11748	10940	14572	8002	5741	3008	6206
1984	4001	4504	4505	6001	14676	12102	12388	7579	8231	8845	5741	5638	5684
1985	4950	7066	7108	6001	7382	10891	7863	10012	6117	7164	5807	3758	5075
1986	4675	5194	6742	6993	11400	19425	14337	8034	7579	8002	5741	4037	6164
1987	4001	5554	4598	5767	8363	11400	10473	7579	6117	7205	5409	3515	4826
1988	4001	4740	6877	7344	11400	7804	7300	6496	6897	5491	3415	3008	4511
1989	2992	4648	5565	5788	8175	8765	10416	10268	6117	7264	6120	3818	4823
1990	4001	4504	6416	6418	11400	6949	10251	5910	6897	5584	3447	3008	4512
1991	2992	4187	4532	5025	8258	8566	11259	5362	7037	4215	3415	3008	4094
DWRSIM Study 771 (1999 REIR/EIS)													
1967	4001	4504	4505	6001	25460	18280	17998	13807	17041	8001	4001	3008	7639
1968	4001	4504	4505	6001	10118	22915	13360	6863	5327	6505	4407	3008	5521
1969	4001	4504	4505	6001	22273	15759	13360	19304	19175	8001	4050	3008	7478
1970	4001	4504	4505	6001	16223	15043	14688	5253	6621	8001	5611	3008	5639
1971	4001	4504	4505	6001	24272	17190	18704	13320	8352	8001	5009	3008	7051
1972	4001	4504	4505	6001	11005	11401	9848	9823	6386	6505	4196	3008	4898
1973	4001	4504	4505	6001	24434	17890	14352	11043	10453	8001	4586	3008	6804
1974	4001	4504	4505	6001	17249	15174	17074	17337	9428	8001	4424	3008	6679
1975	4001	4504	4505	6001	11398	22785	18066	9986	13276	8001	4733	3008	6653
1976	4001	4504	4505	4505	6589	6505	7798	6115	6705	4001	2992	3008	3694
1977	5464	3496	3497	4733	12010	5643	7092	6896	6890	4001	2992	3008	3965
1978	5448	3496	3497	9807	28467	22004	20066	18020	9663	8001	4521	3008	8205
1979	4001	4504	4505	4505	11146	18296	15747	8994	11192	6505	4001	3008	5816
1980	4001	4504	4505	6001	23052	16686	14974	10961	8991	8001	4554	3008	6591
1981	4001	4504	4505	6001	10479	9351	13192	7692	5310	4993	3497	3008	4618
1982	4001	4504	4505	6001	19572	17467	16099	15450	12856	8001	4001	3008	6966
1983	4001	4504	4505	6001	17033	13856	11814	13368	16200	8001	4001	3008	6413
1984	4001	4504	4505	6001	16498	16279	15511	8408	9865	8001	5253	3008	6144
1985	4001	4504	4505	6001	7274	11401	9041	11010	5378	4993	3497	3008	4502
1986	4001	4504	4505	6001	11398	18540	14839	10929	8235	8001	5237	3008	5985
1987	4001	4504	4505	4505	7400	11401	9949	5318	6638	4993	3497	3008	4206
1988	4001	4504	4505	6001	11005	11401	7193	6261	6705	4001	2992	3008	4318
1989	5464	3496	3497	4733	10821	7725	9949	10002	5310	4993	3497	3008	4374
1990	4001	4504	4505	4505	11398	6652	10234	5708	6319	4001	2992	3008	4092
1991	5448	3496	3497	4733	11974	5643	10655	5773	5983	4001	2992	3008	4055
Change: DWRSIM 771 - DWRSIM 409													
1967	-505	-2034	-2615	0	506	3391	2896	2519	1614	-1	-1740	-2787	75
1968	-0	-960	-180	0	217	2613	3035	-716	-1513	-1219	-852	-1150	-44
1969	-1156	-1171	-2200	0	-174	386	2538	-1283	-620	-1	-1691	-2913	-500
1970	-0	-58	-380	0	194	2674	3109	-2326	-958	-1357	-130	-864	-6
1971	-1062	-1372	-1214	-2483	1497	2167	2425	3854	530	-1448	-732	-3032	-52
1972	-1474	-1981	-1730	-102	-395	1	37	2244	-454	-1335	-2624	-783	-519
1973	-1617	-1443	-2956	0	1026	1426	3610	2603	152	-1372	-716	-1139	-26
1974	-1614	-2765	-2086	0	222	2933	782	1972	649	-1	-1317	-3325	-275
1975	-1397	-1762	-1479	0	-2	3503	2367	2264	1250	-262	-1008	-3204	16
1976	-1241	-1809	-1850	-1360	-2020	-1502	323	-251	-192	-1749	-423	0	-728
1977	2472	-1715	-3689	228	3927	-1254	195	2391	2890	-0	-423	0	303
1978	2456	-41	-3335	3806	-92	2577	-1136	2212	889	-1	-781	-2219	261
1979	-1025	-1812	-479	-1789	-254	1927	2171	1415	310	0	-667	-389	-36
1980	-0	-1592	-1892	0	8	576	3890	999	1412	-1	-748	-2428	14
1981	-596	-1558	-1084	0	-797	-584	969	113	-807	-2097	-1334	-484	-498
1982	-792	-2973	-2655	0	1392	387	2209	-318	3152	-1	-1800	-967	-143
1983	-0	-0	-0	0	748	302	66	2428	1628	-1	-1740	0	207
1984	-0	-0	-0	0	1822	4177	3123	829	1634	-844	-488	-2630	460
1985	-949	-2562	-2603	0	-108	510	1178	998	-739	-2171	-2310	-750	-574
1986	-674	-690	-2237	-992	-2	-885	502	2895	656	-1	-504	-1029	-179
1987	-0	-1050	-93	-1262	-963	1	-524	-2261	521	-2212	-1912	-507	-619
1988	-0	-236	-2372	-1343	-395	3597	-107	-235	-192	-1490	-423	0	-193
1989	2472	-1152	-2068	-1055	2646	-1040	-467	-266	-807	-2271	-2623	-810	-449
1990	-0	-0	-1911	-1913	-2	-297	-17	-202	-578	-1583	-455	0	-420
1991	2456	-691	-1035	-292	3716	-2923	-604	411	-1054	-214	-423	0	-39

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-26. Comparison of SWP+CVP San Luis Reservoir Storage (TAF) between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
	DWRSIM Study 409 (1995 DEIR/EIS)												
1967	675	949	1277	1699	1994	2038	2038	2038	1928	1786	1372	1643	0
1968	1812	1948	2005	2038	2038	2038	1794	1434	961	768	415	401	0
1969	673	847	1138	1616	1970	2038	2038	2038	1935	1671	1235	1519	0
1970	1819	1955	2012	2038	2038	2038	1867	1552	1090	886	448	419	0
1971	689	1003	1299	1724	1891	2026	1799	1597	1254	999	531	668	0
1972	1010	1288	1538	1847	1972	2038	1742	1310	797	590	449	439	0
1973	737	1025	1292	1687	2019	2038	1858	1692	1359	1117	637	603	0
1974	956	1245	1513	1847	1977	2038	1982	1964	1734	1302	871	1096	0
1975	1458	1748	1876	2038	2038	2038	1939	1798	1564	1206	713	918	0
1976	1261	1538	1747	1906	2031	2037	1783	1507	1267	985	613	548	0
1977	661	707	966	1219	1269	1349	1349	1302	1098	910	699	751	0
1978	907	1044	1554	1853	2038	2038	2038	2038	1816	1158	672	776	0
1979	1181	1512	1516	1847	1972	2038	1913	1805	1471	1125	624	578	0
1980	778	1101	1401	1847	1998	2038	2038	1996	1613	1104	635	871	0
1981	1277	1607	1717	1883	2007	2038	1816	1455	960	767	415	361	0
1982	591	908	1196	1648	1940	2023	2038	2038	1935	1615	1255	1469	0
1983	1739	1875	1936	2038	2038	2038	2038	2038	1935	1793	1684	1821	0
1984	1981	2038	2038	2038	2038	2038	1901	1617	1188	944	486	682	0
1985	1079	1401	1657	1847	1972	2016	1677	1330	834	643	458	404	0
1986	623	737	1014	1402	1794	2030	2038	1921	1596	1126	632	695	0
1987	1067	1243	1304	1564	1768	1986	1662	1257	798	640	418	366	0
1988	463	512	776	1163	1182	1129	891	666	480	386	160	107	0
1989	179	263	387	679	813	1114	953	691	347	318	344	380	0
1990	426	355	465	878	912	881	736	560	425	339	168	155	0
1991	258	320	369	559	699	1130	1030	829	648	548	185	164	0
	DWRSIM Study 771 (1999 REIR/EIS)												
1967	253	582	1030	1509	1799	1876	1891	1719	1724	1637	1495	1509	0
1968	1565	1725	1869	1990	2038	2038	1802	1388	937	454	374	353	0
1969	519	851	1277	1754	1895	1990	1961	1730	1750	1631	1435	1440	0
1970	1490	1617	1755	1879	2037	2038	1849	1485	1066	724	510	533	0
1971	715	1073	1504	1875	1929	1992	1779	1385	1073	840	685	785	0
1972	1041	1311	1661	1806	1945	2024	1695	1206	728	270	152	163	0
1973	321	633	1008	1486	1874	1949	1806	1430	1161	952	663	792	0
1974	1074	1403	1703	1871	1998	2038	1888	1498	1297	1083	946	1068	0
1975	1344	1592	1751	1893	2033	2038	1899	1532	1326	1053	888	983	0
1976	1237	1544	1710	1851	2010	2038	1771	1354	1016	662	440	415	0
1977	492	578	696	916	916	916	876	665	444	279	206	262	0
1978	138	197	684	1329	1809	1951	1961	1768	1510	927	677	820	0
1979	1107	1302	1433	1546	1702	1783	1651	1307	1055	751	375	442	0
1980	705	1071	1505	1764	1937	2038	2038	1838	1657	1361	1340	1533	0
1981	1848	1992	2038	2038	2038	2038	1832	1409	956	469	358	302	0
1982	432	789	1211	1721	1876	1969	1899	1605	1528	1313	1154	1253	0
1983	1506	1852	2030	2038	2038	2038	2038	1897	1842	1716	1588	1651	0
1984	1822	2004	2038	2038	2038	2038	1816	1396	1081	878	649	795	0
1985	1053	1417	1698	1852	1991	2038	1726	1228	720	170	80	121	0
1986	142	331	709	1222	1733	1985	1989	1744	1622	1265	933	1096	0
1987	1371	1525	1800	2038	2038	2038	1758	1295	896	490	443	308	0
1988	321	408	728	1255	1276	1276	1102	836	628	398	130	123	0
1989	80	299	589	1031	1031	1545	1357	886	410	80	80	123	0
1990	262	343	639	1155	1349	1431	1306	1046	879	551	315	312	0
1991	241	320	440	566	510	1056	1096	997	727	445	366	457	0
	Change: DWRSIM 771 - DWRSIM 409												
1967	-422	-367	-247	-190	-195	-162	-147	-319	-204	-149	123	-134	0
1968	-247	-223	-136	-48	0	0	8	-46	-24	-314	-41	-48	0
1969	-154	4	139	138	-75	-48	-77	-308	-185	-40	200	-79	0
1970	-329	-338	-257	-159	-1	0	-18	-67	-24	-162	62	114	0
1971	26	70	205	151	38	-34	-20	-212	-181	-159	154	117	0
1972	31	23	123	-41	-27	-14	-47	-104	-69	-320	-297	-276	0
1973	-416	-392	-284	-201	-145	-89	-52	-262	-198	-165	26	189	0
1974	118	158	190	24	21	0	-94	-466	-437	-219	75	-28	0
1975	-114	-156	-125	-145	-5	0	-40	-266	-238	-153	175	65	0
1976	-24	6	-37	-55	-21	1	-12	-153	-251	-323	-173	-133	0
1977	-169	-129	-270	-303	-353	-433	-473	-637	-654	-631	-493	-489	0
1978	-769	-847	-870	-524	-229	-87	-77	-270	-306	-231	5	44	0
1979	-74	-210	-83	-301	-270	-255	-262	-498	-416	-374	-249	-136	0
1980	-73	-30	104	-83	-61	0	0	-158	44	257	705	662	0
1981	571	385	321	155	31	0	16	-46	-4	-298	-57	-59	0
1982	-159	-119	15	73	-64	-54	-139	-433	-407	-302	-101	-216	0
1983	-233	-23	94	0	0	0	0	-141	-93	-77	-96	-170	0
1984	-159	-34	0	0	0	0	-85	-221	-107	-66	163	113	0
1985	-26	16	41	5	19	22	49	-102	-114	-473	-378	-283	0
1986	-481	-406	-305	-180	-61	-45	-49	-177	26	139	301	401	0
1987	304	282	496	474	270	52	96	38	98	-150	25	-58	0
1988	-142	-104	-48	92	94	147	211	170	148	12	-30	16	0
1989	-99	36	202	352	218	431	404	195	63	-238	-264	-257	0
1990	-164	-12	174	277	437	550	570	486	454	212	147	157	0
1991	-17	0	71	7	-189	-74	66	168	79	-103	181	293	0

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-27. Comparison of CVP + SWP Deliveries [Banks+Tracy-San Luis Reservoir Storage Change] between DWRSIM Studies 771 and 409

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total TAF
DWRSIM Study 409 (1995 DEIR/EIS)													
1967	5108	6067	6192	5053	5472	5636	7644	8128	12106	13084	12660	6689	5662
1968	6594	5355	5949	3702	4835	6480	8766	9725	13873	14426	13279	6919	6028
1969	4650	5623	6516	4599	5258	5541	6727	7690	11331	10871	12451	6470	5293
1970	6148	5601	6500	4277	4822	6543	8864	9829	14032	14605	13447	7013	6135
1971	4663	5664	6597	4706	6021	7994	9931	10989	14792	15434	14251	7759	6564
1972	5465	6269	7198	5866	6300	7370	9552	10950	14491	14653	13580	7462	6586
1973	5267	6101	6908	5149	6404	7527	9797	9630	13382	15046	13930	7437	6430
1974	5122	6084	6993	5605	5978	7500	9491	8994	12729	15091	13922	7462	6333
1975	5140	6067	7811	5005	6018	7644	9930	11049	14371	15492	14259	7798	6672
1976	5449	6286	7187	5876	6295	5940	7339	7757	9929	12209	9597	5134	5370
1977	3596	5660	6845	729	5167	2896	2825	3158	4504	4874	4373	2706	2856
1978	1878	1024	2518	5500	2122	5280	6313	6696	10344	13540	12377	6471	4468
1979	4440	5378	6266	5324	5585	7041	8705	8268	13713	14491	13335	6890	5999
1980	4575	5513	6453	5368	5456	5445	6262	7455	12117	11510	12500	6479	5378
1981	4424	5395	7376	4618	5541	6735	8757	9745	13853	14426	13276	6912	6097
1982	4641	5614	6533	4664	6467	7392	8355	9742	13008	13793	13978	7647	6144
1983	6636	6012	6944	4448	4628	4948	6594	6273	9410	10105	11950	6086	5070
1984	4460	4341	5242	3218	4144	6341	8572	9723	13873	14473	13305	6949	5710
1985	4571	5530	7545	4710	5777	6692	9393	10061	13815	14393	13267	7346	6220
1986	5164	5996	6815	5100	5763	6409	8213	9257	11784	14091	13085	7016	5954
1987	4977	5978	6793	4971	6085	7293	9245	10043	13248	13857	12365	6894	6139
1988	5009	5291	6882	4979	6040	5586	6964	6773	8894	8850	8560	4389	4719
1989	3456	3991	4911	3568	4423	6507	8172	8311	11281	11759	10864	5896	5016
1990	4722	5120	6052	4538	5464	4972	6057	5666	8073	8729	7802	4075	4300
1991	2990	2812	4276	3081	3863	4133	5471	6142	8495	6648	10132	4897	3797
DWRSIM Study 771 (1999 REIR/EIS)													
1967	6652	5462	4066	4098	5510	6310	6604	7936	11192	12702	13596	11041	5742
1968	7969	5747	5627	5595	5980	7058	8134	9758	12991	13336	12295	8319	6203
1969	6034	4958	4277	4375	3547	4635	6554	7790	10940	12588	13791	9075	5343
1970	6928	5075	4245	5546	5474	7091	8117	9758	12991	13401	12328	8369	5992
1971	6034	4958	4261	5595	6158	7904	9092	10994	14553	15076	13807	9512	6513
1972	7009	5815	5481	6310	6224	7644	8756	10587	13948	14295	13206	8588	6508
1973	7140	5731	5042	3789	5762	7497	8621	10376	12789	14263	13092	8991	6220
1974	6554	5445	6505	5139	6356	7562	8571	10376	13444	14767	13515	9142	6478
1975	6700	6403	6278	5790	6374	7969	9193	11108	14738	15271	13970	9613	6842
1976	7058	5831	7416	5822	5754	6489	7310	8961	11764	11856	11140	8251	5892
1977	6050	5159	4407	2098	2125	2618	3462	3887	4840	3806	5220	3546	2849
1978	2716	2218	1789	1496	4105	4977	5899	7172	12369	14621	13889	8873	4834
1979	6619	6386	4733	5660	5402	6928	7999	9465	12839	13238	12181	8151	6009
1980	5920	4823	4163	4277	3460	3952	5226	6538	10873	10978	11628	7898	4811
1981	5952	4638	5123	5025	5924	7058	8201	9872	13159	13580	12425	8386	5994
1982	6066	4974	4310	4424	6842	7400	7226	8815	12570	14783	13873	9545	6083
1983	7074	5176	6635	3139	3079	3984	6016	6326	9361	10197	12441	7646	4892
1984	4602	3680	3497	5074	5302	7042	8134	9758	13058	13450	12360	8268	5685
1985	5985	4857	6554	5595	6392	7562	8772	10604	14016	14442	12750	8151	6376
1986	7790	5882	5025	3106	3547	4830	5999	7302	9781	12458	11596	8335	5168
1987	6196	5210	4424	4619	5726	6603	7999	9742	12722	13011	12051	8638	5849
1988	6375	3613	5904	2732	3755	4163	5596	6456	8268	8294	7741	5495	4126
1989	4472	3613	2879	2423	2305	2814	8604	10197	13243	10766	11287	8352	4884
1990	7514	5025	5611	2879	3115	4066	5495	6359	8201	8619	7725	5647	4239
1991	4326	3596	2992	2098	1981	2423	3361	3757	4739	4716	4489	3479	2531
Change: DWRSIM 771 - DWRSIM 409													
1967	1544	-606	-2126	-955	37	674	-1040	-192	-913	-383	936	4352	80
1968	1375	392	-322	1892	1145	578	-633	33	-882	-1090	-984	1399	175
1969	1383	-665	-2239	-224	-1711	-906	-173	100	-391	1716	1340	2605	50
1970	780	-526	-2255	1269	652	548	-747	-71	-1042	-1204	-1120	1356	-142
1971	1371	-707	-2336	888	137	-91	-839	5	-239	-358	-444	1753	-52
1972	1544	-454	-1717	444	-76	274	-797	-362	-543	-358	-374	1125	-78
1973	1873	-370	-1866	-1360	-642	-30	-1176	746	-593	-783	-838	1553	-210
1974	1432	-639	-488	-466	378	62	-920	1382	715	-324	-408	1680	145
1975	1561	335	-1534	784	356	325	-737	59	367	-221	-289	1815	170
1976	1610	-454	229	-54	-541	549	-28	1204	1834	-353	1543	3117	522
1977	2454	-501	-2438	1369	-3042	-278	637	729	336	-1069	848	840	-7
1978	838	1195	-729	-4004	1983	-303	-414	476	2025	1080	1512	2402	366
1979	2179	1008	-1533	336	-184	-113	-705	1197	-874	-1253	-1154	1261	10
1980	1344	-690	-2290	-1090	-1996	-1494	-1036	-917	-1244	-532	-872	1420	-567
1981	1528	-757	-2253	407	383	323	-556	127	-694	-846	-851	1473	-103
1982	1425	-639	-2223	-240	375	8	-1129	-927	-438	990	-105	1899	-61
1983	439	-836	-309	-1309	-1549	-964	-578	53	-49	92	492	1561	-178
1984	143	-661	-1745	1856	1158	701	-439	35	-816	-1024	-945	1319	-25
1985	1414	-673	-991	885	615	870	-621	542	200	48	-516	804	156
1986	2626	-114	-1790	-1994	-2216	-1579	-2213	-1955	-2003	-1633	-1489	1319	-787
1987	1219	-769	-2369	-352	-359	-690	-1246	-301	-526	-846	-314	1744	-290
1988	1366	-1677	-978	-2247	-2285	-1423	-1367	-317	-626	-556	-819	1107	-593
1989	1016	-378	-2033	-1145	-2119	-3693	433	1886	1962	-992	423	2456	-132
1990	2792	-95	-441	-1660	-2349	-906	-561	693	128	-109	-77	1571	-61
1991	1336	784	-1284	-983	-1883	-1709	-2109	-2385	-3756	-1932	-5643	-1418	-1266

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-28. South of Delta SWP & CVP Deliveries [Exports/Interruptible/Local/Changes in Reservoirs] (cfs) for DWRSIM Study 771

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1922	7011	5600	5038	4611	5665	6692	7939	8860	13069	14720	13331	8715	6109
1923	6377	5129	6844	5456	4458	6286	8645	10210	13540	13955	12859	8799	6188
1924	6474	5297	4583	3179	2757	3570	4729	5559	7104	7076	6793	5237	3762
1925	3856	3348	2761	1521	2099	5164	6998	8226	10734	11207	10095	6850	4396
1926	5255	4188	3607	2968	3090	5359	7199	9088	11927	12183	11298	8077	5082
1927	5938	4944	4209	3228	6853	7392	8577	10291	13473	14297	13054	8631	6087
1928	6247	5079	5738	5554	5886	7180	8426	10178	13523	13890	12811	8782	6232
1929	6442	5297	4567	3066	3306	4334	5838	6795	8784	8979	8306	5993	4326
1930	4555	3734	3136	2415	3900	5180	7670	9104	11826	12118	11200	8144	5007
1931	6117	5079	4339	2561	2658	3326	4578	5299	6784	6068	6891	4850	3532
1932	3677	3096	2550	1830	3348	4497	6090	7120	9221	9402	8680	6228	3966
1933	4702	3885	3266	2285	2370	2724	4527	5266	6717	6653	6322	4850	3232
1934	3628	3129	2550	1683	2478	3976	5368	6258	8045	8166	7558	5556	3523
1935	4246	3532	2957	2074	3090	4172	7653	10259	13775	14183	13054	8749	5294
1936	6312	5179	4485	2968	3383	7684	7922	9234	13557	14004	12843	8598	5802
1937	6198	5112	4388	3245	4944	6497	6292	7039	12028	13370	12290	8211	5407
1938	5954	4826	3786	5668	5376	6611	7065	8193	11557	13679	13900	10866	5881
1939	8101	6272	5673	5651	5611	6513	7636	9218	12280	12557	11623	7909	5976
1940	5743	4658	3965	2545	3696	6530	9031	10649	14195	14639	13152	9135	5909
1941	6718	5566	4648	3635	4800	6269	8897	9055	12565	14411	10176	8497	5746
1942	7808	4911	4144	5424	5665	6985	8056	9657	11322	14021	12778	8396	5983
1943	7775	6053	5364	4968	6079	5863	7351	7039	12028	13272	12209	8245	5807
1944	6019	4877	4193	5847	5365	6790	7788	9397	12549	12866	11900	8009	5768
1945	5808	4709	4030	3749	5755	7034	8157	9803	12649	13516	12420	8329	5790
1946	6052	4927	4241	6253	5106	7505	8846	10665	14179	14704	13445	9018	6331
1947	6653	5415	4746	4106	5611	6627	8830	10698	14179	13939	12095	9152	6157
1948	7710	6289	5055	2757	2740	3261	6326	11153	14666	14801	13071	9808	5891
1949	7938	6087	5347	3537	3558	4806	8359	9852	12868	13289	12193	8530	5814
1950	6474	5280	4583	2805	3810	5261	8661	10275	13456	13874	12794	9018	5810
1951	6751	5465	4388	6221	6745	7636	8779	10633	14061	14508	13347	9253	6503
1952	6848	5633	4843	4611	4565	6172	6796	7949	11238	15126	13705	8951	5818
1953	6865	5011	4404	5700	6151	7001	8309	10080	13473	13972	12778	8497	6168
1954	6182	6860	5429	5651	6601	7587	8981	10861	14363	14850	13624	9354	6657
1955	6930	5684	4973	4269	5629	5814	7418	8942	11691	12069	11087	7741	5565
1956	5808	4726	3737	4090	6704	6839	8712	10129	13725	15338	14014	9539	6236
1957	7076	5784	5412	6448	6385	7603	8729	10584	13977	14395	13282	9219	6570
1958	6832	5616	4876	5944	5791	7327	7670	8519	10582	14183	12924	8581	5964
1959	8946	6171	5461	5245	5953	5895	8275	9934	13254	13712	11022	8346	6167
1960	6100	4961	4290	2968	2844	6660	8443	10259	13439	13809	12469	8967	5744
1961	6702	5549	4811	3212	4152	6237	8140	9820	12817	12606	10729	8514	5628
1962	6426	5280	4567	2838	2730	7733	9535	11479	15271	15679	12453	9976	6273
1963	7320	6087	5364	4497	6403	7359	8577	10389	13221	14769	13494	9068	6428
1964	6686	5616	6941	5782	5174	5830	8594	10194	13439	12963	11249	8329	6081
1965	7418	6137	4859	3781	5358	7424	7804	10291	13574	14037	12908	9001	6190
1966	6686	5482	7088	5326	6457	7636	8863	10682	14195	14541	11444	9001	6480
1967	6621	5431	4030	4074	5485	6237	6561	7933	11170	12687	13575	10950	5717
1968	7971	5684	5559	5586	5852	7001	8090	9738	12969	13370	12258	8261	6174
1969	6003	4911	4225	4350	3504	4578	6510	7754	10902	12524	13754	8984	5309
1970	6897	5028	4176	5521	5467	6969	8073	9722	12985	13386	12274	8261	5959
1971	6019	4911	4209	5554	6133	7847	9065	10958	14498	15061	13770	9438	6484
1972	7011	5734	5461	6253	6182	7571	8678	10535	13876	14281	13120	8665	6478
1973	6979	5667	4990	3765	5899	7408	8577	10340	12733	14199	13054	8934	6187
1974	6539	5381	6437	5115	6331	7440	8561	10340	13406	14752	13477	9085	6447
1975	6686	6322	6226	5765	6349	7847	9166	11072	14700	15257	13965	9505	6809
1976	7060	5768	7380	5798	5660	6351	7132	8779	11490	11614	10924	8060	5793
1977	5938	5062	4306	2074	2099	2578	3418	3867	4835	3547	5183	3506	2800
1978	2701	2154	1769	1472	4080	4936	5855	7136	12347	14622	13868	8816	4812
1979	6572	6356	4664	5635	5376	6871	7956	9446	12801	13191	12144	8093	5979
1980	5905	4759	4111	4253	3418	3846	5166	6502	10834	10947	11591	7841	4777
1981	5889	4591	5071	4985	5917	7018	8174	9836	13120	13533	12388	8295	5962
1982	6052	4927	4258	4383	6835	7343	7199	8779	12498	14769	13851	9488	6056
1983	7027	5129	6583	3098	3018	3928	5956	6291	9305	10166	12404	7556	4854
1984	4588	3633	3445	5050	5261	6985	8107	9722	12985	13419	12323	8194	5654
1985	5986	4810	6502	5570	6367	7489	8729	10584	13977	14378	12745	8093	6349
1986	7775	5818	4990	3082	3450	4790	5956	7283	9776	12476	11607	8278	5145
1987	6198	5179	4306	4529	5683	6546	7905	9592	12549	12850	11884	8497	5775
1988	6328	3936	5656	2724	3748	4172	5620	6470	8364	8589	7834	5539	4162
1989	4246	3432	2892	2415	2244	2757	8577	10161	13221	10947	11266	8295	4854
1990	7483	4188	5998	3488	3090	4025	5435	6339	8146	8280	7655	5606	4207
1991	4279	3532	2957	2074	1955	2366	3301	3705	4717	4669	4451	3422	2499
1992	2620	2104	1737	1342	1905	3131	5267	6128	7893	7987	7444	5505	3201
1993	4198	3482	2924	2318	4962	7782	8897	9608	13288	14980	13152	8698	5689
1994	6344	5095	6844	5440	5575	5229	7972	9348	12448	11483	10778	7942	5701
Minimum	2620	2104	1737	1342	1905	2366	3301	3705	4717	3547	4451	3422	2499
Average	6209	4994	4629	4081	4698	5971	7493	8947	12010	12662	11677	8155	5522
Maximum	8946	6860	7380	6448	6853	7847	9535	11479	15271	15679	14014	10950	6809

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-29. South of Delta SWP & CVP Deficits (cfs) for DWRSIM Study 771

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total
1922	360	335	305	43	1141	506	429	464	677	802	629	262	359
1923	206	124	191	317	717	799	1101	1212	1736	2070	1605	649	647
1924	525	328	461	1982	3493	3797	5290	6208	8565	9345	8063	4616	3178
1925	3450	2570	2575	3641	4274	2204	3022	3541	4936	5182	4713	2969	2599
1926	2068	1747	1729	1960	3022	1748	2536	2302	3299	3771	3094	1372	1728
1927	1027	664	835	1418	691	457	647	707	1013	1208	938	380	603
1928	314	192	256	447	1136	951	1118	1244	1770	2119	1654	665	716
1929	542	328	477	2096	3068	3033	4181	4972	6885	7443	6551	3843	2620
1930	2751	2184	2201	2747	2474	2187	2349	2663	3843	4287	3623	1725	1993
1931	1206	856	998	2600	3716	4041	5442	6452	8868	9768	8405	4952	3457
1932	3646	2805	2787	2817	2345	2297	3304	3819	5456	5995	5162	2649	2599
1933	1816	1331	1427	2626	3724	4383	5208	6108	8492	9268	8022	4515	3434
1934	3303	2462	2494	3479	3878	3391	4652	5509	7608	8223	7234	4246	3408
1935	3044	2385	2380	2573	2707	2622	1840	1000	1450	1761	1345	531	1426
1936	428	276	400	1679	1789	652	899	984	1400	1680	1312	531	726
1937	428	259	368	1061	2061	1238	1017	1130	1618	1940	1491	598	797
1938	493	309	433	703	747	7	0	0	0	0	0	0	162
1939	0	8	18	30	1090	1205	1454	1602	2291	2737	2126	867	810
1940	688	428	611	2366	2284	717	882	968	1400	1664	1573	531	851
1941	428	259	368	597	593	1	1	0	0	233	2922	0	326
1942	6	0	21	30	730	733	1017	756	1081	1306	1003	413	428
1943	339	209	302	471	744	815	1118	1228	1753	2103	1638	665	687
1944	542	331	470	755	1288	945	1302	1423	2038	2444	1898	783	858
1945	623	377	546	898	1412	815	1050	1163	1669	1989	1540	632	767
1946	515	309	451	724	735	642	697	756	1081	1306	1003	413	521
1947	330	210	298	1055	2149	1813	1151	1260	1803	2168	2126	682	908
1948	542	343	481	2422	3545	4123	3660	838	1215	1485	1134	430	1220
1949	363	225	335	1673	2834	2561	1660	1898	2784	3084	2631	1288	1287
1950	848	654	754	2357	2564	2106	1358	1492	2196	2515	2046	835	1190
1951	588	369	526	779	727	772	1050	1163	1652	1973	1540	632	710
1952	509	318	445	691	57	0	0	0	0	0	0	0	122
1953	3	10	25	26	709	817	899	886	1282	1534	1182	481	474
1954	401	242	354	551	835	805	849	935	1349	1615	1247	514	585
1955	411	268	363	1049	1437	1455	2116	2449	3518	3885	3322	1692	1325
1956	1173	883	981	860	764	441	613	675	980	1160	906	363	591
1957	298	184	266	421	1088	805	1101	1212	1736	2087	1621	665	693
1958	525	335	461	732	1070	473	647	707	1013	1208	938	380	512
1959	314	196	291	443	907	671	933	1033	1467	1761	2825	565	688
1960	450	276	403	2194	3406	2090	1375	1508	2213	2564	2290	835	1183
1961	588	385	526	1950	2474	2220	1677	1947	2835	3767	4046	1305	1431
1962	881	654	770	2324	3644	1147	630	691	997	1241	2922	380	982
1963	298	192	254	431	735	799	664	740	1047	1257	971	397	470
1964	314	194	282	454	990	1042	1437	1586	2257	3014	2922	850	926
1965	688	436	591	1186	1070	1439	2013	1475	2112	2385	1964	902	981
1966	669	469	591	691	717	496	681	740	1064	1452	2922	397	657
1967	330	194	282	459	693	782	781	138	190	233	174	77	261
1968	54	49	76	101	799	817	1118	1228	1753	2103	1638	665	627
1969	548	326	468	739	446	0	0	0	0	0	0	0	152
1970	3	10	25	26	781	850	1134	1244	1770	2119	1654	682	621
1971	548	326	484	746	493	561	765	838	1198	1436	1117	447	541
1972	363	234	315	519	1129	838	1139	1228	1776	2119	1639	665	722
1973	556	352	477	1195	943	750	1000	1098	1568	1875	1459	598	716
1974	477	292	412	675	843	691	681	756	1081	1290	1003	413	520
1975	330	210	298	470	1088	545	664	724	1030	1241	955	397	480
1976	314	201	282	454	1615	1911	2685	2988	4179	4792	3916	1793	1516
1977	1369	873	1030	3072	4274	4773	6568	7867	10767	12110	10193	6296	4175
1978	4670	3679	3567	2988	1205	717	513	0	0	0	0	0	1046
1979	0	0	0	30	1378	847	1101	1212	1753	2087	1621	665	645
1980	525	327	464	743	1156	799	1085	1195	1719	2054	1589	649	742
1981	531	326	470	735	889	801	1034	1130	1618	1940	1508	615	700
1982	499	309	435	678	709	799	647	707	1013	1208	938	380	502
1983	319	192	284	434	467	1	1	0	0	0	0	0	102
1984	6	0	21	30	870	717	983	1098	1568	1875	1459	598	557
1985	477	293	416	665	1070	903	1101	1212	1719	2070	1654	649	738
1986	525	335	461	1785	1967	1221	1689	1862	2643	3144	2467	1035	1154
1987	818	494	660	1413	1825	1862	1912	2175	3104	3539	2924	1356	1332
1988	995	705	851	2519	2502	3196	4383	5265	7271	7768	6941	4246	2814
1989	3044	2452	2445	2747	4130	4611	1442	1589	2415	4320	3526	919	2030
1990	588	385	559	2357	3302	3407	4568	5411	7490	8093	7136	4213	2866
1991	3028	2385	2380	3072	4400	4985	6685	8030	10935	11704	10340	6397	4485
1992	4751	3746	3600	3570	4092	3976	4468	5262	7332	7967	6981	3910	3599
1993	2751	2109	2120	2235	781	408	244	252	375	444	711	145	759
1994	119	74	91	186	1180	961	1319	1456	2089	3762	2922	800	903
Minimum	0	0	0	26	57	0	0	0	0	0	0	0	102
Average	924	668	754	1301	1734	1493	1709	1855	2614	3015	2652	1247	1205
Maximum	4751	3746	3600	3641	4400	4985	6685	8030	10935	12110	10340	6397	4485

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-30. Available Water For Delta Wetlands Diversions under 1995 Water Quality Control Plan and
Delta Wetlands Final Operations Criteria (cfs)

DW%	90%	90%	90%	90%	75%	50%	0%	0%	50%	75%	90%	90%	
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Oct - Mar (TAF)
1922	0	0	416	2,102	2,783	2,376	0	0	2,024	0	0	0	461
1923	0	0	14,793	14,456	0	0	0	0	0	51	0	0	1,755
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	7,038	0	0	0	0	0	0	0	422
1926	0	0	0	109	2,128	0	0	0	0	0	0	0	134
1927	0	3,199	0	9,823	19,849	2,314	0	0	0	0	0	0	2,111
1928	0	1,218	0	7,132	2,213	6,505	0	0	0	0	0	0	1,024
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	4,583	0	0	0	0	0	0	0	0	275
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	1,639	2,613	0	0	0	0	0	0	0	0	255
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	187	0	0	0	0	0	0	0	0	11
1935	0	0	0	8,347	0	0	0	0	0	0	0	0	501
1936	0	0	0	11,104	11,508	991	0	0	0	0	0	0	1,416
1937	0	0	0	0	4,068	5,623	0	0	0	0	0	0	582
1938	0	4,954	16,329	14,297	34,940	23,535	0	0	3,733	0	46	0	5,643
1939	2,728	0	4,084	6,033	960	0	0	0	0	0	0	0	828
1940	0	0	0	7,990	7,278	6,453	0	0	0	64	0	0	1,303
1941	0	0	12,873	19,842	25,504	8,897	0	0	160	0	924	0	4,027
1942	943	0	18,671	30,505	26,316	2,435	0	0	1,021	0	60	0	4,732
1943	0	1,611	9,493	33,337	12,955	13,773	0	0	0	0	0	0	4,270
1944	0	0	0	3,019	4,826	807	0	0	0	0	0	0	519
1945	0	0	0	0	6,376	3,221	0	0	0	0	0	0	576
1946	0	0	19,160	15,044	0	422	0	0	0	51	0	0	2,078
1947	0	0	0	0	0	0	0	0	0	0	75	0	0
1948	0	0	0	0	0	0	0	0	0	51	60	0	0
1949	0	0	0	0	0	913	0	0	0	64	0	0	55
1950	0	0	0	3,154	1,809	0	0	0	0	39	46	0	298
1951	0	17,887	30,714	25,622	11,740	2,904	0	0	0	0	46	0	5,332
1952	0	0	14,999	26,244	18,474	10,332	0	0	3,724	3,272	2,844	616	4,203
1953	35	0	19,142	24,419	4,286	582	0	0	0	0	60	0	2,908
1954	0	0	0	11,483	11,922	2,065	0	0	0	0	46	0	1,528
1955	0	0	6,181	5,280	0	0	0	0	0	0	0	0	688
1956	0	0	26,198	44,925	16,820	3,143	0	0	0	51	60	0	5,465
1957	3,036	0	0	302	3,746	1,932	0	0	0	51	0	0	541
1958	0	0	4,922	12,589	21,123	12,257	0	0	3,362	613	3,168	0	3,053
1959	328	0	0	16,242	10,196	0	0	0	0	0	46	0	1,606
1960	0	0	0	0	0	0	0	0	0	0	60	0	0
1961	0	0	0	0	821	0	0	0	0	0	75	0	49
1962	0	0	0	0	5,656	0	0	0	0	0	60	0	339
1963	9,363	0	6,732	2,340	12,345	0	0	0	0	0	0	0	1,847
1964	0	8,478	0	7,615	0	0	0	0	0	0	60	0	966
1965	0	0	19,957	30,729	2,679	0	0	0	0	64	60	0	3,202
1966	0	5,317	1,740	11,108	3,455	496	0	0	0	0	46	0	1,327
1967	0	356	12,744	18,126	8,052	4,098	0	0	5,371	5,467	2,178	87	2,603
1968	738	0	2,686	14,755	12,139	1,425	0	0	0	0	0	0	1,905
1969	0	0	6,184	36,108	32,869	11,112	0	0	2,818	417	1,846	3,535	5,176
1970	313	1,388	20,689	48,182	21,438	4,321	0	0	0	0	0	0	5,780
1971	0	5,499	17,922	13,754	0	1,567	0	0	0	51	46	0	2,324
1972	0	0	3,159	2,100	215	0	0	0	0	0	60	0	328
1973	0	3,472	6,486	19,565	17,114	5,314	0	0	0	0	0	0	3,117
1974	0	14,891	17,861	26,204	8,820	9,919	0	0	0	1,015	2,816	828	4,662
1975	0	0	0	2,822	12,342	9,054	0	0	598	0	1,802	0	1,453
1976	3,475	0	0	0	454	0	0	0	0	0	0	0	236
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	17,771	7,920	6,460	0	0	0	0	0	0	1,929
1979	0	0	0	8,337	9,089	3,895	0	0	0	0	0	0	1,279
1980	0	0	3,219	30,753	32,228	9,507	0	0	0	0	46	0	4,542
1981	0	0	2,540	13,671	3,648	1,352	0	0	0	0	0	0	1,273
1982	0	10,999	16,249	25,857	20,195	12,695	0	0	877	1,625	2,692	4,549	5,160
1983	8,819	18,142	38,390	52,532	47,491	36,495	0	0	11,835	14,121	6,707	11,086	12,112
1984	12,416	37,108	52,339	32,698	8,293	3,082	0	0	0	0	0	0	8,756
1985	0	10,277	5,473	0	640	0	0	0	0	0	60	0	983
1986	0	0	0	4,819	46,285	18,154	0	0	0	0	0	0	4,155
1987	0	0	0	0	806	25	0	0	0	0	60	0	50
1988	0	0	0	7,394	0	0	0	0	0	0	0	0	444
1989	0	0	0	0	0	0	0	0	0	0	60	0	0
1990	0	0	0	1,289	0	0	0	0	0	0	0	0	77
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	717	0	0	0	0	0	0	0	43
1993	0	0	0	21,161	6,303	426	0	0	577	0	60	0	1,673
1994	0	0	0	0	1,442	0	0	0	0	0	0	0	86
Avg ('22-'94)	578	1,984	5,945	11,102	8,114	3,437	0	0	495	371	360	284	1,870

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-31. Unused CVP and SWP Permitted Pumping Capacity for Delta Wetlands Exports (cfs)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Jun - Sep (TAF)
1922	3,353	3,108	0	0	0	3,052	0	0	0	4,176	1,494	1,558	434
1923	0	0	0	2,693	7,805	4,582	0	0	3,922	0	3,706	1,613	554
1924	3,971	4,570	1,946	660	2,821	7,424	0	0	9,262	9,852	10,098	6,633	2,151
1925	6,899	6,284	1,537	4,155	0	6,047	0	0	6,472	6,160	5,007	2,919	1,234
1926	5,370	5,662	2,506	0	0	4,590	0	0	5,633	5,396	210	5,322	994
1927	4,394	0	0	0	562	3,678	0	0	3,728	1,184	3,397	1,438	585
1928	32	0	0	0	3,324	3,268	0	0	4,992	1,639	1,332	4,028	719
1929	3,581	1,511	547	347	2,292	6,706	0	0	6,774	9,299	9,626	5,003	1,842
1930	6,704	5,427	0	0	4,270	0	0	0	5,951	5,689	470	4,482	995
1931	4,671	4,956	819	1,636	5,283	7,534	0	0	10,959	10,958	6,991	5,171	2,045
1932	8,753	6,872	0	0	1,552	8,138	0	0	8,959	9,120	6,259	5,407	1,785
1933	5,289	6,334	4,956	967	4,699	6,356	0	0	10,774	10,974	8,048	5,339	2,108
1934	8,232	6,838	839	0	5,245	7,052	0	0	6,892	10,730	7,870	5,087	1,835
1935	8,558	3,998	3,934	0	5,954	253	0	0	2,940	598	4,845	3,272	699
1936	2,670	4,402	4,250	0	0	268	0	0	3,939	1,444	5,040	1,558	719
1937	4,020	4,385	1,456	27	0	3,998	0	0	4,153	4,827	6,146	2,180	1,038
1938	1,694	0	0	1,523	6,558	5,114	0	0	0	484	0	0	29
1939	0	0	4,567	5,966	5,321	4,508	0	0	5,239	4,957	1,462	6,112	1,066
1940	5,695	6,553	6,575	0	0	0	0	0	4,134	0	2,129	2,017	497
1941	3,109	1,629	0	0	651	5,428	0	0	0	3,965	0	0	238
1942	0	0	1,658	7,182	6,301	3,979	0	0	0	2,875	0	0	173
1943	0	0	0	6,559	5,856	5,036	0	0	4,633	3,119	2,698	1,340	707
1944	857	2,066	649	2,526	5,295	3,722	0	0	4,045	972	5,349	5,457	949
1945	4,947	0	0	106	790	3,884	0	0	2,998	452	5,007	3,289	705
1946	1,523	0	0	0	6,674	2,271	0	0	3,275	0	3,153	2,348	527
1947	3,435	1,220	0	628	1,052	2,600	0	0	5,669	5,591	0	1,372	758
1948	3,256	2,738	4,254	0	6,791	4,047	0	0	2,351	0	0	892	195
1949	1,369	2,015	0	706	3,570	0	0	0	3,734	0	4,503	2,953	671
1950	3,841	3,713	3,910	0	0	2,214	0	0	3,316	0	0	804	247
1951	2,833	0	0	0	1,746	3,289	0	0	4,563	712	0	695	358
1952	1,483	0	0	0	7,542	5,525	0	0	0	0	0	0	0
1953	0	3,372	6,932	6,710	5,816	3,727	0	0	1,404	2,452	0	0	231
1954	0	0	0	2,547	4,099	2,946	0	0	4,939	582	0	2,079	456
1955	1,662	0	0	0	3,342	5,071	0	0	4,192	3,688	5,446	3,390	1,003
1956	4,768	2,738	0	0	165	4,438	0	0	204	0	0	0	12
1957	0	1,847	624	83	4,235	3,057	0	0	3,598	0	779	957	320
1958	0	0	0	0	3,748	3,933	0	0	0	0	0	0	0
1959	0	1,175	3,363	5,858	5,500	5,482	0	0	5,816	5,754	0	2,181	825
1960	4,134	4,150	860	923	0	2,481	0	0	5,475	4,957	0	2,197	758
1961	3,223	881	0	0	0	3,579	0	0	5,751	5,672	0	4,045	928
1962	3,906	3,595	0	2,871	0	0	0	0	4,228	923	0	1,930	425
1963	0	0	0	0	0	0	0	0	3,116	13	161	116	204
1964	455	0	0	0	4,698	4,581	0	0	5,886	5,689	0	2,028	816
1965	3,630	0	0	0	0	1,254	0	0	4,504	0	0	586	305
1966	1,190	0	0	1,699	5,461	3,379	0	0	5,663	4,957	0	2,936	813
1967	3,532	0	0	0	0	1,380	0	0	0	0	0	0	0
1968	0	1,091	5,420	5,751	5,344	3,578	0	0	5,845	5,672	242	3,289	903
1969	2,573	750	0	0	3,645	7,119	0	0	0	0	0	0	0
1970	0	4,726	7,253	7,088	6,447	3,912	0	0	5,322	3,395	2,389	2,516	817
1971	2,312	0	0	0	4,427	1,318	0	0	1,981	0	0	0	119
1972	0	957	0	0	2,480	2,732	0	0	5,328	4,306	0	2,508	729
1973	1,565	0	0	0	0	903	0	0	3,010	354	2,828	127	379
1974	0	0	0	1,453	5,521	3,582	0	0	1,210	0	0	0	73
1975	0	717	0	2,736	5,186	3,322	0	0	0	403	0	0	24
1976	0	0	0	705	4,265	4,271	0	0	5,186	5,087	3,674	3,423	1,042
1977	3,971	4,670	4,854	5,630	9,172	8,401	0	0	10,068	10,063	7,186	6,785	2,046
1978	10,558	8,065	1,408	0	0	2,349	0	0	3,239	6,063	1,413	0	643
1979	0	1,629	2,147	0	5,704	3,979	0	0	2,675	2,940	5,154	1,978	765
1980	1,079	0	0	0	7,078	7,053	0	0	3,445	5,054	0	0	510
1981	223	4,234	4,899	5,901	4,977	3,605	0	0	5,751	5,542	600	3,827	943
1982	3,126	0	0	0	0	3,098	0	0	0	0	0	0	0
1983	0	0	1,896	9,121	9,233	7,804	0	0	0	656	0	2,418	184
1984	6,552	7,620	8,210	7,620	6,586	4,030	0	0	3,528	1,070	2,584	553	464
1985	1,089	0	0	0	3,703	2,867	0	0	5,804	5,737	0	2,443	839
1986	3,158	2,267	0	0	0	753	0	0	3,551	4,566	5,040	160	799
1987	593	3,494	2,349	1,581	4,026	2,836	0	0	5,263	4,794	0	4,902	898
1988	4,719	6,233	0	0	7,150	6,848	0	0	6,421	6,453	7,821	5,894	1,595
1989	7,744	4,200	3,516	1,652	8,968	0	0	0	6,051	5,819	0	2,214	845
1990	1,516	4,654	673	0	4,996	5,694	0	0	5,816	8,209	7,365	5,659	1,623
1991	8,118	6,368	6,164	6,718	10,217	0	0	0	10,976	11,072	8,000	6,247	2,178
1992	8,265	7,326	6,850	2,768	0	2,984	0	0	8,556	9,559	10,146	6,919	2,111
1993	8,232	7,359	80	0	0	104	0	0	0	5,054	0	804	352
1994	0	1,931	0	0	2,470	4,942	0	0	5,392	5,315	291	3,205	852
Avg ('22-'94)	2,910	2,470	1,533	1,577	3,570	3,671	0	0	4,226	3,658	2,410	2,419	763

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-32. Delta Wetlands Diversions (cfs) with Unlimited Demands

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (TAF)
1922	0	0	0	1,723	2,409	49	0	0	296	0	0	0	270
1923	0	0	3,871	15	0	0	0	0	0	51	0	0	237
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1926	0	0	0	0	2,128	0	0	0	0	0	0	0	128
1927	0	0	0	3,576	357	49	0	0	0	0	0	0	240
1928	0	1,218	0	2,719	30	49	0	0	0	0	0	0	242
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	2,238	0	0	0	0	0	0	0	0	135
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	1,786	0	0	0	0	0	0	0	0	108
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1937	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1938	0	0	3,871	15	31	49	0	0	296	0	46	0	259
1939	822	0	37	15	31	0	0	0	0	0	0	0	54
1940	0	0	0	0	4,000	177	0	0	0	64	0	0	256
1941	0	0	0	3,871	31	49	0	0	160	0	924	0	303
1942	943	0	2,179	15	31	49	0	0	296	0	60	0	215
1943	0	1,611	1,676	15	31	49	0	0	0	0	0	0	204
1944	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1945	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1946	0	0	3,871	15	0	422	0	0	0	51	0	0	263
1947	0	0	0	0	0	0	0	0	0	0	75	0	5
1948	0	0	0	0	0	0	0	0	0	51	60	0	7
1949	0	0	0	0	0	913	0	0	0	64	0	0	59
1950	0	0	0	0	1,809	0	0	0	0	39	46	0	114
1951	0	0	3,871	15	31	49	0	0	0	0	46	0	242
1952	0	0	3,871	15	30	49	0	0	296	130	115	87	277
1953	35	0	3,319	15	31	49	0	0	0	0	60	0	211
1954	0	0	0	3,668	255	49	0	0	0	0	46	0	242
1955	0	0	3,000	885	0	0	0	0	0	0	0	0	234
1956	0	0	0	3,871	30	49	0	0	0	51	60	0	245
1957	755	0	0	302	2,087	49	0	0	0	51	0	0	195
1958	0	0	3,000	885	31	49	0	0	296	130	115	0	271
1959	137	0	0	3,871	31	0	0	0	0	0	46	0	246
1960	0	0	0	0	0	0	0	0	0	0	60	0	4
1961	0	0	0	0	821	0	0	0	0	0	75	0	54
1962	0	0	0	0	4,000	0	0	0	0	0	60	0	245
1963	0	0	3,000	885	31	0	0	0	0	0	0	0	236
1964	0	3,533	0	28	0	0	0	0	0	0	60	0	218
1965	0	0	0	3,871	31	0	0	0	0	64	60	0	243
1966	0	0	1,740	2,145	31	49	0	0	0	0	46	0	242
1967	0	0	3,871	15	31	49	0	0	296	130	115	87	277
1968	53	0	1,093	15	30	49	0	0	0	0	0	0	75
1969	0	0	0	3,871	31	49	0	0	296	130	115	87	276
1970	53	25	13	15	31	49	0	0	0	0	0	0	11
1971	0	0	3,871	15	0	1,567	0	0	0	51	46	0	334
1972	0	0	3,000	200	30	0	0	0	0	0	60	0	198
1973	0	0	3,000	885	31	49	0	0	0	0	0	0	239
1974	0	4,000	13	15	31	49	0	0	0	1,015	688	87	355
1975	0	0	0	799	31	49	0	0	296	0	649	0	110
1976	137	0	0	0	265	0	0	0	0	0	0	0	24
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1979	0	0	0	3,417	533	49	0	0	0	0	0	0	241
1980	0	0	3,000	885	30	49	0	0	0	0	46	0	242
1981	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1982	0	0	3,871	15	31	49	0	0	296	130	115	87	277
1983	53	25	13	15	31	49	0	0	296	130	115	87	49
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	0	0	3,000	0	640	0	0	0	0	0	60	0	223
1986	0	0	0	2,356	1,708	49	0	0	0	0	0	0	248
1987	0	0	0	0	806	25	0	0	0	0	60	0	54
1988	0	0	0	2,999	0	0	0	0	0	0	0	0	181
1989	0	0	0	0	0	0	0	0	0	0	60	0	4
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	3,871	31	49	0	0	296	0	60	0	259
1994	0	0	0	0	1,442	0	0	0	0	0	0	0	87
Avg ('22-'94)	42	143	850	818	659	80	0	0	47	32	58	7	165

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-33. Delta Wetlands Storage (TAF) with Unlimited Demands

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	0	0	0	106	238	238	234	227	238	0	0	0
1923	0	0	238	238	125	0	0	0	0	3	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	222	96	92	86	0	0	0	0
1926	0	0	0	0	118	0	0	0	0	0	0	0
1927	0	0	0	220	238	238	234	227	101	21	0	0
1928	0	72	72	238	238	238	234	227	101	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	138	25	22	17	11	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	110	108	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	230	238	234	227	101	5	0	0
1937	0	0	0	0	222	238	234	227	101	0	0	0
1938	0	0	238	238	238	238	234	227	238	200	196	191
1939	238	237	238	238	238	112	108	101	0	0	0	0
1940	0	0	0	0	230	238	234	227	101	97	0	0
1941	0	0	0	238	238	238	234	227	230	0	57	52
1942	106	105	238	238	238	238	234	227	238	53	50	45
1943	41	136	238	238	238	238	234	227	101	0	0	0
1944	0	0	0	0	230	238	234	227	101	34	0	0
1945	0	0	0	0	222	238	234	227	101	66	0	0
1946	0	0	238	238	125	148	144	138	12	7	0	0
1947	0	0	0	0	0	0	0	0	0	0	5	0
1948	0	0	0	0	0	0	0	0	0	3	4	0
1949	0	0	0	0	0	56	52	46	0	4	0	0
1950	0	0	0	0	100	0	0	0	0	2	3	0
1951	0	0	238	238	238	238	234	227	101	50	45	0
1952	0	0	238	238	238	238	234	227	238	238	238	238
1953	237	35	238	238	238	238	234	227	137	0	4	0
1954	0	0	0	226	238	238	234	227	101	58	53	0
1955	0	0	184	238	125	0	0	0	0	0	0	0
1956	0	0	0	238	238	238	234	227	208	203	200	195
1957	238	127	106	124	238	238	234	227	101	97	42	0
1958	0	0	184	238	238	238	234	227	238	238	238	233
1959	238	167	0	238	238	112	108	101	0	0	3	0
1960	0	0	0	0	0	0	0	0	0	0	4	0
1961	0	0	0	0	46	0	0	0	0	0	5	0
1962	0	0	0	0	222	219	215	209	83	18	14	0
1963	0	0	184	238	238	235	231	224	98	90	73	61
1964	29	238	237	238	121	0	0	0	0	0	4	0
1965	0	0	0	238	238	207	203	197	71	67	63	23
1966	0	0	107	238	238	238	234	227	101	0	3	0
1967	0	0	238	238	238	238	234	227	238	238	238	238
1968	238	172	238	238	238	238	234	227	101	0	0	0
1969	0	0	0	238	238	238	234	227	238	238	238	238
1970	238	238	238	238	238	238	234	227	101	0	0	0
1971	0	0	238	238	125	219	214	208	83	78	74	69
1972	66	43	227	238	238	112	108	101	0	0	4	0
1973	0	0	184	238	238	238	234	227	101	72	0	0
1974	0	238	238	238	238	238	234	227	148	203	238	238
1975	235	191	190	238	238	238	234	227	238	205	238	233
1976	238	237	236	224	238	112	108	101	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	222	238	234	227	101	0	0	0
1979	0	0	0	210	238	238	234	227	101	0	0	0
1980	0	0	184	238	238	238	234	227	101	0	3	0
1981	0	0	0	238	238	238	234	227	101	0	0	0
1982	0	0	238	238	238	238	234	227	238	238	238	238
1983	238	238	238	238	238	238	234	227	238	238	238	238
1984	238	238	238	238	238	238	234	227	101	28	0	0
1985	0	0	184	184	217	91	87	81	0	0	4	0
1986	0	0	0	145	238	238	234	227	101	0	0	0
1987	0	0	0	0	45	43	39	33	0	0	4	0
1988	0	0	0	184	68	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	4	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	238	238	238	234	227	238	0	4	0
1994	0	0	0	0	80	0	0	0	0	0	0	0
Avg ('22-'94)	36	37	87	136	162	142	139	135	80	42	39	35

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-34. Delta Wetlands Discharge for Exports (cfs) under Unlimited Demands

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (TAF)	Calendar (TAF)
1922	0	0	0	0	0	0	0	0	0	3,741	0	0	225	226
1923	0	0	0	0	2,000	1,988	0	0	0	0	0	0	240	241
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	2,000	0	0	1,320	0	0	0	200	200
1926	0	0	0	0	0	1,873	0	0	0	0	0	0	113	113
1927	0	0	0	0	0	0	0	0	2,000	1,184	220	0	205	205
1928	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	2,000	0	0	0	71	0	0	0	125	125
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	1,709	0	0	0	0	0	0	103	103
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	2,000	1,444	0	0	207	208
1937	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1938	0	0	0	0	0	0	0	0	0	484	0	0	29	29
1939	0	0	0	0	0	2,000	0	0	1,587	0	0	0	216	216
1940	0	0	0	0	0	0	0	0	2,000	0	1,467	0	209	209
1941	0	0	0	0	0	0	0	0	0	3,609	0	0	217	218
1942	0	0	0	0	0	0	0	0	0	2,875	0	0	173	173
1943	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1944	0	0	0	0	0	0	0	0	2,000	972	431	0	205	205
1945	0	0	0	0	0	0	0	0	2,000	452	952	0	205	205
1946	0	0	0	0	2,000	0	0	0	2,000	0	0	0	241	241
1947	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	647	0	0	0	39	39
1950	0	0	0	0	0	1,585	0	0	0	0	0	0	95	96
1951	0	0	0	0	0	0	0	0	2,000	712	0	674	204	204
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	203
1953	0	3,372	0	0	0	0	0	0	1,404	2,095	0	0	414	211
1954	0	0	0	0	0	0	0	0	2,000	582	0	809	204	205
1955	0	0	0	0	2,000	1,988	0	0	0	0	0	0	240	241
1956	0	0	0	0	0	0	0	0	204	0	0	0	12	143
1957	0	1,847	319	0	0	0	0	0	2,000	0	779	611	335	205
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	234
1959	0	1,175	2,696	0	0	2,000	0	0	1,587	0	0	0	449	216
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	692	0	0	0	0	0	0	42	42
1962	0	0	0	0	0	0	0	0	2,000	923	0	154	185	186
1963	0	0	0	0	0	0	0	0	2,000	13	161	116	138	166
1964	455	0	0	0	2,000	1,923	0	0	0	0	0	0	264	237
1965	0	0	0	0	0	452	0	0	2,000	0	0	586	183	203
1966	322	0	0	0	0	0	0	0	2,000	1,519	0	0	231	212
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	66
1968	0	1,091	0	0	0	0	0	0	2,000	1,519	0	0	278	212
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1971	0	0	0	0	2,000	0	0	0	1,981	0	0	0	240	262
1972	0	354	0	0	0	2,000	0	0	1,587	0	0	0	237	216
1973	0	0	0	0	0	0	0	0	2,000	354	1,049	0	205	205
1974	0	0	0	0	0	0	0	0	1,210	0	0	0	73	116
1975	0	717	0	0	0	0	0	0	0	403	0	0	67	24
1976	0	0	0	168	0	2,000	0	0	1,587	0	0	0	226	227
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1979	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1980	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1981	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	2,000	1,070	334	0	205	205
1985	0	0	0	0	0	2,000	0	0	1,241	0	0	0	195	196
1986	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1987	0	0	0	0	0	0	0	0	432	0	0	0	26	26
1988	0	0	0	0	2,000	1,052	0	0	0	0	0	0	184	184
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	3,741	0	0	225	226
1994	0	0	0	0	0	1,253	0	0	0	0	0	0	76	76
Avg ('22-'94)	11	117	41	2	192	363	0	0	888	567	74	40	138	139

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-35. Delta Wetlands Diversions (cfs) Limited by South-of-Delta Delivery Deficits

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (TAF)
1922	0	0	0	1,723	2,409	49	0	0	296	0	0	0	270
1923	0	0	3,556	15	0	0	0	0	0	51	0	0	218
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1926	0	0	0	0	2,128	0	0	0	0	0	0	0	128
1927	0	0	0	3,576	357	49	0	0	0	0	0	0	240
1928	0	1,218	0	2,719	30	49	0	0	0	0	0	0	242
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	2,238	0	0	0	0	0	0	0	0	135
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	1,786	0	0	0	0	0	0	0	0	108
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1937	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1938	0	0	3,871	15	31	49	0	0	296	0	46	0	259
1939	337	0	37	15	31	0	0	0	0	0	0	0	25
1940	0	0	0	0	4,000	177	0	0	0	64	0	0	256
1941	0	0	0	3,871	31	49	0	0	160	0	377	0	270
1942	137	0	37	15	31	49	0	0	296	0	60	0	38
1943	0	359	13	15	31	49	0	0	0	0	0	0	28
1944	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1945	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1946	0	0	3,871	15	0	422	0	0	0	51	0	0	263
1947	0	0	0	0	0	0	0	0	0	0	75	0	5
1948	0	0	0	0	0	0	0	0	0	51	60	0	7
1949	0	0	0	0	0	913	0	0	0	64	0	0	59
1950	0	0	0	0	1,809	0	0	0	0	39	46	0	114
1951	0	0	3,871	15	31	49	0	0	0	0	46	0	242
1952	0	0	3,871	15	30	49	0	0	296	130	115	87	277
1953	35	0	55	15	31	49	0	0	0	0	60	0	15
1954	0	0	0	3,668	255	49	0	0	0	0	46	0	242
1955	0	0	3,000	885	0	0	0	0	0	0	0	0	234
1956	0	0	0	3,871	30	49	0	0	0	51	60	0	245
1957	755	0	0	302	270	49	0	0	0	51	0	0	86
1958	0	0	3,000	885	31	49	0	0	296	130	115	0	271
1959	137	0	0	52	31	0	0	0	0	0	46	0	16
1960	0	0	0	0	0	0	0	0	0	0	60	0	4
1961	0	0	0	0	821	0	0	0	0	0	75	0	54
1962	0	0	0	0	4,000	0	0	0	0	0	60	0	245
1963	0	0	3,000	885	31	0	0	0	0	0	0	0	236
1964	0	1,893	0	28	0	0	0	0	0	0	60	0	119
1965	0	0	0	3,871	31	0	0	0	0	64	60	0	243
1966	0	0	1,740	2,145	31	49	0	0	0	0	46	0	242
1967	0	0	3,871	15	31	49	0	0	296	130	115	87	277
1968	53	0	37	15	30	49	0	0	0	0	0	0	11
1969	0	0	0	3,871	31	49	0	0	296	130	115	87	276
1970	53	25	13	15	31	49	0	0	0	0	0	0	11
1971	0	0	3,871	15	0	485	0	0	0	51	46	0	269
1972	0	0	2,797	15	30	0	0	0	0	0	60	0	175
1973	0	0	3,000	885	31	49	0	0	0	0	0	0	239
1974	0	4,000	13	15	31	49	0	0	0	1,015	688	87	355
1975	0	0	0	332	31	49	0	0	296	0	649	0	82
1976	137	0	0	0	85	0	0	0	0	0	0	0	13
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1979	0	0	0	721	31	49	0	0	0	0	0	0	48
1980	0	0	3,000	885	30	49	0	0	0	0	46	0	242
1981	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1982	0	0	3,871	15	31	49	0	0	296	130	115	87	277
1983	53	25	13	15	31	49	0	0	296	130	115	87	49
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	0	0	3,000	0	640	0	0	0	0	0	60	0	223
1986	0	0	0	2,356	1,708	49	0	0	0	0	0	0	248
1987	0	0	0	0	806	25	0	0	0	0	60	0	54
1988	0	0	0	2,999	0	0	0	0	0	0	0	0	181
1989	0	0	0	0	0	0	0	0	0	0	60	0	4
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	3,871	31	49	0	0	296	0	60	0	259
1994	0	0	0	0	446	0	0	0	0	0	0	0	27
Avg ('22-'94)	24	103	732	720	612	65	0	0	47	32	51	7	144

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-36. Delta Wetlands Storage (TAF) Limited by South-of-Delta Delivery Deficits

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	0	0	0	106	238	238	234	227	238	91	47	25
1923	22	20	238	238	236	233	229	223	97	92	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	222	96	92	86	0	0	0	0
1926	0	0	0	0	118	10	5	0	0	0	0	0
1927	0	0	0	220	238	238	234	227	101	21	0	0
1928	0	72	72	238	238	238	234	227	101	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	138	25	22	17	11	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	110	108	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	230	238	234	227	101	5	0	0
1937	0	0	0	0	222	238	234	227	101	0	0	0
1938	0	0	238	238	238	238	234	227	238	230	226	221
1939	238	237	238	238	238	180	175	169	43	0	0	0
1940	0	0	0	0	230	238	234	227	101	97	0	0
1941	0	0	0	238	238	238	234	227	230	222	238	233
1942	238	237	238	238	238	238	234	227	238	230	227	221
1943	218	238	238	238	238	238	234	227	101	0	0	0
1944	0	0	0	0	230	238	234	227	101	34	0	0
1945	0	0	0	0	222	238	234	227	101	66	0	0
1946	0	0	238	238	210	233	229	223	97	92	0	0
1947	0	0	0	0	0	0	0	0	0	0	5	0
1948	0	0	0	0	0	0	0	0	0	3	4	0
1949	0	0	0	0	0	56	52	46	0	4	0	0
1950	0	0	0	0	100	0	0	0	0	2	3	0
1951	0	0	238	238	238	238	234	227	101	50	45	0
1952	0	0	238	238	238	238	234	227	238	238	238	238
1953	237	235	238	238	238	238	234	227	137	0	4	0
1954	0	0	0	226	238	238	234	227	101	58	53	0
1955	0	0	184	238	158	68	63	57	0	0	0	0
1956	0	0	0	238	238	238	234	227	208	203	200	195
1957	238	223	207	225	238	238	234	227	101	97	42	0
1958	0	0	184	238	238	238	234	227	238	238	238	233
1959	238	237	236	238	238	201	197	191	65	0	3	0
1960	0	0	0	0	0	0	0	0	0	0	4	0
1961	0	0	0	0	46	0	0	0	0	0	5	0
1962	0	0	0	0	222	219	215	209	83	18	14	0
1963	0	0	184	238	238	235	231	224	189	180	163	151
1964	127	238	237	238	236	233	229	223	97	0	4	0
1965	0	0	0	238	238	207	203	197	71	67	63	23
1966	0	0	107	238	238	238	234	227	101	0	3	0
1967	0	0	238	238	238	238	234	227	238	238	238	238
1968	238	237	238	238	238	238	234	227	101	0	0	0
1969	0	0	0	238	238	238	234	227	238	238	238	238
1970	238	238	238	238	238	238	234	227	101	0	0	0
1971	0	0	238	238	211	238	234	227	103	98	93	88
1972	85	67	238	238	238	235	231	224	98	0	4	0
1973	0	0	184	238	238	238	234	227	101	72	0	0
1974	0	238	238	238	238	238	234	227	148	203	238	238
1975	235	219	218	238	238	238	234	227	238	205	238	233
1976	238	237	236	235	238	140	135	129	3	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	222	238	234	227	220	212	205	200
1979	197	195	195	238	238	238	234	227	220	97	0	0
1980	0	0	184	238	238	238	234	227	101	0	3	0
1981	0	0	0	238	238	238	234	227	101	0	0	0
1982	0	0	238	238	238	238	234	227	238	238	238	238
1983	238	238	238	238	238	238	234	227	238	238	238	238
1984	238	238	238	238	238	238	234	227	101	28	0	0
1985	0	0	184	184	217	210	206	199	73	0	4	0
1986	0	0	0	145	238	238	234	227	101	0	0	0
1987	0	0	0	0	45	43	39	33	0	0	4	0
1988	0	0	0	184	68	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	4	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	238	238	238	234	227	238	230	227	221
1994	218	217	216	215	238	235	231	224	154	0	0	0
Avg ('22-'94)	48	53	97	141	170	160	156	152	94	61	52	48

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-37. Delta Wetlands Discharges (cfs) for Export Limited by South-of-Delta Delivery Deficits

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (TAF)	Calendar (TAF)
1922	0	0	0	0	0	0	0	0	0	2,256	602	287	189	190
1923	0	0	0	0	0	0	0	0	2,000	0	1,378	0	204	204
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	2,000	0	0	1,320	0	0	0	200	200
1926	0	0	0	0	0	1,711	0	0	0	0	0	0	103	103
1927	0	0	0	0	0	0	0	0	2,000	1,184	220	0	205	205
1928	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	2,000	0	0	0	71	0	0	0	125	125
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	1,709	0	0	0	0	0	0	103	103
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	2,000	1,444	0	0	207	208
1937	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	895	0	0	2,000	575	0	0	209	209
1940	0	0	0	0	0	0	0	0	2,000	0	1,467	0	209	209
1941	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1944	0	0	0	0	0	0	0	0	2,000	972	431	0	205	205
1945	0	0	0	0	0	0	0	0	2,000	452	952	0	205	205
1946	0	0	0	0	470	0	0	0	2,000	0	1,376	0	232	232
1947	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	647	0	0	0	39	39
1950	0	0	0	0	0	1,585	0	0	0	0	0	0	95	96
1951	0	0	0	0	0	0	0	0	2,000	712	0	674	204	204
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	1,404	2,095	0	0	211	211
1954	0	0	0	0	0	0	0	0	2,000	582	0	809	204	205
1955	0	0	0	0	1,414	1,415	0	0	844	0	0	0	221	222
1956	0	0	0	0	0	0	0	0	204	0	0	0	12	41
1957	0	229	244	0	0	0	0	0	2,000	0	779	611	233	205
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	549	0	0	2,000	921	0	0	209	209
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	692	0	0	0	0	0	0	42	42
1962	0	0	0	0	0	0	0	0	2,000	923	0	154	185	186
1963	0	0	0	0	0	0	0	0	483	13	161	116	47	67
1964	337	0	0	0	0	0	0	0	2,000	1,442	0	0	228	208
1965	0	0	0	0	0	452	0	0	2,000	0	0	586	183	203
1966	322	0	0	0	0	0	0	0	2,000	1,519	0	0	231	212
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1971	0	0	0	0	452	0	0	0	1,981	0	0	0	147	164
1972	0	280	0	0	0	0	0	0	2,000	1,470	0	0	226	209
1973	0	0	0	0	0	0	0	0	2,000	354	1,049	0	205	205
1974	0	0	0	0	0	0	0	0	1,210	0	0	0	73	87
1975	0	235	0	0	0	0	0	0	0	403	0	0	38	24
1976	0	0	0	0	0	1,545	0	0	2,000	0	0	0	214	214
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	1,881	1,458	0	201	201
1980	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1981	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	2,000	1,070	334	0	205	205
1985	0	0	0	0	0	72	0	0	2,000	1,064	0	0	189	189
1986	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1987	0	0	0	0	0	0	0	0	432	0	0	0	26	26
1988	0	0	0	0	2,000	1,052	0	0	0	0	0	0	184	184
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	1,057	2,382	0	0	207	208
Avg ('22-'94)	9	10	3	0	87	187	0	0	927	491	140	44	114	115

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-38. Diversion and Discharge Rules from the Final Operations Criteria and Application to the Daily Delta Wetlands Operations Model

Diversion Rules	Discharge Rules
X2 at Chipps Island: The X2 location must be downstream of Chipps Island (74 km) for at least 1 day prior to Delta Wetlands diversions in September through November, and for at least 10 days if the initial Delta Wetlands diversion occurs after November 30. The combined Delta Wetlands diversions are then limited to 5,500 cfs for 5 days.	**San Joaquin Inflow:** During the period of April through June, Bacon Island discharges for export are limited to 50% of the San Joaquin River inflow at Vernalis. No Delta Wetlands discharges for export are simulated in April or May because the monthly DWRSIM results do not allow an accurate simulation of the "split-month" VAMP pulse flows and exports. There may be some opportunity for discharging stored water from Bacon Island at the allowable 50% of San Joaquin River flow during April and May. Such discharges were not included in the daily results shown in this report.
X2 at Collinsville: The X2 locations must always be downstream of Collinsville (81 km). This is approximately equivalent to an outflow of 7,100 cfs.	**Webb Tract Discharge Prohibition:** No discharges from Webb Tract are allowed from January through June.
X2 Shift: The Delta Wetlands diversions cannot cause a cumulative upstream shift in the X2 location of more than 2.5 km. This is generally equivalent to limiting the Delta Wetlands diversions to less than 25% of the outflow.	**Habitat Island Discharges:** No discharges from Delta Wetlands habitat islands can be exported by Delta Wetlands or rediverted onto the Delta Wetlands reservoir islands.
Diversion Prohibition: No Delta Wetlands diversions are allowed in the months of April or May.	**Export Capacity:** Delta Wetlands discharges are limited to a specified fraction of the unused permitted CVP and SWP export capacity. This fraction is 75% in February and July, and 50% from March through June (but no Delta Wetlands discharges are simulated in April or May). Delta Wetlands discharges can use 100% of the unused permitted export capacity in August through January.
Surplus Available Water: Delta Wetlands diversions are limited to a specified fraction of the "surplus" available water for diversions as defined by the required Delta outflow and the E/I ratio. Delta Wetlands may divert 90% of this available water in August through January, 75% in February or July, and 50% in March or June.	**Environmental Water:** Delta Wetlands discharges for export made during December through June will be mitigated by an allocation of 10% of the discharge volume to an "environmental water account" that will be controlled by DFG. The daily modeling assumed that an additional 10% of any Delta Wetlands discharges for export were released to increase Delta outflows during the December-June period.
Delta Outflows: Delta Wetlands diversions are limited to a specified fraction of Delta outflow. A maximum of 25% of outflows can be diverted in June through December, and a maximum of 15% of outflows can be diverted in January through March.	**Discharge Maximum:** A calendar-year maximum of 250 TAF of Delta Wetlands storage can be exported. The daily water-year model specifies the amount of Delta Wetlands export from the previous January-September. Any remaining export volume can be exported during the October-December period. The 250-TAF cumulative export limit is reset on January 1.
DFG Limits: At the request of DFG, Delta Wetlands diversions can be limited to a specified fraction of the San Joaquin River flow for a maximum of 15 days between December and March. This criterion is a "real-time" adaptive management criterion that was not included in the daily modeling.	
Delta Smelt: A daily monitoring program is required during Delta Wetlands diversion periods. The Delta Wetlands diversion rate must be reduced to 50% if delta smelt are sampled near the Delta Wetlands islands. This was not included in the daily modeling.	

Table 3A-38. Continued

Diversion Rules	Discharge Rules
DCC Gates and Delta Inflow: During the November-through-January period, Delta Wetlands diversions will be limited to 3,000 cfs if the DCC gates are closed and Delta inflow is less than 30,000 cfs. Delta Wetlands diversions will be limited to 4,000 cfs if the inflow is less than 50,000 cfs and DCC gates are closed.	
Topping Off: The FOC allow some Delta Wetlands diversions for replacement of evaporative losses from the reservoir islands in June through October. This allowance was not included in the daily modeling; Delta Wetlands storage discharge for export generally begins in June from Bacon Island and in July from Webb Tract, so the potential gain in Delta Wetlands storage is limited to about 10 TAF.	

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-39 Comparison of Monthly and Daily Operations Model Results for Delta Wetlands Diversions and Exports (1985-1994)

Delta Wetlands Diversions (cfs)

Monthly Model Results

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	(TAF)
85	0	0	3,000	0	640	0	0	0	0	0	60	0	223
86	0	0	0	2,356	1,708	49	0	0	0	0	0	0	248
87	0	0	0	0	806	25	0	0	0	0	60	0	54
88	0	0	0	2,999	0	0	0	0	0	0	0	0	181
89	0	0	0	0	0	0	0	0	0	0	60	0	4
90	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0	0	0	0
93	0	0	0	3,871	31	49	0	0	296	0	60	0	259
94	0	0	0	0	1,442	0	0	0	0	0	0	0	87

Daily Model Results

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	(TAF)
85	0	1,186	2,356	659	226	49	0	0	0	0	128	0	278
86	0	0	0	0	4,074	260	0	0	0	0	0	295	279
87	0	0	0	0	110	1,777	0	0	0	0	154	0	123
88	0	0	0	269	0	0	0	0	0	0	0	0	16
89	0	0	0	0	0	978	0	0	0	0	750	0	104
90	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	199	0	0	0	0	0	0	12
92	0	0	0	0	86	21	0	0	0	0	0	0	6
93	0	0	0	1,729	2,361	650	0	0	1,036	0	425	17	375
94	0	0	0	0	491	1,187	0	0	0	0	141	0	110

Delta Wetlands Exports (cfs)

Monthly Model Results

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	(TAF)
85	0	0	0	0	0	2,000	0	0	1,241	0	0	0	195
86	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212
87	0	0	0	0	0	0	0	0	432	0	0	0	26
88	0	0	0	0	2,000	1,052	0	0	0	0	0	0	184
89	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0	0	0	0
93	0	0	0	0	0	0	0	0	0	3,741	0	0	225
94	0	0	0	0	0	1,253	0	0	0	0	0	0	76

Daily Model Results

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	(TAF)
85	0	0	287	110	0	0	0	0	590	2,839	95	0	237
86	0	0	0	0	0	0	0	0	1,435	1,977	0	0	206
87	259	0	0	0	0	89	0	0	753	706	108	0	115
88	0	0	0	0	259	0	0	0	0	0	0	0	16
89	0	0	0	0	0	0	0	0	750	9	501	191	88
90	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	0	0	0	0	98	0	0	0	6
92	0	0	0	0	0	89	0	0	0	0	0	0	5
93	0	0	0	0	0	1,184	0	0	157	2,729	0	0	246
94	91	933	0	0	0	0	0	0	757	625	0	126	153

Notes: See "Notes and Acronyms" at end of tables section.

Table 3A-40. Delta Wetlands Diversions (cfs) under Cumulative Conditions

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (TAF)
1922	0	0	0	0	4,000	307	0	0	214	0	0	0	272
1923	0	0	3,871	15	0	0	0	0	0	0	0	0	234
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1926	0	0	0	0	15	0	0	0	0	0	0	0	1
1927	0	0	0	3,299	664	49	0	0	0	0	0	0	242
1928	0	0	0	3,375	559	49	0	0	0	0	0	0	240
1929	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	379	0	0	0	0	0	0	0	0	23
1933	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1937	0	0	0	0	3,050	1,165	0	0	0	0	0	0	254
1938	0	0	3,871	15	31	49	0	0	296	0	0	0	257
1939	2,474	1,468	13	15	31	0	0	0	0	0	0	0	241
1940	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1941	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1942	0	0	3,871	15	31	49	0	0	0	0	0	0	239
1943	0	0	3,871	15	31	49	0	0	0	0	0	0	239
1944	0	0	0	0	4,000	177	0	0	0	0	0	0	252
1945	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1946	0	0	3,871	15	0	1,039	0	0	0	0	0	0	297
1947	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	3,871	15	31	49	0	0	0	0	0	0	239
1952	0	0	3,871	15	30	49	0	0	296	130	115	87	277
1953	53	25	13	15	31	49	0	0	0	0	0	0	11
1954	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1955	0	0	3,000	885	0	0	0	0	0	0	0	0	234
1956	0	0	0	3,871	30	49	0	0	0	0	0	0	238
1957	0	0	0	1,854	2,263	49	0	0	0	0	0	0	251
1958	0	0	1,913	1,972	31	49	0	0	296	0	0	0	257
1959	1,698	0	762	1,988	31	0	0	0	0	0	0	0	270
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	4,000	0	0	0	0	0	0	0	241
1963	0	0	3,000	0	1,510	49	0	0	0	0	0	0	275
1964	0	4,000	0	188	30	0	0	0	0	0	0	0	254
1965	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1966	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1967	0	0	3,871	15	31	49	0	0	296	130	0	154	274
1968	1,304	0	2,785	133	30	49	0	0	0	0	0	0	259
1969	0	0	0	3,871	31	49	0	0	296	0	0	3,343	457
1970	688	25	13	15	31	49	0	0	0	0	0	0	49
1971	0	0	3,871	15	31	49	0	0	0	0	0	0	239
1972	0	0	157	2,048	1,429	0	0	0	0	0	0	0	219
1973	0	0	3,000	885	31	49	0	0	0	0	0	0	239
1974	0	4,000	13	15	31	49	0	0	0	0	0	0	247
1975	0	0	3,000	885	31	49	0	0	0	0	0	0	239
1976	217	0	0	1,834	454	0	0	0	0	0	0	0	151
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1979	0	0	0	0	4,000	307	0	0	0	0	0	0	259
1980	0	0	259	3,626	30	49	0	0	0	0	0	0	239
1981	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1982	0	0	3,871	15	31	49	0	0	0	0	0	1,291	317
1983	2,674	25	13	15	31	49	0	0	296	130	115	87	207
1984	53	25	13	15	30	49	0	0	0	0	0	0	11
1985	0	0	3,000	885	31	0	0	0	0	0	0	0	236
1986	0	0	0	1,894	2,219	49	0	0	0	0	0	0	251
1987	0	0	0	0	806	25	0	0	0	0	0	0	50
1988	0	0	0	2,516	0	0	0	0	0	0	0	0	152
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	3,871	31	49	0	0	0	0	0	0	238
1994	0	0	0	1,316	2,859	0	0	0	0	0	0	0	252
Avg ('22-'94)	126	131	817	838	722	75	0	0	27	5	3	68	169

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-41. Delta Wetlands Storage (TAF) under Cumulative Conditions

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1922	0	0	0	0	222	238	234	227	233	0	0	0
1923	0	0	238	238	125	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	222	96	92	86	0	0	0	0
1926	0	0	0	0	1	0	0	0	0	0	0	0
1927	0	0	0	203	238	238	234	227	101	0	0	0
1928	0	0	0	208	238	238	234	227	101	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	23	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	230	238	234	227	101	0	0	0
1937	0	0	0	0	169	238	234	227	101	0	0	0
1938	0	0	238	238	238	238	234	227	238	0	0	0
1939	152	238	238	238	238	112	108	101	0	0	0	0
1940	0	0	0	0	230	238	234	227	101	0	0	0
1941	0	0	0	238	238	238	234	227	101	0	0	0
1942	0	0	238	238	238	238	234	227	127	0	0	0
1943	0	0	238	238	238	238	234	227	101	0	0	0
1944	0	0	0	0	230	238	234	227	101	0	0	0
1945	0	0	0	0	222	238	234	227	101	0	0	0
1946	0	0	238	238	125	186	182	175	49	22	14	9
1947	6	5	4	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	238	238	238	238	234	227	101	0	0	0
1952	0	0	238	238	238	238	234	227	238	238	238	238
1953	238	238	238	238	238	238	234	227	101	0	0	0
1954	0	0	0	238	238	238	234	227	101	0	0	0
1955	0	0	184	238	125	0	0	0	0	0	0	0
1956	0	0	0	238	238	238	234	227	101	0	0	0
1957	0	0	0	114	238	238	234	227	101	0	0	0
1958	0	0	118	238	238	238	234	227	238	58	44	0
1959	104	71	117	238	238	112	108	101	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	222	96	92	86	0	0	0	0
1963	0	0	184	156	238	238	234	227	101	0	0	0
1964	0	238	227	238	238	112	108	101	0	0	0	0
1965	0	0	0	238	238	238	234	227	101	0	0	0
1966	0	0	0	238	238	238	234	227	101	0	0	0
1967	0	0	238	238	238	238	234	227	238	238	157	161
1968	238	60	231	238	238	238	234	227	101	0	0	0
1969	0	0	0	238	238	238	234	227	238	42	0	199
1970	238	238	238	238	238	238	234	227	101	0	0	0
1971	0	0	238	238	238	238	234	227	101	0	0	0
1972	0	0	10	135	215	89	85	79	0	0	0	0
1973	0	0	184	238	238	238	234	227	101	0	0	0
1974	0	238	238	238	238	238	234	227	101	0	0	0
1975	0	0	184	238	238	238	234	227	101	0	0	0
1976	13	0	0	113	137	11	7	1	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	222	238	234	227	101	0	0	0
1979	0	0	0	0	222	238	234	227	101	0	0	0
1980	0	0	16	238	238	238	234	227	101	0	0	0
1981	0	0	0	238	238	238	234	227	101	0	0	0
1982	0	0	238	238	238	238	234	227	109	12	0	77
1983	238	238	238	238	238	238	234	227	238	238	238	238
1984	238	238	238	238	238	238	234	227	101	0	0	0
1985	0	0	184	238	238	112	108	101	0	0	0	0
1986	0	0	0	116	238	238	234	227	101	0	0	0
1987	0	0	0	0	45	43	39	33	0	0	0	0
1988	0	0	0	155	38	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	238	238	238	234	227	101	0	0	0
1994	0	0	0	81	238	112	108	101	0	0	0	0
Avg ('22-'94)	20	25	75	125	159	142	139	135	68	12	9	13

Note: See "Notes and Acronyms" at end of tables section.

Table 3A-42. Delta Wetlands Discharges for Export (cfs) under Cumulative Conditions

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Total (TAF)	Calendar (TAF)
1922	0	0	0	0	0	0	0	0	0	3,661	0	0	221	221
1923	0	0	0	0	2,000	1,988	0	0	0	0	0	0	240	241
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	2,000	0	0	1,320	0	0	0	200	200
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1928	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	376	0	0	0	0	0	0	0	23	23
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1937	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1938	0	0	0	0	0	0	0	0	0	3,741	0	0	225	226
1939	0	0	0	0	0	2,000	0	0	1,587	0	0	0	216	216
1940	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1941	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1942	0	0	0	0	0	0	0	0	1,578	1,928	0	0	211	211
1943	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1944	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1945	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1946	0	0	0	0	2,000	0	0	0	2,000	324	0	0	261	261
1947	0	0	0	46	0	0	0	0	0	0	0	0	3	3
1948	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1954	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1955	0	0	0	0	2,000	1,988	0	0	0	0	0	0	240	241
1956	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1957	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1958	0	0	0	0	0	0	0	0	0	2,803	100	658	215	248
1959	0	543	0	0	0	2,000	0	0	1,587	0	0	0	249	216
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	2,000	0	0	1,320	0	0	0	200	200
1963	0	0	0	451	0	0	0	0	2,000	1,519	0	0	239	249
1964	0	0	160	0	0	2,000	0	0	1,587	0	0	0	226	216
1965	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1966	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1967	0	0	0	0	0	0	0	0	0	0	1,200	0	72	251
1968	0	2,961	0	0	0	0	0	0	2,000	1,519	0	0	390	212
1969	0	0	0	0	0	0	0	0	0	3,064	562	0	218	219
1970	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1971	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1972	0	0	0	0	0	2,000	0	0	1,203	0	0	0	193	193
1973	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1974	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1975	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	224
1976	0	199	0	0	0	2,000	0	0	0	0	0	0	132	121
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1979	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1980	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1981	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1982	0	0	0	0	0	0	0	0	1,866	1,453	80	0	205	205
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1985	0	0	0	0	0	2,000	0	0	1,587	0	0	0	216	216
1986	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1987	0	0	0	0	0	0	0	0	432	0	0	0	26	26
1988	0	0	0	0	2,000	568	0	0	0	0	0	0	155	155
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	2,000	1,519	0	0	212	212
1994	0	0	0	0	0	2,000	0	0	1,587	0	0	0	216	216
Avg ('22-'94)	0	51	2	7	115	309	0	0	1,064	857	27	9	147	147

Note: See "Notes and Acronyms" at end of tables section.

Notes and Acronyms

The following acronyms and terms appear in the tables that accompany Chapter 3A.

CCWD	Contra Costa Water District
cfs	cubic feet per second
CVP	Central Valley Project
DCC	Delta Cross Channel
DFG	California Department of Fish and Game
E/I ratio	allowable amount of exports as a percentage of inflow
km	kilometer
SJR	San Joaquin River
SWP	State Water Project
TAF	thousand acre-feet
VAMP	Vernalis Adaptive Management Plan
WQCP	Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary

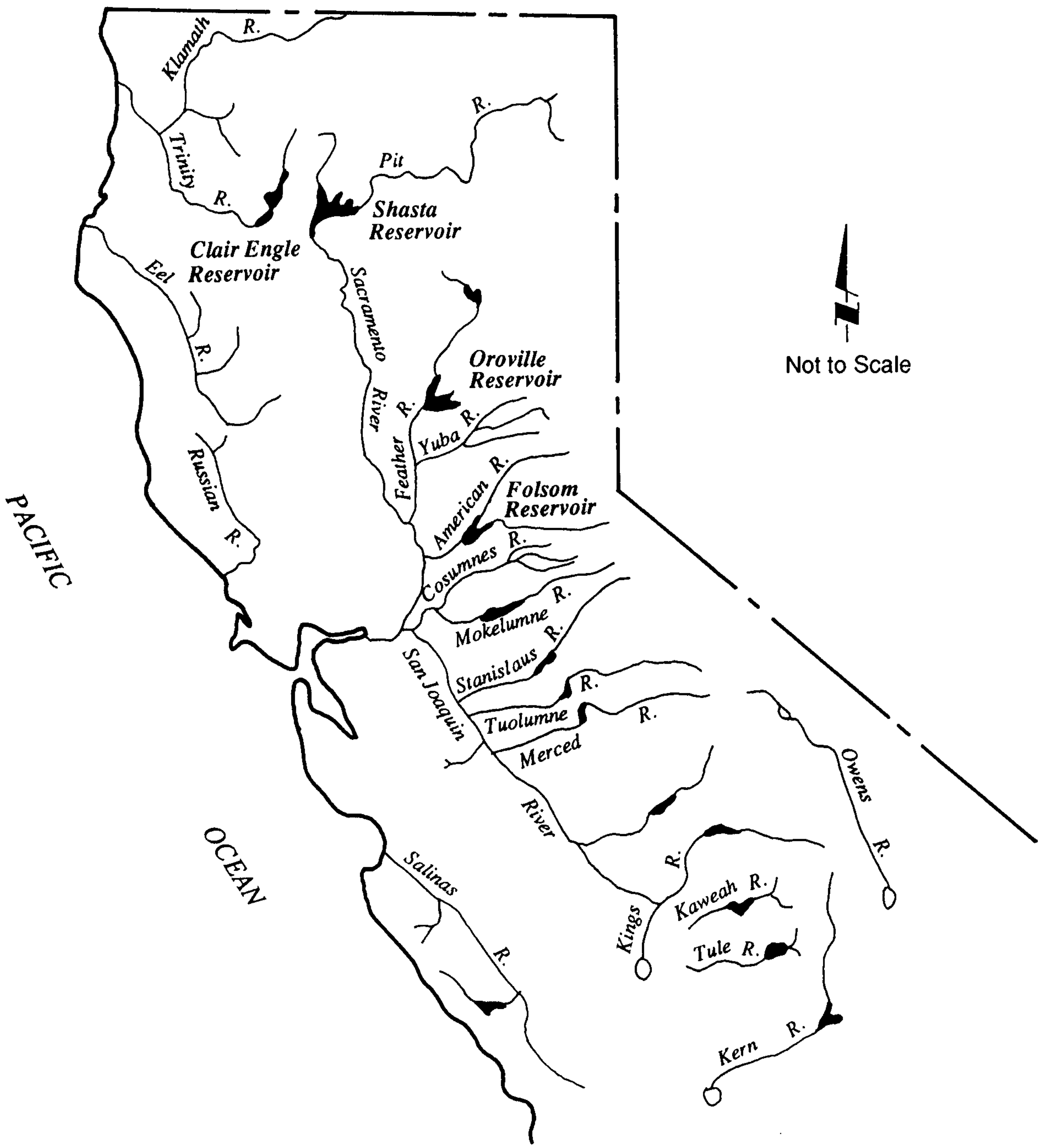

Figure 3A-1
Upstream Reservoirs Included in the DWRSIM Statewide Water Supply Planning Model

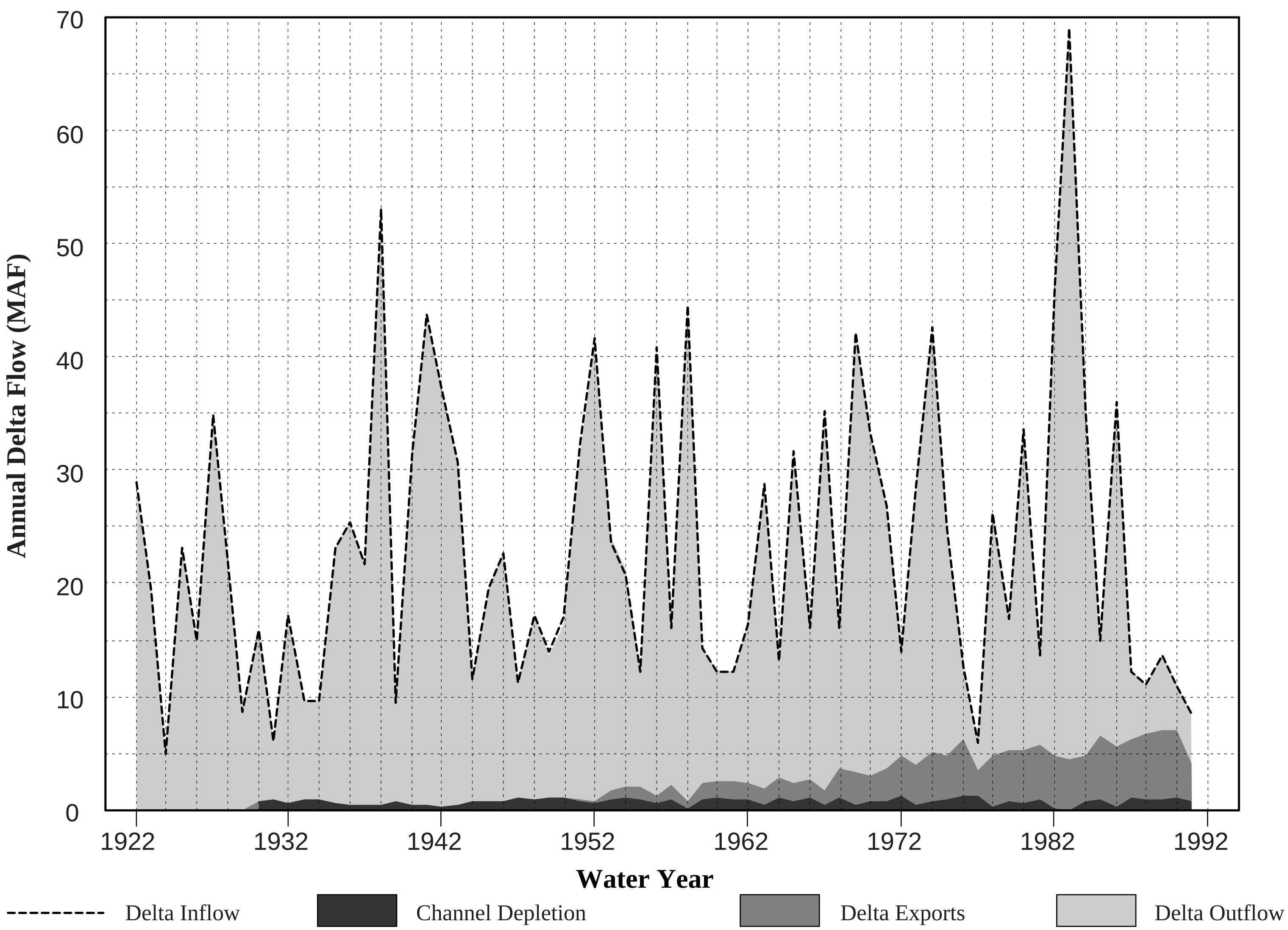

Figure 3A-2
Historical Annual Delta Inflow, Channel Depletion, Delta Exports, and Delta Outflow for 1922-1991

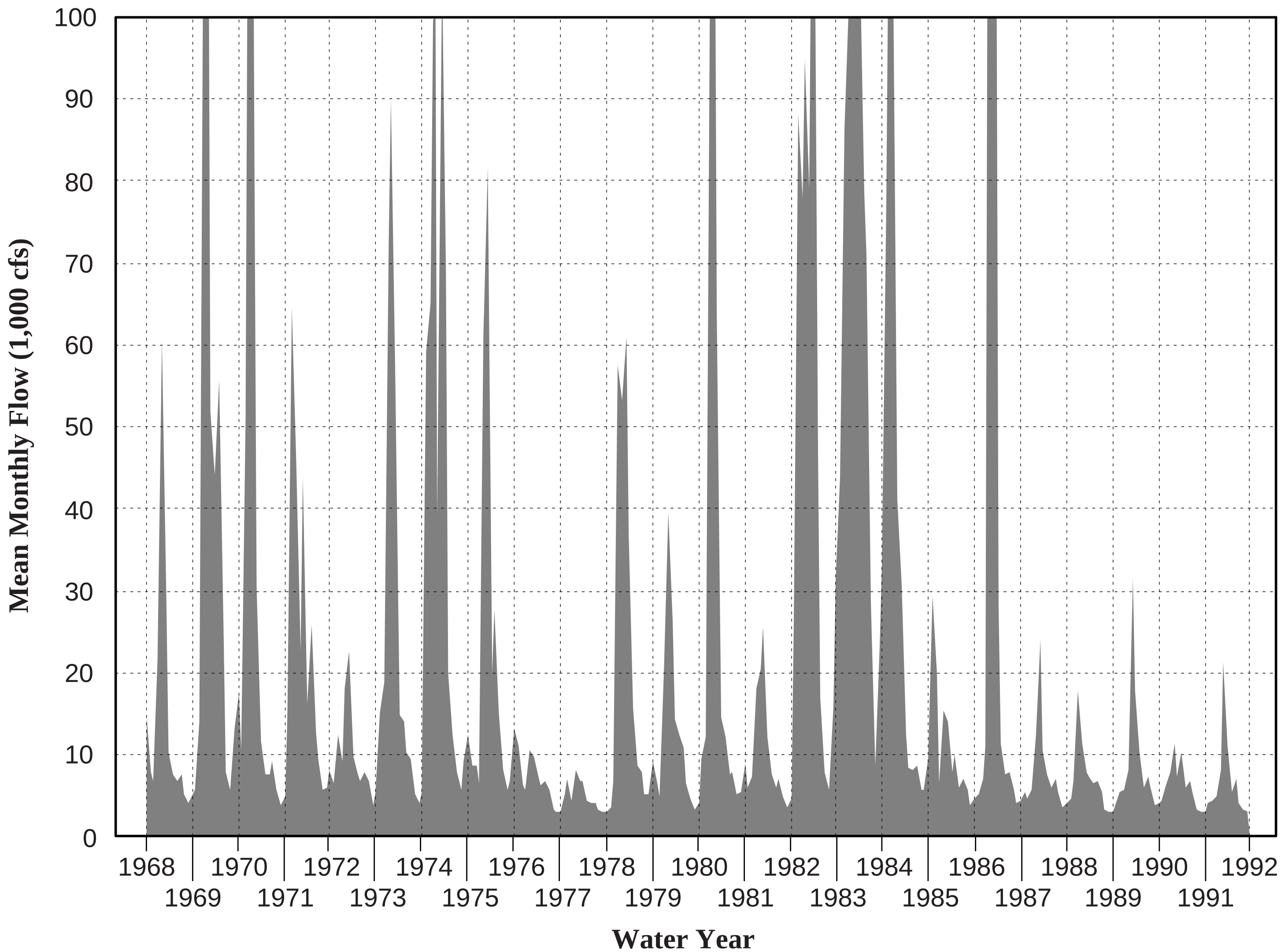

Figure 3A-3
Historical Mean Monthly Delta Outflow for 1968-1991

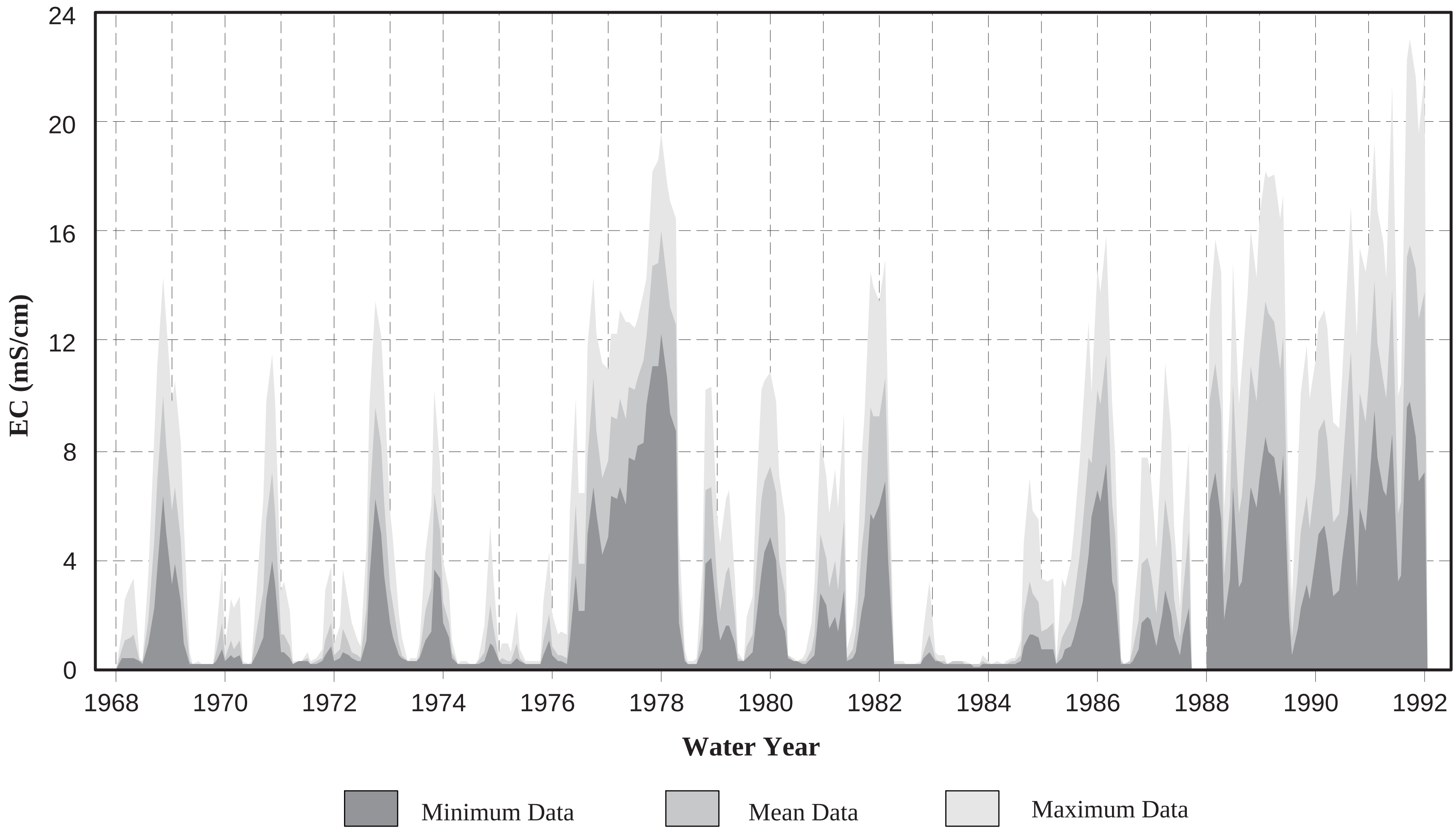

Figure 3A-4
Historical Minimum, Mean, and Maximum Monthly EC at Pittsburg for 1968-1991

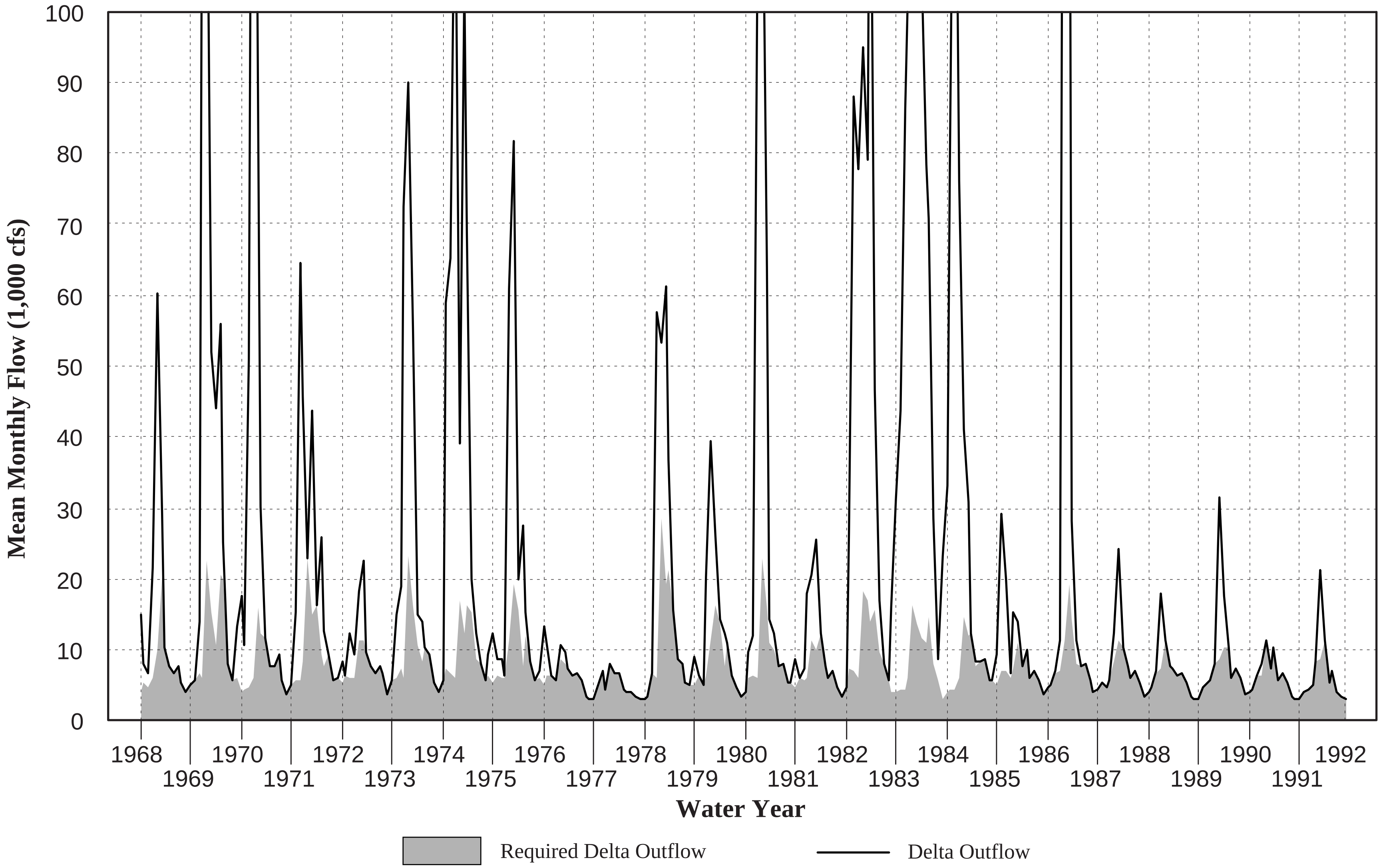

Figure 3A-5
DeltaSOS-Simulated Mean Monthly Delta Outflow and Required Delta Outflow for 1968-1991 for the No-Project Alternative

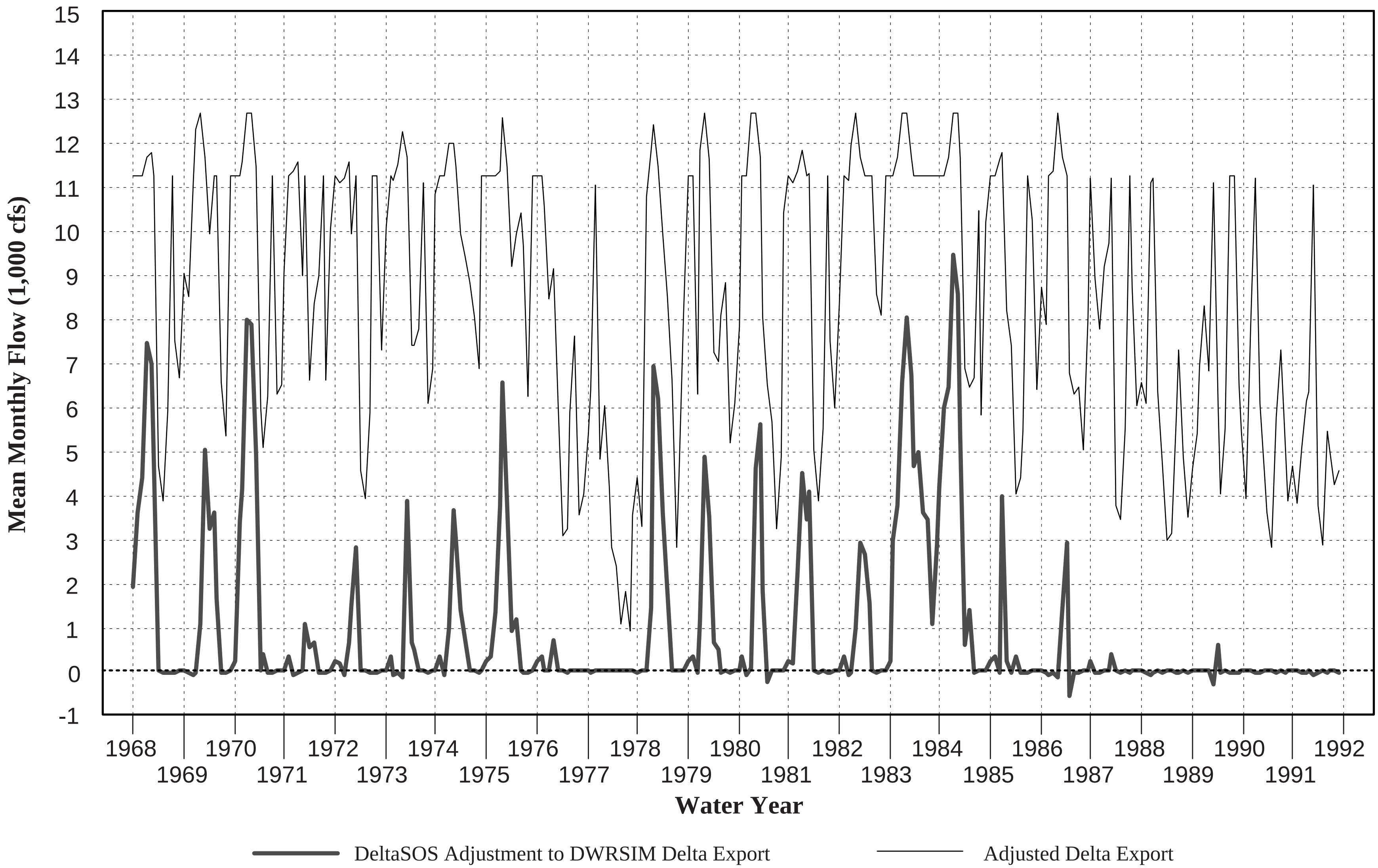

Figure 3A-6
DeltaSOS-Simulated Mean Monthly Delta Export and Export Adjustment for 1968-1991 for the No-Project Alternative

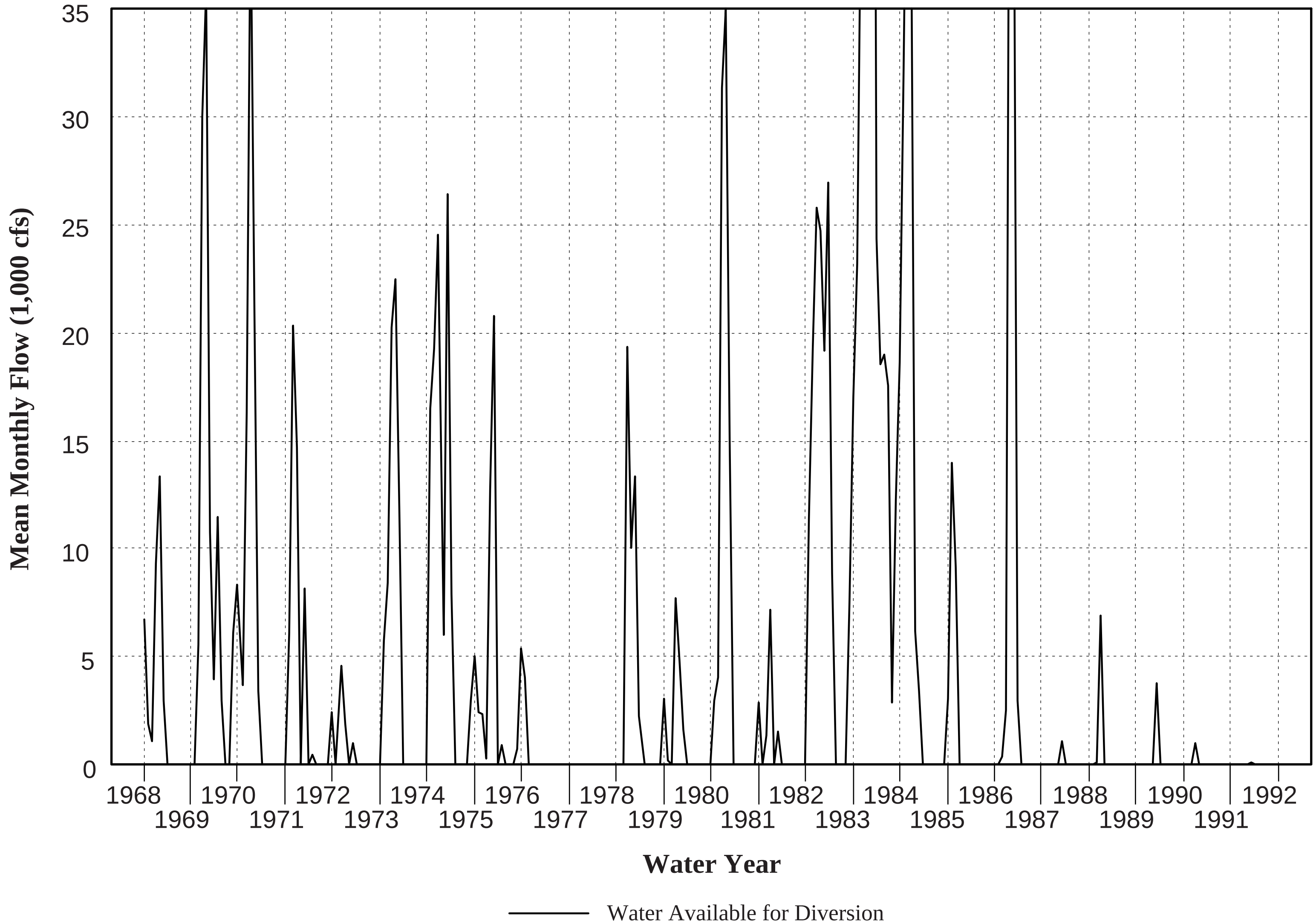

Figure 3A-7
DeltaSOS-Simulated Mean Monthly Water Available for DW Diversion for 1968-1991 for the No-Project Alternative

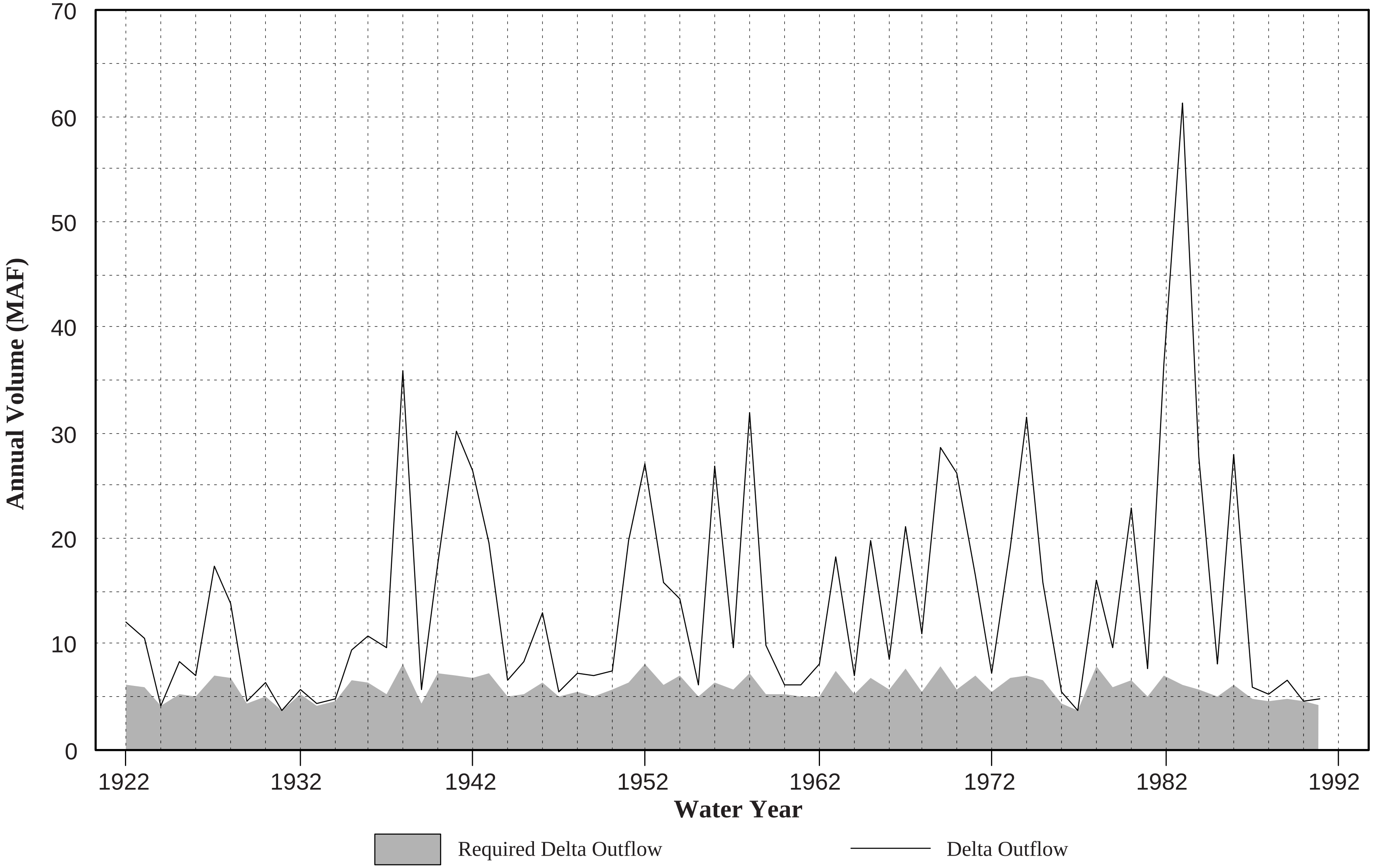

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Figure 3A-8
DeltaSOS-Simulated Annual Delta Outflow and Required Delta Outflow for 1922-1991 for the No-Project Alternative

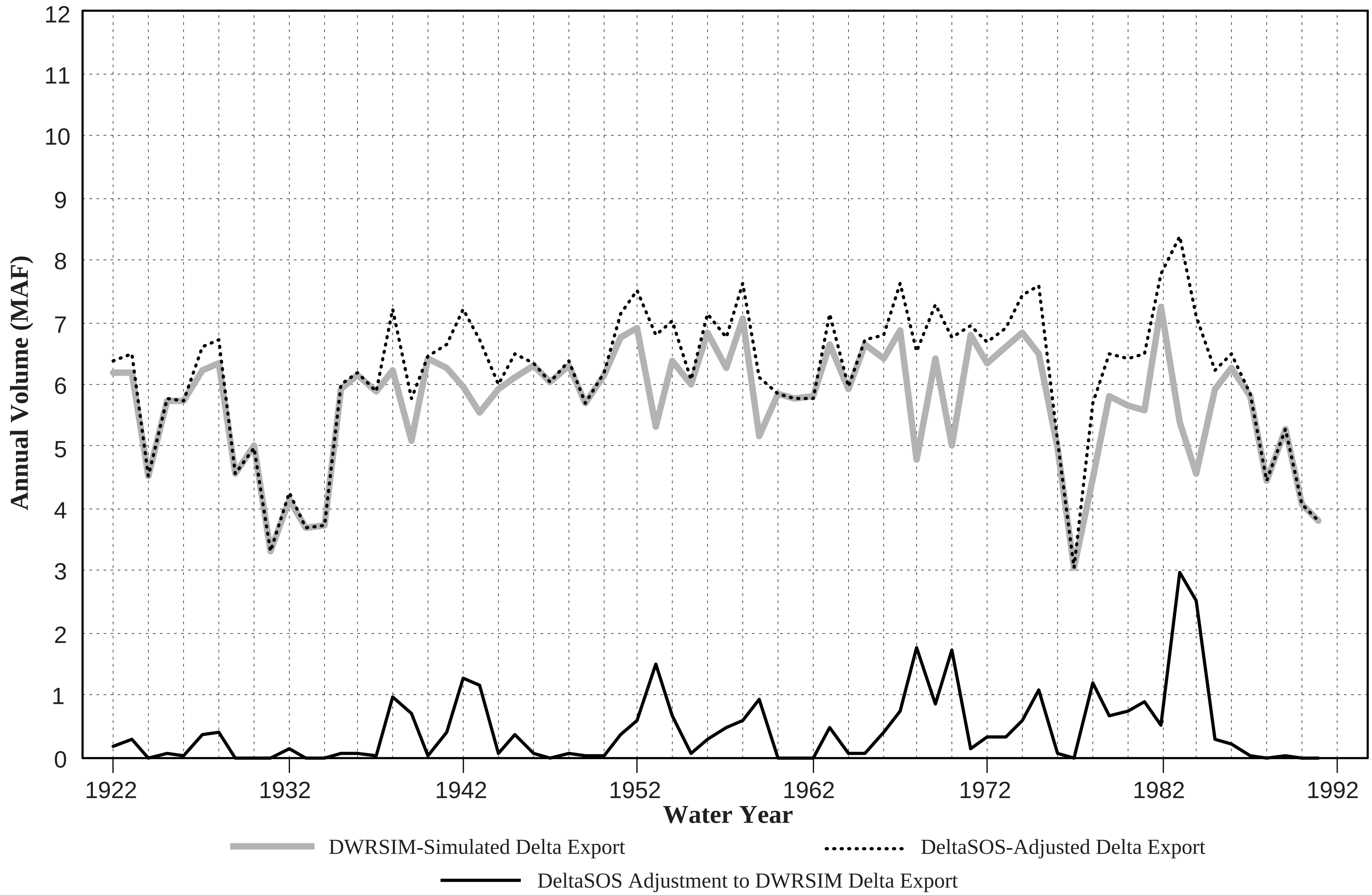

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Figure 3A-9
DWRSIM-Simulated and DeltaSOS-Adjusted Annual Delta Export for 1922-1991 for the No-Project Alternative

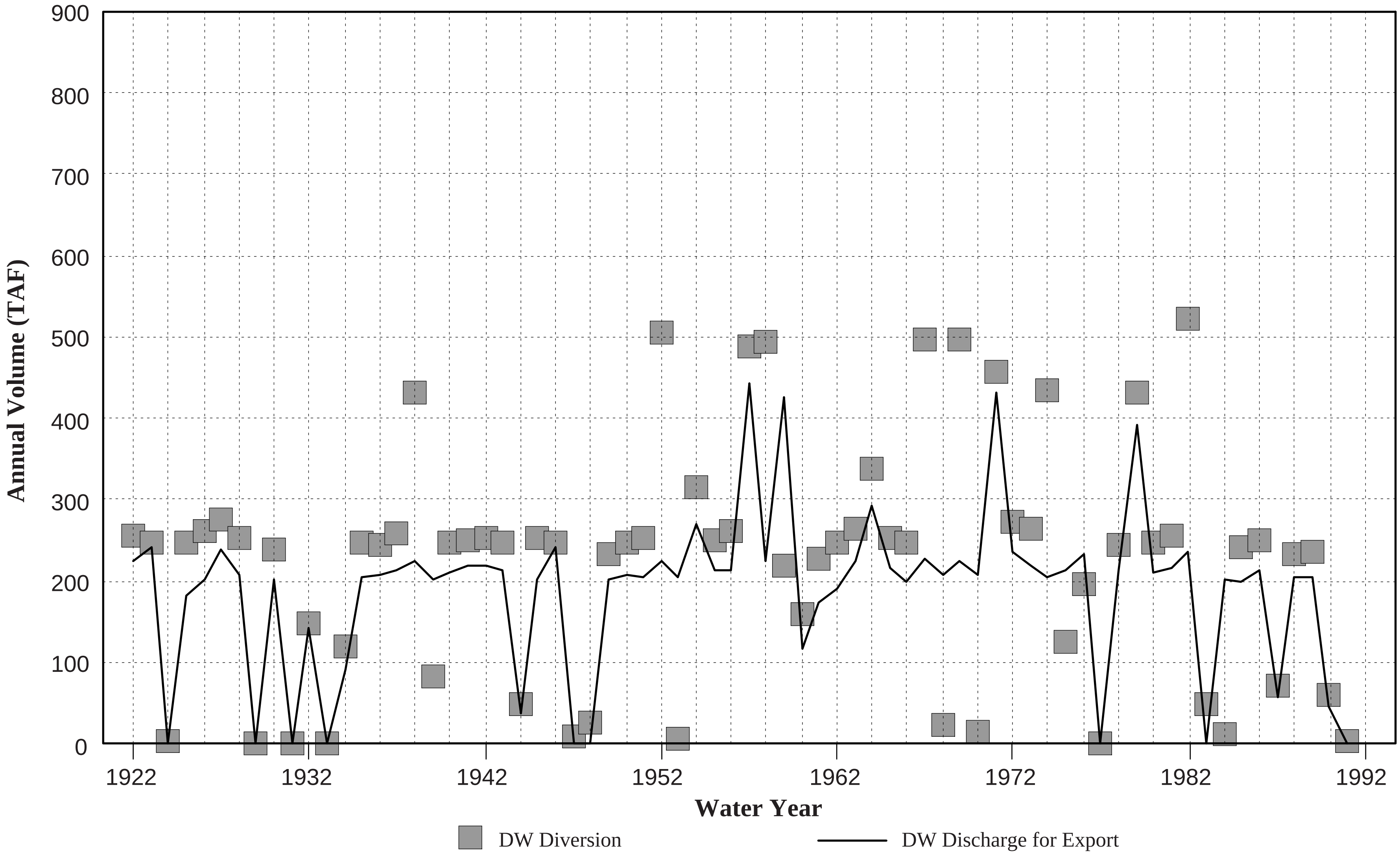

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Figure 3A-10
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 1

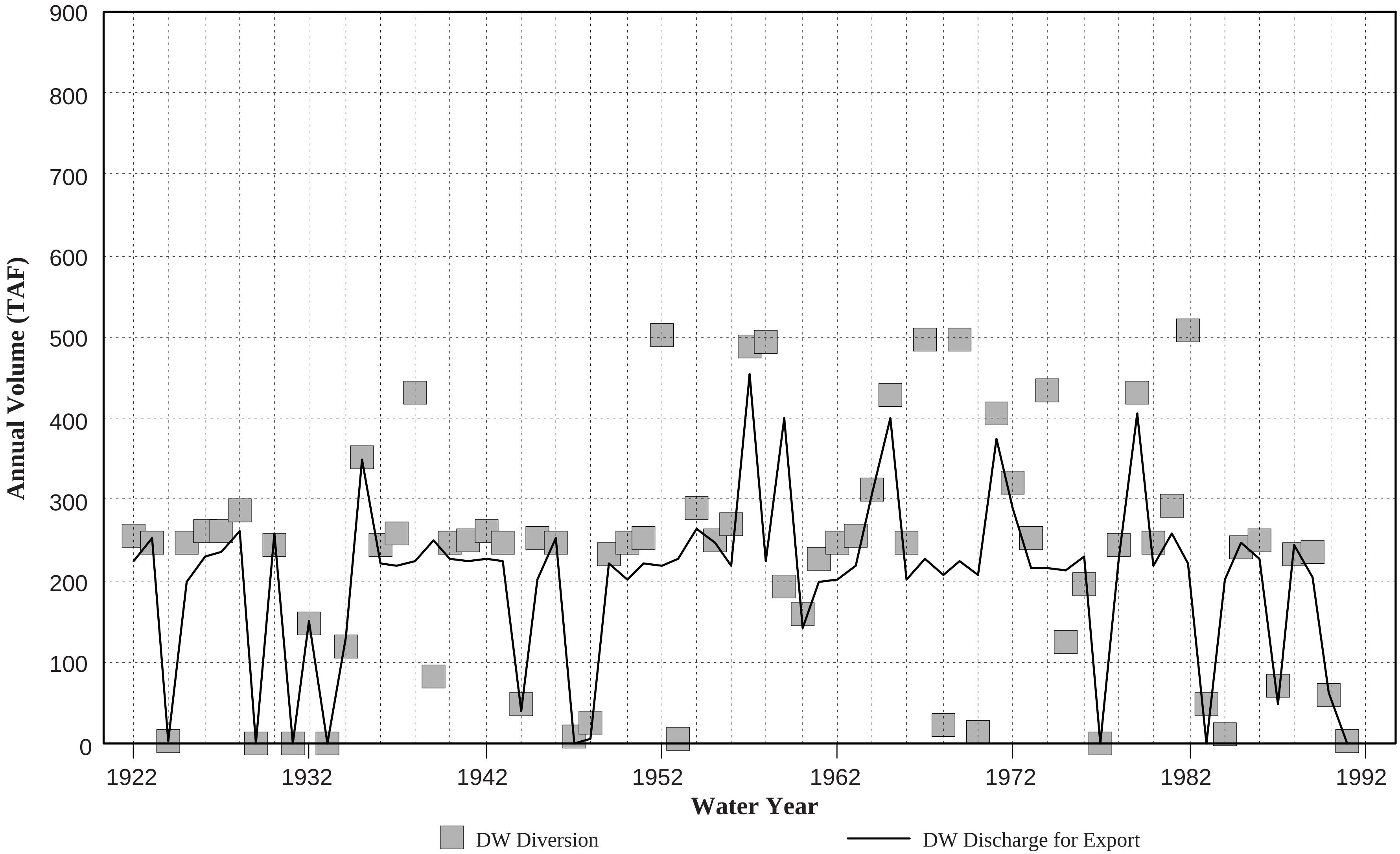

Figure 3A-11
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 2

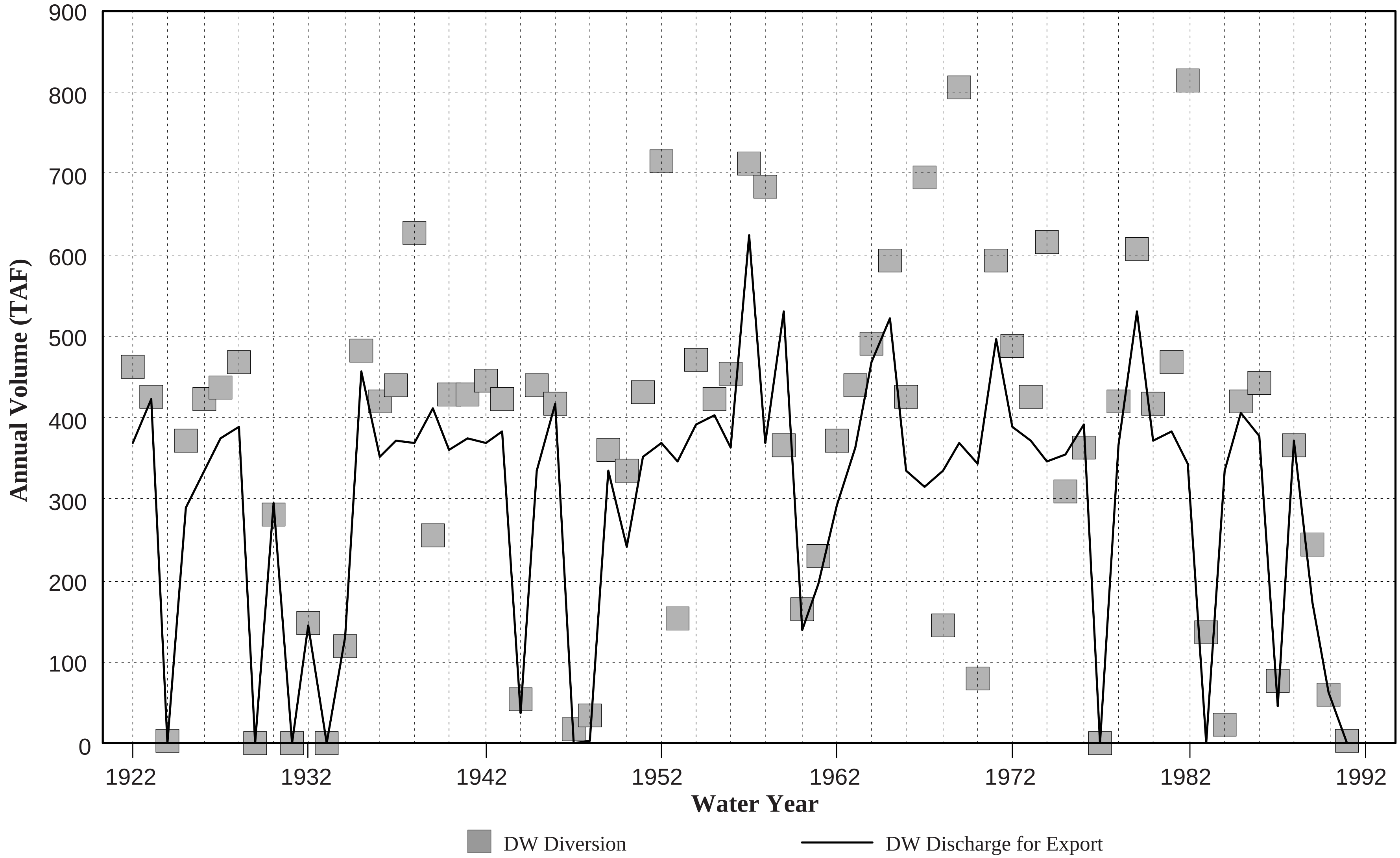

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Figure 3A-12
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 3

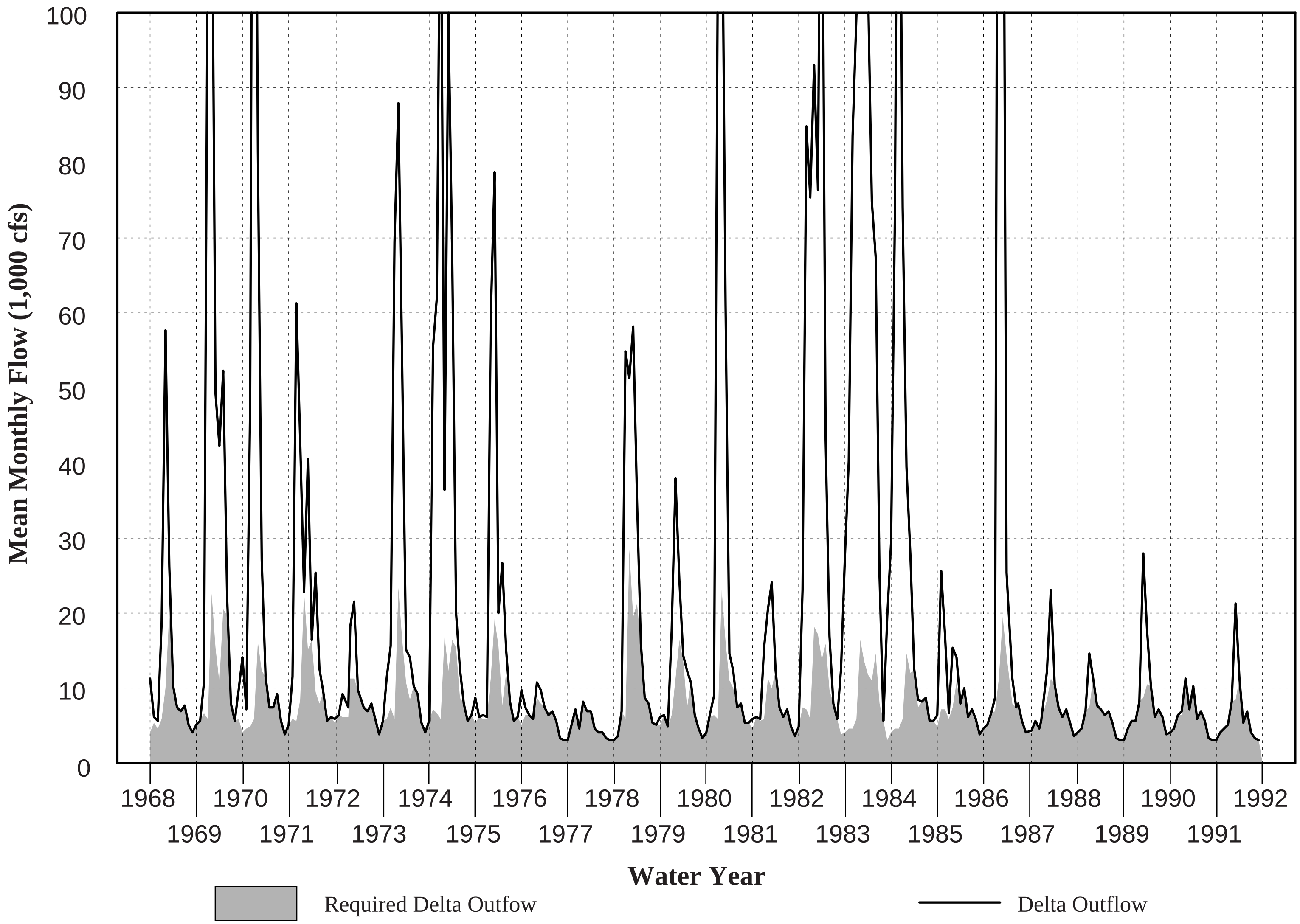

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Figure 3A-13
DeltaSOS-Simulated Mean Monthly Delta Outflow and Required Delta Outflow for 1968-1991 for the No-Project Alternative under Cumulative Conditions

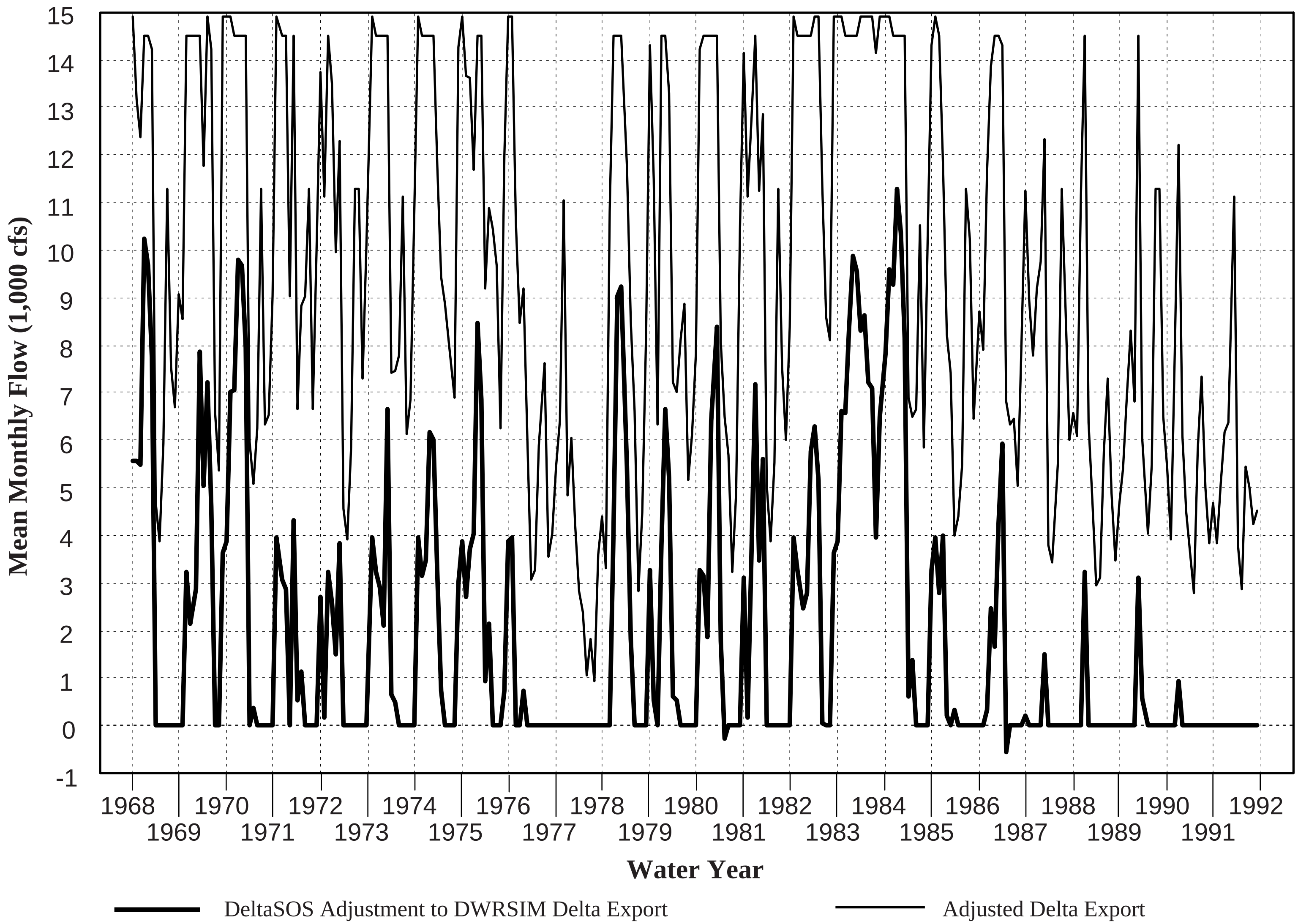

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Figure 3A-14
DeltaSOS-Simulated Mean Monthly Delta Export and Export Adjustment for 1968-1991 for the No-Project Alternative under Cumulative Conditions

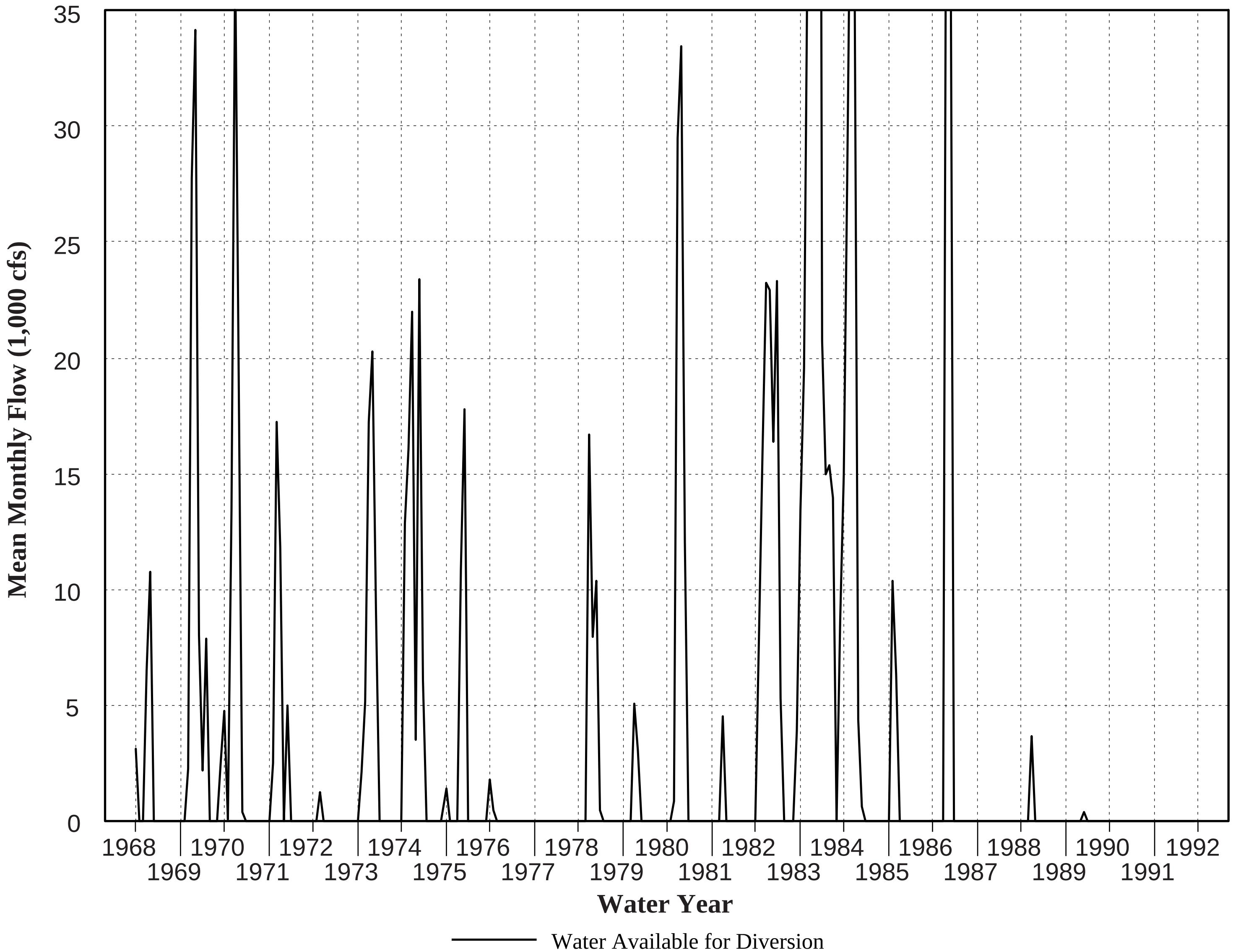

Figure 3A-15
DeltaSOS-Simulated Mean Monthly Water Available for Diversion for 1968-1991 for the No-Project Alternative under Cumulative Conditions

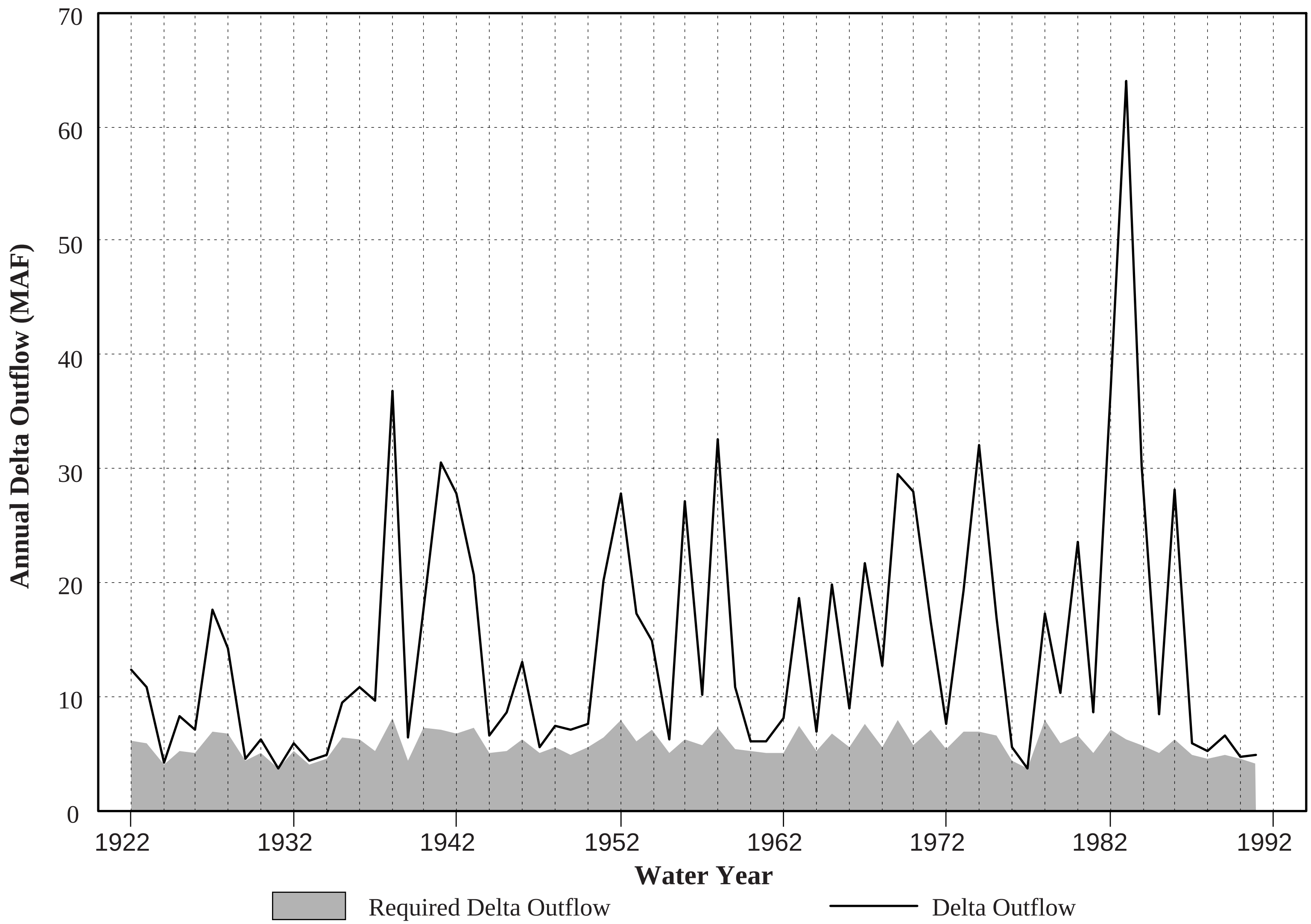

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Figure 3A-16
DeltaSOS-Simulated Annual Delta Outflow and Required Delta Outflow for 1922-1991 for the No-Project Alternative under Cumulative Conditions

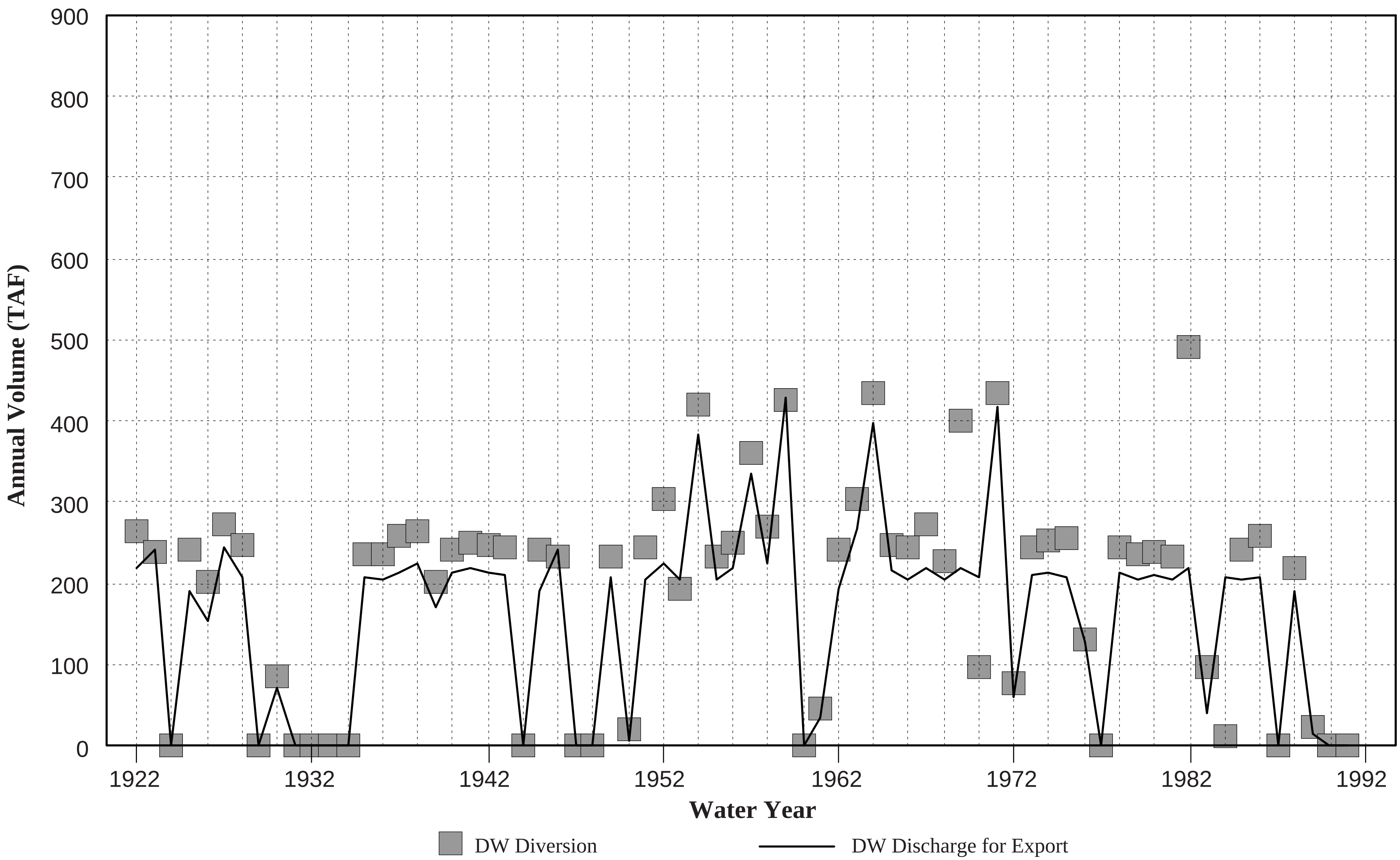

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Figure 3A-17
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 1 under Cumulative Conditions

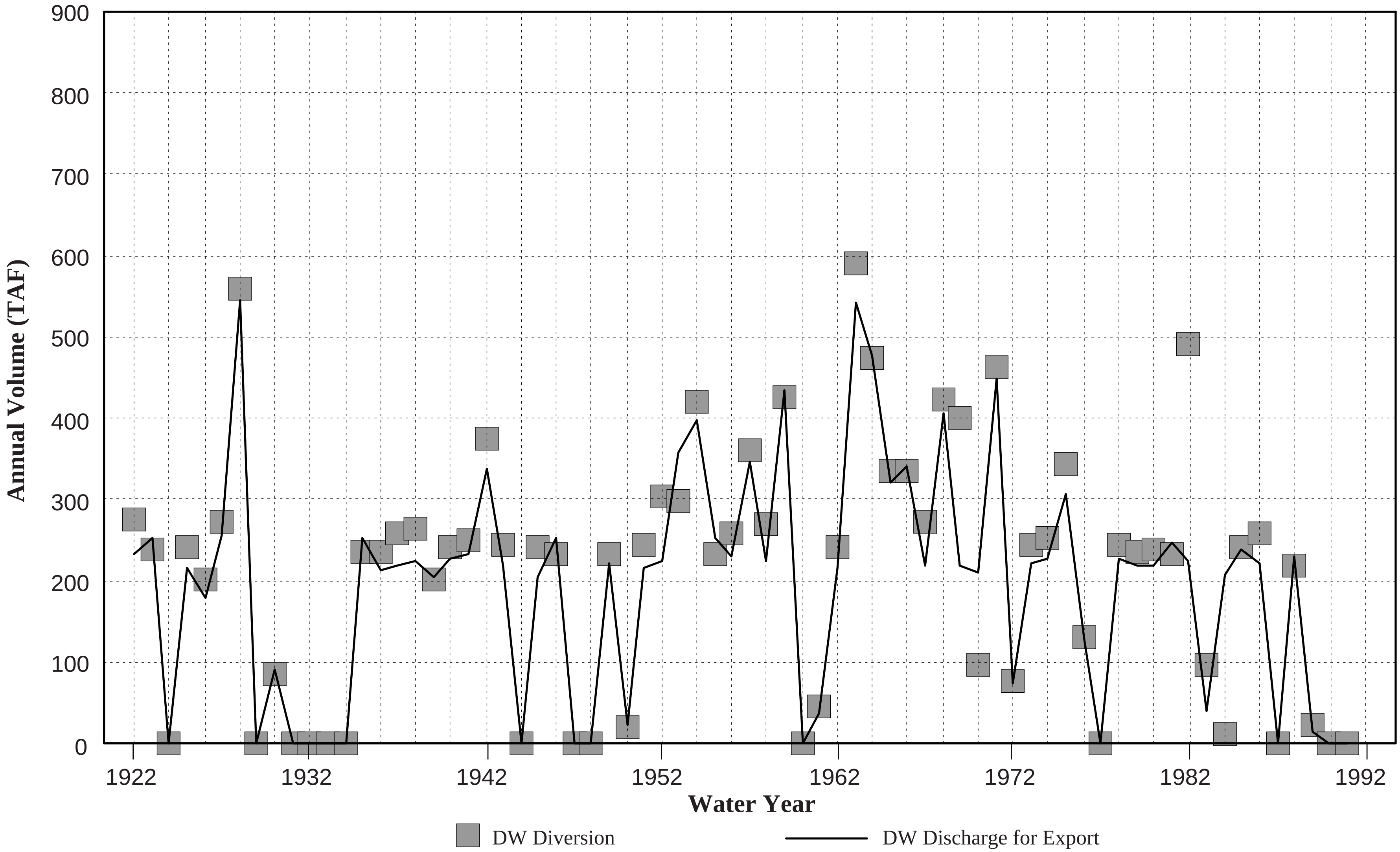

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Figure 3A-18
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 2 under Cumulative Conditions

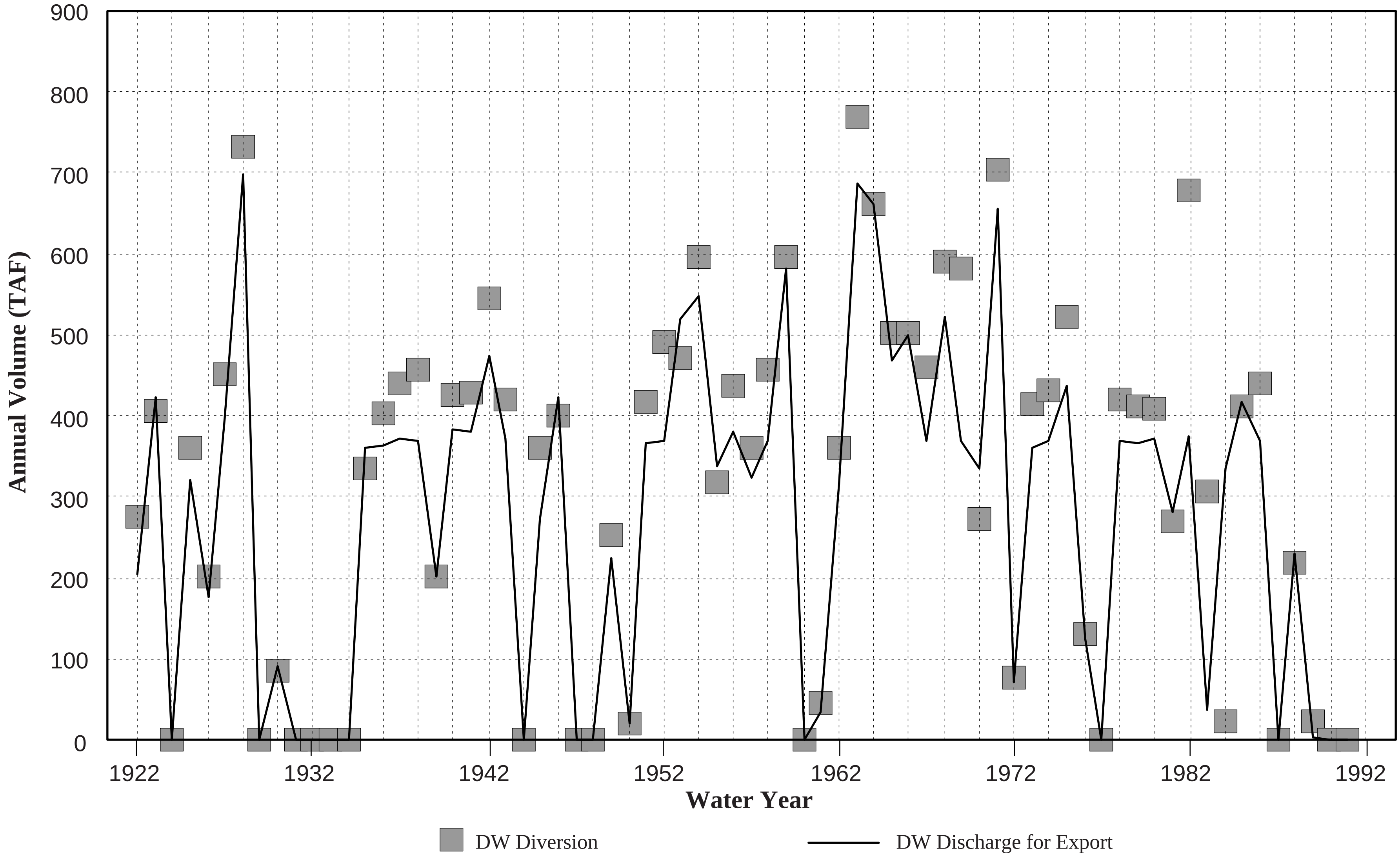

Figure 3A-19
DeltaSOS-Simulated Annual DW Diversion and DW Discharge for Export for 1922-1991 for Alternative 3 under Cumulative Conditions

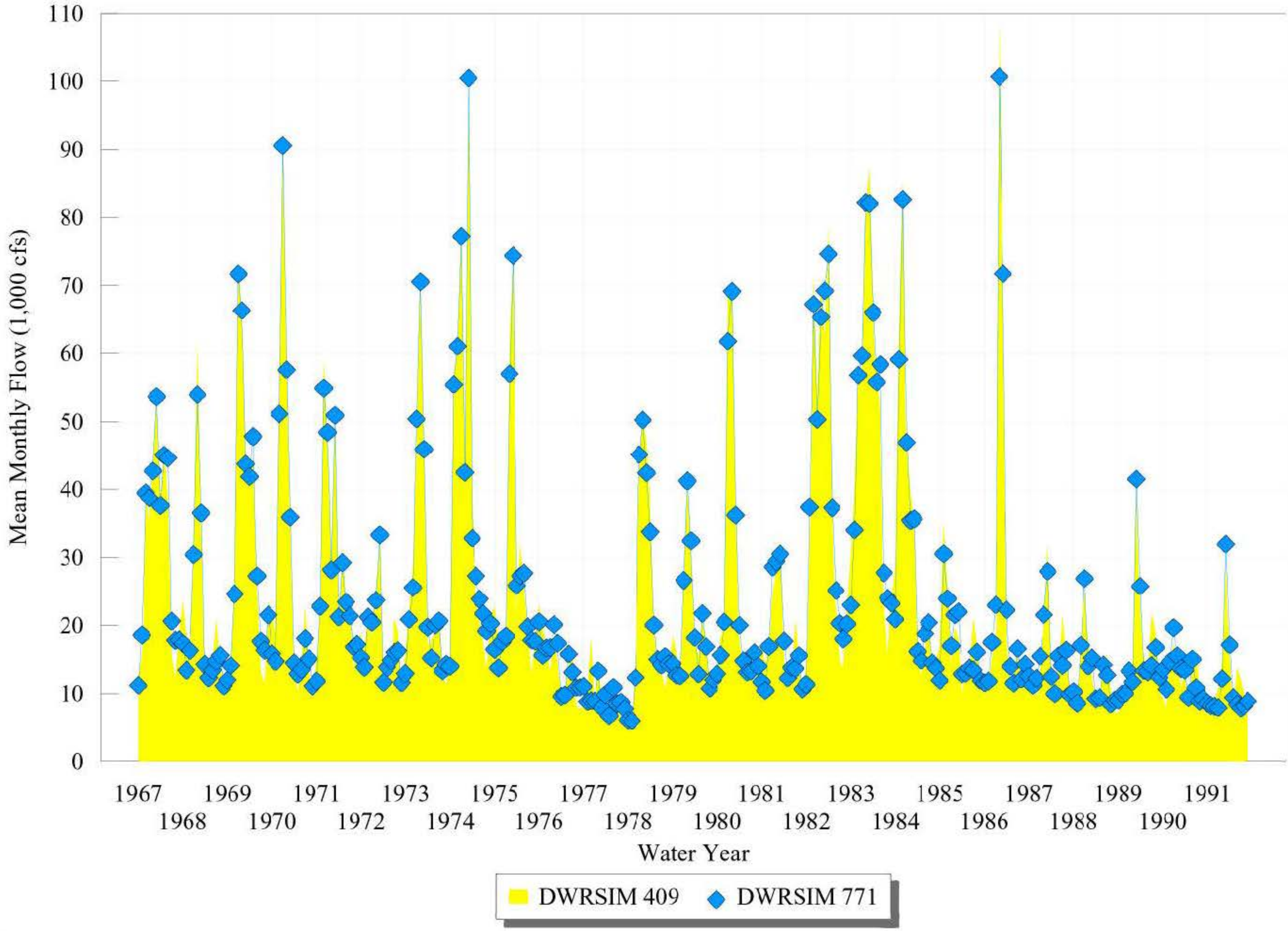

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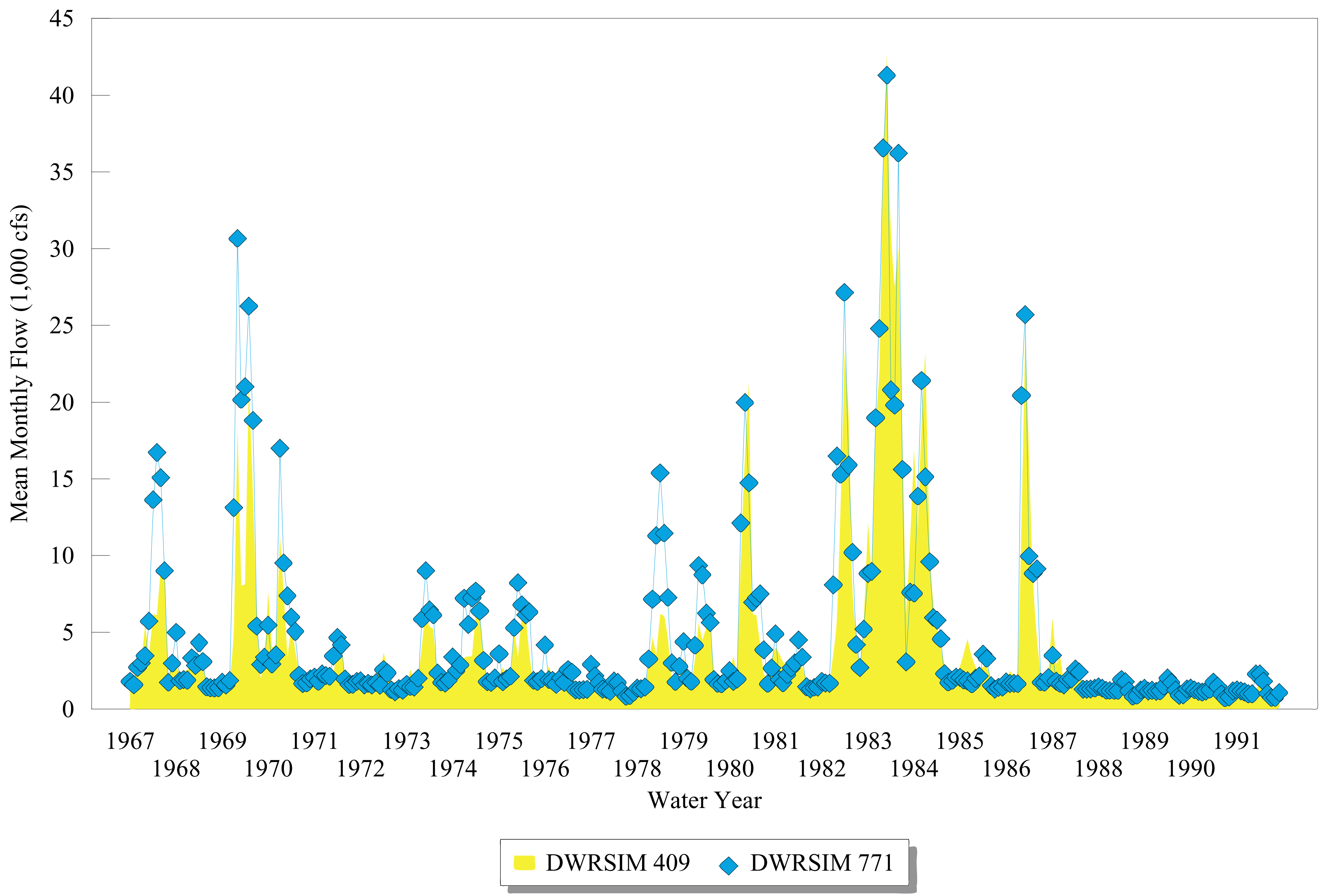
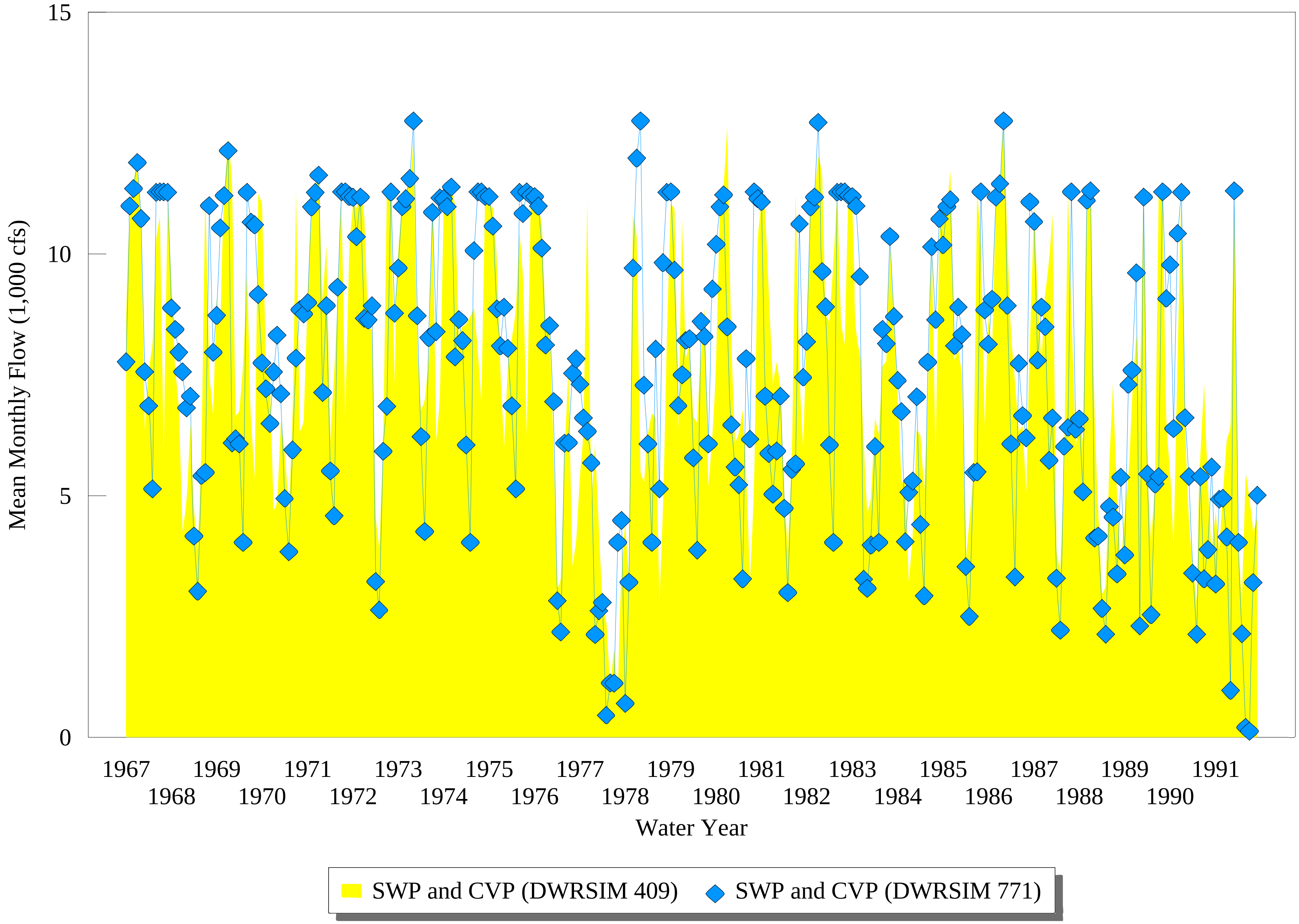
Figure 3A-20
DWRSIM-Simulated Mean Monthly Sacramento River Flows: Studies 409 and 771



Jones & Stokes

Figure 3A-21
DWRSIM-Simulated Mean Monthly San Joaquin River Flows: Studies 409 and 771



Jones & Stokes

Figure 3A-22
DWRSIM-Simulated Mean Monthly SWP and CVP Exports: Studies 409 and 771

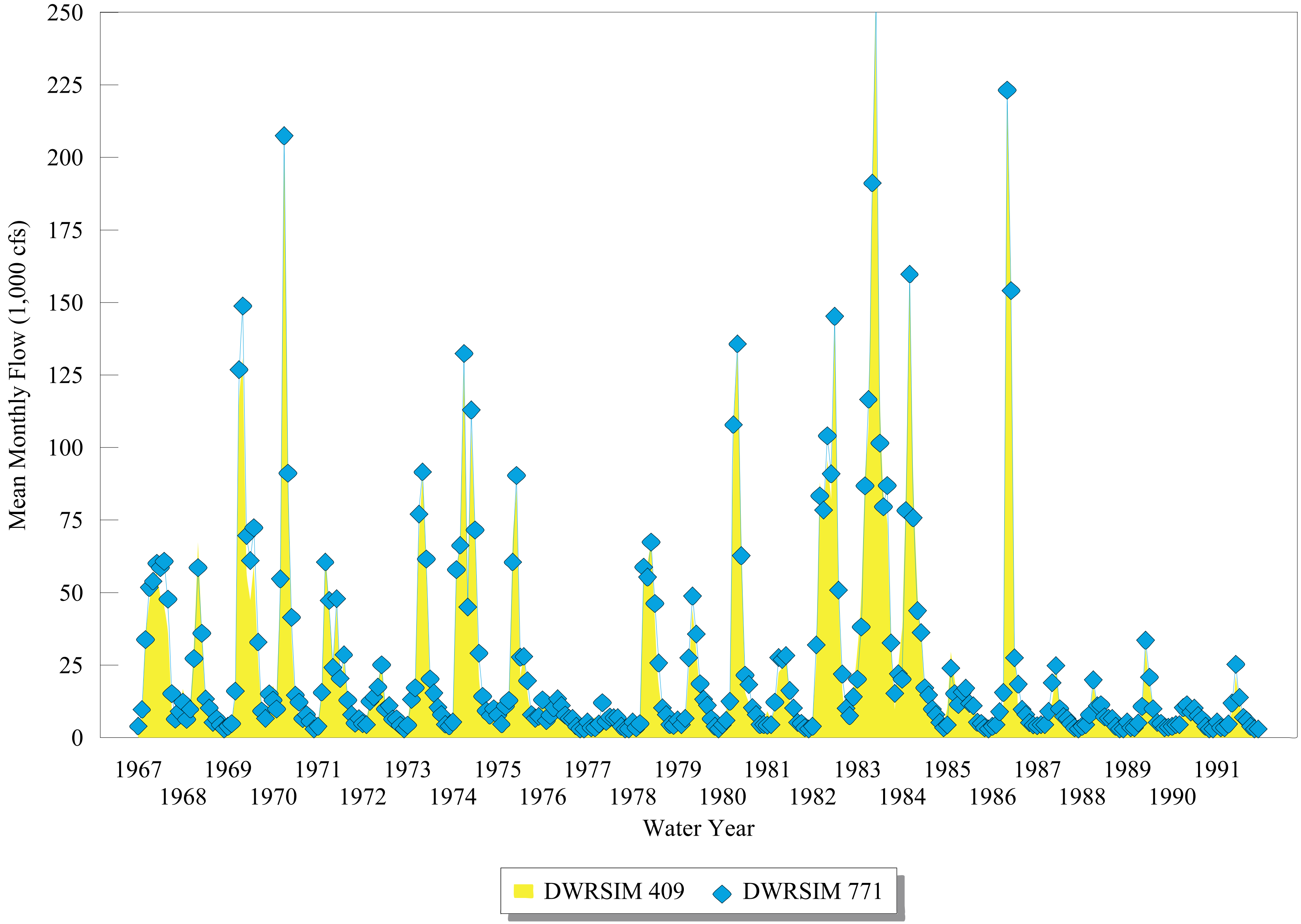


Figure 3A-23
DWRSIM-Simulated Mean Monthly Delta Outflow: Studies 409 and 771

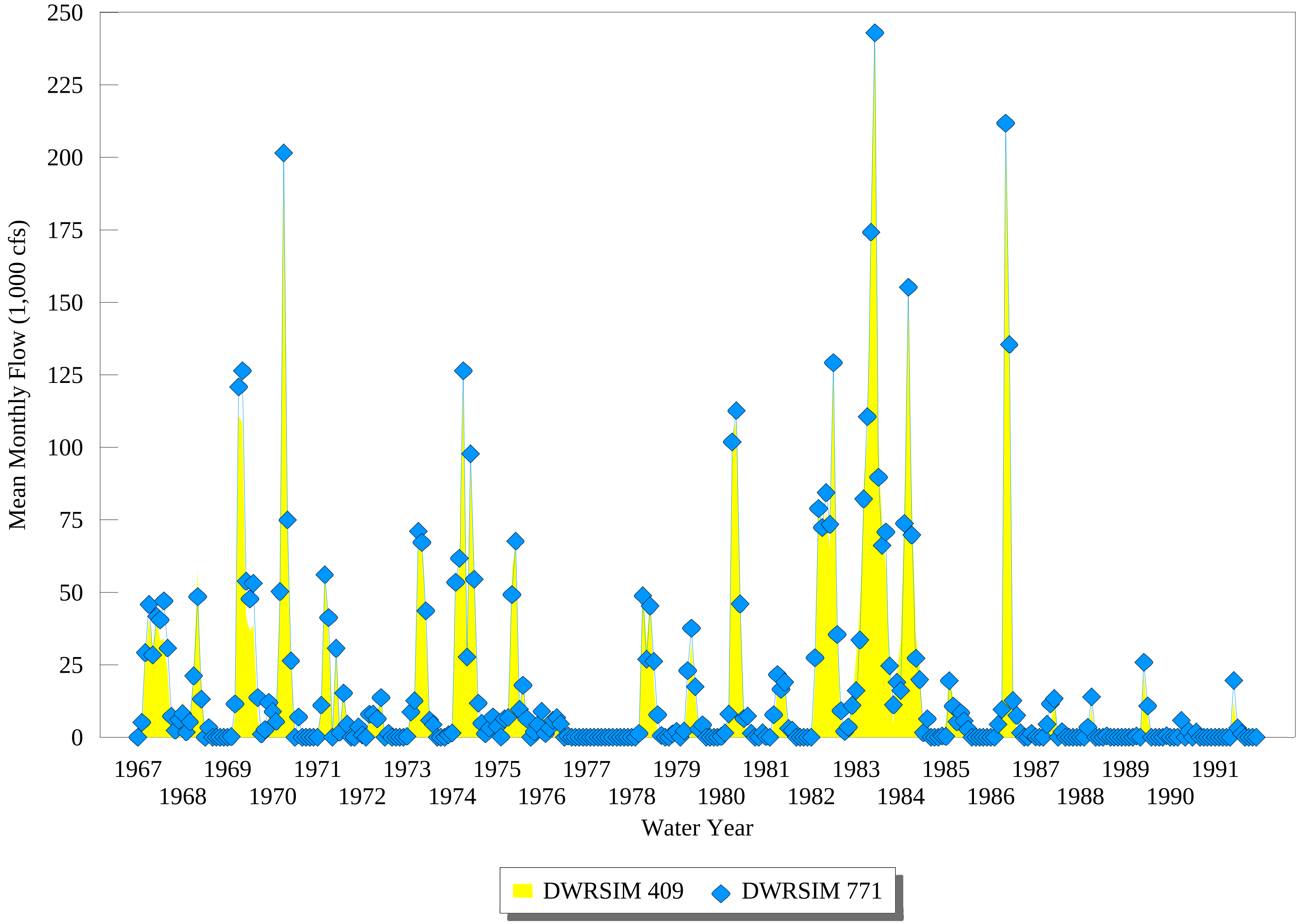


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Figure 3A-24
DWRSIM-Simulated Mean Monthly Available Water for Delta Wetlands Diversion: Studies 409 and 771

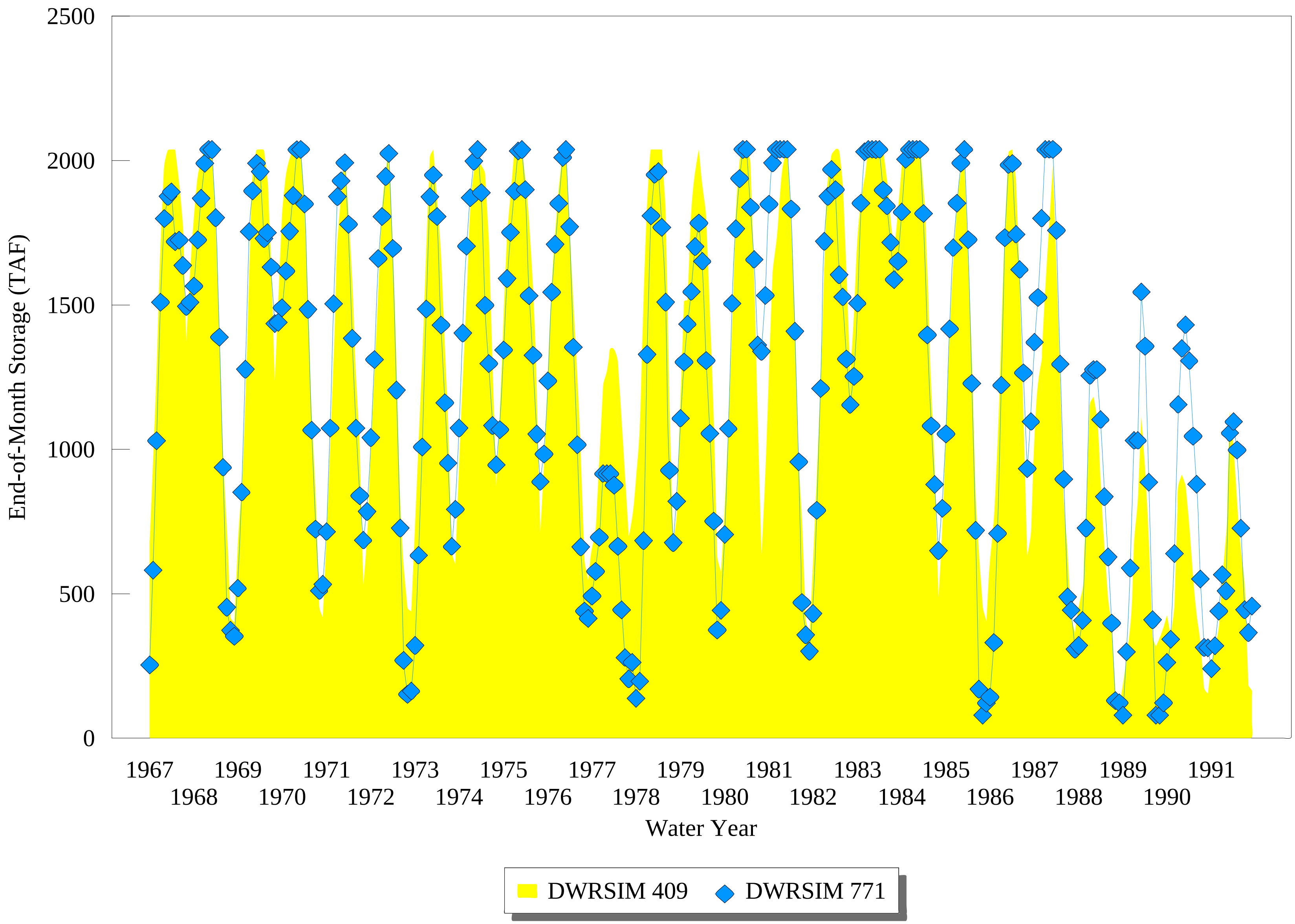

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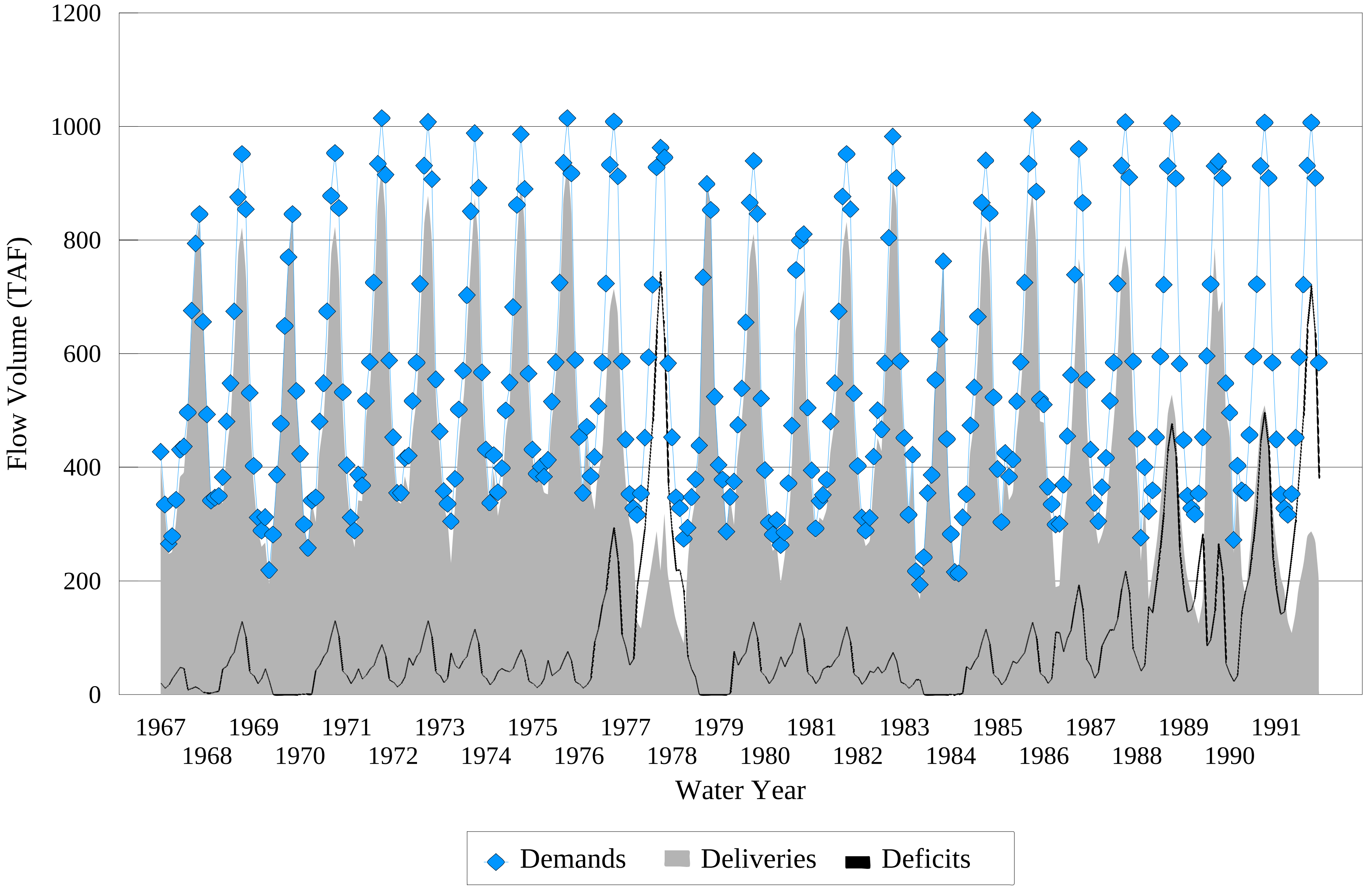
Figure 3A-25
DWRSIM-Simulated Mean Monthly SWP and CVP San Luis Reservoir Storage: Studies 409 and 771



Jones & Stokes

Figure 3A-26
South-of-Delta Demands and Deliveries: DWRSIM Study 771 with VAMP

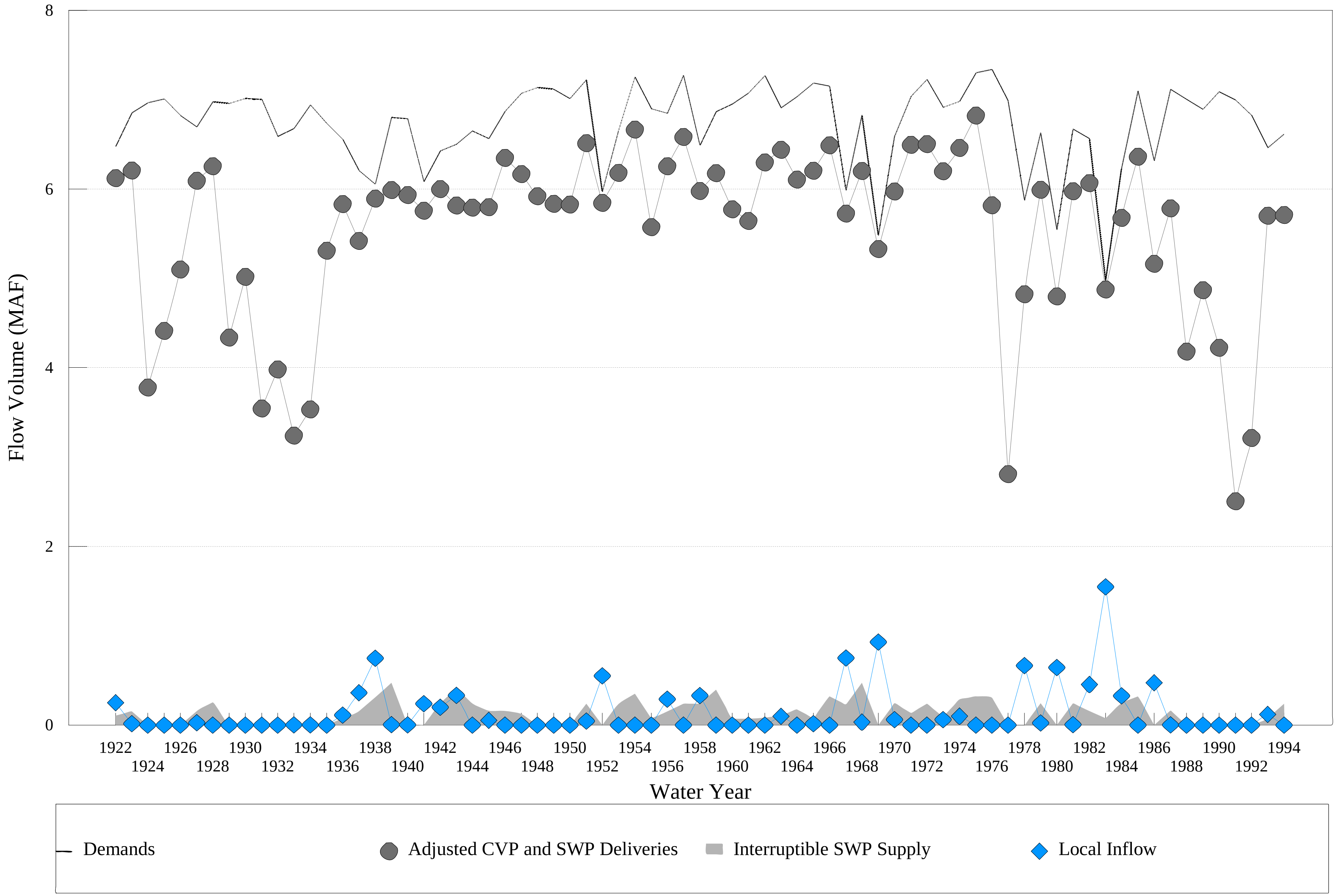


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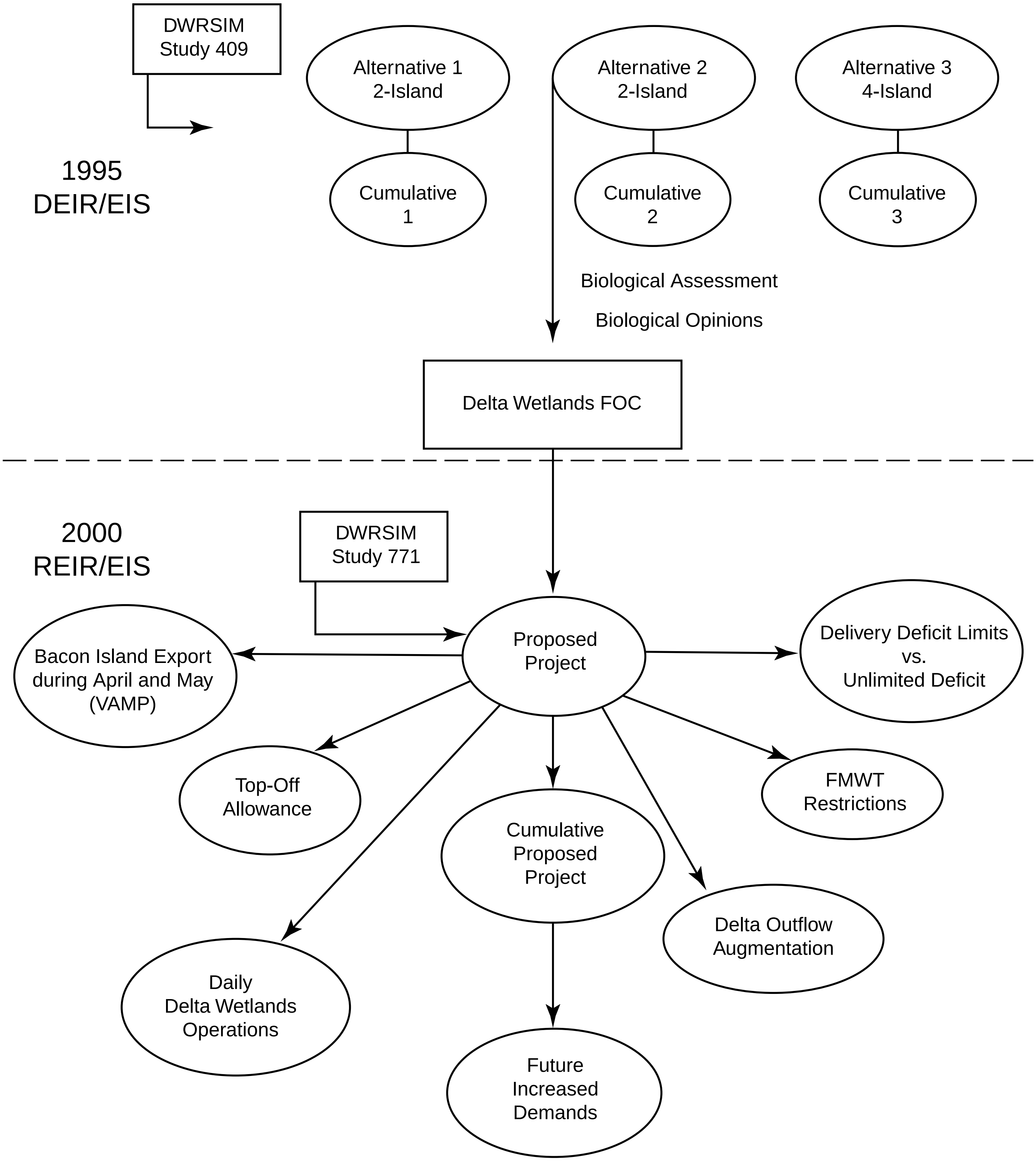
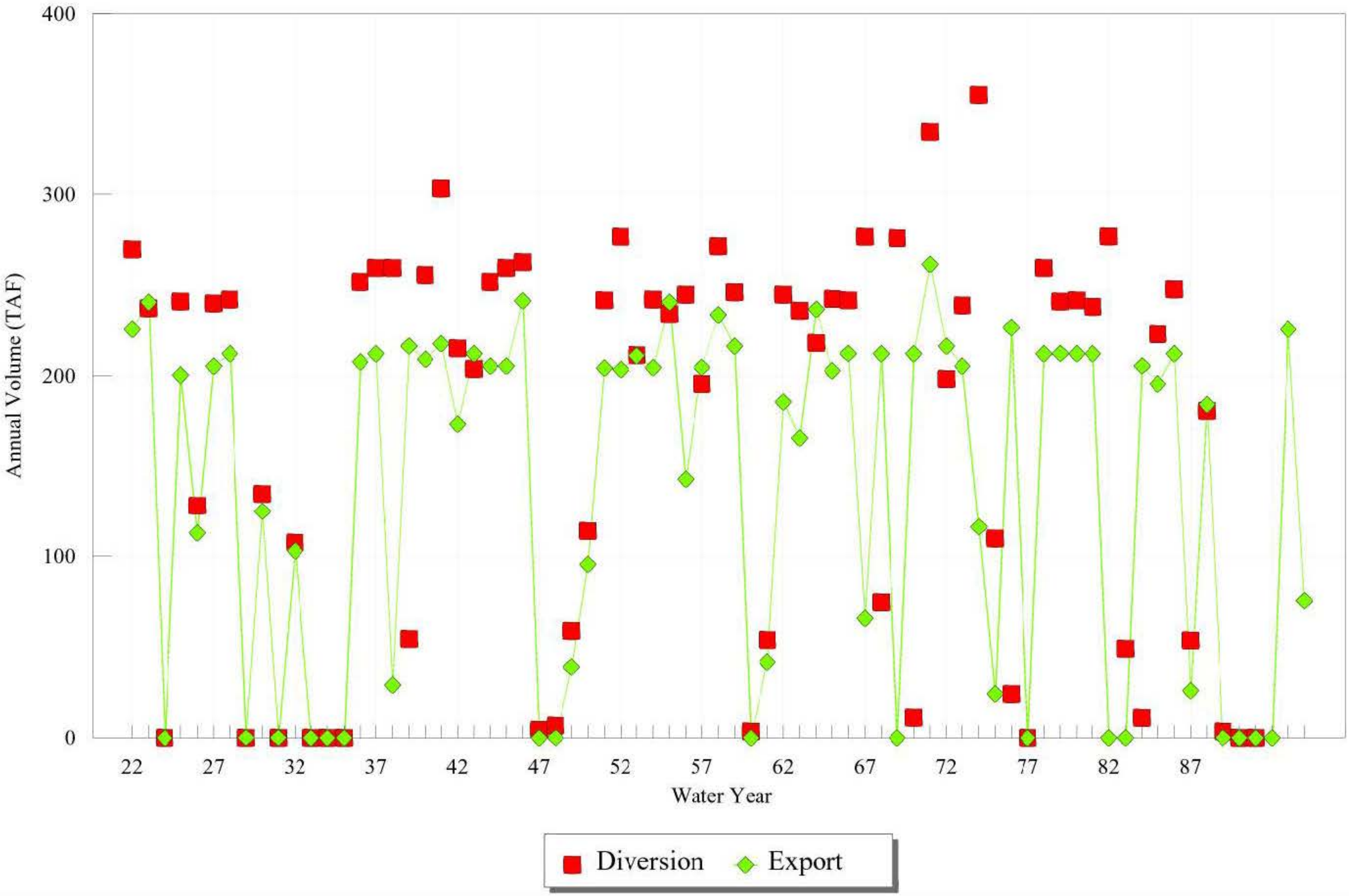
Figure 3A-27
Annual Demands and Deliveries for South-of-Delta Water Supply: DWRSIM Study 771 as Adjusted by DeltaSOS for Joint Point of Diversion



Jones & Stokes

Figure 3A-28
Relationship between 1995 DEIR/EIS Alternatives and 2000 REIR/EIS Simulated Potential Project Operations



Jones & Stokes

Figure 3A-29
Simulated Annual Delta Wetlands Diversion and Export Volumes Unlimited by South-of-Delta Delivery Deficits

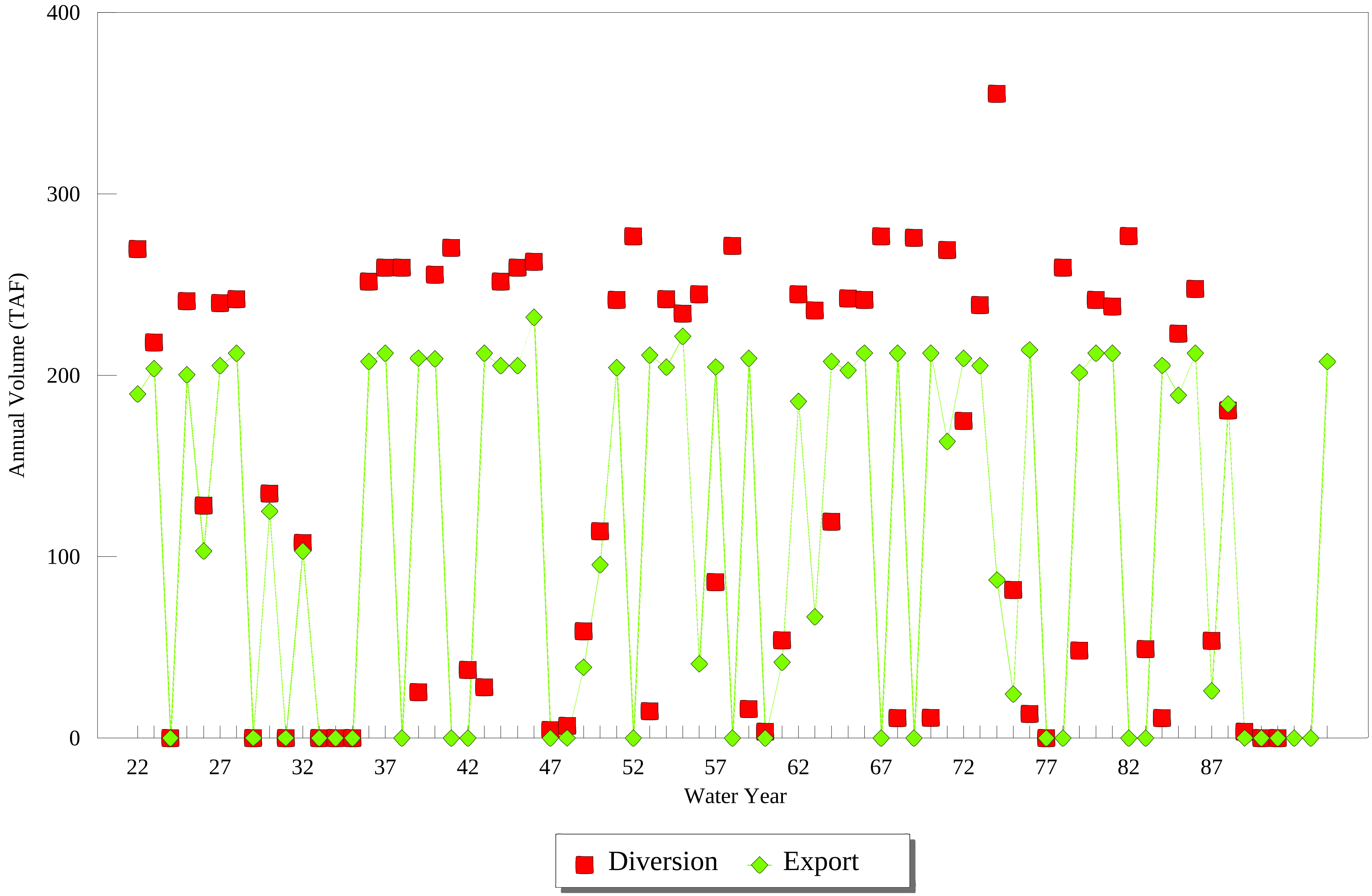


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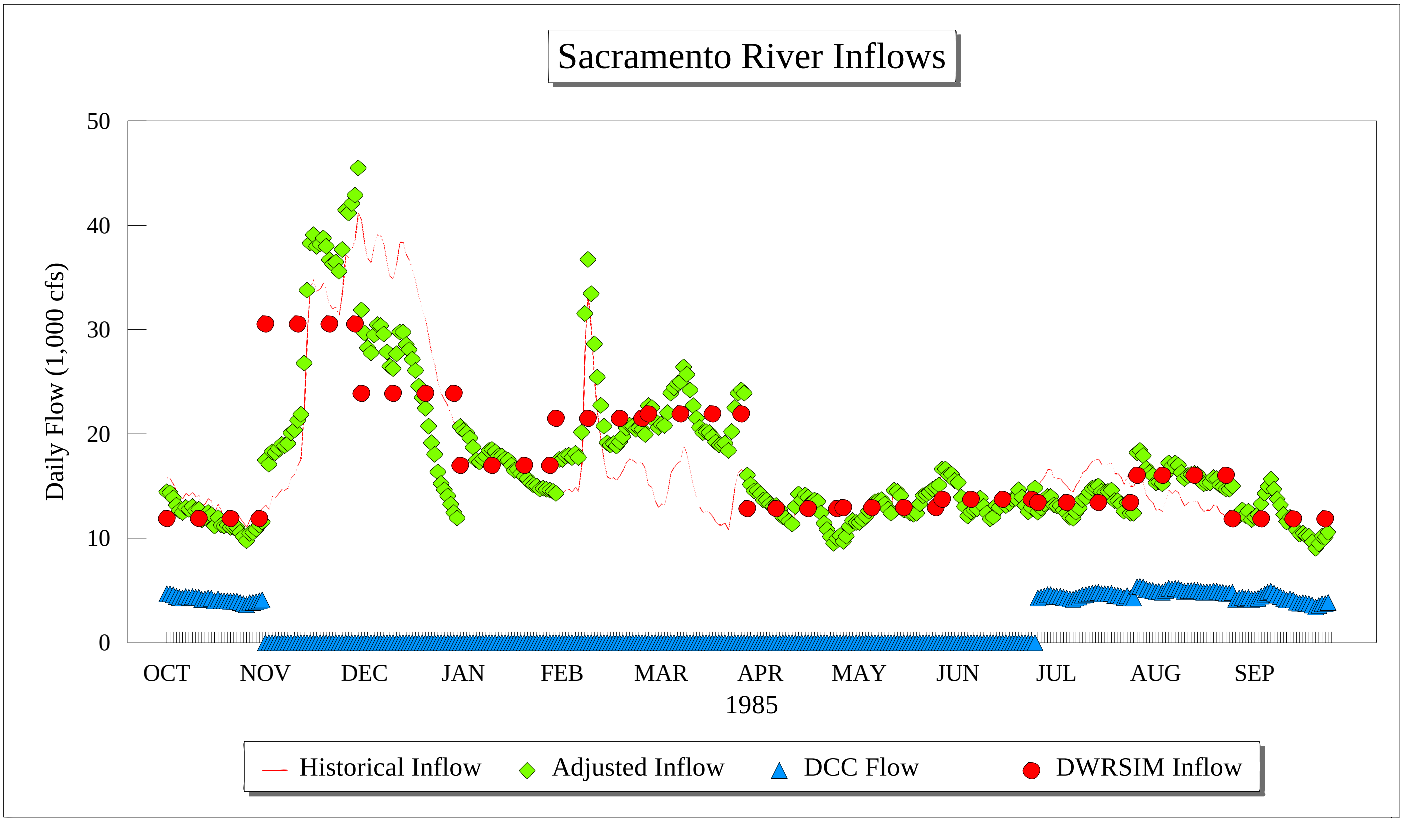
Figure 3A-30
Simulated Annual Delta Wetlands Diversion and Export Volumes Limited by South-of-Delta Delivery Deficits



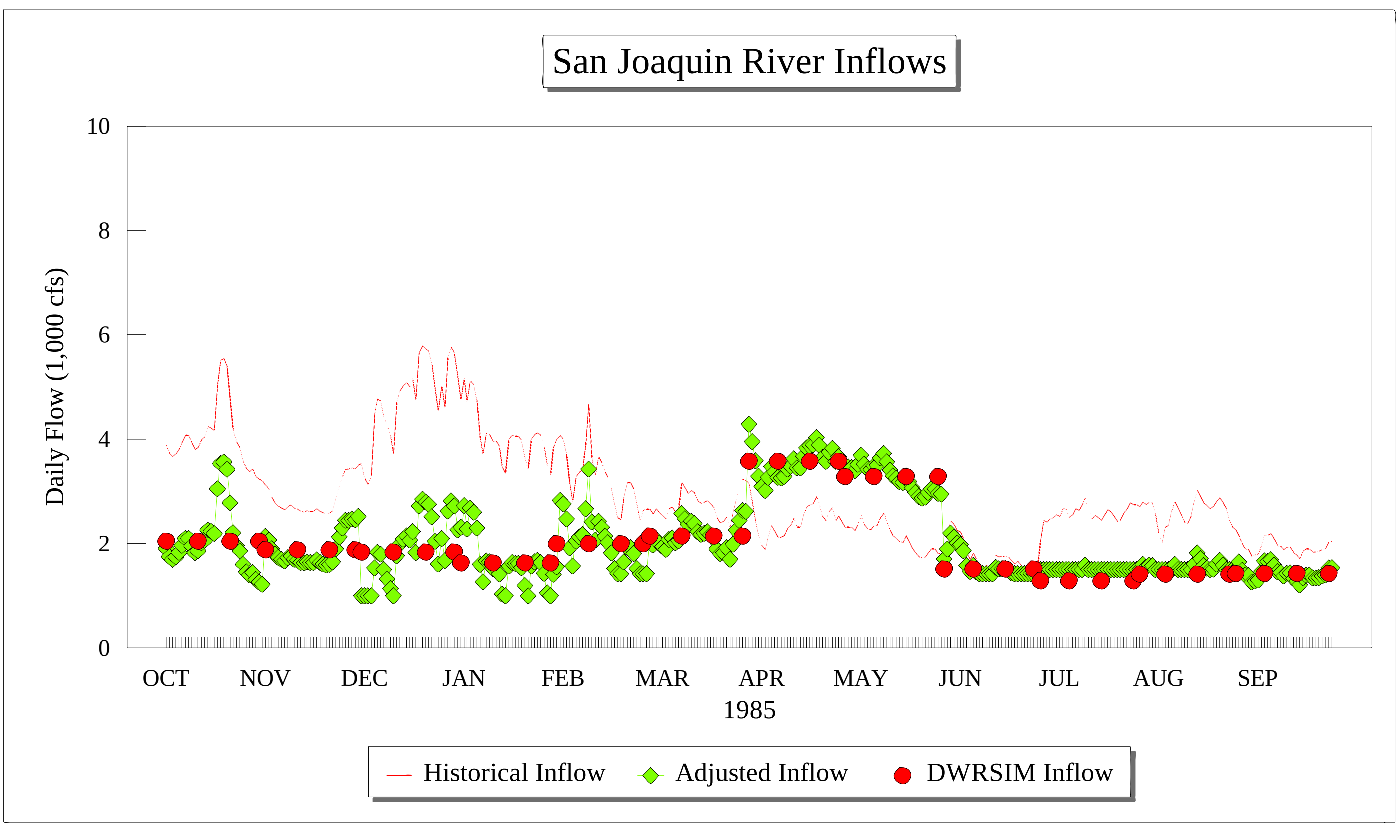


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Figure 3A-31
Daily Adjusted Sacramento and San Joaquin River Inflows for Simulating Delta Wetlands Final Operations Criteria for 1985

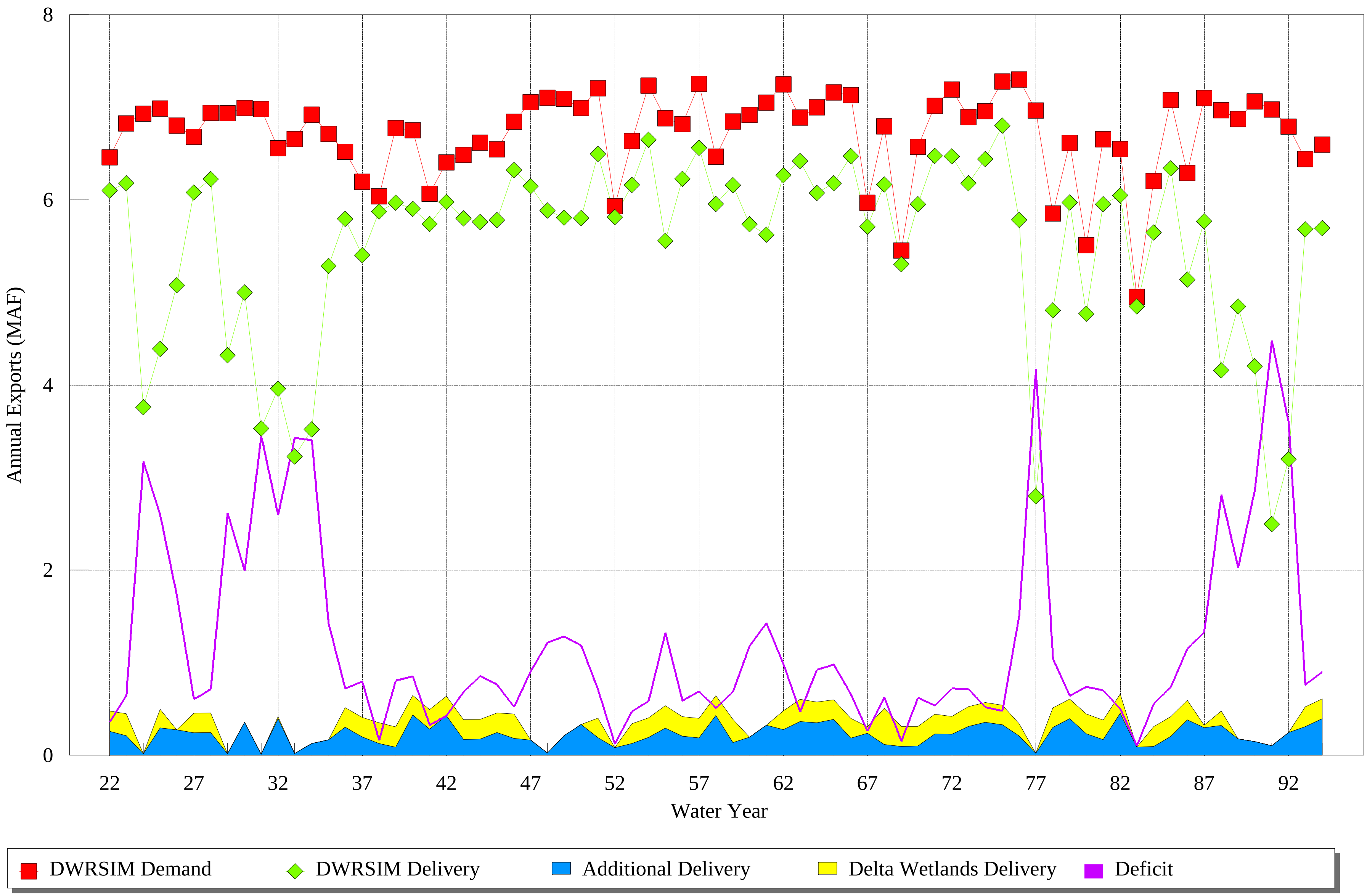

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Figure 3A-32
Simulated Annual Delta Demands and Deliveries under Cumulative Conditions

Chapter 3B. Affected Environment and Environmental Consequences - Hydrodynamics

Chapter 3B. Affected Environment and Environmental Consequences - Hydrodynamics

SUMMARY

Delta hydrodynamic conditions are the influences on the movement of water in Delta channels (e.g., tidal forces and inflows) and the effects of the movement of water in Delta channels (e.g., changes in channel flows and stages, export flows, and outflow). This chapter describes Delta hydrodynamic conditions; discusses the Delta model developed by Resource Management Associates (RMA), which was used to simulate hydrodynamic effects of the DW project; identifies Delta hydrodynamic variables that could be affected by operation of the DW project; and presents results of simulations using the RMA model to determine DW project effects on those variables.

Delta hydrodynamic variables considered in the initial selection process for the hydrodynamics impact assessment were local Delta channel velocities and stages, export flows, outflows, net channel flows, and inflow source contributions. Because the most important effects of changes in outflow and changes in inflow source contributions are linked with potential water quality or fishery impacts, DW project effects associated with these changes are addressed in Chapter 3C, "Water Quality", and Chapter 3F, "Fishery Resources", rather than in this chapter. DW project effects on exports are discussed in Chapter 3A, "Water Supply and Water Project Operations". This chapter discusses potential effects of DW project diversions and discharges on local channel velocities and stages and on net channel flows.

DW project operations under Alternative 1, 2, or 3 would have less-than-significant effects on local channel velocities and stages and on net channel flows. Under cumulative conditions, however, implementation of Alternative 1, 2, or 3 could contribute to a significant effect on net channel flows. This cumulative impact would be reduced to a less-than-significant level through monitoring of the effects of DW operations and control of operations to prevent unacceptable hydrodynamic effects during periods of flows that are higher than historical flows. The No-Project Alternative would not cause adverse effects on Delta hydrodynamic conditions.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

No substantive changes have been made to this chapter since the 1995 DEIR/EIS was published. The analysis of hydrodynamic effects of DW project operations described in this chapter incorporated the results of the DeltaSOS simulations of project operations performed for the 1995 DEIR/EIS. Additional simulations were performed for the updated evaluation of project operations under the proposed project in the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations"; however, the differences in DeltaSOS results in the 1995 DEIR/EIS and 2000 REIR/EIS evaluations of Alternatives 1 and 2 do not affect the conclusions of this chapter. Therefore, the analysis of hydrodynamic effects was not updated for the 2000 REIR/EIS, and the results of the 1995 evaluation are presented here.

INTRODUCTION

This chapter assesses the potential impacts of the DW project on Delta hydrodynamics, the movement of water through Delta channels. Effects assessed in the impact discussion of this chapter are possible changes in net Delta channel flows and local channel flows and stages resulting from implementation of the DW project. Other effects related to hydrodynamics are discussed in this chapter but are analyzed more fully in other chapters. Chapter 3A, "Water Supply and Water Project Operations", discusses issues related to effects of the DW project on the CVP and the SWP. Chapter 3C, "Water Quality", discusses changes in levels of water quality variables that may result from changes in channel flows, including possible effects of reduced outflow on salinity intrusion. Chapter 3F, "Fishery Resources", discusses possible effects on fish habitat associated with the position of the estuarine salinity gradient that could result from changes in net channel flows and reduced Delta outflow.

The DW reservoir islands may be used for water banking or for storage and discharge of water being transferred through the Delta by other entities. The frequency and magnitude of these uses is uncertain at this time, and such uses may be subject to further environmental review. The analytical tools described in this chapter could also be used to describe the effects of these uses.

The discussion of hydrodynamics in this chapter includes several terms that may not be familiar to all readers. The following are definitions of key terms as they are used in this document:

Hydrology. General description of the movement of water in the atmosphere, on the earth surface, in the soil, and in the ground; used in this document to refer to rainfall and streamflow conditions.

Hydraulics. Study of the practical effects and control of moving water; used to refer to the relationship between channel geometry and flow, velocity, and depth of water.

Stage. Water surface elevation; the elevation above mean sea level (msl) datum.

Tidal hydraulics or tidal hydrodynamics. Water movements caused by tidal forces; used to describe the movement of water caused by tidal stage variations in San Francisco Bay.

Tidal prism. The volume of water that moves past a location as the result of a change in tidal stage; used in this document to refer to the change in volume between low tide and high tide, estimated as the upstream water surface area times the change in tidal stage.

Hydraulic gradient. Difference in water surface elevation between two points; describes the water surface slope that controls the movement of water along a channel.

Hydraulic radius. Channel cross-section area divided by the perimeter of the channel; used in this document as the effective depth of water in a channel.

Conveyance. The flow capacity of a channel related to the hydraulic radius, used to describe the flow in channels.

Tidal flow. Flow caused by tidal changes in stage and hydraulic gradient; describes the fluctuating flows in a channel caused by the tide.

Net flow. Long-term average of flows in a channel; used to describe the magnitude and direction of flow in a channel after flows during a tidal cycle are averaged.

Transport. Movement of mass from one location to another; used in this document to refer to the movement of salt or fish from one location to another caused by net flows.

Mixing. Exchange of mass between two volumes; used in this document to refer to the movement of salt or fish from one location to another caused by the tidal movement of water within the Delta channels.

Historical Delta flows. Measured Delta inflows and exports, estimated Delta outflow, and simulated net channel flows corresponding to the inflows and exports.

Tidal excursion. The distance between the most upstream position and most downstream position of a floating object that is released

from a location at mean tide and tracked over a complete tidal cycle.

- **Model calibration**. Adjustments made to a model (i.e., equations or coefficient values) to provide results that more closely follow observed data; used especially during initial model development and testing.

- **Model confirmation**. Comparative testing of model results with measured data to determine the adequacy of model simulations for describing the observed behavior of the modeled variables; used especially during model application to conditions different from those used to calibrate the model.

AFFECTED ENVIRONMENT

Sources of Information

Ongoing studies and analyses of the Bay-Delta have served as important sources of information on hydrodynamics for this analysis (see those cited in Chapter 3A, "Water Supply and Water Project Operations"). The major source of information for this chapter was simulation results from the hydrodynamic and water quality modules of the Delta model developed by RMA. These models were used to simulate the effects of the DW project alternatives on Delta channel flows and salt transport. Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project", describes the RMA Delta hydrodynamic modeling results, and Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project", describes the RMA Delta salinity modeling results, which are based on the hydrodynamic modeling results.

Table 3B-1 lists the available hydrologic information for describing historical Delta conditions. All hydrologic information (data and model results) are presented for water years (beginning in October and ending in September; for example, water year 1967 begins on October 1, 1966, and ends on September 30, 1967). Historical Delta conditions are described with a combination of measurements and estimated values. Some historical conditions are represented by measured streamflows (i.e., Sacramento River and San Joaquin River flows), and others consist of operational records (i.e., CCWD diversions). Many historical conditions must be estimated because measurements are not available. For example, DWR estimates DCC and Georgiana Slough flows, net channel depletion, QWEST flow, and Delta outflow. This chapter presents monthly average net channel flows simulated with the RMA Delta hydrodynamic model to complete the description of historical Delta conditions.

RMA Simulations

RMA performed modeling of Delta hydrodynamic and water quality conditions for this analysis based on monthly average historical hydrology for the 25-year period of water years 1967-1991. This period was selected because there are historical EC data for confirmation of model results and almost all major CVP and SWP facilities were operational during this period.

The simulated monthly average results from the RMA model were summarized with a series of relationships that describe net channel flows, EC values and chloride (Cl^-) concentrations, and inflow source contributions at key locations. These relationships were incorporated into the impact assessment models developed for the 1995 DEIR/EIS analysis (the DeltaSOS model, the Delta Drainage Water Quality [DeltaDWQ] model, and the Delta Movement of Organisms Vulnerable to Entrainment [DeltaMOVE] model), as described below and shown in Figure 3-1 in Chapter 3, "Overview of Impact Analysis Approach".

The RMA model and other models used for the impact assessment of DW project effects on hydrodynamics are described below under "Overview of Models and Modeling Tasks" in the section "Impact Assessment Methodology".

RMA Simulations and DeltaSOS

As described in more detail in Chapter 3A, DeltaSOS is the monthly Delta operations model developed by JSA to simulate operations of the DW project integrated with Delta operations of the CVP and SWP. Net channel flows simulated with the RMA model have been described in the DeltaSOS assessment model as a series of algebraic "hydraulic geometry" equations that estimate channel flow splits and diversions as a function of Delta inflows, exports, and net channel depletions. DeltaSOS results include DW project diversions and discharges.

Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", describes the hydrologic inputs for the 1995 DEIR/EIS DeltaSOS simulations of the DW project; Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model", describes application of the DeltaSOS model; and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", presents the DeltaSOS monthly simulation results for operations of the DW project alternatives as presented in the 1995 DEIR/EIS.

RMA Simulations and DeltaDWQ

DeltaDWQ is the monthly Delta water quality model developed by JSA to simulate the effects of Delta agricultural drainage on channel EC patterns and concentrations of dissolved organic carbon (DOC). RMA model results were incorporated into the DeltaDWQ model for assessment of DW project effects on water quality constituents. Delta channel EC patterns are described in the DeltaDWQ assessment model as a series of algebraic "negative exponential" equations that estimate EC as a function of "effective" Delta outflow. Inflow source contributions are described in the DeltaDWQ assessment model as mass balance "mixing" equations that estimate the inflow source contributions as a function of river inflows, exports, and diversions. Effects of DW project diversions and discharges on inflow source contributions are included in the DeltaDWQ assessment model.

DeltaDWQ is described in more detail in Chapter 3C, "Water Quality". Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model", describes the application of the DeltaDWQ model for water quality impact assessment of the DW project.

RMA Simulations and DeltaMOVE

DeltaMOVE is the monthly Delta transport model developed by JSA to simulate the effects of Delta channel flows on movement of organisms vulnerable to entrainment. DeltaMOVE is a "mass balance" model that estimates net movement from both tidal mixing and net channel flows in 10 major Delta volume elements. The results of the RMA hydrodynamic modeling have been described in the DeltaMOVE assessment model to allow evaluations of the net movement of organisms vulnerable to entrainment in exports or agricultural diversions. DeltaMOVE is described in more detail in Chapter 3F, "Fishery Resources". Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species", describes the application of the DeltaMOVE model for fishery impact assessment of the DW project.

Regional Delta Hydrodynamics

Delta hydrodynamics depend primarily on the physical arrangement of Delta channels, inflows, diversions and exports from the Delta, and tides. Delta hydrodynamics govern channel flows and Delta outflow dynamics related to tidal variations in stage, velocity, and flow. Delta outflow dynamics have important effects on salinity intrusion and estuarine habitat conditions.

Delta Channels

Delta channels are generally less than 30 feet deep unless dredged and vary in width from less than 100 feet to over 1 mile. Some channels are edged with aquatic and riparian vegetation, but most are bordered by steep banks of mud or riprapped levees (Kelley 1966, DeHaven and Weinrich 1988). Vegetation is generally removed from channel margins to improve flow and facilitate levee maintenance.

Delta hydrodynamic simulations depend on accurate geometry data for each of the Delta channels. Surface area is important in determining the upstream tidal flow for a given change in stage at a Delta channel location represented by a model node. Cross-sectional area is important for estimating channel flow velocity. Cross-sectional areas and lengths of channels (with corresponding friction factors) determine divisions of flow when tidal flows can move into more than one channel. Volume determines the change in stage corresponding to a tidal inflow or outflow at a channel location. Tidal flushing at a location can be estimated as the tidal flow divided by the volume. Table B1-1 in Appendix B1 summarizes important hydraulic geometry data for major Delta channel segments.

Delta Inflows

The RMA Delta model uses five separate inflows to the Delta as simulation inputs: Sacramento River, Yolo Bypass, San Joaquin River, eastside streams (including the Mokelumne, Cosumnes, and Calaveras Rivers), and rainfall in the Delta. Historical monthly average inflows for 1967-1991 were used for simulations of historical Delta hydrodynamics using the RMA model. Historical data may not represent conditions that would occur with existing reservoir and diversion facilities and under current operations criteria. Therefore, monthly average inflows for 1967-1991 simulated by DWR's operations planning model DWRSIM were used for impact assessment modeling in the 1995 DEIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations". The DWRSIM simulations are projections of Delta inflows and exports that would occur under the range of hydrologic conditions represented by the 70-year hydrologic record, but with current facilities and demand for exports and under 1995 WQCP objectives.

Historical Sacramento River flow is limited to about 80,000 cfs, with higher flows diverted to the Yolo Bypass. Flows simulated by DWRSIM for low-flow periods are similar to historical values. Differences in the monthly flows between the historical and simulated patterns may be attributed to changes in upstream reservoir operations, upstream diversions, or releases made for Delta exports (changes in demands for beneficial water uses).

Upstream storage and diversions increased considerably in the San Joaquin River Basin during the 25-year period. Increased storage capacity has allowed greater diversions of runoff for seasonal storage and subsequent use. The San Joaquin River inflow to the Delta is now regulated to satisfy maximum salinity standards (with minimum flows) and pulse-flow requirements, as specified in the 1995 WQCP. Although upstream storage and diversions from the eastside streams changed over the 25-year period, historical and simulated monthly values for inflow are similar.

The monthly Delta rainfall estimate was combined with estimates of Delta ET to produce model inputs for Delta channel diversions and agricultural drainage. These estimates are described in Appendix A1 and are similar to the net channel depletion values used in DWRSIM.

Delta Diversions and Exports

Delta export pumping occurs at four locations: the CVP Tracy Pumping Plant, the SWP Banks Pumping Plant, CCWD Rock Slough intake, and Vallejo and North Bay Aqueduct pumps at Barker Slough.

Historical annual exports increased to approximately 6 MAF during the late 1980s. Exports simulated by DWRSIM for the 1995 WQCP objectives averaged about 6 MAF, except in some low runoff years when this volume of water was not available.

Delta Tidal Effects

Tidal changes strongly influence Delta channel conditions twice daily by changing water surface elevation, current velocity, and flow direction. The effects of ocean tides on Delta hydrodynamic conditions are modified by freshwater inflow and diversion rates. The extent of tidal influence depends on the tidal prism volume relative to river discharge at a particular Delta location, as described below.

Tidal effects are more intense closer to Suisun Bay, but even in the central Delta, water surface elevation can vary by more than 5 feet during one tidal cycle. Tidally influenced channel velocities can range from -2 fps to more than +3 fps (with negative figures indicating upstream flood tide flow). High river flows can cause high stages and velocities in some channel segments. Diversions and export pumping can also increase channel velocities.

Tidal effects are not uniform from day to day. There is a distinct pattern of tidal variations within a lunar month. The tidal range is greatest during "spring" tides and smallest during "neap" tides. The mean tide elevation may also change slightly during the spring-neap lunar cycle. This adds a net "tidal outflow" component to daily Delta outflow estimates. However, as described below under "Average Tide at the Downstream Boundary (Benicia)", the RMA hydrodynamic model simulated a constant average tide for every tidal day throughout each month.

Delta Outflow Effects

Salinity Intrusion. Seawater intrusion in Suisun Bay is directly related to Delta outflow patterns. Salinity intrusion in the central Delta is increased when in-Delta diversions and exports, in combination with low Delta inflow, cause net flow to reverse in the lower San Joaquin River near Antioch and Jersey Point. Some salt is transported into the central Delta by the tidal flow patterns. Historical 1968-1991 and simulated Delta salinity patterns are discussed in more detail in Chapter 3C, "Water Quality", and in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project". The possible effects of DW project operation on salinity intrusion are assessed in Chapter 3C.

Estuarine Entrapment Zone. The estuarine "entrapment zone", or null zone, is an important aquatic habitat region associated with high levels of biological productivity. The entrapment zone is the zone of transition between gravitational circulation and riverlike net seaward flow. Gravitational circulation is the flow pattern caused by salinity (density) gradients in which mean bottom flow is landward and mean surface flow is seaward. Gravitationally induced currents are usually small fractions of tidal currents and are weakened by enhanced vertical mixing associated with increased tidal flows (Smith 1987). In general, gravitational currents are highest in the region of the steepest salinity gradient (i.e., greatest change in salinity with distance). High outflows move the salinity gradient seaward, decreasing the influence of gravitational circulation on the Delta.

The location of the entrapment zone is determined by the magnitude and duration of Delta outflow. The zone moves seaward rapidly in response to increased freshwater discharge. With decreased discharge, the zone gradually moves upstream. The hydrodynamic behavior of the estuarine entrapment zone has been described by Arthur and Ball (1980). EPA has proposed that the location of the upstream boundary of the entrapment zone (salinity of 2 ppt), referred to as X2, is an appropriate estuarine management variable (San Francisco Estuary Project 1993). Estuarine habitat standards for the February-June period have been included in the 1995 WQCP. The possible effects of DW project operation on estuarine habitat conditions are assessed in Chapter 3F, "Fishery Resources".

Hydrodynamics near the DW Project Islands

Hydrodynamics in channels adjacent to DW project islands (Figure 2-1 in Chapter 2, "Delta Wetlands Project Alternatives") depend largely on overall Delta hydrodynamics. The channels bordering Bacon Island and Holland Tract function primarily as transport channels moving water toward the export pumps. Net flow in these channels generally moves upstream toward the CVP and SWP pumps and the CCWD intake. Sand Mound Slough along the west side of Holland Tract is blocked by a tide gate at the Rock Slough confluence that permits flow only to the north during ebb tides, to prevent water and salt movement into Rock Slough from Sand Mound Slough.

Webb Tract is bordered by the San Joaquin River on the north and east, Fishermans Cut on the west, and False River on the southwest. Franks Tract, a flooded island area, is south of Webb Tract. Net flow near Webb Tract is usually westerly, except during periods of low Delta inflow and high export volumes, when net flow reverses and water is transported into Old River and toward the CVP and SWP pumps.

Bouldin Island is bordered by the Mokelumne River on the north and west, Little Potato Slough on the east, and Potato Slough on the south. Net flow around Bouldin Island is nearly always toward the San Joaquin River. Reverse flows, during periods of low Delta inflow and high export volumes, occur only in Potato Slough (reverse flow to the east) along the southern edge of the island.

Existing irrigation diversions and agricultural drainage discharges probably have minor effects on adjacent channel hydrodynamics. Hydrodynamic effects of these diversions and discharges are small compared with tide-induced fluctuations in water surface elevation, velocity, and channel flow.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Variables

Overview of Models and Modeling Tasks

As indicated above under "Sources of Information", several models have been used for the impact assessment of DW project effects on water supply, hydrodynamics, water quality, and fisheries. Results from DWRSIM were used as the initial water budget for DeltaSOS simulations of the No-Project Alternative and the DW project alternatives (see Appendix A3 and Chapter 3A). Results from DeltaSOS simulations were used as the inputs for various impact assessment models. The hydrodynamic and water quality modules of the RMA Delta model were used to simulate historical monthly average net channel flows and EC patterns and to estimate inflow source contributions in major Delta channels and export locations. The results from the RMA models were incorporated into the impact assessment models. This section provides an overview of the most important steps in the formulation, calibration, confirmation, and application of these models.

Table 3B-2 summarizes preliminary calibration and confirmation tasks for the RMA Delta hydrodynamic and water quality models. The source of required data for each of the models is given in the first column. The models used in each task are listed in the second column. The preliminary calibration or confirmation analysis (i.e., purpose for each task) is listed in the third column. The fourth column indicates where the results of the analysis can be found in this document or in supporting references.

The RMA hydrodynamic model was originally calibrated (by adjustment of hydraulic roughness coefficients) with historical tidal stage data from several locations in the Delta. The calibration was demonstrated with July 1979 data from 12 locations. The RMA Delta hydrodynamic model is described below under "RMA Hydrodynamic Model Formulation and Assumptions"; the model and tidal calibration are also described in Appendix B1. A more complete description of the model and calibration can be found in Smith and Durbin (1989).

The long-term tide pattern at the downstream boundary (near Benicia) was used to simulate tidal hydraulics (stages, flows, and velocities) in the major Delta channels. Results of these simulations are summarized in this chapter and more fully described in Appendix B1.

Historical Delta inflows and exports were used to calibrate the RMA water quality model (by adjusting tidal mixing coefficients) with daily patterns of EC at 19 Delta locations for 1972. Flows and EC data for 1976 and 1978 were used to confirm the RMA water quality model results. These results are shown in Smith and Durbin (1989).

Historical monthly average Delta inflows and exports for water years 1967-1991 were used as inputs to the RMA Delta model to simulate monthly average net channel flows in the Delta. The simulated historical net Delta channel flows are used as a reference with which to compare the simulated No-Project Alternative channel flows. The simulated channel flows are summarized in this chapter and Appendix B1. The simulated net channel flow "split" relationships were evaluated and summarized with equations that were incorporated into the DeltaSOS model (Appendix A2). The most important net channel flow-split relationships are presented in this chapter and Appendix B1.

Because Delta channel flows were not measured during the 1967-1991 period, daily EC measurements were used to provide indirect confirmation of the RMA hydrodynamic and water quality model simulations. Monthly averages of daily EC records (minimum, mean, maximum) collected by Reclamation and DWR for 1968-1991 and compiled by CCWD (Leib pers. comm.) were used to confirm the end-of-month EC patterns simulated by the RMA Delta hydrodynamic and water quality models using monthly average inflows and exports for 1967-1991. The measured and simulated EC patterns were evaluated and summarized with equations that were incorporated into the DeltaDWQ model (Appendix C4). The results of these historical monthly EC simulations are shown in Chapter 3C and Appendix B2.

Table 3B-3 shows the three major tasks for assessment of impacts of the DW project on hydrodynamics. The assessment of hydrodynamic impacts of each DW alternative was accomplished by comparison with Delta hydrodynamic conditions simulated for the No-Project Alternative under the 1995 WQCP objectives, as described in Chapter 3A.

Delta inflows and exports and DW operations (diversions and discharges for export) were simulated with the DeltaSOS model, as described in Chapter 3A and in Appendices A2 and A3. The DWRSIM-simulated water supply conditions were compared with historical reservoir inflows and Delta conditions in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project".

The Delta hydrodynamic model was used to simulate channel tidal flows and velocities during maximum DW diversions and maximum DW discharge conditions. Representative inflows and exports were selected for these simulations. The results are given in Appendix B1 and summarized in this chapter.

The results of the DeltaSOS model simulations of net flows for the No-Project Alternative and each DW project alternative are presented in this chapter as the DW project hydrodynamic impact assessment. Appendix B1 provides a more detailed description of these hydrodynamic simulations. The results of the DeltaDWQ model simulations of source contributions and EC based on the simulated channel flows are presented in Chapter 3C and Appendix B2.

RMA Hydrodynamic Model Formulation and Assumptions

The RMA Delta model, developed jointly with DWR, represents the hydrodynamic responses of the Delta to tidal fluctuations and inflows. The model is a branched one-dimensional formulation representing the Delta as a network of volume elements (nodes) and channels (links). Nodes are discrete units characterized by surface area, depth, side slope, and volume as a function of water depth (stage). Nodes are interconnected by channels (links), each characterized by length, cross-sectional area, hydraulic radius (depth), and friction factor (Manning's "n" value) as a function of water depth. Water is modeled to flow from one node to another through one or more links representing the significant channels between nodes (Smith and Durbin 1989). A node represents about half the volume of the channels connecting to the node. Thus, the full channel volume is represented by the two nodes connected to the channel (link). The RMA Delta model is formulated with approximately 375 nodes and 465 connecting channels (see Figure B1-1 in Appendix B1).

The RMA Delta model combines a hydrodynamic module and a water quality module. The hydrodynamic portion of the model simulates average velocity and flow in the cross section of each channel (link) and the average stage at each volume element (node) throughout a typical tidal stage variation and with specified monthly average inflows. Tidal flows simulated with the hydrodynamic model are used to estimate net channel flows and tidal mixing between model nodes, both of which are used to simulate mixed concentrations of water quality variables at model nodes in the RMA water quality model, as described in Appendix B2.

The hydrodynamic portion of the model operates on a 1.5-minute time step and estimates stage at the nodes and velocity and flow (and direction) in the Delta channels for a repeating average tide. The model requires boundary conditions to be specified for Delta inflows, Delta exports, and the average tidal boundary conditions at the downstream end of Suisun Bay near Benicia. Delta agricultural diversions and drainage discharges are treated as sinks or sources at appropriate nodes.

Time Step of Inputs and Calculations. The RMA model can use any desired time step for inputs. The 1995 DEIR/EIS impact assessment of the DW project used monthly average flows for the 25-year period of water years 1967-1991 and DW operations specified as monthly average diversions and discharges for each of the four DW islands. Although hydrologic conditions can be specified and used in the RMA model at a daily time step, monthly simulations are considered accurate enough for impact assessment of the DW project. Conventional water supply planning models (i.e., DWRSIM and PROSIM) simulate monthly average conditions. Seasonal and year-to-year impacts can be generally described with monthly model results. Variations in DW operations resulting from daily changes in river inflows, Delta exports, or DCC gate operations for flood control or fishery management were not simulated for the hydrodynamic impact assessments. Possible effects of daily operations of the DW project are discussed in Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments".

The RMA model summarizes hydrodynamic results as average ebb tide flow, average flood tide flow, and net (positive or negative) channel flows for each set of hydrologic inputs (net flow = ebb tide flow - flood tide flow). The sign convention of the RMA model is based on the assumption that positive flow in a channel is from a lower number node to a higher number node. Most node numbers increase from upstream to downstream so that positive channel flows correspond to river flow and ebb tide flow. Flood tide flows for these channels are negative. Because the hydrologic inputs to the RMA model for the DW impact assessment were monthly averages, the model outputs are also monthly average net channel flows. The RMA model simulates tidal hydraulics for the specified 19-year average Benicia tide, but the net channel flows are monthly averages. DW project operations are simulated as constant diversions or discharges over monthly periods.

Average Tide at the Downstream Boundary (Benicia). The tidal boundary condition used in the RMA model is the 19-year average of measured tides at Benicia typically used in Delta hydrodynamic studies. Although averaging tide measurements smooths the differences between extreme tides throughout the lunar tide cycle (28 days), it is justified because the hydrologic inputs used in the impact assessment simulations are monthly averages. The hydrodynamic model repeats this average tide for each set of monthly inputs. Because the tidal cycle is 25 hours long, net channel flows are averages for the 25-hour tidal period in units of cfs.

Hydrologic Inputs. The required hydrologic inputs for the RMA Delta model consist of monthly river inflows, Delta exports, agricultural diversions and drainage flows, and simulated DW diversions and discharges for each island. The model inputs are specified in a hydrologic input file, with monthly values for water years 1967-1991 for each required input variable. Historical inflows and exports were used for the historical simulations. Values for river inflows, Delta exports, and combined DW project diversions and discharges were obtained from DeltaSOS model results for simulation of each DW alternative and the No-Project Alternative for the 1995 DEIR/EIS (see Appendix A3).

Simulated Delta Facilities. The simulation results produced by the RMA model depend on assumptions regarding Delta channel configurations and geometry, the DCC gate operation pattern, Delta export pumping capacities for the CVP Tracy Pumping Plant and the SWP Banks Pumping Plant, permitted pumping rate for Banks Pumping Plant, and the tidal operation pattern of the Clifton Court intake and the Suisun Marsh salinity control gate.

The hydrodynamic analysis included the assumption that channel geometry will remain unchanged, without any of the modifications that have been proposed by DWR for north Delta or south Delta channels. Existing CVP and SWP pumping capacities, as simulated by the DeltaSOS model (described in Appendix A2), were also assumed in the RMA model to remain unchanged. The hydrodynamic analysis assumed, however, that the proposed gate at the head of Old River was in place and operational, as described in the 1995 WQCP.

The RMA model inputs specified monthly operation (open or closed) of the Delta channel control gates at the DCC, the Suisun Marsh salinity control gate, and the proposed barrier at the head of Old River. Appendix A2 describes the assumed operation of these Delta facilities. The partial temporary barriers that have been installed and operated by DWR in the south Delta were not simulated.

Simulation of Tidal Gate Operations in the Delta. Several Delta tidal gates are operating and several others are proposed. The most important Delta tidal gates currently in operation are the gate at the entrance to Clifton Court Forebay and the Suisun Marsh salinity control gate. The RMA model also simulated operating tidal gates on Tom Paine Slough in the south Delta and on Sand Mound Slough at Rock Slough. The RMA model also simulated the DCC gates and the gates at the head of Old River, but these gates were assumed to be either open or closed during an entire month and therefore were not simulated to operate as tidal gates.

Clifton Court Forebay. Inflow to Clifton Court Forebay is controlled by a gated weir that allows inflow during high tides and prevents outflow during ebb tides. The gate is represented in the RMA Delta model by a channel that approximates the head loss through the gated weir. The RMA model computes Clifton Court inflow based on channel hydraulic characteristics and the simulated head difference between Old River and Clifton Court, assuming a constant outflow to the Banks Pumping Plant. The gate is assumed to be open for several hours near high tides to approximate the current operating schedule.

Suisun Marsh Salinity Control Gate. The RMA Delta model simulates operation of the tidal gate that controls flow into Montezuma Slough. Operation of the tidal gate produces a net inflow of Sacramento River water into the Suisun Marsh channels for salinity control. Almost all flood tide flow (i.e., out of Suisun Marsh into the Sacramento River) is blocked by the gates. During ebb tide, in contrast, the gates are held open, thus producing a net ebb flow of low-salinity water from the Sacramento River into Suisun Marsh. The magnitude of the net ebb flow depends on the Sacramento River flow.

Simulated Delta Tidal Hydraulics

In RMA hydrodynamic simulations, the same average tide is used for all specified inflows and exports. Therefore, a single pattern of Delta tidal flows induced by the average tide, without any inflows or exports, can be described for all hydraulic simulations. A more complete description of simulated Delta tidal hydraulics is given in Appendix B1, “Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project”. Table B1-2 in Appendix B1 shows simulated tidal flows and tidal excursions for selected Delta locations.

Simulated 25-hour average flood tide flows throughout the Delta are summarized in Figure 3B-1. Arrows indicate the direction of flow during flood tide. The flow in most Delta channels will switch direction during ebb tide. Because the RMA model uses the average tidal pattern as the underlying basis for simulation of all monthly average Delta inflows and exports, net channel flows estimated by the RMA model are in addition to the average tidal flows shown on this “tidal map” of the Delta.

Tidal flows throughout the Delta provide tidal exchange mixing that governs salinity intrusion, tidal flushing flows that control water quality, and tidal currents that may influence fish movement and transport of planktonic organisms. Because the time of peak tidal flows is delayed as the tide progresses upstream, tidal flows in the south and north Delta are out of phase with the Benicia boundary condition.

Appendix B1 presents detailed descriptions and geographical representations of tidal hydraulics at important locations throughout the Delta as simulated by the RMA hydrodynamic model. A series of figures in Appendix B1 shows simulated tidal flows over the 25-hour tidal cycle at locations in Suisun Bay; along the Sacramento, San Joaquin, Old, Middle, and Mokelumne Rivers; and in the south Delta.

Simulated Historical Delta Channel Flows

The RMA Delta hydrodynamic model was used to simulate monthly average Delta channel flows for the 25-year 1967-1991 period, based on historical monthly average inflows and exports obtained from DWR’s DAYFLOW database. The resulting channel flows are described here because they provide the basic flow patterns that govern possible hydrodynamic, water quality, and fishery impacts. The specified historical inflows and exports and the simulated channel flows are described in detail in Appendix B1 (see section entitled “Simulations of Monthly Average Net Delta Channel Flows Using Historical Delta Inflows and Exports”).

The channel flows simulated by the RMA model and described in this section are net flows superimposed on the average tidal flows described in the previous section. These net channel flows represent Delta hydrodynamic conditions that would have been associated with historical Delta inflows and exports during 1967-1991. Much of this period was prior to the increase in Delta export demand to the levels reached in the late 1980s. The results of this historically based simulation of Delta flows provide a reference baseline for evaluating the simulated Delta hydrodynamics for the No-Project Alternative and the DW project alternatives, in the absence of historical measurements characterizing Delta channel flows.

Sacramento River Channel Flows. Sacramento River diversions into Steamboat and Sutter Sloughs and into the DCC and Georgiana Slough are determined by channel geometry, tidal hydraulics, Sacramento River inflow, and operation of the DCC gates. Delta exports, Mokelumne River or Yolo Bypass inflows, and other Delta conditions do not substantially affect these Sacramento River diversions, according to the RMA Delta model results.

Figure 3B-2 shows the historical Sacramento River inflow and the RMA-simulated diversions to Steamboat and Sutter Sloughs, the DCC, and Georgiana Slough for water years 1967-1991. The RMA model results based on historical inflows indicate that a considerable portion (20%-40%) of the Sacramento River inflow is diverted into Steamboat and Sutter Sloughs and returned to the Sacramento River channel at Rio Vista (see Figure B1-25 in Appendix B1).

The RMA model results also indicate that a considerable portion (15%-60%) of the Sacramento River inflow is diverted into the DCC and Georgiana Slough and conveyed into the central Delta. Simulated channel flows indicate that, when the DCC is open, DCC flow is greater than Georgiana Slough flow (see Figure B1-26 in Appendix B1). Closing the DCC increases the Georgiana Slough flow but reduces diversions from the Sacramento River by about half. Because the DCC is closed when Sacramento flows are greater than 25,000 cfs, the range of diversions to the DCC and Georgiana Slough is relatively constant, between approximately 4,000 cfs and 12,000 cfs.

The RMA model results indicate that a considerable portion of Sacramento River flow below Rio Vista is diverted through Threemile Slough to the San Joaquin River. The proportion of the Sacramento

River flow diverted into Threemile Slough is greatest when central Delta outflow (QWEST flow) is negative (i.e., net San Joaquin River flows are reversed upstream into the central Delta). The diverted Threemile Slough flow is usually greater than the reversed San Joaquin River flow, so that the simulated flows at Antioch (which are the sum of QWEST and Threemile Slough flows) were almost always positive.

For the simulations based on historical inflows and exports, the Suisun Marsh salinity control gate was assumed to be open (i.e., not forcing fresh water into Suisun Marsh). Net channel flows simulated to be diverted through Montezuma Slough into Suisun Marsh are about 2% of Delta outflow for moderate and high Delta outflows (see Figure B1-28 in Appendix B1). At a Delta outflow of 10,000 cfs, however, Montezuma Slough net flow is simulated to be zero. When Delta outflow is less than 10,000 cfs, a small upstream net flow transports water from Suisun Marsh into the Sacramento River channel near Collinsville.

San Joaquin River Channel Flows. The San Joaquin River divides into several distributory channels through the Delta. Figure 3B-3 shows historical 1967-1991 San Joaquin River inflow at Vernalis and flow downstream of the head of Old River simulated by the RMA model. The historical simulations did not include an Old River barrier (temporary barriers have been used in some years). The RMA model simulates diversions into the head of Old River to be about 60% of San Joaquin River inflow when the inflow is above 2,000 cfs and is not directly affected by exports. Nearly all San Joaquin River inflow is diverted into Old River when the San Joaquin River inflow is less than about 2,000 cfs (see Figure B1-30 in Appendix B1). When San Joaquin River inflow is less than 2,000 cfs, a slight reverse flow in the upper San Joaquin River below the head of Old River is simulated by the RMA model when exports exceed the San Joaquin River inflow.

Water flows out of the central Delta through the lower San Joaquin River and through Franks Tract and several connecting channels (Fishermans Cut, False River, and Dutch Slough). Central Delta water consists of inflows from the San Joaquin River and eastside streams as well as Sacramento River flow diverted through the DCC and Georgiana Slough. In the RMA model simulation, False River carries about 40% of the central Delta outflow (QWEST flow), whereas Dutch Slough carries about 5% of central Delta outflow. About 55% of total central Delta outflow remains in the main channel of the lower San Joaquin River (see Figure B1-32 in Appendix B1).

Hydraulic relationships govern the magnitude of channel flows in Old and Middle Rivers regardless of the direction of flow. As simulated by the RMA model, flows in Old and Middle Rivers move downstream during periods of high San Joaquin River inflow. During periods of low San Joaquin River inflow, Old and Middle River flows are usually reversed, however, and move from the central Delta upstream toward the Delta export locations at the Banks and Tracy Pumping Plants.

Figure 3B-4A shows the hydraulic flow split simulated by the RMA model between the Old River and Middle River channels at Bacon Island for 1967-1991 historical Delta inflows and exports. The simulation location is north of the Santa Fe Cut and Woodward Canal, which transport flows between Old and Middle Rivers, and corresponds to the tidal flow measurement stations installed by USGS and DWR in 1987. The simulated channel flows indicate that Old River conveys about 60% of the total flow and Middle River conveys about 40% of the total flow in the two channels. The simulated division of flow between Old and Middle Rivers remains consistent whether the flow is downstream during high San Joaquin River inflows or upstream to supply Delta export pumping.

USGS flow data provide an opportunity to test and confirm RMA simulations of Delta channel flows in this portion of the Delta. Figure 3B-4B shows the measured relationship between Old River and Middle River flows obtained from USGS daily measurements of channel flow for 1987-1989. The USGS measurements indicate that approximately 55% of the total flow is in Middle River near Bacon Island and about 45% is in Old River. The procedures used by USGS to calibrate the flow measurement stations are described in Interagency Ecological Program for the Sacramento-San Joaquin Estuary (1995). The difference between the USGS estimates and the RMA-simulated division of flows between the two channels can be resolved by adjusting values for modeled channel geometry variables (and assumed friction factors) in the two channels. These adjustments (i.e., Old River from 60% to 45% of flow) were not made for the DW project impact assessments because the likely effects of these channel flow adjustments on hydrodynamic, water quality, or fishery impacts were considered relatively minor.

Criteria for Determining Impact Significance

Assessment of the Delta hydrodynamic impacts of DW project operations was accomplished by considering hydrodynamic variables in the Delta and selecting those that would likely be changed or influenced by DW operations. The selected "impact variables" were then analyzed with the RMA Delta model to determine whether significant changes from the simulated No-Project Alternative conditions would likely occur with any proposed DW project operations.

Delta hydrodynamic variables that were determined to be outside the influence of the proposed DW project operations were not selected as impact variables. This screening evaluation was based on the recognition that basic hydrologic conditions in the Sacramento and San Joaquin River Basins and tidal fluctuations from San Francisco Bay are beyond the control of any proposed DW project operation.

Possible Hydrodynamic Impact Variables

The following types of Delta hydrodynamic variables were considered in the initial selection process:

Local channel velocities and stages that respond to changes in tidal prism volume caused by flooding or diking of tidal wetlands, changes in channel geometry, or changes in the operation of tidal gates or major siphons;

Delta export flows that respond to changes in pumping limitations (physical or regulatory), export demands, Delta inflows, Delta water quality standards, or required minimum Delta outflows or QWEST flows;

Delta outflows that respond to changes in required minimum outflows, Delta inflows, Delta exports, or net in-Delta diversions;

Delta channel net flows that respond to changes in Delta inflows, diversions, and exports; modified operations of Delta facilities (DCC, Clifton Court Forebay, and Suisun Marsh salinity control gate); and modified channel conveyance capacities that might be affected by dredging, widening, clearing, cutting of new Delta channels, installation of barriers, or the presence of different hydraulic gradients (water surface slope); and

Delta inflow source contributions of Sacramento River or San Joaquin River inflows, eastside streams, agricultural drainage, tidal mixing from the downstream Benicia boundary, or DW project discharges.

Possible types of effects of DW operations on each hydrodynamic variable are briefly described below. Selected impact variables are summarized in Table 3B-4, with the method of analysis and assessment and the Delta locations selected to represent possible hydrodynamic effects of DW operations. Several Delta hydrodynamic variables would probably not be changed by DW project operations.

Local Channel Velocities and Stages. The DW project may change Delta hydraulics in local channels adjacent to proposed DW siphons or discharge pumps. These possible effects were evaluated with RMA Delta model simulations of flow, velocity, and stage with maximum (i.e., worst-case) DW diversions and discharges and appropriate Delta inflow and export conditions. Simulations were performed for Delta channels surrounding each DW project island (Bacon Island, Webb Tract, Bouldin Island, and Holland Tract). Results are discussed later in this chapter.

The significance criteria for possible local channel hydraulic effects were exceedance of the historical flows or exceedance of a scouring velocity threshold of approximately 3 fps (Suits pers. comm.). Channel flows in the Delta are highly variable. Increases above the historical range of channel flows may, however, cause unrecognized effects. Therefore, hydraulic effects of DW project diversions or discharges are considered significant if they increase local Delta channel flows above the historical range or if they produce channel velocities of greater than 3 fps.

Delta Exports. The DW project might change Delta exports and associated channel flows toward the export pumping plants by providing an additional source of water. Possible increases in Delta exports in general have been simulated using the DeltaSOS model, as described in Chapter 3A, "Water Supply and Water Project Operations", and Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives". RMA Delta hydrodynamic simulations were used to evaluate potential effects of DW project operations on export volumes at individual export locations (see "Delta Inflow Source Contributions" below) and associated channel flows leading toward the export pumps.

Significance criteria for these possible effects on exports and channel flows were developed based on historically permitted export capacities and the corresponding channel flows that have been associated with historical exports. The Corps' restrictions for the SWP Banks Pumping Plant allow it to increase its diversion into Clifton Court Forebay by one-third of the San Joaquin River flow when that flow is greater than 1,000 cfs at Vernalis during December 15-March 15. The physical pumping capacity at the SWP Banks Pumping Plant that can be used to export this extra water is approximately 3,620 cfs, for a total assumed SWP and CVP export capacity of 14,500 cfs (10,300 cfs at Banks and 4,200 cfs at Tracy). The extra rate of SWP export pumping, with existing Clifton Court intake facilities, was successfully demonstrated by DWR during February 1993.

Under the Corps' restrictions for the SWP Banks Pumping Plant, DW discharges for export cannot cause Delta exports and associated channel flows to increase above specified historical export pumping rates and channel flows (3-day average of 6,680 cfs). Therefore, it is assumed that proposed DW project alternative operations would not result in significant impacts on exports or associated channel flows. Possible effects of DW operations on export water quality and fisheries are described in Chapter 3C, "Water Quality", and Chapter 3F, "Fishery Resources", respectively.

Delta Outflow. The DW project may change Delta outflow by diverting water for seasonal storage on the reservoir islands during periods of excess Delta inflows, or by discharging some or all of the stored water for increased Delta outflow to potentially benefit fish and estuarine habitat conditions as directed by water purchasers. Reducing agricultural diversions onto the DW project islands may increase Delta outflow. Possible effects of DW project operations on Delta outflows were simulated with the DeltaSOS model, as described in Chapter 3A and Appendix A3.

Proposed DW diversions to reservoir island storage would generally occur only during periods of high Delta outflow; therefore, effects on Delta outflow would often be proportionately small. However, potential DW diversions are sizable (averaging 4,000 cfs during periods of diversion), and reductions in Delta outflow during periods of DW diversions were simulated in the DeltaSOS modeling.

As discussed in Chapter 3A, the 1995 WQCP specifies monthly minimum Delta outflow objectives as necessary flows for fish transport, as necessary flows to control salinity intrusion at agricultural control locations during the irrigation season or at municipal water supply intakes, or as required outflow for estuarine habitat management. Many of the salinity standards can be approximated with "equivalent" Delta outflow standards. The minimum Delta outflow allowed by the 1995 WQCP is approximately 3,400 cfs during dry and critical year types and 4,500 cfs in other year types. During the irrigation season, the 1995 WQCP requires a minimum Delta outflow of about 7,000 cfs to control salinity intrusion at Emmaton.

A basic assumption of the analysis was that SWRCB terms and conditions in any water right permit granted for DW project operations would prohibit violation of Delta outflow or salinity requirements. Therefore, the modeling performed for this impact assessment did not allow these requirements to be exceeded, and DW project effects on Delta outflow were not selected as a hydrodynamic impact variable in this chapter. However, the simulated effects of DW operations on Delta outflow, as evaluated in the 1995 DEIR/EIS, are reported in Appendix B1 (Table B1-11) for 1968-1991, and the secondary effects of DW project effects are assessed in other chapters. Possible effects of reduced outflow on salinity intrusion are described in Chapter 3C, "Water Quality". Possible effects of reduced Delta outflow on the position of the estuarine salinity gradient and associated fishery habitat and transport are described in Chapter 3F, "Fishery Resources".

Delta Channel Net Flow. The DW project would change flows in some Delta channels because diversions to the DW reservoir islands and discharges from the DW islands would be modifications of existing agricultural operations. Changes in diversion and discharge from No-Project Alternative conditions include:

- reduced agricultural diversions for irrigation, salt leaching, and weed control;
- increased diversion for flooding and managing wildlife and waterfowl habitat;

diversion of excess Delta inflow for seasonal storage on the reservoir islands, including temporary storage of water being transferred from upstream reservoirs for export; and

discharge of seasonal storage to increase Delta export and/or increase Delta outflow.

Proposed DW operations would also modify hydraulic gradients in some Delta channels. During diversion periods of several weeks, lowered stage levels at the DW intake siphons may cause flows in several central Delta channels to increase. During the discharge periods, increased stage at the DW discharge locations may cause flows in Old and Middle Rivers and their connecting canals to increase. Potential effects of DW diversions and discharges on local Delta channel flows were simulated with the RMA Delta hydrodynamic model. The DeltaSOS assessment model was used to evaluate changes in monthly average net channel flows at selected locations.

DCC and Georgiana Slough flows simulated by the RMA model depend directly on Sacramento River inflow and are not directly affected by Delta exports or DW project operations. In contrast, net central Delta outflow downstream of the Mokelumne River (i.e., QWEST flow) would be reduced by DW diversions.

Channel flows at three locations have been selected to describe possible effects of DW project operations on Delta channel net flows:

San Joaquin River flow at Antioch is used to indicate net Delta outflow from the central Delta. Threemile Slough flow from the Sacramento River to the San Joaquin River upstream of Jersey Point also contributes to Antioch flows. San Joaquin River flow at Antioch is almost equivalent to the flow that will be measured by USGS at Jersey Point with its newly established flow-monitoring station. (Dutch Slough contributes to Antioch flow but not to Jersey Point flow.)

Threemile Slough flow represents flow between the Sacramento River near Emmaton and the San Joaquin River near Bradford Island, upstream of Jersey Point and False River. Threemile Slough flows are influenced by Sacramento River flow and San Joaquin River flows from the central Delta (QWEST flow). Closure of the DCC increases Threemile Slough flow because Sacramento River flows are increased and QWEST flows are reduced.

Old River flow at Bacon Island is used to indicate flow past Bacon Island and Holland Tract. Negative flows at this location (i.e., upstream) indicate that net flow is moving toward the Delta export pumps. The Old River channel carries approximately half the total net flow toward the export pumps. The remainder flows in Middle River on the east side of Bacon and Victoria Islands. Old River therefore represents flow conditions in both Old River and Middle River. USGS has operated a flow-measuring station on Old River and Middle River downstream (north) of Woodward Canal near Bacon Island.

Delta channel flows are highly variable because of hydrologic variability in tidal flows and Delta inflows and exports. Increases in channel flows above historical flows may cause unrecognized effects. Therefore, DW project effects are considered significant if they increase channel flows above historical flows.

Delta Inflow Source Contributions. The sources of water in Delta inflows affect water quality at Delta export locations and other locations in the Delta. The water source contributions are governed by the combination of hydrologic inflows and hydrodynamic flows within the Delta. The relative contributions of inflow water from the different Delta inflow sources are especially important for subsequent water quality and fishery impact analyses.

The DW project may change the relative contributions of water in the Delta from different inflow sources by diverting water that would otherwise have been transported to other locations (e.g., to the Delta export pumps and Delta outflow). During periods of DW discharges, the DW reservoir islands would supply a new source of water that might replace other inflow sources at the Delta export pumps or Delta outflow. Possible effects of DW operations on Delta inflow source contributions were simulated with the RMA hydrodynamic Delta model and are described in this chapter. The RMA results were summarized in the DeltaDWQ assessment model.

Effects of DW project operations on Delta inflow source contributions were not selected as a hydrodynamic impact variable because significance criteria for changes in inflow source contributions are linked with potential fishery or water quality impacts and therefore are described in subsequent chapters. The changes in source contributions are described and evaluated in Appendix B1, “Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project”; potential water quality impacts are described in Chapter 3C, “Water Quality”; and potential fishery impacts are described in Chapter 3F, “Fishery Resources”.

Summary of Criteria for Impact Significance

The hydrodynamic effects of the proposed DW project alternatives were assessed based on the following criteria:

Hydrodynamic effects on local channel velocities and stages. A project alternative is considered to have a significant impact on local channel hydraulics if it would cause local flows to substantially exceed historical flows or cause channel velocities to exceed the scouring velocity threshold of approximately 3 fps, or cause local stages to be substantially reduced from historical stages.

Hydrodynamic effects on net channel flows. A project alternative is considered to have a significant impact on net channel flows if it would cause monthly average net channel flows to increase substantially above historical net channel flows during DW operations.

Simulated Delta Hydrodynamics for Historical Conditions and the No-Project Alternative

Possible impacts of the DW project alternatives are compared below with Delta hydrodynamic conditions under the No-Project Alternative. This section describes the simulation results for the No-Project Alternative as the reference point that represents Delta hydrodynamic conditions under the 1995 WQCP. The RMA Delta model was used to simulate possible hydrodynamic effects of each of the DW alternatives and the No-Project Alternative in local channels for representative channel flows with maximum DW diversion and discharge conditions. The DeltaSOS model results for the 1995 DEIR/EIS for the 70-year period of 1922-1991 were used to evaluate changes in net channel flows at selected key Delta locations.

Comparison of Inflows, Exports, and Outflows under Historical Conditions and the No-Project Alternative

Monthly average net Delta channel flows simulated with the RMA model using historical 1967-1991 inflows and exports are presented as a reference in Appendix B1, “Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project”. Results from the RMA model simulations of net channel flows were incorporated into DeltaSOS for estimating net channel flows for historical and No-Project Alternative conditions.

The comparison of the No-Project Alternative with historical conditions provides a reference for understanding conditions under the No-Project Alternative. All impact assessments compare simulations of DW project operations with simulations of the No-Project Alternative.

Figure 3B-5 shows the comparison of the No-Project Alternative and historical 1967-1991 Delta conditions for Sacramento River and San Joaquin River inflows and Delta exports. Monthly average Delta inflows were about the same for historical conditions and the No-Project Alternative. Table B1-3 in Appendix B1 gives monthly historical inflows and exports for 1968-1991.

Simulated Delta exports for some years under the No-Project Alternative were substantially greater than historical exports, and Delta outflows were therefore correspondingly reduced in the No-Project Alternative simulations. Assumed minimum Delta outflows required to satisfy 1995 WQCP objectives under the No-Project Alternative are simulated to be slightly higher than historical conditions for some months of some years.

Figure 3B-6 shows simulated monthly Delta outflow, combined DCC and Georgiana Slough diversions, and central Delta outflow (QWEST flow) for the No-Project Alternative and historical conditions. Monthly average No-Project Alternative flows differ from historical flows because of differences in Sacramento River inflow, DCC closure standards, and Delta exports. Table B1-4 in Appendix B1 gives the monthly historical channel flows simulated with the RMA model for 1968-1991.

Simulated Delta Channel Flows for the No-Project Alternative

As described under "Criteria for Determining Impact Significance", three Delta channel locations have been selected for analysis of Delta hydrodynamic effects of DW project operations. DW project operations would most directly modify channel flows in the San Joaquin River downstream of the DW islands (e.g., San Joaquin River flow near Antioch), in Threemile Slough (flow from the Sacramento River to the San Joaquin River), and in Old and Middle Rivers between the DW islands and the Delta export pumps. Table B1-10 in Appendix B1 gives the monthly channel flows simulated by the DeltaSOS model (based on RMA model results) at selected Delta locations for the No-Project Alternative for water years 1968-1991.

The patterns of simulated flows for the No-Project Alternative were somewhat different from those of simulated historical flows in the San Joaquin River at Antioch, Threemile Slough, and Old River at Woodward Canal, as shown in Figure 3B-7. The No-Project Alternative simulation assumed 1995 WQCP Delta objectives and existing Delta facilities and water supply demands applied to the 1922-1991 hydrologic record, as documented in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model".

Simulated flows for the lower San Joaquin River at Antioch were generally lower under the No-Project Alternative than under simulated 1967-1991 historical conditions by several thousand cubic feet per second. Antioch flows were lower in the No-Project Alternative simulation primarily because No-Project Alternative export levels are higher than historical export levels, although some changes in Sacramento River inflows and diversions through the DCC, Georgiana Slough, and Threemile Slough also modify simulated net flows past Antioch. Reverse flows were simulated at Antioch for only a few months during 1967-1991 for both historical conditions and the No-Project Alternative.

Simulated flows in Old River (and Middle River) were larger in the upstream (negative) flow direction toward the Delta export pumps for the No-Project Alternative simulation than for historical conditions (Figure 3B-7). Simulated flows in Old River at Woodward Canal were about 50% higher than flows in Middle River at Victoria Canal. In contrast, USGS measurements suggest that the two channels should have nearly equal flows. Because this discrepancy in the relative flows in Old and Middle Rivers does not change the tidal flows or the total net flow moving toward the export pumps, there are no likely effects on the impact assessments caused by this discrepancy. Periods of downstream (positive) flows in Old and Middle Rivers, resulting from San Joaquin River inflows in excess of total Delta export volumes, were simulated only rarely for the No-Project Alternative.

Simulated Delta Inflow Source Contributions for the No-Project Alternative

Simulated contributions from each Delta inflow source to the Delta export locations (CCWD Rock Slough intake and the SWP Banks and CVP Tracy Pumping Plants) are governed by Delta hydrodynamics. Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project", presents detailed RMA simulation results regarding inflow source contributions. These results were summarized as representative export source contributions in the DeltaDWQ assessment model.

As simulated by the RMA model and approximated in the DeltaDWQ assessment model, most Delta export water comes from the Sacramento River in most months (see Table B1-12 in Appendix B1). In some months with substantial San Joaquin River inflows, the source contribution from the San Joaquin River to Delta exports was dominant. During the irrigation season, the simulated contribution from Delta agricultural drainage to Delta exports was variable at about 5%-10% for the No-Project Alternative. During winter periods, the contribution from agricultural island drainage was generally 20%-25% or higher.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Under Alternative 1, water would be diverted for storage on Bacon Island and Webb Tract, and Bouldin Island and Holland Tract would be managed for wetlands and wildlife habitat under an HMP. Under this alternative, the maximum storage volume of the two reservoir islands would be approximately 238 TAF. Maximum storage may increase slightly over the life of the project because of subsidence on the reservoir islands.

Water would be diverted to the reservoir islands at a maximum monthly average diversion rate of 4,000 cfs, which would fill the two reservoir islands in one month. The maximum initial daily average diversion rate would be 9,000 cfs during several days when siphoning of water onto empty reservoir islands begins; at this time, the maximum head differential would exist between island bottoms and channel water surfaces. The maximum monthly average discharge rate is assumed to be 4,000 cfs, allowing the reservoir islands to empty in one month. The maximum initial daily average discharge rate would be 6,000 cfs.

Alternative 1 includes the assumption that DW discharge water is included in WQCP export pumping limits that depend on inflow. Under Alternative 1, discharges of water from the DW islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and the 1995 WQCP export limits do not prevent use of that capacity. Such unused capacity could exist when the amount of available water (i.e., total inflow less Delta outflow requirements) is less than the amount specified by the export limits.

Figures 2-2 and 2-3 in Chapter 2, "Delta Wetlands Project Alternatives", show the proposed locations for siphon stations and discharge pump stations on the two reservoir islands. Localized hydraulic effects of siphons (with screens) and discharges would occur near these locations.

Hydrodynamic Effects of Maximum DW Diversions and Discharges on Local Channel Velocities and Stages

For hydrodynamic simulations of maximum DW siphoning operations to fill storage reservoirs, Delta inflows and exports were specified to produce flows and velocities in Delta channels expected during a typical period of high Delta inflows when DW would divert water to storage.

The DW diversion rate would be limited to a maximum of 9,000 cfs. This diversion rate would decrease as Bacon Island and Webb Tract were filled and the siphon head differential decreased, as described in the next section.

The DW discharge rate would be limited to a maximum of 6,000 cfs and this discharge rate would decrease as the reservoir islands were emptied and the pumping head increased.

Likely hydrodynamic effects in the channels surrounding the DW project were evaluated relative to the net flows and tidal flows in the channels surrounding the DW project islands. The results of these local hydrodynamic comparisons are detailed in Appendix B1.

DW Reservoir Island Siphon Hydraulics

Each DW reservoir island would have two siphon stations, each with 16 siphons having a diameter of 2.8 feet. Booster pumps would be included for some siphons as required to fill the reservoir islands to the maximum surface elevation of 6 feet above sea level. The siphon stations are more fully described in Chapter 2, " Delta Wetlands Project Alternatives".

Siphon hydraulics are governed by the head difference between the tidal stage and reservoir surface elevation; the fixed head loss through the fish protection screens; and the hydraulic head losses caused by friction and turbulence, which increase with velocity. The effective siphon head difference will generate a velocity "head" and a friction "head" that can be computed as follows:

$$\text{siphon head (ft)} - \text{head loss (ft)} = (1 + f \times L/D) \times V^2/(2 \times g)$$

where:

f = friction factor of about 0.015,
L = length (240 feet),
D = diameter (2.8 feet) of the siphon, and
g = gravitational force (32 ft/sec^2).

The constant head loss is expected to be less than 0.5 foot.

As the tide varies (from approximately 0 to +4 feet), siphon flow will vary as the square root of the total effective head. The siphon flow will decrease as the reservoir island fills. Booster pumps would be inserted into about half the siphons on each reservoir island to maintain a minimum filling rate of between 2,000 cfs down to 1,000 cfs as the effective head decreases. The booster pumps are assumed to provide a constant "boost" to the effective siphon head of approximately 8 feet.

The simulated diversion filling pattern for the siphons relative to fluctuating tidal stage is shown in Figure 3B-8 for either of the reservoir islands, with an initial diversion rate of 4,500 cfs for the 32 siphons. After about 2 weeks of siphoning (producing storage of 80 TAF), booster pumps that provide an effective head boost of 8 feet are simulated for 16 of the siphons, maintaining a diversion rate of greater than 1,000 cfs for the remainder of the filling period, which lasts a total of approximately 4 weeks.

DW Reservoir Island Discharge Hydraulics

Each DW reservoir island would have a single discharge station with 32 (Webb Tract) or 40 (Bacon Island) discharge pumps and pipes, as described and shown in Appendix 2 , "Supplemental Description of the Delta Wetlands Project Alternatives". As Figure 2-5 in Appendix 2 indicates, the discharge facilities would include submerged discharge expansion chambers located approximately 5 feet below low tide elevation so the discharge culverts would remain submerged throughout the tidal cycle.

Each discharge pump would have a maximum flow rate of about 100 cfs. The pipe would have a diameter of 3 feet and an inside area of about 6 square feet, so that the maximum pipe velocity would be about 16.5 ft/sec (100 cfs/6 ft2 = 16.5 ft/sec). The expansion chamber, with a width of 10 feet and a depth of 3 feet, would reduce the maximum discharge velocity to about 3.3 ft/sec (100 cfs/30 ft2). The maximum velocity of discharges entering the adjacent channel would therefore be slightly greater than the assumed scour velocity threshold of 3.0 ft/sec. However, the discharge would be horizontal and would flow into the channel above the bottom. The discharge leaving the expansion chamber can be described as a turbulent plane jet having certain well-known characteristics (Fischer et al. 1979).

A turbulent jet discharge will spread out as it enters the channel by entraining ambient water from the sides and bottom of the jet. The velocity will remain highest along the center of the jet and will be lowest at the edges of the jet. The proposed discharge pipes would be separated by 25 feet, so there would be about 15 feet of ambient water between the discharge expansion chambers (each chamber is 10 feet wide). Turbulent plane jets are observed to spread out at a constant angle of approximately 7E. The discharge jets will be expected to spread and join each other at a distance of about 65 feet. At this distance, the jet flow will be about 250 cfs and the average jet velocity will be approximately 2.1 ft/sec (maintaining the same momentum flux). At this distance, the discharge velocity will be less than the scour velocity threshold of 3 ft/sec and will be comparable to maximum tidal velocities of 1-2 ft/sec (see tidal velocity discussions in Appendix B1).

The discharge facilities would be clearly identified with pilings to anchor and protect the discharge culverts. The relatively high discharge velocities would be confined to the nearshore area (50-100 feet from shore) of the channels that are several hundred feet wide. The effects of the DW discharges therefore are not expected to have any localized significant impacts on channel scouring or on boating safety. The allowable mixing zone for purposes of water quality monitoring may be determined by SWRCB in cooperation with regional board requirements for similar jet discharges into tidal waters.

Hydrodynamics during Maximum DW Diversions and Discharges

Hydrodynamic changes caused by maximum DW project diversions would not persist throughout an entire diversion period of several weeks. After the first few days of diversions, hydrodynamic effects would decrease as siphoning rates decreased during filling in response to decreasing head differential.

The maximum DW diversions would occur at four siphon stations with capacities of 2,250 cfs each. Two stations are on Bacon Island, one on Middle River and one on Old River. The other two stations are on Webb Tract, one on the San Joaquin River and the other on False River, adjacent to Franks Tract. Proposed DW project filling would cause greatest hydrodynamic changes in Delta channels adjacent to the DW project islands in the central Delta. The results of RMA model simulations for diversions adjacent to each DW island are described in Appendix B1.

Table B1-7 in Appendix B1 lists the net flows in each major Delta channel simulated for the typical diversion period, with and without the maximum initial daily average DW diversions of 9,000 cfs. Figure B1-45 shows the directions of these net flows in the major Delta channels in the absence of DW diversions.

Hydrodynamics in the channels surrounding the project islands were simulated with maximum initial daily average DW discharges to estimate maximum expected changes during DW project discharge operations for all project alternatives.

Table B1-8 in Appendix B1 lists the net flows in each major Delta channel simulated for the typical discharge period, with and without the maximum DW discharges of 6,000 cfs. Figure B1-48 in Appendix B1 shows the direction of these net flows in the major Delta channels.

Hydrodynamic simulation of channel flows, velocities, and stages during periods of maximum DW diversion and maximum DW discharges indicate that the channel stages most affected by DW operations would be those in the south Delta. Table B1-9 in Appendix B1 lists simulated channel stages during periods of maximum DW diversions and discharges. The results indicate that stages would not be substantially changed by DW operations. The minimum and maximum stages would be lowered in some channels by as much as 0.25 foot (3 inches). However, because these south Delta channels normally experience tidal fluctuations of more than 5 feet, this is not considered a substantial change (5%) for these south Delta channels. These simulations did not include DWR's proposed south Delta project barriers. These tidal gates are designed to help control minimum tidal stages in south Delta channels and may also reduce the potential effects of DW operations on channel stages.

Summary of Project Impacts and Recommended Mitigation Measures

Impact B-1: Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Diversions. The hydrodynamic simulation results for the maximum possible initial daily average DW diversion rate of 9,000 cfs under Alternative 1 indicate that maximum possible channel velocities and stages are within the range of conditions normally encountered during tidal fluctuations in the Delta channels surrounding the DW project islands. No hydrodynamic effects resulting from maximum diversions were identified as significant. Therefore, this possible hydrodynamic impact is considered less than significant.

Mitigation. No mitigation is required.

Impact B-2: Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Discharges. The hydrodynamic simulation results for the maximum possible initial daily average DW discharge rate of 6,000 cfs under Alternative 1 indicate that maximum possible channel velocities and stages are within the range of conditions normally encountered during tidal fluctuations in the Delta channels surrounding the DW project islands. No hydrodynamic effects resulting from maximum discharges were identified as significant. Therefore, this possible hydrodynamic impact is considered less than significant.

Mitigation. No mitigation is required.

Hydrodynamic Effects on Net Channel Flows

DW monthly diversion and discharge operations were simulated with DeltaSOS for the 1995 DEIR/EIS as reported in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives". Under Alternative 1, the simulated 70-year average annual operations consisted of 222 TAF/yr of diversions and 188 TAF/yr of discharge for export.

Table A3-7 in Appendix A3 shows results of simulated monthly DW operations for the 70-year 1922-1991 simulation period. Operations were simulated as diversions to storage (cfs), end-of-month storage volume (TAF), and discharges for export (cfs). Model simulations showed that diversions would generally occur early in a water year (October-February) and discharges of 2,000-4,000 cfs would generally occur during summer (June-August).

Table B1-11 (Appendix B1) shows simulated changes in channel flows for Alternative 1 compared with channel flows simulated for the No-Project Alternative at four selected Delta locations of concern for hydrodynamic effects for water years 1968-1991. This recent period includes a range of hydrologic conditions similar to those of the 1922-1991 period (Appendix A1). Outflow was reduced by the DW diversions in the simulations. San Joaquin River flows at Antioch were simulated to be reduced by about 70% of the DW diversions during the months when water was being diverted to fill the reservoir islands. Threemile Slough flows from the Sacramento River were increased by about 30% of the DW diversion flow. Simulated flows in the Old and Middle River channels toward the export pumps were each increased during months with DW discharges for export by approximately 50% of the DW discharges. The maximum net flows are not increased because these are controlled by the export capacity.

Summary of Project Impacts and Recommended Mitigation Measures

Impact B-3: Hydrodynamic Effects on Net Channel Flows. All simulated changes are well within the historical range of Delta channel flows at the locations selected for hydrodynamic impact assessment. The simulated flow changes would not result in significant hydrodynamic effects. Therefore, this possible hydrodynamic impact is considered less than significant.

Mitigation. No mitigation is required.

Effects on Inflow Source Contributions

Table B1-12 in Appendix B1 shows simulation results for inflow source contributions from the Sacramento and San Joaquin Rivers, Delta agricultural drainage, and the DW project islands to the representative Delta exports (CCWD Rock Slough intake and SWP Banks and CVP Tracy Pumping Plants) during 1968-1991 for the No-Project Alternative and the DW project alternatives. DW project discharges were simulated to contribute between about 15% and about 30% of the total amount of exported water. During months with substantial DW contributions, contributions from other inflow sources were reduced proportionately. No hydrodynamic impacts are associated with source contribution changes.

The potential water quality impacts resulting from these simulated DW discharge contributions at Delta export locations are evaluated in Chapter 3C, "Water Quality". The potential fishery effects of the increased pumping required to export DW discharges are evaluated in Chapter 3F.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Alternative 2 would have the same physical arrangement and operating capacities as Alternative 1. The diversion-period modeling assumptions for this alternative are the same as for Alternative 1. Under Alternative 2, it is assumed that discharges from the DW islands would be exported by the SWP and CVP pumps when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps. DW discharges would be allowed to be exported in any month when such capacity exists, without regard for the export limits (percentage of total Delta inflow). Under this alternative, it is assumed that export of DW discharges is limited by the WQCP Delta outflow requirements and the permitted combined pumping rate of the export pumps but is not subject to the 1995 WQCP "percent inflow" export limited.

The average monthly maximum diversion rate to storage on the reservoir islands under Alternative 2 would be 4,000 cfs; the maximum initial daily average diversion rate would be 9,000 cfs. The maximum monthly discharge rate is assumed to be 4,000 cfs, and the maximum discharge rate would be 6,000 cfs. Locations of siphon stations for project diversions and pumping stations for project discharges would be the same as those for Alternative 1, as shown in Chapter 2.

Under Alternative 2, DW discharge water would be allowed up to the permitted pumping capacity limits.

Hydrodynamic Effects of Maximum DW Diversions and Discharges on Local Channel Velocities and Stages

The analysis of effects of maximum diversions and discharges on local flow patterns for Alternative 2 would be identical to that described above for Alternative 1. The impacts of maximum DW diversions and discharges on local channel velocities and stages under Alternative 2 would be the same as under Alternative 1.

Hydrodynamic Effects on Net Channel Flows

Monthly operations for Alternative 2 were simulated with DeltaSOS for the 1995 DEIR/EIS as reported in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives". The 70-year average annual DW operations for Alternative 2 were simulated to be 225 TAF/yr of diversions and 202 TAF/yr of discharge for export.

Table A3-10 in Appendix A3 shows results of simulated monthly DW operations of Alternative 2 for 1922-1991. Diversions would generally occur during the early or middle part of a water year (October-March) and discharges would generally occur during the middle or late part of a year (February-March or June-August).

Detailed results of hydrodynamic simulation of Alternative 2 are presented in Appendix B1. Table B1-11 in Appendix B1 gives the simulated changes in channel flows for Alternative 2 compared with channel flows simulated for the No-Project Alternative. Outflow was reduced by the DW diversions. San Joaquin River flows at Antioch were simulated to be reduced by an amount equal to 70% of the DW diversions during months when water was diverted to the DW reservoir islands. Threemile Slough flows from the Sacramento River were increased by an amount equal to 30% of DW diversions. Simulated flows in the Old and Middle River channels were each increased toward the export pumps by about 50% of the DW discharges during months with DW discharges for export. The changes in these channel flows correspond with the periods of DW diversions and discharges.

The impact of Alternative 2 on net channel flows would be the same as described for Alternative 1.

Effects on Inflow Source Contributions

Table B1-12 in Appendix B1 shows results for simulated source contributions from DW discharges at the representative Delta export locations for Alternative 2. The DW discharges were simulated to contribute between 15% and 30% of the total amount of exported water. The changes in other source contributions caused by DW discharges are also given in Table B1-11. No hydrodynamic impacts are associated with these changes. The potential water quality impacts resulting from these simulated DW discharge contributions at Delta export locations are evaluated in Chapter 3C, "Water Quality". The potential fishery effects of the increased pumping required to export DW discharges are evaluated in Chapter 3F.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Under Alternative 3, water would be diverted for storage in reservoirs on all four DW project islands. A habitat reserve would be created on Bouldin Island north of State Route 12. Under this alternative, DW initial storage volume is assumed to be approximately 406 TAF; this volume may increase slightly over the life of the project.

The diversion-period modeling assumptions for this alternative are the same as for Alternatives 1 and 2. The discharge-period modeling assumptions for this alternative are the same as for Alternative 2 (permitted export pumping rate limits). Under Alternative 3, DW discharge water would be allowed up to the limits of the permitted export pumping rates.

The maximum average monthly diversion rate is assumed to be about 6,000 cfs, which would fill the four reservoir islands in about one month (maximum initial daily average diversion rate of 9,000 cfs). The maximum monthly average discharge rate is also assumed to be 6,000 cfs (maximum discharge rate of 12,000 cfs). Under Alternative 3, siphon and pump stations would be constructed on Bouldin Island and Holland Tract to support water storage operations on these islands (see Figures 2-10 and 2-11 in Chapter 2). Siphon and pump stations on Bacon Island and Webb Tract would be located as for Alternatives 1 and 2.

Likely DW monthly operations under Alternative 3 were simulated with DeltaSOS as reported in Appendix A3. The 70-year average annual DW operations for this alternative were simulated to be 356 TAF/yr of diversions and 302 TAF/yr of discharge for export.

Hydrodynamic Effects of Maximum DW Diversions and Discharges on Local Channel Velocities and Stages

The analysis of effects of maximum diversions and discharges on local flow patterns under Alternative 3 for Bacon Island and Webb Tract would be identical to that reported above for Alternative 1. Results of simulations of maximum diversions and discharges from Holland Tract and Bouldin Island under Alternative 3 were similar to results for Alternative 1. DW would divert water to Holland Tract from Old River and Franks Tract and would discharge from Holland Tract to Old River. DW would divert to Bouldin Island from Little Potato Slough and the Mokelumne River, and would discharge from Bouldin Island to Little Potato Slough.

Summary of Project Impacts and Recommended Mitigation Measures

Impact B-4: Hydrodynamic Effects on Local Velocities and Stages during Maximum DW Diversions. This impact is described above under Impact B-1. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact B-5: Hydrodynamic Effects on Local Velocities and Stages during Maximum DW Discharges. This impact is described above under Impact B-2. This impact is considered less than significant.

Mitigation. No mitigation is required.

Hydrodynamic Effects on Net Channel Flows

Table A3-13 in Appendix A3 shows the results of monthly simulated DW operations under Alternative 3 for 1922-1991. Model simulations show that diversions of 2,000-6,000 cfs would generally occur early in a water year (October-February) and discharges of 2,000-6,000 cfs would generally occur during the middle part (February-March) or late part (June-August) of a water year.

The DW project was simulated to have only limited operations in several years because of limited availability of water for diversions. The simulations showed the additional DW water storage capacity on four reservoir islands (406 TAF) used in most years when water was available, but water available for diversion limited the DW storage to less than the maximum capacity in some years.

Detailed results of hydrodynamic simulation of Alternative 3 are presented in Appendix B1. Table B1-11 in Appendix B1 shows monthly simulated changes in channel flows for Alternative 3 compared with channel flows simulated for the No-Project Alternative. Outflow was reduced by an amount equivalent to the DW diversions. Simulated San Joaquin River flows at Antioch were reduced by 70% of DW diversions during months when water was diverted to fill the four reservoir islands. Simulated flows in Old and Middle River channels south of Bacon Island toward the export locations were each increased by about 50% of DW discharges during months with DW discharges for export. The changes in these channel flows correspond with the periods of DW diversions and discharges.

Summary of Project Impacts and Recommended Mitigation Measures

Impact B-6: Hydrodynamic Effects on Net Channel Flows. This impact is described above under Impact B-3. The simulated changes between the No-Project Alternative and Alternative 3 are considered less-than-significant effects because they are well within the historical range of Delta channel flows at these locations.

Mitigation. No mitigation is required.

Effects on Inflow Source Contributions

Table B1-12 in Appendix B1 shows the monthly simulated source contributions from DW discharges in the representative Delta exports for Alternative 3. Because of higher discharge capacity, DW discharges were simulated to contribute between 15% and 40% of the total exported water. The changes in other source contributions caused by DW discharges are also given in Table B1-12. No hydrodynamic impacts are associated with these changes. The potential water quality impacts from these simulated DW discharge contributions at Delta export locations are evaluated in Chapter 3C, "Water Quality".

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The No-Project Alternative (intensified agricultural use of the four DW project islands) represents Delta water supply conditions predicted under the 1995 WQCP objectives. Consumptive use of water to supply crop ET would likely be somewhat greater under No-Project Alternative intensified agriculture conditions compared with existing agricultural land uses, but not measurably so at the scale of monthly Delta water supply modeling (e.g., DWRSIM or DeltaSOS).

The DeltaSOS simulation results for the No-Project Alternative under the 1995 WQCP were described above under "Impact Assessment Methodology". The No-Project Alternative as simulated by DeltaSOS would not cause adverse hydrodynamic effects relative to existing conditions as of 1989.

CUMULATIVE IMPACTS

Cumulative hydrodynamic impacts were assessed qualitatively without specific simulations using the RMA Delta hydrodynamic model. As described in Chapter 3A, the cumulative water supply impacts of the proposed DW project were evaluated with the same set of WQCP Delta standards, but assuming SWP pumping permitted at full capacity at Banks Pumping Plant (10,300 cfs).

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. DW project effects on hydrodynamic conditions are inextricably tied to past and present hydraulic modifications that have been made in the Delta for various beneficial purposes, such as levee construction for land reclamation and flood control; channel dredging for navigation and levee maintenance; channel enlargement and deepening for navigation; operation of diversion pumps, siphons, and drainage pumps; and construction of export pumping plants (CVP Tracy Pumping Plant, SWP Clifton Court and Banks Pumping Plant) and associated facilities for water management (i.e., the DCC and the Suisun Marsh salinity control gate).

The cumulative effects of the DW alternatives therefore were evaluated in conjunction with past and present actions in the previous sections, which assumed the existing arrangement of Delta channels and continued operation of existing Delta hydraulic facilities and diversions. The focus of this section is on the evaluation of impacts of the DW project alternatives added to impacts of other future projects. This cumulative impact evaluation is based on the following scenario: increased upstream demands; increased demands south of the Delta; an increased permitted pumping rate at the SWP Banks Pumping Plant (see Chapter 3A, "Water Supply and Water Project Operations"); implementation of DWR's South Delta and North Delta Programs; additional storage south of the Delta in Kern Water Bank, Los Banos Grandes Reservoir, Metropolitan Water District of Southern California's (MWD's) Diamond Valley Reservoir and Arvin-Edison projects, and CCWD's Los Vaqueros Reservoir.

Future activities in the Delta will include continued maintenance of existing channels (dredging) and levees (placement of riprap and other reinforcement measures). New facilities (e.g., channel gates and barriers) may be constructed, and existing channels may be modified for navigation or for increased water conveyance (e.g., DWR North and South Delta Programs). Some existing agricultural lands may be converted to urban development or to wetlands and other wildlife habitat uses, changing the water diversion and discharge patterns for these lands.

Cumulative Impacts, Including Impacts of Alternative 1

The DeltaSOS simulations of Alternative 1 under cumulative future conditions are summarized in the cumulative impact section of Chapter 3A and are described in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives". Alternative 1 would be operated in fewer years under cumulative conditions than under existing conditions because of limited availability of water for DW diversions. Because of greater assumed export pumping capacity, however, greater DW diversions for export were simulated in several of the years.

Impact B-7: Cumulative Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Diversions. Because the basic tidal hydraulics that control local channel velocities and stages are not expected to change substantially under cumulative future conditions, possible hydrodynamic impacts of Alternative 1 during maximum DW diversions under cumulative future conditions are expected to be similar to those described above for Impact B-1. This cumulative impact is considered less than significant.

Mitigation. No mitigation is required.

Impact B-8: Cumulative Hydrodynamic Effects on Local Channel Velocities and Stages during Maximum DW Discharges. Because the basic tidal hydraulics that control local channel velocities and stages are not expected to change substantially under cumulative future conditions, possible hydrodynamic impacts of Alternative 1 during maximum DW discharges under cumulative future conditions are expected to be similar to those described above for Impact B-2. This cumulative impact is considered less than significant.

Mitigation. No mitigation is required.

Impact B-9: Cumulative Hydrodynamic Effects on Net Channel Flows. Under future conditions, the full physical capacity (10,300 cfs) at SWP Banks Pumping Plant was assumed in the DeltaSOS simulations (see Appendix A3). Use of full capacity at the Banks Pumping Plant may require implementation of DWR's South Delta Project to provide sufficient channel conveyance and Clifton Court diversion capacity, to protect agricultural diversion siphons and pumps at low tidal stages, and to maintain water quality that is sufficient for south Delta irrigation uses. This may allow flows in the Old River and Middle River channels during periods of maximum Delta exports that are higher than historical flows . DW discharges would contribute to these channel flows during periods with available water for diversion and during periods with available export pumping capacity for DW discharges.

Pumping at full SWP capacity would increase, by about 3,620 cfs (6,680 cfs to 10,300 cfs), the total export capacity of the SWP pumps. Because the Old River and Middle River channels each carry about half of the export flow (not supplied by diversion from the San Joaquin River at the head of Old River), the increased assumed pumping rate under cumulative conditions would be expected to increase the maximum net flow in the Old and Middle River channels by about 1,800 cfs each. However, because tidal flows in these channels are substantial under No-Project Alternative conditions (see Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project"), these channels (with modifications included in the DWR South Delta Project) are expected to provide sufficient flow conveyance for maximum export pumping without any hydrodynamic impacts from channel scouring or other hydraulic effects (i.e., navigation or recreation effects).

Nevertheless, because the possible hydrodynamic effects of DW project operations on south Delta channels under cumulative future conditions is uncertain at this time, this cumulative hydrodynamic impact is considered significant. Implementing Mitigation Measure B-1 would reduce Impact B-9 to less-than-significant level.

Mitigation Measure B-1: Operate the DW Project to Prevent Unacceptable Hydrodynamic Effects in the Middle River and Old River Channels during Flows That Are Higher Than Historical Flows. USGS and DWR tidal flow measurements (i.e., velocities and stages) in south Delta channels, as well as tidal hydrodynamic model simulations, should be used to determine the effects of DW operations, and DW operations should be controlled to prevent unacceptable hydrodynamic conditions in south Delta channels. Measures that may be used to prevent unacceptable hydrodynamic effects include establishing minimum tidal stages and maximum channel velocities. DW operations would be reduced or eliminated during these extreme tidal conditions.

Cumulative Impacts, Including Impacts of Alternative 2

Cumulative hydrodynamic conditions in the south Delta for Alternative 2 would be the same as described for Alternative 1. The DeltaSOS simulations of operations of Alternative 2 under cumulative future conditions are summarized in the cumulative impact section of Chapter 3A and are described in Appendix A3. Alternative 2 would be operated in fewer years under cumulative conditions than under existing conditions because of limited availability of water for DW diversions. Because of greater assumed export pumping capacity, however, greater DW exports were simulated in several of the years. The cumulative impacts and mitigation measure are the same as described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

Cumulative hydrodynamic conditions in the south Delta for Alternative 3 would be the same as described for Alternative 1. The DeltaSOS simulations of operations of Alternative 3 under cumulative future conditions are summarized in the cumulative impact section of Chapter 3A and are described in Appendix A3. Alternative 3 would be operated in fewer years, or with reduced diversions, under cumulative conditions in comparison with existing conditions because of limited availability of water for DW diversions. Because of greater assumed export pumping capacity, however, greater DW exports were simulated in several of the years. The cumulative impacts and mitigation measure are the same as described for Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

The No-Project Alternative, as simulated by DeltaSOS under cumulative conditions, would not cause adverse Delta hydrodynamic effects.

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Table 3B-1. Available Information for Describing Historical Delta Conditions

1. DAYFLOW, DWR's database for historical daily Delta flows

	Item	Source
A.	Sacramento River	USGS measurements
B.	San Joaquin River	USGS measurements
C.	Eastside streams (Mokelumne, Calaveras, Cosumnes Rivers)	USGS measurements
D.	Yolo Bypass	DWR estimates
E.	Delta exports	CVP, SWP, CCWD records
F.	Channel depletion	DWR estimates
G.	Delta outflow	DWR estimates
H.	DCC and Georgiana Slough	DWR estimates
I.	QWEST	DWR estimates

2. RMA-simulated monthly average net channel flows, based on monthly average DAYFLOW inflows, exports, and channel depletions

   A. Old River diversions
   B. Sutter Slough and Steamboat Slough diversions
   C. DCC and Georgiana Slough flow (monthly DCC operations)
   D. Threemile Slough flow
   E. Jersey Point flow
   F. Antioch flow
   G. Chipps Island flow
   H. Old River and Middle River flow (at Bacon Island)

Table 3B-2. Preliminary Model Calibration and Confirmation Tasks for Assessment of Impacts of the Delta Wetlands Project on Delta Hydrodynamics

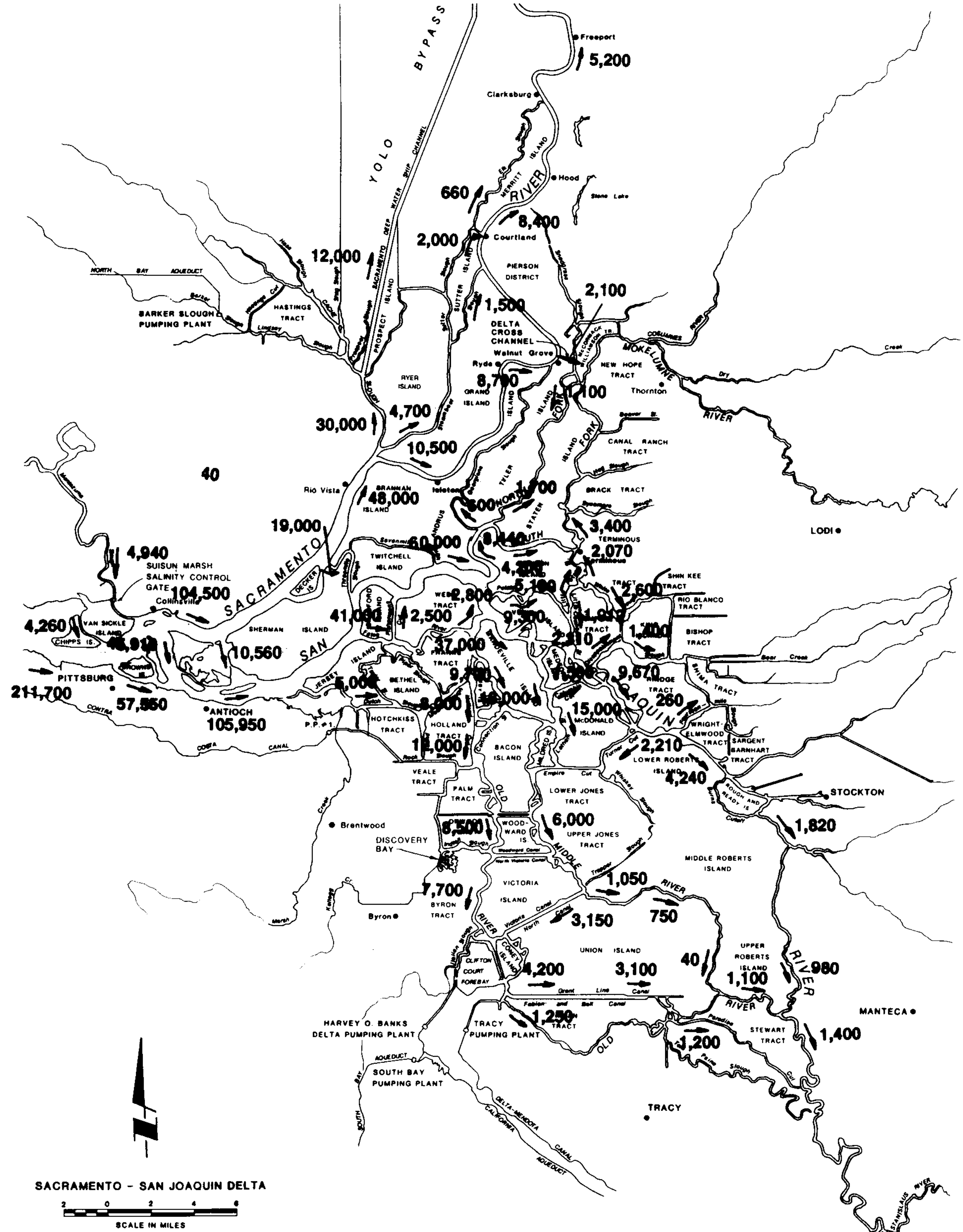
Data	Model	Analysis	Results
Tidal stage for July 1979 at 12 Delta locations	RMA Delta hydrodynamic model	Tidal stage calibration of hydraulic roughness coefficients	Smith and Durbin (1989); Appendix B1
Average tide at Benicia	RMA Delta hydrodynamic model	Simulation of typical Delta tidal hydraulics (stages, flows, and velocities)	Chapter 3B; Appendix B1
Historical Delta inflows and exports for 1972, 1976, and 1978	RMA Delta hydrodynamic model and RMA Delta water quality model	Calibration with daily EC measurements at 19 Delta locations	Smith and Durbin (1989)
Historical monthly average Delta inflows and exports for 1967-1991 (from DAYFLOW)	RMA Delta hydrodynamic model	# Simulated historical Delta channel flows # Estimated channel flow split relationships for the DeltaSOS model	Appendix B1; Chapter 3B Appendix B1; Appendix A3; Chapter 3B
Historical monthly average Delta flows and EC data at 12 locations (Reclamation and DWR)	RMA Delta hydrodynamic model and RMA Delta water quality model (EC data used to confirm hydrodynamic results)	# Confirmation of simulated monthly historical EC patterns # Estimated channel EC relationships with Delta outflow and exports for the DeltaDWQ model	Appendix B2; Chapter 3C Appendix B2; Chapter 3C

Table 3B-3. Modeling Tasks for Assessment of Impacts of the Delta Wetlands Project on Delta Hydrodynamics

Data	Model	Analysis	Results
1922-1991 DWRSIM estimates of Delta inflows and exports	DeltaSOS	Delta inflows and exports for the No-Project Alternative, cumulative No-Project Alternative, and DW alternatives	Chapter 3A; Appendices A1 and A3
Representative Delta inflows and exports for maximum DW diversions and maximum DW discharges	RMA Delta hydrodynamic model	Simulated Delta channel tidal flows and velocities	Chapter 3B; Appendix B1
Simulated Delta inflows and exports for the No-Project Alternative and DW operations for each DW alternative	DeltaSOS	Simulated monthly Delta net channel flows	Chapter 3B; Appendix B1

Table 3B-4. Impact Variables Selected for Assessment of Effects of Delta Wetlands Project Operations on Delta Hydrodynamics

Response Variable	Method of Analysis and Assessment	Locations for Assessment	EIR/EIS Chapter
Local channel velocities and stages	RMA model for maximum diversion and discharge	Channels adjacent to DW islands	3B
Delta export	70-year simulation of export using DeltaSOS	CCWD Rock Slough SWP Banks Pumping Plant CVP Tracy Pumping Plant	3A
Delta outflow	70-year simulation of outflow using DeltaSOS	Chipps Island/Collinsville	3C and 3F
Delta channel flow	70-year simulations using DeltaSOS	San Joaquin River at Antioch Threemile Slough Old River at Woodward Canal	3B



Source: Adapted from California Department of Water Resources 1993.

Jones & Stokes

Figure 3B-1
Average Flood Tide Flows (cfs) Simulated by the RMA Delta Model

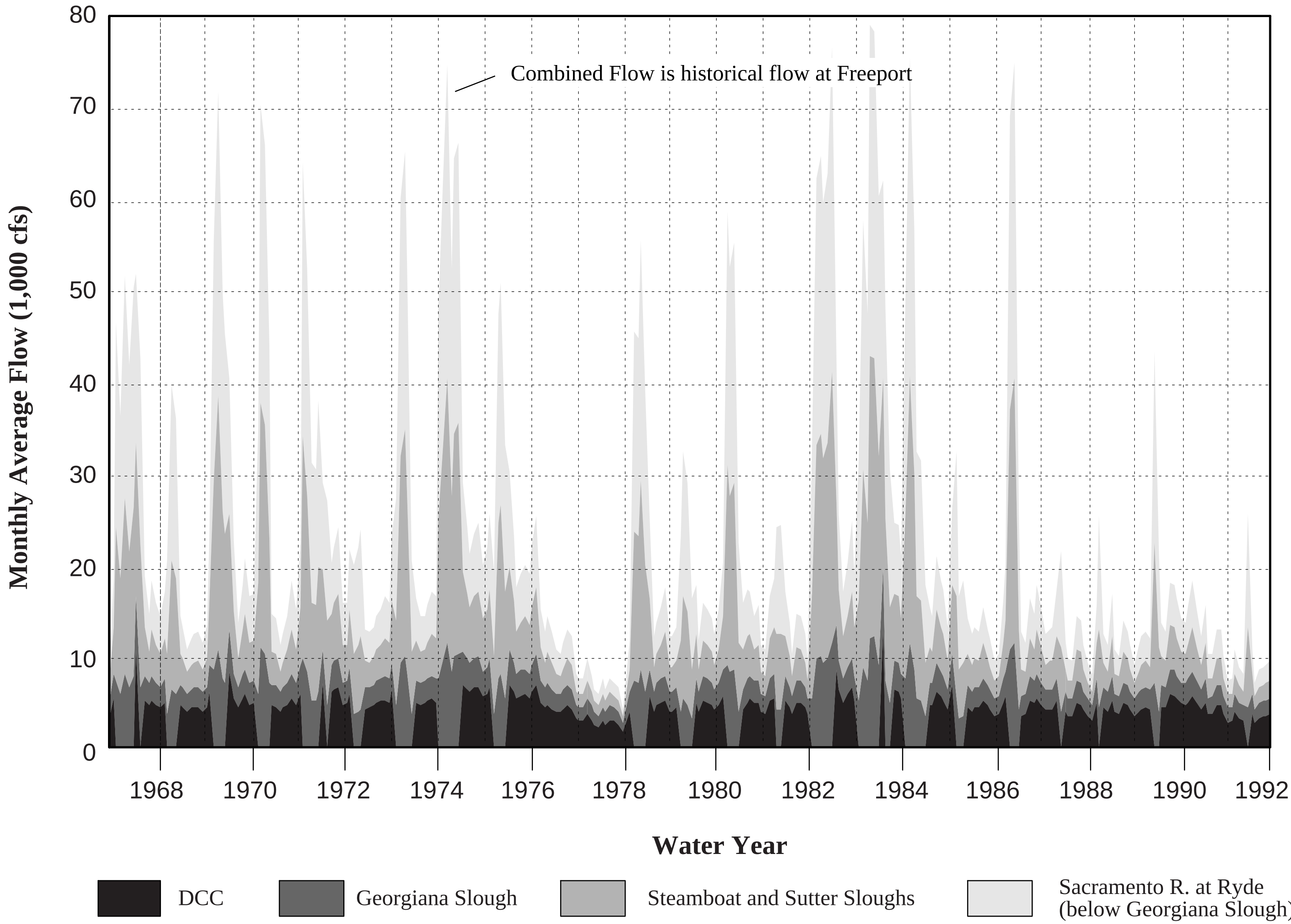


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Figure 3B-2
Monthly Average Historical Sacramento River Flow and Simulated Diversions to Steamboat and Sutter Sloughs, the DCC, and Georgiana Slough for 1967-1991

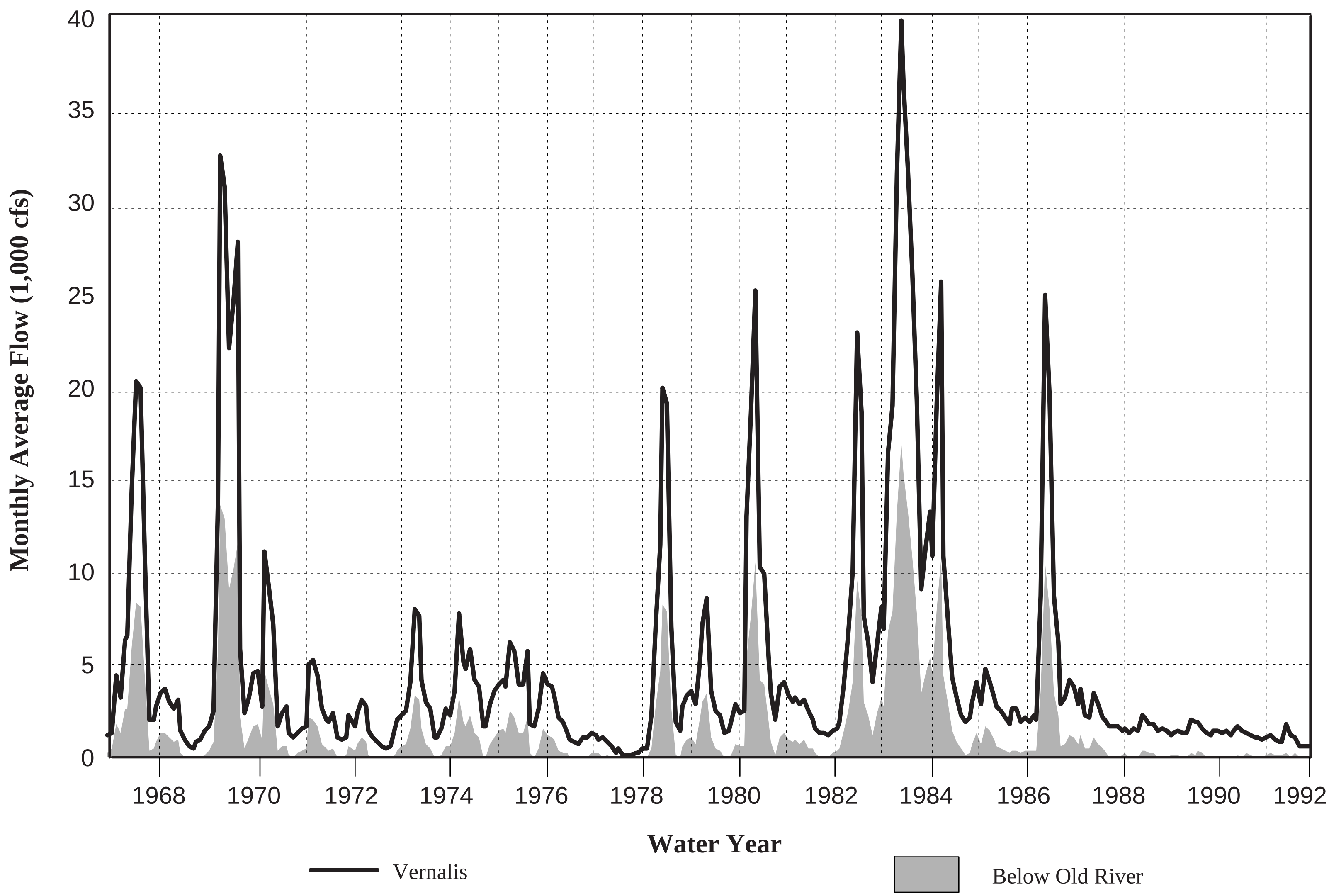

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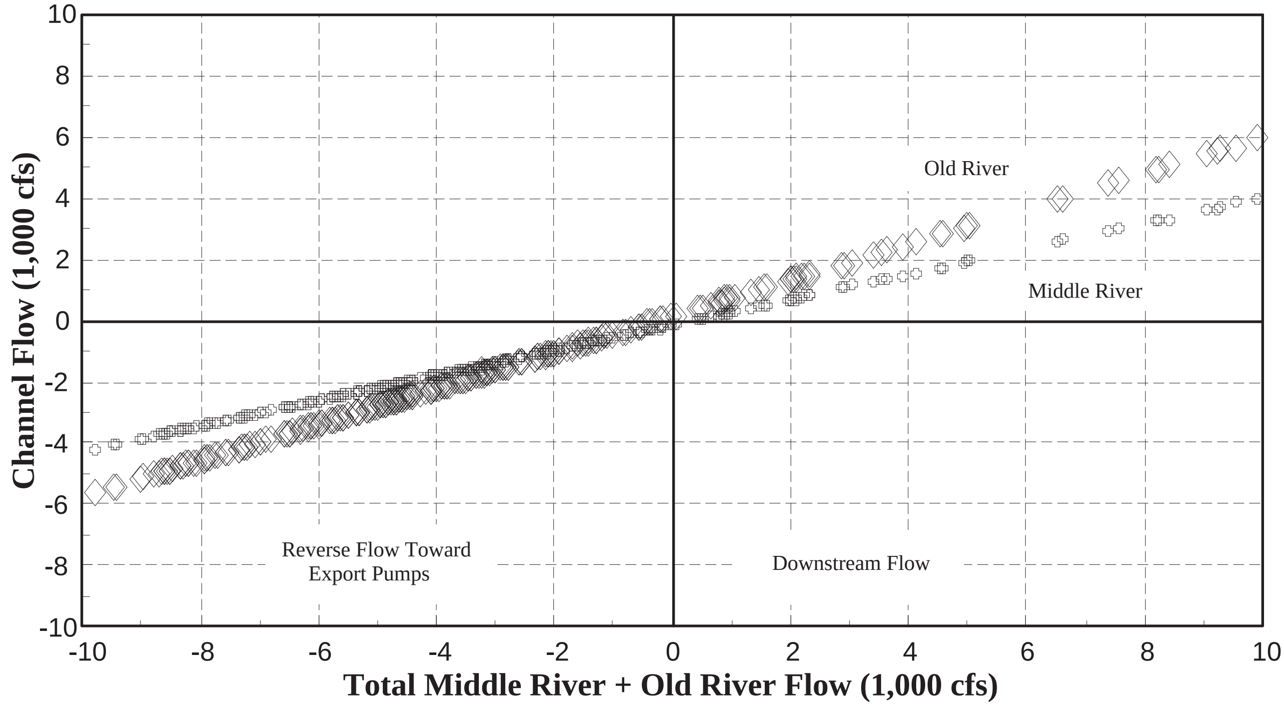
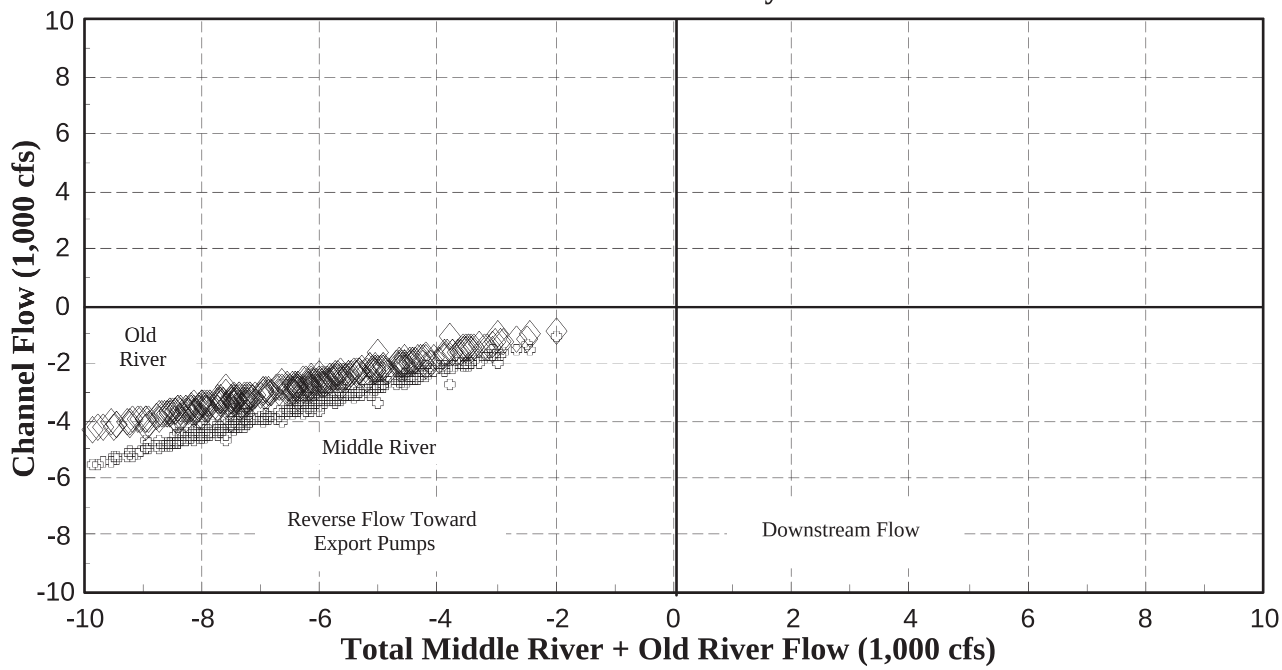
Figure 3B-3
Monthly Average Historical San Joaquin River Flow at Vernalis and Simulated Flow Downstream of the Head of Old River for 1967-1991

A. Simulated Monthly (1967-1991) Net Flows from the RMA Delta Model



B. USGS-Measured Daily Net Flows



Source: 1990-1991 UVM data, USGS

Figure 3B-4
Comparison of Simulated and Measured Old River and Middle River Channel Flows at Bacon Island Ultrasonic Velocity Meter (UVM) Stations

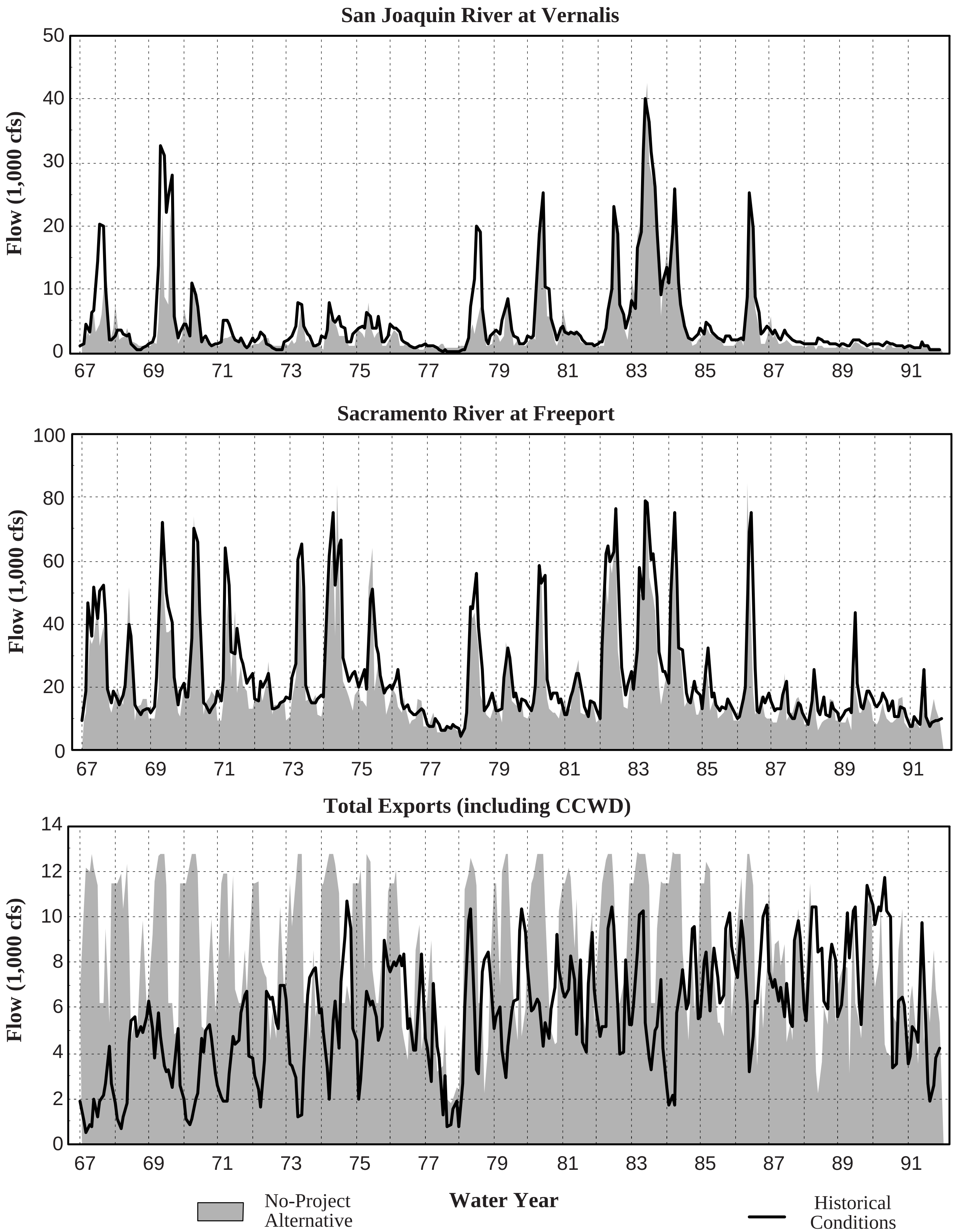


Figure 3B-5
Simulated Monthly Average Delta Channel Flows for the No-Project Alternative and measured Historical Conditions for 1967-1991

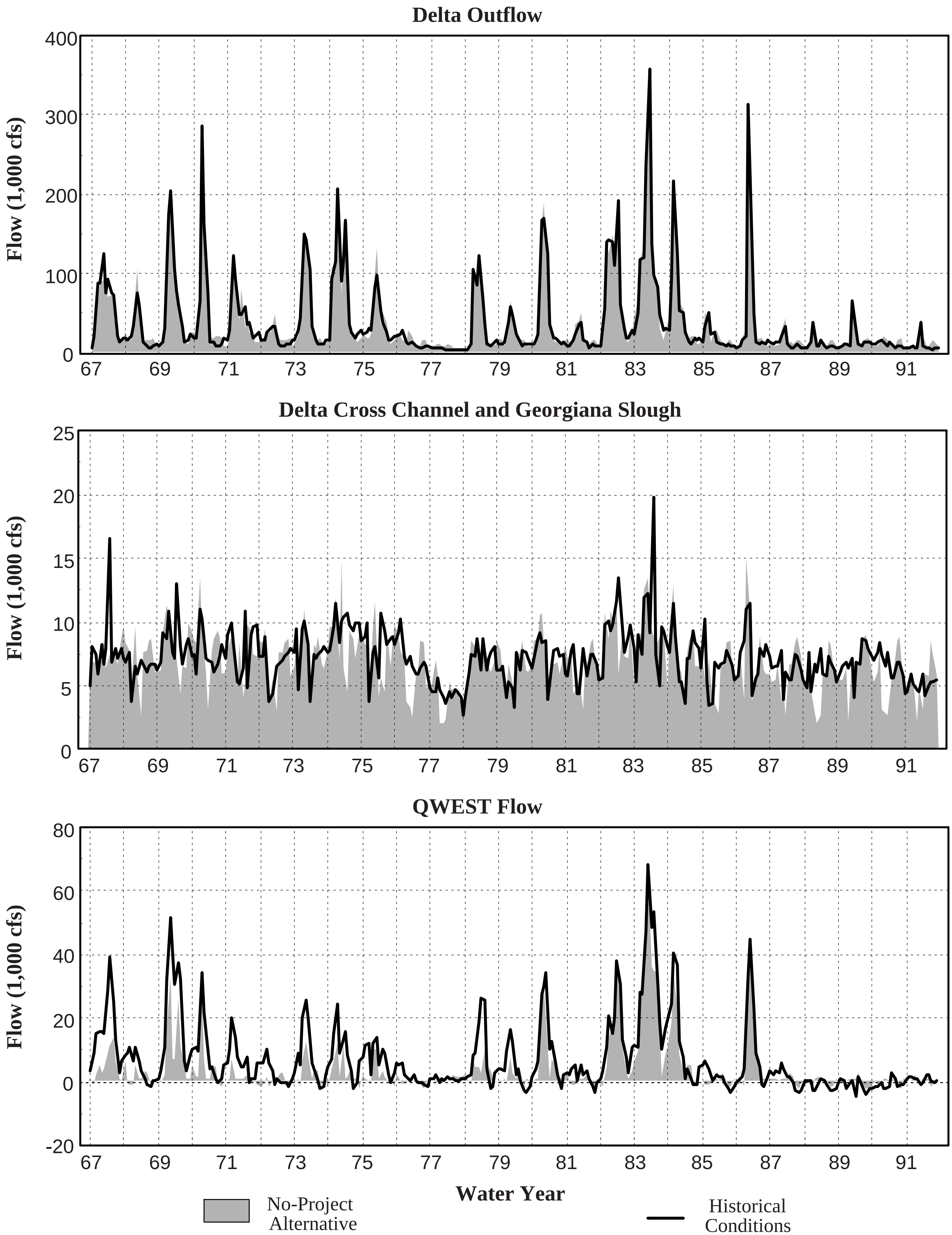


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Figure 3B-6
Simulated Monthly Average Delta Outflow, Channel Flows, and QWEST Flow for the No-Project Alternative and Simulated Historical Conditions for 1967-1991

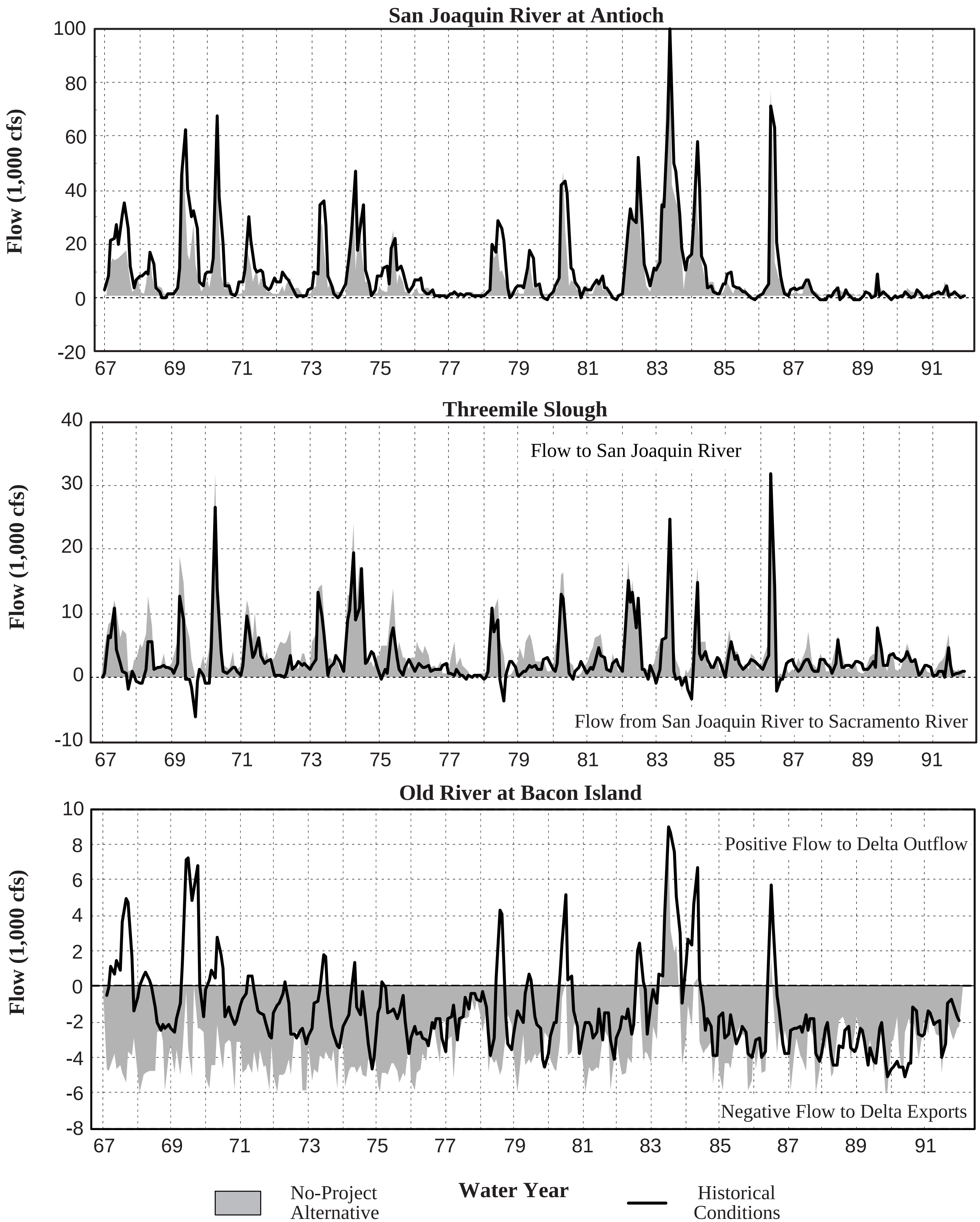

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Figure 3B-7
Simulated Monthly Average Flows in Selected Delta Channels for the No-Project Alternative and Simulated Historical Conditions for 1967-1991

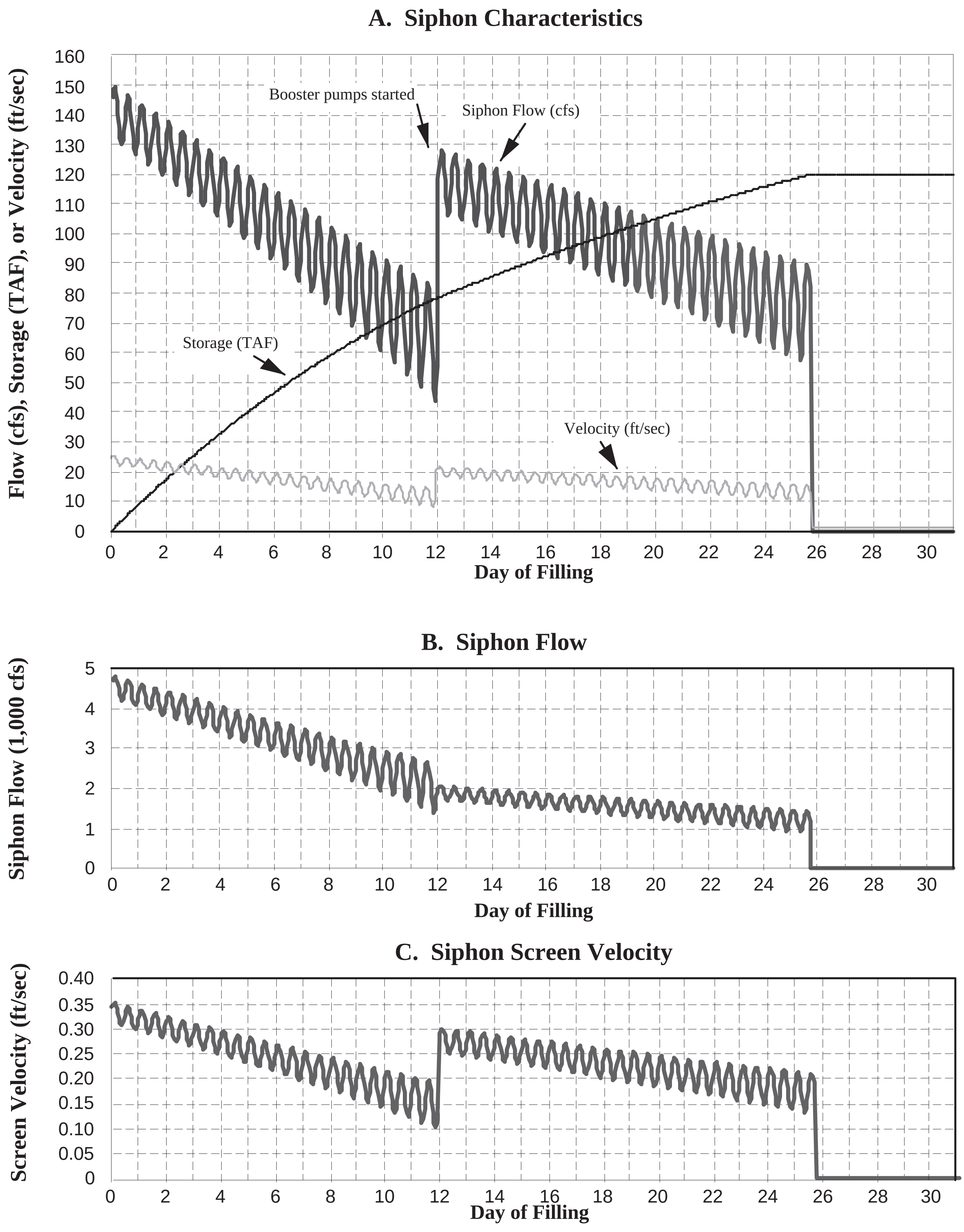

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Figure 3B-8
Simulated Flow Characteristics at a Typical DW Siphon Station during Reservoir Island Filling with Total of 16 36-inch Siphons and 16 36-inch Siphons with Booster Pumps

Chapter 3C. Affected Environment and Environmental Consequences - Water Quality

Chapter 3C. Affected Environment and Environmental Consequences - Water Quality

SUMMARY

The maintenance of beneficial uses of Delta waters depends on the levels of several key water quality variables (constituent concentrations and other water quality characteristics, such as temperature) in Delta waters. This chapter describes those key water quality variables, objectives associated with maintaining beneficial uses of Delta waters, existing Delta water quality conditions, and impacts of the DW project on levels of key variables in Delta channels and exports. Information is also presented on estimated historical Delta water quality conditions to provide a context for assessing water quality effects of the No-Project Alternative.

Diverting water onto the DW project islands would reduce Delta outflows and could increase salinity in Delta channels or exports. Discharges from the DW project islands could contribute to changes in concentrations of water quality constituents and other variables in Delta channel receiving waters and Delta exports. Variables that could be adversely affected are salinity, concentrations of dissolved organic carbon (DOC), temperature, suspended sediments (SS), dissolved oxygen (DO), and chlorophyll. Increases in DOC and salinity could indirectly increase trihalomethanes (THMs) in treated drinking water supplies that are exported from the Delta. Also of concern are pollutants that may remain in some DW island soils as a result of past agricultural and waste disposal activities; if pollutants are present, they could contaminate stored water that is later discharged into Delta channels.

Water quality impacts of salinity increases were assessed for Chipps Islands, Emmaton, Jersey Point, and Delta exports (representative of diversions at CCWD Rock Slough intake and SWP Banks and CVP Tracy Pumping Plants). Water quality impacts of increases in DOC and resulting THM concentrations were assessed for Delta exports. Impacts of other variables and potential water pollutants in island soils were assessed qualitatively because quantitative models for these variables are not presently available.

The 1995 DEIR/EIS analysis found that DW project diversions under Alternative 1, 2, or 3 could result in significant salinity increases at Chipps Island, Emmaton, and Jersey Point and in Delta exports during periods of low Delta outflow. However, the 2000 REIR/EIS analysis found that as a result of incorporation of the FOC terms into proposed project operations (Alternatives 1 and 2), estimated salinity effects at Chipps Island and in Delta exports would be less than significant. All other salinity impacts would be reduced to less-than-significant levels through adjustments made to DW project diversions based on salinity estimates at these locations with and without DW project diversions. DW project discharges under Alternative 1, 2, or 3 could result in significant elevations of DOC concentrations in Delta exports and elevations of THM concentrations in treated drinking water. These impacts would be reduced to less-than-significant levels through adjustments of DW project discharges based on measurements of DOC and bromide (Br^-) in stored water during intended discharge periods and monitoring of channel receiving waters.

DW project discharges under Alternative 1, 2, or 3 could also result in significant changes in other water quality variables (temperature, SS, DO, and chlorophyll) in Delta channel receiving waters. This impact would be reduced to a less-than-significant level through adjustments of DW project discharges based on measurements of these variables in stored water during intended discharge periods and monitoring in channel receiving waters. Potential contamination of stored water by pollutant residues under Alternative 1, 2, or 3 would also be a significant impact. This impact would be reduced to a less-than-significant level through assessment and necessary remediation of soil contamination prior to project implementation to eliminate sources of potential contamination.

Water quality impacts under cumulative conditions would be similar to the direct and indirect impacts described above for Alternatives 1, 2, and 3. Additionally, use of the recreation facilities constructed on the DW project islands would contribute to pollutant loading in the Delta from regional boating activities. The potential increase in pollutant loading from the DW project facilities and boating activities under Alternative 1, 2, or 3, in combination with other boating facilities in the Delta, is considered a significant and unavoidable cumulative impact.

Implementation of the No-Project Alternative would not result in measurable water quality effects relative to existing conditions.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The analysis of DW project effects on water quality was updated in the 2000 REIR/EIS. The revised analysis provides new simulation results of project effects on salinity, DOC, and THMs. The new results are based on updated simulations of project operations (see Chapter 3A) and incorporation of new information on DOC loading and THM formation. This chapter includes the 1995 DEIR/EIS analysis of project effects on water quality followed by the 2000 REIR/EIS analysis. Additionally, minor changes were made in response to comments received on the 1995 DEIR/EIS and 2000 REIR/EIS.

INTRODUCTION

This chapter assesses the potential impacts of the DW project alternatives on:

levels of Delta water quality variables for which Delta objectives have been established (i.e., salinity),

levels of other water quality variables that could affect beneficial uses of the Delta, and

Delta export concentrations of constituents associated with the quality of water treated for municipal use.

Some issues related to this water quality assessment are discussed more fully in other chapters. Chapter 3A, "Water Supply and Water Project Operations", discusses issues related to effects of DW project operations on water supply available for export by the CVP and the SWP. Chapter 3B, "Hydrodynamics", discusses potential DW project effects on local and net channel flows. Chapter 3F, "Fishery Resources", discusses potential localized and general fish habitat changes resulting from DW project operations and project-related changes in outflow and export.

The DW reservoir islands may be used for water banking or for storage and discharge of water being transferred through the Delta by other entities. The frequency and magnitude of these uses is uncertain at this time, and impacts related to these uses would have to be analyzed separately. However, the analytical tools described in this chapter could also be used to analyze the effects of these uses.

The discussion of water quality in this chapter includes several terms that may not be familiar to all readers. The following are definitions of key terms as they are used in this document:

Delta standards. A general term referring to all applicable water quality objectives; flow requirements; and other restrictions on diversions, exports, channel flows, or gate operations.

Historical conditions. The combination of measured inflows and exports, estimated channel depletion and Delta outflow, simulated channel flows, and measured or simulated EC and other water quality variables.

Mixing zone. A localized region surrounding a discharge pipe (or diffuser) that is used for initial mixing and dilution of a discharge with the channel water.

Entrapment zone. An area or zone of the Bay-Delta estuary where riverine current

meets upstream-flowing estuarine currents and variations in flow interact with particle settling to trap particles. The entrapment zone generally corresponds to a surface salinity (EC) range of 2-10 mS/cm specific conductance (Kimmerer 1992).

Additional terms are defined below in the section from the 2000 REIR/EIS entitled "Definition of Terms".

AFFECTED ENVIRONMENT

Delta waters serve several beneficial uses, each of which has water quality requirements and concerns associated with it. The Delta is a major habitat area for important species of fish and aquatic organisms, as well as a source of water for municipal, agricultural, recreational, and industrial uses. Dominant water quality variables that influence habitat and food-web relationships in the Delta are temperature, salinity, SS (and associated light levels), DO, pH, nutrients (nitrogen and phosphorus), DOC, and chlorophyll. Other key constituents that are monitored in water for municipal use are Br^- concentrations (measured in raw water) and concentrations of THMs formed in the disinfection of water (measured in treated water). Also of concern in this water quality assessment are pollutants that may remain in some DW island soils as a result of past agricultural and waste disposal activities. If such pollutants are present, they may contaminate stored water that is later released into Delta channels.

Sources of Information

Water Quality Appendices

This chapter is supported by a series of technical appendices that provide an evaluation of available Delta water quality data and document methods and results of impact assessment models used in this discussion. Following are descriptions of the information presented in these water quality appendices:

- Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project", describes the available Delta salinity (EC) data and the results of the RMA Delta hydrodynamic and water quality modeling of Delta salinity conditions for the 1995 DEIR/EIS.

- Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data", describes the water quality data for Delta inflows and exports (from DWR's Municipal Water Quality Investigations [MWQI] program) available at the time that the 1995 DEIR/EIS was prepared and discusses the likely loading (sources) of salt and DOC in the Delta. (The MWQI program is described below.)

- Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data", describes the water quality data for Delta agricultural drainage (MWQI) available at the time that the 1995 DEIR/EIS was prepared, and discusses the likely loading (sources) of salt and DOC from agricultural practices in the Delta.

- Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project", describes several water quality experiments that were conducted to identify the likely loading (sources) of salt and DOC from wetlands in the Delta, including contributions from vegetative decay and peat soil oxidation.

- Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model", describes the DeltaDWQ water quality assessment model, which was used to evaluate possible effects of DW project operations on DOC and salinity in Delta exports for the 1995 DEIR/EIS.

- Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water", describes the WTP model, which was used in the 1995 DEIR/EIS to evaluate possible effects of DW project operations on THM concentrations in treated drinking water from a typical water treatment plant.

- Appendix C6, "Assessment of Potential Water Contaminants on the Delta Wetlands Project Islands", describes the sampling of DW islands soils to identify possible sources of contamination from previous agricultural activities on the DW islands and discusses potential sources of water quality degradation related to recreational boating and facilities.

- # Appendix G from the 2000 REIR/EIS, "Water Quality Assessment Methods", describes the assessment methods used to characterize existing water quality conditions and to analyze the potential effects of DW project operations on water quality for the 2000 REIR/EIS.

The results and conclusions from these technical water quality appendices are described below under "Impact Assessment Methodology". Details and additional information about these water quality issues can be found in the appendices. All data and model results in this chapter and the appendices are presented for water years rather than calendar years (i.e., beginning in October of the previous calendar year and ending in September of the specified year).

Agency Water Quality Sampling Programs in the Delta

State and federal agencies have conducted various ongoing water quality sampling programs in the Delta. The following sections review studies that provided data on key water quality variables used for impact assessment of the DW project alternatives in the 1995 DEIR/EIS.

Interagency Ecological Program of the Sacramento-San Joaquin Estuary. The Interagency Ecological Program (IEP), previously the Interagency Ecological Study Program (IESP), was initiated in 1970 by DWR, DFG, Reclamation, and USFWS to provide information about the effects of CVP and SWP exports on fish and wildlife in the Bay-Delta estuary. Other agencies (e.g., SWRCB, EPA, the Corps, and USGS) have joined IEP and provide staff members and funding to assist in obtaining biological, chemical, and hydrodynamic information about the Bay and Delta.

The fishery and water quality components of IEP were combined in 1985 to better coordinate investigations of the Delta food web (Brown 1987). Further reorganization of IEP occurred in 1993. Fishery components of IEP were initially designed to document habitat requirements and general food-web relationships of estuarine and migratory species. Water quality components were focused on salinity and algal productivity (nutrient) effects.

Agencies participating in IEP conduct extensive programs of routine sampling, as well as more intensive special studies, in the Delta. IEP maintains its data in EPA's centralized database (STORET) and other database systems to allow access to and analysis of collected data. Annual IEP reports are issued, and newsletters and annual meetings provide participants and the interested public with timely information about study results.

SWRCB Biennial Reports for Clean Water Act Section 305(b). SWRCB, in fulfilling requirements of Section 305(b) of the Clean Water Act, prepares biennial reports on water quality conditions in California. SWRCB's 1986 report identified approximately 40 miles of the lower San Joaquin River from Vernalis to Stockton as a segment that did not fully support fishery-related designated uses because of water quality limitations. The 1988 report did not list the lower San Joaquin River, but water quality remains a concern for this river. In contrast, the Sacramento River, the largest tributary to the Delta, has relatively good water quality because of the large amount of dilution provided by runoff from the watershed and releases from storage reservoirs.

Municipal Water Quality Investigations Program. DWR's MWQI program encompasses the previous Interagency Delta Health Aspects Monitoring Program (IDHAMP) and Delta Island Drainage Investigations (DIDI). IDHAMP was initiated by DWR in 1983 to provide a reliable and comprehensive source of water quality information for judging the suitability of the Delta as a source of drinking water (DWR 1989). Issues of concern included sodium, asbestos, and the potential formation of disinfection byproducts (DBP) such as THMs in treated drinking water from the Delta.

As the MWQI program has proceeded, assessment of more water quality constituents has been added. These constituents include pesticide residues and concentrations of organic materials and THM precursors that are contributed to Delta waters from agriculture drains and from algal biomass in the Delta. The ionic compositions of inflowing rivers and exported water have been compared to provide a means of chemically tracking the movement of water through the Delta.

MWQI studies have documented that Delta exports contain relatively high concentrations of DOC, a THM precursor. Agricultural drainage discharges containing natural decomposition products of peat soil and crop residues are considered dominant sources of DOC in

Delta waters (DWR 1994). Additionally, DOC is contributed to Delta waters by Delta inflows.

The MWQI program has determined that Br^- in Delta water contributes significantly to formation of the THMs observed in treated drinking water from the Delta. Sources of Br^- in Delta water are seawater intrusion, San Joaquin River inflow containing agricultural drainage, and possible connate groundwater. Br^- measurements are relatively difficult to make but have been included in the MWQI study since January 1990.

The Delta agricultural drainage component of the MWQI program has located and sampled discharge points of irrigation drainage water in the Delta since 1985. The program initially focused on Empire Tract, Grand Island, and Tyler Island, collecting monthly samples from agricultural drains on these islands. Several new monitoring stations were added to the program in 1987, allowing a much broader interpretation of patterns among islands with different soil and farming practices (DWR 1990). Drainage discharges from Bouldin and Bacon Islands and Webb and Holland Tracts are currently sampled under this program. Figure 3C-1 shows the location of Delta agricultural drainage pumps and MWQI sampling locations (not all drains are sampled).

In general, intensive surveys of agricultural drains on Delta islands have shown high DOC concentrations that may represent a significant contribution to DOC concentrations in Delta waters (DWR 1990). The salt content of the drainage water is found to be greatest during October-March as a result of the leaching of salts from Delta island soils between growing seasons.

In 1988, the DWR MWQI program analyzed agricultural drainage from approximately 30 Delta drains for a wide spectrum of agricultural pesticides. The drains were sampled during periods of heavy pesticide use or high drainage discharge to document concentrations during worst-case events. Pesticides were generally not detected in drainage water, except for small amounts of atrazine, simazine, and 2,4-D (DWR 1989).

More recent results of the MWQI data collection program were presented in the 2000 REIR/EIS. See the section from the 2000 REIR/EIS entitled "Updated Measurements of Inflow, Export, and Agricultural Water Quality" below.

Toxic Substances Monitoring Program. Initiated in 1976, the Toxic Substances Monitoring Program (TSMP) is a statewide program for assessing water quality based on sampling of resident aquatic organisms (e.g., freshwater clams, carp, bass, and trout) to determine the extent of synthetic organic chemicals and heavy metals in California rivers and major waterways. This approach to water quality monitoring is based on the assumption that an organism integrates toxicant exposure over time and concentrates pollutants to measurable levels (SWRCB 1985).

Although pesticides are rarely detected in Delta waters, data from various monitoring programs conducted by DWR and SWRCB have shown that contamination by synthetic organic chemicals is prevalent in sediment and organisms collected throughout the Delta. DDT, toxaphene, Aldrin, and other agricultural pesticides are consistently detected in fish collected from the Sacramento and San Joaquin Rivers and the Delta. Most pollutant concentrations in fish do not exceed standards established by the U.S. Food and Drug Administration or the National Academy of Sciences for the consumption of fish tissues. However, the presence of pollutants in fish demonstrates that organic chemicals are being bioaccumulated through the Delta food chain.

Monitoring Program for D-1485 Standards. D-1485 (SWRCB 1978), issued by SWRCB in August 1978, amended previous water right permits of DWR and Reclamation for the SWP and CVP facilities, respectively. D-1485 also set numerical water quality objectives and requirements for Delta outflow, export pumping rates, salinity as measured by electrical conductivity (EC), and chloride (Cl^-) to protect three broad categories of beneficial uses: fish and wildlife, agriculture, and municipal and industrial water supply. The standards included adjustments to reflect hydrologic conditions under different water-year types.

D-1485 has required DWR and Reclamation to conduct comprehensive water quality monitoring of the Delta. Annual reports have been prepared on observed water quality conditions in the Delta and compliance with limits set in D-1485 (DWR 1978). Similar monitoring requirements are included in the 1995 WQCP. DWR and Reclamation are responsible for adjusting their operations to satisfy the applicable objectives. Figure 3C-2 shows a map of the D-1485 water quality monitoring stations in the Delta. Some of these stations have continuous EC monitors; others are sampled routinely for chemical and biological measurements.

EC monitors at Jersey Point and Emmaton are especially important for managing the linkage between upstream reservoir releases and export pumping limits needed to satisfy Delta water quality objectives. The CVP and SWP operations staffs have access to telemetered data from these and several other EC monitors. The DWR Delta Operations Water Quality Section prepares and distributes a daily report of data on flows and EC to assist in decision making on Delta water project operations.

Delta Water Quality Issues

Water quality requirements and concerns are associated with each beneficial use of Delta water. Beneficial uses include agriculture, municipal and industrial water supply, fish and wildlife, and recreation (SWRCB 1975). Water is diverted for agricultural crop and livestock production at more than 1,800 siphons. Drainage water is returned to the Delta through pumping stations operated independently by reclamation districts (Figure 3C-1).

The Delta export pumping plants (SWP Banks, CVP Tracy, and SWP North Bay Aqueduct) and CCWD diversions at Rock Slough and Old River intake supply a combination of agricultural, industrial, and municipal users and also some wildlife uses (water supply for refuges). Industrial intakes and discharges occur near Sacramento, Stockton, and Antioch. A wide variety of fish and wildlife inhabit or migrate through the Delta. Many public and private recreational facilities are located in the Delta.

Recognized Delta water quality issues include the following:

- High-salinity water from Suisun Bay intrudes into the Delta during periods of low Delta outflow. Salinity adversely affects agricultural, municipal, recreational, and industrial uses.
- Delta exports have elevated concentrations of DBP precursors (e.g., DOC), and the presence of Br^- increases the potential for formation of brominated DBP.
- Agricultural drainage in the Delta contains high levels of nutrients, SS, DBP precursors (DOC), and minerals (salinity), as well as traces of agricultural chemicals (pesticides).
- Synthetic and natural contaminants have bioaccumulated in Delta fish and other aquatic organisms. Synthetic organic chemicals and heavy metals are found in Delta fish in quantities occasionally exceeding acceptable standards for food consumption.
- The San Joaquin River delivers water of relatively poor quality to the Delta, with agricultural drainage to the river being a major source of salts and pollutants. The Sacramento River also contains agricultural drainage, but in lower concentrations because river flows are higher.
- Populations of striped bass and other species have declined significantly from recent historical levels. Causes of the declines are uncertain, although water quality conditions in the Bay and Delta, decreases in Delta inflow and outflow rates, and increases in Delta exports are suspected of contributing to the declines.
- The location of the estuarine salinity gradient and its associated “entrapment zone”, with relatively high biological productivity, is controlled by Delta outflow. The location of the entrapment zone relative to the available estuarine habitat area must be appropriate to protect estuarine species.

Delta Water Quality Variables

Water quality conditions in the Delta are influenced by natural environmental processes, water management operations, and waste discharge practices. The DW project would provide an additional method of water management in the Delta and thus would influence Delta water quality. This section describes water quality variables that might be affected by DW operations and identifies several key variables selected for impact assessment purposes. Some of the selected variables are assessed with impact assessment models and are discussed quantitatively in the impact assessment. Others cannot be assessed with impact assessment models and are therefore discussed qualitatively. Variables that have not been identified as current problems in the Delta and those that are not likely to be affected by DW operations were not selected as impact assessment variables.

Table 3C-1 lists the major water quality variables considered for use in this impact assessment.

Flow

Delta water quality conditions can vary dramatically because of year-to-year differences in runoff and water storage releases, and seasonal fluctuations in Delta flows. Concentrations of materials in inflowing rivers are often related to streamflow volume and season.

Transport and mixing of materials in Delta channels are strongly dependent on river inflows, tidal flows, agricultural diversions, drainage flows, wastewater effluents, exports, and cooling water flows. Possible water quality effects of the DW project depend on flows in the Delta. An accurate assessment of possible Delta water quality effects therefore requires consideration of the patterns of Delta channel flows (see Chapter 3B, "Hydrodynamics"). Channel flow was not selected as a variable for impact assessment in this chapter but is considered in Chapter 3B.

Temperature

Temperature governs rates of biochemical processes and is considered a major environmental factor in determining organism preferences and behavior. Fish growth, activity, and mortality are related to temperature. The maximum (saturated) concentration of DO in water is lower at higher temperatures.

Water temperatures are determined predominantly by surface heat exchange processes, which are a function of weather. Delta temperatures are only slightly influenced by water management activities. The most common environmental impacts associated with water temperatures are localized effects of discharges of water at substantially elevated temperatures (e.g., thermal shock). DW discharges may influence temperatures in surrounding Delta channels because stored water may become warmer during storage periods. Temperature is discussed qualitatively for impact assessment, with measurements proposed as part of impact mitigation to prevent any significant impacts from occurring.

Suspended Sediments

The presence of SS (often measured as turbidity) is a general indicator of surface erosion and runoff into water bodies or resuspension of sediment materials. Following major storms, water quality is often degraded by inorganic and organic solids and associated adsorbed contaminants, such as metals, nutrients, and agricultural chemicals, that are resuspended or introduced in runoff. Such runoff and resuspension episodes are relatively infrequent, persist for only a limited time, and therefore are not often detected in regular sampling programs.

The attenuation of light in Delta waters is controlled by SS concentrations (with some effects from chlorophyll). SS concentrations are often elevated in the entrapment zone as a result of increased flocculation (i.e., aggregation of particles) in the estuarine salinity gradient. High winds and tidal currents also contribute to increased SS in the estuary.

The DW reservoir islands are expected to act as settling basins; therefore, SS concentrations are expected to be considerably lower in discharges than in Delta channels. Nevertheless, resuspension of SS materials from the reservoir bottoms into the water on the DW reservoir islands is possible and might have an impact on Delta channel SS concentrations. As the reservoir islands are emptied, the discharge water may have higher SS concentrations. SS is discussed qualitatively for impact assessment, with measurements proposed as part of impact mitigation.

Dissolved Oxygen

DO is often used as an indicator of the balance between sources of oxygen (e.g., aeration and photosynthesis) and the consumption of oxygen in decay and respiration processes. The DO saturation concentration changes with temperature, and DO concentration often varies diurnally. DO concentrations in Delta channels are not generally considered to be a problem, except near Stockton and in some dead-end sloughs. DO concentrations in MWQI agricultural drainage samples are sometimes slightly depressed (e.g., less than 5 milligrams per liter [mg/l]), indicating the presence of a large quantity of organic material (measured by DOC). DO is discussed qualitatively for impact assessment, with measurements proposed as part of impact mitigation.

pH

The measurement of the overall acidity or alkalinity of water is its pH. The pH of Delta water is governed by inflows, aquatic productivity, and the buffering capacity of the carbonate system (especially in estuarine water), so it is relatively constant in the Delta. DW discharges are not expected to have any measurable effect on channel pH. Therefore, pH was not selected as a variable for impact assessment.

Electrical Conductivity

EC is a general measure of dissolved minerals and is the most commonly measured variable in Delta waters. EC is generally considered a conservative parameter, not subject to sources or losses internal to a water body. Therefore, changes in EC values can be used to interpret the movement of water and the mixing of salt in the Delta (see Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project").

EC values increase with evaporation, decrease with rainfall, and may be elevated in agricultural drainage flows in the Delta. Because EC changes with temperature, Delta EC measurements are standardized to 25°C.

Seawater intrusion from the modeled downstream boundary of the estuary at Benecia has a large effect on salinity in the Suisun Bay portion of the estuary. The estuarine entrapment zone, an important aquatic habitat region associated with high levels of biological productivity is defined by the mean daily EC range of about 2-10 mS/cm (Arthur and Ball 1980).

The location of the estuarine salinity gradient and associated entrapment zone is estimated from EC monitoring data and is directly related to Delta outflow. DW project operations will have direct effects on channel EC during DW discharge periods and may indirectly influence EC by changing Delta outflow during periods of DW diversions. Reducing agricultural diversions and drainage from the DW project islands also may affect Delta EC values. EC has therefore been selected as a variable for impact assessment.

Dissolved Minerals

Beneficial uses of Delta water for agricultural, municipal, and industrial water supply can be limited by levels of dissolved minerals. Major parameters for judging Delta water quality have included salinity and concentrations of total dissolved solids (TDS); Cl^-; sodium (Na^+); and more recently, Br^- (Delta M&I Workgroup 1989).

Determining concentrations of specific anions or cations may be important for particular water uses. Cl^- and Br^- concentrations are important in evaluating domestic water supply quality, and sodium concentration is important for both agricultural and domestic water quality. The ratio of Cl^- to EC (using units of mg/l for Cl^- and microsiemens per centimeter [FS/cm] for EC) can be used to distinguish between sources of water from different inflows (e.g., Sacramento River, San Joaquin River, and seawater) sampled at different Delta locations.

DW project operations would influence relative contributions of water from different Delta inflow sources. Therefore, the project would affect mineral concentrations in the Delta. Cl^- and Br^- concentrations were selected as impact assessment variables. The Delta salinity model developed by RMA was used to simultaneously simulate EC and concentrations of Cl^-. These simulations were compared with historical EC measurements and were then summarized to provide estimates of Cl^- and Br^- concentrations for impact assessment with the DeltaDWQ model (see Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model").

The assessment of project effects on salinity (Cl^- and Br^-) has been updated by the 2000 REIR/EIS. The 2000 REIR/EIS used a revised analytical model (DeltaSOQ) to assess project impacts on salinity and other water quality variables. These methods are summarized below in the section from the 2000 REIR/EIS entitled "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS".

Dissolved Organic Carbon

DOC concentration is one of the primary variables that influence the potential for formation of DBP. DBP concentrations are important in judging the quality of drinking water sources (Delta M&I Workgroup 1989).

The most common DBP is THM compounds formed during chlorination of DOC in drinking water supplies; these potentially carcinogenic substances include chloroform and bromoform (Bellar and Lichtenberg 1974; Wilkins et al. 1979). Chloroform has been shown to increase the risk of liver and kidney cancer in mice when administered at high doses (National Cancer Institute 1976). Using data of the National Cancer Institute (1976) and considering water treatability, EPA established a maximum contaminant level (MCL) of 100 micrograms per liter (Fg/l) or parts per billion (ppb) for THMs in finished (treated) drinking water (44 FR 68624).

The MCL standard was under review by EPA during preparation of the 1995 DEIR/EIS. EPA lowered the MCL standard for THM to 80 Fg/l. Changes to THM and other DBP rules made after issuance of the 1995 DEIR/EIS are discussed below in the section from the 2000 REIR/EIS entitled "Changes in Disinfection Byproduct Rules". The suspected carcinogenic risk to humans from THMs has led some communities to study and revise their methods of disinfecting drinking water.

THM levels in drinking water can be reduced through the use of alternatives to chlorination in treating water for human consumption (e.g., ozonation or chloromines), although other potentially harmful DBP compounds may be formed during these other disinfection processes. Disinfection itself is being more carefully regulated by EPA to avoid problems from various pathogens (i.e., viruses). Reducing DOC concentrations in raw water before chlorination with flocculation or granular activated carbon adsorption can reduce all DBP levels, but may be quite expensive.

Minimizing DOC concentrations in the raw water source is a major water quality goal for drinking water uses. DW operations may directly influence DOC concentrations in Delta channels and exports. DOC was selected as a variable for impact assessment. The DeltaDWQ model was used to estimate the potential impacts of DW operations on export DOC concentrations.

The assessment of project effects on DOC has been updated by the 2000 REIR/EIS. The methods used in the revised analysis are summarized below in the section entitled "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS".

Trihalomethanes and Trihalomethane Formation Potential

THM formation potential (THMFP) is measured in the MWQI samples as an index of THM concentrations that could be produced by maximum chlorination of Delta water. Several types of laboratory tests have been developed to measure THMFP in water samples. Whereas THMFP is measured in raw untreated water, the regulatory requirement for THM concentrations applies to the finished or fully treated water delivered to homes and commercial users. THM concentrations generally increase with higher chlorine doses and with higher DOC and higher Br^- concentrations (DWR 1994).

There are four types of THM molecules, which can be differentiated by molecular weight: chloroform ($CHCl_3$), dichlorobromomethane ($CHCl_2Br$), dibromochloromethane ($CHClBr_2$), and bromoform ($CHBr_3$). Total THM concentration (by weight) is the basis for current EPA drinking water standards. The greater weight of total THMs resulting from increased bromine incorporation, however, complicates comparison of THM precursors from two water samples with different Br^- concentrations. One method to normalize the total THM concentrations is to use molar THM concentrations, the standard chemistry method, which essentially counts the number (moles) of THM molecules per liter of water.

A slightly different technique, giving equivalent results, is to measure only the carbon weight of each THM molecule because each molecule has one carbon atom. The carbon-fraction concentrations of the four THM molecules are added together to calculate the carbon equivalent of the THM concentration (C-THM), called the "total formation potential carbon" (TFPC) in the DWR MWQI program.

Dividing the C-THM concentration (Fg/l) by the DOC concentration (Fg/l) in a water sample gives the fraction of DOC molecules that were converted to THM molecules during the THMFP assay. This C-THM/DOC ratio is called the THM yield.

These THM-related variables are discussed in greater detail in Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data"; Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project"; and Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water".

Simulated THM concentration in treated drinking water using Delta exports as the raw water source, modeled with the EPA water treatment plant (WTP) model (described in Appendix C5), was selected as a variable for impact assessment.

The assessment of project effects on THM concentration in treated drinking water was updated in the 2000 REIR/EIS. The methods used in the 2000 REIR/EIS to simulate DW project effects on DBPs (i.e., THM and bromate) are summarized below in the section entitled "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS".

Ultraviolet Absorbance and Color

Ultraviolet absorbance (UVA) is the absorbance of light with a wavelength of 254 nanometers (nm), as measured with a spectrophotometer and reported in units of 1/cm (fraction absorbed in one centimeter of water). UVA, used in the study of humic acids and THM precursors, has been found to be linearly related to both DOC and C-THM concentrations (see Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data").

UVA may be useful as a field measurement variable for estimating DOC and C-THM concentrations in DW discharges and Delta channels, but UVA was not selected as a variable for impact assessment because DOC and C-THM impact assessments will be sufficient (provide the same results). Color is a similar measure of light absorbance but is not selective for the humic and fulvic acid component of DOC materials.

Chlorophyll

Algal biomass and organic chemicals associated with algal processes may produce flavor and odor in water supplies as well as contribute to THM formation. Alternatively, algal biomass may be a desirable habitat constituent for fish and aquatic organisms. Chlorophyll concentration is the most common measure of algal biomass. Fluorometric devices have been developed that may provide a field measurement technique for chlorophyll. Algal biomass may increase during water storage on the DW reservoir islands and during wetland and wildlife management on the habitat islands. Chlorophyll is discussed qualitatively for impact assessment, with measurements proposed as part of impact mitigation.

Nitrate and Phosphate

Nitrate (NO_3^-) and phosphate (PO_4^{3-}), nutrients required for aquatic plant and algal growth, are supplied to the Bay-Delta estuary by river inflows, by agricultural drainage, from biochemical recycling in the water column, and from sediment releases. Macrophytes and wetland vegetation obtain these nutrients from the sediment. Ammonia from sources such as wastewater effluents and agricultural fertilizers is oxidized rapidly to nitrate in Delta channels, and ammonia concentrations are usually quite low.

Because DW operations are not likely to change the supply or concentrations of these nutrients in Delta channels, they were not selected as variables for impact assessment.

Contaminant Residues

Residues from pesticides, herbicides, trace metal compounds, and other agricultural or industrial chemicals may produce serious pollution conditions in Delta water and may bioaccumulate in Delta fish and aquatic organisms. These residues can be measured in water, soils, sediments, and organisms inhabiting Delta channels. The detection of a particular compound depends on its persistence and mobility in the environment, as well as its source characteristics. Contaminant residues were selected as a variable for impact assessment because of possible contamination of stored water on the DW reservoir islands. Appendix C6, "Assessment of Potential Water Contaminants on the Delta Wetlands Project Islands", describes sampling of the DW project islands for possible contaminants.

Water Quality of Delta Inflows and Exports

Concentrations of many water quality constituents are often higher in Delta exports than in Sacramento River inflow. Possible sources of water quality constituents in the Delta are seawater intrusion, inflows from the San Joaquin River and eastside streams, biological production in Delta channels, agricultural drainage from Delta islands, and treatment plant effluents. Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data", provides detailed information on the existing water quality characteristics of Delta inflows and exports and the observed changes in these characteristics during water transport through the Delta (data for EC, Cl^-, Br^-, DOC, and THMFP are presented and interpreted in this appendix). Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project", includes historical data on EC.

Historical water quality data from the Delta inflows (Sacramento and San Joaquin Rivers) and the export locations (CCWD Rock Slough, SWP Banks, and CVP Tracy Pumping Plants) were used to characterize Delta water quality and to confirm the simulations of historical EC conditions performed using the RMA Delta water quality model. These data on inflow water quality are used in the DeltaDWQ assessment model to evaluate effects of DW operations on water quality of the Delta exports. Selected historical data are briefly summarized in the following sections.

Information on existing water quality characteristics of Delta inflows and exports was updated in the 2000 REIR/EIS; see the section from the 2000 REIR/EIS entitled "Updated Measurements of Inflow, Export, and Agricultural Drainage Water Quality" below. The updated information generally confirms the description of Delta conditions presented in the 1995 DEIR/EIS.

Temperature and Suspended Sediments

USGS operates monitoring stations for daily measurements of temperature and SS on the Sacramento River at Freeport and on the San Joaquin River at Vernalis. Data from these measurements indicate the seasonal and storm-event patterns of temperature and SS. Turbidity data collected by the MWQI program are described in Appendix C1. Available Delta temperature data are discussed as part of the fishery assessment in Chapter 3F, "Fishery Resources".

Electrical Conductivity Data

Figure 3C-3 shows monthly average EC measurements from the Sacramento River at Greene's Landing for water years 1968-1991 from EPA's STORET database (Baughman pers. comm.). Average EC is generally in the range of 100-200 FS/cm. Sacramento River EC measurements decrease with higher flows, exhibiting a typical flow-dilution relationship that can be approximated with the following equation, estimated from the 1968-1991 data:

$$\text{Sacramento River EC (FS/cm)} = 5{,}000 \ \% \ \text{flow (cfs)}^{-0.35}$$

This equation was used to develop an input data set relating inflow EC levels to inflow volume for RMA salt modeling, as described in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project", and for DeltaDWQ modeling as described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model". The equation predicts that EC values would be greater than 200 FS/cm only when Sacramento River flows are less than 10,000 cfs. Some measured values were greater than 200 FS/cm when flows were higher than 10,000 cfs because of variations in the sources of minerals (EC) in the Sacramento River watershed.

The monthly average EC values for the San Joaquin River are usually higher than EC values for the Sacramento River, with typical values varying between 200 FS/cm and 1,000 FS/cm. Figure 3C-4 indicates that EC measurements from the San Joaquin River at Vernalis (Baughman pers. comm.) also generally decrease with increases in flow, exhibiting a flow-dilution relationship that can be approximated with the following equation, estimated from the 1968-1991 data:

$$\text{San Joaquin River EC (mS/cm)} = 25 \ \% \ \text{flow (cfs)}^{-0.5}$$

Several San Joaquin River monthly average EC values above 1,000 FS/cm (1.0 mS/cm) were observed during winter in recent years (1988-1991) (Figure 3C-4, upper panel). These values are higher than EC values estimated with the flow-dilution equation. These elevated EC values suggest that an additional load of salt may have been released in drainage into the San Joaquin River during recent years. For impact assessment purposes, however, this equation was used as an estimate of San Joaquin River EC values. Because the simulated inflows will be different from historical inflows (due to differences in reservoir operations and diversions), the historical EC values cannot be used directly.

Chloride and Bromide Concentrations

Each Delta inflow has a specific chemical composition that can be used to characterize the inflow source (see Appendix C1). Concentrations of each mineral constituent increase directly with EC. Cl^- and Br^- are the two minerals of greatest interest for the DW impact assessment. Where Br^- measurements are available, data indicate that all three sources of Delta water (Sacramento River, San Joaquin River, and seawater) have a nearly identical and constant Br^-/Cl^- concentration ratio of 0.0035 (see Figure C1-5 in Appendix C1). Variability in the Br^-/Cl^- ratio is greatest for the Sacramento River because of the low concentrations of Cl^- and Br^-. Estimating the Br^-/EC ratio directly would provide identical results.

In Sacramento River inflows, EC values are generally between 100 FS/cm and 200 FS/cm, Cl^- concentrations are usually between 5 mg/l and 10 mg/l, and the Cl^-/EC value for Sacramento River inflows averages about 0.04 (Figure 3C-5). The graphical presentation of mineral concentrations in the Sacramento River shows much scatter because the low concentrations are reported in whole units of mg/l. Br^- concentrations are very low in the Sacramento River, averaging less than 0.05 mg/l (Br^-/Cl^- = 0.0035; Br^-/EC = 0.0001).

In San Joaquin River inflows, Cl^- concentrations fluctuate between about 20 mg/l and 150 mg/l. Cl^-/EC values increase from about 0.10 at low EC values to about 0.15 at high EC values (Figure 3C-6). The change in the Cl^-/EC ratio value may be explained by the fact that San Joaquin River inflow is a mixture of San Joaquin River water, containing significant agricultural drainage, and Stanislaus River water. Nevertheless, the Cl^-/EC value of 0.10 to 0.15 in the San Joaquin River inflow is distinct from the lower Cl^-/EC value of about 0.04 in the Sacramento River. Br^- concentration would be about 0.5 mg/l when Cl^- concentration is 150 mg/l (Br^-/Cl^- = 0.0035; Br^-/EC = 0.00035 to 0.00052).

The Cl^-/EC value for seawater is approximately 0.35. The Cl^-/EC value has averaged about 0.30 for MWQI samples from Mallard Island near the confluence of the Sacramento and San Joaquin Rivers (Figure 3C-7) because some mixture of Sacramento River water and ocean water was presumably collected in the samples. Br^- concentrations would be about 17.5 mg/l at Mallard Island when Cl^- concentration is 5 g/l (Br^-/Cl^- = 0.0035; Br^-/EC = 0.001).

Concentrations of Dissolved Organic Carbon

DOC concentrations in Sacramento River inflow are generally the lowest measured in the Delta, usually approximately 2.0 mg/l. Sacramento River DOC concentrations sometimes exceed 3.0 mg/l, however. Daily measurements during storm events in 1993 have confirmed that Sacramento River DOC concentrations can exceed 2.0 mg/l as the result of the presence of DOC material in surface runoff (Agee pers. comm.). DOC concentrations in the San Joaquin River (generally ranging between 3.0 mg/l and 6.0 mg/l) are usually higher than Sacramento River DOC concentrations. Available data on Delta DOC concentrations are discussed in Appendix C1. Flow regressions were estimated for river inflow concentrations of DOC using available data and were used to calculate inflow DOC concentrations in DeltaDWQ for impact assessment purposes.

Potential Water Contaminants on the DW Project Islands

Potential water contaminants on the DW project islands include residues from pesticides applied by agricultural operations, materials from waste disposal sites, and residues at maintenance and repair facilities for agricultural equipment.

Appendix C6, "Assessment of Potential Water Contaminants on the Delta Wetlands Project Islands", describes the results of soil sampling conducted on the DW project islands and laboratory analysis for pesticide residues. The results indicated that, in general, DW island soils do not contain significant concentrations of agricultural chemicals. Pesticide residues were low to nondetectable for agricultural chemicals known to have high potential to leach from soils. Detected residues of three herbicides observed in one soil sample from Bacon Island were the result of recent application and do not represent a concern regarding water contamination because herbicides undergo rapid chemical degradation.

Incidental discharges of petroleum-based materials, sewage, and litter into Delta channels and onto the DW project islands could occur in connection with the proposed recreational boating facilities and activities. Petroleum products contain chemicals toxic to aquatic organisms, and improperly treated sewage can introduce into Delta channels pathogens that are harmful to human health and nutrients that stimulate biological growth. The magnitude and significance of discharges depends on facility locations and services provided; types of boating activities and changes from existing conditions; timing of the activities; and quality factors associated with boat size, age, and maintenance. Information is provided in Appendix C6 regarding the potential for DW operations to contribute to water quality problems as a result of recreational boating. Boating activities associated with DW project implementation are not likely to cause significant adverse water quality impacts. As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications; nevertheless, the analysis of impacts on water quality associated with construction and operation of these facilities is provided in this chapter.

The following discussions describe other potential water contaminants on the four DW project islands.

Bacon Island

Bacon Island is the most densely populated of the DW project islands. Most of the domestic wastewater from homes and farm worker barracks is disposed of by septic tank systems. Before garbage collection service was provided by individual counties or private firms, many farm operators disposed of domestic trash at selected locations on the island. Abandoned vehicles, used automobile tires, various containers, and common household or farm-related trash can be found at these sites. Figure 3C-8 shows the locations of known or visible garbage disposal sites on Bacon Island.

Bacon Island has several permanent farm operation facilities, with designated areas for maintenance and repair of farm machinery. Fugitive diesel fuel and gear and motor oil drippings are evident in the soils in most of these areas. Used oils are stored in aboveground containers and are collected by a waste oil recycler as necessary (Shimasaki pers. comm.).

Partially filled or empty pesticide containers are stored in structures at selected sites on Bacon Island (Figure 3C-8). Most of these structures are elevated above ground surface and their contamination of surface soils is unlikely. Disposal of metal, plastic, and paper pesticide containers is regulated by the California Department of Food and Agriculture (DFA) under a set of container guidelines. Under these regulations, containers are completely rinsed three times with tap water, allowed to dry, punctured by mechanical means, and stored in these areas until the number of containers accumulated is sufficient to be disposed of by a certified waste hauler. Rinse waters are typically applied to fields where the chemical was used. Staff members of the county agricultural commissioner's office inspect these areas during normal field visits to farm operations (Gianelli pers. comm.).

A potential source of contamination by heavy metals is the site of a discontinued copper salvaging operation, located at the northwestern corner of Bacon Island (Figure 3C-8). A hazardous waste investigation and site cleanup was conducted on the site and high levels of copper, zinc, lead, and other heavy metals were detected in soils surrounding the illegal operation area. Levels of copper and lead were found to exceed hazardous waste criteria established by DHS. Soils were also tested for EPA priority pollutants, most of which are synthetic organic compounds, but no compounds were observed to exceed their detection limits. DHS (Region One Surveillance and Enforcement Section) issued a letter stating that cleanup has been adequate and that constituents of concern are at background levels. (Ambacher pers. comm.)

Webb Tract

No indications of domestic garbage sites were observed on Webb Tract during field surveys in August and September 1988. Historically, few people have lived on Webb Tract and the potential for the presence of major trash deposits is thought to be fairly low. Some farmers live in small mobile homes during the growing season. Users of the few permanent structures on the island rely on septic systems for waste disposal. Few farm machine repair and pesticide storage areas are located on the island. Most of the farmers rebuild or repair machinery during idle periods, typically in workshops located off the island (Dinelli pers. comm.).

Bouldin Island

No visible signs of waste dumping have been observed during field visits to Bouldin Island, which accommodates several homes. All homes and office buildings on Bouldin Island use septic systems for domestic sewage disposal. Domestic trash is transported off the island by a certified waste disposal firm. Farm machinery repair facilities on Bouldin Island are located on the eastern end of the island, about ½ mile south of the SR 12 bridge at Terminous (Wilkerson pers. comm.). Oil and grease drippings are evident in localized areas.

Pesticide storage areas are absent from Bouldin Island because of the island's proximity to the Stockton-Lodi area, where major agricultural chemical distributors are located. Because pesticide formulations are mixed at distributors' facilities, minimal onsite storage or mixing is required (Wilkerson pers. comm.). Most farmers use the same chemical distributor each year and through experience know quantities of compounds needed to minimize waste and overuse. Additionally, many of the compounds are aerially applied; chemicals are handled and loaded at Bouldin Island airstrip.

Holland Tract

Domestic garbage dumps have not been observed on Holland Tract. Few people live on the island; most visitors to Holland Tract are boaters with berthing leases at the marinas (Lindquist pers. comm.). Trash generated at the marinas is collected by a private waste hauling firm. Domestic waste dumping was not evident during field surveys. No signs of pesticide storage areas were identified on Holland Tract during numerous field surveys.

Several landowners previously used Holland Tract lands to spread paper pulp waste produced by Gaylord Container Corporation's paper recycling facility in Antioch. The pulp waste was the byproduct of recycled corrugated cardboard, which was made into new paper products. The waste disposed of on the island consisted of short paper fibers, minor amounts of plastic, and adhesive compounds.

Information about the disposal of pulp recycling wastes on Holland Tract was obtained from the lessee of the property where the disposal operations took place. The pulp disposal operation began in 1979 and ended in 1993. Approximately 450 tons per day of wet material was delivered to the Holland Tract disposal site, where the material was stockpiled and allowed to dry. About 80% of the wet weight was water and 20%, or 90 tons per day, was actual pulp waste. Starting in 1987, the materials were disked or plowed into the soil to improve the soil's percolation and water-retention capabilities (Laxson pers. comm.).

Recycled pulp waste was disposed of on Holland Tract under a land use permit issued by the Contra Costa County Planning Department (Permit 2127). The permit included requirements for groundwater monitoring near the disposal sites; two 4-inch wells approximately 30 feet deep were installed to monitor groundwater quality. Quarterly analytical reports were forwarded to CCWD under the terms of the county permit. In 1984, monitoring was discontinued after one well was accidentally destroyed by a bulldozer.

A chemical analysis of waste pulp spread on Holland Tract was conducted for CCWD in 1988 (Gartrell pers. comm.). Concern had been raised over the potential effects that trace metals, particularly lead, could have on CCWD drinking water supplies in nearby Rock Slough. Testing was performed by the DHS laboratory to determine the maximum metal concentrations under worst-case conditions. Twenty-seven trace metals were analyzed but none were found at levels that exceeded DHS hazardous waste criteria. Extractable and purgable organics also were not detected. Additional data collected by Gaylord Container Corporation and analyzed by Emcon Associates in 1989 confirm that metal concentrations were similar to background soil concentrations (Hsiong and Isham pers. comm.).

The Central Valley Regional Water Quality Control Board (CVRWQCB), after reviewing results of chemical testing of the pulp waste, does not believe that metal concentrations in pulp wastes represent a potential threat to surface water or drinking water quality (Landau pers. comm.). Trace metals in pulp waste are under study by Gaylord Container Corporation for review by CVRWQCB (Roe pers. comm., Hsiong and Isham pers. comm.). Dioxin contamination of the pulp byproduct spread on Holland Tract is highly unlikely because the pulp was not subjected to chlorination, which is essential in the formation of dioxins (Landau pers. comm.).

IMPACT ASSESSMENT METHODOLOGY

DW project operations may cause water quality effects in the Delta by two primary mechanisms:

- # DW project discharges may have EC levels or contain concentrations of water quality constituents, such as Cl^-, Br^-, or DOC, that may affect water quality in Delta channels and exports.

- # DW project diversions or discharges may change Delta outflow or Delta channel flows, which might influence salinity intrusion or shift the contributions of water quality constituents from different Delta inflow sources. These changes may affect water quality in Delta channels and exports.

Table 3C-2 gives a summary of the 1995 DEIR/EIS impact assessment methods for the major water quality variables selected for impact assessment: salinity (EC, Cl^-, Br^-) and DOC concentrations in the Delta, and THM concentrations in treated drinking water obtained from the Delta.

The 2000 REIR/EIS analyzed project effects on these major water quality variables using methods similar to those used in the 1995 DEIR/EIS. See the section entitled "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS" below.

Overview of the Impact Assessment Models and Modeling Tasks

The following models were used for the 1995 DEIR/EIS assessment of potential DW project effects on the major water quality variables selected for impact assessments: the RMA water quality model, the DeltaDWQ model, and the EPA WTP model. This section provides an overview of the most important steps in the development, calibration, confirmation, and application of these models for the impact assessment for water quality.

The water quality assessment models rely on accurate hydrodynamic modeling of channel flows to allow simulation of salt transport and mixing in the Delta. The RMA Delta hydrodynamic model was used to simulate tidal and net channel flows in the major Delta channels, as described in Chapter 3B, "Hydrodynamics". The simulated net channel "flow-split" relationships were evaluated and summarized with equations that are incorporated into the DeltaSOS model (Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model"). The assumed water budget for Delta agricultural islands is incorporated into the DeltaDWQ model (Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model").

There are many unpredictable processes and events that may affect water quality in the Delta that are not simulated with the assessment models developed for simulating likely effects of DW project operations. Examples of unpredictable factors that are expected to influence conditions under the No-Project Alternative and under the DW project alternatives include occasional slugs of relatively high-salinity San Joaquin River inflows, intensive agricultural salt leaching following periods of drought, and increases in DOC concentrations in storm runoff. These unpredictable water quality effects will be considered in actual DW operations, however, because they will be detected with routine monitoring data used to demonstrate compliance with the 1995 WQCP objectives and in data collection needed to satisfy mitigation requirements imposed on the DW project by the Corps and SWRCB.

Figure 3-1 in Chapter 3, "Overview of Impact Analysis Approach", shows the relationship between the assessments performed using these models. Table 3C-3 summarizes the preliminary model calibration and confirmation tasks described below for the models used in the water quality impact assessment. Table 3C-4 summarizes the modeling tasks for the impact assessment.

Methods for Assessing Impacts on Salinity (Electrical Conductivity, Chloride, Bromide)

There exist extensive historical data on EC from about 20 Delta locations. These measurements allow the RMA Delta water quality model to be calibrated and tested. Comparisons of EC data and RMA simulation results are summarized in this chapter and are described in detail in Appendix B2. The simulated end-of-month EC patterns are quite similar to the patterns of measured mean monthly EC at most of the available measurement locations most of the time. There is some variation between the simulated and measured EC patterns because the model simulations used mean monthly flows and exports rather than the actual daily flows. These differences are discussed in Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments". During periods of salinity intrusion caused by low Delta outflow, there are additional differences between measured and simulated EC patterns caused by uncertainties in estimated Delta channel depletion and estimated Delta outflow.

Historical daily Delta inflows and exports were used to test and calibrate the RMA water quality model (by adjusting tidal mixing coefficients) with daily EC measurements from 19 Delta locations for 1972. Flows and EC data for 1976 and 1978 were used to confirm the RMA water quality model results. These calibration results are shown in Smith and Durbin (1989).

Historical monthly average Delta inflows and exports for 1967-1991 were used to simulate monthly average net channel flows and end-of-month salinity patterns in the Delta. The historical Delta salinity simulations were used as a reference for judging the reliability of the RMA Delta water quality model. These results are described in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project", and are summarized in this chapter.

The RMA Delta water quality model was also used to simulate the mean monthly contributions of each Delta inflow source (Sacramento and San Joaquin Rivers, Yolo Bypass and eastside streams, agricultural drainage, and tidal mixing from the downstream model boundary) at selected Delta channel and export locations. These simulated mean monthly source contributions were summarized and incorporated into the DeltaDWQ model for impact assessment of DW project operations on Delta EC and on Cl^- and Br^- concentrations in Delta exports.

Methods for Assessing Impacts on Dissolved Organic Carbon and Trihalomethane

The simulated effects of DW project operations on DOC concentrations depend on the estimated inflow concentrations and inflow source contributions, and on the assumed sources of DOC from Delta agricultural drainage and from the DW habitat and reservoir islands. The simulated effects of DW project operations on THM concentrations in drinking water also depend on the assumed chlorination and other treatment processes at the simulated water treatment plant.

The DWR MWQI program has collected water samples from Delta channel, export, and agricultural drainage locations. The MWQI program measurements are the primary water quality measurements used to estimate changes in DOC between the Delta inflows and the Delta export locations and the contribution of DOC from Delta agricultural drainage, in units of grams of DOC per square meter per year (g-DOC/m^2/year). The analyses of these data on Delta DOC and related variables are described in Appendices C1, "Analysis of Delta Inflow and Export Water Quality Data", and C2, "Analysis of Delta Agricultural Drainage Water Quality Data".

Because there are no measurements of agricultural drainage flows in the Delta, the MWQI measurements of DOC concentrations cannot be used to estimate the relative contributions of DOC from Delta agricultural land. Possible contributions of DOC from crop residue, wetlands plants, and peat soil leaching have not been measured. Several water quality experiments were conducted to estimate these potential DOC source contributions for impact assessment purposes. Results of these experiments are described in Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project".

There was no existing model for estimating the relationship between the water budget for Delta agricultural islands (diversions, ET, and drainage) and the corresponding salinity (EC) and DOC concentration patterns in agricultural drainage. The Delta drainage water quality model DeltaDWQ was developed for assessment of impacts associated with contributions of the DW project island discharges to DOC concentrations in Delta exports. This model combines the simulated monthly channel flows estimated in DeltaSOS with simulated monthly agricultural drainage and DW project discharge concentrations to estimate DOC concentrations in Delta exports.

Finally, the simulated export concentrations of DOC and Br^- were used to simulate expected monthly average THM concentrations in a typical water treatment plant obtaining its water supply from Delta exports. The EPA WTP model was used for the THM impact assessment. Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water", describes this model and the results of THM impact assessment for the DW project alternatives.

This chapter summarizes the use of these water quality impact assessment models, selected criteria for judging impact significance, and the results of the impact assessments for the constituents selected for impact assessment. However, the accompanying technical appendices should be consulted for many details that are not repeated in this chapter.

Analytical Approach and Impact Mechanisms

Assessment of water quality impacts requires establishing a point of reference with which conditions under DW project operations can be compared. The point of reference used for this assessment is the No-Project Alternative. The simulated No-Project Alternative represents Delta water quality conditions that are likely to exist in the absence of DW project operations, with a repeat of the hydrologic conditions represented by the Delta hydrologic record, but with existing facilities, water demands, and Delta standards. The relationship between the No-Project Alternative and historical water quality conditions is described below.

The 1962-1991 25-year period was used in the 1995 DEIR/EIS because:

the range of hydrologic conditions of the 25-year period is similar to those of the 70-year 1922-1991 period (Appendix A1),

most reservoirs and diversion facilities were operational during this period, and

historical EC and water quality data are available for this period.

Conditions under the No-Project Alternative and the DW project alternatives were simulated using models discussed in the following sections. For a model to be considered a reliable predictive tool, simulations produced by the model are confirmed through comparison with observed historical conditions. For this analysis of water quality effects of DW project operations, simulated historical conditions were compared with historical data from the sampling programs described above under "Sources of Information".

The following four locations in the Delta were selected for assessment of impacts related to Delta salinity conditions:

Chipps Island, usually considered to be the primary station for monitoring Delta outflow water quality because it is located downstream of the confluence of the Sacramento and San Joaquin Rivers, where river flows and Delta agricultural drainage have combined;

Emmaton, one of the locations for Delta agricultural salinity objectives located on the Sacramento River downstream of Threemile Slough;

Jersey Point, one of the locations for Delta agricultural salinity objectives, and an important location for monitoring effects of agricultural drainage contributions to water quality in central Delta outflows; and

Delta exports from the southern Delta, assumed to be representative of CCWD diversions at Rock Slough intake #1; SWP exports at Banks Pumping Plant, where water is diverted from the Delta across Clifton Court Forebay into the California Aqueduct; and CVP exports at Tracy Pumping Plant, where Delta water is diverted into the Delta-Mendota Canal (DMC).

A representative Delta export location was used because the impact assessment methods cannot reliably distinguish between water quality conditions at the three major export locations. Localized effects of agricultural drainage at the CCWD Rock Slough intake and effects of water quality of San Joaquin River inflows at the CVP Tracy Pumping Plant are described in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project". For impact assessment purposes, the likely effects of DW project operations on Delta export water quality were assessed for representative south Delta exports with the DeltaDWQ model, described in Appendix C4. The representative export water quality might be compared with historical water quality collected from Old River at Holland Tract.

Impacts related to DOC and THM concentrations were assessed for Delta exports only.

Water Quality Effects of DW Discharges: Contributions of Constituents

DW project discharges may contain elevated levels of water quality constituents that could affect water quality in Delta channels and Delta exports. Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data", describes likely average monthly concentrations of water quality constituents in drainage water from Delta upland and lowland islands. The estimates for lowland islands were used to represent DW island discharges under the No-Project Alternative. Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model)", describes conceptual water, salt, and DOC budgets for typical Delta agricultural islands. Estimated agricultural drainage concentrations of EC and DOC under the No-Project

Alternative are presented. Cl^- and Br^- concentrations were also estimated with DeltaDWQ. Likely concentrations of these constituents in discharges under the DW project alternatives were estimated for comparison with conditions under the No-Project Alternative.

DW discharges may change export water quality and potentially affect THM concentrations in treated drinking water. The EPA WTP model, described in Appendix C5, "Modeling Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water", was used to simulate THM concentrations in Delta export water chlorinated in a typical water treatment plant.

Water Quality Effects of DW Operations: Changes in Channel Flows and Outflow

DW project operations may influence salinity intrusion to the Delta and contributions of water quality constituents from different inflow sources by changing Delta channel flows and outflows. Chapter 3B, "Hydrodynamics", describes hydrodynamic modeling of the DW project performed by RMA for JSA and the lead agencies using its link-node hydrodynamic model of the Delta. RMA also performed salt transport modeling of monthly average Delta conditions under contract to DW and provided modeling results to JSA for use in performing water quality impact analyses. Appendix B1, "Hydrodynamic Modeling Methods and Results for the Delta Wetlands Project", describes the hydrodynamic modeling results and Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project", describes the salinity modeling results. The RMA modeling was based on 25-year (1967-1991) historical inflows and exports.

The RMA Delta salinity model uses the results from the RMA Delta hydrodynamic model and provides detailed simulations of salinity in all Delta channels. For impact assessment purposes, the observed relationships between effective Delta outflow and salinity at selected locations were used to summarize the likely effects of changes in Delta outflow caused by DW project operations on EC at the four locations selected for impact assessment. The next section of this chapter shows that the DeltaDWQ results and the RMA Delta salinity model results indicated similar relationships between effective Delta outflow and EC at the locations selected for impact assessment. The detailed RMA modeling and the effective outflow relationships provided similar results. The negative exponential relationships between effective Delta outflow and EC were incorporated into the DeltaDWQ model and used for impact assessment of the alternatives. Comparisons between the historical EC data and the RMA salinity model results and the effective Delta outflow relationships are more fully described in Appendix B2.

As described in Appendix B2, the effective Delta outflow is the equivalent steady-state outflow that will maintain the observed EC value at a particular monitoring station. Calculations of effective outflow incorporate the sequence of previous Delta outflows. The monthly change in effective outflow is calculated as a function of the previous month's effective outflow and this month's average outflow:

Change in effective outflow = (outflow - effective outflow) % (1 - exp[-effective outflow/R])

where R is a "response" factor that is approximately 5,000 cfs for monthly average flows, as simulated in the DeltaSOS and DeltaDWQ impact assessment models.

This effective Delta outflow calculation was used to allow impact assessment of Delta salinity intrusion to be estimated at selected locations in the DeltaDWQ model. EC values or Cl^- concentrations at selected channel locations resulting from salinity intrusion were estimated from negative exponential relationships with effective Delta outflow, as described in Appendix B2. Following are the equations for the selected channel locations for impact assessment:

Chipps Island EC (FS/cm) = 30,000 % exp(-0.00025 % effective outflow)

Emmaton EC (FS/cm) = 10,000 % exp(-0.00040 % effective outflow)

Jersey Point EC (FS/cm) = 8,000 % exp(-0.00040 % effective outflow)

Delta export EC (FS/cm) = 5,000 % exp(-0.00050 % effective outflow)

Delta export Cl^- (mg/l) = 1,667 % exp(-0.00050 % effective outflow)

At high outflows, the Delta salinity will no longer be influenced by salinity intrusion effects and each of these negative exponential equations will approach zero. The salinity at each channel location will then be determined by the mass balance of salinity from Delta inflows and from agricultural drainage. These salinity mass-balance relationships are included in the DeltaDWQ assessment model as described in Appendix C4, "DeltaDWQ: Delta Drainage Water Quality Model".

The DeltaDWQ model results for historical inflows and exports were confirmed with measured EC and Cl^- data for 1968-1991. Salinity intrusion effects resulting from changes in effective Delta outflow, simulated with the DeltaSOS model for DW project alternatives, are adequately estimated in the DeltaDWQ model. The effects of river inflows and agricultural drainage are also adequately represented by the DeltaDWQ model. Model uncertainties in monthly Sacramento and San Joaquin River inflow EC values or monthly flow and EC values of agricultural drainage discharges do not reduce the accuracy of impact assessment results because the same estimates of river inflows and drainage discharges are used for each of the DW project alternatives.

Confirmation of Salinity Simulations Performed Using the RMA and DeltaDWQ Models

The following sections summarize observed historical Delta salinity patterns. The sections also compare observed and simulated values to describe confirmation of the RMA and DeltaDWQ model simulations of Delta salinity conditions with historical inflows and exports. A similar method was used in the 2000 REIR/EIS to confirm the results of simulated Delta conditions; see the section from the 2000 REIR/EIS below entitled "Simulated Delta Water Quality for the No-Project Alternative".

The RMA model confirmation, performed through comparison between simulations of historical monthly average Delta salinity conditions and measured historical EC data for 1968-1991, is described in detail in Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project". The DeltaDWQ estimates are compared with the historical EC data for 1968-1991 at the four locations selected for impact assessment.

Historical EC data are missing for some periods; Table B2-1 in Appendix B2 provides a statistical summary of the historical EC data and the model results. The following discussion is based on graphical summaries, rather than statistical summaries, to demonstrate the correspondence between simulation results and general patterns of data.

Chipps Island (Pittsburg). Figure 3C-9 shows the measured monthly average EC at Pittsburg (near Chipps Island) for 1968-1991 and the RMA model EC simulations and DeltaDWQ model EC estimates for historical Delta inflows, outflows, and exports. The RMA model simulations and the DeltaDWQ estimates of EC match the measured monthly average EC values relatively well. The negative exponential relationship with effective Delta outflow is generally confirmed. Some of the scatter in the monthly average EC data may be attributed to uncertain monthly outflow estimates, and some scatter may be caused by monthly averaging of EC during periods of large EC changes. The scatter is largest during periods of low Delta outflow, when salinity intrusion effects are greatest.

EC values at Chipps Island increase above 3 mS/cm at an effective outflow of about 10,000 cfs. Chipps Island has EC values that are within the entrapment zone (5-15 mS/cm) for flows between 3,500 cfs and 7,500 cfs. Both the RMA model and the DeltaDWQ estimates provide adequate simulations of Chipps Island historical EC patterns. The response of EC at Chipps Island to changes in Delta outflow caused by DW project operations can be adequately simulated with the DeltaDWQ estimates based on DeltaSOS calculations of effective Delta outflow.

Emmaton. Figure 3C-10 shows the measured monthly average EC at Emmaton for 1968-1991 and the RMA model EC simulations and DeltaDWQ model EC estimates for historical Delta inflows, outflows, and exports. The RMA model simulations and the DeltaDWQ estimates of EC match the measured monthly average EC values relatively well. The negative exponential relationship with effective Delta outflow is generally confirmed. Some of the scatter in the measurements may be attributed to uncertain monthly outflow estimates, and some scatter may be caused by monthly averaging of EC during periods of large outflow changes.

EC values at Emmaton increase above 3 mS/cm at an effective outflow of about 3,000 cfs. Emmaton has EC values that are within the entrapment zone (5-15 mS/cm) only for flows of less than about 2,000 cfs (not allowed under the 1995 WQCP objectives). Both the RMA model and DeltaDWQ estimates provide adequate simulations of Emmaton historical EC patterns. The response of EC at Emmaton to changes in Delta outflow caused by DW project operations can be adequately simulated with the DeltaDWQ estimates based on DeltaSOS calculations of effective Delta outflow.

Jersey Point. Figure 3C-11 shows the measured monthly average EC at Jersey Point for 1968-1991 and the RMA model EC simulations and DeltaDWQ model EC estimates for historical Delta inflows and exports. The RMA model simulations and the DeltaDWQ estimates of EC match the measured monthly average EC values relatively well. The negative exponential relationship with effective Delta outflow is generally confirmed. Some of the scatter in the measurements may be attributed to uncertain monthly outflow estimates, and some scatter may be caused by monthly averaging of EC during periods of large outflow changes.

EC values at Jersey Point increase above 3 mS/cm at an effective outflow of about 2,500 cfs. During 1967-1991, Jersey Point had no measured monthly average EC values within the entrapment zone (greater than 5 mS/cm). Both the RMA model and DeltaDWQ estimates provide generally accurate simulations of Jersey Point historical EC patterns. The response of EC at Jersey Point to changes in Delta outflow caused by DW project operations can be adequately simulated with the DeltaDWQ estimates based on DeltaSOS calculations of effective Delta outflow.

Delta Exports. Figure 3C-12 shows the measured monthly average EC at the CCWD Rock Slough intake for 1968-1991 and the RMA model EC simulations and DeltaDWQ model EC estimates for historical Delta inflows and exports. The RMA model simulations and the DeltaDWQ estimates of EC match the measured monthly average EC values relatively poorly for the CCWD diversions compared with the other stations. The negative exponential relationship with effective Delta outflow is generally confirmed at low Delta outflow. Some of the scatter in the CCWD EC measurements may be attributed to uncertain monthly outflow estimates, and some scatter may be caused by monthly averaging of EC during periods of large outflow changes. The effects of San Joaquin River inflows and local agricultural drainage on CCWD EC measurements are also likely causes for some of the differences between measured and simulated EC values at the CCWD diversion. Appendix B2 gives a more complete discussion of the differences between CCWD and Old River EC measurements (see Figure B2-16).

The monthly average EC value for CCWD diversions has never been greater than 1.5 mS/cm. Both the RMA model and DeltaDWQ estimates provide similar estimates of CCWD historical EC patterns. The deviations between simulated and measured EC at the CCWD diversion are likely caused by local agricultural drainage or tidal gate failures in Sand Mound Slough; the salinity intrusion effects follow those simulated for and observed at Jersey Point. Therefore, the response of EC at the CCWD location (and other export locations) to changes in Delta outflow caused by DW project operations can be adequately simulated with the DeltaDWQ estimates based on DeltaSOS calculations of effective Delta outflow.

Figure 3C-13 shows the measured monthly average Cl^- concentration at the CCWD diversion for 1968-1991 and the RMA model and DeltaDWQ Cl^- estimates for historical Delta inflows and exports. The CCWD diversions are assumed to be similar to other southern Delta export locations (Cl^- measurements are not available from other export locations). The RMA model and DeltaDWQ estimates of Cl^- concentrations match the measured monthly average Cl^- concentrations relatively well, although there is considerable deviation from measured Cl^- concentrations in many months. The negative exponential relationship with effective Delta outflow is generally confirmed at low Delta outflow. Some of the scatter in the measurements may be attributed to uncertain monthly outflow estimates, and some scatter may be caused by monthly averaging of Cl^- during periods of large outflow changes. The effects of San Joaquin River inflows and local agricultural drainage on CCWD Cl^- measurements are also likely causes for some of the differences between measured and simulated Cl^- concentrations.

The monthly average Cl^- concentration at CCWD diversions has never been greater than 300 mg/l. Both the RMA model and the DeltaDWQ estimates provide generally similar simulations of CCWD historical Cl^- patterns as a function of effective Delta outflow. The deviations between simulated and measured Cl^- at the CCWD diversions is likely caused by local agricultural drainage or tidal gate failures in Sand Mound Slough; the salinity intrusion effects follow those simulated and observed at Jersey Point. Therefore, the response of Cl^- at the CCWD diversion (and other export locations) to changes in Delta outflow caused by DW project operations can be adequately simulated with the DeltaDWQ estimates based on DeltaSOS calculations of effective Delta outflow.

Simulated Water Quality for the No-Project Alternative

Possible impacts of the DW project alternatives are compared with Delta water quality conditions represented as the No-Project Alternative. The No-Project alternative is simulated with DWRSIM and DeltaSOS, as described in Chapter 3A, "Water Supply and Water Project Operations", to represent likely Delta conditions that would result from a repeat of the historical hydrologic sequence, but with existing water project facilities (reservoirs, diversions, and canals) and with current levels of demands for upstream diversions and Delta exports. Delta conditions are assumed to be controlled by objectives of the 1995 WQCP and other applicable water rights, agreements, and requirements.

No-Project Alternative conditions and historical conditions are different because of the differences in upstream reservoir operations and diversions, Delta standards and requirements, and demands for Delta exports. The comparison between salinity levels simulated for the No-Project Alternative and simulated for historical conditions are presented here to provide a reference for describing the No-Project Alternative as estimated with DeltaDWQ for impact assessment purposes. The previous section of this chapter has described the differences between measured EC and simulated historical EC.

Simulated EC or Cl^- for the No-Project Alternative and for historical Delta outflows at the four locations selected for impact analysis are shown to demonstrate the simulated similarities between the No-Project Alternative and simulated historical conditions. Differences in inflow, export, and outflow between these simulated cases are shown in Appendix B1. Appendix B2 describes the comparison of simulated historical and No-Project Alternative salinity in detail. The purpose here is to better understand conditions under the No-Project Alternative as the basis for impact assessment. Simulated historical conditions are used so that the natural variability in measured EC and Cl^- is removed from the comparisons.

Simulated Electrical Conductivity at Chipps Island. Figure 3C-14 shows simulated patterns of EC at Chipps Island for 1968-1991 for the No-Project Alternative and for historical Delta outflow.

During periods of high Delta inflow, salts at Chipps Island are flushed and salinity becomes similar to river inflow EC (assumed to be 150 FS/cm). During periods of low Delta inflow, outflow is often controlled by required minimum outflow objectives or salinity standards. Some monthly values differ between the two cases, but the maximum seawater intrusion (during periods of lowest Delta outflow) simulated for each year under the No-Project Alternative is generally similar to EC simulations based on historical outflows, as shown by the peak values of EC simulated for Chipps Island. The maximum monthly EC value for Chipps Island was about 16,000 FS/cm for the simulated No-Project Alternative. The maximum monthly simulated EC values were slightly lower for the No-Project Alternative than for historical conditions because the simulated minimum Delta outflow for the No-Project Alternative required under the 1995 WQCP objectives was higher than historical outflows.

Simulated Electrical Conductivity at Emmaton. The lower panel of Figure 3C-14 shows simulated patterns of EC at Emmaton for 1968-1991 for historical Delta outflows and for the No-Project Alternative outflows. Simulated peak EC values for the No-Project Alternative outflows were generally lower than for historical conditions at Emmaton because of higher simulated minimum Delta outflows for the No-Project Alternative. Some years had higher EC for the No-Project Alternative. The simulated maximum EC values for Emmaton for the No-Project Alternative were about 5,000 FS/cm, less than the maximum simulated historical EC values at Emmaton of about 7,000 FS/cm. The reduced peak EC values for the No-Project Alternative are the result of minimum Delta outflows simulated under the No-Project Alternative being higher than historical outflows because of the 1995 WQCP objectives.

Simulated Electrical Conductivity at Jersey Point. Figure 3C-15 shows simulated patterns of EC at Jersey Point for 1968-1991 for historical Delta outflows and for the No-Project Alternative outflows. Simulated peak EC values were generally lower for the No-Project Alternative than for the historical conditions at Jersey Point because simulated minimum Delta outflows for the No-Project Alternative were higher than historical outflows because of the 1995 WQCP outflow objectives.

Simulated values for the No-Project Alternative were lower than simulated values for historical conditions during several months at the ends of many of the water years with greatest seawater intrusion. For such years, Delta outflow values for the No-Project Alternative as simulated by DeltaSOS to satisfy the 1995 WQCP objectives were greater than historical Delta outflow values. The simulated maximum EC values for the No-Project Alternative at Jersey Point of about 3,000 FS/cm were less than the maximum simulated EC values for historical outflows of about 4,000 FS/cm.

Simulated Chloride Concentrations of Delta Exports. Figure 3C-15 also shows the patterns of Cl^- concentration in Delta exports simulated for 1968-1991 for historical Delta outflows and for the No-Project Alternative outflows. Maximum simulated Cl^- concentrations in Delta exports were sometimes lower for the No-Project Alternative than for historical conditions because of higher simulated minimum Delta outflows for the No-Project Alternative.

Seawater intrusion effects are much less pronounced in Delta exports than at Jersey Point because Sacramento River diversions through the DCC and Georgiana and Threemile Sloughs into the central Delta mix with tidal flows from the lower San Joaquin River to produce relatively freshwater conditions in Delta exports. In addition to seawater intrusion episodes, other fluctuations in simulated Cl^- concentrations in Delta exports are caused by variations in San Joaquin River inflow and agricultural drainage effects. These effects are included in the DeltaDWQ estimates of Delta export Cl^- concentrations.

Simulated Concentrations of Dissolved Organic Carbon and Trihalomethanes in Delta Exports for the No-Project Alternative. Monthly export concentrations of DOC were estimated for the 1995 DEIR/EIS using the DeltaDWQ model (Appendix C4, “DeltaDWQ: Delta Drainage Water Quality Model”). THM concentrations in treated drinking water were estimated on a monthly basis using the EPA WTP model (Appendix C5, “Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water”).

Figure 3C-16 shows simulated monthly values for DOC concentrations in Delta exports and for THM concentrations in Delta exports treated as drinking water for 1968-1991 under the No-Project Alternative. The simulated DOC concentrations were highest in winter as a result of rainfall drainage and salt leaching from the agricultural islands. Many of the simulated peak DOC concentrations each year exceeded 5 mg/l. Simulated DOC concentrations in the remainder of the year were generally between 3 mg/l and 5 mg/l. Simulated DOC and THM concentrations for historical Delta inflows and exports are also shown.

The THM concentrations for treated (chlorinated) drinking water from Delta exports simulated for the No-Project Alternative fluctuated between about 30 Fg/l and 125 Fg/l. High DOC concentrations simulated in the winter drainage period contributed to increased THM concentrations. Elevated summer temperatures necessitate higher chlorination doses for treatment and result in highest THM concentrations. Because THM drinking water standards are based on annual averages (as described in the next section), the 12-month moving average pattern of simulated THM concentrations is shown in Figure 3C-16 for the No-Project Alternative.

Measures of Potential Water Quality Impacts and Criteria for Determining Impact Significance

The selected water quality impact assessment variables and the methods that were used to evaluate potential impacts of DW operations on each impact assessment variable are described below and identified in Table 3C-5. The significance criteria developed for each variable (as described in this section) and the location for assessing each variable are also identified.

The significance criteria used in the 2000 REIR/EIS are identical to those used in the 1995 DEIR/EIS except that the THM criterion has been updated in response to changes in the federal DBP rules; see the section from the 2000 REIR/EIS below entitled “Criteria for Determining Impact Significance”.

The impact significance criteria for water quality variables that have regulatory objectives or numerical standards, such as those contained in the 1995 WQCP, are developed from the following general considerations:

- Numerical water quality objectives have been established to protect beneficial uses, and therefore represent concentrations or values that should not be exceeded; violation of the limits would be significant.

- Natural variability caused by tidal flows, river inflows, agricultural drainage, and biological processes in the Delta channels is sometimes quite large relative to the numerical standards or mean values of water quality variables.

- Changes in water quality variables that are greater than natural variations, but are within the limits established by numerical water quality objectives, may cause potential significant impacts; a criterion for determining significant changes is necessary.

For variables with numerical water quality criteria, the numerical limits are assumed to adequately protect beneficial uses and provide the basic measure of an allowable limit that will adequately protect beneficial uses. Because it is assumed that there are benefits in maintaining water quality that is better than that specified by the numerical water quality criteria, a significance criterion is established at 90% of the specified water quality limit. Increases in a water quality variable resulting in exeedence of 90% of the numerical standard at a location is considered a significant water quality impact. Variables without numerical limits would not have a maximum significance criterion.

Natural variability is difficult to describe with a single value, but it is assumed that 10% of the specified numerical criterion (for variables with numerical criteria) or 10% of the mean value (for variables without numerical criteria) would be a reasonable representation of natural variability that would be expected to occur without causing a significant impact. Measurement errors and modeling uncertainties are likewise assumed to be about 10% of the measured or modeled values. Simulated changes that are less than 10% of the numerical criterion or less than 10% of the measured or simulated mean value of the variable would not be considered significant water quality impacts because the simulated change would not be greater than natural variability and model uncertainty.

A second significance criterion is based on the assumption that some changes may be substantial in comparison with natural variability of the water quality variable, and could result in significant impacts. Because the change in water quality that should be considered substantial is not known, judgment must be applied to establish an appropriate significance threshold. Based on professional experience, the second significance criterion has been selected to be 20% of the numerical limits (for variables with numerical limits), or 20% of the mean value (for variables without numerical limits). It is assumed that this 20% change criterion would prevent relatively large changes that may have potentially significant impacts on beneficial uses.

The selected 20% change significance criterion is a relatively simple rule that is used in this impact assessment for all water quality variables. However, it may be determined that some beneficial uses are more sensitive to specific water quality variables than to others, and that other significance criteria should be applied. Because the proposed mitigation measure for all water quality variables is to limit the estimated effects of DW operations on water quality so that they remain less than the specified significance criterion (90% of limit and 20% change), the significance criterion used for impact significance can be adjusted, as appropriate, in the terms and conditions of the water right permits and in the mitigation measures and monitoring plan required by the lead agencies.

Criteria for Electrical Conductivity and Chloride

EC and Cl^- concentrations are directly controlled by existing (1995 WQCP) Delta objectives for agricultural, fishery, and water supply uses and Suisun Marsh standards for estuarine and fish and wildlife habitat uses. Current (1995 WQCP) Delta EC and Cl^- objectives vary with month and water-year type. The 1995 WQCP objectives only apply for some months and at some locations. The applicable objectives for Cl^- are either 150 mg/l or 250 mg/l at the three south Delta export locations (CCWD Rock Slough, SWP Banks, and CVP Tracy). Applicable EC objectives are specified for Chipps Island, Emmaton, Jersey Point, and the export locations. Significance criteria for EC and Cl^- may therefore be different for each month at each Delta location

Increases in EC values and Cl^- concentrations resulting in exceedance of 90% of these standards at specified locations in the Delta are considered to be significant water quality impacts. Changes in EC values and Cl^- concentrations are also considered to be significant if they exceed 20% of the applicable objective.

The selected thresholds for impact significance for EC values and Cl^- concentrations (see Table 3C-5) may vary with month and water-year type at locations with applicable Delta objectives. For example, estuarine EC objectives specified in the 1995 WQCP are applicable at Chipps Island during several months (February to June of some years). The minimum applicable EC objective at Chipps Island is about 2,400 FS/cm (corresponding to the 2-ppt salinity location [X2] at Chipps Island). The 1995 WQCP agricultural objectives for EC, ranging from 450 FS/cm to 2,200 FS/cm, are applicable at Jersey Point from April through August 15. Similar EC objectives are applicable at Emmaton. The 1995 WQCP contains an EC objective for Delta exports of 1,000 FS/cm for all months.

The selected significance threshold of a 20% change relative to the EC objective also applies at these locations. For Chipps Island, the threshold of 20% change is equivalent to an allowable increase of 520 FS/cm when the 2,600-FS/cm estuarine objective is applicable. At Emmaton and Jersey Point, the threshold of 20% change is equivalent to an allowable increase of 90 FS/cm when the 450-FS/cm EC objective is applicable. The threshold of a 20% change is equivalent to an allowable increase of 200 FS/cm in Delta exports.

The 1995 WQCP includes Cl^- objectives that apply at the three export locations. The Cl^- objective at the CCWD intake is 150 mg/l for some portion of each water-year type, and 250 mg/l for the remainder of the year. The applicable Cl^- objective at the other export locations is 250 mg/l. The selected significance criteria of 90% of the Cl^- objective (i.e., 135 mg/l or 225 mg/l) and a 20% change relative to the objective (i.e., 30 mg/l or 50 mg/l) applies at these locations.

Bromide Criteria

Although Br^- concentrations are generally correlated with Cl^- concentrations, no water quality objectives apply to Br^-. The bromide-to-chloride ratio (Br^-/Cl^-)of 0.0035 in seawater and San Joaquin River water indicates that a Cl^- concentration of 150 mg/l (the lowest Cl^- objective for water supply) corresponds to a Br^- concentration of about 0.5 mg/l (150 mg/l % 0.0035 = 0.525 mg/l). An increase in Br^- of 0.1 mg/l would correspond to a 20% increase relative to the equivalent Cl^- concentration at the applicable Cl^- objective of 150 mg/l. For a 250-mg/l Cl^- objective, the 20% increase in Br^- concentration would be about 0.175 mg/l. Therefore, increases in Br^- concentrations in Delta exports exceeding 0.1 mg/l are considered to be significant water quality impacts. Field monitoring of Cl^- concentrations can be used to estimate the Br^- concentration for mitigation purposes. Mitigation for Cl^- would also control Br^-.

Criteria for Dissolved Organic Carbon

DOC concentrations in the Delta exhibit relatively large fluctuations (see Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data"). Although no water quality objectives apply to DOC concentrations, criteria for DOC can be determined from average data on Delta DOC and the estimated effects of DOC concentrations on THM concentrations in treated drinking water (see Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water"). Increases in export DOC of more than 20% of the mean DOC concentration (5 mg/l), or about 1 mg/l, are considered to be significant water quality impacts. DOC concentrations can be reliably estimated using UVA field measurements for mitigation monitoring purposes (see Appendix C3, "Water Quality Experiments on Potential Sources of Dissolved Organics and Trihalomethane Precursors for the Delta Wetlands Project"). Because THM standards involve annual average criteria, the estimated export DOC increases might also be averaged for purposes of mitigation monitoring compliance.

Trihalomethane Criteria

The EPA standard for THM concentrations in drinking water was specified at 100 Fg/l when the 1995 DEIR/EIS was being prepared; the standard was subsequently changed to 80 Fg/l. THM concentrations vary season-ally because of DOC and temperature variations. Therefore, averages of quarterly or monthly samples are used for EPA compliance monitoring. An increase in THM resulting in a concentration of more than 90% of the EPA standard of 100 Fg/l (as simulated on a monthly average basis) or an increase of more than 20% of the standard, or 20 Fg/l, was considered to be a significant impact in the 1995 DEIR/EIS analysis. Because the THM criterion is an annual average value, simulated monthly THM concentrations might be averaged for purposes of mitigation monitoring compliance.

DW discharges would likely be exported for only a few months during a year. The increase in monthly THM concentrations resulting from DW discharges would therefore not be expected to increase the annual average THM concentrations substantially. THM concentrations can be estimated based on field monitoring of UVA measurements from Delta channels and stored water and the simulated relationship between the UVA of raw water and expected THM concentrations in treated water, as described in Appendix C3.

Other Water Quality Criteria

Temperature, SS, DO, and chlorophyll are considered to be highly transient variables exhibiting significant daily or hourly fluctuations that cannot be predicted quantitatively in this water quality assessment. These variables cannot be quantitatively assessed because DW project operations are simulated based on average monthly flows and modeling techniques are not available to reliably simulate patterns of these variables.

The water quality impacts of these variables, however, can be assessed qualitatively. The following significance criteria for these other water quality variables are based on their observed fluctuations in the Delta (DWR 1989). Mitigation monitoring to compare DW discharge water quality with channel water quality should be required.

Temperature. In the 1995 DEIR/EIS analysis of project impacts on fisheries (see Chapter 3F, "Fishery Resources"), increases of more than 1ºF in water temperatures in channels near DW project discharge locations, when channel temperature exceeds 60ºF, were considered significant impacts requiring mitigation. The biological opinions issued in 1997 and 1998 by NMFS, USFWS, and DFG specify the temperature criteria and monitoring methods considered appropriate for protecting fish resources.

Suspended Sediments. SS concentrations in Delta channels typically average approximately 15 mg/l, and standard deviations are typically 50% of the mean value (DWR 1989). Therefore, increases in channel SS concentrations of more than 20% of the channel SS concentration are considered significant impacts that must be mitigated. The SS criteria and appropriate monitoring methods would be specified by SWRCB.

Dissolved Oxygen. DO concentrations in Delta channels are normally near saturation values that range from about 11.5 mg/l at 10ºC to about 8.5 mg/l at 25ºC. Diurnal variations in DO caused by algal photosynthesis often exceed 1 mg/l. Based on fish response to water low in DO (i.e., less than 5 mg/l), decreases in channel DO concentrations of more than 20% or resulting in DO concentrations below 5 mg/l are considered significant impacts that must be mitigated. The DO criteria and appropriate monitoring methods would be specified by SWRCB.

Chlorophyll. Chlorophyll concentrations in Delta channels average about 10 Fg/l on an annual basis (DWR 1989). In spring and summer, however, chlorophyll concentrations often exceed 20 Fg/l, with maximum values greater than 50 Fg/l during phytoplankton "blooms". Chlorophyll concentrations can be estimated in the field with calibrated fluorometric monitors. Based on available data on chlorophyll in south Delta channels, increases of more than 20% in channel chlorophyll concentrations are considered significant impacts that must be mitigated. The chlorophyll criteria and appropriate monitoring would be specified by SWRCB.

Pollutant Contamination

Another water quality variable that cannot be quantitatively predicted in this water quality assessment is pollutant contamination. The DW project islands contain several sites of potential soil contamination caused by historical agricultural operations or waste disposal. These sites potentially could release pollutants into water stored on the reservoir islands at concentrations that might exceed water quality standards. Contamination of stored water exceeding applicable water quality standards is considered a significant impact that would be prevented through mitigation.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

As defined in the 1995 DEIR/EIS, Alternative 1 involves potential year-round diversion and storage of surplus water on Bacon Island and Webb Tract (reservoir islands). Bouldin Island and Holland Tract (habitat islands) would be managed primarily as wildlife habitat.

It was assumed that under Alternative 1, DW diversions could occur in any month with surplus flows. In DeltaSOS modeling, it is assumed that discharges of water from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and the 1995 WQCP "percent inflow" export limits do not prevent use of that capacity. Such unused capacity would exist when the amount of available water (i.e., total inflow less Delta channel depletion and Delta outflow requirements) is less than the amount specified by the export limits, or when pumping capacity is not being used for other reasons.

Water would be diverted to the reservoir islands (238-TAF water storage capacity) at a maximum average monthly diversion rate of 4,000 cfs, which would fill the two reservoir islands in one month. The maximum initial daily average diversion rate would be 9,000 cfs during several days when siphoning of water onto empty reservoirs begins; at this time, the maximum head differential would exist between island bottoms and channel water surfaces. The maximum initial daily average discharge rate would be 6,000 cfs, but the maximum monthly average discharge rate is assumed to be 4,000 cfs, allowing the two reservoir islands to empty in one month.

For the 2000 REIR/EIS, project operations under Alternative 1 were revised by the FOC terms and RPMs. The FOC terms specify the allowable timing and magnitude of project diversions for storage and discharges for export or outflow. See Chapter 2, "Delta Wetlands Project Alternatives", and Chapter 3A, "Water Supply and Water Project Operations", for more information.

Delta Salinity Conditions (Electrical Conductivity, Chloride, and Bromide)

Water quality impacts of salinity increases were assessed for four selected locations in the Delta: Chipps Island, Emmaton, Jersey Point, and Delta exports (representative of the CCWD Rock Slough intake, the SWP Banks Pumping Plant, and the CVP Tracy Pumping Plant). Impacts were measured based on changes in EC values and Cl^- concentrations from the values simulated for the No-Project Alternative. The monthly results for the 1968-1991 period simulated for the 1995 DEIR/EIS are shown in Table B2-2 in Appendix B2.

DW project diversions would potentially occur during months with relatively high Delta outflows, when EC values in the Delta are low. Because DW discharges and export of DW discharges would not change Delta outflow, effects of DW discharges on Delta EC would be minor. DW discharge salinity may be less than export salinity, creating a small water quality benefit.

Chipps Island

Figure 3C-17 shows the monthly EC values for Alternative 1 at Chipps Island and the changes from the monthly EC values for the No-Project Alternative for 1968-1991 as simulated for the 1995 DEIR/EIS. Appendix B2 (Table B2-2) gives the monthly results for the 1968-1991 simulations. DWRSIM results that were used in the DeltaSOS simulations required Delta outflows that would constrain DW project operations to satisfy applicable 1995 WQCP objectives for outflow and EC. Thus, simulated DW operations would not have caused significant adverse impacts by exceeding the applicable EC standards for Chipps Island. Some of the simulated EC values may have exceeded the 90% significance criterion because this criterion was not included in the DeltaSOS simulations. The selected significance criterion for change (20% of the applicable maximum EC limit) may also have been violated, because it was not included in the DeltaSOS simulations.

Table 3C-6 shows an example of the procedure that should be used to determine significant water quality impacts of DW project operations, which would require mitigation of reducing DW project operations to comply with the selected significance criteria, as specified in DW mitigation requirements. Table 3C-6 shows changes in EC at Chipps Island simulated to result from operations under Alternative 1 for the 1922-1991 period, compared with the selected monthly significance criteria for Chipps Island. The significance criteria depend on the applicable EC objective, which may change with month or with year type or runoff conditions, as specified in the 1995 WQCP.

Significance criteria for Chipps Island were estimated from the 1995 WQCP minimum outflow objectives, using the relationship between effective Delta outflow and EC at Chipps Island (Figure 3C-9). These outflow objectives may vary for some water-year types. Once the equivalent EC objective is determined, the significance criteria are estimated as 90% and 20% of the maximum EC limit.

The applicable estuarine salinity (X2) objective for Chipps Island for February to June (of some years) requires an effective outflow of 11,400 and is equivalent to an EC value of about 2,600 FS/cm. However, for some months with lower runoff, the estuarine salinity objective is at Collinsville (requiring an effective outflow of 7,100 cfs), and the Chipps Island EC value would be approximately 5,000 FS/cm (Figure 3C-9). During most other months, the required Delta outflow is between 3,000 cfs and 4,500 cfs, corresponding to EC values of between 10,000 FS/cm and 14,000 FS/cm. These designated monthly significance criteria for Chipps Island are therefore approximate, and may not accurately reflect the applicable standard in each year of simulated operation.

Significant water quality impacts of DW operations will occur only during months for which DW diversions are simulated. Table 3C-6 evaluates significant impacts at Chipps Island for September through March, which are the only months in the 1995 DEIR/EIS simulations with DW diversions of more than 500 cfs (Table B2-2). Most DW diversions are simulated for October-January. In October, DW diversions of greater than 500 cfs were simulated for 16 years of the 70-year (1922-1991) simulation period. The 90% criterion of 9,900 FS/cm was never exceeded, but changes in EC of more than the 20% change criterion of 2,200 FS/cm were simulated in 8 of the years. These changes in EC were considered significant. Similar results were determined for November and September. Very few significant changes were simulated in December through March. During these months, the simulated outflows were higher and the changes in EC caused by DW diversions were correspondingly lower. No significant changes were shown for April through August because DW diversions were not simulated for these months under Alternative 1.

The determination of significant EC changes at Chipps Island shown in Table 3C-6 is based on the monthly simulation results and approximate significance criteria estimated from the outflow objectives. These results are presented to illustrate the method for determining significant impacts. Mitigation requirements to be specified by the EIR/EIS lead agencies would incorporate all applicable EC objectives and anticipated DW operations, as estimated with daily flows and appropriate averaging periods (see Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments"). Mitigation monitoring would incorporate both field measurements and calculations of likely effects because EC monitoring and other water quality measurements would be affected once DW begins operations. Impacts would be estimated based on changes from the conditions estimated for the No-Project Alternative from the monitoring measurements.

For some months at Chipps Island, simulated EC values were lower for Alternative 1 than for the No-Project Alternative (see Table B2-2 in Appendix B2). These reductions in EC values would occur because agricultural diversions for irrigation on the DW project islands would be reduced and Delta outflow would be slightly increased.

The project effects on Chipps Island EC that were reported in the 2000 REIR/EIS are less than those reported above from the 1995 DEIR/EIS. As a result of incorporation of the FOC terms into proposed project operations, none of the simulated changes in EC at Chipps Island were found to exceed the significance criterion. Therefore, this impact was determined to be less than significant. See the section from the 2000 REIR/EIS entitled "Impacts of the Proposed Project" below.

Emmaton

Figure 3C-17 also shows the monthly EC values for Alternative 1 at Emmaton and the changes from the monthly EC values for the No-Project Alternative for 1968-1991 as simulated for the 1995 DEIR/EIS. Applicable EC objectives for Emmaton for April to August range from 450 FS/cm to 2,780 FS/cm, depending on water-year type. DWRSIM results that were used in the DeltaSOS simulations required Delta outflows that would constrain DW project operations to correspond with the applicable objectives in each month of each water-year type. Thus, the simulated DW operations could not have caused significant adverse impacts by exceeding the applicable EC objectives for Emmaton. The only possible significant impacts would result from DW project operations exceeding the selected threshold of a 20% change.

Some of the simulated changes between Alternative 1 and the No-Project Alternative at Emmaton were greater than 90 FS/cm but did not occur during a month with applicable EC objectives for Emmaton. However, if a change in EC is greater than 20% of the applicable EC objective, the change in EC would be considered a significant impact at Emmaton and would require mitigation. Mitigation requirements would be similar to those discussed above for Chipps Island.

For some months at Emmaton, simulated EC values were lower for Alternative 1 than for the No-Project Alternative. These reductions in EC values would occur because agricultural diversions for irrigation on the DW project islands would be reduced and Delta outflow would be slightly increased. Simulated EC values were increased by simulated DW diversions during other months but did not exceed a significance criterion because there are no applicable EC objectives for Emmaton for those months.

Because the FOC terms now limit DW diversions, the changes in Emmaton EC values under simulated project operations presented in the 2000 REIR/EIS are less than those predicted in the 1995 DEIR/EIS and presented above. However, the new analysis concludes that DW project operations could still exceed the significance criterion of a 20% change. See the section from the 2000 REIR/EIS entitled "Impacts of the Proposed Project" below.

Jersey Point

Figure 3C-18 shows the monthly EC values for Alternative 1 at Jersey Point and the changes from the monthly EC values for the No-Project Alternative for 1968-1991 as simulated for the 1995 DEIR/EIS. Applicable EC objectives for Jersey Point for April to August range from 450 FS/cm to 2,200 FS/cm, depending on water-year type. DWRSIM results that were used in the DeltaSOS simulations required Delta outflows that would constrain DW project operations to correspond with the applicable objectives in each month of each water-year type. Thus, the simulated DW operations would not have caused significant adverse impacts by exceeding the applicable EC objectives for Jersey Point. The only possible significant impacts would result from DW project operations exceeding the selected threshold of a 20% change.

Some of the simulated changes between Alternative 1 and the No-Project Alternative at Jersey Point were greater than 90 FS/cm but did not occur during a month with applicable EC objectives for Jersey Point. However, if a change in EC is greater than 20% of the applicable EC objective, the change in EC would be considered a significant impact at Jersey Point and would require mitigation.

For some months at Jersey Point, simulated EC values for Alternative 1 were less than those for the No-Project Alternative. These reductions in EC values would occur because agricultural diversions for irrigation on the DW project islands would be reduced and Delta outflow would be slightly increased. Simulated EC values were increased by simulated DW diversions during other months but did not exceed significance criteria because there are no applicable EC objectives for Jersey Point for those months.

Because the FOC terms now limit DW diversions, the changes in Jersey Point EC values under simulated project operations presented in the 2000 REIR/EIS are less than those predicted in the 1995 DEIR/EIS and presented above. However, the new analysis concludes the project operations could still exceed the significance criterion of a 20% change. See the section from the 2000 REIR/EIS entitled "Impacts of the Proposed Project" below.

Delta Exports

Figure 3C-18 also shows the monthly Cl^- concentrations for Alternative 1 in Delta exports and the changes from the monthly Cl^- concentrations for the No-Project Alternative for 1968-1991as simulated for the 1995 DEIR/EIS. Monthly values are given in Table B2-2 for the 1968-1991 period. The applicable Cl^- objective for all Delta exports is 250 mg/l, with some periods of 150 mg/l required for CCWD diversions (depending on water-year type). DWRSIM results that were used in the DeltaSOS simulations required Delta outflows that would constrain DW project operations to correspond with the applicable objectives in each month of each water-year type. Thus, the simulated DW operations could not have caused significant adverse impacts by exceeding the applicable Cl^- objectives for CCWD (or other export locations). The only possible significant impacts would result from DW project operations exceeding the selected threshold of a 20% change.

Some of the simulated changes between Alternative 1 and the No-Project Alternative in Delta exports were greater than 30 mg/l but may not have occurred during a month with applicable 150-mg/l Cl^- objectives for CCWD. However, if a change in Cl^- is greater than 20% of the applicable Cl^- objective, the change in Cl^- would be considered a significant impact in Delta exports and would require mitigation. Because the 250-mg/l objective is applicable in all months, any increase in Delta export Cl^- concentration of greater than 50 mg/l or above the significance criterion of 225 mg/l would be considered a significant impact that would require mitigation.

For some months, simulated Delta export Cl^- concentrations for Alternative 1 were less than those for the No-Project Alternative. These reductions in Cl^- concentrations would occur because agricultural diversions for irrigation on the DW project islands would be reduced and Delta outflow would be slightly increased. Simulated Cl^- concentrations were increased during other months by simulated DW diversions that reduce Delta outflow, while some increased Cl^- concentrations were the result of DW discharges of water with relatively high Cl^- concentrations compared with southern Delta channel Cl^- concentrations. Figure 3C-18 indicates that no Cl^- changes of greater than 50 mg/l were simulated during the 1968-1991 period in the 1995 DEIR/EIS analysis.

The project effects on Delta export Cl^- reported in the 2000 REIR/EIS are less than those reported above from the 1995 DEIR/EIS. See the section from the 2000 REIR/EIS entitled "Impacts of the Proposed Project" below.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-1: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives. Implementation of Alternative 1 may cause reductions in Delta outflow during periods of DW project diversions. Outflow reductions could result in adverse impacts on salinity near Chipps Island. However, as a result of incorporation of the FOC terms into proposed project operations, simulated changes in EC at Chipps Island did not exceed the significance criteria in the 2000 REIR/EIS simulations. (See the section from the 2000 REIR/EIS below entitled "Impacts of the Proposed Project"). Therefore, this impact is considered less than significant.

Mitigation Measure C-1 was recommended in the 1995 DEIR/EIS to reduce potential project effects on salinity at Chipps Island. Because this impact is considered less than significant, no mitigation is required. However, the EIR/EIS lead agencies likely will require that DW monitor salinity effects of the project to demonstrate compliance with the FOC terms and Delta salinity standards. Therefore, Mitigation Measure C-1 is still recommended.

Mitigation Measure C-1: Restrict DW Diversions to Limit EC Increases at Chipps Island. DW shall obtain daily EC measurements for Chipps Island and calculate the change in EC attributable to scheduled DW diversions, and shall restrict daily diversions whenever the 90% maximum criterion or 20% change criterion would be exceeded. DW shall submit to SWRCB a monthly report of measured EC, estimated No-Project Alternative conditions, and calculated EC contribution from DW operations.

The estimated EC without DW diversions would be compared with the expected EC value produced by maximum possible DW diversions each day. Possible DW diversions would be restricted if the expected maximum effect on the Chipps Island EC value exceeded the selected significance criterion of an EC increase. The magnitude of the decrease in Delta outflow that would be allowable without this criterion being exceeded can be estimated by the approximate relationship between effective Delta outflow and EC at Chipps Island (Appendix B2, "Salt Transport Modeling Methods and Results for the Delta Wetlands Project"). DW diversions would be more restricted at lower Delta outflows to satisfy this mitigation condition.

Impact C-2: Salinity (EC) Increase at Emmaton. Implementation of Alternative 1 may cause reductions in Delta outflow during periods of DW project diversions that would significantly increase salinity near Emmaton. Although DW project operations under Alternative 1 would not violate established water quality objectives for Emmaton, changes in salinity (EC) may exceed 20% of the applicable objective during periods of low Delta outflow, as indicated by the simulation results. Therefore, this impact is considered significant.

Implementing Mitigation Measure C-2 would reduce Impact C-2 to a less-than-significant level.

Mitigation Measure C-2: Restrict DW Diversions to Limit EC Increases at Emmaton. DW shall obtain daily EC measurements for Emmaton and calculate the change in EC attributable to scheduled DW diversions, and shall restrict daily diversions whenever the 90% maximum criterion or 20% change criterion would be exceeded. DW shall submit to SWRCB a monthly report of measured EC, estimated No-Project Alternative conditions, and calculated EC contribution from DW operations.

The estimated EC without DW diversions would be compared with the expected EC value produced by maximum possible DW diversions each day. Possible DW diversions would be restricted if the expected maximum effect on the Emmaton EC value exceeded the selected significance criterion of an EC increase during periods with applicable EC objectives for Emmaton. The magnitude of the decrease in Delta outflow that would be allowable without this criterion being exceeded can be estimated by the approximate relationship between effective Delta outflow and EC at Emmaton (Appendix B2). DW diversions would be more restricted at lower Delta outflows to satisfy this mitigation condition.

Impact C-3: Salinity (EC) Increase at Jersey Point. Implementation of Alternative 1 may cause reductions in Delta outflow during periods of DW project diversions that would significantly increase salinity near Jersey Point. Although DW project operations under Alternative 1 would not violate established water quality objectives for Jersey Point, changes in salinity (EC) may exceed 20% of the applicable objective during periods of low Delta outflow. Therefore, this impact is considered significant.

Implementing Mitigation Measure C-3 would reduce Impact C-3 to a less-than-significant level.

Mitigation Measure C-3: Restrict DW Diversions to Limit EC Increases at Jersey Point. DW shall obtain daily EC measurements for Jersey Point and calculate the change in EC attributable to scheduled DW diversions, and shall restrict daily diversions whenever the 90% maximum criterion or 20% change criterion would be exceeded. DW shall submit to SWRCB a monthly report of measured EC, estimated No-Project Alternative conditions, and calculated EC contribution from DW operations.

The estimated EC without DW diversions would be compared with the expected EC value produced by maximum possible DW diversions each day. Possible DW diversions would be restricted if the expected maximum effect on the Jersey Point EC value exceeded the selected significance criterion of an EC increase during periods with applicable EC objectives for Jersey Point. The magnitude of the decrease in Delta outflow that would be allowable without this criterion being exceeded can be estimated by the approximate relationship between effective Delta outflow and EC at Jersey Point (Appendix B2). DW diversions would be more restricted at lower Delta outflows to satisfy this mitigation condition.

Impact C-4: Salinity (Chloride) Increase in Delta Exports. Implementation of Alternative 1 may cause reductions in Delta outflow during periods of DW project diversions that would cause increases in Cl^- concentrations. DW discharges of high-salinity water could also cause an adverse impact on salinity in Delta exports. However, as a result of incorporation of the FOC terms into proposed project operations, simulated changes in export Cl^- did not exceed the significance criteria in the 2000 REIR/EIS simulations. (See the section from the 2000 REIR/EIS below entitled "Impacts of the Proposed Project".) Therefore, this impact is considered less than significant.

Mitigation Measure C-4 was recommended in the 1995 DEIR/EIS to reduce potential project effects on salinity in Delta exports. Because this impact is considered less than significant, no mitigation is required. However, the EIR/EIS lead agencies likely will require that DW monitor salinity effects of the project to demonstrate compliance with the FOC terms and Delta salinity standards. Therefore, Mitigation Measure C-4 is still recommended.

Mitigation Measure C-4: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports. DW shall obtain daily Cl^- concentration measurements from CCWD Rock Slough intake and calculate the change in concentration attributable to scheduled DW diversions, and shall restrict daily diversions whenever the 90% maximum criterion or 20% change criterion would be exceeded. DW shall submit to SWRCB a monthly report of measured Cl^-, estimated No-Project Alternative conditions, and calculated Cl^- contribution from DW operations.

The estimated Cl^- concentration without DW diversions would be compared with the expected Cl^- value produced by maximum possible DW diversions each day. Possible DW diversions would be restricted if the expected maximum effect on Cl^- concentration of Delta exports exceeded the selected significance criterion of 30 mg/l or 50 mg/l or exceeded the 90% maximum criterion. The magnitude of the decrease in Delta outflow that would be allowable without this threshold being exceeded can be estimated by the approximate relationship between effective Delta outflow and EC at Chipps Island (Appendix B2). DW diversions would be more restricted at lower Delta outflows to satisfy this mitigation condition. Measurement of Cl^- concentration in DW storage water could be used to calculate expected Cl^- concentration in Delta exports with maximum DW discharges. DW discharges would be limited if necessary to avoid violation of the significance criteria.

Export Concentrations of Dissolved Organic Carbon

Water quality impacts resulting from increases in export DOC concentrations were assessed for Delta exports in the south Delta. Impacts were measured based on DOC concentrations for Alternative 1 and the change in DOC concentration from No-Project Alternative conditions, as simulated by the DeltaDWQ model for the 1995 DEIR/EIS analysis.

Figure 3C-19 shows monthly DOC concentrations for Alternative 1 and the changes from the No-Project Alternative DOC concentrations in Delta exports for 1968-1991 as simulated for the 1995 DEIR/EIS. Measurements of DOC from the Penitencia Water Treatment Plant for 1991 are shown for reference. The simulation results indicated that Alternative 1 would slightly reduce export DOC concentrations during many months without DW diversions or DW discharges. During these months, the amounts of DW island agricultural drainage containing relatively high DOC concentrations would be reduced under Alternative 1 compared with DOC concentrations expected under the No-Project Alternative. Slightly less agricultural drainage would be exported, and the export DOC concentrations would be slightly reduced. The monthly results are given in Table C5-3 in Appendix C5 for 1968-1991.

Simulated export DOC concentrations were also slightly decreased under Alternative 1 during months with DW diversions because DW diversions reduced the relative contribution of agricultural drainage and San Joaquin River inflow to Delta exports. DW diversions would require a greater contribution of Sacramento River inflow to Delta exports.

For example, during a month with approximately 12,000 cfs of export pumping and 3,000 cfs of agricultural drainage, the contribution of agricultural drainage in exported water would be about 25% (3,000/12,000). DW diversions of 3,000 cfs would increase the total diversions to 15,000 cfs, and thereby reduce the agricultural drainage contribution in exports to 20% (3,000/15,000). The agricultural drainage would be replaced by Sacramento River water. In this example, about 20% of the agricultural drainage would be diverted onto the DW reservoir islands.

The effects of Alternative 1 on export DOC concentrations during months with DW discharges for export would depend on the difference between the estimated DOC concentration in DW discharge and the DOC simulated for operations under the No-Project Alternative. For some months, the DeltaDWQ simulations indicated that DW discharges could increase the export DOC concentrations slightly.

The selected significance criterion for a change in export DOC concentration is 0.8 mg/l, 20% of the mean value (4 mg/l).

Table 3C-7 gives a summary of the changes in export DOC concentrations (from No-Project Alternative DOC concentrations) resulting from DW operations under Alternative 1 for 1967-1991, as simulated for the 1995 DEIR/EIS (see Appendix C5 for monthly results). The DeltaDWQ results are reported for each month as either increases in DOC concentration or decreases in DOC concentration. The number of months (out of 25) and the average change in DOC concentration are given for both increases and decreases. For example, the largest average monthly increase in DOC of 0.17 mg/l occurs in July. Increases in DOC during July were simulated in 15 years, with decreases simulated in 10 years. The five largest simulated changes, and the five greatest percentage changes (from No-Project Alternative values) are also shown for each month. The highest simulated DOC concentration change in July was 1.0 mg/l. All other simulated changes were less than 0.8 mg/l.

Table 3C-7 indicates that Alternative 1 caused only one month of simulated changes in export DOC concentrations from the No-Project Alternative DOC concentrations that were more than the selected significance criterion of 0.8 mg/l. Any simulated change in export DOC concentration of more than 0.8 mg/l was considered a significant impact that would require mitigation.

The 2000 REIR/EIS presented a revised analysis of project effects on DOC concentrations in Delta exports. The project effects on export DOC reported in the 2000 REIR/EIS are greater than those reported above from the 1995 DEIR/EIS. Results of the revised analysis conclude that the proposed project would result in a significant impact on export concentrations of DOC. See the discussion of export concentrations of DOC in the section from the 2000 REIR/EIS below entitled “Impacts of the Proposed Project”.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-5: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy). Discharges from the DW project islands may have relatively high DOC concentrations that may significantly increase DOC concentrations in Delta exports. Simulation results predict that in some months DOC increases would exceed 0.8 mg/l. Based on the selected significance criterion, these increases would be considered a significant impact.

Implementing Mitigation Measure C-5 would reduce Impact C-5 to a less-than-significant level.

Mitigation Measure C-5: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports. DW shall make measurement of DOC concentrations in stored DW project water and in channels receiving the DW discharge water and shall estimate the increase in export DOC that would result from maximum DW discharges. DW shall limit project discharges if this expected maximum effect on export DOC exceeds the selected significance criterion of an allowable change in export DOC concentration of 0.8 mg/l. DW shall submit to SWRCB a monthly report of DOC concentrations in water stored on the DW reservoir islands, DOC channel concentrations estimated for the No-Project Alternative, and DOC increases in Delta exports attributable to DW project operations.

The DOC measurements should be obtained using the best available monitoring equipment (which may now include field automated TOC analyzers) or could be obtained through conversion of field measurements of UVA using known relationships with DOC concentrations (Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data", and Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data").

Trihalomethane Concentrations in Treated Drinking Water

Impacts of increases in THM concentrations in treated drinking water caused by implementation of Alternative 1 were assessed based on simulated THM concentrations and changes from THM concentrations under the No-Project Alternative. Figure 3C-19 (lower panel) gives the monthly patterns of simulated THM concentrations in treated drinking water for Alternative 1 and the changes between the No-Project Alternative and Alternative 1 as simulated for the 1995 DEIR/EIS. Measurements of THM from the Penitencia Water Treatment Plant for 1991 are shown for reference.

Under the 1995 DEIR/EIS significance criteria, implementation of Alternative 1 would cause a significant adverse impact on THM levels in treated drinking water exported from the Delta if one of the following were exceeded because of DW project discharges:

- 90% of the THM objective for treated drinking water of 100 Fg/l (90 Fg/l) or
- an increase of THM concentration of more than 20% of the THM objective (20 Fg/l).

Figure 3C-19 indicates that in the 1995 DEIR/EIS simulations, the monthly THM concentrations under Alternative 1 were greater than 90 Fg/l only for 1977, and the changes in THM concentrations were always simulated to be less than 20 Fg/l. The monthly results for 1968-1991 are given in Table C5-3 in Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water".

Table 3C-8 gives a summary of the changes in THM concentrations in treated (chlorinated) export water (from No-Project Alternative THM concentrations) resulting from DW operations under Alternative 1 for 1967-1991, as simulated for the 1995 DEIR/EIS (see Appendix C5 for monthly results). The results from the EPA WTP model are reported for each month as either increases or decreases in DOC concentrations. The number of months (out of 25) and the average change in THM concentration are given for both increases and decreases. For example, the largest average monthly increase in THM of 3.21 Fg/l occurs in July. Increases occurred in 15 years, with decreases simulated in 10 years. The five largest simulated changes, and the five greatest percentage changes (from No-Project Alternative values) are also shown for each month. None of the simulated monthly changes were greater than 20 Fg/l.

The 1995 DEIR/EIS analysis found that under Alternative 1, THM concentrations would be reduced slightly in most months without DW discharges because agricultural drainage amounts from the DW islands would be reduced from amounts expected to be discharged under the No-Project Alternative. Agricultural drainage contains relatively high DOC concentrations that would be converted to THMs by chlorination of Delta export water.

The effects of Alternative 1 on THM concentrations during discharge and export of DW stored water would depend on changes in DOC concentration caused by implementation of the DW project and the temperature of the Delta export water. Temperature has a strong influence on the conversion of DOC to THM in the simulated water chlorination process (see Appendix C5).

Because of substantial monthly variations in THM concentrations, the EPA monitoring requirements allow monthly or quarterly THM samples to be averaged; at the time that the 1995 DEIR/EIS was being prepared, the THM objective was an annual average of 100 Fg/l. Because DW project discharges would occur for a limited period each year, the possible effects on annual average THM concentrations are much less than the increases attributable to increased DOC or Br^- concentrations during the discharge period. Therefore, the significance criteria for THM concentrations applied during periods of DW discharge is a worst-case approach that will reduce any possible increase in THM concentrations to a less-than-significant level.

The 2000 REIR/EIS presents a revised analysis of project effects on THM concentrations in treated drinking water. The analysis uses new methods to predict THM formation and updated significance criteria to reflect changes in the federal DBP rules to a standard of 80 Fg/l for treated drinking water. As concluded above, the project would result in exceedance of the 20% change threshold in some simulated months. Therefore, the impact is considered significant. See the discussion of project effects on THM concentrations in treated drinking water in the section from the 2000 REIR/EIS below entitled "Impacts of the Proposed Project from the 2000 Revised Draft EIR/EIS".

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-6: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, and CVP Tracy). Discharges from the DW project islands may have relatively high DOC concentrations that may result in increases in THM concentrations in treated (chlorinated) drinking water from the Delta export locations. This impact is considered significant.

Implementing Mitigation Measure C-6 would reduce Impact C-6 to a less-than-significant level. This measure has been revised since it was originally presented in the 1995 DEIR/EIS. As previously stated, the measure recommended restricting increases of more than 20% of the standard of 100 Fg/l (20 Fg/l) then in effect, or preventing concentrations from exceeding 90% of that standard (90 Fg/l). As now stated, the measure reflects the change in the standard to 80 Fg/l.

Mitigation Measure C-6: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater Than 72 Fg/l in Treated Delta Export Water. DW shall make daily estimates of DOC and Br^- concentrations in stored DW project water and in Delta channels receiving DW discharge water and predict THM increases likely to be caused by DW project discharges, and shall restrict discharges whenever the 20% change criterion would be exceeded. DW shall submit to SWRCB a monthly report of measured DOC and Br^- concentrations, estimated No-Project Alternative conditions, and calculated THM increases that could be attributable to DW operations.

The DOC measurements should be obtained using the best available monitoring equipment (which may now include field automated TOC analyzers) or could be obtained from the relationship between field measurements of UVA and DOC concentrations (see Appendix C1, "Analysis of Delta Inflow and Export Water Quality Data"). Br^- concentrations could be estimated from Cl^- measurements.

Estimates of THM increases likely to be caused by DW project discharges would be accomplished using the predictive relationships for DOC increases in export water described above for Mitigation Measure C-5. THM formation could then be predicted based on relationships among DOC, Br^-, temperature, and chlorination dose (see Appendix C5, "Modeling of Trihalomethane Concentrations at a Typical Water Treatment Plant Using Delta Export Water").

An allowable DW discharge flow would be estimated each day during an intended discharge period based on the relationships described above. The allowable DW discharge flow would be defined as the discharge rate that would not cause an increase in THM level in treated export water exceeding 16 Fg/l or a resulting THM concentration exceeding 72 Fg/l. Restricting DW discharges to avoid violation of the significance criterion would avoid significant adverse impacts on water quality of treated export water.

Changes in Other Water Quality Variables

Other water quality variables include temperature, SS, DO, and chlorophyll (Table 3C-5). Under Alternative 1, levels of these water quality characteristics will vary widely with daily fluctuations in conditions affecting them (e.g., DW storage volumes, weather patterns, flow characteristics, and water quality of receiving water for DW discharges).

The high variability typical of these parameters and the uncertainty regarding daily conditions that may coincide to produce adverse impacts do not allow a quantitative impact assessment to be performed. It is likely that conditions will occasionally combine under operation of Alternative 1 to produce impacts exceeding the significance criteria for these transient water quality variables. Habitat island discharges would be relatively small and are likely to have better water quality than agricultural drainage under the No-Project Alternative. The significance criteria and mitigation requirements for changes in these water quality variables would be determined by SWRCB and would be included in project operation permits.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-7: Changes in Other Water Quality Variables in Delta Channel Receiving Waters. Discharges of stored water from the DW reservoir islands may adversely affect channel water quality under some daily patterns of water quality conditions in the channel receiving waters and in the stored DW project water. For example, stored DW project water with a low DO level discharged at a high flow rate may decrease DO levels by more than 1 mg/l in a receiving Delta channel. Therefore, this impact is considered significant.

Implementing Mitigation Measure C-7 would reduce Impact C-7 to a less-than-significant level.

Mitigation Measure C-7: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality. DW shall monitor water quality variables in water stored on the reservoir islands during intended discharge periods and in Delta channel receiving waters, and shall limit discharges as needed to avoid significant adverse effects on levels of these variables in the receiving channels. DW shall submit to SWRCB a monthly report of measurements of variables in reservoir and channel water. It is possible that monitoring could be integrated with monitoring being performed under existing programs (e.g., IEP and MWQI), but DW would be required to monitor and report in any case.

Field measurements of the four selected variables could be obtained using the following techniques:

temperature - temperature probes,
SS - turbidity measurements,
DO - calibrated DO probes, and
chlorophyll - calibrated fluorometric monitors.

Levels of the four variables in stored water and receiving water would be related using the expected dilution ratio at each location of a DW discharge pumping station. The expected dilution ratio would be estimated based on channel flow rates and intended DW discharge rates using specified mixing-zone assumptions.

Effects of Pollutant Contaminants

Sites of potential soil contamination resulting from historical agricultural operations or waste disposal exist on the DW islands (Figure 3C-8).

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-8: Potential Contamination of Stored Water by Pollutant Residues. Water storage on the reservoir islands could mobilize soil contaminants at historical pollution sites. If the contaminant concentrations are sufficiently high, mobilization in the stored water may cause a significant adverse impact on stored water quality and on Delta channel water quality after DW discharges stored water. Therefore, this impact is considered significant.

Implementing Mitigation Measure C-8 would reduce Impact C-8 to a less-than-significant level.

Mitigation Measure C-8: Conduct Assessments of Potential Contamination Sites and Remediate as Necessary. DW shall conduct preliminary site assessments at potential contamination sites, in addition to those already performed for this analysis, including assessment of sites associated with agricultural airstrip operations. If the results of a preliminary site assessment indicate that contamination at a site is likely to contaminate stored water, DW shall initiate an appropriate site investigation to either rule out the site as a pollutant source or confirm the need for site cleanup or remediation. Such site assessments and remediation typically would be performed under the supervision of DHS. All required assessments and remediation would be completed prior to the beginning of DW project operations.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Alternative 2 represents DW operations with two reservoir islands (Bacon Island and Webb Tract) and two habitat islands (Bouldin Island and Holland Tract).

As defined in the 1995 DEIR/EIS, under Alternative 2, DW diversions could occur in any month with surplus flows, as under Alternative 1. In DeltaSOS modeling, it was assumed that discharges from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps. Under this alternative, it was assumed that export of DW discharges would be allowed in any month when such capacity exists and would not be constrained by the 1995 WQCP "percent inflow" export limits. Export of DW discharges would be limited by Delta outflow requirements and the permitted combined pumping rate of the export pumps but would not be subject to strict interpretation of the "percent inflow" export limit.

The maximum monthly average diversion rate to reservoir island storage would be 4,000 cfs (maximum initial daily average diversion rate of 9,000 cfs). The maximum monthly average discharge rate is assumed to be 4,000 cfs (maximum initial daily average discharge rate of 6,000 cfs).

For the 2000 REIR/EIS, project operations under Alternative 2 were revised by the FOC terms and RPMs. The FOC terms specify the allowable timing and magnitude of project diversions for storage and discharges for export or outflow. For more information, see Chapter 2, "Delta Wetlands Project Alternatives", and Chapter 3A, "Water Supply and Water Project Operations".

The impacts on water quality under Alternative 2 operations would be similar to impacts described for Alternative 1, but the frequency and severity of adverse impacts reported in the 1995 DEIR/EIS generally were higher because opportunities to export DW water would be increased. Figures 3C-20 and 3C-21 show the salinity variables for Alternative 2 as simulated for the 1995 DEIR/EIS. Figure 3C-22 shows the export DOC and treated drinking water THM concentrations for Alternative 2 as simulated for the 1995 DEIR/EIS. Tables B2-2 in Appendix B2 and C5-3 in Appendix C5 give the monthly values for Alternative 2 for 1968-1991.

Patterns of changes for all water quality variables between the No-Project Alternative and Alternative 2 are very similar to the changes for Alternative 1.

Mitigation monitoring would be required to prevent significant water quality impacts under Alternative 2. The mitigation measures proposed for Alternative 2 would be the same as those described above under "Impacts and Mitigation Measures of Alternative 1".

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. Diversions to the reservoir islands (406-TAF capacity) would be allowed during any month with available surplus flows. The diversion and discharge operations for Alternative 3 would be the same as for Alternative 2, but the assumed diversion and discharge rates are higher. The maximum average monthly diversion rate would be about 6,000 cfs, which would fill the four reservoir islands in about one month (maximum diversion rate of 9,000 cfs). The maximum monthly discharge rate is assumed to be 6,000 cfs (maximum discharge rate of 12,000 cfs).

The 2000 REIR/EIS did not address water quality effects of the project under Alternative 3 because the FOC and biological opinions apply only to a two-reservoir-island project. Therefore, the results for Alternative 3 are the same as those presented in the 1995 DEIR/EIS.

Delta Salinity Conditions (Electrical Conductivity, Chloride, and Bromide)

Water quality impacts of salinity increases were assessed for four selected locations in the Delta: Chipps Island, Emmaton, Jersey Point, and Delta exports (representative of the CCWD Rock Slough intake, the SWP Banks Pumping Plant, and the CVP Tracy Pumping Plant). Impacts were measured based on changes in EC values and Cl^- concentrations from the values simulated for the No-Project Alternative. The impacts on salinity under Alternative 3 would be similar to those from the 1995 DEIR/EIS for Alternative 1 that are described above under "Impacts and Mitigation Measures of Alternative 1"; however, the severity of impacts generally would be greater because of increased diversions and discharges. Figures 3C-23 and 3C-24 show the simulated salinity variables for Alternative 3. Tables B2-2 in Appendix B2 and C5-3 in Appendix C5 give the monthly results for Alternative 3 for 1968-1991.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-9: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives. This impact is described above under Impact C-1. The simulation results for Alternative 3 show the significance criteria being exceeded in some months. This impact is therefore considered significant. Implementing Mitigation Measure C-1 would reduce Impact C-9 to a less-than-significant level.

Mitigation Measure C-1: Restrict DW Diversions to Limit EC Increases at Chipps Island. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact C-10: Salinity (EC) Increase at Emmaton during April-August. This impact is described above under Impact C-2. This impact is considered significant. Implementing Mitigation Measure C-2 would reduce Impact C-10 to a less-than-significant level.

Mitigation Measure C-2: Restrict DW Diversions to Limit EC Increases at Emmaton. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact C-11: Salinity (EC) Increase at Jersey Point during April-August. This impact is described above under Impact C-3. This impact is considered significant. Implementing Mitigation Measure C-3 would reduce Impact C-11 to a less-than-significant level.

Mitigation Measure C-3: Restrict DW Diversions to Limit EC Increases at Jersey Point. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact C-12: Salinity (Chloride) Increase in Delta Exports. This impact is described above under Impact C-4. The simulation results for Alternative 3 show the significance criteria being exceeded in some months. This impact is therefore considered significant. Implementing Mitigation Measure C-4 would reduce Impact C-12 to a less-than-significant level.

Mitigation Measure C-4: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Export Concentrations of Dissolved Organic Carbon

Water quality impacts of increases in export DOC concentrations were assessed for Delta exports in the south Delta. Impacts were measured based on DOC for Alternative 3 and the change in DOC from No-Project Alternative conditions, as simulated by the DeltaDWQ model. Figure 3C-25 shows simulated monthly DOC concentrations for Alternative 3 and the changes from the simulated No-Project Alternative DOC concentrations in Delta exports for 1968-1991.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-13: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy). This impact is described above under Impact C-5. This impact is considered significant. Implementing Mitigation Measure C-5 would reduce Impact C-13 to a less-than-significant level.

Mitigation Measure C-5: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Trihalomethane Concentrations in Treated Drinking Water

Impacts of increases in THM concentrations in treated drinking water caused by implementation of Alternative 3 were assessed based on simulated THM concentrations and changes from THM concentrations under the No-Project Alternative. Figure 3C-25 (lower panel) gives the seasonal patterns of simulated THM concentrations in treated drinking water for Alternative 3 and the changes between the No-Project Alternative and Alternative 3.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-14: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, and CVP Tracy). This impact is described above under Impact C-6. Implementing Mitigation Measure C-6 would reduce Impact C-14 to a less-than-significant level.

Mitigation Measure C-6: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater Than 72 Fg/l in Treated Delta Export Water. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Changes in Other Water Quality Variables

Other water quality variables include temperature, SS, DO, and chlorophyll. Under Alternative 3, levels of these water quality characteristics will vary widely with daily fluctuations in conditions affecting them (e.g., DW storage volumes, weather patterns, flow characteristics, and water quality of receiving water for DW discharges).

The high variability typical of these parameters and the uncertainty regarding daily conditions that may coincide to produce adverse impacts do not allow a quantitative impact assessment to be performed. It is likely that conditions will combine under operation of Alternative 3 to produce impacts exceeding the significance criteria for these transient water quality variables.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-15: Changes in Other Water Quality Variables in Delta Channel Receiving Waters. This impact is described above under Impact C-7. This impact is considered significant. Implementing Mitigation Measure C-7 would reduce Impact C-15 to a less-than-significant level.

Mitigation Measure C-7: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Effects of Pollutant Contaminants

Sites of potential soil contamination resulting from historical agricultural operations or waste disposal exist on the proposed DW reservoir islands.

Summary of Project Impacts and Recommended Mitigation Measures

Impact C-16: Potential Contamination of Stored Water by Pollutant Residues. This impact is described above under Impact C-8. This impact is considered significant. Implementing Mitigation Measure C-8 would reduce Impact C-16 to a less-than-significant level.

Mitigation Measure C-8: Conduct Assessments of Potential Contamination Sites and Remediate as Necessary. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The No-Project Alternative (intensified agricultural use of the four DW project islands) represents Delta water quality conditions predicted under the 1995 WQCP. Compared with existing agricultural land uses, irrigation diversions and agricultural drainage would be somewhat greater under the intensified agriculture conditions of the No-Project

Alternative. At the scale of monthly water quality modeling (e.g., DeltaSOS and DeltaDWQ models), effects on Delta salinity and export water quality generally would be similar to those under existing conditions.

The DeltaDWQ results for the No-Project Alternative were described above under "Impact Assessment Methodology".

The No-Project Alternative, as simulated by DeltaSOS, DeltaDWQ, and the EPA WTP model, would not cause measurable water quality effects relative to existing conditions.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. DW project effects on Delta water quality conditions are inextricably tied to past and present environmental factors and conditions. Cumulative water quality impacts are bounded by the requirements and controls mandated by various regulatory measures, such as the SWRCB 1995 WQCP objectives and the regional water quality control board basin plans and National Pollutant Discharge Elimination System (NPDES) discharge permits.

The cumulative water quality effects of the DW alternatives therefore were evaluated in conjunction with past and present actions in the previous sections, which assumed the 1995 WQCP objectives; existing agricultural drainage loading patterns; and continued operation of existing Delta export pumping plants, gate and barrier facilities, and diversions. The focus of this section is on the evaluation of impacts of the DW project alternatives added to impacts of other likely future projects. This cumulative impact evaluation from the 1995 DEIR/EIS was based on the following scenario: increased upstream demands; increased demands south of the Delta; an increased permitted pumping rate at the SWP Banks Pumping Plant (see Chapter 3A, "Water Supply and Water Project Operations"); implementation of DWR's South Delta and North Delta Programs; and additional storage south of the Delta in the Kern Water Bank, Los Banos Grandes Reservoir, MWD's Diamond Valley Reservoir and Arvin-Edison projects, and CCWD's Los Vaqueros Reservoir.

Future activities affecting water quality in the Delta will include continued agricultural and municipal diversions, discharges from treated municipal wastewater and agricultural drainage, and maintenance of existing channels and levees. New facilities (e.g., channel gates and barriers) may be constructed, and existing channels may be modified for navigation or for increased water conveyance (e.g., DWR North and South Delta Programs). Some existing agricultural lands may be converted to urban development or to wetlands and other wildlife habitat uses, changing the water diversion and discharge patterns for these lands. Increasing populations in the watershed may result in higher concentrations of water quality variables associated with wastewater and increased surface runoff.

Cumulative water quality impacts were assessed qualitatively without specific DeltaDWQ simulations being performed. As described in Chapter 3A, "Water Supply and Water Project Operations", the cumulative water supply impacts of the DW project alternatives and the No-Project Alternative were evaluated with a slightly different set of Delta export pumping limitations (SWP pumping at full capacity), which represents reasonably foreseeable future Delta conditions and regulatory objectives.

Because total diversions (exports and DW diversions) are limited by the percentage of inflow criteria specified in the 1995 WQCP, the increased export capacity reduces the available water for DW diversions in some months. However, slightly higher DW project discharges and export of DW discharges would be possible. Delta outflow would be reduced during months of increased exports or increased DW project diversions. Results of the DeltaSOS simulations for the 1995 DEIR/EIS (Table A3-25) indicated that cumulative water quality impacts would be similar to the impacts described above for the DW project alternatives, and the same mitigation measures would apply.

Cumulative Impacts, Including Impacts of Alternative 1

The DeltaSOS simulations of Alternative 1 under cumulative future conditions that were performed for the 1995 DEIR/EIS are summarized in the cumulative impacts section of Chapter 3A and are described in Appendix A3. Alternative 1 would be operated in fewer years under cumulative conditions than under existing conditions because of limited availability of water for DW diversions. Because of greater assumed export pumping capacity, however, greater DW exports were simulated in several of the years. In the 1995 DEIR/EIS, the average annual simulated DW diversion for Alternative 1 under cumulative future conditions was 191 TAF/yr, with discharges for export of 161 TAF/yr (Table 3A-3).

Delta Salinity Conditions (Electrical Conductivity, Chloride, and Bromide)

Because Delta salinity conditions are directly linked with Delta outflow, which will be changed by cumulative future conditions as well as DW operations, Alternative 1 will have significant cumulative impacts whenever DW project operations change cumulative future salinity conditions in excess of the selected significance criterion (i.e., maximum of 90% of established objectives or maximum change of 20% of established objectives).

Although the 1995 WQCP is assumed to remain the applicable water quality objectives, and the 70-year historical hydrologic conditions are assumed to represent the likely cumulative future hydrologic conditions, other factors may change the Delta inflows and therefore affect Delta outflow. It is likely that the cumulative future water quality impacts of Alternative 1 would be similar to those simulated for Alternative 1, in comparison with operations under the No-Project Alternative. Similar mitigation measures to limit DW operations during periods of moderate Delta outflow would be required to prevent the occurrence of significant water quality impacts.

Impact C-17: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives under Cumulative Conditions. This impact is described above under Impact C-1. This impact is considered less than significant. However, Mitigation Measure C-1 is recommended, as explained above under Impact C-1.

Mitigation Measure C-1: Restrict DW Diversions to Limit EC Increases at Chipps Island. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact C-18: Salinity (EC) Increase at Emmaton under Cumulative Conditions. This impact is described above under Impact C-2. This impact is considered significant. Implementing Mitigation Measure C-2 would reduce Impact C-18 to a less-than-significant level.

Mitigation Measure C-2: Restrict DW Diversions to Limit EC Increases at Emmaton. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact C-19: Salinity (EC) Increase at Jersey Point under Cumulative Conditions. This impact is described above under Impact C-3. This impact is considered significant. Implementing Mitigation Measure C-3 would reduce Impact C-19 to a less-than-significant level.

Mitigation Measure C-3: Restrict DW Diversions to Limit EC Increases at Jersey Point. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact C-20: Salinity (Chloride) Increase in Delta Exports under Cumulative Conditions. This impact is described above under Impact C-4. This impact is considered less than significant. However, Mitigation Measure C-4 is recommended, as explained above under Impact C-4.

Mitigation Measure C-4: Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Export Concentrations of Dissolved Organic Carbon

The assessment of Alternative 1 effects on export DOC concentrations, using the Delta channel flows simulated with DeltaSOS and Delta inflow and agricultural drainage concentrations simulated with DeltaDWQ, provided the basis for the qualitative assessment of impacts of Alternative 1 under cumulative future conditions. The possibility of high export DOC concentrations in DW discharges relative to cumulative future export DOC concentrations under the No-Project Alternative is considered significant and must be mitigated with a combination of DOC measurements and limitations on DW discharges. The significant impacts of Alternative 1 under future conditions would be similar to those described for Alternative 1.

Impact C-21: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions. This impact is described above under Impact C-5. This impact is considered significant. Implementing Mitigation Measure C-5 would reduce Impact C-21 to a less-than-significant level.

Mitigation Measure C-5: Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Trihalomethane Concentrations in Treated Drinking Water

The assessment of effects of Alternative 1 on THM concentrations in treated drinking water provided the basis for the qualitative assessment of significant impacts of Alternative 1 under cumulative future conditions. Water quality objectives for THM concentrations, as well as treatment technology for drinking water disinfection are likely to change in the future.

Although the average effects of operations under Alternative 1 on cumulative future THM concentrations in treated drinking water are expected to be generally small, the possibility of high DOC concentrations in DW discharges relative to cumulative future export DOC concentrations under the No-Project Alternative must be considered significant and be mitigated with a combination of DOC measurements, estimates of THM concentrations, and limitations on DW discharges. The significant impacts of Alternative 1 under future conditions would be similar to those described for Alternative 1.

Impact C-22: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, and CVP Tracy) under Cumulative Conditions. This impact is described above under Impact C-6. Implementing Mitigation Measure C-6 would reduce Impact C-22 to a less-than-significant level.

Mitigation Measure C-6: Restrict DW Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater Than 72 Fg/l in Treated Delta Export Water. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Changes in Other Water Quality Variables

The effect of operations of Alternative 1 under cumulative future conditions would be similar to the effects described for Alternative 1 compared with operations under the No-Project Alternative. Similar significant impacts are possible and similar mitigation measures would be required. Significance criteria and mitigation requirements will be determined by SWRCB and would be included in project operation permits.

Impact C-23: Changes in Other Water Quality Variables in Delta Channel Receiving Waters under Cumulative Conditions. This impact is described above under Impact C-7. This impact is considered significant. Implementing Mitigation Measure C-7 would reduce Impact C-23 to a less-than-significant level.

Mitigation Measure C-7: Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Effects of Pollutant Contaminants

Appendix C6, "Assessment of Potential Water Contaminants on the Delta Wetlands Project Islands", analyzes pollutant loading effects from the recreational use of DW boating facilities. Sources of potential pollution resulting from the presence of recreation facilities and from boating activities include the discharge of petroleum-based materials (e.g., fuel, oil, and grease), sewage, and litter. Although the direct effects are considered minor (based on a 5% increase in boating use in the Delta as described in Chapter 3J, "Recreation and Visual Resources"), the potential increase in pollutant loading from the DW project facilities and boating activities, in combination with other boating facilities in the Delta, could cause periodic pollution problems in Delta waters. As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications; nevertheless, the analysis of impacts on water quality associated with construction and operation of these facilities is provided in this chapter.

Impact C-24: Increase in Pollutant Loading in Delta Channels. Pollutant loading associated with recreational boat use in the Delta, including pollutant loading effects caused by the DW project, could result in periodic pollution problems in Delta waters. This cumulative impact is considered significant and unavoidable.

Implementing Mitigation Measures C-9 and RJ-1 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure C-9: Clearly Post Waste Discharge Requirements, Provide Waste Collection Facilities, and Educate Recreationists regarding Illegal Discharges of Waste. Prior to operation of the DW recreation facilities, DW shall post notices at all DW recreation facilities describing proper methods of disposing of waste. Waste discharge requirements shall be posted and enforced in accordance with local and state laws and ordinances. Prior to operation of the DW recreation facilities, DW shall provide waste collection receptacles on and around the boat docks for the boaters using the DW recreation facilities. Prior to operation of the DW recreation facilities, DW shall provide educational materials to inform recreationists about the deleterious effects of illegal waste discharges and the location of waste disposal facilities throughout the Delta.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at the Proposed Recreation Facilities. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. This mitigation measure is described in more detail in Chapters 3J, “Recreation and Visual Resources”, and 3L, “Traffic and Navigation”.

Cumulative Impacts, Including Impacts of Alternative 2

Effects of operations of Alternative 2 under future cumulative conditions would be the same as those described above for operations of Alternative 1 under future cumulative conditions. The impacts and mitigation measures would be the same as described for Alternative 1 cumulative conditions.

Cumulative Impacts, Including Impacts of Alternative 3

Effects of operations of Alternative 3 under future cumulative conditions would be the same as those described above for operations of Alternative 1 under future cumulative conditions. The impacts and mitigation measures would be the same as described for Alternative 1 cumulative conditions except that all impacts are considered significant.

Cumulative Impacts, Including Impacts of the No-Project Alternative

The No-Project Alternative would not contribute to cumulative Delta water quality impacts.

ANALYSIS OF WATER QUALITY FROM THE 2000 REVISED DRAFT EIR/EIS

The remainder of this chapter includes the analysis of effects of the proposed project on water quality that was conducted for the 2000 REIR/EIS. This information, which was presented as Chapter 4, "Water Quality", in the 2000 REIR/EIS, has been modified slightly from the 2000 REIR/EIS version in response to comments received on the 2000 REIR/EIS. However, these minor changes do not change the conclusions of the analysis.

FOCUS OF THE REVISED DRAFT EIR/EIS ANALYSIS

Issues Raised in Water Right Hearing Testimony and Comments on the 1995 Draft EIR/EIS

As described in the 1995 DEIR/EIS, the Delta Wetlands Project could affect water quality in Delta waters during project diversion and discharge operations. Project effects on salinity and DOC concentrations in Delta channels and exports are a major concern for other Delta water users, especially providers of municipal drinking water. Project effects on other water quality variables (e.g., temperature, suspended sediments, dissolved oxygen, and chlorophyll) were also described qualitatively in the 1995 DEIR/EIS. Project effects on temperature and dissolved oxygen were addressed during the ESA consultation process, and no new information on other variables, such as suspended sediment and chlorophyll, has been presented in testimony or comment letters. Therefore, the 2000 REIR/EIS analysis focuses on project effects on DOC and salinity.

The Delta Wetlands Project could affect water quality in the following ways:

- Diverting water onto the project islands would reduce Delta outflows. As a result, brackish water from Suisun Bay would intrude into the central Delta and salinity in Delta channels and exports would increase.

- While water is stored on the reservoir islands, salinity and DOC concentrations would increase because of evaporative losses, and DOC concentrations would increase as a result of peat-soil leaching and algal growth. Therefore, discharges from the Delta Wetlands Project islands would contribute to increased concentrations of salinity and DOC in Delta channel receiving waters and in exports.

- Increases in DOC and salinity could indirectly cause increases in THMs and other disinfection byproducts (DBPs) in treated drinking-water supplies that are diverted or exported from the Delta.

Although commenters on the 1995 DEIR/EIS and parties to the water right hearing generally agreed on the processes through which the Delta Wetlands Project could affect water quality, the methods and assumptions used to determine the magnitude of those impacts were debated at length. The magnitude of the effect of project operations on other water users' water quality depends on several factors:

quality of water when it is diverted onto the project islands;

length of time that water is held on the islands;

rate of peat-soil leaching and other DOC-loading mechanisms;

quality of receiving waters at the time of project discharges; and

amount of Delta Wetlands water exported (the portion of total exports), which is determined by the rate of release from the reservoir islands.

The following components of the Delta Wetlands impact analysis for water quality were the focus of many comments:

the concentrations of constituents in Delta inflow and Delta agricultural drainage, and resulting baseline water quality;

DOC loading rates from peat-soil leaching, plant material growth and degradation, and interceptor well pumping activities under project operations;

the question of whether ceasing agricultural activities on the Delta Wetlands Project islands can be considered to benefit water quality and to what degree it may offset the effects of project diversions and discharges; and

methods of determining how much DBP would form as a result of export salinity (bromide [Br^-]) and DOC concentration.

Several commenters suggested that the lead agencies could obtain a more accurate estimate of the potential range of project effects by using new data on Delta DOC loading and ambient salinity developed through DWR programs. Commenters also suggested that revised methods of predicting the relationship between DOC and salinity levels and the formation of THMs and other DBPs at municipal water treatment plants would yield a better estimate of project effects.

The remainder of this chapter updates the assessment of Delta Wetlands Project effects on water quality presented in Chapter 3C and Appendices C1 through C5 of the 1995 DEIR/EIS (see above). New information has been reviewed and the previous analysis has been revised as appropriate.

Summary of Issues Addressed in the 2000 Revised Draft EIR/EIS
Analysis of Water Quality

The analysis presented in this chapter addresses the following questions, which represent the concerns expressed by stakeholders at the SWRCB water right hearing on the Delta Wetlands Project and in comments on the 1995 DEIR/EIS:

What will be the DOC loading on the reservoir islands from short-term and long-term peat-soil leaching, plant material growth and decay, and interceptor well water returns?

What impact will DOC from reservoir island water have on in-Delta water quality and senior water right holders?

What impact will Delta Wetlands Project operations have on salinity in the Delta and at diversion points for senior water right holders?

What impact would the Delta Wetlands Project's incremental change of DOC and salinity (Br^-) have on the formation of DBPs, including THMs and bromate, at municipal treatment plants receiving Delta water?

The analysis addresses these questions by providing new estimates of monthly Delta export water quality using a revised version of the DeltaSOS model. As described in Chapter 3A, "Water Supply and Water Project Operations", the 2000 REIR/EIS analysis incorporates new baseline DWRSIM model input, revised Delta standards and AFRP program measures, and Delta Wetlands Project operating rules. It augments the previously presented information with the most recent DWR data on Delta water quality constituents, and with updated information on the assumed relationship between constituents in raw water and municipal water treatment plant operations.

Definition of Terms

The following are definitions of key terms as they are used in this chapter:

Central Delta Water: Used in the DeltaSOQ model to represent the source of export water from the central Delta, which includes a mixture of water from the Sacramento, Mokelumne, and Cosumnes Rivers; seawater intrusion from the western Delta; and some portion of the San Joaquin River that does not flow directly to the export locations.

Delta Drainage Water Quality Model (DeltaDWQ): A model developed for the 1995 DEIR/EIS analysis to estimate how much the Delta Wetlands islands contribute to EC, DOC, Cl^-, and Br^- levels at Delta channel locations and in Delta diversions and exports under no-project conditions and under project operations.

Delta Exports: The water pumped from the Delta to south-of-Delta users by DWR at Banks Pumping Plant and by Reclamation at the CVP Tracy Pumping Plant, and the amount diverted by CCWD at its Rock Slough and Old River intakes.

Delta Standards, Operations, and Quality Model (DeltaSOQ): A modified version of the DeltaSOS model that incorporates equations that predict the water quality of agricultural drainage and Delta Wetlands reservoir island storage. This model also incorporates equations that predict the effects of agricultural drainage and Delta Wetlands discharges on EC levels and DOC concentrations in Delta channels and exports.

Electrical Conductivity (EC): A general measure of dissolved minerals (i.e., salinity); the most commonly measured variable in Delta waters.

Leaching: The removal of soluble substances from soil by percolating water.

Simulated Disinfection System (SDS): A method of determining THM formation potential. This laboratory analytical method was developed to simulate municipal water treatment facilities' actual disinfection process (and THM concentrations) more closely than other methods; it uses a much lower chlorine (Cl_2) dose and much less contact time.

Trihalomethane (THM): A class of carcinogenic substances, including chloroform ($CHCl_3$) and bromoform ($CHBr_3$), formed from chlorination of drinking-water supplies.

Trihalomethane Formation Potential (THMFP): The potential for creation of THMs during chlorination or other oxidation treatment processes used for disinfection of municipal water supplies; an index of the maximum possible THM concentrations that could be produced by maximum chlorination of Delta water.

Ultraviolet Absorbance (UVA): A physical measurement used in the study of humic acids and THM precursors, often found to be linearly related to DOC concentration. UVA may provide a measure of the humic and fulvic acid portion of total DOC in a water sample; this portion of total DOC is thought to be the precursor for THM.

Water Treatment Plant (WTP) Model: A U.S. Environmental Protection Agency (EPA) model used for the 1995 DEIR/EIS to estimate THM concentrations at a typical water treatment plant that may use Delta exports containing water released from the Delta Wetlands Project islands. The model consists of a series of subroutines that simulate removal of organic THM precursor compounds and formation of THM. A more detailed description of the operation of the WTP model is provided in Appendix C5 of the 1995 DEIR/EIS. The model predicts total THM concentration, then estimates the relative concentrations of each of the four types of THM molecules by using separate regression equations for each type of THM molecule.

Organization of the 2000 Revised Draft EIR/EIS Analysis of Water Quality

The remainder of this chapter presents information supporting the updated evaluation of water quality effects of Delta Wetlands Project operations in sections that can be divided into two themes. The first half describes new and updated information that has been considered in the analysis of project impacts, and is organized into the following major sections:

"Overview of Sources of New and Updated Information": Provides an overview of the following four sections.

"Updated Measurements of Inflow, Export, and Agricultural Drainage Water Quality": Presents Delta water quality data recently collected by the DWR MWQI program and other programs.

"California Department of Water Resources Special Multipurpose Applied Research Technology Station Studies": Describes DWR's recent peat-soil flooding experiments.

"Reported Estimates of Dissolved Organic Carbon Loading": Summarizes available estimates of DOC loading under existing and with-project conditions.

"Changes in Disinfection Byproduct Rules": Discusses changes in rules for TOC removal and THM concentrations for water treatment.

The contents of these sections are described more fully under “Overview of Sources of New and Updated Information”.

The second half of the remainder of this chapter presents the impact analysis for the Delta Wetlands Project and is organized as follows:

“Impact Assessment Methodology”: Describes the methods used to assess project impacts and explains how the new and updated information has been incorporated into the modeling used to determine those impacts. Includes discussions of the updated methods for estimating project effects on DOC and salinity levels and for predicting the formation of THMs and bromate at water treatment plants. These methods are described more fully in Appendix G of the 2000 REIR/EIS, “Water Quality Assessment Methods”.

“Criteria for Determining Impact Significance”:

  - describes the impact significance thresholds used in the 1995 DEIR/EIS analysis,
  - summarizes comments on these criteria,
  - discusses the relationship between the significance thresholds and mitigation triggers of water right terms and conditions, and
  - presents the criteria used in the 2000 REIR/EIS.

“Environmental Consequences”:

  - presents the results of simulations of Delta water quality conditions for the No-Project Alternative and of effects of the proposed project on Delta salinity, export DOC levels, and THMs produced at water treatment plants,
  - compares the impacts of the 1995 DEIR/EIS project alternatives on water quality to those identified for the proposed project using the new information and updated methods presented in this analysis,
  - describes options for applying the recommended mitigation and discusses how mitigation measures may be refined in water right permit terms and conditions,
  - describes cumulative impacts of the proposed project, and
  - discusses the implications of the changes in water quality information and assessment methods with regard to Alternatives 1 and 3 in the section “Impact Evaluation of Project Alternatives from the 1995 Draft EIR/EIS”.

OVERVIEW OF SOURCES OF NEW AND UPDATED INFORMATION

A great amount of water quality data is collected in the Delta each year. Data are collected by the Municipal Water Quality Investigations (MWQI) program of the DWR Division of Planning and Local

Assistance, the Interagency Ecological Program (IEP), and the U.S. Geological Survey (USGS) Water Resources Division.

DWR's MWQI program has collected data on numerous water quality variables in Delta inflows and exports. The MWQI data include measurements of EC, DOC, THMFP, and related variables; therefore, they are the most relevant source of baseline Delta water quality information for this assessment. Appendices C1 and C2 of the 1995 DEIR/EIS presented MWQI monitoring data collected through water year 1991. The following text includes the most recent MWQI data through water year 1998.

The MWQI program has also collected data on Delta agricultural drainage water quality, including measurements from drainage pumps on the four Delta Wetlands Project islands. Delta agricultural drainage data from 1986-1991 were included in Appendix C4 of the 1995 DEIR/EIS; the following text includes the MWQI data on agricultural drainage through 1998 (California Department of Water Resources 1999a). However, most of the drainage sampling was discontinued in 1994, so only limited information from drainage sampling is available to augment the information presented in the 1995 DEIR/EIS. The MWQI data are used to estimate the contributions of water quality constituents of concern from Delta sources under no-project conditions and under project operations.

Also evaluated for this assessment of Delta Wetlands Project effects are data from DWR's Special Multipurpose Applied Research Technology Station (SMARTS), which conducts peat-soil flooding experiments at the DWR Bryte facility in West Sacramento (California Department of Water Resources 1999b), and data from flooded-island studies conducted jointly by DWR and the USGS on Twitchell Island. In addition, this chapter summarizes information on potential DOC loading received from water right hearing participants. This information has been used to refine the assumptions used in the 1995 DEIR/EIS regarding the potential loading of DOC from the Delta Wetlands islands under no-project conditions and under project operations.

Since publication of the 1995 DEIR/EIS, standards for total organic carbon (TOC) removal before treatment have been adopted under the Safe Drinking Water Act, and EPA has revised its standard for THM concentrations in drinking water. These newly adopted standards and potential future standards are also described below.

This chapter and the accompanying appendix (Appendix G of the 2000 REIR/EIS) describe methods for calculating Delta Wetlands Project contributions to salinity, DOC concentrations, and THMFP in water that could be exported from the Delta and subsequently treated for municipal use. Revised equations used to predict formation of THMs and bromate at treatment plants have been reviewed and incorporated, as appropriate, into the revised analysis.

The following sections present the results of this review of new and updated information:

"Updated Measurements of Inflow, Export, and Agricultural Drainage Water Quality" presents data collected since 1995 on existing inflow, export, and agricultural drainage water quality. These data, reported by the DWR MWQI program and other programs, are used to update assumptions of existing water quality conditions in the Delta for impact analysis.

"California Department of Water Resources Special Multipurpose Applied Research Technology Station Studies" describes the methods and results from these peat-soil flooding experiments and discusses the applicability of these results to the Delta Wetlands Project.

“Reported Estimates of Dissolved Organic Carbon Loading” summarizes information from the 1995 DEIR/EIS, estimates from recent in-field and experimental data, and evidence presented at the Delta Wetlands water right hearing and in comments on the 1995 DEIR/EIS regarding DOC loading under existing and with-project conditions.

“Changes in Disinfection Byproduct Rules” discusses new, revised, and proposed rules for TOC removal and THM concentrations for water treatment.

This information is used to estimate existing Delta conditions (e.g., inflow and export water quality, agricultural drainage operations and water quality) and to provide input toward an estimate of DOC loading under existing (i.e., agricultural) and project conditions. The “Impact Assessment Methodology” section that follows describes how this information is incorporated into the quantitative modeling used to determine impacts of the Delta Wetlands Project.

UPDATED MEASUREMENTS OF INFLOW, EXPORT, AND AGRICULTURAL DRAINAGE WATER QUALITY

Measured data on the quality of water in Sacramento and San Joaquin River inflows, at Delta export locations, and in agricultural drainage in the Delta are presented below. Data on Delta inflow and export EC, Cl^-, Br^-, DOC, and THMFP are taken from the DWR MWQI data collection program. Agricultural drainage data from the MWQI program on the Delta Wetlands islands and from USGS, DWR, and California Urban Water Agencies (CUWA) investigations on Twitchell Island are summarized below; Appendix G of the 2000 REIR/EIS includes more detailed information about agricultural drainage from the Delta Wetlands islands.

Measurements of Delta Water Quality Variables in Delta Inflows and Exports

Data on Delta inflow and export water quality constituents, as reported by the DWR MWQI program, are used to describe existing inflow and export water quality conditions and to determine how the concentrations of constituents change as water flows through the Delta. The difference between concentrations of a selected water quality constituent, such as DOC, in Delta inflows and concentrations in exports is used to estimate the net contribution from Delta sources, including agricultural drains. For a discussion of the way that these contributions are estimated for the impact assessment and used in the quantitative modeling, see “Delta Source Contributions of Salinity and Dissolved Organic Carbon” in Appendix G of the 2000 REIR/EIS.

This section describes MWQI program measurements of EC values and the concentrations of several constituents in Sacramento and San Joaquin River inflows and at Delta export locations collected during the most recent 15-year period, 1984-1998 (California Department of Water Resources 1999a). The 1995 DEIR/EIS analysis used data from the 10-year period of 1982-1991 (see Appendix C1, “Analysis of Delta Inflow and Export Water Quality Data”, in the 1995 DEIR/EIS). The 15-year period used in this REIR/EIS reflects several significant hydrological events. The 1988-1993 water years were a significant period of drought. In addition, flooding events and wet-year-type conditions experienced in 1995, 1997, and 1998 provide recent data that broaden the span of much of the range of potential hydrological conditions (except those of extreme drought, such as the 1976-1977 period). Sacramento River inflows are generally the largest source of Delta water and have lower concentrations of DOC and related constituents than other sources;

therefore, the Sacramento River concentrations are used as the baseline for determining Delta source contributions.

The DWR MWQI data collection program has changed each year. Sampling from the Sacramento River and Delta export locations began in 1983. Several assay techniques for THMFP measurement have been used since 1992; major revisions were made in 1994 and 1996. Results from the differing assay methods are not directly comparable. DOC measurements began in 1987, and Br^- and UVA measurements began in 1990. The use of UVA data is explained below.

The number of samples collected at each station each year has also changed. At the SWP Banks Pumping Plant, for example, five samples were collected in water year 1982; nine samples were collected in water year 1983; and 11 or 12 (monthly) samples were collected in water years 1984 through 1989. During water years 1990 through 1994, sampling was generally conducted on a weekly or biweekly schedule. Intensive sampling began in May 1995 and continued through August 1996, averaging 11 samples per month. Recent sampling has returned to a monthly schedule. Intensive sampling was also conducted in the Sacramento River at Greene's Landing from February 1993 through water year 1995. During this period, samples were often collected daily for several consecutive months. Samples from the San Joaquin River at Vernalis, from the Old River near the Rock Slough intake for CCWD's diversion, and at the CVP Tracy Pumping Plant for the DMC have generally been collected on a regular monthly schedule.

A standardized data set of monthly values for the entire 1984-1998 period was created using the first grab sample collected in each calendar month and eliminating any additional samples collected that month. Samples were often, but not always, collected on about the same day at each of the sampling stations. The mean values of the monthly samples did not differ by more than 10% from those of the entire data set. This is the same method used for the data from the 1982-1991 period in the 1995 DEIR/EIS analysis, as summarized in Table C1-1 of Appendix C1 of the 1995 DEIR/EIS.

The MWQI program did not collect data on all these variables for all years of the 1984-1998 period. However, the graphs show all available data plotted against the 1984-1998 time period to provide for easy comparison of water quality conditions for each year. The following sections describe the data for EC, Cl^-, Br^-, DOC, and THMFP.

Delta Electrical Conductivity Values

EC is a general measure of dissolved minerals (i.e., salinity) and is the most commonly measured variable in Delta waters. High levels of dissolved minerals can limit beneficial uses of Delta water for agricultural, municipal, and industrial water supplies. Changes in EC values can be used to interpret the movement of water and the mixing of salt in the Delta (see 1995 DEIR/EIS Appendix B2, "Salt Transport Modeling Methods and Results").

Figure 3C-26 and Table 3C-9 show 1984-1998 EC measurements for the DWR MWQI samples from Sacramento and San Joaquin River inflows and from the following three export locations:

- the SWP Banks Pumping Plant,
- the CVP Tracy Pumping Plant, and
- Rock Slough for CCWD's pumping plant.

The data show ranges of EC values at these monitoring locations that are consistent with those presented in the 1995 DEIR/EIS for 1982-1991.

The EC values for the Sacramento River are generally in the range of 100 to 200 microsiemens per centimeter (FS/cm), although measurements during the 1986, 1995, and 1997 high-flow periods were less than 100 FS/cm, and 5% of the values exceeded 200 FS/cm. Sacramento River EC measurements, shown in Figure 3C-27, generally decrease with higher flows, exhibiting a typical flow-dilution relationship.

The EC values for the San Joaquin River are usually much higher than Sacramento River EC values, fluctuating between 150 and 1,300 FS/cm. Figure 3C-28 indicates that San Joaquin River EC measurements also generally decrease with higher flows, exhibiting a flow-dilution relationship.

Several San Joaquin River EC values observed during the winters of 1988-1993 exceeded 1,000 FS/cm and are as much as 500 FS/cm higher than the EC values estimated with the flow-dilution equation. These elevated EC values suggest that an additional load of salt drainage may have been released into the San Joaquin River during these drought years. Values in the recent postdrought years 1995-1998 indicate a lower trend of San Joaquin salt content similar to the pre-drought period. Measurements, when available, are superior to flow-regression estimates of inflow water quality; flow regressions must be used for planning and assessment studies.

Observed EC values at the three export locations have fluctuated between about 200 and 1,000 FS/cm. During months when low EC values were measured, corresponding to periods of high Delta outflow, the export locations each had similar EC values. During months when high EC values were measured, EC values at Rock Slough (CCWD) were generally the highest because effects of salinity intrusion are usually strongest there. Local agricultural drainage may also have different effects at each export location.

The DWR MWQI EC data presented here and in the 1995 DEIR/EIS clearly indicate that EC (representing dissolved salts) usually increases between Sacramento River inflow and the export locations. The net source of elevated EC may differ for each month and each export location, however. San Joaquin River inflows, seawater intrusion, agricultural drainage, and municipal discharges (e.g., from Stockton) may each contribute to elevated EC measurements.

Delta Chloride Data

Cl^- concentration is important in evaluating the quality of the domestic water supply and is a major parameter for judging Delta water quality. The ratio of Cl^- to EC (using units of mg/l for Cl^- and FS/cm for EC) can be used to distinguish between sources of water from different inflows (e.g., Sacramento River, San Joaquin River, and seawater) sampled at different Delta locations. Delta Wetlands Project operations would influence the relative contributions of water from different Delta inflow sources; therefore, they would affect concentrations of minerals (including Cl^-) in the Delta. (See 1995 DEIR/EIS Appendices B2 and C1 for more information.)

For example, seawater has a Cl^- concentration of 19,000 mg/l and an EC value of approximately 55,000 FS/cm, for a Cl^-:EC ratio of about 0.35 (CRC 1989). As described below, Sacramento River water, with a Cl^- concentration of approximately 6 mg/l and an EC value of 150 FS/cm, has a Cl^-:EC value of about 0.04. Therefore, a mixture of 1% seawater and 99% Sacramento River water would have a Cl^- concentration of 196 mg/l and an EC concentration of 699 FS/cm, resulting in a Cl^-:EC ratio of 0.28. A Cl^-:EC ratio of more than 0.20 indicates that seawater intrusion is a dominant source of salinity in the Delta.

Figure 3C-29 and Table 3C-9 show DWR MWQI data on Cl^- concentrations for water years 1984 through 1998 for the two Delta inflow and three Delta export locations. Cl^- concentration patterns are similar but not identical to the EC patterns because each major water source has a different Cl^-:EC ratio value. Figure 3C-30 shows the Cl^-:EC ratios for each of the monthly DWR MWQI samples. These two figures will be described together. The patterns among the different monitoring locations seen in the updated (1984-1998) data are essentially identical to those described in the 1995 DEIR/EIS for 1982-1991.

Sacramento River Cl^- concentrations were less than 10 mg/l in 94% of the monthly measurements (Figure 3C-29), and the Cl^-:EC value (mg/l:FS/cm) in this inflow averaged 0.04 (Figure 3C-30). Some of the scatter in the Sacramento Cl^-:EC values was caused by low Cl^- concentrations.

San Joaquin River Cl^- concentrations fluctuated between 7 and 183 mg/l (Figure 3C-29), and Cl^-:EC ratio values increased from 0.055 at low EC values to 0.16 at high EC values (Figure 3C-30). The variability in the Cl^-:EC values of this inflow may be explained by the fact that the inflow represents a mixture of water from the San Joaquin River, Stanislaus River, and especially during wet periods, other tributaries. Nevertheless, the Cl^-:EC value of 0.055 to 0.16, averaging 0.12, for the San Joaquin River inflow is distinct from the lower Cl^-:EC value of about 0.04 for the Sacramento River.

There are only three basic sources of Delta salinity: seawater, San Joaquin River water, and Sacramento River water. The proportion of water from each of these sources in exports can be estimated by evaluating the Cl^-:EC ratio together with the Cl^- concentrations and EC values.

Measurements of Cl^- concentrations from the export locations fluctuated between 11 and 303 mg/l (Figure 3C-29). The Cl^- concentrations in CCWD diversions from Rock Slough were the highest, indicating a stronger influence from seawater intrusion or local agricultural drainage at this location.

Cl^-:EC values for the export locations were greater than 0.16 (the maximum San Joaquin River ratio) during periods with the highest Cl^- concentrations (Figure 3C-30). These high Cl^-:EC values suggest that seawater intrusion is the dominant source of Cl^- during these periods. CCWD water diverted at Rock Slough usually has a higher Cl^-:EC value than water exported from the other export locations, suggesting a higher seawater contribution at this location.

Delta Bromide Data

Similar to Cl^- concentration, Br^- concentration is important in evaluating domestic water supply quality and influences the potential formation of DBPs, including THM and bromate. Br^- is more difficult to measure than Cl^-, so measurements of Cl^- are often used to calculate Br^- concentrations based on observed ratios of Br^- to Cl^-.

Figure 3C-31 shows DWR MWQI Br^-:Cl^- values, based on Br^- measurements that began in January 1990. The Br^-:Cl^- value for concentrations measured from San Joaquin River samples (mostly in the range of 0.0025 to 0.0035) is similar to the Br^-:Cl^- value for seawater (0.0035). Br^-:Cl^- values for Sacramento River inflow were scattered (mostly 0.001 to 0.006) because of low concentrations of Cl^- and Br^-, but they were generally lower than those of seawater or San Joaquin River water. These DWR MWQI data suggest that Br^- concentrations may be adequately estimated from Cl^- measurements. Based on the limited data available during the preparation of the 1995 DEIR/EIS, a single value of 0.0035 was assumed for all source waters for impact assessment purposes. The recent postdrought data (1993-1998) more clearly show an average Br^-:Cl^- ratio that is approximately 0.0030 for San Joaquin River water and 0.0020 for Sacramento River water. Therefore, these revised Br^-:Cl^- ratios are used in the REIR/EIS analysis.

Delta Dissolved Organic Carbon Data

Figure 3C-32 shows DWR MWQI measurements of DOC at Delta inflow and export locations since collection began in 1987. DOC is considered to be the major organic precursor of DBPs, including THMs. DOC is therefore one of the most important water quality variables for assessment of potential formation of DBPs in treated drinking water from the Delta.

DOC concentrations in Sacramento River samples are generally the lowest measured in the Delta, with average measured values of 2.3 mg/l (Figure 3C-32 and Table 3C-9). American River samples have even lower DOC concentrations (California Department of Water Resources 1989). Sacramento River DOC concentrations sometimes exceed 3 mg/l, with 21 of the 124 measured DOC values above 3 mg/l and two above 5 mg/l. Daily measurements taken periodically between 1993 and 1995 have confirmed that Sacramento River DOC concentrations can be elevated above 2 mg/l when sources of DOC material appear in surface runoff, with 430 of 694 measurements at or above 2 mg/l (California Department of Water Resources 1999a).

DOC concentrations in the San Joaquin River were higher and more variable than Sacramento River DOC concentrations. The average measured DOC value was 3.7 mg/l (Table 3C-9); 98 of the 118 measured DOC values (83%) were between 2.5 mg/l and 6 mg/l and four exceeded 8 mg/l during major storm events. The San Joaquin River must therefore be considered a major source of DOC relative to the Sacramento River, which has comparatively low DOC concentrations.

DOC concentrations at the export locations averaged 3.7 mg/l, with 85% of the measured values in the range of 2.5 to 6 mg/l. The DWR MWQI data clearly show that Delta sources or San Joaquin River inflow contribute DOC. The relative influences of the various possible sources cannot be easily identified from these data alone. The patterns seen in the more recent (1992-1998) data shown in Figure 3C-32 and Table 3C-9 are similar to the 1987-1991 data described in the 1995 DEIR/EIS; however, the newer data also show that DOC concentrations measured in some wet months are considerably higher than the average concentration of DOC.

Figure 3C-33 compares DWR MWQI measurements of DOC and Cl^- to EC values for the Sacramento and San Joaquin Rivers for 1984-1998. DOC concentrations in Sacramento and San Joaquin River samples do not demonstrate a clear relationship to concentrations of either EC or Cl^-. Therefore, it is not possible to estimate DOC concentrations in the river inflows as a function of either flow or salinity. Consequently, frequent measurements are the only accurate method for establishing the river-inflow DOC concentrations.

Delta Trihalomethane Precursor Data

To provide a comparative measure of THM precursors in Delta water, the DWR MWQI program has developed assays for determining THMFP, an index of the maximum possible THM concentrations that could be produced by maximum chlorination of Delta water. Starting in 1984, the assay was performed by spiking a water sample with an initial 120-mg/l concentration of Cl_2, holding the sample for 7 days (168 hours) at 25°C, then measuring the THM species with standard EPA procedures (gas chromatograph purge and trap, EPA method 502.2).

In 1994, the original method was discontinued and a buffered variation was implemented in which the pH of the sample was adjusted to a constant value of about 8.2. In 1996, two new methods were implemented, one of them a reactivity method in which the sample is spiked with a Cl_2 dose of 4.5 times the

DOC concentration and held for 7 days. However, both the buffered and reactivity methods have been discontinued.

The SDS method is currently used for the MWQI program. This method was developed to simulate the actual disinfection process (and THM concentrations) of municipal water treatment facilities more closely than other methods; it uses a much lower Cl_2 dose and much less contact time. Because the SDS method results in substantially lower values for THMFP and very few SDS data are available, only data generated from the original, buffered, or reactivity methods were plotted for the analysis of data trends presented below.

The four types of THM molecules are chloroform ($CHCl_3$), dichlorobromomethane ($CHCl_2Br$), dibromochloromethane ($CHClBr_2$), and bromoform ($CHBr_3$). The carbon-fraction concentrations of the four types of THM molecules are added together to calculate the carbon equivalent of the total THM concentration, called the C-THM concentration. The DWR MWQI program uses the term “total formation potential carbon” (TFPC) for the same variable.

Dividing the C-THM concentration by the initial DOC concentration in a water sample provides a direct estimate of the fraction of the initial DOC concentration that was converted to THM molecules during the THMFP assay. The ratio of C-THM to DOC is called the “THM yield” and is generally in the range of 0.005 to 0.02 for the high chlorination dose used in the THMFP assay.

Delta C-THM Data. Figure 3C-34 and Table 3C-9 show the C-THM concentrations measured by the DWR MWQI for 1984-1998. The results indicate conditions similar to those analyzed in the 1995 DEIR/EIS for 1982-1991.

The Sacramento River concentrations of C-THM averaged 28 Fg/l, with 25% of the measured concentrations greater than 30 Fg/l. Most (90%) export concentrations of C-THM were between about 30 and 90 Fg/l, and were generally higher than Sacramento River concentrations. San Joaquin River C-THM concentrations averaged 47 Fg/l, exceeding Sacramento River concentrations but remaining almost the same as export concentrations (Table 3C-9). Because the C-THM concentrations for Sacramento River inflow fluctuated, and because the San Joaquin River C-THM concentrations were similar to those measured at the export locations, it is difficult to directly estimate the monthly contributions of C-THM from Delta sources.

Figure 3C-35 shows the data for ratios of C-THM to DOC for the two inflow and three export locations for 1984-1998. With allowances made for a certain amount of scatter in both measurements, these ratios for THM yield from DOC range from 0.005 to 0.02, indicating that approximately 0.5% to 2% of DOC became THM molecules during the THMFP assay in most samples. The THM yield has less scatter in the results from 1994-1998; this change may be related to the introduction of the new measurement methods described above, which served to better standardize pH and Cl_2 dose in the samples. This yield relationship shown in Figure 3C-35 suggests that DOC measurements can be used to estimate the C-THM concentration in a THMFP assay. This relatively constant C-THM:DOC value might be used to condition Delta Wetlands operations; therefore, frequent DOC measurements may be used to monitor project effects on THM concentration and minimize the need for using the comparatively expensive and time-consuming THMFP assay procedure. This procedure for estimating THMFP is described in Appendix C-3 of the 1995 DEIR/EIS and is illustrated in Figure 3C-36.

Delta Ultraviolet Absorbance Data. UVA (254-nanometer [nm] wavelength) was added to the DWR MWQI program as a measurement variable in 1990. UVA is measured with a spectrophotometer and reported in units of 1/cm. UVA may provide a measure of the humic and fulvic acid portion of total DOC in a water sample; this portion of total DOC is thought to be the precursor for THM. The ratio of UVA to

DOC may increase with a higher proportion of humic substances. A greater yield of THM molecules may also be expected from samples with higher UVA:DOC values because the humic substances are thought to be the most active THM-precursor component of DOC.

Figure 3C-37 and Table 3C-9 show data from 1990-1998 and indicate that most Delta inflow and export samples have UVA (1/cm):DOC (mg/l) ratios of between 0.02 and 0.04, with an average slightly above 0.03. The Sacramento and San Joaquin River UVA:DOC values tend to be slightly lower than the UVA:DOC values for the export locations (Table 3C-9). The MWQI program calls this ratio the specific UVA (i.e., SUVA). The patterns shown in Figure 3C-37 are the same as those indicated in the 1995 DEIR/EIS.

Data on Delta Agricultural Drainage Salinity and Dissolved Organic Carbon

The purpose of the agricultural drainage data analysis is to estimate annual loading of DOC and salinity from existing agricultural operations. Agricultural drainage discharges containing natural decomposition products of peat soil and crop residues are considered dominant sources of DOC in Delta waters. Also, because the objectives specified in the 1995 WQCP substantially protect Delta water supplies from salinity intrusion effects during periods of reduced Delta outflow, agricultural drainage is the major remaining source of concern with regard to elevated salinity in Delta waters. This section updates information about measurements of water quality constituents in agricultural drainage presented in Appendix C2, "Analysis of Delta Agricultural Drainage Water Quality Data", of the 1995 DEIR/EIS.

There are two general ways to estimate the observed DOC loads (expressed as grams per square meter [g/m^2]) from the agricultural islands in the Delta:

- Multiply the annual drainage volume (expressed as water depth in meters [m]) by the average DOC concentration (mg/l) of the drainage water to estimate the DOC load.

- Multiply the DOC increase observed between the Sacramento and San Joaquin River inflows and the export locations by the export flow to estimate the increased mass of DOC. This increased mass (g) of DOC is then divided by the area of the Delta agricultural islands to estimate the average load of DOC (g/m^2).

Both methods have been used to evaluate the DOC load from Delta agricultural islands under existing conditions. The following section summarizes the results of these analyses; Appendix G, "Water Quality Assessment Methods", of the 2000 REIR/EIS presents detailed information on agricultural drainage water quality for Bacon Island, Webb Tract, Bouldin Island, Holland Tract, and Twitchell Island.

The 1995 DEIR/EIS presented water quality data collected at a large number of Delta island agricultural drainage pumping stations from 1986 through 1991 to determine annual drainage volumes and DOC concentrations. DWR stopped monitoring drainage water quality at the majority of Delta island drainage pumping locations in July 1994. The data used in the 2000 REIR/EIS were updated to include the more recent measurements. The following analysis presents agricultural drainage water quality data collected from the Delta Wetlands Project island locations from 1986 through 1994, with the exception of Bacon Island, where sampling was continued through August 1999, and Twitchell Island (not a project island), the location of several DWR and USGS studies that began in 1994.

Agricultural Drainage Volumes

The 1995 DEIR/EIS presented a detailed analysis of drainage volume calculations for Delta islands based on available data collected by DWR in 1954-1955. Because DWR stopped monitoring drainage water quality at the majority of Delta island drainage pumping locations in July 1994, no comprehensive drainage volume measurements have been collected since preparation of the 1995 DEIR/EIS that would substantially change the results of the analysis.

A study by USGS (U.S. Geological Survey 1997) determined that measuring electrical power usage from Delta pumps might be a reliable method of determining drainage volumes if more calibration of drainage pumps (volume per kilowatt-hour [kwh]) and regular monthly power usage records were available. However, no Delta-wide estimates of drainage flow were attempted. This method was used to estimate the drainage from Twitchell Island for calendar year 1995; the results were determined to be very close to (within 10% of) the flow measured using flow meters in the two Twitchell Island drainage pumps.

Dissolved Organic Carbon and Salt Budgets for Delta Islands

Results presented in the 1995 DEIR/EIS showed that 1986-1991 MWQI measurements of drainage EC from many of the Delta island agricultural drains show a strong seasonal pattern, with the highest EC values in drainage water during winter. EC values generally ranged from low values characteristic of Delta channel water (137 to 568 FS/cm) to much higher values (1,280 to 2,870 FS/cm). This range in drainage EC values is expected because of the variation in Delta precipitation and irrigation, leaching, and drainage practices. Higher EC values indicate that the salt has become concentrated in the agricultural soils through ET. Cl^- concentrations in agricultural drainage samples follow the seasonal EC patterns. DOC concentrations in these samples have a similar seasonal pattern; however, the variation in DOC concentrations is greater because the agricultural soils can be a source of DOC, and because evaporation of soil water during the growing season can increase DOC concentrations.

Agricultural drainage from Delta islands will have a Cl^-:EC ratio that reflects that of the original applied water because Cl^- and the dissolved solids that contribute most of the EC in water are conservative in water and not removed by biological or other physical and chemical processes. The concentrations of dissolved substances in drainage will vary because of dilution by rainwater or increases from evaporation losses.

Table 3C-10 summarizes the average DWR MWQI drainage data available for the Delta Wetlands islands and Twitchell Island. A detailed description of these results for each island is provided in Appendix G of the 2000 REIR/EIS.

CALIFORNIA DEPARTMENT OF WATER RESOURCES SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION STUDIES

SMARTS is a new test facility located in West Sacramento that began operating in 1998 and is managed under DWR's MWQI program. The facility consists of a series of large tanks specifically designed for conducting a variety of water quality studies under controlled static or continuous water-flow conditions. The first studies at SMARTS were designed to measure DOC loads from peat soils. Two reports from SMARTS studies have been prepared (California Department of Water Resources 1999b, 1999c) and are referred to below as SMARTS 1 and SMARTS 2. For the purpose of this analysis of Delta Wetlands Project effects on water quality, results of the SMARTS studies were evaluated for information on potential DOC loading rates from peat soils and are summarized below. The following summary and interpretation of the SMARTS reports were reviewed by MWQI's consultant Marvin Jung, who confirmed that the loading calculations described below are appropriate (Jung pers. comm.).

Summary of Methods

The SMARTS experiments measured DOC loading from peat soils by partially filling tanks with peat soil taken from Twitchell Island and measuring changes in EC and DOC concentrations in the peat-soil pore water and surface water. EC values were used to track evaporation and salt loading from the peat soil; DOC concentrations were measured to track DOC loading from the peat soil.

The SMARTS 1 report presents results of a 12-week experiment and SMARTS 2, results of a 27-week experiment. The SMARTS facility tanks have a diameter of 5 feet, with a surface area (for peat-water interface) of 1.8 square meters (m^2). The control tank (tank 9) was filled with 11 feet of water (volume of 1,616 gallons) with no peat soil. The following conditions varied for the eight experimental tanks:

- # water flow,
- # depth of peat soil,
- # depth of water, and
- # initial peat-soil composition.

These conditions are described below.

Water-Flow Conditions

The experiment used two water-flow conditions: "static" and "flushing". Four of the tanks (1, 3, 5, and 7) held static water depths above the peat soil. The static tanks were refilled as needed to compensate for evaporation losses, so the water level was held constant. However, the term "static" does not mean that there was no movement of water in the tanks. The surface water in the static tanks was mixed with submersible pumps that circulated about 1,680 gallons per day (gpd) in SMARTS 1; the mixing increased with larger 2,880-gpd pumps in SMARTS 2. Because the water depth was held constant in the static tanks, the load (g/m^2) for a static tank can be estimated as the change in DOC concentration (mg/l [equivalent to g/m^3]) times the depth of water (m).

Other tanks (2, 4, 6, and 8) were flushed repeatedly during the experiment. The total water volume in each tank was replaced weekly as water was added continuously while being removed from the top of the tank. The load of the flushing tanks can be estimated as the weekly flushing depths times the difference between the weekly inflow and outflow concentration. However, the volume of outflow from the tanks and DOC concentrations in the outflow were not directly measured. The pumps were set at the beginning of the experiment to flush a certain volume. Weekly measurements were not conducted to verify the assumed volume of water being pumped from the flushing tanks, and for the SMARTS 1 experiment, it was reported, when the output was checked, that the observed flushing volumes appeared to be as much as 50% more than anticipated. DOC concentration in the tank water was measured weekly; this measurement was assumed to represent the outflow DOC concentration. Because the cumulative depth of water for the flushing tanks was large (either 26 feet [8 meters] or 138 feet [42 meters]), very small changes in the measured tank DOC concentrations result in large changes in the load estimate (where DOC load = flushing depth C outflow concentration). The loading estimates were sensitive to even very low concentrations of DOC. Because the flushing volumes (i.e., depths) and changes in outflow DOC concentration are uncertain for the flushing tanks, DOC load estimates obtained from the flushing tanks are questionable and are not applied to the Delta Wetlands Project. Therefore, the results reported below focus on DOC loading from the static tanks (1, 3, 5, and 7).

Water and Peat Depth

The water and peat depth for the four static tanks varied; the water depth was either 2 feet (0.6 meters) or 7 feet (2.1 meters), and the peat depth was either 1.5 feet or 4 feet.

Initial Peat-Soil Composition

The initial peat-soil composition (e.g., pore-water DOC and EC concentrations, peat-soil density, soil salt content) also varied in each tank and for each experiment. Oxidized peat soils were taken from the top 2 feet of Twitchell Island to use in the experiments. The intent was for each tank to have similar soil characteristics. However, in SMARTS 1, although all the peat soil was mixed together before the tanks were filled, peat-soil pore-water EC measurements in the eight tanks ranged widely (842 to 2,140 FS/cm) at the start of the experiment. In SMARTS 2, two different peat-soil sources were used. Initial peat-soil pore-water EC values had an even greater range, with one peat-soil source resulting in initial pore-water EC values of 578 to 1,232 FS/cm (tanks 5–8) and the other source resulting in initial pore-water EC values of 3,640 to 4,800 FS/cm (tanks 1–4).

Dissolved Organic Carbon and Salinity Measurements

The SMARTS static tank results can be evaluated by considering that two pools of EC or DOC are being measured:

- EC or DOC in the peat-soil pore-water volume, measured by the bottom sampling spigot (0.5 foot from the bottom of the tank), and
- surface-water EC or DOC.

The amount of salt (EC) or DOC observed in the surface water is directly influenced by the concentration in the peat-soil pore water and the exchange rate caused by mixing processes. There may be a gradient of pore-water EC and DOC concentrations as EC and DOC are transferred from the soil into the surface water, but the average pore-water EC and DOC concentrations are assumed to be characterized by the measurements made from the bottom port. The peat-soil pore-water volume was not directly measured in the SMARTS studies but can be approximated from previous peat-soil measurements, which reported 40% to 60% solids (Table C3-8 in Appendix C3 of the 1995 DEIR/EIS). Because the percentage of solids averages 50%, the porosity of peat soil is assumed to be 50%, and the pore-water volume is assumed to be half the peat-soil volume.

Summary of Results

SMARTS 1 Pore-Water EC and DOC Concentrations

Table 3C-11 summarizes the results of the SMARTS 1 (12-week) experiment, and Table 3C-12 summarizes the results of the SMARTS 2 (27-week) experiment.

The peat-soil pore-water measurements of EC for the SMARTS 1 experiment ranged from 842 to 2,140 FS/cm at the start of the experiment. The range of measurements from the eight tanks indicates that although all the peat soil was mixed together before the tanks were filled, the peat-soil salt content in each tank varied.

The initial peat-soil pore-water DOC concentrations (week 1) for SMARTS 1 ranged from 143 to 226 mg/l (Table 3C-11). This range is higher than any soil DOC values measured by the USGS at Twitchell Island (U.S. Geological Survey 1998), which were generally in the range of 40 to 100 mg/l. They are also greater than the DOC in surface saturated soil samples collected from Holland Tract, which were in the range of 25 to 75 mg/l (as shown in Table C3-8 in Appendix C3 of the 1995 DEIR/EIS).

By the fifth week, approximate peat-soil pore-water DOC concentrations had increased to between 271 and 341 mg/l. By week 9, the peat-soil pore-water DOC concentrations were 58 to 386 mg/l, and in the final sampling at week 12, they were 74 to 358 mg/l (Table 3C-11). Pore-water DOC did not increase between weeks 9 and 12 in most of the peat-soil pore-water measurements. Therefore, although the flooded peat-soil DOC concentration is high, these results may indicate that the peat soil does not contain an unlimited supply of DOC, at least in the limited depth samples used in the experiment.

SMARTS 2 Pore-Water EC and DOC Concentrations

The SMARTS 2 peat-soil pore-water EC values on week 1 (January 21, 1999) ranged from 3,640 to 4,800 FS/cm in tanks 1–4 and from 578 to 1,232 FS/cm in tanks 5–8 (Table 3C-12). By week 15, the pore-water EC values were 2,383 to 3,280 FS/cm in tanks 1–4 and 455 to 998 FS/cm in tanks 5–8. As described above, these two groups of tanks were filled with different peat-soil sources from different locations on Twitchell Island. The peat soil used to fill tanks 1–4 is extremely high in soil EC (dissolved minerals apparently had not been leached by rainfall or field-flooding operations).

SMARTS 2 DOC concentrations in the peat-soil pore water were very high in tanks 1–4, but were relatively low in tanks 5–8. Again, the soils for these tanks came from different locations on Twitchell Island. The differences illustrate the wide range of peat-soil conditions in the Delta. On January 21 (week 1), the peat-soil pore-water DOC ranged from 82 to 96 mg/l in tanks 1–4 and from 11 to 28 mg/l in tanks 5–8. By April 28 (week 15), the peat-soil pore-water DOC concentration had increased to between 342 and 561 mg/l in tanks 1–4 and between 30 and 84 mg/l in tanks 5–8. On July 21 (week 27), the DOC concentration of peat-soil pore water in tanks 1–4 ranged from 368 to 590 mg/l and from 40 to 100 mg/l in tanks 5–8. The DOC concentrations in the peat-soil pore water increased substantially during the first months but did not continue to increase from week 15 to week 27, even though the temperature was higher. The experimental design called for the same peat-soil content in all eight tanks. However, because the peat-soil composition differed between tanks 1–4 and tanks 5–8, peat-soil composition is another factor to consider in the interpretation of the SMARTS 2 results.

DOC Loading Estimates

The DOC load that was transferred from the peat-soil pore water into the surface water through the various possible exchange processes (including the submersible pumps) can be calculated from the final water DOC concentration and surface water depth in the static tanks. These calculations result in loading estimates of 24 to 32 g/m^2 for the static tanks with 1.5 feet of peat (tanks 1 and 7) and 53 to 54 g/m^2 for the static tanks with 4 feet of peat in SMARTS 1 (tanks 3 and 5) (Table 4-3). The SMARTS 2 experiment resulted in a wide range of load estimates because the tanks' peat-soil pore-water DOC concentrations varied considerably. The SMARTS 2 experiment data for week 27 indicated that the DOC load from the high-DOC static peat tanks (tanks 1 and 3) was 73 to 121 g/m^2, and from the low-DOC static peat tanks (tanks 5 and 7), 23 to 42 g/m^2 (Table 3C-12).

Application to the Delta Wetlands Project

The peat-soil DOC loads measured in the SMARTS tanks are higher than the estimates obtained from agricultural drainage samples, and the peat-soil pore-water DOC concentrations were considerably higher than any DOC concentrations that have been measured in Delta peat soils. DOC loads in the static tanks are higher than the DOC load estimates from the Delta agricultural drains, but the peat-soil pore-water DOC concentrations in the SMARTS experiments were probably higher than would be experienced in undisturbed Delta agricultural peat soils that are flooded, based on USGS measurements at Twitchell Island. To determine the applicability of the SMARTS results to the Delta Wetlands Project, the experimental variables (i.e., water-flow condition, depth of peat, depth of water, and initial peat-soil composition) were evaluated for their consistency with proposed Delta Wetlands Project operations.

As discussed above, results from the static tanks were used to determine DOC loading estimates. The submersible pumps may mimic wave-induced mixing that would occur on the Delta Wetlands islands. The observed SMARTS loads were proportional to the depth of the peat soil and the DOC concentration of the peat-soil pore water. Likewise, DOC loading of flooded agricultural peat soils on the Delta Wetlands islands would be proportional to the depth of oxidized peat soil on the islands. Release of DOC is generally much greater for oxidized soil than for anaerobic (reduced) soils. Under existing agricultural practices, depth of oxidized soil on the Delta Wetlands islands has been assumed to be 2 feet based on DWR's Delta depletion analysis. Therefore, it is unlikely that Delta soils will have 4 feet of recently oxidized (aerobic) peat. The tanks with a 1.5-foot peat layer are perhaps the most realistic representation of Delta agricultural peat soils; however, loading estimates from both the 1.5-foot and 4-foot peat-soil depths were considered.

Peat soil composition on Delta islands is variable. However, the initial peat-soil pore-water EC and DOC concentrations reported for tanks 1–4 in the SMARTS 2 report exceed measured results from most other Delta soils. Initial pore-water EC values in tanks 1–4 were 3,640 to 4,800 FS/cm and pore-water DOC reached 374 to 590 mg/l by week 27. In comparison, samples of soil water (i.e., pore water extracted from soil samples) collected at the soil surface and at a depth of 2 feet from the demonstration wetland site on Holland Tract in 1992 yielded EC values between 612 and 1,990 FS/cm and DOC concentrations between 24 and 71 mg/l with an average of 55 mg/l (n=9). Soil-water samples collected from an agricultural field on Holland Tract in 1992 included measured EC values between 455 and 11,500 FS/cm and DOC concentrations between 41 and 240 mg/l with an average of 141 mg/l (n=9) (see Tables C3-8 and C3-9 in Appendix C3 of the 1995 DEIR/EIS). The SMARTS 2 pore-water DOC measurements are considerably higher than those of the surface or 2-foot-deep peat samples collected on Holland Tract.

The SMARTS 1 surface-water load estimates for static tanks with 1.5 feet of peat soil (tanks 1 and 7) were 24 to 32 g/m^2, and for static tanks with 4 feet of peat soil (tanks 3 and 5) were 53 to 54 g/m^2. For the SMARTS 2 tanks filled with peat soil that produced pore-water DOC concentrations of 40 to 100 mg/l (tanks 5–8), the DOC load estimates were 23 to 42 g/m^2 for static tanks with 1.5 and 4.0 feet of peat, respectively. These values suggest that submerged peat soil with a previous history of agricultural use may produce a DOC load of 2 to 5 times the measured agricultural drainage DOC loads (of about 12 g/m^2).

CCWD sent a letter to the SWRCB (Shum pers. comm.) suggesting that the 12-week load estimates from the SMARTS 1 experiment should be multiplied by 52/12 to estimate the annual loads. However, it seems clear from the measurements that the DOC concentrations in the water and in the peat-soil pore-water samples were approaching loading limits after week 9 (SMARTS 1); it would not be reasonable to expect 4 times these observed 12-week loads to originate from the peat soil during a year of submergence. The SMARTS 2 experiments confirm that the peat-soil pore-water DOC and the surface-water DOC concentrations do not continue to increase during longer submergence as rapidly as during the initial 3 months of submergence. The SMARTS 2 results indicate that surface-water DOC did continue to increase for the life of the experiment (27 weeks) in the static tanks, but average weekly peat-soil pore-water DOC concentrations increased at a slower rate after week 11 in all static tanks.

In conclusion, loading estimates from static tanks were considered in the context of estimates from other studies and expert testimony (described in the next section) to develop assumptions about Delta Wetlands reservoir islands under initial-fill operations. The loading observed in the SMARTS experiments may correspond to the first year of flooding of agricultural soils, but it is unlikely that the high initial level of peat-soil pore-water DOC would be produced in subsequent years from moist peat soils (U.S. Geological Survey 1998). The SMARTS experiments have not tested the DOC load from a second year of peat-soil submergence. It is likely that the DOC loads in subsequent years will be less than those measured for the first year of peat-soil submergence.

It should be noted that the SMARTS experiments do not represent the proposed conditions on the Delta Wetlands islands, and the experimental design and sampling methods may not be applicable to in-situ conditions. However, the SMARTS experiments provide the best source of experimental or laboratory data on DOC release from peat soils.

See “Impact Assessment Methodology” below and Appendix G of the 2000 REIR/EIS for more information about how results of the SMARTS studies were used in the impact analysis.

REPORTED ESTIMATES OF DISSOLVED ORGANIC CARBON LOADING

DOC loading is a function of many variables, including peat-soil depth, pore-water concentration, pore-water and water column mixing, and plant material growth and degradation. Agricultural production, wetland habitat, and flooded island conditions may result in different DOC loadings. For example, DOC loading from plant material growth and decay (including algal blooms) is expected to be greater under agricultural production or wetland habitat conditions than under flooded reservoir conditions.

During the Delta Wetlands Project water right hearing and in comments on the 1995 DEIR/EIS, the estimates of DOC loading on the Delta Wetlands islands under agricultural, reservoir, and wetland habitat conditions were debated at length. The EIR/EIS lead agencies have received a wide range of estimates of potential DOC loading rates. Table 3C-13 summarizes the loading estimates for agricultural drainage, seasonal wetland, and flooded island conditions that were presented in the 1995 DEIR/EIS, obtained from the Twitchell Island and SMARTS experiments, and presented at the SWRCB water right hearing for Delta Wetlands by expert witnesses. For purposes of comparison, these estimates are presented in similar units; all estimates have been reported as grams of DOC per square meter per year ($g/m^2/yr$). Units of $g/m^2/yr$ can be converted to pounds per acre per year (lbs/ac/yr) by multiplying the value by 8.9. For example, 10 $g/m^2/yr$ is equivalent to 89 lbs/ac/yr.

Source loading estimates represent attempts to characterize DOC loading from individual DOC loading components, such as vegetation residue, primary production, and peat soil, or from all components and factors expressed as a total DOC load. Some estimates are based on actual field data collection and experiments; others are based only on general theory calculations (e.g., organic carbon production and hydrodynamics). Some of the DOC load estimates vary considerably; the estimates range over several orders of magnitude from less than 5 to more than 1,800 $g/m^2/yr$.

The following text describes the estimates of DOC loading rates presented in Table 3C-13 and summarizes DOC loading estimates and criticisms of the 1995 estimates presented at the water right hearing. Consult the sources listed in the notes for Table 3C-13 for more detail about how these estimates were derived. The use of DOC loading estimates for the impact analysis is described under “Impact Assessment Methodology”.

Dissolved Organic Carbon Loading in Existing Agricultural Drainage

Estimates of DOC loading from agricultural operations in the Delta provide a baseline DOC loading level for the impact analysis. The 1995 DEIR/EIS used information from DWR MWQI agricultural measurements to establish existing DOC budgets and loading estimates. Those estimates have been updated based on DWR MWQI measurements of DOC concentrations and annual drainage volume (see Appendix G of the 2000 REIR/EIS). That fraction of the average DOC concentrations not accounted for in applied-water DOC was multiplied by estimated annual drainage depth to provide a calculated load. A similar method of load calculation was conducted for Twitchell Island records. These estimates are described further in Appendix G of the 2000 REIR/EIS.

Assumed agricultural loads from two modeling studies are also included in the list of agricultural drainage estimates. Using the Delta Wetlands island drainage load values as a reasonable range of likely DOC loads, an average of 12 $g/m^2/yr$ was used in the DeltaDWQ model in the 1995 DEIR/EIS. This average value for the project islands was supported further when the model was calibrated to export DOC concentration data; the loading estimate of 12 $g/m^2/yr$ correlated well with DOC concentrations measured at the SWP and CVP pumping plants (see Appendices C2 and C4 of the 1995 DEIR/EIS).

Estimates of drainage flows and drainage DOC concentrations presented in an MWQI report titled “Candidate Delta Regions for Treatment to Reduce Organic Carbon Loads, MWQI-CR #2” (Jung and Tran 1999) were used to calculate the average DOC load for Delta lowlands islands. These estimates were based on DOC concentrations and drainage volumes from DWR Delta lowlands modeling. The calculated load was 8 $g/m^2/yr$.

Dissolved Organic Carbon Loading under Project Conditions

Estimates from the 1995 DEIR/EIS

Several experiments were conducted for the Delta Wetlands Project to assess DOC loading under seasonal wetland and reservoir operations (see Appendix C3 of the 1995 DEIR/EIS). The methods and results of these experiments were challenged at the water right hearing and in comments on the 1995 DEIR/EIS. A brief summary of the experiment results and a discussion of challenges to those results follows.

In the wetland demonstration experiment, a portion of Holland Tract was flooded and a shallow flooded wetland habitat (0.5 meter deep) was created. Water samples were collected for approximately 3 months, and a DOC load was estimated. The wetland demonstration project estimated a total DOC load of 7 to 17 $g/m^2/yr$. In addition, a second experiment was conducted to ascertain the DOC load generated from the decay of wetland plants. Wetland plant decay experiments suggested a load of 5.1 to 7.5 $g/m^2/yr$. Compared to agricultural conditions, wetlands may provide lower DOC loads because the peat soil of wetlands generally will be more moist and less aerobic than that of agricultural soils. However, a seasonal wetland loading of 12 $g/m^2/yr$ was assumed in DeltaDWQ, equivalent to the assumed agricultural drainage load.

Additional experiments were conducted to assess DOC loading under Delta Wetlands Project reservoir operations. At the demonstration wetland on Holland Tract, loading was estimated for an extended period of time when a seasonal wetland was deep-flooded (to approximately 0.8 m) to characterize possible reservoir operations. In this experiment, the overall DOC load was estimated from the combined flooded wetland and water storage periods at the Holland Tract wetland demonstration project. The result was an estimated DOC load of 21 $g/m^2/yr$.

In 1991, as part of DWR's emergency water bank, Tyler Island was flooded for approximately one month. DOC loading was estimated based on collected water samples. The Tyler Island experiment resulted in an estimated total DOC load of 30 to 36 $g/m^2/yr$. Much of the DOC loading was probably the result of the rapid decay of cornfield vegetation residue and oxidized surface peat soil.

Parties to the water right hearing questioned the validity of these experimental results. CUWA, CCWD, and others argued that the Holland Tract flooded wetland experiment was stopped too soon; they said that it was unclear whether the level of DOC had started to level off or not, and that the reported DOC loading was therefore underestimated. Additionally, for all the experiments, CUWA stated that the testing procedure for THMFP was inaccurate in waters containing more than 10 mg/l of DOC and that the laboratory used for water quality testing did not maintain good laboratory practices (Krasner testimony 1997).

Estimates from the Special Multipurpose Applied Research Technology Station Studies

The SMARTS experiments provided estimates of DOC loading from flooded peat soils obtained from a field on Twitchell Island that had been in agricultural conditions during the previous year. The results of the SMARTS experiments are discussed above in detail; Table 3C-13 includes loading results from the static tanks.

Estimates from Water Right Hearing Participants

Table 3C-13 summarizes the range of estimated DOC loads provided in testimony. A wide range of DOC estimates was provided; the estimates were based on physical/chemical process theory, including molecular diffusion, advection, and bioturbation (i.e., mixing by benthic organisms). Estimates from Stuart Krasner and Richard Losee for CUWA, K. T. Shum for CCWD, and Michael Kavanaugh for Delta Wetlands are briefly discussed below. Refer to the hearing exhibits for more information on how these values were developed. The estimates of DOC loading provided in testimony are theoretical; no direct in-field or experimental results on DOC loading under project conditions were presented.

Stuart Krasner of CUWA estimated the potential impact of the Delta Wetlands Project on THM formation and water treatment operations using estimated DOC concentrations from the Delta Wetlands reservoirs of 8, 16, and 32 mg/l. Assuming a reservoir depth of 6 meters and an initial applied-water DOC concentration of 3 mg/l, the resulting DOC loading estimates would be 30, 78, and 174 $g/m^2/yr$, respectively (Krasner testimony 1997).

Richard Losee of CUWA provided independent estimates of DOC from primary production (i.e., algae biomass) and from peat soil. Losee identifies the following sources of primary production on the reservoir islands:

- planktonic algae or phytoplankton,
- benthic or attached algae,
- submersed macrophytes,
- floating vegetation,
- emergent macrophytes, and
- terrestrial vegetation.

Based on *Cladophora* production rates in a shallow MWD reservoir reported by Losee and assuming a Delta Wetlands reservoir depth of 6 meters, DOC loading from primary production is calculated as 50 to 1,250 $g/m^2/yr$. Losee also estimated peat soil as a source of DOC by determining the amount of organic carbon that is potentially available from mass estimates of the organic carbon in the sediment pools. This analysis resulted in an estimated DOC concentration of 300 mg/l in water 6 meters deep, which translates into a DOC loading estimate of 1,830 $g/m^2/yr$. Losee's DOC loading estimates were the highest estimates presented at the hearing and more than 10 times greater than measurements from the SMARTS experiments. (Losee testimony 1997.)

K. T. Shum of CCWD and Losee provided an estimate of DOC loading from seepage control pump operations (see Chapter 3D). They estimated groundwater DOC concentrations of 20 to 40 mg/l (loading of 9.2 to 18.4 $g/m^2/yr$) based on an assumption that 8,100 af of water would be pumped through the wells on Bacon Island during a 9-month storage period. (Losee and Shum testimony 1997.)

Shum also testified about the magnitude of the flux of TOC from the peat sediments when molecular diffusion is the only transport process present. This estimate is based on an assumed peat-soil pore-water DOC concentration of 70 mg/l from the top 0.3 meter of the soil and a water column DOC concentration of 10 or 40 mg/l. Based on a 5- to 25-fold increase in the DOC diffusion loading rate as a result of various transport mechanisms such as bioturbation, wave pumping, and seepage, the resulting loading values were 16 to 160 $g/m^2/yr$. (Shum testimony 1997.)

Michael Kavanaugh for Delta Wetlands estimated DOC loading on habitat and reservoir islands based on diffusion from sediments, vegetative biomass, and algae production. Results for the reservoir islands were 3.5 to 11.9 g/m^2/yr for Bacon Island and 3.5 to 12.7 g/m^2/yr for Webb Tract; results for the habitat islands were 7.3 to 20.6 g/m^2/yr for Bouldin Island and 3.7 to 10.3 g/m^2/yr for Holland Tract. (Kavanaugh testimony 1997.)

See "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS" below and Appendix G of the 2000 REIR/EIS for information about how estimates presented in testimony were considered in the impact analysis.

CHANGES IN DISINFECTION BYPRODUCT RULES

Since release of the 1995 DEIR/EIS, new or revised standards have been adopted or proposed regarding DBPs in treated drinking water. The following sections describe new rules for TOC removal before treatment and revised and proposed THM standards.

Total Organic Carbon Removal Requirements

Since release of the 1995 DEIR/EIS, standards for TOC removal before treatment have been adopted under the Safe Drinking Water Act (SDWA). TOC consists of both DOC and particulate organic carbon (POC). DOC represents more than 90% of the TOC present in Delta waters (California Department of Water Resources 1994). The SDWA rules specify requirements for the removal of TOC. Municipal water treatment plants may remove this substance by enhanced coagulation (e.g., using alum); water systems that obtain their water supplies from surface-water or groundwater sources and use conventional filtration processes may use enhanced softening to remove TOC.

The following table shows the percentage of TOC that must be removed based on the alkalinity and TOC concentrations in source water. Removal of TOC before chlorination will generally reduce the THM concentrations. Because Delta water generally has an alkalinity between 60 and 120 mg/l as calcium carbonate ($CaCO_3$), removal of 25% or 35% of the raw-water TOC will be required. This TOC would be removed before the water is chlorinated to reduce the necessary Cl_2 dose and to reduce the subsequent formation of THMs.

Requirements for Percentage of Total Organic Carbon to be Removed
for Systems Using Conventional Treatment

	Alkalinity (mg/l as $CaCO_3$)		
Source Water TOC (mg/l)	0-60	60-120	>120
2–4	35%	25%	15%
4–8	45%	35%	25%
>8	50%	40%	30%

Revised Trihalomethane Standards

The EPA maximum contaminant level (MCL) for THM concentrations in drinking water has been revised from 100 to 80 Fg/l since release of the 1995 DEIR/EIS. Because THM concentrations vary seasonally, the THM standard is applied to a moving annual average based on quarterly or monthly samples at the treatment plants. Many water treatment plants have responded to the regulatory change by using enhanced coagulation with Cl_2 as the primary disinfectant or by changing treatment technology (e.g., ozone [O_3]).

EPA has also proposed future ("Stage 2") THM rules. The proposed rule, which is expected to go into effect in 2002, would lower the MCL for THMs to 40 Fg/l. To respond to this regulatory change, treatment plants will likely need to install treatment systems using O_3, granular activated carbon (GAC), and/or membranes. These changes will increase water treatment costs.

IMPACT ASSESSMENT METHODOLOGY FOR THE 2000 REVISED DRAFT EIR/EIS

This section provides an overview of the assessment methods used to evaluate water quality impacts of the proposed Delta Wetlands Project in the 2000 REIR/EIS and explains how the new or updated information described above has been incorporated into the assumptions and methods used. The section focuses on the quantitative models used to estimate Delta drainage and export water quality (i.e., DOC and salinity) and DBP concentrations (i.e., THMs and bromate) at the treatment plants under baseline and with-project conditions. Additional information about these methods can also be found in the section from the 1995 DEIR/EIS above entitled "Impact Assessment Methodology", Appendix G of the 2000 REIR/EIS, and Appendix C4 of the 1995 DEIR/EIS.

Modeling Delta Wetlands Project Effects on Salinity and Dissolved Organic Carbon

Water quality at Delta export locations is a function of the quality of water coming into the Delta, the ways in which that quality may change as a result of in-Delta activities, the volume of Delta inflows and exports, and the proportion of the export water coming from each source. Export water is a mixture of water from the central Delta, San Joaquin River water, and Delta agricultural drainage. Under Delta Wetlands Project operations, Delta Wetlands discharges would be another source of export water and would therefore affect Delta export water quality. Quantitative modeling is used to estimate the contribution of the Delta Wetlands islands to levels of water quality constituents at Delta channel locations and in Delta diversions and exports.

Modeling Used for the 1995 Draft EIR/EIS Impact Assessment

Before the 1995 DEIR/EIS was prepared, no model existed for estimating the relationship between the water budget for Delta agricultural islands (diversions, ET, and drainage) and the salinity (EC) and DOC concentration patterns in agricultural drainage. The Delta drainage water quality model DeltaDWQ was developed to estimate the contribution of the Delta Wetlands islands to levels of EC, DOC, Cl^-, and Br^- at

Delta channel locations and in Delta diversions and exports under no-project conditions and under project operations. DeltaDWQ combined all of the following:

- # DeltaSOS simulations of monthly channel flows;
- # DeltaSOS estimates of monthly diversion, storage, and discharge volumes for the Delta Wetlands Project islands; and
- # simulations of water quality constituent concentrations in monthly agricultural drainage flows and Delta Wetlands Project discharges.

DeltaDWQ simulated Delta agricultural drainage water quality by simultaneously accounting for water, salt, and DOC budgets. Refer to Appendix C4 in the 1995 DEIR/EIS for a detailed description of the DeltaDWQ model.

Modeling Used for the 2000 Revised Draft EIR/EIS Impact Assessment

For the 2000 REIR/EIS, the DeltaSOS model was modified to incorporate the equations for predicting the water quality of agricultural drainage and Delta Wetlands reservoir island storage. The revised model also incorporated equations that would predict the effects of agricultural drainage and Delta Wetlands discharges on constituent concentrations in Delta channels and exports. Simplified water budget and DOC and salt loading functions were included in the model. This modification of DeltaSOS with water quality calculations is called the DeltaSOQ model. Use of the DeltaSOQ model eliminates the need for a separate DeltaDWQ model. This section provides a summary of the assessment method; Appendix G of the 2000 REIR/EIS describes the method in detail by:

- # describing the methods included in DeltaSOQ for estimating Delta source contributions of DOC and salt concentrations,
- # explaining the assumptions and methods used for calculating DOC loading from agricultural drainage and Delta Wetlands discharges, and
- # demonstrating the calibration of the model using historical water quality measurements of Delta inflows and exports.

Estimating Changes in Salinity. The salinity (EC and Cl^-) of water from the central Delta, the San Joaquin River, agricultural drainage, and the Delta Wetlands Project islands and the proportions in which water from these sources is present in the exports determine export salinity. The volume of Delta flows and exports and salinity intrusion from Suisun Bay are used in calculations of Delta salinity. Methods used to simulate project effects on salinity in the 2000 REIR/EIS are similar to the methods described in the 1995 DEIR/EIS, but the equations have been updated to reflect updated salinity measurements from MWQI and other sources. Appendix G of the 2000 REIR/EIS provides more detail on the equations used to calculate salinity in DeltaSOQ.

Estimating Changes in Dissolved Organic Carbon. Project effects on DOC concentrations in Delta exports are a function of the following:

the DOC concentrations in water diverted onto the Delta Wetlands islands;

evaporative losses;

DOC loading from peat soils and plant growth;

residence time (i.e., the length of time water is stored on the islands before being discharged);

DOC concentrations in Delta receiving waters at the time of Delta Wetlands discharges; and

the relative amount of Delta Wetlands water in exports.

The methods used to estimate DOC under existing conditions (i.e., DOC in Delta inflows and Delta agricultural drainage) are based on DOC measurements and mass balance estimates, similar to the methods used for salinity (see Appendix G of the 2000 REIR/EIS). Although Delta Wetlands would cease farming operations on the islands under project conditions, the contribution of Delta Wetlands islands to agricultural drainage DOC (estimated as 1 g/m^2/month or 12 g/m^2/yr, as shown in Appendix C4 of the 1995 DEIR/EIS) is simulated as a constant under no-project and with-project conditions in response to comments on the 1995 DEIR/EIS. To determine project effects on DOC concentrations in the exports, the model includes an estimate of DOC loading under project operations in addition to the no-project estimate, as described below.

An additional load of DOC could result from inundation of the peat soils during reservoir operations under the proposed project. Reservoir operations might cause more DOC to be mixed from the pore water into the water column than when the peat soils are drained under agricultural practices. Measured data on DOC loading under flooded peat-soil conditions similar to conditions proposed by Delta Wetlands are not available; therefore, an estimated range of possible DOC loading from reservoir operations is based on experimental results.

For purposes of impact analysis, a range of potential DOC loads on the reservoir islands was assumed. In the long term, repeated filling and emptying of the Delta Wetlands reservoir islands might leach out most of the soluble organic material, and DOC loading from peat soils might decline over time. However, the first fillings of the islands would likely result in high DOC loading. The analysis presents three simulations of potential project effects on DOC in Delta exports: an assumption for long-term DOC loading (1 g/m^2/month of storage), an assumption for initial-filling DOC loading (4 g/m^2/month of storage), and an assumption for high initial-filling DOC loading (9 g/m^2/month of storage). The initial-fill assumptions include potential DOC loads from interceptor well operations. The loading estimates are summarized in Table 3C-14 and are discussed in more detail in Appendix G of the 2000 REIR/EIS.

Modeling Delta Wetlands Project Effects on Disinfection Byproducts

The potential effects of Delta Wetlands Project operations on treated-drinking-water DBPs (i.e., THM and bromate) are evaluated as an additional level of water quality impact assessment. DBP concentrations are determined by the raw water quality parameters (DOC and Br^-) as well as the treatment process parameters (chlorination dose, pH, temperature); therefore, only representative estimates of the incremental effects of increased DOC and Br^- concentrations on these DBP concentrations can be calculated. The latest Malcolm Pirnie equation for use in predicting THM concentrations and the Ozekin predictive equation for bromate formation in treating drinking water were evaluated for use in the impact analysis. The review of these assessment methods and the equations used in the DeltaSOQ model are described in

Appendix G of the 2000 REIR/EIS. Potential effects of Delta Wetlands Project operations on THM concentrations are calculated in the model; the effects on bromate concentration are not calculated because no reliable relationship between bromate and DOC or Br^- could be identified.

CRITERIA FOR DETERMINING IMPACT SIGNIFICANCE

The State CEQA Guidelines encourage each public agency to develop and publish thresholds of significance. The SWRCB has not published specific significance criteria for projects affecting Delta water quality; however, the SWRCB and EPA have established regulatory objectives and numerical standards, such as those contained in the 1995 WQCP, to protect beneficial uses of Delta waters. The criteria used to determine the significance of effects of Delta Wetlands Project operations on water quality were set to conform with these existing objectives and standards. For Delta water quality variables for which no regulatory objectives or numerical standards have been set, the selected significance threshold is a percentage change from existing measured values that encompasses natural variability in water quality constituents.

Since release of the 1995 DEIR/EIS, numerical requirements for TOC removal before water treatment have been established under the Safe Drinking Water Act, and EPA has revised its standard for THM concentrations in drinking water. Also, during the Delta Wetlands water right hearing, some protestants raised concerns about the adequacy of the 1995 DEIR/EIS significance criteria in protecting Delta water quality. As discussed below, these factors were considered when significance criteria were established for the 2000 REIR/EIS impact analysis for water quality.

Significance Criteria Used in the 1995 Draft EIR/EIS

For the 1995 DEIR/EIS analysis, it was assumed that there are benefits to maintaining water quality better than that specified by the numerical water quality criteria. Therefore, significance thresholds for variables with numerical water quality criteria were established at 90% of the specified water quality standards. If simulated project operations caused the value for a water quality variable to exceed 90% of the numerical standard for that variable, the effect was considered in the 1995 DEIR/EIS to be a significant water quality impact. Maximum significance criteria were not set for constituents that do not have numerical regulatory standards.

A second significance criterion was based on the assumption that some changes may be substantial compared with the natural variability of the water quality variable under no-project conditions and could be considered significant impacts. Natural variability caused by tidal flows, river inflows, agricultural drainage, and biological processes in the Delta channels is sometimes quite large relative to the numerical standards or mean values of water quality variables. Natural variability was assumed to be at least 10% of the specified numerical limit for variables with numerical limits or 10% of the mean value for variables without numerical limits. Measurement errors and modeling uncertainties were likewise assumed to be at least 10% of the measured or modeled values.

It would be unreasonable to establish a significance threshold that does not allow for project effects that fall within the range of natural variability of the constituents in question; doing so would make effects attributed to the project indistinguishable from no-project conditions. Therefore, simulated changes that were less than 10% of either the numerical limit or the measured or simulated mean value of the variable were not considered to be identifiable. In other words, these changes would be indistinguishable from the minimum range of assumed natural variability and model uncertainty. Based on professional experience, it was further considered reasonable that distinguishable changes from no-project conditions would be identified as significant when they would result in a variance greater than 10% of the mean or standard condition. This adds 10%, adding up to 20% of the numerical limits for water quality variables with numerical limits or 20% of the mean value for variables without numerical limits.

Comments on Significance Criteria

Several parties to the water right hearing and commenters on the 1995 DEIR/EIS have questioned the adequacy of the significance thresholds used in the impact analysis for water quality, arguing that these thresholds would not ensure the protection of all beneficial uses, most notably municipal water uses. The challenges are based on the concern that natural variability differs among water quality constituents and that any change for some constituents may unacceptably degrade resources that are already impaired. In addition, some parties have argued that economic effects on treatment plant operators (increases in treatment costs) that could result from project-related increases in salinity and DOC concentrations should be considered significant impacts.

The determination of impact significance and proposed mitigation described in the 1995 DEIR/EIS and in the 2000 REIR/EIS are intended to ensure that the project complies with NEPA and CEQA requirements. NEPA requires that an EIS disclose the direct, indirect, and cumulative effects of the proposed action but does not require significance determinations for individual project effects (40 CFR 1502.16). A lead agency is directed by CEQA to assess the significant environmental effects of a proposed project and has discretion regarding the most appropriate methodology for determining the significance of effects. The lead agency may adopt thresholds of significance for general use developed through a public review process, or may use other methods for determining impact significance for each particular project, based on substantial evidence. In addition, the State CEQA Guidelines state that a change in the environment is not significant if it complies with a "standard". A standard is defined as, among other things, a quantitative requirement adopted by a public agency through a public review process. (State CEQA Guidelines Sections 15126, 15064.7, and 15064.) Also, the State CEQA Guidelines state that economic changes resulting from a project "shall not be treated as significant effects on the environment"; similarly, NEPA requires discussion of economic effects to the extent that they are interrelated with environmental impacts (State CEQA Guidelines Section 15064; 40 CFR 1508.14). Therefore, economic effects will be considered by the SWRCB and USACE in their project approval processes, but no significance thresholds are required for such effects.

Normally, significance thresholds are based on established regulatory standards. The 1995 WQCP established numerical objectives for some of the Delta water quality variables assessed in this analysis (i.e., Cl^-, EC). In this EIR/EIS, significance thresholds for these variables are set to be more stringent than the adopted standards based on the following assumptions:

- It would be beneficial to maintain water quality that is better than that specified by the water quality objectives.

- Measurement errors and modeling uncertainties account for 10% of measured or modeled values.

The significance thresholds of a change of 20% of the numerical limit and a change to a value that is more than 90% of the allowed limit for these variables therefore exceed the expectations of CEQA and NEPA.

Established standards do not exist for project effects on DOC concentrations in Delta waters. In the absence of recognized standards, this analysis proposes 20% of average measured DOC values as the significance threshold for the assessment of project effects. This criterion was selected to detect changes that exceed the range of natural variability and that can therefore be attributed to project operations. It would be unreasonable to establish a significance threshold that does not allow for project effects that are within the natural variability of the constituents in question because project effects would be impossible to differentiate from no-project conditions.

In addition, EPA has set numerical limits for THM levels at municipal water treatment plants. Although the Delta Wetlands Project would not directly produce THMs, project contributions to DOC and Br^- concentrations in Delta waters could affect the subsequent formation of THMs at treatment plants. Therefore, the 20% and 90% significance thresholds described above have also been applied to the THM limits, with potential THM increases calculated based on estimated increases in DOC concentrations under unmitigated project operations. The potential effects of DOC loading under project operations are thus covered under two significance determinations, one for increases in DOC concentrations and one for estimated effects on treatment plant production of THMs.

The impact assessment for Delta Wetlands Project effects on water quality is performed using the available monthly average measurements and simulations of monthly average Delta conditions and project operations. Use of monthly data allows for a preliminary estimate of the number of months in which unmitigated project operations could substantially affect water quality; it also provides the basis for a comparison of relative effects of the project alternatives, consistent with CEQA and NEPA requirements. However, Delta Wetlands would be required to adjust actual operations daily in response to daily monitoring of actual Delta conditions and the quality of water stored on the Delta Wetlands islands. The significance criteria and estimates of the potential for project operations to cause exceedances of specified parameters presented in this impact assessment are used to develop mitigation measures under CEQA and NEPA on a monthly time step (see “Recommended Mitigation and Application to Delta Wetlands Project Operations” below). However, significance criteria for CEQA/NEPA analysis may differ from the requirements in water right terms and conditions that may be used to trigger changes in project operations.

During the water right decision process, the SWRCB considers a project’s effects on present and anticipated beneficial uses of Delta water. For example, some beneficial uses are more sensitive to changes in specific water quality variables than to changes in other variables; in these cases, the lead agencies may apply a mitigation trigger other than 90% of a specified limit or 20% change. In other words, the SWRCB may apply different performance standards for triggering mitigation, based on substantial evidence, in the terms and conditions of the water right permits. Possible mitigation approaches and the relationship between CEQA/NEPA mitigation measures and the terms and conditions of water right permits are discussed in “Recommended Mitigation and Application to Delta Wetlands Project Operations” below.

Summary of Significance Criteria Used in the 2000 Revised Draft EIR/EIS Analysis

The significance criteria used in the 2000 REIR/EIS analysis are identical to those used in the 1995 DEIR/EIS except that the THM criterion has been updated in response to changes in the federal Disinfection Byproducts Rule. The selected water quality impact assessment variables and the significance criteria used in the 2000 REIR/EIS for each variable are summarized in Table 3C-15.

The EPA standard for THM concentrations in drinking water has been revised from 100 to 80 Fg/l since preparation of the 1995 DEIR/EIS. For the 2000 REIR/EIS analysis, the significance criterion was lowered to exceedance of 72 Fg/l (90% of 80 Fg/l) or changes greater than 16 Fg/l (20% of 80 Fg/l) to reflect the new THM standard. Because the THM standard is based on an annual running average of THM measurements, the significance criterion may be applied more appropriately to the annual average THM values. However, the monthly criterion has been used for both the 1995 DEIR/EIS and 2000 REIR/EIS analyses to provide a more conservative approach to THM impact analysis.

Changes in export DOC concentrations caused by Delta Wetlands Project operations could affect TOC removal requirements at treatment plants (see "Changes in Disinfection Byproduct Rules" above). An increase in export DOC might cause the TOC removal requirement to change from 25% to 35%. Although the project-related changes in export DOC are within existing variations in DOC, the Delta Wetlands Project could affect the frequency with which treatment plants would need to meet higher TOC removal requirements and, as a result, could affect the cost of treatment operations. As discussed above, changes in treatment costs are not considered an environmental impact (State CEQA Guidelines Section 15064[e]). No new significance criteria were needed for this water quality variable.

ENVIRONMENTAL CONSEQUENCES

Water quality impacts of Delta Wetlands Project operations were assessed by comparing conditions under simulated project operations with conditions under the simulated No-Project Alternative. The simulated No-Project Alternative represents Delta water quality conditions that are likely to exist in the absence of Delta Wetlands Project operations (i.e., continued and intensified farming operations on the four Delta Wetlands Project islands), with a repeat of the historical hydrologic conditions, but with existing facilities, water demands, and Delta standards. See Chapter 3A for a description of the DeltaSOS modeling assumptions.

The 25-year period of 1967-1991 was used in the 1995 DEIR/EIS assessment of water quality effects for several reasons:

- # The range of hydrologic conditions during this period is similar to that of the full 73-year period of the hydrologic record (1922-1994) (see Appendix A1 of the 1995 DEIR/EIS).
- # Most reservoirs and diversion facilities were operational during this 25-year period.
- # Historical EC and water quality data are available for this period.

The full 1922-1994 period was used in the 2000 REIR/EIS assessment. The results from the most recent 23-year period of the hydrologic record (1972-1994) are shown graphically to illustrate the model calculations and results.

As described in the 1995 DEIR/EIS, four locations in the Delta (Chipps Island, Emmaton, Jersey Point, and Delta exports) were selected for assessment of impacts related to Delta salinity conditions. A representative Delta export location was used because the impact assessment methods cannot distinguish reliably between water quality conditions at the major export or diversion locations (CVP exports at Tracy, SWP exports at Banks, and CCWD diversions at Rock Slough or Old River intakes).

Impacts related to DOC and THM concentrations were assessed for Delta exports only. Export DOC concentrations were evaluated with the DeltaSOQ model for a range of estimates of DOC loading from the

Delta Wetlands reservoir islands. THM concentrations in treated drinking water were evaluated using the revised THM equation (see Appendix G of the 2000 REIR/EIS).

Simulated Delta Water Quality for the No-Project Alternative

As noted above, the No-Project Alternative is simulated to represent likely Delta conditions that would result from a repeat of the historical hydrologic sequence, but with existing water project facilities (reservoirs, diversions, and canals) and current levels of demand for upstream diversions and Delta exports. Delta conditions under the No-Project Alternative are assumed to be controlled by objectives of the 1995 WQCP and other applicable water rights, agreements, and requirements. The results of simulations of the No-Project Alternative are compared with historical data to confirm the reliability of the DeltaSOQ model in predicting general trends. Water quality conditions were simulated for 1922 through 1994 (73 years) for the 2000 REIR/EIS analysis based on the results of baseline water supply and operations modeling (i.e., DWRSIM results; see Chapter 3A, "Water Supply and Water Project Operations"). Results for the entire 73-year study period are presented in tables, and a series of figures compares simulation results and available historical data for 1972 to 1994.

Because of the differences in facilities, levels of demand, and regulatory requirements between the No-Project Alternative and historical conditions, however, the No-Project Alternative simulation results should not be expected to correspond in all details to historical Delta operations and should not be confused with actual Delta operating conditions for the years compared. Once the reliability of DeltaSOQ in predicting trends is established, the simulated No-Project Alternative serves as the baseline condition with which simulated Delta Wetlands Project operations are compared for impact assessment purposes, as described below.

Simulated Electrical Conductivity at Delta Channel Locations and Chloride in Delta Exports

As reported in the 1995 DEIR/EIS, the simulated maximum EC values at all four Delta locations and the export Cl^- concentrations were generally lower than measured historical values because Delta outflow, as simulated by DeltaSOS, satisfies the 1995 WQCP objectives and therefore is generally higher than historical flows.

Figure 3C-38 shows simulated patterns of EC at Chipps Island for 1972-1994 for the No-Project Alternative. Table 3C-16 lists the simulated no-project EC values at Chipps Island for the entire 1922-1994 study period. During periods of high Delta inflow, salts at Chipps Island are flushed and salinity becomes similar to river-inflow EC (assumed to be 150 FS/cm). During periods of low Delta inflow, outflow is often controlled by required minimum outflow objectives or salinity standards. The maximum monthly EC value for Chipps Island was 12,355 FS/cm for the simulated No-Project Alternative.

Figure 3C-39 shows simulated patterns of EC at Emmaton for 1972-1994 for the No-Project Alternative. Table 3C-17 lists the simulated no-project EC values at Emmaton for the entire 1922-1994 study period. The simulated maximum EC value for Emmaton for the No-Project Alternative was 3,115 FS/cm.

Figure 3C-40 shows simulated patterns of EC at Jersey Point for 1972-1994 for the No-Project Alternative outflows. Table 3C-18 lists the simulated no-project EC values at Jersey Point for the entire

1922-1994 study period. The simulated maximum EC value for the No-Project Alternative at Jersey Point was 2,522 FS/cm.

Seawater intrusion effects are much less pronounced in central Delta exports than at Jersey Point; Sacramento River diversions through the DCC and Georgiana and Threemile Sloughs into the central Delta mix with tidal flows from the lower San Joaquin River to produce relatively freshwater conditions in Delta exports. In addition to seawater intrusion episodes, other fluctuations in simulated EC and Cl^- concentrations in Delta exports are caused by variations in San Joaquin River inflow and agricultural drainage effects. These effects are included in the DeltaSOQ estimates of Delta export EC and Cl^- concentrations.

Figures 3C-41 and 3C-42 show the simulated patterns of EC and Cl^- concentration, respectively, in Delta exports for 1972-1994 for the No-Project Alternative. Simulated monthly EC values reach a maximum of about 1,000 FS/cm during low-outflow periods when seawater intrusion is greatest. Maximum simulated monthly Cl^- concentrations are about 230 mg/l, which is less than the maximum allowable (i.e., WQCP objective) concentration of 250 mg/l. Table 3C-19 lists the simulated export EC values for the No-Project Alternative for the entire 1922-1994 study period and the flow-weighted average export EC values for each water year. Table 3C-20 lists the simulated export Cl^- concentrations for the No-Project Alternative for the entire study period. The flow-weighted average export Cl^- concentrations range from 38 to 171 mg/l, with an overall average export Cl^- concentration of 87 mg/l.

Simulated Dissolved Organic Carbon in Delta Exports

Figure 3C-43 shows simulated monthly values of DOC concentrations in Delta exports for 1972-1994 for the No-Project Alternative. Historical DOC data from the export locations was available only after 1986; however, the graph shows the data plotted against the 1972-1994 time period to provide for easy comparison with Cl^- data in Figures 3C-38 through 3C-42. Table 3C-21 lists the simulated export DOC concentrations for the No-Project Alternative for the entire 1922-1994 study period. The simulated monthly values ranged from 2.4 to 11.4 mg/l but were generally between about 3 and 6 mg/l, with occasional DOC concentrations of greater than 10 mg/l that correspond to periods when Delta agricultural drainage returns are highest (i.e., December–March) (see Table G-2 in Appendix G of the 2000 REIR/EIS) account for a high portion of the exported water. The simulated DOC concentrations were highest in the winter months (January–March) because of rainfall, drainage, and leaching of salt from the agricultural islands. The simulated flow-weighted average export DOC concentrations for the No-Project Alternative ranged from 3.2 to 6.2 mg/l, with an average export DOC concentration of 4.3 mg/l.

Estimated Trihalomethane Concentrations for a Typical Treatment Plant

Figure 3C-44 shows the estimated THM concentrations in chlorinated drinking water from Delta exports for the No-Project Alternative for 1972-1994. Table 3C-22 lists the simulated THM concentrations for the No-Project Alternative for the entire 1922-1994 study period. The concentrations were estimated using the revised THM equation described in Appendix G of the 2000 REIR/EIS. The monthly values ranged from 32 to 171 Fg/l, but were generally between about 30 and 80 Fg/l, with occasional THM concentrations of greater than 100 Fg/l that corresponded to high DOC or Cl^- concentrations at the export locations. Because the THM drinking-water MCL standard (80 Fg/l) is based on an annual moving average, the flow-weighted annual average THM concentrations may be more relevant for regulatory compliance purposes than the monthly concentrations. The average flow-weighted THM concentration for the No-Project Alternative was 55.7 Fg/l.

Impacts of the Proposed Project

The proposed project represents Delta Wetlands Project operations with two reservoir islands (Bacon Island and Webb Tract) and two habitat islands (Bouldin Island and most of Holland Tract). As described in Chapter 3A, the proposed project in the 2000 REIR/EIS analysis is represented by Alternative 2 of the 1995 DEIR/EIS with the revisions described in Chapter 2. The most consequential of these changes is the addition of the FOC terms. Under the proposed project, discharges from the Delta Wetlands Project islands would be exported in any month when combined CVP and SWP delivery deficits exist, there is unused pumping capacity within the permitted pumping rate at the SWP and CVP pumps, and the FOC and other operating rules are met.

Significant water quality impacts of Delta Wetlands Project operations may occur during months for which Delta Wetlands diversions or discharges are simulated. Project diversions could occur during months with relatively high Delta outflows, when EC values in the Delta are low. Most diversions would occur from November through February, the only months with simulated diversions of more than 500 cfs. Most project discharges would occur from June through August.

Operational Scenarios and Maximum Water Quality Effects

The section entitled "Analysis of Water Supply and Operations from the 2000 Revised Draft EIR/EIS" in Chapter 3A presents DeltaSOS simulation results for the proposed project under two operational scenarios for discharge to export. To establish the maximum potential effects from Delta Wetlands Project operations, all project discharges are assumed to reach the exports under both scenarios. In one scenario, project discharges are assumed to be exported if pumping capacity exists within the permitted pumping limits at the SWP and CVP pumping plants and if the FOC terms and other operating rules are met. In the other scenario, project discharges for export are subject to these same limits and are limited to periods when there are simulated south-of-Delta delivery deficits.

The salinity impacts of the proposed project are expected to be substantially less than shown in the 1995 DEIR/EIS because of the restrictions on project diversions incorporated into the project description (see Chapters 2 and 3A). Because of evaporation, the Delta Wetlands discharge salinity would be only slightly higher with the delivery-deficit restriction than it would be without such a restriction.

DOC loading from the reservoir islands is anticipated to increase with the period of storage; as a result, the proposed project operations defined by the second scenario (with discharges limited by south-of-Delta delivery deficits) represent the worst-case DOC loading. The simulations of project operations show that Delta Wetlands discharges under the second scenario are sometimes delayed by a few months compared with discharges under the first scenario; additionally, carryover storage on the reservoir islands is more likely under the delivery-deficit restriction (see Tables 3-15 and 3-18). Therefore, the DOC loading and Delta Wetlands discharge DOC concentrations are highest under the simulated conditions of the second scenario. For this reason, the second scenario has been used in the REIR/EIS DeltaSOQ simulations.

Table 3C-32 compares the impact conclusions of the 1995 DEIR/EIS and the 2000 REIR/EIS and summarizes recommended mitigation measures.

Delta Salinity Impacts (Electrical Conductivity, Chloride)

Water quality impacts of salinity increases were assessed for four selected locations in the Delta: Chipps Island, Emmaton, Jersey Point, and Delta exports. To simulate maximum project effects, it is assumed in DeltaSOQ that all Delta Wetlands discharges go to the export facilities. Therefore, when Delta Wetlands is discharging for exports, Delta outflow would not change, so Delta Wetlands discharges would not affect EC values at Chipps Island, Emmaton, or Jersey Point. Delta Wetlands discharges would change the export EC and Cl^- concentration if the Delta Wetlands discharge salinity were different from the central Delta salinity.

Delta Wetlands diversions are allowable only when Delta outflow is relatively large, so the simulated effects of the diversions are generally small at any of the Delta locations. The diversions may reduce the export fractions from the San Joaquin River or from agricultural drainage, causing a slight change in export salinity. Depending on the magnitude of Delta flows and exports and the timing of Delta Wetlands discharges, the EC values and Cl^- concentrations of these discharges may be less than or greater than export salinity. DWRSIM results used in the DeltaSOS simulations include required Delta outflows that are designed to satisfy applicable 1995 WQCP objectives for EC at all Delta locations. Therefore, simulated Delta Wetlands diversions are not allowed to prevent the Delta salinity objectives from being met.

The applicable 1995 WQCP EC objective changes with month, water-year type, or runoff conditions, or with the applicable minimum required outflow. Significance criteria may therefore differ for each month at each Delta location. Once the monthly effective EC objective is determined, the significance criteria are established as 90% and 20% of the maximum EC limit under the applicable conditions. For example, the applicable estuarine salinity (X2) objective for Chipps Island for February to June of some years requires an effective outflow of 11,400 cfs and is equivalent to an EC value of about 2,600 FS/cm. However, for some months with lower runoff, the X2 objective is at Collinsville (requiring an effective outflow of 7,100 cfs), and the Chipps Island EC value would be approximately 5,000 FS/cm. During most other months, the required Delta outflow is between 3,000 and 4,500 cfs, corresponding to EC values of between 10,000 and 14,000 FS/cm.

Chipps Island. Table 3C-23 compares the monthly changes in simulated EC values for the proposed project at Chipps Island with the EC values for the No-Project Alternative. In the table, positive values represent increases in EC and negative values represent decreases in EC under the proposed project when compared to the simulated No-Project Alternative.

The project effects on Chipps Island EC shown in Table 3C-23 are less than those reported in the 1995 DEIR/EIS (Table 3C-6) because the FOC terms now limit Delta Wetlands Project operations. The average changes in EC at Chipps Island in months with major Delta Wetlands diversions (December through February) are relatively small percentages (0.8 to 2.8%) of the No-Project Alternative values (shown in Table 3C-16). The largest simulated project increase in EC at Chipps Island during February through June, when the significance criterion would be 520 FS/cm, is 140 FS/cm. Therefore, as a result of incorporating the FOC terms into proposed project operations, none of the simulated changes in EC at Chipps Island exceed the significance criterion. This impact is considered less than significant. Although no mitigation is required, the EIR/EIS lead agencies likely will require that Delta Wetlands monitor salinity effects of the project to demonstrate compliance with the FOC terms and Delta salinity standards.

Emmaton. Table 3C-24 compares the monthly changes in simulated EC values for the proposed project at Emmaton with the EC values for the No-Project Alternative. EC objectives for Emmaton, applicable from April to August, range from 450 to 2,780 FS/cm, depending on water-year type. It is unlikely that Delta Wetlands would divert during these months, except to compensate for evaporative losses (if permitted to do so). The changes in Emmaton EC values under simulated project operations are less than those predicted in the 1995 DEIR/EIS because the FOC terms now limit Delta Wetlands diversions. As shown in the table, the largest simulated project increases in EC at Emmaton occur in August 1974 and August 1975 (120 and 103 FS/cm, respectively). These are wet years and the applicable EC standard during these years is a 14-day moving average of 450 FS/cm, with an associated 20% change significance criterion of 90 FS/cm. Therefore, monthly simulated project operations indicate that the significance criterion would be exceeded in these two months. As reported in the 1995 DEIR/EIS, this impact is considered significant and mitigation is recommended (see Table 3C-32).

Jersey Point. Table 3C-25 compares the monthly changes in simulated EC values for the proposed project at Jersey Point with the EC values for the No-Project Alternative. EC objectives for Jersey Point, applicable from April to August, range from 450 to 2,200 FS/cm, depending on water-year type. The results for Jersey Point are less than those predicted in the 1995 DEIR/EIS because the FOC terms limit Delta Wetlands diversions in these months. As shown in the table, the largest simulated project increases in EC at Jersey Point occur in August 1974 and August 1975 (96 and 82 FS/cm, respectively). These are wet years and the applicable EC standard is a 14-day moving average of 450 FS/cm, with an associated 20% change significance criterion of 90 FS/cm. Therefore, monthly simulated project operations indicate that the significance criterion would be exceeded in one month. As reported in the 1995 DEIR/EIS, this impact is considered significant and mitigation is recommended (see Table 3C-32).

Delta Exports. Table 3C-26 compares the monthly changes in simulated export EC values for the proposed project with the export EC values for the No-Project Alternative. The results reflect changes caused by both diversion and discharge operations of Delta Wetlands. The applicable EC standard is 1,000 FS/cm and the 20% change criterion is 200 FS/cm. None of the simulated monthly EC changes was greater than the criterion, so these impacts on export EC values are considered less than significant. Changes in export EC values are less than those presented in the 1995 DEIR/EIS because the FOC terms limit Delta Wetlands diversions and simulated delivery deficits limit Delta Wetlands discharges. Although no mitigation is required, the EIR/EIS lead agencies likely will require that Delta Wetlands monitor effects of the project on Delta export salinity to demonstrate compliance with the FOC terms and Delta salinity standards.

Commenters on the 1995 DEIR/EIS raised the concern that salinity in water diverted onto the reservoir islands might be very high because Delta Wetlands would divert water during an initial winter stormflow, which may be higher in salinity because of the proportion of agricultural drainage in Delta channels at that time. However, as described in Chapter 3A (see "Restrictions for Fish Protection" in the section "Revisions to DeltaSOS"), for monthly modeling purposes, diversions are restricted until the previous month's Cl^- concentration is less than 150 mg/l. Although this restriction on diversions is not specified in the FOC, it is used in DeltaSOQ to approximate the daily restrictions on project operations that would be applied in response to daily changes in Delta water quality that cannot be directly modeled in the monthly model. The FOC restriction against diverting until the X2 location has been downstream of Chipps Island for 1 or 10 days will generally result in Cl^- concentration decreasing to less than the concentration of 150 mg/l simulated in DeltaSOQ.

Table 3C-27 compares the monthly changes in simulated export Cl^- concentrations for the proposed project with the Cl^- concentrations for the No-Project Alternative. The simulated export Br^- changes would be directly proportional to the export Cl^- changes. The maximum simulated increase in Cl^- is 24 mg/l, which is equivalent to less than 0.1 mg/l of Br^-. The applicable Cl^- objective for all Delta exports is 250 mg/l, with some periods of 150 mg/l required for CCWD diversions (depending on water-year type). The impacts on export Cl^- concentrations shown in Table 3C-27 are less than those presented in the 1995 DEIR/EIS because the FOC terms limit Delta Wetlands diversions and the assumed delivery deficits limit Delta Wetlands discharges. DeltaSOQ also limits diversions until the central-Delta Cl^- concentration is reduced to less than

150 mg/l. This lowers the Delta Wetlands discharge Cl^- concentrations compared with those in the 1995 DEIR/EIS simulations.

As a result of incorporating the FOC terms into proposed project operations, none of the simulated changes in export Cl^- concentrations exceed the 20% change criterion (Table 3C-27). Therefore, this impact is considered less than significant. Although no mitigation is required, the EIR/EIS lead agencies likely will require that Delta Wetlands monitor effects of the project on Delta export salinity to demonstrate compliance with the FOC terms and Delta salinity standards.

Export Concentrations of Dissolved Organic Carbon

An additional load of DOC could result from inundation of the peat soils during reservoir operations under the proposed project. In the long term, repeated filling and emptying of the Delta Wetlands reservoir islands might leach out most of the soluble organic material, and DOC loading from peat soils should therefore decline over time. At least the first few fillings, however, might result in high DOC loading. Therefore, the tables and discussion presented below show export DOC concentrations under three assumptions for DOC loading to stored water: an assumed initial-filling DOC loading of 4 g/m^2/month of storage, an assumed high DOC loading of 9 g/m^2/month of storage, and an assumed long-term DOC loading of 1 g/m^2/month of storage. Total Delta agricultural drainage DOC contributions (12 g/m^2/year) are assumed to remain the same under no-project and proposed project conditions, resulting in an additional 1 g/m^2/month of DOC loading on the project islands.

The simulated effects of proposed project operations on export DOC concentrations during months with Delta Wetlands discharges for export depend on the difference between the estimated DOC concentration in the discharges under project conditions and the export DOC simulated for the No-Project Alternative. The selected significance criterion for a change in export DOC concentration is 0.8 mg/l, which is 20% of the mean measured export DOC concentration (4 mg/l).

Export Concentrations of Dissolved Organic Carbon under Long-Term Reservoir Operations. Figure 3C-45 shows the simulated export DOC concentrations and the simulated Delta Wetlands reservoir storage DOC concentrations for 1972-1994 using the long-term reservoir island loading assumption of 1 g/m^2 per month during periods of flooding. Periods when Delta Wetlands DOC concentration is shown as 0 mg/l are those periods when the reservoirs are empty. The DOC concentration in stored water increases during the storage period as follows:

$$\frac{\text{Monthly DOC loading rate } (g/m^2)}{\text{Storage depth } (m)} =$$

$$\text{Monthly increase in storage DOC concentration } (g/m^3\text{, or mg/l})$$

For a given loading rate, as depth of stored water increases, the DOC will be diluted more and DOC concentration will be reduced. Concentration will be higher with less water depth for the same loading rate. Under the assumed long-term loading rate of 1 g/m^2/month, when the reservoir is full (i.e., storage depth is 6 meters), the Delta Wetlands DOC concentration increases during the storage period by 0.167 mg/l per month (1 $g/m^2 \div 6$ m). This corresponds to an increase of approximately 2.0 mg/l per year.

For example, as shown in Table 3-14, the simulated Delta Wetlands reservoir filled in November 1974 and remained full until March of water-year 1976. The initial Delta Wetlands DOC concentration was assumed to equal the export DOC concentration of 3 mg/l. With an increase of 2 mg/l per year, the DOC concentration increased to about 5 mg/l in water-year 1974, and further increased to about 7 mg/l in 1975 (Figure 4-20). About half of the Delta Wetlands storage water was discharged in March 1976. With the average depth of Delta Wetlands storage reduced, the subsequent increase in Delta Wetlands DOC concentration was more rapid until June 1976, when all but 3 TAF of Delta Wetlands storage water was discharged, with a DOC concentration of 10 mg/l. The very high Delta Wetlands DOC concentration of 20 mg/l shown in July 1976 corresponds to the very small remaining volume, which was discharged in July. A similar rapid increase in Delta Wetlands DOC concentration was simulated in 1987, when a Delta Wetlands storage volume of 40 TAF was simulated. Periods with the greatest effect on export DOC resulting from Delta Wetlands discharges can be identified by comparing the simulated export DOC for the long-term loading and for the no-project conditions (Figures 3C-45 and 3C-43). Because Delta Wetlands discharges are a small proportion of total exports, Delta Wetlands discharges with high DOC concentrations do not result in dramatic changes in export DOC concentrations, as illustrated in the figure.

Table 3C-28 compares the resulting monthly changes in simulated export DOC concentrations for the proposed project with DOC concentrations for the No-Project Alternative. The simulation results indicate that the proposed project would increase average export DOC concentrations during months when Delta Wetlands discharges occur. Simulated export DOC concentrations decreased slightly during months with Delta Wetlands diversions because the diversions reduced the fraction of agricultural drainage and San Joaquin River inflow in exports. The DeltaSOQ model assumes that the Delta Wetlands habitat islands, and the reservoir islands during periods of no storage, would contribute the same DOC load as agricultural drainage. As shown in the table, some of the simulated monthly changes (20 out of 876) were greater than or equal to 0.8 mg/l. This occurred in 15 of the 73 simulated water-years. These results are higher than those predicted in the 1995 DEIR/EIS (Table 3C-7), which showed a change greater than 0.8 mg/l in one of 300 months. Therefore, project effects on export DOC are considered significant and mitigation is recommended (see Table 3C-32).

Export Concentrations of Dissolved Organic Carbon under Initial-Filling Operations. To simulate DOC loading under initial-filling operations, an assumed DOC load of 4 g/m^2/month during storage periods was simulated. Figure 3C-46 shows the simulated DOC concentrations in the Delta Wetlands storage water and exports using the initial-fill DOC-loading assumption. Table 3C-29 compares the monthly changes in simulated export DOC concentrations for the proposed project under the initial-filling DOC-loading assumption with the simulated DOC concentrations under the No-Project Alternative. As shown in the table, increases in export DOC concentrations greater than or equal to 0.8 mg/l were simulated in at least one month of approximately half (37) of the years. As described above under the long-term load assumption, project impacts on export DOC are considered significant and mitigation is recommended (see Table 3C-32).

Export Concentrations of Dissolved Organic Carbon under High Initial-Filling Operations. Figure 3C-47 shows the simulated DOC concentrations in Delta Wetlands storage water and exports using the high initial-filling DOC loading assumption of 9 g/m^2/month during the flooded period. Table 3C-30 compares the resulting monthly changes in simulated export DOC concentrations for the proposed project with DOC concentrations for the No-Project Alternative. As shown in the table, simulated monthly changes were greater than or equal to 0.8 mg/l in 41 of the simulated water-years when discharges from the project are simulated (48 of the 73 simulated water- years). The following section describes how the recommended mitigation (Table 3C-32) would affect Delta Wetlands operations.

Example of Discharge of Delta Wetlands Storage Water with High Dissolved Organic Carbon Concentrations under Mitigation Recommended in the 1995 Draft EIR/EIS. As described in the 1995 DEIR/EIS, the recommended mitigation for high DOC concentrations in water stored on the Delta Wetlands islands is to restrict Delta Wetlands discharges to prevent DOC increases of more than 0.8 mg/l in Delta exports on a monthly basis. High DOC concentrations in Delta Wetlands storage water are anticipated particularly during the first several fill operations. Changes in export DOC under the assumed initial-fill or high initial-fill DOC load rates are shown in Tables 3C-29 and 3C-30. Implementation of the recommended mitigation measure would affect Delta Wetlands' ability to export water.

An example of how Delta Wetlands discharges would be restricted to prevent significant increases in DOC at the export pumps is presented here. Channel DOC concentration is assumed to be 4 mg/l. The highest observed DOC load from the SMARTS 2 experiment (121 g/m^2 from tank 3) is used in this example to represent worst-case DOC loading in the first year of Delta Wetlands storage operation. With DOC loading at a given rate (g/m^2) during the first year of storage, the DOC concentration (g/m^3, or mg/l) depends on the depth of water (m) in which the DOC is diluted. If the depth of stored water were 20 feet (6 meters), the DOC concentration of the stored water would increase by the end of the first year of storage by 20 mg/l ($121\ g/m^2 \div 6$ meters $= 20\ g/m^3$). If the depth of water were only 10 feet (3 meters), representing a half-filled reservoir island, the DOC concentration of the stored water would increase by the end of the first year of storage by 40 mg/l ($121\ g/m^2 \div 3$ meters $= 40\ g/m^3$). The worst-case DOC concentrations for Delta Wetlands storage water, therefore, would be 24 to 44 mg/l.

A mass balance equation for export DOC is used to determine the applicable Delta Wetlands discharge rate when the DOC concentration in stored water is high. The allowable increment of export DOC concentration will be specified by the SWRCB as one of the terms and conditions of the water right permits. Consistent with the 1995 DEIR/EIS mitigation measure, the significance threshold of 0.8 mg/l of DOC is used in this example as the allowable increment. A relatively low export flow of 5,000 cfs is assumed for this example, to limit the Delta Wetlands discharge during dry summer conditions. The following mass balance for export DOC would apply to the discharge of DOC from the Delta Wetlands islands:

$$\text{Delta Wetlands DOC (mg/l)} \cdot \text{Delta Wetlands discharge (cfs)} + \text{Export DOC (mg/l)} \cdot \text{Export flow (cfs)} = \\ \text{(Export DOC + Allowed DOC increment [mg/l])} \cdot \\ \text{(Delta Wetlands discharge + Export flow)}$$

The DOC mass balance equation can be rearranged to solve for the allowable Delta Wetlands discharge:

$$\text{Delta Wetlands discharge} = \frac{DOC_{increment} \bullet Export_{without\ Delta\ Wetlands}}{(\text{DeltaWetlands DOC} - DOC_{export} - DOC_{increment})}$$

For an export DOC of 4 mg/l, with an assumed Delta Wetlands DOC of 24 mg/l and an allowable DOC increment of 0.8 mg/l, the Delta Wetlands discharge would be limited to 208 cfs. This would require 240 days (8 months) to empty one Delta Wetlands reservoir island (100 TAF). If both Delta Wetlands reservoir islands were filled, more than a year (16 months) would be required to discharge the Delta Wetlands storage (200 TAF). DOC concentrations may continue to increase during the discharge period. Assuming Delta Wetlands DOC concentrations were 44 mg/l with exports at 5,000 cfs, a Delta Wetlands discharge of only 104 cfs would be allowed.

The Delta Wetlands discharge rate could be twice as high as the rates reported above if the export pumping were increased to 10,000 cfs, and more Delta Wetlands discharge could occur during high-flow periods when the entire Delta Wetlands discharge would not be transported to the exports (i.e., Webb discharge during periods of high QWEST and Delta outflow). In comparison to the worst-case assumptions presented above, a Delta Wetlands discharge of 2,000 cfs would be allowed when the export pumping was 10,000 cfs and the Delta Wetlands DOC concentration was no greater than 5 mg/l more than the export DOC. If the SWRCB adopts a more stringent allowable DOC increment (i.e., less than 0.8 mg/l), the Delta

Wetlands discharge rate would be lower. In conclusion, Delta Wetlands discharges could be limited substantially if initial storage of Delta Wetlands water results in DOC concentrations in the stored water corresponding to the high initial-fill loading illustrated above.

Trihalomethane Concentrations in Treated Drinking Water

Table 3C-31 compares the monthly changes in simulated treated-drinking-water THM concentrations for the proposed project with THM concentrations for the No-Project Alternative. The DeltaSOQ calculations of THM for typical treatment conditions indicated that the monthly increases in THM concentrations under the proposed project were almost always less than the criterion of 16 Fg/l. As shown in Table 3C-31, the 20% change threshold would be exceeded in 6 out of 876 months. This is considered a significant impact, as in the 1995 DEIR/EIS. The mitigation measure has been revised to reflect the new standards for THM (see Table 3C-32).

If the THM MCL is reduced to 40 Fg/l as proposed by EPA, water treatment plant operations will need to be modified to provide acceptable THM concentrations for the range of DOC and Br^- that is observed in Delta diversions and exports, even without Delta Wetlands Project operations (see "Changes in Disinfection Byproduct Rules" above). Because the linear relationship between treated THM concentrations and Delta DOC and Br^- concentrations under improved treatment conditions will likely remain similar to the relationship under existing treatment conditions (i.e., a 10% increase in DOC or Br^- will increase THM concentration by 10%), the mitigation measures adopted to limit project-related increases in DOC or Br^- are still appropriate methods for controlling changes in THM concentrations as a result of project operations. If new THM regulations take effect, the allowable project-related increase in DOC at the exports could be reduced and the mitigation requirement for Delta Wetlands operations could be changed if needed.

The effect of project-related changes in THM concentrations at the treatment plant is primarily an economic one. The project-related changes in export DOC are within existing seasonal variations in DOC, so operators would have to be prepared to treat those levels under existing or future standards. However, the Delta Wetlands Project could affect the frequency with which higher DOC levels reach the treatment plants, as well as the time (i.e., season) that these DOC levels reach the plants; as a result, the project could affect the cost of treatment operations. Although NEPA and CEQA do not require a significance determination of the economic impacts on treatment plant operators, the EIR/EIS lead agencies acknowledge this potential effect of the project. Incremental increases in the cost of water treatment with the proposed project will be considered by USACE and the SWRCB in their project approval processes.

Because of substantial monthly variations in THM concentrations, the current EPA monitoring requirements allow averaging of monthly or quarterly THM samples. The THM MCL is an annual moving average of 80 Fg/l. Because Delta Wetlands Project discharges would occur for a limited period each year, the possible effects on annual average THM concentrations would be less than the increases in these concentrations attributable to increased DOC or Br^- concentrations during the discharge period. The flow-weighted annual increase in THM concentrations might be a closer approximation of the actual regulatory requirements (Table 3C-31). As described below, mitigation requirements could consider both a maximum monthly and an annual average acceptable change in DOC or expected THM concentrations.

Recommended Mitigation and Application to Delta Wetlands Project Operations

CEQA requires that, for each significant impact identified, an EIR discuss feasible measures to avoid or substantially reduce the project's significant environmental effect; mitigation measures are not required for effects that are not found to be significant (State CEQA Guidelines Section 15126.4[a]). NEPA, on the other hand, does not require federal agencies preparing an EIS to avoid or mitigate impacts even if mitigation is feasible (*Robertson v. Methow Valley Citizens Council* (1989) 490 U.S. 332). In practice, however, most individual federal agency regulations require that adverse effects of a project on protected resources be mitigated.

In the 1995 DEIR/EIS, proposed mitigation measures to offset significant impacts on water quality were based on limiting Delta Wetlands Project operations (i.e., diversions and discharges) so that the levels of water quality variables would remain below the 90% and 20% significance thresholds. This basic mitigation requirement remains the recommended method to prevent significant water quality impacts of Delta Wetlands Project operations. As explained in the description of the 1995 DEIR/EIS mitigation measures, Delta Wetlands Project operations would be regulated based on information from real-time monitoring of actual daily Delta flows, Delta Wetlands Project operating capacities, CVP and SWP operations, Delta water quality, quality of water stored on the Delta Wetlands Project islands, and fisheries. The effects of Delta Wetlands Project operations on Delta flows, water quality, and fish entrainment patterns would be reported in monthly operating reports.

The NEPA and CEQA lead agencies will adopt final mitigation requirements that would be used to trigger adjustments to Delta Wetlands' operations in response to project monitoring. Those mitigation requirements may differ from the significance criteria proposed above to meet CEQA/NEPA requirements (see discussion under "Comments on Significance Criteria" above). The adopted mitigation requirements will specify monitoring and averaging periods for determining Delta Wetlands Project effects; therefore, they may differ from the mitigation requirements that are based on the monthly simulations used in the 1995 DEIR/EIS and the 2000 REIR/EIS, which provide a reasonable analysis of the potential for significant project impacts. The lead agencies could specify annual averages, daily maximums, or monthly averages as mitigation triggers, with different criteria used for different variables. The application of different averaging periods for water quality variables is consistent with other water quality standards (e.g., objectives in the WQCP and EPA standards for quality of drinking water). For example, EPA's THM standard is applied to a moving annual average based on quarterly or monthly sampling at treatment plants (see "Changes in Disinfection Byproduct Rules" above). The lead agencies will make a final determination of the mitigation requirements to be applied to the Delta Wetlands Project in the terms and conditions of the water right permits and in the mitigation and monitoring plans they adopt.

The effects of Delta Wetlands diversions on salinity and X2 location could be easily determined with daily calculations and comparison with daily measurements at the established Delta monitoring locations (i.e., Chipps, Collinsville, Emmaton, Jersey Point, and export and diversion locations).

The effects of anticipated Delta Wetlands discharges on salinity and DOC concentrations at the Delta export and diversion locations would be estimated from measurements of Delta Wetlands storage water quality and the measured water quality at the export and diversion locations. The allowable Delta Wetlands discharge flow could then be calculated; the flow would be restricted to preclude Delta Wetlands discharge from causing salinity and DOC concentrations to exceed the allowable increases established by the SWRCB in water right terms and conditions. For example, if the monthly maximum increase in DOC concentration were established as 0.8 mg/l (corresponding to 20% of the average export DOC value, which was used as the significance criterion) and if the measured Delta Wetlands DOC concentration were 8 mg/l greater than the export DOC concentration, then the Delta Wetlands Project discharge would be limited to 10% of the export pumping (including Delta Wetlands discharge). Such suggested permit conditions would be used to prevent Delta Wetlands Project operations from exceeding acceptable increases in DOC or Cl^- concentrations based on the averaging period (e.g., monthly, annual) adopted by the lead agencies for each variable.

For salinity increases, the 1995 WQCP objectives are generally expressed as monthly average values. The allowable salinity increases from the Delta Wetlands Project could be specified as similar monthly average values, which might be different in each month at each location. An annual limit on the salinity increase resulting from Delta Wetlands discharges might also be specified. Some method for tracking salinity credits from Delta Wetlands operations (i.e., credits for Delta Wetlands discharge salinity being lower than export salinity) might also be allowed.

For DOC, there is no applicable adopted standard, but setting a moving annual average for DOC increases similar to that used for the EPA THM standards may be an appropriate condition for the Delta Wetlands Project. Alternately, the lead agencies could specify a set of monthly and/or annual acceptable increases similar to those described above for salinity.

Potential effects on water treatment costs for downstream water users caused by Delta Wetlands operations are an economic issue outside the scope of this environmental analysis. However, the SWRCB may choose to establish a monitoring and compensation plan for these potential effects in the water right terms and conditions. A procedure for establishing Delta Wetlands' contribution to increased water treatment costs (e.g., for TOC removal) would need to be determined and agreed to by Delta Wetlands and the water treatment operators.

The lead agencies would incorporate into the water right permit terms and conditions and the project mitigation monitoring plan selected mitigation triggers for each water quality variable of concern. These triggers would consist of the suggested significance thresholds (or other adopted criteria) combined with averaging periods deemed most appropriate for each respective water quality variable. In this way, the lead agencies could adopt mitigation measures other than those recommended in the 1995 DEIR/EIS and 2000 REIR/EIS and could address potential effects on beneficial uses and economic considerations that are beyond the scope of this EIR/EIS.

Cumulative Impacts

Cumulative water supply effects were evaluated using DeltaSOS simulations of the Delta Wetlands Project, as described above, but under the assumption that SWP pumping is permitted at full capacity of Banks Pumping Plant. This scenario represents reasonably foreseeable future Delta conditions and regulatory standards (refer to Chapter 3A).

As described in Chapter 3A, the proposed project would be operated in fewer years under cumulative conditions than under existing conditions because of limited availability of water for Delta Wetlands diversions. However, because of greater assumed export pumping capacity at Banks Pumping Plant, simulated Delta Wetlands export volumes under cumulative conditions were greater in several of the years than under existing conditions. The average annual simulated Delta Wetlands diversion under cumulative future conditions was 169 TAF/yr, with discharges for export of 147 TAF/yr. These simulated operations are not limited by south-of-Delta delivery deficits and represent the greatest possible DOC-loading impacts at export and diversion locations. Because DOC loads are proportional to the period of storage, loads under cumulative conditions could be somewhat less than for the proposed project, even if simulated exports are slightly higher.

Changes in water quality conditions (levels of EC, Cl^-, DOC, and THM) between the cumulative future no-project conditions and the cumulative with-project conditions would be similar to the changes simulated between no-project and proposed project conditions described above. Results of the revised analyses indicate that Delta Wetlands discharges to export under the proposed project would be less than previously reported for the 1995 DEIR/EIS (refer to Chapter 3A). Consequently, impacts on most water quality constituents would be reduced. Similarly, water quality impacts under cumulative conditions would be less than those presented in the 1995 DEIR/EIS analysis for cumulative conditions. However, there remains the likelihood that project operations under future cumulative conditions could exceed applicable significance criteria and would therefore require mitigation.

The significance conclusions about the cumulative impacts of the project on water quality concentrations are the same as described in the 1995 DEIR/EIS, and mitigation measures are recommended (see Table 3C-32).

Impact Evaluation of Project Alternatives from the 1995 Draft EIR/EIS

As described in Chapter 2, project operations under Alternative 1 in the 1995 DEIR/EIS were assumed to be the same as project operations under Alternative 2, except that discharges to export were assumed to be more restricted (i.e., by strict interpretation of the E/I ratio, the maximum allowed exports as a percentage of inflow). As shown in the 1995 DEIR/EIS analysis and described in Chapter 3 of the 2000 REIR/EIS, operations under Alternative 1 provide fewer opportunities for Delta Wetlands discharges to export than Alternative 2 operations. Changes in simulated Alternative 1 project operations between the 1995 DEIR/EIS analysis and the 2000 REIR/EIS analysis are similar in magnitude and direction to the changes described above for the proposed project (i.e., Alternative 2). Therefore, Delta Wetlands discharges to exports under Alternative 1 would be less than previously reported in the 1995 DEIR/EIS. The resulting impacts of Alternative 1 on salinity, DOC levels, and potential formation of THMs are less than those estimated for Alternative 1 in the 1995 DEIR/EIS, but remain significant.

Alternative 3, the four-reservoir-island alternative, has not changed since the 1995 DEIR/EIS was published. The FOC and biological opinion terms were developed for the two-reservoir-island operations represented by Alternative 2 in the 1995 DEIR/EIS and are not applicable to a four-reservoir-island alternative. New simulations of Alternative 3, which are based on the Delta water budget developed from DWRSIM study 771 and include AFRP actions, result in minor changes in project diversion, storage, and discharge operations. There are no changes to the conclusions of the environmental impact analysis presented in the 1995 DEIR/EIS for Alternative 3.

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Table 3C-1. Important Delta Water Quality Variables and Characteristics

Variable	Unit	Characteristic
Physical habitat parameters		
Flow	cfs	Governs dilution, transport, and mixing; both tidal flow and flow from inflows and pumping may be significant
Temperature	ºF	Governs biochemical rates and regulates biological production; determines dissolved oxygen saturation concentration
Suspended sediments (SS)	mg/l	Sediments or other particulates that adsorb chemicals and block light transmission through water
Dissolved oxygen (DO)	mg/l	Dissolved oxygen concentration in water; available to supply oxidation and respiration requirements
pH	standard unit	Measure of acidity or alkalinity of water
Electrical conductivity (EC)	FS/cm	Measure of dissolved anions and cations; conservative variable, easily measured with monitors
Dissolved minerals		
Salinity	ppt	Measure of salt content of water (measured in ppt)
Total dissolved solids (TDS)	mg/l	Measure of total dissolved materials
Chloride (Cl^-)	mg/l	Dominant anion; important to agricultural soil condition; 1995 WQCP water supply objective
Bromide (Br^-)	mg/l	Trace anion; important for trihalomethane (THM) production
Cl^-/EC ratio	mg/l/FS/cm	Ratio of chloride (mg/l) to EC (FS/cm); helps to identify the source of the water
Nutrient and organic constituents		
Dissolved organic carbon (DOC)	mg/l	Measure of dissolved organic content
Trihalomethanes (THMs)	Fg/l	Disinfection byproducts (DBPs) formed during the chlorination of water for municipal use
Trihalomethane formation potential (THMFP) is chlorinated	Fg/l	Measure of potential formation of THMs when water
C-THM	Fg/l	Carbon-fraction concentrations of THM compounds
Cl-THM	Fg/l	Chlorine-fraction concentrations of THM compounds
Br-THM	Fg/l	Bromine-fraction concentrations of THM compounds
UVA	1/cm	Ultraviolet light (254-nm wavelength) absorption of water; has been found to be directly related to the DOC content

Table 3C-1. Continued

Variable	Unit	Characteristic
Color	standard unit	Measure of dissolved organics expressed in color absorbance units
Chlorophyll	Fg/l	Measure of algal pigment indicating algal biomass
Nitrate (NO_3^-)	mg/l	Major nitrogen nutrient essential for plant growth
Phosphate (PO_4^{3-})	mg/l	Major phosphorus nutrient essential for plant growth
Contaminants		
Pesticides	Fg/l	Agricultural pest control residues with potential toxicity
Herbicides	Fg/l	Agricultural vegetation control residues with potential toxicity
Trace metals	Fg/l	Industrial residues with potential toxicity

Table 3C-2. Summary of 1995 Draft EIR/EIS Assessment of Delta Wetlands Project Impacts on Water Quality

I. Water quality effects on EC, Cl^-, Br^-, and DOC are directly linked with the assumed water budget on Delta islands (estimated in DeltaDWQ) and Delta channel flows (estimated in DeltaSOS). DOC effects also depend on the assumed sources of DOC resulting from agricultural drainage and DW habitat or reservoir island operations (estimated in DeltaDWQ). THM concentrations in treated drinking water were simulated with the EPA WTP model.

II. EC, Cl^-, and Br^- effects are governed by:

- # inflows (Sacramento and San Joaquin Rivers),
- # seawater intrusion (governed by Delta outflow),
- # Delta exports and channel flows, and
- # Delta island drainage and evapotranspiration (ET).

III. DOC effects are governed by:

- # inflows,
- # Delta channel processes (vegetation and sediments),
- # Delta exports and channel flows, and
- # Delta island drainage (sources).

IV. Changes in DOC sources can be comparatively described as a function of land use. DOC sources on the DW project islands may therefore change:

DOC Source	Agriculture	Habitat Islands	Reservoir Islands
Peat soil oxidation	f(Temp, O_2)	reduced source	reduced source
Peat soil leaching	f(water flow)	reduced source	reduced source
Vegetation residue	(biomass)	reduced source	reduced source

V. THM effects are governed by:

- # Delta export DOC and Br^- concentrations and
- # Water treatment processes (temperature or chlorination dose).

VI. DW project operations will change Delta water quality variables by reducing outflow during diversion periods and by discharging water that may have elevated salinity or DOC concentrations. Reducing agricultural diversions onto the DW islands may reduce salinity and reduce the contribution of DOC from agricultural drainage.

Table 3C-3. Preliminary Model Calibration and Confirmation Tasks and Summary of Preliminary Analyses for the Assessment of Impacts of the Delta Wetlands Project on Water Quality

Data	Model	Analysis	Results
Historical Delta inflows and exports for 1972, 1976, and 1978	RMA Delta water quality model	Calibration with daily EC measurements at 19 Delta locations	Smith and Durbin (1989)
Historical 1968-1991 data on Delta EC and CCWD Cl^- concentrations	RMA Delta water quality model and DeltaDWQ model	Confirmation of simulated historical EC patterns	Appendix B2 of the 1995 DEIR/EIS
Historical 1982-1991 MWQI measurements of channel and drainage samples	DeltaDWQ model	Simulation of Delta agricultural drainage (flow, EC, DOC) and export water quality (EC, Cl^-, Br^-, DOC) for the No-Project Alternative	Appendices C1, C2, and C4 of the 1995 DEIR/EIS
DW demonstration wetlands water quality experiments	DeltaDWQ model	Comparison of source loading of DOC from agricultural drainage and wetlands	Appendix C3 of the 1995 DEIR/EIS
THM measurements from Penitencia Water Treatment Plant	EPA WTP model	Confirmation of simulated THM concentrations	Appendix C5 of the 1995 DEIR/EIS

Table 3C-4. Modeling Tasks for Assessment of Impacts of the Delta Wetlands Project on Water Quality

Data	Model	Analysis	Results
DeltaSOS-simulated flows for the No-Project Alternative and the DW project alternatives	DeltaDWQ model	Simulation of water quality impacts (EC, Cl^-, Br^-, DOC) of the DW project alternatives	Chapter 3C, Appendix B2, and Appendix C4 of the 1995 DEIR/EIS
DeltaDWQ-simulated export water quality for the No-Project Alternative and the DW project alternatives	EPA WTP model	Simulation of treated drinking water THM concentrations	Chapter 3C and Appendix C5 of the 1995 DEIR/EIS

Table 3C-5. Water Quality Response Variables and Significance Criteria for Impact Assessments

Variable	Impact Assessment Method	Significance Threshold	Location of Assessment
Electrical conductivity	RMA Delta model results for 1967-1991 incorporated in DeltaDWQ model	a. Increase of 20% of applicable standards or b. 90% of applicable standard	Chipps Island, Emmaton, Jersey Point, and representative exports (CCWD, SWP, and CVP)
Chloride	RMA Delta model results for 1967-1991 incorporated in DeltaDWQ model	a. Increase of 20% of applicable standards or b. 90% of applicable standard	Representative exports
Bromide	RMA Delta model results for 1967-1991 incorporated in DeltaDWQ model	Increase of 20% equivalent of Cl^- standards	Representative exports
Dissolved organic carbon	DeltaDWQ model	Increase of 0.8 mg/l (or 20% of mean value)	Representative exports
Trihalomethanes	EPA WTP modeling	a. Increase of 20% of standard (20 Fg/l) or b. 90% of applicable standard (90 Fg/l)	Treated water from representative exports
Temperature	Evaluation of historical Delta field data[a]	Increase of 1°F, when channel temperature exceeds 60°F	Delta channel waters receiving DW discharges
Suspended sediments	Evaluation of historical Delta field data[a]	Increase of 20% of mean channel concentration	Delta channel waters receiving DW discharges
Dissolved oxygen	Evaluation of historical Delta field data[a]	Decrease of 20% of mean channel concentration	Delta channel waters receiving DW discharges
Chlorophyll	Evaluation of historical Delta field data[a]	Increase of 20% of mean channel concentration	Delta channel waters receiving DW discharges
Pollutant contaminants	Survey of DW project islands for contaminant sites	Presence of significant contamination from waste disposal or agricultural operations	Specific contaminated sites on DW project islands

[a] Source: DWR 1989.

Table 3C–6. Example of Determination of Significant Water Quality Impacts and Mitigation Requirements for Alternative 1 at Chipps Island Based on 1922–1991 DeltaDWQ Simulation Results

October
Outflow Objective: 4,000 cfs
Equivalent EC: 11,000 µS/cm
20% Change: 2,200 µS/cm
90% Limit: 9,900 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
8,343	3,262	3,267	7,765
8,362	3,871	3,251	7,728
7,858	3,019	3,195	8,252
7,791	2,867	3,097	8,237
8,376	3,019	2,945	7,406
7,640	2,451	2,818	8,151
7,409	2,610	2,785	8,426
10,769	3,871	2,222	4,742
6,977	1,710	2,041	8,309
11,600	3,213	1,784	3,860
11,882	3,726	1,763	3,707
11,730	3,871	1,742	3,756
11,706	1,020	1,017	3,043
5,417	631	887	10,071
13,812	1,263	850	2,107
19,597	3,871	210	621

November
Outflow Objective: 4,500 cfs
Equivalent EC: 10,000 µS/cm
20% Change: 2,000 µS/cm
90% Limit: 9,000 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
8,176	3,606	3,248	7,932
9,162	4,000	2,991	6,683
7,107	2,939	2,979	9,050
8,389	1,328	2,029	6,477
11,338	4,000	1,779	3,986
11,639	4,000	1,741	3,798
6,609	1,196	1,416	8,272
14,110	3,373	958	2,136
13,857	4,000	939	2,185
13,846	654	648	1,896
15,371	4,000	544	1,444
18,663	2,258	354	833
17,638	4,000	346	922
25,347	906	78	290
31,138	4,000	14	178
40,244	4,000	1	153

December
Outflow Objective: 4,500 cfs
Equivalent EC: 10,000 µS/cm
20% Change: 2,000 µS/cm
90% Limit: 9,000 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
11,083	3,871	1,978	4,320
6,883	1,744	1,879	8,292
7,497	1,686	1,773	7,295
7,022	1,198	1,719	7,919
10,949	1,040	1,220	3,636
13,339	3,784	1,189	2,586
10,987	1,627	970	3,365
6,604	863	835	7,700
25,725	3,871	53	260
27,368	3,871	31	219
32,649	2,726	15	175
49,670	3,871	0	150
51,188	3,871	0	150

January
Outflow Objective: 4,500 cfs
Equivalent EC: 10,000 µS/cm
20% Change: 2,000 µS/cm
90% Limit: 9,000 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
9,798	3,326	2,128	5,300
11,465	3,871	1,857	3,999
7,721	2,005	1,839	7,067
9,858	2,491	1,798	4,924
10,094	2,047	1,797	4,753
8,728	1,593	1,557	5,655
7,133	990	1,047	7,079
14,277	3,845	945	2,081
6,947	869	912	7,226
15,311	3,871	731	1,642
15,206	3,871	691	1,622
15,055	3,871	675	1,637
16,802	3,871	447	1,122
15,763	1,479	185	1,016
22,329	3,293	102	383
19,685	1,065	52	457
38,413	3,871	2	154

February
Outflow Objective: 11,400 cfs
Equivalent EC: 2,600 µS/cm
20% Change: 520 µS/cm
90% Limit: 2,340 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
17,380	3,684	412	1,016
16,169	2,520	336	1,101
24,242	3,354	101	333
25,005	3,132	53	270
24,946	634	52	271
20,498	742	27	385
29,069	4,000	26	200
32,451	4,000	10	171
34,625	2,465	5	161
36,089	4,000	4	158

March
Outflow Objective: 11,400 cfs
Equivalent EC: 2,600 µS/cm
20% Change: 520 µS/cm
90% Limit: 2,340 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
25,740	3,769	57	263
22,185	1,106	34	320
35,067	3,871	6	161
38,043	1,091	1	153
43,558	3,210	1	151

Note: No April–August DW Diversions of greater than 300 cfs.

September
Outflow Objective: 3,000 cfs
Equivalent EC: 14,000 µS/cm
20% Change: 2,800 µS/cm
90% Limit: 12,600 µS/cm

No–Project Effective Outflow (cfs)	DW Diversion (cfs) (>500 cfs)	Change in Chipps EC (µS/cm)	Alt 1 Chipps EC (uS/cm)
8,852	3,879	3,804	7,781
8,853	3,880	3,805	7,782
8,854	3,881	3,806	7,783
7,683	2,749	3,192	8,469
8,425	3,000	2,977	7,387
11,302	4,000	2,131	4,356
13,292	4,000	1,306	2,717
6,730	734	878	7,535

1. Specify appropriate EC criteria based on the 1995 WQCP outflow or EC objectives.
2. Estimate Chipps Island EC for the No–Project Alternative and DW project operations.
3. Determine DW project effects and mitigation requirements.
4. Shading indicates significant impacts that would require mitigation.

Table 3C-7. Summary of Changes between Alternative 1 and the No-Project Alternative in DeltaDWQ-Simulated Export DOC Concentrations (mg/l) for 1967-1991

October

x>0	%	x<=0	%
Five Largest Values			
0.13	2.70	-0.52	-15.7
0.07	1.71	-0.52	-14.5
0.07	1.69	-0.44	-14.5
0.04	1.49	-0.42	-13.7
0.04	1.08	-0.42	-13.0
25-yr Summary			
Number of months			
9		16	
Average			
0.04	1.13	-0.17	-5.15

November

x>0	%	x<=0	%
Five Largest Values			
0.31	7.89	-0.51	-18.0
0.15	3.56	-0.51	-17.0
0.12	3.51	-0.49	-16.3
0.09	2.64	-0.49	-16.3
0.08	2.49	-0.43	-13.5
25-yr Summary			
Number of months			
12		13	
Average			
0.08	2.23	-0.22	-7.25

December

x>0	%	x<=0	%
Five Largest Values			
0.09	1.69	-1.21	-22.9
0.07	1.55	-0.77	-16.9
0.07	1.28	-0.68	-13.9
0.04	0.68	-0.43	-12.0
0.03	0.64	-0.41	-9.96
25-yr Summary			
Number of months			
7		18	
Average			
0.05	0.90	-0.27	-5.93

January

x>0	%	x<=0	%
Five Largest Values			
0.195	3.18	-1.78	-26.0
0.10	1.79	-0.87	-17.3
0.10	1.66	-0.86	-15.7
0.08	1.46	-0.78	-15.2
0.05	1.20	-0.68	-12.4
25-yr Summary			
Number of months			
9		16	
Average			
0.07	1.26	-0.37	-6.60

February

x>0	%	x<=0	%
Five Largest Values			
0.15	3.20	-0.60	-15.8
0.12	2.58	-0.04	-0.86
0.09	1.77	-0.03	-0.65
0.08	1.47	-0.03	-0.62
0.07	1.47	-0.02	-0.39
25-yr Summary			
Number of months			
14		11	
Average			
0.05	1.04	-0.07	-1.79

March

x>0	%	x<=0	%
Five Largest Values			
0.40	11.1	-0.39	-14.7
0.20	6.02	-0.33	-12.1
0.18	5.05	-0.12	-3.57
0.13	4.77	-0.11	-3.38
0.12	3.71	-0.03	-1.17
25-yr Summary			
Number of months			
20		5	
Average			
0.11	2.96	-0.20	-6.99

April

x>0	%	x<=0	%
Five Largest Values			
0.40	12.0	-0.34	-7.51
0.36	8.37	-0.15	-3.98
0.29	6.94	-0.09	-2.70
0.14	3.40	-0.02	-0.46
0.10	2.08	-0.00	-0.08
25-yr Summary			
Number of months			
20		5	
Average			
0.09	2.28	-0.12	-2.94

May

x>0	%	x<=0	%
Five Largest Values			
0.39	10.3	-0.29	-7.52
0.33	8.65	-0.18	-5.76
0.30	8.43	-0.18	-5.15
0.21	6.37	-0.17	-4.71
0.15	4.16	-0.14	-3.95
25-yr Summary			
Number of months			
17		8	
Average			
0.11	2.87	-0.13	-3.70

June

x>0	%	x<=0	%
Five Largest Values			
0.71	14.0	-0.20	-4.48
0.15	4.44	-0.15	-4.09
0.07	2.35	-0.08	-2.09
0.07	2.17	-0.07	-1.98
0.07	2.10	-0.06	-1.73
25-yr Summary			
Number of months			
18		7	
Average			
0.07	1.81	-0.08	-2.24

July

x>0	%	x<=0	%
Five Largest Values			
1.00	27.8	-0.18	-5.15
0.53	12.0	-0.09	-3.06
0.35	11.0	-0.09	-3.05
0.24	6.71	-0.05	-1.22
0.17	5.36	-0.02	-0.84
25-yr Summary			
Number of months			
15		10	
Average			
0.17	4.72	-0.05	-1.48

August

x>0	%	x<=0	%
Five Largest Values			
0.75	13.2	-0.39	-11.9
0.32	11.1	-0.15	-4.36
0.31	9.40	-0.08	-2.37
0.21	6.67	-0.05	-1.63
0.18	4.70	-0.02	-0.75
25-yr Summary			
Number of months			
17		8	
Average			
0.14	3.64	-0.09	-2.75

September

x>0	%	x<=0	%
Five Largest Values			
0.26	10.4	-0.50	-17.6
0.17	4.53	-0.48	-16.4
0.13	3.58	-0.44	-15.8
0.11	3.57	-0.42	-14.8
0.08	2.31	-0.13	-4.43
25-yr Summary			
Number of months			
15		10	
Average			
0.07	2.17	-0.20	-6.98

Note: The value "x" represents the calculated change in units of measurement.

Table 3C-8. Summary of Changes between Alternative 1 and the No-Project Alternative in DeltaDWQ-Simulated Export THM Concentrations ($\mu g/l$) for 1967-1991

October

x>0	%	x<=0	%
Five Largest Values			
2.9	3.46	-5.30	-13.6
1.3	2.20	-5.00	-11.9
1.2	1.61	-4.30	-11.8
1.0	1.59	-4.00	-11.1
0.5	1.23	-3.80	-10.1
25-yr Summary			
Number of months			
9		16	
Average			
0.86	1.31	-1.66	-4.31

November

x>0	%	x<=0	%
Five Largest Values			
3.7	6.50	-4.8	-17.5
2.6	3.16	-4.8	-15.8
1.4	3.12	-4.4	-13.9
1.1	2.73	-4.2	-13.7
1.0	2.45	-3.6	-10.8
25-yr Summary			
Number of months			
12		13	
Average			
1.03	2.04	-1.86	-6.05

December

x>0	%	x<=0	%
Five Largest Values			
1.3	2.02	-13.7	-27.3
0.5	1.18	-6.5	-15.0
0.5	1.05	-5.7	-13.2
0.3	0.63	-3.1	-11.7
0.2	0.43	-2.9	-8.50
25-yr Summary			
Number of months			
6		19	
Average			
0.48	0.93	-2.18	-5.33

January

x>0	%	x<=0	%
Five Largest Values			
1.8	0.00	-14.6	-28.3
0.6	1.52	-7.1	-18.1
0.6	1.45	-6.4	-16.6
0.6	1.37	-5.3	-14.9
0.5	1.24	-4.9	-12.5
25-yr Summary			
Number of months			
7		18	
Average			
0.66	1.02	-2.49	-6.01

February

x>0	%	x<=0	%
Five Largest Values			
1.1	2.64	-4.7	-14.8
1.1	2.53	-0.3	-0.73
1.0	2.09	-0.2	-0.56
0.8	1.96	-0.2	-0.55
0.5	1.46	-0.2	-0.53
25-yr Summary			
Number of months			
10		15	
Average			
0.58	1.41	-0.40	-1.23

March

x>0	%	x<=0	%
Five Largest Values			
1.1	2.64	-4.7	-14.8
1.1	2.53	-0.3	-0.73
1.0	2.09	-0.2	-0.56
0.8	1.96	-0.2	-0.55
0.5	1.46	-0.2	-0.53
25-yr Summary			
Number of months			
20		5	
Average			
1.04	2.68	-1.9	-6.56

April

x>0	%	x<=0	%
Five Largest Values			
5.5	10.8	-4.9	-9.04
4.3	8.45	-2.8	-6.10
3.5	8.16	-1.3	-3.23
1.4	2.77	-0.7	-1.36
1.1	1.88	-0.2	-0.49
25-yr Summary			
Number of months			
19		6	
Average			
1.13	2.29	-1.67	-3.41

May

x>0	%	x<=0	%
Five Largest Values			
6.8	11.3	-4.0	-7.62
5.7	9.93	-3.8	-7.52
4.3	8.24	-2.8	-5.59
3.0	6.41	-2.5	-5.27
2.6	5.11	-2.0	-4.77
25-yr Summary			
Number of months			
14		11	
Average			
1.93	3.50	-1.53	-3.11

June

x>0	%	x<=0	%
Five Largest Values			
14.7	15.1	-3.4	-4.83
2.7	4.99	-2.6	-4.38
1.9	3.49	-1.4	-2.33
1.7	3.35	-0.7	-1.43
1.3	2.44	-0.6	-1.13
25-yr Summary			
Number of months			
14		11	
Average			
1.54	2.21	-1.34	-2.21

July

x>0	%	x<=0	%
Five Largest Values			
16.8	26.1	-4.4	-7.33
14.8	15.0	-3.3	-5.63
5.6	8.05	-3.0	-4.80
4.3	7.50	-1.5	-2.95
2.6	4.81	-1.5	-2.23
25-yr Summary			
Number of months			
15		10	
Average			
3.21	4.61	-1.65	-2.86

August

x>0	%	x<=0	%
Five Largest Values			
19.3	15.6	-8.7	-16.2
4.6	6.17	-4.2	-7.75
3.2	4.41	-3.9	-7.33
2.4	4.38	-3.7	-6.68
2.2	4.25	-0.8	-1.65
25-yr Summary			
Number of months			
15		10	
Average			
2.89	3.68	-2.29	-4.29

September

x>0	%	x<=0	%
Five Largest Values			
3.9	5.65	-5.7	-15.2
2.3	3.81	-5.7	-14.2
2.3	3.48	-5.2	-14.1
1.7	2.43	-4.3	-11.5
1.2	1.93	-1.7	-3.99
25-yr Summary			
Number of months			
14		11	
Average			
1.02	1.64	-2.42	-6.13

Note: The value "x" represents the calculated change in units of measurement.

Table 3C-9 Summary of Average DWR MWQI Data on Water Quality at Delta Channel and Export Locations

Drainage Location	Samples (#)		EC (µS/cm)	Cl^- (mg/l)	DOC (mg/l)	Cl^-:EC Ratio	Br^-:Cl^- Ratio	C-THM (µg/l)	C-THM:DOC Ratio	UVA:DOC Ratio
Sacramento River - Greene's Landing	164	AVG	159	6.8	2.3	0.041	0.0032	28	0.0116	0.0275
		MIN	70	1.0	1.3	0.009	0.0010	7	0.0039	0.0070
		MAX	253	19.0	5.5	0.080	0.0267	122	0.0358	0.0538
San Joaquin River - Vernalis	162	AVG	647	86.0	3.7	0.124	0.0030	47	0.0125	0.0277
		MIN	117	7.0	1.4	0.055	0.0002	21	0.0051	0.0160
		MAX	1320	183.0	11.4	0.161	0.0056	160	0.0226	0.0394
SWP Banks Pumping Plant	172	AVG	439	69.8	3.8	0.143	0.0031	52	0.0134	0.0333
		MIN	143	14.0	1.6	0.083	0.0021	12	0.0043	0.0277
		MAX	877	185.0	10.5	0.225	0.0041	204	0.0272	0.0474
CVP Tracy Pumping Plant	172	AVG	490	72.4	3.8	0.138	0.0030	50	0.0135	0.0317
		MIN	151	12.0	1.9	0.077	0.0021	19	0.0057	0.0200
		MAX	1150	181.0	11.0	0.217	0.0052	154	0.0251	0.0463
CCWD Rock Slough	175	AVG	514	93.7	3.6	0.154	0.0030	51	0.0145	0.0326
		MIN	146	9.0	1.1	0.056	0.0019	24	0.0070	0.0242
		MAX	1250	303.0	9.1	0.254	0.0044	735	0.1008	0.0426

Sources: 1995 DEIR/EIS and California Department of Water Resources 1999a.

Table 3C-10. Summary of Average DWR MWQI Data on Water Quality of Delta Island Drainage

Drainage Location	Sampling Dates	Grab Samples (#)		EC (μS/cm)	Cl^- (mg/l)	Br^- (mg/l)	Cl^-:EC Ratio	Br^-:Cl^- Ratio
Bacon Island	JAN '90 - AUG '99	111	AVG	589	102	0.24	0.17	0.0029
			MIN	200	18	0.05	0.04	0.0005
			MAX	1280	211	0.70	0.42	0.0045
Bouldin Island	MAR '87 - JUL '94	121	AVG	426	32	0.19	0.07	0.0061
			MIN	137	8	0.02	0.04	0.0025
			MAX	1300	94	0.56	0.13	0.0150
Holland Tract	JAN '90 - JUL '94	87	AVG	1177	211	0.65	0.18	0.0032
			MIN	559	64	0.18	0.11	0.0020
			MAX	2870	542	1.18	0.22	0.0052
Webb Tract	JAN '90 - APR '93	33	AVG	1143	183	0.61	0.16	0.0037
			MIN	568	97	0.41	0.11	0.0017
			MAX	2530	378	0.90	0.23	0.0065
Twitchell Island	JAN '94 - JAN '98	476	AVG	937	174	0.45	0.18	0.0028
			MIN	337	49	0.15	0.14	0.0008
			MAX	1980	328	0.72	0.24	0.0050

Drainage Location	Sampling Dates	Grab Samples (#)		DOC (mg/l)	UVA (1/cm)	C-THM (μg/l)	TTHMFP (μg/l)
Bacon Island	JAN '90 - AUG '99	111	AVG	11.4	0.52	129	1236
			MIN	3.4	0.15	18	178
			MAX	29.5	1.27	333	3080
Bouldin Island	MAR '87 - JUL '94	121	AVG	33.7	1.41	271	2511
			MIN	3.5	0.13	45	415
			MAX	96.0	3.48	691	6350
Holland Tract	JAN '90 - JUL '94	87	AVG	18.2	0.83	207	2044
			MIN	5.8	0.34	77	814
			MAX	37.0	1.55	549	6165
Webb Tract	JAN '90 - APR '93	33	AVG	29.7	1.32	258	2487
			MIN	10.0	0.47	102	1075
			MAX	57.0	2.54	483	4551
Twitchell Island	JAN '94 - JAN '98	476	AVG	20.1	0.93	213	2041
			MIN	1.1	0.13	33	360
			MAX	58.9	2.62	519	4840

Sources: 1995 DEIR/EIS and California Department of Water Resources 1999a.

Table 3C-11. Results of SMARTS 1 Flooded Peat Soil DOC and Salt (EC) Load Experiments

TANK	Peat Depth (feet)	Water Depth (feet)	Initial Surface Water DOC (mg/l)	Surface Water DOC (mg/l) Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Water Load of DOC (g/m^2)
1 static	1.5	2.0	1	8	11	15	20	23	25	30	32	35	39	40	40	24
2 flushing	1.5	2.0	1	10	10	11	10	9	8	7	8	7	5	4	4	55
3 static	4.0	2.0	1	23	31	43	59	73	83	99	114	135	108	92	88	53
4 flushing	4.0	2.0	1	18	15	19	18	15	12	14	11	9	8	6	7	92
5 static	4.0	7.0	1	6	8	10	13	16	18	20	19	24	26	27	26	54
6 flushing	1.5	7.0	1	8	5	4	5	4	3	3	3	3	3	2	2	143
7 static	1.5	7.0	1	5	6	7	9	11	11	12	14	15	17	19	16	32
8 flushing	4.0	7.0	1	4	3	2	2	2	2	2	2	2	2	2	2	90
9 control	0.0	11.0	1	2	2	1	2	2	2	2	2	2	2	3	2	4
Water Supply			1					1	1	1	1	1	1	1	1	

TANK	Peat Water DOC (mg/l) Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
1 static	158				287				58			74
2 flushing	205				301				301			279
3 static	222				273				283			270
4 flushing	145				282				324			301
5 static	143				271							323
6 flushing	226				338				339			341
7 static	155				336				386			341
8 flushing	208				341				374			358

TANK	Peat Depth (feet)	Water Depth (feet)	Initial Surface Water EC (µS/cm)	Surface Water EC (µS/cm) Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Water Load of Salt (g/m^2)
1 static	1.5	2.0	135	148	160	167	178	193	204	216	220	236	245	248	256	49
2 flushing	1.5	2.0	135	153	158	160	159	163	165	173	175	179	174	161	152	96
3 static	4.0	2.0	135	157	190	228	228	267	304	203	383	483	532	340	354	89
4 flushing	4.0	2.0	135	180	188	188	188	193	185	208	187	206	201	167	171	214
5 static	4.0	7.0	135	138	149	160	167	180	185	193	212	218	225	229	226	130
6 flushing	1.5	7.0	135	135	135	156	158	155	150	153	164	159	174	177	148	272
7 static	1.5	7.0	135	136	136	146	147	152	152	157	168	169	174	177	177	60
8 flushing	4.0	7.0	135	142	147	154	156	155	152	154	163	160	172	165	154	294
9 control	0.0	11.0	135	135	137	140	141	145	144	146	150	151	150	154	153	40
Water Supply			135	135	135	135	135	135	135	158	158	150	182	134	145	

TANK	Peat Water EC (µS/cm) Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
1 static	842				1017				345			395
2 flushing	986				1044				1138			1141
3 static	1480				1094				1181			1226
4 flushing	2060				1434				1388			1446
5 static	1931				2000							1852
6 flushing	1830				1516				1535			1830
7 static	1890				1762				1637			1590
8 flushing	2140				1730				1765			1563

Table 3C-12. Results of SMARTS 2 Flooded Peat Soil DOC and Salt (EC) Load Experiments

TANK	Peat Depth (feet)	Water Depth (feet)	Surface Water DOC (mg/l) Initial	Week 1 Jan 21	Week 3 Feb 3	Week 5 Feb 18	Week 7 Mar 4	Week 9 Mar 17	Week 11 Mar 31	Week 13 Apr 13	Week 15 Apr 28	Week 17 May 12	Week 19 May 26	Week 21 Jun 9	Week 23 Jun 23	Week 25 Jul 7	Week 27 Jul 21	Water Load of DOC (g/m²)
1 static	1.5	2.0	1.3	10.7	16.0	19.7	23.0	28.0	33.4	39.3	51.8	65.2	76.9	88.3	99.6	106.5	121	73
2 flushing	1.5	2.0	1.3	16.8	9.6	4.5	4.6	5.4	5.6	4.2	6.6	12	9.9	7.4	7.3	8.05	5	65
3 static	4.0	2.0	1.3	8.6	10.7	13.4	16.8	27.2	39.4	45.1	66.1	88.7	109.0	134.0	146.0	170.1	200	121
4 flushing	4.0	2.0	1.3	11.3	4.7	3.5	4.2	4.4	4.8	4.6	7.5	13.6	11.1	8.2	8.3	8.28	7	62
5 static	4.0	7.0	1.3	1.9	2.3	2.5	2.9	3.5	4.0	4.3	5.4	6	6.9	7.6	8.9	10.3	12.2	23
6 flushing	1.5	7.0	1.3	1.8	1.4	1.2	1.0	1.0	1.3	1.0	1.2	1.2	1.4	1.3	1.4	1.39	1.4	38
7 static	1.5	7.0	1.3	2.2	4.8	3.6	3.8	5.0	6.3	6.9	10.3	13.0	15.7	17.2	18.6	19.54	20.8	42
8 flushing	4.0	7.0	1.3	2.8	1.8	1.4	1.6	1.4	1.7	1.5	2.8	2.7	3.5	3.2	4.0	3.66	3.3	75
9 control	0.0	11.0	1.3	1.1	1.3	1.3	1.1	1.1	1.1	1.0	1.0	1.2	1.1	1.0	1.2	1.07	1.3	0
Water Supply				1.3	1.1	1.0	0.9	0.8	1.0	0.8	0.8	0.9	0.8	1.0	1.1	1.1	0.9	

TANK	Peat Water DOC (mg/l) Initial	Week 1	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 15	Week 17	Week 19	Week 21	Week 23	Week 25	Week 27
1 static		82.1	126		233		441.7		561		600		544		590
2 flushing		96	109		214		295.6		426		429		413		392
3 static		85.5	114		161		229.5		342		381		380		374
4 flushing		94.6	118		170		259.8		416		453		411		368
5 static		14.1	16.7		21.1		28.2		35.1		42.2		45.3		46.8
6 flushing		11.3	16.7		20		26.6		29.7		35.6		36.4		40.1
7 static		27.5	32.4		45.6		47.0		52.8		54.2		55.8		57.8
8 flushing		27.9	33.6		47.1		63.0		83.5		97.4		106.0		99.5

TANK	Peat Depth (feet)	Water Depth (feet)	Surface Water EC (µS/cm) Initial	Week 1	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 15	Week 17	Week 19	Week 21	Week 23	Week 25	Week 27	Water Load of Salt (g/m²)
1 static	1.5	2.0	116	312	244	386	411	432	461	465	428	574	632	664	717	780	851	300
2 flushing	1.5	2.0	116	483	276	166	166	167	186	142	145	206	219	211	209	177	162	335
3 static	4.0	2.0	116	248	276	302	348	424	500	410	563	825	1029	1177	1378	1513	1597	605
4 flushing	4.0	2.0	116	621	187	172	175	178	198	149	203	249	251	232	234	195	192	466
5 static	4.0	7.0	116	177	182	186	191	191	199	195	171	222	236	243	253	254	260	206
6 flushing	1.5	7.0	116	170	148	139	142	143	163	127	119	152	179	181	177	139	146	43
7 static	1.5	7.0	116	184	188	191	193	195	204	157	206	222	234	238	246	246	251	193
8 flushing	4.0	7.0	116	194	152	142	145	146	166	161	124	159	187	185	180	144	150	202
9 control	0.0	11.0	116	170	173	172	171	170	129	133	143	175	180	182	185	183	185	155
Water Supply				116	154	141	142	152	170	151	122	147	161	176	165	149	149	

TANK	Peat Water EC (µS/cm) Initial	Week 1	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 15	Week 17	Week 19	Week 21	Week 23	Week 25	Week 27
1 static		3640	3960		2730		3770		3159		3310		3260		3260
2 flushing		3740	3680		2430		2110		2383		2620		2530		2320
3 static		4000	4450		3400		3100		3115		3310		3140		3010
4 flushing		4800	4790		3290		3130		3280		3360		3300		2880
5 static		708	797		761		790		550		676		714		663
6 flushing		578	604		619		635		454.8		673		658		675
7 static		936	985		915		924		702		990		1021		1021
8 flushing		1232	1321		1308		1250		998		1265		1291		1249

Table 3C-13. Comparative Estimates of DOC Loading Rates (g/m^2/yr)

Source Estimates	Vegetation Residue	Primary Production	Peat Soil	Total DOC Load	Notes
Existing Agricultural Drainage Conditions					
Bacon Island				9.3	a
Webb Tract				10.4	b
Bouldin Island				22.4	c
Holland Tract				2.5	d
Twitchell Island				10	e
Twitchell Island, flow weighted				19	e
DeltaDWQ Model for Agricultural Conditions (1995 DEIR/EIS)				12	f
MWQI-CR#2				8	g
Seasonal Wetland and Flooded Island Conditions (1995 DEIR/EIS)					
Wetland Demonstration				7-17	h
Vegetation Decay Experiment	5.4-7.5				i
Flooded Wetland Demonstration				21	j
Tyler Island Flooding				30-36	k
DeltaDWQ Model for Seasonal Wetlands				12	l
DeltaDWQ Model for Flooded Islands				14-20	m
SMARTS Experiments—Peat Soil Flooding Conditions					
SMARTS 1—1.5 feet of peat (tanks 1 and 7)				24-32	n
SMARTS 1—4.0 feet of peat (tanks 3 and 5)				53-54	n
SMARTS 1—control (tank 9)		4			o
SMARTS 2—1.5 feet of peat (tanks 1 and 7)				42-73	p
SMARTS 2—4.0 feet of peat (tanks 3 and 5)				23-121	p
Water Right Hearing Testimony on Delta Wetlands Project Conditions					
Stuart Krasner, 8 mg/l DOC discharge				30	q
Stuart Krasner, 16 mg/l DOC discharge				78	q
Stuart Krasner, 32 mg/l DOC discharge				174	q
Richard Losee, algal biomass and peat soil		50-1,250	1,830		r
Richard Losee and K.T. Shum, groundwater seepage control pumping				9.2-18.4	s
K.T. Shum, molecular diffusion			16-160		t
Michael Kavanaugh, reservoir islands				3.5-12.7	u
Michael Kavanaugh, habitat islands				3.7-20.6	u

To obtain lb/acre, multiply g/m^2 value by 8.9.

Notes:

a. Calculated based on mean drainage depth of 1.73 m and mean excess DOC concentration of 5.4 mg/l. Source: 2000 REIR/EIS, Appendix G.
b. Calculated based on mean drainage depth of 0.5 m and mean excess DOC concentration of 20.7 mg/l. Source: 2000 REIR/EIS, Appendix G.
c. Calculated based on mean drainage depth of 0.83 m and mean excess DOC concentration of 27.1 mg/l. Source: 2000 REIR/EIS, Appendix G.
d. Calculated based on mean drainage depth of 0.4 m and mean excess DOC concentration of 6.2 mg/l. Source: 2000 REIR/EIS, Appendix G.
e. Calculated based on metered drainage volume from Twitchell Island in 1995 (11,232 af), Twitchell Island acreage of 3,580 acres, and mean DOC drainage concentration of 22.6 mg/l (n=231). Applied water DOC concentration assumed to be 3 mg/l (Sacramento River source). Flow-weighted average estimated from weekly flow-weighted DOC measurements from 1995. Sources: USGS 97-350; DWR's "Estimation of Delta Island Diversion and Return Flows", February 1995; MWQI.
f. DeltaDWQ assumed an agricultural drainage DOC loading for Delta lowlands of 12 g/m^2 per year, or 1 g/m^2 per month for 12 months. Source: 1995 DEIR/EIS, Appendix C4.
g. Loadings calculated from data presented in "Candidate Delta Regions for Treatment to Reduce Organic Carbon Loads, MWQI-CR#2" (Marvin Jung Associates in association with Limit to Infinity Enterprises, January 1999). Calculations based on DOC concentrations and volumes of drainage water presented in MWQI-CR#2 converted to mass loadings per square meter for an assumed 420,000-acre Delta lowland area. Loading factor does not account for initial DOC concentration of applied water.
h. Based on measurements of Holland Tract demonstration wetland. Source: 1995 DEIR/EIS, Appendix C3.
i. Based on bench-scale vegetation decay experiments utilizing Holland Tract demonstration wetland vegetation. Source: 1995 DEIR/EIS, Appendix C3.
j. Source: 1995 DEIR/EIS, Appendix C3.
k. DWR sponsored flooding of Tyler Island for a period of 1 month. Depth of stored water estimated based on acre-feet stored divided by Tyler Island acreage. Estimated depth multiplied by DOC concentration of discharge water provided for estimated DOC loading. Source: 1995 DEIR/EIS, Appendix C3.
l. DeltaDWQ assumed habitat island operation would provide a total of 12 g/m^2 per year of DOC between the months of October and March, or 1 g/m^2 per month for the months of October, February, and March and 3 g/m^2 per month for the months of November through January.
m. DeltaDWQ assumed wetland vegetation decay would provide a maximum of 8 g/m^2 per year of DOC if the islands were dry from May through August, based on wetland vegetation decay experiments. Dry reservoir islands were assumed to provide a total of 12 g/m^2 per year of DOC, or 1 g/m^2 per month for dry-period months. For periods when islands were flooded, DOC loads were assumed to be 0.5 g/m^2 per month for those months with flooded conditions to simulate lower DOC release conditions as suggested in flooded wetland/water storage experiments. Depending on monthly conditions, DeltaDWQ modeled a hydrologic year at a possible maximum load of 20 g/m^2 per year (12 dry months with wetland vegetation decay) or a possible minimum load of 6 g/m^2 per year (year-round wet period with no vegetation decay).
n. Loading estimate calculated from data provided in "A Trial Experiment on Studying Short-Term Water Quality Changes in Flooded Peat Soil Environments" (Marvin Jung Associates in association with MWQI, July 1999). Trial experiment used the top 2 feet of soil scraped from Twitchell Island agricultural fields with large clumps of vegetation and roots removed by hand.
o. Primary production DOC load calculated from data provided in "A Trial Experiment on Studying Short-Term Water Quality Changes in Flooded Peat Soil Environments" (Marvin Jung Associates in association with MWQI, July 1999). Primary production was measured in a control tank containing no peat.
p. Loading estimate calculated from data provided in "First Progress Report on Experiment #2: Seasonal Water Quality Changes in Flooded Peat Soil Environments Due to Peat Soil, Water Depth, and Water Exchange Rate" (Marvin Jung Associates, October 1999). This is the second experiment using the SMARTS test facility, and is to continue for at least one year. Data collected span January 21, 1999, through July 21, 1999.
q. Estimates provided by Stuart Krasner for CUWA. Krasner provides discussion of potential water quality effects based on assumed DOC discharge concentrations of 8 mg/l, 16 mg/l, and 32 mg/l. Source: Krasner testimony 1997, page 28. Loading factor in table was calculated by Jones & Stokes based on assumed reservoir depth of 6 m, minus an initial applied water DOC concentration of 3 mg/l.
r. Estimates provided by Richard Losee for CUWA. Algal biomass loading estimate was based on *Cladophora* production rates in a shallow MWD reservoir. Source: Losee testimony 1997, page 6. Peat soil DOC contributions were estimated based on conversion of peat soil to DOC. Testimony presented assumed DOC concentrations in 6-meter-deep storage reservoir water column of 300 mg/l. Source: Losee testimony 1997, page 11. Loading factor in table calculated by Jones & Stokes based on assumed reservoir depth of 6 m.
s. Estimates calculated based on rebuttal testimony provided by Richard Losee and K. T. Shum. Groundwater seepage loading based on 8,100-af perimeter well pumping estimate for Bacon Island during a period of nine months. Seepage water DOC concentration assumed to be 20-40 mg/l. Source: Losee and Shum testimony 1997, page 3.
t. Estimates calculated based on rebuttal testimony provided by K. T. Shum. Molecular diffusion DOC flux based on an assumed peat-soil pore-water DOC concentration of 70 mg/l (top 0.3 m of peat soil) and water column DOC concentration of 40 mg/l (3.1 g/m^2 per year) and a scenario in which the water column DOC concentration is 10 mg/l (6.2 g/m^2 per year). Loading value was estimated based on a 5- to 25-fold increase in DOC diffusion (misquoted from Kavanaugh testimony – Kavanaugh assumed 10-fold increase resulting in diffusion ranging from 5 to 25 mg/m^2 per day) as a result of external force, including advective currents, bioturbation, etc. Source: Shum testimony 1997, page 3.
u. Estimates based on testimony from Michael Kavanaugh. Source: Kavanaugh testimony 1997, Table V.

Table 3C-14. Estimates of Dissolved Organic Carbon Loading Using the DeltaSOQ Impact Analysis

	Assumed DOC Loading		Supporting Information
	$(g/m^2/month)$	$(g/m^2/year)$	
Agricultural Operations	1	12	MWQI agricultural drainage data for the Delta Wetlands Islands Twitchell Island drainage data MWQI-CR#2 Delta region organic carbon study
Wetland Habitat Operations	1	12	Holland Tract wetland demonstration Vegetation decay experiment MWQI agricultural drainage data
Long-Term Reservoir Operations	1[a]	12	DeltaDWQ Model—1995 DEIR/EIS Tyler Island flooding Holland Tract flooded wetland demonstration
Initial-Fill Reservoir Operations	4[a]	48	SMARTS 1 static tanks 1, 3, 5, and 7 SMARTS 2 static tanks 5 and 7
High Initial-Fill Reservoir Operations	9[a]	108	SMARTS 2 static tanks 1 and 3

[a] For the impact analysis, the agricultural DOC loading estimate (1 $g/m^2/month$) is assumed under both no-project and with-project conditions. Therefore, the reservoir operation DOC loading assumptions are added to the agricultural loading (i.e., Total monthly reservoir operations DOC loading = Reservoir operations loading + agricultural operations loading).

Table 3C-15. Water Quality Impact Assessment Variables and Significance Criteria

Variable	Significance Threshold	Location of Assessment	Discussion of Criteria and Changes Since the 1995 DEIR/EIS
Electrical conductivity and chloride	a. Increase of 20% of applicable standards or b. 90% of applicable standard	Chipps Island, Emmaton, Jersey Point, and representative export location (CCWD, SWP, and CVP) for EC; representative export location for Cl^-[a]	The 1995 WQCP objectives for EC and Cl^- have not changed since the 1995 DEIR/EIS was published. These objectives only apply in some months and at some locations. Therefore, significance criteria for EC and Cl^- are different for each month at each Delta location. For example, the applicable objectives for Cl^- are either 150 mg/l or 250 mg/l at the export locations. The same criteria used in the 1995 DEIR/EIS are used in the REIR/EIS analysis.
Bromide	Increase of 20% equivalent of Cl^- standards, using the Br^-:Cl^- ratio	Representative export location[a]	There are no numerical standards for Br^-. Because the ratio of Br^- to Cl^- is relatively uniform (0.0035) in the Delta, a change of 0.1 mg/1 Br^- (equivalent to about 28 mg/l Cl^- or 20% of the most restrictive Cl^- objective of 150 mg/l) is used as the 20% significance criterion. The same criteria used in the 1995 DEIR/EIS are used in the REIR/EIS analysis.
Dissolved organic carbon	Increase of 0.8 mg/l (or 20% of mean value)	Representative export location[a]	There are no numerical standards for DOC. Increases in export DOC of more than 20% of the mean DOC concentration (5 mg/l), or about 1 mg/l, are considered to be significant water quality impacts. This criterion is the same as that used in the 1995 DEIR/EIS.

Table 3C-15. Continued

Variable	Significance Threshold	Location of Assessment	Discussion of Criteria and Changes Since the 1995 DEIR/EIS
Trihalomethanes	a. Increase of 20% of standard (16 Fg/l) or b. 90% of applicable standard (72 Fg/l)	Treated water from representative export location[a]	The EPA standard for THM concentrations in drinking water has been revised from 100 Fg/l to 80 Fg/l since preparation of the 1995 DEIR/EIS. For REIR/EIS analysis, the significance criterion was lowered to exceedances of 72 Fg/l (90% of 80 Fg/l) or changes greater than 16 Fg/l (20% of 80 Fg/l) to reflect the new THM standard.

Notes:

[a] As described in the 1995 DEIR/EIS, a representative Delta export location was used for the impact assessment because the impact assessment methods cannot reliably distinguish between water quality conditions of CVP exports at Tracy Pumping Plant, SWP exports at Banks Pumping Plant, and CCWD diversions at Rock Slough or Old River.

Table 3C-16. Simulated No-Project Chipps Island EC (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	11185	10558	4956	2361	153	161	202	150	175	2507	6878	9988	4131
1923	6886	5489	158	161	235	1459	226	731	2155	4589	7916	10086	3774
1924	10598	10248	10066	8453	3736	2193	5268	5419	5477	8337	10925	12295	8118
1925	9989	11172	9758	8084	150	182	253	767	2155	5794	9049	11279	5908
1926	11236	10585	10240	5175	164	1485	413	1656	5274	7203	9744	11649	6311
1927	11440	2976	4471	257	150	151	150	194	1865	3484	6224	9409	3406
1928	9118	3851	3947	509	231	150	179	673	3474	3990	6706	10070	3833
1929	10590	10244	9227	7617	3150	2098	3903	4702	5880	8528	11025	12351	7810
1930	9840	11093	8656	1509	1157	254	1249	2129	5281	7206	9745	11650	5797
1931	11441	10695	10298	8701	5986	6284	5530	5525	5514	8355	10934	12300	9469
1932	9972	11163	4057	2042	916	1693	1912	2028	2057	5745	9025	11266	4510
1933	11229	10581	10238	7652	5315	4173	2701	4246	5913	8544	11033	12355	8357
1934	9822	11083	10033	5031	1807	1871	2277	5456	5446	8323	10918	12291	7045
1935	10007	11181	11818	380	1534	310	151	177	1607	4353	7803	10630	4448
1936	10885	10399	10144	220	150	167	232	580	2266	4634	7937	10587	4501
1937	10862	10387	10138	6884	151	150	198	413	2049	4545	7895	10677	5551
1938	10910	1917	150	161	150	150	150	150	152	2350	6399	5618	2619
1939	2210	4114	1475	801	722	1409	2164	3623	5268	7200	9742	11648	4259
1940	11440	10695	10297	349	150	150	150	485	2730	3759	6759	10061	3915
1941	10585	10241	152	150	150	150	150	150	459	2864	5468	8338	3370
1942	3867	6203	150	150	150	163	150	152	259	2677	6336	8731	2963
1943	5188	2726	317	150	150	150	160	279	2715	3758	6194	9663	3056
1944	10258	10073	9761	2761	161	257	1529	2774	3047	6222	9259	11390	6123
1945	11297	8817	4910	5808	150	157	571	1003	1997	4523	7884	10672	4977
1946	10685	7582	150	150	228	365	1158	1257	2140	4583	7913	10686	4140
1947	10915	10345	5653	6370	1869	839	1635	3423	5526	7312	9771	11663	6771
1948	11448	10699	10300	7886	3148	1585	245	185	1120	4116	7682	9887	6295
1949	10495	10195	8863	7821	4103	153	1072	1697	2690	6049	9174	11345	6659
1950	11272	10605	10250	2753	176	595	458	1015	2075	4556	7900	9741	5254
1951	10419	152	150	150	150	161	747	683	2993	3844	6735	9394	3035
1952	10232	7437	152	150	150	150	150	150	152	1118	3460	2975	2451
1953	3197	3814	151	150	172	276	562	220	841	3083	6276	7948	2864
1954	6724	4257	5383	245	150	150	151	304	2990	3843	6734	10084	3974
1955	10597	7506	1086	610	1614	2226	2720	2357	3148	6268	9282	11402	5025
1956	11304	10621	150	150	150	151	238	152	594	2952	6305	7692	3263
1957	2376	6340	8160	4358	182	151	384	518	2127	3571	6813	9401	4239
1958	5341	6206	1403	163	150	150	150	150	154	2092	3410	3676	2208
1959	3184	6741	5122	163	150	322	2450	2026	5421	5817	8073	9869	4762
1960	10485	10190	10036	8210	431	752	1649	1814	4990	7080	9675	11612	6900
1961	11420	10202	6142	5134	261	982	2060	2350	5492	7298	9764	11660	6445
1962	11446	10698	7216	6994	150	277	1293	1628	3198	4997	8103	10785	5643
1963	221	3920	736	1500	150	198	150	166	1504	3356	6243	8576	2397
1964	9077	560	4255	416	1377	1791	3469	3337	5282	7206	9738	11645	5083
1965	11438	9506	150	150	157	404	151	246	2461	3675	6197	8855	3640
1966	9969	1646	2003	207	189	241	1583	1830	4862	5611	8119	10793	4135
1967	10972	5161	158	150	150	150	150	150	150	657	3891	3416	2001
1968	2874	6591	2372	174	150	154	938	2114	5492	5843	8068	10766	4298
1969	10958	10099	1310	150	150	150	150	150	158	2230	4973	1783	2903
1970	2723	2379	150	150	150	151	727	1402	4178	4199	6155	9790	3134
1971	10444	1573	150	150	214	150	309	174	1057	3180	6268	6089	2688
1972	7876	8903	2505	2023	642	203	1872	1972	4599	5515	8137	10802	5008
1973	10661	2648	658	150	150	150	312	717	1956	3514	6818	9007	3121
1974	8480	150	150	150	150	150	150	170	837	2466	3971	2961	1914
1975	4036	7050	4701	2043	150	150	177	178	354	2780	4709	4916	2955
1976	1788	5158	5653	4817	1239	1860	3605	4993	5479	8338	10926	12295	5472
1977	9969	11161	11807	10609	3128	5682	5395	5450	5488	8342	10928	12297	9747
1978	9990	11172	10156	150	150	150	150	195	1718	3433	6843	8763	3762
1979	7548	8749	9319	337	150	153	399	1090	1800	4439	7844	10651	4705
1980	10479	8829	2459	150	150	150	269	442	1881	3489	6838	8498	4463
1981	9424	9652	3021	194	194	180	590	1997	5448	7279	9781	11669	5704
1982	11451	167	150	150	150	150	150	150	260	1861	3748	1309	1541
1983	376	152	150	150	150	150	150	150	150	165	810	287	270
1984	251	150	150	150	151	154	495	845	2221	3602	6231	9271	2878
1985	9741	297	763	2969	723	584	1487	1944	5365	7242	9756	11655	4596
1986	11444	10697	5455	1047	150	150	178	415	2067	3552	6224	8316	4203
1987	9530	9705	9791	6288	819	254	1897	3954	5169	7157	9713	11632	6881
1988	11431	10690	6480	479	1689	1850	3987	5064	5511	8353	10934	12300	6298
1989	9972	11163	11808	10104	3785	158	301	1929	5415	7264	9766	10877	7412
1990	11018	10469	10180	4097	2111	3114	2614	4015	5458	8328	10920	12293	7414
1991	9988	11171	11812	10612	3150	218	917	3666	5610	8400	10958	12313	6911
1992	9939	11145	11798	10645	231	740	1927	3955	5535	8365	10940	12303	6055
1993	9973	11164	8668	150	150	154	151	165	323	2750	7000	9691	3615
1994	6665	8340	6189	4665	275	1597	3062	3748	5475	8336	10925	12295	6414
Average	8810	7538	5218	2767	854	769	1162	1646	3043	5055	7853	9629	4460

Table 3C-17. Simulated No-Project Emmaton EC (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	2673	2448	817	343	150	150	150	150	150	364	1293	2250	904
1923	1295	940	150	150	151	233	151	173	315	738	1588	2283	759
1924	2462	2339	2277	1751	568	320	888	923	937	1715	2579	3091	1757
1925	2250	2668	2172	1638	150	150	151	175	315	1013	1939	2708	1333
1926	2692	2457	2337	867	150	236	156	254	889	1383	2167	2845	1385
1927	2767	435	713	152	150	150	150	150	278	522	1121	2056	704
1928	1961	589	608	161	151	150	150	169	520	616	1247	2278	757
1929	2459	2338	1996	1501	464	307	599	762	1034	1774	2615	3113	1676
1930	2199	2639	1814	238	205	151	213	311	891	1384	2167	2845	1264
1931	2767	2496	2356	1828	1061	1136	949	948	946	1720	2582	3093	2127
1932	2244	2665	629	300	185	258	284	298	302	1001	1931	2703	915
1933	2689	2456	2336	1511	899	652	392	667	1042	1779	2618	3115	1825
1934	2193	2636	2265	834	271	279	331	932	930	1711	2576	3090	1513
1935	2256	2672	2909	155	241	153	150	150	249	688	1555	2473	1010
1936	2564	2392	2303	151	150	150	151	164	330	747	1595	2458	1028
1937	2556	2388	2301	1295	150	150	150	156	301	728	1582	2490	1232
1938	2574	285	150	150	150	150	150	150	150	341	1166	970	571
1939	322	640	235	177	172	228	316	547	888	1382	2167	2845	835
1940	2767	2496	2356	154	150	150	150	159	397	572	1261	2275	877
1941	2457	2337	150	150	150	150	150	150	158	418	935	1715	766
1942	592	1115	150	150	150	150	150	150	152	389	1149	1837	603
1943	870	396	153	150	150	150	150	152	394	572	1113	2140	605
1944	2343	2279	2173	401	150	152	241	403	447	1120	2006	2749	1317
1945	2714	1864	807	1016	150	150	164	192	295	724	1579	2488	1025
1946	2493	1490	150	150	151	155	205	214	313	736	1587	2493	899
1947	2575	2373	979	1158	279	180	252	511	948	1414	2176	2851	1436
1948	2770	2498	2357	1579	464	246	151	150	202	641	1519	2215	1349
1949	2425	2321	1879	1560	638	150	198	259	391	1076	1979	2732	1420
1950	2705	2464	2340	400	150	165	158	193	304	731	1584	2166	1127
1951	2399	150	150	150	150	150	174	170	438	588	1255	2051	673
1952	2334	1449	150	150	150	150	150	150	150	201	518	435	538
1953	472	582	150	150	150	152	163	151	180	453	1134	1598	547
1954	1252	669	915	151	150	150	150	153	438	588	1254	2283	770
1955	2462	1469	199	166	250	324	395	342	464	1132	2014	2753	1045
1956	2717	2470	150	150	150	150	151	150	165	432	1141	1523	736
1957	345	1150	1661	690	150	150	155	161	311	537	1276	2053	812
1958	905	1116	228	150	150	150	150	150	150	307	509	557	414
1959	470	1256	855	150	150	153	355	298	924	1019	1635	2209	928
1960	2422	2319	2266	1676	157	174	253	272	825	1349	2144	2831	1523
1961	2760	2323	1100	857	152	190	303	341	940	1409	2174	2849	1383
1962	2769	2497	1387	1325	150	152	217	251	472	827	1644	2528	1206
1963	151	602	173	238	150	150	150	150	238	499	1125	1789	478
1964	1947	163	669	157	225	270	519	496	891	1384	2165	2844	1069
1965	2767	2087	150	150	150	156	150	151	357	556	1114	1876	805
1966	2243	253	295	151	150	151	246	274	797	969	1649	2531	869
1967	2596	863	150	150	150	150	150	150	150	168	597	510	448
1968	419	1216	344	150	150	150	187	309	940	1025	1633	2522	860
1969	2591	2288	219	150	150	150	150	150	150	325	821	269	645
1970	396	345	150	150	150	150	172	228	653	657	1103	2182	609
1971	2408	245	150	150	151	150	153	150	196	469	1132	1086	564
1972	1576	1892	363	298	167	150	279	291	740	946	1654	2535	1007
1973	2484	384	168	150	150	150	153	172	289	527	1277	1925	667
1974	1759	150	150	150	150	150	150	150	180	357	612	433	405
1975	625	1340	762	300	150	150	150	150	154	404	763	809	528
1976	269	863	979	787	212	278	544	826	937	1715	2579	3092	1083
1977	2243	2665	2905	2466	460	986	917	930	939	1717	2580	3092	2243
1978	2250	2669	2308	150	150	150	150	150	261	513	1284	1847	841
1979	1481	1843	2026	154	150	150	156	199	271	706	1567	2481	1004
1980	2420	1868	357	150	150	150	152	158	280	523	1282	1764	936
1981	2060	2136	443	150	150	150	165	294	930	1404	2180	2853	1259
1982	2771	150	150	150	150	150	150	150	152	278	570	219	387
1983	155	150	150	150	150	150	150	150	150	150	178	152	154
1984	151	150	150	150	150	150	160	180	324	543	1123	2010	599
1985	2166	153	175	434	172	164	236	288	911	1394	2171	2847	998
1986	2768	2497	932	195	150	150	150	156	303	534	1121	1708	905
1987	2096	2154	2183	1137	178	151	282	609	865	1370	2157	2839	1478
1988	2764	2495	1187	159	258	277	615	842	945	1720	2582	3093	1368
1989	2244	2665	2905	2289	577	150	153	286	922	1400	2175	2562	1691
1990	2612	2416	2316	637	309	458	379	621	932	1712	2577	3090	1604
1991	2250	2668	2907	2467	464	151	185	555	968	1734	2591	3099	1657
1992	2233	2659	2901	2479	151	173	286	609	951	1724	2584	3095	1416
1993	2245	2665	1818	150	150	150	150	150	153	400	1327	2149	824
1994	1236	1716	1112	754	152	248	449	570	936	1715	2579	3091	1328
Average	1991	1657	1133	592	222	210	248	312	518	909	1629	2225	954

Table 3C-18. Simulated No-Project Jersey Point EC (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	2169	1988	684	304	150	150	150	150	150	321	1065	1830	753
1923	1066	782	150	150	151	217	151	168	282	620	1301	1857	637
1924	2000	1902	1851	1430	484	286	740	769	779	1402	2093	2503	1436
1925	1830	2165	1767	1341	150	150	151	170	282	841	1581	2196	1096
1926	2184	1996	1899	723	150	219	155	233	741	1136	1764	2306	1138
1927	2244	378	600	151	150	150	150	150	253	447	927	1675	593
1928	1599	501	516	158	151	150	150	165	446	523	1027	1852	635
1929	1997	1900	1627	1231	401	276	509	639	857	1449	2122	2520	1370
1930	1789	2142	1481	221	194	151	200	279	743	1137	1764	2306	1041
1931	2244	2027	1915	1492	878	939	789	789	787	1406	2096	2505	1731
1932	1825	2162	533	270	178	237	257	269	272	831	1575	2192	762
1933	2181	1995	1899	1239	749	552	344	563	864	1453	2124	2522	1490
1934	1785	2139	1842	697	247	253	295	776	774	1399	2091	2502	1240
1935	1835	2167	2357	154	223	152	150	150	229	581	1274	2008	838
1936	2082	1943	1873	151	150	150	151	161	294	628	1306	1996	853
1937	2075	1940	1871	1066	150	150	150	155	271	613	1296	2022	1015
1938	2089	258	150	150	150	150	150	150	150	303	963	806	486
1939	288	542	218	172	168	213	283	468	740	1136	1763	2306	698
1940	2244	2027	1915	153	150	150	150	158	347	488	1039	1850	731
1941	1996	1900	150	150	150	150	150	150	157	364	778	1402	643
1942	504	922	150	150	150	150	150	150	151	341	950	1500	512
1943	726	347	152	150	150	150	150	152	345	488	920	1742	514
1944	1904	1853	1768	351	150	151	222	353	388	926	1635	2229	1084
1945	2201	1522	676	843	150	150	161	184	266	609	1293	2020	850
1946	2024	1222	150	150	151	154	194	201	280	619	1300	2025	749
1947	2090	1929	813	957	253	174	232	439	789	1161	1771	2310	1179
1948	2246	2028	1916	1293	401	227	151	150	191	543	1246	1802	1109
1949	1970	1887	1533	1278	541	150	188	237	342	891	1613	2216	1166
1950	2194	2001	1902	350	150	162	157	184	274	615	1297	1763	931
1951	1949	150	150	150	150	150	169	166	380	500	1034	1670	568
1952	1897	1189	150	150	150	150	150	150	150	191	444	378	460
1953	408	496	150	150	150	152	160	151	174	392	937	1308	468
1954	1031	565	762	151	150	150	150	152	380	500	1034	1856	646
1955	1999	1205	189	163	230	289	346	304	401	936	1641	2232	866
1956	2203	2006	150	150	150	150	151	150	162	375	943	1248	619
1957	306	950	1359	582	150	150	154	159	279	460	1051	1672	679
1958	754	923	212	150	150	150	150	150	150	275	437	475	361
1959	406	1035	714	150	150	153	314	268	769	845	1338	1797	772
1960	1968	1885	1843	1371	156	169	233	248	690	1109	1745	2295	1249
1961	2238	1889	910	716	151	182	272	303	782	1158	1769	2309	1136
1962	2246	2028	1139	1090	150	152	204	231	408	691	1345	2053	995
1963	151	512	168	220	150	150	150	150	220	429	930	1461	413
1964	1588	160	565	155	210	246	445	427	743	1137	1762	2305	886
1965	2243	1700	150	150	150	155	150	151	315	475	921	1531	674
1966	1824	233	266	150	150	151	227	249	667	805	1349	2055	725
1967	2107	721	150	150	150	150	150	150	150	165	508	438	389
1968	365	1003	305	150	150	150	180	277	782	850	1337	2047	718
1969	2103	1860	205	150	150	150	150	150	150	290	687	245	546
1970	346	306	150	150	150	150	168	212	552	556	912	1776	518
1971	1956	226	150	150	151	150	152	150	187	405	935	899	481
1972	1291	1543	321	268	164	150	253	263	622	787	1353	2058	836
1973	2018	337	165	150	150	150	152	167	262	452	1052	1570	564
1974	1437	150	150	150	150	150	150	150	174	316	520	376	354
1975	530	1102	639	270	150	150	150	150	153	353	641	677	453
1976	245	720	813	659	200	252	465	690	780	1402	2093	2503	896
1977	1825	2162	2354	2003	398	819	764	774	781	1403	2094	2504	1824
1978	1830	2165	1876	150	150	150	150	150	239	440	1057	1508	703
1979	1215	1504	1651	153	150	150	155	189	247	595	1284	2015	833
1980	1966	1525	315	150	150	150	151	156	254	448	1056	1442	779
1981	1678	1739	384	150	150	150	162	266	774	1153	1774	2312	1037
1982	2247	150	150	150	150	150	150	150	151	252	486	205	339
1983	154	150	150	150	150	150	150	150	150	150	172	152	153
1984	151	150	150	150	150	150	158	174	289	464	928	1638	509
1985	1763	152	170	377	168	161	219	260	758	1145	1767	2308	829
1986	2245	2028	775	186	150	150	150	155	273	457	927	1397	754
1987	1707	1753	1776	940	173	151	256	517	722	1126	1755	2301	1212
1988	2241	2026	980	157	236	251	522	703	786	1406	2095	2505	1125
1989	1825	2162	2354	1862	492	150	152	259	768	1150	1770	2079	1382
1990	2120	1963	1883	540	277	396	333	527	776	1400	2092	2502	1313
1991	1830	2165	2355	2004	401	151	178	474	805	1417	2103	2509	1356
1992	1816	2157	2351	2013	151	169	259	517	791	1409	2097	2506	1163
1993	1826	2162	1484	150	150	150	150	150	153	350	1091	1749	689
1994	1019	1403	919	633	152	228	390	486	779	1402	2093	2503	1092
Average	1623	1356	936	503	208	198	228	279	444	757	1333	1810	794

Table 3C-19. Simulated No-Project Export EC (μS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	759	726	374	274	265	303	367	424	272	302	493	705	426
1923	484	419	287	308	433	334	360	435	307	363	576	722	419
1924	752	751	731	626	395	478	561	588	532	713	920	965	656
1925	786	873	739	693	325	386	382	506	346	483	673	830	586
1926	834	799	761	451	321	346	402	498	445	554	717	885	576
1927	865	326	386	311	302	319	375	435	293	322	477	675	410
1928	608	347	355	288	317	298	341	429	354	346	494	737	407
1929	779	751	672	579	364	443	530	557	499	699	907	958	638
1930	771	862	645	350	395	279	442	508	453	559	720	888	558
1931	869	820	770	689	565	652	575	800	646	775	892	979	766
1932	833	912	467	376	364	540	468	491	413	546	693	842	532
1933	796	819	787	623	515	526	528	585	646	771	895	974	707
1934	805	896	761	471	501	495	448	608	481	752	886	964	657
1935	816	865	914	390	452	327	386	407	311	366	591	776	517
1936	757	777	758	329	324	292	359	427	305	375	590	764	485
1937	766	767	735	535	334	363	395	400	312	397	592	768	535
1938	754	280	284	340	272	239	297	262	295	291	459	421	359
1939	308	354	321	377	360	350	453	493	436	546	711	878	452
1940	853	817	797	372	311	310	356	423	322	326	497	718	461
1941	755	740	308	294	320	356	375	372	284	319	409	587	424
1942	355	457	288	419	395	345	373	401	275	312	460	611	395
1943	407	317	267	361	365	298	397	436	349	349	470	688	393
1944	703	727	702	375	388	332	467	465	337	463	687	838	549
1945	829	640	406	477	322	386	446	470	302	371	596	775	488
1946	729	553	298	306	421	330	436	448	309	372	584	775	458
1947	797	754	445	509	333	318	433	513	466	571	719	879	574
1948	865	808	790	615	534	388	386	426	280	354	560	722	568
1949	774	757	652	609	440	299	451	503	325	453	685	842	572
1950	843	799	777	377	298	315	386	470	299	370	573	710	507
1951	769	274	320	314	314	334	421	415	338	335	489	672	410
1952	733	540	283	287	427	358	364	311	294	266	325	315	371
1953	332	372	406	398	367	326	408	396	251	310	458	567	384
1954	491	359	415	298	302	296	346	422	340	335	491	729	409
1955	771	548	258	305	320	363	494	489	335	478	696	848	483
1956	843	790	341	280	306	354	398	448	283	298	460	549	423
1957	314	476	585	384	335	309	393	461	302	320	498	676	425
1958	418	464	263	300	303	370	321	330	293	263	309	327	330
1959	328	487	418	352	358	363	478	478	446	473	583	725	465
1960	776	761	740	632	301	307	446	480	432	546	711	875	598
1961	865	760	474	471	270	324	436	464	460	565	720	886	566
1962	868	813	541	588	338	289	441	466	339	393	584	790	528
1963	250	346	247	314	275	268	364	387	285	309	455	607	340
1964	641	253	359	280	333	335	488	498	445	550	711	873	481
1965	855	694	289	314	301	308	368	400	328	327	458	635	433
1966	663	295	315	334	376	329	444	439	426	459	586	793	453
1967	808	415	287	294	261	297	333	307	304	285	330	327	344
1968	322	481	356	355	337	306	419	447	449	472	582	795	451
1969	803	739	271	323	241	285	280	256	293	294	386	280	378
1970	321	358	417	305	384	349	408	426	387	367	466	702	411
1971	750	271	273	269	315	282	372	387	256	301	458	452	360
1972	564	641	293	298	291	281	443	447	404	443	588	804	462
1973	784	320	256	269	270	306	363	413	285	314	500	638	387
1974	585	253	265	305	355	345	396	439	262	278	339	305	336
1975	360	511	381	332	360	354	361	387	276	292	374	389	364
1976	295	402	428	403	335	336	498	539	451	628	819	937	487
1977	710	819	886	857	673	719	588	791	591	751	896	998	805
1978	916	944	776	367	313	363	317	357	330	384	500	614	465
1979	523	629	675	330	392	373	388	442	279	376	586	770	485
1980	743	636	301	322	286	323	415	428	337	377	492	596	458
1981	616	699	375	390	352	329	404	463	452	559	714	877	543
1982	848	257	258	316	314	318	253	313	291	279	332	286	331
1983	299	310	292	262	224	214	281	287	225	308	247	316	278
1984	422	331	278	319	383	338	431	463	302	326	470	659	408
1985	695	256	252	325	312	304	442	477	447	556	709	870	466
1986	846	790	433	322	283	258	377	396	342	347	483	589	450
1987	650	700	709	497	345	306	441	520	435	548	710	881	576
1988	865	826	493	319	465	444	529	574	475	649	868	957	593
1989	793	864	912	795	702	295	352	475	476	579	728	824	658
1990	833	810	767	419	430	451	457	571	468	678	875	963	649
1991	809	890	942	946	902	332	428	572	688	788	905	989	706
1992	819	911	962	870	377	351	454	542	503	709	936	984	644
1993	800	894	658	330	278	269	337	396	268	325	498	685	437
1994	476	600	458	396	309	332	482	542	449	623	812	931	538
Average	677	610	498	413	365	347	411	456	373	445	598	728	470

Table 3C-20. Simulated No-Project Export Chloride Concentrations (mg/l)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	181	171	66	36	32	38	51	62	32	40	100	163	79
1923	95	77	33	38	62	43	49	63	40	62	121	167	72
1924	171	170	169	134	61	67	92	96	92	143	192	225	137
1925	170	195	167	137	38	49	51	73	46	88	146	197	115
1926	191	179	176	79	38	44	54	72	79	113	169	208	116
1927	203	46	64	35	36	39	52	63	36	48	92	153	69
1928	131	54	56	32	37	35	44	60	53	55	100	168	69
1929	181	175	152	119	53	61	81	87	91	144	198	230	134
1930	167	197	143	43	51	30	61	73	80	114	169	211	110
1931	203	188	181	146	100	112	96	123	107	149	202	232	168
1932	169	199	73	50	49	81	69	72	56	95	147	192	93
1933	175	180	176	124	88	82	77	90	108	151	200	231	145
1934	167	197	176	81	69	69	63	100	86	146	199	229	131
1935	167	201	215	49	62	39	54	58	39	61	121	179	95
1936	171	176	170	38	46	35	49	62	40	64	123	180	91
1937	173	174	169	103	48	54	58	60	40	66	121	180	106
1938	174	34	33	44	41	36	45	39	41	38	91	77	59
1939	41	57	40	49	47	46	66	74	77	111	164	203	80
1940	194	179	171	47	39	42	49	61	45	51	100	165	83
1941	174	172	36	35	47	53	56	56	36	45	76	129	76
1942	55	88	34	63	59	46	53	58	33	43	91	135	66
1943	70	44	29	54	55	45	58	65	49	54	90	157	65
1944	159	167	161	53	50	41	69	68	48	91	150	192	109
1945	189	142	71	88	41	55	66	70	38	63	123	179	91
1946	164	115	35	37	59	41	64	65	40	63	123	180	82
1947	184	175	82	96	43	37	60	77	84	115	168	213	117
1948	204	189	179	129	79	50	51	58	31	57	119	166	114
1949	181	175	146	126	70	34	63	73	44	88	150	199	117
1950	197	184	177	53	33	37	51	66	38	63	123	163	97
1951	177	30	42	42	41	44	61	58	48	53	99	153	70
1952	169	113	31	35	62	54	55	47	39	31	49	45	60
1953	49	58	54	55	50	40	57	54	26	44	90	122	61
1954	99	59	76	33	34	34	44	58	48	53	99	168	71
1955	181	115	27	35	40	49	72	71	48	93	155	202	91
1956	196	184	47	42	43	48	57	67	35	42	91	116	76
1957	42	93	127	63	41	37	54	66	39	49	101	154	75
1958	76	90	29	34	37	55	48	50	39	32	46	50	49
1959	48	97	73	44	47	47	70	69	80	87	127	167	85
1960	178	173	173	133	34	35	62	68	75	110	166	211	125
1961	206	177	92	82	28	38	60	65	83	116	169	211	115
1962	205	188	112	114	43	34	64	67	49	70	128	186	104
1963	25	55	25	39	31	29	50	54	34	46	89	134	51
1964	143	26	59	31	42	43	73	74	79	112	167	212	92
1965	202	159	33	41	38	38	51	56	44	50	89	142	77
1966	146	36	41	42	51	41	64	62	73	84	128	186	81
1967	188	74	32	34	28	37	50	46	44	36	52	49	53
1968	46	96	48	44	42	36	59	64	81	87	127	187	81
1969	189	172	30	46	36	43	42	38	44	39	68	34	66
1970	45	49	57	46	58	48	59	61	62	60	90	160	69
1971	173	31	29	29	37	32	50	52	28	43	90	87	57
1972	121	143	39	37	33	30	62	63	68	81	129	191	87
1973	184	43	26	30	32	41	50	60	35	47	100	144	65
1974	125	26	28	39	48	47	58	65	29	36	54	43	49
1975	57	105	65	43	48	50	50	54	32	40	65	68	57
1976	37	72	80	69	42	43	75	86	82	135	193	228	92
1977	154	185	205	183	100	117	97	119	100	148	201	230	171
1978	152	195	178	46	39	54	48	54	45	57	101	135	84
1979	105	138	151	40	59	54	55	65	33	63	121	181	91
1980	172	142	40	45	43	48	61	64	47	57	101	130	86
1981	133	154	54	50	44	40	56	66	81	113	166	209	106
1982	200	26	26	41	47	48	38	47	38	35	52	35	50
1983	39	41	44	39	34	32	42	43	34	45	26	42	38
1984	63	50	42	48	57	45	63	67	39	50	91	149	69
1985	159	26	26	46	37	36	63	69	80	112	165	210	87
1986	200	184	79	38	42	39	57	59	49	53	92	129	85
1987	144	157	162	94	42	35	62	79	77	111	165	208	118
1988	202	183	98	36	63	60	81	92	85	139	196	226	116
1989	168	201	217	178	106	32	42	66	85	117	170	194	139
1990	198	184	179	67	58	66	65	88	84	141	199	228	134
1991	170	200	216	192	135	38	57	86	112	151	203	232	141
1992	170	196	215	194	46	42	63	83	90	145	200	229	124
1993	165	192	143	42	33	31	44	55	30	45	103	157	77.3
1994	92	130	90	67	36	42	71	82	81	134	197	227	108
Average	146	128	96	66	50	46	59	67	57	80	127	166	86.9

Table 3C-21. Simulated No-Project Export DOC Concentrations (mg/l)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	2.4	2.5	2.6	3.4	3.6	3.6	3.9	4.1	3.4	3.3	3.2	3.3	3.2
1923	3.5	3.3	4.7	4.9	5.1	5.0	4.0	4.8	3.5	3.1	3.8	3.6	4.0
1924	4.2	4.3	3.8	4.9	5.2	7.8	6.2	6.6	4.8	5.6	6.9	5.4	5.0
1925	5.1	5.6	4.3	7.8	5.7	5.3	4.1	5.1	3.9	4.2	4.3	3.9	5.0
1926	4.6	4.9	4.0	5.2	5.9	5.4	4.4	5.4	4.0	4.0	3.3	4.5	4.6
1927	4.4	3.6	3.6	5.7	4.6	4.2	4.0	4.6	3.5	3.3	3.7	3.6	4.1
1928	3.8	3.5	3.6	5.2	5.4	3.9	4.0	5.0	3.9	3.5	3.5	4.2	4.1
1929	4.2	3.8	3.7	5.3	5.2	7.5	5.9	6.3	4.5	5.4	6.3	4.7	4.8
1930	4.9	5.1	3.7	6.1	7.1	4.5	5.1	5.8	4.3	4.2	3.4	4.4	4.8
1931	4.6	4.7	3.7	6.1	6.9	9.1	6.3	8.0	5.5	6.2	5.4	4.9	5.4
1932	5.8	6.2	6.3	5.7	5.6	6.5	5.0	5.3	4.2	4.9	4.7	4.7	5.6
1933	4.9	5.4	4.8	6.2	6.1	7.5	5.7	6.3	5.5	6.0	5.6	4.8	5.7
1934	5.4	5.9	3.9	5.3	8.7	7.9	5.6	6.8	4.5	6.0	5.6	4.8	5.6
1935	5.6	4.6	4.7	6.9	6.6	5.3	4.4	4.6	3.7	3.3	4.2	4.0	4.8
1936	4.2	4.5	4.5	6.0	4.9	4.0	4.1	4.6	3.4	3.2	4.0	3.5	4.3
1937	4.2	4.2	3.7	5.5	5.2	4.0	4.4	4.0	3.4	3.6	4.1	3.6	4.3
1938	3.7	3.4	3.6	5.6	4.0	4.0	4.0	4.0	3.9	3.2	3.1	3.4	3.8
1939	3.6	3.4	4.3	6.6	5.8	5.9	5.2	5.7	4.1	4.1	3.6	5.0	4.5
1940	5.0	5.6	5.8	6.9	5.0	4.1	3.9	4.5	3.4	3.1	3.4	3.6	4.5
1941	3.9	3.6	4.9	4.8	4.7	4.0	4.0	4.0	3.5	3.5	3.1	3.2	4.0
1942	3.6	3.4	3.5	4.0	4.0	4.5	4.2	4.3	3.6	3.5	3.2	3.4	3.7
1943	3.7	3.7	3.7	4.0	4.0	4.0	4.5	4.0	3.8	3.6	3.6	3.6	3.8
1944	3.8	3.8	3.6	5.7	6.4	5.0	5.1	5.2	3.8	3.4	4.4	4.7	4.4
1945	4.7	3.6	3.7	5.2	4.9	5.3	5.0	4.0	3.6	3.3	4.3	4.1	4.3
1946	4.1	3.7	4.1	4.8	5.8	5.2	5.0	5.2	3.8	3.4	4.0	4.0	4.3
1947	4.3	3.9	3.8	5.2	5.2	5.4	5.4	6.2	4.4	4.4	3.5	3.8	4.4
1948	4.3	4.2	4.7	5.0	8.8	6.3	4.5	4.8	3.8	3.4	3.5	3.8	4.5
1949	3.9	4.0	3.7	5.5	6.1	5.0	5.2	5.7	3.9	3.4	4.3	4.1	4.4
1950	4.4	4.4	4.5	6.0	4.9	5.1	4.5	5.2	3.7	3.3	3.4	3.7	4.4
1951	4.1	3.5	4.4	4.8	4.3	4.4	4.7	4.7	3.7	3.3	3.3	3.5	4.0
1952	3.7	3.5	4.5	4.5	4.5	4.0	4.0	4.0	3.8	3.3	3.3	3.5	3.9
1953	3.7	4.1	5.0	5.2	5.0	5.1	4.6	4.5	3.4	3.5	3.3	3.4	4.1
1954	3.5	3.5	3.6	5.7	4.7	4.6	4.1	5.0	4.1	3.4	3.5	3.9	4.0
1955	3.9	3.6	3.7	6.5	5.3	6.0	5.4	5.6	3.9	3.8	4.4	4.1	4.6
1956	4.6	4.1	5.2	4.0	4.1	4.4	4.3	4.6	3.5	3.1	3.2	3.3	4.0
1957	3.6	3.7	3.5	4.7	5.6	4.6	4.6	5.0	3.8	3.3	3.5	3.6	4.0
1958	3.6	3.6	3.6	6.6	4.6	4.5	4.0	4.0	3.8	3.0	3.1	3.2	3.9
1959	3.6	3.5	3.9	5.7	5.1	5.4	5.2	5.4	4.1	4.2	3.3	3.8	4.2
1960	4.3	4.3	3.7	5.6	5.2	4.9	5.2	5.6	4.1	4.1	3.4	3.8	4.4
1961	4.1	3.7	3.6	6.1	4.4	5.4	5.5	6.0	4.2	4.2	3.4	4.3	4.4
1962	4.3	4.3	3.6	6.1	5.7	4.1	4.7	5.0	3.6	3.2	3.2	3.6	4.2
1963	3.5	3.4	3.5	6.0	4.3	4.4	4.2	4.2	3.4	3.2	3.2	3.4	3.9
1964	3.5	3.5	3.5	5.5	5.7	5.7	5.5	5.7	4.2	4.2	3.3	3.8	4.2
1965	4.2	3.6	4.0	4.5	4.4	4.7	4.2	4.5	3.7	3.3	3.4	3.5	4.0
1966	4.0	3.8	4.1	6.1	5.5	5.3	5.1	5.4	4.2	4.2	3.4	4.0	4.5
1967	4.3	3.6	4.5	5.5	3.7	4.0	4.0	4.0	4.2	3.6	3.1	3.4	4.0
1968	3.6	3.5	4.7	6.6	4.6	4.7	4.9	5.4	4.2	4.2	3.4	4.0	4.3
1969	4.0	3.7	3.7	5.0	4.0	4.0	4.0	4.0	4.0	3.4	3.3	3.4	3.9
1970	3.7	4.5	4.3	4.0	4.0	4.4	4.5	4.7	3.8	3.5	3.5	3.7	4.0
1971	3.8	3.5	4.4	4.7	5.2	4.2	4.3	4.4	3.4	3.2	3.3	3.4	3.9
1972	3.5	3.6	3.6	4.9	5.2	5.1	5.4	5.7	4.2	4.0	3.5	4.0	4.2
1973	3.9	4.5	4.0	5.2	3.7	3.9	4.0	4.5	3.3	3.0	3.4	3.2	3.9
1974	3.5	3.3	3.8	4.3	4.6	4.1	4.4	4.7	3.4	3.2	3.3	3.4	3.7
1975	3.7	3.6	3.6	5.6	5.2	4.7	4.2	4.4	3.7	3.3	3.3	3.4	3.9
1976	3.7	3.5	3.6	4.9	6.0	5.8	5.9	6.4	4.2	4.3	4.2	4.2	4.4
1977	4.5	4.9	5.0	8.1	10.0	11.4	6.6	6.1	5.4	6.1	5.7	5.8	6.2
1978	8.0	7.8	4.2	6.3	4.5	4.9	4.0	4.0	3.8	3.9	3.3	3.4	4.5
1979	3.7	3.7	3.8	6.0	4.5	4.6	4.3	4.8	3.4	3.5	4.1	3.6	4.2
1980	3.7	3.5	3.5	4.9	4.0	4.0	4.5	4.0	3.9	3.8	3.2	3.4	3.8
1981	3.8	4.2	4.5	6.5	5.6	5.1	4.7	5.4	4.2	4.2	3.5	4.2	4.5
1982	4.2	3.6	3.7	5.0	4.5	4.0	4.0	4.0	3.8	3.3	3.2	3.5	3.9
1983	3.8	4.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.3	3.1	3.7	3.9
1984	4.0	4.0	4.0	4.0	4.0	4.5	4.7	5.0	3.6	3.3	3.7	3.5	3.9
1985	3.7	3.9	3.6	5.0	5.6	5.6	5.1	5.6	4.3	4.3	3.4	3.9	4.3
1986	4.2	4.0	3.7	6.1	4.0	4.0	4.0	4.0	4.0	3.5	3.7	3.3	4.1
1987	3.6	3.9	3.7	4.9	5.9	5.1	5.3	6.0	4.0	4.0	3.4	4.4	4.3
1988	4.5	5.3	3.6	6.1	8.2	7.8	6.1	6.5	4.4	4.5	5.5	5.0	5.4
1989	5.2	4.6	4.4	5.6	9.9	4.8	4.8	6.2	4.6	4.5	3.5	4.0	4.8
1990	3.9	4.8	3.8	5.5	7.3	7.0	5.8	6.8	4.5	5.2	5.5	5.0	5.2
1991	5.5	5.7	5.7	10.2	11.3	5.4	5.5	6.9	6.0	6.5	5.9	5.4	6.2
1992	5.5	6.7	6.4	6.5	6.6	5.5	5.3	6.5	4.7	5.4	6.6	5.4	6.0
1993	5.4	6.4	4.2	5.2	4.1	3.5	3.6	4.1	3.3	3.4	3.1	3.3	4.0
1994	3.5	3.6	3.3	4.7	5.7	5.4	5.3	5.8	4.0	4.0	3.3	3.9	4.2
Average	4.2	4.2	4.1	5.5	5.4	5.1	4.7	5.1	4.0	3.9	3.9	3.9	4.3

Table 3C-22. Estimated No-Project Treated Water THM Concentrations (µg/l)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	39.4	40.3	32.0	38.2	40.0	40.4	45.6	50.0	37.5	37.6	42.7	51.8	40.6
1923	46.4	42.0	52.4	55.3	61.9	57.2	47.2	58.4	40.2	38.3	53.7	56.5	49.5
1924	66.7	68.7	60.0	71.9	63.4	96.5	81.9	88.8	63.9	84.6	114.7	96.0	73.0
1925	80.7	94.4	68.4	114.8	64.2	61.6	48.7	63.9	45.1	55.4	64.3	66.1	69.6
1926	77.4	79.5	64.1	66.5	67.0	62.3	52.4	68.2	51.5	56.0	52.7	78.5	64.2
1927	75.0	42.1	44.5	63.8	52.1	47.7	47.1	55.9	39.1	38.3	49.3	54.7	50.3
1928	55.2	41.6	43.1	57.9	60.7	44.1	46.3	60.6	46.5	41.2	47.6	66.4	50.2
1929	67.8	61.1	56.5	75.2	61.4	91.5	76.0	81.6	59.5	81.1	107.3	84.2	69.8
1930	78.4	85.4	55.5	70.8	83.4	49.5	62.4	72.7	54.9	59.4	54.5	76.3	64.9
1931	77.9	77.8	60.8	92.1	93.9	126.1	84.1	114.6	76.2	94.4	92.5	88.4	84.7
1932	92.3	105.3	78.7	67.3	65.8	83.7	62.6	66.5	50.8	65.0	71.0	78.0	73.5
1933	79.4	87.3	77.4	89.4	80.1	95.9	72.6	82.5	76.3	91.6	95.2	87.2	85.1
1934	85.7	100.4	62.6	68.7	108.2	98.2	68.2	91.5	58.2	90.9	94.9	85.7	80.5
1935	88.8	78.3	81.9	80.6	80.2	60.0	52.6	55.5	42.5	40.6	60.0	65.6	63.9
1936	67.3	71.9	71.9	67.5	57.0	44.8	47.5	55.7	39.0	39.7	57.2	57.5	56.1
1937	67.9	68.3	59.4	75.0	60.5	47.6	52.6	48.4	39.1	44.6	57.8	58.0	58.3
1938	60.2	37.9	39.9	64.3	45.7	45.0	46.2	45.5	44.9	36.7	40.6	42.8	45.6
1939	40.9	41.0	48.8	76.8	67.6	68.0	64.5	71.5	51.9	56.9	56.9	85.7	57.3
1940	83.8	91.1	92.7	80.8	56.9	47.1	45.3	55.0	39.6	36.0	45.9	56.1	57.9
1941	62.0	57.7	54.7	54.1	55.2	47.5	47.9	47.8	39.9	40.0	39.7	47.1	49.7
1942	43.3	44.6	39.4	48.8	48.3	52.7	49.4	52.0	40.2	40.7	42.7	50.3	45.3
1943	46.6	42.2	40.4	47.6	47.7	46.3	54.0	49.2	44.6	42.4	48.0	55.5	46.6
1944	58.8	60.5	56.9	67.5	75.1	57.6	63.6	64.9	44.4	44.6	66.7	78.3	60.2
1945	77.4	54.3	45.7	67.3	56.1	62.9	61.4	49.9	41.1	40.7	61.3	66.1	56.2
1946	64.1	51.2	45.7	53.9	70.1	59.7	61.5	63.7	43.0	41.3	56.8	64.9	54.7
1947	70.8	62.6	48.5	69.9	59.7	60.9	65.5	78.4	56.8	62.2	55.6	66.2	61.6
1948	73.9	69.1	75.7	72.7	112.2	74.4	53.0	57.5	41.9	41.3	50.0	59.5	62.4
1949	63.4	64.5	55.9	79.4	76.2	56.1	63.1	71.6	44.8	44.1	66.0	69.5	61.8
1950	73.9	71.9	72.8	71.4	54.2	57.0	52.8	64.3	42.0	40.7	49.4	57.6	58.0
1951	66.5	38.5	51.0	54.5	49.0	51.2	57.1	56.0	43.5	38.9	44.7	54.0	49.6
1952	59.5	49.2	49.9	50.5	54.6	47.5	47.7	46.5	43.4	36.8	38.6	40.0	46.5
1953	43.0	48.7	59.7	62.5	59.0	58.7	55.8	53.8	37.2	40.4	44.1	49.2	49.1
1954	47.2	42.5	45.0	63.8	52.3	51.3	47.2	60.6	47.6	40.5	46.8	61.7	49.6
1955	63.1	50.9	40.3	72.8	60.5	70.7	67.7	70.2	45.3	50.5	67.4	69.6	59.0
1956	77.2	66.9	60.1	45.9	47.5	51.5	51.6	56.8	39.4	36.0	42.2	47.0	50.0
1957	41.8	48.4	51.0	57.0	64.3	51.5	55.0	62.1	42.7	38.6	47.4	55.9	50.2
1958	45.5	47.0	39.9	73.9	52.0	54.1	46.7	46.9	43.1	33.2	35.6	37.7	45.9
1959	41.7	46.9	48.9	66.1	59.8	62.9	65.1	66.8	52.1	54.3	48.3	60.0	53.5
1960	69.2	69.5	59.0	81.6	58.7	55.5	62.9	69.3	51.9	56.3	53.3	66.6	62.6
1961	70.7	60.5	47.8	78.5	48.5	61.7	66.5	73.4	54.5	59.5	54.0	74.4	61.1
1962	74.3	71.6	50.6	85.8	65.7	45.7	57.8	62.1	42.4	40.3	46.9	60.0	57.4
1963	37.5	40.9	37.9	68.5	47.2	48.8	49.0	49.9	38.3	36.6	42.6	49.3	45.4
1964	52.6	38.1	41.9	60.9	65.4	65.1	69.5	71.9	53.5	58.4	53.1	65.6	55.1
1965	72.3	56.1	44.7	52.0	49.3	53.1	49.1	54.4	43.2	38.5	44.2	52.8	50.2
1966	60.5	42.6	47.2	69.4	65.1	60.8	62.8	65.4	53.0	54.0	49.8	66.5	56.9
1967	70.6	45.8	49.8	62.1	40.8	44.6	47.0	46.4	48.0	41.0	37.2	39.8	47.3
1968	42.3	47.0	54.7	76.4	52.6	53.2	58.5	65.6	53.4	54.9	49.6	65.9	54.2
1969	66.0	59.0	40.4	58.1	45.1	46.0	45.9	45.4	46.1	38.8	40.2	37.8	47.4
1970	42.5	52.7	51.3	46.4	48.1	51.2	54.5	57.5	45.7	42.5	46.4	58.0	49.0
1971	60.9	38.8	48.6	51.2	58.6	46.3	50.7	51.5	37.8	37.2	43.9	44.9	46.6
1972	49.8	54.7	40.6	55.6	58.1	56.7	66.3	70.0	52.0	51.6	50.5	66.1	54.1
1973	64.3	52.0	43.2	57.0	41.4	44.4	47.2	54.1	36.7	35.5	46.5	48.9	47.3
1974	50.4	36.3	41.9	49.1	54.0	47.9	52.9	58.3	37.0	36.1	39.1	39.2	43.7
1975	44.1	49.0	43.7	63.9	60.4	54.6	49.5	52.4	41.1	37.6	41.0	42.6	47.2
1976	41.6	44.2	45.5	60.5	68.7	66.6	74.4	83.5	54.4	63.1	70.6	75.8	58.3
1977	69.8	80.9	85.2	133.5	135.0	160.2	88.5	86.4	72.8	93.1	97.4	105.2	98.1
1978	123.0	131.4	67.6	72.9	51.2	58.7	46.7	47.5	44.3	46.5	45.0	50.0	57.7
1979	50.0	54.1	57.3	68.1	54.6	55.3	51.6	58.7	37.6	42.2	58.3	58.9	54.1
1980	58.7	51.7	40.4	56.6	46.0	46.8	54.7	49.0	45.3	45.8	42.9	49.3	49.2
1981	55.1	64.6	53.4	76.1	64.2	58.4	56.7	67.0	53.5	58.8	55.0	72.4	60.6
1982	70.9	39.7	40.9	57.4	52.7	46.7	45.3	46.6	43.0	36.9	38.1	39.0	46.0
1983	43.2	50.0	46.1	45.5	44.7	44.5	45.9	46.0	44.7	49.4	33.7	42.9	44.5
1984	48.9	46.9	45.8	46.7	48.0	52.3	57.9	61.7	40.6	39.0	48.4	53.3	48.2
1985	57.1	42.2	38.8	58.1	62.8	62.9	62.1	69.4	54.4	60.3	54.2	67.8	55.5
1986	70.9	66.3	47.1	69.4	45.9	45.4	47.9	48.3	47.1	40.9	49.4	47.4	52.6
1987	53.6	60.3	58.1	65.4	67.5	56.9	64.0	76.3	51.4	56.2	53.5	76.8	60.1
1988	77.5	87.6	48.6	68.6	100.5	94.9	78.0	86.7	56.7	67.3	91.9	89.7	74.2
1989	83.3	78.0	78.3	91.6	135.5	53.1	55.1	76.6	59.0	63.3	56.0	68.0	70.0
1990	66.4	78.5	62.0	67.7	87.9	86.3	71.8	88.3	57.6	78.2	93.4	90.3	74.4
1991	87.7	96.6	100.2	171.3	166.9	61.6	65.9	89.8	83.7	98.7	100.7	97.4	93.2
1992	88.5	112.3	111.6	109.3	77.0	62.6	64.4	83.4	61.6	81.7	112.5	97.4	86.9
1993	84.9	107.7	62.9	59.6	45.6	39.0	41.0	48.4	36.8	39.9	41.8	50.9	50.5
1994	46.8	51.8	43.6	57.9	64.3	61.8	66.3	74.8	51.2	59.0	56.4	70.4	56.3
Average	63.8	61.5	54.9	68.6	64.4	60.2	57.5	63.6	48.2	51.2	56.8	63.1	55.7

Table 3C-23. Differences in Chipps Island EC between Proposed Project and Simulated No-Project (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0	0	18	897	3	-0	-1	-0	1	5	3	-28	75
1923	-2	10	13	0	0	-19	-1	-8	-24	-23	-11	-36	-8
1924	-19	-10	-5	-19	-20	-3	-42	-66	-23	-11	-6	-3	-19
1925	-2	-1	25	11	0	0	-1	-8	-3	-1	-1	-0	2
1926	-0	-0	-0	-13	10	6	-3	-19	-65	-28	-14	-8	-11
1927	-4	6	18	163	0	-0	-0	-1	-24	-8	-4	-31	10
1928	-3	936	285	352	3	-0	-0	-7	-43	-13	-6	-3	125
1929	-2	-1	25	-5	-15	-2	-34	-57	-22	-10	-5	-3	-11
1930	-2	-1	24	883	86	-1	-12	-27	-68	-29	-15	-8	69
1931	-4	-2	-1	-17	-6	-2	-45	-68	-24	-11	-6	-3	-16
1932	-2	-1	16	820	52	12	-16	-26	-5	-3	-1	-1	71
1933	-0	-0	-0	-16	-26	-59	-37	-55	-22	-10	-5	-3	-19
1934	-2	-1	25	-4	-9	-2	-22	-60	-21	-10	-5	-3	-9
1935	-2	-1	-0	-1	-0	-3	-0	-0	-19	-9	-4	-2	-3
1936	-1	-1	-0	-0	0	0	-1	-6	-30	-12	-6	-34	-8
1937	-18	-9	-5	-17	2	0	-1	-4	-2	-1	-0	-0	-5
1938	-0	5	0	0	0	-0	-0	-0	0	3	-3	-23	-2
1939	151	63	24	2	1	-19	-25	-45	-68	-29	-15	-8	3
1940	-4	-2	-1	-1	0	0	-0	-4	-33	-20	-9	-34	-9
1941	-18	-9	0	0	0	-0	-0	-0	6	4	271	101	30
1942	131	66	0	-0	0	-0	-0	-0	6	8	4	-26	16
1943	-0	197	4	-0	0	-0	-0	-2	-34	-11	-4	-32	10
1944	-4	-2	24	-3	20	5	-10	-33	-41	-19	-9	-5	-6
1945	-3	12	22	-5	0	0	-4	-12	-23	-10	-5	-2	-2
1946	11	18	0	0	0	18	-5	-15	-28	-24	-12	-6	-4
1947	-3	13	24	9	-8	-12	-18	-42	-75	-33	1	-19	-14
1948	-11	-6	-3	-18	-4	-23	-1	-1	-14	-19	-9	-34	-12
1949	-18	-9	20	-7	-19	1	-5	-20	-38	-31	-15	-8	-13
1950	-4	-2	-1	-8	16	-1	-4	-12	-29	-22	-16	-38	-10
1951	-19	0	0	0	0	-0	-7	-8	-39	-12	-10	-34	-11
1952	-9	9	5	0	0	-0	-0	-0	0	11	37	42	8
1953	37	19	0	-0	0	-1	-5	-1	-11	-5	-2	-28	0
1954	-1	8	21	155	0	-0	-0	-2	-34	-11	-10	-5	10
1955	-3	12	947	161	44	-20	-30	-32	-47	-22	-11	-6	83
1956	-3	-2	0	0	0	-0	-1	-0	-7	-13	-6	-29	-5
1957	380	193	111	256	3	-0	-3	-5	-28	-20	-9	-34	70
1958	-3	10	1171	4	0	-0	-0	-0	0	21	39	-5	103
1959	84	40	40	0	0	0	-21	-27	-67	-25	-17	-38	-3
1960	-20	-10	-5	-19	-2	-10	-18	-24	-65	-28	-14	-7	-19
1961	-4	12	25	-4	26	-4	-20	-30	-71	-31	2	1	-8
1962	1	0	23	9	0	-1	-12	-21	-45	-17	-8	-6	-6
1963	0	8	603	409	0	-1	-0	-0	-19	-7	-3	-29	80
1964	-3	263	222	5	-4	-1	-30	-43	-73	-32	-16	-29	22
1965	-16	6	0	0	0	-4	-0	-1	-29	-18	-8	-32	-9
1966	-16	1401	728	2	0	-1	-15	-23	-60	-22	-16	-8	164
1967	-4	9	14	0	0	-0	-0	-0	0	6	39	47	9
1968	44	22	36	0	0	-0	-8	-26	-64	-24	-11	-6	-3
1969	-3	13	7	0	0	-0	-0	-0	0	23	53	29	10
1970	39	24	0	0	0	-0	-6	-17	-48	-14	-6	-3	-3
1971	-2	4	0	0	0	0	-2	-0	-13	-15	-11	-28	-6
1972	-2	-1	1764	293	13	-1	-18	-26	-59	-22	-10	-17	160
1973	3	7	519	0	0	-0	-2	-8	-26	-9	-4	-31	37
1974	-3	0	0	-0	0	-0	-0	-0	-10	437	595	165	99
1975	59	39	29	135	0	-0	-0	-0	11	10	464	133	73
1976	70	44	35	-1	16	-22	-39	-62	-81	-38	-20	-11	-9
1977	-6	-3	-2	-1	-0	-0	-43	-67	-23	-11	-6	-3	-14
1978	-2	-1	25	-0	0	0	-0	-1	-22	-8	-4	-30	-3
1979	-2	-1	-1	-1	0	-0	-3	-13	-26	-11	-5	-3	-5
1980	11	19	1898	0	0	-0	-1	-4	-25	-9	-9	-32	154
1981	-4	-2	12	76	1	-0	-5	-24	-68	-30	-15	-8	-6
1982	-4	0	0	0	0	-0	-0	-0	6	22	43	20	7
1983	4	0	0	-0	0	0	-0	-0	0	0	8	2	1
1984	2	0	0	-0	0	-0	-4	-10	-29	-9	-4	-31	-7
1985	-4	0	556	228	102	-1	-14	-25	-68	-30	-15	-22	59
1986	-12	-6	17	640	0	-0	-0	-4	-27	-9	-4	-29	47
1987	-3	-1	-1	-15	140	0	-17	-46	-72	-31	-16	-8	-6
1988	-5	-3	20	374	116	21	-25	-57	-21	-10	-5	-3	34
1989	-2	-1	-0	-18	-5	-0	-2	-22	-52	-22	-11	-37	-14
1990	-20	-11	-5	-12	-11	-43	-33	-51	-19	-9	-5	-3	-19
1991	-1	-1	-0	-0	-0	-1	-9	-41	-16	-8	-4	-2	-7
1992	-1	-1	-0	-0	-1	-10	-21	-47	-18	-9	-4	-2	-10
1993	-1	-1	24	0	0	-0	-0	-0	9	9	5	-27	2
1994	-1	-0	20	-5	14	-12	-31	-48	-77	-36	-19	-10	-17
Minimum	-20	-11	-5	-19	-26	-59	-45	-68	-81	-38	-20	-38	-19
Average	10	46	129	78	7	-3	-10	-19	-30	-6	15	-7	17
Maximum	380	1401	1898	897	140	21	-0	-0	11	437	595	165	164

Note: Difference is Proposed Project minus No-Project.

Table 3C-24. Differences in Emmaton EC between Proposed Project and Simulated No-Project (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0	0	4	140	0	-0	-0	-0	0	1	1	-10	11
1923	-0	2	0	0	0	-2	-0	-0	-3	-5	-3	-12	-2
1924	-7	-3	-2	-6	-4	-0	-10	-15	-5	-3	-2	-1	-5
1925	-1	-0	8	3	0	0	-0	-1	-0	-0	-0	-0	1
1926	-0	-0	-0	-3	0	1	-0	-2	-15	-8	-5	-3	-3
1927	-2	1	4	5	0	-0	-0	-0	-3	-1	-1	-10	-1
1928	-1	191	56	21	0	-0	-0	-0	-8	-2	-2	-1	21
1929	-1	-0	8	-1	-3	-0	-6	-12	-5	-3	-2	-1	-2
1930	-1	-0	8	109	8	-0	-1	-3	-16	-8	-5	-3	7
1931	-2	-1	-0	-5	-2	-1	-11	-16	-6	-3	-2	-1	-4
1932	-1	-0	3	117	4	1	-2	-3	-1	-1	-0	-0	10
1933	-0	-0	-0	-5	-6	-12	-6	-11	-5	-3	-2	-1	-4
1934	-1	-0	9	-1	-1	-0	-3	-14	-5	-3	-2	-1	-2
1935	-1	-0	-0	-0	-0	-0	-0	-0	-2	-2	-1	-1	-1
1936	-0	-0	-0	-0	0	0	-0	-0	-4	-3	-2	-12	-2
1937	-6	-3	-2	-5	0	0	-0	-0	-0	-0	-0	-0	-1
1938	-0	1	0	0	0	0	-0	-0	0	0	-1	-6	-0
1939	21	13	2	0	0	-2	-3	-8	-16	-8	-5	-3	-1
1940	-2	-1	-0	-0	0	0	-0	-0	-5	-4	-2	-12	-2
1941	-6	-3	0	0	0	-0	-0	-0	0	1	65	31	7
1942	25	17	0	-0	0	-0	-0	-0	0	1	1	-8	3
1943	-0	31	0	-0	0	-0	-0	-0	-5	-2	-1	-11	1
1944	-1	-1	8	-1	0	0	-1	-5	-7	-5	-3	-2	-1
1945	-1	4	5	-1	0	0	-0	-1	-3	-2	-1	-1	-0
1946	4	5	0	0	0	1	-0	-1	-4	-5	-3	-2	-1
1947	-1	4	6	2	-1	-1	-2	-7	-18	-9	0	-7	-3
1948	-4	-2	-1	-5	-1	-2	-0	-0	-1	-4	-3	-12	-3
1949	-6	-3	6	-2	-4	0	-0	-2	-6	-8	-5	-3	-3
1950	-2	-1	-0	-1	0	-0	-0	-1	-4	-5	-5	-13	-3
1951	-7	0	0	0	0	-0	-0	-0	-6	-2	-3	-11	-3
1952	-3	3	0	0	0	-0	-0	-0	0	1	7	7	1
1953	6	4	0	0	0	-0	-0	-0	-1	-1	-1	-8	-0
1954	-0	2	5	5	0	-0	-0	-0	-6	-2	-3	-2	-0
1955	-1	3	100	10	5	-3	-5	-4	-8	-6	-3	-2	7
1956	-1	-1	0	0	0	-0	-0	-0	-0	-2	-2	-9	-1
1957	56	50	34	53	0	-0	-0	-0	-4	-4	-2	-11	14
1958	-1	3	146	0	0	0	-0	-0	0	3	7	-1	13
1959	14	11	9	0	0	0	-3	-3	-16	-6	-5	-13	-1
1960	-7	-4	-2	-6	-0	-1	-2	-3	-14	-8	-5	-3	-4
1961	-2	4	6	-1	1	-0	-3	-4	-17	-9	1	0	-2
1962	0	0	6	3	0	-0	-1	-2	-8	-4	-2	-2	-1
1963	0	1	48	46	0	-0	-0	-0	-2	-1	-1	-9	7
1964	-1	16	46	0	-0	-0	-5	-7	-17	-9	-5	-11	0
1965	-6	2	0	0	0	-0	-0	-0	-4	-3	-2	-10	-2
1966	-5	194	101	0	0	-0	-2	-3	-13	-5	-5	-3	22
1967	-2	2	0	0	0	-0	-0	-0	0	0	8	8	1
1968	7	6	5	0	0	-0	-1	-3	-15	-6	-3	-2	-1
1969	-1	4	1	0	0	-0	-0	-0	0	3	12	3	2
1970	6	3	0	0	0	-0	-0	-2	-10	-3	-1	-1	-1
1971	-1	0	0	0	0	0	-0	-0	-1	-3	-3	-7	-1
1972	-1	-0	308	39	1	-0	-2	-3	-12	-5	-3	-6	26
1973	1	1	38	0	0	-0	-0	-0	-3	-2	-1	-10	2
1974	-1	0	0	0	0	0	-0	-0	-1	66	120	27	18
1975	12	11	6	18	0	-0	-0	-0	0	2	103	30	15
1976	8	10	8	-0	1	-3	-7	-14	-19	-12	-7	-4	-3
1977	-2	-1	-1	-0	-0	-0	-10	-16	-6	-3	-2	-1	-4
1978	-1	-0	9	-0	0	0	-0	-0	-2	-1	-1	-9	-1
1979	-1	-0	-0	-0	0	-0	-0	-1	-3	-2	-2	-1	-1
1980	4	6	333	0	0	-0	-0	-0	-3	-2	-2	-10	27
1981	-1	-1	2	1	0	-0	-0	-3	-16	-8	-5	-3	-3
1982	-2	0	0	0	0	-0	0	-0	0	3	8	2	1
1983	0	0	0	0	0	0	-0	-0	0	0	1	0	0
1984	0	0	0	-0	0	-0	-0	-1	-4	-2	-1	-10	-1
1985	-1	0	45	38	7	-0	-1	-3	-16	-8	-5	-8	4
1986	-4	-2	4	62	0	0	-0	-0	-3	-2	-1	-9	4
1987	-1	-0	-0	-4	10	0	-2	-9	-16	-9	-5	-3	-3
1988	-2	-1	5	22	13	3	-5	-13	-5	-3	-2	-1	1
1989	-1	-0	-0	-6	-1	-0	-0	-3	-12	-6	-4	-13	-4
1990	-7	-4	-2	-2	-1	-7	-5	-10	-5	-3	-2	-1	-4
1991	-0	-0	-0	-0	-0	-0	-1	-8	-4	-2	-1	-1	-1
1992	-0	-0	-0	-0	-0	-1	-3	-9	-4	-3	-2	-1	-2
1993	-0	-0	8	0	0	-0	-0	-0	0	1	1	-9	0
1994	-0	-0	5	-1	0	-1	-5	-9	-18	-11	-7	-4	-4
Minimum	-7	-4	-2	-6	-6	-12	-11	-16	-19	-12	-7	-13	-5
Average	1	8	19	9	0	-0	-2	-3	-6	-2	2	-3	2
Maximum	56	194	333	140	13	3	0	-0	0	66	120	31	27

Note: Difference is Proposed Project minus No-Project.

Table 3C-25. Differences in Jersey Point EC between Proposed Project and Simulated No-Project (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0	0	3	112	0	-0	-0	-0	0	1	1	-8	9
1923	-0	2	0	0	0	-2	-0	-0	-3	-4	-3	-10	-2
1924	-5	-3	-1	-5	-3	-0	-8	-12	-4	-3	-2	-1	-4
1925	-0	-0	7	3	0	0	-0	-0	-0	-0	-0	-0	1
1926	-0	-0	-0	-2	0	0	-0	-2	-12	-6	-4	-2	-2
1927	-1	1	3	4	0	-0	-0	-0	-2	-1	-1	-8	-0
1928	-1	153	45	17	0	-0	-0	-0	-6	-2	-1	-1	17
1929	-0	-0	6	-1	-2	-0	-5	-10	-4	-3	-2	-1	-2
1930	-0	-0	6	87	6	-0	-1	-3	-13	-7	-4	-2	6
1931	-1	-1	-0	-4	-1	-1	-9	-13	-5	-3	-2	-1	-3
1932	-0	-0	2	94	3	1	-2	-3	-1	-0	-0	-0	8
1933	-0	-0	-0	-4	-5	-9	-4	-9	-4	-3	-2	-1	-3
1934	-0	-0	7	-1	-1	-0	-2	-11	-4	-2	-1	-1	-1
1935	-0	-0	-0	-0	-0	-0	-0	-0	-2	-1	-1	-1	-0
1936	-0	-0	-0	-0	0	0	-0	-0	-3	-2	-1	-9	-1
1937	-5	-3	-1	-4	0	0	-0	-0	-0	-0	-0	-0	-1
1938	-0	0	0	0	0	0	-0	-0	0	0	-1	-4	-0
1939	17	10	2	0	0	-1	-3	-7	-12	-7	-4	-2	-1
1940	-1	-1	-0	-0	0	0	-0	-0	-4	-3	-2	-9	-2
1941	-5	-3	0	0	0	-0	-0	-0	0	1	52	25	6
1942	20	13	0	-0	0	-0	-0	-0	0	1	1	-7	2
1943	-0	25	0	-0	0	-0	-0	-0	-4	-2	-1	-8	1
1944	-1	-1	7	-0	0	0	-1	-4	-5	-4	-2	-1	-1
1945	-1	3	4	-1	0	0	-0	-1	-2	-2	-1	-1	-0
1946	3	4	0	0	0	1	-0	-1	-3	-4	-3	-2	-0
1947	-1	4	5	2	-1	-1	-2	-6	-14	-7	0	-6	-2
1948	-3	-2	-1	-4	-0	-2	-0	-0	-1	-3	-2	-9	-2
1949	-5	-3	5	-2	-3	0	-0	-2	-5	-6	-4	-2	-2
1950	-1	-1	-0	-1	0	-0	-0	-1	-3	-4	-4	-10	-2
1951	-5	0	0	0	0	-0	-0	-0	-5	-2	-2	-9	-2
1952	-2	2	0	0	0	-0	-0	-0	0	1	5	6	1
1953	5	3	0	0	0	-0	-0	-0	-1	-1	-0	-7	-0
1954	-0	1	4	4	0	-0	-0	-0	-4	-2	-2	-1	-0
1955	-1	3	80	8	4	-2	-4	-4	-6	-4	-3	-2	6
1956	-1	-0	0	0	0	-0	-0	-0	-0	-2	-1	-7	-1
1957	45	40	27	43	0	-0	-0	-0	-3	-3	-2	-9	11
1958	-1	2	116	0	0	0	-0	-0	0	2	6	-1	10
1959	11	9	7	0	0	0	-2	-3	-13	-5	-4	-10	-1
1960	-6	-3	-1	-5	-0	-1	-2	-2	-11	-6	-4	-2	-4
1961	-1	3	5	-1	1	-0	-2	-3	-13	-7	0	0	-2
1962	0	0	5	2	0	-0	-1	-2	-6	-3	-2	-2	-1
1963	0	1	39	37	0	-0	-0	-0	-2	-1	-1	-7	6
1964	-1	13	36	0	-0	-0	-4	-6	-13	-7	-4	-9	0
1965	-5	2	0	0	0	-0	-0	-0	-3	-3	-2	-8	-2
1966	-4	155	81	0	0	-0	-1	-2	-11	-4	-4	-2	17
1967	-1	2	0	0	0	-0	-0	-0	0	0	6	7	1
1968	6	5	4	0	0	-0	-1	-3	-12	-5	-3	-2	-1
1969	-1	4	1	0	0	-0	-0	-0	0	2	10	3	1
1970	5	3	0	0	0	-0	-0	-1	-8	-2	-1	-1	-1
1971	-0	0	0	0	0	0	-0	-0	-1	-2	-2	-6	-1
1972	-0	-0	247	31	1	-0	-2	-3	-10	-4	-2	-5	21
1973	1	1	31	0	0	-0	-0	-0	-3	-1	-1	-8	2
1974	-1	0	0	0	0	0	-0	-0	-1	53	96	22	14
1975	9	9	5	14	0	-0	-0	-0	0	1	82	24	12
1976	7	8	7	-0	1	-2	-6	-11	-15	-9	-6	-3	-3
1977	-2	-1	-1	-0	-0	-0	-8	-13	-4	-3	-2	-1	-3
1978	-0	-0	7	-0	0	0	-0	-0	-2	-1	-1	-8	-0
1979	-1	-0	-0	-0	0	-0	-0	-1	-2	-2	-1	-1	-1
1980	3	5	266	0	0	-0	-0	-0	-2	-1	-2	-8	22
1981	-1	-1	2	1	0	-0	-0	-2	-13	-7	-4	-2	-2
1982	-1	0	0	0	0	-0	0	-0	0	2	6	2	1
1983	0	0	0	0	0	0	-0	-0	0	0	0	0	0
1984	0	0	0	-0	0	-0	-0	-1	-3	-1	-1	-8	-1
1985	-1	0	36	30	5	-0	-1	-2	-13	-7	-4	-6	3
1986	-4	-2	3	50	0	0	-0	-0	-3	-1	-1	-7	3
1987	-1	-0	-0	-3	8	0	-2	-7	-13	-7	-4	-2	-3
1988	-1	-1	4	17	11	2	-4	-10	-4	-2	-1	-1	1
1989	-0	-0	-0	-5	-1	-0	-0	-2	-10	-5	-3	-11	-3
1990	-6	-3	-2	-2	-1	-6	-4	-8	-4	-2	-1	-1	-3
1991	-0	-0	-0	-0	-0	-0	-1	-6	-3	-2	-1	-1	-1
1992	-0	-0	-0	-0	-0	-0	-2	-7	-3	-2	-1	-1	-2
1993	-0	-0	6	0	0	-0	-0	-0	0	1	1	-7	0
1994	-0	-0	4	-1	0	-1	-4	-7	-14	-9	-5	-3	-3
Minimum	-6	-3	-2	-5	-5	-9	-9	-13	-15	-9	-6	-11	-4
Average	1	6	15	7	0	-0	-1	-3	-5	-2	2	-3	1
Maximum	45	155	266	112	11	2	0	-0	0	53	96	25	22

Note: Difference is Proposed Project minus No-Project.

Table 3C-26. Differences in Export EC between Proposed Project and Simulated No-Project (µS/cm)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	-0	-0	1	18	-18	-0	1	1	-2	15	-7	-10	-1
1923	-0	0	-24	-1	-1	0	0	1	33	-1	-9	-2	-1
1924	-1	-0	-0	-1	-0	-2	-1	-1	-3	-3	-2	-0	-1
1925	-0	-0	1	1	-26	83	1	2	95	2	2	2	8
1926	2	2	1	2	-24	23	1	2	-2	-2	-1	-0	-1
1927	-0	0	1	-36	-4	-1	0	1	22	9	-1	-2	-2
1928	0	36	12	-20	-0	-0	0	1	27	19	0	1	6
1929	1	1	2	1	0	-1	1	0	-2	-2	-1	-0	0
1930	0	0	2	-4	57	2	1	1	10	-2	-1	-0	5
1931	-0	0	0	-1	-0	-3	-2	3	-6	-4	-1	-1	-1
1932	-0	-0	-0	-1	0	-24	0	1	-2	-2	-1	-0	-2
1933	-0	-0	-0	-1	-1	-1	0	0	-5	-4	-2	-1	-1
1934	-0	-0	2	-0	-1	-4	-1	-2	-2	-4	-2	-1	-1
1935	-0	-0	-0	-0	-1	1	0	0	-1	-1	-1	-1	-0
1936	-0	-0	-0	-0	-34	-2	0	1	8	-3	-1	-3	-5
1937	-1	-1	-1	-1	-35	0	0	0	51	32	1	1	1
1938	1	1	-28	1	0	0	0	0	-3	-0	-0	-1	-3
1939	1	3	-1	-0	-1	1	1	0	-16	-15	-2	-1	-2
1940	-1	-1	-1	-1	-28	-2	0	1	13	-1	-10	-3	-4
1941	-1	-1	-1	-24	-1	0	0	0	-1	-1	13	7	-1
1942	3	4	-1	0	0	-1	0	1	-3	-0	0	-2	0
1943	-0	3	-0	0	0	0	1	0	34	25	0	-2	5
1944	0	0	2	1	-58	-3	1	0	12	-6	-17	-1	-5
1945	-1	1	1	-0	-32	-8	0	0	36	5	-6	0	-1
1946	1	1	-28	0	9	-6	1	1	53	-1	8	1	2
1947	1	2	2	2	1	1	1	1	-3	-2	0	-2	0
1948	-1	-0	0	-1	-1	1	1	1	-0	-1	-1	-3	-1
1949	-1	-1	1	-0	-0	-6	0	1	16	-2	-1	-1	0
1950	-0	-0	-0	-0	-19	9	0	1	-1	-1	-1	-3	-2
1951	-2	-0	-35	-0	-1	-1	1	1	-11	-3	-1	-20	-7
1952	-1	0	-29	-1	-2	0	0	0	-3	-1	1	1	-3
1953	1	0	-3	-1	-1	-1	1	1	49	68	1	-1	11
1954	1	2	2	-40	-3	1	1	2	22	6	-0	-15	-2
1955	0	1	4	-8	25	25	2	2	26	-1	0	0	6
1956	1	1	1	11	-0	-0	1	1	2	-0	-0	-2	1
1957	5	10	4	10	-4	-0	1	2	38	-0	3	-7	5
1958	0	1	15	-9	-0	-1	0	0	-3	-0	1	-0	0
1959	2	2	2	-1	-1	9	1	1	19	9	-1	-2	3
1960	-1	-0	-0	-0	1	1	1	1	-3	-2	-1	-1	-0
1961	-0	1	1	0	-8	13	0	0	-3	-3	-0	-0	-0
1962	-0	-0	1	1	-26	-0	0	1	63	21	0	4	4
1963	1	1	-7	1	1	1	0	1	3	-0	-1	-4	-0
1964	-7	-10	10	-0	0	-1	0	0	28	4	-1	-2	1
1965	-1	1	0	-30	-0	-0	1	1	-4	-1	-1	-14	-5
1966	-8	16	8	-0	-1	-1	1	0	45	31	-0	0	6
1967	1	1	-34	0	-0	-0	0	0	-3	-1	1	1	-3
1968	1	1	-1	-1	-1	-1	1	1	14	10	-1	-0	2
1969	0	1	0	-33	0	0	0	0	0	-0	2	0	-3
1970	0	-0	-1	0	0	-1	1	1	-10	-1	-1	-0	-1
1971	-0	-0	-21	-0	-3	-5	0	1	7	-1	-1	-2	-2
1972	-0	-7	55	9	0	1	1	1	49	32	0	0	12
1973	2	2	-12	-4	0	-0	1	1	7	0	-15	-2	-2
1974	-0	-25	-0	-0	-1	-1	1	1	38	11	25	6	5
1975	3	4	2	0	0	-1	1	1	-2	10	21	7	4
1976	1	3	2	1	-1	46	1	1	45	-1	-0	0	7
1977	1	1	1	3	1	-2	-0	-10	-3	-3	-1	-0	0
1978	1	0	2	-0	-28	-6	0	0	-0	-1	-1	-2	-5
1979	-0	-0	-0	-0	2	-1	1	1	-1	16	-20	-0	0
1980	1	1	56	-9	0	0	1	0	55	49	1	-1	13
1981	1	1	2	-70	-0	0	1	1	-16	-32	-2	-2	-8
1982	-1	-1	-21	-1	-1	0	0	0	-3	-0	1	-1	-2
1983	-1	-1	0	0	0	0	0	0	0	-1	-1	-1	-0
1984	0	0	0	0	0	-1	1	2	20	8	-1	-2	3
1985	0	0	-9	9	-10	1	1	1	-44	-44	-2	-3	-6
1986	-2	-2	-0	-15	0	0	0	0	13	13	-0	-2	-0
1987	-0	0	0	-0	-16	1	-0	-1	14	-2	-1	-1	-1
1988	-0	-0	1	-30	9	9	-0	-1	-2	-1	-1	-0	-4
1989	-0	-0	-0	-1	-3	1	-0	-0	-3	-2	-1	-3	-1
1990	-2	-1	-1	-1	-0	-1	-1	-1	-2	-2	-1	-1	-1
1991	-0	-0	-0	-1	-6	2	-1	-1	-7	-5	-2	-1	-0
1992	-1	-1	-1	-1	-1	2	-1	-3	-3	-3	-3	-1	-1
1993	-1	-1	1	-26	-1	-1	0	1	-3	-1	-0	-2	-4
1994	-0	-0	1	-0	-7	-0	-0	1	48	52	-0	1	6
Minimum	-8	-25	-35	-70	-58	-24	-2	-10	-44	-44	-20	-20	-8
Average	-0	1	-1	-4	-4	2	0	0	11	4	-1	-1	0
Maximum	5	36	56	18	57	83	2	3	95	68	25	7	13

Note: Difference is Proposed Project minus No-Project.

Table 3C-27. Differences in Export Chloride Concentrations between Proposed Project and Simulated No-Project (mg/l)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Difference
1922	-0.0	-0.0	0.3	6.6	-3.6	-0.1	0.1	0.3	-0.5	4.3	-2.3	-3.4	-0.36
1923	-0.0	0.1	-4.4	-0.1	-0.2	-0.0	0.1	0.2	9.3	-0.3	-4.5	-0.8	-0.10
1924	-0.3	-0.2	-0.1	-0.3	-0.2	-0.4	-0.3	-0.5	-0.5	-0.3	0.0	-0.0	-0.30
1925	-0.1	-0.1	0.5	0.2	-4.6	23.9	0.1	0.4	23.6	0.3	0.3	0.3	0.59
1926	0.3	0.3	0.2	0.2	-4.3	7.6	0.2	0.3	-0.9	-0.5	-0.3	-0.1	-1.28
1927	-0.1	0.1	0.3	-6.1	-0.7	-0.1	0.1	0.2	6.0	1.9	-0.5	-0.6	-0.85
1928	-0.0	12.0	3.7	-3.0	-0.0	-0.0	0.1	0.2	7.7	4.5	-0.0	0.1	1.91
1929	0.1	0.1	0.6	0.0	-0.0	-0.2	0.0	-0.2	-0.4	-0.2	0.0	-0.0	0.03
1930	-0.0	-0.0	0.5	2.6	20.9	0.4	0.1	0.2	2.2	-0.6	-0.3	-0.1	1.36
1931	-0.1	-0.0	-0.0	-0.3	-0.1	-0.3	-0.5	0.2	-0.9	-0.4	-0.2	-0.1	-0.31
1932	-0.1	-0.1	0.0	2.9	0.1	-2.5	0.1	0.1	-0.4	-0.3	-0.1	-0.0	0.01
1933	-0.1	-0.1	-0.1	-0.4	-0.4	-0.4	-0.0	-0.2	-0.7	-0.4	-0.2	-0.1	-0.18
1934	-0.1	-0.1	0.6	-0.1	-0.2	-0.6	-0.2	-0.7	-0.5	-0.4	-0.2	-0.1	-0.10
1935	-0.1	-0.1	-0.1	-0.0	-0.2	0.2	0.1	0.1	-0.1	-0.2	-0.2	-0.1	-0.11
1936	-0.1	-0.1	-0.1	-0.0	-7.7	-0.4	0.0	0.2	-0.0	-3.0	-0.2	-0.8	-2.78
1937	-0.4	-0.3	-0.2	-0.3	-7.9	0.0	0.1	0.0	13.7	7.8	0.2	0.2	-1.23
1938	0.1	0.1	-5.4	0.1	0.0	0.0	0.0	0.0	-0.6	-0.0	-0.1	-0.3	-0.66
1939	0.6	0.8	-0.0	-0.1	-0.1	0.1	0.1	-0.0	-7.6	-5.5	-0.4	-0.2	-1.12
1940	-0.2	-0.2	-0.2	-0.1	-5.5	-0.5	0.1	0.2	0.7	-0.3	-6.4	-0.8	-1.99
1941	-0.4	-0.2	-0.1	-4.5	-0.1	0.0	0.0	0.0	-0.3	-0.1	4.3	2.1	-0.01
1942	1.2	1.1	-0.1	0.0	0.0	-0.1	0.1	0.2	-0.5	-0.0	0.0	-0.6	0.11
1943	-0.0	1.3	-0.0	0.0	0.0	0.0	0.1	0.0	3.7	2.1	0.0	-0.6	0.13
1944	0.0	0.0	0.6	0.2	-10.6	-0.6	0.1	-0.0	1.2	-3.2	-6.1	-0.1	-2.65
1945	-0.1	0.2	0.3	-0.1	-6.4	-1.5	0.1	0.0	9.6	1.0	-3.1	0.0	-0.84
1946	0.2	0.4	-5.5	0.0	4.1	-1.0	0.2	0.2	15.3	-0.3	0.9	0.0	0.75
1947	0.1	0.4	0.5	0.3	0.2	0.2	0.1	-0.0	-1.1	-0.6	0.1	-0.5	0.04
1948	-0.2	-0.1	-0.1	-0.3	-0.1	0.0	0.1	0.2	-0.1	-0.3	-0.2	-0.8	-0.25
1949	-0.4	-0.2	0.4	-0.1	-0.2	-1.0	0.1	0.1	2.9	-0.6	-0.3	-0.2	-0.45
1950	-0.1	-0.1	-0.0	-0.0	-3.4	2.4	0.1	0.2	-0.3	-0.4	-0.3	-0.9	-1.29
1951	-0.5	-0.0	-7.5	-0.1	-0.1	-0.1	0.1	0.1	-3.9	-1.4	-0.2	-7.3	-2.02
1952	-0.3	0.1	-5.2	-0.2	-0.3	0.0	0.0	0.0	-0.6	-0.1	0.3	0.3	-0.58
1953	0.3	0.2	-0.6	-0.1	-0.2	-0.1	0.1	0.2	12.8	17.1	0.2	-0.4	2.47
1954	0.2	0.3	0.5	-6.8	-0.5	0.1	0.1	0.3	6.9	1.3	-0.1	-5.7	-0.11
1955	0.0	0.3	3.9	-1.1	8.7	9.3	0.2	0.3	7.0	-0.3	-0.0	0.0	0.83
1956	0.1	0.1	0.1	1.7	-0.0	-0.1	0.2	0.3	0.3	-0.1	-0.1	-0.6	0.07
1957	2.1	2.7	1.0	3.2	-0.7	-0.1	0.1	0.3	8.2	-0.2	-1.1	-4.0	1.16
1958	0.0	0.2	7.2	-1.6	-0.0	-0.3	0.0	0.0	-0.6	0.1	0.4	-0.1	0.51
1959	0.6	0.7	0.5	-0.2	-0.1	3.1	0.1	0.2	3.1	1.2	-0.3	-0.8	0.29
1960	-0.4	-0.2	-0.1	-0.3	0.1	0.1	0.1	0.1	-0.9	-0.6	-0.3	-0.2	-0.21
1961	-0.1	0.3	0.4	-0.0	-1.3	3.7	-0.0	-0.1	-1.1	-0.7	0.0	0.0	-0.40
1962	-0.0	-0.0	0.4	0.2	-5.2	-0.0	0.1	0.1	15.7	4.4	-0.0	0.1	0.02
1963	0.1	0.2	0.4	1.4	0.1	0.2	0.1	0.2	0.9	-0.1	-0.5	-1.4	0.19
1964	-2.6	-1.4	3.1	-0.0	-0.0	-0.2	-0.0	-0.1	6.7	-0.9	-0.3	-0.7	0.43
1965	-0.3	0.2	-0.0	-6.5	-0.1	-0.1	0.1	0.2	-2.2	-0.3	-0.2	-5.6	-1.81
1966	-3.3	8.1	3.7	-0.0	-0.1	-0.1	0.1	0.0	13.1	8.5	-0.2	-0.0	2.71
1967	0.1	0.2	-6.0	0.0	-0.0	-0.1	0.0	0.0	-0.7	-0.2	0.4	0.4	-0.56
1968	0.3	0.4	0.0	-0.1	-0.1	-0.1	0.1	0.1	1.4	0.6	-0.2	-0.1	0.38
1969	-0.0	0.3	0.1	-7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.1	-0.76
1970	0.2	0.0	-0.2	0.0	0.0	-0.1	0.1	0.2	-5.4	-2.8	-0.2	-0.1	-1.09
1971	-0.1	-0.0	-3.7	-0.1	-0.5	-0.9	0.1	0.1	1.1	-0.2	-0.2	-0.5	-1.03
1972	-0.0	-2.6	19.0	2.6	0.1	0.2	0.1	0.1	13.1	7.6	-0.0	-0.2	3.40
1973	0.3	0.3	-0.9	-0.7	-0.0	-0.1	0.1	0.2	1.2	-0.2	-5.9	-0.7	-0.79
1974	-0.1	-4.4	-0.1	-0.0	-0.1	-0.2	0.1	0.2	11.1	3.9	8.0	1.9	1.76
1975	0.8	0.8	0.5	0.4	-0.0	-0.1	0.1	0.2	-0.5	2.5	6.8	2.1	1.34
1976	0.3	0.7	0.6	0.1	-0.1	11.8	0.1	-0.2	8.1	-0.5	-0.2	-0.1	0.99
1977	0.1	0.1	0.1	0.4	0.1	-0.1	-0.3	-1.5	-0.6	-0.3	-0.1	-0.0	-0.20
1978	-0.1	-0.0	0.6	-0.0	-5.6	-1.3	0.0	0.0	-0.1	-0.3	-0.1	-0.6	-1.00
1979	-0.1	-0.1	-0.1	-0.1	-0.2	-0.1	0.1	0.2	-0.2	-1.0	-11.7	-0.1	-1.08
1980	0.2	0.4	19.9	-2.0	0.0	0.0	0.2	0.0	17.0	15.3	0.0	-0.5	3.45
1981	0.1	0.2	0.3	-12.5	-0.0	0.1	0.1	0.1	-7.0	-11.8	-0.4	-0.3	-2.85
1982	-0.2	-0.1	-3.6	-0.2	-0.1	0.0	0.0	0.0	-0.6	-0.0	0.4	-0.1	-0.42
1983	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-0.1	-0.3	-0.10
1984	0.0	0.0	0.0	0.0	0.0	-0.1	0.2	0.3	1.2	-0.3	-1.5	-0.6	-1.08
1985	-0.0	0.0	-0.3	2.5	-1.6	0.2	0.1	0.2	-13.4	-13.3	-0.5	-0.7	-1.72
1986	-0.5	-0.3	0.1	-0.8	0.0	0.0	0.0	0.0	3.6	2.8	-0.1	-0.6	-0.81
1987	-0.0	-0.0	-0.0	-0.2	-2.4	0.1	-0.0	-0.3	2.6	-0.6	-0.4	-0.2	-0.34
1988	-0.1	-0.1	0.4	-4.3	11.5	7.4	-0.1	-0.5	-0.4	-0.3	-0.1	-0.1	-1.55
1989	-0.1	-0.0	-0.0	-0.4	-0.4	0.1	-0.0	-0.1	-0.9	-0.5	-0.3	-1.0	-0.38
1990	-0.5	-0.3	-0.2	-0.2	-0.0	-0.4	-0.3	-0.4	-0.4	-0.3	-0.2	-0.1	-0.25
1991	-0.1	-0.1	-0.1	-0.1	-1.0	0.3	-0.1	-0.4	-1.0	-0.5	-0.3	-0.2	0.02
1992	-0.2	-0.2	-0.2	-0.1	-0.1	0.3	-0.2	-0.6	-0.6	-0.4	-0.3	-0.2	-0.05
1993	-0.2	-0.2	0.4	-5.0	-0.2	-0.1	0.0	0.2	-0.5	-0.1	0.1	-0.6	-0.76
1994	-0.0	-0.0	0.3	-0.1	-1.2	-0.1	-0.1	-0.0	11.9	10.1	-0.3	-0.0	2.01
Minimum	-3.3	-4.4	-7.5	-12.5	-10.6	-2.5	-0.5	-1.5	-13.4	-13.3	-11.7	-7.3	-2.9
Average	-0.1	0.3	0.4	-0.6	-0.5	0.8	0.0	0.0	2.5	0.6	-0.4	-0.5	-0.15
Maximum	2.1	12.0	19.9	6.6	20.9	23.9	0.2	0.4	23.6	17.1	8.0	2.1	3.5

Note: Difference is Proposed Project minus No-Project.

Table 3C-28. Differences in Export DOC (mg/l) between Proposed Project and Simulated No-Project (mg/l) Assuming Long-Term DOC Load (1 g/m²/month)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0.0	0.0	-0.0	-0.2	-0.1	-0.0	0.0	0.0	-0.0	0.2	0.1	0.1	-0.00
1923	0.0	0.0	-0.1	0.0	-0.0	0.0	0.0	0.0	0.4	0.0	0.4	0.0	0.05
1924	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.01
1925	0.0	0.0	-0.0	0.0	-0.3	0.7	-0.0	0.0	1.3	0.0	0.0	0.0	0.12
1926	0.0	0.0	0.0	0.0	-0.6	0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.05
1927	-0.0	-0.0	-0.0	-0.9	-0.0	-0.0	-0.0	-0.0	0.3	0.2	0.1	0.0	-0.07
1928	0.0	-0.1	-0.0	-0.6	-0.0	0.0	-0.0	-0.0	0.2	0.3	-0.0	-0.0	-0.05
1929	0.0	0.0	-0.0	0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.00
1930	-0.0	-0.0	-0.0	-0.7	-0.7	0.0	-0.0	-0.0	0.2	-0.0	-0.0	-0.0	-0.10
1931	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.0	-0.1	-0.0	-0.1	-0.0	-0.0	-0.01
1932	-0.0	-0.0	-0.0	-0.5	-0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.07
1933	-0.0	-0.0	-0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.1	-0.0	-0.0	-0.00
1934	-0.0	-0.0	-0.0	0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.1	-0.0	-0.0	-0.01
1935	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.00
1936	-0.0	-0.0	-0.0	-0.0	-0.4	-0.0	-0.0	-0.0	0.7	0.5	0.0	0.0	0.04
1937	0.0	0.0	0.0	0.0	-0.4	0.0	-0.0	0.0	0.6	0.6	0.0	0.0	0.04
1938	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.02
1939	-0.0	-0.0	-0.0	0.0	-0.0	0.1	-0.0	-0.0	0.8	0.4	0.0	0.0	0.11
1940	0.0	0.0	0.0	0.0	-0.2	-0.0	-0.0	-0.0	1.0	0.0	0.8	0.0	0.12
1941	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.01
1942	-0.0	-0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.01
1943	-0.0	-0.1	-0.0	0.0	0.0	0.0	-0.0	0.0	1.6	1.3	0.0	0.0	0.26
1944	0.0	0.0	0.0	0.1	-0.2	-0.0	0.0	0.0	0.6	0.3	0.3	0.0	0.10
1945	0.0	0.0	0.0	0.0	-0.2	-0.0	-0.0	0.0	0.5	0.1	0.4	0.0	0.06
1946	0.0	0.0	-0.2	0.0	-0.1	-0.1	0.0	0.0	0.2	0.0	0.3	0.0	0.02
1947	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.01
1948	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.00
1949	0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	0.5	-0.0	-0.0	-0.0	0.04
1950	0.0	0.0	0.0	0.0	-0.4	0.2	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.01
1951	-0.0	-0.0	-0.3	-0.0	0.0	-0.0	-0.0	-0.0	0.2	0.1	-0.0	0.3	0.00
1952	0.0	0.0	-0.4	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.05
1953	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.5	0.8	0.0	0.0	0.12
1954	0.0	0.0	0.0	-1.0	-0.0	0.0	-0.0	-0.0	0.1	0.1	-0.0	0.3	-0.04
1955	0.0	0.0	-0.3	-0.3	-0.2	-0.4	-0.0	-0.0	0.3	-0.0	-0.0	-0.0	-0.08
1956	-0.0	-0.0	-0.0	0.8	0.0	-0.0	0.0	0.0	0.1	-0.0	-0.0	0.0	0.10
1957	-0.0	0.1	0.1	-0.1	-0.0	-0.0	-0.0	0.0	0.9	0.0	0.4	0.4	0.16
1958	0.0	0.0	-0.3	-0.3	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.06
1959	-0.0	-0.0	-0.0	-0.0	-0.0	0.1	-0.0	-0.0	0.9	0.6	0.0	0.0	0.13
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	0.02
1961	0.0	0.0	0.0	0.0	-0.2	0.1	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.00
1962	0.0	0.0	-0.0	0.0	-0.2	-0.0	-0.0	-0.0	0.8	0.4	0.0	0.2	0.08
1963	0.0	0.0	-0.3	-0.3	0.0	0.0	0.0	-0.0	0.1	-0.0	0.0	0.0	-0.04
1964	0.1	-0.2	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.6	0.6	0.0	0.0	0.07
1965	0.0	0.0	-0.0	-0.2	0.0	-0.0	0.0	0.0	0.3	0.0	0.0	0.2	0.02
1966	0.2	-0.4	-0.2	0.0	0.0	-0.0	-0.0	-0.0	0.3	0.3	0.0	0.0	-0.00
1967	0.0	0.0	-0.6	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.07
1968	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.9	0.8	0.0	0.0	0.13
1969	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.04
1970	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	0.9	0.7	0.0	0.0	0.14
1971	0.0	0.0	-0.1	0.0	-0.1	-0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.02
1972	0.0	0.1	-0.3	0.0	-0.0	0.0	-0.0	-0.0	0.6	0.5	0.0	0.0	0.07
1973	0.0	0.0	-0.4	-0.0	0.0	0.0	-0.0	0.0	0.4	0.1	0.4	0.0	0.02
1974	0.0	-0.2	-0.0	0.0	-0.0	0.0	0.0	0.0	0.2	-0.1	-0.1	-0.0	-0.03
1975	-0.0	0.0	-0.0	-0.1	-0.0	0.0	-0.0	-0.0	-0.0	0.1	-0.1	-0.0	-0.01
1976	-0.0	-0.0	-0.0	-0.0	-0.1	0.4	-0.0	-0.0	1.3	0.0	0.0	0.0	0.16
1977	0.0	0.0	0.0	0.1	0.0	-0.1	-0.0	-0.7	-0.0	-0.1	-0.0	-0.0	0.01
1978	-0.0	-0.0	-0.0	-0.0	-0.2	-0.1	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.04
1979	-0.0	-0.0	-0.0	-0.0	1.0	-0.0	0.0	0.0	0.0	1.3	1.4	0.0	0.29
1980	0.0	0.0	-0.3	-0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	-0.00
1981	0.0	0.0	0.0	-0.7	-0.0	0.0	-0.0	-0.0	0.4	0.4	-0.0	-0.0	0.00
1982	0.0	0.0	-0.2	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.02
1983	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.01
1984	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	1.3	0.7	0.4	0.0	0.28
1985	0.0	0.0	-0.3	0.0	-0.2	0.1	-0.0	-0.0	0.3	0.3	0.0	0.0	0.01
1986	0.0	0.0	0.0	-0.7	0.0	0.0	0.0	0.0	0.3	0.4	-0.0	0.0	-0.02
1987	0.0	0.0	0.0	0.0	-0.3	0.1	-0.0	-0.0	0.5	-0.0	-0.0	-0.0	0.01
1988	0.0	0.0	-0.0	-0.8	-1.5	-0.8	-0.1	-0.1	-0.0	-0.1	-0.1	-0.0	-0.23
1989	-0.0	-0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.0	-0.02
1990	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.01
1991	-0.0	-0.0	-0.0	-0.0	-0.1	0.1	-0.0	-0.1	-0.1	-0.1	-0.1	-0.0	-0.00
1992	-0.0	-0.0	-0.0	-0.0	-0.0	0.1	-0.0	-0.1	-0.0	-0.1	-0.1	-0.0	-0.01
1993	-0.0	-0.0	-0.0	-0.2	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.03
1994	-0.0	-0.0	-0.0	0.0	-0.2	-0.0	-0.0	-0.0	0.6	1.2	0.0	0.0	0.13
Minimum	-0.03	-0.36	-0.64	-1.05	-1.48	-0.82	-0.08	-0.67	-0.07	-0.08	-0.08	-0.04	-0.23
Average	0.01	-0.01	-0.06	-0.09	-0.08	0.01	-0.01	-0.02	0.29	0.17	0.06	0.02	0.02
Maximum	0.19	0.13	0.08	0.84	0.97	0.72	0.02	0.01	1.65	1.29	1.39	0.44	0.29

Note: Difference is Proposed Project minus No-Project.

Table 3C-29. Differences in Export DOC (mg/l) between Proposed Project and Simulated No-Project (mg/l) Assuming Initial-Filling DOC Load (4 g/m²/month)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0.0	0.0	-0.0	-0.2	-0.1	-0.0	0.0	0.0	-0.0	0.8	0.3	0.3	0.1
1923	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.6	0.0	0.3
1924	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	0.0
1925	0.0	0.0	-0.0	0.0	-0.3	0.8	0.0	0.0	2.2	0.0	0.0	0.0	0.2
1926	0.0	0.1	0.0	0.1	-0.6	0.2	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
1927	0.0	0.0	0.0	-0.9	-0.0	-0.0	-0.0	-0.0	0.7	0.5	0.3	0.0	0.0
1928	0.0	-0.1	0.0	-0.6	-0.0	0.0	-0.0	-0.0	1.0	0.8	0.0	0.0	0.1
1929	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0
1930	0.0	0.0	0.0	-0.7	-0.5	0.0	-0.0	-0.0	0.7	-0.0	-0.0	-0.0	-0.1
1931	-0.0	0.0	0.0	0.0	0.0	-0.1	-0.0	-0.0	-0.0	-0.1	-0.0	-0.0	-0.0
1932	-0.0	-0.0	-0.0	-0.5	-0.0	0.7	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1933	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
1934	-0.0	0.0	-0.0	0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.1	-0.0	-0.0	-0.0
1935	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1936	-0.0	-0.0	-0.0	-0.0	-0.4	-0.0	-0.0	-0.0	1.1	0.9	0.0	0.0	0.1
1937	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	1.0	1.2	0.0	0.0	0.2
1938	0.0	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1939	-0.0	-0.0	-0.0	0.0	-0.0	0.8	0.0	0.0	2.9	1.3	0.1	0.1	0.5
1940	0.1	0.1	0.1	0.1	-0.1	0.0	0.0	0.0	1.4	0.0	1.4	0.0	0.3
1941	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1942	-0.0	-0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1943	-0.0	-0.1	-0.0	0.0	0.0	0.0	-0.0	0.0	4.5	3.5	0.1	0.1	0.7
1944	0.1	0.1	0.1	0.2	-0.1	0.1	0.0	0.0	1.0	0.6	0.8	0.1	0.3
1945	0.1	0.0	0.0	0.1	-0.2	-0.0	0.0	0.0	0.8	0.3	1.0	0.0	0.2
1946	0.0	0.0	-0.2	0.0	-0.1	-0.0	0.0	0.0	0.8	0.0	1.1	0.0	0.2
1947	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	0.0
1949	0.0	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	1.0	0.0	-0.0	0.0	0.1
1950	0.0	0.0	0.0	0.0	-0.4	0.3	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	-0.0
1951	0.0	0.0	-0.3	0.0	0.0	-0.0	-0.0	-0.0	0.8	0.3	0.0	0.8	0.1
1952	0.0	0.0	-0.4	0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1953	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	1.4	2.5	0.0	0.0	0.4
1954	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.9	0.1
1955	0.0	0.0	-0.3	-0.3	-0.1	-0.1	0.0	-0.0	1.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
1957	-0.0	0.2	0.2	-0.0	0.0	-0.0	-0.0	0.0	2.3	0.0	1.1	1.2	0.5
1958	0.0	0.0	-0.3	-0.2	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1959	-0.0	-0.0	-0.0	0.0	-0.0	0.6	0.0	-0.0	3.1	2.0	0.1	0.1	0.5
1960	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1961	0.0	0.0	0.0	0.0	-0.1	0.3	0.0	-0.0	0.0	-0.0	-0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	-0.2	-0.0	-0.0	-0.0	1.2	0.6	0.0	0.5	0.2
1963	0.0	0.0	-0.3	-0.2	0.0	0.1	0.0	-0.0	0.2	0.0	0.1	0.1	-0.0
1964	0.2	-0.2	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	2.5	2.3	0.0	0.1	0.4
1965	0.1	0.0	0.0	-0.2	0.0	0.1	0.0	0.0	0.9	0.0	0.0	0.6	0.1
1966	0.6	-0.3	-0.2	0.1	0.0	0.0	0.0	0.0	1.2	1.2	0.0	0.0	0.2
1967	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.1
1968	-0.0	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	2.9	2.7	0.1	0.1	0.5
1969	0.1	0.1	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
1970	-0.0	-0.0	-0.0	0.0	0.0	-0.0	0.0	-0.0	2.7	2.1	0.1	0.1	0.5
1971	0.1	0.1	-0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.1
1972	0.0	0.4	-0.3	0.0	0.0	0.0	0.0	0.0	2.1	1.8	0.0	0.1	0.3
1973	0.1	0.1	-0.4	0.0	0.0	0.0	0.0	0.0	0.9	0.2	1.0	0.0	0.2
1974	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	-0.1	-0.1	-0.0	0.0
1975	0.0	0.1	0.0	-0.1	0.0	0.0	-0.0	-0.0	-0.0	0.4	-0.1	-0.0	0.0
1976	-0.0	-0.0	-0.0	-0.0	-0.0	2.2	0.0	0.0	4.5	0.1	0.1	0.1	0.6
1977	0.1	0.1	0.1	0.2	0.2	0.1	0.1	-0.6	0.0	-0.0	0.0	0.0	0.1
1978	0.0	0.0	0.0	0.0	-0.2	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1979	-0.0	-0.0	-0.0	-0.0	1.0	-0.0	0.0	0.0	0.0	2.7	3.1	0.1	0.6
1980	0.1	0.0	-0.3	-0.0	0.0	0.0	0.0	0.0	0.7	1.0	0.0	0.0	0.1
1981	0.0	0.0	0.0	-0.7	0.0	0.1	-0.0	-0.0	0.9	1.1	0.0	0.0	0.1
1982	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1983	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
1984	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	3.9	2.1	1.1	0.1	0.9
1985	0.1	0.1	-0.3	0.1	-0.2	0.2	0.0	0.0	1.1	1.0	0.0	0.0	0.2
1986	0.1	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	0.7	1.0	0.0	0.0	0.1
1987	0.0	0.0	0.0	0.0	-0.3	0.1	-0.0	-0.0	1.3	0.0	0.0	0.0	0.1
1988	0.0	0.0	0.0	-0.8	-1.3	-0.4	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0	-0.3
1989	-0.0	-0.0	-0.0	0.0	-0.1	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1990	-0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1991	-0.0	-0.0	-0.0	-0.0	-0.1	0.1	-0.0	-0.1	-0.1	-0.1	-0.0	-0.0	-0.0
1992	-0.0	-0.0	-0.0	-0.0	-0.0	0.1	-0.0	-0.1	-0.0	-0.1	-0.1	-0.0	-0.0
1993	-0.0	-0.0	-0.0	-0.2	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1994	-0.0	-0.0	-0.0	0.0	-0.2	-0.0	-0.0	-0.0	1.7	3.6	0.1	0.1	0.4
Minimum	-0.03	-0.34	-0.62	-1.01	-1.28	-0.39	-0.06	-0.64	-0.06	-0.08	-0.08	-0.03	-0.29
Average	0.03	0.01	-0.05	-0.07	-0.06	0.09	0.00	-0.01	0.82	0.53	0.18	0.08	0.14
Maximum	0.60	0.38	0.19	0.85	0.97	2.18	0.07	0.04	4.53	3.60	3.11	1.15	0.92

Note: Difference is Proposed Project minus No-Project.

Table 3C-30. Differences in Export DOC (mg/l) between Proposed Project and Simulated No-Project (mg/l) Assuming High Initial-Filling DOC Load (9 g/m²/month)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0.0	0.0	-0.0	-0.2	-0.1	-0.0	0.0	0.0	-0.0	1.8	0.7	0.6	0.2
1923	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	3.1	0.0	3.5	0.1	0.6
1924	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1
1925	0.0	0.0	-0.0	0.1	-0.2	1.1	0.0	0.0	3.6	0.1	0.1	0.1	0.4
1926	0.1	0.1	0.1	0.1	-0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	-0.8	-0.0	-0.0	-0.0	0.0	1.5	1.1	0.7	0.0	0.2
1928	0.0	-0.1	0.0	-0.5	0.0	0.0	0.0	0.0	2.2	1.8	0.0	0.1	0.3
1929	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	-0.6	-0.3	0.1	-0.0	-0.0	1.5	0.0	0.0	0.0	-0.0
1931	0.0	0.0	0.0	0.0	0.0	-0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
1932	0.0	0.0	-0.0	-0.5	-0.0	1.7	0.0	0.0	-0.0	-0.0	-0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
1934	0.0	0.0	-0.0	0.0	-0.0	-0.1	-0.0	-0.0	-0.0	-0.1	-0.0	-0.0	-0.0
1935	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1936	-0.0	-0.0	-0.0	-0.0	-0.4	-0.0	-0.0	-0.0	1.7	1.5	0.0	0.0	0.3
1937	0.0	0.0	0.0	0.1	-0.3	0.0	0.0	0.0	1.7	2.0	0.1	0.0	0.3
1938	0.0	0.0	-0.2	0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	-0.0
1939	-0.0	-0.0	-0.0	0.0	-0.0	2.0	0.0	0.0	6.4	2.9	0.1	0.2	1.0
1940	0.2	0.3	0.2	0.3	-0.1	0.0	0.0	0.0	2.0	0.0	2.3	0.1	0.5
1941	0.1	0.1	0.1	-0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	0.0
1942	-0.0	0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1943	-0.0	-0.1	-0.0	0.0	0.0	0.0	-0.0	0.0	9.3	7.2	0.2	0.2	1.5
1944	0.2	0.2	0.2	0.4	0.1	0.2	0.1	0.1	1.7	1.1	1.5	0.2	0.5
1945	0.1	0.1	0.1	0.2	-0.1	0.0	0.0	0.0	1.4	0.5	2.1	0.1	0.4
1946	0.1	0.0	-0.1	0.1	0.1	-0.0	0.0	0.0	1.6	0.0	2.3	0.1	0.4
1947	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	1.8	0.0	0.0	0.0	0.2
1950	0.0	0.0	0.0	0.0	-0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	-0.3	0.0	0.0	-0.0	0.0	-0.0	1.8	0.7	0.0	1.7	0.3
1952	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1953	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	0.0	0.0	3.0	5.3	0.1	0.1	1.0
1954	0.1	0.1	0.1	-0.9	0.1	0.1	0.0	0.0	1.5	0.6	0.0	1.9	0.3
1955	0.1	0.1	-0.3	-0.2	0.2	0.4	0.0	0.0	2.3	0.1	0.1	0.1	0.2
1956	0.1	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1
1957	-0.0	0.3	0.4	-0.0	0.0	-0.0	0.0	0.0	4.6	0.1	2.2	2.3	0.9
1958	0.1	0.1	-0.3	-0.1	0.1	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	-0.0
1959	-0.0	0.0	-0.0	0.0	0.0	1.4	0.0	0.0	6.7	4.5	0.1	0.2	1.0
1960	0.2	0.2	0.1	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.1
1961	0.1	0.0	0.0	0.1	-0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1962	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.0	1.9	1.1	0.0	1.0	0.4
1963	0.0	0.0	-0.3	-0.2	0.0	0.1	0.0	0.0	0.4	0.0	0.2	0.2	0.0
1964	0.5	-0.2	0.0	0.0	0.0	-0.0	-0.0	-0.0	5.5	5.1	0.1	0.1	0.8
1965	0.2	0.1	0.1	-0.2	0.1	0.2	0.0	0.0	1.8	0.0	0.0	1.3	0.3
1966	1.3	-0.3	-0.1	0.1	0.1	0.0	0.0	0.0	2.6	2.6	0.1	0.1	0.5
1967	0.1	0.1	-0.6	0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1968	-0.0	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	6.4	6.0	0.1	0.2	1.1
1969	0.2	0.1	0.1	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	5.8	4.4	0.1	0.1	1.1
1971	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	1.5	0.0	0.0	0.0	0.2
1972	0.0	0.8	-0.3	0.1	0.1	0.1	0.0	0.0	4.6	3.9	0.1	0.1	0.8
1973	0.1	0.1	-0.3	0.1	0.0	0.0	0.0	0.0	1.8	0.4	2.0	0.0	0.4
1974	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	-0.1	-0.0	0.0	0.1
1975	0.0	0.3	0.0	-0.1	0.0	0.0	0.0	0.0	-0.0	0.8	-0.1	0.0	0.1
1976	-0.0	0.0	0.0	0.0	-0.0	5.1	0.1	0.1	9.8	0.3	0.2	0.2	1.4
1977	0.2	0.2	0.2	0.5	0.5	0.4	0.2	-0.6	0.1	0.1	0.1	0.1	0.2
1978	0.1	0.1	0.0	0.1	-0.2	-0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	-0.0
1979	-0.0	0.0	0.0	0.0	1.0	-0.0	0.0	0.0	0.0	5.0	6.0	0.1	1.0
1980	0.1	0.1	-0.3	-0.0	0.0	0.0	0.0	0.0	1.6	2.2	0.0	0.1	0.3
1981	0.0	0.1	0.1	-0.6	0.1	0.1	0.0	0.0	1.9	2.2	0.1	0.1	0.4
1982	0.1	0.0	-0.1	0.1	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	0.0
1983	-0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0
1984	0.0	0.0	0.0	0.0	0.0	-0.0	0.0	0.0	8.3	4.4	2.4	0.2	2.0
1985	0.2	0.2	-0.2	0.3	-0.0	0.3	0.1	0.1	2.5	2.3	0.1	0.1	0.4
1986	0.1	0.1	0.1	-0.5	0.0	0.0	0.0	0.0	1.5	2.1	0.1	0.0	0.3
1987	0.0	0.1	0.0	0.1	-0.3	0.1	0.0	0.0	2.6	0.1	0.0	0.1	0.2
1988	0.1	0.1	0.0	-0.8	-0.9	0.3	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.2
1989	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
1990	-0.0	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1991	-0.0	-0.0	0.0	-0.0	-0.1	0.1	-0.0	-0.1	-0.1	-0.1	-0.0	-0.0	-0.0
1992	-0.0	-0.0	-0.0	-0.0	-0.0	0.1	-0.0	-0.1	-0.0	-0.1	-0.1	-0.0	-0.0
1993	-0.0	-0.0	-0.0	-0.2	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
1994	-0.0	-0.0	-0.0	0.0	-0.2	-0.0	-0.0	-0.0	3.6	7.6	0.1	0.2	0.9
Minimum	-0.03	-0.32	-0.58	-0.94	-0.94	-0.07	-0.04	-0.60	-0.06	-0.07	-0.08	-0.03	-0.18
Average	0.07	0.05	-0.02	-0.03	-0.02	0.22	0.01	0.00	1.70	1.11	0.38	0.17	0.33
Maximum	1.26	0.79	0.36	0.86	0.97	5.14	0.19	0.11	9.83	7.56	5.98	2.35	1.96

Note: Difference is Proposed Project minus No-Project.

Table 3C-31. Differences in Estimated THM Concentrations between Proposed Project and No-Project (µg/l)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Flow Weighted Average
1922	0.0	0.0	0.0	-1.2	-1.9	-0.1	0.0	0.1	-0.3	2.8	0.9	0.7	-0.06
1923	0.0	0.0	-2.3	0.0	-0.1	0.1	0.0	0.1	5.5	-0.0	5.5	0.1	0.57
1924	0.1	0.2	0.1	0.3	0.1	-0.6	-0.3	-0.5	-0.3	-0.6	-0.8	-0.2	0.02
1925	0.0	0.1	-0.5	0.3	-3.8	13.4	0.0	0.1	19.9	0.3	0.3	0.3	1.64
1926	0.5	0.5	0.3	0.5	-7.3	1.8	-0.0	-0.0	-0.1	-0.3	-0.1	-0.2	-0.73
1927	-0.0	-0.0	0.0	-10.7	-0.5	-0.3	-0.0	0.0	3.6	2.5	1.1	-0.0	-0.67
1928	0.0	-0.3	0.5	-7.1	-0.2	0.2	-0.1	-0.2	3.9	3.7	-0.1	-0.1	-0.22
1929	0.0	0.0	0.0	0.2	-0.0	-0.7	-0.2	-0.3	-0.3	-0.6	-0.7	-0.2	-0.09
1930	-0.0	-0.0	0.0	-7.2	-3.5	0.5	-0.5	-0.6	2.6	-0.5	-0.3	-0.4	-1.15
1931	-0.2	-0.2	-0.1	-0.1	-0.1	-1.7	-0.8	-0.7	-0.9	-1.1	-0.7	-0.4	-0.35
1932	-0.2	-0.2	-0.4	-5.0	-0.1	0.6	-0.1	-0.1	-0.3	-0.5	-0.3	-0.2	-1.05
1933	-0.1	-0.1	-0.0	-0.0	-0.2	0.1	-0.2	-0.3	-0.7	-0.9	-0.6	-0.2	-0.12
1934	-0.1	-0.0	0.0	0.1	-0.2	-1.1	-0.4	-0.8	-0.4	-0.9	-0.7	-0.3	-0.23
1935	-0.1	-0.1	-0.0	-0.0	-0.3	0.5	0.3	-0.1	-0.2	-0.2	-0.4	-0.3	-0.05
1936	-0.2	-0.2	-0.1	-0.1	-5.3	-0.4	-0.1	-0.0	8.2	6.0	0.1	0.1	0.43
1937	0.2	0.2	0.2	0.3	-5.5	0.0	0.0	0.0	9.2	8.9	0.2	0.2	0.68
1938	0.2	0.1	-2.8	0.2	0.0	0.0	0.0	0.0	-0.5	-0.1	-0.1	-0.1	-0.30
1939	-0.2	0.1	-0.2	0.0	-0.2	0.7	-0.0	-0.1	9.0	4.2	0.1	0.3	1.01
1940	0.4	0.5	0.5	0.4	-2.9	-0.2	0.0	0.0	11.3	0.1	10.1	0.2	1.49
1941	0.3	0.2	0.1	-1.9	-0.0	0.0	0.0	0.0	-0.2	-0.1	0.0	0.2	-0.17
1942	0.0	0.1	-0.2	0.0	0.0	-0.2	0.2	0.0	-0.5	-0.1	-0.1	-0.1	-0.08
1943	-0.0	-0.4	-0.1	0.0	0.0	0.0	-0.0	0.0	20.0	15.5	0.4	0.4	2.69
1944	0.4	0.5	0.4	0.9	-4.8	-0.2	0.2	0.1	7.6	4.1	3.8	0.4	1.23
1945	0.5	0.3	0.2	0.5	-3.4	-0.5	0.0	0.0	6.6	1.7	5.7	0.1	0.79
1946	0.2	0.1	-2.7	0.2	-0.8	-0.9	0.1	0.1	4.9	-0.0	4.9	0.1	0.39
1947	0.2	0.2	0.1	0.4	0.4	0.2	-0.1	-0.2	-0.3	-0.3	-0.1	-0.1	0.08
1948	-0.0	0.0	0.1	-0.0	-0.3	0.2	-0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.03
1949	-0.0	-0.0	0.0	0.2	0.3	-0.1	-0.2	-0.3	5.7	-0.1	-0.2	-0.1	0.41
1950	-0.0	0.0	0.0	0.1	-4.6	2.6	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.34
1951	-0.1	-0.0	-4.6	-0.0	-0.0	-0.2	-0.0	-0.0	1.8	1.1	-0.0	2.9	-0.02
1952	0.0	0.0	-5.3	-0.1	-0.1	0.0	0.0	0.0	-0.4	-0.1	-0.1	-0.1	-0.61
1953	-0.0	-0.1	-0.5	-0.0	-0.1	-0.2	-0.0	0.0	6.9	11.8	0.1	0.2	1.79
1954	0.2	0.2	0.2	-12.8	-0.2	0.3	-0.0	-0.1	2.4	1.1	-0.1	3.6	-0.47
1955	0.0	0.0	-3.4	-3.8	-1.1	-2.5	-0.2	-0.2	4.3	-0.2	-0.2	-0.1	-0.86
1956	-0.0	0.0	-0.1	10.0	0.1	-0.0	0.1	0.2	0.6	-0.0	-0.0	-0.0	1.18
1957	-0.1	1.5	1.3	-0.1	-0.2	-0.1	-0.0	0.1	11.5	0.1	5.7	6.2	2.20
1958	0.2	0.2	-2.7	-3.6	-0.1	-0.1	0.0	0.0	-0.4	-0.1	-0.1	-0.0	-0.66
1959	-0.1	0.0	-0.0	-0.1	-0.1	1.2	-0.1	-0.1	11.8	7.7	0.1	0.2	1.36
1960	0.3	0.3	0.2	0.6	0.4	0.2	0.0	-0.0	0.0	-0.2	-0.1	-0.0	0.19
1961	0.1	0.1	0.1	0.2	-2.0	2.2	-0.2	-0.3	-0.1	-0.3	-0.1	-0.1	-0.07
1962	0.0	0.0	0.0	0.2	-3.0	-0.0	-0.0	-0.1	11.6	5.3	0.1	3.5	1.29
1963	0.1	0.1	-3.3	-2.7	0.1	0.5	0.1	-0.0	0.7	-0.1	0.2	0.1	-0.39
1964	0.8	-2.5	0.3	-0.1	-0.1	-0.4	-0.2	-0.3	9.0	8.0	0.1	0.1	0.77
1965	0.2	0.2	-0.0	-3.8	0.0	-0.1	0.1	0.1	3.2	0.0	0.0	2.8	0.06
1966	2.5	-3.1	-1.5	0.2	0.1	-0.2	0.0	-0.1	5.6	5.4	0.0	0.1	0.41
1967	0.2	0.1	-7.9	-0.1	-0.1	0.1	0.0	0.0	-0.6	-0.2	-0.1	-0.1	-0.81
1968	-0.1	-0.0	-0.4	-0.1	-0.0	-0.3	-0.1	-0.2	11.2	10.4	0.1	0.2	1.36
1969	0.3	0.2	0.1	-5.3	0.0	0.0	0.0	0.0	0.0	-0.1	-0.0	-0.0	-0.56
1970	-0.0	-0.1	-0.1	0.0	0.0	-0.1	0.0	0.0	9.5	7.9	0.2	0.3	1.46
1971	0.3	0.2	-1.2	0.4	-0.8	-0.3	0.1	0.1	2.8	0.0	0.0	0.0	0.12
1972	0.1	1.5	-1.3	0.7	-0.0	0.2	-0.1	-0.1	9.2	7.8	0.1	0.2	1.22
1973	0.3	0.1	-4.7	-0.2	0.0	0.1	0.0	0.0	4.9	1.0	4.4	0.0	0.33
1974	0.1	-3.1	-0.1	0.1	-0.0	0.1	0.0	0.1	3.0	-0.5	0.1	0.1	-0.04
1975	0.1	0.6	0.0	-1.2	-0.0	0.0	-0.1	-0.0	-0.5	1.6	-0.1	0.2	0.08
1976	-0.1	0.0	0.0	-0.1	-0.6	7.2	-0.1	-0.3	18.4	0.1	0.2	0.3	1.75
1977	0.4	0.5	0.5	1.2	0.2	-1.0	-0.2	-9.8	-0.6	-0.9	-0.6	-0.4	0.05
1978	-0.1	-0.1	-0.0	-0.2	-3.1	-0.9	0.0	0.0	-0.1	-0.3	-0.2	-0.1	-0.60
1979	-0.1	-0.1	-0.1	-0.1	11.6	-0.1	0.1	0.1	0.0	15.6	17.5	0.4	3.23
1980	0.4	0.4	-1.2	-1.2	0.0	0.0	0.1	0.0	4.0	4.9	0.0	0.0	0.42
1981	0.1	0.2	0.1	-11.1	-0.2	0.4	-0.1	-0.3	3.5	3.3	-0.1	-0.0	-0.29
1982	0.0	0.0	-2.1	-0.0	-0.0	0.0	0.0	0.0	-0.4	-0.2	-0.1	-0.1	-0.27
1983	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1	-0.2	-0.08
1984	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.1	14.8	8.1	4.4	0.3	3.16
1985	0.4	0.2	-3.4	1.0	-2.9	1.1	0.0	-0.0	1.7	1.6	-0.0	0.0	-0.16
1986	0.1	0.1	0.1	-7.8	0.0	0.0	0.0	0.0	3.8	5.6	-0.0	0.0	-0.19
1987	0.0	0.1	0.1	0.2	-4.4	0.7	-0.3	-0.5	6.3	-0.2	-0.1	-0.1	0.10
1988	0.0	0.0	0.0	-10.3	-15.4	-8.1	-1.1	-1.4	-0.7	-0.8	-1.1	-0.8	-3.58
1989	-0.5	-0.4	-0.3	-0.3	-1.5	0.1	-0.4	-0.7	-0.5	-0.5	-0.3	-0.3	-0.33
1990	-0.2	-0.2	-0.1	-0.0	0.1	-0.1	-0.5	-0.7	-0.4	-0.6	-0.7	-0.3	-0.23
1991	-0.1	-0.1	-0.1	-0.7	-1.3	0.8	-0.4	-0.9	-1.1	-1.3	-0.9	-0.5	-0.14
1992	-0.2	-0.3	-0.2	-0.1	-0.1	0.8	-0.5	-1.0	-0.6	-1.0	-1.4	-0.6	-0.17
1993	-0.3	-0.3	-0.5	-2.8	-0.2	0.1	-0.0	0.0	-0.4	-0.2	-0.1	-0.1	-0.51
1994	-0.1	-0.1	-0.0	0.0	-2.0	-0.1	-0.3	-0.3	9.4	19.8	0.2	0.3	1.65
Minimum	-0.5	-3.1	-7.9	-12.8	-15.4	-8.1	-1.1	-9.8	-1.1	-1.3	-1.4	-0.8	-3.6
Average	0.1	-0.0	-0.7	-1.1	-1.0	0.2	-0.1	-0.3	3.8	2.2	0.8	0.3	0.28
Maximum	2.5	1.5	1.3	10.0	11.6	13.4	0.3	0.2	20.0	19.8	17.5	6.2	3.2

Note: Difference is Proposed Project minus No-Project.

Table 3C-32. Comparison between Delta Wetlands Project Impacts on Water Quality in the 1995 DEIR/EIS and the 2000 REIR/EIS

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Comparison between 1995 DEIR/EIS and 2000 REIR/EIS
CHAPTER 3C. WATER QUALITY	
Impact C-1: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives (S) C **Mitigation Measure C-1:** Restrict DW Diversions to Limit EC Increases at Chipps Island (LTS)	**Salinity Increase at Chipps Island.** As a result of incorporating the FOC terms into proposed project operations, estimated project effects on EC concentrations at Chipps Island are less than those reported in the 1995 DEIR/EIS. Simulated changes in EC concentrations do not exceed the significance criteria. Therefore, this impact is considered less than significant, and no mitigation is required. (LTS)
Impact C-2: Salinity (EC) Increase at Emmaton during April-August (S) C **Mitigation Measure C-2:** Restrict DW Diversions to Limit EC Increases at Emmaton (LTS) **Impact C-3:** Salinity (EC) Increase at Jersey Point during April-August (S) C **Mitigation Measure C-3:** Restrict DW Diversions to Limit EC Increases at Jersey Point (LTS)	**Salinity Increase at Emmaton and Jersey Point.** Estimated effects of project diversions on EC at these locations are less than those reported in the 1995 DEIR/EIS. The EC significance criterion of a 20% change from No-Project Alternative conditions would still be exceeded; such exceedances would be infrequent. As reported in the 1995 DEIR/EIS, this impact is considered significant. (S) The same mitigation is recommended to reduce this impact to a less-than-significant level. (LTS)
Impact C-4: Salinity (Chloride) Increase in Delta Exports (S) C **Mitigation Measure C-4:** Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports (LTS)	**Salinity Increase in Delta Exports.** As a result of incorporating the FOC terms into proposed project operations, estimated project effects on EC concentrations at these locations are less than those reported in the 1995 DEIR/EIS. Simulated changes in EC concentrations do not exceed the significance criteria. Therefore, this impact is considered less than significant, and no mitigation is required. (LTS)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Table 3C-32. Continued

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Comparison between 1995 DEIR/EIS and 2000 REIR/EIS
Impact C-5: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) (S) C **Mitigation Measure C-5:** Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports (LTS)	**Increases in DOC Concentrations in Delta Exports.** Changes in DOC concentrations of greater than 0.8 mg/l were simulated under the initial-fill and long-term DOC loading assumptions. As reported in the 1995 DEIR/EIS, this impact is considered significant. (S) The same mitigation is recommended to reduce the impact to a less-than-significant level. (LTS)
Impact C-6: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) (S) C **Mitigation Measure C-6:** Restrict DW Discharges to Prevent Increases of More Than 20 Fg/l in THM Concentrations or THM Concentrations of Greater than 90 Fg/l in Treated Delta Export Water (LTS)	**Increase in THM Concentrations in Treated Drinking Water.** Where project operations were simulated to result in monthly increases of THM concentrations in treated water, the increases were almost always less than the criterion of 16 Fg/l. These results are similar to those predicted in the 1995 DEIR/EIS in which the largest monthly increase was less than the previous criterion of 20 Fg/l. Effects on THM concentrations are considered a significant impact because the 20% change threshold would be exceeded in some months. (S) The mitigation measure has been revised to reflect the new standards for THM. Implementation would be the same as described in the 1995 DEIR/EIS except for the difference in the numerical thresholds: C Restrict Delta Wetlands Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater than 72 Fg/l in Treated Delta Export Water (LTS)
Impact C-7: Changes in Other Water Quality Variables in Delta Channel Receiving Waters (S) C **Mitigation Measure C-7:** Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality (LTS)	These effects were not reassessed in the REIR/EIS. Project effects on temperature and dissolved oxygen have been addressed through the Endangered Species Act consultation process, and no new information on other variables (e.g., suspended sediment and chlorophyll) has been presented.

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Table 3C-32. Continued

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Comparison between 1995 DEIR/EIS and 2000 REIR/EIS
Impact C-8: Potential Contamination of Stored Water by Pollutant Residues (S) C **Mitigation Measure C-8:** Conduct Assessments of Potential Contamination Sites and Rededicate as Necessary (LTS)	This potential project effect was not reassessed in the REIR/EIS. The impact and mitigation remain the same as presented in the 1995 DEIR/EIS.
Cumulative Impacts	
Impact C-17: Salinity (EC) Increase at Chipps Island during Months with Applicable EC Objectives under Cumulative Conditions (S) C **Mitigation Measure C-1:** Restrict DW Diversions to Limit EC Increases at Chipps Island (LTS) **Impact C-18:** Salinity (EC) Increase at Emmaton during April-August under Cumulative Conditions (S) C **Mitigation Measure C-2:** Restrict DW Diversions to Limit EC Increases at Emmaton (LTS) **Impact C-19:** Salinity (EC) Increase at Jersey Point during April-August under Cumulative Conditions (S) C **Mitigation Measure C-3:** Restrict DW Diversions to Limit EC Increases at Jersey Point (LTS) **Impact C-20:** Salinity (Chloride) Increase in Delta Exports under Cumulative Conditions (S) C **Mitigation Measure C-4:** Restrict DW Diversions or Discharges to Limit Chloride Concentrations in Delta Exports (LTS)	**Increase in Salinity under Cumulative Conditions.** The proposed project would be operated in fewer years under cumulative conditions than under existing conditions because of limited availability of water for Delta Wetlands diversions. However, it is assumed under the cumulative future scenario that export pumping capacity at Banks Pumping Plant would be greater. Therefore, simulated exports are greater in several years than under the proposed project. Changes in water quality conditions under cumulative future conditions would be similar to those described for the proposed project and therefore would be smaller than the changes described for cumulative conditions in the 1995 DEIR/EIS. Changes in project operations resulting from the FOC terms reduce the impact on salinity at Chipps Island and in Delta exports to less-than-significant levels. (LTS) Effects on EC at Emmaton and Jersey Point are still considered a significant impact. (S) The same mitigation is recommended to reduce these impacts to less-than-significant levels. (LTS)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Table 3C-32. Continued

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Comparison between 1995 DEIR/EIS and 2000 REIR/EIS
Impact C-21: Elevated DOC Concentrations in Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions (S)	**Increase in DOC Concentrations in Delta Exports under Cumulative Conditions.** Because DOC loads are proportional to period of storage, it is possible that DOC loads under cumulative conditions could be somewhat less than for the proposed project because greater export pumping capacity would provide more frequent opportunities for discharge of Delta Wetlands Project water. However, as reported in the 1995 DEIR/EIS, the significance criteria would be exceeded in some years, so the impact is considered significant. (S)
C **Mitigation Measure C-5:** Restrict DW Discharges to Prevent DOC Increases of Greater Than 0.8 mg/l in Delta Exports (LTS)	The same mitigation is recommended to reduce the impact to a less-than-significant level. (LTS)
Impact C-22: Elevated THM Concentrations in Treated Drinking Water from Delta Exports (CCWD Rock Slough, SWP Banks, CVP Tracy) under Cumulative Conditions (S) C **Mitigation Measure C-6:** Restrict DW Discharges to Prevent Increases of More Than 20 Fg/l in THM Concentrations or THM Concentrations of Greater than 90 Fg/l in Treated Delta Export Water (LTS)	**Increase in THM Concentrations in Treated Drinking Water under Cumulative Conditions.** Changes would be similar to those described for the proposed project. Because DOC loads are proportional to period of storage, it is possible that DOC loads under cumulative conditions could be somewhat less than for the proposed project and that changes in THM concentrations in treated water would be less than for the proposed project. However, the impact is significant. (S) C Restrict Delta Wetlands Discharges to Prevent Increases of More Than 16 Fg/l in THM Concentrations or THM Concentrations of Greater than 72 Fg/l in Treated Delta Export Water (LTS)
Impact C-23: Changes in Other Water Quality Variables in Delta Channel Receiving Waters under Cumulative Conditions (S) C **Mitigation Measure C-7:** Restrict DW Discharges to Prevent Adverse Changes in Delta Channel Water Quality (LTS)	See discussion of Impact C-7 above.

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

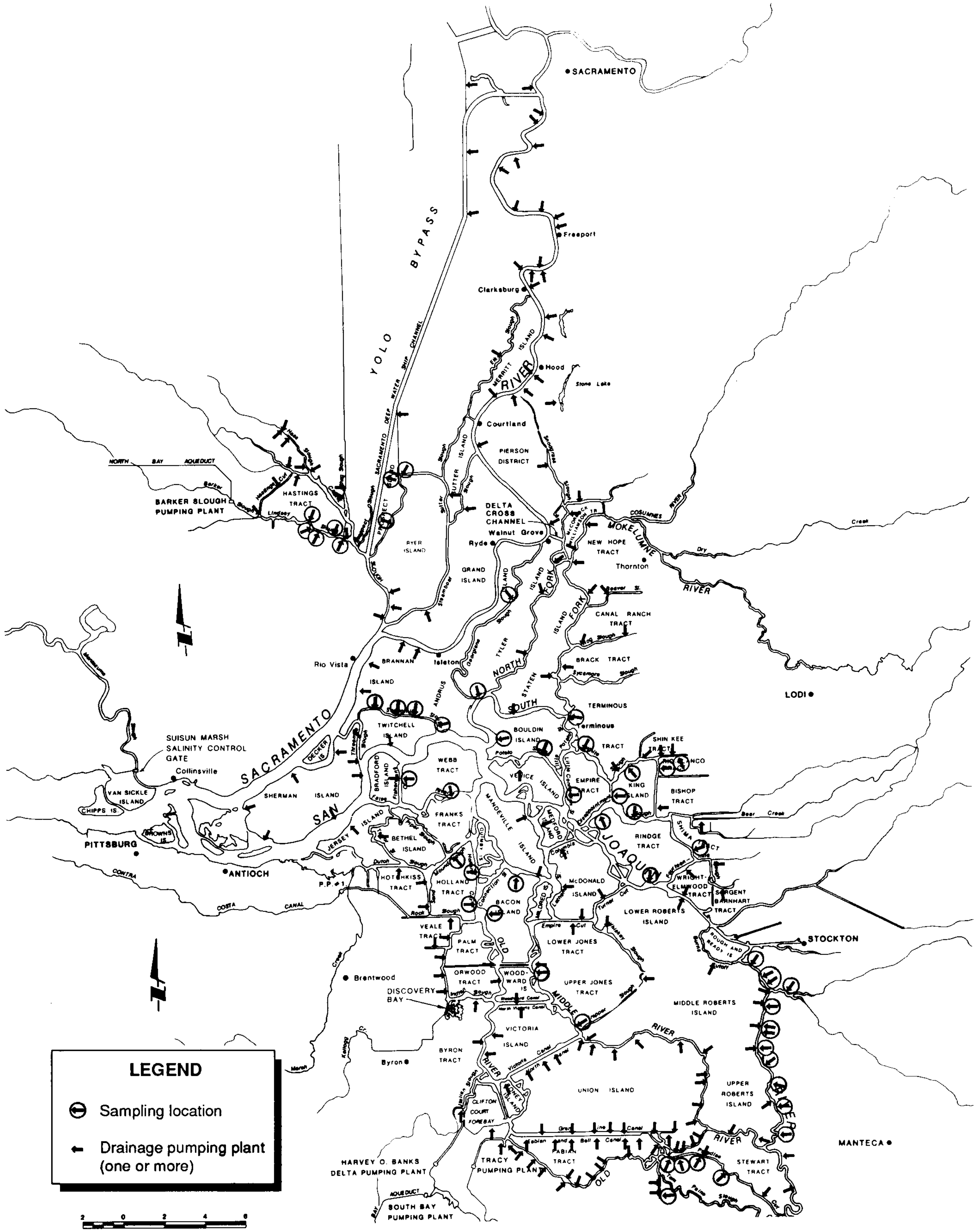
Table 3C-32. Continued

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Comparison between 1995 DEIR/EIS and 2000 REIR/EIS
Impact C-24: Increase in Pollutant Loading in Delta Channels (SU) C **Mitigation Measure C-9:** Clearly Post Waste Discharge Requirements, Provide Waste Collection Facilities, and Educate Recreationists regarding Illegal Discharges of Waste (SU)	No change from 1995 DEIR/EIS.

Notes:

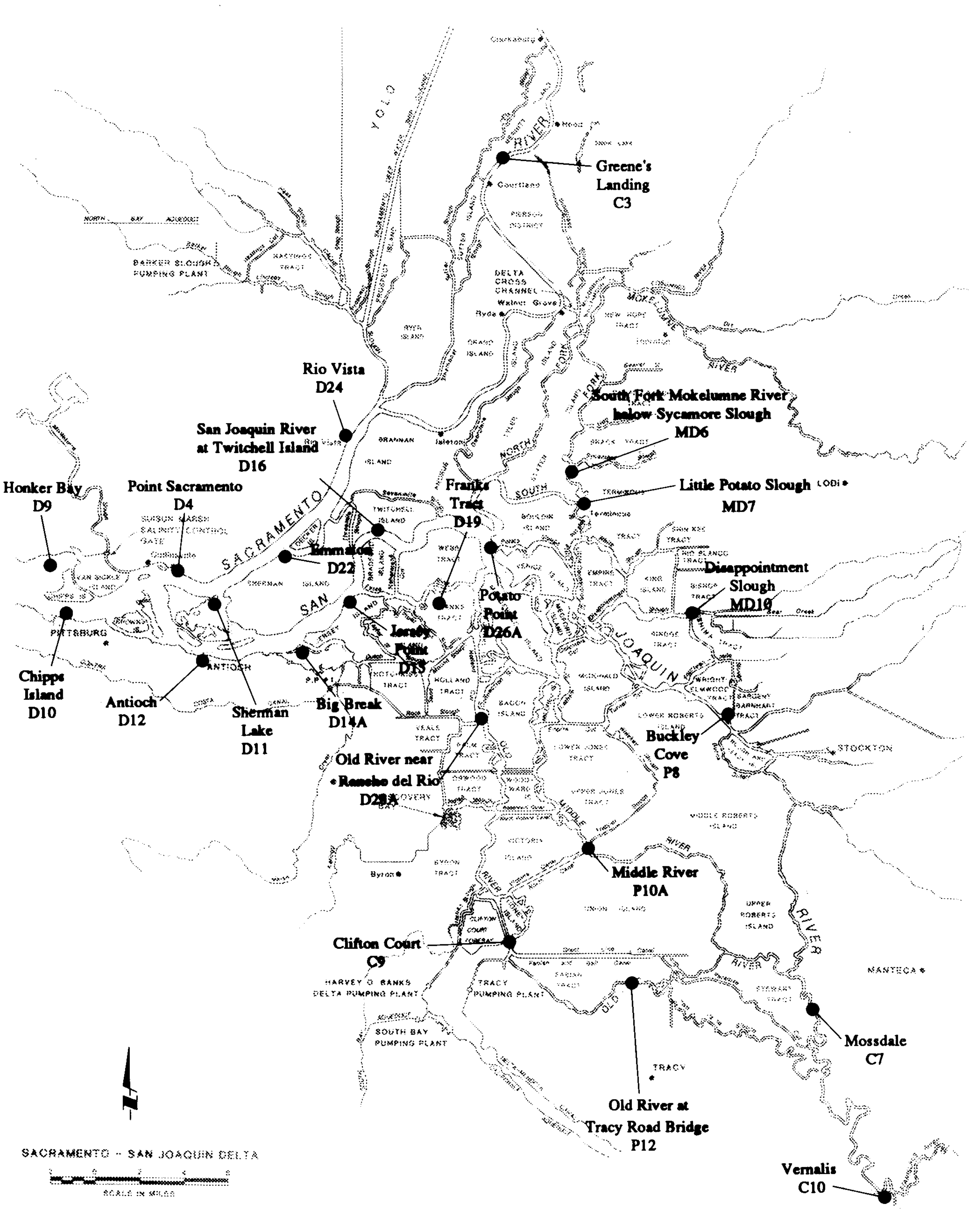
Impacts C-9 through C-16 of the 1995 DEIR/EIS describe impacts of Alternative 3, the four-reservoir-island alternative. There is no change to the assessment of Alternative 3; therefore, the impacts and mitigation measures have not changed.

S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.



Source: California Department of Water Resources 1993.

Figure 3C-1
Agricultural Drainage Returns in the Delta and MWQI Sampling Locations



Source: Adapted from California Department of Water Resources 1993.

Figure 3C-2
D-1485 Water Quality Monitoring Locations

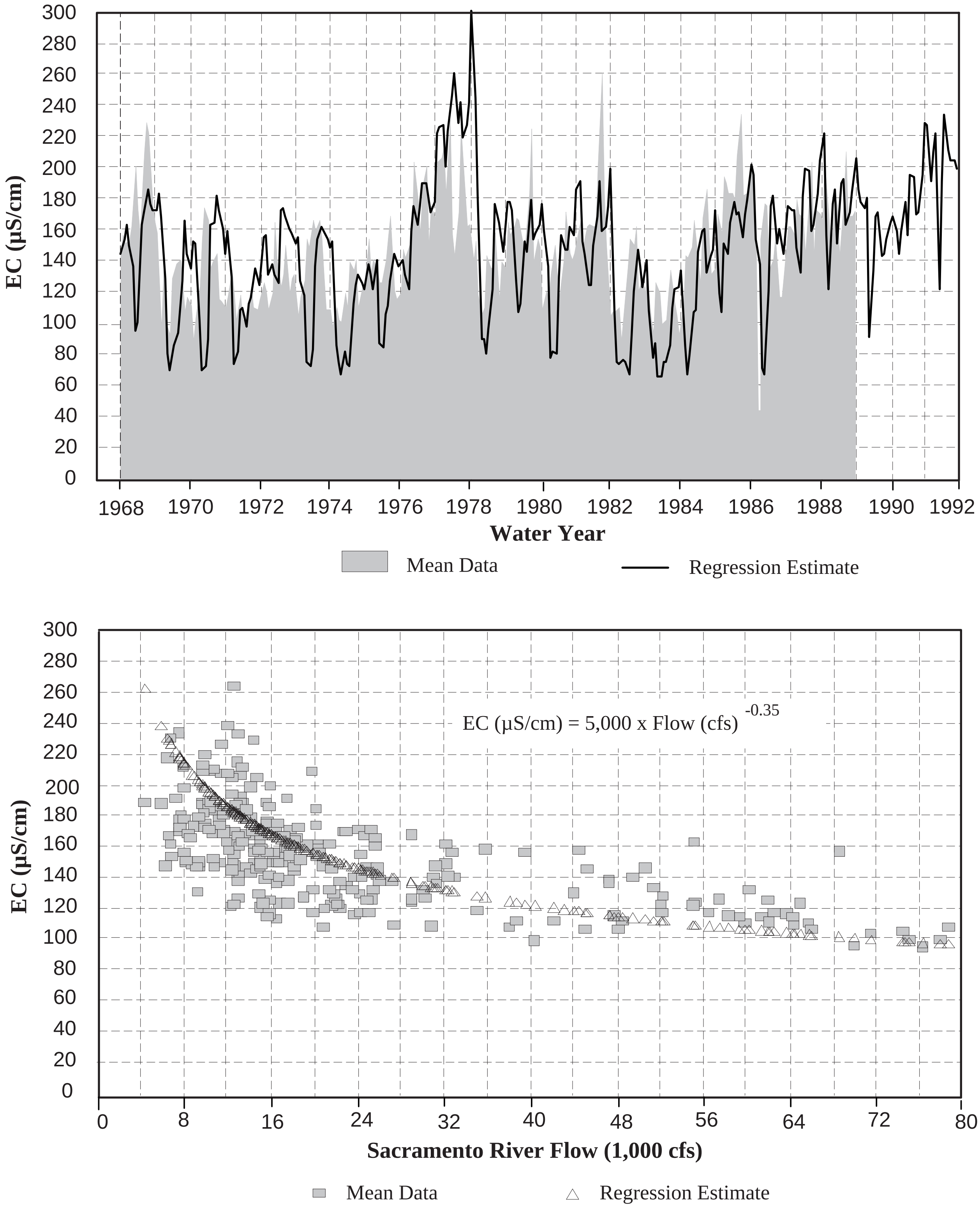


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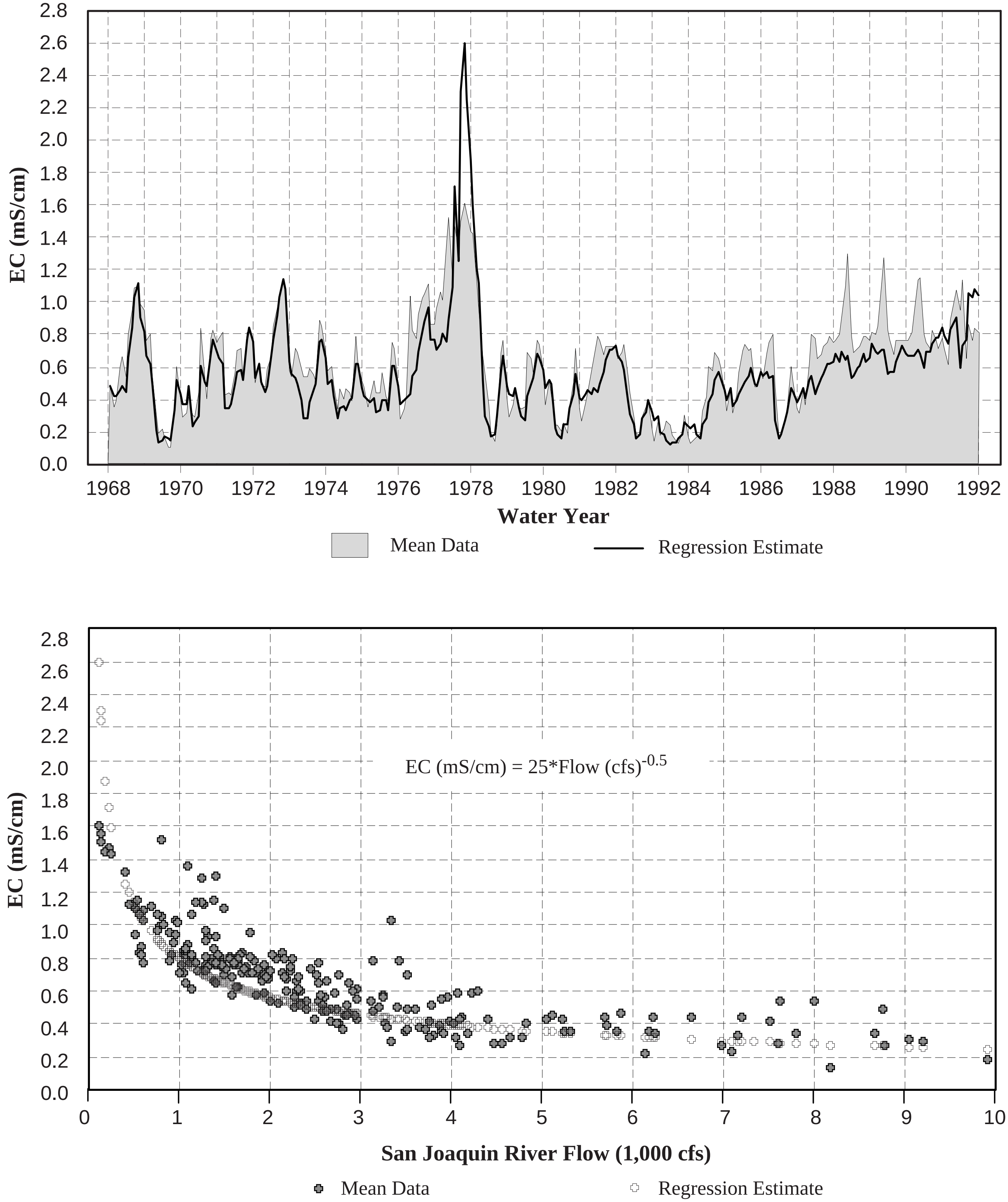
Figure 3C-3
Relationship between Simulated End-of-Month and Measured Mean Monthly EC at Greene's Landing and Sacramento River Flow for 1968-1991



Jones & Stokes

Figure 3C-4
Relationship between Simulated End-of-Month and Measured Mean Monthly EC at Vernalis and San Joaquin River Flow for 1968-1991

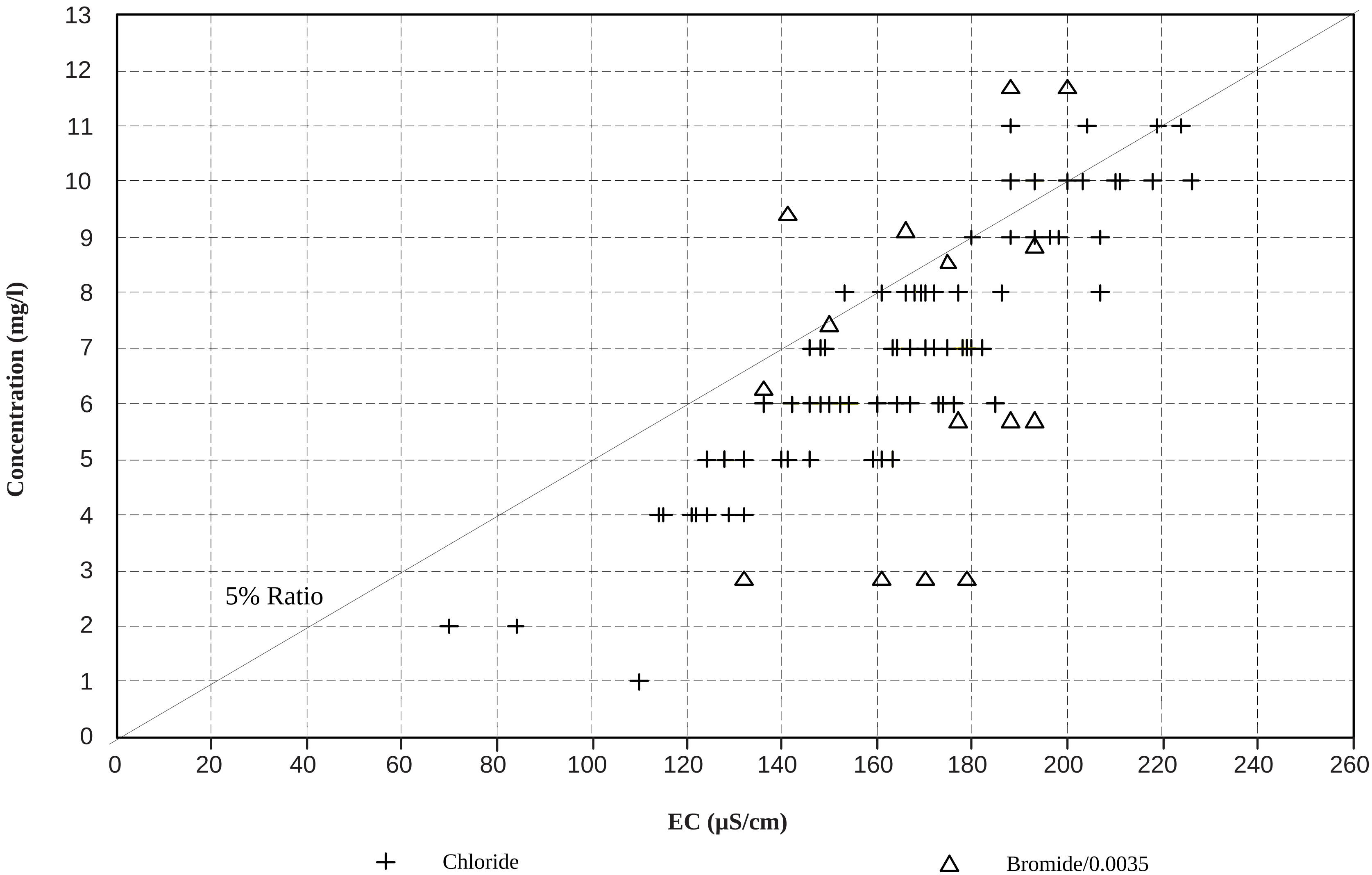


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Figure 3C-5
Relationship between EC and Concentrations of Chloride and Bromide in the Sacramento River at Greene's Landing (1982-1991 MWQI Monthly Samples)

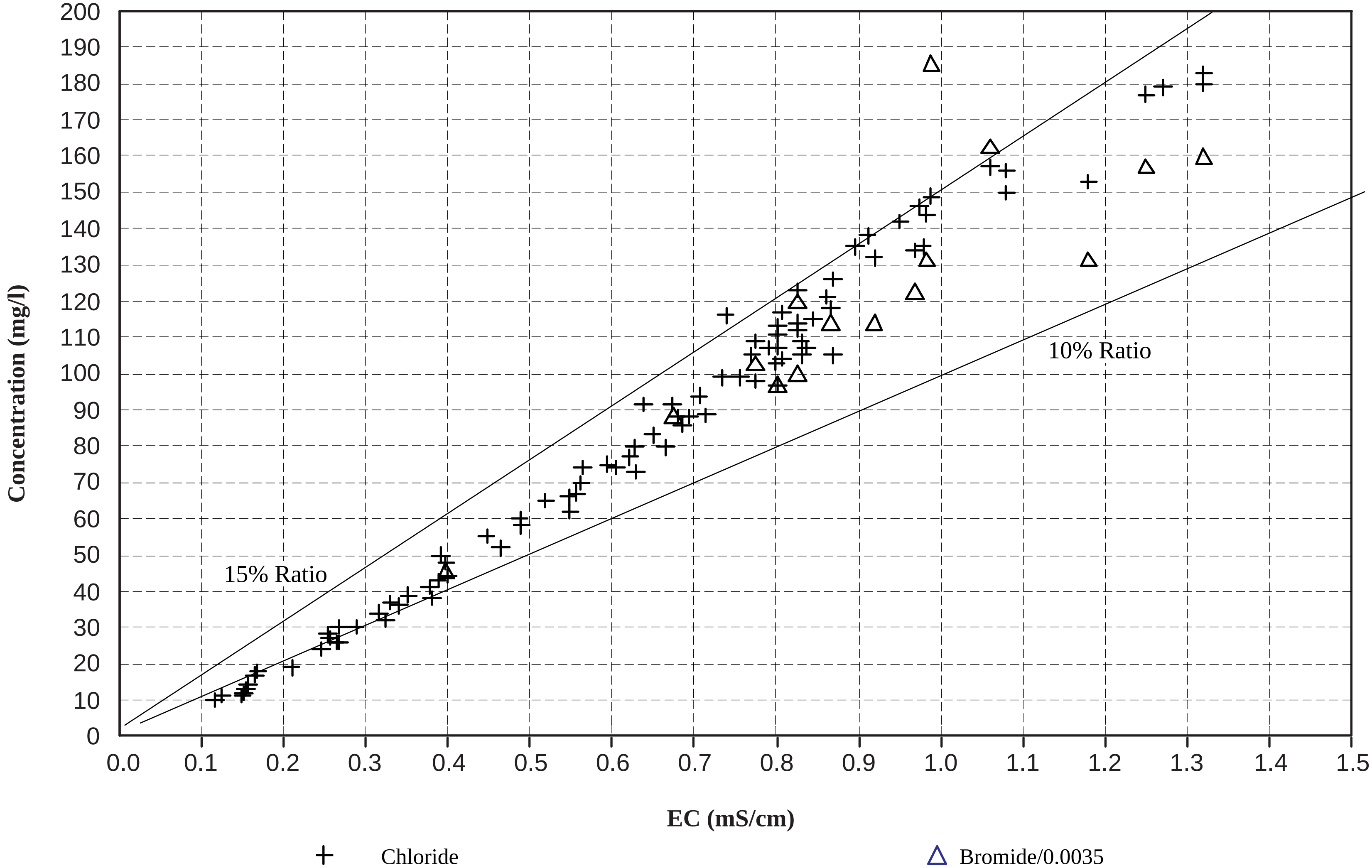

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Figure 3C-6
Relationship between EC and Concentrations of Chloride and Bromide in the San Joaquin River at Vernalis (1982-1991 MWQI Monthly Samples)

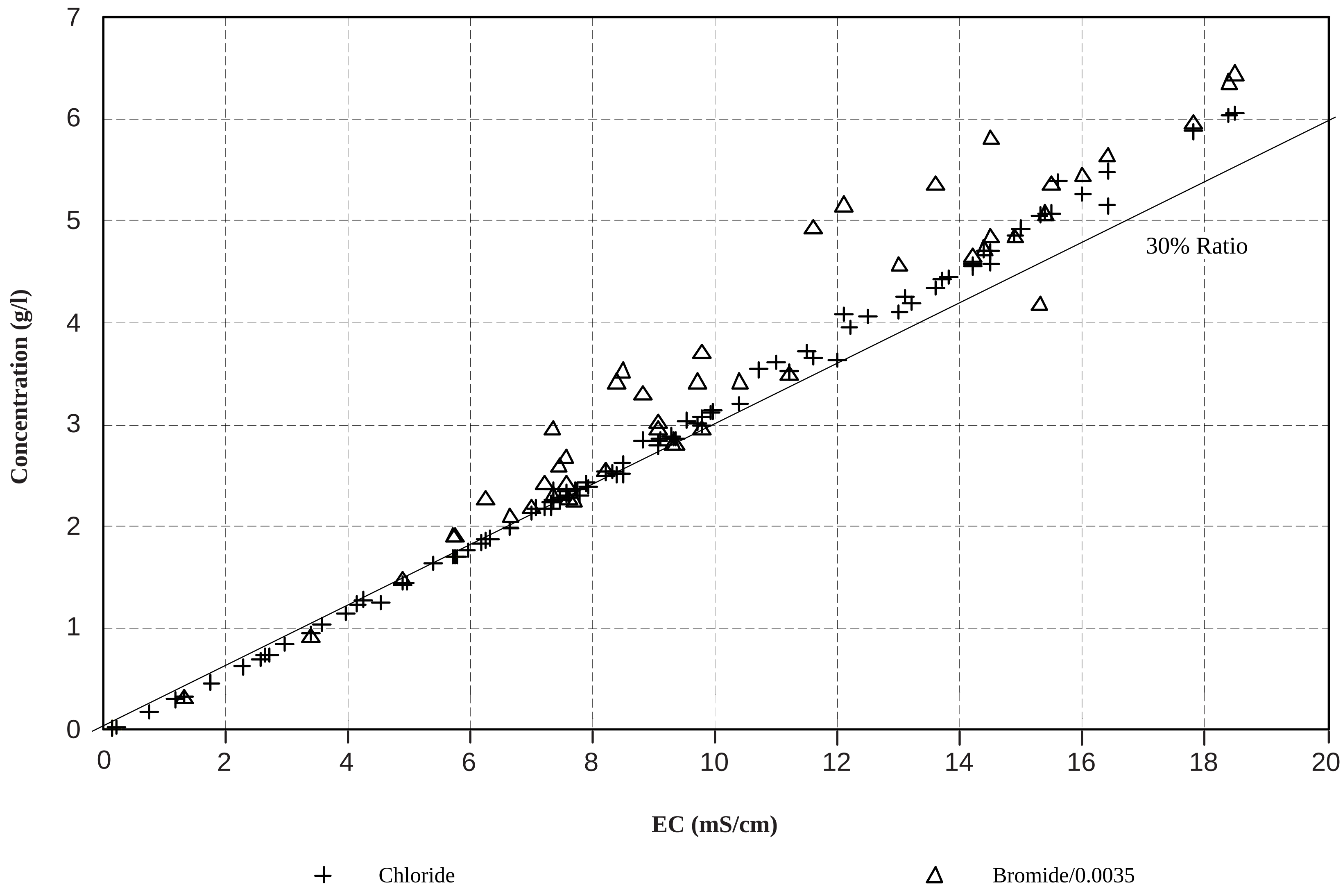
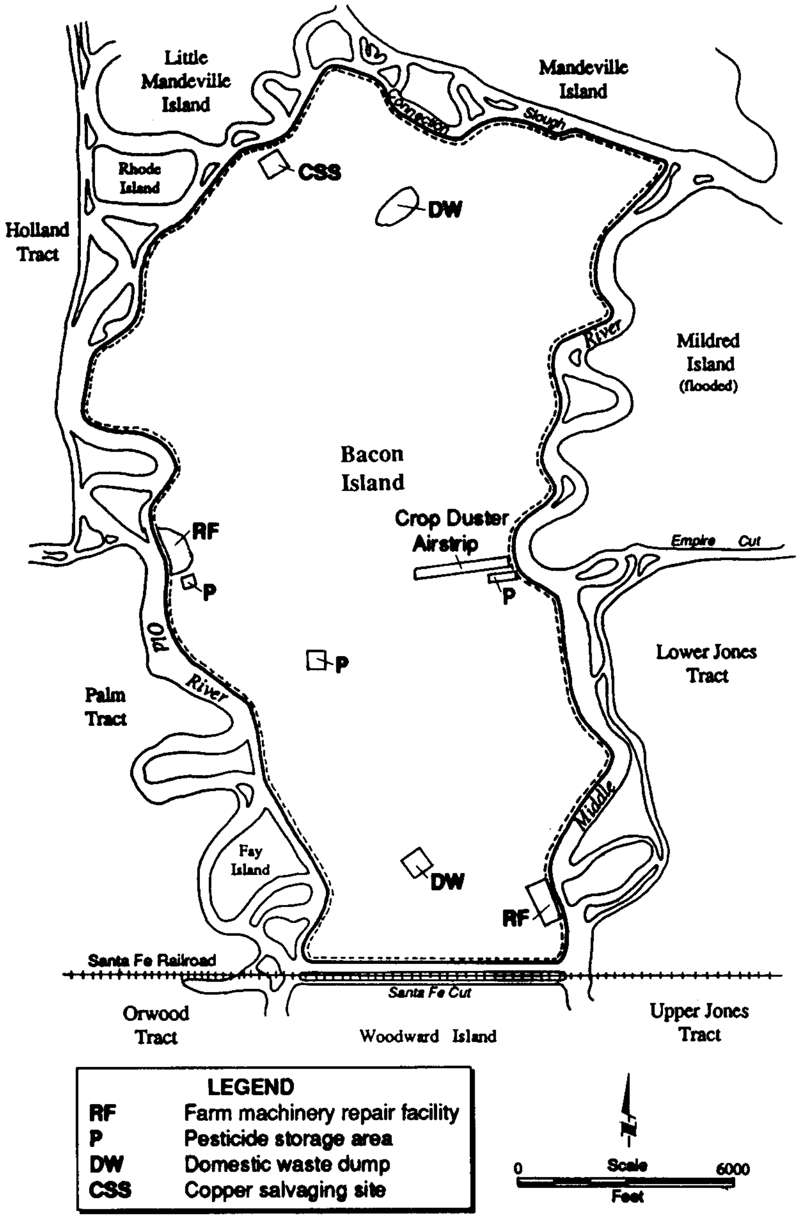
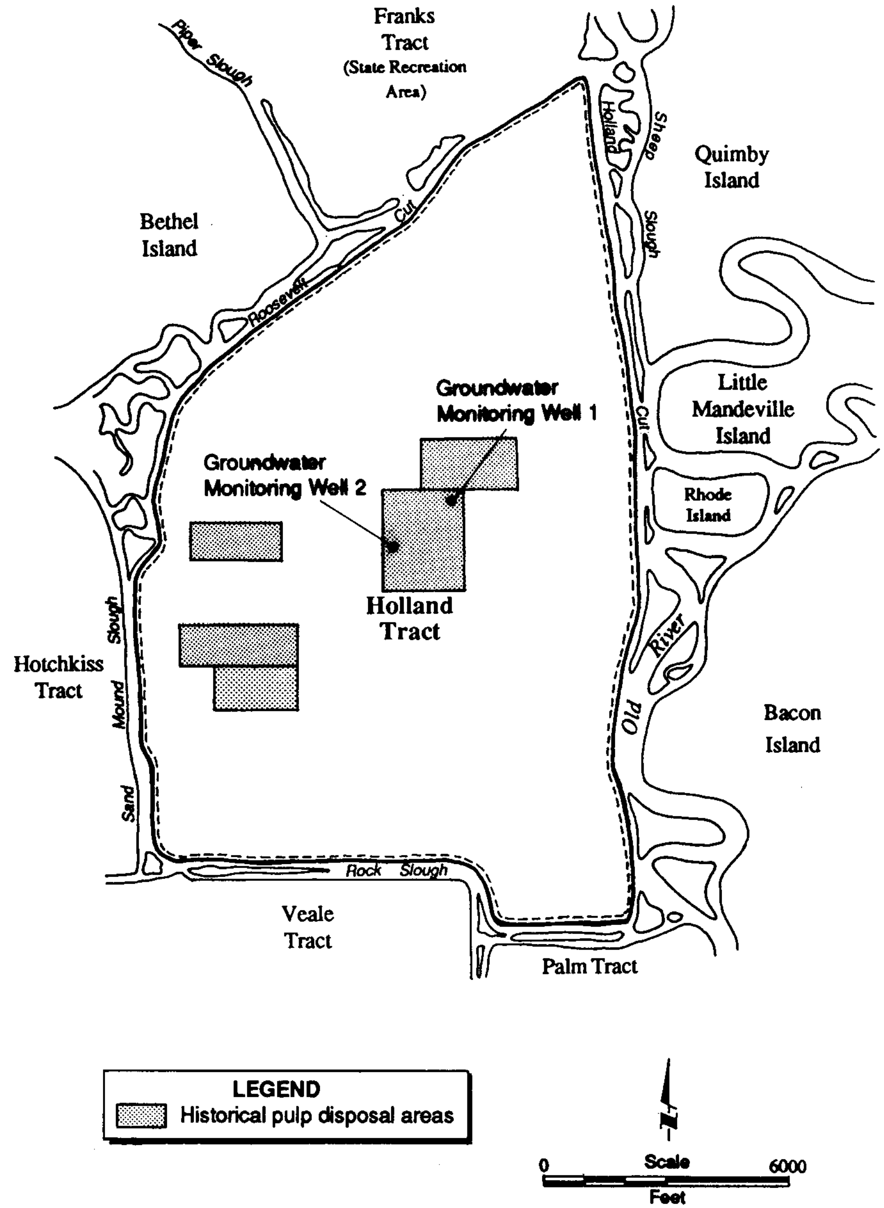


Figure 3C-7
Relationship between EC and Concentrations of Chloride and Bromide in Water from Mallard Island (Chipps Island) (1982-1991 MWQI Monthly Samples)





Note: Only Bacon Island and Holland Tract are shown because no potential contaminant sites exist on Webb Tract and Bouldin Island.

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Figure 3C-8
Potential Contaminant Sites on the Delta Wetlands Project Islands

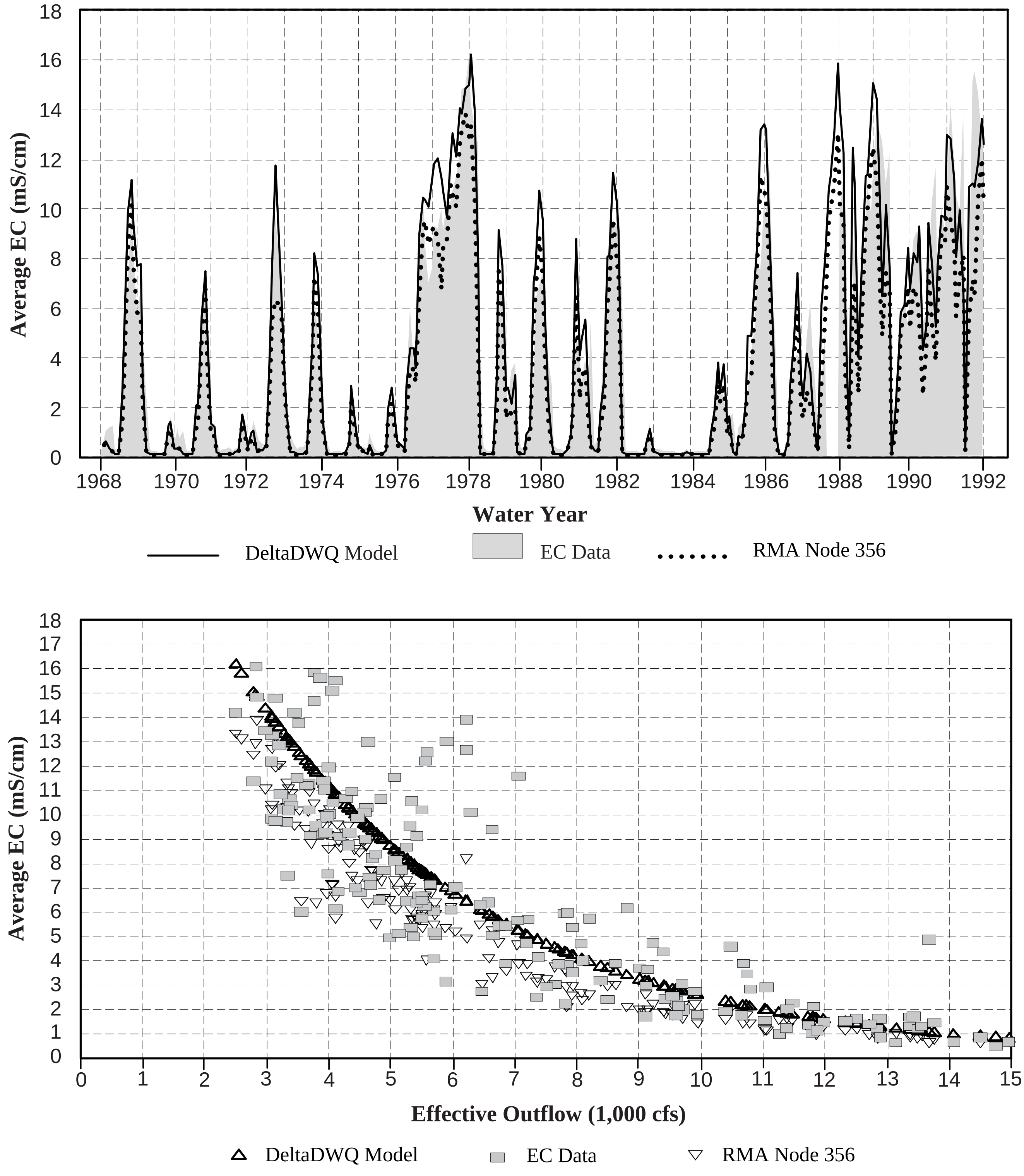

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Figure 3C-9
Comparison of Average Monthly Measured EC at Pittsburg (Chipps Island) with RMA and DeltaDWQ Model Simulations for 1968-1991

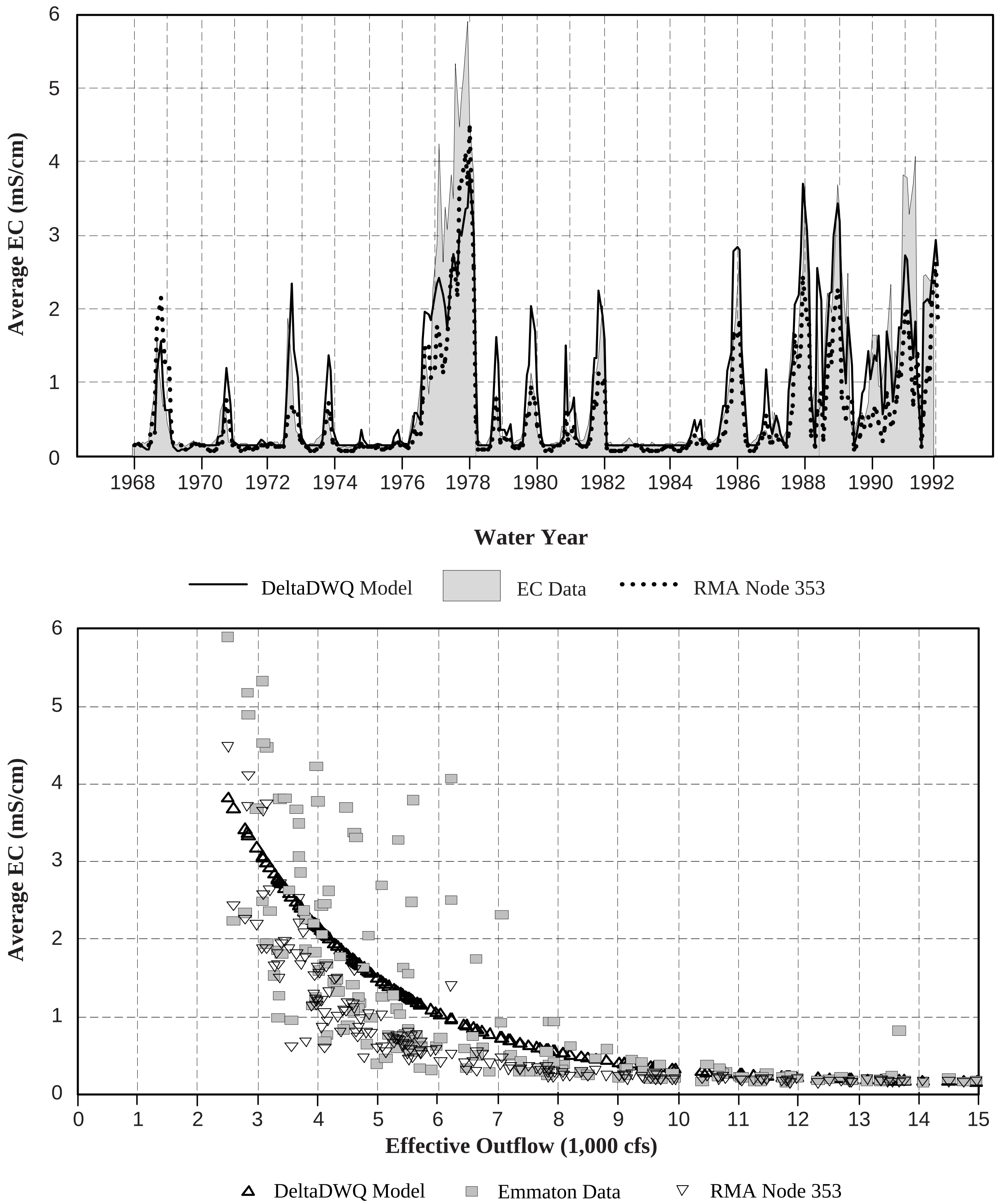

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Figure 3C-10
Comparison of Average Monthly Measured EC at Emmaton with RMA and DeltaDWQ Model Simulations for 1968-1991

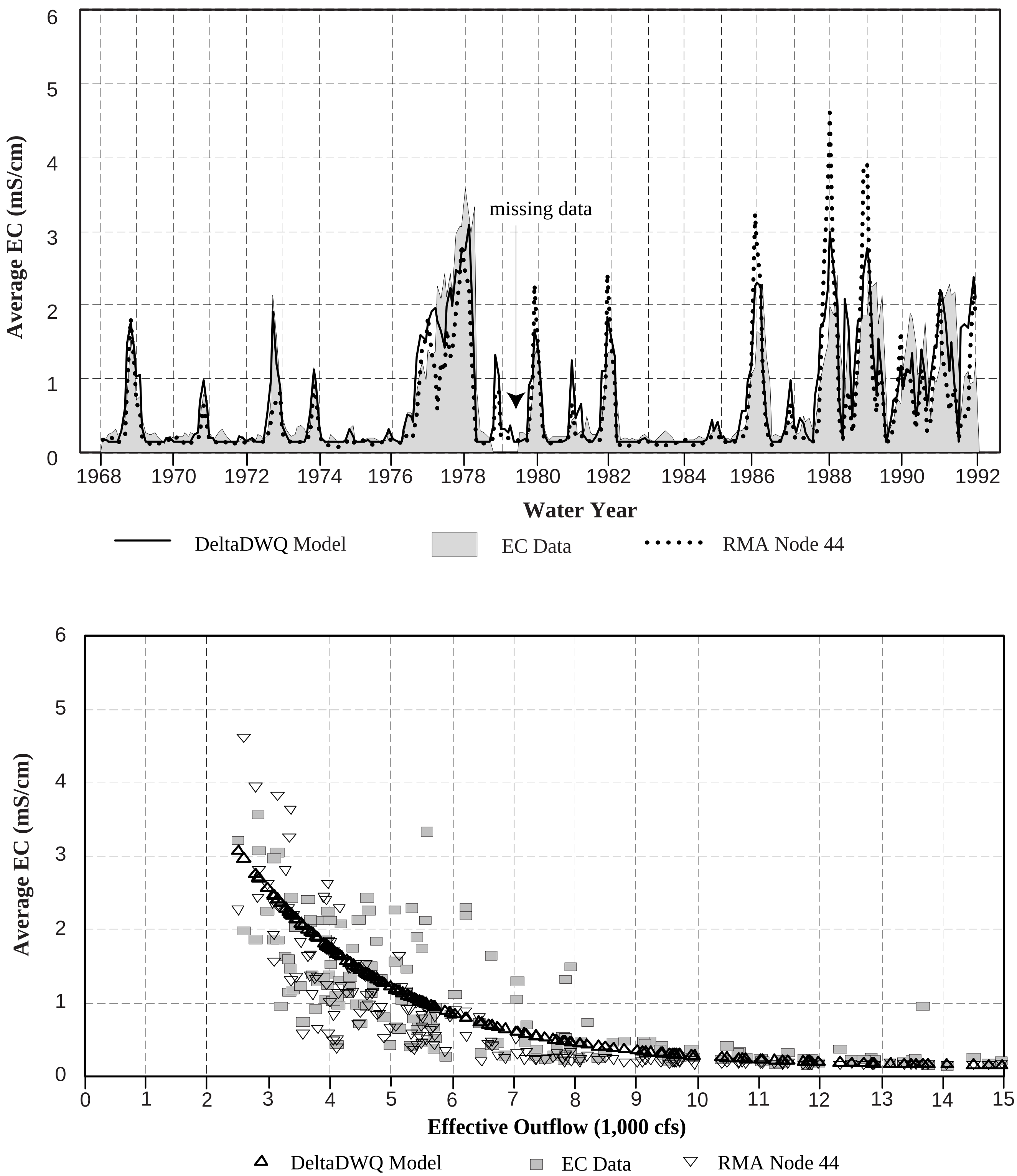

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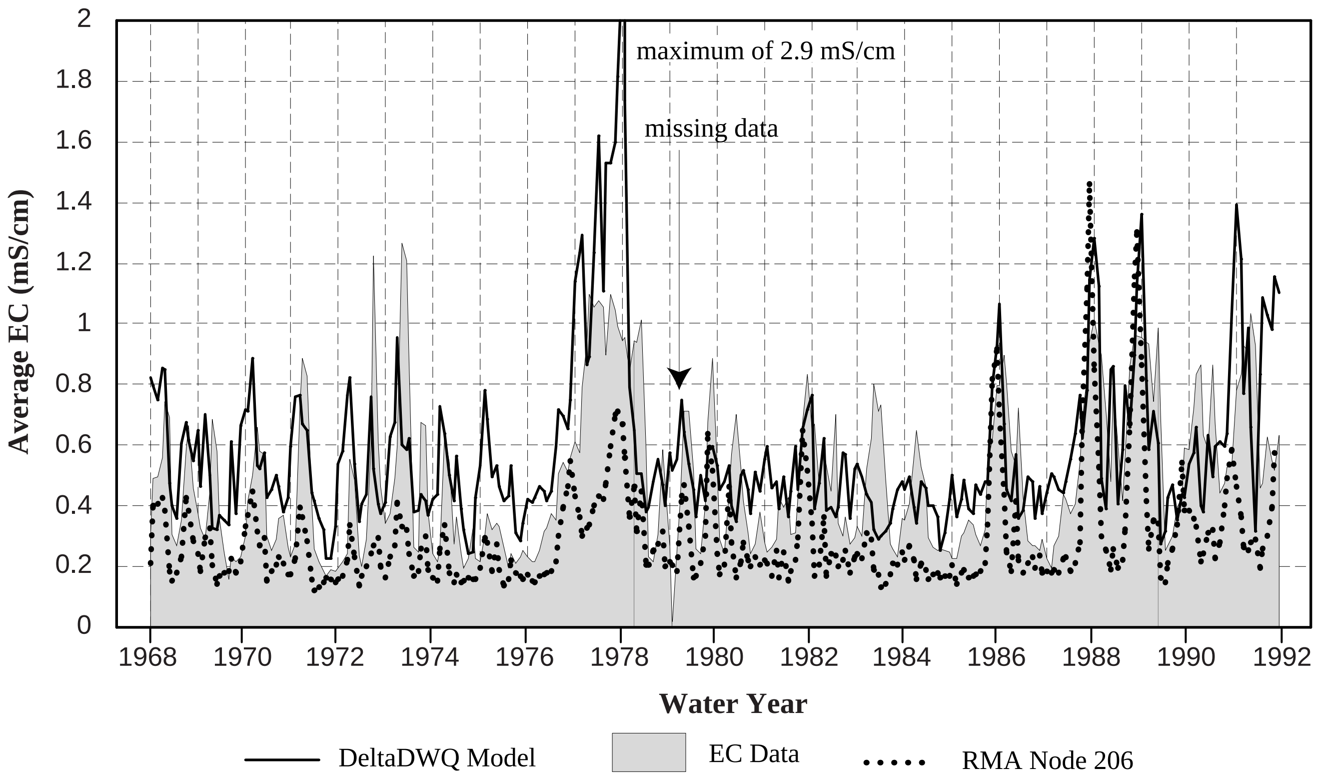
Figure 3C-11
Comparison of Average Monthly Measured EC at Jersey Point with RMA and DeltaDWQ Model Simulations for 1968-1991



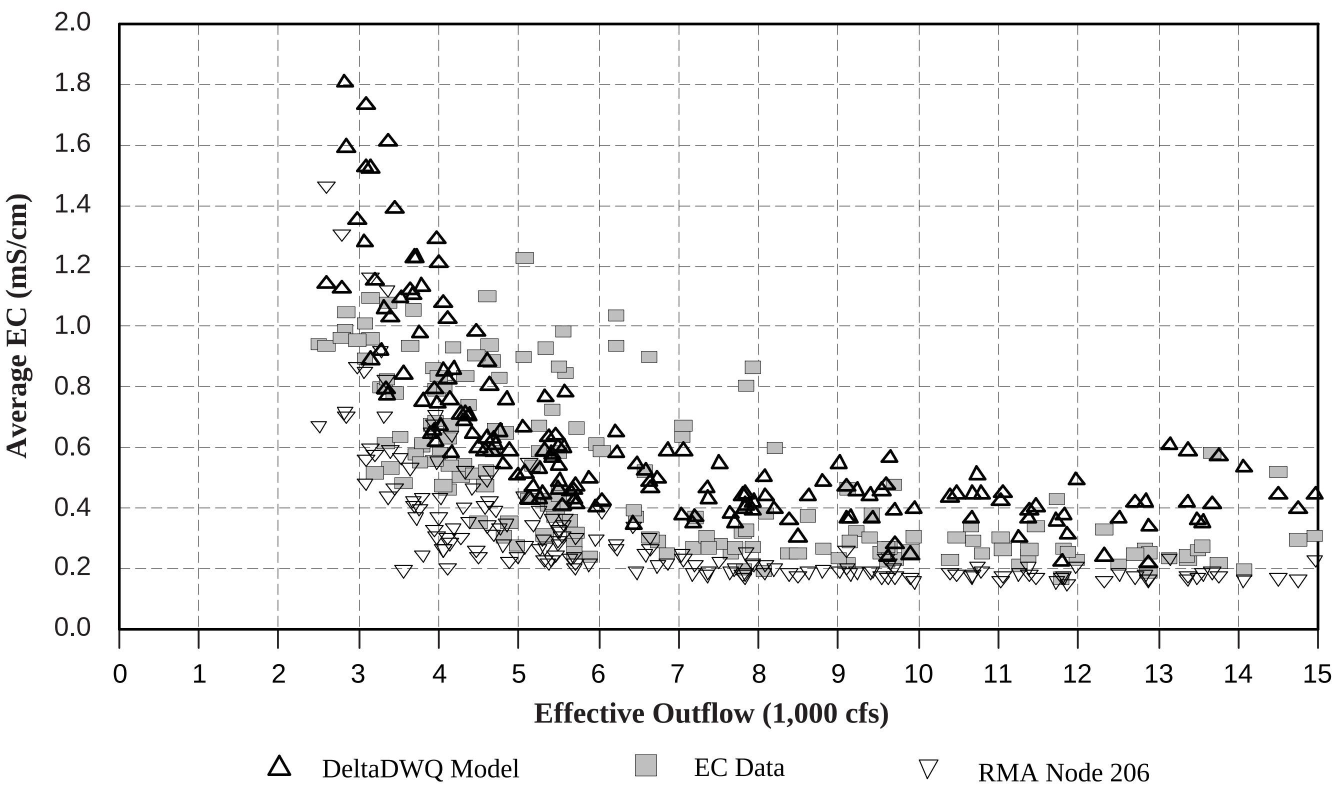


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Figure 3C-12
Comparison of Average Monthly Measured EC at the CCWD Rock Slough Diversion with RMA and DeltaDWQ Model Simulations for 1968-1991

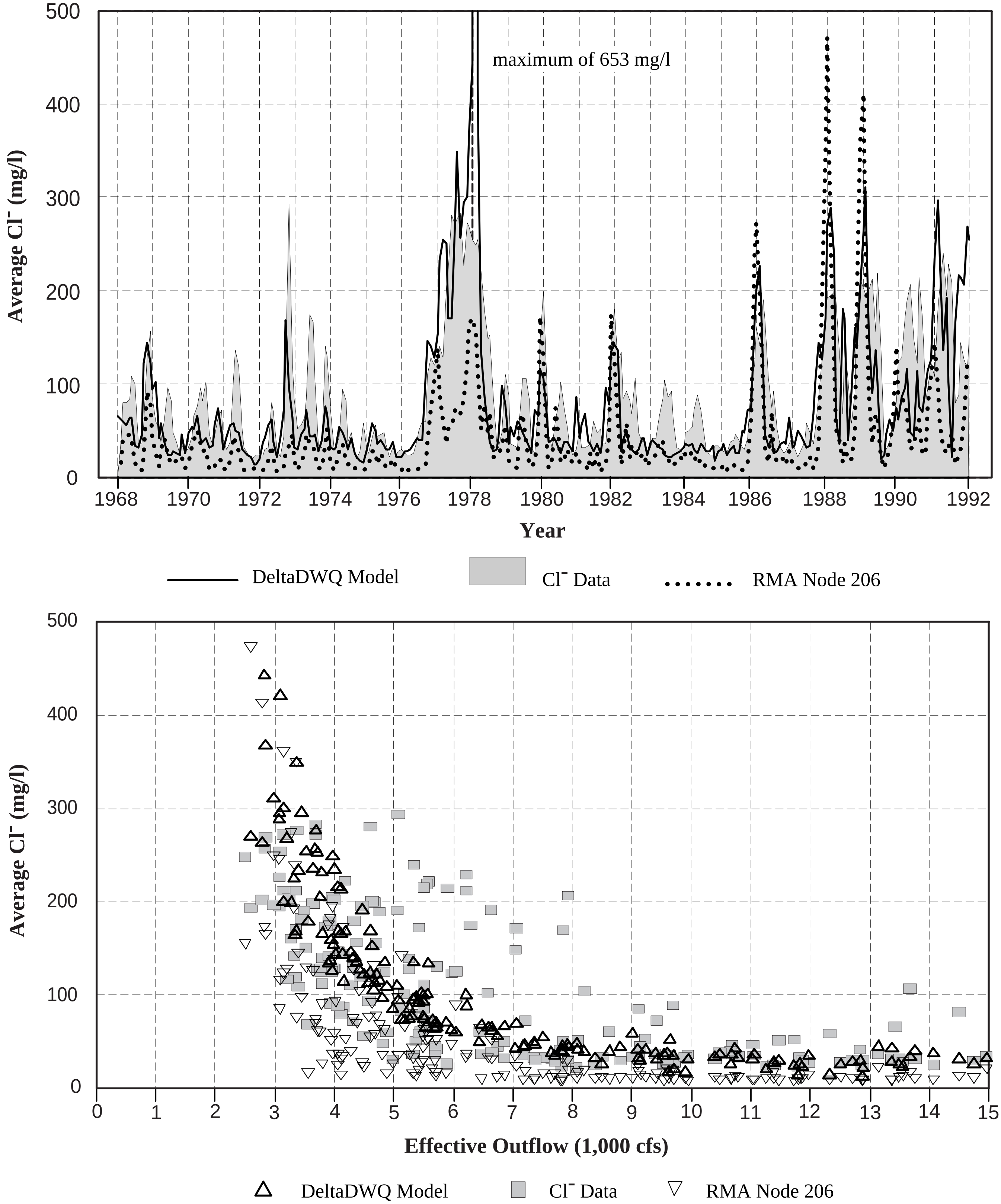

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Figure 3C-13
Comparison of Average Monthly Measured Chloride at the CCWD Rock Slough Diversion with RMA and DeltaDWQ Model Simulations for 1968-1991

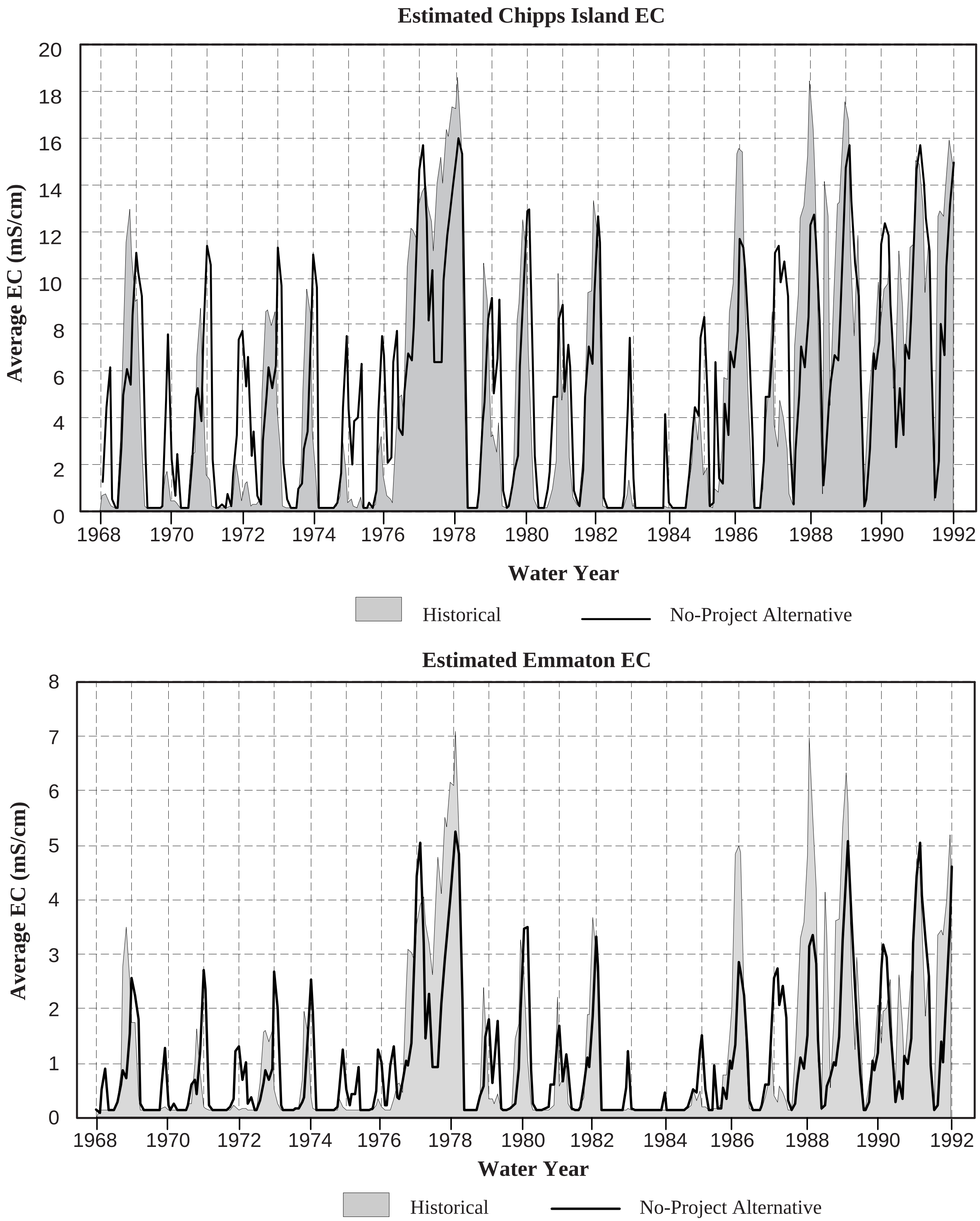

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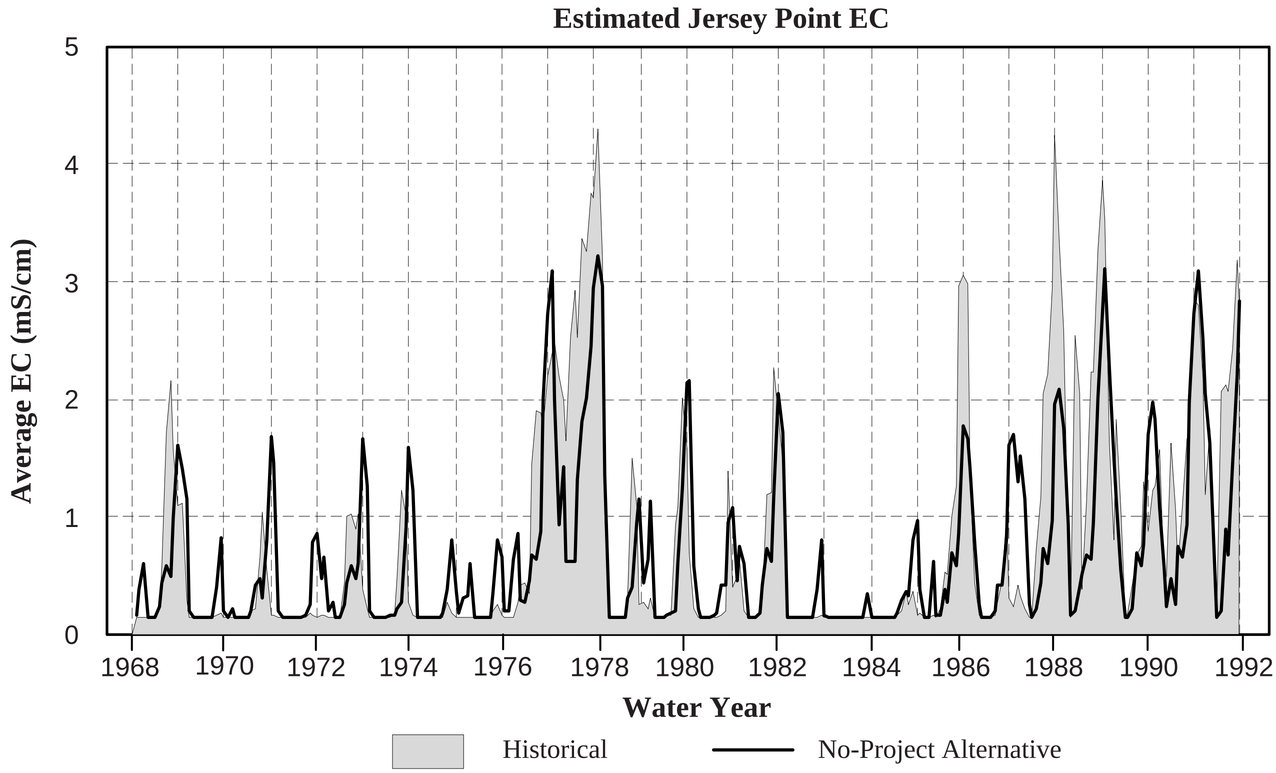
Figure 3C-14
Comparison of EC at Chipps Island and EC at Emmaton Simulated for the No-Project Alternative and for Historical Outflows for 1968-1991



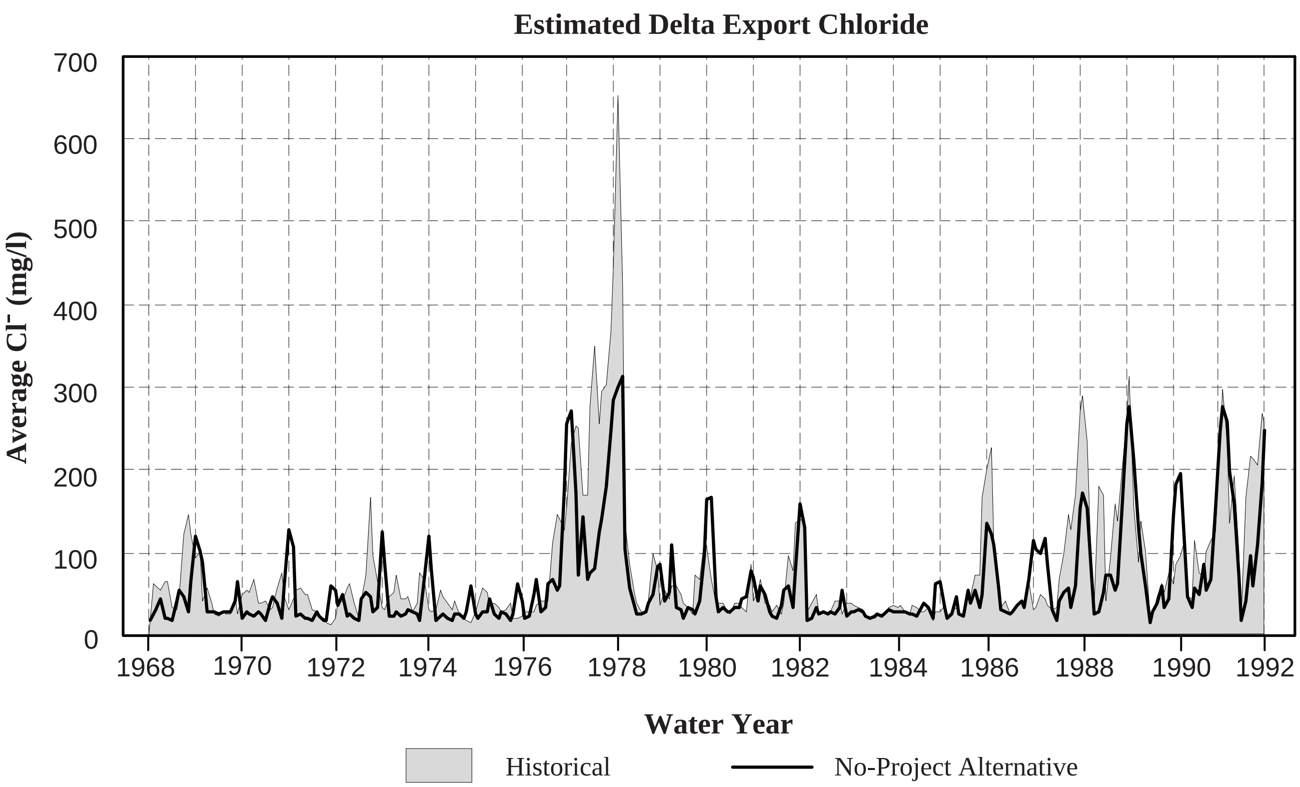


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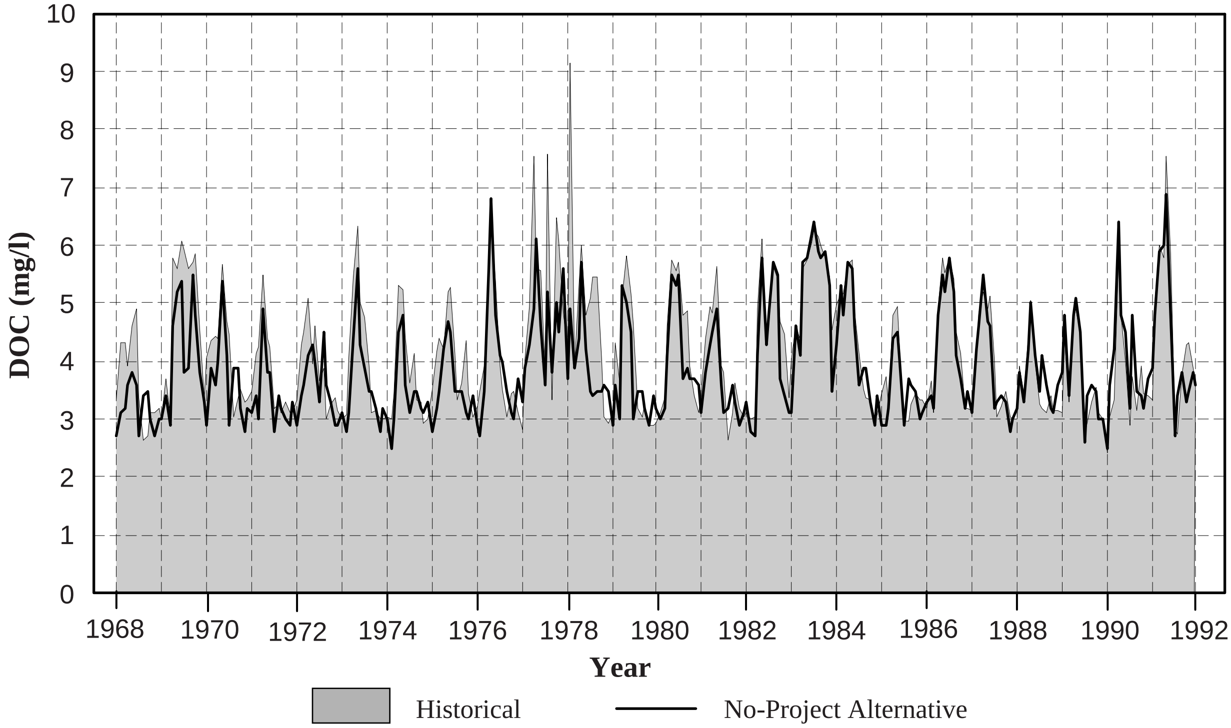
Figure 3C-15
Comparison of EC at Jersey Point and Chloride in Delta Exports Simulated for the No-Project Alternative and for Historical Outflows for 1968-1991



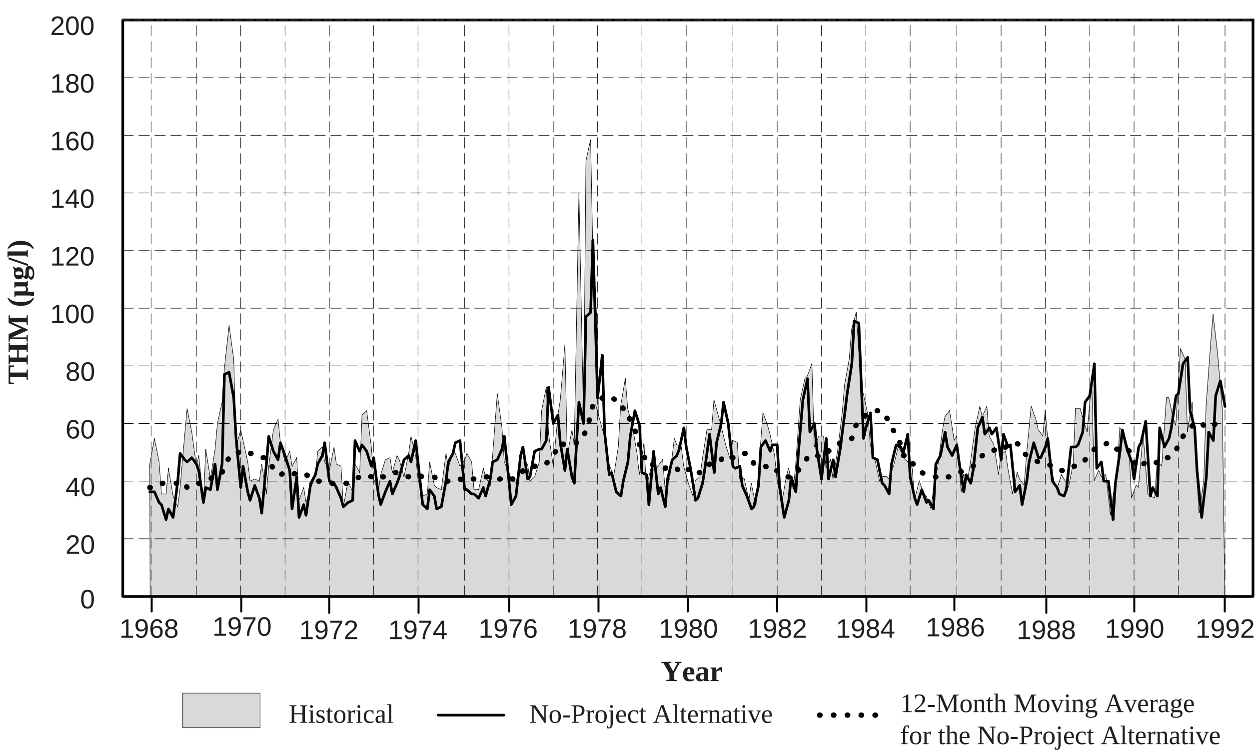


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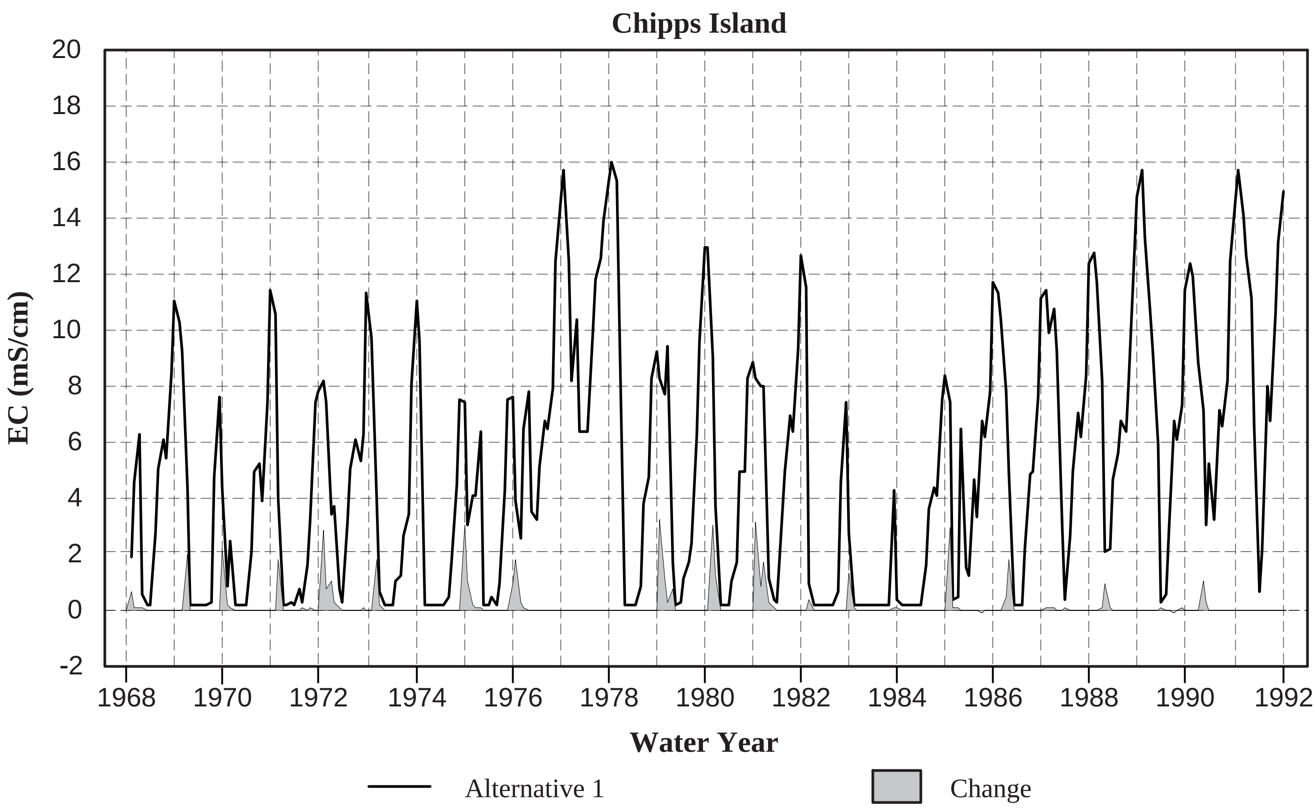
Figure 3C-16
Comparison of Export DOC and THM Concentrations Simulated for the No-Project Alternative and for Historical Inflows and Exports for 1968-1991



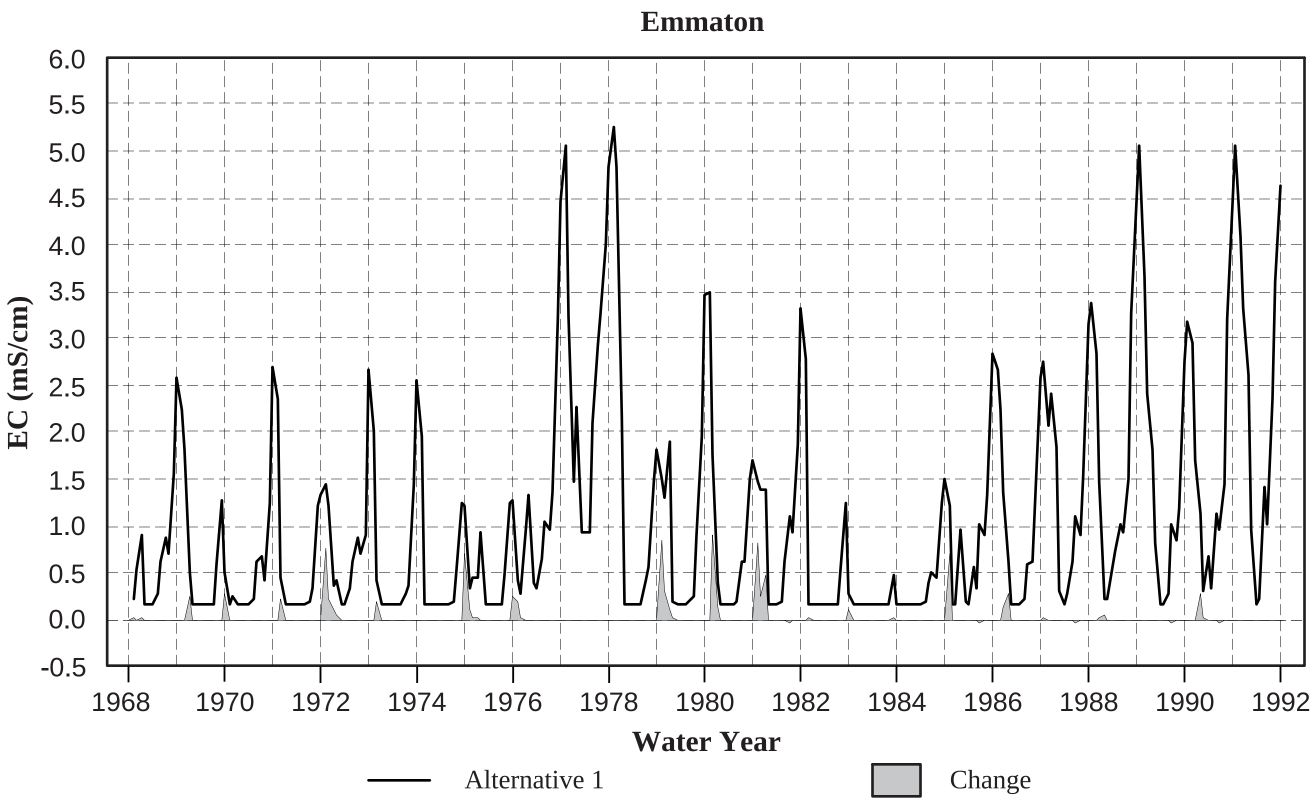
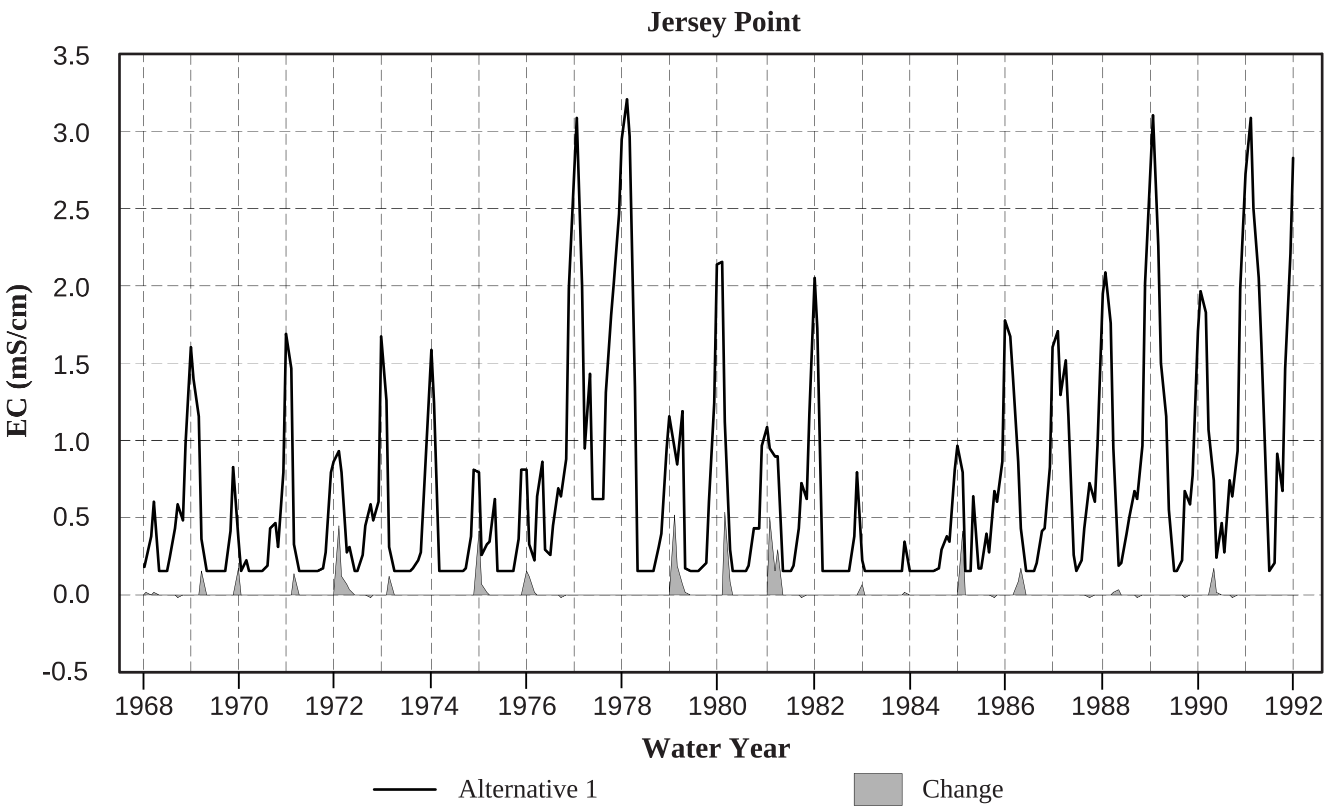


Figure 3C-17
Simulated End-of-Month EC Values and Predicted Changes in EC at Chipps Island and Emmaton under Alternative 1 Operations for 1968-1991



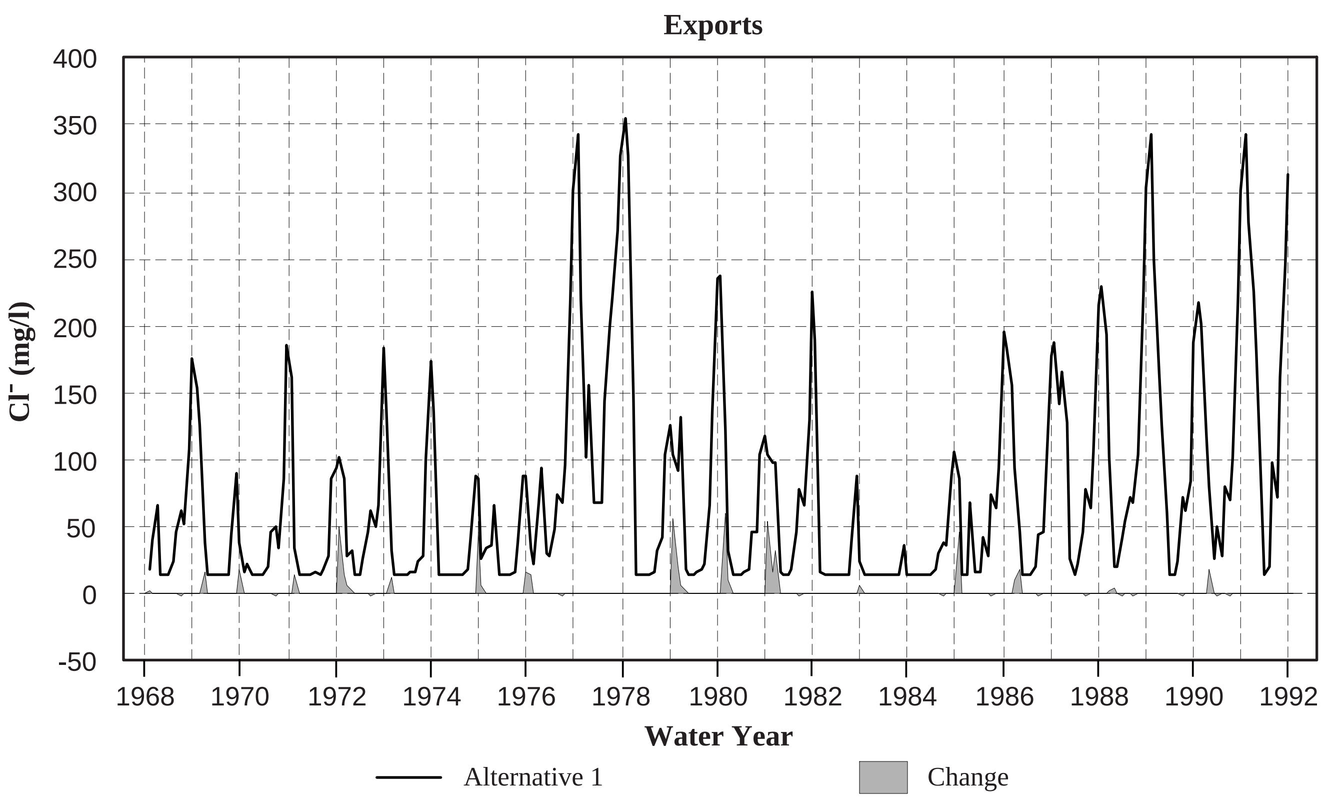


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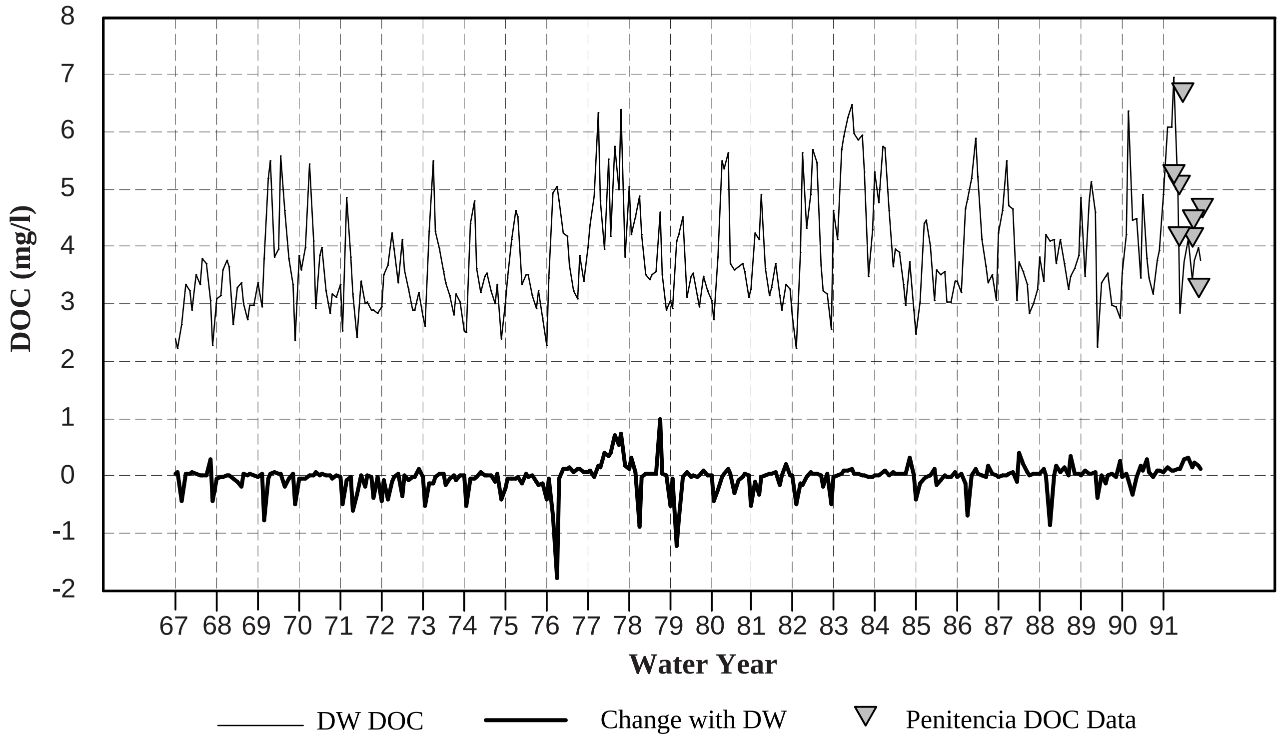
Figure 3C-18
Simulated End-of-Month Values for and Predicted Changes in Jersey Point EC and Export Chloride under Alternative 1 Operations for 1968-1991



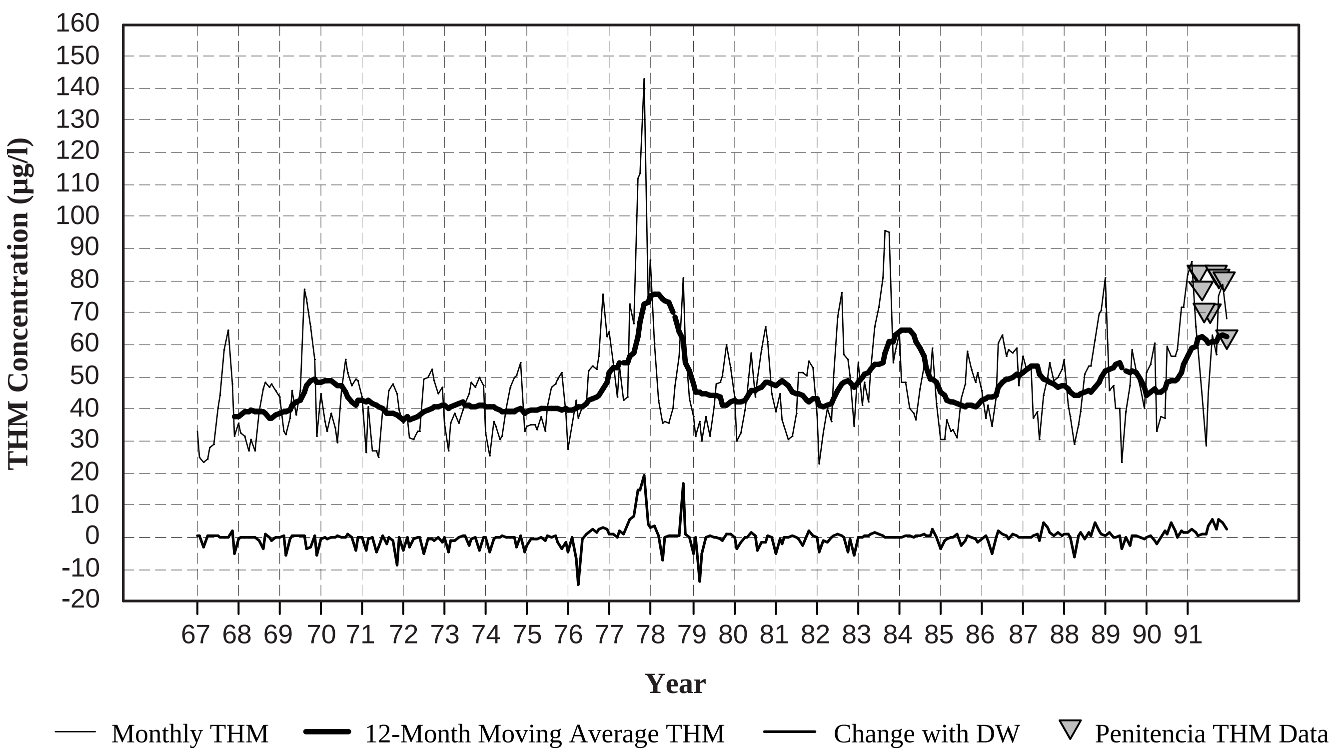


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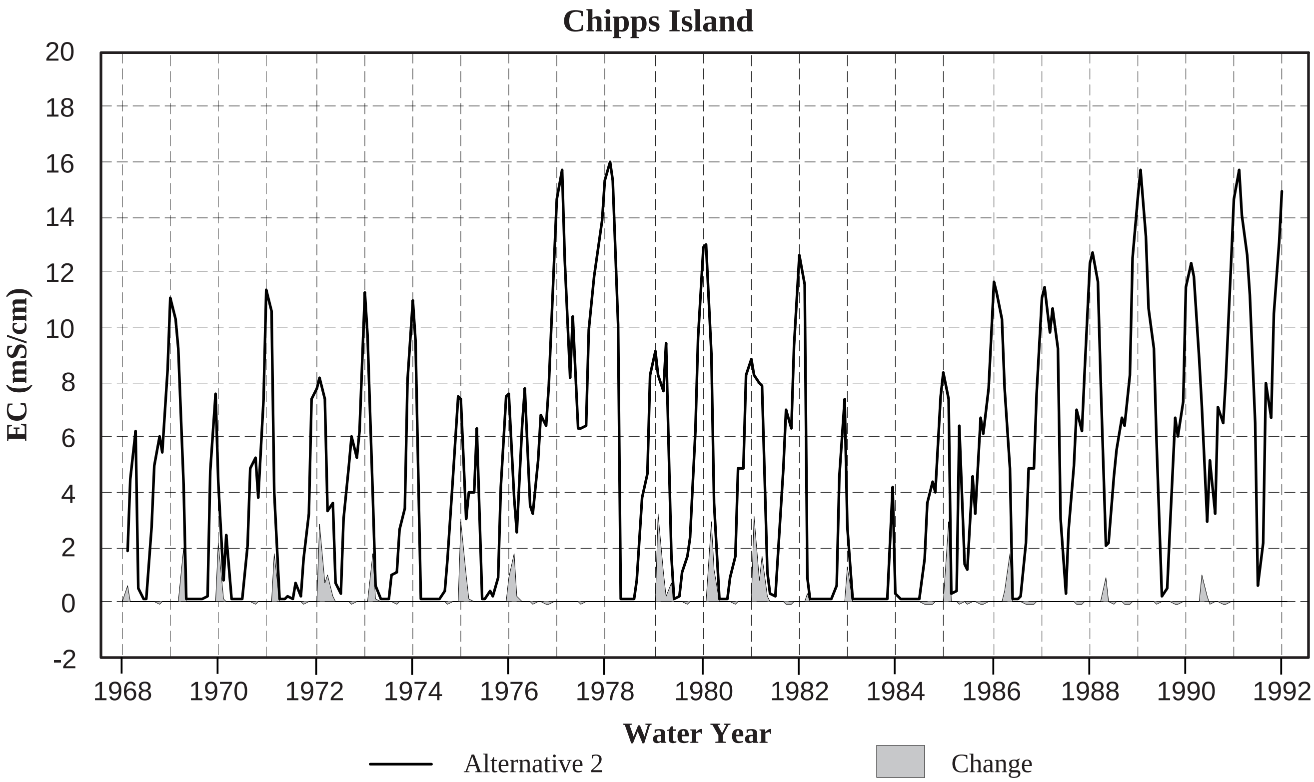
Figure 3C-19
Simulated Inflow DOC and Final THM Concentration in Delta Exports under Alternative 1 Compared with the No-Project Alternative



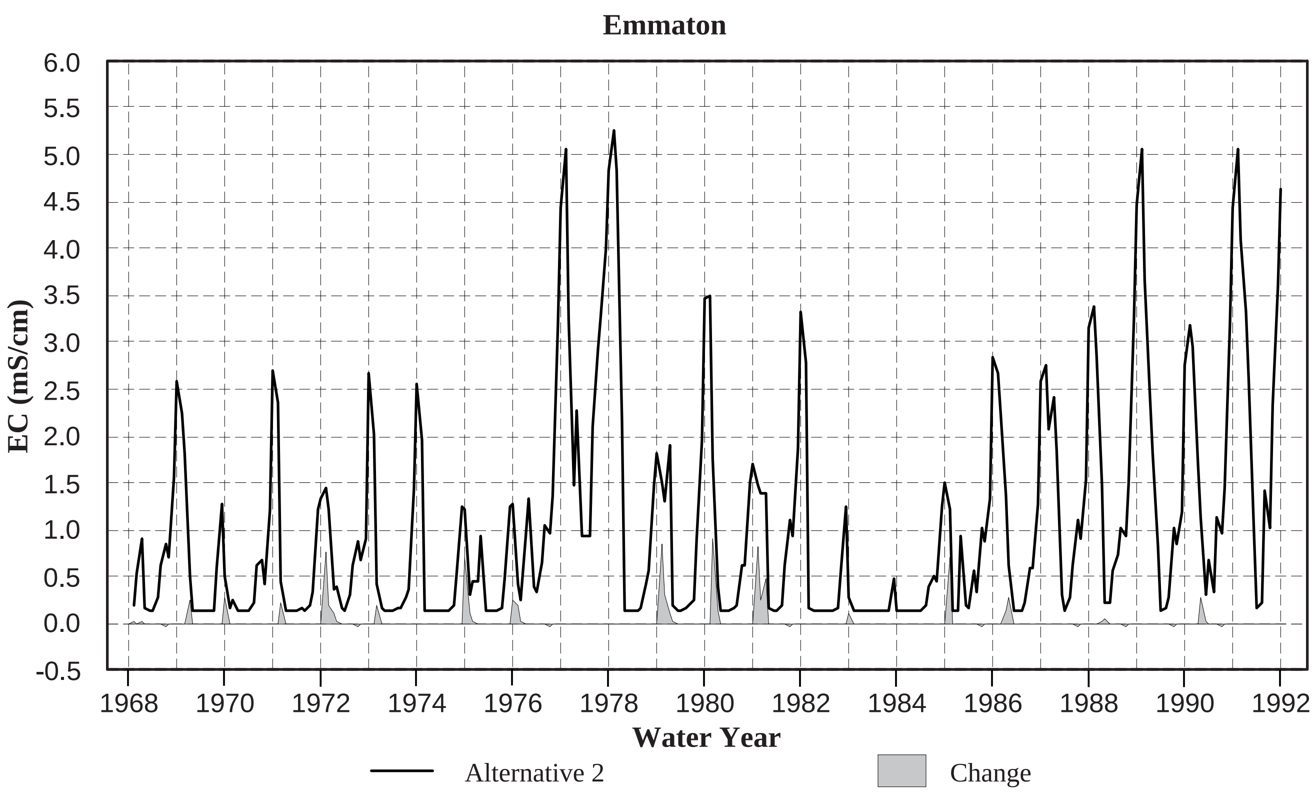


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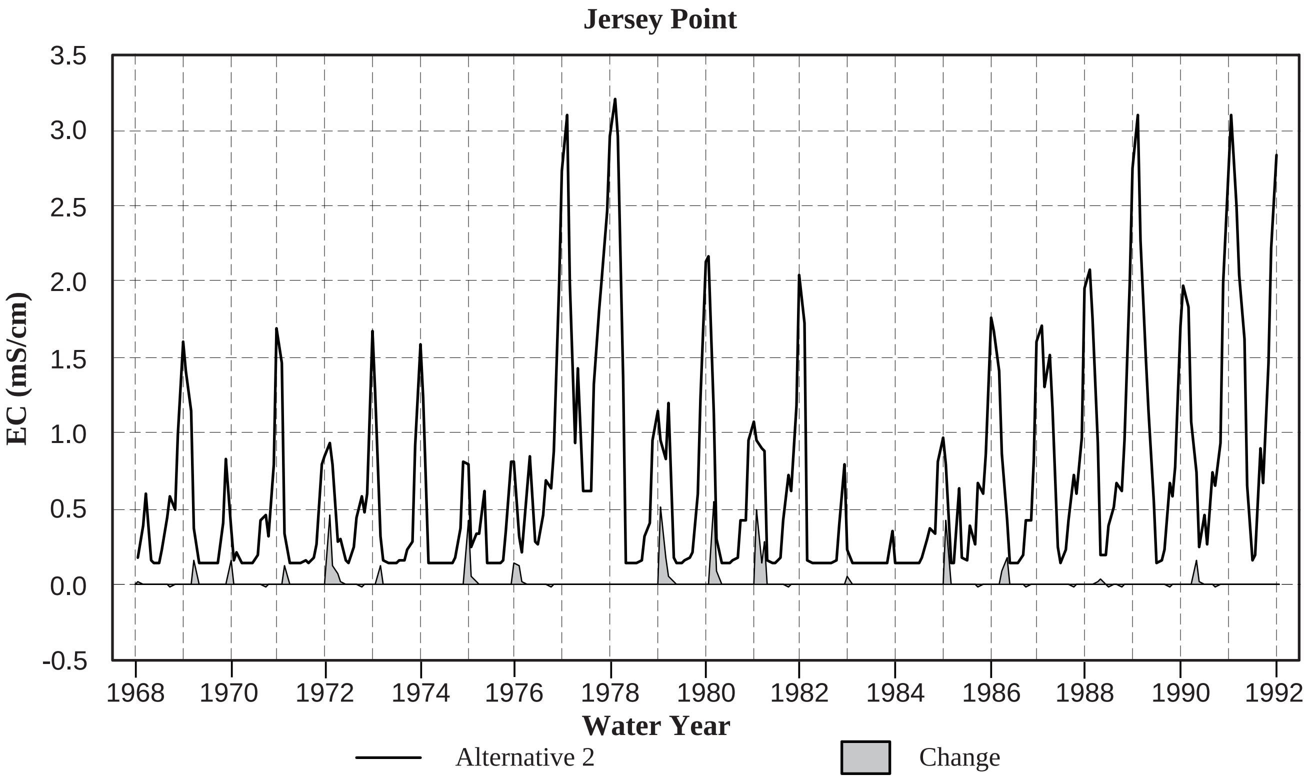
Figure 3C-20
Simulated End-of-Month EC Values and Predicted Changes in EC at Chipps Island and Emmaton under Alternative 2 Operations for 1968-1991



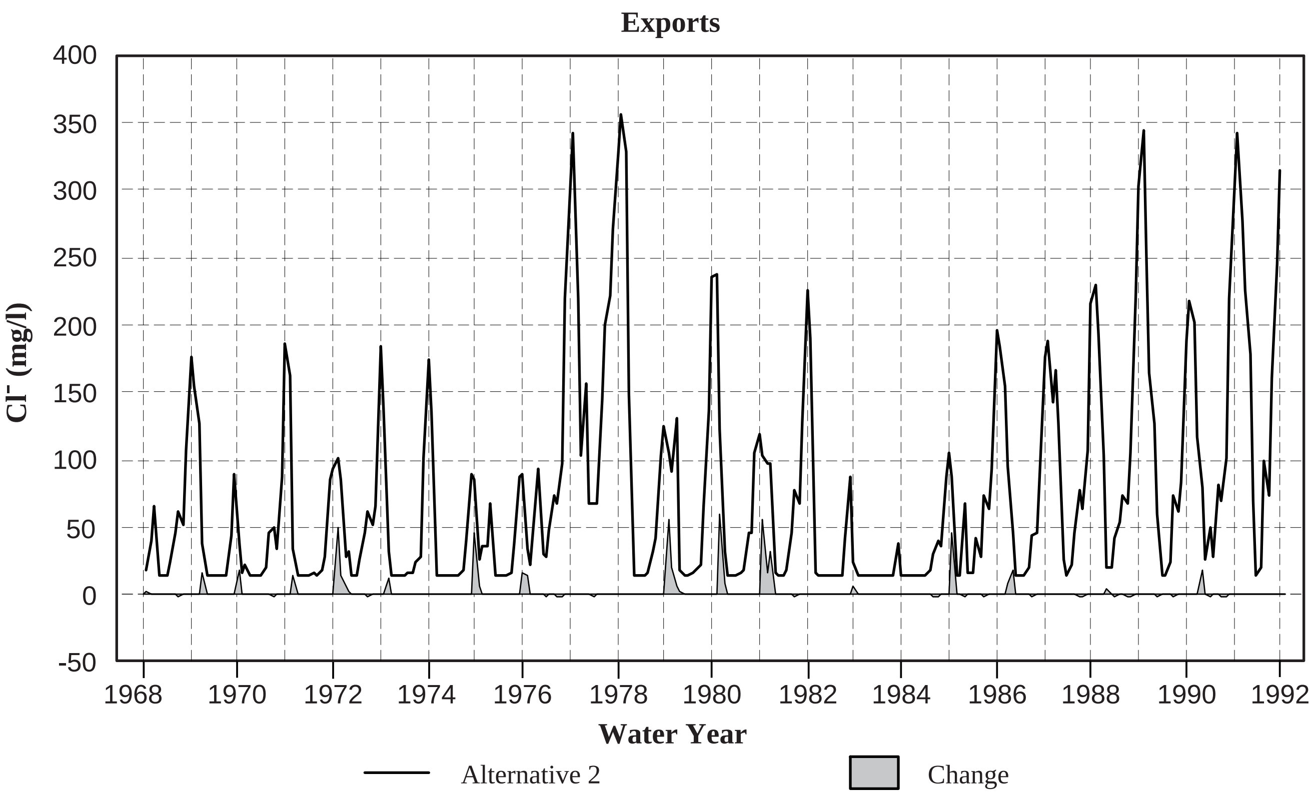


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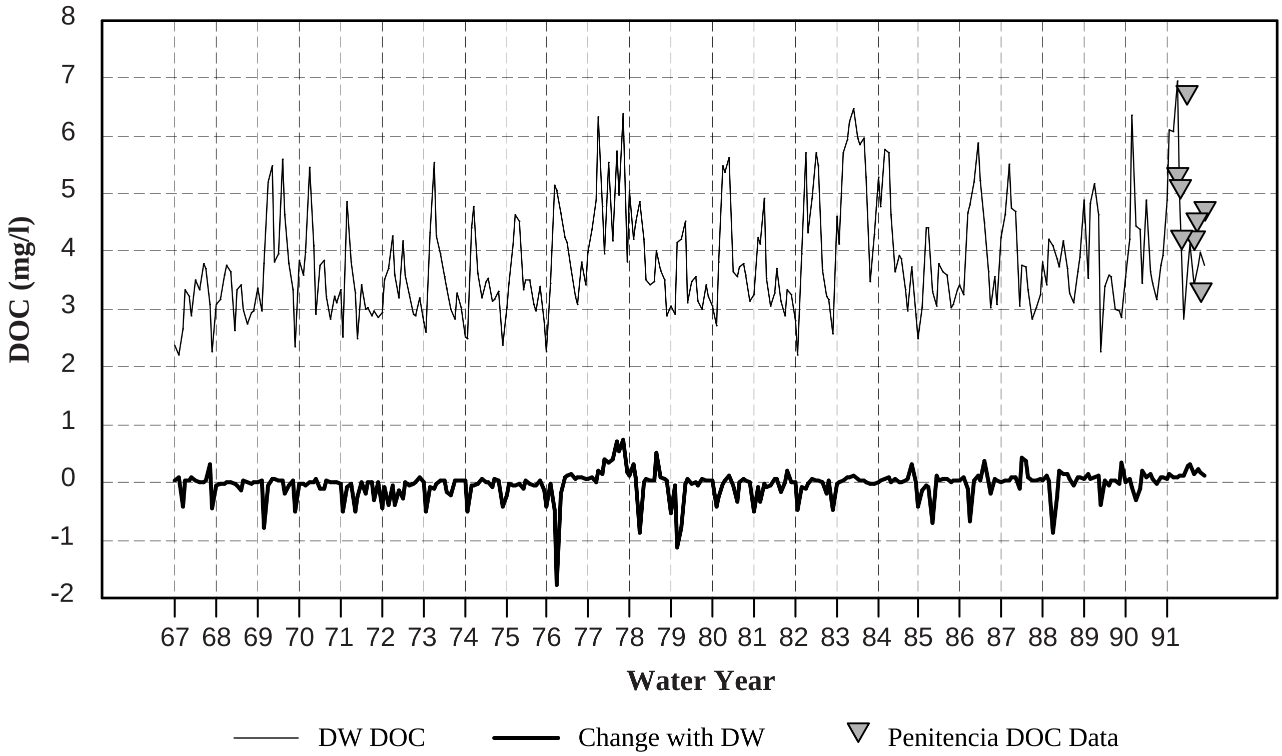
Figure 3C-21
Simulated End-of-Month Values for and Predicted Changes in Jersey Point EC and Export Chloride under Alternative 2 Operations for 1968-1991



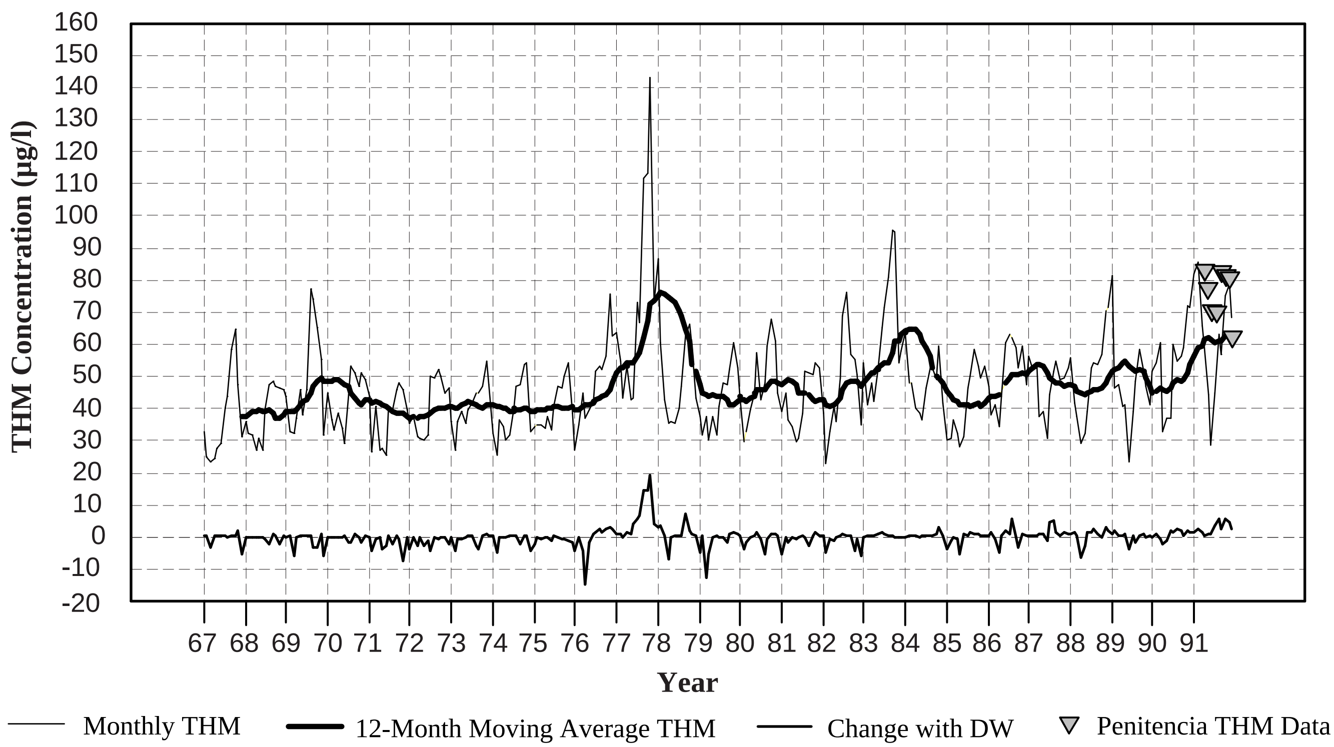


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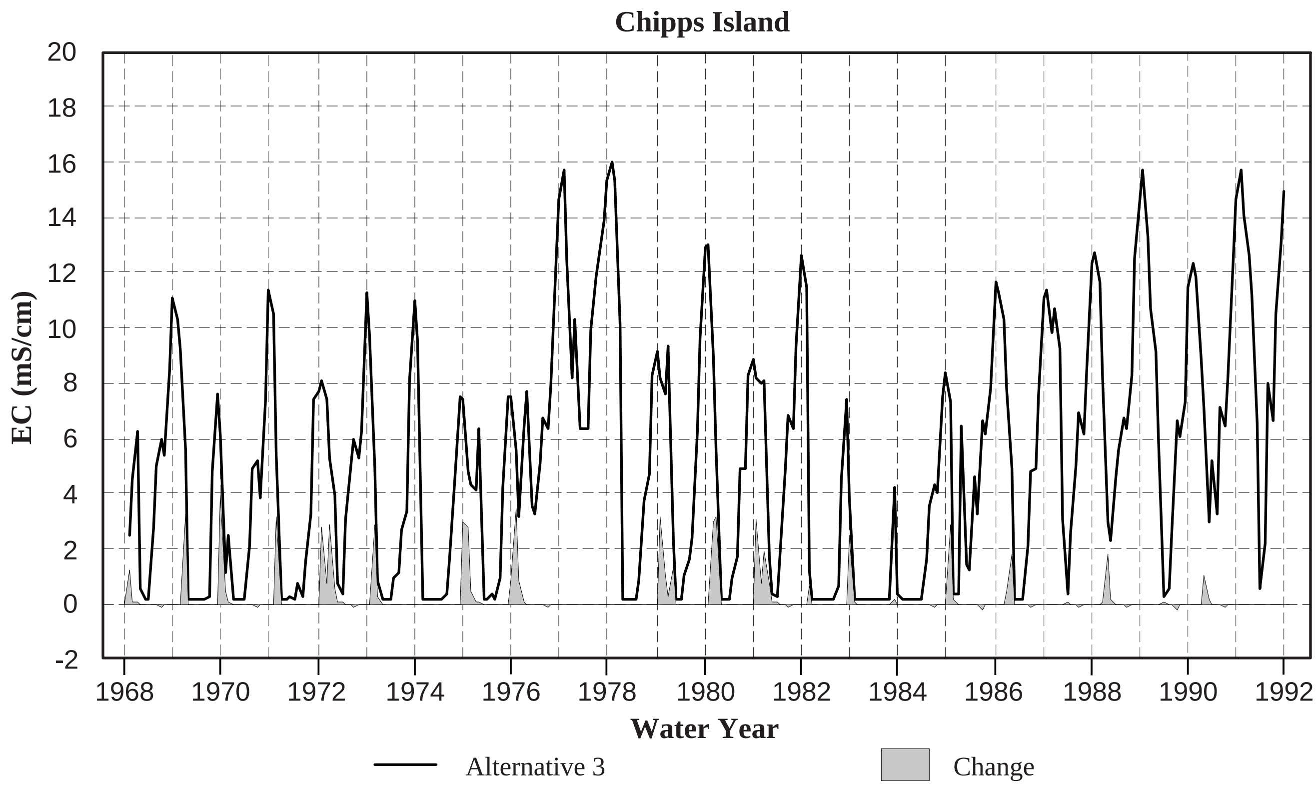
Figure 3C-22
Simulated Inflow DOC and Final THM Concentration in Delta Exports under Alternative 2 Compared with the No-Project Alternative



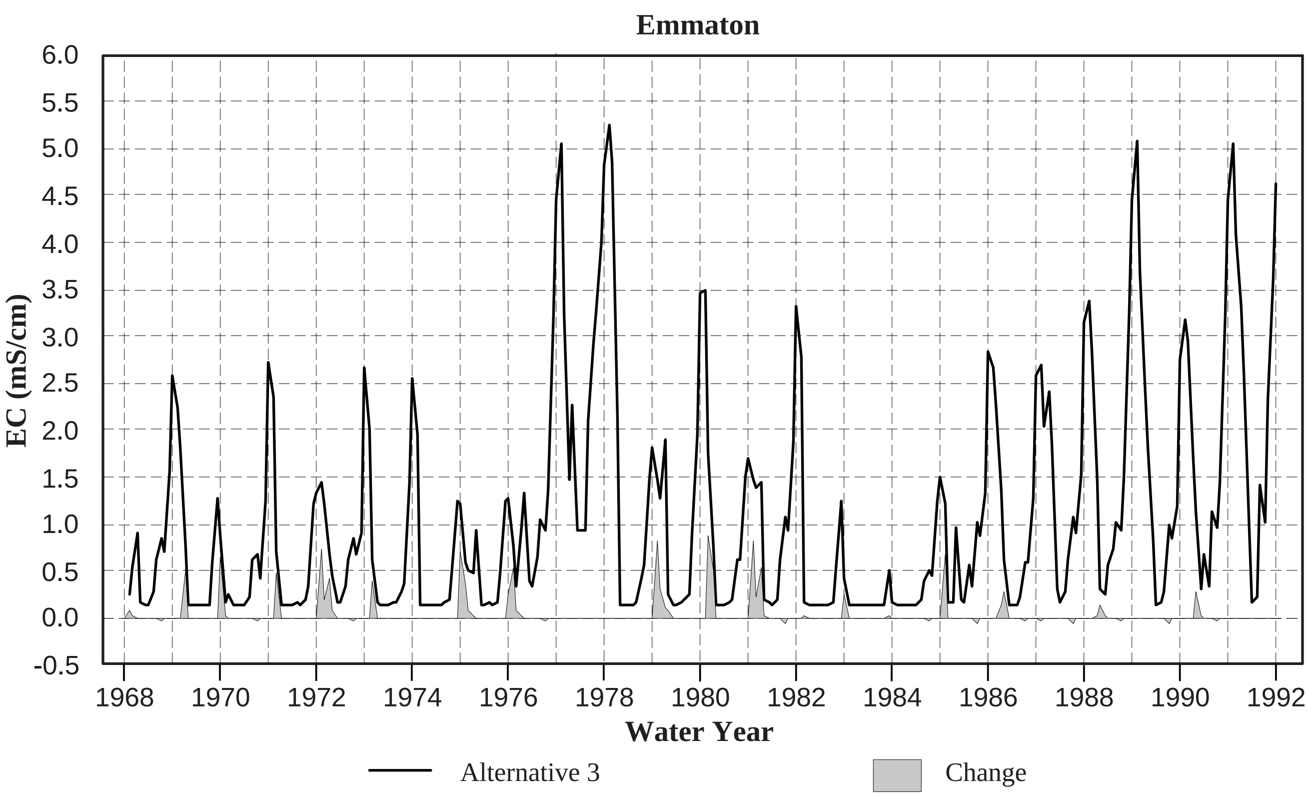
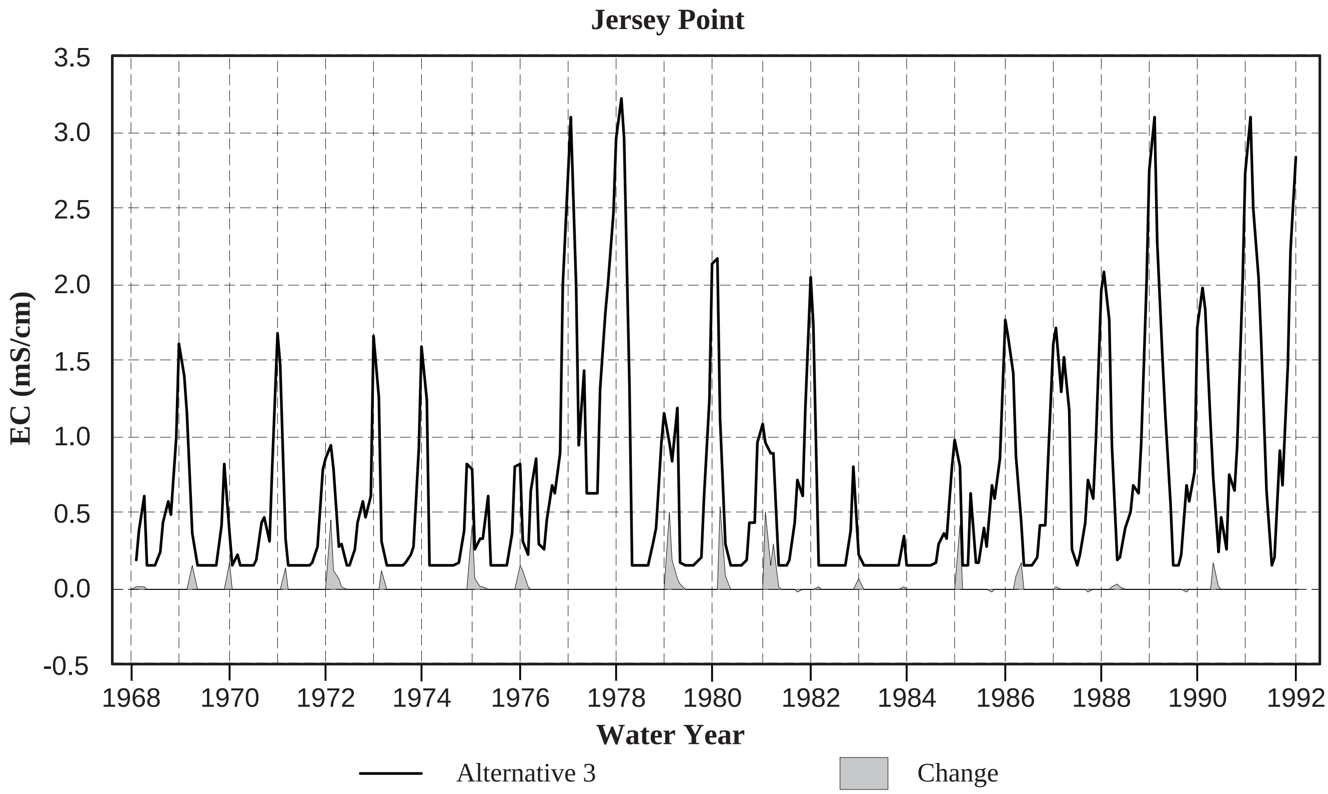


Figure 3C-23
Simulated End-of-Month EC Values and Predicted Changes in EC at Chipps Island and Emmaton under Alternative 3 Operations for 1968-1991



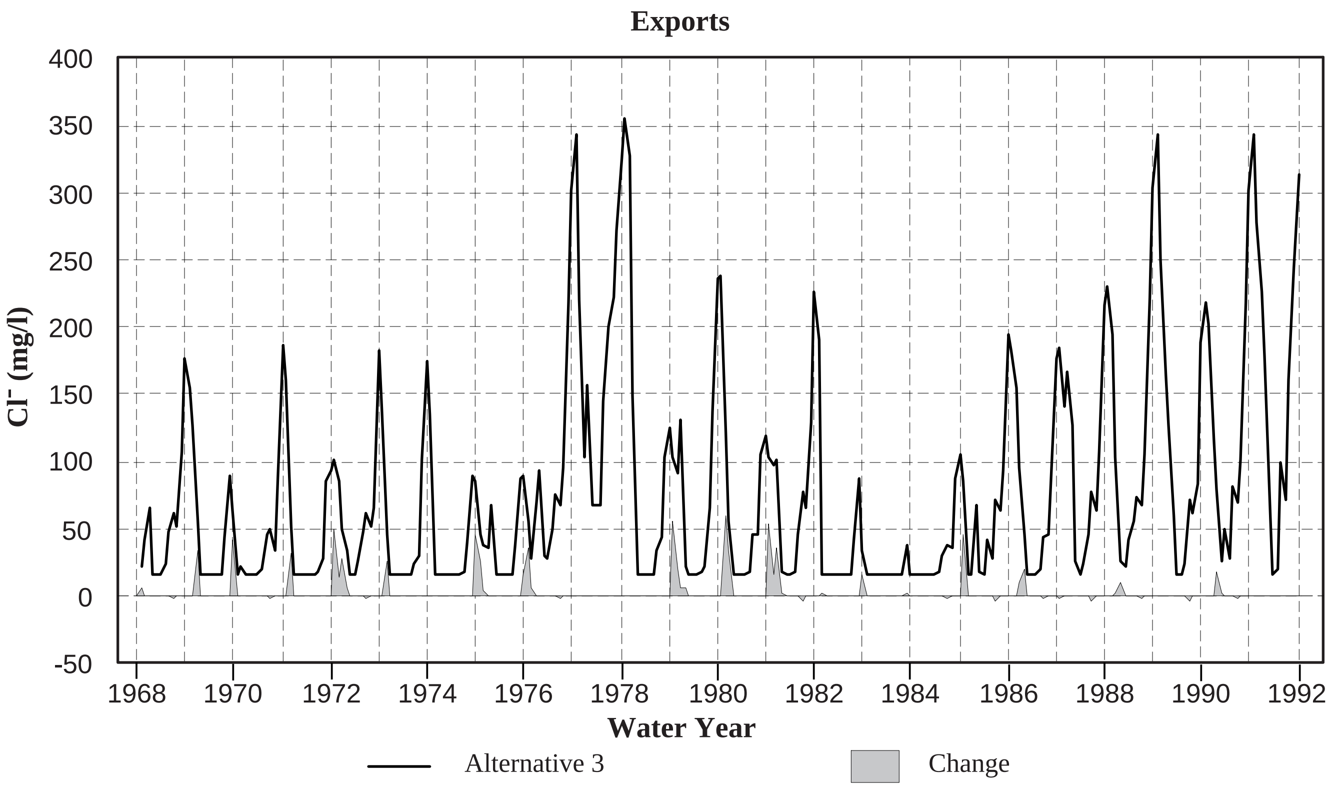
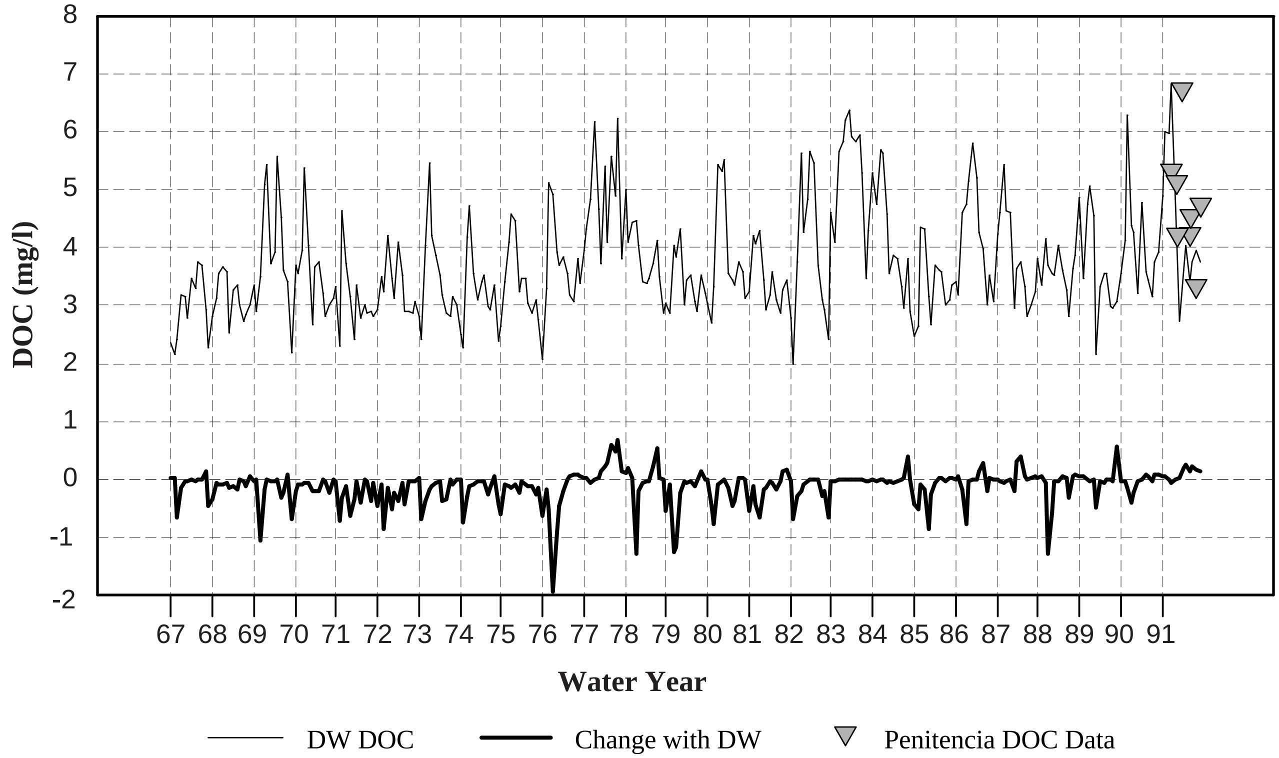


Figure 3C-24
Simulated End-of-Month Values for and Predicted Changes in Jersey Point EC and Export Chloride under Alternative 3 Operations for 1968-1991



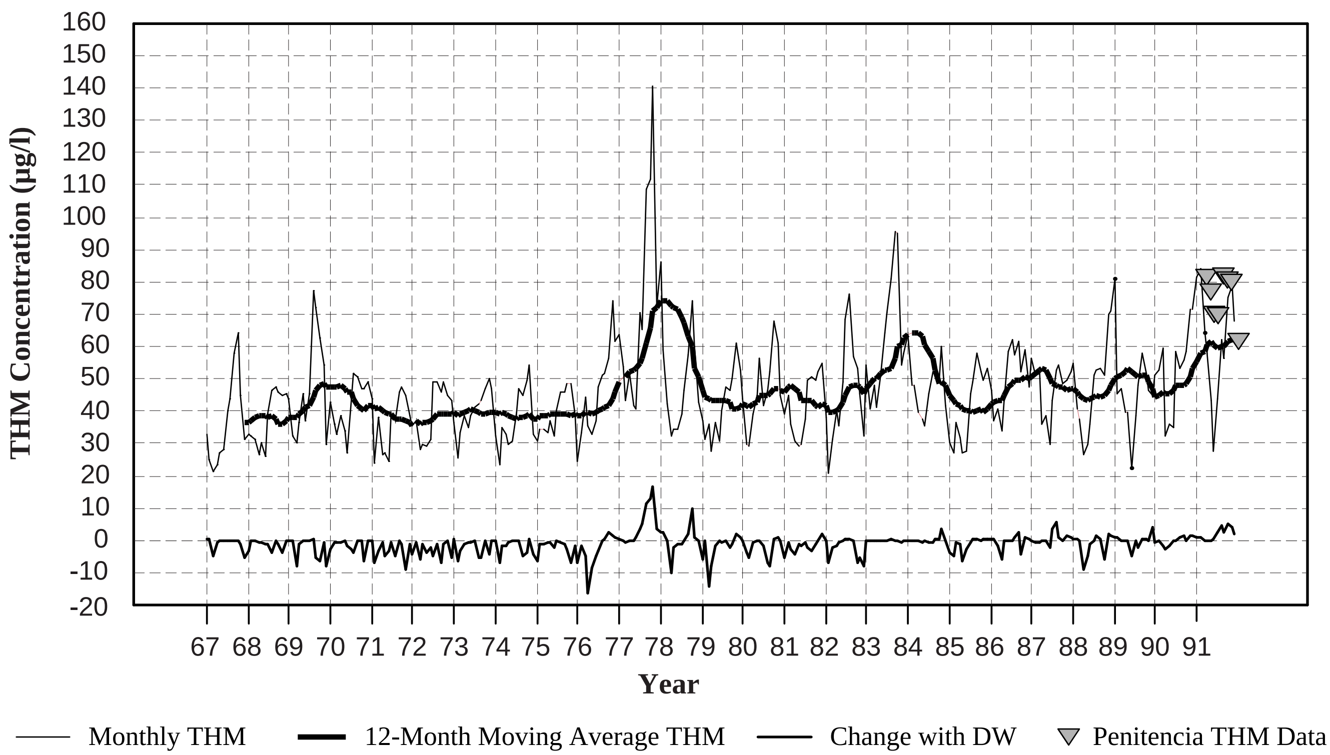


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Figure 3C-25
Simulated Inflow DOC and Final THM Concentration in Delta Exports under Alternative 3 Compared with the No-Project Alternative

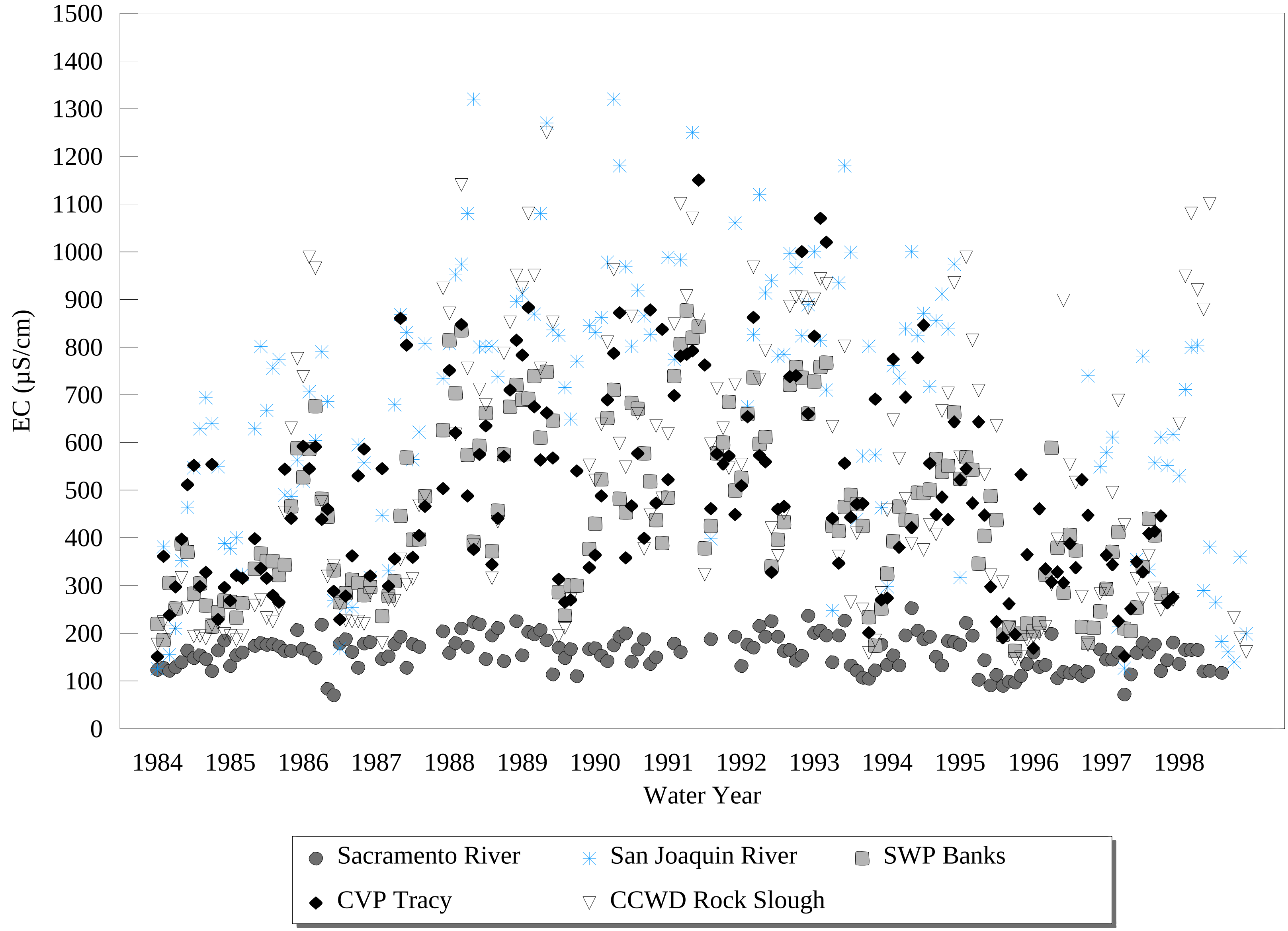

Figure 3C-26
1984-1998 MWQI Monthly EC Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations

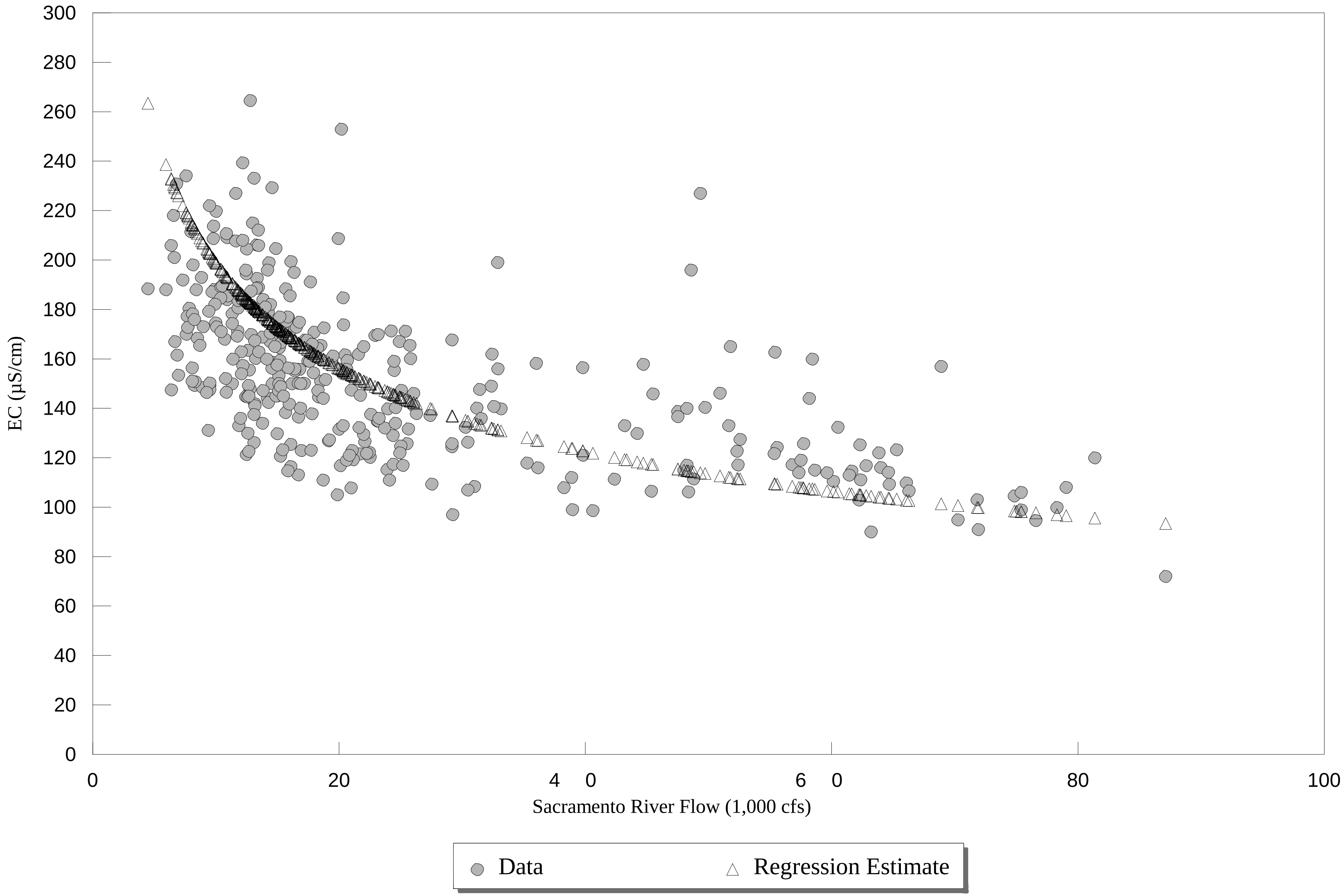

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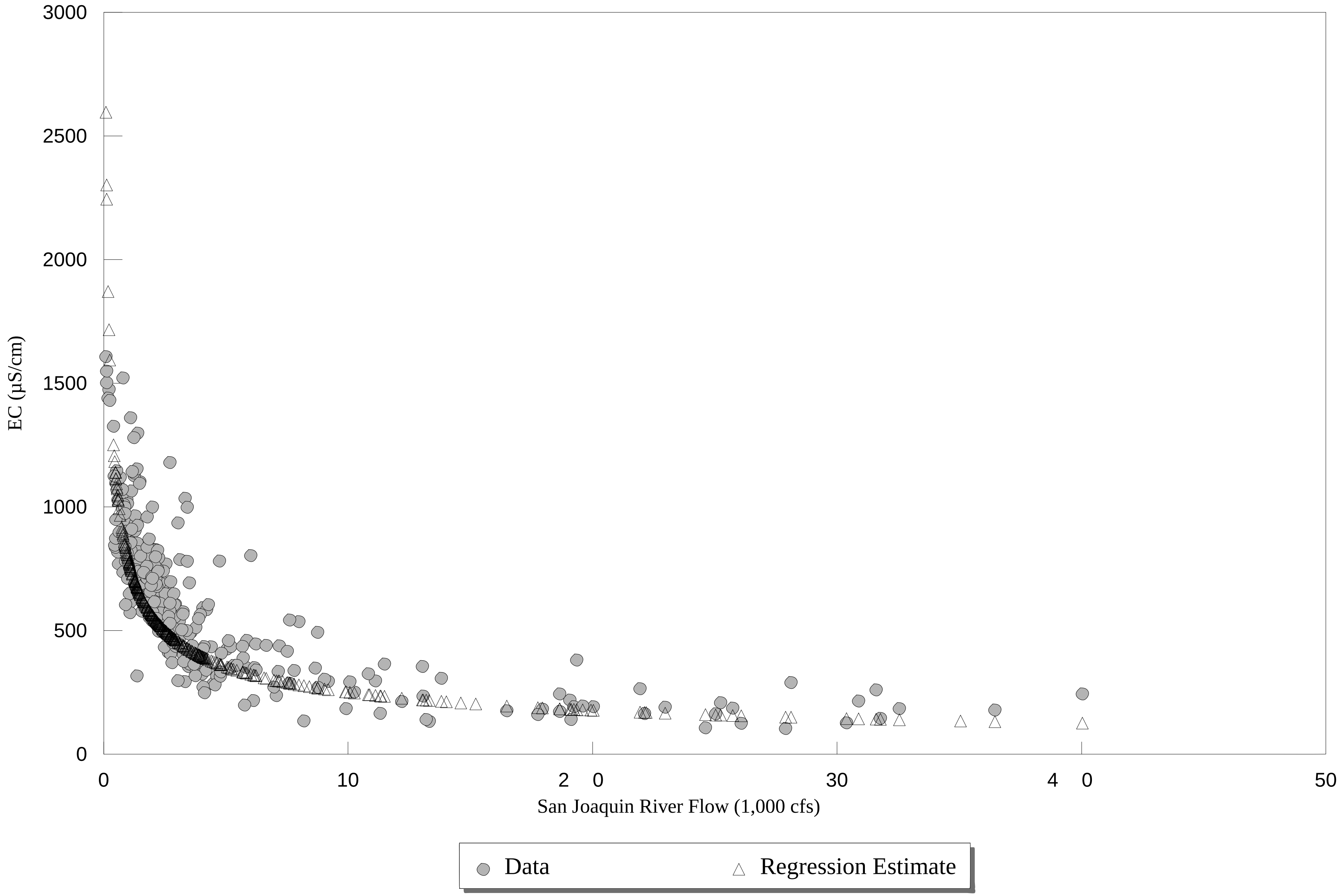
Figure 3C-27
Relationship between Measured Mean Monthly EC at Greene's Landing and Sacramento River Flow for 1968-1998



Jones & Stokes

Figure 3C-28
Relationship between Measured Mean Monthly EC at Vernalis and San Joaquin River Flow for 1968-1998

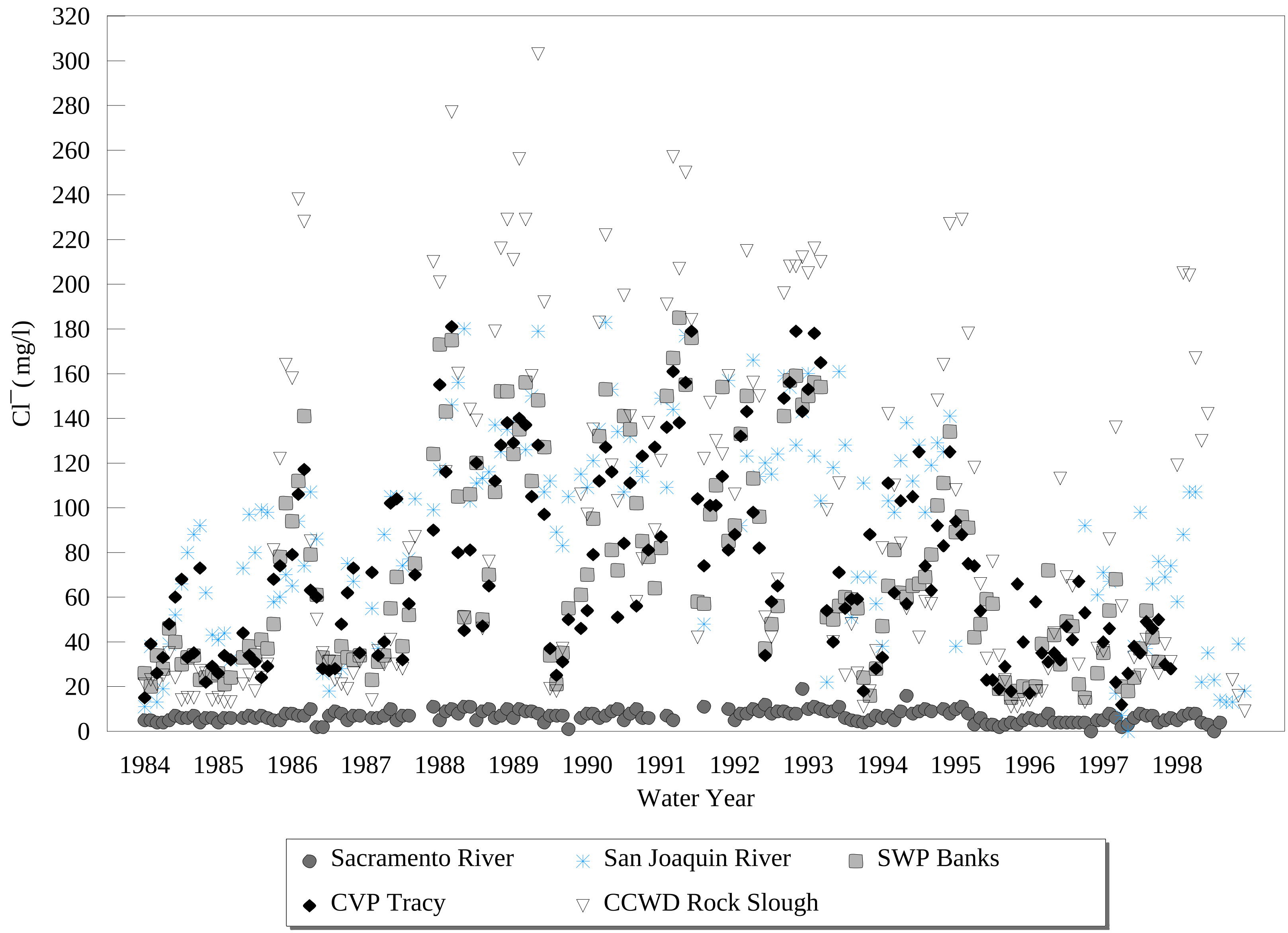


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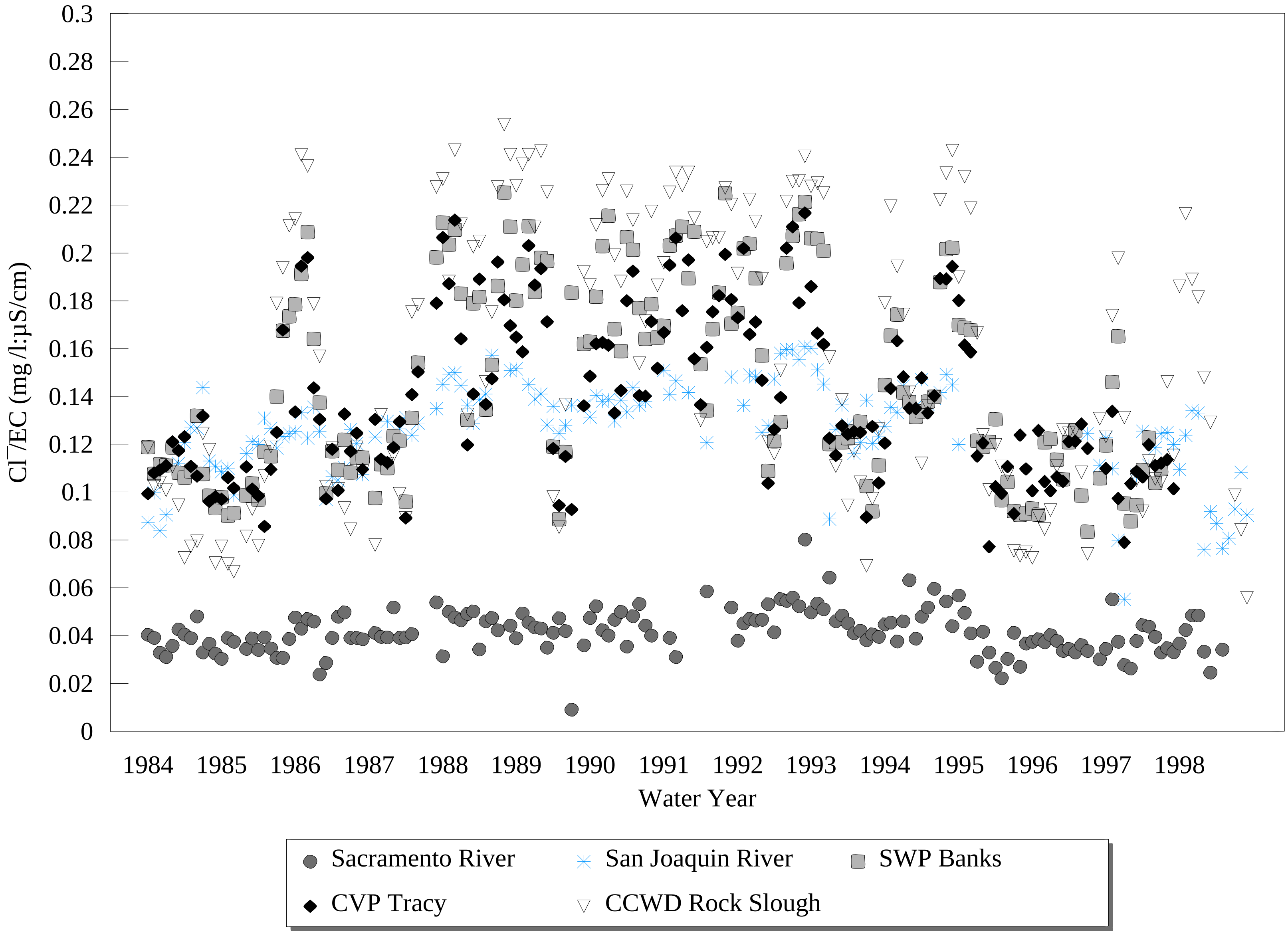
Figure 3C-29
1984-1998 MWQI Monthly Cl^- Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations



Jones & Stokes

Figure 3C-30
1984-1998 MWQI Monthly Cl^- :EC Ratio Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations

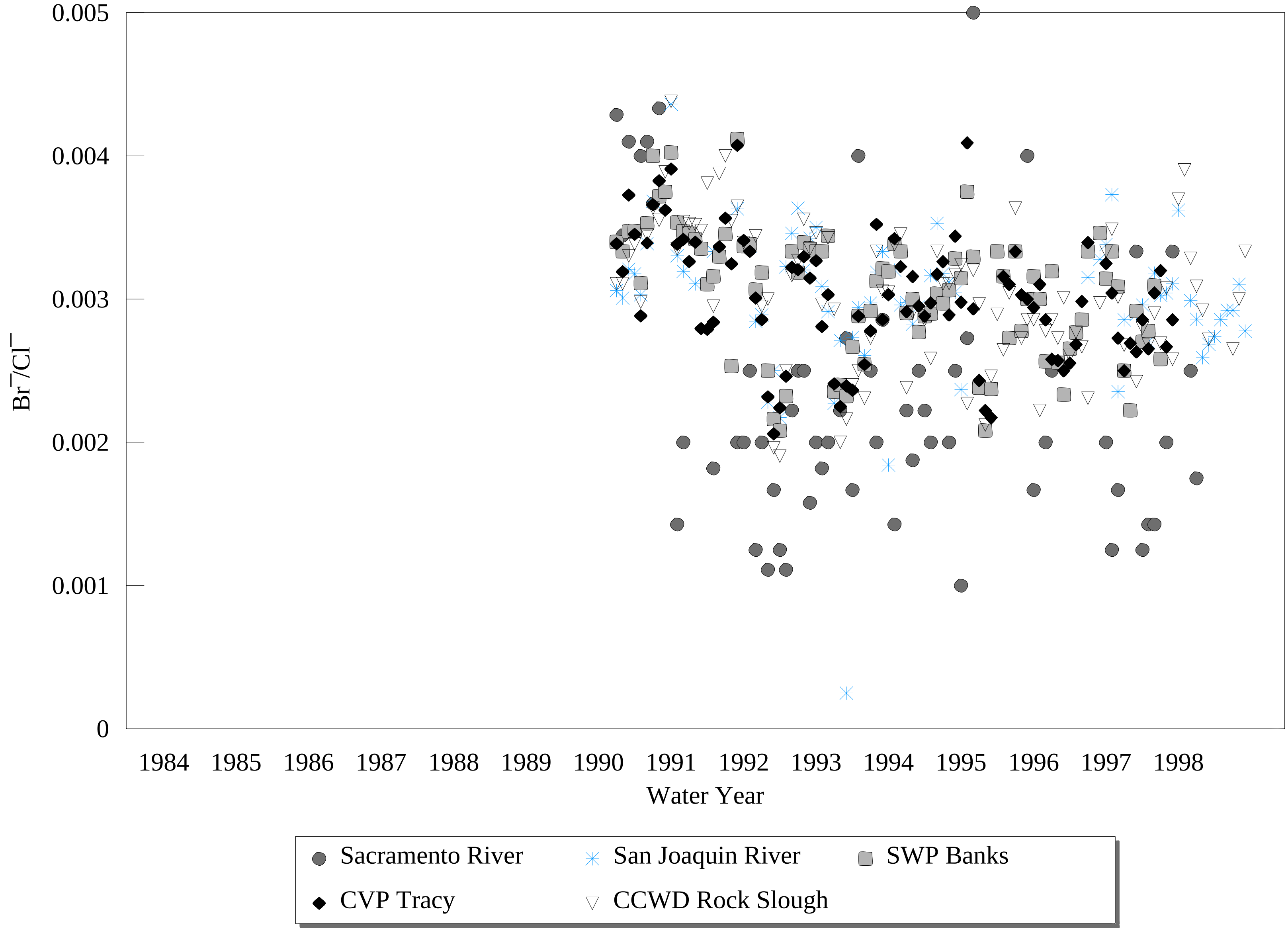
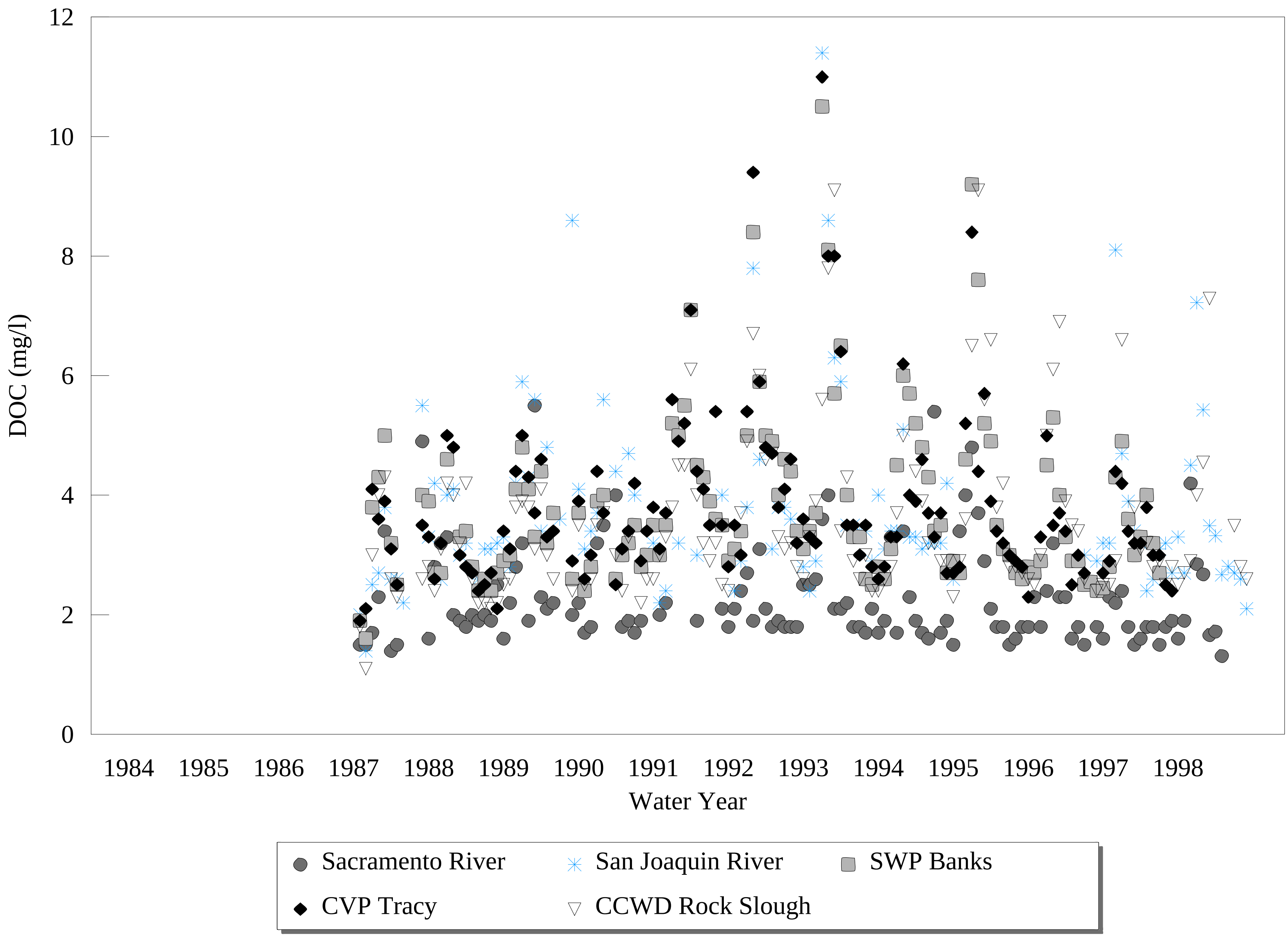
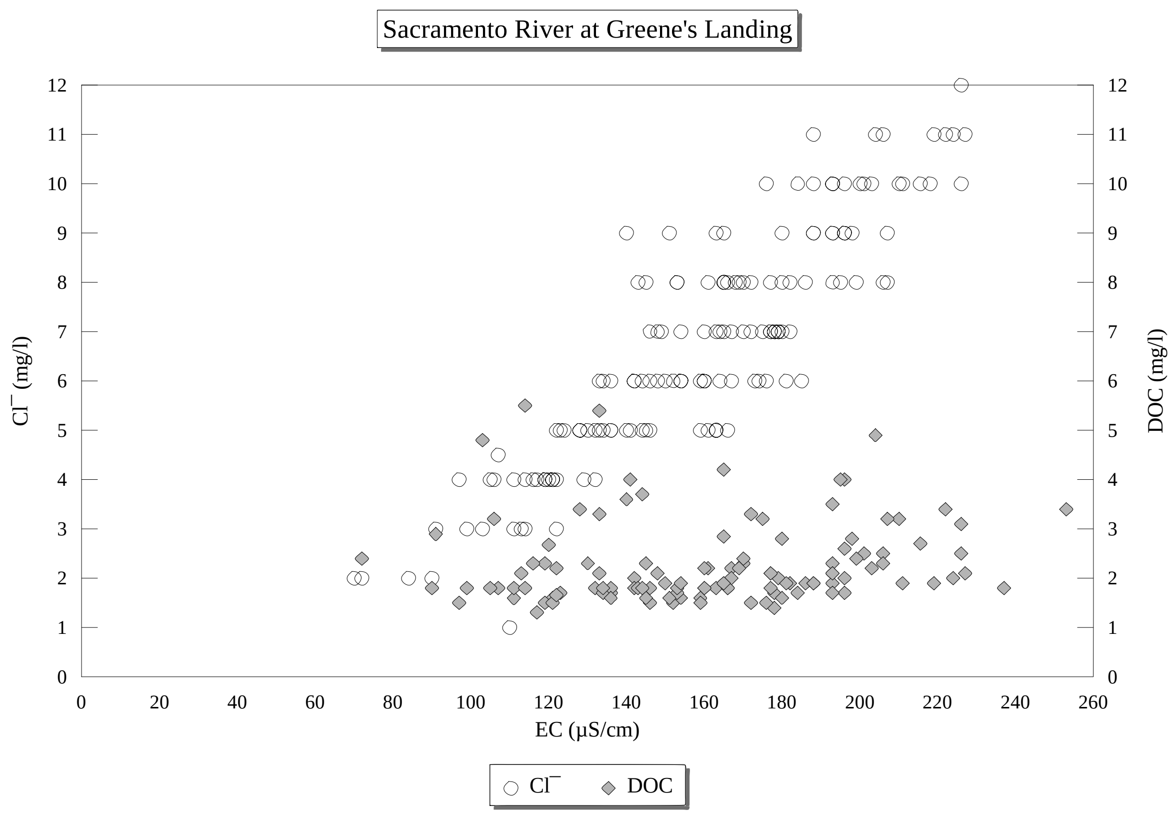


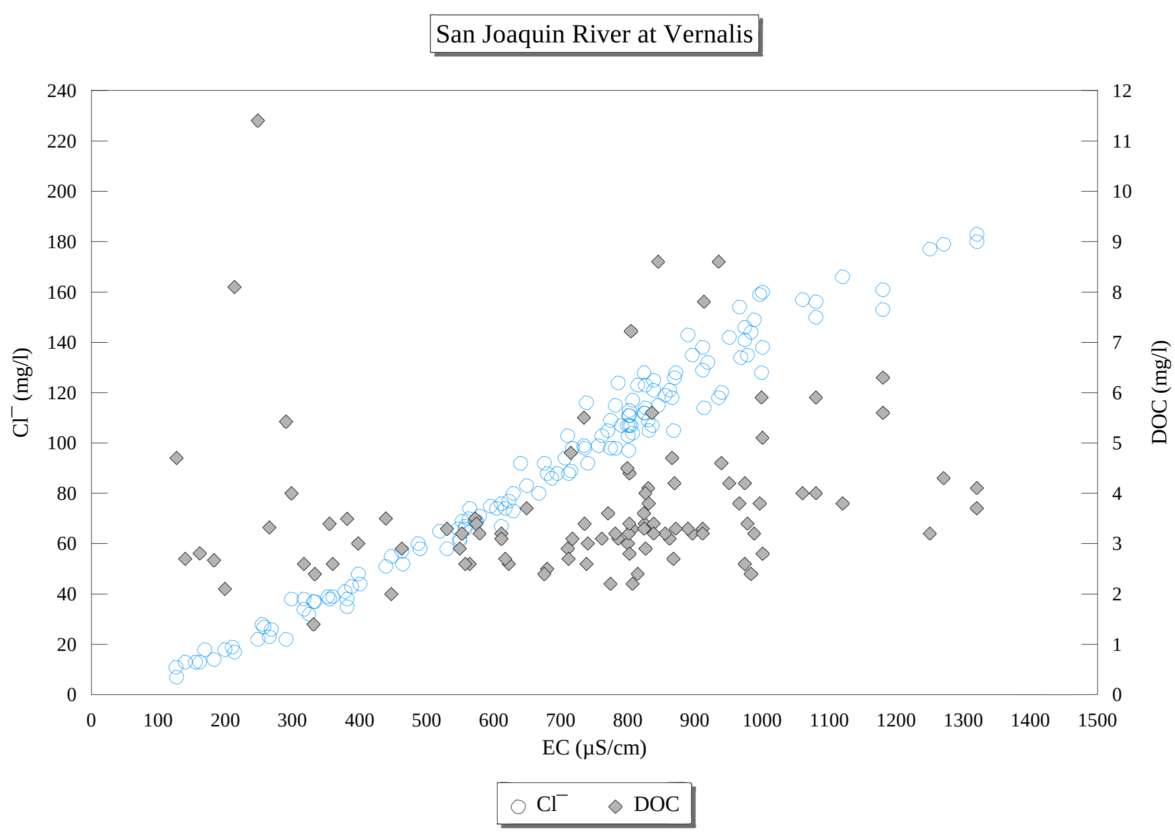
Figure 3C-31
1984-1998 MWQI Monthly Br^- :Cl^- Ratio Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations



Jones & Stokes

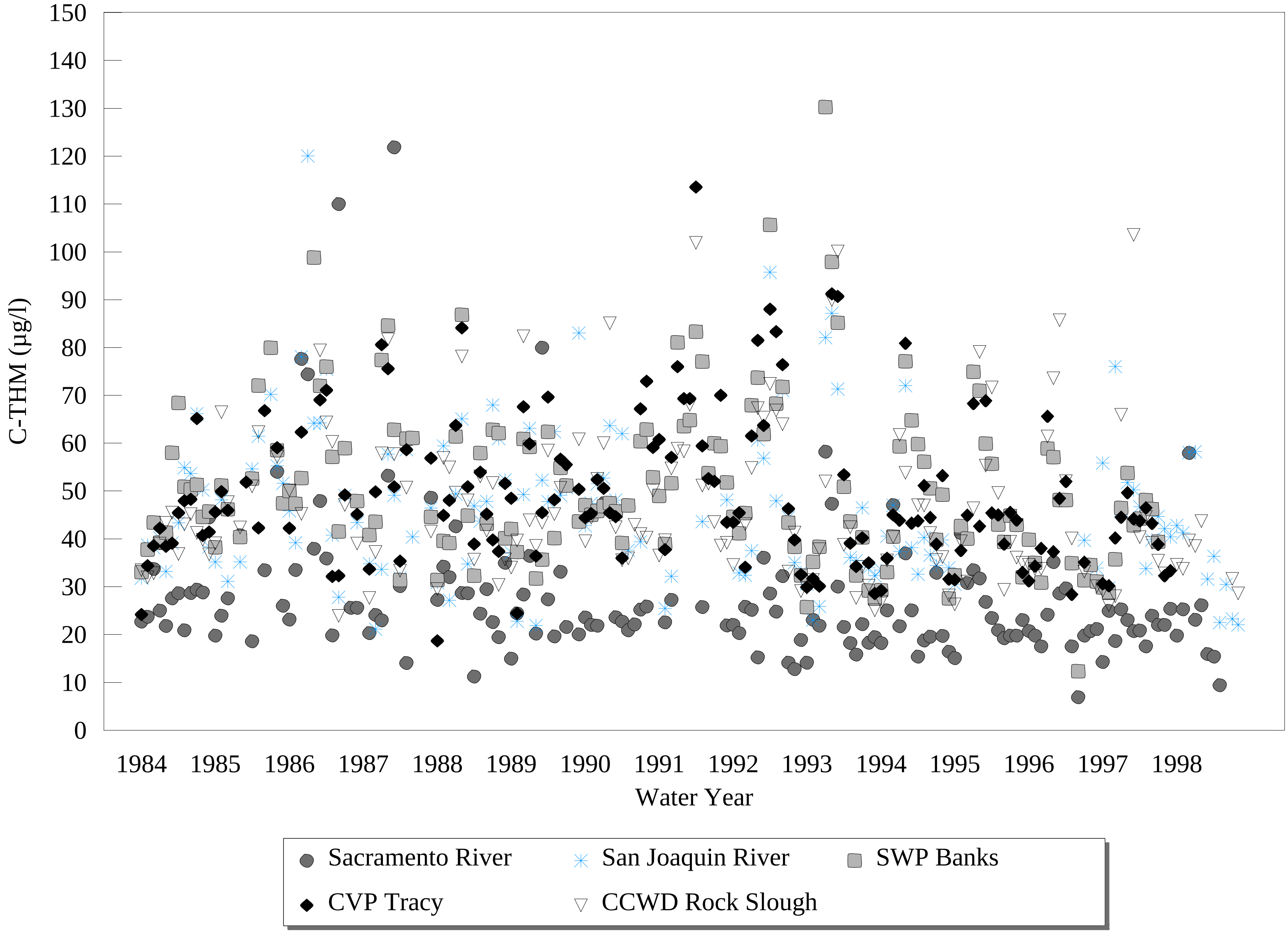
Figure 3C-32
1984-1998 MWQI Monthly DOC Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations





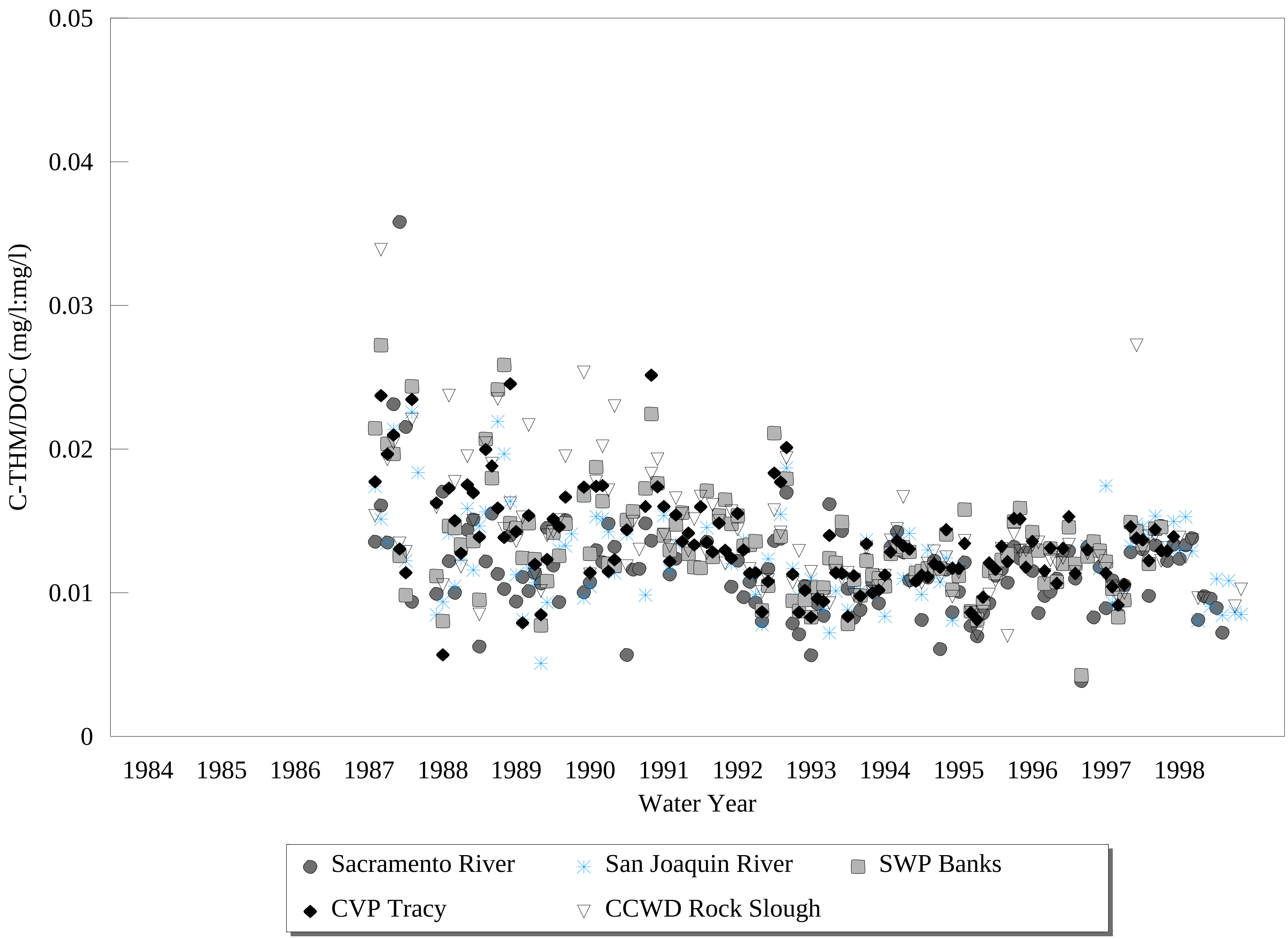
Jones & Stokes

Figure 3C-33
DOC and Cl^- Compared to EC Values in 1984-1998 Monthly Sacramento and San Joaquin River Samples



Jones & Stokes

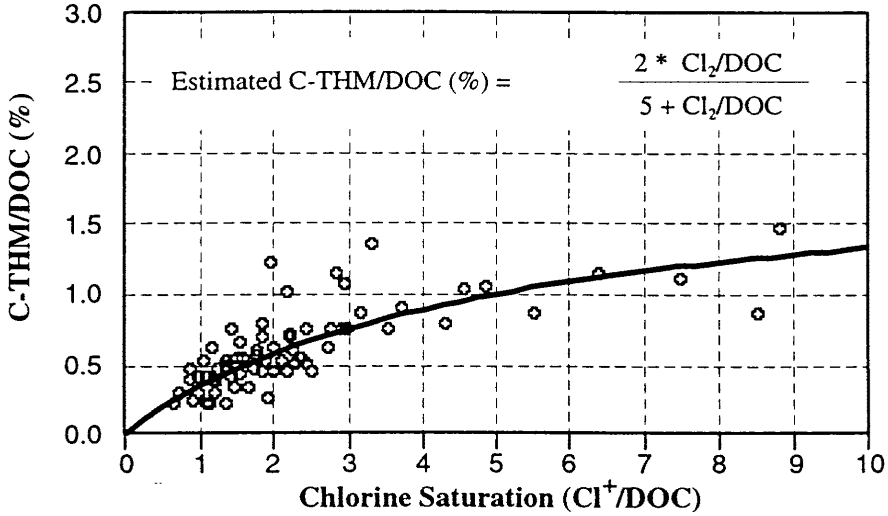
Figure 3C-34
1984-1998 MWQI Monthly C-THM Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations



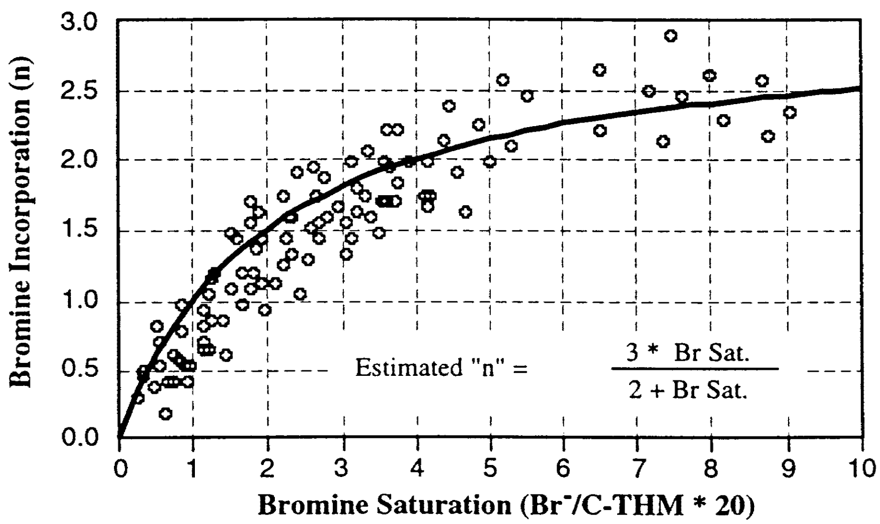
Jones & Stokes

Figure 3C-35
1984-1998 MWQI Monthly C-THM:DOC Ratio Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations

Step 1: From measured DOC and chlorine dose, estimate the THM yield (the fraction of DOC that will become C-THM):



Step 2: From calculated bromide (chloride * 0.0035) and estimated C-THM, estimate bromine saturation and bromine incorporation (n):

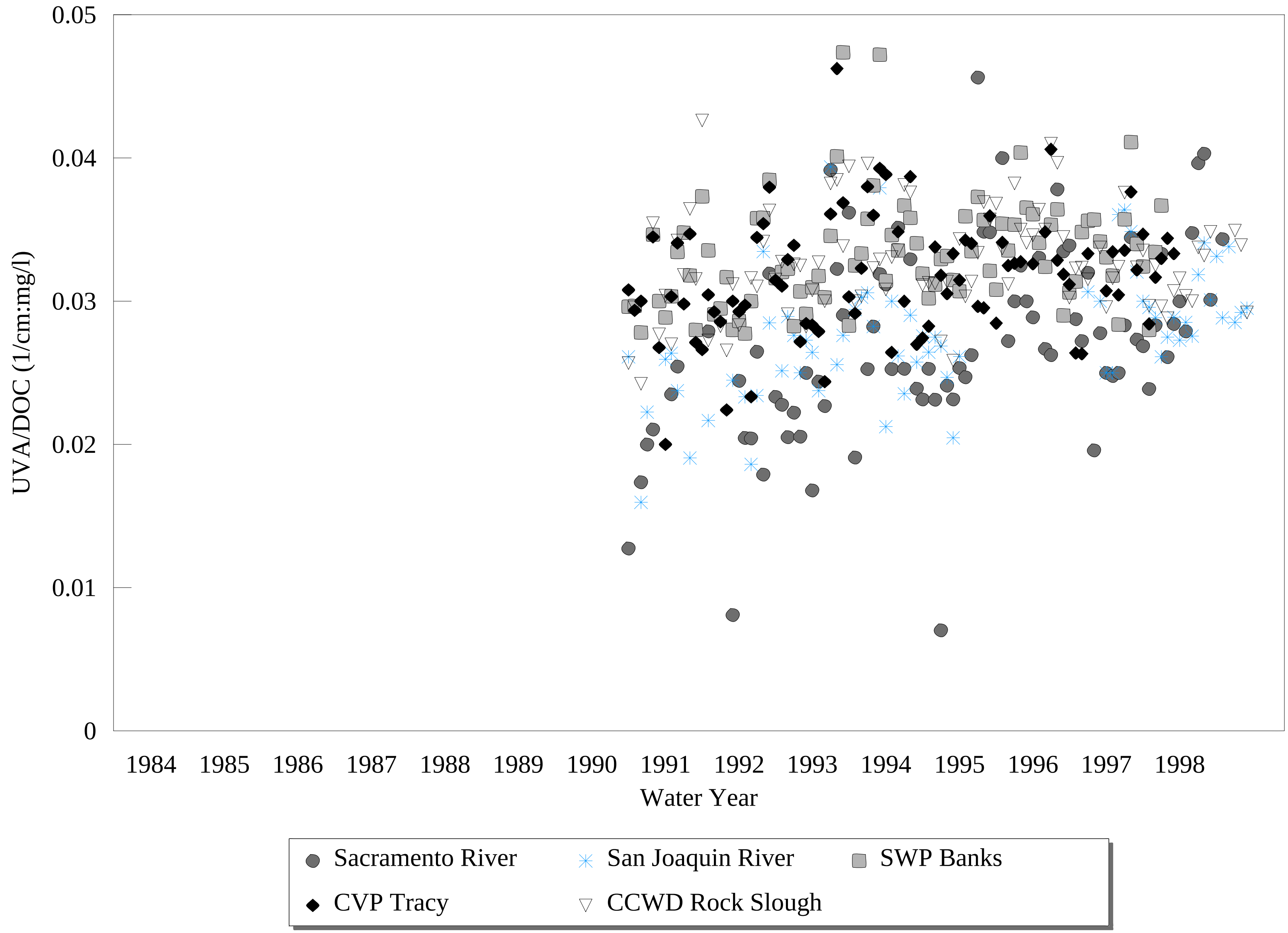


Step 3: Estimate the THM molar weight and the distribution of THM species as a function of "n":

THM (Molar Weight) = 119 + 44.5 * n

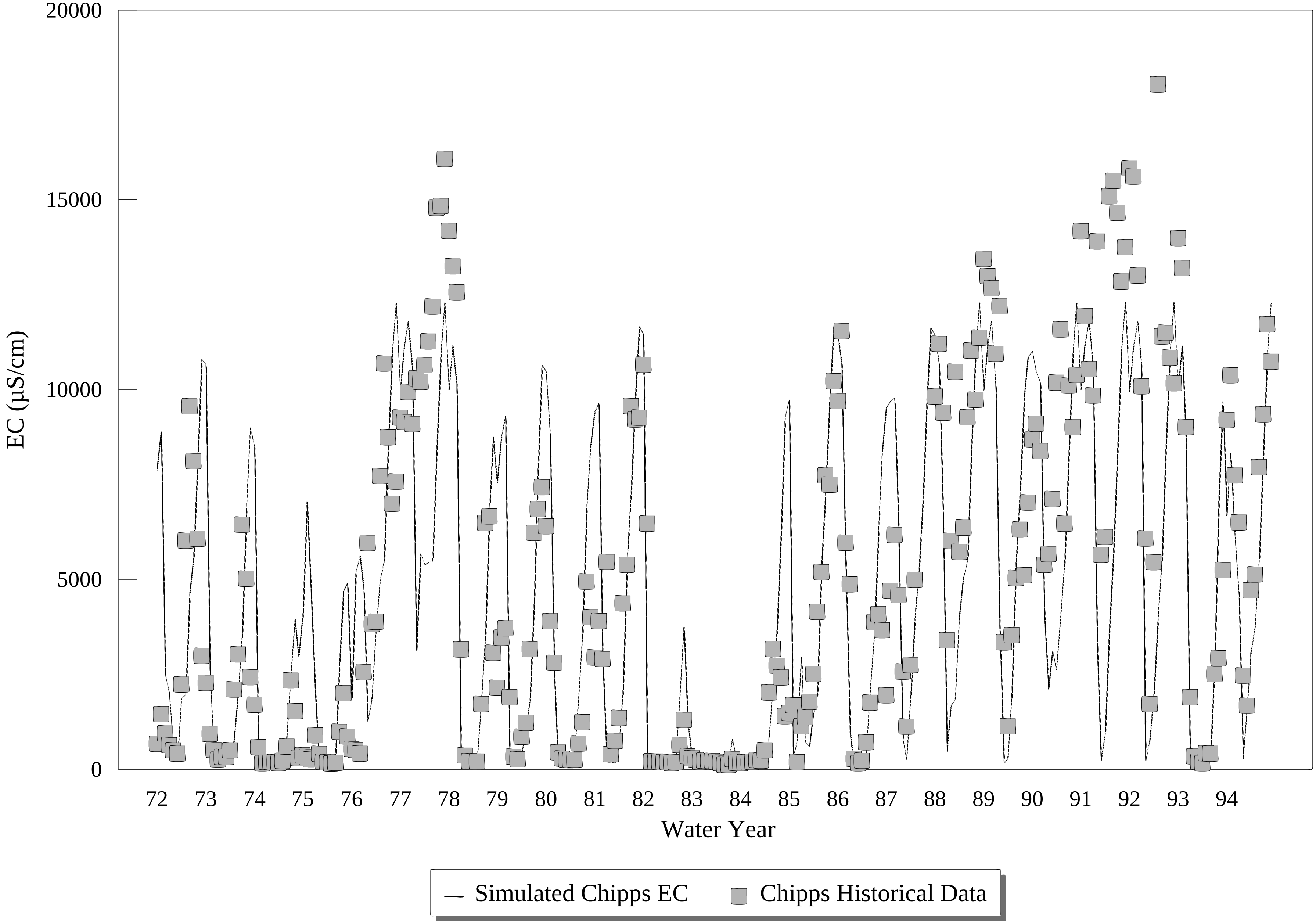
$CHCl_3$	$= (1 - \frac{1}{3}n)^3$	$= 1 - n + \frac{1}{3}n^2 - \frac{1}{27}n^3$
$CHCl_2Br$	$= 3 * (1 - \frac{1}{3}n)^2 * \frac{1}{3}n$	$= n - \frac{2}{3}n^2 + \frac{1}{9}n^3$
$CHClBr_2$	$= 3 * (1 - \frac{1}{3}n) * (\frac{1}{3}n)^2$	$= \frac{1}{3}n^2 - \frac{1}{9}n^3$
$CHBr_3$	$= (\frac{1}{3}n)^3$	$= \frac{1}{27}n^3$

Figure 3C-36
General THM Prediction Model



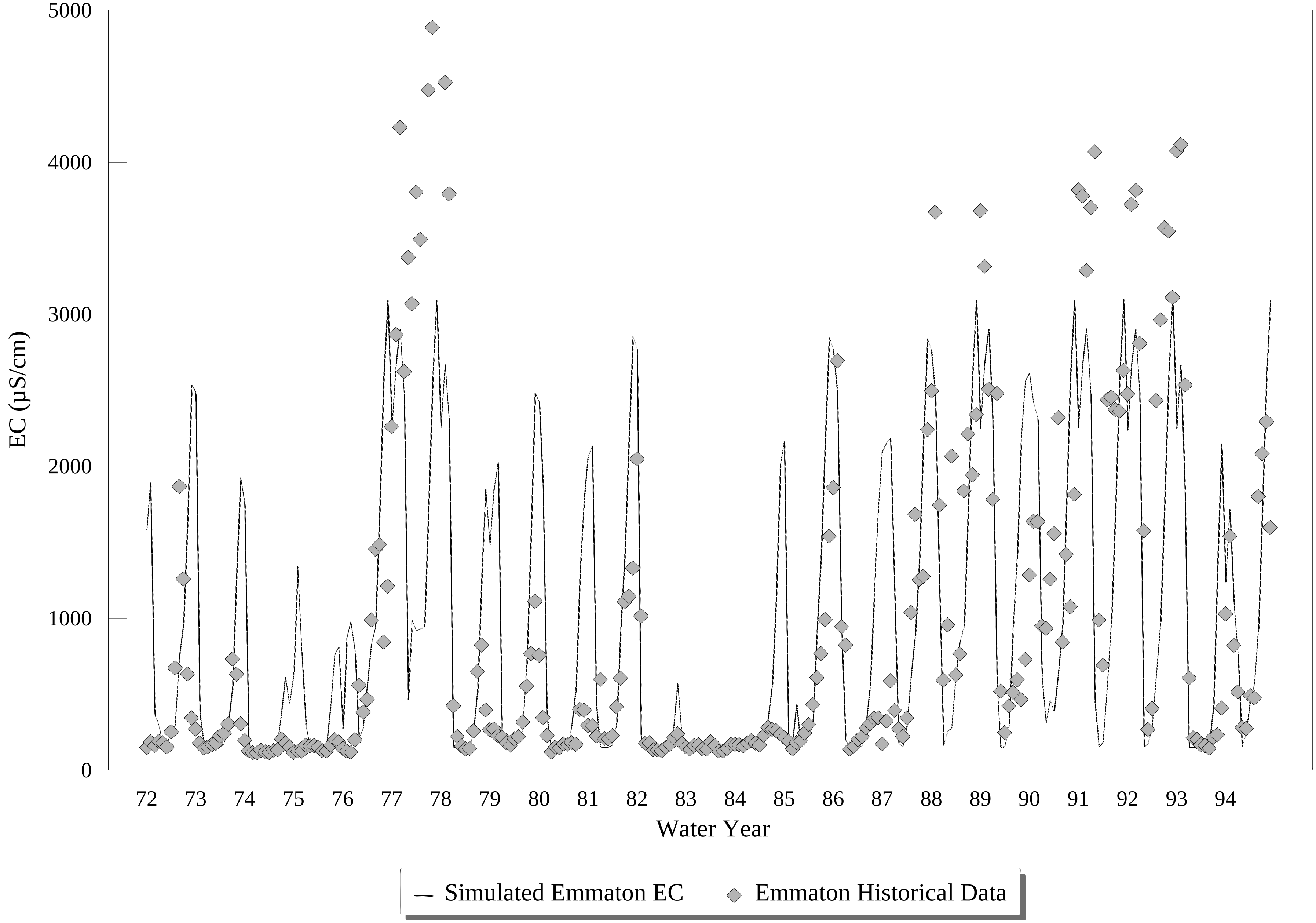
Jones & Stokes

Figure 3C-37
1984-1998 MWQI Monthly UVA:DOC Ratio Values from the Sacramento and San Joaquin Rivers and at Delta Export Locations



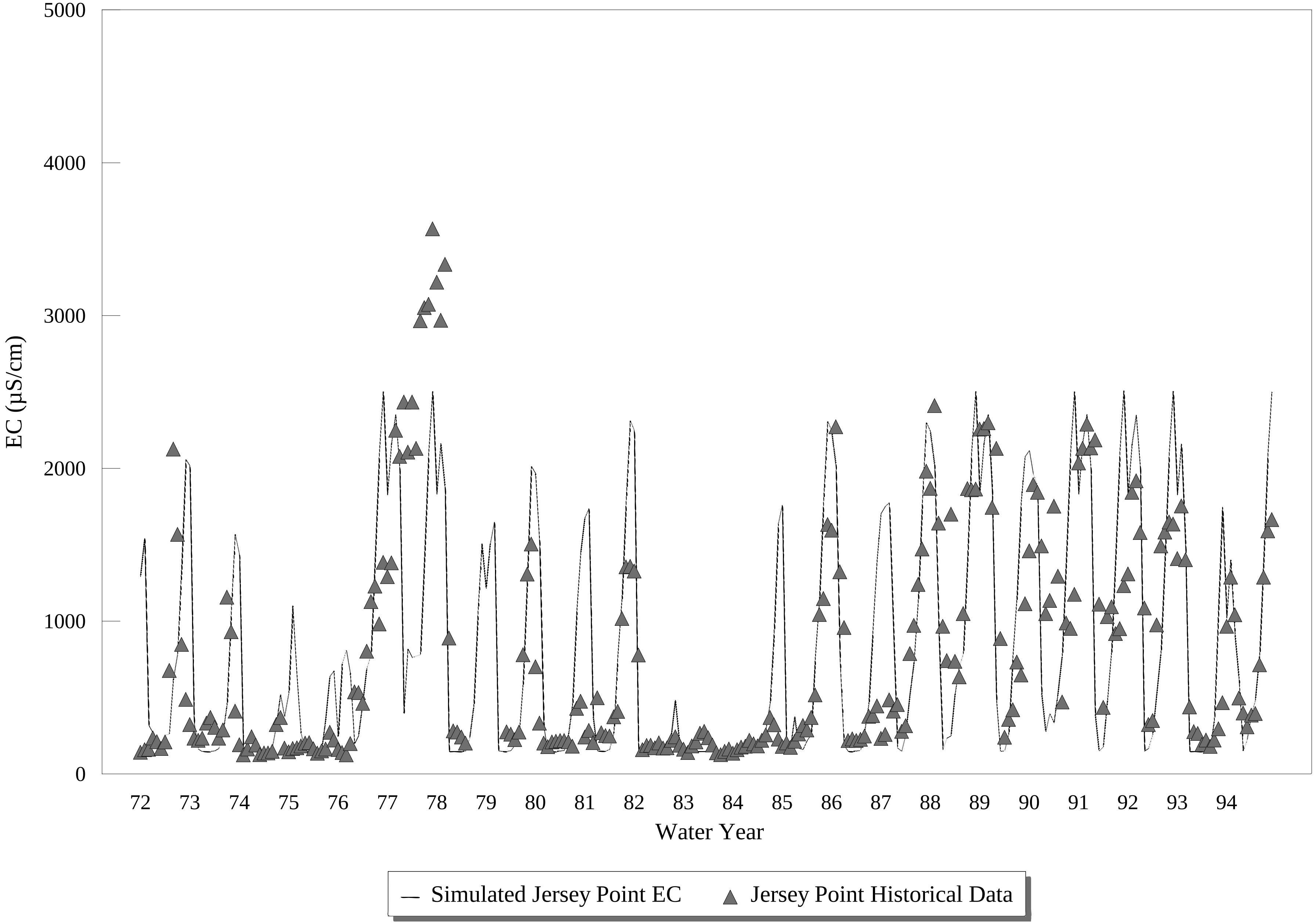
Jones & Stokes

Figure 3C-38
Simulated No-Project Chipps Island EC Compared to Historical EC Data



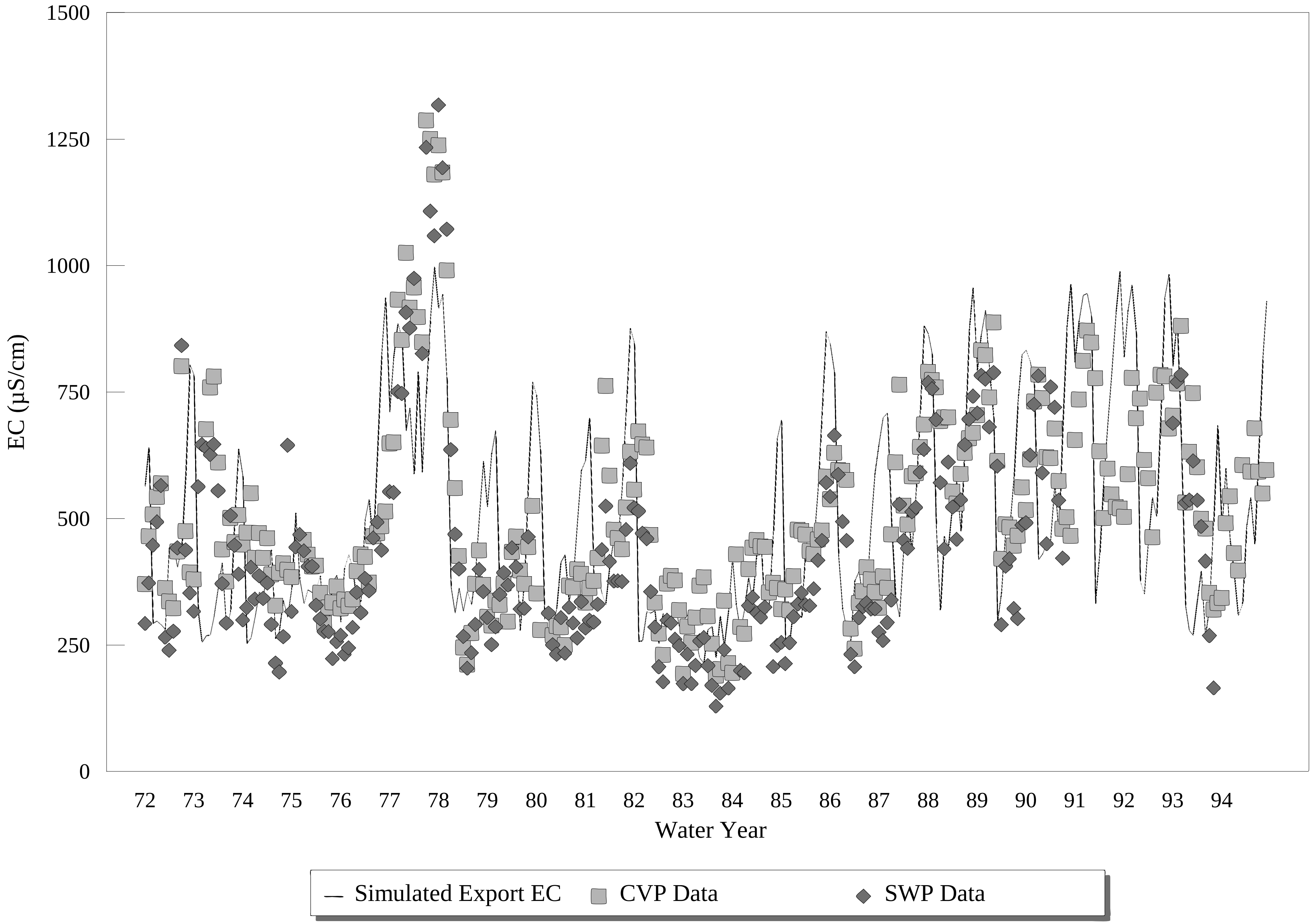
Jones & Stokes

Figure 3C-39
Simulated No-Project Emmaton EC Compared to Historical EC Data



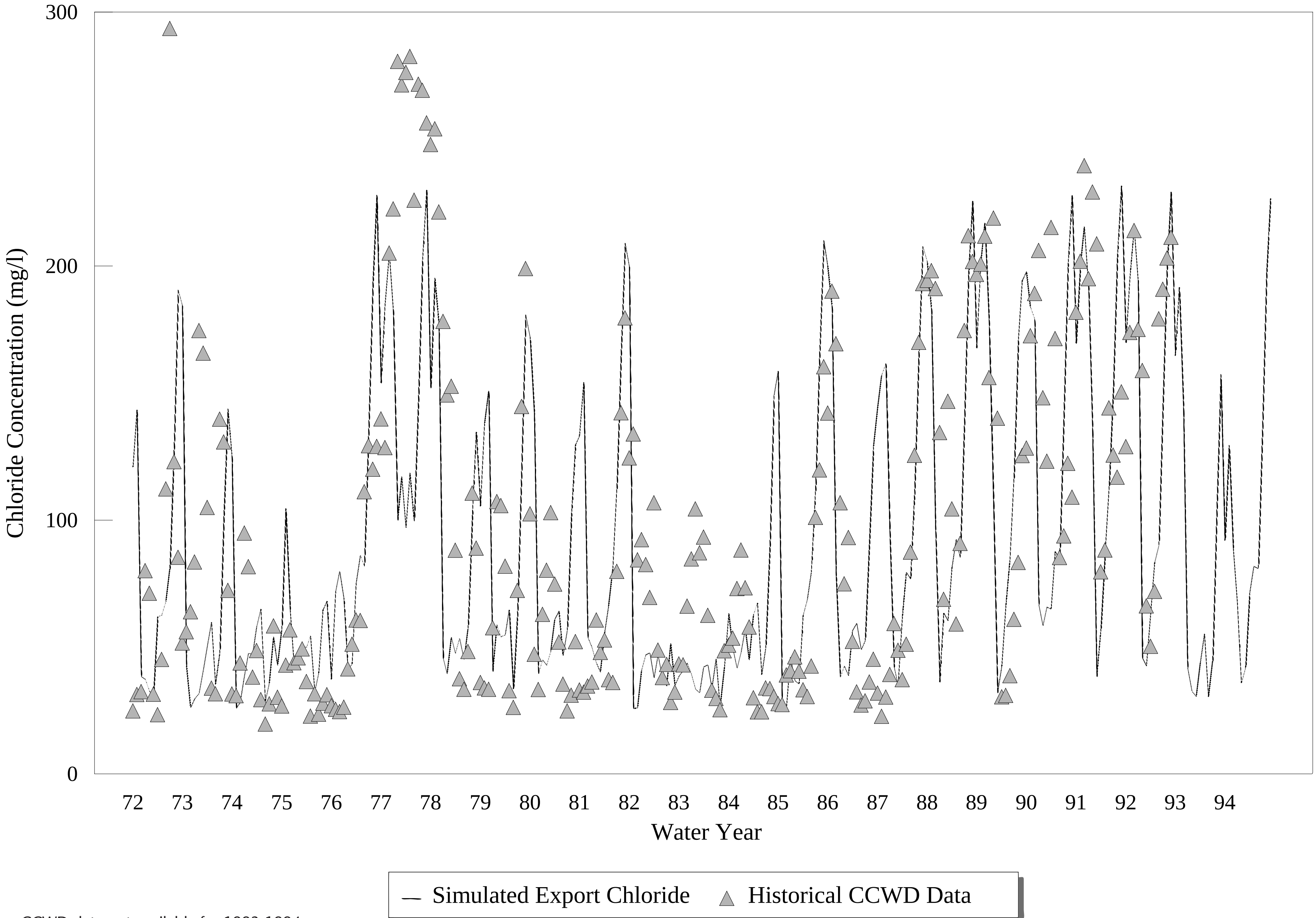
Jones & Stokes

Figure 3C-40
Simulated No-Project Jersey Point EC Compared to Historical EC Data



Jones & Stokes

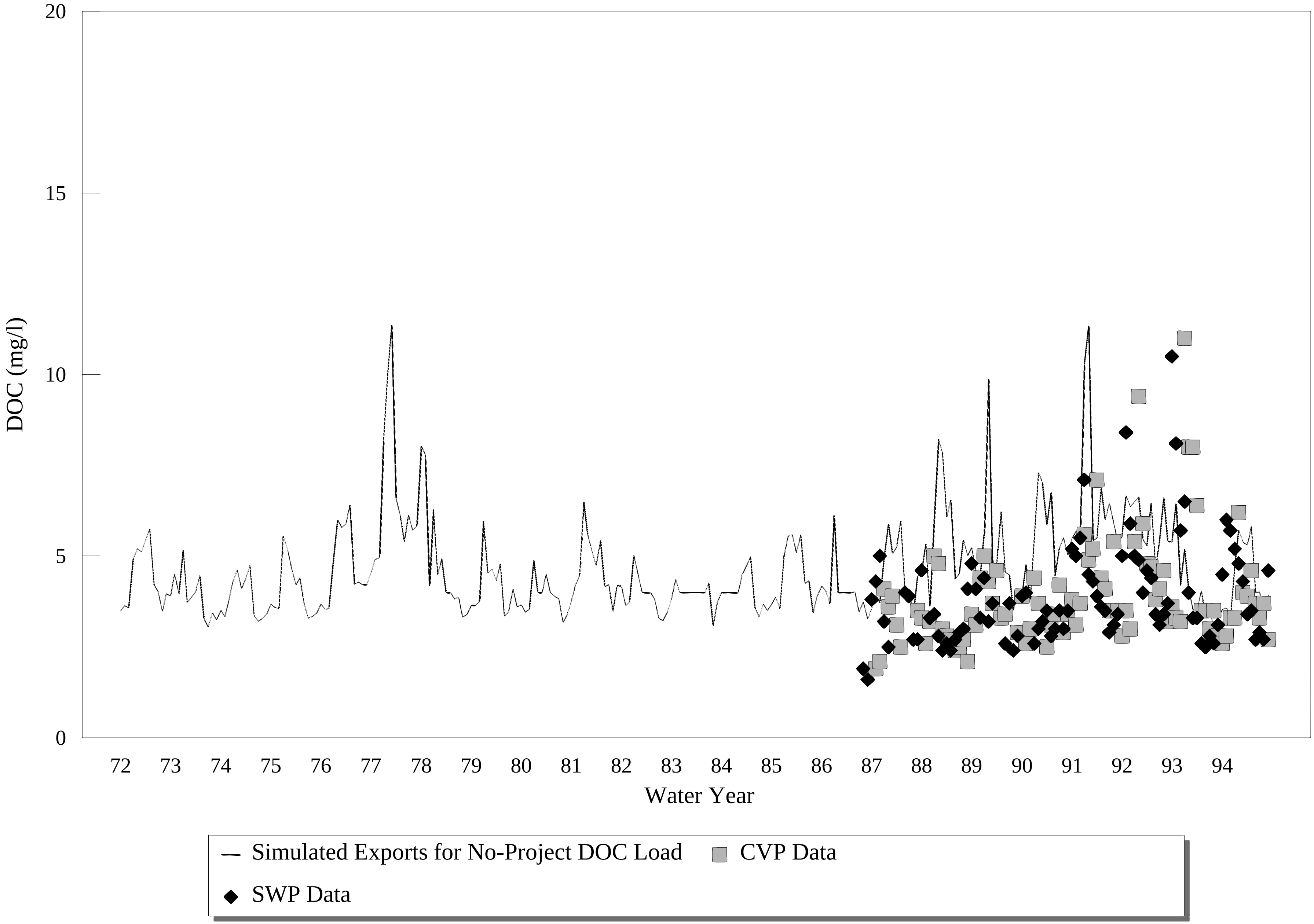
Figure 3C-41
Comparison of Simulated No-Project Export EC with Historical MWQI Export EC Values



Note: CCWD data not available for 1993-1994.

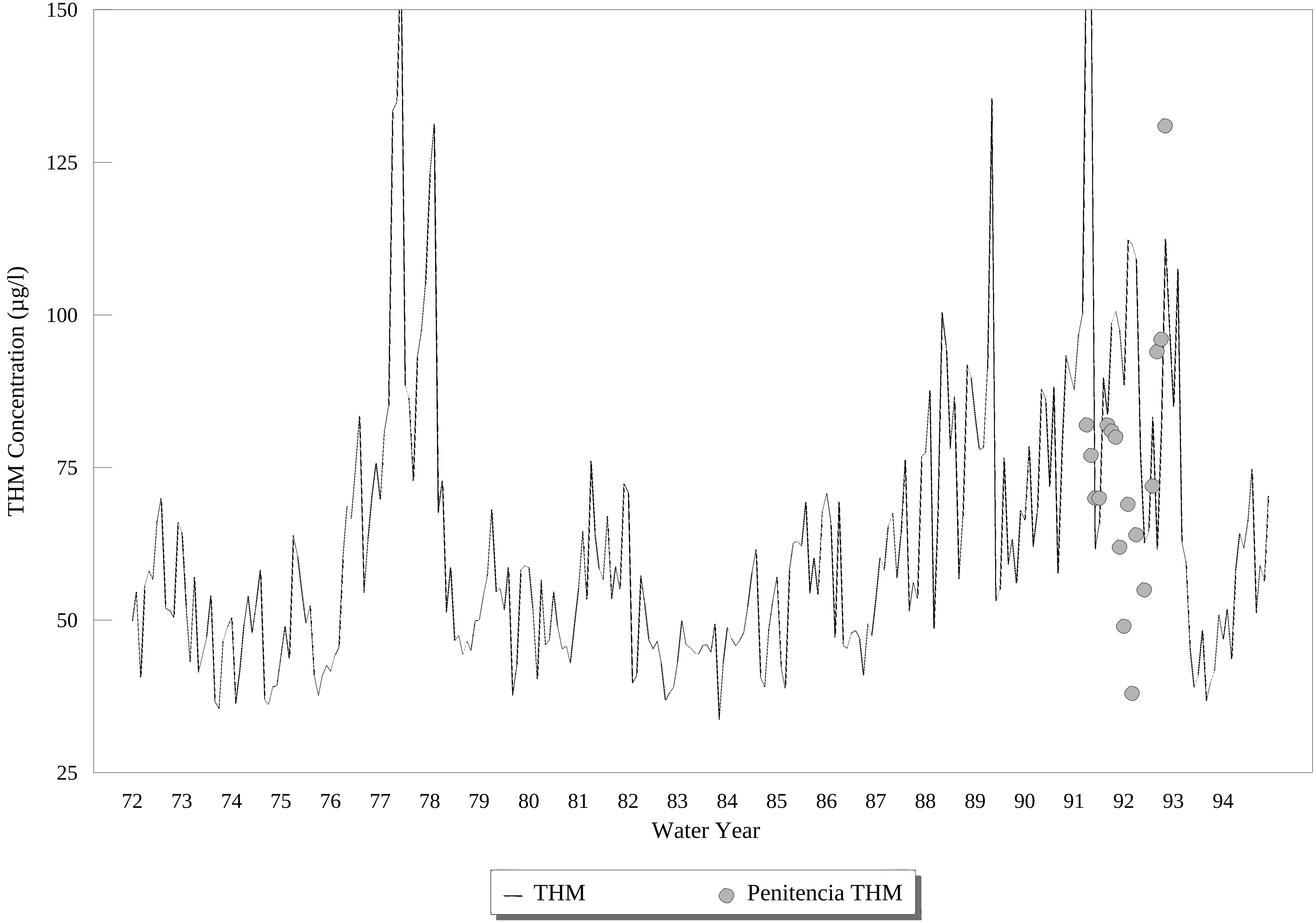
Jones & Stokes

Figure 3C-42
Estimated Export Cl⁻ Concentration for No-Project and Historical CCWD Rock Slough Cl⁻ Values



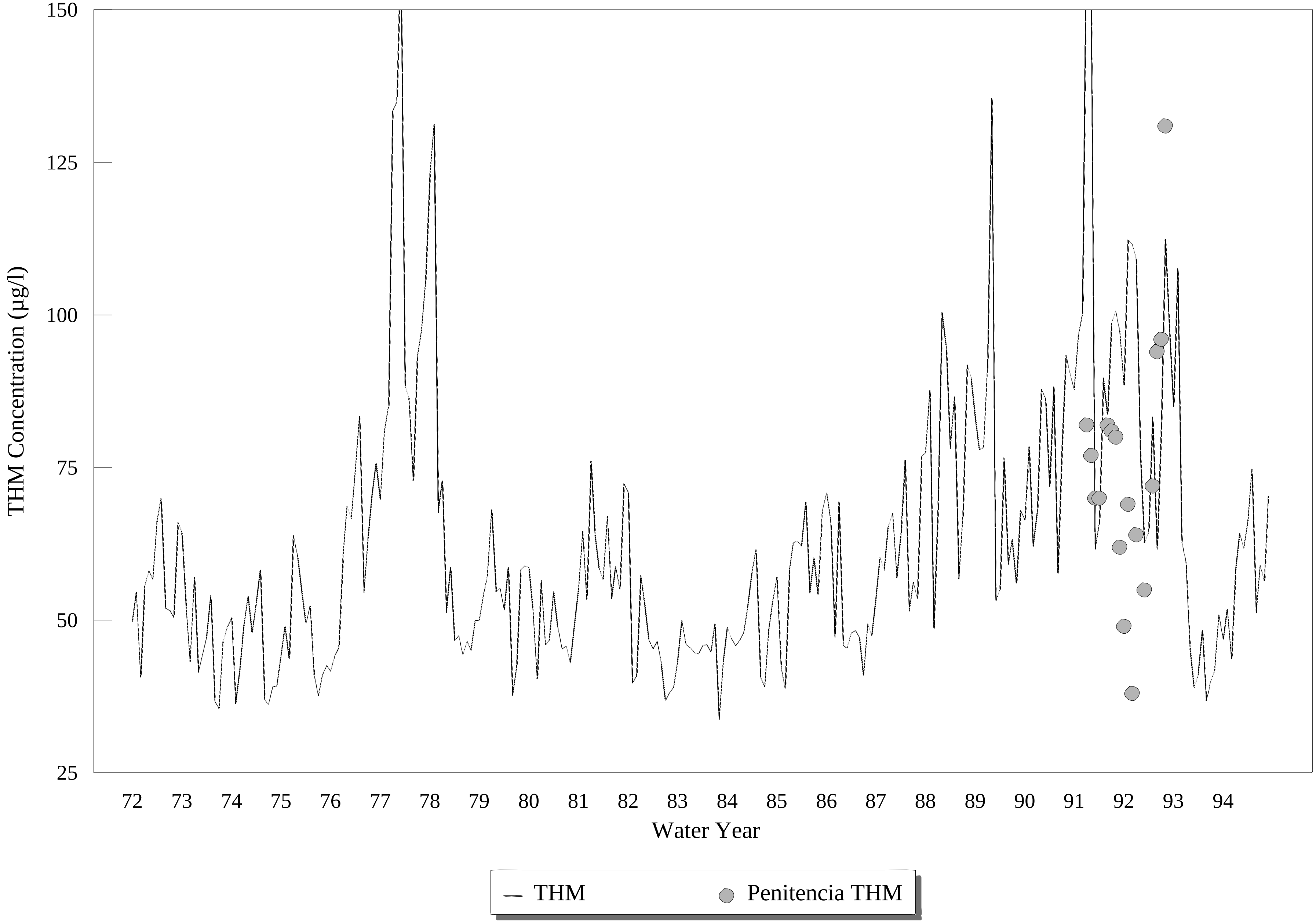
Jones & Stokes

Figure 3C-43
Simulated No-Project Delta Export DOC Concentrations with MWQI Drainage DOC Measurements



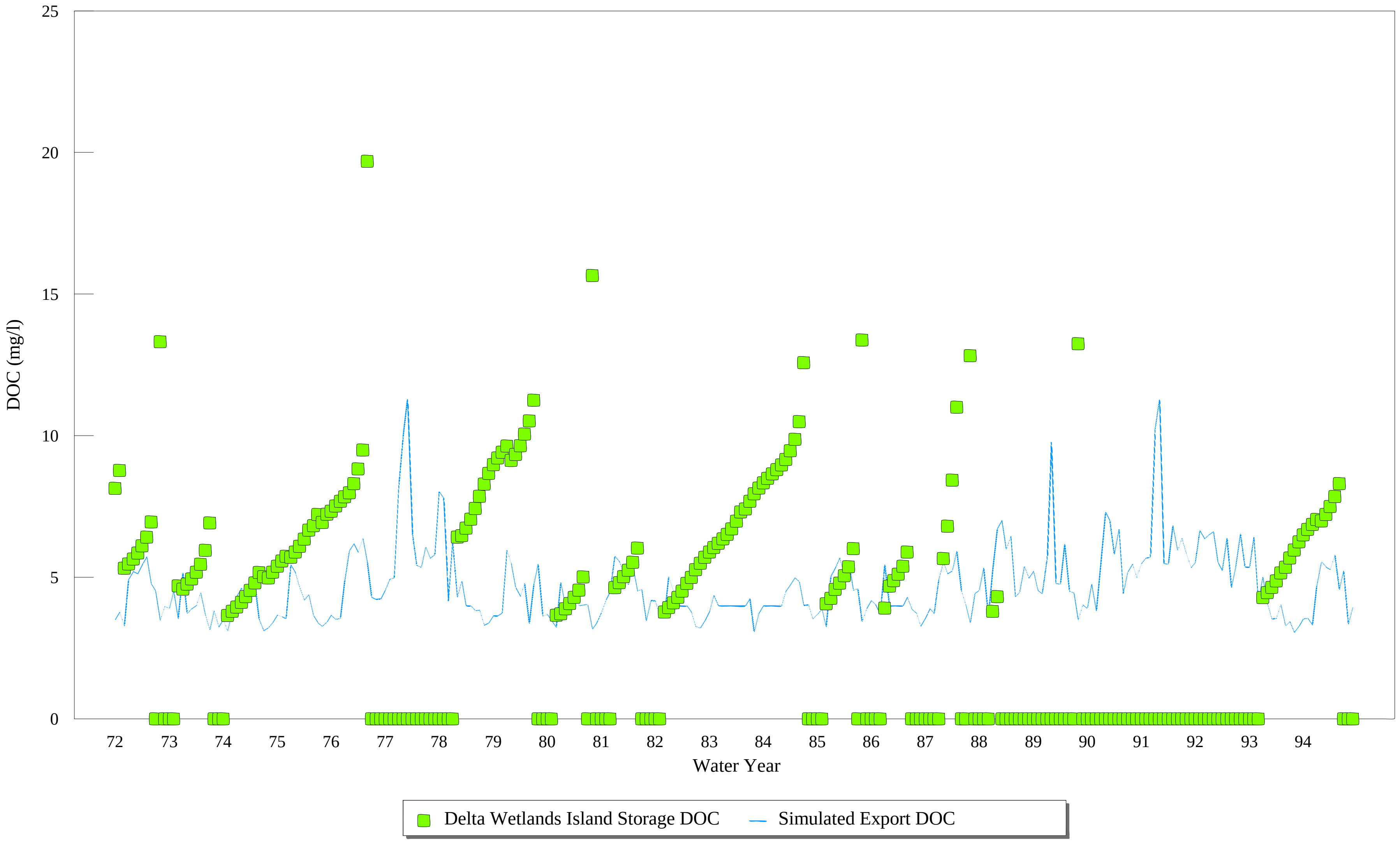
Jones & Stokes

Figure 3C-44
Simulated Treated Water THM Concentration for the No-Project Condition



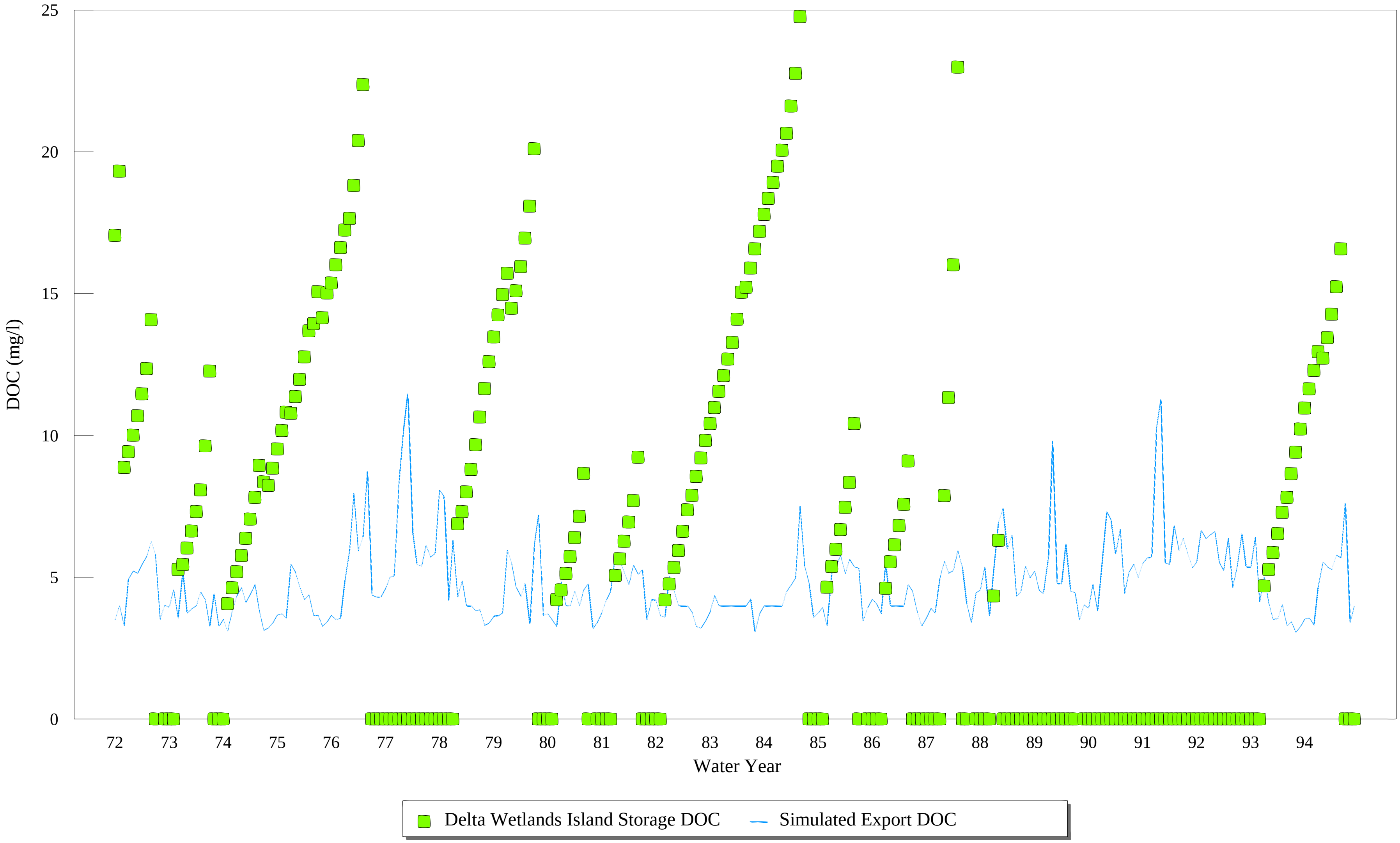
Jones & Stokes

Figure 3C-44
Simulated Treated Water THM Concentration for the No-Project Condition



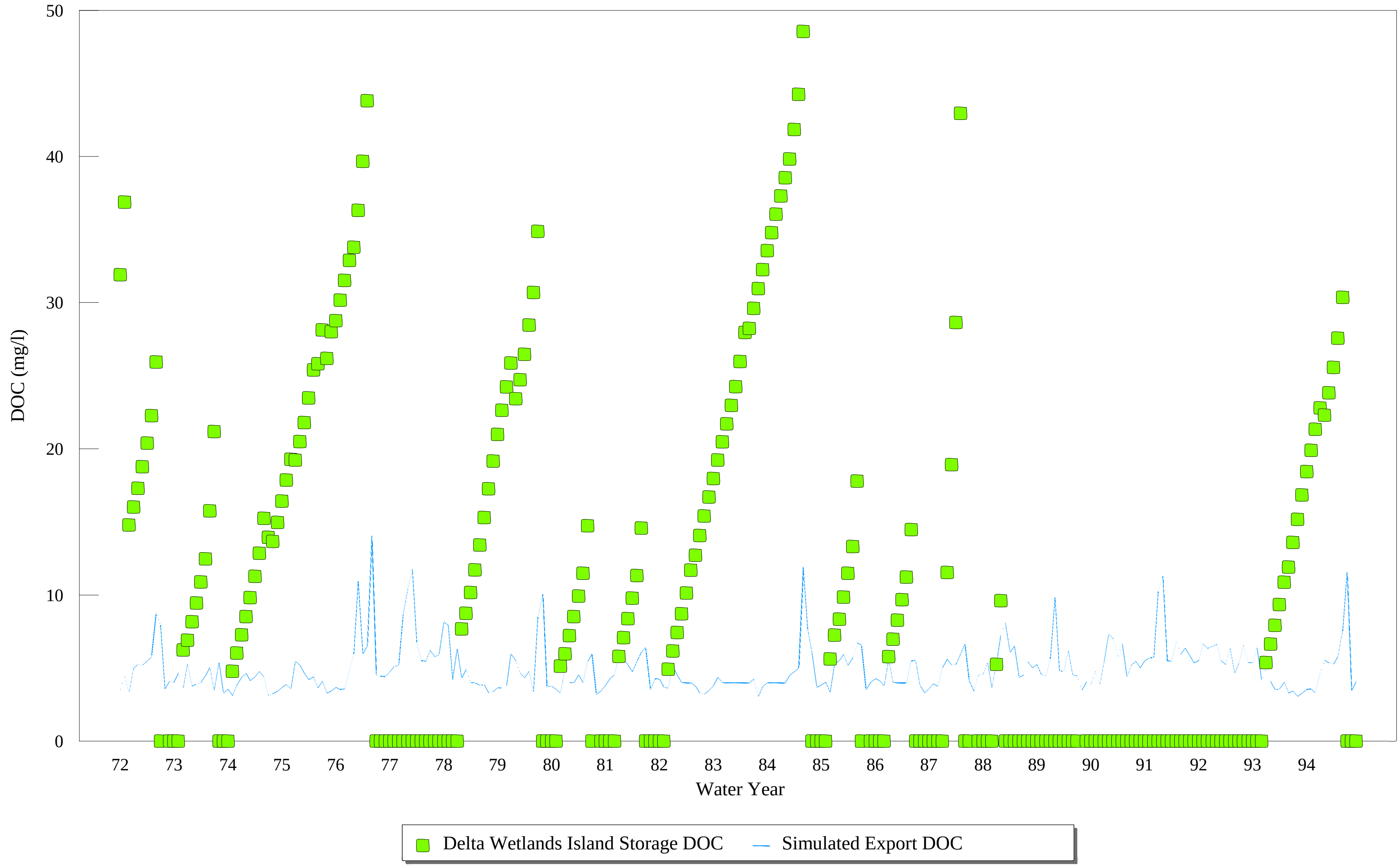
Jones & Stokes

Figure 3C-45
Simulated Export DOC and Delta Wetlands Reservoir Island Storage DOC with Assumed Long-Term DOC Load (1 g/m^2/mo)



Jones & Stokes

Figure 3C-46
Simulated Export DOC and Delta Wetlands Reservoir Island Storage DOC with Assumed Initial DOC Load (4 g/m^2/mo)



Jones & Stokes

Figure 3C-47
Simulated Export DOC and Delta Wetlands Reservoir Island Storage DOC with Assumed High Initial DOC Load (9 g/m^2/mo)

Chapter 3D. Affected Environment and Environmental Consequences - Flood Control

Chapter 3D. Affected Environment and Environmental Consequences - Flood Control

SUMMARY

This chapter describes flood control features of the DW project alternatives and identifies impacts of the alternatives on levee reliability and flood control on the DW project islands. Key flood control issues discussed are reliability of interior and exterior levees around the DW project islands, seepage impacts on neighboring islands, and effects of wind and wave erosion on levees.

Delta Wetlands proposed features and programs as part of Alternatives 1, 2, and 3 to minimize potential impacts on levee stability and seepage. The 1995 DEIR/EIS concluded that incorporation of those programs would reduce flood control impacts to less-than-significant levels. However, a new geotechnical evaluation of the proposed levee design and seepage-control system was performed for the 2000 REIR/EIS. This evaluation identifies the following as significant impacts:

- *a potential decrease in long-term levee stability on the DW reservoir islands, and*
- *a potential increase in seepage on adjacent islands resulting from project operations.*

Mitigation is proposed to reduce both impacts to a less-than-significant level. In addition, the following impacts are identified as less than significant:

- *a potential decrease in levee stability on the DW project islands during or immediately after project construction,*
- *potential property damage resulting from levee failure, and*
- *cumulative effects on Delta flood hazards.*

Because the rate of subsidence would increase under the No-Project Alternative, levee stability would decline over time and the potential for seepage and for levee failure during seismic activity would increase. The cumulative risk of levee failure would increase under the No-Project Alternative. The perimeter levees could be substantially buttressed and improved to increase long-term levee stability.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The analysis of DW project effects on levee stability and seepage was updated in the 2000 REIR/EIS. This chapter consists of the 1995 analysis of project effects on flood control followed by the updated analysis of project effects on levee stability and seepage. Additionally, minor text changes were made to update information in response to comments received on the 1995 DEIR/EIS and 2000 REIR/EIS, and some impact discussions from the 1995 DEIR/EIS were revised to reflect the updated conclusions about these impacts in the 2000 REIR/EIS analysis.

INTRODUCTION

This chapter assesses potential impacts of the DW project alternatives on DW island levee reliability and flood control in the Delta. The discussion in this chapter includes several terms that may not be familiar to all readers. The following are definitions of key terms as they are used in this EIR/EIS:

Buttress. An exterior pier, often sloped, used to steady a structure by providing greater resistance to lateral forces to prevent buckling. See also "toe berm".

Toe berm. The section projecting at the base of a dam, levee, or retaining wall.

Levee crest. The top of a levee.

Borrow area. An excavated area or pit created by the removal of earth material to be used as fill in a different location.

Subsidence. A local or regional sinking of the ground. In the Delta, this results primarily from peat soil being converted into gas.

Settlement. The sinking of surface material as a result of compaction of soils or sediment caused by an increase in the weight of overlying deposits or by pressure resulting from earth movements.

Seismicity. The frequency, intensity, and distribution of earthquake activity in a given area.

Liquefaction. The process in which soil loses cohesion when subject to seismic activity (i.e., shaking).

Seepage. A slow movement of water through permeable soils caused by increases in the hydraulic head (see below).

Piezometer. A sandpipe monitoring well used to measure the depth to the groundwater surface in the aquifer.

Hydraulic head. The pressure created by water within a given volume.

Hydrostatic pressure. The pressure of water at a given depth due to the weight of the fluid above it.

Additional definitions of terms are provided below in the section from the 2000 REIR/EIS entitled "Definition of Terms".

AFFECTED ENVIRONMENT

This section describes levee and flood conditions on the DW project islands. Information for this section is based, in part, on information collected for the 1990 draft EIR/EIS. Where conditions have not changed, this information has been used. Descriptions of levee and flood conditions have been updated using more recent information from DWR; the Bay-Delta Oversight Council; and DW's geotechnical engineers, Harding Lawson Associates (HLA) and Hultgren Geotechnical Engineers, where appropriate.

Sources of Information

Information on levees and flood control in the Delta and on the DW project islands was collected from reports by DWR, the Bay-Delta Oversight Council, and DW's engineering consultants. Local reclamation district engineers and consulting engineers were also contacted for further information. Appendix D1 is an annotated list of geotechnical reports prepared for the DW project and consulted for much of the information in this chapter.

Delta Levee Stability

History of Delta Levees

Prior to reclamation for agriculture, the Delta was a tidally influenced marshland. Reclamation began in 1850 and involved the use of extensive levee systems, internal drainage networks, and pumps. In 1861, the California Legislature created a state commission to manage reclamation projects. In 1868, the responsibility for reclamation was given to landowners and their reclamation districts, and Delta island reclamation began on a large scale.

Between 1871 and 1879, most of the Delta islands were enclosed by levee systems. By the late 1870s, steam-powered dredges were being used to build levees, and between 1880 and 1916, most of the Delta marshes were reclaimed (DWR 1982). By the mid-1940s, the Delta had been completely transformed from a tidal wetland to a series of channels separated by islands protected by levees.

Delta Levee System

The Delta levee system initially served to control island flooding. Today the levees are necessary to prevent inundation of island interiors during normal runoff and tidal cycles because island interiors have been lowered by extensive soil subsidence. Subsidence is the lowering of the interior land level primarily as a result of microbial decomposition, topsoil erosion, and oxidation of the islands' peat soils. Delta lands have historically subsided at rates that are among the highest in the world. The land surface of some Delta islands is subsiding at a rate of 2-3 inches per year (U.S. Soil Conservation Service [SCS] 1989). Levees that were originally built 2 or 3 feet above ground level must now be maintained, in many cases, at heights of over 20 feet above ground level as a result of interior island subsidence (DWR 1982, 1988; Bay-Delta Oversight Council 1993).

Before reclamation, the surface elevations of the Delta soils were approximately at sea level. Therefore, the difference between sea level and existing elevations of the island interiors represents the magnitude of subsidence that has taken place on each island since reclamation began. The lowest surface elevations of Bacon and Bouldin Islands and Holland and Webb Tracts are -20.3, -19.9, -17.9, and -20.5 feet relative to mean sea level, respectively (Northpoint Engineers 1988).

Delta Levee Failure Mechanisms

More than 100 Delta island levee failures have occurred since the early 1890s (DWR 1982). Figure 3D-1 shows the 15 Delta islands that have flooded since 1967. Levee failures occur as a consequence of overtopping or levee instability.

Overtopping occurs when the crest of the levee is lower than the water level. Overtopping can occur not only as a result of floodflows, but also as a consequence of high tides and wind (Bay-Delta Oversight Council 1993). Factors contributing to levee instability include seepage, settlement, erosion, subsidence, and seismicity. These factors are described below.

Seepage. Water seeping through or beneath levees contributes to erosion problems and subsequent levee instability. Sandy levees are especially susceptible to seepage erosion and the resulting formation of "pipes" (large voids) in the levee material. (Bay-Delta Oversight Council 1993). Regional and project-specific seepage conditions are described below.

Seepage of water from waterways or adjacent islands is a major concern of Delta land users. The amount of seepage that occurs is controlled by the permeability of soils, length of the seepage path, and height of the hydraulic head (i.e., the pressure created by water within a given volume). The problem is worsened in the Delta by the decline in the level of peat soils, which increases the hydraulic head between channel water surfaces and the islands, and by the presence of permeable subsurface sand layers. Seepage has been reported to increase after flooding of an adjacent island and to cease after the flooded island has been drained (DWR 1982, HLA 1989).

Under existing conditions, seepage fluctuates with exterior channel water levels; dredging episodes in exterior channels; and variations in farming practices, such as weed control, flooding adjacent to levees, or lowering of interior water levels. Seepage varies from island to island and within individual islands as a function of soil conditions and levee conditions. Site-specific information on groundwater conditions on the DW islands and neighboring islands was collected by Hultgren Geotechnical Engineers under contract to DW between 1989 and 1997 to give an indication of existing seepage through the aquifer. Results of groundwater monitoring to date have been published in three reports (see Appendix D1, "Annotated List of Geotechnical Reports Prepared for the Delta Wetlands Project").

Water seeps onto Delta islands by two primary routes: high seepage passes through or immediately beneath levee embankments, and deep seepage passes through permeable materials below the peat that underlies most levee embankments. High seepage is not transmitted from flooded islands to adjacent islands and is addressed by individual reclamation districts as it occurs. Subsurface sand layers provide the primary conduits for deep seepage. These layers may permit the seepage to travel from a flooded island to an adjacent island. If clay is present under channels between islands, or if it overlies sand layers, the permeability of the seepage path and resultant seepage are greatly reduced.

Settlement. The construction of Delta levees over soft foundation materials has caused ongoing consolidation of levee material and levee settlement. Delta islands are subject to levee cracking, seepage, and instability of varying degrees because of differential settlement and the composition of the levee soils. The levees are raised periodically to compensate for settlement. The process of raising levees increases the load on the underlying materials, causing more settlement, and the cycle repeats itself. Levees commonly settle at various rates, which depend on factors such as the nature of underlying material and the length of time since the levee crest was last raised with additional fill (HLA 1989).

Wind and Wave Erosion. Levee exterior (water-side) slopes are subject to varying erosional effects of channel flows, tidal action (which can cause water levels in some channels to vary by as much as 4 feet daily), wind-generated waves, and boat wakes. To counter erosion, riprap (rock) may be placed on a levee, or a berm may be placed as a buffer in front of the levee. Although vegetation can contribute to piping problems, it is generally desirable as another tool in controlling erosion. (Bay-Delta Oversight Council 1993.)

Subsidence. Subsidence (i.e., lowering of the land surface) results primarily from peat soil being converted into a gas. Many Delta islands are composed of peat soils that decompose when exposed to oxygen and higher temperatures, a process that is accelerated by agricultural activity (Bay-Delta Oversight Council 1993).

Seismicity. Faults are considered active if they have moved at least once during the last 11,000 years. Active faults that have the potential to produce earthquake effects on Delta levees exist (DWR 1982). None of the Delta levee failures are known to have been the direct result of an earthquake. However, an earthquake could potentially cause levee failures through lateral deformation, settlement, or liquefaction because Delta levees are founded on sand, silt, clay, and peat that, when saturated, generally lose strength under seismic acceleration.

The height differential between the top of existing levees and island interior bottoms is gradually increasing because of subsidence. This growing differential increases levee vulnerability to earthquake effects because hydrostatic pressure (i.e., the pressure of water at a given depth due to the weight of the fluid above it) becomes greater relative to the resisting forces of the levees and foundation soils.

DWR has an emergency plan to protect Delta water supplies in the event that levees are damaged by an earthquake. The plan calls for cessation of pumping in the south Delta, release of water from upstream reservoirs, use of Clifton Court Forebay as a temporary supply, and rapid repair of damaged levees (Argent 1988).

DW Project Islands

Levee Failure. Since 1932, two DW project islands, Holland and Webb Tracts, have flooded as a result of levee overtopping or stability failure. Using levee data from 1974, the Corps calculated the statistical frequency of levee failure resulting from overtopping or levee instability on Delta islands, based on the assumption that no major rehabilitation work would be done (Table 3D-1). The Corps predicted that Bouldin Island would experience levee failure more than 18 times in 100 years, or an average of once every 5.5 years under existing conditions. The Corps predicted that levees on Bacon Island, Holland Tract, and Webb Tract would fail once every 11-24 years under existing conditions. (DWR 1982.)

Seepage. The DW project islands and adjacent islands experience seepage problems of varying degrees under existing conditions. Existing levees will continue to have at least some high seepage caused by the high hydraulic heads between exterior water surfaces and interior island bottoms. Site-specific data on seepage in the DW project area indicate that water levels in sand aquifers are within a few feet of the interior elevations of the islands (HLA 1992a).

Current agricultural land use practices (see Chapter 3I, "Land Use and Agriculture") on many Delta islands lower groundwater levels and accelerate subsidence in peat material at or near the island surfaces. Because of continued subsidence, associated increases in levee heights, and corresponding hydrostatic pressures, seepage is expected to increase over time in the DW project island interiors under existing conditions.

HLA, under contract to DW, issued questionnaires pertaining to seepage on Delta islands to reclamation engineers in 1988. Although most of the information collected was not specific, results indicated that all islands adjacent to DW project islands have some problem with seepage, subsidence, or ground settlement. District engineers reported no seepage on many islands after flooding events on adjacent islands. However, some islands have reported increases in seepage after such flooding (HLA 1991, Holmes pers. comm.).

Hultgren Geotechnical Engineers collected baseline groundwater data from 34 piezometers between 1989 and 1997 on islands adjacent to the DW islands. As seepage through the deep aquifer increases and decreases, groundwater levels within the aquifer will rise and fall accordingly. Thus, measuring preproject and during-project groundwater levels provides the most reliable indicator of changes in seepage through the aquifer (see Appendix D1 for an annotated bibliography of geotechnical reports prepared for the DW project from 1989 through 1994).

Settlement. Typical levees on Delta islands consist of a layer of fill, about 10 feet thick, composed mostly of sand with some peat and clay. The fill is underlain by peat and soft clay, which in turn is typically underlain by sand, silt, and clay (HLA 1989). The peat and soft clay foundation materials are highly compressible and create continual settlement problems for Delta island levees, including the proposed project levees.

Wind and Wave Erosion. The DW project islands are subject to varying erosional effects from wind-generated waves, channel flows, and tidal action. Exterior levee slopes on the DW project islands are constructed with erosion control material (e.g., riprap) to counter wind and wave erosion.

Subsidence. If current DW agricultural practices continue, the surfaces of the DW islands will decline roughly 6-10 feet over the next 50 years, assuming peat layers are at least 10 feet thick (HLA 1989). Table 3D-2 shows DWR's (1982) estimates of projected island bottom subsidence in 50 years. Island bottom elevations below sea level are predicted to subside 16-18 feet between 1982 and 2032. If the existing levees are maintained and built to greater heights to compensate for the subsidence, hydrostatic pressures on the DW project levees would increase and greatly increase the risk of seepage and levee failure.

Seismicity. No active faults are known to pass beneath the DW project islands, although the islands are within the zones of influence of several active faults. The major active fault systems and their distances west of Webb Tract are the Concord-Green Valley (22 miles), Calaveras (27 miles), Hayward (37 miles), Rodgers Creek (43 miles), San Andreas (54 miles), and Vacaville/ Winters (26 miles) fault systems (HLA 1989). The Midland fault passes near the western edges of Holland and Webb Tracts but is not considered to be active (DWR 1982).

Flood Control System

Existing System in the Delta

Levee systems throughout the Delta are either federal "project levees" or "nonproject levees". Project levees within the Delta are maintained to federal Corps standards by the State of California or by local landowners under state supervision. Nonproject levees are defined as levees constructed and maintained by local landowners and reclamation districts and constitute about 65% of levees in the Delta flood control system (DWR 1982). Federal and state agencies have no jurisdiction over nonproject levees and cannot require maintenance of these levees. Maintenance of nonproject levees is largely financed by landowners to widely ranging and less stringent standards than are applied to project levees.

Nonproject levees are maintained, repaired, and upgraded by local reclamation districts according to the state's Flood Hazard Mitigation Plan for the Delta. The Delta Flood Protection Act of 1988 increased the financial assistance to Delta reclamation districts responsible for maintaining nonproject levees. The Delta Flood Protection Act of 1988 authorized $12 million annually between fiscal years 1988–1989 and 1998–1999, with the money to be split between supplementing local revenues and funding special levee projects in the western Delta and flood protection for Walnut Grove and Thornton. The Delta Flood Protection Act also focused on protecting and enhancing the fish, plant, and wildlife resources of the Delta. Under the Delta Flood Protection Act, no project receiving funding from the act can result in a net long-term loss of riparian, fishery, or wildlife habitat, and a DFG finding to that effect must be issued before funds are disbursed.

Financing of the Levee System

Costs of maintaining and repairing the levee system in the Delta are substantial (DWR 1982, 1993). State and local governments have invested millions of dollars in the past 10 years to maintain and repair eroded levees. In some instances, the expenditures exceeded the appraised value of the island or tract being protected. The average annual cost of levee maintenance on nonproject levees in the Delta ranged from $3,000 to $165,000 per levee mile, averaging $11,800 per levee mile between 1981 and 1991 (DWR 1993).

Beginning in 1988, state cost-sharing was increased to 75% of costs exceeding $1,000 per mile under the Delta Levee Rehabilitation Act of 1988. Under the 75% cost-share proportion established by the Delta Levee Rehabilitation Act, the state cost could increase to approximately $170,000 per year, or $8.5 million over 50 years if projected based on experience from 1981-1991. This cost is approximately twice current costs.

The Delta Flood Protection Act provided $60 million over a 10-year period to control subsidence and rehabilitate levees on eight western Delta islands. Subsidence makes levees more difficult to maintain because of greater hydrostatic pressure and is most directly controlled through elimination of agricultural cultivation of peat soils. (DWR 1988.)

Local Reclamation Districts

Landowners throughout the Delta, including those on the DW project islands, have organized into local reclamation districts to reclaim and protect lands from overflow. Generally, each landowner has one vote per $1 of assessed value of taxable land and improvements. Typically, each district is governed by a board of three trustees. The districts finance levee maintenance work by assessments on protected landowners.

Flood Control System for the DW Project Islands

Existing System. The four DW project islands are completely bounded by nonproject levees. On Webb Tract, the nonproject levee along the San Joaquin River on the north side of the island borders the Stockton ship channel and is classified as a "direct agreement" levee. The Port of Stockton has assured the federal government that this and other direct agreement levees will be maintained. The federal government will repair damage to this levee resulting from wave wash from large ships (DWR 1982).

Financing. During 1980-1986, over $36 million of federal, state, and local reclamation district money was spent on emergency levee repairs on the DW project islands (Table 3D-3). Approximately 85% of this money was spent on Holland and Webb Tracts, where major levee breaks occurred in 1980. During 1981-1986, $1,362,000 was spent on levee maintenance work on the four DW project islands (Table 3D-3). Approximately 40% of this maintenance cost was reimbursed by the state under the Delta Levee Maintenance Subventions Program. During this period, up to 50% of maintenance costs exceeding $1,000 per mile of nonproject levees was reimbursable under the subventions program.

Emergency repair and maintenance costs for nonproject levees on the DW project islands totaled about $37 million over the periods shown in Table 3D-3. Of this total, approximately 95% was state or federal public money; only about 5% was raised by reclamation districts through assessments of landowners within their jurisdiction. As part of the Delta Flood Protection Act West Delta Islands Program to meet the water quality objectives for the Delta, Holland and Webb Tracts can receive funding for subsidence control and levee rehabilitation.

Local Reclamation Districts

Bacon Island. Levees on Bacon Island are maintained by Reclamation District No. 2028. The reclamation district engineer inspects the island levees in spring and fall or when levee problems are reported by the local landowners. The district engineer generally specifies, supervises, and coordinates any required levee repair or rehabilitation. Levee maintenance can be performed by the reclamation district at any time during the year and can include vegetation control, road maintenance, and the raising of levees that have subsided (Sinnock pers. comm.). The materials used for levee reconstruction on Bacon Island have been primarily dredged from adjoining channels.

The levees are maintained to reclamation district standards requiring top widths of 20 feet, exterior levee slopes of 2:1, and interior slopes of 4:1 (Sinnock pers. comm.). The minimum top width prescribed in DWR Bulletin 192-82 (DWR 1990) and Corps bulletins is 16 feet, but accepted practice in the Delta is to require 20-foot top widths to allow equipment maneuvers and car passage.

Webb Tract. Webb Tract levees are maintained by Reclamation District No. 2026. The levees are inspected approximately twice each year by the reclamation district engineer or more often in response to local alert. The reclamation district engineer specifies, supervises, and coordinates levee rehabilitation work. The reclamation district and landowners maintain all levees, including those along the Stockton ship channel, where bank protection against wave wash is under federal jurisdiction (Kjeldsen pers. comm.). The materials used for levee reconstruction on Webb Tract were primarily dredged from adjoining channels. Borrow areas were developed on Webb Tract in 1990 and have since been used as the primary source of fill material to improve the levees. The levees are maintained to local reclamation district standards with top widths of 20 feet, exterior levee slopes of 2:1, and interior slopes of 4:1 (Sinnock pers. comm.).

Flood waters rushing through a levee breach on January 18, 1980, created the blowout pond on the east end of Webb Tract. The Corps emergency pumps were moved to Webb Tract after being removed from Holland Tract in May 1980. The Corps removed its emergency pumps and turned over the island to the local reclamation district in mid-December 1980; the district then began rehabilitating its own pumps for final drawdown. Water was not drawn down below the island bottom until February 1981 (Kjeldsen pers. comm.).

Bouldin Island. Bouldin Island levees are maintained by Reclamation District No. 756. The reclamation district engineer specifies, supervises, and coordinates any levee rehabilitation work and generally inspects the levees approximately three times each year. Materials used for levee reconstruction on Bouldin Island were a combination of dredged soils from adjoining channels and imported material from other sources. Borrow areas were developed on Bouldin Island in 1990 and have since been used as the primary source of fill material to improve the levees. Levees are maintained to local reclamation district standards of top widths of 20 feet, exterior levee slopes of 2:1, and interior slopes of 4:1. (Wright pers. comm.)

Holland Tract. Holland Tract levees are maintained by Reclamation District No. 2025 according to the same maintenance procedures and standards as those previously discussed for Bouldin Island. Materials used for levee reconstruction on Holland Tract were a combination of dredged soils from adjoining channels and imported material from other sources. (Wright pers. comm.) Borrow areas were developed on Holland Tract in 1990 and have since been used as the primary source of fill material to improve the levees.

The levee on the northern tip of Holland Tract breached on January 18, 1980. Flood waters scoured out the blowout pond now present at that location. The Corps installed emergency pumps after the breach; the pumps operated until April 25, 1980, when dismantling began. The surface water level was drawn down to the island bottom by May 5, 1980 (Wright pers. comm.).

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Impacts on levee reliability and flood control reported in the 1995 DEIR/EIS were evaluated through comparison of the levee improvement design for the DW project alternatives with conditions studied, based primarily on results of the preliminary geotechnical investigations by DW's consultants, HLA (1989) and Moffatt & Nichol (1988).

The geotechnical studies included field investigations, monitoring, modeling, and levee stability analyses for the DW project islands. Potential effects on levee stability and the flood risk that could exist during project construction or operation were identified. HLA assisted DW in development of project design and operation measures that would reduce or eliminate those potential effects. DW incorporated these measures into design of the DW project alternatives. Therefore, the DW project includes measures that avoid or reduce significant impacts relative to flood control. Appendix D1 is an annotated bibliography of the geotechnical studies performed for this project.

The methods used to evaluate levee stability and seepage for the 2000 REIR/EIS are described below in the sections before the 1995 DEIR/EIS was prepared from the 2000 REIR/EIS entitled "Seepage Analysis Methodology" and "Methodology Used for the Levee Stability Analysis". Appendix H of the 2000 REIR/EIS provides more detailed information about the independent analysis of levee stability and seepage issues performed by URS Corporation (URS) for the 2000 REIR/EIS.

The impact analysis for flood control impacts is based on the preliminary levee design described below. The levee stability analysis assumed the maximum levee cross section described below. Variation from the preliminary design may require supplemental levee stability analysis, and if results of the new analysis differ significantly from the existing results, supplemental environmental review may be required prior to final approval of the levee design.

There is a potential of some level of continuing subsidence on the DW project islands, even with the cessation of farming activities. As a result, the water storage capacity of the reservoir islands could increase in future years. The rate of subsidence, however, would be substantially less than under existing conditions. Reduced rates of subsidence and increased water storage capacity on the reservoir islands would not be expected to substantially increase or decrease levee stability analyzed in this chapter.

Criteria for Determining Impact Significance

An alternative is considered to have a significant impact on flood control if it would:

- decrease levee stability on the DW project islands during project construction,
- induce additional seepage on adjacent islands when compared to no-project conditions,
- substantially decrease regional supplies of levee material,
- decrease long-term levee stability on the DW project islands below long-term stability under existing conditions, or
- increase risk of cumulative levee failure and flooding in the project vicinity.

An alternative is considered to have a beneficial impact on flood control if it would increase long-term levee stability on the DW project islands or reduce the cumulative risk of levee failure in the project vicinity.

Additional criteria were included in the 2000 REIR/EIS analysis; see the section below entitled "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS".

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands) and management of Bouldin Island and Holland Tract (habitat islands) primarily for wetlands and wildlife habitat. The reservoir islands would be managed primarily for water storage, with wildlife habitat and recreation constituting secondary uses. The impacts of Alternative 1 on flood control in the project area are described below.

Flood Control Features

Bacon Island and Webb Tract

The exterior levees of the DW reservoir islands, Bacon Island and Webb Tract, would be improved to bear the stresses and erosion potential of interior island water storage and drawdown. Water would be stored on the islands to a maximum elevation of 6 feet above sea level. This storage elevation is subject to a number of constraints, including, but not limited to, water availability, seepage monitoring, and DSOD regulations. The DW project's design, construction, monitoring, and maintenance measures to address flood control are detailed below.

Levee Design. Under Alternative 1, the exterior levees of the reservoir islands would be improved. A typical improved levee would have a 2:1 exterior (water-side) slope, a crest about 22 feet wide (including the thickness of erosion protection on the interior slope) at an elevation of about +9 feet, a 3:1 or steeper initial interior slope down to an elevation near -3 feet, and wide toe berms to buttress the levee. Alternatively, the interior slope may be inclined at about 5:1 and be without toe berms. Figure 3D-2 shows examples of potential initial levee improvements on levees with a 3:1 existing interior slope. The initial levee crest would be constructed approximately 8 feet wider than the long-term planned width (22 feet) to accommodate settlement and to allow for future levee raising. (HLA 1993.) The new slopes would meet or exceed criteria for Delta levees outlined in DWR Bulletin 192-82.

During final design, the range of existing conditions, including various existing slope inclinations and thickness of peat, would be checked. Each levee section with a different soil condition or levee geometry may require a slightly different toe berm thickness and slope. During final design, consideration will be given to steepening the upper portion of the interior slopes to inclinations of between 2:1 and 2.5:1. A slightly steeper slope may reduce the amount of new fill required and limit both settlement and the potential for cracking.

Erosion Protection in Levee Design. The interior slopes of perimeter levees would be protected from erosion by conventional rock revetment similar to existing exterior slopes or other conventional systems, such as soil cement or a high-density polyethylene liner. The erosion protection would be sized to withstand design storms with a 50-year return period (Moffatt & Nichol 1988). There exists only a 2% chance of a 50-year severe wind event occurring in any year.

Moffatt & Nichol Engineers, in its September 1988 report to DW, gave a preliminary assessment of the effect of winds and waves on levees. For final levee design, DW would evaluate the expected waves along each section of the interior levees of the reservoir islands, considering fetch, angle of incidence, wind speed and duration, and depth of reservoir. Riprap or other suitable erosion protection measures would be sized for each section of interior levee slope based on these studies. In areas where final design studies indicate that wave splash and runup could potentially erode the levee crest if it is unprotected, the levee crest would be hardened or the erosion-protection facing would be extended up as a splash berm. Frequent monitoring of levee conditions conducted during and after the construction phase of the DW project is described below.

Project Features to Control Seepage. Interceptor wells would be installed in the exterior levees of the reservoir islands in those locations where substantial seepage to adjacent islands is predicted to occur (Figure 3D-3). The system would not be installed along noncritical sections of levee, such as the south side of Webb Tract bordering Franks Tract. The interceptor wells would be installed prior to diversions of water to the islands and filling of the reservoirs. As the reservoirs are filled, water would be pumped from the interceptor wells into the reservoirs. The interceptor wells would be pumped sufficiently to maintain the hydraulic heads at distances of 500-1,000 feet from the project island perimeters (i.e., beneath levees of adjacent islands) within existing conditions as determined by the results of background seepage monitoring described below. Relief wells and other alternative methods of seepage control may be substituted for or used to augment the interceptor well system during final design.

Because of the potential for increased seepage to adjacent islands, DW has undertaken an extensive program to document existing locations and amounts of seepage. DW, working with the Central Delta Water Agency, formed a Seepage Review Committee representing reclamation districts and their district engineers on islands surrounding the DW project islands. Committee members reviewed their records on historical seepage problem areas to suggest monitoring locations.

Identified purposes of the Seepage Review Committee are to:

- provide a line of communication from DW to reclamation districts on adjacent islands and the Central Delta Water Agency through district engineers;
- inform the reclamation district engineers about significant technical issues that could affect the adjacent islands; and
- review and provide comments on DW's proposed plan and findings related to seepage issues to DW, reclamation districts, and the Central Delta Water Agency.

HLA, under contract to DW, designed and implemented a groundwater monitoring program to document preproject seepage patterns. By January 1992, 34 piezometers had been installed on 17 islands in the Delta (HLA 1992b). Hultgren Geotechnical Engineers continued to monitor 30 piezometers through 1997. Before the end of the monitoring period, two monitoring wells on Webb Tract were damaged beyond use, and two on McDonald Island were no longer monitored because they were influenced by a relief well demonstration project (described below) and were not believed representative of background conditions. Piezometers were installed vertically through levee crowns at boring depths ranging from 36 feet below ground surface to approximately 135 feet below ground surface. Water levels were measured weekly to monitor hydraulic head in the sand aquifer. To supplement weekly manual measurements, automated data acquisition devices were used continuously for 1-2 weeks in individual piezometers to record piezometric conditions as affected by tides and flood stages (HLA 1992b).

Groundwater monitoring has shown that tidal fluctuations in nearby Delta channels affect groundwater levels in baseline piezometers. Daily groundwater fluctuations in individual piezometers range from 0.5 foot to 3 feet (HLA 1992b).

Seepage Monitoring Program. A seepage monitoring program would be implemented to provide early detection of seepage problems caused by the project. Seepage monitoring would use the piezometer readings on islands adjacent to the reservoir islands, infrared aerial photography, weir monitoring, visual inspection, and other methods as appropriate. The seepage monitoring program would quantify and document seepage impacts as the basis for appropriate mitigation and compensation measures. Diversions of water onto the DW project islands would continue only if seepage to adjacent and neighboring islands does not increase beyond existing conditions or if increases can be effectively mitigated.

Piezometer Monitoring. To monitor seepage caused by project operations, daily mean water levels for individual piezometers and groups of three or more piezometers on islands adjacent to DW project islands would be compared with seepage performance standards described below. The piezometers on neighboring islands are also referred to as "seepage monitoring wells". In addition to the 34 baseline piezometers, additional piezometers are proposed for locations 1 or more miles from perimeters of the DW project islands to determine variations in groundwater levels that are not attributable to the project (HLA 1992a). These additional piezometers are also referred to as "background monitoring wells".

Recommended locations of the proposed piezometers for Alternative 1 are shown in Figure 3D-3. A piezometer spacing of 1,500 feet to 2,000 feet on neighboring islands would closely monitor a continuous aquifer that underlies both a DW project island and a neighboring island. A minimum spacing of 1,000 feet would be used for critical seepage risk locations, and a maximum spacing of about 4,000 feet would be used in other areas. The spacing of monitoring piezometers will be influenced by the character of the underlying aquifer and the distance from the DW reservoir island.

Cooperation from neighboring reclamation districts and landowners would be needed for DW to install monitoring piezometers and periodically access them to download data from the devices. If, for some reason, an adjacent reclamation district or landowner would not allow piezometers to be placed over a long stretch of levee on their property, DW would place several piezometers on the DW reservoir island levees to monitor groundwater levels. Based on that information, DW would maintain the average groundwater level beneath the reservoir levee near historical levels.

Pressure transducers (instruments that detect fluid pressure and produce electrical signals related to the pressure) connected to electronic data loggers (to record the electronic signals) would be installed in each piezometer at least 1 year before the first project filling. The data loggers would be programmed to measure groundwater levels at least once per hour, and the readings would be averaged to compute a daily mean for each piezometer (HLA 1992a). Water level measurements taken concurrently in sloughs and rivers near the DW project islands also would be recorded.

Seepage Performance Standards. DW developed the following recommended performance standards to be used during filling and water storage periods to determine net increases in seepage caused by the DW project (HLA 1992a). The recommended seepage performance standards were approved by the Seepage Review Committee. The seepage performance standard for individual piezometers is 1 foot above two standard deviations of the previous year's background groundwater data for that location; the standard for a group of three or more piezometers is 0.25 foot above two standard deviations of the previous year's data for that group. These standards would be evaluated by comparison with data collected from background seepage monitoring activities. Using this comparison, net seepage increases caused by the project could be detected within approximately 1 week (Hultgren pers. comm.).

Hypothetical patterns of seepage relative to performance standards for individual piezometers are presented graphically in Figure 3D-4. This figure illustrates three scenarios: no seepage increase (Case I), a seepage increase that is not attributable to the project (Case II), and a seepage increase that is caused by the project (Case III). Mean water levels in individual piezometers surpass the seepage performance standard in Case II; however, mean water levels in background piezometers show a corresponding increase, indicating a regional seepage increase not caused by the project (Figure 3D-4). The seepage increase in individual piezometers in Case III is attributable to the project because background piezometers do not show a corresponding increase (Figure 3D-4).

It was assumed that final seepage performance standards will be set by SWRCB in consultation with the local reclamation districts governing adjacent islands, the technical review group described below, and DWR.

Evaluation of Monitoring Information. DW has proposed the continuation of a technical review group, similar to the Seepage Review Committee, to work with DW and its engineers to jointly evaluate any seepage increases caused by the project and cooperatively review appropriate corrective actions. During diversions, DW would submit biweekly reports describing the results of seepage monitoring to the technical review group, SWRCB, and DWR. If seepage exceeds performance standards, additional diversions of water would be halted, the technical review team would be informed, and remedial actions described below would be implemented. The committee would be informed and DW would implement one or more of the seepage control measures described below. Water diversions would not be restored until seepage monitoring indicated that seepage levels are not exceeding the performance standards. DW would also submit quarterly seepage reports summarizing the results of ongoing seepage monitoring.

Remedial Measures to Control Seepage. If seepage monitoring detects seepage caused by the project that exceeds the seepage performance standards, DW would undertake appropriate measures to reduce the seepage to preproject levels. These measures may consist of installing additional interceptor wells or other available measures described below.

One potential method for controlling seepage is implementation of a relief well program. A relief well is a well that drains a pervious soil layer to relieve seepage. A relief well program for Alternative 1 would consist of relief wells installed at regular spacings near the toes of existing levees on neighboring islands. Discharge elevations for the relief well system would be set to maintain water levels within historical levels to control subsidence rates. (HLA 1992a.)

The effectiveness of relief wells in controlling seepage was tested in the McDonald Island drawdown demonstration study, conducted by HLA under contract to DW (HLA 1990a). This investigation sought to demonstrate that groundwater head in a sand aquifer can be lowered using a groundwater relief well system and that such a system is a viable option for controlling seepage caused or increased by the proposed project. Results from the McDonald Island drawdown demonstration indicate that dewatering was effective in controlling essentially all seepage through the sand aquifer into the island and that a gravity flow relief system can control hydraulic head in the sand aquifer within a desired range by adjusting the discharge head level (HLA 1990a, b).

Relief wells would provide neighboring reclamation districts and landowners with benefits unrelated to the DW project. In addition to providing valuable reclamation capabilities on neighboring islands, relief wells can reduce the risk of levee instability as subsidence continues (HLA 1992a).

The effect that increased seepage may have on levee stability can also be offset through construction of toe berms with an internal drainage system on neighboring islands. Berm construction would depend on the agreement of the affected landowner and the reclamation district. Other measures may be more feasible where an agreement cannot be reached.

Other technically feasible seepage control measures include lowering the design pool elevation on the DW reservoir islands, developing wetland easements adjacent to levees on neighboring islands, purchasing farmlands affected by increased seepage, constructing a combination of seep and interior ditches and increasing pumping rates, installing clay blankets, and installing impervious cutoff walls through project island levees.

Siphon and Pump Station Erosion Control Measures. Facilities needed for the proposed water storage operations include intake siphons to divert water into the island interiors and pump stations to discharge the stored water from the islands. A new intake siphon complex and a new discharge pumping station would be constructed on the reservoir islands. (See locations in Chapter 2, Figures 2-2, 2-3, 2-7, and 2-8).

Because flow velocities could cause erosion at the interior toes of the newly reconstructed levees, expansion chambers are proposed for the siphon outlets and pump outlets (see siphon and pump designs in Appendix 2, Figures 2-2 and 2-5). These chambers would dissipate exit flow energies, decrease the exit velocities onto the island interiors, and prevent erosion to the interior levee toes.

The outlets from the proposed pump stations would discharge underwater on the channel side of the levees. The discharge velocities from the pump outlets would not exceed 5 feet per second when water is entering the Delta channels. Exit velocities would be reduced to this level by an expansion chamber fitted to the end of each discharge pipe. Additionally, rock riprap would be placed around the outlets where necessary to protect the embankments and dissipate energy. Velocities at the intake ends of the siphons would not cause erosion to the exterior channel sides of the levee embankments.

Construction Techniques. Placing levee construction materials on soft or poorly consolidated foundation soils can lead to rapid compression, slumping, and ground heave. To control these problems during construction, the toe berm fill will be started prior to fill being placed on the slopes or levee crest. After the toe berm has been installed, the slope and crest fills may be completed. The first fill placement would be no more than 5 feet thick on peat or clay substrates and no greater than 8 feet thick on sand substrate. These placement limits would allow pore pressures in foundation materials to dissipate and would permit monitoring of the existing levees with piezometers as construction proceeds (HLA 1989).

Peat foundation materials are expected to consolidate and pore pressures are expected to dissipate quickly after the first placement of fill (HLA 1989). The fill on the crest would be allowed to remain in place as long as possible prior to placement of the road surface; this will allow some settlement and minor grading to occur prior to completion of the levee road.

The second placement could be possible within a few months of the first. As the peat foundation material consolidates, permeability and rates of pore pressure dissipation would decline, and the interval between fill placements may increase. On clay or clayey peat materials, pore pressure would dissipate more slowly, and many months may be needed between fill placements (HLA 1989).

DW constructed a levee test section (a section of levee built to determine its stability characteristics) on Bouldin Island away from existing levees. The test section was brought to failure so that strength and behavior of foundation materials could be evaluated. The test section was constructed using conventional construction equipment (i.e., scrapers). Fill was placed until failure occurred, while measures of pore pressure, shear strength, and settlement were made. Strength of foundation materials was determined through back-calculation of the stresses when failure occurs and then evaluation of lateral deformation, cracking, and settlement. Results from the test section will be used during the final design phase for the DW project to determine safe rates of levee construction. Results of the test on Bouldin Island are described in the Wilkerson Dam report (HLA 1992b).

Construction Monitoring. DW engineers would monitor rates of settlement, consolidation, and strength gain during the levee reconstruction process. Piezometers and other equipment used to determine settlement (e.g., settlement plates and slope inclinometers) would be installed prior to construction near existing levees where they are unlikely to be damaged by construction activity. If monitoring detects levee stability problems, construction would be halted until the problem is corrected or compensated for through modification of designs or procedures.

Sources of Levee Materials. Materials needed to improve the existing levees would be obtained primarily from sand deposits within the interiors of the islands. Some peat may also be mixed with sand dredged for reconstructing the levees. Analyses performed on 66 sand samples from the island interiors indicated that sands on all project islands are suitable for use as levee fill (HLA 1989).

Supplies of suitable sand deposits for levee construction exist on all the DW project islands (HLA 1989). Sand frequently lies beneath layers of soft peat approximately 10-15 feet deep, which must first be removed from the borrow areas. The 1995 DEIR/EIS reported that the borrow pits would generally be more than 400 feet inward from the top of a levee to avoid structural impacts on the levee and at least 2,000 feet inward from the final toe of an improved levee where seepage restrictions are required. Additional analysis completed for the 2000 REIR/EIS indicates that borrow pits should be located at least 800 feet from the levee in areas of potentially high seepage; see the section below from the 2000 REIR/EIS entitled “Adequacy of Borrow Area Setbacks”.

It is anticipated that rock revetment would be quarried from either the Dutra-McNeer quarry or the Basalt quarry of Syar Industries. Both of these quarry operations are presently ongoing. Riprap material would be barged from the quarry to the construction site (see Chapter 3L, “Traffic and Navigation”). Levee construction under Alternative 1 would require approximately 470,000 tons of rock for Bacon Island

and 405,000 tons of rock for Webb Tract (Forkel pers. comm.).

Postconstruction Monitoring and Maintenance. Reconstructed exterior levees would be maintained for the life of the project. Maintenance activities for the reservoir island levees and their erosion protection would include the following measures.

- DW will conduct a weekly inspection of the levees to check for surface erosion, slumping, tension cracking, damaged erosion protection, seepage, and encroaching vegetation. Results of weekly monitoring inspections would be submitted to the governing local reclamation district and DWR for review and to SWRCB for permit compliance.

- If weekly inspections indicate erosion, cracking, or seepage problems, DW will implement corrective actions, including, but not limited to, placement of fill material; placement or installation of erosion protection material; reshaping or grading of fill material; herbicide application; selective burning; and/or installation of relief wells, toe berms on adjacent islands, or other seepage control measures described below.

- Tall grasses, brush, and/or trees will be kept cleared from the levee crest, slope, and stability berm.

- Areas of erosion will be repaired through replenishment of the protective cover as needed.

- The road surface will be regraded and/or patched as required for all-weather accessibility.

- Levee profile surveys will be conducted by DW annually for the first 5 years of operation and triannually thereafter. Results of levee profile surveys will be submitted to DWR, SWRCB, and the Corps for review.

- The levee crest will be raised by the addition of fill to maintain the crest at or above DWR Bulletin 192-82 criteria, additional erosion protection will be placed to protect the added fill, and the all-weather road surface will be reestablished after the fill is placed.

Wave Erosion Protection, Monitoring, and Maintenance Program. A weekly visual inspection of levees would be conducted by DW to ensure that erosion protection materials are not eroded beyond 50-year storm design criteria. Results of visual inspections would be included in DW's quarterly report to the local reclamation districts and DWR. If visual monitoring indicates that erosion is occurring more rapidly than anticipated during design analysis, corrective action will be taken immediately. Corrective actions include, but are not limited to, installing wave protection barriers, increasing erosion protection placement, and/or lowering reservoir water levels (HLA 1992c). Appropriate corrective action to ensure protection of the levee crest would be determined in the field based on conditions encountered.

Bouldin Island and Holland Tract

Under Alternative 1, Bouldin Island and most of Holland Tract (3,014 acres) would be devoted to wildlife habitat. On the habitat islands, the existing levee system would be improved to meet state-recommended standards for Delta levees identified in DWR Bulletin 192-82. The interior slope faces and toe berms of the perimeter levees would be planted with grass to resist erosion from rainfall and would be maintained in a manner similar to current practices. Levee tops would be modified to accommodate construction and operation of recreation facilities. The recreation facilities would be constructed on a raised pile foundation interior of the center line of the levees and would not require levee improvements beyond those currently required. As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications; nevertheless, the analysis of impacts on levee stability and seepage associated with construction and operation of these facilities is provided in this chapter. Routine maintenance activities on perimeter levees would not differ from current practices and would include, but are not limited to, placement of fill material and gravel, reshaping of fill material, grading, discing, mowing, selective burning, rodent control, and installation of rock revetment.

Changes in Flood Control Conditions

Bacon Island and Webb Tract

Settlement during Construction. DW's proposed material placement procedures, use of the levee test section, and construction monitoring program would contribute to adequate levee reliability. Levee stability analyses by HLA (1989) calculated safety factors during construction of the proposed DW levee improvements. Adequate safety factors were calculated if lifts of fill did not exceed 5 feet until sufficient time was allowed for consolidation and strength gain in foundation materials. As proposed, levee reconstruction on the DW project islands would be staged over several years to allow time for consolidation of foundation materials. Therefore, reconstruction of reservoir island levees would not affect levee stability during construction.

The 2000 REIR/EIS levee stability analysis also evaluated postconstruction levee conditions; see the section below from the 2000 REIR/EIS entitled "Results of the New Analysis of Delta Wetlands Project Effects on Levee Stability".

Settlement and Long-Term Levee Stability. Reconstruction of levees by DW would cause compression of substrates and settlement of the new levees. Extent of settlement would vary both with thickness of fill and with peat thickness below the fill.

HLA estimated depths of settlement resulting from fill placement in an area directly underlain by 20 feet of peat. If fill is added up to an elevation of 15 feet above the initial ground surface and then is continuously placed as the ground settles (keeping the surface of the fill 15 feet above the original ground elevation), 15 feet of settlement is predicted. This condition would result in the thicknesses of the underlying peat compressing from 20 feet to 5 feet. The total thickness of the fill would be 30 feet: the initial 15 feet of fill thickness plus another 15 feet placed over time to maintain the top elevation of the fill as the fill mass settles. (HLA 1989, Hultgren pers. comm.) Approximately one-half of the estimated settlement would occur within 2-3 months after fill placement, one-quarter of the settlement would occur within 3 years, and the remaining one-quarter would occur over the next 30-50 years (HLA 1989). Figure 3D-5 shows examples of settlement of initial fill (the initial fill profile is shown in Figure 3D-2) and the additional fill required to raise the levee crest.

Differential settlement can create tensions in the soil, resulting in cracks parallel to the existing levee. Cracking may also occur where the reconstructed levee joins with an existing levee, where levees cross subsurface peat or clay-filled channels, or where new interior levees abut existing levees. These factors differ for each site on the DW project islands and would be investigated in detail before construction begins and before settlement monitoring locations are chosen. Monitoring and maintenance of levees as described above would quickly detect any cracking problems and replenish fill material where cracking occurs.

Differential settlement caused by levee reconstruction may also affect existing levees. Any cracking of the existing levees caused by levee reconstruction would be mitigated by placement of sand against the inside of the existing levees. Movement of soil from levee cracks or water seeping through cracks would be slowed by the fill and would be monitored for subsequent maintenance needs, including placement of additional fill or implementation of erosion control measures.

Stability analyses by HLA (1993) calculated that under Alternative 1, levee reconstruction would increase the factor of safety for levee stability 14%-28% (depending on levee slope design) over existing conditions. The inward (toward island interior) factor of safety would increase immediately after construction and continue to increase as the peat foundations consolidate and gain strength under the weight of new fill. The outward (toward Delta channels) factor of safety would decrease about 10% when the reservoir is full, but the margin of safety would still be greater than that computed for existing conditions. There is a slight decrease in the factor of safety calculated for the exterior levee slope when the reservoir is full because the island would be filled to 6 feet above the channel water levels. However, the consequence of a levee breach would be much less when the island reservoir is full or partially full than when the island is empty, as it is now, because improved DW project levees are more likely to minimize the size of a levee breach if one occurs and because the hydraulic head between the channel water level and reservoir water level (approximately 6 feet) would be less than the existing head between the channel water level and island interiors (16-18 feet) (HLA 1993). Therefore, the existing conditions pose a higher risk to levee stability than the levee configurations under Alternative 1.

The independent evaluation of levee stability included in the 2000 REIR/EIS verified that levee improvements would increase the factor of safety (FS) toward the reservoir islands when compared to the existing conditions. However, the long-term FS toward the slough would decrease when compared to existing conditions. See "Results of the New Analysis of Delta Wetlands Project Effects on Levee Stability" below.

In conclusion, levee settlement or instability is not predicted to adversely affect levee reliability because the proposed initial placement of fill would be staged over several years until sufficient levee heights are reached, and because the proposed annual maintenance program would replenish the levee slopes with new fill to compensate for settlement. Any diminishing of levee height or cracking would be corrected annually. Levee stability analysis indicates that implementing Alternative 1 would improve levee stability and safety factors toward the reservoir islands, but would decrease levee stability and safety factors toward the adjacent slough.

Seepage. Dredging of material for improvements to the levees would cause exposure of subsurface sand deposits on the reservoir island interiors. Under proposed water storage operations, such exposed areas would be subject to up to 24 feet of hydraulic head. Such exposure of sand deposits has the potential to permit seepage beneath the DW project levees to adjacent islands.

An engineering model (SEEP) was used by HLA (1989) to analyze seepage potential of water storage on Webb Tract across Fishermans Cut to Bradford Island. This location was identified as being particularly sensitive because of the short seepage distance across Fishermans Cut. Fixed hydraulic levels were tested under a range of permeability conditions of soil materials to determine the effect of flooding and exposed borrow pit excavation. The model indicated that both hydraulic heads and seepage levels in sands on Bradford Island would increase as a result of flooding of Webb Tract. This analysis assumed a water storage elevation of +4 feet based on a previous project description; however, the currently proposed water storage level of +6 feet would not alter the results of the study (Tillis pers. comm.). Seepage levels would still increase on Bradford Island as a result of the proposed +6 feet water storage under Alternative 1.

Alternative 1 incorporates an interceptor well system to control seepage to adjacent islands and a seepage monitoring system described above under "Flood Control Features". The monitoring system would verify that seepage on adjacent islands is controlled at or below existing conditions and would detect the need for additional seepage control measures to be implemented. A measurable seepage performance standard based on background monitoring data to determine existing seepage conditions would be used to trigger the implementation of additional seepage control measures. The 1995 DEIR/EIS concluded that implementation of the seepage monitoring and control program under Alternative 1 would control seepage at existing conditions.

The 2000 REIR/EIS included an independent analysis of the ability of the proposed interceptor well system to control groundwater seepage, the long-term reliability of the proposed system, and the adequacy and effectiveness of the proposed seepage monitoring program. See "Results of the New Analysis of Delta Wetlands Project Effects on Seepage" below.

Wind and Wave Erosion. The proposed flooding of reservoir islands could result in wind and wave erosion of the interior levee slopes because of the long wind fetch across the islands and the water depths during water storage. Prolonged removal of levee slope material by wave erosion of the interior levee slopes could eventually affect levee reliability. Interior slopes of perimeter levees would be constructed with erosion control material (rock revetment or riprap) similar to that used on exterior levee slopes.

The erosion control measures, erosion monitoring program, and levee maintenance measures described above under "Flood Control Features" would be implemented as part of Alternative 1. Perimeter levees would be inspected weekly, and any potential erosion problems would be reported and would trigger maintenance measures, which could include placement of additional rock revetment, replenishment of fill, or lowering of pool elevations.

The 2000 REIR/EIS also included an independent analysis of wave runup to evaluate the reservoir island levees' freeboard and erosion potential. The analysis concluded that wave runup would not result in substantial erosion or overtopping of the proposed levees on the reservoir islands. See the section below entitled, "Wave Runup and Erosion".

Slope Slippage during Drawdown of Stored Water. If levee soils remain saturated while external water pressure is removed, as could occur during drawdown of the reservoirs, the levee slope could become unstable. The rate of drawdown would be slow enough to allow substantial drainage of the relatively permeable slope materials (Tillis and Hultgren pers. comms.). Drawdown is considered rapid if a water level is lowered faster than the soil's ability to drain; in this case, the weight of saturated soil exceeds the stabilizing effect of water pressure against the levee embankment, which can result in slope slippage. Based on a discharge rate of 4,000 cfs, the reservoir drawdown rate could be as fast as 18 inches per day at the higher reservoir stages (Hultgren pers. comm.). This drawdown rate would not be considered rapid from this perspective (Tillis and Hultgren pers. comms.). Therefore, the possibility of slope failure during drawdown would be minimal under Alternative 1. Any interior slope slippage following drawdown would be corrected during maintenance replenishment of fill material. DW's proposed drawdown schedule would not threaten levee stability during drawdown of stored water.

See also the 2000 REIR/EIS results of the levee stability analysis for the sudden drawdown condition under "Results of the New Analysis of Delta Wetlands Project Effects on Levee Stability" below.

Erosion at Siphon and Pump Stations. High-velocity water releases at siphon and pump stations could erode levee materials. Operation of the proposed siphon and pump stations would not cause substantial levee toe erosion on interior or exterior levee slopes because the stations would be equipped with expansion chambers, which reduce flow velocities through dissipation, and rock revetment will be placed in the interiors of the islands to minimize erosion potential of the levee toe surfaces at the siphon and pump stations.

Project-Induced Seismic Activity. Although deep well water injection and reservoir flooding have been associated with triggering earthquakes, there is no evidence to support that theory in the Delta area. The presence of the Sacramento and San Joaquin Rivers and the existing flooding of Franks Tract have not increased seismic activity in the region. Creating reservoirs on Bacon Island and Webb Tract would not be likely to increase seismic risk in the Delta region.

Liquefaction and Levee Movement during Seismic Activity. The two predominant risks to Delta levees during earthquakes are liquefaction (loss of soil cohesion when subject to shaking) of poorly consolidated sands beneath levees and damage caused by movement of levees under seismic acceleration. The materials used for levee reconstruction could be subject to liquefaction resulting from seismic acceleration; however, both these risks would be reduced by the proposed buttressing of the DW project island levees. Soil borings indicate that some of the sand layers beneath the peat on the DW project islands have a potential for liquefaction, but levee reconstruction and island flooding would probably not increase nor decrease the potential for liquefaction and levee failure (HLA 1989). Because the proposed levees are broader than the existing levees and broader levees distribute seismic effects over a larger area, total levee failure caused by substrate liquefaction would be less likely with the proposed levees than with the existing levees. The buttressed project levees would have much greater mass than existing levees and may be less vulnerable to failure from seismic acceleration. The level of potential risk of levee movement under seismic shaking may be somewhat lower than many existing levels because levee stability would increase under Alternative 1.

An earthquake powerful enough to cause failure of project levees would likely destroy many of the existing weaker levees on neighboring islands. Even if they failed under seismic activity, project levees would be likely to offer some protection against wind-generated wave erosion. DW project levees would probably be more intact and more easily repaired following a breach than would other Delta levees. Thus, Alternative 1 would likely produce an overall benefit in levee protection under seismic activity.

An updated evaluation of seismically induced levee deformations was completed for the 2000 REIR/EIS; see the description of the dynamic (i.e., seismic) stability analysis under "Results of the New Analysis of Delta Wetlands Project Effects on Levee Stability" below.

Levee Fill Availability. Sources of suitable levee reconstruction material are located on the DW project islands or in existing quarries in the region. Borrow quantities for Alternative 1 are shown in Table 3D-4. It is unlikely that levee construction and improvement under Alternative 1 would deplete regional supplies of levee materials.

Bouldin Island and Holland Tract

Habitat management on Bouldin Island and Holland Tract would not decrease levee stability or require substantial amounts of levee material during project construction. A habitat type defined as "borrow pond" is included in the HMP (Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands") and would provide a source of adequate borrow material for initial construction under the project. Borrow ponds would be managed similarly to lake habitat but may be deeper than the proposed lakes and would be occasionally disturbed to facilitate extraction of borrow for long-term maintenance of the project. Any future borrow excavation for levee maintenance outside these areas would be subject to review by the HMP oversight team, but overall, habitat management on these islands would not impair long-term levee maintenance activities.

Habitat management would slow the rate of subsidence on these islands relative to subsidence rates under existing agricultural use. Therefore, implementation of Alternative 1 would increase long-term levee stability on habitat islands by decreasing subsidence.

Summary of Project Impacts and Recommended Mitigation Measures

Impact D-1: Change in Long-Term Levee Stability on Reservoir Islands. Implementation of Alternative 1 would increase levee stability on the reservoir islands toward the islands and decrease levee stability toward the slough; see the section below from the 2000 REIR/EIS entitled "Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands". This impact is considered significant.

Implementing Mitigation Measure RD-1 would reduce Impact D-1 to a less-than-significant level.

Mitigation Measure RD-1: Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure. This measure is described below in the section from the 2000 REIR/EIS entitled "Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands".

Impact D-2: Potential for Seepage from Reservoir Islands to Adjacent Islands. Implementation of Alternative 1 could increase the potential for seepage beneath the DW island levees to adjacent islands during project operation. The proposed project seepage monitoring and control measures that are detailed above are intended to control seepage at or below existing conditions. This impact which is described in the section below from the 2000 REIR/EIS entitled "Potential Seepage on Adjacent Islands Resulting from Project Operations", is considered significant.

Implementing Mitigation Measure RD-2 would reduce impact D-2 to a less-than-significant level.

Mitigation Measure RD-2: Modify Seepage Monitoring Program and Seepage Performance Standards. This measure is described below in the section from the 2000 REIR/EIS entitled "Potential Seepage on Adjacent Islands Resulting from Project Operations".

Impact D-3: Potential for Wind and Wave Erosion on Reservoir Islands. Implementation of Alternative 1 could result in wind and wave erosion of the interior levee slopes of perimeter levees on reservoir islands because of the long wind fetch across the islands and the water depths during water storage. Interior slopes of the levees would be constructed with rock revetment to prevent erosion of the interior levee slopes. The erosion control design measures, erosion monitoring program, and levee maintenance measures described above would be implemented under Alternative 1. Therefore, this impact is considered less than significant.

Mitigation. No additional mitigation is required.

Impact D-4: Potential for Erosion of Levee Toe Berms at Pump Stations and Siphon Stations on Reservoir Islands. Implementation of Alternative 1 would not cause substantial levee toe erosion at siphon and pump stations on interior or exterior levee slopes. Pump and siphon units would be equipped with expansion chambers, which reduce flow through dissipation, and routine inspection and maintenance of the levees would identify any erosion problems and include implementing erosion control measures as needed. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact D-5: Change in Potential for Levee Failure on DW Project Islands during Seismic Activity. Implementation of Alternative 1 would require strengthening and reconstructing perimeter levees on reservoir islands and improving perimeter levees on habitat islands. Existing levees on reservoir islands would be buttressed and broadened, and levees on habitat islands would be improved to meet DWR's recommended standards for Delta levees. The overall risk of levee failure caused by earthquakes is discussed below under "Potential Levee Failure on Delta Wetlands Project Islands during Seismic Activity". The change in the potential risk of levee failure is considered significant.

Implementing Mitigation Measure RD-1 would reduce Impact D-5 to a less-than-significant level.

Mitigation Measure RD-1: Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure. This measure is described below in the section from the 2000 REIR/EIS entitled "Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands".

Impact D-6: Increase in Long-Term Levee Stability on Habitat Islands. Implementation of Alternative 1 would slow the rate of subsidence on Bouldin Island and Holland Tract relative to subsidence rates under existing agricultural use. Decreased subsidence contributes to increased long-term levee stability on habitat islands. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Impacts and mitigation measures of Alternative 2 are the same as those of Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. The impacts of Alternative 3 on flood control in the project area are described below.

Flood Control Features

The exterior levees of the four DW project islands would be reconstructed as described for levee reconstruction on Webb Tract and Bacon Island under Alternative 1. The design, construction, monitoring, and maintenance measures for reservoir island perimeter levees for Alternative 3 would be as described for Alternative 1.

Alternative 3 would require interior levees to be constructed around several parcels not owned by DW: the two marina sites at the south edge of Holland Tract, and across Bouldin Island on the southern and northern sides of SR 12. The interior levee on the south side of SR 12 would be designed and constructed in accordance with standards of DWR's DSOD. Interior levee designs have been submitted to DSOD for review and approval (Hultgren pers. comm.). The levee on the southern side of SR 12 on Bouldin Island is described in Chapter 3E, "Utilities and Highways", and in Appendix E1, "Design and Construction of Wilkerson Dam South of SR 12 on Bouldin Island".

The methods of fill placement and staged construction for interior levees would be similar to those described for the exterior levees, except that fill would be compacted to DSOD standards. The DSOD levees would be protected from wind and wave erosion on the water side with a method of slope protection, potentially a high-density polyethylene surface or placement of riprap.

The DSOD levee on Bouldin Island may require a longer construction period than all other elements of the project. Borrow material from the island would be used for interior levee construction. An estimated 8,900,000 cubic yards of borrow material would be needed for the DSOD levee construction (Table 3D-5).

Changes in Flood Control Conditions

Bacon Island, Webb Tract, Bouldin Island, and Holland Tract

Settlement during Construction. Settlement impacts on the reservoir islands under Alternative 3 would be similar to those described above for reservoir islands under Alternative 1. Stability analysis (HLA 1989) indicates that levee reconstruction on the DW islands would allow time for consolidation of foundation materials and would not affect levee stability during construction.

Interior Levees. The toe of the proposed interior levee along the southern side of SR 12 across Bouldin Island would be set back from the highway to protect the roadbed from settlement problems caused by the new levee (HLA 1989). DWR's DSOD must approve the final design of this interior levee (see Chapter 3E and Appendix E1 for further detail regarding the proposed DSOD levee).

Given that DSOD must approve the design and construction of these interior levees, no increase in flooding hazard or decrease in public safety is expected to occur during project operation.

Settlement and Long-Term Levee Stability. Long-term levee stability impacts on Alternative 3 reservoir islands would be similar to those described for the two reservoir islands under Alternative 1.

Seepage. The seepage mitigation, monitoring, and control program under Alternative 3 would control seepage impacts as described for Alternative 1 but would be expanded to include Bouldin Island and Holland Tract.

Under Alternative 3, 142 more piezometers would be installed on neighboring islands than would be installed under Alternative 1. Figure 3D-6 shows the proposed interceptor well system and seepage monitoring system for Alternative 3.

Wind and Wave Erosion. The erosion control measures, erosion monitoring program, and levee maintenance measures described for Alternative 1 would be implemented as part of Alternative 3. Alternative 3 would require approximately 470,000 tons, 405,000 tons, 385,000 tons, and 400,000 tons of rock for levee improvements on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, respectively (Forkel pers. comm.). Potential erosion effects would be monitored weekly, and proposed maintenance measures would be implemented to maintain levees at conditions equal to or better than existing conditions.

Liquefaction and Levee Movement during Seismic Activity. Liquefaction effects of seismic shaking under Alternative 3 would be similar to those described above for reservoir islands under Alternative 1.

Levee Fill Availability. As under Alternative 1, sources of suitable levee reconstruction material are adequate for Alternative 3 and are located on the DW project islands or in existing quarries in the region. Borrow quantities proposed for Alternative 3 are shown in Table 3D-5.

Summary of Project Impacts and Recommended Mitigation Measures

Impact D-7: Change in Long-Term Levee Stability on Reservoir Islands. This impact is described above under Impact D-1. This impact is considered significant.

Implementing Mitigation Measure RD-1 would reduce Impact D-7 to a less-than-significant level.

Mitigation Measure RD-1: Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure. This measure is described below in the section from the 2000 REIR/EIS entitled "Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands".

Impact D-8: Potential for Seepage from Reservoir Islands to Adjacent Islands. This impact is described above under Impact D-2. This impact is considered significant.

Implementing Mitigation Measure RD-2 would reduce Impact D-2 to a less-than-significant level.

Mitigation Measure RD-2: Modify Seepage Monitoring Program and Seepage Performance Standards. This measure is described below in the section from the 2000 REIR/EIS entitled "Potential Seepage on Adjacent Islands Resulting from Project Operations".

Impact D-9: Potential for Wind and Wave Erosion on Reservoir Islands. This impact is described above under Impact D-3. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact D-10: Potential for Erosion of Levee Toe Berms at Pump Stations and Siphon Stations on Reservoir Islands. This impact is described above under Impact D-4. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact D-11: Change in Potential for Levee Failure on DW Project Islands during Seismic Activity. This impact is described above under Impact D-5. This impact is considered significant.

Mitigation. No mitigation is required.

Implementing Mitigation Measure RD-1 would reduce Impact D-11 to a less-than-significant level.

Mitigation Measure RD-1: Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure. This measure is described below in the section from the 2000 REIR/EIS entitled "Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands".

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the NEPA and CEQA lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Flood Control Features

Levee maintenance and operation under the No-Project Alternative would be the same as existing routine maintenance procedures.

Changes in Flood Control Conditions

Bacon Island, Webb Tract, Bouldin Island, and Holland Tract

Settlement and Long-Term Levee Stability. Under the No-Project Alternative, which would consist of intensified agricultural operations on the project islands, the DW island interiors would subside an additional 6-10 feet over the next 40 years (HLA 1989). Levee heights would increase as the island interiors subside. Long-term stability analyses indicate that levee reliability would decrease below existing conditions under the No-Project Alternative.

Seepage. The loss of peat through subsidence and oxidation could lead to greater infiltration and increased seepage onto the island. Seepage under the No-Project Alternative would exceed existing conditions.

Wind and Wave Erosion. Wind and wave erosion under No-Project conditions would be similar to existing erosion. The No-Project Alternative would not increase erosion on the DW project island levees.

Liquefaction and Levee Movement during Seismic Activity. Because the No-Project Alternative would decrease levee stability compared with existing conditions, the risk of seismically induced levee failures would increase.

Summary of Project Impacts and Recommended Mitigation Measures

Decrease in Long-Term Levee Stability. Implementation of the No-Project Alternative would result in increased levee heights on the DW project islands as the island interiors subside. Long-term levee stability analyses indicate that levee reliability would decrease under the No-Project Alternative. Implementing the following measure would reduce this effect of the No-Project Alternative.

Buttress Perimeter Levees. The perimeter levees of the DW project islands could be substantially buttressed to increase levee stability under the No-Project Alternative. The need for improvements to those levees over time would be evaluated by the local reclamation districts.

Increase in Potential for Seepage onto Project Islands. Implementation of the No-Project Alternative would cause the loss of peat through subsidence and oxidation on DW project islands, which could lead to greater infiltration and increased seepage onto the DW project islands.

Increase in Potential for Levee Failure during Seismic Activity. Implementation of the No-Project Alternative would decrease long-term levee stability, which would increase the potential for seismically induced levee failures.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. The following sections consider only those impacts that may contribute cumulatively to impacts on flood control on the Delta islands.

Cumulative Impacts, Including Impacts of Alternative 1

Cumulative Flood Hazard

The 2000 REIR/EIS updated the analysis of cumulative flood hazard conditions in the Delta; see the section from the 2000 REIR/EIS entitled "Cumulative Impacts" below.

Impact D-12: Decrease in Cumulative Flood Hazard in the Delta. Implementation of planned levee improvements throughout the Delta, combined with improvements on the DW project islands, would likely reduce the cumulative risk of flooding in the Delta. This impact is considered beneficial.

Mitigation. No mitigation is required.

Financing of the Levee System

Implementation of Alternative 1 would reduce the need for public financing of maintenance and repair work on the levee systems around the DW project islands. DW would continue to seek reimbursement for maintenance work on the channel sides of exterior levees. During the early 1980s, public financing of this work on the four islands exceeded $36 million, or about $5.5 million each year. Alternative 1 would have a substantial fiscal benefit at the state and federal levels. Savings would result from the project because the risk of levee failure toward the islands would be reduced, the cost of project-specific maintenance and rehabilitation work on the levees above state or federal standards would be borne entirely by DW, and the cost of reclamation would be much lower than in the case of existing Delta levees because much of the routine levee maintenance would not fall within the state or federal cost-sharing programs.

Impact D-13: Decrease in the Need for Public Financing of Levee Maintenance and Repair on the DW Project Islands. Implementation of Alternative 1 would likely reduce the need for public financing of levee maintenance and repair on the DW project islands. Savings at the state and federal level would result from project implementation because the risk of levee failure would be reduced, so the cost of reclamation would be much lower than in the case of existing levees. This impact is considered beneficial.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impacts of this alternative would be the same as those described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

Implementation of planned levee improvements throughout the Delta, combined with improvements on the DW project islands, would likely reduce the cumulative risk of flooding in the Delta. Similar to Alternative 1, Alternative 3 would also reduce the need for public financing of maintenance and repair work on the levee systems around the DW islands.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Although levee reliability on the Delta Wetlands Project islands would decline over time under the No-Project Alternative, implementation of planned levee improvements throughout the Delta would likely result in a cumulative improvement in levee conditions.

LEVEE STABILITY AND SEEPAGE ANALYSIS FROM THE 2000 REVISED DRAFT EIR/EIS

The remainder of this chapter includes the levee stability and seepage analysis that was conducted for the 2000 REIR/EIS. This information, which was presented as Chapter 6, "Levee Stability and Seepage", in the 2000 REIR/EIS, has been modified slightly from the 2000 REIR/EIS version in response to comments received on the 2000 REIR/EIS. However, those minor changes do not change the conclusions of the analysis.

FOCUS OF THE 2000 REVISED DRAFT EIR/EIS ANALYSIS

Chapter 6 of the 2000 REIR/EIS presented information, developed since the 1995 DEIR/EIS was published, on potential Delta Wetlands Project effects on levee stability and seepage. The 1995 DEIR/EIS described Delta Wetlands' proposed preliminary levee design and seepage control system; that system includes operational measures developed by Delta Wetlands to avoid or reduce potential effects of project construction and operation on levee stability and use of adjacent islands for agriculture. In response to testimony presented at the Delta Wetlands water right hearing, the lead agencies determined that new information should be presented in the 2000 REIR/EIS to augment the evaluation presented in Chapter 3D, "Flood Control", of the 1995 DEIR/EIS.

Delta Wetlands' Proposed Levee Design and Seepage Control System

As described above, Delta Wetlands proposes to improve the levees surrounding the reservoir islands. Under existing conditions, levee conditions are greatly variable. A typical present levee condition is a 20-foot-wide crest at an approximate elevation of +8.5 feet above mean sea level with an exterior (water-side) slope of 2:1 (horizontal to vertical) and an interior (land-side) slope of 4:1. Under the proposed project, a typical improved levee would have an exterior slope of 2:1, a crest about 22 feet wide (including the thickness of erosion protection on the interior slope) at an elevation of about +9 feet, a 3:1 or steeper initial interior slope down to an elevation near -3 feet, and wide land-side toe berms to buttress the levee. Alternatively, the interior slope may be inclined at about 5:1 and may not have toe berms. Figure 3D-2 shows examples of potential initial levee improvements on levees with a 3:1 existing interior slope. The new slopes would meet or exceed criteria for Delta levees outlined in DWR Bulletin 192-82. Levee-improvement materials would be obtained primarily from sand deposits on the project islands. Each borrow area would generally be located more than 400 feet inward from the toe of a levee so that the borrow excavation would not cause structural impacts on the levee and would be at least 2,000 feet inward from the final toe of an improved levee where a greater setback is necessary to control seepage.

The interior slopes of these perimeter levees would be protected from erosion by conventional rock revetment similar to that used on existing exterior slopes, or by other conventional systems such as soil cement or a high-density polyethylene liner. In areas where final design studies indicate that wave splash and runup could potentially erode the levee crest if it is unprotected, the levee crest would be hardened or the erosion-protection facing would be extended up as a splash berm.

The proposed project includes a seepage-control system that would consist of interceptor wells installed in the exterior levees of the reservoir islands in locations where substantial seepage to adjacent islands through subsurface materials is predicted to occur (Figure 3D-3). Water captured by the interceptor wells would be pumped back into the reservoirs. The interceptor wells would be used to maintain the hydraulic heads in subsurface materials within preproject ranges at distances of 500 to 1,000 feet from the project island perimeters (i.e., beneath levees of adjacent islands). Relief wells and other alternative methods of seepage control may be substituted for or used to augment the interceptor well system during final design.

Delta Wetlands would implement a seepage monitoring program to provide early detection of seepage problems caused by project operations. A network of wells (i.e., piezometers) located immediately across the channels from the reservoir islands would be used to monitor seepage; background wells at distant locations would establish water-level changes that typically occur without project operations. Delta Wetlands has proposed seepage performance standards for the project that would be used to determine the amount of interceptor-well pumping needed to ensure that seepage is reduced to acceptable levels. The seepage-control system and seepage performance standards are described in more detail under "Project Features to Control Seepage" above.

1995 Draft EIR/EIS Evaluation, Comments, and New Information

1995 Draft EIR/EIS Evaluation

The evaluation of project effects presented in the 1995 DEIR/EIS was performed by comparing the proposed levee improvement design with existing conditions as described in the results of the preliminary investigations performed by Delta Wetlands' geotechnical consultants. These investigations included numerous field studies, monitoring, modeling, and levee stability analyses (see Appendix D1 of the 1995 DEIR/EIS for a listing). The impact analysis concluded that because of the elements and operational measures incorporated into the project design, the project would have no significant impacts on levee stability and seepage.

New Information Developed for This Evaluation

Several commenters on the 1995 DEIR/EIS and protestants against Delta Wetlands' water right applications questioned the adequacy of Delta Wetlands' proposal with regard to levee stability and seepage to adjacent islands. To address this issue regarding the project's potential effects, an additional independent analysis of levee stability and seepage issues has been performed to provide information to supplement the 1995 DEIR/EIS discussion.

The analysis of these issues, performed by URS, is included as Appendix H of the 2000 REIR/EIS, "Levee Stability and Seepage Analysis Report for the Delta Wetlands Project Revised Draft EIR/EIS". The remainder of this chapter updates the assessment of potential Delta Wetlands Project effects presented in the 1995 DEIR/EIS by summarizing the findings of the URS analysis and, as requested by the USACE and SWRCB, presenting new information on boat-wake effects on levee erosion.

Summary of Issues Addressed in the 2000 Revised Draft EIR/EIS Analysis of Levee Stability and Seepage

The 2000 REIR/EIS analysis of issues related to flood control addresses the following questions, which represent the concerns expressed at the water right hearing and in comments on the 1995 DEIR/EIS:

- Can a pumped-well system (i.e., Delta Wetlands' proposed interceptor-well system) control groundwater seepage?
- What is the long-term reliability of the proposed interceptor-well system of seepage control?
- Would the proposed seepage monitoring program be adequate and effective?
- Could operation of the seepage-control system result in substantial water diversion onto the reservoir islands?
- Would the proposed setbacks for borrow-pit areas be adequate to prevent excessive seepage increases in the underlying sand aquifer?
- Would rapid changes in the reservoir water level cause additional stresses on underlying soil layers and additional settlement of the levees and interiors of reservoir islands?
- Would Delta Wetlands operations reduce the levees' dynamic or static stability?
- Would the construction and operation of the interceptor-well system reduce levee stability?
- What potential damage to adjacent islands could result if a reservoir island's levee failed or if the owner abandoned the project?
- Would increased wave action from Delta Wetlands Project-related boat use in Delta channels contribute to levee erosion and adverse effects on channel island habitats?

The information presented below adds more detail to the impact evaluation presented in the 1995 DEIR/EIS; however, the analysis does not address every extreme of conditions that could be encountered during project implementation. The discussion below is based on a proposed preliminary design of flood- and seepage-control features of the project and represents a general evaluation of the environmental feasibility of these features. Specific design issues, including site-specific geotechnical evaluations, will be addressed in detail as the lead agencies and the applicant proceed through the permit approval processes. Nonetheless, the level of detail presented below is adequate for purposes of NEPA and CEQA impact analysis and for determining the general feasibility of Delta Wetlands' proposal for levee stability and seepage control.

Definition of Terms

The following are definitions of key terms as they are used in this chapter:

Aquifer: A porous soil or geological formation lying between impermeable strata that contains groundwater; yields groundwater to springs and wells.

Bearing Capacity: The maximum load that a structure can support, divided by its effective bearing area (the part of the structure that carries the load).

Borrow Area: An excavated area or pit created by the removal of earth material to be used as fill in a different location.

Buttress: To steady a structure by providing greater resistance to lateral forces to prevent failure.

Design Response Spectrum: The specified range of ground motion in response to seismic activity that is assumed for an analysis based on historical data and local soil conditions.

Dynamic and Static Stability: The stability of levees under seismic movement or without seismic movement.

Factor of Safety for Slope Stability (FS): A calculated number representing the degree of safety of a slope against instability. The FS is expressed mathematically as the ratio of stabilizing effects (forces or moments) and destabilizing effects acting on a potentially unstable soil mass in a slope. When the FS is greater than 1, the soil mass in the slope is, in theory, stable; when the FS is less than 1, the slope is, in theory, unstable. For a given slope geometry and soil conditions, a calculated FS is associated with a unique slope failure configuration. The most critical failure configuration is associated with the minimum FS calculated in a slope stability analysis. Several agencies (such as the Association of State Dam Safety Officials and USACE) have developed criteria that provide different design FSs stipulated for various slope conditions (e.g., under long-term loading, shortly after construction, etc.). These FSs are typically above 1 and are recommended or required for various conditions, including consideration of uncertainties in design and risks to life and property.

Freeboard: The vertical distance between a design maximum water level and the top of a structure such as a levee, dike, floodwall, or other control surface. The freeboard is a safety margin intended to accommodate unpredictable rises in water level.

Hydraulic Conductivity: A measure of the capacity of a porous medium to transmit water, often expressed in centimeters per second. The hydraulic conductivity is equal to the rate of flow of water through a cross section of one unit area under a unit hydraulic gradient.

Hydraulic Gradient: The rate of change in total hydraulic head per unit distance of flow measured at a specific point and in a given direction, often resulting from frictional effects along the flow path.

Hydraulic Head: The force exerted by a column of liquid expressed as the height of the liquid above the point at which the pressure is measured (the force of the liquid column being directly proportional to its height).

Interceptor Well: In the context of the Delta Wetlands Project, a pumped well located on an island levee for controlling groundwater flow off the island.

Interceptor-Well System: A seepage-control system that would consist of actively pumped wells installed in the exterior levees of the reservoir islands in locations where substantial seepage to adjacent islands is predicted to occur.

Levee Crest: The top of a levee.

Liquefaction: The process in which loose saturated soils lose strength when subject to seismic activity (i.e., shaking).

Overtopping: Passing of water over the top of a levee as a result of wave runup or surge action.

Passive-Flow Relief-Well System: A system of wells that passively relieve elevated hydrostatic pressures in an aquifer by allowing flow to the surface. (Hydrostatic pressure is the pressure exerted by a liquid, such as water, at rest.)

Phreatic: Of or pertaining to groundwater.

Phreatic Surface: The surface of a body of unconfined groundwater at atmospheric pressure.

Piezometer: A sandpipe monitoring well used to measure the depth to the groundwater surface in the aquifer.

Piping: The removal of fine soil particles from the soil mass by high hydraulic gradients. For example, excessively high exit hydraulic gradients at the surface may cause upward transport of soil, resulting in sand boils.

Rock Revetment: A stone covering used to protect soil or surfaces from erosion by water or the elements. Also referred to as riprap.

Seepage: A slow movement of water through permeable soils caused by increases in the hydraulic head (see "hydraulic head" above).

Seepage Flux: The rate of flow of water across a given line or surface, typically expressed in gallons per minute (gpm) or cfs.

Settlement: The sinking of surface material as a result of compaction of soils or sediment caused by an increase in the weight of overlying deposits, by pressure resulting from earth movements, or by the removal of water from the soil or sediment.

Slope Deformations: Changes in the shape or size of a slope.

Splash Berm: An extended area of facing on an island levee designed to protect against erosion of the levee crest by wave splash and runup.

- # *Stratigraphy:* The composition, characteristics, distribution, and age relation of layered rocks and soils.

- # *Toe Berm:* The section projecting at the base of a dam, levee, or retaining wall.

- # *Wave Runup*: The vertical height above stillwater level to which water from an incident wave will run up the face of a structure.

- # *Wind Fetch:* An area of water over which wind blows, generating waves.

- # *Yield Acceleration:* Pseudostatic horizontal force that will give a calculated factor of safety of 1 in slope-stability analyses.

NEW INFORMATION PRESENTED IN THE 2000 REVISED DRAFT EIR/EIS

Information used to prepare the discussion of levee stability and seepage in the 2000 REIR/EIS was summarized from URS's report of new technical analyses of Delta Wetlands' proposed levee design and seepage-control system (Appendix H of the 2000 REIR/EIS) and from testimony presented at the water right hearing. Information on boat-wake-induced erosion is based on a literature review and discussion with knowledgeable individuals.

Results of the New Analysis of Delta Wetlands Project Effects on Seepage

As described previously in this chapter and confirmed by the URS seepage analysis, Delta Wetlands Project operations would increase the potential for seepage onto islands adjacent to the reservoir islands. These seepage effects would occur because deep sand aquifers underlie the reservoir islands and adjacent islands, as well as the channels or sloughs separating them. Storing water on the reservoir islands would increase the elevation of the phreatic (i.e., groundwater) surface and the hydraulic pressure on the aquifer, thereby inducing seepage through the sand aquifer onto the neighboring islands.

Delta Wetlands considered several technically feasible methods for controlling seepage onto the adjacent islands. These measures include pumping from reservoir island levees, pumping from levees of adjacent islands, using passive or active relief wells or trenches on adjacent islands, and using a continuous cutoff wall in the reservoir island levees. Installing seepage control measures on the adjacent islands may be hydraulically more efficient because it would require less pumping. However, these potential solutions would require permission from neighboring reclamation districts and property owners. A continuous cutoff wall may be used, but this is not the preferred seepage control method because it is costly. Delta Wetlands has proposed to install a system of interceptor wells on the reservoir island levees to control seepage because installing such a system would not require permission from adjacent reclamation districts and property owners.

The following discussions summarize URS's seepage analysis methodology and the findings of the analysis; where appropriate, references are given to specific sections of URS's analysis (Appendix H of the 2000 REIR/EIS).

Seepage Analysis Methodology

Previous analyses prepared by Delta Wetlands' consultants (Hultgren and Tillis, Harding Lawson Associates, and Moffatt & Nichols) used a two-dimensional finite element model (SEEP) to evaluate seepage conditions and used plan-view modeling techniques to assess the impacts of borrow pits on seepage and on pumping rates. Plan-view modeling considered only horizontal seepage within the sand aquifer, where most seepage would occur. This approach does not include seepage through other elements of the subsurface strata or the effects of vertical infiltration from the storage reservoirs or adjacent channels. Consequently, the plan-view modeling approach does not adequately simulate the localized seepage conditions near the proposed interceptor-well system. Delta Wetlands plans to use the SEEP model in its final design for the seepage control system.

To better evaluate the performance of the proposed interceptor-well system, URS used a two-dimensional finite element model (SEEP/W) (Geo-Slope International Ltd. 1994) for two cross sections each of Bacon Island and Webb Tract. The cross sections were selected based on available data to be conservative and reasonably representative of relatively high seepage conditions that would be encountered on the reservoir islands. The two-dimensional modeling approach considers all major elements of subsurface stratigraphy and vertical infiltration from the reservoir islands and channels.

The following parameters deemed critical for the evaluation of seepage effects of reservoir operations were considered in the URS analysis:

- average total hydraulic head in the sand aquifer near the levee centerline on a reservoir island,

- seepage flux (seepage flow through a vertical section) near the project-island levee centerline,

- average total hydraulic head in the sand aquifer at an adjacent-island levee,

- seepage flux at the centerline of the adjacent-island levee, and

- water-table level at the far inland toe of the adjacent-island levee.

No site-specific investigation or testing was performed as a part of the URS analysis. The lead agencies considered the previously collected soil profiles adequate for the level of analysis presented in the 2000 REIR/EIS. The characterizations of soils, levee properties, seismic setting, and hydraulic and hydrologic conditions were based on available data, publications, and professional engineering judgment and experience. As discussed in Appendix H of the 2000 REIR/EIS, significant additional detailed predesign soil profiling and analysis will be required before construction.

The model input parameters, calibration, and sensitivity analyses are described in Section 2, "Seepage Issues", of Appendix H of the 2000 REIR/EIS.

Ability of a Pumped-Well System to Control Groundwater Seepage

Using the SEEP/W model, URS evaluated three conditions:

- existing seepage conditions,
- a full reservoir with no interceptor well pumping, and
- a full reservoir with pumping.

The analysis determined that a pumped-well system (i.e., the proposed interceptor-well system) with wells spaced at 160 feet on center and a pumping rate of 5 to 12 gpm, depending on local conditions, would be adequate to maintain seepage at existing levels beneath the levees on adjacent islands (Table 2.3.2 of Appendix H). For both Webb Tract and Bacon Island, URS notes that the interceptor well system should extend to the bottom of the sand aquifer, the pumping well should be screened over the entire length of the aquifer to achieve the required drawdown at the well, and the pumps should be sized to efficiently handle the required pump rate.

URS concluded that the interceptor-well system of seepage control as proposed by Delta Wetlands "appears effective to control undesirable seepage effects" and that "a properly functioning interceptor well system can be used to minimize the effects of the proposed reservoirs on adjacent islands, including the potential for rises in the groundwater table or flooding". The summary of findings also notes that the proposed spacing of 160 feet between interceptor wells appears to be adequate. The findings indicate that spacings and pumping rates will be more precisely defined for each levee section during the final design of the project and note that adjustments in the design of the interceptor-well system will be required to accommodate varying site-specific conditions. Following detailed investigations of subsurface conditions, adjustments in the well interceptor system design will be required to accommodate varying conditions, ranging from areas where little or no pumping may be needed to areas where pumping rates may be much higher than is typical (e.g., along localized gravelly portions of the aquifer). For example, previous studies have shown variations in the hydraulic conductivity of the sand aquifer up to five to six times those used in the URS analyses. Such a higher conductivity could require pumping rates of as much as 50 to 60 gpm in some portions of the reservoir levee pump field for wells spaced at 160 feet to maintain seepage at existing levels. (See Sections 2.3.5 and 4.1 of Appendix H.)

Long-Term Reliability of the Proposed Interceptor-Well System

Delta Wetlands' geotechnical consultants conducted a series of demonstration projects on McDonald Island in 1990 to show the effectiveness of a pumped-well system and a passive-flow relief-well system in lowering the hydraulic head in the sand aquifer. Mildred Island, located immediately west of McDonald Island, has been flooded since 1983. The analysis showed that both a pumped-well system and a passive-flow relief-well system reduced the hydraulic head, but that the passive-relief system resulted in less drawdown. Evidence was presented in water right hearing testimony that McDonald Island land became saturated and unfarmable after the demonstration projects were completed. Delta Wetlands' geotechnical consultant Ed Hultgren testified, however, that the relief wells became less effective with time as they became clogged with silt. Hultgren added that the demonstration wells were constructed for the demonstration project only, not for long-term use, and that when the demonstration projects were complete, the wells were not maintained.

URS reviewed the previously prepared reports and generally concurred with their findings that the drawdown test on McDonald Island showed:

the interceptor-well system could be effective in controlling seepage, and

an interceptor-well system installed on the perimeter of the reservoir islands could be a viable system to control the seepage into the neighboring islands.

URS also concluded, however, that the McDonald Island demonstration projects show that final design and proposed maintenance programs must address the potential migration of fine materials from the sand aquifer to a pumped-well system (Section 2.2.7 of Appendix H). Migration of fine materials from the sand aquifer could decrease the efficiency of the wells and could result in subsidence or slumping of the levees (see "Effect of the Interceptor-Well System on Levee Stability" below.) Regular performance monitoring, maintenance, and "redevelopment" (cleaning) of the wells will be required to ensure long-term effectiveness of the proposed interceptor-well system. The report states the following (Section 2.5 of Appendix H):

- The design of the well screen and surrounding gravel pack will need to accommodate the grain sizes of the aquifer.

- The perforated section of the well casing should stay submerged (i.e., should not extend above the elevation of the deepest expected drawdown of the water table) to minimize the possibility of fouling of the screen by organic growths.

- It would be useful for the individual wells to be equipped with flow meters so that any dropoff in output can be identified.

- It would be necessary, during the final design, to evaluate the likelihood of power outages and their consequences on seepage control and to consider whether providing standby generators would be advisable.

Adequacy and Effectiveness of the Proposed Seepage Monitoring Program

Delta Wetlands has proposed a monitoring program to ensure that there is no net seepage onto adjacent islands. The proposed monitoring program includes hourly measurements of water levels in seepage monitoring wells (i.e., piezometers), background monitoring wells, and adjacent sloughs and channels. The seepage and background monitoring wells are located on the levees of islands adjacent to the reservoir islands; the locations proposed by Delta Wetlands for Alternatives 1 and 2 are shown in Figure 3D-3. Delta Wetlands proposes to implement additional seepage control measures if the monitoring data indicate that water levels in the seepage monitoring wells have exceeded performance standards and the increased seepage is attributable to reservoir-island filling. URS reviewed the monitoring program and determined that it is appropriate in concept, but recommends modifying the program as follows (Section 2.4 of Appendix H):

- The background monitoring wells should be at least 1,000 feet from the nearest seepage monitoring wells.

- More than one background monitoring well should be used for each row of seepage monitoring wells.

- At least 1 year of data should be used to establish reference water levels in the background monitoring wells and in at least half of the seepage monitoring wells before reservoir operations begin.

- A running straight-line mean from the monitoring well data should be used in the application of the seepage performance standards.

- The seepage performance standard of 1 foot should be reduced to 0.5 foot for the single-well condition.

The seepage performance standards should be reevaluated periodically after reservoir operations begin.

Additionally, URS notes that the proposed seepage monitoring system does not account for the relationship between groundwater elevations and seasonal or local variation within each adjacent island. Local conditions could include changes in groundwater levels attributable to local pumping for farming operations. To monitor trends in groundwater management on the neighboring islands, URS recommends that Delta Wetlands supplement the proposed background well system with in-field monitoring wells installed across each neighboring island. These additional wells would be placed one-half mile to 1 mile apart, beginning near the levee adjacent to the reservoir island and continuing across the adjacent island, so that groundwater levels at increasing distance from the reservoir island can be compared. During final design, the specific location and spacing of these wells would be finalized based on groundwater conditions in each neighboring island.

Water Diversion onto the Storage Islands through Interceptor-Well Pumping

Under certain water-level conditions in the reservoir islands and adjacent channels, water from adjacent channels could be inadvertently diverted onto the reservoir islands through operation of the interceptor-well system or direct seepage. Using the SEEP/W model, URS evaluated the volume of seepage and the rate of interceptor-well pumping under full-reservoir conditions. For this evaluation, it was assumed that water pumped from the interceptor wells would be returned to the reservoirs. The study concluded that if Delta Wetlands operated the seepage-control system at the minimum rate necessary to prevent net seepage on adjacent islands, the simulated flux of water from the slough toward the reservoir islands would be about the same as the flux under simulated existing conditions for most locations and would constitute approximately 8% of the total water pumped from the wells (Section 2.6 of Appendix H). The proposed seepage monitoring program could be used in conjunction with pumping-rate monitoring to determine the volume of channel water being pumped onto the reservoir through the interceptor-well system or through direct seepage.

Adequacy of Borrow-Area Setbacks

URS used the SEEP/W model to evaluate whether Delta Wetlands' proposed borrow-area setbacks would be adequate to prevent excessive seepage increases in the underlying sand aquifer. URS concluded that borrow areas located 400 feet from the toe of the reservoir island levees would have an insignificant effect on the total hydraulic head conditions within the sand aquifer near the levees or the required pump rate at the interceptor-well system. The modeling showed that setting the borrow area back 800 feet from the levee in accordance with USACE standards would result in no effects on seepage conditions or operation of the interceptor-well system (Section 2.3 of Appendix H).

Effects of Rapid Changes in Reservoir Water Levels on Settlement of Island Interiors

URS evaluated the conceptual mechanisms that would lead to land-surface subsidence on the interiors of the reservoir islands and concluded that additional settlement caused by operation of the Delta Wetlands Project would be nominal. The weight of water stored on the reservoir islands would compact the soil and lead to settlement of the reservoir island interiors. The evaluation determined that project operations would result in approximately 1 foot of additional settlement over the life of the project, with most soil compaction occurring during the first year of water storage operations. This predicted settlement is only a fraction of the land-surface subsidence that would be expected to occur if the existing agricultural practices are continued in the future. Under existing agricultural practices, land-surface subsidence would continue until all peat materials have oxidized, which would result in a long-term lowering of the ground surface of approximately 15 feet on Webb Tract and 10 feet on Bacon Island. (Section 2.7 of Appendix H.)

Results of the New Analysis of Delta Wetlands Project Effects on Levee Stability

The four Delta Wetlands islands are bounded by "nonproject" levees. Federal "project" levees are maintained to USACE standards by the State of California or by local landowners under state supervision; nonproject levees are defined as levees constructed and maintained by local landowners and reclamation districts. Delta Wetlands' proposed improvements to its levees are described above under "Flood Control Features" and are summarized above under "Delta Wetlands' Proposed Levee Design and Seepage Control System". Placement of toe berm fill and fill on the levee slopes and crest would take place in stages to allow for consolidation of material. Delta Wetlands' proposed project includes regular inspection and maintenance of the levees.

The main objective of the levee-stability analysis performed by URS was to evaluate Delta Wetlands' proposed levee-strengthening method for the reservoir islands. The analysis focused on the static and dynamic slope stability of the proposed levee configuration. Other performance conditions were studied as well, including:

- load bearing capacity;
- slope deformations and settlement and their effects on levee stability; and
- potential effects associated with geologic and seismic hazards, such as liquefaction.

The following discussions summarize URS's methodology for analyzing levee stability and the findings of the analysis; where appropriate, references are given to specific sections of URS's analysis (Appendix H of the 2000 REIR/EIS).

Methodology Used for the Levee Stability Analysis

For the evaluation of Delta Wetlands project effects on levee stability, URS reviewed published literature on peat soil as well as the geotechnical studies, including slope-stability analyses, previously prepared for Delta Wetlands by its own consultants. URS reviewed the assumptions and results of these studies and used information from these reports to develop the soil parameters included in its analysis.

The URS analysis considered both the dynamic and static stability of the proposed levee improvements by using four cross sections, two for each of the reservoir islands. The cross sections were selected to be reasonably representative of conditions that would be encountered on the reservoir islands, and that would represent conservative estimates for stability issues. (Some cross sections were therefore different from the cross sections used for the seepage analysis, which were selected to allow for conservative analysis of seepage effects.) The analysis considered the potential for failure of the slope toward the island and the slope toward the slough. For both slopes, the following cases were considered:

- existing conditions;

- the end of construction (i.e., soil-consolidation condition);

long-term conditions;

sudden drawdown (i.e., an emergency evacuation of stored water); and

pseudostatic conditions (i.e., the stability of the slope during seismic loading, which is analyzed to determine yield acceleration and estimate earthquake-induced deformation).

Static Stability Analysis. URS analyzed the static stability of levees using the limit equilibrium method based on Spencer's procedure of "slices" using the computer program UTEXAS3 (Wright 1991). The program iteratively balances the FS and the side force inclination until both force and moment equilibrium forces are satisfied. The UTEXAS3 model can simulate rapid undrained loading that follows a period of soil consolidation (end of levee construction) and rapid drawdown (emergency evacuation of stored water). Section 3, "Slope Stability Issues", of Appendix H details the review of previous studies and describes selected parameters and methods used in this analysis.

Dynamic (i.e., Seismic) Stability Analysis. For the evaluation of seismically induced levee deformations and geologic hazards, URS reviewed previous ground-motion studies for the project area, developed and updated dynamic soil parameters based on recent findings and published data, and developed design earthquake ground motions based on horizontal earthquake acceleration time histories recorded during the 1992 Landers and 1987 Whittier Narrows earthquakes. Results from the recent CALFED study on seismic hazards and probability of levee failure in the Delta (CALFED Bay-Delta Program 1999b) were used to construct the design response spectrum.

The design earthquake ground motions developed for the analysis used a hazard exposure level corresponding to a 10% probability of exceedance in 50 years; this level corresponds to a return period of about 1 in 475 years and is consistent with the requirement adopted by the 1997 Uniform Building Code. Dynamic responses and deformations of the levee induced by the design earthquake motions were computed for the long-term levee conditions at two cross sections each for Webb Tract and Bacon Island. The seismically induced geologic hazards assessed for the analysis included liquefaction, loss of bearing capacity, settlement, and levee overtopping. The evaluation also considered wave-height estimates and erosion, borrow requirements, and the effect of interceptor wells on slope stability. The literature reviewed and methods used for this analysis are described in Appendix A to the URS report (see Appendix H of the 2000 REIR/EIS).

Effect of Delta Wetlands Operations on Levee Stability

In the 1995 DEIR/EIS, levee improvements were estimated to increase the long-term FSs in comparison with existing conditions, resulting in a beneficial effect. Independent review of levee stability issues by URS verified that Delta Wetlands' proposed levee improvements would increase the long-term FS toward the reservoir islands in comparison with existing conditions but determined that the long-term FS toward the slough would decrease (Table 3D-6).

The URS evaluation also found that, compared with existing conditions, the FS toward the reservoir islands would decrease for both the end-of-construction case and the sudden drawdown condition. (Section 3.5 of Appendix H.)

The "end-of-construction" results presented in Table 3D-6 represent conditions after construction of levee improvements in a single stage; the single-stage analysis was conducted to demonstrate that the levees cannot be constructed in a single stage. Delta Wetlands has proposed to construct the levees in multiple stages to facilitate consolidation of levee materials. Delta Wetlands has proposed two conceptual land-side levee slope configurations—a 3:1 initial slope flattening to a 10:1 slope or a uniform 5:1 slope (Figure 3D-2). The uniform 5:1 slope fill configuration results in a lower end-of-construction FS than the 3:1-to-10:1 fill configuration, so Table 3D-6 presents the FS results for the uniform 5:1 slope configuration to provide the most conservative estimates of levee stability.

The seismic-stability evaluation of the reservoir island levees indicated that as much as 2 feet of deformation on the reservoir side of the levees and 4 feet on the slough side could be experienced during a probable earthquake in the region (Section 3.6 of Appendix H). Stability is improved from existing conditions on the reservoir side and is less than existing conditions on the slough side.

With regard to levee stability, URS concluded that the "levee strengthening measures conceptually proposed by Delta Wetlands are generally appropriate and adequate to provide stability of the reservoir islands' levees". The report notes that construction of the levee-strengthening fills must be implemented in carefully planned staged construction to prevent stability failures to the new fill loads. URS estimated that construction of the levees could take 4 to 6 years, depending on final levee design. The report also outlines conceptual measures that would improve the long-term stability of the slough side of the levees, improve stability under sudden drawdown conditions, and mitigate slough-side deformation under seismic conditions. Delta Wetlands plans to implement detailed subsurface exploration programs along the reservoir island levees, stability evaluations, and site-specific design and construction methods as part of final design. The report concludes that these steps will be essential to achieving safety and effectiveness of the proposed levee system. (Section 4.2 of Appendix H.)

Effect of the Interceptor-Well System on Levee Stability

As discussed previously, a network of interceptor wells would be used to control seepage onto adjacent islands. Delta Wetlands has suggested that these wells would probably be 6 inches in diameter and spaced approximately 160 feet on center. A 6-inch-diameter well could require drilling a 12-inch-diameter space to accommodate the well and packing. URS determined that the wells would not substantially affect stability of the levees or the supporting levee foundation because the area occupied by the wells is so small compared to the area occupied by the levees.

A high rate of continuous pumping in the interceptor wells can result in the migration of fine materials from the sand aquifer, which can cause internal erosion or piping in the levee material, and over time, lead to weakened levee foundations and potential settlement and stability problems. URS recommends that to minimize the risk to levee stability from excessive migration of fine-grained material from the aquifer, Delta Wetlands should:

- monitor individual wells' flows to judge well pumping efficiency (an indicator of internal soil erosion);
- redevelop (i.e., clean) the wells periodically or in response to flow monitoring that indicates a drop in well efficiency; and
- in severe cases, abandon and rebuild the well. (Section 3.10 of Appendix H.)

Delta Wetlands may be required to identify the criteria by which they would judge when an interceptor well would need to be replaced.

Wave Runup and Erosion

The proposed flooding of reservoir islands could result in wave runup on the interior levee slopes because of the long wind fetch across the islands, the water depths during storage, and wind conditions. Longer wind fetch, deeper water, and faster winds increase wave height. Delta Wetlands estimated wave runup on the reservoir islands and is proposing to include erosion protection on the interior levee slopes. These slopes would be protected from erosion by conventional rock revetment (i.e., riprap) or other conventional systems, such as soil cement or high-density polyethylene liner. During final design, site-specific requirements for erosion protection will be evaluated and riprap or other suitable erosion protection measures will be designed for each levee section. Delta Wetlands is also proposing an erosion monitoring program, which includes weekly inspections of levees and maintenance measures to address potential erosion problems.

URS completed an independent analysis of wave runup to evaluate freeboard and erosion potential of the reservoir island levees (see Section 3.8 in Appendix H). The analysis used the most severe wind conditions in the area (i.e., 60 miles per hour in fall), the longest wind fetch on Bacon Island and Webb Tract (i.e., 3.15 miles and 2.83 miles, respectively), and full storage conditions to represent worst-case wave runup potential. Both the 3:1 and 5:1 levee slope configurations were evaluated. The results of the analysis are shown in Table 3D-7. URS concluded that these results are consistent with the wave runup estimates published in DWR Bulletin 192-82. The proposed reservoir island levees will have an interior slope freeboard of 3 vertical feet (Figure 3D-2) and, as described above, will include placement of riprap on the interior slopes. As shown in the table, the estimated worst-case runup could result in overtopping if a 3:1 levee design is used. However, the analysis concludes that the proposed flatter (5:1) levee slope would reduce wave runup and avoid overtopping under the worst-case conditions. The final design of the levee will consider the potential for wave runup, and Delta Wetlands will implement a final levee design according to those site-specific conditions. Additionally, during project operations, the erosion monitoring program would be implemented. In conclusion, wave runup will not result in substantial erosion or overtopping of the proposed levees on the reservoir islands.

Potential Damages to Adjacent Islands in the Event of a Reservoir Island Levee Failure

Although a worst-case, or catastrophic-failure, analysis is not required under NEPA or CEQA, the USACE and SWRCB asked URS to evaluate the potential for damages to neighboring Delta islands in the event that a reservoir island levee failed.

URS's levee stability analysis indicates that failure of a Delta Wetlands Project levee is unlikely, but that the most probable types of failure are:

- failure of a reservoir island levee toward the adjacent channel or slough with a full reservoir,
- failure of the levee into the reservoir island with the reservoir low or empty, and
- failure of an adjacent island's levee caused by seepage effects attributable to reservoir operations.

To evaluate the potential effects of a levee breach under full reservoir conditions, URS performed hydraulic analyses assuming breach widths (i.e., lengths of failed levee) of 40, 80, 200, and 400 feet. Assuming that the reservoir was full at the time of a breach, URS determined that the maximum velocity of water on the bank opposite the breach would be 2, 9, 12, and 16 fps, respectively. The maximum breach width of 400 feet would result in a maximum discharge rate of 123,000 cfs. Figure 3.5.47 of Appendix H shows the velocity distribution of flows under this failure scenario. The maximum velocity on the opposite bank would be approximately 16 fps for 30-40 minutes. It is expected that the riprapped levee would be able to withstand these velocities, although floating structures and moored boats might be damaged (Section 3.5.4 of Appendix H).

The analysis concluded that the proposed conceptual levee design would provide adequate protection against failure of the reservoir levee with the reservoir empty, with high FSs for long-term failure into the reservoir island and adequate FSs for sudden drawdown at most locations. The report notes that adjustments to levee geometry may be needed at some locations to provide an adequate FS during sudden drawdown (Section 3.5.4 of Appendix H).

Failure of an adjacent island's levee caused by seepage effects attributable to reservoir operations is addressed by the seepage analysis.

New Information on Erosion Effects of Boat Wake

After the 1995 DEIR/EIS was released, the lead agencies received comments from several parties about the impacts on Delta island levees of increased boat wake that could result from increased boating activity if the proposed project were implemented. As described in Chapter 2, "Delta Wetlands Project Alternatives", Delta Wetlands has removed construction of recreation facilities from its CWA permit applications; nevertheless, the analysis of impacts on levee stability and seepage associated with construction and operation of these facilities is presented in this chapter. The lead agencies believed it would be helpful for reviewers to be given information about this subject, and directed that such information be included in this revised chapter on levee stability and seepage. Concerns about potential boat-wake impacts relate to the potential contribution of increased wake action to significant levee erosion and the erosion of channel islands and water-side habitats.

A literature search and conversations with knowledgeable individuals indicates that there are no current data related to wake-action impacts on channel islands. In the 1970s, the California Department of Navigation (now the California Department of Boating and Waterways) and DWR conducted two studies; however, these studies were based on unsubstantiated assumptions and reported conflicting findings, and are not reliable sources of information. The California Department of Boating and Waterways is currently conducting a 6-year study with Scripps Institute of Oceanography that addresses wake-action impacts; the study has not been completed.

Margit Aramburu, executive director of the Delta Protection Commission; Don Waltz, chief of the Facilities Division of the California Department of Boating and Waterways; and Ron Flick, research associate at Scripps Institute of Oceanography and staff oceanographer for the California Department of Boating and Waterways, were each contacted for information on this issue during April and May 1999. Each indicated that impacts of boat wakes on Delta islands are difficult to generalize. They explained that impacts vary according to several factors related to boat use, including boat size, boat speed, proximity of boats to the islands, and type of boating activity, and that these factors should be considered with others such as currents and the presence of wind-blown waves.

Because of the lack of data to quantify the relationship between boating and wake effects, it is not currently possible to estimate the erosion or habitat effects of increased wake action resulting from increased boating use of Delta waterways under the proposed project. However, the potential for such effects are recognized. This issue was considered during the endangered-species consultation between the EIR/EIS lead agencies and DFG, NMFS, and USFWS. As a result, the FOC terms developed in the consultation process include a measure (number 53) specifically intended to mitigate boat-wake effects. Under this term, Delta Wetlands is required to contribute a set fee for each boat berth added to any of the project islands beyond pre-project conditions; these funds would be used for aquatic habitat restoration (see also page 55 of the DFG biological opinion in Appendix C of the 2000 REIR/EIS). This measure is in addition to the requirement that Delta Wetlands mitigate the effects of project construction and operations on aquatic habitat and shallow shoal habitat. The FOC terms have been adopted as part of the federal and state biological opinions for Delta Wetlands Project effects on listed fish species, and Delta Wetlands is required to incorporate these terms into the proposed project. Additional mitigation has been recommended to reduce the magnitude of project effects on boat wake. For more information, see Chapter 3J, “Recreation and Visual Resources”.

IMPACT ASSESSMENT METHODOLOGY FOR THE 2000 REVISED DRAFT EIR/EIS

Analytical Approach and Impact Mechanisms

Impacts on seepage and levee stability were assessed based on the ways in which construction and operation of the Delta Wetlands project alternatives would affect seepage on adjacent islands and levee stability. Effects of the project alternatives on seepage and levee stability were based on previous work prepared by Delta Wetlands’ consultants and new technical analyses prepared by URS (Appendix H of the 2000 REIR/EIS).

Criteria for Determining Impact Significance

An alternative is considered to have a significant impact on seepage or levee stability if it would:

- induce additional seepage on adjacent islands when compared to no-project conditions,
- decrease levee stability on the Delta Wetlands Project islands during or immediately following project construction,
- decrease long-term levee stability when compared to existing levee conditions, and
- cause property damage in the event of levee failure.

Levee Standards and Significance Criteria

During and subsequent to the water right hearing, parties expressed an interest in using existing levee standards as a significance criterion in the levee stability analysis or in identifying which standard or standards would be applied to the Delta Wetlands Project. Table 3D-8 summarizes standard FSs for various levee or dam conditions, as adopted or recommended by USACE, DWR, and the Division of Safety of Dams (DSOD). FSs are only one element used to regulate levees and dams; other design considerations are also used. Figure 3D-7 compares different levee standards for minimum freeboard, maximum slopes, and crest width. As shown in Table 3D-8 and Figure 3D-7, USACE has published standards and guidelines for project and nonproject levees, DWR has published guidelines for levee rehabilitation in the Delta, and DSOD establishes standards for dams.

The purpose of the impact assessment is to determine the difference in levee stability between existing conditions and with-project conditions. The relative change in the FSs between the project and existing conditions is used as the basis for evaluating the impact of the proposed project. Because the analysis evaluates the *change* in levee conditions, a given FS standard cannot be used to determine the significance of the change. However, these standards would be considered during project approval and final design.

The USACE and SWRCB can choose to adopt a given standard to be applied to the final levee design for the Delta Wetlands islands. Because the Delta Wetlands levees are nonproject levees, rehabilitation of those levees under existing conditions would follow DWR and USACE's recommendations for nonproject levees. Delta Wetlands has committed to improving levees on all four project islands to meet levee design criteria for Delta levees identified in DWR Bulletin 192-82; Bulletin 192-82 does not include FS but requires a given levee design (Figure 3D-7). The USACE and SWRCB, however, may include more conservative standards or guidelines for the reservoir island levees in the terms and conditions of project approval.

Additionally, if the levees are determined to be "dams" as defined by the California Water Code (Sections 6002 through 6008), Delta Wetlands would be required to meet DSOD's standards and design review requirements. DSOD has oversight and approval authority for structures that are considered dams under the Water Code. Dams under jurisdiction are artificial barriers that are at least 25 feet high or have an impounding capacity of at least 50 af. However, Water Code Section 6004(c) provides the following exclusion for structures in the Sacramento-San Joaquin Delta:

> The levee of an island adjacent to tidal waters in the Sacramento-San Joaquin Delta, as defined in Section 12220, even when used to impound water, shall not be considered a dam and the impoundment shall not be considered a reservoir if the maximum possible water storage elevation of the impounded water does not exceed four feet above mean sea level, as established by the United States Geological Survey 1929 Datum.

Therefore, if the Delta Wetlands levee structure is built to impound water to a level of 6 feet above mean sea level as proposed and evaluated in this document, it would be considered a dam within DSOD jurisdiction and would be subject to DSOD review and permit approval. The levees would be required to meet DSOD standards for dams (Table 3D-8). Delta Wetlands would submit final design drawings, specifications, geotechnical reports, survey data, and an application to DSOD for approval before levee construction (Driller pers. comm.).

ENVIRONMENTAL CONSEQUENCES

The following section addresses project impacts on seepage and levee stability. The text addresses the four criteria listed above that are used to determine significance. Table 3D-9 compares the 1995 DEIR/EIS and 2000 REIR/EIS impact conclusions.

Potential Seepage on Adjacent Islands Resulting from Project Operations

As described in previous sections of this chapter, operation of the Delta Wetlands Project would induce seepage on adjacent islands if seepage control measures were not implemented. The Delta Wetlands Project includes a network of pumped wells to control seepage and a seepage monitoring program. It also has a set of seepage performance standards that, if exceeded, would trigger implementation of other measures to control seepage, including drawdown of the reservoir islands' water levels. Independent review of the seepage control program, seepage monitoring program, and performance standards by URS (Appendix H of the 2000 REIR/EIS) indicated that the proposed seepage control program could effectively control the seepage onto adjacent islands. However, the review also indicated that the seepage monitoring program and performance standards might not provide adequate warning that an adverse effect was about to occur and might not trigger additional mitigation measures in a timely enough manner to prevent adverse effects on adjacent islands. Therefore, potential seepage on adjacent islands is considered significant and the following mitigation is recommended.

Mitigation Measure RD-2: Modify Seepage Monitoring Program and Seepage Performance Standards. URS has recommended that the seepage monitoring program and the seepage performance standards be modified to include the following requirements:

- Locate the background monitoring wells at least 1,000 feet from the nearest seepage monitoring wells.
- Use more than one background monitoring well for each row of seepage monitoring wells.
- Use at least 1 year of data to establish reference water levels in all the background monitoring wells and in at least half of the seepage monitoring wells.
- Use a running straight-line mean from the monitoring-well data when applying the seepage performance standards.
- Reduce the seepage performance standard for the single-well condition from 1 foot to 0.5 foot.
- Reevaluate seepage performance standards 2, 5, and 10 years after reservoir operations begin and then every 10 years.

Implementing the recommended changes to the seepage monitoring program and seepage performance standards would reduce this impact to a less-than-significant level.

Potential Decrease in Levee Stability on the Delta Wetlands Project Islands during or Immediately after Project Construction

As described earlier in this chapter, levee improvements would be completed in layers or lifts less than 5 feet thick and allowed to settle to ensure that an appropriate FS would be maintained. Delta Wetlands estimated that it would take several years to complete levee improvements. Independent review of levee stability issues by URS verified that levee improvements could not be completed in a single lift. As shown in Table 3D-6, if the levees were constructed in a single lift, the FSs would be less than 1, indicating that the levees would not be strong enough to support their own weight. The levee construction methods described above under “Flood Control Features” are adequate to maintain an appropriate FS; therefore, this impact is considered less than significant and no mitigation is required.

Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands

In the 1995 DEIR/EIS, levee improvements were estimated to increase the long-term FSs when compared to the existing conditions, resulting in a beneficial effect. Independent review of levee stability issues by URS (Appendix H of the 2000 REIR/EIS) verified that levee improvements would increase the FSs toward the reservoir islands when compared to the existing conditions. As shown in Table 3D-6, the long-term FS toward the reservoir islands at the cross sections evaluated would increase by 27 to 36 percent. However, the long-term FS toward the slough would decrease by 10 to 17 percent when compared to existing conditions. URS suggests that slough-side levee improvements would achieve an appropriate FS with the proposed levee design. However, slough-side levee improvements would have substantial adverse environmental effects (e.g., significant fishery habitat and water quality impacts); consequently, although slough-side levee improvements would be technically feasible, they would not be environmentally feasible or practical. This impact is considered significant and the following mitigation measure is recommended.

Mitigation Measure RD-1: Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure. Delta Wetlands’ final levee design shall provide a minimum FS of 1.3 in accordance with DWR’s requirements for rehabilitating levees in the Delta (Table 3D-8). This recommended FS is more conservative than USACE’s recommended 1.25 FS for nonproject levees. After detailed geotechnical studies have been completed to support the levee design efforts, it is anticipated that the conceptual levee design will be modified (e.g., change in slope, crest width, lift compaction, and other levee design and construction factors) to achieve the desired FS without affecting the existing levees’ slough faces and incurring the significant environmental impacts.

Alternately, at locations where there are no practical design options to achieve this FS, measures could be implemented to reduce the risk of catastrophic levee failure. URS has recommended increasing the width of the levee cross section to provide additional buffer if the slough side of the levee fails. The buffer would provide sacrificial material that could be allowed to erode until emergency action could be taken to restore levee integrity. Although this option would not improve the factor of safety, it would greatly reduce the risk of catastrophic failure.

Potential Levee Failure on Delta Wetlands Project Islands during Seismic Activity

By improving the reservoir island levees, the stability of reservoir island levee slopes under seismic conditions would increase toward the reservoir island and would decrease toward the slough. Results of the dynamic stability analysis concluded that as much as 4 feet of levee deformation could occur under seismic conditions. This impact is considered significant. The following mitigation measure is recommended to reduce this impact to a less-than-significant level.

Mitigation Measure RD-1: Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure.

This mitigation measure is described above.

Potential Property Damage Resulting from Levee Failure

Implementing the Delta Wetlands project would increase the levees' FS toward the reservoir islands and decrease their FS toward the adjacent sloughs when compared to existing conditions. Levee failure is unlikely, however, because the long-term FSs exceed 1 (Table 3D-6). Failure into the reservoir island with the project would have no greater effect on property than a failure under the existing conditions, although the risk of failure would be somewhat less because of increased long-term FSs.

URS evaluated the potential effects of a worst-case levee failure, a levee breach toward the slough when the reservoir islands are full. Hydraulic analyses were completed assuming breach widths of 40, 80, 200 and 400 feet. The maximum likely breach of 400 feet would result in a maximum discharge rate of 123,000 cfs. Figure 3.5.47 of Appendix H shows the velocity distribution of flows under this failure scenario. The maximum velocity on the opposite bank would be approximately 16 fps. Assuming the reservoir was at full storage (+6 feet) and the channel was at a relatively low tide (-2 feet) when the levee failed, the adjacent levees would experience the 16 fps velocity for approximately 30-40 minutes. The adjacent riprapped levee would be expected to withstand these velocities for the limited amount of time. Because the potential risk of a levee failure is very small, this impact is considered less than significant and no mitigation is required.

Cumulative Impacts

Levee stability conditions in the Delta are expected to improve in the future through the implementation of levee improvements using existing and future state and federal funding and implementation of proposed projects under the CALFED Bay-Delta Program. Since 1988, federal, state, and local agencies have completed more than $160 million in improvements to Delta levees using Senate Bill (SB) 34 funds, Assembly Bill (AB) 360 funds, emergency levee repair funds for work performed by USACE under Public Law (PL) 84-99, and local funds (CALFED Bay-Delta Program 1999a). Improvements to Delta levees are ongoing. The CALFED Bay-Delta Program's Long-term Levee Protection Plan outlines a long-term strategy to reduce the risk of catastrophic breaching of Delta levees. The CALFED Levee Program includes a cost-sharing program to reconstruct Delta levees, the "Special Flood Control Projects" program to provide additional flood protection for key Delta levees that protect public benefits of statewide significance, improvements to existing emergency response capabilities, and development of a risk management strategy in response to the threat that earthquakes pose to Delta levees (CALFED Bay-Delta Program 1999b).

Implementing the Delta Wetlands Project would not contribute significantly to cumulative flood hazards in the Delta. The proposed project would improve long-term levee stability on the habitat islands and would improve long-term stability of the levee slope toward the reservoir islands. As described above, long-term stability toward the slough would be reduced on the reservoir islands; however, because the resulting FS still would be greater than 1, the likelihood of levee failure under the proposed project is low. Additionally, analysis indicates that neighboring levees would not be significantly damaged if the levee failed when the reservoir was full. Therefore, the cumulative effect on levee failure in the Delta is considered less than significant and no mitigation is required.

Impact Evaluation of Project Alternatives from the 1995 Draft EIR/EIS

As described in Chapter 2, the difference between Alternative 1 and Alternative 2 is water discharge operations. Consequently, the levee system and proposed seepage control plan are the same under Alternative 1 as under Alternative 2. The impacts and mitigation measures described above would also apply to both Alternative 1 and Alternative 2.

Under Alternative 3, water would be stored on all four islands, so levee improvements and seepage control measures would be implemented on all islands. Although the 2000 REIR/EIS did not analyze levee stability and seepage for Bouldin Island and Holland Tract, it can be reasonably assumed that the levee stability and seepage impact conclusions presented above for the proposed project would be similar to the findings for the other reservoir islands under Alternative 3.

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Table 3D-1. Historic Flooding and Predicted Statistical Frequency of Levee Failures on the DW Islands

		Predicted Failures per 100 Years		
Island	Years of Levee Failure Since 1932	Under Existing Conditions	After 20 Years	After 40 Years
Bacon Island	None	5.63	7.25	8.77
Webb Tract	1950, 1980	8.81	9.29	9.29
Bouldin Island	None	18.25	18.25	18.25
Holland Tract	1980	4.17	5.68	7.89

Source: DWR 1982.

Table 3D-2. Predicted Future Subsidence on the DW Project Islands

Island	Subsidence since Reclamation (feet)	Estimated Maximum Thickness of Organic Soils (feet)	Estimated Future Rate of Subsidence (inches/year)	Predicted Additional Subsidence in Next 50 Years[a] (feet)	Predicted Island Botton Elevation by 2032[b] (feet)
Bacon Island	18	18	3.0	13	-31
Webb Tract	18	33	3.0	13	-31
Bouldin Island	17	31	3.0	13	-30
Holland Tract	16	24	3.0	13	-29

[a] Base year is 1982; therefore, this table shows estimates of subsidence between 1982 and 2032.

[b] Predicted island bottom elevation is sum of "Subsidence since Reclamation" and "Predicted Additional Subsidence in Next 50 Years". Elevation is in relation to mean sea level.

Source: DWR 1982.

Table 3D-3. Expenditures for Emergency Levee Repairs (1980-1986) and Levee Maintenance (1981-1986) on the DW Project Islands ($1,000)

Island (Reclamation District No.)	Nonproject Levee Mileage	Emergency Expenditures (1980-1986)				Maintenance Expenditures (1981-1986)			Combined Expenditures		
		Federal[a]	State[b]	Local District	Total	State[c]	Local District	Total	Public	Local District	Total Expenditures
Bacon Island (2028)	14.3	467	259	74	800	354	482	836	1,080	556	1,636
Webb Tract (2026)	12.8	14,537	6,846	582	21,965	12	25	37	21,395	607	22,002
Bouldin Island (756)	18.0	2,350	2,103	288	4,741	118	221	339	4,571	509	5,080
Holland Tract (2025)	10.9	6,655	1,837	177	8,669	59	91	150	8,551	268	8,819
Total	56.0	25,989	11,045	1,121	36,175	543	819	1,362	35,597	1,940	37,537

[a] Federal emergency expenditures through the Federal Emergency Management Agency (FEMA).

[b] State emergency expenditures under the Natural Disaster Assistance Act (NDAA).

[c] State maintenance expenditures under the Delta Levee Maintenance Subventions Program.

Source: DWR 1993.

Table 3D-4. Assumed Borrow Site Requirements for Alternatives 1 and 2

	Borrow Quantity (cubic yards)	Borrow Site Configuration		
		Depth (feet)	Total Area (acres)	Average Size (acres)
Perimeter levees				
Bacon Island	330,000	5	41	10
Webb Tract	410,000	5	51	10
Bouldin Island	1,830,000	10	113	10
Holland Tract	250,000	5	31	10
Inner levees				
Bacon Island	160,000	5	20	10
Webb Tract	600,000	5	74	10
Bouldin Island	400,000	5	50	10
Holland Tract	200,000	5	25	10
Total levee borrow				
Bacon Island	490,000	5	61	10
Webb Tract	1,010,000	5	125	10
Bouldin Island	2,230,000	5 or 10	163	10
Holland Tract	450,000	5	56	10

Source: Forkel pers. comm.

Table 3D-5. Assumed Borrow Site Requirements for Alternative 3

		Borrow Site Configuration		
	Borrow Quantity (cubic yards)	Depth (feet)	Total Area (acres)	Average Size (acres)
Perimeter levees				
Bacon Island	330,000	5	41	10
Webb Tract	410,000	5	51	10
Bouldin Island	1,830,000	10	113	10
Holland Tract	250,000	5	31	10
Inner levees				
Bacon Island	160,000	5	20	10
Webb Tract	600,000	5	74	10
Bouldin Island	400,000	5	50	10
Holland Tract	200,000	5	25	10
DSOD levee borrow				
Bouldin Island	8,900,000	30	184	184
Total levee borrow				
Bacon Island	490,000	5	61	10
Webb Tract	1,010,000	5	125	10
Bouldin Island	11,130,000	5, 10, or 30	347	10
Holland Tract	450,000	5	56	10

Source: Forkel pers. comm.

Table 3D-6. Summary of Factors of Safety

Cross Section	Factor of Safety							
	Existing Conditions		End of Construction[a]		Long-Term		Sudden Drawdown[b]	
	Toward Island	Toward Slough	Toward Island	Toward Slough	Toward Island	Toward Slough	Toward Island	Toward Slough
Webb Tract (Station 160+00)	1.24	1.29	0.62	1.29	1.57	1.12	0.88	1.12
Webb Tract (Station 630+00)	1.40	1.34	0.89	1.34	1.82	1.12	1.18	1.12
Bacon Island (Station 25+00)	1.23	1.48	0.90	1.48	1.63	1.33	1.07	1.33
Bacon Island (Station 265+00)	1.21	1.49	0.86	1.49	1.64	1.23	0.98	1.23

Notes:

[a] Represents conditions after construction of levee improvements in a single stage. It was assumed that at the end of construction, the toward-slough factor of safety would be the same as under existing conditions.

[b] Under the sudden-drawdown scenario, the toward-slough factor of safety would be the same as the long-term toward-slough factor of safety.

Source: Section 3, "Slope Stability Issues", of Appendix H of this REIR/EIS.

Table 3D-7. Summary of Results from the Worst-Case Runup Analysis

	Bacon Island		Webb Tract	
	5:1 interior levee slope	3:1 interior levee slope	5:1 interior levee slope	3:1 interior levee slope
Wave runup without riprap (feet)	4.0	6.4	3.8	6.1
Wave runup with riprap[1] (feet)	2.2	3.5	2.1	3.4
Reservoir setup[2] (feet)	0.4	0.4	0.3	0.3

Assumptions:
- Wind speed = 60 mph
- Fetch on Bacon Island = 3.15 miles
- Fetch on Webb Tract = 2.83 miles

Notes:

[1] If riprap is used on the bank slopes, the runup would be reduced to 55% of the estimated runup values.

[2] Reservoir setup is defined as a general tilting of the reservoir due to sheer stresses caused by winds.

Source: Appendix H.

Table 3D-8. Stability Criteria Adopted for Levees and Used for Dam Safety Evaluations

	Design Condition Factor of Safety		
Criterion	End of Construction	Long Term	Sudden Drawdown
U.S. Army Corps of Engineers minimum factors of safety for "project" levees[a]	1.3	1.4	1.0
U.S. Army Corps of Engineers guidelines for nonfederal levee rehabilitations in the Delta under PL 84-99[b]	–	1.25	–
California Department of Water Resources criteria for "nonproject" levee rehabilitations in the Delta[c]	–	1.3	–
Factors of safety for dam safety evaluations under DSOD jurisdiction[d]	–	1.5	1.25

Notes:

[a] U.S. Army Corps of Engineers 1978.
[b] U.S. Army Corps of Engineers 1988.
[c] California Department of Water Resources 1989b.
[d] Association of State Dam Safety Officials 1989.

Definitions:

"Project" levees = Levees maintained to USACE standards by the State of California or by local landowners under state supervision.

"Nonproject" levees = Levees constructed and maintained by local landowners and reclamation districts.

Table 3D-9. Comparison between Delta Wetlands Projects on Flood Control in the 1995 DEIR/EIS and the 2000 REIR/EIS

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	**Differences between 2000 REIR/EIS and 1995 DEIR/EIS**
CHAPTER 3D. FLOOD CONTROL	
Impact D-1: Increase in Long-Term Levee Stability on Reservoir Islands (B) C No mitigation is required.	**Potential Decrease in Long-Term Levee Stability on the Delta Wetlands Reservoir Islands.** Independent analyses by URSGWC indicate that the levee's long-term factor of safety would increase by 27 to 36 percent toward the reservoir islands but would decrease by 10 to 17 percent toward the sloughs. This impact is considered significant and mitigation is recommended to reduce the impact to a less-than-significant level. (S) C Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure (LTS)
----	**Potential Decrease in Levee Stability on the Delta Wetlands Project Islands During or Immediately After Project Construction.** Independent analyses by URSGWC verified that the levee construction methods described in the 1995 DEIR/EIS are adequate to maintain an appropriate factor of safety. Therefore, the impact is considered less than significant and no mitigation is required. (LTS)
Impact D-2: Potential for Seepage from Reservoir Islands to Adjacent Islands (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required.	**Potential Seepage on Adjacent Islands Resulting from Project Operations.** Analyses by URSGWC indicate that seepage control measures proposed by Delta Wetlands would be adequate to control seepage; however, the seepage control performance criteria were not adequate to detect adverse impacts. This impact is considered significant and mitigation is recommended to reduce the impact to a less-than-significant level. (S) C Modify Seepage Monitoring Program and Seepage Performance Standards (LTS)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Table 3D-9. Continued

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Differences between 2000 REIR/EIS and 1995 DEIR/EIS
Impact D-3: Potential for Wind and Wave Erosion on Reservoir Islands (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required.	**Potential for Wind and Wave Erosion on Reservoir Islands.** Analysis by URSGWC confirmed that the levee design and erosion protection measures proposed by Delta Wetlands would be adequate to address the potential for erosion and overtopping of the levees under worst-case wave runup conditions. This impact is considered less than significant. (LTS)
Impact D-4: Potential for Erosion of Levee Toe Berms at Pump Stations and Siphon Stations on Reservoir Islands (LTS) C Measures that would minimize effects of this impact have been incorporated by the project applicant into this alternative's project description. No additional mitigation is required.	These effects were not reevaluated in the REIR/EIS. The impact conclusions and mitigation remain the same as presented in the 1995 DEIR/EIS.
Impact D-5: Decrease in Potential for Levee Failure on Delta Wetlands Project Islands during Seismic Activity (B) C No mitigation is required.	**Potential Levee Failure on Delta Wetlands Project Islands during Seismic Activity.** Analyses by URSGWC indicate that deformation of as much as 4 feet of the reservoir island levee slopes would be experienced during a probable earthquake in the region. Compared to existing conditions, levee stability on the reservoir islands would be greater on the reservoir side and would be less on the slough side. This impact is considered significant and mitigation is recommended to reduce the impact to a less-than-significant level. (S) C Adopt Final Levee Design that Achieves Recommended Factor of Safety and Reduces the Risk of Catastrophic Levee Failure (LTS)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

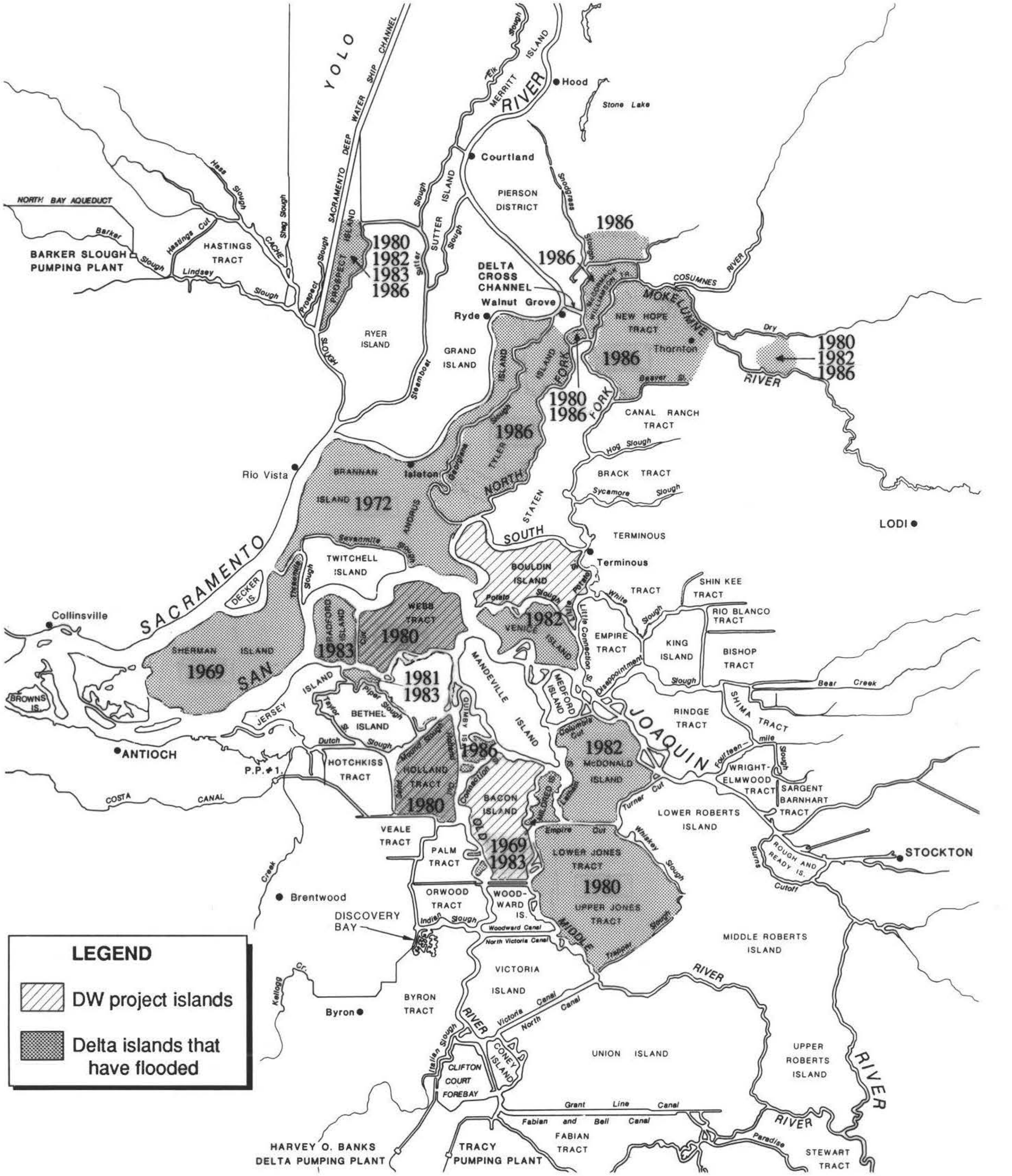
Table 3D-9. Continued

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Differences between 2000 REIR/EIS and 1995 DEIR/EIS
----	**Potential Property Damage Resulting from Levee Failure.** The project would have no effect on property compared to existing conditions if a levee were to fail into a reservoir island. There would be potential for property damage to occur if a levee failed toward the slough under full reservoir conditions, but the effect is considered less than significant because the risk of levee failure is very low. (LTS)
Impact D-6: Increase in Long-Term Levee Stability on Habitat Islands (B) C No mitigation is required.	These effects were not re-evaluated in the REIR/EIS. The impact conclusions and mitigation remain the same as presented in the 1995 DEIR/EIS.
Cumulative Impacts	
Impact D-12: Decrease in Cumulative Flood Hazard in the Delta (B) C No mitigation is required.	**Cumulative Effects on Delta Flood Hazard.** Implementation of the Delta Wetlands Project would not significantly contribute to cumulative flood hazards in the Delta. This impact is considered less than significant and no mitigation is required. (LTS)
Impact D-13: Decrease in the Need for Public Financing of Levee Maintenance and Repair on the Delta Wetlands Project Islands (B) C No mitigation is required.	This impact was not re-evaluated in the REIR/EIS. The impact conclusion remains the same as presented in the 1995 DEIR/EIS.

Notes:

Impacts D-7 through D-11 of the 1995 DEIR/EIS describe impacts of Alternative 3, the four-reservoir-island alternative. The REIR/EIS does not analyze levee stability and seepage for Bouldin Island and Holland Tract. However, it can be reasonably assumed that the impact conclusions shown here for the proposed project would also apply to these islands under Alternative 3.

S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

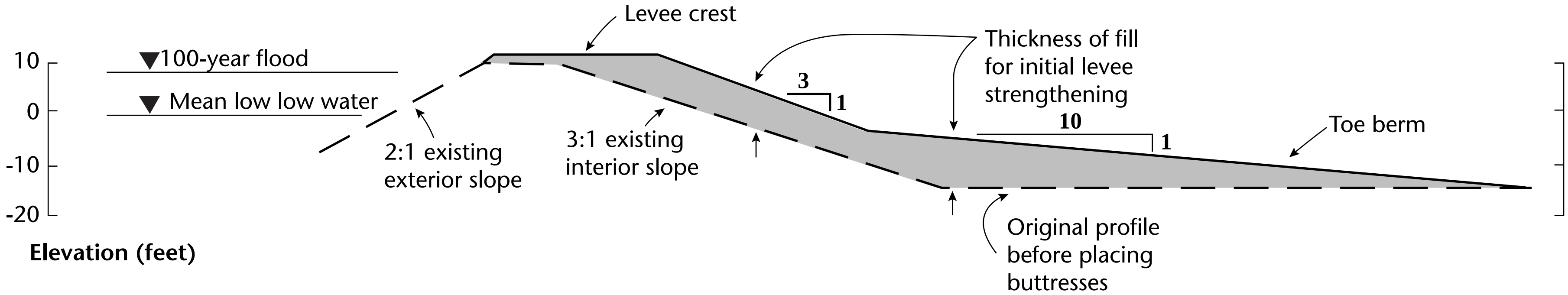


Source: California Department of Water Resources 1993.

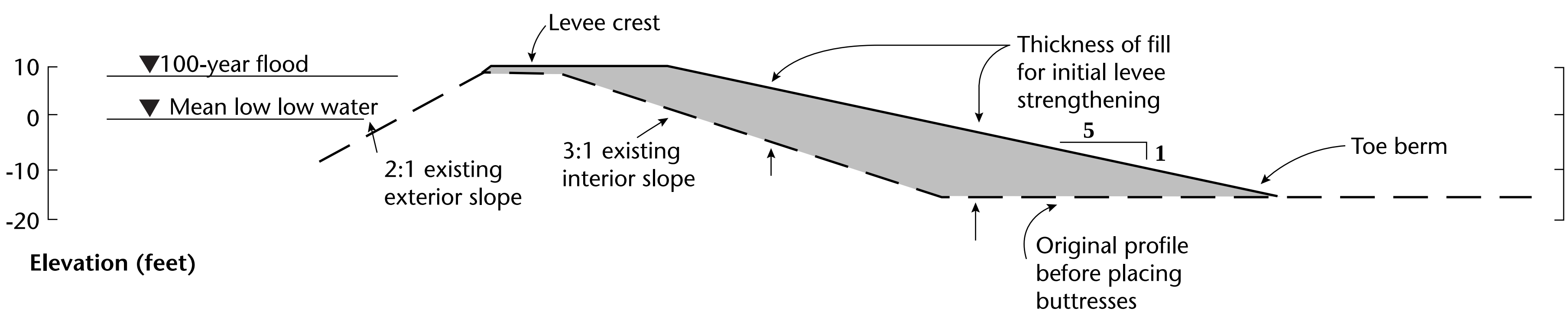
Jones & Stokes

Figure 3D-1
Recent Flooding on Delta Islands, 1967-1992

Example A: Broken-Slope Buttress



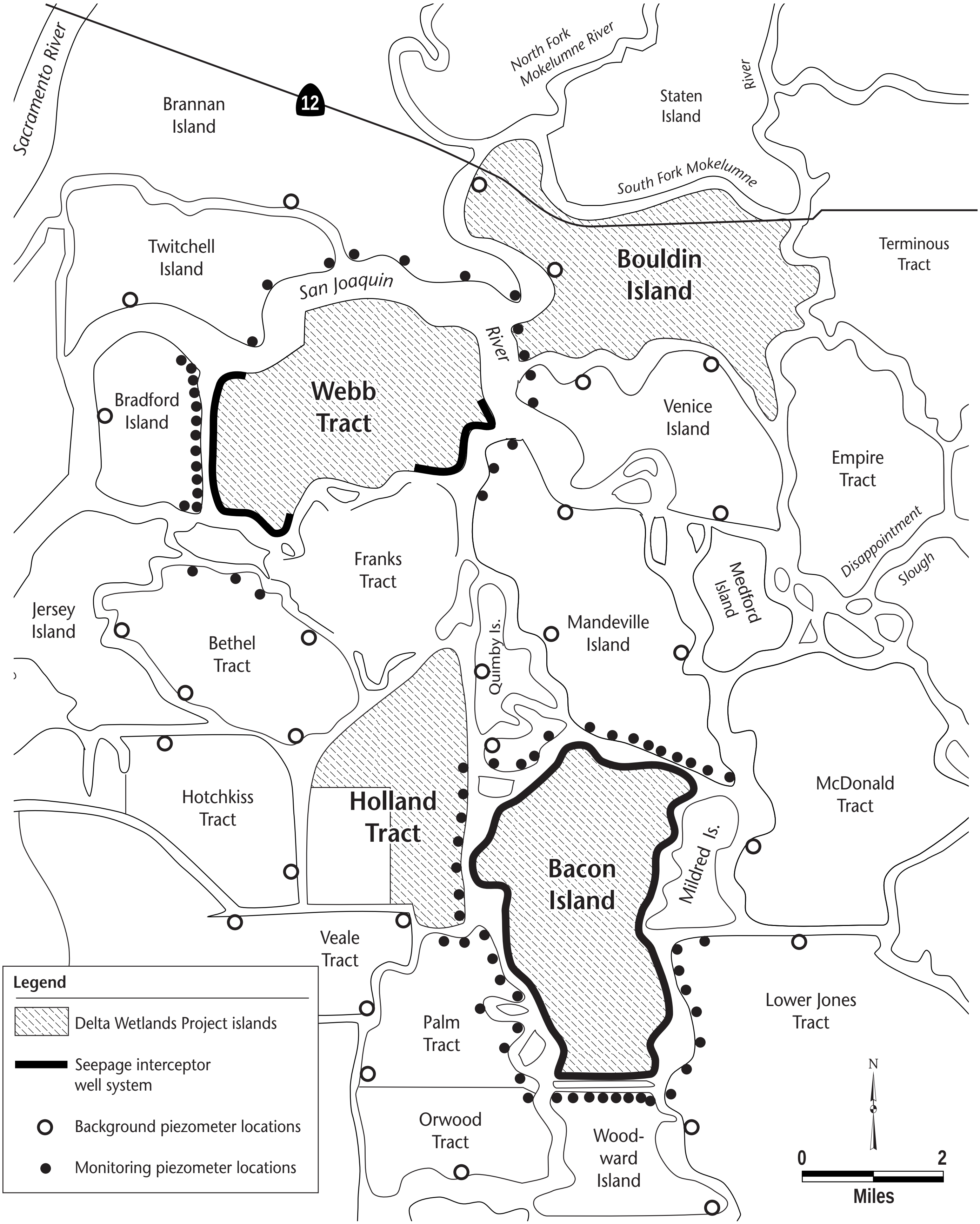
Example B: Constant-Slope Buttress



Source: Harding Lawson Associates 1993.

Jones & Stokes

Figure 3D-2
Examples of Initial Levee Strengthening on Reservoir Islands



Jones & Stokes

Figure 3D-3
Seepage Interceptor Well System and Proposed Locations of Seepage Monitoring Piezometers under Alternatives 1 and 2

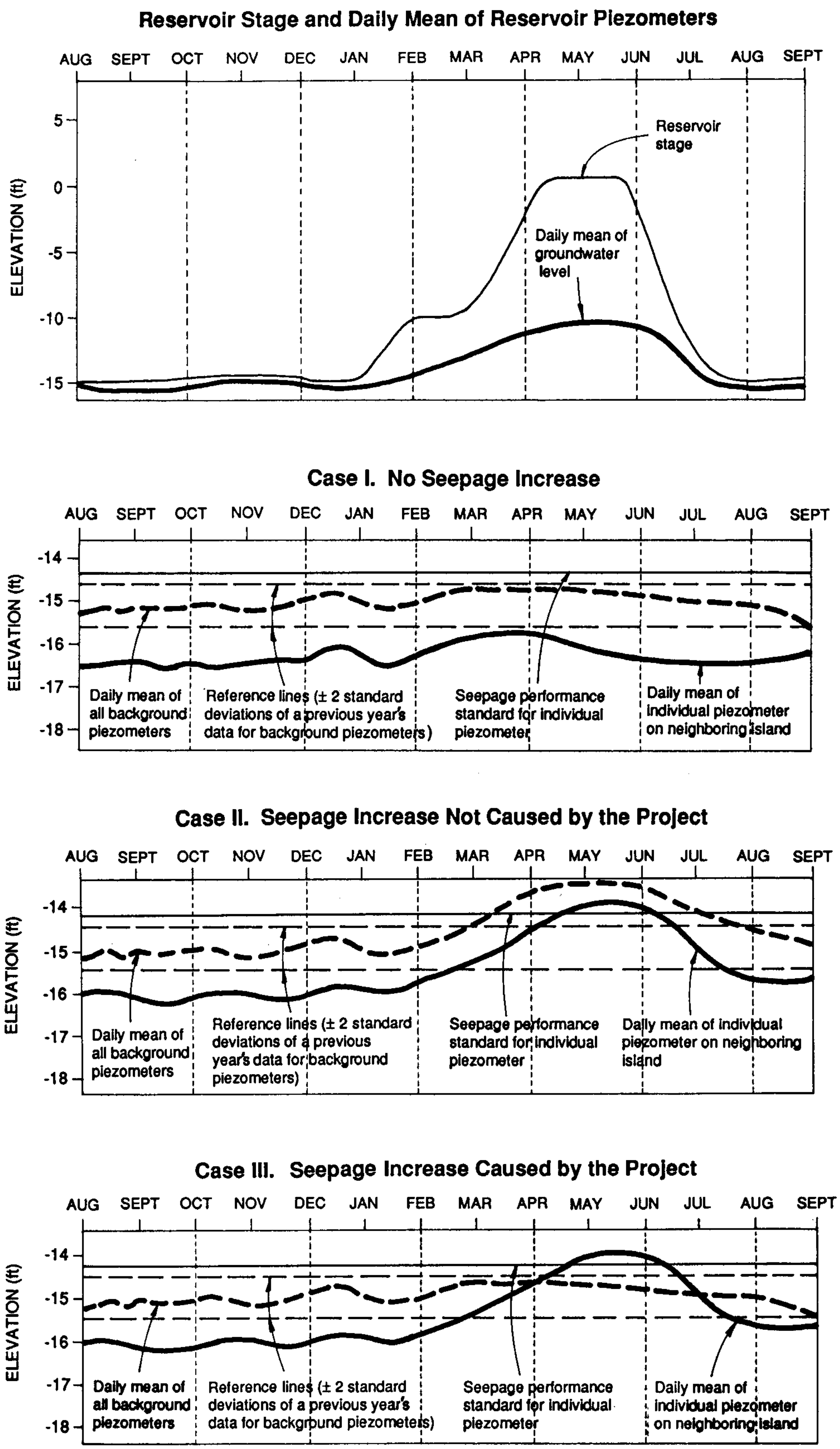
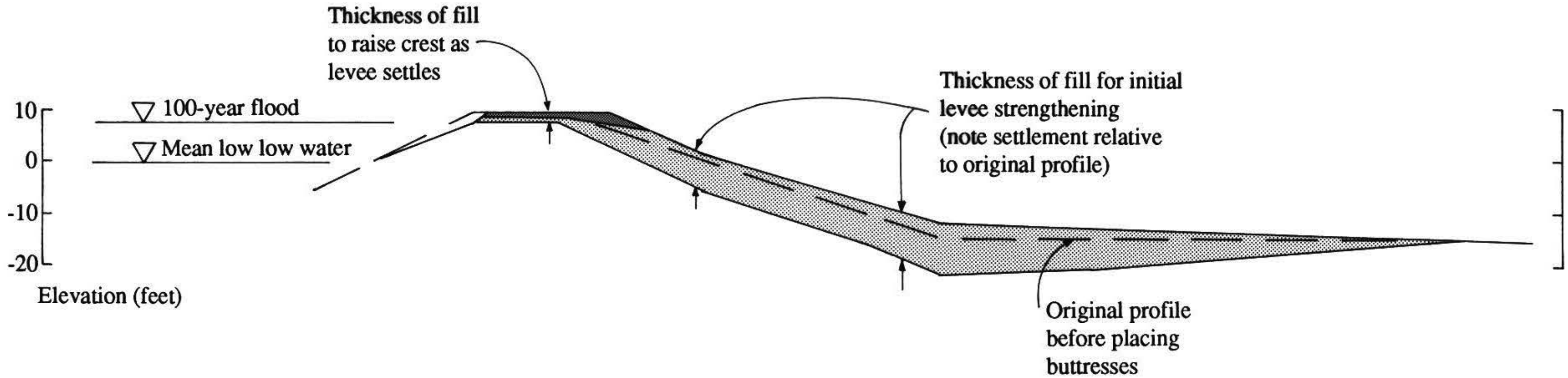
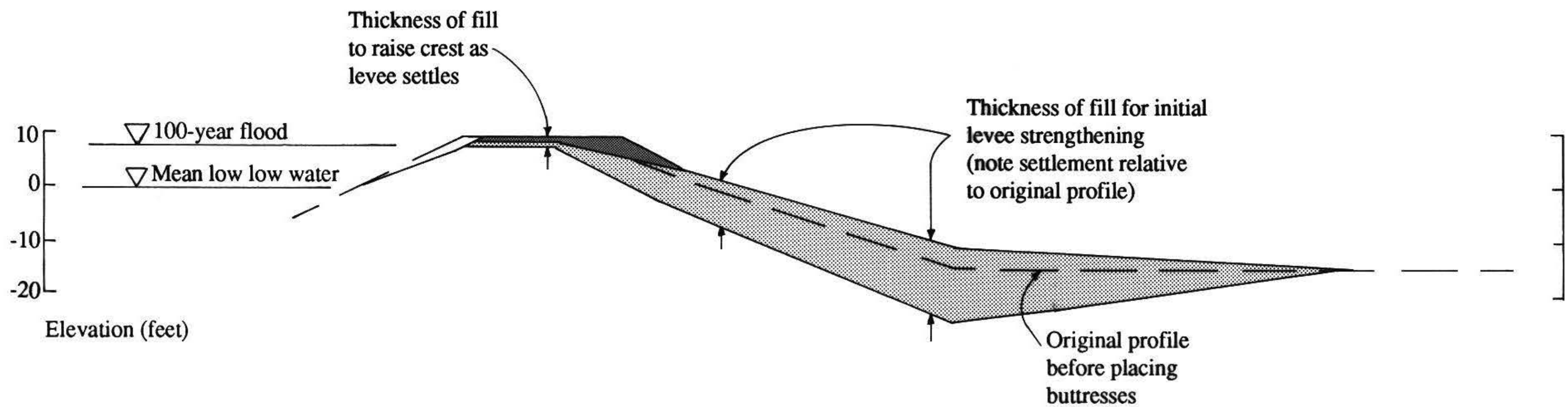


Figure 3D-4
Hypothetical Patterns of Seepage Relative to Performance Standards

Example A: Broken-Slope Buttress



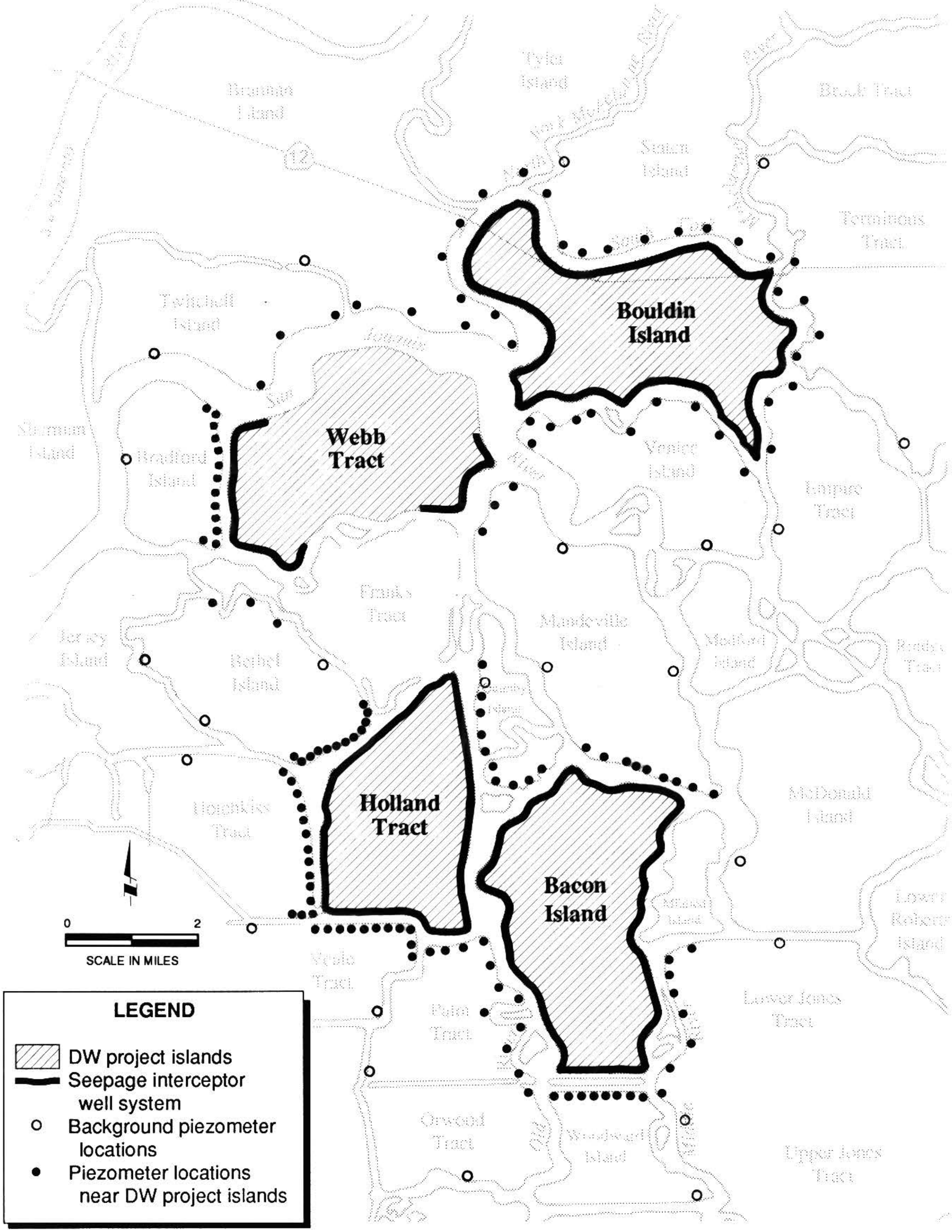
Example B: Constant-Slope Buttress



Source: Harding Lawson Associates 1993.

Jones & Stokes

Figure 3D-5
Examples of Settlement of Initial Fill and Rising Crest with Additional Fill



Source: Hultgren pers.comm.

Jones & Stokes

Figure 3D-6
Seepage Interceptor Well System and Proposed Locations of Seepage Monitoring Piezometers for Alternative 3

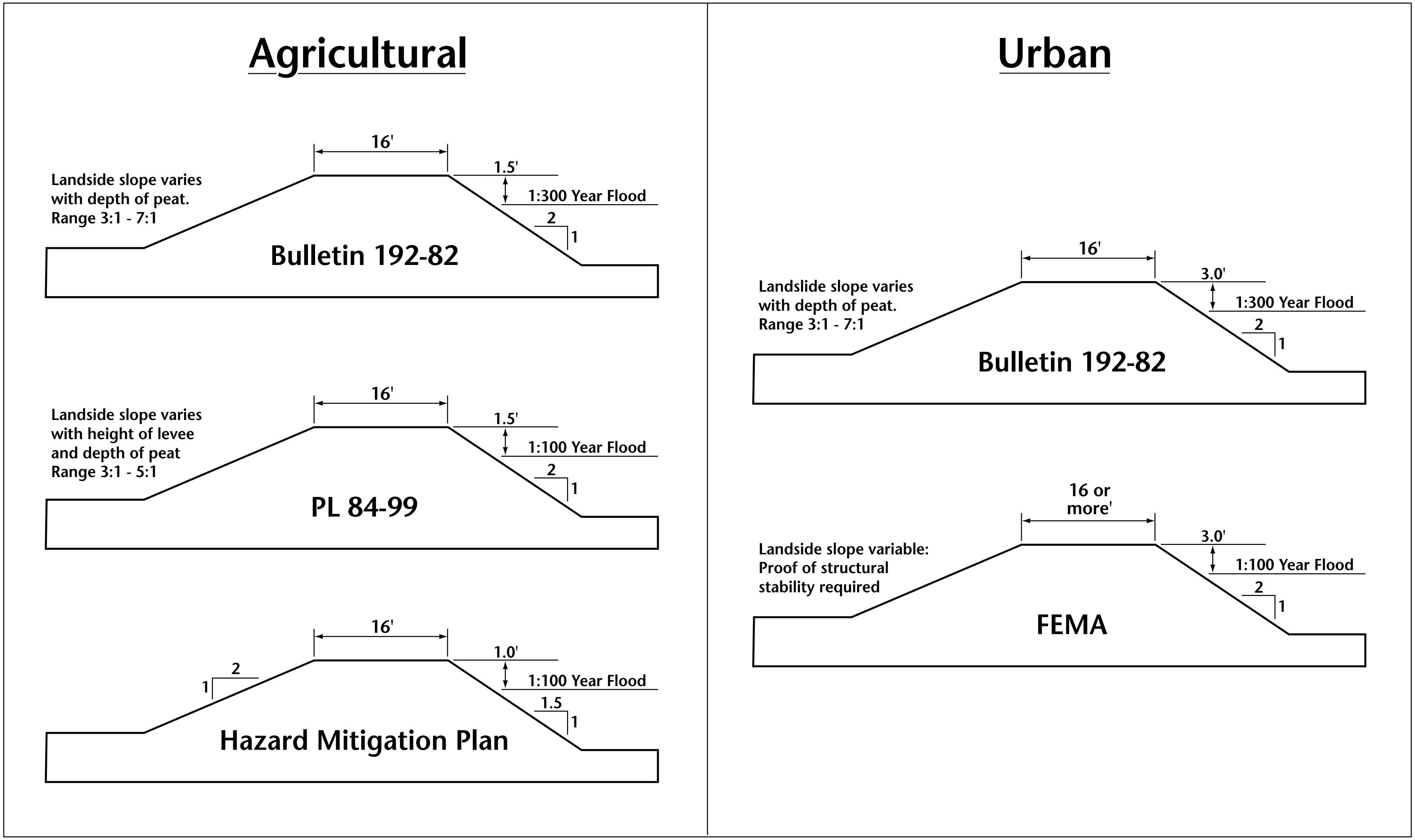


Figure 3D-7
Levee Geometric Standards

Chapter 3E. Affected Environment and Environmental Consequences - Utilities and Highways

Chapter 3E. Affected Environment and Environmental Consequences - Utilities and Highways

SUMMARY

This chapter discusses the effects of construction and operation of the DW project alternatives on existing utility infrastructure, public services, highways, county roads, and ferry services on the DW project islands.

Impacts on utilities and highways were analyzed in the 1995 DEIR/EIS. A new evaluation of project effects on natural gas pipelines and facilities was subsequently performed for the 2000 REIR/EIS, and additional impacts and mitigation measures were identified.

The results of these analyses indicated that implementation of Alternative 1, 2, or 3 would result in significant impacts on the natural gas pipelines that cross Bacon Island. Levee improvements and island inundation could adversely affect the pipelines and Pacific Gas & Electric Company's (PG&E's) ability to inspect the pipelines. Mitigation is recommended to reduce these impacts to less-than-significant levels. Implementation of Alternative 1, 2, or 3 would result in significant impacts on electrical utilities and emergency services. Existing PG&E overhead electrical distribution lines would be inundated on reservoir islands during water storage operations and would need to be extended on Webb Tract, Bouldin Island, and Holland Tract to serve proposed siphon, pump, and recreation facilities. Operation of the recreation facilities on the DW project islands would increase demand for police and fire services on the DW project islands and in adjacent waterways. These impacts are considered significant. To mitigate impacts on electrical utilities to a less-than-significant level, DW, in coordination with PG&E, would permanently relocate the affected electrical lines on reservoir islands to the improved perimeter levees during project construction and would extend the existing electrical lines on the DW project islands to serve new facilities. DW would also incorporate adequate lighting, security services, and fire protection features into design and operation of the recreation facilities to reduce impacts on police and fire services. As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications; nevertheless, this chapter provides the analysis of impacts on utilities and services associated with construction and operation of these facilities. Also, under Alternative 3, fog hazard along SR 12 on Bouldin Island could increase and result in a significant and unavoidable impact on traffic safety; no mitigation is available to reduce this impact to a less-than-significant level. Implementing Alternative 1, 2, or 3 is not expected to result in any significant cumulative impacts.

Implementation of Alternative 1, 2, or 3 would result in less-than-significant impacts on ferry service operations to Webb Tract and on water supply, sewage, and solid waste facilities and services. Additionally, implementation of Alternative 3 would result a less-than-significant impact on the structural integrity of SR 12.

Beneficial impacts on utilities and roadways are associated with improvement of existing levees under Alternative 1, 2, or 3. Utilities and county roads on levees would benefit from levee improvements on the DW project islands.

Implementation of the No-Project Alternative would increase the subsidence rate of DW project island soils and, consequently, would increase the risk of failure of roads associated with DW island levees and maintenance requirements for gas lines on Bacon Island.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The analysis of project effects on natural gas pipelines and facilities was updated in the 2000 REIR/EIS. This chapter consists of the 1995 analysis of project effects on utilities and highways followed by the updated analysis of project effects on natural gas pipelines and facilities. Additionally, minor changes were made to update information regarding the existing utility infrastructure in response to comments received on the 1995 DEIR/EIS and 2000 REIR/EIS.

AFFECTED ENVIRONMENT

This section describes the utility and roadway infrastructure on the DW project islands. Information on utilities and roadways is based, in part, on information collected for the 1990 draft EIR/EIS. Where conditions have not changed, this information has been used to describe current conditions. The description of utilities and roadway conditions has been updated, however, to reflect changes in public access on Holland Tract Road, reconstruction of Bacon Island Bridge, and electrical utility line mapping and information on ferry service for Webb Tract. More information on existing use of roads is given in Chapter 3L, “Traffic and Navigation”. Information about the gas facilities and transmission pipelines on Bacon Island has been updated and is discussed below in the section from the 2000 REIR/EIS entitled “Affected Environment: Updated Information Presented in the 2000 Revised Draft EIR/EIS”.

Sources of Information

Information on utilities, services, and highways on the DW project islands was collected from current maps and communication with the affected public utility or service agency, county, or state agency. The DWR 1993 Delta atlas (DWR 1993) provided baseline mapping information.

Information used to prepare the analysis of project effects on natural gas facilities and transmission pipelines for the 2000 REIR/EIS was taken from comments on the 1995 DEIR/EIS and from evidence in testimony provided by PG&E and Delta Wetlands at the 1997 water right hearings. In addition, data from the U.S. Department of Transportation (DOT), Office of Pipeline Safety (U.S. Department of Transportation 1999), were used in the 2000 REIR/EIS analysis.

Highways, County Roads, and Ferry Service

Figure 3E-1 shows the highways and county roads in the project vicinity.

Bacon Island

A county road provides limited access to portions of Bacon Island (Figure 3E-1). Bacon Island Road enters Bacon Island near its southeast corner and runs northward on the eastern perimeter levee to a private bridge to Mandeville Island; the road provides access to the Bullfrog Landing Marina and agricultural properties on Bacon Island.

As part of the San Joaquin County Regional Transportation Improvement Program, realignment and reconstruction of the Bacon Island Bridge between Bacon Island and Mandeville Island began in April 1994 (Vidad pers. comm.) and was completed after the 1995 DEIR/EIS was issued. The new bridge is located approximately 300 feet north of the existing bridge.

Webb Tract

No county roads exist on Webb Tract; the Delta Ferry Authority provides ferry service to Webb Tract from Jersey Island (Figure 3E-1). The ferry operates from 8:00 a.m. to 5:00 p.m., Monday through Friday during fall, winter, and spring and Friday through Tuesday during summer. A total of 21,938 passengers used the ferry system in Contra Costa County in fiscal year 1998–1999 (California Office of the Controller 2000). Based on this figure, year-round average daily use is estimated at 85 passengers. The ferry system is funded through the Delta Ferry Authority. The Delta Ferry Authority is composed of Contra Costa County, Webb Tract Reclamation District, and Bradford Reclamation District. Each reclamation district provides approximately $50,000 per year in funding for the ferry service (Heringer pers. comm.), while Contra Costa County collects approximately $15,000 per year in local funds to support the ferry service (Cutler pers. comm.). The Delta Ferry Authority collects these monies to fund operation of the ferry.

The DW project and Bradford Island have a mutual need for the use of the ferry system. DW anticipates the ferry system would be used by recreationists and staff workers that are employed at the recreation facilities on Webb Tract. DW does not foresee the withdrawal of funding or discontinuing the ferry service (Forkel pers. comm.).

Bouldin Island

SR 12, a two-lane highway between Lodi on the east side of the Delta and Rio Vista on the west side of the Delta, crosses Bouldin Island (Figure 3E-1). SR 12 runs along the bottom of Bouldin Island at 10-15 feet below water levels in exterior channels. At the east end of the island, SR 12 crosses Little Potato Slough on a swing bridge, and at the west end of the island it crosses the Mokelumne River, also on a swing bridge. No county roads exist on Bouldin Island.

Holland Tract

Holland Tract Road, a county road, enters the southwest corner of Holland Tract (Figure 3E-1). Since 1991, access northward on the western perimeter levee has been blocked by a locked gate. This county road also runs eastward on the south levee to the Holland Tract Marina at the southeast corner of the island, where it also ends at a locked gate. In 1993, the Contra Costa County Department of Public Works abandoned those sections of Holland Tract Road on the west and east perimeter levees past the locked gates (Badst pers. comm.).

Gas Facilities and Transmission Pipelines

The Delta is generally a fertile area for natural gas exploration, and exploratory wells are continually being drilled throughout the area. Known underground gas fields and storage areas in the project vicinity are shown in Figure 3E-2. It is possible that gas wells may be drilled on the project islands by third-party mineral right holders. Gas wells could be drilled on the reservoir islands during drawdown periods. The compatibility of gas drilling with water storage or wildlife habitat management of the islands would be reviewed by the lead agencies or oversight management team for the habitat islands; the administering county; and the California Department of Conservation, Division of Oil and Gas, prior to granting an oil or gas well permit for gas exploration on the islands. The county would be the lead agency under CEQA for permitting gas wells.

Implementation of the DW project would not affect the likelihood of gas exploration on DW project islands; mineral rights would not change under the DW project from current conditions, and future proposals to drill on the islands would be subject to environmental review by the county and by the California Department of Conservation under an oil or gas well permit. Assumptions regarding the future locations and timing of gas well drilling on the project islands would be speculative, and these issues are not addressed in this document.

Bacon Island

The 1995 DEIR/EIS included information about PG&E's gas facilities and transmission pipelines across Bacon Island. This information has been superseded by updated information presented in the 2000 REIR/EIS and has therefore been removed from this section. The revised information is presented in the section from the 2000 REIR/EIS below entitled "Affected Environment: Updated Information Presented in the 2000 Revised Draft EIR/EIS".

Webb Tract

Presently, two wells are producing natural gas and two more wells have been approved for future drilling on Webb Tract. Additionally, there are several previously plugged and abandoned gas extraction wells on Webb Tract (Marshall pers. comm.).

Bouldin Island and Holland Tract

No gas facilities or transmission pipelines exist on Bouldin Island or Holland Tract.

Electrical Distribution Lines

PG&E operates 12-kilovolt (kV) electrical distribution lines on all four project islands to serve residences and farm operations (Figure 3E-3). These lines typically run on wooden utility poles.

Police and Fire Protection Services

Bacon Island and Bouldin Island

Police protection for Bacon Island and Bouldin Island is provided by the San Joaquin County Sheriff's Department. The department's main headquarters is in French Camp, California. The San Joaquin County Sheriff's department marine patrol division provides water patrol services to approximately 600 square miles of waterways in the Delta area. The marine patrol unit is staffed by four deputy officers and one supervisor; reserve officers are also used during major events and holidays. The marine patrol division substation, located at Steven's Anchorage in Stockton, responds to emergencies on Bouldin Island and Bacon Island. Through a mutual aid agreement with San Joaquin County, the Sacramento County Sheriff's Department, the Contra Costa County Sheriff's Department, and the U.S. Coast Guard also provide emergency services to Bacon and Bouldin Islands if needed. The San Joaquin County Sheriff's Department is responsible for law enforcement and investigation in the area regarding, but not limited to, drownings, boat accidents, drunkenness, theft, vandalism, property crimes, trespassing, disturbances, and enforcement of boat speed limits. (Bohnak pers. comm.)

Fire protection for Bouldin Island is provided by the San Joaquin County Delta Fire Protection District, Station 1. The Delta Fire Protection District's service area encompasses approximately 95 square miles and provides fire protection and emergency services to Bouldin Island. Station 1 is located in Lodi and is staffed by two full-time firefighters. Volunteer firefighters are also available to respond to fire emergencies as needed. Station 1 is equipped with four engines, including Type 1, 2, and 3 engines; one rescue unit; and two fire boats. The fire boats are launched at Tower Park Marina and Paradise Marina. Response time from Station 1 to Bouldin Island is approximately 2-3 minutes. The district has a Class VI Fire Department Insurance Service Office Rating and operates under a mutual aid agreement with other fire departments within San Joaquin County. (Davidson pers. comm.)

Bacon Island is not currently in a fire protection district. Fire protection services are the responsibility of the landowners.

Webb Tract and Holland Tract

The Contra Costa County Sheriff's Department provides law enforcement services for Webb and Holland Tracts. The department's headquarters is in Martinez. The Contra Costa County Sheriff's Department Delta marine patrol division provides emergency service to Webb and Holland Tracts through its substation in Oakley. The marine patrol is staffed by two deputy officers year round; an additional deputy officer is available during the peak summer season (Memorial Day through Labor Day). Contra Costa County has a statewide mutual aid agreement with the San Joaquin County Sheriff's Department and the U.S. Coast Guard to respond to emergency situations in the Delta. Typical crimes reported to the sheriff's department in the Delta area include disturbances, thefts, and vandalism of property. (Hunt pers. comm.)

The Contra Costa County Fire Protection District provides fire protection for Holland Tract. The district is staffed by approximately 480 full-time firefighters, and the district service area encompasses approximately 350 square miles. Knightsen Station 94, located in Knightsen, provides emergency services to Holland Tract and is staffed by volunteer firefighters. Response time from Station 94 to Holland Tract is less than 7 minutes. The district has a Class III Fire Department Insurance Service Office Rating and operates under a statewide mutual aid agreement with other fire agencies in and around San Joaquin County. (Bell pers. comm.)

Similar to Bacon Island, Webb Tract is not currently in a fire protection district. Fire protection is the responsibility of the landowners.

Water Supply Facilities and Sewage Disposal Service

Existing water supply and sewage treatment facilities support farmsteads, rural residences, and seasonal barracks on Bacon Island; trailers, a residence, and a clubhouse on Webb Tract; rural residences and farmsteads mostly north of SR 12 on Bouldin Island; and rural residences, a trailer, and two marinas on Holland Tract. See Chapter 3I, "Land Use and Agriculture", for more information on existing structures and land uses on the DW project islands. Agricultural water supply under existing conditions is described in Chapters 3A, "Water Supply and Water Project Operations", and 3C, "Water Quality".

Water supply for existing buildings and facilities on the DW project islands is provided by wells on the islands, water pumped from nearby channels, and bottled water service. Well water and pumped water are treated on the islands. Treatments include pretreatment reverse osmosis systems and filtering systems. All water services are privately managed; no public facilities are available on the DW project islands.

Septic systems are primarily used for sewage disposal at existing buildings and facilities on the DW project islands. A lagoon treatment system on Holland Tract serves a marina. Waste is transported to a "lagoon" lined with material to prevent seepage into the ground and is treated through evaporation and aerobic decomposition.

Solid Waste Service

Solid waste collection and disposal service for the DW project islands is provided by private waste collection service(s) authorized to operate in Contra Costa and San Joaquin Counties. The waste is collected and transported to the appropriate county landfills in compliance with county and state regulations governing solid waste disposal.

The Marine Plastic Pollution Research and Control Act of 1987 (33 U.S.C. 1901 et seq.) requires that all ports, terminals, and marinas provide adequate reception facilities for disposal of garbage from vessels with which they conduct commerce. This act sets performance standards to ensure that garbage is removed from the vessels and processed in accordance with U.S. Coast Guard and U.S. Department of Agriculture (USDA) regulations. However, the installation of equipment to handle garbage is not a requirement. Waste collection and disposal activities are also subject to regulations stated in the California Administrative Code, Title 14, Division 7. (California State Lands Commission 1994.)

Other Utility Facilities

PG&E and Western Area Power Administration Transmission Lines

Two major electrical transmission lines cross Hotchkiss Tract and Veale Tract to the west and southwest of Holland Tract: PG&E's 500-kV Table Mountain-to-Tesla line and Western Area Power Administration's 230-kV Intertie line.

Santa Fe Railroad

Santa Fe Railroad's Stockton-to-Richmond rail line crosses the Delta in an east-west direction immediately south of the south end of Bacon Island (Figure 3E-1). The single-track line traverses a narrow linear causeway within Santa Fe Cut, which separates Bacon Island from Woodward Island to the south. Santa Fe Cut between the south edge of the island and the railroad causeway is approximately 400 feet wide along its entire length. Nineteen freight trains and eight passenger trains use the Richmond-Stockton line daily (Colbert pers. comm.).

Mokelumne Aqueduct

East Bay Municipal Utility District (EBMUD) owns and operates the Mokelumne Aqueduct, which crosses the Delta immediately south of the Santa Fe rail line (Figure 3E-1). The aqueduct, consisting of three above-ground steel and concrete pipelines, crosses Woodward Island south of Bacon Island, approximately 800 feet south of the rail line. Siphons connect the pipelines beneath Old River and Middle River west and east of Woodward Island. The aqueduct provides water to over 1 million people in the east Bay Area.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Impacts on utilities, services, and highways were assessed based on how construction and operation of the DW project alternatives would benefit or adversely affect the existing utility infrastructure or service. Effects of the project alternatives on highways and county roads were evaluated based on how the project operation could affect the integrity of the roadway levees through wave erosion and differential settlement; these effects are based on the assessment of levee stability described in Chapter 3D, "Flood Control". Potential changes in operation of the ferry system to Webb Tract were evaluated through discussions with the Delta Ferry Authority and estimation of changes in passenger travel during project operation. Effects of the project alternatives on gas and electrical lines and facilities on the DW project islands were determined through discussions with the affected utility agency and estimation of alterations to the existing infrastructure and any changes in existing operation of the facilities that would be needed during project operation. Increased risk to facilities on adjacent islands was assessed using estimated changes in risk of levee failure during construction and operation of the DW project alternatives. Potential effects of the DW project alternatives on emergency services and public utilities were evaluated based on how project operation would affect the ability of the service agencies and existing facilities to adequately serve the DW project islands.

There is a potential of some level of continuing subsidence on the DW project islands even with the cessation of farming activities. As a result, the water storage capacity of the reservoir islands could increase in future years. The rate of subsidence, however, would be substantially less than under existing conditions. Reduced rates of subsidence and increased water storage capacity on reservoir islands would not be expected to substantially increase or decrease utility and roadway effects analyzed in this chapter.

Criteria for Determining Impact Significance

In the 1995 DEIR/EIS analysis, an alternative was considered to have a significant impact on utilities and highways if it would:

- increase risk of structural failure of existing railways and roadways, gas facilities and pipelines, electrical transmission or distribution lines, and water distribution facilities;
- result in a need for new systems, or substantial alterations to or increased maintenance of power or natural gas facilities, communication systems, water infrastructure, sewer lines, septic tanks, or solid waste services;
- result in increased demand for existing emergency services beyond their current capacity; or
- increase traffic hazards to motor vehicles, bicyclists, or pedestrians by degrading the existing infrastructure.

An alternative was considered to have a beneficial impact on utilities and highways if it would improve the existing utility or roadway infrastructure.

Similar criteria were developed to evaluate specific impacts on the natural gas facilities and transmission pipelines on Bacon Island. These criteria are described below in the section from the 2000 REIR/EIS entitled "Impact Assessment Methodology for the 2000 Revised Draft EIR/EIS".

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands), with Bouldin Island and Holland Tract (habitat islands) managed primarily as wildlife habitat. Reservoir islands would be managed primarily for water storage, with wildlife habitat and recreation constituting secondary uses. The impacts of Alternative 1 on utilities and highways in the project area are described below. Most of the impacts on utilities and highways under Alternative 1 are considered less than significant; mitigation is recommended for impacts that are considered significant.

Highways, County Roads, and Ferry Service

Bacon Island

Under Alternative 1, Bacon Island Road, the existing county road, would remain along the east side of Bacon Island to the private bridge to Mandeville Island. Implementation of Alternative 1 would improve the eastern perimeter levee on Bacon Island, thereby improving the structural integrity of Bacon Island Road.

Construction of Alternative 1 would not conflict with reconstruction of the Bacon Island Bridge. Public access to Bacon Island will be maintained during construction, and flooding of the island is not anticipated to conflict with construction access for Bacon Island Bridge reconstruction. DW would coordinate with San Joaquin County and the California Department of Transportation (Caltrans) during DW construction scheduling to plan levee construction work on Bacon Island in conjunction with the Bacon Island Bridge reconstruction.Therefore, implementation of Alternative 1 would not affect Bacon Island Bridge reconstruction.

Chapter 3D, "Flood Control", discusses the topic of levee reliability with regard to wave erosion and settlement, and Chapter 3L, "Traffic and Navigation", addresses any construction-related safety and traffic impacts on Bacon Island Road.

Webb Tract

Implementation of Alternative 1 would reduce ferry traffic from Jersey Island to Webb Tract as farming operations on Webb Tract cease. However, the ferry would be used by DW workers and by recreationists to reach the island during project operation. Based on estimated recreation use-days under Alternative 1 (see Chapter 3J, "Recreation and Visual Resources"), the number of ferry passengers is expected to decline to approximately 55% of existing use during hunting season (October-January). Ferry use during spring and summer could also decline substantially. However, the current operation schedule for the ferry is not proposed to change during project operation. Because revenues for the ferry are not generated by passenger fees, funding for the ferry system would not be affected by reduced use during project operation, and the likelihood of service failure would not increase due to financial constraints. The operation and maintenance cost of running the ferry may decline as ferry traffic, especially heavy grain truck traffic, is reduced after project implementation.

Bouldin Island

Water storage levels during operation of the proposed project would not differ significantly from existing storage levels during agriculture production, so the risk of levee failure or traffic hazards (e.g., fog) along SR 12 would not change under Alternative 1. Therefore, implementation of Alternative 1 would not affect SR 12.

Holland Tract

As on Bouldin Island, projected water storage levels on Holland Tract under Alternative 1 would not exceed current water storage levels. Holland Tract Road would not be adversely affected by management of the island for wildlife habitat; the road would benefit from levee erosion control measures (i.e., levee revegetation) under Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-1: Increase in the Structural Integrity of County Roads. Implementation of Alternative 1 would result in levees surrounding reservoir islands being raised and widened. Erosion-resistant facing would be placed on the interior slopes of the levees. These levee improvement activities would increase the structural integrity of Bacon Island Road on the eastern perimeter levee of Bacon Island.

Because subsidence rates on habitat islands would decrease under Alternative 1, the stability of levees surrounding Bouldin Island and Holland Tract would increase. DW would undertake levee rehabilitation on the habitat islands as needed consistent with the state standards described in DWR Bulletin 192-82 (DWR 1982), which would strengthen the levees. Holland Tract Road would benefit from the increased levee stability and the probable reduction of road maintenance activities. (See Chapter 3D, "Flood Control", for more detailed information regarding subsidence and erosion control.) This impact is therefore considered beneficial.

Mitigation. No mitigation is required.

Impact E-2: Reduction in Ferry Traffic from Jersey Island to Webb Tract. Implementation of Alternative 1 would cause cessation of farming operations on Webb Tract, and ferry traffic from Jersey Island to Webb tract would decline. Alternative 1 could generate approximately 15 passengers per hunting day (3 hunting days per week during the October-January season) for recreation access to Webb

Tract, resulting in a decline of ferry use from the existing average of 40 passengers per day. The current ferry schedule (5 days per week) would not change during project operation. The ferry would provide transportation for DW workers year round. A projected net decline in ferry use during project operation would not result in a need for a new system or adversely affect operation and maintenance of the existing system. Reductions in traffic on the ferry, especially heavy grain truck traffic during harvest, could result in reduced operations and maintenance costs. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Gas Facilities and Transmission Pipelines

Bacon Island

The 1995 DEIR/EIS discussion of project effects on gas facilities and transmission pipelines across Bacon Island has been superseded by the updated information presented in the 2000 REIR/EIS and has therefore been removed from this section. The revised discussion is presented below in the section from the 2000 REIR/EIS entitled "Environmental Consequences". The impact and mitigation statements below have been revised to reflect the conclusions in that section.

Webb Tract

Storage of water on Webb Tract would not preclude future natural gas exploration; however, existing wells might have to be abandoned. During the final design of the proposed project, DW would need to consult with the Department of Conservation, Division of Oil and Gas, and with existing mineral rights holders to determine whether producing wells located on Webb Tract need to be abandoned and whether previously abandoned wells need to be reabandoned (Marshall pers. comm.).

Bouldin Island and Holland Tract

As stated previously, no gas facilities or transmission pipelines exist on Bouldin Island or Holland Tract.

Summary of Project Impacts and Recommended Mitigation Measures

The impacts and mitigation measures summarized below include the two impacts on natural gas facilities identified in the 1995 DEIR/EIS and the additional impacts and mitigation measures identified in the 2000 REIR/EIS. A detailed description of these impacts and mitigation measures is provided in the section from the 2000 REIR/EIS below entitled "Environmental Consequences".

Impact E-3: Increase in the Risk to Gas Lines Crossing Exterior Levees on Bacon Island Resulting from Levee Improvements. Implementation of Alternative 1 could cause settlement issues or increased loads on the pipelines at the levee crossings and may require corrective measures during levee construction and settlement. This impact, which is described below under "Risk of Pipeline Leak or Rupture Resulting from Levee Improvements", is considered significant.

Implementation of Mitigation Measures RE-1 and RE-2 would reduce Impact E-3 to a less-than-significant level.

Mitigation Measure RE-1: Monitor Locations Where Gas Pipelines Cross Bacon Island Levees during and after Levee Construction. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Levee Improvements".

Mitigation Measure RE-2: Implement Corrective Measures to Reduce Risk of Pipeline Failure during Levee Construction. This mitigation measures is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Levee Improvements".

Impact E-4: Increase in PG&E Response Time to Repair a Gas Line Failure on Bacon Island. Implementation of Alternative 1 would delay and complicate repairs to PG&E pipeline facilities. However, the risk of a pipeline leak or rupture on Bacon Island is very low, and such a leak or rupture would be equally likely under dry or wet conditions. The potential impact on PG&E's operation is economic in nature. Because economic effects are not considered environmental impacts under CEQA and NEPA, no significance conclusion is made and no mitigation is identified. This impact is explained in greater detail in the section from the 2000 REIR/EIS below entitled

"Potential Delay in Emergency Repairs and Unscheduled Interruption of Service".

Impact RE-1: Increase in the Risk to Line 57-A from Island Inundation. Although the long-term risk of pipeline leak or rupture would not increase under proposed project operations, the currently unused pipeline (Line 57-A) on Bacon Island may need additional weighting before the island is flooded to prevent the line from floating. This impact is described below in the section from the 2000 REIR/EIS entitled "Risk of Pipeline Leak or Rupture Resulting from Island Inundation". The need to weight the pipeline is considered a substantial alteration to the existing system and a significant impact.

Implementing Mitigation Measure RE-3 would reduce Impact RE-1 to a less-than-significant level.

Mitigation Measure RE-3: Securely Anchor Line 57-A before Bacon Island Flooding. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Island Inundation".

Impact RE-2: Potential Interference with Pipeline Inspection Procedures. This impact is described in the section from the 2000 REIR/EIS below entitled "Potential Interference with Pipeline Inspection Procedures". The impact on access for pipeline inspections and on monitoring facilities is considered significant.

Implementation of Mitigation Measures RE-4 and RE-5 would reduce this impact to a less-than-significant level.

Mitigation Measure RE-4: Provide Adequate Facilities on Bacon Island for Annual Pipeline Inspection. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Potential Interference with Pipeline Inspection Procedures".

Mitigation Measure RE-5: Relocate Cathodic Protection Test Stations before Bacon Island Flooding. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Potential Interference with Pipeline Inspection Procedures".

Electrical Distribution Lines

Bacon Island

PG&E may provide electrical service for the discharge pump stations on the reservoir islands under Alternative 1. This would require adding capacity to the existing distribution lines but would not require new distribution easements or structures on Bacon Island. Therefore, Alternative 1 would not substantially change the existing electrical infrastructure by increasing capacity on the lines.

Electrical lines along Bacon Island's perimeter levees would be modified as needed during project construction and levee improvements. DW would negotiate with PG&E regarding necessary arrangements for the needed work. Modifications to existing lines during levee construction would not substantially alter the existing system on Bacon Island. Before temporary or permanent modification or relocation of existing electrical lines, DW would conduct special-status plant surveys in areas that could be affected by the proposed modifications. If threatened or endangered plant species are found, DW will avoid disturbing those plants when making changes to existing electrical lines.

Webb Tract

As stated previously, PG&E may provide electrical service for discharge pump stations on the reservoir islands. If provision of electrical service is required, PG&E would add capacity to the existing distribution lines. Adding capacity would not require new distribution easements or structures, as described above for Bacon Island.

Some distribution lines are located on Webb Tract on the perimeter levees, and one line traverses the island. Consequently, inundation of Webb Tract would alter the existing system. The PG&E overhead distribution line that crosses the bottom of Webb Tract and connects to Bradford Island and Mandeville Island distribution lines (Figure 3E-3) would need to be relocated during construction. This would substantially affect the existing infrastructure on Webb Tract. Before temporary or permanent modification or relocation of existing electrical lines, DW would conduct special-status plant surveys in areas that could be affected by the proposed modifications. If threatened or endangered plant species are found, DW will avoid disturbing those plants when making changes to existing electrical lines.

Bouldin Island and Holland Tract

Wildlife habitat management on Bouldin Island and Holland Tract would be compatible with operation of PG&E electrical facilities. Some existing distribution lines that serve farming operations would no longer be needed. Infrastructure stability may be enhanced and maintenance needs reduced under Alternative 1 conditions because subsidence rates will be lower with wildlife management uses than under existing agriculture management. Chapter 3D, "Flood Control", discusses subsidence rates under existing and project conditions. Wildlife habitat management would not affect existing electrical utility lines on Holland Tract and Bouldin Island.

Recreation Facilities

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on electrical distribution utilities presented below assumes that the recreation facilities would be constructed and operated. This information provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-5: Inundation of Electrical Distribution Utilities on the Reservoir Islands. Implementation of Alternative 1 would cause inundation of existing PG&E overhead distribution lines on Webb Tract during water storage operations. Maintenance of electrical service between Bradford Island and Mandeville Island would require raising or relocating the distribution lines. This impact is considered significant.

Implementing Mitigation Measure E-1 would reduce Impact E-5 to a less-than-significant level.

Mitigation Measure E-1: Relocate Electrical Distribution Lines to the Perimeter Levee around Webb Tract. DW, in coordination with PG&E, shall permanently relocate the existing electrical distribution lines on Webb Tract to the improved perimeter levees during project construction. The new or relocated distribution lines would be located along perimeter levees and would be installed overhead near the toe of the new slopes, similar to existing installations. Before temporarily or permanently modifying or relocating existing electrical lines, DW would conduct special-status plant surveys in areas that could be affected by the proposed modifications. If threatened or endangered plant species are found, DW will avoid disturbing those plants when making changes to existing electrical lines.

Impact E-6: Possible Need to Increase Capacity of the Existing Electrical Distribution Lines on the DW Project Islands. Implementation of Alternative 1 may require PG&E to provide electrical service for discharge pump stations, siphon stations, and recreation facilities on the DW project islands. If electrical service is required, PG&E would add capacity to the existing distribution lines. The proposed locations for some pump and siphon stations and recreation facilities (see Chapter 2, Figures 2-2 and 2-3) are adjacent to or within existing electrical line easements. Increasing capacity of existing distribution lines would not require new distribution easements or structures on the islands. Therefore, this impact is considered less than significant.

It may also be necessary to relocate or upgrade electrical lines and substation facilities to serve new project facilities; any relocation or upgrade of electrical substation facilities (50,000 volts and above) may require formal approval from the California Public Utilities Commission (CPUC). If, when specific design details are submitted, the CPUC determines that the NEPA and CEQA documentation already completed for the DW project does not cover site- specific environmental impacts in enough detail, it may require additional environmental documentation before it provides approvals.

Mitigation. No mitigation is required.

Impact E-7: Possible Need to Expand the Existing Electrical Distribution Lines on Webb Tract, Bouldin Island, and Holland Tract to Serve a Proposed Siphon Station and Recreation Facilities. Implementation of Alternative 1 may require PG&E to provide electrical service to a siphon station on the northeast end of Webb Tract and to recreation facilities along the perimeters of Webb Tract, Bouldin Island, and Holland Tract that would not easily be serviced by existing lines. Because service to these facilities would require an extension of existing service lines, this impact is considered significant.

Implementing Mitigation Measure E-2 would reduce Impact E-7 to a less-than-significant level.

Mitigation Measure E-2: Extend Electrical Distribution Lines to Serve New Siphon and Pump Stations and Recreation Facilities. DW, in coordination with PG&E, shall extend existing electrical distribution lines on the reservoir islands where needed to serve new siphon and pump stations and recreation facilities. Before modifying existing electrical lines, DW would conduct special-status plant surveys in areas that could be affected by the proposed modifications. If threatened or endangered plant species are found, DW will avoid disturbing those plants when making changes to existing electrical lines.

Police and Fire Protection Services

Implementation of Alternative 1 would result in an incremental increase in demand for police and fire protection services on the DW project islands. Construction and operation of the proposed recreation facilities on the DW project islands would result in the following conditions that would contribute to the need for emergency services:

- construction of new buildings,
- an increase in the number of people visiting the DW project islands,
- an increase in boating use on waterways adjacent to the DW project islands, and
- establishment of boat facilities, which commonly attract criminal activities (e.g., vandalism and theft).

Therefore, operation of the recreation facilities under Alternative 1 would increase the need for emergency services on the DW project islands. As described above, DW has removed construction of recreation facilities from its CWA permit applications. Nevertheless, the analysis of impacts on police and fire protection services presented below assumes that the recreation facilities would be constructed and operated.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-8: Increase in Demand for Police Services on the DW Project Islands. Implementation of Alternative 1 would increase demands on police service during project operation. Construction of the recreation facilities would increase recreation activity in the Delta and could attract criminal activity, which is currently very low on the DW project islands. This impact is considered significant.

Implementing Mitigation Measures E-3 and E-4 would reduce Impact E-8 to a less-than-significant level.

Mitigation Measure E-3: Provide Adequate Lighting in and around Buildings, Walkways, Parking Areas, and Boat Berths. DW should provide illumination, in compliance with the recommendations of the Contra Costa County Sheriff's Department and the San Joaquin County Sheriff's Department, in and around recreation facilities, walkways, parking areas, and boat berths on all the DW project islands. Also, DW should consult with both sheriff's departments for building design recommendations in order to avoid features that may promote criminal activity.

Mitigation Measure E-4: Provide Private Security Services for Recreation Facilities and Boat Docks. DW should provide 24-hour onsite private security for the recreation facilities and boat docks on all four DW project islands. The security service will assist the San Joaquin County Sheriff's Department and Contra Costa County Sheriff's Department by deterring criminal activity.

Impact E-9: Increase in Demand for Fire Protection Services on the DW Project Islands. Implementation of Alternative 1 would increase demands on fire protection services during project operation. Construction of the recreation facilities would increase the number of people recreating on the DW project islands. Also, two of the DW project islands (Webb Tract and Bacon Island) are not currently serviced by a fire protection district. This impact is considered significant.

Implementing Mitigation Measures E-5 and E-6 would reduce Impact E-9 to a less-than-significant level.

Mitigation Measure E-5: Incorporate Fire Protection Features into Recreation Facility Design. DW should incorporate the required design features identified in the Uniform Building Codes and the Uniform Fire Codes into the design of the recreation facilities and boat docks.

Mitigation Measure E-6: Provide Fire Protection Services to Webb Tract and Bacon Island. DW, in coordination with the county and the local agency formation commission (LAFCO), should incorporate Webb Tract and Bacon Island into an existing fire protection district or create a new fire protection district to serve these islands. In addition, as part of the operation of the proposed recreation facilities, caretaker staff would be available 24 hours a day, trained, and certified to serve as volunteer firefighters. DW would acquire firefighting equipment necessary to provide adequate fire protection services on Webb Tract.

Water Supply Facilities and Sewage Disposal Service

Implementation of Alternative 1 would require the provision of water and sewage services to the proposed recreation facilities on the DW project islands. DW would need to provide new water sources and supply infrastructure for the recreation facilities. The recreation facilities would use gray water wherever possible to reduce the need for potable water consistent with county policies. To support recreation facilities, DW would need to increase bottled-water delivery service, drill and maintain new wells, and construct water treatment facilities as necessary to supply water at the recreation facilities.

DW would need to install sewage disposal systems that meet San Joaquin County and Contra Costa County requirements and standards for sewage disposal systems and design at the proposed recreation facilities. Facilities on the habitat islands would most likely be served by septic systems, and facilities on the reservoir islands would be served by a dual treatment system whereby gray water is treated to a tertiary level and released and black water is held in the system for offsite disposal.

DW will need to obtain the appropriate state and local permits for these facilities. Design of sewage disposal and water supply facilities would be site specific for each recreation facility, and the governing county would approve the final designs before issuing building or encroachment permits.

Implementation of Alternative 1 would also increase boating use and demand for boating-related sewage treatment and pumpout facilities. Pumpout stations would not be constructed at the recreation facility boat docks for sewage disposal. Boaters docked at the DW project facilities would use pumpout stations open to the public on Andrus Island, Empire Tract, Terminous Tract, or other pumpout stations in the Delta (Figure 3E-4). Water quality issues associated with boat use and sewage disposal are addressed in Appendix C6, "Assessment of Potential Water Contaminants on the Delta Wetlands Project Islands".

As described above, DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on water supply and sewage disposal presented below assumes that the recreation facilities would be constructed and operated. This information provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-10: Increase in Demand for Water Supply Services. Implementation of Alternative 1 would increase the need for potable water on the DW project islands. As part of the recreation facility design, DW will increase bottled-water delivery service, drill new wells, and incorporate water purification techniques as necessary to increase water supply at the recreation facilities. New services would need to be consistent with county policies. Therefore, this impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-7 would monitor the effectiveness of those measures.

Mitigation Measure E-7: Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities. Before construction of the proposed recreation facilities, DW should demonstrate to the Corps and SWRCB that it has obtained all required permits and approvals from local and state agencies for the design and construction of utilities and services including, but not limited to, water supply, sewage disposal, and solid waste disposal on the DW project islands.

In order to obtain a sewage permit in San Joaquin County, DW would be required to submit an application along with a work plan for the recreation facilities to the San Joaquin County Environmental Health Department. The work plan would then be reviewed by the Environmental Health Department to ensure compliance with all county requirements, and a permit would be issued or denied based on the findings of the review (Borgman pers. comm.).

Contra Costa County Environmental Health Division issues sewage permits in Contra Costa County. As with San Joaquin County, DW would be required to submit an application. In addition, DW would be required to submit three sets of plans for the recreation facilities along with a site map depicting existing structures and resources on the islands, and a safety plan. Issuance of the permit would be based upon compliance with all county requirements, review of the application, and site visit information obtained by the health inspector (Fung pers. comm.).

If, when specific design details are submitted to the appropriate regulating agencies, the agency determines that site-specific environmental impacts are not covered in enough detail by the NEPA and CEQA documentation already completed for the DW project, additional environmental documentation may be required prior to approval of permits, entitlements, or alternative treatment methods.

Impact E-11: Increase in Demand for Sewage Disposal Services. Implementation of Alternative 1 would result in an increased need for sewage disposal at the proposed recreation facilities. As part of the recreation facility design, DW will install a new sewage disposal system at each facility consistent with San Joaquin County and Contra Costa County requirements for sewage disposal systems and design. Therefore, this impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-7 (described above) would monitor the effectiveness of those measures.

Mitigation Measure E-7: Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities

Solid Waste

Under Alternative 1, use of the recreation facilities would increase demand for solid waste removal services on the DW project islands. DW would need to contract with a private waste collection and disposal service authorized to operate in Contra Costa County and San Joaquin County to serve the recreation facilities. As described above, DW has removed construction of recreation facilities from its CWA permit applications. Nevertheless, the analysis of impacts on solid waste services presented below assumes that the recreation facilities would be constructed and operated.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-12: Increase in Demand for Solid Waste Removal Implementation of Alternative 1 would result in the need for solid waste removal at the recreation facilities. DW will contract with a private waste collection and disposal service to respond to the need for removal of solid waste from the recreation facilities. The amount of solid waste generated at the recreation facilities would not likely exceed capacity of the collection service or local landfills. Therefore, this impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-7 (described above) would monitor the effectiveness of those measures.

Mitigation Measure E-7: Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities

Infrastructure Facilities on Adjacent Islands

Infrastructure on adjacent islands includes transportation and water conveyance facilities (Figure 3E-1), underground gas fields and storage areas (Figure 3E-2), and gas and electrical lines (Figure 3E-3). Increased risk of levee failure and seepage to adjacent islands caused by proposed water storage on Bacon Island and Webb Tract could threaten the reliability of these facilities and increase maintenance and repair costs; however, DW has made a commitment to improve levees around DW islands, which would increase the reliability of the DW island levees. DW would also mitigate any seepage problems beyond existing seepage levels by installing an interceptor well system around the project island levees (see Appendix D2, "Levee Design and Maintenance Measures", for more information on seepage control). Project features would maintain potential levee stability and seepage impacts at existing levels or better, so implementation of Alternative 1 would not increase the risk to adjacent utilities. Adjacent utilities would not be affected by Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Impacts and mitigation measures under this alternative are the same as under Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. The impacts of Alternative 3 on utilities and highways in the project area are described below. Most of the impacts on utilities and highways are considered less than significant; mitigation is recommended for one impact that is considered significant, and no mitigation is available for one impact that is considered significant.

Highways, County Roads, and Ferry Service

Bacon Island

The effect of implementation of Alternative 3 on the structural integrity of Bacon Island Road would be identical to that described above under "Impacts and Mitigation Measures of Alternative 1". Reconstruction of the bridge connecting Bacon Island to Mandeville Island would not be affected under Alternative 3.

Webb Tract

The effect of implementation of Alternative 3 on ferry traffic from Jersey Island to Webb Tract would be identical to that described above under "Impacts and Mitigation Measures of Alternative 1".

Bouldin Island

Increased Flood Risk on SR 12. Under Alternative 3, DW proposes to construct levees along SR 12 to protect the highway and the NBHA north of the highway from the water storage operations on the south side of SR 12.

To retain water and protect the existing highway, a dam would be required along the south side of SR 12 across Bouldin Island. The dam, Wilkerson Dam, would be constructed according to standards of DWR's DSOD because water would be impounded within the Bouldin Island reservoir to a maximum pool elevation of +6 feet. Design features for Wilkerson Dam include measures to control settlement, seepage, and wave erosion. Extensive geotechnical studies have been conducted for the dam, and design specifications have been developed and submitted to DSOD for review and approval (HLA 1992, 1993). Appendix E1, "Design and Construction of Wilkerson Dam South of SR 12 on Bouldin Island", presents detailed information on the dam design, construction staging and monitoring, and results of geotechnical studies for Wilkerson Dam. Levee reliability is described in Chapter 3D, "Flood Control", based on preliminary technical analyses and design specifications (HLA 1989, 1992, 1993) and Moffatt & Nichol (1988).

Implementation of Alternative 3 could increase the risk of structural failure of SR 12 by increasing the risk of flood damage from the reservoir south of the highway. Appendix E1 describes dam design features that would minimize the risk of failure. The proposed dam would be protected from wind and wave erosion on the water side with a high-density polyethylene surface or riprap or cement soil, the toe of the proposed dam would be set back from the highway to protect the roadbed from mud heave or settlement problems caused by the new levee, and seepage through the dam would be monitored and controlled by a drainage system. Therefore, water storage operations south of SR 12 would not affect SR 12 roadway stability.

The levee along the north side of SR 12 would hold back water present year round within the NBHA. The entire habitat area would be regraded during project construction to achieve a desired mix of habitats, including year-round water in ditches and interconnecting ponds. The regrading design for the NBHA should be reviewed by Caltrans to verify that the probability of adverse flooding impacts on SR 12 would be negligible. As proposed, the water level in the NBHA would not differ substantially from current water levels during agricultural production. Therefore, the levee on the north side of SR 12 would not require DSOD's approval, and operation of the NBHA would not affect the structural integrity of SR 12.

Highway Safety. Low-lying winter fog is an existing traffic hazard on SR 12 and in the project area. Because implementing Alternative 3 would increase the amount of water surface area adjacent to SR 12, the amount of fog produced on Bouldin Island could increase and affect traffic conditions on SR 12 (Costa pers. comm.). Constructing reservoirs on DW project islands would not substantially increase regional fog hazards in the Delta but may create patches of fog on each island. Because SR 12 is a regional transportation route, increasing fog on Bouldin Island may increase traffic hazards. The reservoir will be constructed 240-370 feet from the existing highway right-of-way (HLA 1992), and the highway is currently raised +4 feet above adjacent fields, which may alleviate some fog hazard problems. Increased potential for fog to rise from the surface of reservoirs under Alternative 3 cannot be avoided, however, and is assumed to increase traffic hazards along SR 12.

Wind conditions on SR 12 would not substantially change from existing conditions under Alternative 3. Construction of levees or soundwalls along roadways does not generally affect wind conditions on the road, and the levees would be set back 240-370 feet from the existing highway right-of-way. Therefore, construction and operation of Alternative 3 would not increase wind hazards on SR 12.

Visibility on the roadway could be adversely affected if the levee on the north side of SR 12 obstructed westbound views of the road along the curved portion of the highway; however, SR 12 is a raised roadway and the curve in the road is gradual. The levee would be constructed to approximately 6 feet in height and will be set back from the roadway at least 50 feet. Based on existing roadway conditions and proposed levee design, visibility on SR 12 for west-bound traffic is not expected to substantially change from existing conditions. Therefore, construction of a levee along the north side of SR 12 would not affect visibility or traffic safety.

Holland Tract

Under Alternative 3, Holland Tract Road would remain along the southern levee of Holland Tract. Implementation of Alternative 3 would include improving the perimeter levee, thereby improving the structural integrity of Holland Tract Road.

Chapter 3D, "Flood Control", addresses levee reliability with regard to erosion and settlement, and Chapter 3L, "Traffic and Navigation", addresses construction-related safety and traffic impacts on Holland Tract Road.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-13: Increase in the Structural Integrity of County Roads. Implementation of Alternative 3 would result in levees surrounding the reservoirs on the DW project islands being raised and widened. Erosion-resistant facing would be placed on the interior slopes of the levees. These levee improvements would increase the structural integrity of Bacon Island Road on the eastern levee of Bacon Island and Holland Tract Road on the southern levee of Holland Tract. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact E-14: Increase in the Risk of Structural Failure of SR 12. Implementation of Alternative 3 could cause the proposed Wilkerson Dam along SR 12 to fail, which would result in the structural failure and inundation of SR 12. Because the design of Wilkerson

Dam would minimize seepage, settlement, and erosion, adverse impacts on the structural integrity of SR 12 caused by levee failure and flooding would have a low probability of occurring (see Appendix E1). The final levee design would also address Caltrans' concerns and must be reviewed for structural stability and approved by DSOD.

As part of Alternative 3, DW, in coordination with Caltrans, will review the regrading design for the NBHA to verify that the probability of adverse flooding impacts along the north side of SR 12 would be negligible. Therefore, this impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-8 would monitor the effectiveness of those measures.

Mitigation Measure E-8: Coordinate Design and Construction of Wilkerson Dam with Caltrans and DSOD. Prior to project construction, DW shall demonstrate to the Corps and SWRCB that it has consulted with and obtained all required permits and approvals from Caltrans and DSOD for the design and construction of Wilkerson Dam.

Impact E-15: Increase in the Fog Hazard on SR 12. Implementation of Alternative 3 could increase the amount of fog produced along SR 12 on Bouldin Island by increasing the water surface area adjacent to the roadway. Fog on the roadway would increase existing traffic hazards on SR 12. This impact is considered significant and unavoidable.

Mitigation. No mitigation is available to reduce this impact to a less-than-significant level.

Impact E-16: Reduction in Ferry Traffic from Jersey Island to Webb Tract. This impact is described above under Impact E-2. This impact is considered less than significant.

Mitigation. No mitigation is required.

Gas Facilities and Transmission Pipelines

Bacon Island

As explained above under "Impacts and Mitigation Measures of Alternative 1", the 1995 DEIR/EIS discussion of project effects on gas facilities and transmission pipelines across Bacon Island has been superseded by the updated information presented in the 2000 REIR/EIS. The revised discussion is presented in the section from the 2000 REIR/EIS below entitled "Environmental Consequences". The impact and mitigation statements below have been revised to reflect the conclusions in that section.

Webb Tract

As explained above under "Impacts and Mitigation Measures of Alternative 1", storage of water on Webb Tract would not preclude future natural gas exploration, but existing wells might have to be abandoned. During the final design of the project, DW would need to consult with the Department of Conservation, Division of Oil and Gas, and with existing mineral right holders to determine whether producing wells on Webb Tract would need to be abandoned and whether previously abandoned wells need to be reabandoned.

Bouldin Island and Holland Tract

As stated previously, no gas facilities or transmission pipelines exist on Bouldin Island or Holland Tract.

Summary of Project Impacts and Recommended Mitigation Measures

The impacts and mitigation measures summarized below include the two impacts on natural gas facilities identified in the 1995 DEIR/EIS and the additional impacts and mitigation measures identified in the 2000 REIR/EIS. A detailed description of these impacts and mitigation measures is provided in the section from the 2000 REIR/EIS below entitled "Environmental Consequences".

Impact E-17: Increase in the Risk to Gas Lines Crossing Exterior Levees on Bacon Island Resulting from Levee Improvements. This impact is the same as Impact E-3. This impact is considered significant.

Implementation of Mitigation Measures RE-1 and RE-2 would reduce Impact E-17 to a less-than-significant level.

Mitigation Measure RE-1: Monitor Locations Where Gas Pipelines Cross Bacon Island Levees during and after Levee Construction. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Levee Improvements".

Mitigation Measure RE-2: Implement Corrective Measures to Reduce Risk of Pipeline Failure during Levee Construction. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Levee Improvements".

Impact E-18: Increase in PG&E Response Time to Repair a Gas Line Failure on Bacon Island. This impact is described above under Impact E-4. The potential impact on PG&E's operation is economic in nature. Because economic effects are not considered environmental impacts under CEQA and NEPA, no significance conclusion is made and no mitigation is identified. This impact is explained in greater detail in the section from the 2000 REIR/EIS below entitled "Potential Delay in Emergency Repairs and Unscheduled Interruption of Service".

Impact RE-3: Increase in the Risk to Line 57-A from Island Inundation. This impact, which is summarized above under Alternative 1 and is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Island Inundation", is considered significant.

Implementing Mitigation Measure RE-3 would reduce Impact RE-3 to a less-than-significant level.

Mitigation Measure RE-3: Securely Anchor Line 57-A before Bacon Island Flooding. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Island Inundation".

Impact RE-4: Potential Interference with Pipeline Inspection Procedures. This impact is summarized above under Alternative 1 and is described in the section from the 2000 REIR/EIS below entitled "Potential Interference with Pipeline Inspection Procedures". The impact on access for pipeline inspections and on monitoring facilities is considered significant.

Implementation of the following mitigation measures would reduce this impact to a less-than-significant level.

Mitigation Measure RE-4: Provide Adequate Facilities on Bacon Island for Annual Pipeline Inspection. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Potential Interference with Pipeline Inspection Procedures".

Mitigation Measure RE-5: Relocate Cathodic Protection Test Stations before Bacon Island Flooding. This mitigation measure is described in the section from the 2000 REIR/EIS below entitled "Potential Interference with Pipeline Inspection Procedures".

Electrical Distribution Lines

Bacon Island

As explained above under "Impacts and Mitigation Measures of Alternative 1", PG&E may provide electrical service for the proposed discharge pump stations on reservoir islands. This would require adding capacity to the existing distribution lines on Bacon Island but would not require new distribution easements or structures.

Webb Tract

The effects of flooding existing electrical distribution facilities that are located on Webb Tract off the perimeter levees are described above under "Impacts and Mitigation Measures of Alternative 1".

Bouldin Island and Holland Tract

Electrical distribution lines that traverse Holland Tract and Bouldin Island would be inundated during water storage operations and would require substantial alteration for existing services to be maintained on the islands. PG&E overhead distribution lines that cross the bottoms of the islands (Figure 3E-3) would need to be raised or relocated during construction. Before temporarily or permanently modifying or relocating existing electrical lines, DW would conduct special-status plant surveys in areas that could be affected by the proposed modifications. If threatened or endangered plant species are found, DW will avoid disturbing those plants when making changes to existing electrical lines.

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-19: Inundation of Electrical Distribution Utilities on the Reservoir Islands. Implementation of Alternative 3 would cause inundation of existing PG&E overhead distribution lines on the bottoms of Webb Tract, Holland Tract, and Bouldin Island during water storage operations. To maintain existing service, the lines would need to be relocated. This impact is considered significant.

Implementing Mitigation Measure E-9 would reduce Impact E-19 to a less-than-significant level.

Mitigation Measure E-9: Relocate Electrical Distribution Lines to the Perimeter Levees around Webb and Holland Tracts and Bouldin Island. DW, in coordination with PG&E, shall permanently relocate the existing electrical distribution lines on Webb and Holland Tracts and Bouldin Island to the improved perimeter levees during project construction. The new or relocated distribution lines would be located along perimeter levees and would be installed overhead near the toes of the new slopes, similar to existing installations. Before temporarily or permanently modifying or relocating existing electrical lines, DW would conduct special-status plant surveys in areas that could be affected by the proposed modifications. If threatened or endangered plant species are found, DW will avoid disturbing those plants when making changes to existing electrical lines.

Impact E-20: Possible Need to Increase Capacity of the Existing Electrical Distribution Lines on the Reservoir Islands. Implementation of Alternative 3 may require PG&E to provide electrical service for discharge pump stations, siphon stations, and recreation facilities on the DW project islands. PG&E would add capacity to the existing distribution lines, which would not require new easements or structures on the islands. Therefore, this impact is considered less than significant.

It may also be necessary to relocate or upgrade electrical lines and substation facilities to serve new project facilities; any relocation or upgrade of electrical substation facilities (50,000 volts and above) may require formal approval from the CPUC. If, when specific design details are submitted, the CPUC determines that the NEPA and CEQA documentation already completed for the DW project does not cover site-specific environmental impacts in enough detail, it may require additional environmental documentation before it provides approvals.

Mitigation. No mitigation is required.

Impact E-21: Possible Need to Expand the Existing Electrical Distribution Lines on Webb Tract, Bouldin Island, and Holland Tract to Serve Proposed Siphon and Pump Stations and Recreation Facilities. Implementation of Alternative 3 may require PG&E to provide electrical service to siphon stations, a pump station, and recreation facilities that would not easily be serviced by existing lines. The following proposed pump station and siphon stations (as shown in Chapter 2, Figures 2-3, 2-10, and 2-11) would not be located adjacent to existing electrical line corridors: a siphon station in the northeastern corner of Webb Tract, a discharge pump station and a siphon station on the eastern side of Bouldin Island, and a siphon station near the northernmost point of Holland Tract. Recreation facilities would also be located along the perimeter levees in areas not serviced by electrical lines. Because electrical service to those facilities would require an extension of existing service lines, this impact is considered significant.

Implementing Mitigation Measure E-2 would reduce Impact E-21to a less-than-significant level.

Mitigation Measure E-2: Extend Electrical Distribution Lines to Serve New Siphon and Pump Stations and Recreation Facilities. This mitigation measure is described above under “Impacts and Mitigation Measures of Alternative 1”.

Police and Fire Protection Services

The effects on emergency services that would result from constructing and operating recreation facilities are described above under "Impacts and Mitigation Measures of Alternative 1".

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-22: Increase in Demand for Police Services on the DW Project Islands. This impact is described above under Impact E-8. This impact is considered significant.

Implementing Mitigation Measures E-3 and E-4 would reduce Impact E-22 to a less-than-significant level.

Mitigation Measure E-3: Provide Adequate Lighting in and around Buildings, Walkways, Parking Areas, and Boat Berths. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure E-4: Provide Private Security Services for Recreation Facilities and Boat Docks. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact E-23: Increase in Demand for Fire Protection Services on the DW Project Islands. This impact is described above under Impact E-9. This impact is considered significant.

Implementing Mitigation Measures E-5 and E-6 would reduce Impact E-23 to a less-than-significant level.

Mitigation Measure E-5: Incorporate Fire Protection Features into Recreation Facility Design. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure E-6: Provide Fire Protection Services to Webb Tract and Bacon Island. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Water Supply Facilities and Sewage Disposal Service

The effects on water supply and sewage disposal services that would result from constructing and operating recreation facilities are described above under "Impacts and Mitigation Measures of Alternative 1".

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-24: Increase in Demand for Water Supply Services. This impact is described above under Impact E-10. This impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-7 would monitor the effectiveness of those measures."

Mitigation Measure E-7: Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact E-25: Increase in Demand for Sewage Disposal Services. This impact is described above under Impact E-11. This impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-7 would monitor the effectiveness of those measures.

Mitigation Measure E-7: Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Solid Waste

The effects on solid waste disposal services that would result from constructing and operating recreation facilities are described above under "Impacts and Mitigation Measures of Alternative 1".

Summary of Project Impacts and Recommended Mitigation Measures

Impact E-26: Increase in Demand for Solid Waste Removal. This impact is described above under Impact E-12. This impact is considered less than significant.

Measures that would minimize the effects of this impact have been incorporated into the project description. However, implementing Mitigation Measure E-7 would monitor the effectiveness of those measures.

Mitigation Measure E-7: Obtain Appropriate Local and State Permits for Recreation Facility Services and Utilities. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Infrastructure Facilities on Adjacent Islands

Under Alternative 3, potential seepage from project islands would be similar to that described for Alternative 1. As part of Alternative 3, DW would install an interceptor well system in the exterior levees of the project islands to control seepage onto adjacent islands, as described in Appendix D2, "Levee Design and Maintenance Measures". Design features and proposed seepage control measures would keep potential adverse seepage problems at existing levels or better, and there would be no change in the risk to facilities on adjacent islands. Adjacent utilities would not be affected by implementation of Alternative 3.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

Implementation of the No-Project Alternative would cause an increase in the rate of subsidence on the island interiors due to continued tillage of areas now in production and increased tillage of areas now fallow. Subsidence gradually increases levee instability, seepage, and threats to utility and highway facilities on the project islands and the risk of a cumulative levee failure on adjacent islands. By increasing the rate of subsidence, implementation of the No-Project Alternative would speed the rate at which these effects begin to occur on the DW project islands.

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Highways, County Roads, and Ferry Service

Bacon Island

Subsidence on Bacon Island would increase the risk of structural failure of the levees. Because Bacon Island Road traverses an existing levee, subsidence would result in increased risk of road failure and higher maintenance and repair needs over time. The levees would eventually have to be rehabilitated as a result of levee degradation.

Webb Tract

Ferry traffic to Webb Tract from Jersey Island would continue to operate at or above existing levels as farming operations increased. Therefore, implementation of the No-Project Alternative would not affect ferry operations.

Bouldin Island

Because SR 12 is a raised roadway, subsidence resulting from continued agricultural production would increase the risk of structural failure and increase maintenance needs for the highway.

Holland Tract

Similar to effects on Bacon Island Road described above, subsidence under the No-Project Alternative would result in increased risk of levee and road failure and higher maintenance and repair needs on Holland Tract Road over time.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in the Risk of Road Failure and Maintenance and Repair Needs. Implementation of the No-Project Alternative would result in increased subsidence rates on DW project islands, which would increase the risk of structural failure of levees and associated roadways on Bacon Island, Holland Tract, and Bouldin Island. More roadway maintenance and repair would be required over time. The perimeter levees eventually would have to be rehabilitated.

Implementing the following measure described in Chapter 3D, "Flood Control", would reduce this effect of the No-Project Alternative.

Buttress Perimeter Levees. The perimeter levees of the DW project islands could be substantially buttressed to increase levee stability under the No-Project Alternative. The need for improvements to these levees over time would be evaluated by the local reclamation districts.

Gas Facilities and Transmission Pipelines

Bacon Island

Continued subsidence resulting from increased agricultural uses would bring gas transmission lines on Bacon Island increasingly closer to the ground surface, requiring frequent restoration of the lines to new depths. Therefore, the No-Project Alternative would increase current maintenance requirements for the gas lines. The change in utility maintenance over time would be substantial.

Under the No-Project Alternative, Bacon Island levees eventually would have to be rehabilitated. As for Alternative 1, levee buttressing could cause differential settlement where the gas lines penetrate the levee. It is reasonable to assume that a monitoring system and corrective measures would be implemented during levee rehabilitation under the No-Project Alternative, as for Alternative 1. The potential effects of levee improvements on gas lines and corrective measures to reduce effects are described in the section from the 2000 REIR/EIS below entitled "Risk of Pipeline Leak or Rupture Resulting from Levee Improvements".

Webb Tract

Existing wells on Webb Tract that are producing gas, future gas wells, and wells that have been plugged and abandoned would not be affected by increased agricultural production over time.

Bouldin Island and Holland Tract

As stated previously, no gas facilities or transmission pipelines exist on Bouldin Island or Holland Tract.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in Maintenance Requirements for Gas Lines on Bacon Island. Implementation of the No-Project Alternative would result in subsidence from increased agricultural uses that would bring gas transmission lines on Bacon Island increasingly closer to the ground surface, requiring increased maintenance and restoration of the lines over time.

Electrical Distribution Lines

Bacon Island, Webb Tract, Bouldin Island, and Holland Tract

Continued subsidence from increased agricultural uses under the No-Project Alternative would increase the risk of instability and failure of perimeter levees surrounding the DW project islands. Electrical distribution facilities located on perimeter levees would subsequently be subject to increased maintenance and risk of structural failure. Electrical facilities located on the interior of the DW project islands would also be disturbed by the effects of subsidence.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in the Risk of Structural Failure and Increase in Maintenance Requirements for Existing Distribution Utilities. Implementation of the No-Project Alternative would result in an increased rate of subsidence, which would result in levee instability and increased maintenance and risk of structural failure of existing electrical utility lines on the DW project islands.

Implementing the following measure would reduce this effect of the No-Project Alternative.

Buttress Perimeter Levees. This measure is described above.

Other Public Services

Implementation of the No-Project Alternative would not increase demands on police, fire, water supply, sewage, or solid waste services on the DW project islands. No new recreation facilities would be constructed, and increases in recreational use of the DW project islands would not result in a substantial demand for emergency services. Therefore, implementing the No-Project Alternative would not affect existing emergency or public services.

Infrastructure Facilities on Adjacent Islands

Under the No-Project Alternative, seepage to adjacent islands would be similar to existing seepage conditions because water would not be stored on the islands in amounts above those needed for intensified agricultural use. The No-Project Alternative would not affect facilities on adjacent islands.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. The following discussion considers only those project effects that may contribute cumulatively to impacts on utilities and highways.

Cumulative Impacts, Including Impacts of Alternative 1

Chapter 3D, "Flood Control", discusses the issue of levee failure on the DW project islands leading cumulatively to levee failures on other Delta islands. Risk of levee failure directly affects risk to roadway and utility stability, so cumulative levee failure would result in cumulative utility structural failure. As discussed in Chapter 3D, implementation of flood control programs such as DWR's Delta water management programs and levee maintenance programs would improve the regional flood control system and reduce flood-related risks to adjacent utilities and roads. Therefore, the cumulative risk of levee failure would be less than the current risk, and a beneficial effect on utility facilities is predicted.

Impact E-27: Cumulative Decrease in the Risk of Structural Failure of Roadways and Utilities. Implementation of planned levee improvements throughout the Delta, combined with levee improvements on the DW project islands, would decrease the cumulative risk of levee failure on Delta islands. Furthermore, increased levee stability in the vicinity of the DW project islands would reduce the cumulative risk of structural failure of roadways and utilities in the area. This impact is considered beneficial.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impact of this alternative is the same as that described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

The cumulative impact of this alternative is the same as that described for Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Although levee reliability on the DW project islands would decline over time under the No-Project Alternative, implementation of planned levee improvements throughout the Delta would likely result in a cumulative improvement in levee conditions.

ANALYSIS OF NATURAL GAS FACILITIES AND TRANSMISSION PIPELINES FROM THE 2000 REVISED DRAFT EIR/EIS

The remainder of this chapter includes the analysis of natural gas facilities and transmission pipelines on Bacon Island that was conducted for the 2000 REIR/EIS. This information, which was presented as Chapter 7, "Natural Gas Facilities and Transmission Pipelines", in the 2000 REIR/EIS, has been modified slightly from the 2000 REIR/EIS version in response to comments received on the 2000 REIR/EIS. However, those minor changes do not change the conclusions of the analysis.

FOCUS OF THE 2000 REVISED DRAFT EIR/EIS ANALYSIS

The remainder of this chapter updates the 1995 DEIR/EIS assessment of Delta Wetlands Project effects on PG&E natural gas facilities and transmission pipelines. During the Delta Wetlands water right hearing, PG&E presented testimony regarding its easements and natural gas pipelines that cross Bacon Island. The testimony focused on the ways in which proposed Delta Wetlands water storage operations could:

- adversely affect PG&E's ability to use its easements,
- decrease the useful life of the pipelines,
- require additional pipeline maintenance,
- increase the threat of pipeline damage,
- reduce or inhibit pipeline access for routine or emergency repairs, and
- interrupt gas supply.

The future use of PG&E's easement is a private property rights dispute. The real property issues are not addressed in this REIR/EIS. Issues related to the operation and maintenance of the pipeline on Bacon Island and the possibility of impacts on regional natural gas service are considered potential environmental effects that require explanation and analysis. The remainder of this chapter updates and supplements the discussions of the Bacon Island pipeline issues originally described in the 1995 DEIR/EIS.

Summary of Issues Addressed in This Analysis

This analysis addresses the following questions:

- What effect will reservoir operations have on the integrity, operation, and maintenance of PG&E's natural gas pipelines across Bacon Island?

- What effect will reservoir operations have on emergency access to the pipeline?

Sources of Information

The information used to prepare the following analysis is taken from comments on the 1995 DEIR/EIS and 2000 REIR/EIS and from evidence and testimony provided by PG&E and

Delta Wetlands at the water right hearing. In addition, data from the DOT, Office of Pipeline Safety (U.S. Department of Transportation 1999), were used in this assessment.

Definition of Terms

The discussion of gas facilities and pipelines in this chapter includes some terms that may not be familiar to all readers. The following are definitions of these terms as they are used in this chapter:

- *Anticorrosion Coating:* The coating of pipelines with paint, epoxy, or other materials to prevent contact of dissimilar metals. The barrier prevents establishment of a corrosion current and corrosion of the pipe.

- *Bending Load:* The result when the opposite ends of an item are forced together (as when a sheet of paper is folded). Pipelines can be subject to this type of load.

- *Cathodic Protection System:* A process used to prevent pipeline corrosion by passing an electric current through the pipe. When dissimilar metals (the pipeline and soil minerals) are placed in solution together, a corrosion current is established. The cathodic protection system creates an opposite current to minimize corrosion.

- *Firm Storage Capacity:* An amount equivalent to guaranteed storage capacity. Utility rates usually vary based on guarantee of service. The first priority is to meet firm demands; consequently, this demand is most expensive. Demands that can be met with less reliability are less expensive.

- *Internal Inspection*: The process of evaluating pipeline stresses from within the pipeline. A robotic device commonly called a “pig” is sent along the inside of the pipeline. The pig measures the shape of the pipeline, noting where the pipeline shape is abnormal (i.e., oval instead of round) and where the pipeline has ripples that indicate that the pipeline is bent or stressed.

- *Pipeline Balancing*: The process that gas utilities use to balance the customer loads (demands) with the available supplies of natural gas. Inflows to the system must be continuously balanced against outflows from the system.

- *Shear Load:* The result when force is applied perpendicular to or on opposite sides of an item (as when a sheet of paper is cut with scissors). Pipelines can be subject to this type of load.

- *Third Party:* An entity that affects a property, but is not the owner of the property (first party) or an agent of the owner (second party).

- *Unbundled Rates:* The individual rates for separate service components of a particular utility. For example, natural gas utilities can be broken down into separate service components such as gas procurement, transportation, storage, and delivery, with distinct rate schedules for each service. Deregulation of the utility industry has allowed this unbundling of services to promote market competition.

AFFECTED ENVIRONMENT: UPDATED INFORMATION PRESENTED IN THE 2000 REVISED DRAFT EIR/EIS

PG&E owns two high-pressure gas transmission pipelines that cross Bacon Island (Figure 3E-5). Line 57-B, constructed in 1974, serves as an input and output conduit for gas stored in the McDonald Island Storage Field; Line 57-A has been removed from operation and has been capped. However, Line 57-A could be used in the future.

Natural Gas Service

Line 57-B connects PG&E's interstate and intrastate gas transmission and distribution system to the utility's underground natural gas storage facility under McDonald Island (Figure 3E-2). The McDonald Island Storage Field has been used primarily to supply gas to the Bay Area and Sacramento/Stockton market centers when other resources, such as gas production fields in Canada and the southwestern United States, are inadequate to meet instantaneous (i.e., peak) demands. The McDonald Island storage facility has supplied gas for up to one-third of PG&E's customers during peak demand periods (Stoutamore pers. comm.).

In 1996, PG&E and other natural gas industry representatives adopted the Gas Accord Settlement. This settlement is the result of an extensive negotiation process that PG&E initiated several years ago. The settlement parties, representing a diverse cross-section of natural gas industry participants, have achieved a far-reaching and comprehensive settlement that restructures PG&E's natural gas services, redefines its role in the gas market, and establishes guaranteed transmission rates. The Gas Accord significantly increases competition and economic efficiency in the Northern California gas industry. It enables customers and marketers to participate fully in the increasingly deregulated, inter-regional natural gas markets, with the goal of achieving lower energy prices through increased competition and customer choice. The accord provides for guaranteed, unbundled, cost-based transmission rates.

The Gas Accord allows continued operational integration of PG&E's gas storage and transmission facilities. PG&E will reserve firm storage capacity for pipeline balancing services. PG&E's Core Procurement Department will contract for a portion of the utility's firm storage capacity on behalf of the core (PG&E's customers). The remaining storage capacity will be marketed in an unbundled storage program that requires PG&E to provide storage to third parties. The McDonald Island Storage Field is PG&E's largest underground natural gas storage facility, and Line 57-B is the only link between the storage field and the PG&E distribution system. Under the new Gas Accord, PG&E's role as a storer of natural gas has increased; consequently, PG&E's use of the McDonald Island Storage Field and reliance on Line 57-B has also increased. The McDonald Island storage facility is used year-round by various marketers and shippers to inject and withdraw gas based on dynamic market conditions resulting from adoption of the Gas Accord.

Pipeline Design Criteria

The DOT Office of Pipeline Safety comprehensively regulates the design, construction, testing, operation, and maintenance of natural gas pipelines and associated facilities in accordance with 49 CFR 192. The following general requirements govern the use of natural gas pipelines:

The materials for the pipe and components for use in pipelines must maintain structural integrity under temperature and other environmental conditions that may be anticipated. They must be chemically compatible with any gas that they transport.

The pipe must be designed with sufficient wall thickness or installed with adequate protection to withstand anticipated external pressures or loads.

Each pipeline component must be able to withstand operating pressures and other anticipated loadings without impairment of its serviceability.

The pipeline must be protected from external corrosion by an external protective coating and a cathodic protection system.

Before a new, repaired, or relocated pipeline can be placed into service, it must be tested to substantiate its maximum allowable operating pressure and to confirm that each leak has been located and eliminated.

The operator shall prepare and follow a manual of written procedures for conducting operations and maintenance activities, responding to emergencies, and handling abnormal conditions.

The operator shall have a patrol program to observe surface conditions on and adjacent to the pipeline right-of-way for indications of leaks, construction activity, and other factors affecting safety and operation.

A pipeline that is abandoned in place or deactivated must be disconnected from all gas sources, purged of gas, and sealed at the ends.

Line 57-A is 18 inches in diameter and Line 57-B has a diameter of 22 inches. Both pipelines are buried as they cross Bacon Island and are designed to operate under temporarily flooded conditions or in saturated soils. The pipelines as constructed are engineered and built to withstand more than the external pressure that would be applied by the load, or weight, of water under full reservoir conditions. Normal operation or integrity of a pipeline would not be impaired by the pressure of overlying water in a full reservoir. According to PG&E's easements, Line 57-A is buried at a minimum of 4 feet and as much as 8 feet below the ground surface; Line 57-B is buried at a minimum of 3.5 feet below the ground surface. Line 57-A has concrete weights, except along approximately 900 feet on the west side of the island, where the pipeline is concrete coated. Line 57-B is entirely concrete coated. Concrete coating and weighting prevents the pipeline from floating out of the trench when inundated or when saturated soils would not have the strength to resist the pipeline's buoyancy. Line 57-B is currently rated for pressures up to 2,160 pounds per square inch (psi) and can convey approximately 1.25 billion cubic feet per day (Bcf/day). As mentioned previously, Line 57-A has been removed from operation and has been capped.

Pipeline Safety

Historically, natural gas transmission and distribution lines and associated facilities have had a very low probability of a full-scale rupture that could lead to an explosion resulting in property damage or fatalities. The most recent data available from the DOT Office of Pipeline Safety for 1985 through 1999 (U.S. Department of Transportation 1999) indicate the following:

Approximately 1.7 million miles of natural gas transmission and distribution pipelines are present in the United States; these lines are subject to DOT jurisdiction. Transmission pipelines include pipelines of similar diameter and operating pressure to the PG&E pipeline crossing Bacon Island. Distribution pipelines are smaller in diameter and operated at a lower pressure than the PG&E pipeline crossing Bacon Island.

During the data collection period, 1,302 reportable incidents (significant leaks) occurred in the nation on natural gas transmission projects similar to the proposed project. The causes of the leaks were identified as follows (totals less than 100% because of rounding):

– 527 incidents (40%) were related to various construction or operating errors, or to other unspecified causes (e.g., improper welding or maintenance);

– 368 incidents (28%) were caused by a third party, such as agricultural operations, and 62 of these occurred on pipelines that were unmarked;

– 300 incidents (23%) were caused by corrosion, and 261 of these were related to uncoated pipelines; and

– 107 incidents (8%) were caused by natural or geologic forces (8 by subsidence, 4 by flooding, and 3 by channel scour).

Of the 1,302 incidents:

– 880 (68%) were on projects constructed before the current Minimum Federal Safety Standards (CFR 49 Part 192) were promulgated in 1970 (35 FR 13257), and therefore on pipelines greater than 30 years old.

– Most leaks were repaired or made safe in less than 1 day:

C 540 leaks (41%) were repaired or made safe in less than 1 hour;

C 1,062 leaks (81% inclusive) were repaired or made safe in 3 hours or less; and
C 36 leaks (less than 3%) took 24 hours or longer to repair or make safe.

– 35 incidents were reported in California.

From the DOT data presented above, it can be concluded that the transmission pipelines that are least prone to leaks or other accidents are those that have been constructed since 1970 and operated in accordance with minimum federal safety standards, are coated to prevent corrosion, and are well marked. In the Delta region of California, where there is risk of subsidence, flooding, channel scour, and seismic activity, no incidents of pipeline rupture or leak related to natural forces have been reported. In addition, no incidents related to corrosion or outside forces were reported. The only incident reported occurred at an above-ground metering facility where a seal failed on an odorant pump.

IMPACT ASSESSMENT METHODOLOGY FOR THE 2000 REVISED DRAFT EIR/EIS

Analytical Approach and Impact Mechanisms

Impacts on natural gas facilities and service were assessed based on the ways in which construction and operation of the Delta Wetlands Project alternatives would benefit or adversely affect the existing utility infrastructure or service. Effects of the project alternatives on gas transmission lines and facilities on the project islands were determined through correspondence with the affected utility company and other experts. Under the Delta Wetlands Project, Bacon Island, which is now used for agricultural operations, would be used for reservoir storage. The levees around the island would be reinforced and the island would be inundated when water is available for diversion from the Delta. Flooding the island and improving the project levees may affect the conditions under which the existing gas pipeline is operated and maintained.

Criteria for Determining Impact Significance

An alternative is considered to have a significant impact on the gas facilities and services if, when compared to existing conditions, it would:

- result in a substantial disruption to existing natural gas service;
- increase risk of structural failure of gas facilities and pipelines;
- result in a need for substantial alterations to, or increased maintenance of, natural gas facilities; or
- result in increased demand for existing emergency services beyond their current capacity.

An alternative is considered to have a beneficial effect if it would improve the existing utility infrastructure when compared to existing conditions.

ENVIRONMENTAL CONSEQUENCES

Flooding of the PG&E easement on Bacon Island under proposed Delta Wetlands Project operations would not increase the risk of structural failure of the operating gas pipeline or cause a physical change in PG&E's ability to supply gas to Bay Area or Sacramento/Stockton market centers. Flooding the island would probably change the manner in which PG&E monitors its pipelines and repairs leaks to the pipeline. These impacts are discussed below; Table 3E-1 provides a comparison between the 1995 EIR/EIS and 2000 REIR/EIS impact conclusions.

Risk of Pipeline Leak or Rupture Resulting from Levee Improvements

The proposed levee buttressing could locally increase the rates of levee settlement or subsidence where the gas pipelines penetrate the Bacon Island exterior levees. Levee settlement or subsidence could increase the shear or bending loads on the pipeline, depending on the location of the pipeline with respect to the compressible levee foundation materials.

Under existing conditions, PG&E is required to maintain these pipelines at levee crossings and to improve or modify the lines in response to ongoing levee repair activities. PG&E designs and installs pipelines in the Delta region with an understanding of internal island subsidence problems (see Chapter 3D for a discussion of subsidence in the central Delta) and of ongoing levee maintenance activities that can increase risks of pipeline failure through differential settlement and line exposure. To monitor the effects of levee settlement on their pipeline, PG&E has installed and maintains tiltmeters on Line 57-B at both the east and west levee crossings of Bacon Island. PG&E commonly practices corrective measures necessary to relieve excessive pipeline stress resulting from levee settlement. The levee improvements proposed by Delta Wetlands are greater than those conducted under ongoing levee maintenance activities. As a result, the need for corrective measures and associated costs may increase during levee construction and settlement when compared to existing pipeline maintenance requirements. The potential for substantial pipeline stress resulting from Delta Wetlands levee improvements is considered a significant impact. The following mitigation measures are recommended.

Mitigation Measure RE-1: Monitor Locations Where Gas Pipelines Cross Bacon Island Levees during and after Levee Construction. During levee strengthening, Delta Wetlands engineers will install equipment to monitor levee settlement and subsidence rates. After levee completion, Delta Wetlands will conduct weekly inspections to check for potential problems at the gas pipeline crossings, including concerns about levee stability, settlement, and subsidence. If the weekly inspection indicates that settlement, erosion, or slumping at the gas pipelines has occurred, Delta Wetlands will notify PG&E and will implement corrective measures to mitigate any decrease in levee stability near the gas lines (see below).

Mitigation Measure RE-2: Implement Corrective Measures to Reduce Risk of Pipeline Failure during Levee Construction. Delta Wetlands shall reimburse PG&E for the incremental increase in maintenance costs associated with installation of new pipeline segments under Bacon Island levees or implementation of other appropriate corrective measures, which would prevent damage to the gas pipeline from increased bending or shear loads at levee crossings during levee construction and settlement.

Risk of Pipeline Leak or Rupture Resulting from Island Inundation

In the long term, the risk of pipeline leak or rupture, which is generally caused by corrosion, ground settlement, or physical damage from ground-disturbing equipment (e.g., farm equipment), would not increase under proposed project operation. The risk of pipeline rupture would decline because implementation of the Delta Wetlands Project would substantially reduce ground-disturbing activities by eliminating agricultural practices such as installation of internal drainage ditches that may cross the pipeline easement on Bacon Island. However, as described in the previous section, risks to the pipeline could increase during Delta Wetlands' construction of levees.

The pipelines across Bacon Island would not require major structural modification for use under the submerged conditions caused by implementation of the proposed project. The operating gas pipeline (Line 57-B) on Bacon Island is concrete coated to prevent it from floating when the land is flooded or when the overlying soils are not strong enough when saturated to overcome pipeline buoyancy. The soils along the easement are already likely to be saturated at the depth of the pipeline because of a high water table.

The currently unused pipeline (Line 57-A) on Bacon Island may need additional weighting before the island is flooded to prevent the line from floating (Grimm pers. comm.). As mentioned previously, Line 57-A has concrete weights or other weighting material, except for approximately 900 feet on the west side of the island where the pipe is concrete coated. PG&E uses concrete saddle weights, drilled chance anchors, and concrete pipe coating to anchor Line 57-A. Under inundated conditions , Line 57-A could float, resulting in unanticipated bending loads that could damage its anticorrosion coating and disrupt the cathodic protection system. Therefore, inundating the island without proper weighting may substantially damage Line 57-A. Although Line 57-A is not used now, PG&E may choose to use it in the future. The need to weight the pipeline is considered a substantial alteration to the existing system. This impact is considered significant and the following mitigation is recommended.

Mitigation Measure RE-3: Securely Anchor Line 57-A before Bacon Island Flooding. Delta Wetlands shall reimburse PG&E for engineering studies, materials, and construction expenses to securely anchor Line 57-A before reservoir operations begin on Bacon Island.

Potential Interference with Pipeline Inspection Procedures

As part of its pipeline operation, inspection, and maintenance procedures required by federal and state regulations (49 CFR 192 and California Public Utilities Commission [CPUC] General Order 112), PG&E conducts annual aerial and walking inspections along the pipeline route to check for small leaks, evidence of internal or external corrosion, or easement encroachment (e.g., new drainage ditches). Valves are also regularly monitored for pressure fluctuations that could be caused by leaks (Grimm pers. comm.). Implementation of the Delta Wetlands Project would not alter PG&E's methods for routine inspection of the pipeline. Walking inspections for minor leaks would have to be scheduled during dry periods, or inspections could be conducted by boat when the island is flooded. To ensure that PG&E has access to the line for annual inspections under wet as well as dry conditions, the following mitigation is recommended.

Mitigation Measure RE-4: Provide Adequate Facilities on Bacon Island for Annual Pipeline Inspection. Delta Wetlands shall provide a suitable ramp and turnaround facilities to launch a boat for regular pipeline inspections, and should provide a suitable staging area for equipment and materials needed for gas pipeline repairs.

PG&E also monitors the pipelines using internal inspection and cathodic protection testing. No valves are located on Bacon Island, and internal inspection ("pigging") could occur regardless of dry or wet conditions. Flooding the island would inundate cathodic protection test stations, rendering them unusable. The cathodic protection test stations would need to be relocated before flooding of Bacon Island. This impact is considered significant and the following mitigation is recommended.

Mitigation Measure RE-5: Relocate Cathodic Protection Test Stations before Bacon Island Flooding. Delta Wetlands shall reimburse PG&E for engineering studies, materials, and construction expenses to relocate cathodic protection test stations to the perimeter levee system, and shall grant PG&E an easement to access the relocated cathodic protection test stations.

Potential Delay in Emergency Repairs and Unscheduled Interruption of Service

As described previously, the risk is very low that a pipeline leak or rupture would occur on Bacon Island, and if a leak or rupture occurred, it is equally likely to occur under dry conditions as under wet (i.e., full or partial-storage) conditions. This conclusion is based on the following considerations:

- Pipeline ruptures or leaks on Bacon Island under the proposed project would be caused by internal or external corrosion or levee settlement or subsidence loads. In recent years, no pipeline ruptures in the Delta have been caused by these modes (U.S. Department of Transportation 1999). PG&E more often must respond to leaks caused by farm equipment; emergency repairs in the Delta caused by ground-disturbing equipment generally occur once or twice a year (Warner pers. comm.).

- Annual inspections to detect small leaks, monitor corrosion protection, identify potential levee subsidence or settlement problems, and prevent future pipeline ruptures or substantial pipeline leaks in those areas by prescribing immediate repair work will still be conducted in accordance with federal and state regulations.

- Based on modeling of water storage operations for the proposed project (see Chapter 3), it is estimated that Bacon Island would be at full storage (filled by the end of December) fewer than 50% of winters, and the reservoir islands would be empty in 437 of the 864 months simulated for the 72-year hydrologic record, or approximately 51% of the time. Therefore, opportunities for repair and replacement of damaged pipeline segments under dry conditions will occur about 50% of the time.

If repairs are needed during flooded conditions on Bacon Island, the Delta Wetlands Project could increase the cost of repair operations, extend the time required by PG&E to make necessary repairs, and possibly increase the duration of service curtailments. The following sections describe the emergency repair procedures and the effects on service under existing conditions and with the Delta Wetlands Project in operation.

Existing Conditions

Emergency Repair Procedures. PG&E is required by the CPUC (CPUC General Order 112(e), which adopts 49 CFR 192) to maintain an emergency-preparedness plan. As described in the hearing testimony, PG&E has a supply of materials and specially trained welders and equipment operators for emergency shallow-water repairs of its pipeline facilities. PG&E's testimony also states that the pipelines crossing Bacon Island are under water most of the time because of shallow groundwater, and that those conditions require special procedures to facilitate repairs.

PG&E stated that it could probably mobilize crews within several weeks under existing (i.e., dry) conditions. The time required for repair cannot be estimated without knowing the conditions that led to the rupture and the extent of the rupture; PG&E would assess both of these factors after excavating and inspecting the damaged portion of the pipeline. To respond to a pipeline failure on Bacon Island under existing conditions, PG&E would:

- # shut off gas flowing through the line at the nearest valves (on McDonald Island, 2.9 miles east of the east side of Bacon Island, and 5.2 miles west of the west side of Bacon Island) and isolate the pipeline segment;

- # release gas within the pipeline section that crosses the island at one of the shut-off valves; and

- # drive equipment to the leak site, excavate the pipeline, dewater the working pit (because of shallow groundwater levels, some dewatering is probably necessary even during the summer), cut out the damaged section, weld a new section in place, and test the pipeline (Warner pers. comm.).

Effects on Service. If Line 57-B were damaged and removed from service, PG&E would curtail deliveries to customers if supplies were not adequate to meet demand. PG&E stated in its testimony that, under existing conditions, it distributes natural gas from three sources: the 400 and 401 lines from Canada, the 300 line from southern California, and local production. Additionally, PG&E stated that these sources of gas currently cannot meet the peak gas demand that occurs during cold weather. Line 57-B connects the McDonald Island storage facility to the distribution system to provide peak capacity and redundancy of supply if one of the other sources is interrupted. If the McDonald Island storage facility were not online during a peak-demand period, PG&E would attempt to balance its system and purchase additional gas to minimize service interruptions; however, PG&E's ability to respond to the situation is limited because the pipelines that connect to the gas sources have limited capacity.

Natural gas, like other utility services, has multiple price schedules based on delivery of the service. A supply that is interruptible is less expensive than a firm supply. If gas service must be curtailed, customers with interruptible supplies would be affected first. Customers with interruptible supplies are usually industrial users that can switch to alternative fuels, such as the electricity-generating facilities in Pittsburg, which can switch to fuel oil when natural gas supplies are curtailed (which occurred during the winter of 1997). Many firm-supply customers may not have an alternative fuel supply. During service interruptions, PG&E would not be able provide alternative service to all customers, and it would be up to customers to meet their individual needs.

Delta Wetlands Project Conditions

Emergency Repair Procedures. Under Delta Wetlands Project conditions, the procedure for pipeline repair described previously would still be used when the reservoir island is not flooded (i.e., during dry periods). PG&E testified that a repair conducted when Bacon Island is partially flooded could be completed using similar techniques as under without-project conditions, except that access to the site may require use of a boat or barge, depending on the depth of stored water relative to the height of existing roads across the island. After accessing the site, PG&E could install sheet piles around the damaged area, dewater a work area, and then complete the pipeline repair as if it were under dry conditions (Clapp testimony). However, because of the logistical problems associated with accessing the site and installing sheet piles around a larger area, PG&E would require additional resources and planning time and would incur greater costs using these techniques under flooded conditions than under dry conditions.

Alternatively, as suggested in the water right hearings, underwater repair methods could be used to repair a damaged pipeline. PG&E stated that it is not currently equipped to service pipelines through water with divers and underwater welding equipment (Warner pers. comm.). However, PG&E staff also testified that the utility has a supply of materials and specially trained welders and equipment operators for emergency shallow-water repairs of its pipeline facilities (Clapp testimony). Nevertheless, underwater repair methods would be costly and require specialized equipment and do not appear to be a practical alternative at this time.

The final practicable repair option is to shut down the pipeline, empty the reservoir, and use dry-condition repair techniques. If a significant pipeline leak occurred on Bacon Island during water- storage operations and the leak could not be repaired by installing sheet piles and dewatering a work area, the pipeline would probably have to be shut down until the reservoir could be drawn down and conventional dry-conditions construction techniques could be used. According to Delta Wetlands' testimony, drawing the stored water down at the maximum rate assuming a full reservoir would take at least three weeks, assuming that Delta Wetlands' operational rules would allow discharge at the maximum rate. Additional time would be required to allow the land surface to dry before equipment could be operated on the ground surface, possibly substantially increasing the waiting period before the pipeline could be repaired. This repair technique, in addition to using sheet piling, appears to be the most practical repair method available if an emergency occurred during reservoir operations.

Additionally, the 1995 DEIR/EIS suggested that directional drilling, which is used for pipeline repairs at Delta channel crossings, would be a practical repair solution. When a line fails under a Delta channel, PG&E directionally drills under the channel adjacent to the damaged line and pulls a new pipeline segment. The new pipeline segment is welded into the existing line on both sides of the channel, and the damaged line is sealed (usually filled with concrete) and abandoned in place. However, under closer review, this technique is not a practicable solution to repair the line across Bacon Island. To drill entirely under Bacon Island, the entrance and exits of the bore would need to be located on the land on Palm Tract and McDonald Island, greatly increasing the bore length (from about 2 miles to 5 miles).

Although technically possible, the construction of a new line under Bacon Island when the reservoir is full would be costly and time-consuming. It could take months to design the new pipeline segment, mobilize the appropriate equipment, obtain the pipe, and secure the necessary permits and leases from the regulatory agencies. For example, the California State Lands Commission requires that detailed engineering plans be prepared and approved before it will grant a lease to cross state lands (the channels adjacent to the Delta Wetlands islands), and the California State Reclamation Board requires that PG&E receive an encroachment permit from the local reclamation district before construction.

Shorter pipeline segments could be installed using directional-drilling techniques by creating temporary gravel islands within Bacon Island. However, the necessary equipment would be difficult to transport to the site. Barges are typically used to move such equipment, but they would not have access to the island interior. A large crane would be required to lift equipment over the levee, from the adjacent channel to the island interior. The storage level (water depth) at the time of repair could limit the size of equipment that could be used, further slowing the repair process. As with a single directional drill, it could take months to design the new pipeline segment, mobilize the appropriate equipment, obtain the pipe, and secure the necessary permits and leases from the regulatory agencies. This does not appear to be a practicable repair technique on Bacon Island.

PG&E contends that the only suitable solution to potential adverse effects on its pipelines and potential interruption of service would be construction of new pipelines around the proposed project. The pipeline incident data collected by the DOT, however, do not support this conclusion. Pipelines very rarely fail catastrophically without external forces or third-party actions. Flooding Bacon Island and discontinuing the current agricultural activities would all but eliminate any potential third-party action that could damage the pipeline. Internal inspection, required by federal and state regulations, detects corrosion or abnormalities in the pipeline walls in advance of potential failure. Furthermore, it is a common industry practice to allow small leaks to go unremedied for months while engineering studies are completed and specialized equipment and personnel are mobilized.

In summary, conducting a repair while the reservoir is inundated or drawing the reservoir down before conducting a dry-land repair would take longer and cost more during Delta Wetlands reservoir operations when compared to existing conditions. Without knowing the specifics of the pipeline rupture, it is difficult to determine the magnitude of the effect on PG&E's repair time and associated costs of the additional time needed to plan for a shallow-water repair or the time required to draw down the reservoir.

Effects on Service. Inundation of the island under Delta Wetlands Project operations could slow PG&E's response time to repair a pipeline leak and could interrupt service for a longer period than would occur under existing conditions. As described above, a severe leak or pipeline rupture would take longer to repair under flooded reservoir conditions than the existing dry conditions. This delay in repairs could result in longer periods of using alternative gas sources.

Impact Conclusion for Potential Delay in Emergency Repair

As evidenced by the Office of Pipeline Safety data, the long-term risk of catastrophic pipeline failure is very low under existing conditions, and implementation of the project would further reduce the risk to the pipeline from potentially damaging third-party activities. Flooding of Bacon Island could delay and complicate repairs to PG&E's pipeline facilities if a rupture occurred during water-storage operations. Flooding the island would also increase the cost of such repairs. If a repair required an immediate drawdown of the reservoir, it is simulated that all the water could be removed within three weeks (under full-reservoir storage) while appropriate engineering studies are being completed and before repair equipment and personnel could be mobilized. The three-week drawdown estimate assumes that Delta Wetlands discharges from Bacon Island would not be restricted by water quality mitigation measures or other operational constraints. The potential impact on PG&E's operations is an economic one. The incremental costs to PG&E (e.g., lost revenue and purchase cost of alternative supplies) and its customers resulting from an extended time required to repair the pipeline under project conditions cannot be determined but are recognized as a potential economic effect of the Delta Wetlands Project. Because economic effects are not considered environmental impacts under CEQA and NEPA, no significance conclusion is made and no mitigation is identified (see also Chapter 3K, "Economic Conditions and Effects").

Cumulative Impacts

Implementing the Delta Wetlands Project would not contribute significantly to cumulative risk of gas pipeline failure in the Delta. Activities in the Delta that could affect gas pipelines include agricultural activities and levee strengthening or maintenance. Because the Delta Wetlands Project would substantially reduce ground-disturbing activities, it would reduce the cumulative risk to pipelines from third-party activities (e.g., farming). PG&E monitors some levee crossings, including the Bacon Island and McDonald Island levee crossings, using monthly inspections of installed tilt meters at the levee crossings (Clapp testimony). Cumulative risks to gas pipelines at levee crossings in the Delta are considered less than significant because PG&E applies monitoring procedures and implements pipeline improvements in response to levee maintenance or settlement on an ongoing basis. Therefore, the cumulative effect on gas pipelines in the Delta is considered less than significant and no mitigation is required.

Impact Evaluation of Project Alternatives from the 1995 Draft EIR/EIS

As described in Chapter 2, Bacon Island would be used for water storage under all three project alternatives. Consequently, effects on PG&E's gas pipeline would be the same under all alternatives. The impacts and mitigation measures described above apply to the proposed project (Alternatives 1 and 2) and also to Alternative 3.

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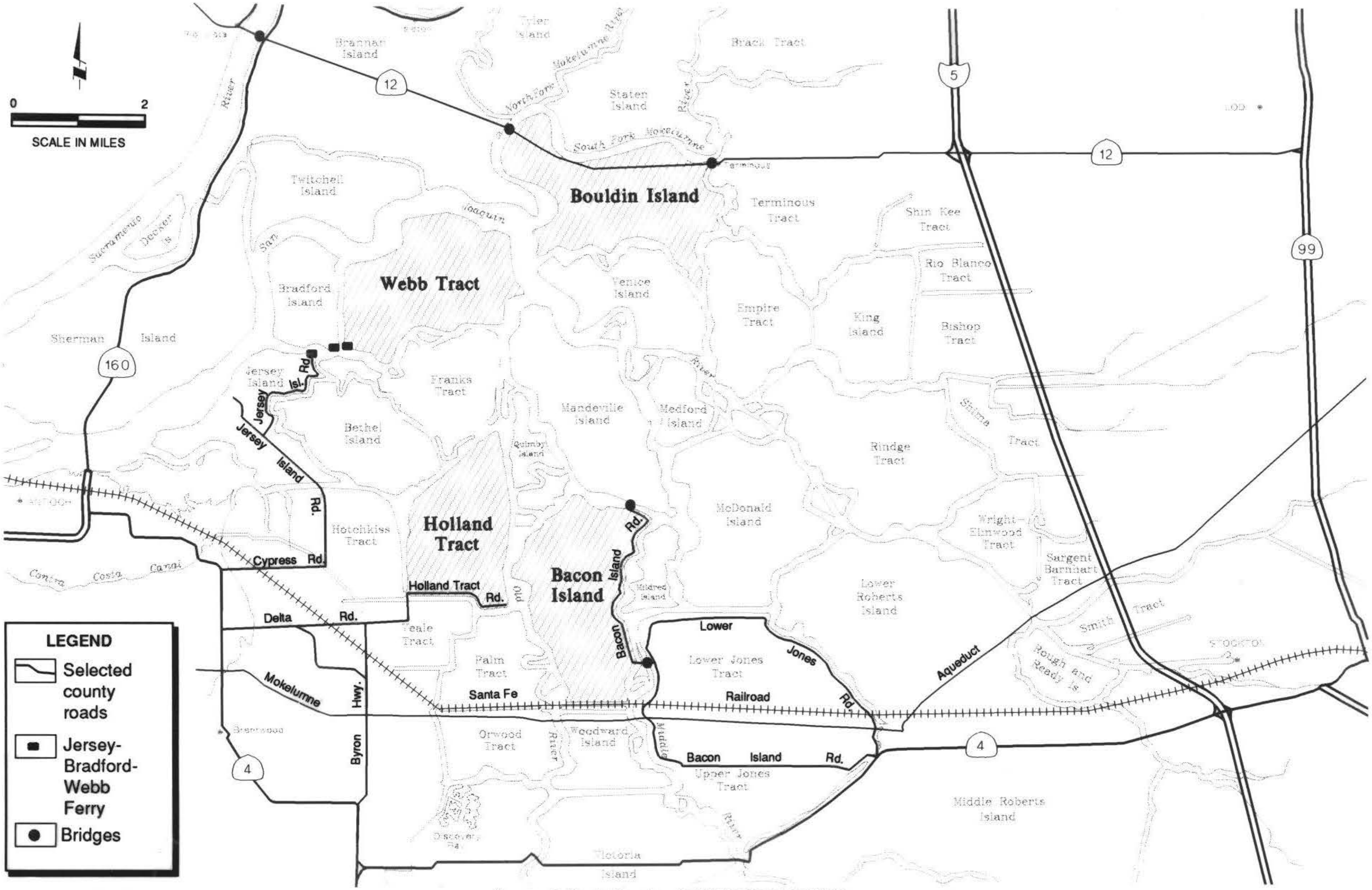
Table 3E-1. Comparison between Delta Wetlands Project Impacts on Natural Gas Facilities in the 1995 Draft EIR/EIS and in the 2000 Revised Draft EIR/EIS

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Differences between 1995 DEIR/EIS and 2000 REIR/EIS
Impact E-3: Increase in the Risk to Gas Lines Crossing Exterior Levees on Bacon Island (LTS) C No mitigation is required.	**Risk of Pipeline Leak or Rupture Resulting from Levee Improvements.** Potential settlement issues or increased loads on the pipelines at the levee crossings may require corrective measures during levee construction and settlement. This impact is considered significant and the following mitigation measures are recommended. (S) 1. Monitor Locations Where Gas Pipelines Cross Bacon Island Levees during and after Levee Construction and • Implement Corrective Measures to Reduce Risk of Pipeline Failure during Levee Construction. (LTS)
----	**Risk of Pipeline Leak or Rupture Resulting from Island Inundation.** The risk of pipeline rupture would decline under project conditions because the project would substantially reduce ground-disturbing activities, such as agricultural practices, that could result in line rupture. This effect is considered beneficial. However, Line 57-A may require additional weighting before the island is flooded. The line could float under inundated conditions, resulting in increased risk of damage to this pipeline and the need for pipeline modifications. Therefore, this impact is considered significant and the following mitigation measure is recommended. (S) • Securely Anchor Line 57-A before Bacon Island Flooding. (LTS)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 DEIR/EIS Alternatives 1 and 2	Differences between 1995 DEIR/EIS and 2000 REIR/EIS
----	**Potential Interference with Pipeline Inspection Procedures.** To the extent practical, walking inspections would be completed during dry periods; however, PG&E would need to modify its inspection practices during inundated conditions by using a boat rather than a walking inspection. According to PG&E, this represents a substantial alteration in PG&E's maintenance procedures. Additionally, flooding Bacon Island would inundate cathodic protection test stations. This impact is considered significant and the following mitigation measures (described in the text) are recommended to assist PG&E in conducting its routine maintenance and reduce the impact to a less-than-significant level. (S) • Provide Adequate Facilities on Bacon Island for Annual Pipeline Inspection. • Relocate Cathodic Protection Test Stations before Bacon Island Flooding. (LTS)
Impact E-4: Increase in PG&E Response Time to Repair a Gas Line Failure on Bacon Island (LTS) C No mitigation is required.	**Potential for Delay in Emergency Repairs and Unscheduled Interruption of Service.** Project operations would not preclude routine inspections and emergency repairs. However, reservoir operations on Bacon Island would delay and complicate the repairs of PG&E's pipeline facilities that would be needed if a rupture occurred during water-storage operations. Flooding the island would also increase the cost of such repairs. The potential impact on PG&E's operations is an economic one. The incremental costs, if any, to PG&E and its customers resulting from an extension of time required to repair the pipeline under project conditions are recognized as a potential economic effect of the Delta Wetlands Project. Because economic effects are not considered environmental impacts under the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA), no significance conclusion is made and no mitigation is identified (see also Chapter 3K, "Economic Conditions and Effects" in the 1995 DEIR/EIS).

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.



Source: California Department of Water Resources 1993.

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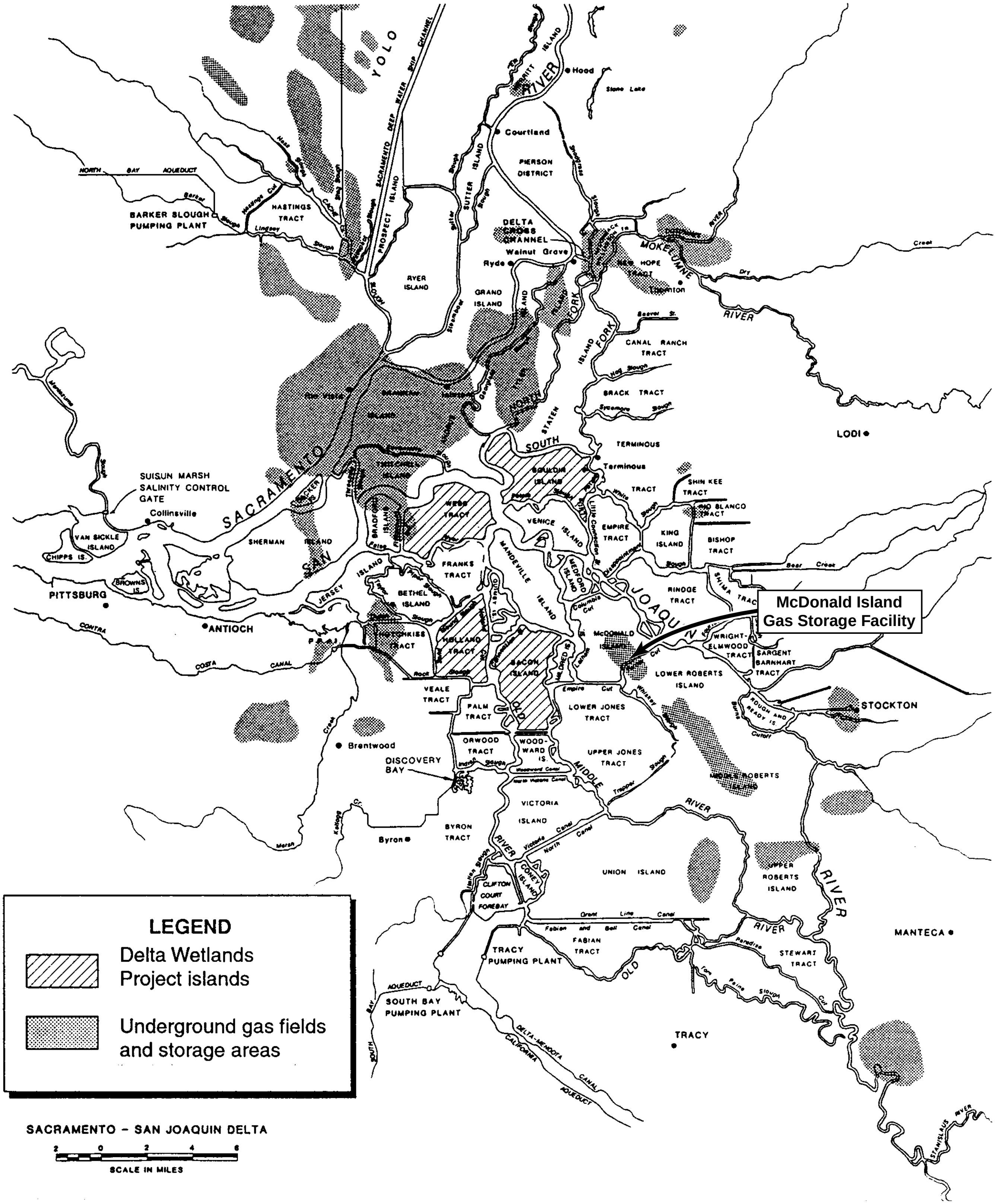
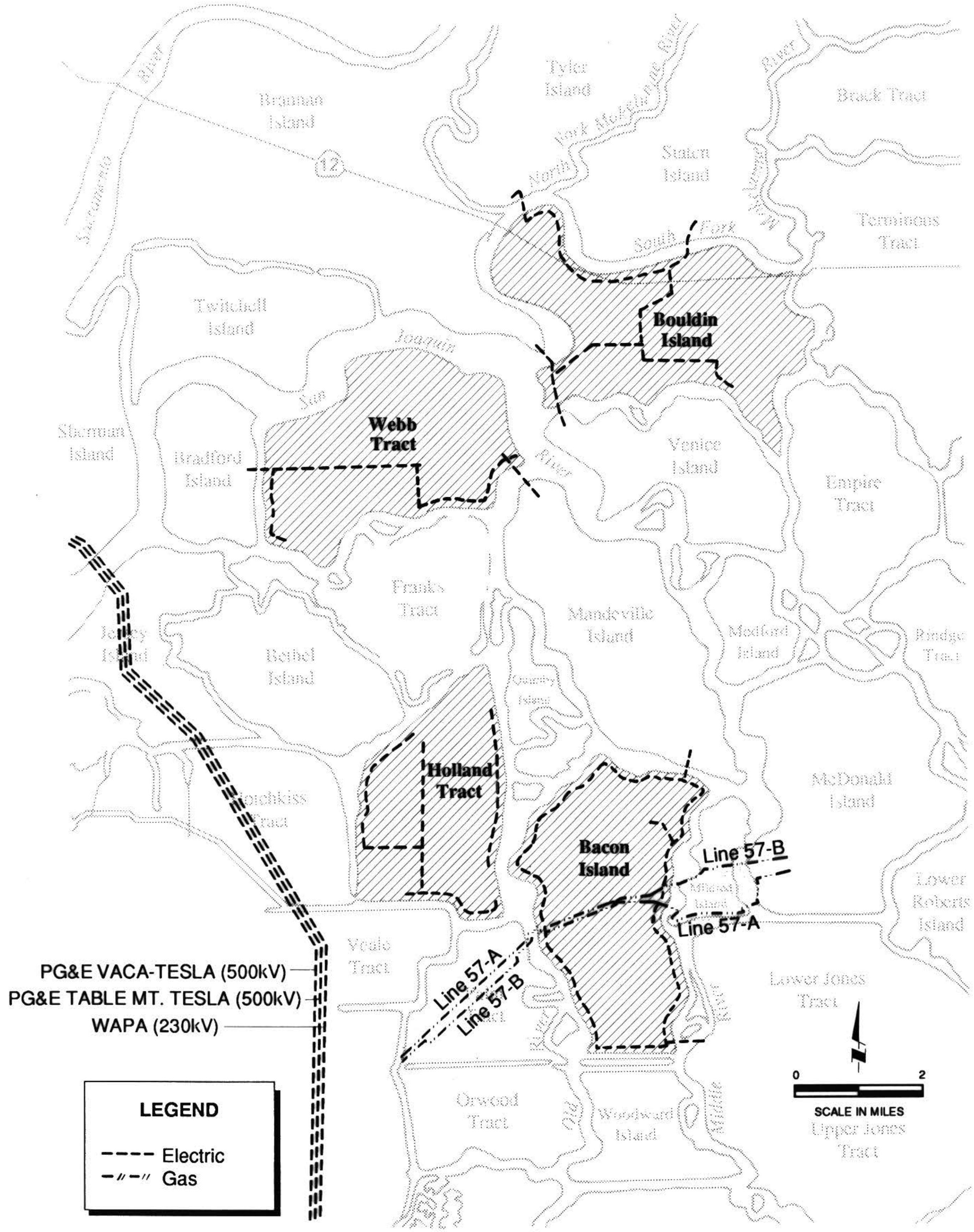
Figure 3E-1
Transportation and Water Conveyance Infrastructure in the Delta Wetlands Project Vicinity



Source: DWR 1993.

Figure 3E-2
Underground Gas Fields and Storage Areas in the Delta Wetlands Project Vicinity



Source: Bennett and Forkel pers. comms.

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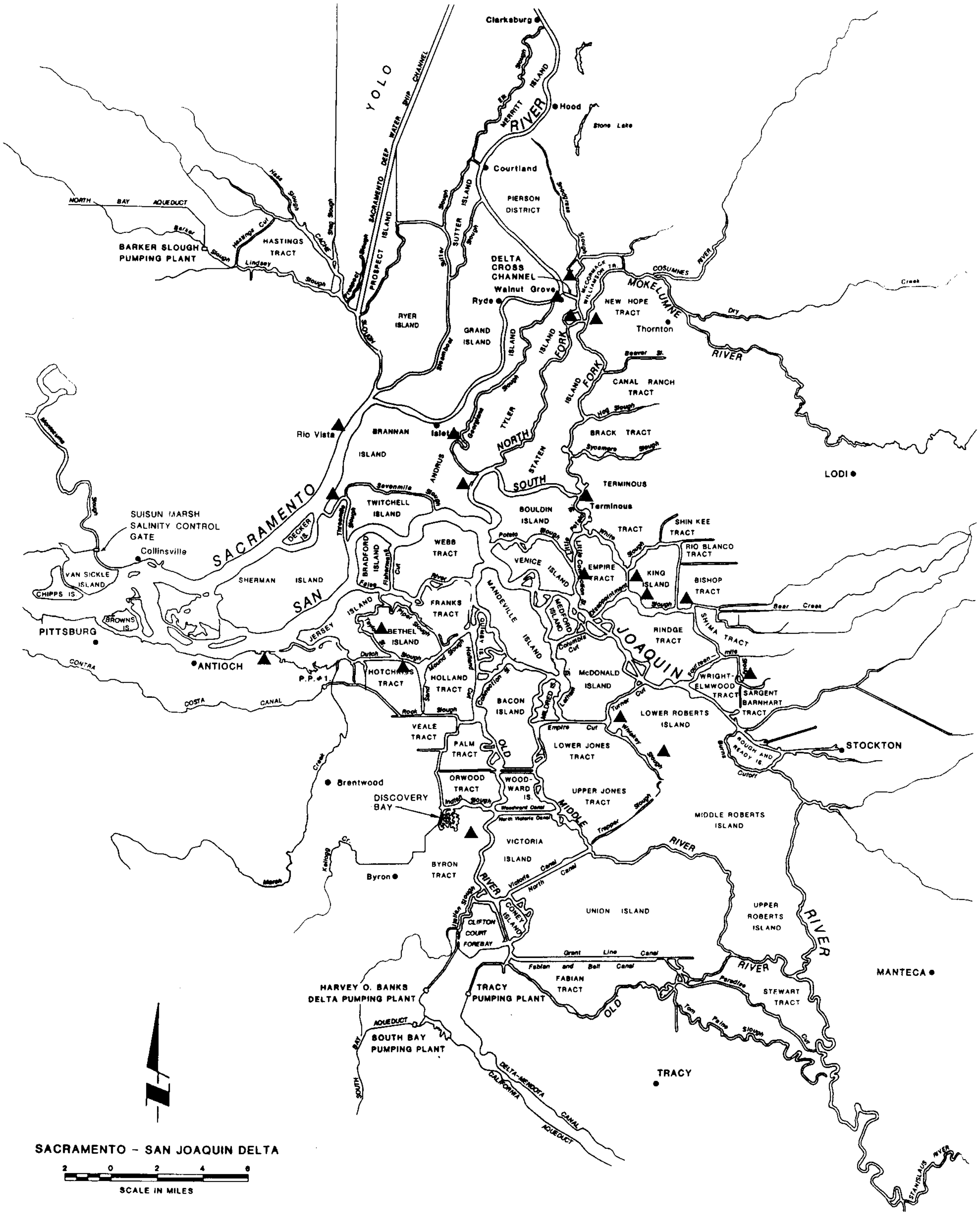
Figure 3E-3
Gas and Electric Transmission and Distribution Lines in the Delta Wetlands Project Vicinity



Source: San Francisco Estuary Project 1995.

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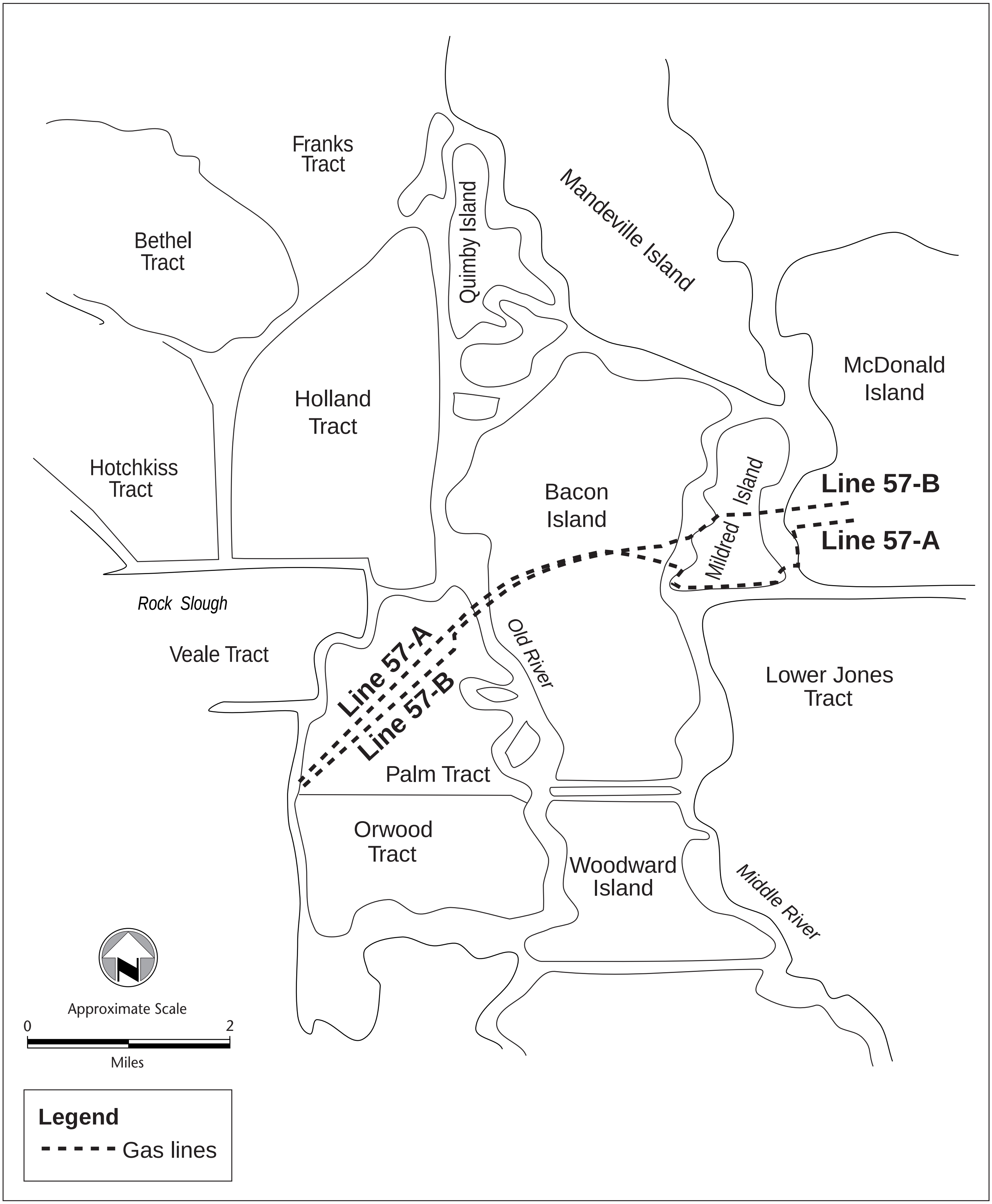
Figure 3E-4
Pumpout Stations in the Delta Wetlands Project Vicinity



Source: Bennett pers. comm., Forkel pers. comm.

Figure 3E-5
Gas Transmission Lines on Bacon Island

Chapter 3F. Affected Environment and Environmental Consequences - Fishery Resources

Chapter 3F. Affected Environment and Environmental Consequences - Fishery Resources

SUMMARY

This chapter summarizes the life histories and habitat needs of chinook salmon, striped bass, American shad, delta smelt, Sacramento splittail, and longfin smelt and analyzes the potential for impacts of DW project operations on these species and their habitats. The habitat requirements and distribution of these species are representative of those of other Delta fish species; therefore, effects of project operations described for these species encompass the range of potential project effects on all Delta fish species.

The 1995 DEIR/EIS analysis found that construction and operation of the DW project facilities under Alternative 1, 2, or 3 could cause or contribute to several significant impacts on fish populations; impact avoidance and mitigation measures were proposed to reduce all significant impacts to a less-than-significant level. The following significant potential impacts were identified:

- *Construction of DW project facilities could degrade spawning and rearing habitat, which could reduce the localized reproductive success of delta smelt, Sacramento splittail, and other Delta species.*
- *Discharge of water from the DW reservoir islands to adjacent channels could increase channel water temperature, which could reduce juvenile chinook salmon survival.*
- *DW project operations could affect flows during the peak out-migration period of Mokelumne and San Joaquin River chinook salmon, indirectly increasing chinook salmon mortality.*
- *DW project operations could reduce transport flows and increase entrainment loss, which could reduce the survival of striped bass eggs and larvae; delta smelt larvae; and, possibly, longfin smelt larvae.*
- *DW project diversions could indirectly increase entrainment losses during November-January, reducing survival of juvenile striped bass and delta smelt.*

The 1995 DEIR/EIS analysis also found that implementation of Alternative 1, 2, or 3 would result in the following less-than-significant impacts: a change in the area of optimal salinity habitat in the Delta, a potential increase in accidental spills of fuel and other materials at boat docks at the DW project islands, and an increase in entrainment loss of juvenile American shad and other species.

Effects on fish species and their habitats under the No-Project Alternative would not differ measurably from effects of current agricultural operations on the DW project islands.

In 1997, USFWS and NMFS issued no-jeopardy biological opinions for effects of the proposed project on delta smelt and winter-run chinook salmon, respectively. The USFWS biological opinion incorporated a conference opinion on project effects on splittail, and the NMFS opinion incorporated a draft conference opinion on project effects on the Central Valley steelhead evolutionarily significant unit (ESU). USFWS formally adopted its conference opinion for splittail as its biological opinion in April 2000, and NMFS formally adopted its conference opinion for steelhead as its biological opinion in May 2000.

In 1998, DFG issued a no-jeopardy biological opinion for project effects on state-listed species, including delta smelt and winter-run chinook salmon.

In August 2000, NMFS issued a biological opinion that states that the project is not likely to jeopardize the continued existence of spring-run chinook salmon. In accordance with Section 2081 of the California Fish and Game Code, DW has requested concurrence directly from DFG that the protective measures in the existing biological opinion adequately address potential project effects on spring-run chinook salmon.

The biological opinions require DW to operate according to the FOC terms and describe RPMs that DW must implement to minimize the adverse impacts of incidental take of listed species. Incorporating the FOC and RPMs into the proposed project reduces to a less-than-significant level the impacts on fish habitat and populations that were identified as significant in the 1995 DEIR/EIS analysis. The FOC and RPMs also provide adequate protection to prevent significant impacts on nonlisted fish species (e.g., striped bass and American shad). The biological opinions apply to the proposed project, but do not apply to Alternative 3; therefore, the impacts and mitigation measures proposed for Alternatives 1 and 2 in the 1995 DEIR/EIS have been modified by the FOC and RPMs, but those identified for Alternative 3 remain as described in the 1995 DEIR/EIS.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

The discussion of effects of the proposed project (Alternative 1 or 2) on fishery resources was updated in the 2000 REIR/EIS. This chapter includes both the 1995 analysis of effects on fishery resources under the No-Project Alternative and Alternatives 1, 2, and 3 and the updated information from the 2000 REIR/EIS. Additionally, minor changes have been made to the updated text in response to comments on the 2000 REIR/EIS.

INTRODUCTION

This chapter assesses impacts of DW project operations and facilities on fish species that reside in the Delta, Suisun Bay, and San Francisco Bay for at least part of their lives. The effects of DW project operations and facilities on habitat conditions common to multiple species and life stages are identified. Factors affecting the population abundance and distribution of individual species are evaluated in detail. Available information was used to identify relationships between species and their habitat.

More than 100 fish species are found in the Delta and Bay, and about 40 of these species are found in the Delta (Table F1-1 in Appendix F1, “Supplemental Information on the Affected Environment for Fisheries”). The impact assessment is limited to species that support important sport and commercial fisheries; species that are unique to the Bay-Delta environment; species that may be in danger of extinction; and species that, when considered as a group, encompass the range of potential responses to the effects of Delta water project operations and facility construction. The species included in this impact assessment are chinook salmon (*Oncorhynchus tshawytscha*), striped bass (*Morone saxatalis*), American shad (*Alosa sapidissima*), delta smelt (*Hypomesus transpacificus*), Sacramento splittail (*Pogonichthys macrolepidotus*), and longfin smelt (*Spirinchus thaleichthys*).

On-island fishery resources were not included in the fishery impact assessment. The existing on-island fishery resources are negligible relative to total fishery resources in the Delta. Existing fish populations on the DW project islands are limited to perennial ponds and drainage ditches. The ponds support introduced sunfish, catfish, and minnows primarily. No fish species that are federally listed as threatened or endangered or that are candidates for listing are known to exist on the project islands.

The discussion of fisheries in this chapter includes some terms that may not be familiar to all readers. The following are definitions of these terms as they are used in this EIR/EIS:

Entrapment zone. An area or zone of the Bay-Delta estuary where riverine current meets upstream-flowing estuarine currents and variations in flow interact with particle settling to trap particles. The entrapment zone generally corresponds to a surface salinity range of 2-10 mS/cm specific conductance) (Kimmerer 1992).

X2. The location in the Bay-Delta estuary relative to the Golden Gate Bridge (measured in kilometers) of the 2-ppt isohaline 1 meter off the bottom (San Francisco Estuary Project 1993). An isohaline is a line connecting all points of equal salinity.

Midwater trawl index. The annual index is the sum of the weighted catch of four monthly samples (September-December) from numerous locations in the Delta and Suisun Bay. The index is assumed to be a measure of abundance when considered in relation to the catch for all other years of the sampling record (1967-1995). In the Bay-Delta estuary, the index has been developed for striped bass, American shad, delta smelt, Sacramento splittail, longfin smelt, and other species.

Entrainment. The process in which fish are drawn into water diversion facilities along with water drawn from a channel or other water body by siphons and/or pumps. Entrainment loss includes all fish not salvaged (i.e., eggs, larvae, juveniles, and adults that pass through the fish screens, are impinged on the fish screens, or are eaten by predators).

Salvage. Removal of fish from screens on diversion structures and the subsequent return of the fish to the water body. Fish eggs and larvae (e.g., delta smelt, striped bass, and longfin smelt) are small and pass through the screens. They are not included in salvage numbers.

Direct effects. Mortality of fish attributable to DW diversions, including entrainment in DW diversions and losses resulting from changes in habitat.

Indirect effects. Mortality of fish attributable to other diversions that results from DW effects on Delta flow conditions.

Additional terms are defined below in the section from the 2000 REIR/EIS entitled "Definition of Terms".

AFFECTED ENVIRONMENT

This section provides an overview of the life histories of selected Delta fish species and factors affecting their population abundance. More detailed information is provided in Appendix F1, "Supplemental Information on the Affected Environment for Fisheries".

Sources of Information

The assessment of potential effects of DW project operations on the habitat and populations of fish species in the Bay-Delta estuary is based on literature review, contacts with appropriate agency experts, analysis of the effects of simulated DW project operations on simulated Delta fish transport patterns, and analysis of other available data.

Ongoing studies and analyses of the Bay-Delta served as important sources of information for this assessment. These studies and reports include the San Francisco Estuary Project (1993), Bay-Delta hearings and workshops sponsored by SWRCB, and evaluations of effects of SWP and CVP operations on two federally listed endangered species, winter-run chinook salmon (NMFS 1995) and delta smelt (USFWS 1995).

This chapter is also based on information presented in the following chapters and appendices:

Chapter 3A, "Water Supply and Water Project Operations", describes Delta conditions related to water supply, provides an overview of historical Delta water supply conditions, and discusses possible impacts of the DW project on Delta and California water supply.

Appendix A3, "DeltaSOS simulations of the Delta Wetlands Project Alternatives", presents detailed results of DeltaSOS simulations of operations of the DW project alternatives and the No-Project Alternative and describes the use of DWRSIM simulation results as initial water budget terms for

DeltaSOS modeling. The analysis of impacts on fishery resources described in this chapter is based on these DeltaSOS simulation results showing estimated changes in channel flows, outflow, and exports that would be associated with operations of each of the DW project alternatives and the No-Project Alternative under a range of hydrologic conditions.

Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments", compares daily hydrologic conditions with monthly average conditions in the Delta and discusses potential differences between impact assessment based on monthly average hydrologic conditions and impact assessment based on actual daily hydrology.

Chapter 3B, "Hydrodynamics", describes Delta hydrodynamic conditions, identifies Delta hydrodynamic variables that could be affected by operation of the DW project, and presents the results of simulations to determine DW project effects on those key variables. Effects of maximum DW diversions and discharges on local and net channel flows are analyzed.

Chapter 3C, "Water Quality", describes key water quality variables and objectives associated with maintaining beneficial uses of Delta waters, existing Delta water quality conditions, and impacts of the DW project on water quality in Delta channels.

Appendix F1, "Supplemental Information on the Affected Environment for Fisheries", provides additional background information on fish species included in the impact assessment.

Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species", provides background information and presents a detailed assessment of impacts of the DW project on fish species that are listed as endangered or threatened or that are candidates for future listing. Appendix F2 includes a detailed description of the models used to assess impacts.

The reader is directed to these chapters and appendices for a more detailed explanation of analytical methods and assumptions integrated into the fishery impact assessment.

Chinook Salmon

The chinook salmon is an important fish species supporting valuable commercial and sport fisheries (Allen and Hassler 1986). The Sacramento-San Joaquin River system supports four runs of chinook salmon: fall, late fall, winter, and spring. Separation of the runs is defined by the timing of upstream migration of adults.

The population abundance of all four runs of chinook salmon has declined relative to historical levels (Appendix F1, "Supplemental Information on the Affected Environment for Fisheries"). A detailed discussion of the winter-run chinook salmon, currently listed as endangered under the California and federal Endangered Species Acts, is provided in Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species". Spring-run chinook salmon was listed in 1999 as threatened under both the California and federal Endangered Species Acts (64 FR 50394). Information on the occurrence of spring-run chinook salmon is provided below in the section from the 2000 REIR/EIS entitled "Affected Environment: Relevant or New Information".

Life History

Adult chinook salmon 2-7 years old migrate from the ocean to spawn in the upstream reaches of the major tributaries to the Sacramento and San Joaquin Rivers. Eggs are deposited in gravel nests and fry emerge after incubating for about 3 months. Juvenile salmon migrate from upstream spawning areas to downstream habitats and to the ocean.

The Delta serves as an immigration path and holding area for adult chinook salmon returning to their natal rivers to spawn. Sacramento River chinook salmon migrate primarily up the mainstem Sacramento River, but some fish use the distributaries of the Mokelumne River and enter the Sacramento River through Georgiana Slough or the DCC (Figure 1-2 in Chapter 1, "Introduction"). San Joaquin River chinook salmon migrate primarily up the mainstem San Joaquin River.

Emigrating juvenile chinook salmon are found in the Delta and Bay throughout the year, but primarily from about October through June (Figure 3F-1). Migration along the fastest and most direct migration route generally results in the highest survival of chinook salmon migrating to the ocean through the Delta.

Factors Affecting Abundance

Factors associated with the historical decline of chinook salmon populations are deleterious water temperatures in spawning and rearing habitat and blockage of adult passage to suitable spawning and rearing areas. Other factors that may affect population abundance include diversion of juveniles off the primary migration path through the Delta, entrainment of juveniles in diversions, predation during juvenile migration, toxic discharge to the rivers, and ocean fishing.

Temperature is a primary factor influencing the survival of chinook salmon in the Delta, especially during May and June (Kjelson et al. 1989a). Survival of juvenile fall-run chinook salmon during migration though the Delta appears to decline when water temperature exceeds 60°F (Kjelson et al. 1989b, USFWS 1992). The relationship between temperature and chinook salmon survival is discussed in detail in Appendix F2.

The most direct routes upstream through the Delta during adult migration to spawning areas are the Sacramento River and San Joaquin River channels. When export rates exceed San Joaquin River inflow, water in the central and south Delta consists primarily of Sacramento River water moved across the Delta by the DCC and Georgiana Slough or pulled by reverse flow through the lower San Joaquin River. Chinook salmon may become confused and their migration may be delayed, possibly resulting in reduced adult survival and fecundity.

Although the most direct route through the Delta for juvenile Sacramento River chinook salmon is the Sacramento River channel, juveniles may be drawn along an alternate route through the DCC and Georgiana Slough (Figure 1-2 in Chapter 1), where migration is delayed and losses to diversions and predation may increase. The division of Sacramento River flow at the DCC and the number of out-migrant juveniles drawn into the DCC depend primarily on DCC gate position and Sacramento River flow volume. USFWS and DFG (1987) found that when the proportion of Sacramento River flow drawn into the DCC and Georgiana Slough was high (greater than 60%) and the DCC gates were open, survival was about 50% lower for juvenile fall-run chinook salmon released above the DCC than for juveniles released below Georgiana Slough. When the DCC gates were closed, only Georgiana Slough drew water out of the Sacramento River, and survival was similar for the two release locations.

Similarly, mortality of juvenile chinook salmon diverted from the San Joaquin River into upper Old River may be greater than that of juveniles migrating down the mainstem San Joaquin River (USFWS 1993a). Entrainment in diversions (agricultural diversions and CVP and SWP exports) also increases juvenile mortality. Entrainment loss to all Delta diversions may exceed several hundred thousand juvenile chinook salmon, including substantial numbers lost to predation (DFG 1992a).

Striped Bass

Striped bass are large predatory fish introduced to the Bay-Delta estuary in about 1880. Adult striped bass live in the ocean and Bay (most may remain in the Bay) and migrate upstream to the Delta and Sacramento River to spawn (DFG 1987a). Striped bass support a large sport fishery in the Delta and Bay.

Life History

About 55% of the adult striped bass population spawn in the Sacramento River upstream of the Delta during May and June, and about 45% spawn in the San Joaquin River between Antioch and Venice Island during April and May (DFG 1987a). Percentages vary from year to year.

Semibuoyant eggs are broadcast-spawned by striped bass in open water and eggs hatch in about 2 days (DFG 1987a). Eggs and newly hatched larvae drift with the current, and Sacramento River eggs or larvae generally reach the Delta within a few days. Newly hatched larvae are carried downstream to the upstream edge of the entrapment zone.

Factors Affecting Abundance

Year-class abundance of striped bass is assumed to depend on the environmental conditions experienced by the eggs and young fish. An important factor affecting striped bass abundance may be the location of X2 (abundance is highest when outflow is sufficient to locate the 2-ppt isohaline in Suisun Bay during April-July). Other primary factors influencing young striped bass abundance are entrainment of eggs, larvae, and juveniles in Delta diversions (DFG 1992a) and discharge of toxic materials into rivers tributary to the Delta and into the estuary. Additionally, declines in the availability of major prey organisms and competition with introduced exotic fish and invertebrate species may adversely affect striped bass abundance (DFG 1992b).

X2 is a function of Delta outflow volume; as outflow increases, X2 is reduced (the 2-ppt isohaline moves downstream). Although dependent on the natural hydrology of the Sacramento-San Joaquin River system, the timing and volume of Delta outflow have been substantially modified by changes in system characteristics (i.e., channelization and flood control projects) and by operations of water project facilities (i.e., reservoirs and diversions) (Herbold et al. 1992). In general, water projects have increased summer and fall outflow and reduced winter and spring outflow (Herbold et al. 1992).

When X2 is in Suisun Bay, the proportion of the juvenile striped bass population in the Delta is lower than when X2 is in the Delta (Figure 3F-2) (DFG 1992b). The highest survival of young-of-year striped bass occurs during high-flow periods when most of the juvenile population is distributed downstream of the Delta.

Young bass are more vulnerable to entrainment in diversions when they are located in the Delta. Significant egg, larval, and juvenile mortality results annually from entrainment in SWP and CVP exports and other Delta diversions, exceeding millions of fish each year (DFG 1992a). The timing of striped bass entrainment in SWP and CVP exports is shown in Figure 3F-3. Net reverse flow in the lower San Joaquin River and in Old and Middle Rivers transports striped bass eggs and larvae toward the SWP and CVP export facilities and may increase entrainment loss.

American Shad

The American shad is the largest member of the herring family and may reach a weight of over 5 kg (Facey and Van Den Avyle 1986). American shad were introduced to the Bay-Delta estuary during the late 1800s and currently support a sport fishery.

Life History

Adult American shad immigrate to fresh water from the ocean and the Bay during March, April, and May. The primary spawning grounds are in the upper Sacramento River and its tributaries. The northern Delta and the northern portion of Old River have also supported shad spawning. (DFG 1987b.) During May-July, shad broadcast-spawn their eggs and sperm into the currents, where the semibuoyant eggs sink slowly and drift with the flow.

Shad spawned in the Sacramento River system generally rear in the tributary rivers downstream of the spawning area. Shad spawned in the Delta appear to rear primarily in the Delta. Most juvenile American shad emigrate from their freshwater rearing areas and pass through the Delta to estuarine and marine habitats between September and December (Stevens 1966).

Factors Affecting Abundance

American shad abundance may be affected by factors similar to those discussed for striped bass. The environmental conditions experienced by the eggs and young fish, especially river flows, are thought to be the most important conditions determining population abundance. Entrainment of young-of-year shad in water diversions from the Delta reduces juvenile survival. Ocean conditions also may be another important factor determining American shad abundance.

Hundreds of thousands of American shad larvae and juvenile fish are entrained each year at the SWP and CVP export facilities and in other Delta diversions (DFG 1987b). Shad spawned in the Delta are entrained as larvae and juveniles primarily during July-August (Figure 3F-3). Shad spawned upstream of the Delta are entrained as juveniles primarily during November and December.

Delta Smelt

The delta smelt is a small (2- to 3-inch-long), translucent, slender-bodied fish with a steely blue sheen. The delta smelt is found only in the Bay-Delta estuary (including the Delta, Suisun Bay, Suisun Marsh, and sometimes San Pablo Bay). Low abundance during 1983-1991 resulted in the delta smelt being listed as a threatened species under the California and federal Endangered Species Acts (58 FR 12854). A detailed discussion of delta smelt is provided in Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species".

Life History

Delta smelt are found where salinity is generally less than 2 ppt (56 FR 50075). Delta smelt adults disperse widely into fresher water in late fall and winter as the spawning period approaches, moving as far upstream as Mossdale on the San Joaquin River and the confluence with the American River on the Sacramento River. Spawning occurs in fresh water from February through June and may peak during late April and early May (Wang 1991, Sweetnam and Stevens 1991, Stevens et al. 1990). Most adult (1-year-old) delta smelt die after spawning (56 FR 50075).

After the eggs hatch (in about 12-14 days), delta smelt larvae float to the surface and are carried by the currents (Stevens et al. 1990). Under natural outflow conditions, the larvae are carried downstream to near the upstream edge of the entrapment zone (e.g., 2-ppt salinity), where they typically remain and grow to adult size.

Factors Affecting Abundance

Year-class abundance of delta smelt depends on the environmental conditions experienced by the eggs and young fish. Factors that may adversely affect abundance of delta smelt include a decline in the availability of major food organisms, low adult population levels resulting in low reproductive success, water diversions from the Delta, reduced Delta outflow, introduced exotic species of fish and invertebrates, toxic substances, and reduced habitat resulting from channelization in the Delta and draining and filling of tidelands (Stevens et al. 1990, Moyle and Herbold 1989, Wang 1986). As with striped bass, an important determinant of smelt abundance may be the location of the population in the estuary, which determines the effect of other factors, such as entrainment in diversions.

Delta outflow affects delta smelt abundance and distribution. High outflow may transport smelt larvae and early juveniles downstream of the Delta, provide improved habitat conditions in Suisun Bay, and cause salinity conditions preferred by larval and juvenile smelt to be located downstream of the Delta and away from the effects of Delta diversions (USFWS 1994). In addition, high outflow dilutes toxic materials and increases turbidity that may reduce predation.

Delta smelt distribution is a function of outflow (Figure 3F-2). Stevens et al. (1990) showed that over 50% of the variation in the proportion of the smelt population found in Suisun Bay is explained by variation in Delta outflow. During high-flow years, the entrapment zone and the majority of delta smelt are located in Suisun Bay throughout summer and into fall (DFG 1992c). During low-flow years, the entrapment zone and the majority of delta smelt are located in the Delta.

Variability in the annual abundance of delta smelt, which is indicated by the fall midwater trawl index (see Appendix F2), may be partially explained by the number of days that X2 is located in Suisun Bay (USFWS 1994). Delta smelt abundance is greatest when X2 is located in Suisun Bay during February-June. Abundance is lowest when X2 is upstream or downstream of Suisun Bay.

Delta smelt are vulnerable to entrainment in diversions throughout their life cycle, particularly in dry years when they are concentrated in the Delta where most fresh water is diverted (DWR 1993b). The number of juvenile smelt entrained at the SWP and CVP fish facilities and in other Delta diversions has exceeded 1 million during some years. Peak entrainment losses of juveniles occur during May, June, and July (Figure 3F-3). High entrainment of larvae likely occurs during late March, April, and May. Entrainment may increase when net flows are reversed in the lower San Joaquin River and in Old and Middle Rivers. Net reverse flow increases transport of delta smelt larvae toward the SWP and CVP export facilities.

Sacramento Splittail

Sacramento splittail are large (more than 30 centimeters [cm] long) cyprinids (minnow family) endemic to the lakes and rivers of the Central Valley (Moyle et al. 1989). Sacramento splittail abundance steadily declined after 1983, and the species was listed as threatened under the federal Endangered Species Act in 1999 (64 FR 5963). DFG has designated Sacramento splittail a species of special concern.

A detailed discussion of Sacramento splittail is provided in Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species".

Life History

Sacramento splittail are freshwater fish capable of tolerating moderate levels of salinity (10-18 ppt) (59 FR 862). Splittail are largely confined to the Delta, Suisun Bay, Suisun Marsh, and Napa Marsh and, outside of the spawning season, are rarely found more than 5-10 miles above the upstream boundaries of the Delta (Moyle et al. 1989, Natural Heritage Institute 1992). Incidental catches of large splittail in fyke traps set by DFG in the lower Sacramento River during spring indicate that splittail migrate from Suisun Bay, the Delta, and lower river reaches to upstream spawning habitats.

Splittail spawn adhesive eggs over flooded streambanks or aquatic vegetation when water temperatures are between 9°C and 20 °C (Moyle 1976, Wang 1986). Spawning has been observed to occur as early as January and to continue through July (Wang 1986). Peak spawning occurs during March through May.

Larval splittail are commonly found in the shallow, weedy areas where spawning occurs. Larvae eventually move into deeper, open-water habitats as they grow and become juveniles (Wang 1986).

Factors Affecting Abundance

Habitat modification is probably the major factor contributing to the decline of splittail (DFG 1992d). Dams, diversions, pollution, and agricultural development have eliminated or altered splittail habitat. Year-class survival is affected by Delta outflow, possibly because spawning success depends on spawning habitat availability (Moyle et al. 1989). The storage of water in upstream reservoirs and diversions reduces the frequency and magnitude of floodflows, thereby affecting the availability of flooded vegetation during the spawning season. Additionally, entrainment in diversions reduces survival of adult and juvenile fish.

The fall midwater trawl index of splittail abundance is positively correlated with Delta outflow during March-May (Appendix F2), indicating that variability in abundance is at least partially explained by flow. Because spawning and early rearing of larval splittail are associated with shallow vegetated areas, inundation of riparian and seasonally flooded habitats may be an important factor determining year-class success. River flow determines the availability of shallow-water habitats with submerged vegetation during late winter and spring (Daniels and Moyle 1983).

Upstream water storage facilities and water diversions have changed the seasonal magnitude and duration of flows to upstream habitats and to the Delta. Reduced duration of flooding may degrade conditions necessary for spawning and larval development. Spawning habitat may be dewatered before larvae have moved to channels that provide permanent rearing conditions.

Thousands of splittail juveniles and adults are entrained in agricultural diversions and exports at the CVP and SWP pumping facilities. Juvenile splittail are salvaged at the state and federal fish protection facilities primarily during May-July (Figure 3F-3). Juveniles from the current year's spawn first appear in salvage during April. Substantial numbers of small juveniles (i.e., less than 30 millimeters [mm] long) and larvae may also be entrained (but not salvaged), but entrainment of larvae and early juveniles depends on the proximity of spawning habitat to a given diversion.

Longfin Smelt

Longfin smelt is a 3- to 6-inch-long silvery fish that is endemic to the Bay-Delta estuary and other estuaries along the Pacific Coast north of San Francisco Bay. Longfin smelt were the most abundant smelt species in the estuary prior to 1984 and have been commercially harvested (Wang 1986).

A detailed discussion of longfin smelt is provided in Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species".

Life History

Except when spawning, longfin smelt are most abundant in Suisun and San Pablo Bays, where salinity generally ranges between 2 ppt and 20 ppt (Natural Heritage Institute 1992). Longfin smelt migrate upstream to the Delta and spawn in fresh water primarily during February through April (Natural Heritage Institute 1992). The eggs are adhesive and are probably deposited on rocks or aquatic plants.

Eggs hatch in 37-47 days at 45ºF. Larval abundance in the Bay-Delta estuary peaks during February-April. (DFG 1992e.) Shortly after hatching, a longfin smelt larva develops a gas bladder that allows it to remain near the water surface (Wang 1991). Larvae are swept downstream into nursery areas in the western Delta and Suisun and San Pablo Bays (DFG 1987c, Baxter pers. comm.).

Factors Affecting Abundance

Year-class abundance of longfin smelt appears to depend on the environmental conditions experienced by the eggs and young fish. An important factor affecting longfin smelt abundance is Delta outflow during their larval and early juvenile life stages. Outflow affects the downstream distribution of smelt and their vulnerability to entrainment in diversions. Population abundance is highest following high outflow during winter and early spring.

The fall midwater trawl index of juvenile abundance is positively related to Delta outflow (Appendix F2). Regression analysis of the abundance index on outflow has indicated that 79% of the index variability is explained by changes in January and February Delta outflow. (Stevens and Miller 1983; DFG 1987c, 1992e.)

Entrainment of longfin smelt by Delta diversions affects spawning adults, larvae, and early juveniles. Older juveniles and prespawning adults generally inhabit areas downstream of the Delta. In normal and wetter years, longfin smelt larvae and young juveniles are transported out of the Delta quickly, except during periods of low Delta outflow, and therefore are unlikely to be entrained in diversions. During the 1987-1992 drought, many juveniles remained in the Delta and were salvaged at the state and federal fish protection facilities during April-June (Figure 3F-3). Given the high salvage rates of young-of-year juveniles in some years, many longfin smelt larvae also are likely entrained, especially during February, March, and April.

Other Fish Species

Although many other fish species reside in the Bay-Delta estuary, potential effects of DW project operations are not assessed for these species individually because their responses to potential changes in habitat conditions caused by DW project operations would be similar to those of one or more of the species life stages discussed above. Assessment of DW project impacts on these other species is therefore encompassed by the discussion of potential effects on the species listed above. Additional species include freshwater resident species (sunfish, catfish, and minnows), steelhead trout (*Oncorhynchus mykiss*), green and white sturgeon (*Acipenser medirostris* and *A. sapidissima*), and numerous Bay species. Steelhead trout was not listed under the federal Endangered Species Act at the time that the 1995 DEIR/EIS was prepared. However, because of the possibility that the species would become listed, it was discussed in Appendix F2 of the 1995 DEIR/EIS, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species". Steelhead was listed in 1998 as threatened under the federal Endangered Species Act (63 FR 11481).

Significant numbers of resident fish are entrained by water diversions, but the actual entrainment impact on populations cannot be determined because information on population size, screening efficiency (except for a few species), and indirect entrainment losses is unavailable. Based on movement patterns and habitat affinities, open-water pelagic fish (e.g., threadfin shad [*Dorosoma petenense*]) are probably most susceptible to entrainment in diversions, followed by bottom-feeding catfish and minnows. Sunfish have the lowest susceptibility to entrainment because of their relatively small home ranges and associations with cover.

Factors affecting abundance of steelhead trout are similar to those for chinook salmon. In the

Sacramento-San Joaquin River system, most steelhead are found in the Sacramento River and its tributaries and are subject to factors affecting Sacramento River chinook salmon.

Young sturgeon survival is probably affected by entrainment in diversions, toxics, and prey availability. Salvage at the SWP fish screens totals about 3,000 fish annually. Flows upstream of the Delta have more effect than Delta outflow on sturgeon spawning success.

The number of Bay fish species greatly exceeds the number of species in the Delta. Biological responses of estuarine and marine species to Delta outflow conditions are highly variable (DFG 1992e, Herrgesell et al. 1983). Some populations remain stable regardless of outflow conditions, particularly species having wide salinity and temperature ranges and a broad range of food requirements (e.g., gobies). Some marine species (e.g., anchovies [*Engraulis mordax*]) may become locally more abundant if salinity increases in response to decreased Delta outflow. Higher Delta outflow may directly or indirectly cause broader dispersal of estuarine species, decreasing intraspecific and interspecific competition (Stevens and Miller 1983). Higher outflow may increase recruitment of marine species into the Bay, provide more habitat for estuarine species, and increase food availability.

Invertebrate Species

Responses of populations of aquatic invertebrate species to potential changes in habitat conditions resulting from DW project operations would be encompassed by the responses of one or more of the fish species life stages discussed in detail above. For example, the response of Bay shrimp (*Crangon franciscorum*) to outflow is similar to the response shown by longfin smelt (i.e., abundance increases at higher outflow).

The distribution and abundance of benthic invertebrates (those living on or in the bottom substrates) respond to changes in habitat availability, largely determined by the location of the salinity gradient, which is a function of Delta outflow. The more stable salinity regime of the interior Delta appears to provide favorable habitat for permanent persistence of a greater species diversity of benthic populations. Greater variability of benthic densities in the western Delta and Suisun Bay is caused by periodic large freshwater outflows and salinity changes. Under dry conditions (e.g., 1976 and 1977), numbers of *Corophium* (an amphipod) decreased in the western Delta, allowing temporary colonization by saltwater-adapted species (Markmann 1986).

Effects of Delta outflow, Delta flow patterns, and diversions on planktonic invertebrates (invertebrates living suspended in the water column) are similar to the effects discussed above for planktonic life stages of striped bass, American shad, delta smelt, and longfin smelt.

Neomysis, a mysid shrimp, is probably the single most important zooplankton species in the diet of Delta and Suisun Bay fish. Some of the annual fluctuations in abundance of this organism and shifts of population distribution between Suisun Bay and the Delta can be attributed to variations in Delta outflow. The highest *Neomysis* densities are observed between salinity of 1.2 ppt and 2.6 ppt (Knutson and Orsi 1983). *Neomysis* has been abundant in only two years since 1977, both characterized by high spring outflow that located the entrapment zone downstream of the Delta (DFG 1987d). Location of the entrapment zone in the Delta reduces both the habitat area available to *Neomysis* and the density of *Neomysis* prey (i.e., phytoplankton and zooplankton) (Orsi and Knutson 1979, Arthur and Ball 1980). Location in the Delta also increases vulnerability to entrainment in Delta diversions.

Populations of the copepod *Eurytemora affinis* have recently declined, possibly reflecting changes in the Delta environment attributable to introduction of competitive and predatory species, reduced Delta outflow, and increased diversions.

IMPACT ASSESSMENT METHODOLOGY

The primary fishery-related effects of DW project facilities and operations would be changes in Delta flows. Water quality, local habitat conditions, and entrainment of fish and invertebrates in diversions could also be affected by DW project operations and facilities.

Simulations of DW Project Operations

Assessment of DW project effects on Delta fish species and their habitat involves predicting fish and habitat responses to changes in Delta conditions that could result from DW project operations. DW diversions, storage, and discharges and estimated changes in channel flows, outflow, and exports were simulated for DW project operations under a range of hydrologic conditions (see Chapter 3A, "Water Supply and Water Project Operations"). Changes in these factors were estimated by comparison of operations under each DW project alternative with operations under the No-Project Alternative. The results of these DW project simulations, in combination with information on fish behavior and habitat needs, provided the basis of the fishery impact analysis described in the following section, "Analytical Approach and Impact Mechanisms", which estimated potential effects of DW project operations on habitat conditions, fish transport, and fish entrainment in Delta facilities.

Models Used and General Modeling Assumptions

The simulations used to estimate DW project effects were performed with DeltaSOS, the monthly Delta operations model developed by JSA to evaluate Delta flow effects of specified Delta water management operations, such as DW's proposed project, with the new Delta standards. As described in Appendix A2, "DeltaSOS: Delta Standards and Operations Simulation Model", DeltaSOS was used to simulate project operations (diversions, storage, and discharges) for the 1995 DEIR/EIS based on the 70-year (1922-1991) hydrologic record according to a specified set of assumptions regarding facilities, demand for exports, and Delta standards.

The historical record of Delta diversions, flows, and water quality provides basic data for evaluating effects of water project operations and facilities on hydrologic conditions. Although this hydrologic record serves as an estimate of likely future hydrologic conditions, it does not provide an accurate estimate of future Delta conditions. Historical data do not represent conditions that would occur with existing reservoirs and diversion facilities, under the current operations criteria, with applicable Bay-Delta standards, and for the existing levels of demand (including municipal, agricultural, industrial, and fish and wildlife needs) for surface water from the Sacramento-San Joaquin River system. Appropriate modeling of future Delta project operations must be based on current and anticipated regulatory standards, facilities, and demand for exports, rather than those conditions that existed during the years of the hydrologic record.

These current conditions are represented in the initial Delta water budget used for the DeltaSOS simulations, which consists of results of DWR's SWP operations planning model DWRSIM. DWR uses DWRSIM to simulate monthly water project operations (e.g., channel flows, exports, and outflow) that would occur under existing conditions and standards, based on the range of hydrologic conditions represented by the hydrologic record for the Delta. For the 1995 DEIR/EIS analysis, DWR provided the SWRCB with the results of DWRSIM 1995-C6B-SWRCB-409, performed in January 1995, based on the hydrologic record for 1922-1991; the DWRSIM results were used by JSA as the initial Delta water budget in the DeltaSOS simulations to evaluate proposed DW project impacts. These DWRSIM results were used by SWRCB to describe likely Delta conditions under the objectives of the 1995 WQCP. DWR is continually refining its DWRSIM runs and used a slight modification of this January run when finalizing the 1995 WQCP. The results of these two runs have no differences that affect the DW project simulations. (The initial water budget used in DeltaSOS modeling is described in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project".) A different DWRSIM study was used for the updated analysis of water supply and project operations for the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations".

In the DWRSIM simulation, Delta operations were controlled by criteria specified by SWRCB in the 1995 WQCP. CVP and SWP operations criteria included in the biological opinions for winter-run chinook salmon and delta smelt are encompassed by and consistent with the operations criteria in the 1995 WQCP (USFWS 1995, Stern pers. comm.).

In the DeltaSOS simulations of the DW project alternatives for the 1995 DEIR/EIS, the CVP and SWP Delta pumping facilities were assumed to export all water that was available under existing operations criteria and existing facility capacities. That is, the DeltaSOS simulations were based on the assumptions that available water would be exported, irrespective of an actual export demand, and that south-of-Delta storage facilities (e.g., MWD's Diamond Valley Reservoir) were available for any required storage of the exported water. This simulated level of export is likely representative of future conditions and the potential availability of water to diversion, storage, and discharge for export by DW. The simulation does not encompass all permutations that may occur under real DW operations for any given year. The timing, frequency, and volumes of diversions to and discharges from the DW reservoir islands will be affected by factors that cannot be simulated (factors other than availability of water and pumping capacity, such as operational decisions at the discretion of DW, DWR, Reclamation, or SWRCB or in response to Endangered Species Act considerations).

Use of the No-Project Alternative as Baseline Reference

Simulated effects of DW project operations on the Delta cannot be directly compared with the historical record of Delta operations for purposes of impact assessment because historical Delta operations did not include current operating criteria; facilities; and conditions, such as demand for exports. To provide a point of reference for assessment of impacts associated with simulated operations of the DW project, it was also necessary to simulate a baseline condition consisting of existing Delta facilities and operating criteria but without operations of the DW project. This point of reference is represented by the simulated No-Project Alternative. As described in Chapter 2, "Delta Wetlands Project Alternatives", the No-Project Alternative represents the intensified agricultural operations that would be implemented on the DW project islands if the DW project were not approved. Results of assessment of all potential impacts of the DW project represent changes that would result from DW project operations in relation to the No-Project Alternative.

Analytical Approach and Impact Mechanisms

As described above, DeltaSOS simulations (based on DWRSIM simulations of Delta flows and diversions corresponding to the 1922-1991 hydrologic record, modified by the 1995 WQCP objectives) provided the data for the evaluation of flow changes resulting from DW operations. Simulation results for total Delta diversions, DW project diversions, DW discharges for export, DCC and Georgiana Slough flows, lower San Joaquin River flow, and Delta outflow were used to determine the effects of DW project operations on fish habitat conditions and individual species entrainment or mortality. Information on the distribution and timing of fish life stages was incorporated into the evaluation of flow effects. Additionally, the impact assessment identified area and type of fish habitat that could be affected by construction activities, including additional levee improvements (i.e., riprapping) and construction of intake and discharge structures, fish screens, and boat docks.

The following discussions describe the methods used to assess effects on fish transport and movement, habitat, and entrainment. These methods are explained in detail in Appendix A, "Detailed Methodology for Using Transport, Chinook Salmon Mortality, and Estuarine Habitat Models", of Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species".

Figure 3-1 in Chapter 3, "Overview of Impact Analysis Approach", provides an overview of the modeling methods described below.

Methods for Assessing Effects on Chinook Salmon

Mortality of juvenile chinook salmon could be affected by discontinuation of unscreened agricultural diversions onto the DW reservoir islands, addition of diversions to fill the reservoir islands (including the resulting reduction in outflow), export of DW discharges (i.e., changes in central Delta flows), and changes in the magnitude and timing of diversions onto the habitat islands.

Mortality indices for fall- and winter-run chinook salmon migrating through the Delta were calculated using a chinook salmon mortality model modified from a model developed by USFWS (Kjelson et al. 1989b). The mortality index should not be construed as the actual level of mortality that would occur because simulated monthly conditions cannot accurately characterize the complex conditions and variable time periods that affect survival during migration through the Delta. The mortality index provides a basis for comparing the effects of alternative DW operations on chinook salmon that could result from changes in diversions and Delta flows.

The USFWS mortality model was developed from studies of hatchery-reared juvenile fall-run chinook salmon released in the Delta during April-June. Use of the model to estimate winter-run mortality assumes applicability of the model to in-river juvenile migration during September-May.

The USFWS mortality model has two major components: mortality attributable to temperature and mortality attributable to Delta exports. The USFWS model assumed that exports affect only salmon drawn off the Sacramento River and into the DCC and Georgiana Slough and then into the Mokelumne River part of the Delta. Salmon continuing down the Sacramento River are assumed to be unaffected by exports. The effect of exports on salmon migrants from the Sacramento River is assumed to depend on the volume of Sacramento River water diverted. Exports composed primarily of San Joaquin River flow would have less effect on salmon migrants from the Sacramento River than would exports composed primarily of Sacramento River flow.

In this impact assessment, a cross-Delta flow parameter (CDFP) was substituted for export. CDFP is calculated with the DeltaMOVE fish transport model discussed below under "Methods for Assessing Effects on Fish Transport" and in Appendix F2. The model simulates introduction of a concentration of particles into the Mokelumne River side of the Delta at the beginning of a month. The Mokelumne River side of the Delta receives inflow from the DCC and Georgiana Slough, as well as inflow from the Mokelumne River. Inflow from the DCC and Georgiana Slough is usually orders of magnitude greater than Mokelumne River inflow. The proportion of the concentration entrained in exports and other Delta diversions at the end of the month is the monthly CDFP. The CDFP, the salmon mortality model, and DeltaMOVE are described in detail in Appendix A of Appendix F2.

After the 1995 DEIR/EIS analysis was completed, USFWS used information collected by DFG to modify the relationship between migration pathway and survival of salmon smolts in the mortality model; the modification allowed for the use of the same model to assess effects on late-fall-, winter-, and spring-run chinook salmon. The use of the modified model to assess effects of the proposed project on spring-run chinook salmon is discussed below in the section from the 2000 REIR/EIS entitled "Project Impacts on Spring-Run Chinook Salmon".

Methods for Assessing Effects on Fish Transport

The distribution of many fish species, including striped bass and delta and longfin smelt, is affected by changes in Delta flow patterns and diversions during the larval and early juvenile life stages. Many other factors affect the distribution of larvae and juveniles in the estuary, including the distribution and timing of spawning, larval growth, and the response of fish to various environmental conditions (i.e., salinity, temperature, and prey distribution).

The fish transport model DeltaMOVE was used to simulate an entrainment index for evaluating the effects of water project operations on fish distribution and entrainment loss in the Delta (Appendix F2). Although relationships between physical and biological factors controlling larval and early juvenile distribution are complex and difficult to ascertain, the fish transport model simulations are based on the assumption that movement of water is representative of the movement of young fish. The fish transport model uses net channel flows, tidal mixing flows, channel volume, and salinity to estimate effects of Delta inflows and water project operations on distribution and entrainment loss of larval and early juvenile life stages. The effects of the DW project on the distribution and potential entrainment loss of larvae and early juvenile life stages were evaluated by comparing entrainment indices for the No-Project Alternative conditions with entrainment indices for conditions under DW project operations.

The entrainment index for Delta conditions with the DW project alternatives indicates the direction and magnitude of potential change in entrainment loss relative to conditions simulated for the No-Project Alternative. The entrainment index should not be construed as the actual level of entrainment that would occur. Simulated monthly conditions, a fixed spawning distribution, and the assumed transport characteristics of a life stage cannot accurately characterize the complex conditions and variable time periods that affect the entrainment process.

Striped bass eggs and larvae and delta and longfin smelt larvae are assumed to be transported primarily by net channel flow and tidal mixing flows. Whether fish are lost as a result of Delta diversions depends on the volume of diversions, the volume of net flow moving fish toward the diversion points, and the length of time that larvae reside in the Delta channels. Increased rate of movement out of the Delta and toward Suisun Bay results in lower losses to Delta diversions. Delta residence time is determined by the magnitude of Delta outflow; higher outflows reduce the period of residence in the Delta spawning areas and increase the proportion of the simulated population transported to Suisun Bay during a given period.

Methods for Assessing Changes in Estuarine Habitat Area

Salinity is an important habitat factor, and estuarine habitat often is defined in terms of a salinity range (Hieb and Baxter 1993). All estuarine species are assumed to have optimal salinity ranges, and different life stages within a species often vary in their salinity preferences. Species year-class production may be determined partly by the amount of rearing habitat available within the optimal salinity range.

Rearing habitat area, based on the estimated optimal salinity range, was calculated for striped bass and delta and longfin smelt. The optimal salinity range is 0.1-2.5 ppt for striped bass, 0.3-1.8 ppt for delta smelt, and 1.1-18.5 ppt for longfin smelt (Obrebski et al. 1992, Hieb and Baxter 1993).

The Bay-Delta estuary has a complex shape, and the area of optimal salinity habitat varies greatly with its location. The geographical location of the upstream and downstream limits of the optimal salinity habitat are computed from monthly average Delta outflow and the optimal salinity range of the species (Appendix F2). The surface area at different locations was estimated from nautical charts. Total area of optimal salinity habitat was computed for each month through addition of all areas contained between the upstream and downstream limits of the optimal salinity range.

The annual optimal salinity habitat area was the weighted average of all months. Details of these calculations of optimal salinity habitat are included in Appendix F2.

Methods for Assessing Direct Entrainment Loss

Direct entrainment loss is the total number of fish diverted onto the DW project islands. Also included in the direct entrainment loss estimate are fish impinged on DW project fish screens and eaten by predators exploiting habitats created by the intake facilities.

The intakes on all DW island siphons would have fish screens. Fish screen operations and design have been developed in consultation with DFG and NMFS; DW will apply the best available technology at the time of construction to obtain the highest efficiency under variable Delta conditions. For juvenile and adult fish greater than 20 mm in length, the fish screens are assumed to nearly eliminate direct entrainment losses. Losses of fish eggs and larvae and juvenile fish that cannot be effectively screened are discussed in greater detail under the respective species in the impact assessment. The screen structures would be in the water only during actual diversions (as assumed in the project description), and predator populations associated with the screens are not likely to increase during the 2- to 4-week diversion period. However, the presence of boat docks, pilings, and other structures associated with the intakes could provide habitat for predatory fish that could increase entrainment losses.

The historical (1979-1990) CVP and SWP salvage records (see Appendix F2) were used to estimate the timing and magnitude of vulnerability to entrainment for screenable-sized fish of all target species (Figure 3F-3). The information was used in conjunction with simulated estimates of the volume and timing of diversions to determine potential entrainment loss.

Daily Operations

Monthly simulations of operations (using DWRSIM and Reclamation's planning model PROSIM) are currently the best available tools for estimating Delta inflows and upstream operations. Monthly simulations provide general information on the monthly timing and volume of DW project diversions and discharges. Simulations of daily operations would provide a more accurate representation of DW project operations. Daily water project operation models, however, are not available to simulate Delta inflows and operation of upstream facilities.

The daily and monthly average flows and operations for several months of an example water year, 1981, are compared in Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species". Detailed daily DW operations are discussed in Appendix A4, "Possible Effects of Daily Delta Conditions on Delta Wetlands Project Operations and Impact Assessments", and in Appendix F of the

2000 REIR/EIS, "Daily Simulations of Delta Wetlands Project Operations".

Use of simulated monthly average flows in the impact assessment provides a general indication of how the DW project would operate and how DW operations may affect Delta flows. DW operations under daily conditions could be less constrained or more constrained than DW operations under monthly average conditions. Effects on fisheries may be similarly under- or overestimated.

In general, the pattern of entrainment loss is similar for daily and average monthly hydrology (see Figure 5-2 in Appendix F2). The magnitude of the entrainment index for daily flows, however, may be substantially greater or less than the entrainment index for monthly average flows. The difference between the daily and monthly average effects indicates the importance of considering flow conditions over time increments of less than a month in developing project operations criteria. The level of DW project effects during actual operation, and actions necessary to avoid substantial adverse effects on delta smelt and other species, will depend on daily flow conditions in the Delta and on the real-time distribution of vulnerable fish life stages. Mitigation was developed to account for impacts of daily operations. The FOC developed during Endangered Species Act consultation, which were incorporated into the proposed project following the release of the 1995 DEIR/EIS, are based on real-time monitoring.

Criteria for Determining Impact Significance

Populations of fish and other aquatic organisms may be reduced because of increased mortality and changes in habitat availability and suitability that affect species survival, growth, migration, and reproduction. In general, impacts on fish populations are significant when project operations cause or contribute to substantial short- or long-term reductions in abundance and distribution. An effect is found to be significant, based on the State CEQA Guidelines, if it:

- substantially reduces the abundance or the range of a rare or threatened species;
- substantially threatens to eliminate an animal community;
- substantially causes fish habitat to drop below self-sustaining levels;
- substantially reduces fish habitat; or
- has considerable cumulative effects when viewed with past, current, and reasonably foreseeable future projects.

NEPA regulations state that the significance of an action is determined by the severity of the impact in the context of local, regional, national, and societal perspectives. Consequently, significance cannot be rigidly defined because the significance of an impact will vary with the species, population dynamics, impact mechanism, and surrounding environment.

In this impact assessment, impacts were considered significant if it was determined that conditions contributing to existing stress would be worsened by DW project operations and facilities, resulting in a substantial reduction in population abundance and distribution. The definition of a "substantial" reduction varies with each species, depending on the ability of the population to maintain or exceed current production levels through mechanisms that compensate for reduced abundance of earlier life stages. Many fish populations are resilient in the face of mortality caused by human activities and can sustain high levels of exploitation. All available data, including information on past responses of fish populations to changes in environmental conditions and direct mortality, were evaluated to assist in determining population dynamics relative to impact mechanisms.

Impacts were considered cumulatively significant if it was determined that project operations and facilities would contribute to existing or future stress that causes or would cause a substantial reduction in population abundance and distribution. Current impacts and population trends and foreseeable future project impacts were considered in the determination of cumulative impact significance.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves potential year-round diversion and storage of water on Bacon Island and Webb Tract (reservoir islands) and management of

Bouldin Island and Holland Tract (habitat islands) primarily for wetlands and wildlife habitat. Existing agricultural diversions would cease; however, water would be diverted for wetland management.

In DeltaSOS simulations of DW project operations under Alternative 1, it is assumed that diversions onto the reservoir islands could occur any time of the year when surplus flows are available (under the 1995 WQCP criteria). Water discharged from the reservoir islands is assumed to be treated as Delta inflow; export of DW discharge by the CVP and SWP Delta pumping facilities would comply with 1995 WQCP criteria for percentage of Delta inflow diverted (percent inflow) (see Chapter 3A, "Water Supply and Water Project Operations"). It was assumed that discharges of water from the DW project islands would be exported in any month when unused capacity within the permitted pumping rate exists at the SWP and CVP pumps and the 1995 WQCP percent inflow limits do not prevent use of that capacity.

Water would be diverted to the reservoir islands (238-TAF water storage capacity) at a maximum average monthly diversion rate of 4,000 cfs, which would fill the two reservoir islands in one month. The maximum average daily diversion rate would be 9,000 cfs during the first day of siphoning of water onto the reservoir islands (see Chapter 2, "Delta Wetlands Project Alternatives", for more information on diversion rates during reservoir filling). The maximum average daily discharge rate would be 6,000 cfs, but the maximum monthly average discharge rate is assumed to be 4,000 cfs, a rate that would empty the two reservoir islands in one month.

Effects of DW project operations under Alternative 1 were determined through comparison of flow and habitat conditions for operations and facilities simulated by DeltaSOS with and without the DW project (i.e., under Alternative 1 and under the No-Project Alternative). The flow and salinity conditions simulated for the No-Project Alternative and Alternative 1 are presented in Chapters 3A, "Water Supply and Water Project Operations", and 3C, "Water Quality". The DeltaSOS simulations of Delta inflows and water project operations provided the basis for most of the species-specific evaluations discussed below under "Potential Species-Specific Effects".

Table 3A-7 in Chapter 3A and Tables A3-7a and A3-7b in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", show the results of DeltaSOS simulations of DW reservoir island diversions and discharges under Alternative 1 performed for the 1995 DEIR/EIS analysis. Habitat island diversions under Alternative 1 (Table 3A-2 in Chapter 3A and Table A1-8 in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project") would vary little from year to year, although timing of diversions would be flexible and would depend on habitat island water management needs.

The fishery impacts identified for Alternative 1 in the 1995 DEIR/EIS, as described in this section, have all subsequently been addressed by the FOC and RPMs included in the no-jeopardy biological opinions issued by NMFS, USFWS and DFG. (See Chapter 2 and the 2000 REIR/EIS section below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions".) Incorporation of the FOC and RPMs into the proposed project reduces the impacts previously identified as significant to a less-than-significant level and further reduces the impacts identified as less than significant in the 1995 DEIR/EIS. For details on these changes, see the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Effects of Construction Activities

Construction activities for Alternative 1 include construction of intake facilities, fish screens (for new and existing diversions), discharge facilities, and boat docks. Boat docks would be constructed in conjunction with each of the discharge and diversion facilities. Additionally, boat docks associated with recreation facilities would be constructed at other locations on the DW reservoir and habitat islands. Piles would be driven to hold the floating docks in place. (See Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", for details on boat docks and siphon and pump stations.) Dredging is not anticipated and exterior levee improvements will be minor. Ongoing maintenance programs for the exterior levees, however, would continue (see Chapter 3D, "Flood Control").

The intake and discharge facilities and boat docks would be situated on relatively steep, riprapped levee slopes. Dredging of levee slopes and channels is not proposed. The proposed location of the facilities is not in what is believed to be preferred spawning or rearing habitat of delta smelt and Sacramento splittail (i.e., shallow vegetated habitat).

Pilings and boat docks constructed on existing riprap add structure and increase habitat diversity. Some species (e.g., some species of sunfish) would benefit from increased habitat diversity. Predation on other species (e.g., delta smelt) may increase (see discussion under "Potential Species-Specific Effects").

Additional discussion of project facilities and predation is provided below in the section from the 2000 REIR/EIS entitled "Effects of Delta Wetlands Project Facilities on Fish Predation".

If intake sites or boat docks were located in or near shallow vegetated habitat, however, spawning habitat for delta smelt, Sacramento splittail, and other Delta resident species may be lost or altered. The habitat area lost would be small relative to the total area of similar habitat in the Delta, and such loss would have minimal effects on fish populations. Loss of habitat could have a significant adverse effect on localized reproduction of delta smelt, Sacramento splittail, and resident species.

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on fishery resources presented below assumes that the recreation facilities would be constructed and operated. USFWS, NMFS, and DFG considered the effects of these facilities on fish species and their habitat during the federal and California ESA consultation process, and the biological opinions include terms and conditions governing construction and operation of these facilities. The information presented in this chapter provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Summary of Project Impacts and Recommended Mitigation Measures

Impact F-1: Alteration of Habitat. Construction of intake facilities and fish screens, discharge facilities, and boat docks on the DW project islands could adversely change spawning and rearing habitat used by Delta fish species, resulting in habitat loss. Specific spawning habitat parameters have not been defined for delta smelt and Sacramento splittail. Shallow vegetated habitat is believed to be important for the spawning success of splittail and delta smelt (USFWS 1995). Shallow vegetated habitat is also important to the spawning and rearing success of other Delta species. Historical and ongoing activities (e.g., dredging, placement of riprap, and levee construction) have destroyed substantial areas of shallow vegetated habitat in the Delta, and recent downward trends in the population abundance of delta smelt and Sacramento splittail may indicate the need to preserve the remaining habitat. Although the loss of habitat area to DW construction activities would be small relative to the total area of similar habitat in the Delta, the impact was determined in the 1995 DEIR/EIS analysis to be significant.

The 1995 DEIR/EIS included Mitigation Measure F-1 (Implement Fish Habitat Management Actions) to reduce this impact to a less-than-significant level. However, the FOC and biological opinion RPMs developed after the 1995 DEIR/EIS was published include measures that address this potential project effect. With the FOC and RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-1 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Effects on Water Quality

This section addresses potential water quality effects of proposed discharges of stored water from the DW reservoir islands (Webb Tract and Bacon Island) and boat-related spills at docks on the DW islands. As described above, DW has removed construction of recreation facilities from its CWA permit applications; nevertheless, the analysis of impacts on fishery resources below assumes that the recreation facilities would be constructed and operated. Effects of DW project operations on seawater intrusion (i.e., the location of X2) are discussed below under "Effects on Delta Outflow".

DW Reservoir Island Discharge

Organic Materials and Toxics. Water discharged from the DW reservoir islands is not expected to contain materials toxic to aquatic organisms. Pesticides, currently a component of Delta agricultural discharge, would be applied at reduced levels on the DW reservoir islands. Soluble toxic materials are not known to be present in the soil or water on the DW reservoir islands.

Although water discharged from the DW reservoir islands would not contain toxic materials, it may have elevated levels of DOC and particulate organic carbon (POC) (e.g., zooplankton and phytoplankton). Discharge of such additional material is expected to have minimal biological effects in the Delta and could increase availability of food for Delta fishes.

Chapter 3C, "Water Quality", contains a detailed analysis of the potential effects of the DW project on Delta water quality.

Dissolved Oxygen. When filled, the DW reservoirs would be relatively shallow (i.e., generally less than 20 feet deep) and water would be well mixed. It is assumed that DO levels in the DW reservoirs would be similar to those in the Delta channels. Algal blooms on the reservoir islands, however, may cause periodic differences between DO levels on the DW reservoir islands and in the Delta channels. With implementation of recommended mitigation, DW discharge would not have been allowed to reduce DO levels in the receiving channel by more than 1 mg/l (see Chapter 3C, "Water Quality"). The FOC terms also include project operating restrictions that preclude significant effects of the proposed project on DO levels. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Water Temperature. Factors controlling the effect of DW discharges on Delta channel water temperature include initial channel water temperature, temperature of the stored water on the DW reservoir islands at the time of discharge, volume of the discharge, volume of the receiving channel, flow and mixing in the receiving channel, and meteorological conditions.

Delta channel water temperature depends primarily on meteorological conditions. During some months (September-October and March-June), water temperature may depend also on flow. Under high-flow conditions, river inflow may affect water temperature in the channels adjacent to the DW reservoir islands.

If the temperature on the DW project islands is substantially greater than water temperature in the Delta channels, DW discharges could increase channel water temperature. Increased channel water temperature could affect survival, growth, and reproduction of aquatic organisms.

If the altered channel water temperature exceeds 60°F (Kjelson et al. 1989b), chinook salmon survival could be significantly reduced. Temperatures greater than 60° may also adversely affect growth (Appendix F2). October and April-June are the months of juvenile chinook salmon migration when the temperature of DW discharge is likely to exceed 60°F and may also exceed water temperature of the receiving channel. The proportion of the juvenile population migrating during October or April-June is variable but could exceed 50% of the annual production. The proportion of the juvenile chinook salmon population exposed to DW discharge would likely be much less because most juvenile chinook salmon do not migrate along the Old and Middle River pathway (USFWS 1987).

Boat Docks

The introduction of DW project boat docks is expected to increase boat-related activities in the Delta. The boat docks would concentrate effects of minor fuel and lubricant spills from individual boat engines and other boat-related discharge at the dock locations. Fueling stations are not proposed as part of the boat docks. The relatively strong tidal currents in the channels surrounding the DW habitat and reservoir islands would disperse spills quickly. Boat docks located adjacent to spawning and early rearing areas of Sacramento splittail, delta smelt, and resident species could have localized, less-than-significant adverse impacts.

Summary of Project Impacts and Recommended Mitigation Measures

Impact F-2: Increase in Temperature-Related Mortality of Juvenile Chinook Salmon. The 1995 DEIR/EIS concluded that as a result of meteorological conditions, water temperature on the DW reservoir islands may be greater than water temperature in the adjacent Delta channels. It also concluded that the discharge of stored DW water could increase channel water temperature and adversely affect the survival rates of juvenile chinook salmon.

The 1995 DEIR/EIS included Mitigation Measure F-2 (Monitor the Water Temperature of DW Discharges and Reduce DW Discharges to Avoid Producing Any Increase in Channel Temperature Greater Than 1EF) to reduce this impact to a less-than-significant level. However, the FOC terms developed after the 1995 DEIR/EIS was published address this potential project effect. With the FOC incorporated into the proposed project, this potential impact is now considered less than significant and Mitigation Measure F-2 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-3: Potential Increase in Accidental Spills of Fuel and Other Materials. Accidental spills of fuel and other materials related to recreational boat use would be concentrated at DW boat dock locations. Such spills could occur adjacent to spawning and early rearing areas of Sacramento splittail, delta smelt, and other Delta species. Because spills would have localized effects, are random, and are not an occurrence of normal project operations, this impact was determined in the 1995 DEIR/EIS analysis to be less than significant (also see Chapter 3C, "Water Quality"). Additionally, the FOC terms include measures intended to compensate for the potential effects of recreational boat use on aquatic habitat. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Potential Flow and General Habitat Effects

This section discusses potential general effects on fish habitat, transport, and entrainment that could result from implementing Alternative 1. The discussion covers the following:

- # effects of DW project diversions on outflow and salinity and, therefore, on habitat availability;
- # effects of DW project diversions and discharges on Delta channel flow patterns, which affect fish transport to suitable habitat and to pumping facilities where they may be vulnerable to entrainment; and
- # effects of DW project diversions and discharges on percentage of Delta inflow diverted, which is associated with fish entrainment at the CVP and SWP export pumping facilities.

Effects on Delta Outflow

Delta outflow is a primary factor associated with Bay-Delta fish abundance, distribution, and habitat conditions. The effects of outflow on transport of fish larvae and juveniles are discussed below under "Potential Species-Specific Effects". Delta outflow also affects the concentration of toxic and organic materials downstream of the Delta (San Francisco Estuary Project 1993).

DW project diversions would directly reduce Delta outflow (Table 3F-1). Although the maximum average monthly DW diversion rate is 4,000 cfs, the maximum average daily DW diversion rate could reach 9,000 cfs for the first day. DW diversions would not be allowed to cause the Delta outflow objectives of the 1995 WQCP to be violated. Under Alternative 1, DW diversions were simulated in the 1995 DEIR/EIS analysis to reduce average monthly outflow by more than 25% during September-January in 18 years of the 70-year simulation. For other months, no DW diversions were simulated, or simulated diversions coincided with high outflow volumes (i.e., reductions in outflow were relatively small). See Chapter 3A, "Water Supply and Water Project Operations", for results of the 1995 DEIR/EIS simulations of outflows under the No-Project Alternative and the project alternatives. Since the 1995 DEIR/EIS analysis was performed, these potential effects of project operations on outflow have been reduced substantially with incorporation of the FOC into the proposed project.

Effects on Salinity

By reducing Delta outflow, DW diversions affect salinity distribution in the estuary. The effect of reduced outflow on salinity is represented by the change in X2 (distance in kilometers of the 2-ppt isohaline from the Golden Gate Bridge). The simulations of DW project operations show that X2 would shift upstream when outflow is reduced by DW diversions.

The 1995 DEIR/EIS analysis determined that during February-June (the critical habitat months for many estuarine species [SWRCB 1995]), DW project operations would cause upstream shifts in X2 of up to 1.4 kilometers (Table 3F-2). During September, October, and November, the simulated upstream shift in X2 was found to approach or exceed 3.5 kilometers in some years. The magnitude of the shift in X2 is a function of both the change in Delta outflow (caused by DW diversion) and the volume of outflow. Simulated reductions in outflow caused by DW diversions have less effect on the location of X2 when the outflow is greater. The greatest shift in X2 occurs with diversions at low outflows, when X2 is located upstream near the confluence of the Sacramento and San Joaquin Rivers.

Although the objectives of the 1995 WQCP would be met under DW project operations, the 1995 DEIR/EIS concluded that the upstream shift in X2 attributable to DW diversions could reduce the area of optimal salinity habitat in Suisun Bay and the Delta. Change in area of optimal salinity habitat in the estuary is discussed in the sections on optimal salinity habitat for individual species under "Potential Species-Specific Effects" below. Since the 1995 DEIR/EIS analysis was performed, the potential effects of proposed project operations on X2 location have been substantially reduced with incorporation of the FOC into the proposed project. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Effects on Delta Flow Patterns

Delta flow patterns potentially affect the movement of fish through the Delta, their arrival in downstream habitats, and their susceptibility to entrainment in diversions. Net flow in the Delta channels is affected by river inflows, channel geometry, location and volume of Delta diversions, and closure or removal of channel barriers.

Channel flows affecting the central Delta (i.e., the San Joaquin River from Stockton to Twitchell Island, including the most northerly parts of Old and Middle Rivers) are discussed in this section. The central Delta is the "switchyard" of the Delta. Channel flows into and out of the central Delta could affect fish movement in the Sacramento, Mokelumne, and San Joaquin Rivers. The channel flows discussed in this section include major inflows to the central Delta from the Sacramento River (i.e., the DCC and Georgiana Slough) and the San Joaquin River (at Stockton), flow between the central Delta and the western Delta (QWEST), and flows in Old and Middle Rivers.

DCC and Georgiana Slough. Diversion of Sacramento River flow through the DCC and Georgiana Slough could have detrimental effects on winter-run chinook salmon and could also affect distribution and survival of other species. Flow through the DCC and Georgiana Slough is a function of Sacramento River flow and operation of the DCC gates. DW project operations would not affect Sacramento River flow and DCC gate operation. The volume of the DCC and Georgiana Slough flow would be the same under Alternative 1 and the No-Project Alternative because exports and DW diversions would not change the DCC and Georgiana Slough flows (see Tables A3-5 and A3-8 in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives").

San Joaquin River at Stockton. With a barrier in Old River, nearly all San Joaquin River flow moves through the Delta past Stockton. The barrier was assumed to be in place during April-May and October for the 1922-1991 simulations. The barrier was assumed to be removed if San Joaquin River inflow exceeded 10,000 cfs.

When the Old River barrier is not in place, Old River flow is a function of San Joaquin River flow and, to a lesser extent, export at the SWP and CVP Delta pumping facilities. When the San Joaquin River flow at Vernalis exceeds 2,000 cfs, Old River flow is approximately 60% of the total San Joaquin River inflow and the flow division is unaffected by exports. For Vernalis flows less than 2,000 cfs, decreased Vernalis flow and increased exports reduce the proportion of flow toward Stockton. When total

San Joaquin River inflow is about 500 cfs, flow toward Stockton is negligible or may be slightly reversed because of exports.

DW project operations under Alternative 1 would not affect total San Joaquin River inflow and Old River barrier placement. The volume of San Joaquin River flow past Stockton would be the same under Alternative 1 and the No-Project Alternative (see Tables A3-5 and A3-8 in Appendix A3).

QWEST Flow. QWEST is a calculated flow parameter representing net flow between the central Delta and the western Delta. Although QWEST criteria are not included in the 1995 WQCP, QWEST criteria have previously been considered for protection of central Delta fish (NMFS 1993). DW project diversions would directly reduce QWEST. DW discharge for export would not affect QWEST.

If QWEST under the No-Project Alternative is simulated to be positive (i.e., net flow is toward Suisun Bay), simulated DW diversions reduce the net flow volume or reverse the direction of net flow. In the 1995 DEIR/EIS analysis, simulated diversions resulted in 14 reversals of net positive flow direction, primarily during September-December in DeltaSOS modeling of Alternative 1 (Tables A3-5 and A3-8 in Appendix A3). If QWEST under the No-Project Alternative is simulated to be negative (i.e., net flow is toward the central Delta), simulated DW diversions would increase the net negative flow volume by an amount equal to the DW diversion.

The effects of change in QWEST on fish species depend on flow conditions throughout the Delta and on the distribution of fish. Fish effects of DW diversions for variable QWEST flow are evaluated under "Potential Species-Specific Effects" below.

Old and Middle Rivers. In all months of the 1922-1991 simulation for the 1995 DEIR/EIS, net flow in Old and Middle Rivers toward the south (i.e., negative flow) averaged between 6,000 cfs and 9,000 cfs (see Tables A3-5 and A3-8 in Appendix A3). The simulation results showed that DW project diversions would increase net southerly flow in Old and Middle Rivers between Bacon Island and Webb Tract (Table 3F-3). The increase would not exceed 4,500 cfs, the maximum diversion capacity of Bacon Island. Flows to the south of Bacon Island would not be affected by DW diversions.

DW discharge for export would also increase net southerly flow in Old and Middle Rivers (Table 3F-3). Net flow would change in Old and Middle Rivers between Webb Tract and Bacon Island only when DW project water is discharged for export from Webb Tract. Discharge from Bacon Island would affect only flows south of Bacon Island. The 1995 DEIR/EIS analysis found that discharge for export could increase net southerly flow by a maximum of 6,000 cfs between Bacon Island and the CVP and SWP Delta pumping facilities and a maximum of 4,000 cfs between Webb Tract and Bacon Island.

The effects of the change in net Old and Middle River flow on fish species depend on concurrent flow changes in the rest of the Delta and on the distribution of fish. More detailed analysis of effects of DW diversions and DW discharges for export are presented under "Potential Species-Specific Effects" below.

Effects on Percentage of Delta Inflow Diverted

Percentage of Delta inflow diverted was introduced in the 1995 WQCP as an export limit to reduce entrainment of various species' life stages by the major export pumps (CVP and SWP) in the south Delta. A major concern is the movement of fish toward the south Delta with water drawn from the Sacramento River. South Delta diversions (SWP, CVP, CCWD, and agricultural diversions) generally exceed the San Joaquin River inflow and draw Sacramento River water across the Delta.

In the 1995 DEIR/EIS simulations of DW project operations under Alternative 1, DW diversions were treated the same as CVP and SWP exports and were limited by the percent inflow criteria of the 1995 WQCP (i.e., during any month, the sum of DW diversions and export as a percentage of Delta inflow would not exceed the maximum allowed under the 1995 WQCP). As interpreted for the analysis of DW Alternative 1, the criteria allow export (plus DW diversion) of 35% or less of Delta inflow during February-June and 65% during July-January; export (plus DW diversions) of between 35% and 45% is allowed under the criteria during February if January runoff is less than 1.5 MAF. The 1995 DEIR/EIS simulation showed that under the 1995 WQCP, percentage of inflow diverted was allowed to exceed 35% in February in 40 of the 70 simulated years. For the No-Project Alternative and Alternative 1, there were 15 years when percentage of inflow diverted exceeded 35% in February. In DeltaSOS modeling, DW discharge for export was included in the calculation of Delta inflow. Percent inflow is calculated by dividing CVP Tracy and SWP Banks export, including export of DW discharge, by Delta inflow.

The 1995 DEIR/EIS analysis determined that DW diversions would increase the percent inflow diverted, but operations would comply with the criteria in the 1995 WQCP. The increase in percent inflow diverted could increase entrainment of estuarine species by Delta diversions. A detailed discussion of entrainment effects of DW project operations is presented below under "Potential Species-Specific Effects". The FOC terms include numerous restrictions on DW project diversions that limit potential effects of the proposed project on entrainment and Delta parameters. See the section from the 2000 REIR/EIS entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Potential Species-Specific Effects

DW project effects on abundance of chinook salmon, striped bass, American shad, delta smelt, Sacramento splittail, and longfin smelt were determined using available species-specific models that relate species effects to habitat conditions. Species abundance indices and habitat conditions under the No-Project Alternative and DW project operations were compared. Results of the assessment of effects are described below for each of these species.

As noted above, the FOC and biological opinion RPMs incorporated into the proposed project since the 1995 DEIR/EIS was published substantially reduce the species-specific effects of the proposed project that are described in this section. With the incorporation of these terms into the proposed project, all the fishery impacts of the proposed project (Alternatives 1 and 2) identified below are reduced to a less-than-significant level. The discussion has been retained in this FEIS to provide reviewers with a description of the methods used to evaluate potential project effects on these species, and to provide context for the discussion of impacts of Alternative 3, which are not addressed by the biological opinions.

Chinook Salmon

Following are major concerns about DW project impacts on chinook salmon:

- increased water temperature from DW discharge,
- increased division of flow off the Sacramento River through the DCC and Georgiana Slough,
- increased division of flow off the San Joaquin River through Old River near Mossdale,
- reduced potential to escape the Delta because of reduced positive QWEST or increased negative QWEST, and
- increased attraction to south Delta diversions (i.e., increased southerly flow in Old and Middle Rivers).

DW effects on potential water temperature changes were discussed previously (see "Water Temperature" under "DW Reservoir Island Discharge"). DW project operations would not affect DCC and Georgiana Slough flows or Old River flow at Mossdale (see "DCC and Georgiana Slough" and "San Joaquin River at Stockton" in the previous section). The 1995 DEIR/EIS found that DW operations would reduce the potential for juvenile chinook salmon to escape the Delta and would increase attraction to south Delta diversions.

The mortality index for chinook salmon during migration through the Delta indicates the effect on migration. The following discussions describe changes in the mortality index of juvenile chinook salmon that were estimated in the 1995 DEIR/EIS analysis to result from simulated DW project operations under Alternative 1 relative to operations of the No-Project Alternative.

For the 1995 DEIR/EIS simulations of Alternative 1, it was assumed that the first available Delta water would be diverted onto the DW reservoir islands. If fish abundance is a function of flow (i.e., water availability), vulnerability to diversion effects under Alternative 1 may also be a function of flow. Migration timing of juvenile chinook salmon each year is assumed to be a function of flow and inherent run characteristics. In the simulation of mortality during migration, the model varied migration timing each year according to occurrence of storm events. For example, seaward migration of winter-run chinook salmon peaks during February and March; however, storm events (increased availability of water) can cause greater proportions of the winter-run chinook salmon population to migrate downstream to rear in the Delta (see Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species"). In the 1995 DEIR/EIS model results, the simulated proportion migrating each month varied by more than 30% from year to year (e.g., during February, migration percentage ranged from 13% to 53% for the 70-year simulation).

Figure 3F-4 shows the total Delta migration mortality for fall-run chinook salmon originating in the Sacramento River. The total Delta mortality index simulated for the 1922-1991 period in the 1995 DEIR/EIS analysis ranged from about 14% to 75% of the annual production of fall-run juveniles entering the Delta (Table 3F-4). The change in the mortality index attributable to DW project operations simulated for Alternative 1 cannot be discerned in Figure 3F-4. The change in fall-run mortality averaged about 0.03% and ranged from -0.02% to 0.20% (Table 3F-4). Reduced mortality is the result of agricultural diversions being forgone during years when the reservoir islands would not fill or discharge.

The relatively small effect of Alternative 1 operations on juvenile fall-run chinook salmon originating in the Sacramento River is attributable to the timing of fall-run migration relative to timing of DW project operations. As discussed above under "Affected Environment", juvenile fall-run out-migrate primarily during April-June; under Alternative 1, water would be diverted to storage primarily during October-February and would be discharged for export primarily during July and August.

A mortality index was not developed specifically for chinook salmon originating in the Mokelumne and San Joaquin Rivers. The effects of DW operations on survival of Mokelumne and San Joaquin River juvenile migrants, however, are potentially several times greater than the effects on survival of juvenile chinook salmon in the Sacramento River. Approximately 20%-40% of Sacramento River juvenile migrants are exposed to central Delta conditions, whereas all Mokelumne and San Joaquin River migrants move through the central Delta and are exposed to the effects of exports and south Delta diversions.

Although potentially greater than the effects of DW operations on Sacramento River juvenile migrants, the effects of DW operations on juvenile fall-run chinook salmon originating in the Mokelumne and San Joaquin Rivers would generally be small. Most juvenile out-migration occurs during April and May, but water would be diverted to storage primarily during October-February and would be discharged for export primarily during July and August. The 1995 DEIR/EIS indicated that diversions to fill the DW project islands that coincide with major periods of juvenile out-migration (e.g., in April and May) could have significant adverse effects; the FOC, however, now prevent DW from diverting to storage in April and May. The 1995 DEIR/EIS also indicated that discharge of DW project water to export during April and May could have adverse effects on chinook salmon, but that the effects would be less than diversion effects because additional Sacramento River water would not be drawn across the Delta. The FOC also include many restrictions on discharges in April and May.

Figure 3F-5 shows the winter-run migration mortality index attributable to all Delta diversions for the 70-year simulation performed for the 1995 DEIR/EIS. The total Delta mortality index simulated for the 1922-1991 period ranged from 6% to 17% of the annual production of winter-run chinook salmon juveniles. The index is lower for winter run than for fall run because water temperature is lower during juvenile winter-run migration through the Delta. Simulated operations under Alternative 1 changed mortality relative to mortality under the No-Project Alternative by -0.02% to 0.43% (an average of 0.08%) (Table 3F-4).

DW project effects on late fall- and spring-run chinook salmon would be similar to effects described for Sacramento River fall run and winter run. Late fall-run juveniles and spring-run yearlings migrate through the Delta during fall. Peak spring-run juvenile migration precedes fall-run migration in the spring. DW diversions and discharges could occur during out-migration of the late fall and spring runs (Tables A3-7a and A3-7b in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives).

The increased mortality of juvenile chinook salmon includes direct DW project effects and indirect effects (i.e., mortality attributable to other Delta diversions that results from DW effects on Delta flow conditions). Mortality estimates, however, did not include the benefits of fish screens, and DW project operations with effective fish screens in place would have minimal direct adverse effects on juvenile chinook salmon mortality. The 1995 DEIR/EIS concluded that DW project operations would have a small but significant indirect adverse impact on survival of chinook salmon juveniles migrating through the central Delta. This impact is less than significant, however, with the subsequent incorporation of the FOC and biological opinion RPMs into the proposed project.

Striped Bass

DW project effects on striped bass were evaluated for transport of eggs, larvae, and early juveniles from April through June; habitat availability for larvae and early juveniles during April through July; and entrainment of larvae and juveniles throughout the year.

Transport. DW project operations could affect striped bass survival and abundance by affecting transport flows. The estimated percentage of the spawned population that is entrained provides an index of losses during transport to downstream optimal low-salinity habitat.

The 1995 DEIR/EIS determined that DW operations would have significant adverse effects on transport and entrainment of striped bass eggs and larvae. Figure 3F-6 shows the total annual entrainment loss of striped bass attributable to all Delta diversions for the 70-year simulation used for the 1995 DEIR/EIS analysis. Total Delta entrainment loss simulated for 1922-1991 ranged from about 1% to 31% of the annual production of striped bass eggs and larvae. The simulations indicated that operations under Alternative 1 could change the annual entrainment loss relative to loss under the No-Project Alternative by -0.02% to 1.5% (Table 3F-5). Reduced entrainment is the result of agricultural diversions being forgone during years when the reservoir islands would not fill or discharge. The increased entrainment index includes direct entrainment that could result from DW operation effects on Delta flow conditions.

The assumed spawning distribution can have a substantial effect on the simulated entrainment index for total Delta diversions (see "Delta Smelt", below). The simulations for striped bass assumed that 55% of the population spawned upstream of the Delta in the Sacramento River and 45% spawned in the San Joaquin River. Eggs spawned in the central Delta would be more affected by exports and diversions than eggs spawned in the Sacramento River or in the lower San Joaquin River. Entrainment losses attributable to DW project operations as analyzed for the 1995 DEIR/EIS could be much larger or smaller than the analysis indicates, depending on the actual distribution of spawning and Delta flow conditions at the time of DW diversions and discharges.

Optimal Salinity Habitat. Striped bass year-class survival may be related to optimal salinity habitat area. DW project diversions would have minor effects on striped bass habitat area. Under the No-Project Alternative and Alternative 1, the annual weighted habitat area available for striped bass during the 1922-1991 period simulated for the 1995 DEIR/EIS ranged from about 51 km^2 to 102 km^2 (Figure 3F-7). Change between habitat area simulated for the same year for DW project operations and for the No-Project Alternative ranged from -1.82 km^2 to 2.86 km^2 (average increase in area for the 70-year simulation of 0.18 km^2) (Table 3F-6). Increased area would result from DW agricultural diversions being forgone during May-July when the DW project does not divert.

Direct Entrainment. Potential entrainment of larvae is described above under "Transport". Operations under Alternative 1 would likely cause minimal direct entrainment of juvenile striped bass. Although the presence of juvenile striped bass (Figure 3F-3) may coincide with the timing of diversions (Table 3A-7 in Chapter 3A, "Water Supply and Water Project Operations"), juvenile striped bass would be screened from DW reservoir and habitat island diversions. Unscreened agricultural diversions would be eliminated from the DW project islands and direct entrainment (and impingement) could be reduced. However, the 1995 DEIR/EIS analysis concluded that indirect effects of diversions under Alternative 1 (e.g., effects on predation and environmental cues that determine successful migration to the Bay) could increase juvenile losses, including losses to entrainment at the SWP and CVP Delta pumps. Substantial salvage of juvenile striped bass has historically occurred at the SWP and CVP fish protection facilities during November-January (Figure 3F-3). This impact was determined in the 1995 DEIR/EIS to be significant. However, the impact has been reduced to a less-than-significant level with the subsequent incorporation of the FOC and biological opinion RPMs into the proposed project.

American Shad

DW project operations would likely have small effects on eggs and larvae of American shad. Most American shad spawn upstream of the Delta (see "Affected Environment") and larvae remain in the rivers to rear. Shad eggs and larvae spawned in the Delta could be affected by DW project operations; however, diversions are unlikely to occur under Alternative 1 during the May-July spawning period (see Chapter 3A). DW discharges for export may coincide with spawning and early rearing of American shad; however, DW discharge for export would primarily affect conditions in the central and south Delta.

Entrainment of juvenile shad in Delta diversions peaks during November and December, coinciding with downstream migration through the Delta. Substantial DW diversions may occur during November and December under Alternative 1 (see Chapter 3A). Juvenile shad would be screened from DW reservoir and habitat island diversions and project operations would likely cause minimal direct entrainment. As with striped bass, the 1995 DEIR/EIS analysis indicated that indirect effects of Alternative 1 operations (e.g., effects on predation and on environmental cues that determine successful migration to the Bay) could increase juvenile losses, including losses to entrainment at the SWP and CVP Delta pumps. The impact was determined to be less than significant because DW diversions primarily affect central Delta conditions. Most shad juveniles migrate down the Sacramento River and would not enter the central Delta.

Delta Smelt

DW project effects on delta smelt were evaluated for transport of larvae and juveniles during February-June; habitat availability for larvae and early juveniles during February-August; and entrainment of larvae, juveniles, and adults throughout the year.

Transport. The 1995 DEIR/EIS concluded that DW project operations would have a significant adverse impact on delta smelt survival and abundance by affecting transport flows. As described in the "Affected Environment" section, delta smelt spawn in freshwater channels in the Delta. After hatching, larvae may require net flow movement for transport to downstream optimal low-salinity habitat. As for striped bass, DeltaMOVE was used to simulate transport of delta smelt to downstream habitat following hatching in the Delta and to calculate an index of entrainment losses during transport.

Figure 3F-8 shows the total annual entrainment loss of delta smelt attributable to all Delta diversions for the 70-year simulation used for the 1995 DEIR/EIS analysis. Total Delta entrainment loss simulated for 1922-1991 ranged from 1% to more than 36% of the annual production of delta smelt larvae. The simulations indicated that operations under Alternative 1 could change the annual entrainment loss relative to loss under the No-Project Alternative by -0.02% to 3.2% (an average increase in the entrainment index of 0.62%) (Table 3F-5). The increased entrainment index includes direct entrainment in DW diversions (and export of DW discharge) and indirect entrainment that could result from DW operation effects on Delta flow conditions.

Little is currently known about factors influencing the annual variability in distribution and timing of delta smelt spawning. Hatching is assumed to take place during February-June. For the impact assessment, 50% of the total annual spawn was assumed to occur on the Sacramento River side of the Delta and 50% of the spawn was assumed to be distributed equally between the San Joaquin River, Mokelumne River, and central Delta areas (i.e., 16.66% in each area). The assumed spawning distribution can have a substantial effect on the simulated entrainment index for total Delta diversions (see Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species"). Larvae hatched on the Sacramento side of the Delta are less affected by export than larvae hatched in the central Delta.

Optimal Salinity Habitat. Delta smelt year-class survival may be related to optimal salinity habitat area. The 1995 DEIR/EIS concluded that DW project diversions would have minor effects on delta smelt habitat area.

Under operations of the No-Project Alternative and Alternative 1, the annual habitat area available for delta smelt during the 1922-1991 period simulated for the 1995 DEIR/EIS ranged from 41 km^2 to 68 km^2 (Table 3F-6). Change in habitat area under DW project operations relative to the area under the No-Project Alternative ranged from -0.91 km^2 to 1.05 km^2 (average increase in area for the 70-year simulation of 0.05 km^2) (Table 3F-6, Figure 3F-9). The relatively small increase in area resulted from increases in outflow attributable to forgone DW agricultural diversions relative to the No-Project Alternative conditions during the rearing period (February-August).

Direct Entrainment. Potential entrainment of larvae is described above under "Delta Smelt Transport". Although the presence of adult and juvenile delta smelt near DW project diversions (Figure 3F-3) may coincide with the timing of DW diversions (see Chapter 3A), older juvenile and adult delta smelt would be screened from DW reservoir and habitat island diversions.

Operations under Alternative 1 would likely have minimal adverse effects on direct entrainment of adult and older juvenile delta smelt. Unscreened agricultural diversions would be eliminated from the DW project islands and direct entrainment (and impingement) could be reduced. However, as with striped bass, the 1995 DEIR/EIS analysis indicated that indirect effects of DW project diversions could increase juvenile and adult delta smelt entrainment at the SWP and CVP Delta pumps and contribute to a significant adverse impact. The subsequent incorporation of the FOC and biological opinion RPMs into the proposed project, however, has reduced this impact to a less-than-significant level.

Sacramento Splittail

Construction of DW project facilities could affect localized Sacramento splittail habitat, and DW project diversions could increase splittail entrainment. Although DW project operations could have adverse effects on localized populations of splittail, the 1995 DEIR/EIS indicated that the effect on overall population abundance would be minimal.

Habitat. As discussed under "Effects of Construction Activities" above, splittail spawning and rearing habitat could be affected near proposed DW project intakes, discharge pumps, and boat docks. Sites for the facilities would be relatively steep, riprapped levee slopes. The facilities are unlikely to be located in preferred spawning or rearing habitat of Sacramento splittail.

Loss of habitat would have significant adverse effects on localized splittail reproduction. If intake siphons, discharge pumps, or boat docks were located in or near shallow vegetated habitat, splittail spawning and rearing habitat could be lost or altered. The area of lost habitat would be small relative to the area of similar habitat available in the Delta, and such loss would have minimal effects on splittail populations.

Splittail spawn over flooded vegetation. Most of the seasonally flooded spawning habitat, representing most of the available spawning habitat, is upstream of the Delta. Spawning area increases as high flows inundate seasonally available habitats. Splittail abundance, although correlated with Delta outflow, is likely not directly dependent on outflow but rather on flooding of habitats upstream of the Delta. DW project operations would not affect splittail spawning habitat upstream of the Delta.

Direct Entrainment. Splittail larvae and early juveniles could be entrained in DW diversions if the DW intakes are located in areas that support spawning and rearing, but entrainment would affect only local populations. The presence of adult and juvenile splittail near DW project diversions (Figure 3F-3) may coincide with the timing of diversions (see Chapter 3A). Adult and juvenile splittail would be efficiently screened from DW project diversions. Also, unscreened agricultural diversions would be eliminated from the DW project islands and direct entrainment (and impingement) could be reduced. The 1995 DEIR/EIS concluded that operations of Alternative 1 would have less-than-significant adverse entrainment effects on adult and older juvenile Sacramento splittail. Additionally, the FOC and RPMs include measures that provide further assurances that project impacts on splittail would be less than significant.

Longfin Smelt

DW project effects on longfin smelt were evaluated for transport of larvae and juveniles during January-April; habitat availability for larvae and early juveniles during January-May; and entrainment of larvae, juveniles, and adults throughout the year.

Transport. The 1995 DEIR/EIS concluded that operations under Alternative 1 would have adverse effects on longfin smelt transport and entrainment loss. However, spawning location is outside the primary influence of central and south Delta diversions, and transport effects of total Delta diversions would be substantially less for longfin smelt than the effects described in the 1995 DEIR/EIS for delta smelt (Figure 3F-10). Longfin smelt spawn primarily in the

Sacramento River; in the confluence area; and, when salinity conditions are adequate, in Suisun Bay.

The entrainment indices for longfin smelt in the 1995 DEIR/EIS ranged from 0.0% to 21% (Figure 3F-10). The change in the entrainment indices for longfin smelt under operations of Alternative 1 ranged from 0% to 5.6% and the average index for the 70-year simulation was 0.8% (Table 3F-5). Simulated diversions onto the DW project islands (Table 3A-7 in Chapter 3A) were greater for periods when longfin smelt would be present than when delta smelt are present; therefore, it was concluded that DW diversions would be more likely to affect longfin smelt. Peak occurrence of longfin smelt larvae is during February and March (see "Affected Environment"). Discharges for export, however, were simulated to occur after the abundance of longfin smelt in the Delta would have declined. Therefore, DW discharge for export would have minimal effects on the entrainment index for longfin smelt.

As with delta smelt, the assumed spawning distribution can have a substantial effect on the simulated entrainment index for Delta diversions (Appendix F2). For the impact assessment, all longfin smelt were assumed to spawn on the Sacramento River side of the Delta. In wetter periods (i.e., when water is available for DW diversions), spawning may be distributed from Rio Vista downstream to Suisun Bay. DW diversion effects on transport conditions in the confluence and Suisun Bay would be less than the effects shown in Figure 3F-10.

The incorporation of the FOC and biological opinion RPMs into the proposed project ensures that project impacts on transport and entrainment of longfin smelt would be less than significant.

Optimal Salinity Habitat. Longfin smelt year-class survival may be related to optimal salinity habitat area.

The 1995 DEIR/EIS concluded that DW project diversions would have less-than-significant adverse effects on longfin smelt habitat area. Under simulated operations of the No-Project Alternative and Alternative 1 for 1922-1991 performed for the 1995 DEIR/EIS, the annual weighted habitat area available for longfin smelt ranged from 122 km^2 to 248 km^2 (Figure 3F-11). Change in habitat area under DW project operations relative to the No-Project Alternative conditions ranged from -7.29 km^2 to 3.04 km^2 and averaged -0.87 km^2 for the 70-year simulation (Table 3F-6). The greater estimated percent change in habitat area for longfin smelt compared with that for delta smelt results from the coincidence of larval longfin smelt presence and simulated DW project diversions to fill the reservoir islands (see Chapter 3A). Reductions in habitat area would be infrequent and substantial habitat area (i.e., greater than 122 km^2) would remain (Figure 3F-11).

Direct Entrainment. Potential entrainment of larvae is described above under "Transport". The 1995 DEIR/EIS concluded that Alternative 1 would likely have minimal and less-than-significant adverse effects on direct entrainment of adult and older juvenile longfin smelt. Although it was determined that the presence of adult and juvenile longfin smelt near DW project intake siphons (Figure 3F-3) may coincide with the timing of diversions (see Chapter 3A), older juvenile and adult longfin smelt would generally be found downstream of the central Delta. Use of fish screens would reduce adverse effects of diversions on adults and larger juveniles.

Summary of Project Impacts and Recommended Mitigation Measures

Impact F-4: Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of DW Project Diversions and Discharges on Flows. The 1995 DEIR/EIS concluded that DW diversions and discharges for export could increase the mortality of juvenile chinook salmon out-migrating through the Delta, primarily by indirectly affecting central Delta flow conditions, which could reduce the success of chinook salmon migration to the bay. It was determined that effects would be less than significant for chinook salmon originating in the Sacramento River (including the fall, late-fall, winter, and spring runs); however, it was also determined that effects could be significant for juveniles originating in the Mokelumne and San Joaquin Rivers if DW diversions to fill the reservoir islands were made during major out-migration periods of these fish.

The latter was determined in the 1995 DEIR/EIS to be a significant impact because nearly all the annual production of Mokelumne and San Joaquin River chinook salmon could be affected and DW diversions could substantially change cross-Delta flow. DW discharges to export would have a relatively small effect on cross-Delta flow and therefore would have fewer impacts on Mokelumne and San Joaquin River out-migrants.

The 1995 DEIR/EIS included Mitigation Measure F-3 (Operate the DW Project under Operations Objectives That Would Minimize Changes in Cross-Delta Flow Conditions during Peak Out-Migration of Mokelumne and San Joaquin River Chinook Salmon) to reduce this impact to a less-than-significant level. However, the FOC and biological opinion RPMs developed after the 1995 DEIR/EIS was published include measures that address this potential project effect. With the FOC and RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-3 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-5: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae. The 1995 DEIR/EIS concluded that the presence of planktonic fish eggs and larvae could coincide with DW diversions and discharges to export, and that project operations could result in an increase in their vulnerability to transport toward the central and south Delta and could increase entrainment losses there. The potential increase in entrainment loss of eggs and larvae was determined to be small (i.e., generally less than 1%) relative to existing losses. However, the impact was considered significant because existing losses to other diversions potentially reduce population abundance and contribute to recent downward trends in the population abundance of striped bass, delta smelt, and longfin smelt.

The 1995 DEIR/EIS included Mitigation Measure F-4 (Operate the DW Project under Operations Objectives That Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt) to reduce this impact to a less-than-significant level. However, the FOC and biological opinion RPMs developed after the 1995 DEIR/EIS was published include measures that address this potential project effect. With the FOC and RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-4 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-6: Change in Area of Optimal Salinity Habitat. DW project diversions could reduce Delta outflow by as much as 9,000 cfs during initial days of filling and could cause X2 to shift upstream. The upstream shift in X2 could reduce the area of optimal salinity habitat available to striped bass, delta smelt, and longfin smelt. The effect on habitat area, however, depends on the duration of the upstream shift in X2 (i.e., diversion) and the coincidence of habitat needs with operations that may affect area. The 1995 DEIR/EIS analysis of habitat area showed that DW project operations could increase habitat area during some years and reduce habitat area during others. The impact was considered less than significant because:

- the change in habitat area would be small relative to the total availability of habitat;
- DW diversions would be infrequent during April through August when optimal salinity habitat needs are important for production of striped bass, delta smelt, and longfin smelt (San Francisco Estuary Project 1993);
- the direct effects of DW diversion on optimal salinity habitat area would be of short duration (about one month) relative to the period of estuarine habitat needs; and
- forgone DW agricultural diversions during April through August could slightly increase optimal salinity habitat area.

Additionally, the potential effects of proposed project operations on X2 location are substantially reduced with incorporation of the FOC into the proposed project. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-7: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt. When juvenile striped bass and delta smelt are distributed primarily in the Delta, export of the first uncontrolled flow to occur during a water year (i.e., uncontrolled flow during November-January) results in high entrainment at the SWP and CVP Delta export pumps. The 1995 DEIR/EIS concluded that DW project diversions could alter Delta flow patterns; affect environmental cues that determine successful migration to the Bay; and, subsequently, increase entrainment losses of striped bass and delta smelt at the SWP and CVP Delta pumps. This impact was considered significant.

The 1995 DEIR/EIS included Mitigation Measure F-5 (Operate the DW Project under Operations Objectives That Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt) to reduce this impact to a less-than-significant level. However, the FOC and biological opinion RPMs developed after the 1995 DEIR/EIS was published include measures that address this potential project effect. With the FOC and RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-5 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-8: Increase in Entrainment Loss of Juvenile American Shad and Other Species. The 1995 DEIR/EIS found that DW diversions could increase entrainment loss of juvenile American shad and other species. The impact was considered less than significant because DW reservoir island diversions would operate with effective fish screens that minimize direct entrainment loss. On the habitat islands, existing unscreened agricultural diversions would be screened. The FOC and biological opinion RPMs provide further assurances that the effects of the proposed project on the entrainment of juvenile American shad and other species will be less than significant. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Alternative 2 is similar to Alternative 1 and involves storage of water on Bacon Island and Webb Tract (reservoir islands) and management of Bouldin Island and Holland Tract as habitat islands. In DeltaSOS simulations of operations of Alternative 2, it is assumed that diversions onto the reservoir islands could occur any time when surplus flows are available in the Delta (i.e., when 1995 WQCP criteria are met). Water discharged from the reservoir islands is assumed to be Delta inflow. It is assumed also that export of DW discharges under Alternative 2 by the CVP and SWP Delta pumping facilities is not subject to the 1995 WQCP criteria for percentage of Delta inflow diverted (see Chapter 3A, "Water Supply and Water Project Operations").

Effects of operations under Alternative 2 were determined through comparison of flow and habitat conditions for operations and facilities simulated by DeltaSOS with and without the DW project (i.e., under Alternative 2 and under the No-Project Alternative). Table 3A-9 in Chapter 3A, "Water Supply and Water Project Operations", and Tables A3-10a and A3-10b in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", show the results of DeltaSOS simulations of reservoir island diversions and discharges under Alternative 2 performed for the 1995 DEIR/EIS. Habitat island diversions under the DW project are the same as for Alternative 1 (see Table 3A-2 in Chapter 3A and Table A1-7 in Appendix A1, "Delta Monthly Water Budgets for Operations Modeling of the Delta Wetlands Project", for the estimates of habitat island diversions made for the 1995 DEIR/EIS analysis).

The effects of construction activities under Alternative 2 would be the same as those described for Alternative 1. The effects of project operations on water quality would also be identical under Alternative 2 to those under Alternative 1. Because the project would have more diversion and discharge opportunities under Alternative 2 than under Alternative 1, the potential flow and general habitat effects and the potential species-specific effects shown in the 1995 DEIR/EIS for Alternative 2 were similar to, but sometimes greater than, those shown for Alternative 1. The same mitigation measures were recommended in the 1995 DEIR/EIS for Alternative 2 as for

Alternative 1. The FOC and biological opinion RPMs, however, were developed based on estimated project operations under Alternative 2; incorporating the FOC and RPMs into the proposed project has subsequently rendered all the fishery impacts identified in the 1995 DEIR/EIS for Alternative 2 less than significant.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on all four DW project islands, with secondary uses for wildlife habitat and recreation; the portion of Bouldin Island north of SR 12 would provide limited habitat. Existing agricultural diversions would cease under Alternative 3. Simulation of DW project operations under Alternative 3 is based on the assumption that diversions onto the reservoir islands could occur any time of the year when surplus flows are available in the Delta (i.e., 1995 WQCP criteria are met). Water discharged from the reservoir islands is assumed to be Delta inflow; it is assumed that DW discharges exported by the CVP and SWP Delta pumping facilities would not be subject to the 1995 WQCP percent inflow criteria (See Chapter 3A, "Water Supply and Water Project Operations").

Effects of DW project operations under Alternative 3 were determined though comparison of flow and habitat conditions for operations and facilities simulated by DeltaSOS with and without the DW project (i.e., under Alternative 3 and under the No-Project Alternative). Table 3A-11 in Chapter 3A, "Water Supply and Water Project Operations", and Tables A3-13a and A3-13b in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives", show the results of DeltaSOS simulations of DW reservoir island diversions and discharges based on hydrologic conditions for 1922-1991.

Effects of Construction Activities

Effects of construction activities under Alternative 3 would be similar to those described for Alternative 1. Additional intake facilities, fish screens, and discharge facilities would be constructed on Bouldin Island, Holland Tract, and Webb Tract under Alternative 3 compared with facilities and fish screens under Alternatives 1 and 2.

Summary of Project Impacts and Recommended Mitigation Measures

Impact F-9: Alteration of Habitat. Construction of intake facilities and fish screens, discharge facilities, and boat docks could have significant adverse impacts on spawning and rearing habitat used by Delta fish species. Additional intake structures, fish screens, and discharge structures would be constructed on Bouldin Island, Holland Tract, and Webb Tract relative to construction under Alternatives 1 and 2. The loss of habitat area, however, would still be small relative to the total area of similar habitat in the Delta, and such habitat loss would have minimal effects on fish populations. The impact, however, is considered significant because historical and ongoing activities (e.g., dredging, placement of riprap, and levee construction) have destroyed substantial areas of spawning and rearing habitat in the Delta, and recent downward trends in the population abundance of delta smelt and Sacramento splittail may indicate the need to preserve the remaining habitat.

Implementing Mitigation Measure F-1 would reduce Impact F-9 to a less-than-significant level.

Mitigation Measure F-1: Implement Fish Habitat Management Actions. DW shall implement the following actions:

- **Six months before beginning construction, DW shall provide USFWS and DFG with detailed habitat maps of the intake, discharge, and boat dock sites**. The maps should show the areas that may be directly affected by construction, and should also show adjacent habitat within 200 feet of the proposed facilities. A mapped area should include the area from the center line of the levee toward the center of the adjacent channel to a depth of -10 feet mean sea level (msl). The maps should identify all physical and biological features, including substrate, depth (relative to msl), and vegetation. Habitats likely to be altered by construction of intake, discharge, and boat dock facilities should be clearly identified, and quality and quantity of each habitat type should be specified. Focus should be on habitats potentially used by Sacramento splittail, delta smelt, and other native species.

Prior to beginning construction, DW shall implement a fish habitat replacement plan. The plan should identify spawning and rearing habitats that should be created or restored to replace shallow vegetated habitat permanently destroyed by construction activities. Shallow vegetated habitat should be replaced at a ratio of 3:1.

The replacement ratio of 3:1 is consistent with habitat restoration and replacement needs identified by USFWS for other Delta projects (e.g., Formal Consultation on Effects of the Proposed Los Vaqueros Reservoir Project on Delta Smelt, September 9, 1993 [USFWS 1993b]). The replacement ratio compensates for the uncertainty of the success of habitat restoration and creation, uncertainty of suitability of the restored habitat for the target species, and the potential time lag between habitat alteration and habitat replacement.

Replacement could be accomplished through independent actions taken by DW, participation in the SB 34 Delta Levees Project Management Program (Littrell pers. comm.), or participation in Category III actions under the 1995 WQCP and similar habitat restoration activities.

DW shall perform construction and maintenance activities that affect in-water habitat only during September-December, when feasible. Best management practices should be implemented to minimize sediment disturbance and to prevent toxic substances associated with construction equipment and materials from entering the Delta channels.

Effects on Water Quality

Under Alternative 3, effects of DW project operations on water quality would be similar to those described for Alternative 1. The FOC terms would not apply to Alternative 3, however, because they were designed for project operations with only two reservoir islands. Additional discharge would occur from the two additional reservoir islands and Webb Tract under Alternative 3.

Summary of Project Impacts and Recommended Mitigation Measures

Impact F-10: Increase in Temperature-Related Mortality of Juvenile Chinook Salmon. Meteorological conditions may result in water temperature on the DW reservoir islands being greater than water temperature in the adjacent Delta channels. Discharge of stored DW water could increase channel water temperature. The water quality objective for the Delta states that "the natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses" (SWRCB 1991). Water temperatures greater than 60°F may adversely affect juvenile chinook salmon survival. If water temperature in the Delta channels exceeds 60°F, an increase in channel water temperature greater than 1°F would have a significant adverse impact on juvenile chinook salmon survival.

Implementing Mitigation Measure F-2 would reduce Impact F-10 to a less-than-significant level.

Mitigation Measure F-2: Monitor the Water Temperature of DW Discharges and Reduce DW Discharges to Avoid Producing Any Increase in Channel Temperature Greater Than 1°F. DW shall monitor water temperature at appropriate time intervals in DW discharge siphons and in the receiving channels. Monitoring would be required during October-June whenever DW project water is discharged.

The volume and timing of discharge from the DW reservoir islands should be adjusted to avoid any calculated increase in channel water temperature greater than 1°F. The need for monitoring and the methodology for calculation of channel water temperature changes attributable to DW project discharge will be determined through consultation with SWRCB and the Regional Water Quality Control Board. Details will be included in the terms and conditions developed by SWRCB for the DW project.

To be consistent with the water quality objectives for the estuary and the Sacramento River at Freeport, the temperature of the discharged water may not be more than 5°F warmer than the receiving water temperature (SWRCB 1991). When the receiving water temperature is greater than 66°F during October-June, the temperature of the discharged water must be less than or equal to the temperature of the receiving water.

Impact F-11: Potential Increase in Accidental Spills of Fuel and Other Materials. Accidental spills of fuel and other materials related to recreational boat use would be concentrated at DW boat dock locations. Such spills could occur adjacent to spawning and early rearing areas of Sacramento splittail, delta smelt, and other Delta species. Because spills would have localized effects, are random, and are not an occurrence of normal project operations, this impact is considered less than significant (see also Chapter 3C, "Water Quality").

Mitigation. No mitigation is required.

Potential Flow and General Habitat Effects

This section discusses potential general effects on fish habitat, transport, and entrainment that could result from implementing Alternative 3. The FOC terms, which have been incorporated into the proposed project and reduce the potential effects of operations under Alternative 1 or 2 on outflow and salinity, would not apply to Alternative 3 because they were designed for project operations with only two reservoir islands. Therefore, as discussed in this section, the effects of Alternative 3 operations on X2 would remain as described in the 1995 DEIR/EIS.

Effects on Delta Outflow

The average monthly diversion rate under Alternative 3 would be 6,000 cfs. The maximum average daily diversion rate would be 9,000 cfs, the same as under Alternatives 1 and 2. The seasonal timing of DW project diversions under Alternative 3 would be similar to the seasonal timing of diversions under Alternative 1 shown in the 1995 DEIR/EIS (Tables 3A-7 and 3A-11 in Chapter 3A), although the magnitude of diversions would increase. The effects on outflow would also be similar to the those described for Alternative 1 in the 1995 DEIR/EIS (Table 3F-1), although outflow would be reduced more often and to a greater extent.

Effects on Salinity

Effects on X2 would be greater than those described for Alternative 1 in the 1995 DEIR/EIS (Table 3F-2). X2 would shift upstream more often under Alternative 3. The impacts of reduced outflow and upstream shift in X2 on fish habitat conditions under Alternative 3 would be similar to, but greater than, the impacts described in the 1995 DEIR/EIS for Alternative 1.

Effects on Delta Flow Patterns

The effects of DW operations under Alternative 3 on Delta flow patterns would be similar to effects described in the 1995 DEIR/EIS for Alternative 1. DCC and Georgiana Slough flows and San Joaquin River flows at Stockton would not be affected by DW operations (Appendix A3, Tables A3-5 and A3-14). The effects on QWEST volume would be greater than effects described for Alternative 1. Simulated DW operations under Alternative 3 resulted in 19 reversals of positive QWEST for the 70-year monthly simulation.

The increased magnitude and frequency of diversion under Alternative 3 would increase the rate of Old and Middle River flows to the south (Table 3F-3). Compared with the 1995 DEIR/EIS results for Alternative 1, discharge for export under Alternative 3 would result in more frequent increased Old and Middle River flow to the south during February, March, May, and June and less frequent increased flow to the south during April, July, August, and September (Appendix A3, Tables A3-7b and A3-13b).

The less frequent increases in southerly flow simulated for Old and Middle Rivers during April, July, August, and September resulted from earlier discharge to export (i.e., during February and March), which would be allowed if CVP and SWP export of discharge is not subject to strict interpretation of the 1995 WQCP criteria for percentage of inflow diverted.

The simulated pattern of discharge for export for Alternative 3 is similar to the pattern simulated for Alternative 2 in the 1995 DEIR/EIS analysis, before incorporation of the FOC into the proposed project (Appendix A3, Table A3-10b).

Potential Species-Specific Effects

Species abundance indices and habitat conditions were compared for operations under the No-Project Alternative and Alternative 3. The FOC terms and biological opinion RPMs, which reduce the potential species-specific effects of operations under Alternative 1 or 2 to a less-than-significant level, would not apply to Alternative 3 because they were designed for project operations with only two reservoir islands. Therefore, as detailed below, the species-specific effects of Alternative 3 operations would remain as described in the 1995 DEIR/EIS. Results of the assessment of effects are described below for each of the six target species of this assessment.

Chinook Salmon

The following discussions describe changes in the mortality index of juvenile chinook salmon that were estimated to result from simulated DW project operations under Alternative 3 relative to operations of the No-Project Alternative. It is assumed that DW project operations would not affect upstream operations; therefore, migration timing under Alternative 3 would be identical to migration timing under Alternative 1.

The relatively small effect of DW operations on juvenile fall-run chinook salmon originating in the Sacramento River is attributable to the timing of fall-run migration relative to timing of DW operations and is similar to the effects described for Alternative 1. Figure 3F-4 shows the Delta migration mortality for fall-run chinook salmon originating in the Sacramento River. The total Delta mortality index simulated for the 1922-1991 period under Alternative 3 ranges from about 14% to 75% of the annual production of fall-run juveniles entering the Delta (Table 3F-4). The change in the mortality index attributable to DW project operations simulated for Alternative 3 cannot be discerned in Figure 3F-4. The increase averages about 0.05% and ranges from -0.04% to 0.33%. Reduced mortality is the result of agricultural diversions being forgone during years when the reservoir islands would not fill or discharge.

Effects of DW project operations under Alternative 3 on fall-run juveniles originating in the Mokelumne and San Joaquin Rivers would be similar to, but greater than, effects described for Alternative 1.

Figure 3F-5 shows the winter-run migration mortality index attributable to all Delta diversions for the 70-year simulation. The total Delta mortality index simulated for the 1922-1991 period ranges from 6% to 17% of the annual production of winter-run chinook salmon juveniles (Table 3F-4). Simulated DW project operations under Alternative 3 changed mortality relative to mortality under the No-Project Alternative by -0.01% to 0.74% (an average of 0.18%).

The increased mortality under Alternative 3 would have a small but significant indirect adverse impact on juvenile chinook salmon greater than the effects described for Alternative 1 in the 1995 DEIR/EIS analysis.

Striped Bass

Transport. DW operations under Alternative 3 would have significant adverse impacts on transport of striped bass eggs and larvae, and the effects would be slightly greater than those described for Alternative 1 in the 1995 DEIR/EIS analysis.

Figure 3F-6 shows the total annual entrainment loss of striped bass attributable to all Delta diversions for the 70-year simulation. Total Delta entrainment loss simulated for 1922-1991 ranged from about 1% to 31% of the annual production of striped bass larvae (Table 3F-5). The simulations indicated that DW project operations under Alternative 3 could change the annual entrainment loss relative to loss under the No-Project Alternative by -0.02% to 1.7%. Reduced entrainment is the result of agricultural diversions being forgone during years when the reservoir islands would not fill or discharge.

Optimal Salinity Habitat. Change in habitat area under Alternative 3 relative to area under the No-Project Alternative ranged from -1.82 km^2 to 2.86 km^2 (average increase in area for the 70-year simulation of 0.23 km^2) (Figure 3F-7 and Table 3F-6). Increased area would result from DW agricultural diversions being forgone during May-July (the average increase in habitat area estimated for Alternative 3 is slightly greater than that estimated for Alternatives 1 and 2 because habitat island diversions are absent under Alternative 3).

Direct Entrainment. DW project diversions under Alternative 3 would cause a significant indirect entrainment impact on juvenile striped bass. Juvenile striped bass would be screened from DW reservoir and habitat island diversions under Alternative 3 and direct entrainment would be minimized.

American Shad

DW project operations under Alternative 3 would likely have less-than-significant impacts on survival of American shad. Juvenile shad would be screened from DW reservoir island diversions and the project would likely cause minimal direct entrainment. As with striped bass, indirect effects of DW project diversions could increase juvenile entrainment at the SWP and CVP Delta pumps.

Delta Smelt

Transport. DW operations under Alternative 3 would have significant adverse impacts on transport of delta smelt larvae. The effects would be slightly greater than those described in the 1995 DEIR/EIS results for Alternative 1.

Figure 3F-8 shows the total annual entrainment loss of delta smelt attributable to all Delta diversions for the 70-year simulation. Total Delta entrainment loss simulated for 1922-1991 ranges from about 1% to 36% of the annual production of delta smelt larvae (Table 3F-5). The simulations indicated that DW project operations under Alternative 3 could change the annual entrainment loss relative to loss under the No-Project Alternative by 0 to 4.1%.

Optimal Salinity Habitat. DW diversions would have less-than-significant effects on habitat area for delta smelt. Change in habitat area under Alternative 3 relative to area under the No-Project Alternative ranged from -1.61 km^2 to 2.36 km^2 (average increase in area for the 70-year simulation of 0.04 km^2) (Figure 3F-9 and Table 3F-6). Increased area would result from DW agricultural diversions being forgone during May-July.

Direct Entrainment. Juvenile and adult delta smelt would be screened from DW reservoir island diversions under Alternative 3. The DW project would likely cause minimal direct entrainment of juvenile and adult delta smelt. Indirect effects of DW project operations (i.e., effects on predation and on environmental cues that determine successful migration to the Bay), however, could increase juvenile entrainment at the SWP and CVP Delta pumps and contribute to a significant adverse impact.

Sacramento Splittail

The effects of DW operations and facilities under Alternative 3 on overall population abundance would be similar to or slightly greater than the effects described in the 1995 DEIR/EIS results for Alternative 1.

Longfin Smelt

Transport. DW operations under Alternative 3 would have less-than-significant adverse effects on transport of longfin smelt larvae. The effects would be greater than those described in the 1995 DEIR/EIS results for Alternative 1 (Table 3F-5).

Figure 3F-10 shows the total annual entrainment loss of longfin smelt attributable to all Delta diversions for the 70-year simulation. Total Delta entrainment loss simulated for 1922-1991 ranged from about 0 to 22% of the annual production of longfin smelt larvae (Table 3F-5). The simulations indicated that DW project operations under Alternative 3 could change the annual entrainment loss relative to loss under the No-Project Alternative by 0 to 9.3%.

Optimal Salinity Habitat. DW diversions under Alternative 3 would have less-than-significant adverse impacts on habitat area for longfin smelt. Change in habitat area under Alternative 3 relative to area under the No-Project Alternative ranged from -12.55 km^2 to 2.54 km^2 (average decrease in area for the 70-year simulation of 0.90 km^2) (Figure 3F-11 and Table 3F-6). The average reduction in habitat area under Alternative 3 would be slightly larger than that described in the 1995 DEIR/EIS results for Alternative 1.

Direct Entrainment. Juvenile and adult longfin smelt would be screened from DW reservoir diversions under Alternative 3. The DW project would likely cause less-than-significant impacts on direct and indirect entrainment of juvenile and adult longfin smelt.

Summary of Project Impacts and Recommended Mitigation Measures

Impact F-12: Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of DW Project Diversions and Discharges on Flows. Simulations of DW project operations show that DW project diversions and discharges for export could increase the mortality of juvenile chinook salmon out-migrating through the Delta. Increased mortality would result primarily from indirect effects of the project on central Delta flow conditions; changes in flows may affect successful migration of chinook salmon to the Bay.

Effects would be less than significant for out-migrant chinook salmon originating in the Sacramento River (including the fall, late-fall, winter, and spring runs), but could be significant for juveniles originating in the Mokelumne and San Joaquin Rivers. If DW diversions to fill the reservoir islands were made during major out-migration periods of Mokelumne and San Joaquin River chinook salmon, the impacts on the out-migrants would be significant. The impact is considered significant because nearly all the annual production of Mokelumne and San Joaquin River chinook salmon could be affected and DW diversions could substantially change cross-Delta flow. DW discharge to export would have a relatively small effect on cross-Delta flow and therefore would have less impacts on Mokelumne and San Joaquin River out-migrants.

Daily DW project effects could be greater or less than the effects described for monthly conditions in this assessment. Implementing Mitigation Measure F-3 would reduce Impact F-12 (daily and monthly) to a less-than-significant level.

Mitigation Measure F-3: Operate the DW Project under Operations Objectives That Would Minimize Changes in Cross-Delta Flow Conditions during Peak Out-Migration of Mokelumne and San Joaquin River Chinook Salmon. DW shall implement fixed and adaptive management measures that would minimize indirect entrainment losses of juvenile chinook salmon originating in the Mokelumne and San Joaquin Rivers.

Fixed Measures. DW would not divert water to fill the reservoir islands during April-June. DW project discharge to export would not be allowed to increase daily cross-Delta flow conditions (i.e., CDFP or other appropriate parameter) by more than 10% during April, May, and June. Cross-Delta flow conditions would be calculated using the fish transport model DeltaMOVE or another suitable model of transport conditions. Fixed measures would be implemented until the adaptive management plan is implemented and the effectiveness of adaptive measures has been demonstrated.

Adaptive Measures. DW, in cooperation with SWRCB and in consultation with USFWS, NMFS, and DFG, would develop an adaptive management plan that may include the following:

- **Methods to estimate the anticipated effects of DW diversions on migration of juvenile chinook salmon originating in the Mokelumne and San Joaquin Rivers**. A methodology would be developed that would provide estimates of actual or anticipated occurrence or movement of juvenile chinook salmon. The estimates may include real-time salvage of juvenile salmon at the CVP and SWP fish protection facilities or simulation of transport conditions and subsequent movement of juvenile salmon. Transport conditions (e.g., CDFP) may be simulated with the fish transport model used in this assessment (DeltaMOVE) or another suitable model of transport conditions. Estimates of transport conditions with and without DW diversions would be based on anticipated Delta diversion levels, inflows, channel flows, tidal flows, and facility operations; other chemical and physical conditions (e.g., temperature and salinity); and measured population distribution of juvenile chinook salmon. Existing or new sampling programs would be identified that provide information on the distribution of juvenile salmon out-migrants in the Delta during April and May.

- **Target migration criteria**. Target migration movement criteria may include Delta transport conditions or the proportion of the population entrained at the

SWP and CVP fish protection facilities. The target values would be based on the distribution and abundance of juvenile salmon originating in the Mokelumne and San Joaquin Rivers.

- **DW operations objectives.** Specific operations objectives for DW diversions would be developed based on the relationship between anticipated DW-affected and target migration criteria.

- **Analysis of effectiveness.** A methodology would be included that allows assessment of effectiveness of the real-time adaptive operations management plan. The methodology may consist of analysis of available data and monitoring requirements for collection of information specific to DW project operations.

- **Alternative actions.** Actions to mitigate unavoidable DW project impacts would be identified and could include adjustments to future DW diversions and non-operations actions (e.g., habitat restoration).

Impact F-13: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae. When the presence of planktonic fish eggs and larvae coincides with DW diversion and discharge to export, increased net flow to the central and south Delta could increase entrainment losses. Reduced net flow to the lower San Joaquin River and to Suisun Bay resulting from DW project diversions could, depending on distribution of fish eggs and larvae, increase vulnerability to transport toward the central and south Delta. Increased entrainment loss of eggs and larvae would be small (i.e., generally less than 1%) relative to existing losses. The impact, however, is considered significant because existing losses to other diversions potentially reduce population abundance and contribute to recent downward trends in the population abundance of striped bass, delta smelt, and longfin smelt.

Daily DW project effects could be greater or less than the effects described for monthly conditions in this assessment. Implementing Mitigation Measure F-4 would reduce Impact F-13 to a less-than-significant level.

Mitigation Measure F-4: Operate the DW Project under Operations Objectives That Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt. DW shall implement fixed and adaptive management measures that would minimize entrainment loss and adverse effects on transport (toward Suisun Bay) of planktonic eggs and larvae.

Fixed Measures. Fixed measures would be the same as described in Mitigation Measure F-3.

Adaptive Measures. DW, in cooperation with SWRCB and the Corps and in consultation with USFWS and DFG, would develop an adaptive management plan that may include the following:

  - **Methods to estimate existing and DW-affected transport indices.** The fish transport model used in this assessment (DeltaMOVE) or another suitable model of transport conditions would be used to estimate transport indices with and without DW operations based on anticipated Delta diversion levels, inflows, channel flows, tidal flows, and facility operations (e.g., DCC gates and Old River barrier); other chemical and physical conditions (e.g., temperature and salinity); and measured distribution and abundance of striped bass eggs and larvae, delta smelt larvae, and longfin smelt larvae. The daily estimation period for the indices will be appropriate to enable DW to change project operations to minimize impacts.

  - **Target transport and entrainment loss index values**. Target transport and entrainment loss index values would be identified and justified for striped bass, delta smelt, and longfin smelt. Target transport index values may be developed through the ongoing California and federal Endangered Species Act consultation with USFWS and DFG or through other appropriate means.

- **DW operations objectives**. Specific operations objectives for DW diversions and discharges for export would be developed based on the relationship between anticipated, DW-affected, and target transport and entrainment loss indices. The objectives would include flexibility to allow integration of DW project operations into the California Water Policy Council and Federal Ecosystem Directorate (CALFED) operations coordination group process.

- **Analysis of effectiveness**. A methodology would be included that allows assessment of the effectiveness of the real-time adaptive operations management plan. The methodology may consist of analysis of available data and monitoring requirements for collection of information specific to DW project operations.

- **Alternative actions**. Actions to mitigate unavoidable DW project impacts would be identified and could include adjustments to future DW operations and non-operations actions (e.g., habitat restoration).

Impact F-14: Change in Area of Optimal Salinity Habitat. As described under Impact F-6 for Alternative 1, DW project diversions could reduce Delta outflow by as much as 9,000 cfs during initial days of filling and could cause X2 to shift upstream. The upstream shift in X2 could reduce the area of optimal salinity habitat available to striped bass, delta smelt, and longfin smelt. The effect on habitat area, however, depends on the duration of the upstream shift in X2 (i.e., diversion) and the coincidence of habitat needs with operations that may affect area. The analysis of habitat area showed that DW project operations could increase habitat area during some years and reduce habitat area during others. The impact is considered less than significant because:

the change in habitat area would be small relative to the total availability of habitat;

DW diversions would be infrequent during April through August when optimal salinity habitat needs are important for production of striped bass, delta smelt, and longfin smelt (San Francisco Estuary Project 1993);

the direct effects of DW diversions on optimal salinity habitat area would be of short duration (about one month) relative to the period of estuarine habitat needs; and

forgone DW agricultural diversions during April through August could slightly increase optimal salinity habitat area.

This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact F-15: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt. When juvenile striped bass and delta smelt are distributed primarily in the Delta, export of the first uncontrolled flow to occur during a water year (i.e., uncontrolled flow during November-January) results in high entrainment at the SWP and CVP Delta export pumps. DW project diversions could alter Delta flow patterns; affect environmental cues that determine successful migration to the Bay; and, subsequently, increase entrainment losses of striped bass and delta smelt at the SWP and CVP Delta pumps. This impact is considered significant because losses of juveniles would potentially reduce population abundance and may contribute to recent downward trends in the population abundance of striped bass and delta smelt.

Daily DW project effects could be greater or less than the effects described for monthly conditions in this assessment. Implementing Mitigation Measure F-5 would reduce Impact F-15 to a less-than-significant level.

Mitigation Measure F-5: Operate the DW Project under Operations Objectives That Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt. DW shall implement fixed and adaptive management measures that would minimize entrainment loss of juvenile striped bass and delta smelt during November-January diversions by DW.

Fixed Measures. During November-January, DW would not divert to fill the reservoir islands until after X2 is at or downstream of Chipps Island for any 5 consecutive days. After the Chipps Island criterion is met, DW

would divert to fill the reservoir islands only when X2 is at or downstream of Collinsville.

Adaptive Measures. DW, in cooperation with SWRCB and the Corps and in consultation with USFWS and DFG, would develop an adaptive management plan that may include the following:

- **Methods to estimate the anticipated effects of DW diversions on entrainment of juvenile striped bass and delta smelt**. A methodology would be developed that would provide estimates of actual or anticipated entrainment of juvenile striped bass and delta smelt. The estimates may include real-time salvage of striped bass and delta smelt at the CVP and SWP fish protection facilities or simulation of transport conditions and subsequent entrainment of bass and smelt. Transport conditions (e.g., CDFP) may be simulated with the fish transport model used in this assessment (DeltaMOVE) or another suitable model of transport conditions. Estimates of transport conditions with and without DW diversions would be based on anticipated Delta diversion levels, inflows, channel flows, tidal flows, and facility operations; other chemical and physical conditions (e.g., temperature and salinity); and measured population distribution of juvenile striped bass and delta smelt. Existing or new sampling programs would be identified that provide information on the distribution in the Delta and Suisun Bay during November-January.

- **Target entrainment values**. DW intakes will include effective fish screens and DW diversions would not directly entrain juvenile striped bass and delta smelt. Target entrainment values may be established for DW project operations based on entrainment at the SWP and CVP fish protection facilities. The target values would be based on the distribution and abundance of juvenile striped bass and delta smelt.

- **DW operations objectives.** Specific operations objectives for DW diversions would be developed based on the relationship between anticipated DW-affected and target entrainment criteria.

- **Analysis of effectiveness.** A methodology would be included that allows assessment of effectiveness of the real-time adaptive operations management plan. The methodology may consist of analysis of available data and monitoring requirements for collection of information specific to DW project operations.

- **Alternative actions.** Actions to mitigate unavoidable DW project impacts would be identified and could include adjustments to future DW diversions and non-operations actions (e.g., habitat restoration).

Impact F-16: Increase in Entrainment Loss of Juvenile American Shad and Other Species. The impact is described above under Impact F-8. The impact is considered less than significant.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The No-Project Alternative (intensified agricultural use of the four DW project islands) represents Delta water supply conditions under implementation of the 1995 WQCP. Consumptive use would not measurably increase above existing conditions (see Chapter 3A, "Water Supply and Water Project Operations"). DW operations, Delta channel flows, exports, and Delta outflow as simulated for the 1995 DEIR/EIS are shown for the No-Project Alternative in Tables 3A-4 and 3A-5 in Chapter 3A and Tables A3-5 and A3-6 in Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives".

The "Affected Environment" section above and Appendix F1, "Supplemental Information on the Affected Environment for Fisheries", discuss historical conditions and the existing condition prior to implementation of the 1995 WQCP. The analysis of implementation of the 1995 WQCP and comparison with conditions prior to implementation of the 1995 WQCP is presented in Appendix 1, "Environmental Report", of the 1995 WQCP (SWRCB 1995).

Under the No-Project Alternative, the adverse effects of levee maintenance, discharge of agricultural drainage water, and unscreened agricultural diversions on the four DW project islands would continue, as would ongoing adverse effects of water project operations and facilities. Under the No-Project Alternative, simulated mortality indices for juvenile chinook salmon in the 1995 DEIR/EIS analysis ranged from about 14% to 75% for fall run and from about 6% to 17% for winter run (Table 3F-4, Figures 3F-4 and 3F-5). Entrainment indices for the 70-year simulation averaged 26% for striped bass, 27% for delta smelt, and 8% for longfin smelt (Table 3F-5, Figures 3F-6, 3F-8, and 3F-10). The simulated available optimal salinity habitat area averaged 76 km^2 for striped bass, 51 km^2 for delta smelt, and 174 km^2 for longfin smelt (Table 3F-6, Figures 3F-7, 3F-9, and 3F-11).

Ongoing actions under the California and federal Endangered Species Acts (for winter-run chinook salmon, delta smelt, and possibly other species) may address adverse effects under the No-Project Alternative. Implementation of fish protection recommendations by the CALFED operations coordination group may also avoid or minimize adverse effects of water project operations that may occur under the No-Project Alternative.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. DW project effects on fishery resources are inextricably tied to past and present environmental conditions. The cumulative impacts of the DW project alternatives therefore were evaluated in conjunction with past and present actions in the previous sections. The focus of this section is on evaluation of the impacts of the DW project alternatives added to impacts of other future projects.

The following discussion considers only those project effects that may contribute cumulatively to impacts on fishery resources in the Sacramento-San Joaquin Delta estuary and in streams and rivers tributary to the Delta. This cumulative impact evaluation is based on the following scenario: increased upstream demands; increased demands south and west of the Delta; an increased permitted pumping rate at the Banks Pumping Plant (see Chapter 3A, "Water Supply and Water Project Operations"); implementation of the DWR South and North Delta Projects; and additional storage south of the Delta in the Kern Water Bank, Los Banos Grandes Reservoir, Metropolitan Water District's Diamond Valley Reservoir and Arvin-Edison projects, and the CCWD Los Vaqueros Reservoir.

Cumulative Impacts, Including Impacts of Alternative 1

As described above for direct impacts of the proposed project, the cumulative fishery impacts identified for Alternative 1 in the 1995 DEIR/EIS, as described in this section, have all subsequently been addressed by the FOC and RPMs included in the no-jeopardy biological opinions issued by NMFS, USFWS and DFG. (See Chapter 2 and the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions".)

Incorporation of the FOC and RPMs into the proposed project reduces the impacts previously identified as significant to a less-than-significant level. In addition, it further reduces the impacts identified as less than significant in the 1995 DEIR/EIS. For details on these changes, see the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Effects of Construction Activities

Future construction activities in the Delta will include continued maintenance of existing channels (dredging) and levees (placement of riprap and other levee reinforcement measures). New facilities (e.g., marinas, channel barriers) may be constructed as well, and existing channels may be modified to allow passage of boats or for conveyance of flow (e.g., the DWR North and South Delta Projects). Spawning and rearing habitat of delta smelt, Sacramento splittail, and other Delta species would be lost or altered. Existing programs and regulations (Corps and DFG regulations) would minimize or mitigate impacts. Additionally, habitat availability may be increased with implementation of existing programs (e.g., actions implemented as part of Category III measures in the Principles of Agreement on Bay-Delta Standards, Anadromous Fish Restoration Program under the CVPIA, and the SB34 Program, Delta Levees Project Management).

Impact F-17: Alteration of Habitat under Cumulative Conditions. Under future conditions, DW and others (e.g., DWR and reclamation districts) would maintain levees, boat docks, and intake and discharge facilities. Maintenance activities would include dredging and replacement of riprap. Alteration of spawning and rearing habitat under future conditions would adversely affect localized reproduction of delta smelt, Sacramento splittail, and resident species. The amount of habitat affected by construction and maintenance activities under cumulative conditions would be small relative to the total amount of similar habitat in the Delta, and the effects would generally be temporary. Additionally, total Delta habitat would likely increase under existing and future Delta programs (e.g., actions implemented as part of Category III measures in the Principles of Agreement on Bay-Delta Standards, Anadromous Fish Restoration Program under the CVPIA, and the SB34 Program, Delta Levees Project Management). Therefore, the 1995 DEIR/EIS concluded that this impact would be less than significant.

Additionally, the FOC and biological opinion RPMs developed after the 1995 DEIR/EIS was published include measures that ensure that this potential project effect would be less than significant. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Effects on Water Quality

The 1995 DEIR/EIS concluded that future water quality conditions (i.e., water temperature and concentrations of organic materials, toxics, and DO) in the Delta would be similar to conditions described for DW project operations in the discussions above. The effects of minor fuel and lubricant spills from individual boat engines and other boat-related discharge could be concentrated at Delta boat dock locations and could affect local populations of fish. These effects would increase under future conditions (see Chapter 3J, "Recreation and Visual Resources") because of increased boat-related activities. As described above, DW has removed construction of recreation facilities from its CWA permit applications; nevertheless, the analysis of impacts on fishery resources below assumes that the recreation facilities would be constructed and operated.

Impact F-18: Potential Increase in Accidental Spills of Fuel and Other Materials under Cumulative Conditions. This impact is described above under Impact F-3. This impact was considered in the 1995 DEIR/EIS analysis to be less than significant. Additionally, the FOC terms include measures intended to compensate for the potential effects of recreational boat use on aquatic habitat. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Potential Flow and General Habitat Effects

Increased demands for water could increase fluctuation in Shasta Reservoir storage, which would adversely affect riverine conditions. Upstream conditions for fish (e.g., water temperature) may continue to deteriorate. Compliance with measures included in the CVP-OCAP winter-run biological opinion (NMFS 1993, 1995) would limit adverse effects on winter-run chinook salmon.

If DW project water is purchased by the CVP and the SWP and the DW project is integrated into CVP and SWP operations, upstream conditions could be affected. Water discharged from the DW reservoir islands to supplement Delta outflow or for CVP and SWP export may modify upstream releases from Shasta, Oroville, and Folsom Dams. In general, reservoir water could be stored for longer periods rather than being released to meet Delta flow needs.

Without specific criteria to reduce Delta habitat degradation (including entrainment losses), ongoing factors and future projects could reduce the survival and abundance of all the species included in this assessment. Ongoing and future actions intended to improve fishery conditions, however, have the potential to reduce Delta and upstream habitat degradation and, consequently, reverse the downward trend in abundance that has characterized the change in many fish populations for at least the last 20-30 years (Appendix F1, "Supplemental Information on the Affected Environment for Fisheries", and Appendix F2, "Biological Assessment: Impacts of the Delta Wetlands Project on Fish Species"). Ongoing and future actions may include:

potential implementation of fish protection recommendations by the CALFED operations coordination group to avoid adverse effects of water project operations (includes integration with the existing biological opinions for winter-run chinook salmon and delta smelt [NMFS 1995, USFWS 1995]),

implementation of Category III, "Non-Flow Factors", as specified in the Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government (SWRCB 1995),

reinitiation of consultation under the federal Endangered Species Act to address exceedance of incidental take, impacts on winter-run chinook salmon or delta smelt not previously considered, listing of new species or designation of critical habitat that may be affected by water project operations, and

implementation of actions included in the Anadromous Fish Restoration Program under the CVPIA.

DW project operations depend on the availability of surplus flows. Under future conditions, surplus flows are likely to be less available than under existing conditions. Reduced availability of surplus flow could result from operations that reduce the frequency of spill from upstream reservoirs, reduction of Delta surplus flows because of buildout by senior water right holders, and changes in the criteria that define surplus flows relative to beneficial uses of water in the Delta (e.g., the ongoing SWRCB actions relative to the 1995 WQCP).

Cumulative Delta flow conditions and exports estimated in the 1995 DEIR/EIS analysis for the No-Project Alternative and Alternative 1 are presented in Tables 3A-12 through 3A-15 in Chapter 3A. DW project diversion patterns for Alternative 1 simulated for 1995 WQCP conditions (Table 3A-7 in Chapter 3A) were similar to the diversion patterns for cumulative conditions (Table 3A-15 in Chapter 3A). The major difference is that under cumulative conditions, less water would be available for DW to divert.

Patterns of DW discharge for export under Alternative 1 simulated in the 1995 DEIR/EIS analysis for 1995 WQCP conditions (Table 3A-7 in Chapter 3A) were similar to the patterns of discharge for export for cumulative conditions (Table 3A-15 in Chapter 3A). For Alternative 1, discharge for export under cumulative conditions shifted to July and away from August and September. This occurred because of the assumed increased pumping rate of the SWP pumps and because the percent inflow standard is rarely limiting during July. The magnitude of discharge for export simulated during the other months, however, was similar because of the reduction in stored water available for discharge.

The effect of the DW project operations under cumulative future conditions would be similar to or less than the direct project effects described in the 1995 DEIR/EIS assessment results shown above because less water would be available for DW to divert.

Potential Species-Specific Effects

The 1995 DEIR/EIS analysis concluded that the species-specific effects of Alternative 1 under cumulative conditions would be similar to the direct effects described above under "Impacts and Mitigation Measures of Alternative 1" because flow and habitat effects of DW project operations would be similar. The following impacts were identified.

Impact F-19: Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of Diversions and Discharges on Flows under Cumulative Conditions. This impact is described above under Impact F-4. The impact was considered significant in the 1995 DEIR/EIS analysis, and Mitigation Measure F-3 (Operate the DW Project under Operations Objectives That Would Minimize Changes in Cross-Delta Flow Conditions during Peak Out-Migration of Mokelumne and San Joaquin River Chinook Salmon) was identified to reduce the impact to a less-than-significant level. With the FOC and

RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-3 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-20: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae under Cumulative Conditions. This impact is described above under Impact F-5. The impact was considered significant in the 1995 DEIR/EIS analysis, and Mitigation Measure F-4 (Operate the DW Project under Operations Objectives That Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt) was identified to reduce the impact to a less-than significant level. With the FOC and RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-4 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-21: Change in Area of Optimal Salinity Habitat under Cumulative Conditions. The impact is described above under Impact F-6. This impact was considered less than significant in the 1995 DEIR/EIS analysis. Additionally, the FOC terms ensure that this cumulative impact would be less than significant.

Mitigation. No mitigation is required.

Impact F-22: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt under Cumulative Conditions. This impact is described above under Impact F-7. The impact was considered significant in the 1995 DEIR/EIS analysis, and Mitigation Measure F-5 (Operate the DW Project under Operations Objectives That Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt) was identified to reduce the impact to a less-than significant level. With the FOC and RPMs incorporated into the proposed project, this potential impact is now less than significant and Mitigation Measure F-5 is no longer required. See the section from the 2000 REIR/EIS below entitled "Changes in the Proposed Project: Final Operations Criteria and Biological Opinions"; see also Table 3F-11.

Mitigation. No mitigation is required.

Impact F-23: Increase in Entrainment Loss of Juvenile American Shad and Other Species under Cumulative Conditions. The impact is described above under Impact F-8. This impact was considered less than significant in the 1995 DEIR/EIS analysis. Additionally, the FOC terms provide further assurance that this cumulative impact would be less than significant.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative effects of construction activities under Alternative 2 would be identical to those described for Alternative 1. The cumulative effects of project operations on water quality and cumulative species-specific effects also would be the same under Alternative 2 as under Alternative 1.

The potential flow and general habitat effects shown in the 1995 DEIR/EIS for Alternative 2 under cumulative conditions were similar to those shown for 1995 WQCP conditions. The patterns of discharges were found to be similar, except that discharges for export were shown to be less under cumulative conditions in August and September.

The same mitigation measures were recommended in the 1995 DEIR/EIS for Alternative 2 as for Alternative 1. However, incorporating the FOC and RPMs into the proposed project has rendered all the fishery impacts identified in the 1995 DEIR/EIS for Alternative 2 under cumulative conditions less than significant, and the mitigation measures recommended in the 1995 DEIR/EIS are no longer required.

Cumulative Impacts, Including Impacts of Alternative 3

The FOC terms, which have been incorporated into the proposed project and reduce the potential effects of Alternative 1 or 2 operations on fisheries under cumulative conditions, would not apply to Alternative 3 because they were designed for project operations with only two reservoir islands. Therefore, as detailed below, the effects of Alternative 3 operations under cumulative conditions would remain as described in the 1995 DEIR/EIS.

Effects of Construction Activities

Effects of construction activities under Alternative 3 would be the same as described in the 1995 DEIR/EIS analysis results for Alternative 1.

Effects on Water Quality

Under Alternative 3, effects of DW project operations on water quality would be the same as described in the 1995 DEIR/EIS analysis results for Alternative 1.

Potential Flow and General Habitat Effects

Potential flow and habitat effects under Alternative 3 are similar to effects described in the 1995 DEIR/EIS analysis results for Alternative 1. Cumulative Delta flow conditions and exports for the No-Project Alternative and Alternative 3 are presented in Tables 3A-12, 3A-13, 3A-18, and 3A-19 in Chapter 3A. DW project diversion patterns for Alternative 3 simulated for 1995 WQCP conditions (Table 3A-11 in Chapter 3A) were similar to the diversion patterns for cumulative conditions (Table 3A-19 in Chapter 3A). The major difference is that under cumulative conditions, less water would be available for DW to divert. For Alternative 3, some diversion would shift to December and January when storm events are generally larger and water is available to meet both the increased diversions of the SWP and the CVP and diversions onto the DW reservoir islands.

Patterns of DW discharge for export under Alternative 3 simulated for 1995 WQCP conditions (Table 3A-11 in Chapter 3A) were similar to the patterns of discharge for export for cumulative conditions (Table 3A-19 in Chapter 3A). For Alternative 3, simulated discharges for export for August and September were absent or reduced under cumulative conditions. DW stored water would be discharged and exported earlier because of the increased SWP pumping rate. The magnitude of discharge for export simulated during the other months, however, was similar because of the reduction in stored water available for discharge.

The effect of the DW project operations under cumulative future conditions would be similar to or less than the effects described previously in this assessment.

Potential Species-Specific Effects

Significant species-specific impacts and mitigation measures under Alternative 3 would be the same as described in the 1995 DEIR/EIS analysis results for Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Under the No-Project Alternative, consumptive use on the DW islands would not measurably increase above existing conditions (see Chapter 3A, "Water Supply and Water Project Operations"). DW operations under the No-Project Alternative would contribute minimally to cumulative impacts on fish species or habitat in the Delta.

ANALYSIS OF FISHERIES FROM THE 2000 REVISED DRAFT EIR/EIS

The remainder of this chapter includes the additional analysis of effects of the proposed project on fisheries that was conducted for the 2000 REIR/EIS. This information, which was presented as Chapter 5, "Fisheries", of the 2000 REIR/EIS, has been modified slightly from the 2000 REIR/EIS version in response to comments received on the 2000 REIR/EIS. Those changes do not change the conclusions of the analysis.

INTRODUCTION

This section of Chapter 3F updates the 1995 DEIR/EIS assessment of Delta Wetlands Project effects on fish species. The 1995 DEIR/EIS assessment focused on the project's effects on chinook salmon *(Oncorhynchus tshawytscha)*, steelhead *(O. mykiss)*, striped bass *(Morone saxatalis)*, American shad *(Alosa sapidissima)*, delta smelt *(Hypomesus transpacificus)*, splittail *(Pogonichthys macrolepidotus)*, and longfin smelt *(Spirinchus thaleichthys)*, all representative fish species that reside in the Delta, Suisun Bay, and San Francisco Bay for at least part of their lives. It examined project effects on habitat conditions that support these species and on factors that affect the species' abundance and distribution. The effects of Delta Wetlands Project facilities and operations on changes in Delta flows, water quality, local habitat conditions, and entrainment of fish in diversions were analyzed using simulations of project operations, data on fish habitat conditions, and information about the distribution and timing of fish life stages in the Delta.

After the 1995 DEIR/EIS was released, DFG, USFWS, and NMFS issued no-jeopardy biological opinions on Delta Wetlands Project effects on listed species (Appendices C, D, and E of the 2000 REIR/EIS). The findings of no jeopardy for fish species are based on the inclusion of the FOC terms agreed to by Delta Wetlands during ESA consultation and the implementation of additional RPMs described in the biological opinions. By incorporating the FOC into proposed project operations, Delta Wetlands has modified the proposed project specifically to avoid or reduce effects on fish. As a result, conditions for fish under the project operations evaluated in this REIR/EIS will be improved from those conditions described in the 1995 DEIR/EIS analysis. With the FOC and RPMs in place, the significant impacts on fish habitat and populations identified in the 1995 analysis are reduced to a less-than-significant level.

FOCUS OF THE 2000 REVISED DRAFT EIR/EIS ANALYSIS

The terms of the FOC and the RPMs in the state and federal biological opinions address many of the concerns expressed in comments on the 1995 DEIR/EIS. The evaluation of project effects on fish species has been updated below to show how application of these measures will reduce project effects from those identified in the 1995 DEIR/EIS. This portion of the chapter also:

discusses listings of fish species that have occurred since 1995 and the relevance of the 1995 DEIR/EIS analysis and the completed state and federal ESA consultations to assessment of project effects on those species, and

evaluates the following information in response to concerns stakeholders expressed at the water right hearing or in comments on the 1995 DEIR/EIS:

  – new DFG data on spring-run chinook salmon and use of these data in the chinook salmon mortality model,

  – new EBMUD data on Mokelumne River chinook salmon, and

  – information regarding potential increases in predation with the construction of Delta Wetlands boat docks and other facilities.

Summary of Issues Addressed in This Chapter

The REIR/EIS analysis of fisheries addresses the following questions:

How do the final terms of the federal and state biological opinions affect the analysis of fishery impacts and mitigation measures presented in the 1995 DEIR/EIS?

How does incorporation of new data on spring-run chinook salmon affect the conclusions related to salmon mortality presented in the 1995 DEIR/EIS?

Will Delta Wetlands Project operations significantly affect Mokelumne River anadromous fish, including outmigrating juvenile salmon, rearing juveniles, outmigrating hatchery-released fall yearlings, and returning adults?

Will the Delta Wetlands Project's proposed boat docks and intake/discharge facilities affect predation in Delta waterways?

Definition of Terms

The following are definitions of key terms as they are used in this chapter:

Anadromous Species: Fishes that mature in marine waters and migrate to fresh water to spawn.

Endangered Species: Any plant or animal species or subspecies whose survival is threatened with extinction and that is included in the federal or state list of endangered species.

Entrainment: The process in which fish are drawn into water diversion facilities along with water drawn from a channel or other water body by siphons and/or pumps. Entrainment loss includes all fish not salvaged (i.e., eggs, larvae, juveniles, and adults that pass through the fish screens, are impinged on the fish screens, or are eaten by predators).

Evolutionarily Significant Unit (ESU): A distinctive group of Pacific salmon or steelhead.

Riprap: A stone covering used to protect soil or surfaces from erosion by water or the elements.

Smolt: A juvenile chinook salmon or steelhead that has undergone physiological change enabling it to survive in saltwater.

Spawning: Laying of eggs, especially by fish.

Take: A term used in Section 9 of the federal ESA that includes harassment of and harm to a species, entrainment, directly and indirectly caused mortality, and actions that adversely modify or destroy habitat.

Threatened Species: A species that is likely to become endangered in the foreseeable future and is included in the federal or state list of threatened species.

CHANGES IN THE PROPOSED PROJECT: FINAL OPERATIONS CRITERIA AND BIOLOGICAL OPINIONS

Following the release of the 1995 DEIR/EIS, USACE and SWRCB concluded consultation with USFWS, NMFS, and DFG on potential effects of the Delta Wetlands Project on fish species listed or proposed for listing under the federal and state ESAs. During the consultation process, the SWRCB, USACE, and the project proponent worked with the resource agencies to revise the project to reduce or avoid adverse effects on fish species. The FOC measures are the result of that effort. The consultations also resulted in no-jeopardy biological opinions from USFWS and NMFS under the federal ESA and a no-jeopardy biological opinion from DFG under the state ESA. To minimize the impacts of incidental taking of fish species, the opinions include RPMs for the project. The FOC and RPMs also provide adequate protection to prevent significant impacts on nonlisted fish species (e.g., striped bass, American shad).

The FOC and RPMs change the conditions under which the Delta Wetlands Project could operate; these measures or criteria are more restrictive than the operations analyzed in the 1995 DEIR/EIS, so fisheries effects would be further reduced. The following section summarizes the changes in project operations that would result from the FOC and measures included in the federal and state biological opinions.

Final Operations Criteria

The FOC terms were developed in response to anticipated impacts of the proposed project, as analyzed in the 1995 DEIR/EIS, on fish species protected under the state and federal ESAs. To avoid or minimize the Delta Wetlands Project's effects on Delta fish populations and habitat, the FOC terms primarily revise the timing and magnitude of allowable diversions for storage and discharges for export or outflow. These restrictions are summarized in Table 2-6. Delta Wetlands also agreed to implement the following measures as part of the FOC:

Meet design criteria for fish screens of 0.2 feet per second (fps) approach velocity.

Conserve in perpetuity 200 acres of shallow-water rearing and spawning habitat.

Contribute $100 per year for boat-wake-erosion mitigation for each boat berth constructed beyond preproject conditions.

Mitigate on a 3:1 basis for the loss of aquatic habitat to construction activities.

Minimize and avoid adverse effects of discharge through changes in water temperature.

Minimize and avoid adverse effects of discharge through changes in dissolved oxygen.

Compensate for incidental entrainment losses of striped bass, American shad, delta smelt, splittail, and longfin smelt from January through March and June through August (no diversions are permitted in April and May).

Limit in-water construction to June through November.

Implement a fish monitoring program that includes:

- in-channel monitoring during diversions from December through August,
- on-island monitoring during diversions,
- monitoring during discharge for export from April through August,
- reporting,
- sample handling protocol,
- coordination with IEP monitoring, and
- a monitoring technical advisory committee.

The full text of the FOC is included in Appendix B of the 2000 REIR/EIS.

Reasonable and Prudent Measures in the Biological Opinions

In their biological opinions for the protection of delta smelt and winter-run chinook salmon, DFG, NMFS, and USFWS specified RPMs that supplement the FOC measures agreed to by Delta Wetlands. These measures are nondiscretionary. Delta Wetlands is required to implement them. Therefore, the measures are included here as modifications to proposed project operations or as additional requirements for mitigating project effects on these listed species.

California Department of Fish and Game Biological Opinion

DFG issued a revised biological opinion in August 1998 regarding effects of the Delta Wetlands Project on state-listed species (California Department of Fish and Game 1998). The full text of the biological opinion is included in Appendix C of the 2000 REIR/EIS. Following is a summary of the RPMs in the DFG biological opinion for the protection of delta smelt and winter-run chinook salmon. (The numbers refer to the original numbering in the biological opinion; missing numbers are for measures that pertain to the protection of terrestrial plant and wildlife species and requirements for communicating information to DFG.)

1.0 Delta Wetlands diversion to storage in March is limited by QWEST. (As mentioned in Chapter 3A, this is a calculated flow parameter representing net flow between the central Delta and the western Delta.)

2.0 Delta Wetlands will establish an environmental water fund to be controlled by DFG; the amount deposited into the fund will be based on the amount of project diversions from October through March and the amount of project discharge.

4.0 Aquatic habitat development measures will be implemented to offset impacts of moving X2 upstream from February through June.

6.0 Aquatic species monitoring will be implemented to minimize adverse impacts of take.

12.0 Fish screens will comply with DFG's fish screen policy.

15.0 Employee orientation on sensitive-species protection will be provided.

16.0 DFG will be notified of dead, injured, and entrapped state-listed species.

17.0 Compliance inspections will be conducted weekly during construction, assessing Delta Wetlands' compliance with the measures of DFG's biological opinion; compliance will be reported and confirmed.

18.0 Delta Wetlands will allow DFG access to the project site.

19.0 In lieu of monitoring for the entrainment of eggs, larvae, and fry as described in FOC measure 7, Delta Wetlands will provide funds to DFG based on the amount of water diverted to storage from January through March and from June through August. These funds will compensate for incidental entrainment.

20.0 Delta Wetlands will establish an aquatic habitat restoration fund.

National Marine Fisheries Service Biological Opinion

NMFS issued a biological opinion on Delta Wetlands Project effects on winter-run chinook salmon in May 1997 (National Marine Fisheries Service 1997). The full text of the biological opinion is included in Appendix D of the 2000 REIR/EIS. The following is a summary of the RPMs specified by NMFS:

1. Properly designed fish screens will be used to reduce entrainment and predation during Delta Wetlands diversion operations.

2. Degradation of Delta habitat during construction, operation, and maintenance activities will be reduced.

3. Appropriate sampling and processing procedures will be used to reduce impacts on juvenile winter-run chinook salmon from discharge monitoring activities.

4. Delta Wetlands operations and daily Delta hydrologic conditions will be monitored.

U.S. Fish and Wildlife Service Biological Opinion

USFWS issued a biological opinion on Delta Wetlands Project effects on delta smelt in May 1997 (U.S. Fish and Wildlife Service 1997). The full text of the biological opinion is included in Appendix E of the 2000 REIR/EIS. The following is a summary of the RPMs specified by USFWS:

1. Immersed plants will be avoided when riprap is placed and when recreation facilities and diversion and discharge structures are built.

2. Submersed aquatic plants will be avoided when riprap is placed and during all in-water work associated with constructing project facilities; in-water work will be limited to June through November.

3. The FOC and a fish monitoring program will be implemented.

An analysis of Delta Wetlands Project impacts under the FOC and RPMs developed during ESA consultation is presented below under "Environmental Consequences".

AFFECTED ENVIRONMENT: RELEVANT OR NEW INFORMATION

The fishery resources chapter (Chapter 3F) and Appendices F1 and F2 of the 1995 DEIR/EIS describe the life histories of Delta fish species and factors affecting their population abundance. Refer to those sections for an overview of Delta fish and their habitats. After the 1995 DEIR/EIS was released, some additional fish species were listed as threatened or endangered under the federal and state ESAs; these listings are described below. Also, the lead agencies received additional information about chinook salmon survival and abundance. DFG provided these data for spring-run chinook salmon throughout the Delta, and EBMUD provided data for fall-run chinook salmon in the Mokelumne River. A literature review regarding enhanced feeding activity by predator species associated with boat docks and other in-water structures was also completed to address the comments received on the 1995 DEIR/EIS and during the water right hearing.

New Species Listings and Endangered Species Act Consultation Status

Additional Species Listed under the California and Federal Endangered Species Acts

Since the release of the 1995 DEIR/EIS, three additional species of fish that occur in the Delta have been listed as threatened under the federal ESA. These new listings are:

Central Valley steelhead ESU (63 FR 11481, March 9, 1998),

splittail (64 FR 5963, February 8, 1999), and

Central Valley spring-run chinook salmon ESU (64 FR 50394, September 16, 1999).

Spring-run chinook salmon was also listed as threatened under the California ESA on February 5, 1999. In addition, the Delta has been designated critical habitat for steelhead and spring-run chinook salmon under the federal ESA (65 FR 7764, February 16, 2000).

Status of Consultation

The 1995 DEIR/EIS fully addressed potential effects of the Delta Wetlands Project on splittail and steelhead. In addition, because these species were proposed for listing at the time, the biological assessment prepared for the Delta Wetlands Project (Appendix F2 in the 1995 DEIR/EIS) analyzed project effects on splittail and steelhead.

The final biological opinion of "no jeopardy" received from NMFS on winter-run chinook salmon (Appendix D of the 2000 REIR/EIS) also contained a "conference opinion" for the Central Valley ESU steelhead. (Similar to a biological opinion for listed species, a conference opinion is applicable to species proposed for listing.) This conference opinion found that the Delta Wetlands Project would not jeopardize the continued existence of steelhead. NMFS formally adopted the conference opinion as its biological opinion on steelhead for the Delta Wetlands Project on May 19, 2000 (see the Appendix to the Responses to Comments volume of this FEIS).

Similarly, the final biological opinion of "no jeopardy" received from USFWS on delta smelt (Appendix E of the 2000 REIR/EIS) included a conference opinion for splittail, which found that the Delta Wetlands Project would not jeopardize the continued existence of splittail. USFWS has formally adopted the conference opinion as its biological opinion on splittail for the Delta Wetlands Project (see Appendix E of the 2000 REIR/EIS). Therefore, no additional consultation is needed to address Delta Wetlands Project effects on splittail.

In 1999, to address potential project effects on Central Valley ESU spring-run chinook salmon, USACE requested consultation with NMFS pursuant to Section 7 of the federal ESA. USACE noted that the project's FOC and other measures to be implemented as RPMs under the federal and California ESA biological opinions for the other species cover the period when spring-run chinook salmon occur in the Delta and, therefore, would minimize adverse effects of the project on spring-run chinook salmon as well. NMFS concurred with this conclusion; in August 2000, NMFS issued a biological opinion that states that the project is not likely to jeopardize the continued existence of spring-run chinook salmon or result in the adverse modification of its critical habitat or that of Central Valley steelhead ESU. NMFS's biological opinion on spring-run chinook salmon is included in the Appendix to the Responses to Comments volume of this FEIS.

DFG's biological opinion on project effects on delta smelt and winter-run chinook salmon also assessed Delta Wetlands' impacts on spring-run chinook salmon, but it made no conclusions about effects on this species because the species was not listed at the time. The RPMs were indicated as minimizing adverse impacts of the incidental taking of spring-run chinook salmon and of the fish species that were then listed. In accordance with Section 2081 of the California Fish and Game Code, Delta Wetlands has requested concurrence directly from DFG that the protective measures in the existing biological opinion adequately address potential project effects on spring-run chinook salmon. DFG will indicate whether additional information or analysis is required to complete consultation pursuant to the California ESA.

New California Department of Fish and Game Data on Spring-Run Chinook Salmon

On August 13, 1999, DFG gave the lead agencies new information about juvenile spring-run chinook salmon occurrence in the Delta (Wernette pers. comm.). The extent of occurrence of juvenile spring-run chinook salmon assumed in the 1995 DEIR/EIS assessment generally corresponds to the extent of occurrence in the information provided by DFG (Table 3F-7).

DFG also furnished new information about the assumed survival of spring-run chinook salmon during migration through the Delta (Wernette pers. comm.). The survival information was incorporated into the chinook salmon mortality model as described below under "Environmental Consequences".

East Bay Municipal Utility District Data on Mokelumne River Chinook Salmon

During the water right hearing and the review period for the 1995 DEIR/EIS, EBMUD commented that the 1995 DEIR/EIS did not adequately address Delta Wetlands Project effects on Mokelumne River anadromous fish (i.e., fall-run chinook salmon and steelhead). The impact of Delta Wetlands diversions on juvenile chinook salmon originating from the Mokelumne River was considered significant in the 1995 DEIR/EIS and mitigation was identified.

In response to EBMUD's comment, the lead agencies asked EBMUD to provide data about tracking and movement of Mokelumne River fish, including timing data for juvenile migration. EBMUD provided raw data in spreadsheet and database files, including tables of summary statistics and summary histograms (Miyamoto pers. comm.). The data provided include adult spawning escapement for 1993-1998 (Table 3F-8), juvenile outmigration for 1994-1999 (Table 3F-9), and coded wire tag data for 1991-1998. This information was used in the revised assessment of Delta Wetlands Project effects on Mokelumne River chinook salmon described below under "Environmental Consequences".

Delta Wetlands Project Facilities and Fish Predation

A literature search was completed to update information presented in the 1995 DEIR/EIS about predation, including potential effects of boat docks and intake/discharge facilities on prey species vulnerability and predator species success. As described below, this information has been used to augment the discussion of potential effects of the project on predation presented in the 1995 DEIR/EIS.

IMPACT ASSESSMENT METHODOLOGY FOR THE 2000 REVISED DRAFT EIR/EIS

Assessment of Delta Wetlands Project effects on Delta fish species and their habitat involves predicting fish and habitat responses to changes in Delta conditions that could result from project operations. The 1995 DEIR/EIS impact assessment used a variety of methods, including:

Delta Wetlands Project operation modeling that determined changes in Delta flows (see Chapter 3A, “Water Supply and Water Project Operations”);

water quality modeling that determined changes in Delta salinity and assessed other factors that could affect fish species and the amount of estuarine habitat available to them (see Chapter 3C, “Water Quality”);

an entrainment index that was used to represent changes in potential entrainment of fish at the Delta Wetlands diversion facilities and the SWP and CVP pumping plants; and

a salmon smolt survival model (mortality index) that was modified from the model developed by USFWS (Kjelson et al. 1989).

These methods were also used in the ESA consultation process; the results of the ESA consultation were the basis for the changes in the project described by the FOC and the RPMs.

For the analysis presented below, Delta Wetlands Project operations modeling was used to determine changes in Delta flows under the FOC and RPMs (see Chapter 3A, “Water Supply and Water Project Operations”). The following summarizes the contents of this analysis:

Because the FOC and RPMs improve conditions for fish, the project’s effects as identified in the 1995 DEIR/EIS are compared with effects under the FOC and RPMs.

Potential effects of the Delta Wetlands Project on spring-run chinook salmon are assessed using the new data provided by DFG on spring-run occurrence and using USFWS’s recently modified salmon smolt survival model.

Impacts on Mokelumne River fall-run chinook salmon are reassessed, considering recent data provided by EBMUD.

Based on additional literature review, the potential impacts of new Delta Wetlands Project boat docks and other facilities on predator-prey interactions in the Delta are assessed in greater detail than in the 1995 DEIR/EIS.

The significance thresholds are the same as those used in the 1995 DEIR/EIS.

ENVIRONMENTAL CONSEQUENCES

Delta Wetlands Project Impacts under the Final Operations Criteria and Implementation of Reasonable and Prudent Measures

The FOC and RPMs developed during ESA consultation were incorporated into the proposed Delta Wetlands Project assessed in the 2000 REIR/EIS. The revised Delta Wetlands operations and RPMs reduce project impacts on fish identified in the 1995 DEIR/EIS for the proposed project to less-than-significant levels, rendering the mitigation measures recommended in that document for Alternatives 1 and 2 unnecessary. Table 3F-11 summarizes the impacts on fish species and habitat identified in the

1995 DEIR/EIS. It also discusses how the FOC and RPMs reduce those impacts to less-than-significant levels and supersede the mitigation measures previously recommended.

Project Impacts on Spring-Run Chinook Salmon

As shown in Figure 3F-1, the occurrence of spring-run chinook salmon overlaps with the occurrence of winter- and fall-run juveniles. Spring-run yearlings occur in the Delta primarily from October through January; the timing of occurrence depends on flow and water temperature conditions (Table 3F-7). Young-of-year juvenile spring-run chinook salmon may occur in the Delta from December through June, depending primarily on two factors—flow conditions that cause early-life-stage chinook salmon to move downstream and the growth of juveniles to smolt size. Analysis of effects on juvenile winter-run and fall-run chinook salmon in the 1995 DEIR/EIS covered the time periods identified for spring-run yearlings and young-of-year juveniles. The occurrence data provided by DFG are more specific than the assumptions used in the 1995 DEIR/EIS but do not alter the conclusion reached in the 1995 DEIR/EIS.

DFG also provided new information about assumed survival of spring-run chinook salmon through the Delta. USFWS has used this information to modify the relationship (i.e., slope) between migration pathway and survival in the USFWS salmon smolt survival model (mortality index). With this modification, the same model can be used to assess effects on late fall-, spring-, and winter-run chinook salmon. The modified slope was based on results of survival experiments carried out by USFWS during the months of December and January (Wernette pers. comm.) (the years of data collection were not specified in the DFG information). For assessment of Delta Wetlands Project effects on spring-run chinook salmon, the slope for the reach 2 relationship (central Delta) was changed from 0.000043 (fall-run relationship) to 0.000054 (spring-run relationship).

The USFWS model states that index values are not estimates of absolute survival and should be used only as tools to aid in evaluating the relative impacts associated with additional pumping. DFG concurs with this approach (Wernette pers. comm.). Therefore, as in the 1995 DEIR/EIS analysis, the model was used in this REIR/EIS analysis to assess impacts based on the changes in the mortality index between without-project and with-project conditions.

Using the assumed spring-run relationship in place of the assumed fall-run relationship does not affect conclusions about project effects reported in the 1995 DEIR/EIS. When both relationships were applied to export conditions under an assumed constant water temperature of 55EF, the timing and magnitude of effects on the fish with and without the Delta Wetlands Project were similar (Figure 3F-12). The effects illustrated in Figure 3F-12 for both the fall- and spring-run relationships are worst-case scenarios; they assume a constant effect of Delta Wetlands diversion and CVP-SWP export, including export of Delta Wetlands discharge, regardless of water source and net channel flow conditions. These factors were considered in the assessment for the 1995 DEIR/EIS.

The revised analysis identifies Delta Wetlands Project effects on survival during the same years indicated in the 1995 simulation, although the magnitude of the effects varies slightly when the new data are used. The direction of change in response to exports, Delta Wetlands operations, and water temperature remains the same. Delta Wetlands Project effects found in this revised analysis of the spring run are consistent with conclusions reached in the 1995 DEIR/EIS, which were based on earlier USFWS data. Although flow changes resulting from Delta Wetlands diversions and discharges could indirectly cause spring-run chinook salmon mortality to increase, this potential increase would be less than significant.

Relative to effects described in the 1995 DEIR/EIS, these impacts will be reduced with implementation of the FOC terms and RPMs from the biological opinions for delta smelt and winter-run chinook salmon.

For Sacramento River fish, the USFWS model assumes that increased mortality attributable to export occurs in the central Delta. Closure of the DCC gates reduces exposure of Sacramento River fish to export effects. The Delta Wetlands Project does not affect operations of the DCC or the proportion of flow drawn through the DCC and Georgiana Slough. Additionally, the FOC terms require reductions in Delta Wetlands diversions if the DCC gates are closed for fishery protection (from November through January).

The effects of water temperature are a primary factor in the survival of juvenile chinook salmon during migration through the Delta. The Delta Wetlands Project also does not affect water temperature in the Sacramento River or in the central Delta when it diverts water to storage. The FOC will minimize effects of Delta Wetlands Project discharge on water temperature, and effects will be limited to locations in channels near the discharge facilities. FOC terms require that project operations not cause a change in receiving water temperature greater than 7°C; they also prohibit channel temperature increases greater than 1°C where channel temperatures are 13° to 25°C, and increases greater than 0.5°C where channel temperatures are more than 25°C (see Appendix B of the 2000 REIR/EIS).

Project Impacts on Mokelumne River Chinook Salmon

For the 1995 DEIR/EIS, a mortality index was developed for chinook salmon that originate in the Sacramento River, but not specifically for chinook salmon in the Mokelumne River. The impact assessment assumed that all juveniles originating in the Mokelumne River and adults returning to the Mokelumne River would be affected by Delta exports and Delta Wetlands Project diversions. The impact of such diversions on juvenile chinook salmon originating in the Mokelumne River was considered significant in the 1995 DEIR/EIS and mitigation was identified (Table 3F-11).

When submitting data on salmon occurrence and survival, EBMUD did not identify any relationships between Delta channel flows (or Delta diversions) and adult migration or juvenile survival. Survival of adult and juvenile chinook salmon in the Mokelumne River does not appear to be affected by net flows in Delta channels.

The evaluations of project effects on migrating adults, juvenile outmigration, and flows from the Mokelumne River are described below.

Adult Spawning Migration

EBMUD indicated that release of Delta Wetlands Project water in August and September could confuse returning adult Mokelumne River salmon seeking cues from the river. The number of adults migrating past Woodbridge Dam daily was compiled to estimate the completion dates of 50% and 90% of the run (Table 3F-8). The data were compared with the timing assumed for adult fall-run chinook salmon in Figure 5-1. In Figure 5-1 and in the data provided by EBMUD, most adult chinook salmon enter the Mokelumne River from September through December, with peak migration in October and November.

EBMUD did not identify, and analysis of the data provided did not show, a relationship between net Delta channel flow (QWEST) and adult migration to the Mokelumne River. Although Delta channel flows varied substantially, the new information indicated minimal variability in the 50% and 90% completion dates for adult chinook salmon migration into the Mokelumne River from 1993 through 1998. For example, average QWEST in October 1993 was -2,359 cfs and was 161 cfs in October 1994. The dates of 50% and 90% completion of annual migration past Woodbridge Dam, however, varied by only a few days between 1993 and 1994 (Table 3F-8). Similarly, the dates of annual migration past Woodbridge Dam during 1994 and 1995 were similar even though QWEST in August averaged -1,780 cfs in 1994 and 1,948 cfs in 1995.

A negative QWEST indicates that very little Mokelumne River water will exit the Delta as outflow and that most of the Mokelumne River water will be present in the water mass moving toward the CVP and SWP export pumps. A negative QWEST (e.g., in October 1993 and August 1994) does not appear to have affected the timing of adult migration in the Mokelumne River when compared to years when QWEST was positive (e.g., October 1994 and August 1995).

Another indicator that adults could be confused by the presence of Mokelumne River water in the central and south Delta channels would be straying to other rivers. However, EBMUD's coded wire tag data show that, of the juvenile chinook salmon released in the Mokelumne River that returned as adults, more than 90% returned to the Mokelumne River and only 10% strayed to other river systems. The data also indicate that, of the adult chinook salmon that originated as juveniles in the Mokelumne River or were produced at the Mokelumne River fish hatchery, 60% to 100% returned to the Mokelumne River regardless of where they were released as juveniles. The coded wire tag data indicate that if straying occurs, juveniles originating from other rivers and released in various Delta locations are most likely to stray as returning adults.

Delta Wetlands discharge and diversion could change the amount of Mokelumne River water present in channels south of the San Joaquin River; however, the available data do not indicate that such changes would affect migration of adult chinook salmon. (See also "Effect of the Delta Wetlands Project on the Concentration of Mokelumne River Water in the Central and South Delta" below.)

Juvenile Outmigration

The EBMUD data on juvenile outmigration indicated that during wet years (water years 1995 through 1999), most annual production of juvenile chinook salmon passes Woodbridge Dam before March (Table 3F-9). According to EBMUD, up to 70% of the entire annual production of juvenile chinook salmon would pass Woodbridge Dam as fry (Miyamoto pers. comm.). A similar pattern of outmigration has been noted in other systems. The high abundance of fall-run fry in the Delta before March coincides with high flows (U.S. Fish and Wildlife Service 1994).

EBMUD and USFWS have indicated concern about the entrainment of fry in Delta diversions after high flows. The available salvage data for the CVP and SWP, however, show that peak entrainment of juvenile chinook salmon occurs during April and May (Figure 3F-13). It is likely that fry and young juvenile chinook salmon rear in the lower portion of rivers and in the Delta channels receiving the river discharge until they reach smolt size (i.e., a level of maturity that allows movement to the ocean). Smolt-sized salmon move past Chipps Island primarily from April through June (U.S. Fish and Wildlife Service 1994) and are salvaged at the CVP and SWP fish protection facilities primarily during April and May (Figure 3F-13).

EBMUD also provided raw data on recovery (capture) of Mokelumne River juvenile chinook salmon marked with coded wire tags. EBMUD did not identify any relationship between net Delta channel flow, export, and entrainment in Delta diversions. The number of tagged fish salvaged at the CVP and SWP fish protection facilities appears to be related to the number and size of fish released: the larger the number and bigger the fish released, the larger the number recovered. In general, the number of fish recovered at the fish protection facilities was small, usually 1 or 2 fish and less than 0.02% of the number released, and was highly variable, ranging from none to as many as 27 fish out of 10,000 to 100,000 released. Because of the relatively high occurrence of zero recoveries and the variability of release dates, number of fish released, release locations, and size at release, the EBMUD data cannot be used to develop accurate relationships between facility operations and entrainment.

The available information does not indicate that Delta Wetlands operations, with the FOC and RPMs in place, would have significant adverse effects on juvenile chinook salmon that originate in the Mokelumne River and rear in the Delta from January through March. The data provided by EBMUD on the recovery of tagged juveniles did not include data on fish released during January through March. They also did not provide information on relationships between flow or diversion and entrainment at the CVP and SWP export facilities. SWP and CVP salvage data indicate that the months of highest entrainment of juveniles are April and May. The FOC terms specify that Delta Wetlands diversions would be limited by several factors during January through March and would not be allowed during April and May. Details of the applicable FOC restrictions are provided under "Summary of the Evaluation of Delta Wetlands Project Effects on Mokelumne River Chinook Salmon" below. (See also the following section, "Effect of the Delta Wetlands Project on the Concentration of Mokelumne River Water in the Central and South Delta".)

Effect of the Delta Wetlands Project on the Concentration of Mokelumne River Water in the Central and South Delta

EBMUD was concerned that discharge of Delta Wetlands Project water could confuse returning adult and juvenile chinook salmon during upstream and downstream migration. A worst-case assessment of the origin of central and south Delta water was completed, based on simulated Delta water supply and operations (Chapter 3A). This assessment assumed that:

tidal flows would not dilute the proportion of Mokelumne River water drawn into the central and south Delta,

Delta Wetlands discharge would retain the Mokelumne River characteristics over the storage period, and

Delta Wetlands discharge would mix completely in the central Delta and would not be drawn toward the export pumps. (This is a very conservative assumption for Bacon Island discharge, the only discharge for exports allowed during January through June.)

The results shown in Table 3F-10 and Figure 3F-14 indicate that the Delta Wetlands Project would have a minimal effect on the proportion of Mokelumne River water moving through the central and south Delta. In most years the Delta Wetlands discharge would have proportionately less Mokelumne River water than the channel receiving the discharge. Project operations, therefore, may reduce slightly the proportion of Mokelumne River water present, but the effect on chinook salmon is likely to be negligible. In addition, under normal operating circumstances, Delta Wetlands would infrequently release water in the winter months (see Table 3A-34 in Chapter 3A), further reducing the probability that the project would affect Mokelumne River salmon.

Summary of the Evaluation of Delta Wetlands Project Effects on Mokelumne River Chinook Salmon

The EBMUD data do not provide evidence that Delta Wetlands Project operations would significantly affect adult chinook salmon migration to the Mokelumne River. The 1995 DEIR/EIS identified project effects on juveniles originating in the Mokelumne River as a significant impact. With implementation of the FOC and RPMs described in the state and federal biological opinions, impacts on chinook salmon, including those originating in the Mokelumne River, would be less than significant. The FOC that would minimize adverse effects on juvenile chinook salmon from the Mokelumne River include the following (see Appendix B of the 2000 REIR/EIS for details):

- Total annual export of Delta Wetlands stored water would be limited to 250,000 af; therefore, the amount of diversion and discharge that could occur in any one year would be restricted.

- The volume of Delta Wetlands diversions and potential effects on Delta channel flow conditions would be limited by:

  - the maximum X2 value (corresponding to a minimum Delta outflow);
  - the maximum allowable change in X2 value;
  - the March QWEST criteria;
  - the percentage of Delta surplus, Delta outflow, and San Joaquin River inflow; and
  - criteria during DCC closures for fish protection.

- Webb Tract would not be allowed to discharge to export during January through June, which includes the period of juvenile chinook salmon migration.

- The volume of Delta Wetlands discharges to export and potential effects on Delta channel flows would be limited to a percentage of unused export capacity.

- Fish screens would be designed to meet a 0.2-fps approach velocity, avoiding direct diversion effects on juvenile chinook salmon.

Effects of Delta Wetlands Project Facilities on Fish Predation

Numerous boat docks and fishing piers are found in the Delta region (see Chapter 3J, "Recreational and Visual Resources"). Docks and piers are present at more than 100 marinas, approximately 23 public recreation facilities that provide boat launching and fishing access, and several private waterfowl hunting clubs. Three of the four Delta Wetlands Project islands (Bacon Island, Webb Tract, and Bouldin Island) do not currently have public recreational boat docks (they do, however, have a limited number of private docks and ramps). The fourth project island, Holland Tract, supports two marinas, one with 335 berths and one with 21 berths. The Delta Wetlands Project may include construction of up to 40 new floating boat docks with as many as 30 berths each. Delta Wetlands may construct fewer and smaller facilities but is proposing the maximum amount, which necessitates worst-case environmental analysis. Also, pilings and other structures would be constructed as part of the siphon and pump facilities on Bacon Island and Webb Tract.

As described above, DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on fish predation assumes that the recreation facilities would be constructed and operated.

The presence of natural or artificial cover (e.g., trees, rootwads, brush piles, or aquatic plants) in water bodies is well known to attract relatively high concentrations of fish (Johnson and Stein 1979). Food may be more abundant in areas with cover (Johnson et al. 1988). Cover can disrupt streamflow patterns and therefore provide fish with refuges from elevated water velocities associated with high flows (Shirvell 1990). By providing small protected spaces and a diversity of space sizes, cover can effectively reduce predation risk for small fish and can ameliorate competitive interactions (Savino and Stein 1982, Bugert et al. 1991).

Installation of boat docks would not be expected to affect fish predator-prey interactions significantly. Pilings and shade associated with boat docks or fishing piers may be used as cover by both predator and prey fish. However, these structurally simple forms of cover attract fish species much less than more complex forms such as brush piles or aquatic plants (Savino and Stein 1982, Gotceitas and Colgan 1987, Lynch and Johnson 1989).

The construction of new boat docks and other facilities on the Delta Wetlands islands is not expected to increase the vulnerability of juvenile chinook salmon or other species to predation. Comprehensive data about predator-prey interactions involving juvenile salmonids and other species in the Delta are unavailable (U.S. Bureau of Reclamation 1983, Interagency Ecological Program 1995). However, juvenile chinook salmon and other species are known to be vulnerable to predators at locations such as Red Bluff Diversion Dam, Clifton Court Forebay, and release sites for fish salvaged from the SWP and CVP facilities (Hall 1980, Pickard et al. 1982, U.S. Bureau of Reclamation 1983). These facilities and release sites attract relatively high concentrations of juvenile salmonids and other fish species that may be substantially disoriented by turbulence and handling associated with diversion, flow constriction, bypasses, and trucking. The high concentration of disoriented fish could create exceptional predator habitat by increasing prey availability. Boat docks, however, would not divert water or constrict flows and would not cause conditions expected to disorient fish.

The additional information reviewed for this evaluation does not provide evidence that predation would increase because of the presence of boat docks and other Delta Wetlands Project facilities or change the 1995 DEIR/EIS conclusion that effects of project facilities on fish predation would be less than significant.

Cumulative Impacts

When added to other past, present, and reasonably foreseeable future actions, effects of the Delta Wetlands Project would not be expected to increase cumulative impacts on fish and fish habitat relative to existing conditions. With implementation of the AFRP under the CVPIA, the Ecosystem Restoration Program under CALFED, and other ongoing programs, fish habitat conditions in and upstream of the Delta are expected to improve for chinook salmon and other species. The FOC terms for the Delta Wetlands Project avoid and minimize project effects on Delta fish and their habitat (Table 2-6). The FOC terms include compensatory measures that potentially improve and increase fish habitat, such as conservation of 200 acres of shallow-water rearing and spawning habitat, habitat replacement at a 3:1 ratio, setting aside of environmental water, and contribution of funds for DFG fish and habitat management (i.e., $100 per year per additional boat berth, compensation for incidental entrainment losses, establishment of aquatic habitat conservation and environmental water funds).

Impact Evaluation of Project Alternatives from the 1995 Draft EIR/EIS

Alternatives 1 and 2 described in the 1995 DEIR/EIS represented two scenarios for Delta Wetlands' proposed project, which differed only in terms of allowable discharges of stored water. The biological assessment for Delta Wetlands Project effects on fish species was based on project operations under the proposed project as described for Alternative 2, which would have the maximum amount of discharge pumping and the maximum effect on fisheries associated with discharges under the proposed project. The FOC and RPMs were developed through ESA consultation based on estimated project effects under Alternative 2 operations; as described above, application of the FOC and RPMs would improve conditions for fish in comparison with conditions described in the evaluation of project effects presented in the 1995 DEIR/EIS. Similarly, application of the FOC and RPMs under Alternative 1 operations would improve conditions for fish.

Alternative 3, the four-reservoir-island alternative, has not changed since the 1995 DEIR/EIS was published. The FOC and biological opinion terms were developed for the two-reservoir-island operations and are not applicable to a four-reservoir-island alternative. There is no change to the conclusions of the environmental impact analysis presented in the 1995 DEIR/EIS for Alternative 3.

CITATIONS

References to the Federal Register (FR) are not included in this list. FR citations in text refer to volume and page number (e.g., 58 FR 12854 refers to Volume 58 of the FR, page 12854).

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Table 3F-1. Average Change in Delta Outflow under DW Project Operations Relative to No-Project Conditions, 1922-1991 Simulation for the 1995 Draft EIR/EIS Analysis

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Change in Flow (cfs)												
Alternative 1												
Mean	(650)	(710)	(524)	(676)	(414)	(142)	30	31	57	35	50	(353)
Standard Deviation	1,261	1,396	1,141	1,286	1,095	745	56	63	35	45	26	1,102
Minimum	(3,880)	(4,011)	(3,892)	(3,856)	(3,977)	(3,797)	(141)	(236)	(49)	(52)	(55)	(3,974)
Median	(10)	(12)	(34)	0	(7)	25	51	60	69	78	60	25
Maximum	(10)	(12)	(21)	15	47	73	330	60	69	78	60	25
Alternative 2												
Mean	(650)	(710)	(524)	(644)	(414)	(163)	(38)	29	57	35	50	(353)
Standard Deviation	1,261	1,396	1,141	1,275	1,095	714	430	68	35	45	26	1,102
Minimum	(3,880)	(4,011)	(3,892)	(3,856)	(3,977)	(3,797)	(3,074)	(252)	(49)	(52)	(55)	(3,974)
Median	(10)	(12)	(34)	0	(7)	25	51	60	69	78	60	25
Maximum	(10)	(12)	(21)	15	47	73	330	60	69	78	60	25
Alternative 3												
Mean	(955)	(1,122)	(949)	(958)	(719)	(266)	(32)	46	107	70	97	(376)
Standard Deviation	1,771	2,063	1,832	1,785	1,683	927	419	112	71	84	48	1,337
Minimum	(5,959)	(5,970)	(5,985)	(5,982)	(5,959)	(5,945)	(2,926)	(383)	(104)	(110)	(115)	(5,931)
Median	41	30	(11)	(11)	(19)	(42)	74	101	131	150	116	69
Maximum	41	30	15	18	83	55	354	101	131	150	116	69
Change in Flow (%)												
Alternative 1												
Mean	(5.85)	(4.34)	(2.88)	(4.03)	(1.18)	(0.20)	0.33	0.47	0.79	0.56	1.02	(2.96)
Standard Deviation	11.13	8.71	6.02	7.72	3.48	2.09	0.32	0.45	0.41	0.70	0.55	10.38
Minimum	(34.36)	(34.07)	(27.82)	(27.32)	(16.65)	(11.76)	(0.32)	(0.94)	(0.19)	(0.56)	(0.64)	(39.06)
Median	(0.24)	(0.25)	(0.38)	0.00	(0.01)	0.10	0.35	0.54	0.91	0.87	1.05	0.66
Maximum	(0.16)	(0.05)	(0.02)	0.33	0.41	1.06	1.80	1.34	1.73	1.95	1.76	0.84
Alternative 2												
Mean	(5.85)	(4.34)	(2.88)	(3.89)	(1.18)	(0.28)	0.16	0.47	0.79	0.56	1.02	(2.96)
Standard Deviation	11.13	8.71	6.02	7.72	3.48	2.08	1.12	0.46	0.41	0.70	0.55	10.38
Minimum	(34.36)	(34.07)	(27.82)	(27.32)	(16.65)	(11.76)	(7.00)	(0.94)	(0.19)	(0.56)	(0.64)	(39.06)
Median	(0.24)	(0.25)	(0.38)	0.00	(0.01)	0.10	0.35	0.54	0.91	0.87	1.05	0.66
Maximum	(0.16)	(0.05)	(0.02)	0.33	0.41	1.06	1.80	1.34	1.73	1.95	1.76	0.84
Alternative 3												
Mean	(7.28)	(6.25)	(4.56)	(5.16)	(1.81)	(0.58)	0.29	0.78	1.51	1.12	1.98	(2.37)
Standard Deviation	14.06	11.65	9.22	9.63	4.70	2.50	1.15	0.76	0.79	1.32	1.03	11.94
Minimum	(42.19)	(39.07)	(39.35)	(33.31)	(19.87)	(13.89)	(6.66)	(1.05)	(0.41)	(1.19)	(1.34)	(44.36)
Median	0.81	0.47	(0.02)	(0.04)	(0.01)	(0.03)	0.51	0.90	1.73	1.68	2.01	1.81
Maximum	1.36	0.86	0.32	0.40	0.73	0.80	1.93	2.24	3.28	3.75	3.39	2.29

Note: Negative values shown in parentheses.

Table 3F-2. Average Change in X2 (Kilometers) under DW Project Operations Relative to No-Project Conditions, 1922-1991 Simulation for the 1995 Draft EIR/EIS Analysis

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alternative 1												
Mean	0.62	0.57	0.42	0.48	0.26	0.11	0.03	0.00	(0.04)	(0.01)	(0.00)	0.33
Standard Deviation	1.05	0.82	0.56	0.66	0.33	0.19	0.06	0.03	0.04	0.01	0.01	0.96
Minimum	(0.00)	(0.00)	(0.00)	(0.02)	(0.03)	(0.09)	(0.05)	(0.07)	(0.13)	(0.04)	(0.01)	(0.00)
Median	0.00	0.01	0.22	0.17	0.09	0.03	0.01	0.00	(0.04)	(0.01)	(0.00)	(0.00)
Maximum	3.23	3.19	2.50	2.45	1.39	0.95	0.29	0.12	0.03	0.05	0.05	3.80
Alternative 2												
Mean	0.62	0.57	0.42	0.47	0.25	0.11	0.04	0.01	(0.04)	(0.01)	(0.00)	0.33
Standard Deviation	1.05	0.82	0.56	0.66	0.33	0.18	0.10	0.04	0.04	0.01	0.01	0.96
Minimum	(0.00)	(0.00)	(0.00)	(0.02)	(0.03)	(0.09)	(0.05)	(0.07)	(0.13)	(0.04)	(0.01)	(0.00)
Median	0.00	0.01	0.22	0.15	0.09	0.03	0.01	0.00	(0.03)	(0.01)	(0.00)	(0.00)
Maximum	3.23	3.19	2.50	2.45	1.39	0.95	0.56	0.18	0.06	0.05	0.05	3.80
Alternative 3												
Mean	0.86	0.87	0.69	0.68	0.38	0.17	0.06	0.01	(0.07)	(0.02)	(0.00)	0.38
Standard Deviation	1.41	1.16	0.93	0.86	0.46	0.24	0.11	0.05	0.07	0.03	0.02	1.10
Minimum	(0.07)	(0.02)	(0.01)	(0.02)	(0.05)	(0.08)	(0.05)	(0.11)	(0.25)	(0.08)	(0.03)	(0.01)
Median	(0.00)	0.00	0.37	0.26	0.17	0.07	0.03	0.01	(0.07)	(0.02)	(0.00)	(0.00)
Maximum	4.27	3.80	3.83	3.13	1.98	1.13	0.54	0.18	0.06	0.10	0.11	4.50

Note: Negative values shown in parentheses.

Table 3F-3. Average Change in Net Flow (cfs) in Old and Middle Rivers near the Northern Confluence with the San Joaquin River under DW Project Operations Relative to No-Project Conditions, 1922-1991 Simulation for the 1995 Draft EIR/EIS Analysis

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alternative 1												
Mean	(0)	(12)	(215)	(39)	(181)	(78)	(200)	(259)	(130)	(910)	(796)	(304)
Standard Deviation	0	67	692	321	776	422	374	431	383	1,362	1,096	775
Minimum	(0)	(515)	(3,335)	(2,708)	(4,000)	(2,691)	(1,332)	(1,843)	(2,822)	(3,741)	(3,755)	(3,379)
Median	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0	0	0	280	0	0	0	0	0
Alternative 2												
Mean	(0)	(12)	(176)	(54)	(674)	(437)	(77)	(283)	(783)	(497)	(293)	(79)
Standard Deviation	0	67	644	335	1,312	1,006	204	613	1,306	1,100	785	424
Minimum	(0)	(515)	(3,335)	(2,721)	(4,486)	(3,822)	(1,053)	(3,771)	(3,780)	(3,741)	(3,755)	(2,861)
Median	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0	0	0	280	0	0	0	0	0
Alternative 3												
Mean	(6)	(10)	(179)	(58)	(792)	(678)	(87)	(270)	(1,187)	(777)	(777)	(191)
Standard Deviation	50	60	669	336	1,581	1,277	225	546	1,844	1,587	1,415	644
Minimum	(425)	(473)	(3,740)	(2,717)	(6,000)	(4,975)	(1,030)	(3,000)	(4,899)	(6,000)	(5,237)	(3,917)
Median	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0	0	0	280	0	0	0	0	0

Note: Negative values shown in parentheses.
DW discharges and diversions are added to the Old and Middle River flow regardless of actual DW discharge and diversion locations.

Table 3F-4. Total Annual Mortality Index for Sacramento River Chinook Salmon; Summary of the 70-Year Simulation from the 1995 Draft EIR/EIS Analysis

	Mortality Index (%)				Change from No-Project Mortality Index (%)		
	No-Project	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Fall-Run Chinook Salmon							
Mean	47.65	47.68	47.69	47.70	0.03	0.04	0.05
Standard Deviation	15.94	15.95	15.93	15.92	0.04	0.06	0.07
Minimum	13.91	13.91	13.91	13.91	-0.02	-0.02	-0.04
Median	50.41	50.42	50.48	50.51	0.02	0.02	0.04
Maximum	74.87	74.85	74.85	74.84	0.20	0.32	0.33
Winter-Run Chinook Salmon							
Mean	11.71	11.80	11.83	11.90	0.08	0.12	0.18
Standard Deviation	2.80	2.80	2.83	2.84	0.10	0.12	0.17
Minimum	6.21	6.25	6.25	6.32	-0.02	-0.02	-0.01
Median	12.44	12.58	12.76	12.79	0.05	0.06	0.12
Maximum	16.52	16.57	16.58	16.72	0.43	0.46	0.74

Note: The values do not account for any incremental benefits of DW fish screens.

The maximum and minimum changes are the largest and smallest differences between the values simulated for the same year for the No-Project Alternative and the specified DW project alternative. They cannot be calculated from the maximum and minimum index values.

Table 3F-5. Total Annual Entrainment Index for Striped Bass, Delta Smelt, and Longfin Smelt; Summary of the 70-Year Simulation from the 1995 Draft EIR/EIS Analysis

	Entrainment Index (%)				Change from No-Project Entrainment Index (%)		
	No-Project	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Striped Bass							
Mean	25.95	26.38	26.32	26.43	0.43	0.38	0.48
Standard Deviation	5.36	5.47	5.45	5.43	0.45	0.39	0.45
Minimum	1.24	1.28	1.28	1.32	-0.02	-0.23	-0.02
Median	27.80	28.01	28.08	28.24	0.24	0.26	0.43
Maximum	30.52	30.54	30.87	30.86	1.52	1.59	1.75
Delta Smelt							
Mean	26.79	27.41	27.58	27.89	0.62	0.80	1.10
Standard Deviation	6.03	6.29	6.37	6.41	0.75	0.84	1.05
Minimum	0.74	0.78	0.78	0.81	-0.02	-0.00	-0.00
Median	28.47	28.80	28.86	29.43	0.25	0.48	0.65
Maximum	34.46	36.29	36.16	36.15	3.22	3.44	4.15
Longfin Smelt							
Mean	8.26	9.10	9.33	9.73	0.84	1.07	1.47
Standard Deviation	4.40	4.95	5.15	5.38	1.24	1.40	1.84
Minimum	0.01	0.01	0.01	0.01	-0.00	-0.00	-0.00
Median	8.26	9.24	9.24	9.62	0.18	0.64	0.98
Maximum	18.65	20.95	21.71	21.70	5.66	6.42	9.31

Note: The maximum and minimum changes are the largest and smallest differences between the values simulated for the same year for the No-Project Alternative and the specified DW project alternative. They cannot be calculated from the maximum and minimum index values.

Table 3F-6. Total Habitat Area for Striped Bass, Delta Smelt, and Longfin Smelt; Summary of the 70-Year Simulation from the 1995 Draft EIR/EIS Analysis

	Habitat Area (km^2)				Change from No-Project Habitat Area (km^2)		
	No-Project	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Striped Bass							
Mean	76.53	76.71	76.70	76.76	0.18	0.16	0.23
Standard Deviation	14.93	14.94	14.92	14.91	0.60	0.61	0.72
Minimum	51.47	51.47	51.47	51.50	-1.82	-1.82	-1.82
Median	76.84	76.84	76.84	76.84	0.00	0.00	0.00
Maximum	101.82	101.82	101.82	101.82	2.86	2.86	2.86
Delta Smelt							
Mean	50.70	50.75	50.75	50.74	0.05	0.05	0.04
Standard Deviation	4.67	4.60	4.60	4.58	0.37	0.40	0.59
Minimum	41.48	41.48	41.48	41.48	-0.91	-1.11	-1.61
Median	49.26	49.70	49.65	49.70	0.00	0.00	0.00
Maximum	67.55	67.49	67.49	67.49	1.05	1.05	2.36
Longfin Smelt							
Mean	173.58	172.71	172.66	172.69	-0.87	-0.93	-0.90
Standard Deviation	34.70	34.82	34.81	34.75	2.34	2.35	2.67
Minimum	122.21	122.03	122.03	122.03	-7.29	-7.29	-12.55
Median	173.70	172.37	172.37	173.63	0.00	0.00	0.00
Maximum	248.22	248.22	248.22	248.22	3.04	1.99	2.54

Note: The maximum and minimum changes are the largest and smallest differences between the values simulated for the same year for the No-Project Alternative and the specified DW project alternative. They cannot be calculated from the maximum and minimum index values.

Table 3F-7. Comparison of Juvenile Spring-Run Chinook Salmon Occurrence in the Delta Assumed in the 1995 Draft EIR/EIS and Provided by DFG in August 1999

	Potential Occurrence in the Delta as a Proportion of Annual Production			
	1995 Draft EIR/EIS		DFG	
Month	Yearlings	Young-of-Year	Yearlings	Young-of-Year
October	X[a]			
November	X[a]		0.37	
December	X[a]	<0.26	0.42	0.01
January	X[a]	0.26-0.50	0.13	0.06
February		>0.50	0.05	0.17
March		0.26-0.50	0.03	0.28
April		<0.26		0.25
May		<0.26		0.16
June		<0.26		0.07

[a] The proportion in the Delta was not estimated, but occurrence was assumed during the months indicated.

Sources: Jones & Stokes Associates 1995, Wernette pers. comm.

Table 3F-8. Dates of Annual Adult Chinook Salmon Migration Past Woodbridge Dam

Year	Date of Percentage of Annual Migration Past Woodbridge Dam	
	50%	90%
1993	November 2	November 20
1994	November 7	November 26
1995	October 28	November 23
1996	October 31	November 20
1997	November 7	November 22
1998	November 3	November 23

Source: Miyamoto pers. comm.

Table 3F-9. Dates of Annual Juvenile Chinook Salmon Migration Past Woodbridge Dam

Year	Date of Percentage of Annual Migration Past Woodbridge Dam	
	50%	90%
1994	May 4	May 24
1995	March 6	June 3
1996	March 4	June 6
1997	February 22	May 30
1998	February 4	May 16
1999	February 19	May 14

Source: Miyamoto pers. comm.

Table 3F-10. Frequency with which Concentrations of Mokelumne River Water in the South Delta Would Exceed the Percentages Given for Each Month,1922-1991 Simulation

	Mokelumne River Water Concentration in the South Delta without the Delta Wetlands Project (%)											
Frequency (%)	October	November	December	January	February	March	April	May	June	July	August	September
0	15	48	55	51	63	51	54	41	26	16	16	12
10	8	10	28	38	38	33	28	25	14	5	8	7
20	5	7	13	25	31	28	27	23	8	5	5	5
30	4	6	10	14	24	21	25	21	7	4	5	4
40	3	5	7	11	20	18	22	20	6	4	5	4
50	2	4	5	7	15	16	21	17	5	3	4	4
60	2	3	4	5	11	14	19	15	5	3	4	4
70	2	2	3	5	9	12	16	13	5	3	3	3
80	1	2	3	3	6	7	15	12	5	3	3	3
90	1	1	2	2	3	3	12	11	5	3	3	3
100	0	0	0	0	0	0	0	0	0	0	2	1

	Mokelumne River Water Concentration in the South Delta with Delta Wetlands Project Diversions (%)											
Frequency (%)	October	November	December	January	February	March	April	May	June	July	August	September
0	15	48	55	51	63	51	54	41	26	16	16	12
10	7	8	26	38	37	33	28	25	14	5	8	7
20	4	6	11	25	30	28	27	23	8	5	5	5
30	4	5	9	12	24	21	25	21	7	4	5	4
40	3	5	7	9	18	18	22	20	6	4	5	4
50	2	4	5	7	15	16	21	17	5	3	4	4
60	2	3	4	5	11	14	19	15	5	3	4	4
70	2	2	3	4	9	11	16	13	5	3	3	3
80	1	2	3	3	6	7	15	12	5	3	3	3
90	1	1	2	2	2	3	12	11	5	3	3	2
100	0	0	0	0	0	0	0	0	0	0	2	1

	Mokelumne River Water Concentration in the South Delta with Delta Wetlands Project Diversions and Discharge (%)											
Frequency (%)	October	November	December	January	February	March	April	May	June	July	August	September
0	15	48	55	51	63	51	54	38	26	15	16	12
10	7	8	26	38	37	33	28	24	14	6	8	7
20	4	6	11	25	30	28	27	22	7	5	5	5
30	4	5	9	12	22	22	26	21	7	4	5	4
40	3	5	7	9	18	18	22	19	5	3	5	4
50	2	4	5	7	12	16	20	17	5	3	4	4
60	2	3	4	5	10	14	19	15	5	3	4	4
70	2	2	3	5	8	10	16	13	5	3	3	3
80	1	2	3	3	6	6	15	12	5	3	3	3
90	1	1	2	2	2	3	11	10	4	3	3	2
100	0	0	0	0	0	0	0	0	0	0	2	1

Table 3F-11. Comparison between Delta Wetlands Project Impacts on Fisheries in the 1995 Draft EIR/EIS and in the 2000 Revised Draft EIR/EIS

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
CHAPTER 3F. FISHERY RESOURCES	
Impact F-1: Alteration of Habitat (S) C **Mitigation Measure F-1**: Implement Fish Habitat Management Actions (LTS)	**Alteration of Habitat.** The impact would be less than significant based on inclusion of the following project elements identified in the California and federal Endangered Species Act (ESA) biological opinions (see final operations criteria [FOC] in Appendix B): - Conserve in perpetuity 200 acres of shallow-water rearing and spawning habitat. - Contribute $100 per year per additional boat berth for boat-wake-erosion mitigation. - Mitigate on a 3:1 basis for aquatic habitat lost to construction activities. - Limit in-water construction to June through November. (LTS) The project elements would minimize and avoid, where feasible, effects on habitat and would replace lost habitat. The following reasonable and prudent measures (RPMs) will further reduce Delta Wetlands Project impacts: *DFG Biological Opinion* - Provide employee orientation on sensitive-species protection. - Report and confirm compliance with construction guidelines. - Allow DFG personnel access to the project site. - Establish an aquatic habitat restoration fund. *NMFS Biological Opinion* - Complete project construction and maintenance in a manner that does not degrade Delta habitat. (Continued on next page)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
	(Continued from previous page) *USFWS Biological Opinion* - Avoid areas of immersed plants while riprap is placed and diversion and discharge structures are built. - Avoid areas of submersed plants while riprap is placed and diversion and discharge structures are built; limit in-water work to June through November.
Impact F-2: Increase in Temperature-Related Mortality of Juvenile Chinook Salmon (S) C **Mitigation Measure F-2**: Monitor the Water Temperature of Delta Wetlands Discharges and Reduce Delta Wetlands Discharges to Avoid Producing Any Increase in Channel Temperature Greater than 1°F (LTS)	**Increase in Temperature-Related Mortality of Juvenile Chinook Salmon.** The impact would be less than significant based on inclusion of the following project elements identified in the California and federal ESA biological opinions (see FOC and RPMs in Appendices B, C, D, and E). (LTS) - Minimize and avoid adverse effects of discharge through changes in water temperature: • when the temperature differential between the discharge and receiving water is greater than 20EF, there shall be no discharge; • when channel water temperature is 55EF or higher and is less than 66EF, it shall not increase by more than 4EF; • when channel water temperature is 66EF or higher and is less than 77EF, it shall not increase by more than 2EF; • when channel water temperature is 77EF or higher, it shall not increase by more than 1EF; and • Delta Wetlands shall develop and implement water temperature monitoring.

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
Impact F-3: Potential Increase in Accidental Spills of Fuel and Other Materials (LTS) C No mitigation is required.	**Potential Increase in Accidental Spills of Fuel and Other Materials.** The impact would be less than significant and would be further minimized by inclusion of the following project elements identified in the California and federal ESA biological opinions: (LTS) - Conserve in perpetuity 200 acres of shallow-water rearing and spawning habitat. - Contribute $100 per year per additional boat berth for boat-wake-erosion mitigation.
Impact F-4: Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of Delta Wetlands Project Diversions and Discharges on Flows (S) C **Mitigation Measure F-3:** Operate the Delta Wetlands Project under Operations Objectives that Would Minimize Changes in Cross-Delta Flow Conditions during Peak Outmigration of Mokelumne and San Joaquin River Chinook Salmon (LTS) **Impact F-5**: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae (S)	**Potential Impacts on Chinook Salmon, Striped Bass, Delta Smelt, Longfin Smelt, American Shad, and Other Species.** Interrelated operations criteria address Impacts F-4, F-5, F-6, F-7, and F-8. The impacts would be less than significant based on inclusion of the following project elements identified in the California and federal ESA biological opinions (see FOC and RPMs in Appendices B, C, D, and E). The impacts reduced or avoided are indicated for each operations criterion by the impact number in parenthesis. (LTS) Total Export Criteria: - Annual export of Delta Wetlands stored water will not exceed 250,000 acre-feet (af). This criterion limits the maximum operation effect that could occur in any given year, constraining impacts F-4 through F-8. Diversion Criteria: - Maximum X2 value limits start of Delta Wetlands diversion, September through November (F-4, F-6, F-7, F-8) (Continued on next page)

Diversion Criteria (continued from previous page):

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
C **Mitigation Measure F-4**: Operate the Delta Wetlands Project under Operations Objectives that Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt (LTS)	- Maximum X2 value limits magnitude of Delta Wetlands diversion, September through March (all impacts) - Delta Wetlands diversion is limited by a maximum allowable change in X2, October through March (all impacts)
Impact F-6: Change in Area of Optimal Salinity Habitat (LTS)	- Delta Wetlands diversion to storage is limited by QWEST in March (see California ESA biological opinion) (F-4, F-5, F-6, F-7)
C No mitigation is required.	- No water is diverted, April and May (F-4, F-5, F-6, F-8)
Impact F-7: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt (S)	- If the delta smelt fall midwater trawl (FMWT) index is less than 239, no diversion from February 15 through June (F-4, F-5, F-6, F-8)
C **Mitigation Measure F-5**: Operate the Delta Wetlands Project under Operations Objectives that Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt (LTS)	- Diversions are limited to a percentage of Delta surplus, year round (all impacts) - Diversions are limited to a percentage of Delta outflow, year round (all impacts) - Diversions are limited to a percentage of San Joaquin River inflow, December through March (all impacts)
Impact F-8: Increase in Entrainment Loss of Juvenile American Shad and Other Species (LTS)	- Diversions are reduced when monitoring detects presence of delta smelt, December through August (all impacts)
C No mitigation is required.	- Diversions are limited if the Delta Cross Channel is closed for fish protection, November through January (F-4, F-6, F-7, F-8)

(Continued on next page)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
	(Continued from previous page) Discharge Criteria: - Bacon Island discharge for export is limited to 50% of San Joaquin River inflow, April through June (F-4, F-5, F-8) - Webb Tract discharge for export is prohibited, January through June (F-4, F-5, F-7, F-8) - Discharge for export or rediversion from habitat islands is prohibited (Bouldin Island, Holland Tract), all year (F-4, F-5, F-7, F-8) - Discharge is limited to a percentage of available unused export capacity, February through July (F-4, F-5, F-7, F-8) - Environmental water will be set aside and provided as a percentage of discharge, February through June (F-5, F-6, F-8) - Discharge is reduced when monitoring detects presence of delta smelt, April through August (F-4, F-5, F-8) Other Criteria: - Meet design criteria for fish screens: 0.2 fps approach velocity (F-7, F-8) - Conserve in perpetuity 200 acres of shallow-water rearing and spawning habitat (F-6) - Compensate for incidental entrainment losses, January through March and June through August (F-7, F-8) - Implement a fish monitoring program (all impacts)

(Continued on next page)

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
	(Continued from previous page) California ESA RPMs: - Delta Wetlands will provide an environmental water fund based on diversions from October through March and discharge (all impacts) - Aquatic habitat development measures will be implemented to offset impacts of moving X2 upstream from February through June (F-6)
Cumulative Impacts	
Impact F-17: Alteration of Habitat under Cumulative Conditions (LTS) C No mitigation is required.	**Alteration of Habitat under Cumulative Conditions.** Similar to the descriptions provided above, Delta Wetlands Project cumulative impacts on fish populations and habitats would be less under the FOC and biological opinion measures than the impacts described in the 1995 DEIR/EIS. The FOC and other measures reduce the Delta Wetlands Project's contribution to cumulative adverse conditions in the Delta. The significance findings made above for the project's direct and indirect impacts are applicable to the related cumulative impact. (LTS) See above discussion under Impact F-1 (page 1).
Impact F-18: Potential Increase in Accidental Spills of Fuel and Other Materials under Cumulative Conditions (LTS) C No mitigation is required.	See above discussion under Impact F-3 (page 3).

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Table 3F-11. Continued

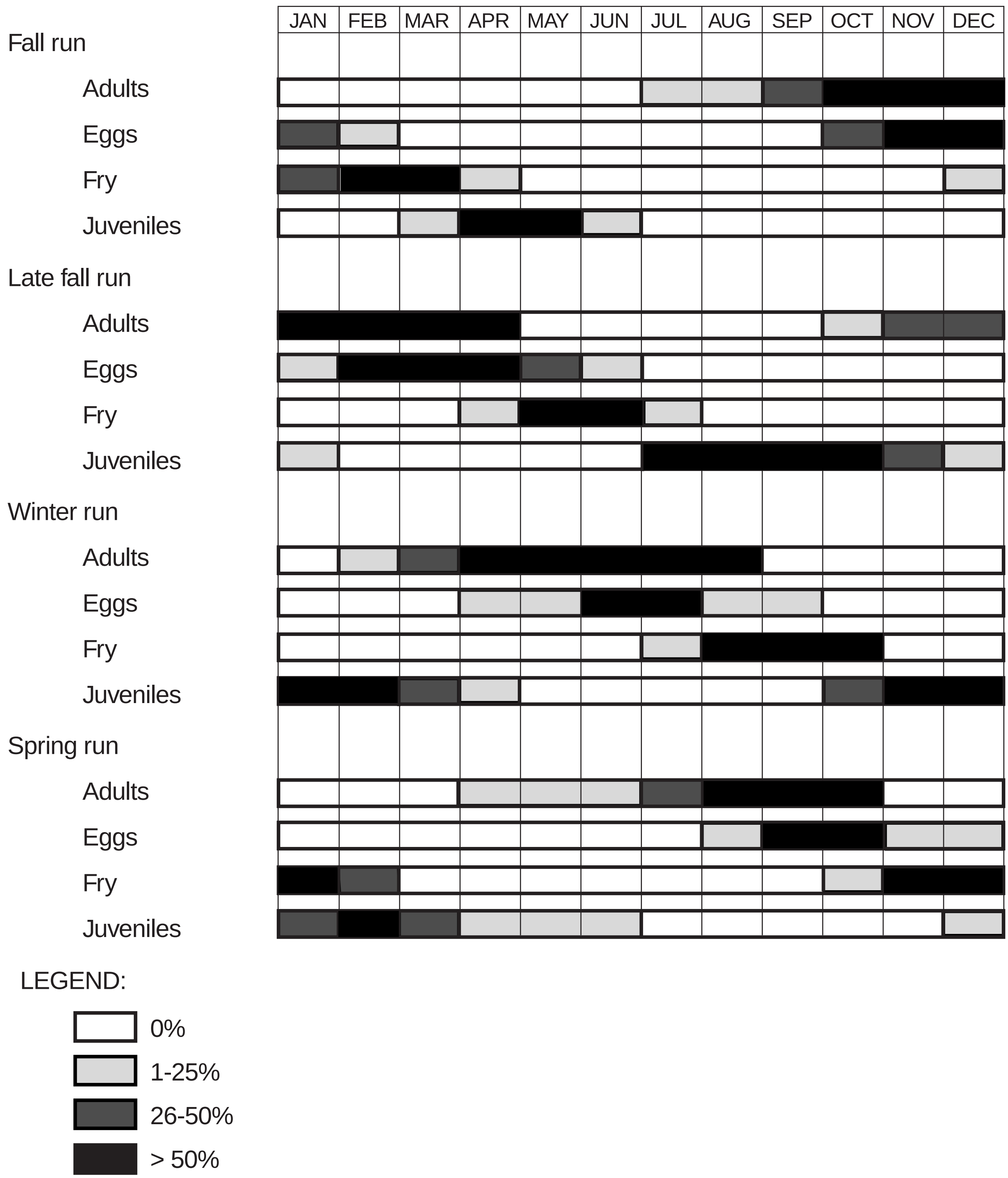
Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
Impact F-19: Potential Increase in the Mortality of Chinook Salmon Resulting from the Indirect Effects of Delta Wetlands Project Diversions and Discharges on Flows under Cumulative Conditions (S) C **Mitigation Measure F-3:** Operate the Delta Wetlands Project under Operations Objectives that Would Minimize Changes in Cross-Delta Flow Conditions during Peak Outmigration of Mokelumne and San Joaquin River Chinook Salmon (LTS)	See above discussion under Impacts F-4 through F-8 (beginning on page 3).
Impact F-20: Reduction in Downstream Transport and Increase in Entrainment Loss of Striped Bass Eggs and Larvae, Delta Smelt Larvae, and Longfin Smelt Larvae under Cumulative Conditions (S) C **Mitigation Measure F-4:** Operate the Delta Wetlands Project under Operations Objectives that Would Minimize Adverse Transport Effects on Striped Bass, Delta Smelt, and Longfin Smelt (LTS)	See above discussion under Impacts F-4 through F-8 (beginning on page 3).
Impact F-21: Change in Area of Optimal Salinity Habitat under Cumulative Conditions (LTS) C No mitigation is required.	See above discussion under Impacts F-4 through F-8 (beginning on page 3).

Note: S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.

Impacts and Mitigation Measures of 1995 Draft EIR/EIS Alternatives 1 and 2	Differences between 1995 Draft EIR/EIS and 2000 Revised Draft EIR/EIS
Impact F-22: Increase in Entrainment Loss of Juvenile Striped Bass and Delta Smelt under Cumulative Conditions (S) C **Mitigation Measure F-5:** Operate the Delta Wetlands Project under Operations Objectives that Would Minimize Entrainment of Juvenile Striped Bass and Delta Smelt (LTS)	See above discussion under Impacts F-4 through F-8 (beginning on page 3).
Impact F-23: Increase in Entrainment Loss of Juvenile American Shad and Other Species under Cumulative Conditions (LTS) C No mitigation is required.	See above discussion under Impacts F-4 through F-8 (beginning on page 3).

Notes: Impacts F-9 through F-16 of the 1995 DEIR/EIS describe impacts of Alternative 3, the four-reservoir island alternative. There is no change to the assessment of Alternative 3; therefore, the impacts and mitigation measures have not changed.

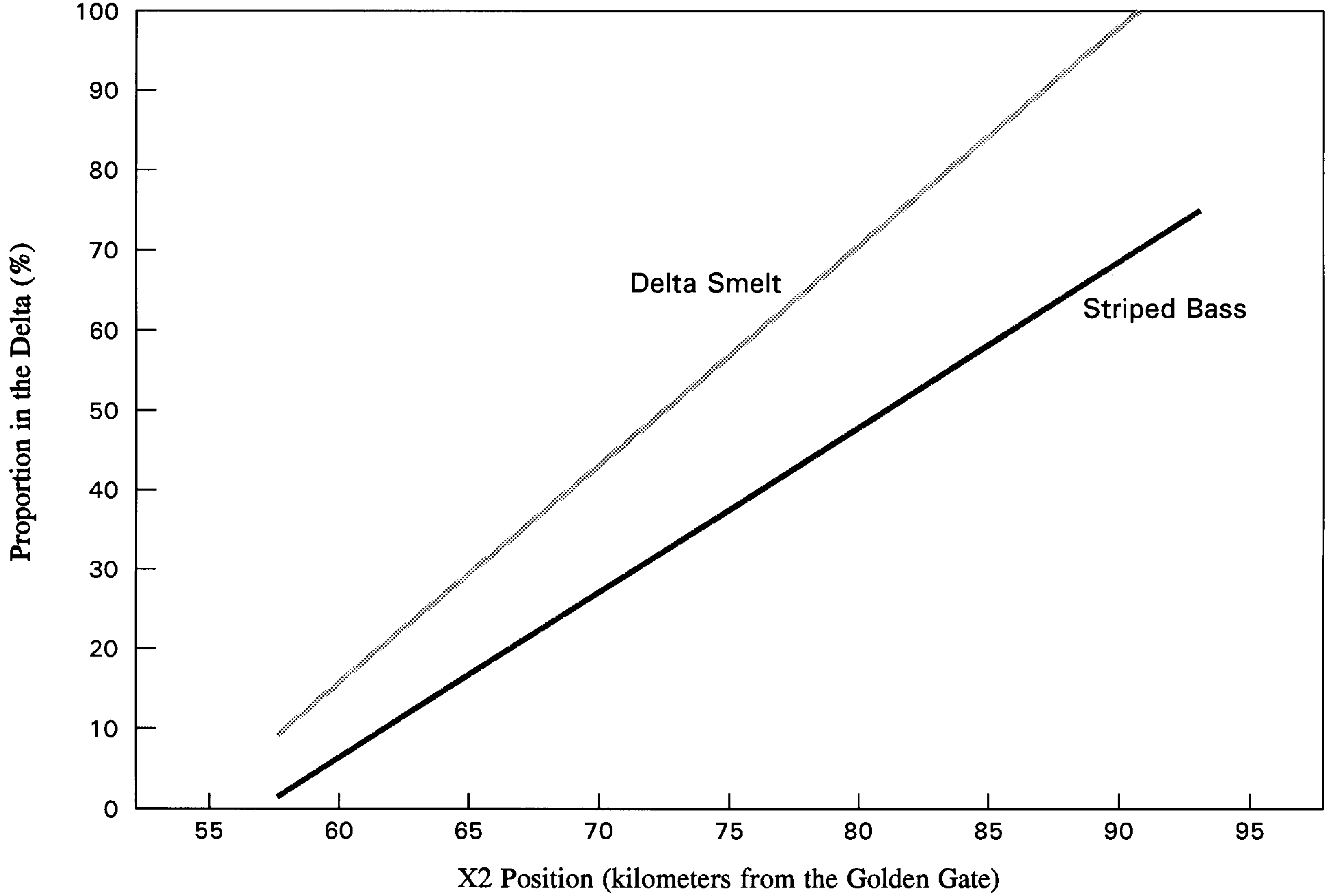
S = Significant; SU = Significant and unavoidable; LTS = Less than significant; B = Beneficial.



Note: Designations for adults represent the percentage of the spawning population that has arrived on the spawning grounds by the month shown. Designations for eggs, fry, and juveniles represent the percentage of the year's brood present during each month.

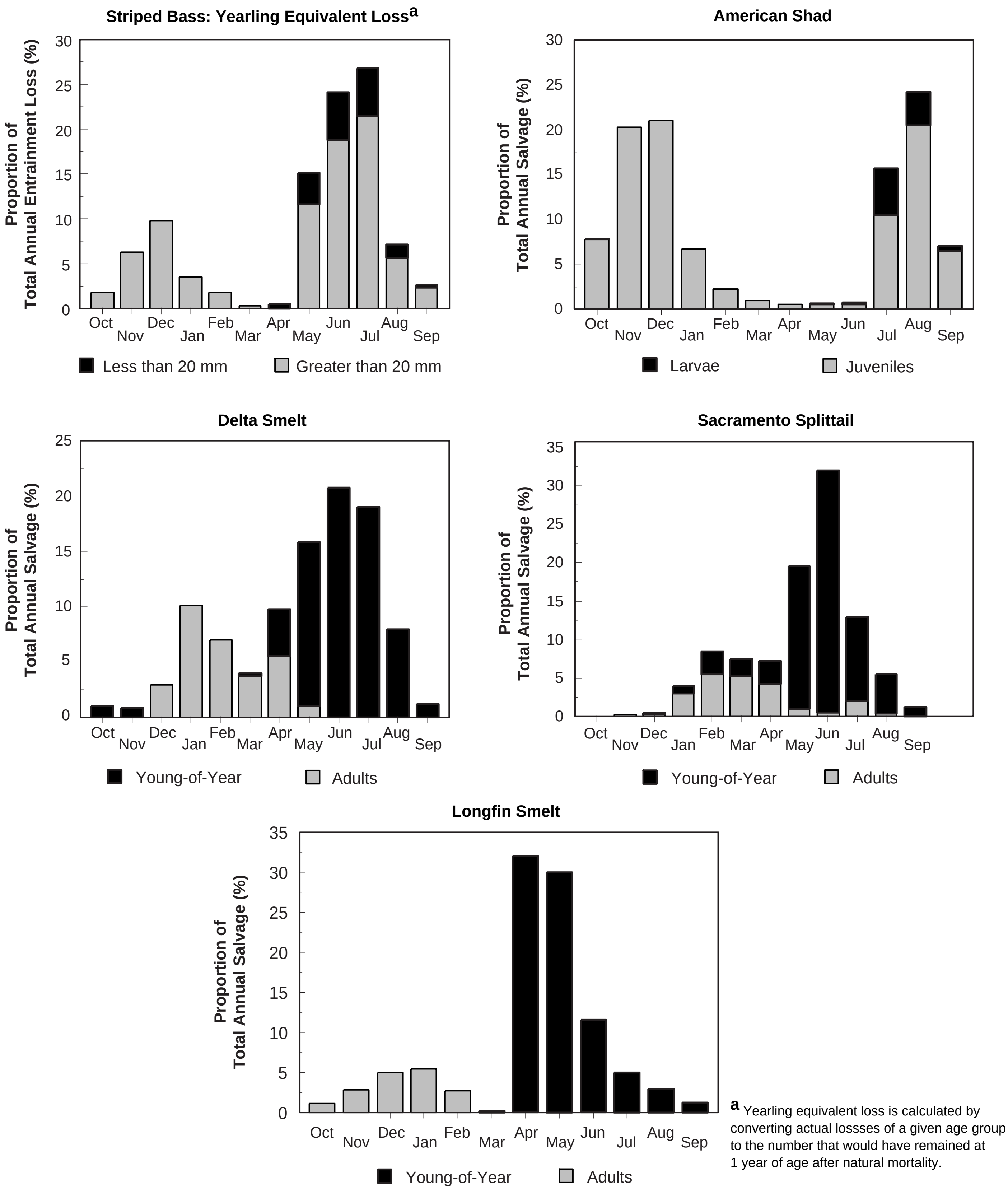
Jones & Stokes

Figure 3F-1
Occurrence of Chinook Salmon by Life Stage in the Sacramento River Basin



Source: DFG 1992b, 1992c.

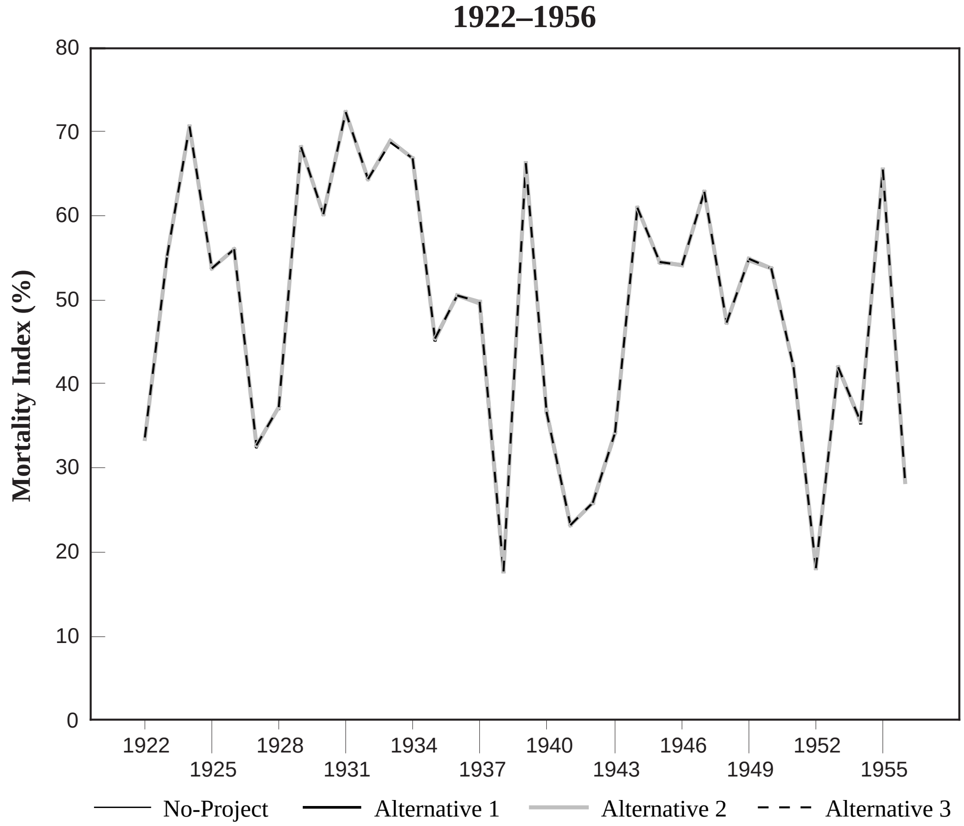
Figure 3F-2
Relationship between the Location of X2 and the Proportion of the Delta Smelt and Striped Bass Populations in the Delta

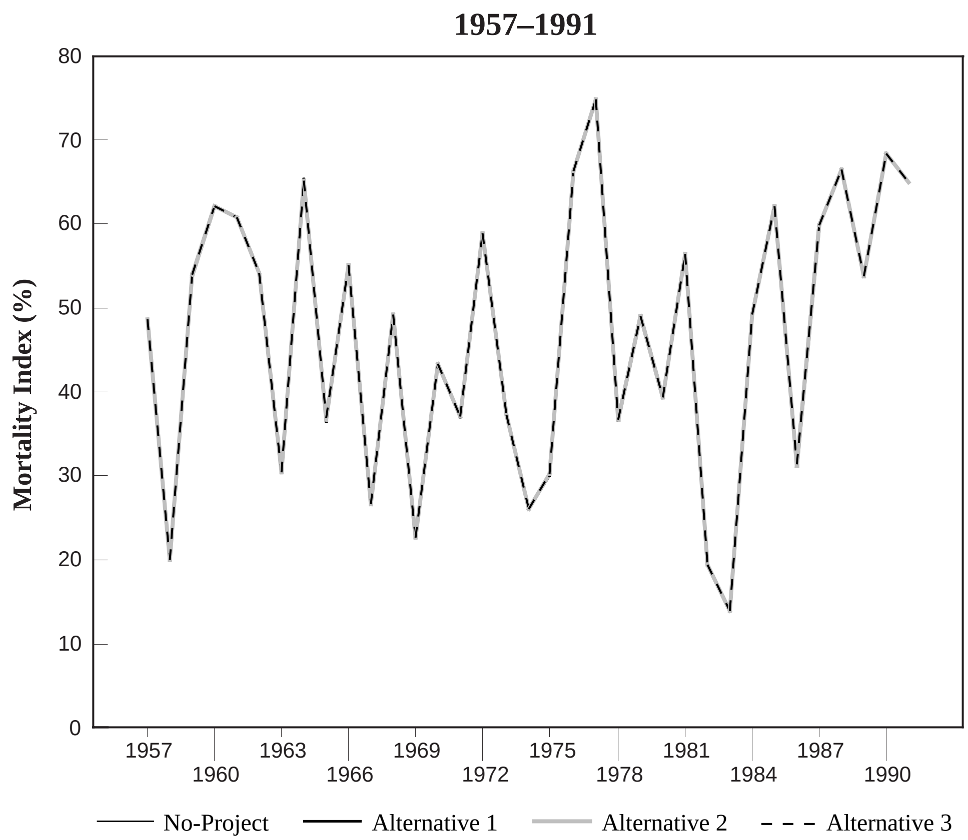


[a] Yearling equivalent loss is calculated by converting actual lossses of a given age group to the number that would have remained at 1 year of age after natural mortality.

Jones & Stokes

Figure 3F-3
Monthly Distribution of Entrainment Loss of Striped Bass and Salvage of American Shad, Delta Smelt, Sacramento Splittail, and Longfin Smelt at the SWP and CVP Fish Protection Facilities, 1979–1990

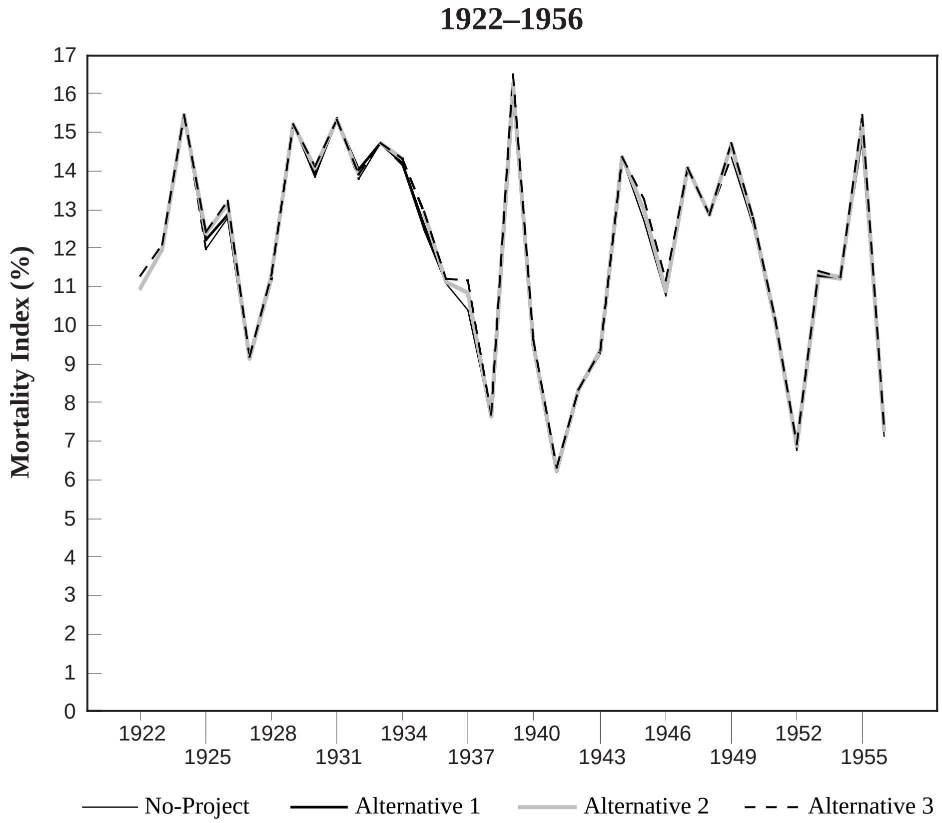


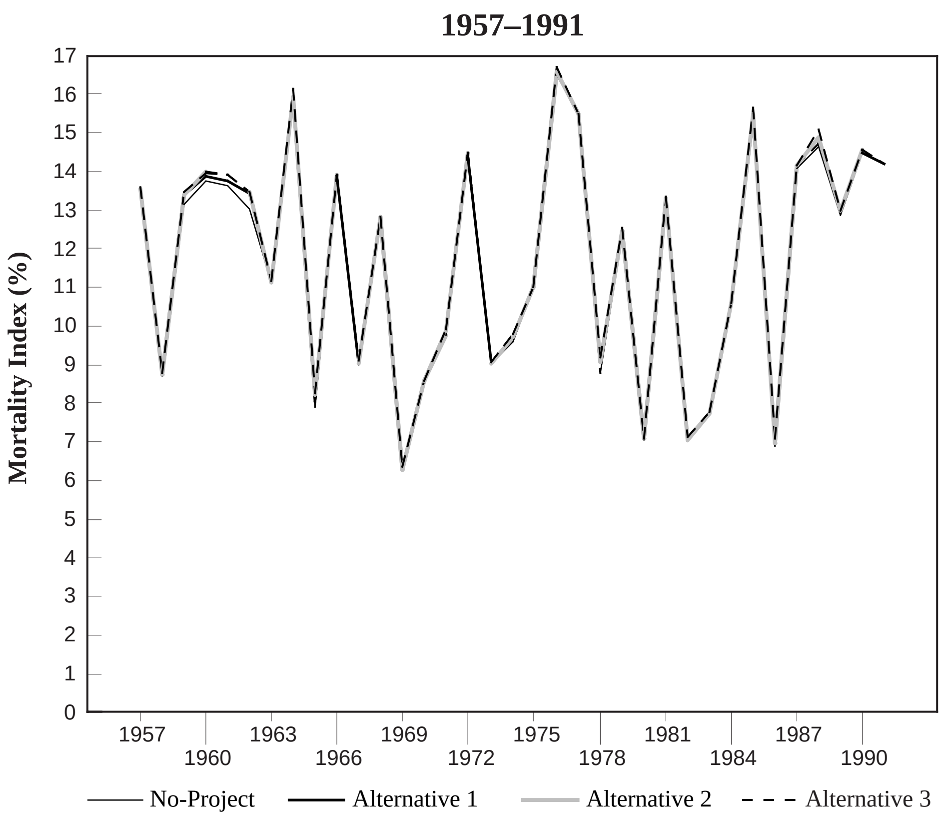


Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

Jones & Stokes

Figure 3F-4
Total Mortality Index for Fall-Run Chinook Salmon from the Sacramento River during Juvenile Migration through the Delta, 1922–1991 Simulation



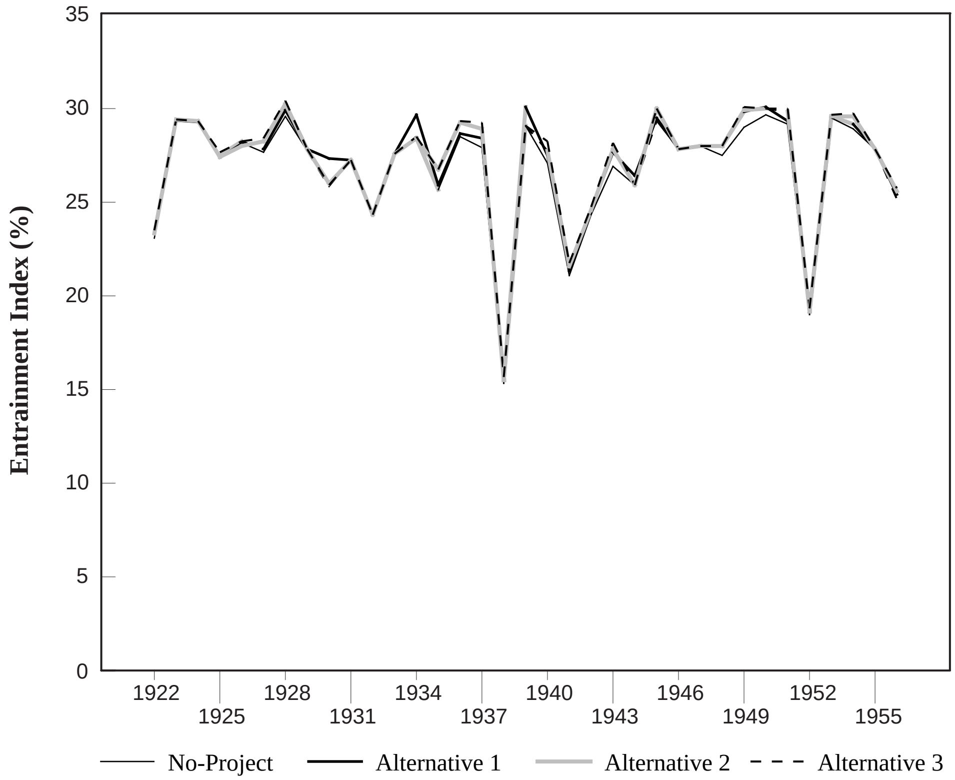


Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

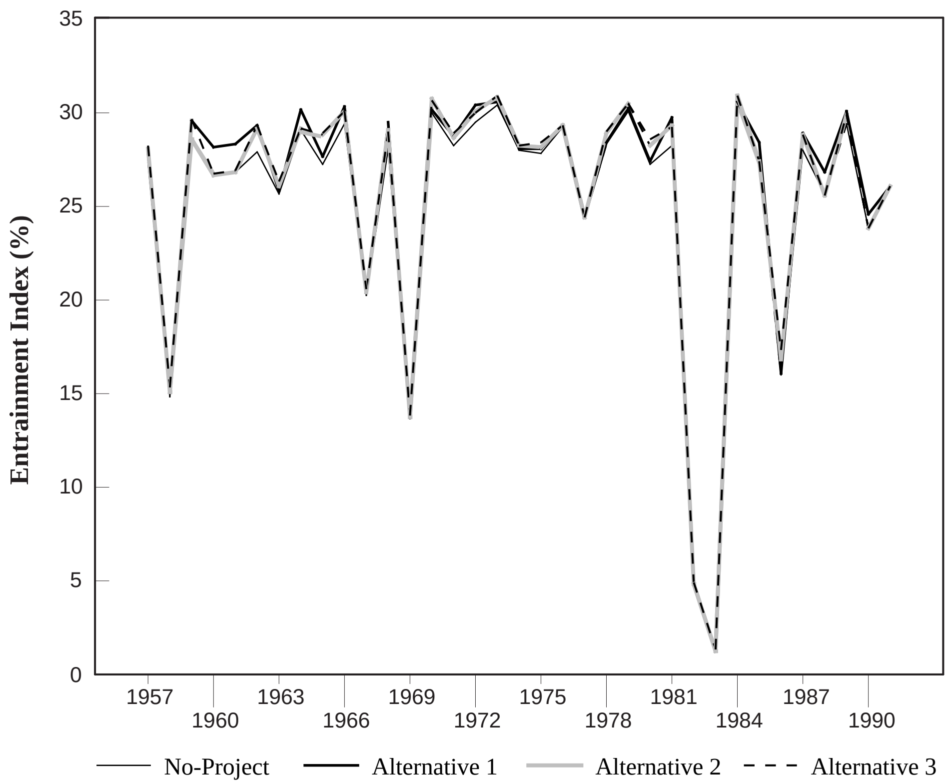
Jones & Stokes

Figure 3F-5
Total Mortality Index for Winter-Run Chinook Salmon from the Sacramento River during Juvenile Migration through the Delta, 1922–1991 Simulation

1922–1956



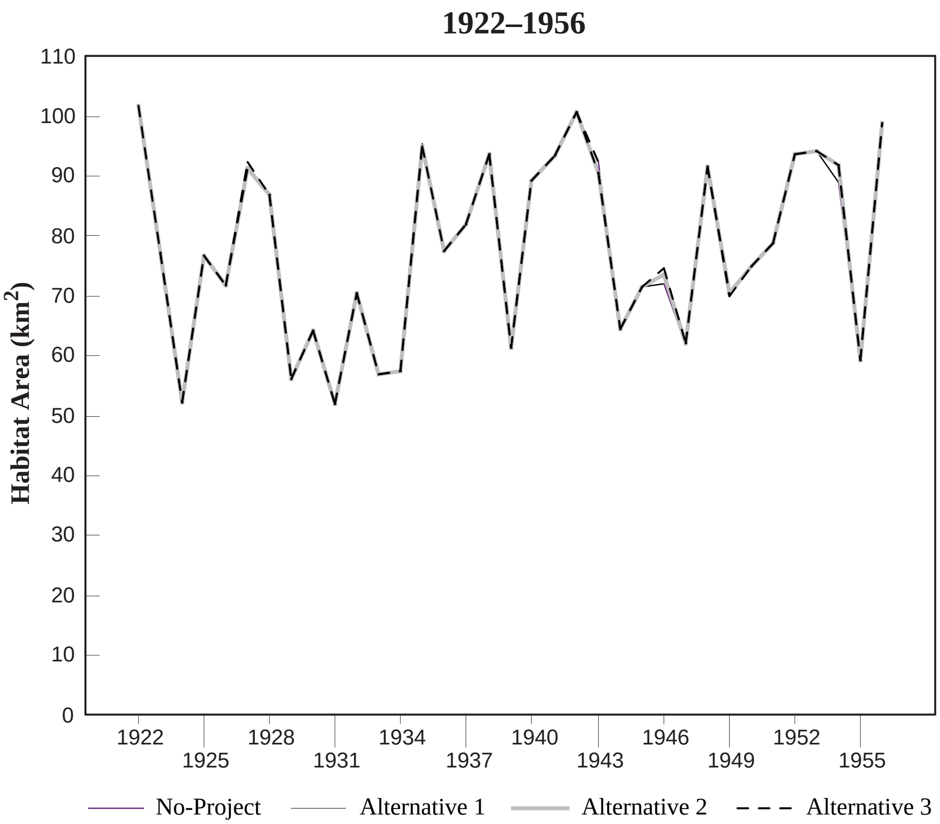
1957–1991

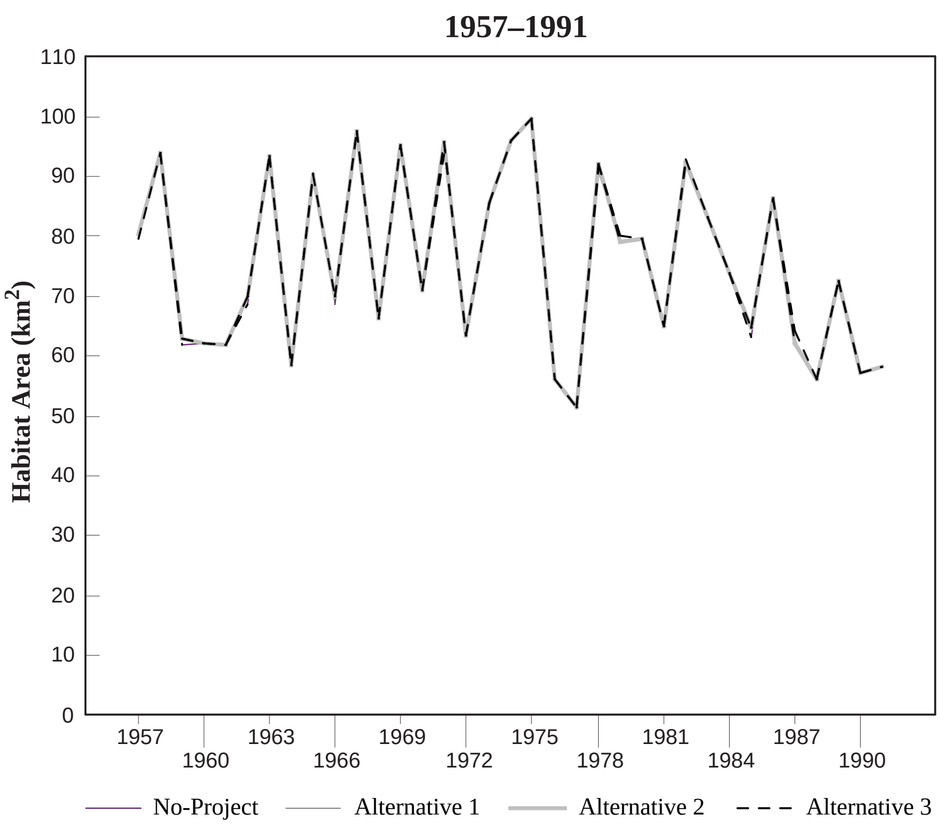


Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

Jones & Stokes

Figure 3F-6
Total Entrainment Index for Striped Bass Eggs and Larvae Entrained in All Delta Diversions, 1922–1991 Simulation





Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

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Figure 3F-7
Estuarine Habitat Area for Striped Bass, 1922–1991 Simulation

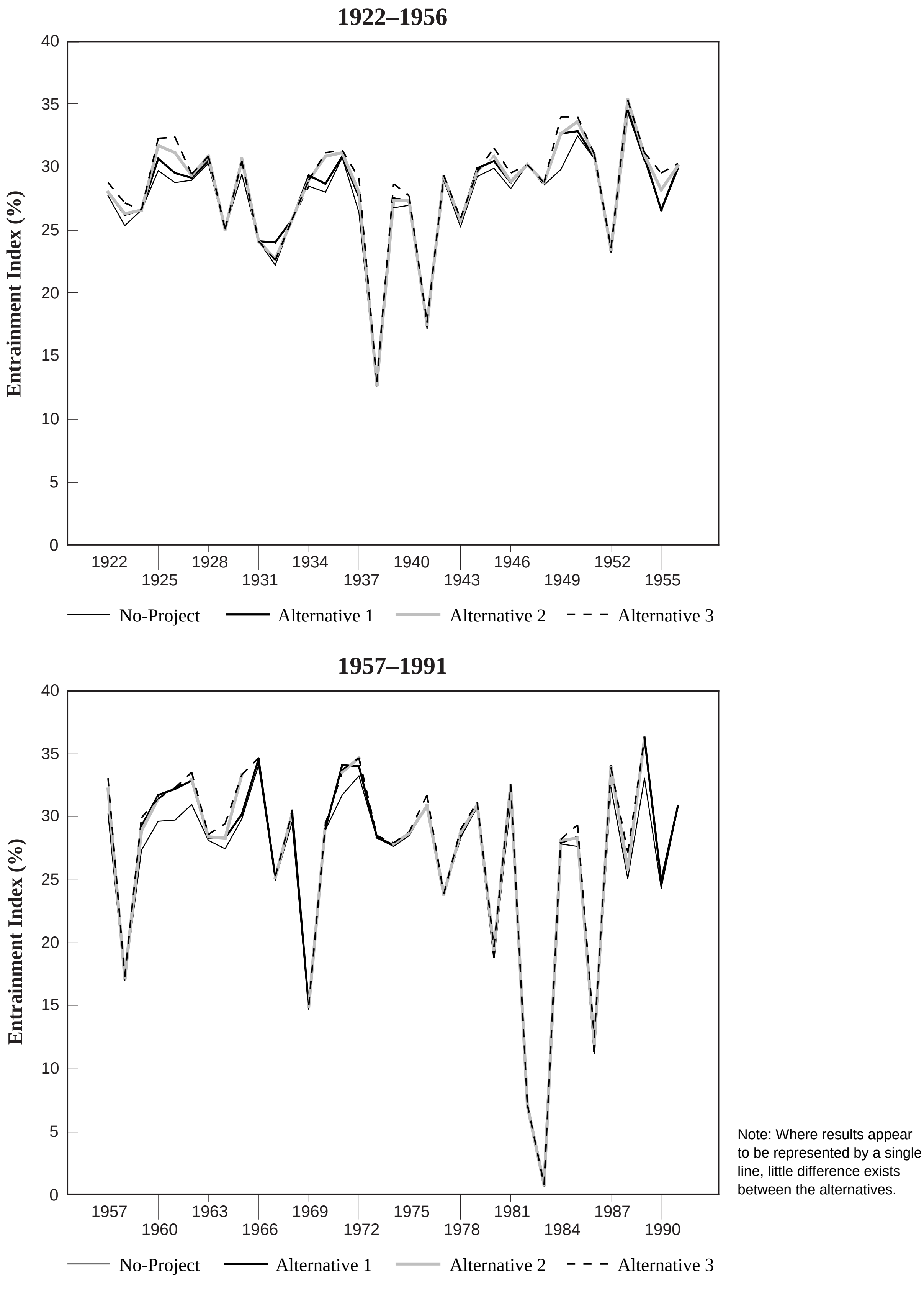

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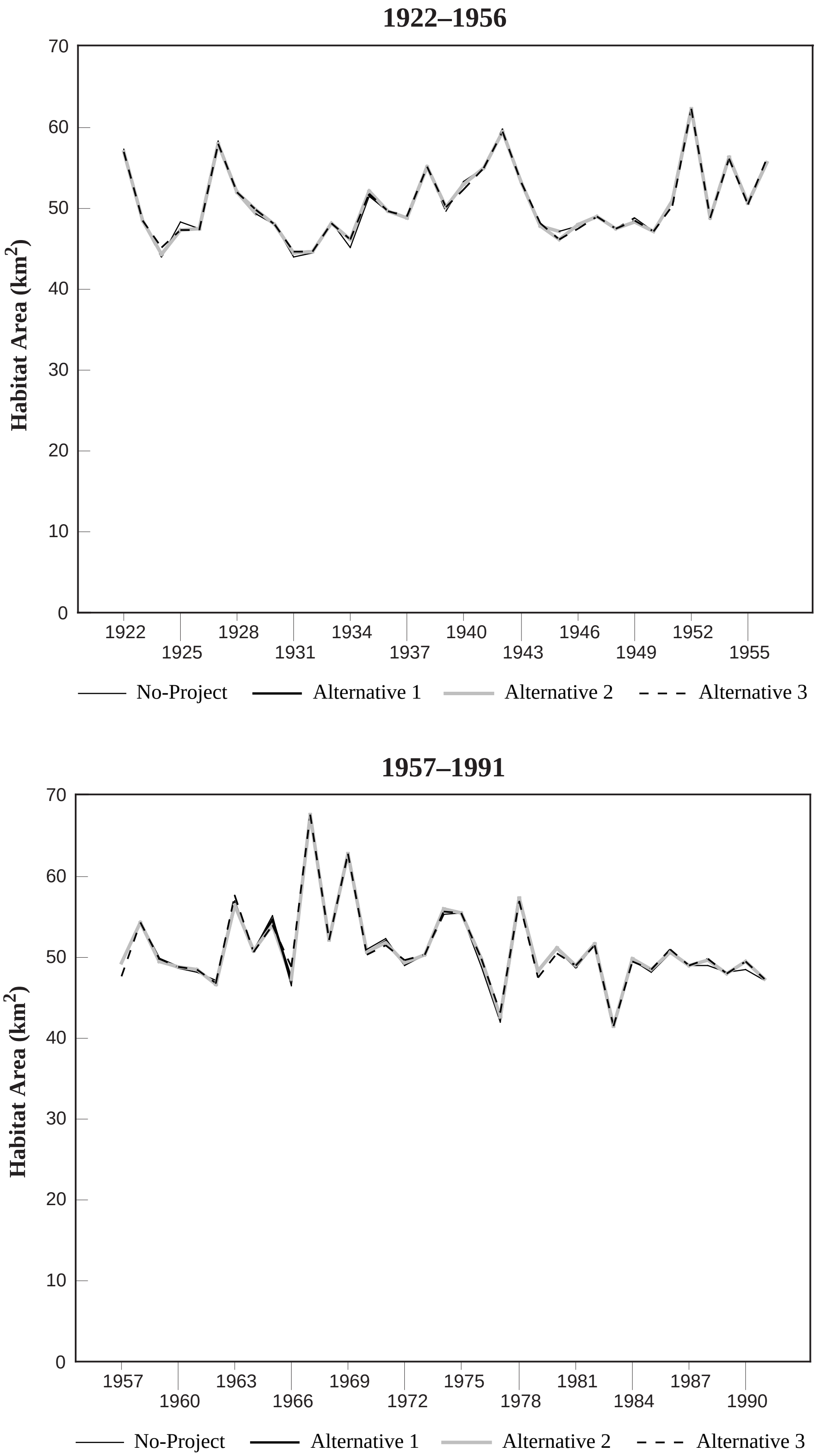
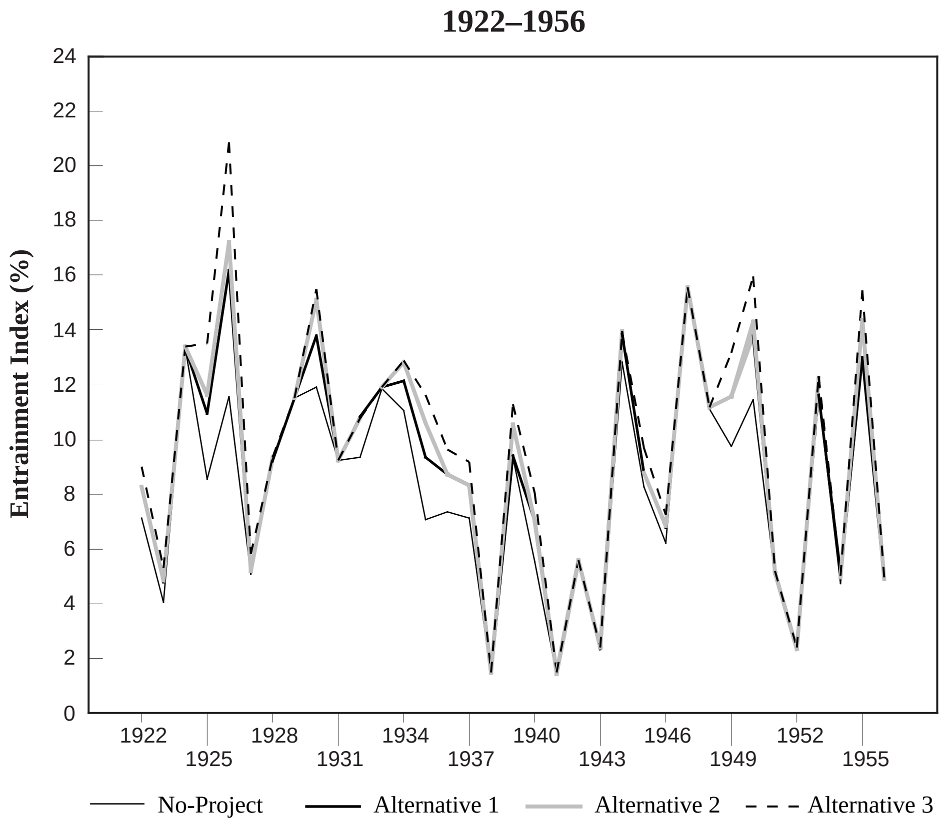
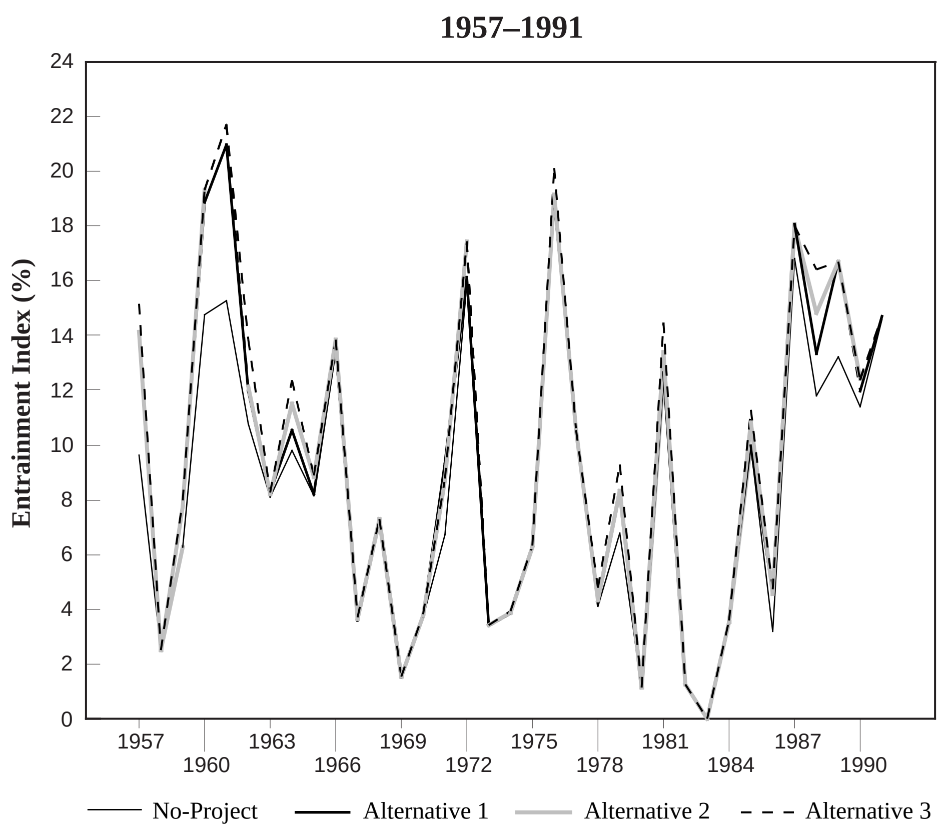
Figure 3F-8
Total Entrainment Index for Delta Smelt Larvae Entrained in All Delta Diversions, 1922–1991 Simulation



Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

Figure 3F-9
Estuarine Habitat Area for Delta Smelt, 1922–1991 Simulation

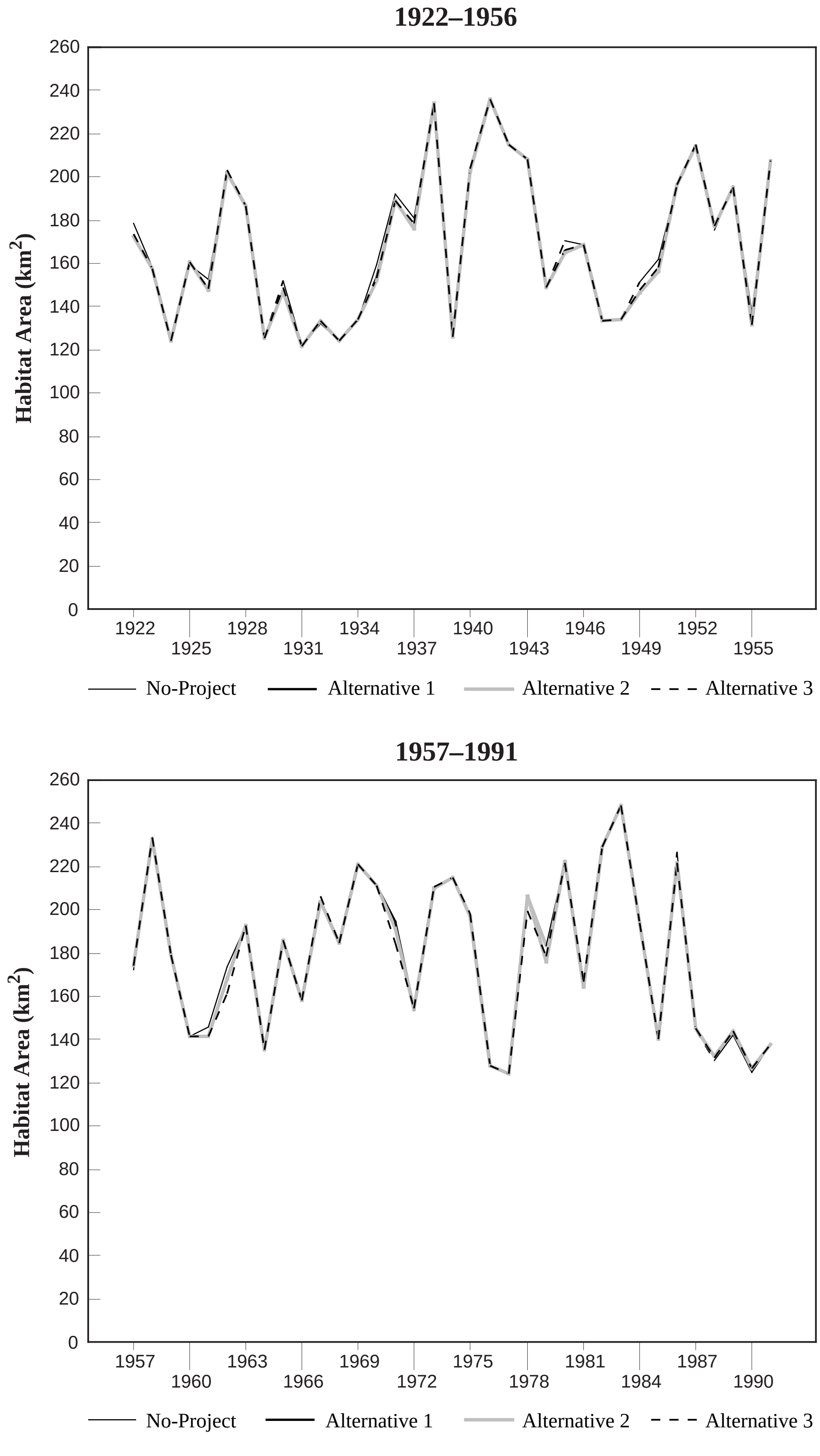




Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

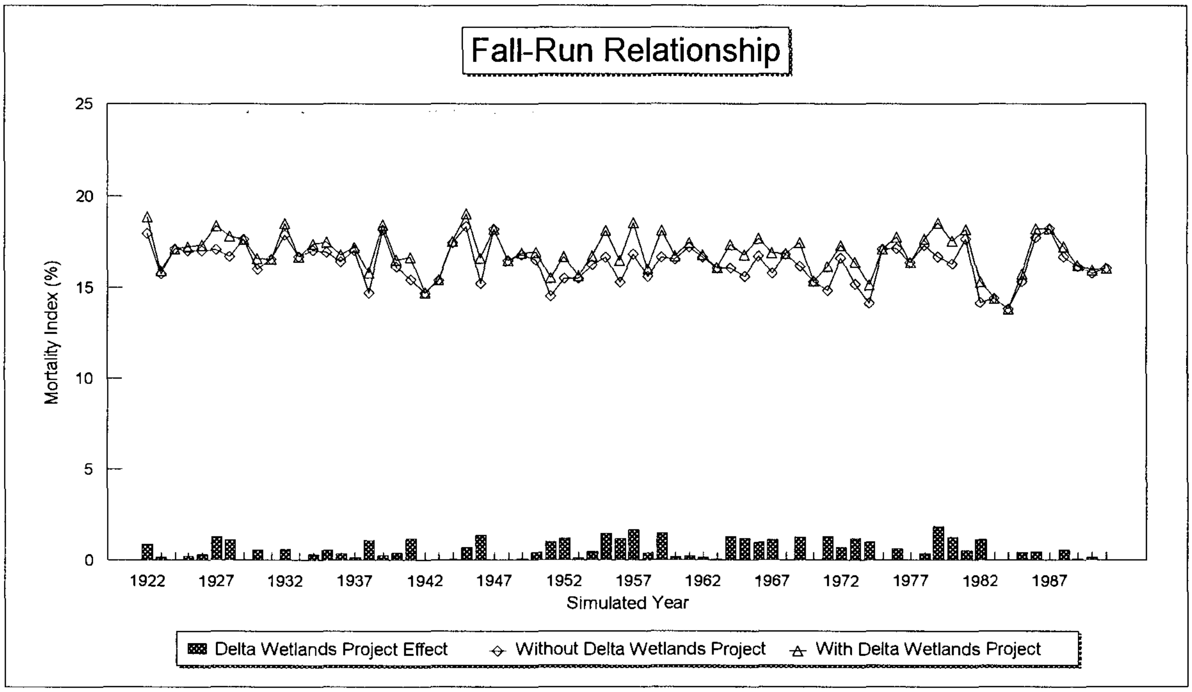
Jones & Stokes

Figure 3F-10
Total Entrainment Index for Longfin Smelt Larvae Entrained in All Delta Diversions, 1922–1991 Simulation



Note: Where results appear to be represented by a single line, little difference exists between the alternatives.

Figure 3F-11
Estuarine Habitat Area for Longfin Smelt, 1922–1991 Simulation



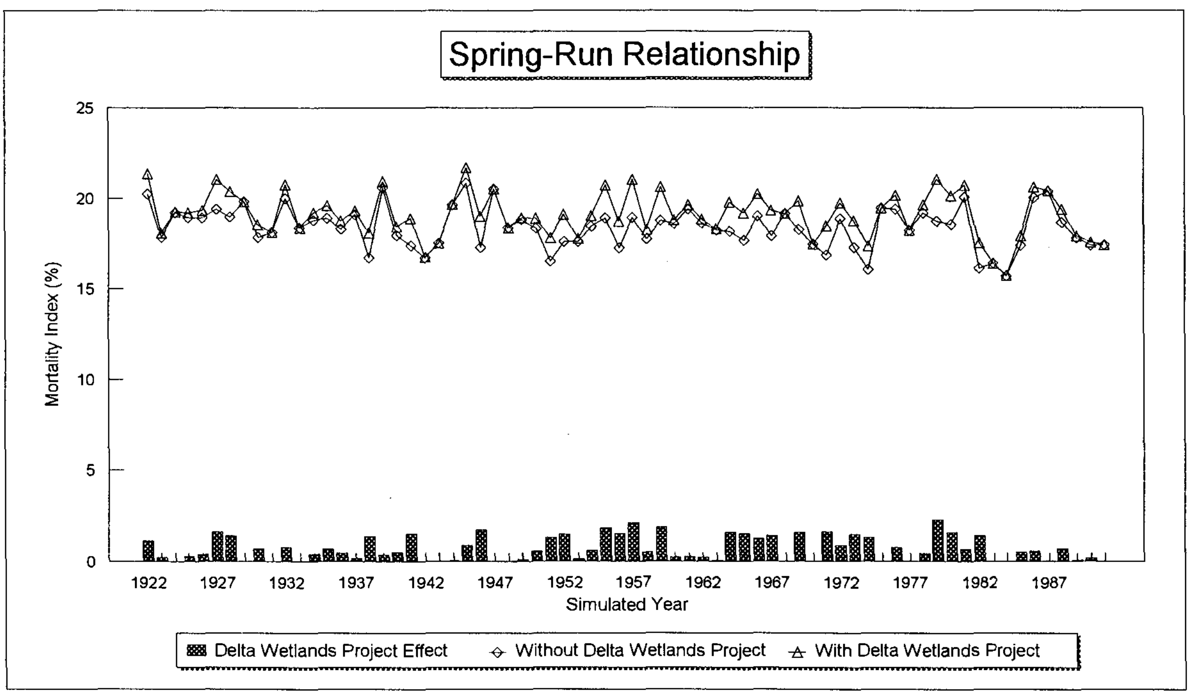
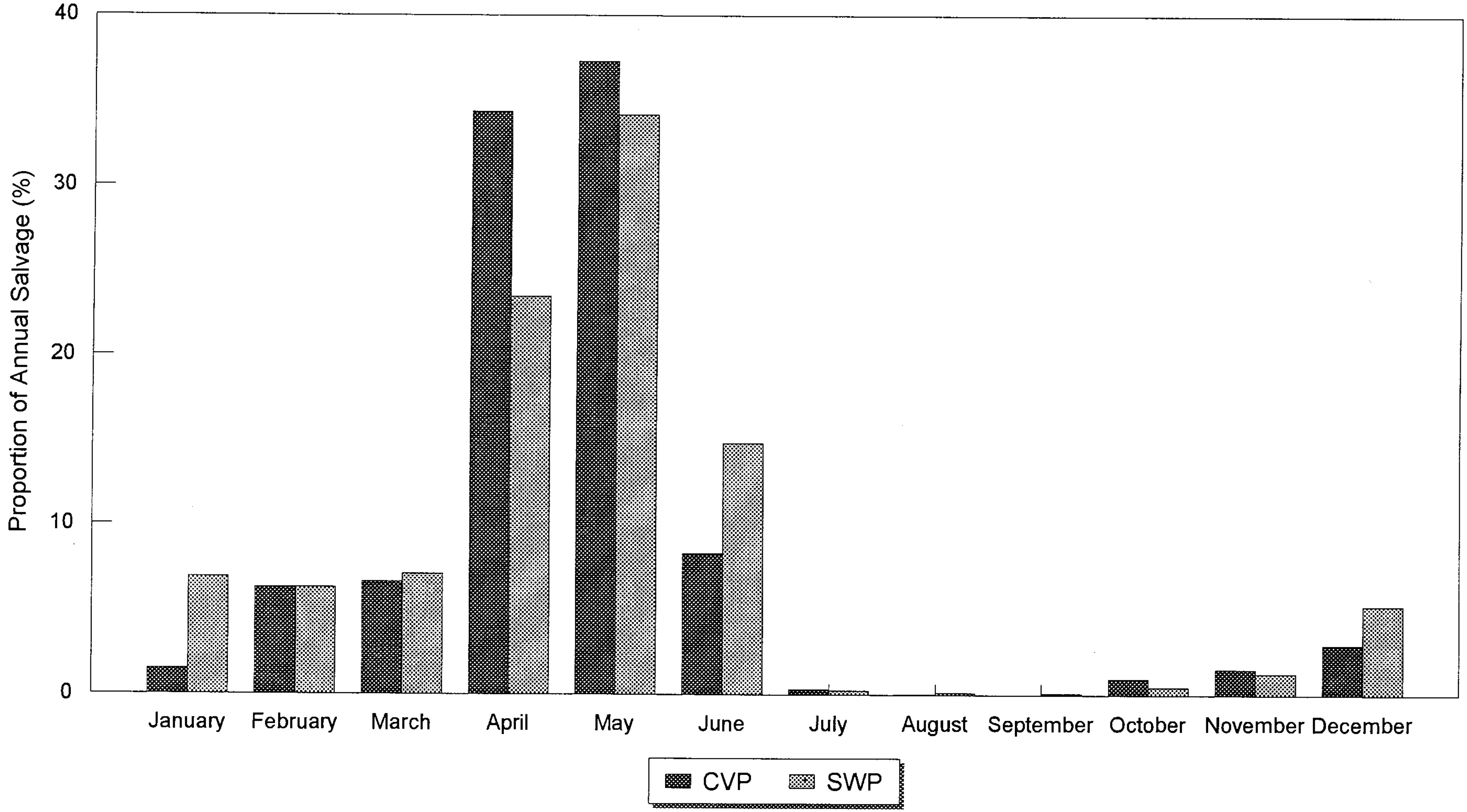


Figure 3F-12
Comparison of the Fall-Run Relationship to the Spring-Run Relationship for Assessment of Delta Wetlands Project Effects on Survival of Juvenile Spring-Run Chinook Salmon



Source: California Department of Fish and Game Salvage Data 1980-1994, Stockton, CA.

Jones & Stokes

Figure 3F-13
Proportion of Annual Salvage of Juvenile Chinook Salmon by Month for the CVP and SWP Fish Protection Facilities

Jones & Stokes

Figure 3F-14
Median Concentration of Mokelumne River Water in the South Delta with and without Delta Wetlands Project Operations

Chapter 3G. Affected Environment and Environmental Consequences - Vegetation and Wetlands

Chapter 3G. Affected Environment and Environmental Consequences - Vegetation and Wetlands

SUMMARY

This chapter describes vegetation and wetland resources on the DW project islands and the impacts of the DW project alternatives on those resources. Impacts of the DW project include conversion of existing vegetation conditions (primarily agricultural) on the reservoir islands to open-water, mudflat, herbaceous, and shallow-water wetland habitats and conversion of existing vegetation conditions (primarily agricultural) on the habitat islands to crops and upland, wetland, woodland, and scrub habitats.

The impact analysis for the reservoir islands provides a description of vegetation and wetland values that would be associated with the various flood conditions on the reservoir islands; because future vegetation conditions are unpredictable, however, it is assumed that the reservoir islands would provide no wetland values that would compensate for project impacts.

Under Alternative 1, 2, or 3, construction of project facilities (e.g., siphon and pump stations or recreation facilities) and levee improvements on sites occupied by special-status plants could result in the loss of special-status plants; this would be considered a significant impact. Avoidance measures are recommended to reduce this impact to a less-than-significant level.

Implementing Alternative 1 or 2 would result in losses of riparian and permanent pond habitats and of upland and agricultural habitats. Losses in acreages of these jurisdictional wetland habitat types on the reservoir islands would be offset by creation of similar vegetation types on the habitat islands as described in the HMP; therefore, these losses are considered less than significant. Implementing the HMP under Alternative 1 or 2 would also result in a beneficial increase in freshwater marsh and exotic marsh habitats and the beneficial cumulative impact of an increase in wetland and riparian habitats in the Delta.

Under Alternative 3, the loss of jurisdictional wetlands on reservoir islands, including riparian, marsh, and pond habitats, would be considered a significant impact. Although a limited amount of habitat would be created in the NBHA to partially offset this impact, DW would need to develop and implement an offsite mitigation plan to reduce this impact to a less-than-significant level.

Under the No-Project Alternative, impacts would result primarily from conversion of fallow, herbaceous upland, riparian, and wetland habitats to agricultural use. In contrast to implementing any of the DW project alternatives, implementing the No-Project Alternative would decrease the diversity of vegetation types on the four DW islands. Implementing the No-Project Alternative would not result in direct disturbance of special-status plants from construction of facilities as described for the DW project alternatives. However, as increasing land subsidence rates and flood risks become critical to levee stability over time, improvements to perimeter levees under the No-Project Alternative could adversely affect known populations of plants.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

No substantive changes have been made to this chapter since the 1995 DEIR/EIS was published. In response comments on the 1995 DEIR/EIS, Mitigation Measure G-2, "Protect Special-Status Plant Populations from Construction and Recreational Activities", has been further defined to include monitoring requirements and performance standards. This minor modification does not change the conclusions of the analysis of project impacts on vegetation and wetlands presented below.

INTRODUCTION

This chapter discusses impacts of the DW project on vegetation and wetlands, most of which would result from water storage operations on the reservoir islands and from management of the habitat islands to provide project compensation. The HMP incorporated into the project description for Alternatives 1 and 2 provides for compensation habitat to be established on the habitat islands to offset the effects of reservoir island operations on vegetation and wetlands. The impact assessment for Alternatives 1 and 2 is therefore based on the assumption that project implementation would include the establishment of compensation habitat acreages as specified in the HMP. Under Alternative 3, all four DW project islands would be used as reservoirs, and the NBHA on Bouldin Island would be used to provide limited compensation habitat.

The following appendices provide more detailed information on vegetation and wetlands under existing conditions and predicted future conditions with project implementation on DW project islands:

Appendix G1, "Plant Species Nomenclature";

Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands";

Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands";

Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives"; and

Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation".

AFFECTED ENVIRONMENT

This section describes vegetation and wetland conditions on the DW project islands. Information on vegetation and wetlands is based in part on information collected for the 1990 draft EIR/EIS and has been updated to current conditions where these changes would affect the impact analysis.

As a result of land management decisions made since 1988, some changes in agricultural land use and vegetation conditions on the islands have occurred. Some of these changes were made in response to annual fluctuations in agricultural market conditions; others were made in anticipation of DW project implementation. Because some of these changes have resulted from project-related actions and influences, information from the 1990 draft EIR/EIS (based on 1988 conditions) provides the most reliable description of typical preproject vegetation and wetland conditions on the DW project islands for assessing the impacts of the DW project alternatives.

Sources of Information

Aerial photographs of the project area, taken in 1987, were used to identify and delineate vegetation types present on the DW project islands. Mappings of vegetation types were verified during surveys conducted in 1988. Classification schemes for habitat types were developed in consultation with DFG and USFWS.

Delineation of jurisdictional wetlands under Section 404 of the Clean Water Act was jointly conducted for the DW project islands by the Natural Resources Conservation Service (NRCS) (formerly the U.S. Soil Conservation Service), USACE, EPA, and USFWS in October 1994. In December 1994 and January 1995, USACE and NRCS, respectively, verified delineations of waters of the U.S., including wetlands, on the DW project islands. Results of the delineation were used to identify the extent and types of jurisdictional wetlands on the DW project islands. Both verifications expired 5 years after they were issued. DW is currently working with USACE and Jones & Stokes to update the delineation to reflect current conditions on the project islands. Because farming conditions on the project islands have not substantially changed since 1994, the wetland conditions described in this chapter are sufficient for impact analysis purposes. However, USACE will verify an updated wetland delineation before it issues a decision on the project.

Special-status plant species that potentially could be found in the project area were identified in consultation with DFG and USFWS (see Appendix H5, "Agency Correspondence regarding the Federal and California Endangered Species Acts") and using California Native Plant Society (CNPS) lists (CNPS 1994), DFG's Natural Diversity Data Base (NDDB) (NDDB 1993), Smith and Berg (1988), and Madrone Associates (1980). Field surveys to locate special-status plant populations were conducted in spring and summer 1988. A portion of Webb Tract that could not be surveyed in 1988 was surveyed in August 1994.

Special-Status Plant Species

Definition of Special-Status Species

Special-status plant species are defined to include:

- species listed by the state of California as rare, threatened, or endangered;
- species that are federally listed, proposed for listing, or candidates for listing as threatened or endangered (55 FR 6184, February 21, 1990, and 50 CFR 17.12 [listed plants] and various notices in the Federal Register [proposed species]); and
- species listed by CNPS as rare and endangered (Smith and Berg 1988).

Special-status plant species potentially occurring in the project area were defined as those special-status species with known populations in or near the project area, and those known from habitats either identical to or similar to those found in the project area. The sources listed above under "Sources of Information" were used to develop a list of potentially occurring special-status plant species: DFG's NDDB (1993), Messersmith (pers. comm.) (included in Appendix H5, "Agency Correspondence regarding the Federal and California Endangered Species Acts"), Smith and Berg (1988), CNPS (1994), and Madrone Associates (1980). Based on this investigation, 14 special-status plants were identified as having the potential to occur in the project area (Table 3G-1), although none of these species were reported previously from the project area (NDDB 1987).

Consultations with DFG (Messersmith pers. comm.) identified seven other species not included in Table 3G-1 (Crampton's tuctoria, Bolander water hemlock, Contra Costa goldfields, Delta coyote thistle, caper-fruited tropidocarpum, Colusa grass, and palmate-bracted bird's beak). Potential habitat for these species does not exist in the project area.

Field Surveys

Field surveys for special-status plant species were conducted during April and August-September 1988. All potential habitat in the project area, including the water and land sides of exterior levees, was surveyed for the presence of special-status plants. The property on the eastern end of Webb Tract was not surveyed in 1988 because access was not available at the time of field surveys. This portion of Webb Tract, however, was surveyed in August 1994. Floristic field survey methods were employed as specified by DFG (1984).

Results of Surveys

Populations of the Suisun Marsh aster, Mason's lilaeopsis, rose-mallow, and Delta tule pea were detected during the field surveys; all were located on the water side of island levees (Dains 1988). These observations are summarized in Table 3G-2, and the locations of the populations of these species on the four DW project islands are shown in Figures 3G-1, 3G-2, 3G-3, and 3G-4. Population sizes at each location are described in Dains (1988). Populations of the Delta mudwort were detected along the exterior slopes of island levees. Population sizes and locations were not recorded during field surveys, however, because the Delta mudwort was not designated as a special-status species at the time surveys were conducted. No unexpected special-status species were observed during the floristic surveys (Dains 1988).

No populations of the other species listed in Table 3G-1 were located. Although suitable habitat (i.e., sandy hummocks) for the Antioch Dunes evening primrose and Contra Costa wallflower appeared to exist in the project area, field surveys indicated that the sites were not suitable because they had previously been tilled.

Habitat Types

Classification Scheme and Mapping Methods

Nineteen habitat types in seven major habitat groups were designated in a classification scheme designed specifically for the DW project islands (Table 3G-3). The habitat-type classification scheme was developed in consultation with DFG and USFWS. The major habitat groups are riparian, marsh, woody non-native, herbaceous upland, agriculture, open water, and developed land. The five agricultural habitat types (grain and seed crops, perennial crops, livestock pasture, waterfowl food crops, and fallow fields) were subdivided by crop type where possible. Abandoned agricultural fields and other weedy sites are included in the marsh or herbaceous upland groups, depending on species composition and field moisture conditions.

Vegetation was mapped on the DW project islands using the habitat classification scheme shown in Table 3G-3 to describe the conditions on the islands as of December 1987. Habitat-type mapping was based on color aerial photographs of all four islands taken on October 5, 1987, at a scale of 1:24,000. Preliminary determinations of habitat types and boundaries were traced onto mylar overlays, based on inspection of the color prints that had been enlarged to a scale of 1:12,000 from the original negatives. Habitat types were mapped to a minimum polygon size of approximately 1 acre.

Habitat types were observed directly from low-altitude aircraft and during vehicle and foot surveys of all four islands during January-June 1988. The initial habitat-type delineations were corrected and refined through these observations.

Descriptions of Habitat Types

The portions of the four DW project islands included in Alternatives 1 and 2 encompass 20,128 acres (about 31 square miles) (Figures 3G-5 through 3G-8). This section describes habitat conditions and acreages that would be affected under implementation of Alternative 1 or 2. Alternative 3 and the No-Project Alternative would include use of the southwest quarter of Holland Tract, which is excluded under Alternatives 1 and 2 (Figure 3G-9).

Acreages of each of the seven habitat types and their subgroups for each alternative are shown in Table 3G-4. The acreage figures were produced by planimeter measurement of areas on the habitat-type maps of the four DW project islands completed in June 1988.

Agriculture. Approximately 63% of the DW project island acreage is in active agricultural use (types A1 and A2 in Table 3G-4). Much of the remaining agricultural land was in a temporary fallow condition (i.e., fallow for less than 2 years) (type A5) in December 1987 because of soil or pest management problems, agricultural "set-aside" programs, land ownership transfers, or farm bankruptcy. All developed land (types D1 and D2) is directly associated with agricultural operations, with the exception of two small commercial marinas on Holland Tract.

Much of the agricultural land remained disked or flooded during the onsite field mapping in spring 1988. A determination of crop types on these fields was made with maps and tables showing crop allocations acquired from farming companies. Farmers and landowners were also contacted to determine which crops were typically grown in each major field and why some fields remained fallow or were abandoned.

The predominant field crops in type A1 are corn, wheat, milo, sunflower, and potato. About 8.8% of the agricultural land is in perennial crops (type A2), such as asparagus (1,492 acres) or vineyards (278 acres). Only 445 acres are permanently managed as pasture and are grazed, primarily by beef cattle (type A3). A much larger area of field crops (type A1), probably several thousand acres, is grazed seasonally by sheep for weed control and stubble reduction.

On Holland Tract, DW's demonstration wetland for testing of watergrass seed production was mapped separately as type A4. During 1988 and 1989, water levels were managed in this wetland to simulate the hydrologic regime of the DW project as proposed at that time.

Management of agricultural lands on the DW project islands must address problems endemic to Delta lands, including poor irrigation drainage, disease outbreaks, declining soil productivity, and weed infestation. The primary method of watering crops on the four islands is to apply water through siphon pipes from sloughs or channels to a network of canals and ditches on each island. Higher elevation fields that are better drained are irrigated with traditional surface irrigation techniques.

The shallow water table, in combination with the organic peat soil, creates a soil condition favorable to the outbreak of plant pathogens and destructive nematodes. Therefore, crop options are limited to shallow-rooted species and varieties that are resistant to diseases, including most grain crops in the grass family. Orchards and most vegetable crops are conspicuously absent. Long-term productivity also is declining as a result of the oxidation of peat soils exposed during cultivation.

Another chronic management problem on Delta islands is field infestation by weeds, especially Johnson grass, canarygrass, smartweed, land kelp, peppergrass, cocklebur, and other moisture-dependent exotic weeds. Drainage and irrigation ditches must also be cleared annually of woody invaders, primarily exotic Himalaya berry, willow, and cottonwood. The extensive network of ditches in the fields is an ever-present transport system for waterborne weed seed (both woody and herbaceous).

Riparian Habitat. Riparian habitat is associated with areas at the margins of perennial and intermittent streams, rivers, and other water bodies that have abundant soil moisture. Two woody riparian habitat types are found on the DW project islands: cottonwood-willow woodland (type R1) and willow scrub (type R2). Type R2 is generally less than 5 years old and consists of four species of willows mixed with cottonwood seedlings. Type R1 is generally older than 5 years and contains cottonwood saplings and trees taller than the willow shrub understory.

Because weeds become established readily on Delta islands, farm management emphasizes "clean farming" practices that include annual disking of fallow fields and periodic clearing of riparian trees and shrubs from the interior ditch systems. Only about 1% of the DW project islands is occupied by woody riparian habitat (types R1 and R2) (Table 3G-4). Most of this habitat type is found on Webb and Holland Tracts, where agricultural management is less intensive and has not kept pace with natural colonization by water-dependent weeds and woody riparian plants.

Most riparian vegetation on the DW project islands is in an early stage of development. Small linear stands of willow and cottonwood are often found in or along ditches or at the toes of perimeter levees that have not been regularly maintained. Maintenance policies of the local reclamation districts do not allow mature woody vegetation on the upper interior levee slopes or on exterior levee faces because of the need to inspect the levees for seepage and structural defects.

The exceptions to the above pattern are the somewhat older and more diverse stands of riparian and marsh vegetation surrounding the blowout ponds on Webb and Holland Tracts. These small lakes (type O2) were scoured into the island bottoms by suddenly inrushing flood waters from exterior channels, typically 15-20 feet higher than the interior island elevations, following levee failures in 1950 on Webb Tract and in 1980 on both islands. The blowout ponds are generally not economically feasible to reclaim as agricultural land. Saturated soils on the pond perimeters prevent mechanical clearing of vegetation.

Riparian vegetation began to become established around the Holland Tract blowout pond in summer 1980 after floodwaters had been pumped from the island. Floodwaters were not pumped from Webb Tract until February 1981 (Kjeldsen pers. comm.). Thus, most riparian vegetation is 15 years old on Holland Tract and 14 years old on Webb Tract.

Marsh. Marsh habitat is dominated by herbaceous plant species growing in soil inundated by water for long periods, if not indefinitely. Tidal marsh (type M2) exists only along the outside margins of the DW project islands. Nontidal freshwater marsh (type M1) occupies 224 acres on the four islands, 77% of which was found on Webb Tract primarily around the two blowout ponds (Table 3G-4). This habitat type is typically associated with riparian and open-water habitats in relatively undisturbed locations. Dominant plants include cattail, tule, bulrush, other emergent wetland species, and button bush.

Exotic marsh vegetation (type M3) occupies 5.6% (1,124 acres) of the DW project islands, primarily on Webb and Holland Tracts (Table 3G-4). In December 1987, this type consisted of former agricultural fields, which, for various reasons, were abandoned or left fallow for more than 2 years and subsequently had been invaded by dense stands of exotic herbaceous weeds. Typical weedy species include nettle, annual smartweeds, peppergrass, field mustard, wild radish, dallisgrass, curly dock, amaranth, and watergrass. The depth to the water table determines whether these abandoned fields are invaded by exotic marsh weeds or herbaceous upland weeds. This type sometimes occupies small untilled sites in actively farmed fields.

Herbaceous Upland. Annual grassland (type H1), found primarily on the broad, gentle interior slopes of the perimeter levees, occupies 7.5% of the project islands (about 1,514 acres). Typical annual grassland species include canarygrass, ripgut brome, mustard, and bur-clover. Levees may be grazed but are not cultivated. A portion of this type is upland habitat on remnant knolls or sand hills on Webb and Holland Tracts. If the sand hills were actively cultivated for dry-farmed grain in December 1987, they are included in agricultural type A1.

Exotic perennial grassland (type H2) is a habitat type with moisture conditions ranging between those of annual grassland (type H1) and exotic marsh (type M3). Soil moisture is adequate year round to support lush growths of perennial grasses (e.g., Bermuda grass, perennial ryegrass, saltgrass, and Johnson grass) and annuals but is not wet enough in the dry season to support typical wetland species (e.g., cattails, rushes, dock, tules, and bulrushes). More mesic (moderately moist) portions of the interior levee slopes may include this habitat type.

Both exotic marsh (type M3) and exotic perennial grassland (type H2) tend to be ruderal plant communities that colonize previously disturbed sites, such as abandoned fields, mowed levees, or flooded corners of active crop lands. If not disturbed for several years, they tend to be replaced by native woody riparian or freshwater marsh species. The abandoned agricultural fields near the blowout ponds on Holland and Webb Tracts demonstrate this natural gradient of vegetation development.

Open Water. Open water covers 2.2% (433 acres) of the land surface on the four DW project islands. Three-fourths of this area consist of canals and major drainage ditches (type O1) with permanent water in the island interiors. These ditches are typically lined with narrow bands of exotic marsh vegetation or Himalaya berry. Plants adapted to drier soil conditions, such as yellow star-thistle, are found along upper ditch slopes and on ditch spoils piles. Overhanging riparian vegetation is rare along the ditches or canals. The 124 acres of permanently ponded water (type O2), consisting primarily of the three blowout ponds on Holland and Webb Tracts, are lined with dense riparian or emergent wetland vegetation. Tidal mudflats (type O3) exist only on the outside margins of Bacon and Bouldin Islands along tidal channels.

Developed Land and Woody Non-Native Vegetation. Approximately 1% of the land area of the DW project islands is occupied by structures, paved roads, or scarified and compacted soil (types D1 and D2). This land type includes all of the levee crown roads and agricultural staging areas. The largest portion of type D2 is a site for processing and storing a pulp by-product used as a soil amendment on Holland Tract. Woody, non-native vegetation consists of ornamental trees (type W1) and shrubs and lawns (type W2) generally associated with structures (type D1).

Habitat Types on the DW Project Islands

Bacon Island

Bacon Island was occupied by five major landowners and farming operations in December 1987. All tillable land on Bacon Island in December 1987 was in production, the island infrastructure was in good repair, and stands of native vegetation were virtually absent (Figure 3G-5). Agricultural crops were diverse and included corn, milo, potato, sunflower, asparagus, grape, kiwi, and potato seed. The dominant annual crops were potato (1,883 acres) and corn (776 acres). No significant bodies of open water were present, except for the major north-south drainage slough.

Webb Tract

Major portions of Webb Tract were under intensive agricultural management, primarily for corn (2,223 acres) and wheat (445 acres), in December 1987. Like Holland Tract, Webb Tract has a mosaic of sand hills and upland habitat in the western half. Elevation varies by 20 feet or less between hilltops and fields.

Two blowout ponds on Webb Tract make up 85% (106 acres) of the perennial ponded water on all four DW project islands (Figure 3G-6). The northernmost lake formed during a levee breach in 1950 and the eastern lake formed following a levee breach in February 1980. Both levee failures resulted in prolonged deep flooding of the island; the 1980 flooding lasted from January 1980 until February 1981. The lakes are surrounded by richly diverse riparian vegetation and have no public access. Fallow fields and extensive stands of riparian vegetation are common on Webb Tract, particularly on the northern and southwestern portions of the island.

Bouldin Island

Bouldin Island Farming Company manages this entire island intensively as an integrated agricultural operation, with corn production representing more than half of the cultivated acreage (Figure 3G-7). Bouldin Island is a good example of clean farming practice; the levees and roads are well maintained, as are the agricultural fields and ditches. Natural or native vegetation is virtually absent, and most of the tillable land is in crops; 712 acres are under the Agricultural Stabilization and Conservation Service set-aside program. Three crops, corn, sunflower, and wheat, accounted for all agricultural production in December 1987.

Holland Tract

Agricultural management on Holland Tract was less intensive than on Bacon and Bouldin Islands in December 1987 and represented only about one-third of all land cover (Figure 3G-8). Holland Tract has natural sand hills and a blowout pond in the northern tip (17 acres) formed during a levee breach in 1980.

Several land use types are unique to Holland Tract among the four DW project islands. Two commercial marinas occupy the southside levee. A hunting club leases a large portion of the southwestern corner. A large, year-round livestock grazing operation with irrigated pasture was located in the southwestern corner of Holland Tract in December 1987. Because of farm bankruptcy and land ownership changes, much of the agricultural land in the southeastern corner of Holland Tract had not been actively managed for several years.

Under Alternative 3 and the No-Project Alternative, approximately 1,113 acres in the southwest quarter and southeast perimeter of the island would be included in the project (Table 3G-4, Figure 3G-9).

Section 404 Jurisdictional Wetlands

Approximately 763 acres of riparian woodland, riparian scrub, freshwater marsh, exotic marsh, canal and ditch, permanent pond, herbaceous upland, and seed and grain crop habitats were delineated by NRCS, USACE, EPA, and USFWS as jurisdictional wetlands under Section 404 of the Clean Water Act. A detailed description of the results of the jurisdictional wetland delineation is presented in Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation".

As described above, Delta Wetlands is currently working with USACE and Jones & Stokes to update the delineation to reflect current conditions on the project islands. The updated delineation will identify waters of the U.S., including wetlands, on the project islands and in channels where project facilities (e.g., pump and siphon stations) would be located. Before issuing a permit under the CWA and Rivers and Harbors Act, USACE will revise the estimates of wetland impacts based on more detailed investigations. Because farming conditions on the project islands have not substantially changed since 1994, the estimated acreage of wetland impacts presented in Appendix G5 is not expected to change significantly.

Regional Values and Distribution of Habitat Types

Madrone Associates (1980) described riparian woodland as the most valuable wildlife habitat in the Delta, providing essential habitat for 34 species of birds and one mammal. Over 100 wildlife species were found to use this habitat type regularly. Riparian woodlands provide wildlife values that can extend roughly 0.25 mile into adjacent habitat, such as agricultural fields or seasonal wetlands. Freshwater perennial marshes were ranked as the second most valuable wildlife habitat in the Delta by Madrone

Associates (1980), supporting 57 different wildlife species.

Madrone Associates (1980) mapped habitat types found on nearly 600,000 acres on Delta islands, such as the four DW project islands; these were distributed as follows:

Habitat Type	Area (acres)	Percentage of Total
Perennial emergent wetland (freshwater and brackish)	10,243	2
Riparian woodland and scrub	7,099	1
Freshwater lakes, ponds, and interior sloughs	6,913	1
Upland	44,446	7
Agriculture	531,156	89
Total	599,857	100

This distribution demonstrates the regional scarcity of riparian woodland and perennial freshwater marsh habitats in the Delta region relative to agricultural lands.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Impacts on vegetation on the DW project islands were evaluated through comparison of predictions of future habitat types and acreages under the DW project alternatives with existing vegetation conditions. Changes in vegetation types would result from the construction of facilities, upgrading of levees, inundation of reservoir islands during water storage and seasonal wetland periods, and implementation of the HMP (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

Alternatives 1, 2, and 3

A detailed description of the approach used to analyze future vegetation conditions on reservoir islands is presented in Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands".

Assessment of future vegetation conditions on reservoir islands is difficult because periods of inundation and drawdown are not predictable between years and the annual hydrologic pattern of the project does not naturally occur in the Delta region. Prediction of future vegetation conditions is based on end-of-month water storage amounts predicted by the DeltaSOS simulations conducted for the 1995 DEIR/EIS. Additional simulations were performed for the updated evaluation of project operations under the proposed project in the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations"; however, the differences in DeltaSOS results in the 1995 DEIR/EIS and 2000 REIR/EIS evaluations of Alternatives 1 and 2 do not affect the conclusions of this chapter. Therefore, the analysis of reservoir island vegetation conditions from the 1995 DEIR/EIS remains unchanged and is presented below. The 1995 DeltaSOS simulations estimated amounts of water that would be available to the project under each of the DW project alternatives in years with hydrologic conditions replicating those of the 70-year 1922-1991 Delta hydrologic record (Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives"). The availability of future water for storage, however, may not follow historical availability. Prediction of future conditions on any island is further complicated because DW may also fill reservoir islands in a sequence that changes each year to maximize the potential for creating wetland habitats. DW may also use reservoir islands to bank or store water being transferred through the Delta by other entities. For this analysis, it was assumed that reservoir islands would fill concurrently as water becomes available for storage. Under this operating scenario, vegetation would be inundated simultaneously on both reservoir islands under Alternative 1 or 2 or on all four islands under Alternative 3. This concurrent filling would have more adverse effects on terrestrial vegetation than sequential filling would have.

Because future habitat conditions are unpredictable and cannot be quantified, reservoir islands were assumed in this impact assessment to provide no vegetation or wetland values that would offset project impacts. Therefore, operation of the reservoir islands to support habitat conditions is not required to offset or compensate for impacts of the project on vegetation or wetland values.

Analysis of future vegetation conditions on the habitat islands under Alternatives 1 and 2 is based on habitat types and acreages described in the HMP (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

USACE has not determined whether wetlands created by operation of reservoir islands or established on habitat islands (except those dedicated as mitigation for jurisdictional wetlands) would be jurisdictional or nonjurisdictional under Section 404 of the Clean Water Act. However, USACE will make this determination in consultation with DW before the project is implemented.

No-Project Alternative

Estimates of island conditions under the No-Project Alternative are based on a feasibility study prepared for DW by the McCarty Company, Diversified Agricultural Services (McCarty pers. comm.). The general recommendation for all islands is to increase cultivated acreage and crop diversification, with a greater emphasis on perennial crops such as asparagus and vineyards.

Criteria for Determining Impact Significance

SWRCB and USACE determined that for this analysis, an alternative would be considered to have a significant impact on vegetation if it would reduce jurisdictional wetland acreage or habitat value over the life of the project or reduce the size or extent of special-status plant populations.

Beneficial impacts would be increases in the quality or extent of riparian or wetland habitats.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Vegetation Conditions

Bacon Island and Webb Tract

Island Interiors. Five types of habitat conditions are predicted to occur on the reservoir islands under the DW project alternatives: full storage, partial storage, shallow storage, nonstorage, and shallow-water wetlands (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands"). The definitions of these habitat conditions are applicable only to the analysis of project impacts on vegetation resources and wildlife.

For this analysis, it was assumed that during periods when water was available for storage, water would be simultaneously diverted onto Bacon Island and Webb Tract as a "worst-case" operating scenario. This operating scenario would have the greatest impact on vegetation and wetlands. However, DW may sequentially fill the reservoir islands. If reservoir islands were sequentially filled, impacts would be lessened.

The frequency of full-, partial-, and shallow-storage periods would increase and the frequency of nonstorage and shallow-water wetland periods would decrease, however, if the DW reservoir islands were used for storage of water for transfer or for water banking (see Chapter 2, "Delta Wetlands Project Alternatives"). Although the frequency and magnitude of such activities is uncertain at this time and these activities would require separate authorization, implementation of the HMP would fully compensate for any vegetation impacts associated with operation of the DW project for water transfer or banking. Impacts on other resources may require analysis in a future CEQA/NEPA process.

Tables G2-1 and G2-2 in Appendix G2 present the monthly frequency with which each of the five conditions described below would be expected to occur on the reservoir islands.

Full Storage. Under full-storage conditions, all portions of the reservoir islands except riprapped levee slopes would be completely inundated. Conditions on islands during full-storage periods would include exposed riprapped levee slopes at elevations higher than the reservoir surfaces and reservoir water depths in excess of 25 feet over the lowest island bottom areas. Little or no aquatic vegetation would be expected to grow in the reservoirs because of constant water circulation and changing pool elevations associated with diversions and releases. Algae may become established on riprap along reservoir edges and in reservoirs during the warm season.

Partial Storage. Partial-storage conditions would provide shallow to deep water storage pools, exposed island bottoms, and riprapped levee slopes above the storage elevation. Reservoir island habitat conditions will vary more under partial-storage conditions that under other storage conditions because, during partial-storage periods, a greater range of areas of exposed island bottoms, reservoir sizes, and water depths can occur. Partial-storage reservoir conditions would range from saturated soils adjacent to reservoir shorelines to reservoir water depths of over 10 feet. Algae would be expected to become established under partial-storage conditions, as described for full storage. Under partial-storage conditions, exposed island bottoms would be largely unvegetated following drawdown from full storage. Vegetation conditions on exposed island bottoms would be expected to be similar to those described below for shallow-water wetland periods if partial storage occurs during the growing season.

Shallow Storage. Shallow storage occurs when stored water volumes are equal to water volumes used to create shallow-water wetlands. Vegetation conditions under shallow-water storage would be similar to those described for partial storage except that the areas of exposed island bottoms would be greater. Shallow storage that occurs following periods of nonstorage during the growing season would create vegetation conditions similar to those that would be created during shallow-water wetland periods (described below).

Nonstorage. Nonstorage conditions would occur during periods when no water is stored and water is not used to create shallow-water wetlands. The reservoir islands would consist of bare ground with little or no vegetation growth during nonstorage periods that follow full-storage periods from November through March. During periods of nonstorage from April through October, plants would be expected to germinate within the first 30 days of nonstorage, although bare ground would be the predominant condition. Vegetation would grow rapidly following germination. Vegetation types and density would be similar to those described for shallow-water wetlands.

Shallow-Water Wetlands. Shallow-water wetland conditions could exist during periods when no storage occurs and water is diverted onto the reservoir islands to flood vegetation and attract waterfowl and other wetland-associated wildlife. Shallow-water wetlands would be created at DW's discretion. For this analysis, however, it was assumed that DW would create shallow-water wetlands in every year in which no water has been stored for 60 or more consecutive days during the growing season (May through October).

Shallow-water wetlands would be managed until the first period of water storage (including storage of water diverted for transfer or banking) or through April if no storage occurs. Wetlands would be flooded between September and November (flooding dates would vary with vegetation maturity) to create shallow-water wetlands. DW will construct an inner-levee system on reservoir islands that would restrict flooding to allow creation of shallow-water wetlands on at least 65% of each reservoir island, 50% of which would maintain mean water depths of 1 foot and allow water to circulate through wetlands.

Grasses, forbs, and emergents are expected to be the dominant plant species of the shallow-water wetlands. The rate at which herbaceous vegetation would become reestablished on the reservoir islands following complete or partial drawdowns of stored water during the growing season is unknown. The vegetation would be sparse because seed sources for future plant crops are expected to be depleted during storage periods as a result of diminished seed viability with extended periods of inundation, export of seeds from islands during releases, and reduced seed crops produced on the islands.

At DW's discretion, reservoir islands may be seeded with watergrass, smartweed, and other important waterfowl forage plant species. If seeded, wetlands and exposed areas would have much denser vegetation than without seeding, and the availability of forage for waterfowl and other wildlife would be increased.

Levee Slopes and Roads. Recently maintained exterior riprapped slope banks generally would remain unvegetated. Vegetation on undisturbed riprapped slopes would be sparse and would include annual and perennial herbaceous species, along with woody species, such as sandbar willow and button bush.

DW would reinforce reservoir island levees using a variety of methods (see Chapter 3D, "Flood Control"). Depending on the method used, between 133 aces and 380 acres of levee area would be riprapped and total levee slopes would occupy between 380 acres and 446 acres. Little or no vegetation would be expected to become established along riprapped porions of inner levee slopes that would be inundated during storage periods. The upper 4 feet of the inner levee would never be inundated; therefore, vegetation similar to that described for the exterior levee slopes may eventually become established. Vegetation similar to that described for shallow-water wetlands would be expected to become established on unriprapped levee slopes during nonstorage periods. Levee vegetation would be disturbed periodically in future years as a result of levee maintenance activities.

Generally, the 16-foot-wide levee roads would not support vegetation, except for Bermuda grass, sueda, star-thistle, and peppergrass growing in the center line. Little vegetation would survive the periodic disturbance and grading for road maintenance and levee crown repair.

Long-Term Soil Productivity. Environmental factors affecting soil conditions would be different under operation of Alternative 1 from factors under the present agricultural management regime. Differences include periods of deep water storage, the possible yearly accumulation of fine silt during the storage period, and the annual accumulation of vegetation biomass in the absence of agricultural harvest. In general, implementing the project could slow the rate of land subsidence and reduce the loss of soil productivity caused by oxidation and wind erosion on Delta islands (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands").

Bouldin Island and Holland Tract

Habitat islands would be managed primarily to offset impacts on wetland and riparian habitats and wildlife on reservoir islands and habitat islands under Alternative 1. Table 3G-5 summarizes the habitat types and acreages to be created on the habitat islands. A detailed description of habitat types and management prescriptions for habitat island habitats is presented in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

Changes in Vegetation Types

Bacon Island and Webb Tract

Under Alternative 1, agriculture would be discontinued on the reservoir islands and riparian and herbaceous upland habitats would be substantially reduced on the reservoir islands as a result of deep flooding during full-storage periods. Some riparian plant seedlings and herbaceous upland species would become established during nonstorage periods and would persist in areas not flooded to provide shallow-water wetlands until the next water storage event.

Marsh vegetation would be lost as a result of deep-water inundation. Marsh vegetation, such as tules and cattails, however, would be expected to become established during some years of extended nonstorage in shallow-water wetlands and areas that maintain saturated soils during extended nonstorage periods.

Bouldin Island and Holland Tract

Table 3G-6 summarizes changes in habitat types that would occur on the habitat islands under Alternative 1 with implementation of the HMP. Agricultural acreage would be reduced and crops would be limited to corn, wheat, and other small grains.

The acreage of freshwater emergent marsh and riparian woodland and scrub habitats would be substantially increased (Table 3G-6). Exotic marsh habitat affected by the project would be replaced with seasonal managed wetland, mixed agriculture/seasonal wetland, and seasonal pond habitats. These out-of-kind habitats will provide substantially higher wildlife values than do the affected exotic marsh habitats (Chapter 3H, "Wildlife"). Two large permanent lakes designed to provide functions and values similar to those of the two blowout ponds on Webb Tract would be established on Bouldin Island. The acreage of herbaceous upland would be slightly reduced under Alternative 1.

The quality of wildlife habitat under Alternative 1 would be substantially higher than that of comparable habitat types under existing conditions because habitats would be managed specifically to provide maximum benefits for wildlife (see Chapter 3H, "Wildlife", and Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

Section 404 Jurisdictional Wetlands

Approximately 567 acres of jurisdictional wetlands would be lost under Alternative 1, primarily on the reservoir islands (Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation"). Direct impacts on jurisdictional wetlands would result from dredge and fill activities associated with placement of pumps and siphons, refurbishment of levees, and grading activity for construction of wildlife habitats on the habitat islands. Indirect impacts on jurisdictional wetlands associated with dredge and fill activities would result from water storage on the reservoir islands.

To offset impacts on jurisdictional wetlands, mitigation wetlands would be constructed on the habitat islands at replacement acreage ratios established by the HMP team (Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", and Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation"). Approximately 711 acres of riparian, marsh, and seasonal wetland habitats are required to be established on the habitat islands to offset impacts. Under Alternative 1, approximately 3,900 more acres of emergent marsh and seasonal wetland habitats would be established than are required to mitigate losses of jurisdictional freshwater exotic marsh habitats.

Summary of Project Impacts and Recommended Mitigation Measures

Impact G-1: Increase in Freshwater Marsh and Exotic Marsh Habitats. Implementing Alternative 1 would result in the loss of approximately 27 acres of freshwater marsh and 147 acres of exotic marsh that have been delineated as jurisdictional wetlands. The HMP team, in consultation with USACE, established a mitigation requirement of replacing the acreage of these affected habitats at a ratio of 2:1 (Table G5-7 in Appendix G5). Implementing the HMP on the habitat islands would replace affected freshwater marsh with approximately 350 acres of tule-dominated emergent marsh (a replacement ratio of 13:1) and would replace affected exotic marsh with 3,761 acres of out-of-kind seasonal managed wetland and mixed agriculture/seasonal wetland (a replacement ratio of 26:1), which will provide higher wildlife values than existing exotic marsh habitat (see Appendices G3 and G5). Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact G-2: Loss of Riparian and Permanent Pond Habitats. Approximately 48 acres of cottonwood-willow woodland (i.e., riparian woodland), 61 acres of willow scrub (i.e., riparian scrub), and 98 acres of permanent pond habitat would be lost with implementation of Alternative 1. The HMP team, in consultation with USACE, established mitigation objectives of replacing the affected acreage of riparian woodland at a ratio of 3:1, riparian scrub at a ratio of 2:1, and permanent ponds at a ratio of 1:1. These mitigation objectives will be met or exceeded with the establishment of approximately 143 acres of riparian woodland, 122 acres of riparian scrub, and 111 acres of permanent lake habitats on the habitat islands (see Appendices G3 and G5). Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact G-3: Loss of Upland and Agricultural Habitats. Approximately 188 acres of jurisdictional wetlands that supported canal and ditch, grain and seed crop, annual grassland, exotic perennial grassland, and unvegetated disturbed habitats would be affected by project implementation. DW will manage 7,335 acres of similar habitats on the habitat islands; these managed habitats will provide greater wildlife values than are associated with affected habitats (see Appendices G3 and G5). Mitigation habitats to be constructed on the habitat islands include corn/wheat fields, seasonal managed wetlands, mixed agriculture/seasonal wetlands, small grain fields, herbaceous uplands, and canals and ditches necessary to manage these habitats. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Indirect Offsite Effects on Vegetation Attributable to Changes in Delta Outflow

Concern exists that increased diversions of water from the Delta may reduce Delta outflow, thereby causing changes in salinity levels in tidal and brackish habitats around Suisun Bay and in Suisun Marsh. Chapter 3B, "Hydrodynamics", and Chapter 3C, "Water Quality", describe changes in outflow and salinity, respectively, predicted to result from project operations. As presented in those chapters, changes in outflow or salinity that may occur during diversion or discharge periods would be small. The predicted small changes in outflow and salinity are not expected to cause adverse effects on offsite wetland vegetation.

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on special-status plants presented below assumes that the recreation facilities would be constructed and operated. The information presented in this chapter provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Special-Status Plant Species

No populations of special-status plant species were found in the interior portions of the DW project islands. Because conditions that favor special-status plant species have not developed on the DW project islands since surveys were conducted, it is unlikely that populations of special-status plants have become established on the islands. Therefore, changes of habitat on the islands caused by water storage would not have an impact on populations of special-status plants.

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on special-status plants presented below assumes that the recreation facilities would be constructed and operated. The information presented in this chapter provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Bacon Island and Webb Tract

Two populations of rose-mallow exist at or near the proposed locations of recreation facilities, and three populations of Mason's lilaeopsis are near proposed locations of recreation facilities on Bacon Island. Two populations of Suisun Marsh aster and one population of Mason's lilaeopsis are located within 100-200 feet of proposed recreation facilities on Webb Tract.

Bouldin Island and Holland Tract

One population of rose-mallow exists near the proposed location of a recreation facility on Bouldin Island. Two populations of the Suisun Marsh aster are located near proposed recreation facilities, and another Suisun Marsh aster population is located within 100-200 feet of a proposed pump station.

One population each of Suisun Marsh aster, Delta tule pea, and Mason's lilaeopsis is located near proposed recreation facilities on Holland Tract.

Summary of Project Impacts and Recommended Mitigation Measures

Impact G-4: Loss of Special-Status Plants. There are five special-status plant species on the DW project islands that are federally listed as category 2 species, state-listed as rare, or listed as locally or regionally uncommon by CNPS. Implementing Alternative 1 could cause the loss of special-status plants resulting from siting of a pump station, siphon station, recreation facility, or other DW project facility on a site occupied by a special-status plant population. Therefore, this impact is considered significant.

Implementing Mitigation Measures G-1, G-2, and G-3 would reduce Impact G-4 to a less-than-significant level.

Mitigation Measure G-1: Site Project Facilities to Avoid Special-Status Plant Populations. DW shall conduct special-status plant surveys before construction of project facilities and shall site facilities to avoid special-status plant populations.

Mitigation Measure G-2: Protect Special-Status Plant Populations from Construction and Recreational Activities. To mitigate potential indirect impacts of construction, DW shall use several measures to protect special-status plants that are within 200 feet of project facility sites. First, the boundaries of each population shall be determined and marked with surveyor's flagging. Second, special-status plants within 100 feet of project facility sites shall be protected by temporary barricades erected 50 feet from the edge of the population nearest to the facility site. Plants 100-200 feet from the construction sites shall be identified with brightly colored flagging on vegetation and/or surveyor's stakes that are plainly visible to construction personnel approaching the area occupied by the plants. Flagging shall not be obscured by vegetation. Construction crews and DW maintenance personnel must be informed of the presence of the plants, the function of the barricades and flagging, and the strict avoidance requirements.

Areas that support special-status plant populations shall not be open to recreation. If special-status plant populations are inadvertently affected by construction or recreational uses, DW shall contact DFG and negotiate appropriate mitigation to offset impacts, including development of a mitigation monitoring program and performance standards.

Mitigation Measure G-3: Develop and Implement a Special-Status Plant Species Mitigation Plan. DW, in consultation with SWRCB, DFG, and USFWS, shall develop and implement a plan for mitigating unavoidable impacts on special-status plant populations. No diversion shall be permitted until California Endangered Species Act consultations have been completed, a no-jeopardy opinion has been issued by DFG, and a mitigation plan and mitigation implementation schedule have been approved by SWRCB's Chief of the Division of Water Rights.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Impacts and mitigation measures of Alternative 2 are the same as those of Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island south of SR 12, and Holland Tract, with secondary uses for wildlife habitat and recreation. Reservoir islands would be managed during fall, winter, and spring nonstorage periods as seasonal wetlands. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area (NBHA).

Vegetation Conditions

Bacon Island, Webb Tract, Bouldin Island South of SR 12, and Holland Tract

Vegetation conditions on the reservoir islands under Alternative 3 would be similar to conditions under Alternative 1 on Bacon Island and Webb Tract for each of the storage condition classes (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands").

North Bouldin Habitat Area

The portion of Bouldin Island north of SR 12 would be managed as the NBHA under Alternative 3. Approximately 50 acres of perennial ponds, 330 acres of seasonal managed wetlands, 170 acres of corn, 200 acres of riparian woodland, and 125 acres of herbaceous uplands would be established and managed for wildlife in the NBHA (see Appendix G2).

Habitat conditions for the NBHA are the same as those described for Bouldin Island and Holland Tract under Alternative 1. Detailed descriptions of how these habitats would be managed are presented in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

Changes in Vegetation Types

Bacon Island, Webb Tract, Bouldin Island South of SR 12, and Holland Tract

Changes in vegetation types on the reservoir islands under Alternative 3 would be the same as those described for the reservoir islands under Alternative 1, except that an additional 1,113 acres of riparian, exotic marsh, herbaceous upland, agricultural, open water, and developed habitats in the southwestern quarter of Holland Tract would also be lost as a result of water storage (Table 3G-4).

North Bouldin Habitat Area

Agriculture would be substantially reduced in the NBHA under Alternative 3. Agricultural habitats would be converted to perennial pond, seasonal managed wetland, riparian woodland, and herbaceous upland habitats.

Section 404 Jurisdictional Wetlands

Under Alternative 3, jurisdictional wetlands would be lost as a result of placement of water operation facilities (e.g., pumps and siphons), land grading and levee improvements, and water storage operations on the reservoir islands.

Summary of Project Impacts and Recommended Mitigation Measures

Impact G-5: Loss of Jurisdictional Wetlands on Reservoir Islands. Implementing Alternative 3 would result in the loss from the reservoir islands of the following wetlands subject to Section 404 jurisdiction: approximately 203 acres of riparian woodland and riparian scrub, 56 acres of freshwater marsh, 147 acres of exotic marsh, 111 acres of perennial ponds, and 188 acres of upland and agricultural habitats. These losses would partially be offset with development of Section 404 wetland habitats on the NBHA. Substantial losses of jurisdictional wetland acreage, however, would still occur because of inundation of the reservoir islands (Table 3G-4). Therefore, this impact is considered significant.

Implementing Mitigation Measure G-4 would reduce Impact G-5 to a less-than-significant level.

Mitigation Measure G-4: Develop and Implement an Offsite Mitigation Plan. DW, in consultation with SWRCB, USACE, DFG, and USFWS, shall implement an offsite mitigation plan for mitigating impacts on Section 404 jurisdictional wetlands that would result from implementation of Alternative 3. Once DW has identified offsite mitigation areas, an HMP team, composed of representatives approved by SWRCB, shall be established to develop the offsite mitigation plan. No diversions would be allowed until a feasible compensation plan that guarantees compensation acreage has been developed by DW and approved by USACE and SWRCB.

Indirect Offsite Effects on Vegetation Attributable to Changes in Delta Outflow

As described above for Alternative 1, changes in outflow or salinity that may occur during diversion or discharge periods would be small (see Chapter 3B, "Hydrodynamics", and Chapter 3C, "Water Quality"). These changes are not expected to cause adverse effects on offsite wetland vegetation.

Special-Status Species

The impact and mitigation measures of Alternative 3 related to special-status plants are the same as those described for Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact G-6: Loss of Special-Status Plants. This impact on the DW project islands is described above under Impact G-4. This impact is considered significant.

Implementing Mitigation Measures G-1, G-2, and G-3 (described above under "Impacts and Mitigation Measures of Alternative 1") would reduce Impact G-6 to a less-than-significant level.

Mitigation Measure G-1: Site Project Facilities to Avoid Special-Status Plant Populations

Mitigation Measure G-2: Protect Special-Status Plant Populations from Construction and Recreational Activities

Mitigation Measure G-3: Develop and Implement a Special-Status Plant Species Mitigation Plan

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Vegetation Conditions

Implementation of the No-Project Alternative would involve intensive agricultural use of the DW project islands and would substantially change habitats on the DW project islands compared with habitats under existing conditions. In general, the impacts would result primarily from conversion of fallow, herbaceous upland, riparian, and wetland habitats to agricultural use (see Appendix G2, "Predictions of Vegetation on the Delta Wetlands Reservoir Islands").

Changes in Vegetation Types

Implementation of the No-Project Alternative would result in conversion of large acreages of corn and wheat crops to potatoes, onions, asparagus, and vineyards on Bacon and Bouldin Islands. Substantial acreages of fallow, exotic marsh (i.e., agricultural weeds growing in saturated soils), and pasture habitat on Holland and Webb Tracts would be converted to corn and wheat. Efficiency of harvest for corn and other seed crops would increase; thus, amounts of waste corn per acre left on Holland and Webb Tracts would be expected to decline to the levels measured on Bouldin Island (105 pounds per acre).

Under the No-Project Alternative, agricultural land use on the DW project islands would increase an estimated 20% (by about 3,000 acres) at the expense of other existing land uses and vegetation types (see Appendix G2). Riparian woodland and riparian scrub would decrease by 50%, and freshwater marsh would decrease by more than 80%.

The changes in agricultural cropping patterns and habitat-type acreages described for this alternative were implemented to a large extent by DW between December 1987 and October 1990.

Section 404 Jurisdictional Wetlands

Under Section 404(f)(1) of the Clean Water Act, normal farming activities, such as plowing, seeding, cultivating, and maintaining drainage ditches, are exempt from Section 404 permit requirements as long as surface materials are not redistributed by blading or grading to fill a Section 404 jurisdictional wetland area. The No-Project Alternative is thus limited to those farming activities to increase cropping intensity that could be implemented without a Section 404 permit. Therefore, implementing the No-Project Alternative would not affect jurisdictional wetlands.

Special-Status Species

Increasing agricultural production under the No-Project Alternative would not result in direct impacts on special-status plants. However, over the long term, increased rates of subsidence on the DW project islands from extensive soil oxidation would require levees to be maintained and built to greater heights. (See Chapter 3D, "Flood Control", for more detail on island subsidence.) More intensive levee maintenance by reclamation districts and farmers could conceivably eliminate special-status plants.

Summary of Project Impacts and Recommended Mitigation Measures

Loss of Special-Status Plants. Implementing the No-Project Alternative could result in the loss of special-status plants through perimeter levee maintenance activities. Implementing the following measure would reduce this effect of the No-Project Alternative.

Protect Special-Status Plant Populations from Levee Maintenance Activities. DW should conduct special-status plant surveys before initiating levee maintenance activities to locate special-status plant populations. Where feasible, construction should be sited to avoid special-status plant populations. If special-status plant populations cannot be avoided, they should be protected from potential indirect impacts of construction as described for Mitigation Measure G-2 above.

Develop and Implement a Special-Status Plant Species Mitigation Plan. DW should develop and implement a mitigation plan that would mitigate unavoidable impacts on special-status plant populations. This measure is described above as Mitigation Measure G-3.

CUMULATIVE IMPACTS

This section briefly analyzes cumulative impacts for major vegetation and wetland issues. The analysis identifies other projects or activities in the Delta region and surrounding areas that may affect habitats that may also be affected by the DW project. These projects are summarized in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives". Beneficial and negative cumulative effects are identified, and the overall effect of DW project impacts on regional habitats is described.

Cumulative Impacts, Including Impacts of Alternative 1

Changes in Reservoir Island Storage Conditions

DWR recently installed four additional pumping units at SWP's Banks Pumping Plant near Clifton Court Forebay, increasing total SWP pumping capacity from 6,400 cfs to 10,300 cfs. If SWP export pumping is increased to full capacity in future years, the frequency with which each storage class would occur on the DW project islands would change. Tables 3G-5 and 3G-6 present the storage class frequencies for the reservoir islands under the 1995 DEIR/EIS cumulative scenario for Alternative 1 based on the 70-year hydrologic record for the Delta. In most months the frequency with which full-, partial-, and shallow-storage conditions would occur would be reduced and the occurrence of nonstorage conditions and the opportunity to create shallow-water wetland conditions would be increased.

Wetland Habitats and Special-Status Plants

Related past, present, and foreseeable future projects may contribute cumulatively to the vegetation impacts identified in this chapter by causing loss or damage to riparian and wetland vegetation types and to special-status plant species. Related past activities in the Delta that have caused cumulative losses of these vegetation resources include levee construction and repair, channel dredging, channel bank riprapping, island drainage, island reclamation for agriculture, and infrastructure construction on the islands (e.g., roads, pump stations, drainage ditches, and equipment buildings).

The cumulative historical loss of riparian woodland, riparian scrub, and freshwater and brackish marsh habitat types in the Delta since initial reclamation began is presumably equivalent to the 530,000 acres now in agriculture (Madrone Associates 1980). This cumulative historical loss amounts to more than 90% of the original extent of these habitats in the Delta.

Under state and federal policies regarding wetlands and special-status plant protection, any further losses of vegetation resources potentially caused by these projects will be avoided or fully compensated for. If such avoidance and mitigation occur, no further cumulative losses of these vegetation resources will take place.

The following foreseeable future projects that would compensate for wetland impacts in the Delta have the potential to increase riparian and wetland habitats along Delta channels, on Delta levees, and on Delta islands:

- # Interim South Delta Program (DWR and Reclamation 1990),
- # Interim North Delta Program,
- # Sherman Island Wildlife Management Plan (DWR 1990a),
- # Twitchell Island Wildlife Management Plan,
- # levee rehabilitation under the Delta Flood Protection Act (DWR 1990b), and
- # the CALFED Bay-Delta Program.

Impact G-7: Increase in Wetland and Riparian Habitats in the Delta. Implementation of Alternative 1 in conjunction with implementation of other Delta projects (see above) would result in an increase in the acreage of permanent and seasonal wetlands and riparian habitat in the Delta. In addition to the DW project, other planned Delta projects would either protect existing wetland and riparian habitats or create new habitats as mitigation to offset wetland and riparian habitat losses associated with past or future projects. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impact of Alternative 2 would be the same as that described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

Other projects and activities in the Delta and surrounding regions that, in combination with Alternative 3, may result in cumulative impacts on vegetation are the same as described above for cumulative impacts with Alternative 1.

Section 404 Jurisdictional Emergent Wetland and Riparian Habitats

Water management and flood control projects could reduce the amounts of emergent wetland and riparian habitats in the Delta region. Alternative 3 would contribute to this impact by reducing emergent wetland and riparian habitats by approximately 72 acres on the DW project islands, but implementation of recommended offsite mitigation could fully compensate for this loss. Cumulative emergent wetland and riparian habitat losses would be offset by habitat restoration and subsidence control projects proposed in the Delta.

Impact G-8: Cumulative Loss of Section 404 Jurisdictional Emergent Wetland and Riparian Habitats. Implementation of water management and flood control projects (including implementation of Alternative 3) could reduce the amount of emergent wetland and riparian habitats in the Delta region. However, this loss would be offset by implementation of habitat restoration, subsidence control, and habitat compensation proposed as part of those projects or as a separate project. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Implementing the No-Project Alternative would not contribute to cumulative effects on vegetation resources in the Delta.

CITATIONS

References to the Code of Federal Regulations (CFR) and the Federal Register (FR) are not included in this list. CFR citations in text refer to title and section (50 CFR 17.12 refers to Title 50 of the CFR, Section 17.12). FR citations in text refer to volume and page numbers (55 FR 6184 refers to Volume 55 of the FR, page 6184).

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Table 3G-1. Special-Status Plants Potentially Occurring on the DW Project Islands

Scientific and Common Names	Status[a] Federal/State/CNPS	Distribution	Habitat
Aster lentus[b] Suisun Marsh aster (Asteraceae - sunflower family)	C2/--/1B	San Francisco, San Pablo, and Suisun Bays and the Delta in Contra Costa and Solano Counties, and San Joaquin Valley	Brackish, salt, and freshwater marshes at or above the zone of tidal fluctuation
Cirsium crassicaule Slough thistle (Asteraceae - sunflower family)	C2/--/1B	Delta and San Joaquin Valley to Kern County	Shallow water or saturated soils in various wetland plant communities along sloughs, canals, and rivers; often in disturbed areas
Erysimum capitatum var. *angustatum* Contra Costa wallflower (Brassicaceae - mustard family)	E/E/1B	Known only from the Antioch Dunes in the City of Antioch	Interior dunes with sparse herb and shrub cover
Eryngium racemosum Delta button-celery (Apiaceae - carrot family)	C2/E/1B	San Joaquin Valley and Delta from Merced County to San Joaquin County	Vernal pools and other seasonal wetlands on floodplains
Hibiscus lasiocarpus[b] Rose-mallow (Malvaceae - mallow family)	C2/--/2	Central Valley from Butte to San Joaquin Counties and adjacent Delta environs	Riparian habitats with freshwater marsh vegetation in areas with slow water velocities, such as canals, sloughs, ponds, and oxbow lakes
Lathyrus jepsonii ssp. *jepsonii*[b] Delta tule pea (Fabaceae - pea family)	C2/--/1B	Delta and Central Valley from Butte to Tulare Counties	River and canal banks in brackish and freshwater marshes and riparian wood-lands, at or above the zone of tidal influence
Lathyrus palustus Marsh pea (Fabaceae - pea family)	--/--/3	Scant within widespread range throughout lowland and montane California	Freshwater marsh
Lilaeopsis masonii[b] Mason's lilaeopsis (Apiaceae - carrot family)	C2/R/1B	Suisun Bay and Delta within areas influenced by tidal fluctuations	Clay-peat deposits and rotting wood located in marsh vegetation along edges of waterways within the tidal zone
Limosella subulata[b] Delta mudwort (Scrophulariaceae - figwort family)	--/--/2	San Joaquin-Sacramento Delta	Edges of riverbanks and slough banks in marsh vegetation rooted within zone of tidal fluctuation
Oenothera deltoides var. *howellii* Antioch Dunes evening primrose (Onagraceae - primrose family)	E/E/1B	Known from the Delta at Antioch Dunes in the City of Antioch and Brannan Island	Interior dunes with sparse herb and shrub cover
Potamogeton zosteriformis Eel-grass pondweed (Potamogetonaceae - pondweed family)	--/--/2	Contra Costa County and various other northern California counties to Oregon and Washington	Open water of ditches, canals, and ponds
Psilocarphus brevissimus var. *globiferus* Tall woolly marbles (Asteraceae - sunflower family)	--/--/1B[b]	In San Francisco Bay and the Sacramento-San Joaquin Delta	Vernal pools and other seasonal wetlands
Sagittaria sanfordii Sanford's sagittaria (Alismataceae - arrowhead family)	C2/--/1B	Widespread but infrequent in the Central Valley and Coast Ranges	Sloughs and sluggish streams with silty or muddy substrate, associated with emergent marsh vegetation
Scutellaria laterifolia Mad-dog skullcap (Lamiaceae - mint family)	--/--/2	San Joaquin and Inyo Counties, New Mexico, and Oregon	Meadows and freshwater marsh

Table 3G-1. Continued

Note: -- = not applicable.

[a] Federal - U.S. Fish and Wildlife Service (50 FR 39526-39584, September 27, 1985):

E = listed as endangered under the federal Endangered Species Act.

C2 = Category 2 candidate species under review for federal listing for which the USFWS presently has some information indicating that listing is possibly appropriate, but for which further biological research is needed to determine threats. This category is administered by the amount of information available and not necessarily the status of the species.

State - California Department of Fish and Game (1988):

E = listed as endangered under the state Endangered Species Act.

R = listed as rare under the state Endangered Species Act.

CNPS - California Native Plant Society (Smith and Berg 1988):

1B = rare and endangered.

2 = List 2 species: rare, threatened, or endangered in California but more common elsewhere.

3 = List 3 species: plants about which more information is needed to determine their status.

[b] Observed on the DW project islands.

Table 3G-2. Populations of Special-Status Plant Species Observed on the DW Project Islands

Species	Bacon Island	Webb Tract	Holland Tract	Bouldin Island
Suisun Marsh aster	6	3	19	8
Mason's lilaeopsis	18	3	0	5
Rose-mallow	10	1	1	1
Delta tule pea	0	1	0	1

Note: All plants listed were observed on the exterior levee slopes along Delta channels.

Source: Dains 1988.

Table 3G-3. Habitat-Type Classification for the DW Project Islands

Habitat Group	Code	Description	Comments	Dominant or Typical Plant Species
Riparian	R1	Cottonwood-willow woodland	Cottonwood and willow trees	Fremont cottonwood, red willow, yellow willow
	R2	Great Valley willow scrub	Willow shrubs and trees	Red willow, yellow willow, sandbar willow, Goodding's willow
Marsh	M1	Freshwater marsh	Inside islands	Cattail, bulrush, yellow nutsedge, pondweed, buttonbush
	M2	Tidal marsh	Outside main islands	Common tule, common reed, Olney's bulrush, California bulrush, common rush
	M3	Exotic marsh[a]	Dense upland and wetland weeds (sometimes dry in summer)	Annual smartweed, peppergrass, amaranth, wild radish, nettles, cocklebur, watergrass
Woody, non-native	W1	Mature trees	Shade trees and windbreaks	Eucalyptus, pine, elm
	W2	Mixed ornamental	Shrubs and lawn	Turf grasses, miscellaneous ornamental shrubs
Herbaceous upland	H1	Annual grassland	True uplands and sand hills	Wild oats, barley, rip-gut brome, Italian rye-grass
	H2	Exotic perennial grassland[a]	Mixed weeds in fields and on levee slopes	Bermuda grass, perennial ryegrass, Johnson grass
Agriculture	A1	Grain and seed crops		Corn, wheat, sunflowers, potatoes
	A2	Perennial crops		Asparagus, vineyards
	A3	Pasture	Permanently grazed	Tall fescue, orchard grass, canary grass, ryegrass, legumes
	A4	Waterfowl food crops	Managed wetlands	Smartweed, watergrass, bulrush
	A5	Fallow	Short-term fallow fields	Yellow star-thistle, Russian thistle, houseweed, lamb's quarter, telegraph weed
Open water	O1	Canals and ditches	Permanent water	Dallis grass, knot grass, Himalaya berry, smartweed
	O2	Permanent ponds	Still water	Water hyacinth, water primrose, azolla
	O3	Mudflats	Tidal, open bare mud	None
Developed	D1	Structures	Buildings and marinas	
	D2	Paving and exposed earth	Roads, landfills, and unvegetated exposed areas	Largely unvegetated

[a] Exotic habitats are dominated by weedy plant species that are not native to the Delta.

Source: JSA 1988.

Table 3G-4. Acreages of Habitat Types on the DW Project Islands under the DW Project Alternatives and the No-Project Alternative

		Bacon Island, Webb Tract, and Bouldin Island (All Alternatives)						Holland Tract				All Islands			
		Bacon Island		Webb Tract		Bouldin Island		Alternatives 1 and 2		Alternative 3 and the No-Project Alternative		Alternatives 1 and 2		Alternative 3 and the No-Project Alternative	
Name	Code[a]	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total
Riparian	R1	0.0	0.00	47.7	0.87	6.9	0.11	80.3	2.56	91.6	2.16	134.9	0.67	146.2	0.69
	R2	3.4	0.06	58.0	1.06	9.9	0.16	24.8	0.79	30.5	0.72	96.1	0.48	101.8	0.48
Marsh	M1	2.7	0.05	172.0	3.14	21.1	0.35	27.8	0.89	27.8	0.65	223.5	1.11	223.5	1.05
	M3	30.4	0.55	783.3	14.32	114.7	1.92	195.5	6.23	259.7	6.11	1,123.9	5.58	1,188.1	5.60
Woody, non-native	W1	0.0	0.00	0.0	0.00	2.8	0.05	4.4	0.14	4.4	0.10	7.2	0.04	7.2	0.03
	W2	0.0	0.00	0.0	0.00	2.2	0.04	0.0	0.00	0.0	0.00	2.2	0.01	2.2	0.01
Herbaceous upland	H1	260.8	4.71	534.6	9.77	349.1	5.83	369.0	11.77	396.3	7.07	1,513.5	7.52	1,540.8	7.25
	H2	267.6	4.83	304.2	5.56	0.0	0.0	263.8	8.41	263.8	6.21	835.6	4.15	835.6	3.93
Agriculture	A1 (corn)	775.8	14.00	2,222.9	40.64	2,459.2	41.09	131.8	4.20	238.2	5.61	5,589.7	27.77	5,696.1	26.82
	A1 (wheat)	0.0	0.00	445.0	8.14	1,182.8	19.76	482.5	15.39	879.5	20.70	2,110.3	10.48	2,570.7	12.10
	A1 (milo)	83.6	1.51	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	83.6	0.42	83.6	0.39
	A1 (potato)	1,882.6	33.99	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	1,882.6	9.35	1,882.6	8.86
	A1 (sunflower)	190.7	3.44	0.0	0.00	888.3	14.84	0.0	0.00	0.0	0.00	1,079.0	5.36	1,079.0	5.08
	A1 (unknown)	158.8	2.87	26.8	0.49	0.0	0.00	0.0	0.00	0.0	0.00	185.6	0.92	185.6	0.87
	A1 subtotal	3,091.5	55.81	2,694.7	49.27	4,530.3	75.69	614.3	19.59	1,117.7	26.31	10,930.8	54.30	11,497.6	54.13
	A2 (asparagus)	1,069.1	19.30	0.0	0.00	0.0	0.00.	423.0	13.49	423.0	9.96	1,492.1	7.41	1,492.1	7.02
	A2 (vineyard)	278.4	5.03	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	278.4	1.38	278.4	1.31
	A2 subtotal	1,347.5	24.33	0	0	0	0	423.0	13.49	423.0	9.96	1,770.5	8.80	1,770.5	8.34
	A3	0.0	0.00	61.0	1.12	34.2	0.57	349.8	11.16	570.7	13.43	445.0	2.21	665.9	3.13
	A5 (fallow)	355.3	6.41	637.9	11.66	711.6	11.89	689.1	21.98	784.7	18.47	2,394.0	11.89	2,489.6	11.72
Open water	O1	91.8	1.66	49.7	0.91	118.1	1.97	39.4	1.26	45.0	1.06	299.0	1.49	304.6	1.43
	O2	1.5	0.03	105.7	1.93	0.0	0.00	16.6	0.53	23.1	0.54	123.8	0.62	130.3	0.61
	O3	1.2	0.02	0.0	0.0	9.3	0.16	0.0	0.00	0.0	0.00	10.5	0.05	10.5	0.05
Developed	D1	12.6	0.23	1.5	0.03	4.2	0.07	9.0	0.29	12.4	0.29	27.3	0.14	30.7	0.14
	D2	73.1	1.32	18.7	0.34	70.6	1.18	28.4	0.91	134.2	5.42	190.8	0.95	296.6	1.40
Total		5,539.4	100.00	5,469.0	100.00	5,985.0	100.00	3,135.2	100.00	4,248.3	100.00	20,128.6	100.00	21,241.7	100.00

Note: Minor discrepancies in totals are the result of rounding.

[a] See Table 3G-3 for code definitions.

Table 3G-5. Acreages of Habitats to Be Developed on the Habitat Islands

Habitat Type	Bouldin Island		Holland Tract		Habitat Islands Combined	
	Total Acres	Percentage of Total Acres	Total Acres	Percentage of Total Acres	Total Acres	Percentage of Total Acres
Corn/wheat	1,629	27	955	31	2,584	29
Small grains	106	2	152	5	258	3
Mixed agriculture/seasonal wetland	1,014	17	631	21	1,645	18
Seasonal managed wetland	1,723	29	393	13	2,116	23
Seasonal pond	66	1	68	2	134	1
Pasture/hay	132	2	72	2	204	2
Emergent marsh[a]	208	3	194	6	402	4
Riparian[a]	170	3	217	7	387	4
Lake[a]	111	2	33	1	144	2
Herbaceous upland[a]	479	8	253	8	732	8
Developed	177	3	58	2	235	3
Canal[a]	70	1	10	0	80	1
Borrow pond	89	1	0	0	89	1
Total	5,974	100	3,036	100	9,010	100

Note: Minor discrepancies in totals are the result of rounding.

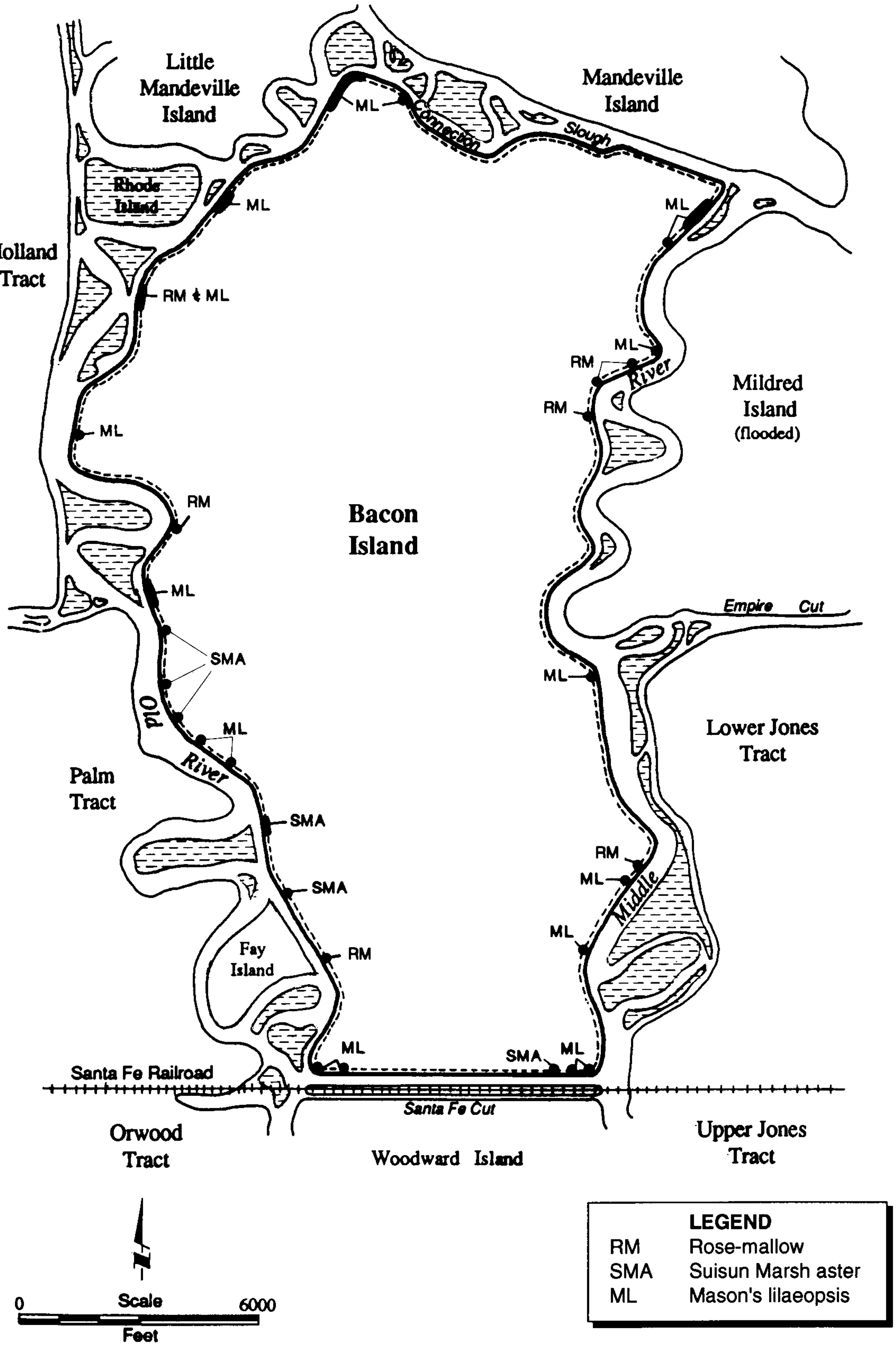
[a] Includes existing acres of habitat unaffected by the DW project.

Table 3G-6. Changes in Habitat Acreages from Existing Conditions to Conditions under Alternatives 1 and 2

Affected Habitat Type	Corresponding Habitat Island Habitat Type	Existing Conditions		Alternatives 1 and 2[a]		Change from Existing to DW Project Conditions	
		Reservoir Islands (acres)	Habitat Islands (acres)	Reservoir Islands (acres)	Habitat Islands (acres)	Acres	Percentage
Riparian woodland	Riparian woodland	48	87	0.0	230	+95	+70.3
Riparian scrub	Riparian scrub	61	35	0.0	157	+61	+63.5
Freshwater marsh	Emergent marsh	175	49	0.0[b]	402	+178	+79.9
Exotic marsh	Mixed agriculture/seasonal wetland Seasonal managed wetland Seasonal pond	814	310	0.0[b]	3,895	+2,771	+246.5
Herbaceous upland	Herbaceous upland	1,367	982	0.0[b]	732	-1,617	-68.8
Corn, wheat, and milo	Corn rotated with wheat Small grains	3,527	4,193	0.0	2,842	-4,878	-63.2
Pasture	Pasture/hay	61	384	0.0	204	-241	-54.2
Other crops and fallow fields	None	4,600	2,775	0.0	0	-7,375	-100.0
Canals and ditches	Canal	142	158	0.0	80	-220	-73.3
Permanent pond	Permanent lake and borrow areas	107	17	0.0[b]	233	+109	+88.2
Total or average		10,902	8,990	0.0[b]	8,775	-11,117	-55.9

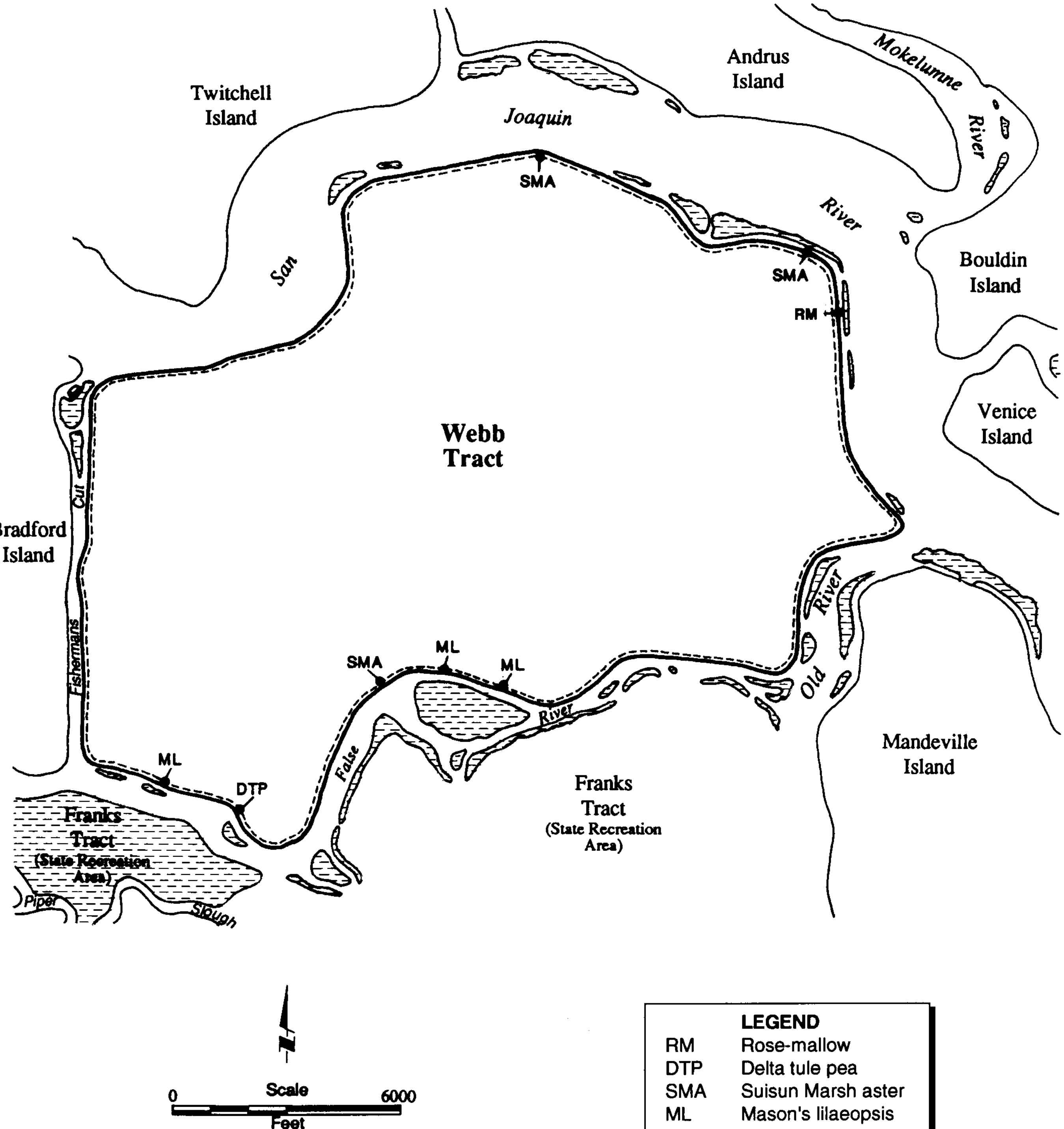
[a] See Impacts G-1, G-2, and G-3; Chapter 3H, "Wildlife"; and Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", for a description of how compensation for project impacts on wildlife associated with these habitats would be achieved (regarding habitat quality versus quantity).

[b] These habitats would exist on reservoir islands during some operating years; however, because the areal extent of these habitat types and the frequency with which they would appear is unpredictable, no habitat acreage is credited.



Source: Dains 1988.

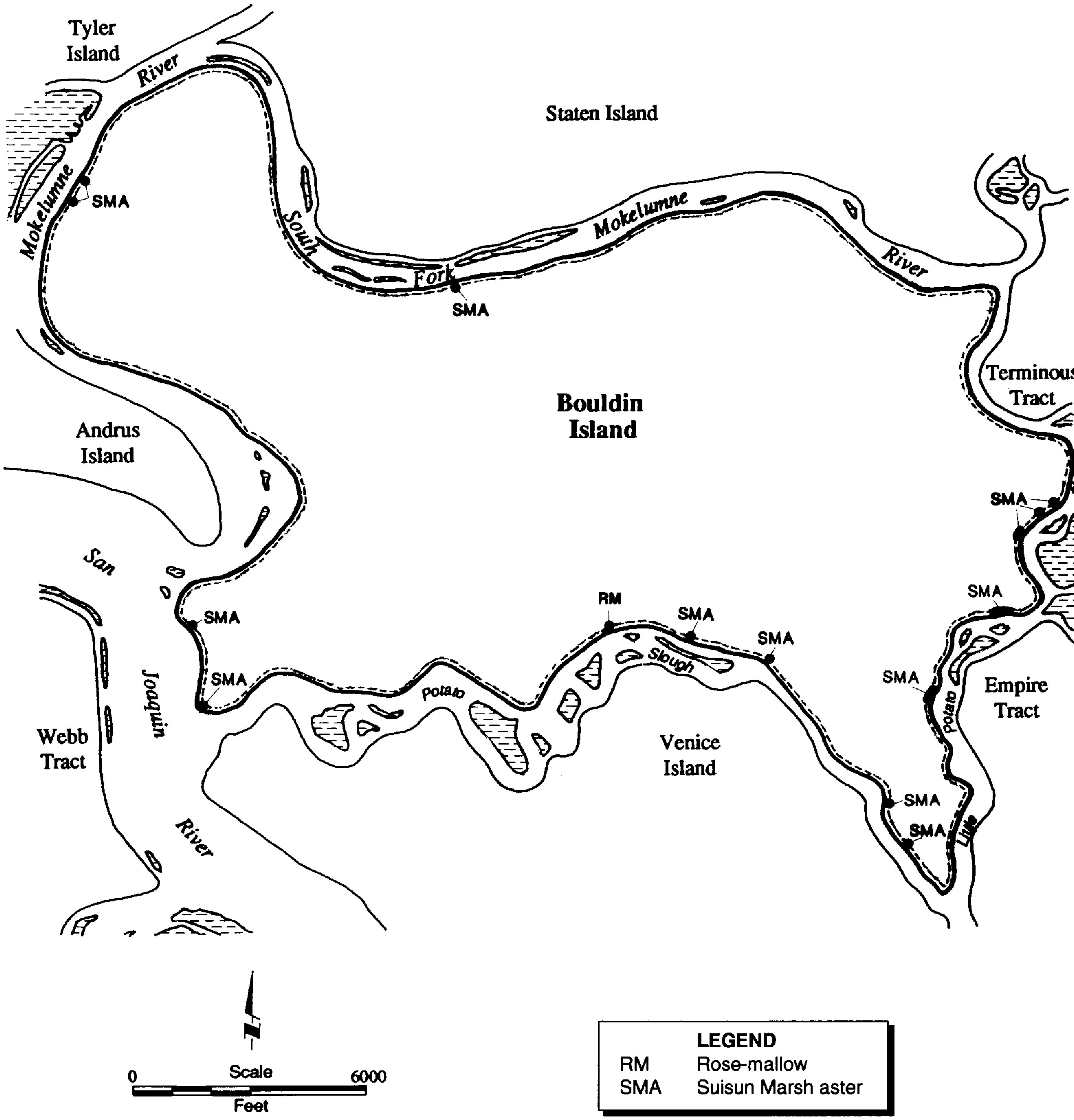
Figure 3G-1
Special-Status Plant Populations on Bacon Island



Source: Dains 1988.

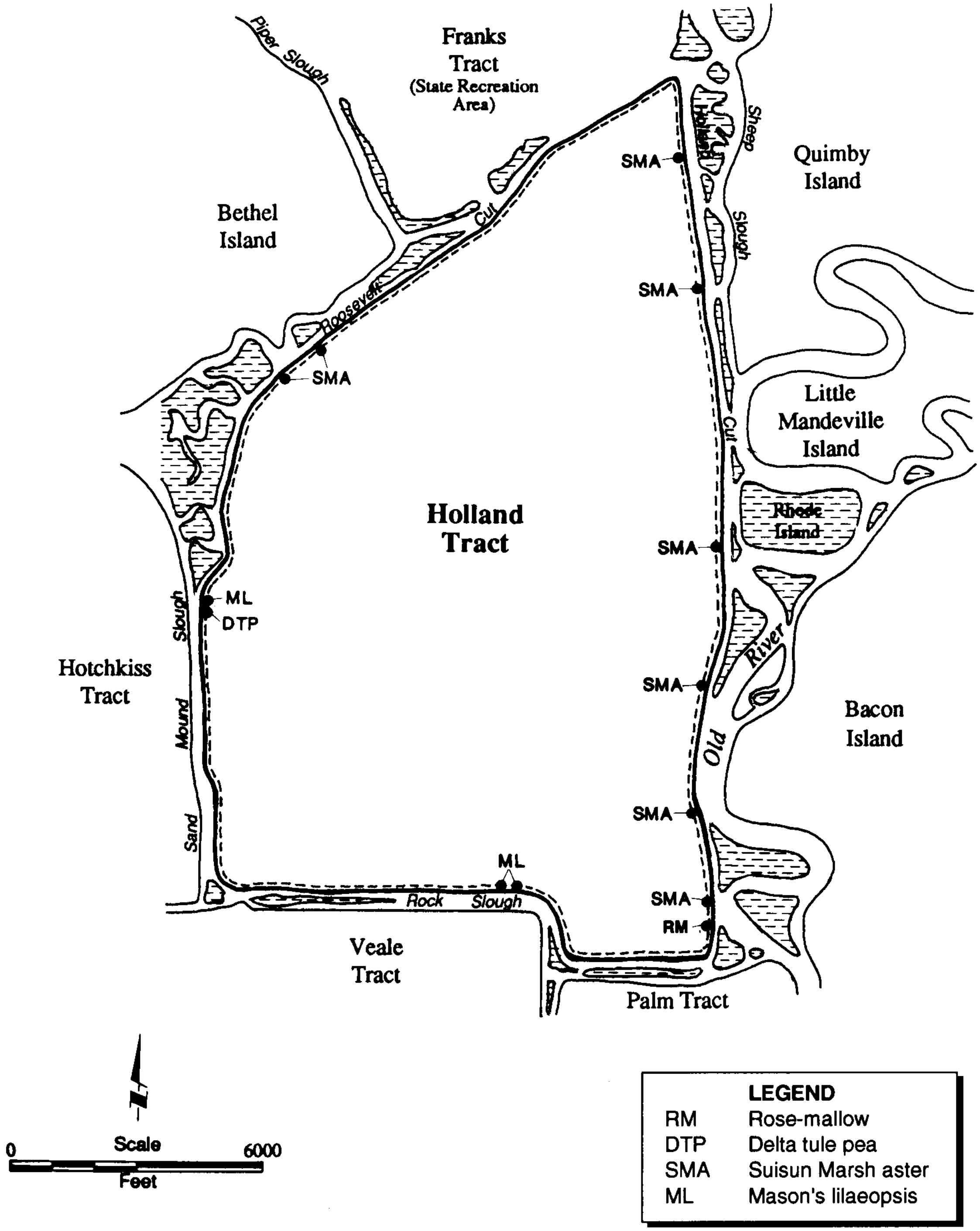
Jones & Stokes

Figure 3G-2
Special-Status Plant Populations on Webb Tract



Source: Dains 1988.

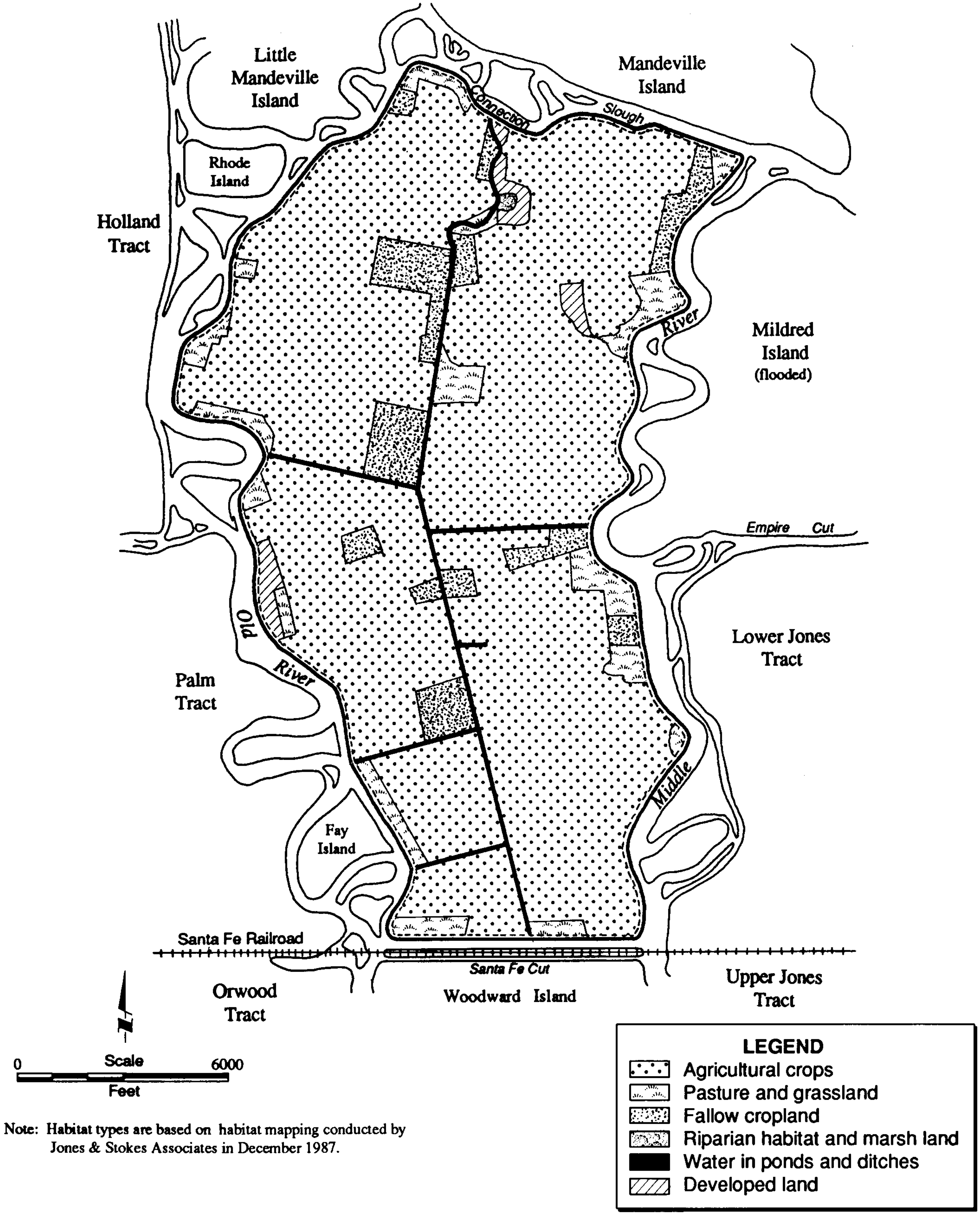
Figure 3G-3
Special-Status Plant Populations on Bouldin Island



Source: Dains 1988.

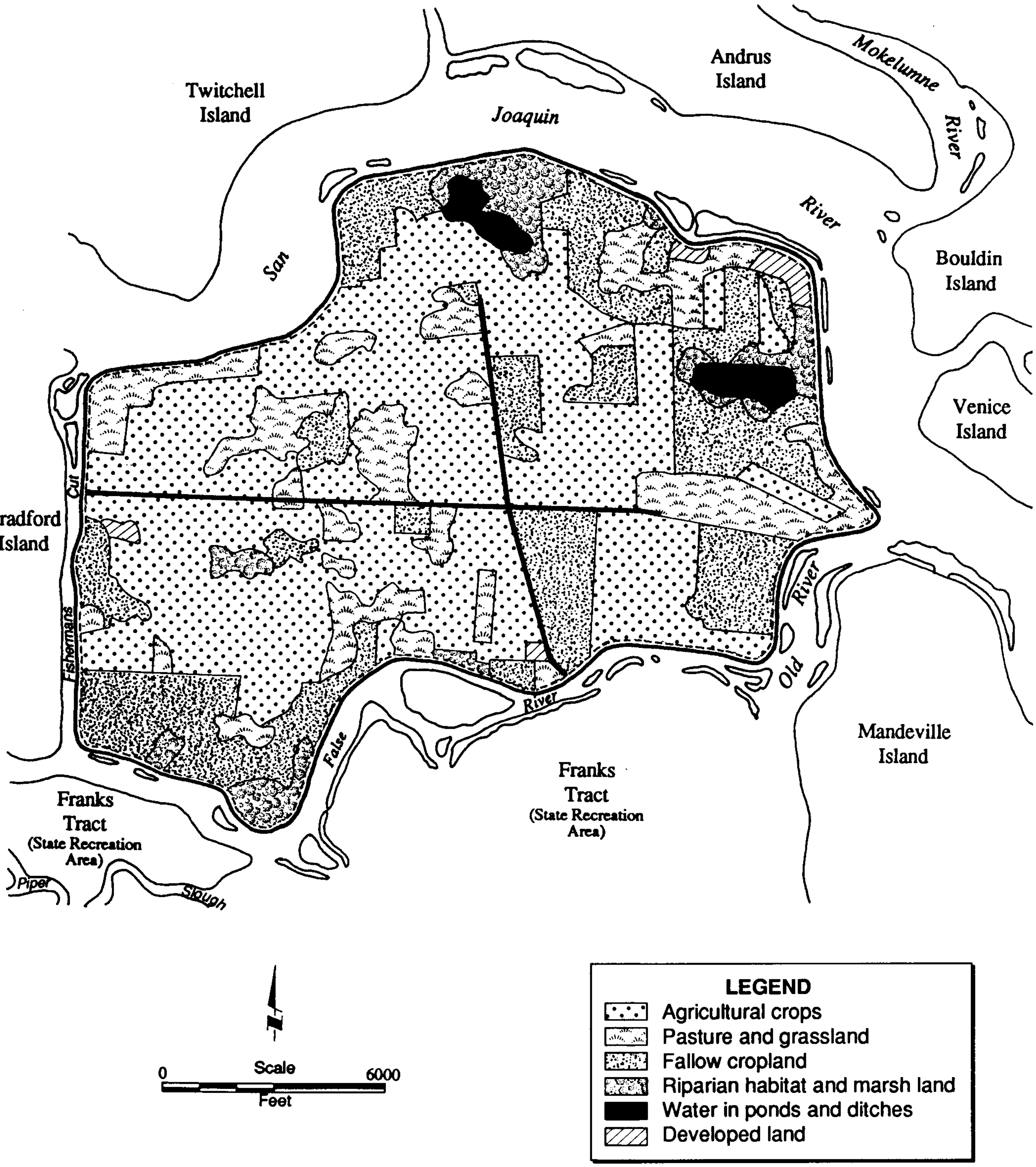
Jones & Stokes

Figure 3G-4
Special-Status Plant Populations on Holland Tract



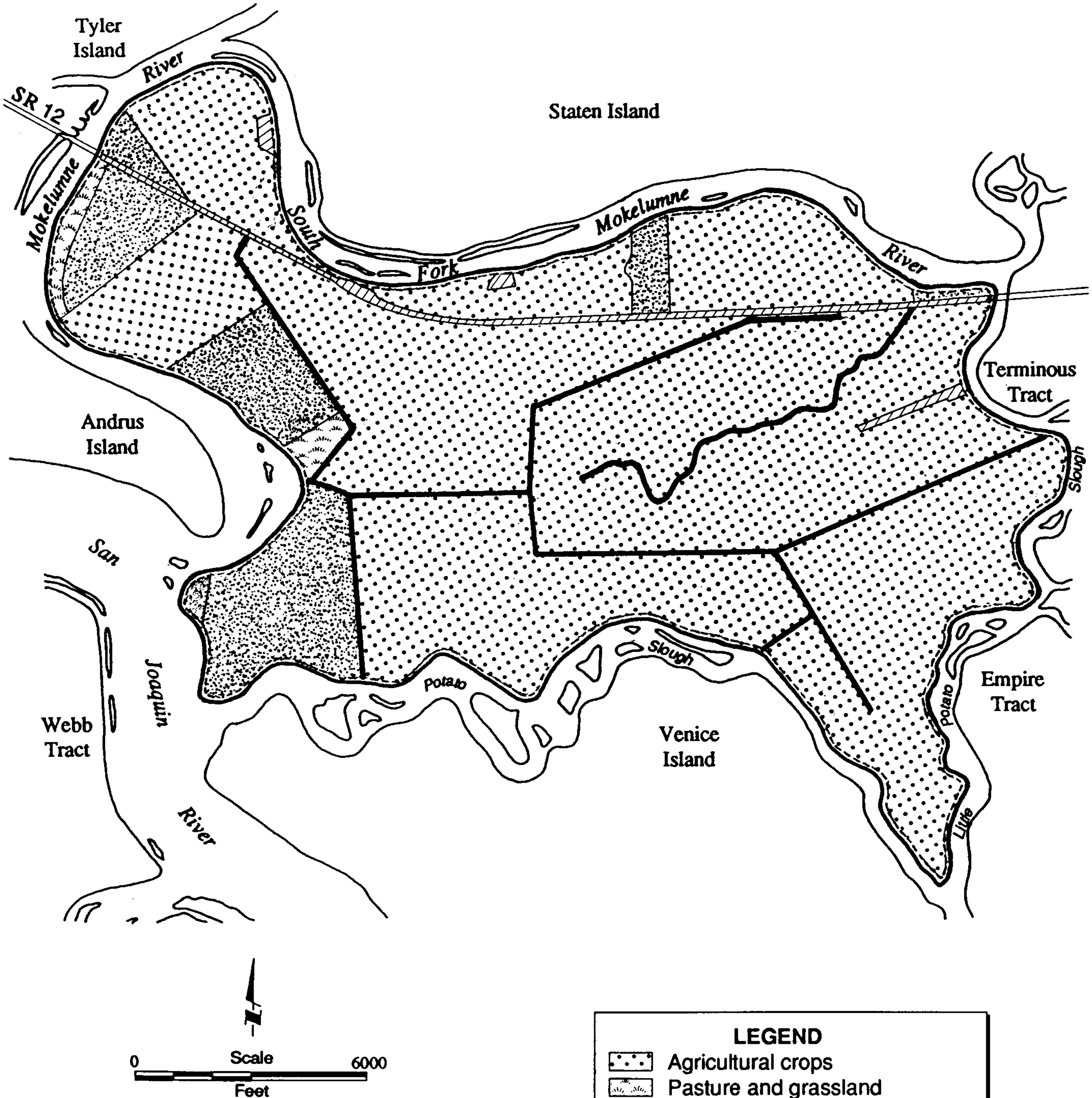
Note: Habitat types are based on habitat mapping conducted by Jones & Stokes Associates in December 1987.

Figure 3G-5
Existing Bacon Island Habitat Types



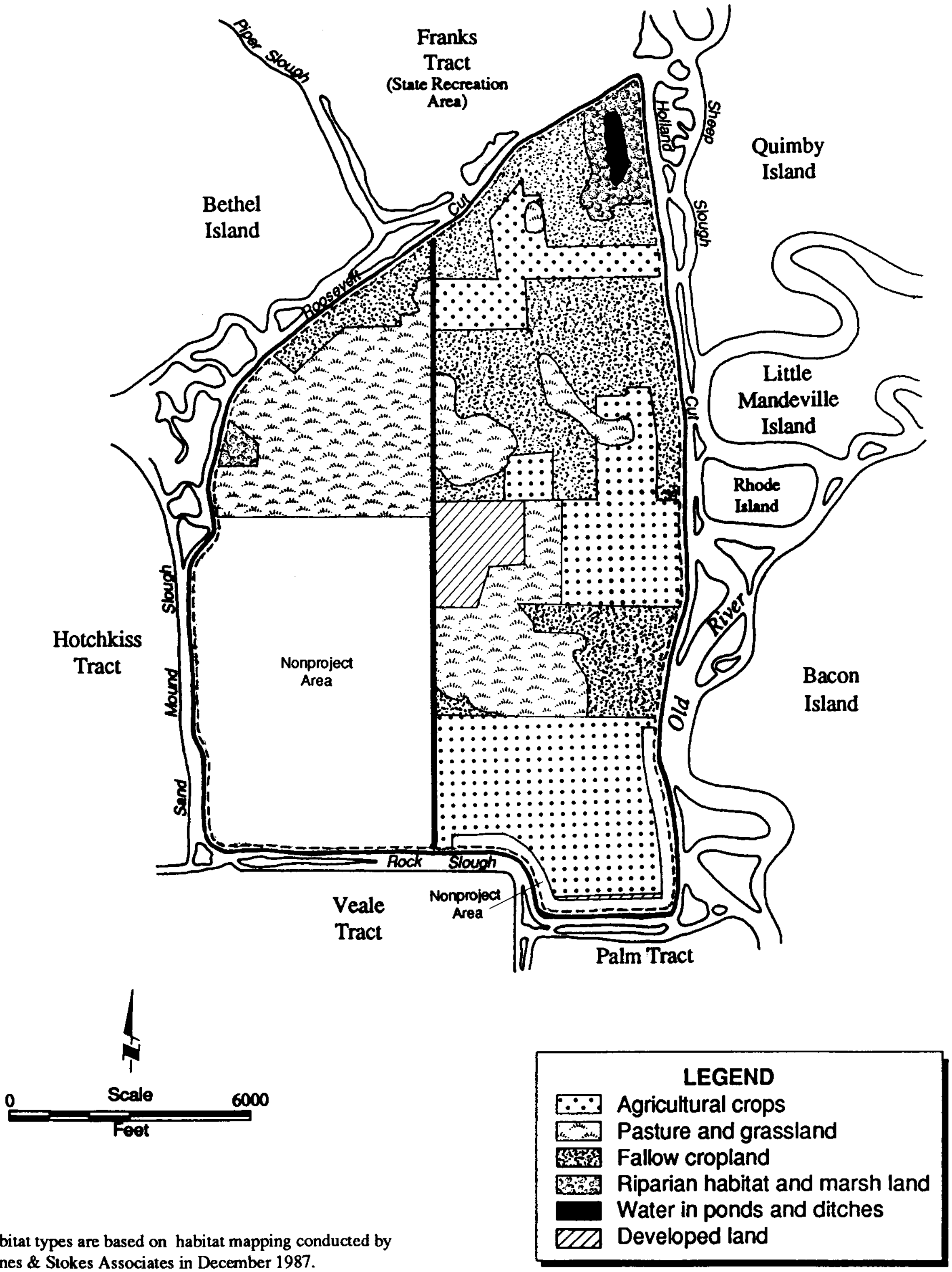
Note: Habitat types are based on habitat mapping conducted by Jones & Stokes Associates in December 1987.

Figure 3G-6
Existing Webb Tract Habitat Types



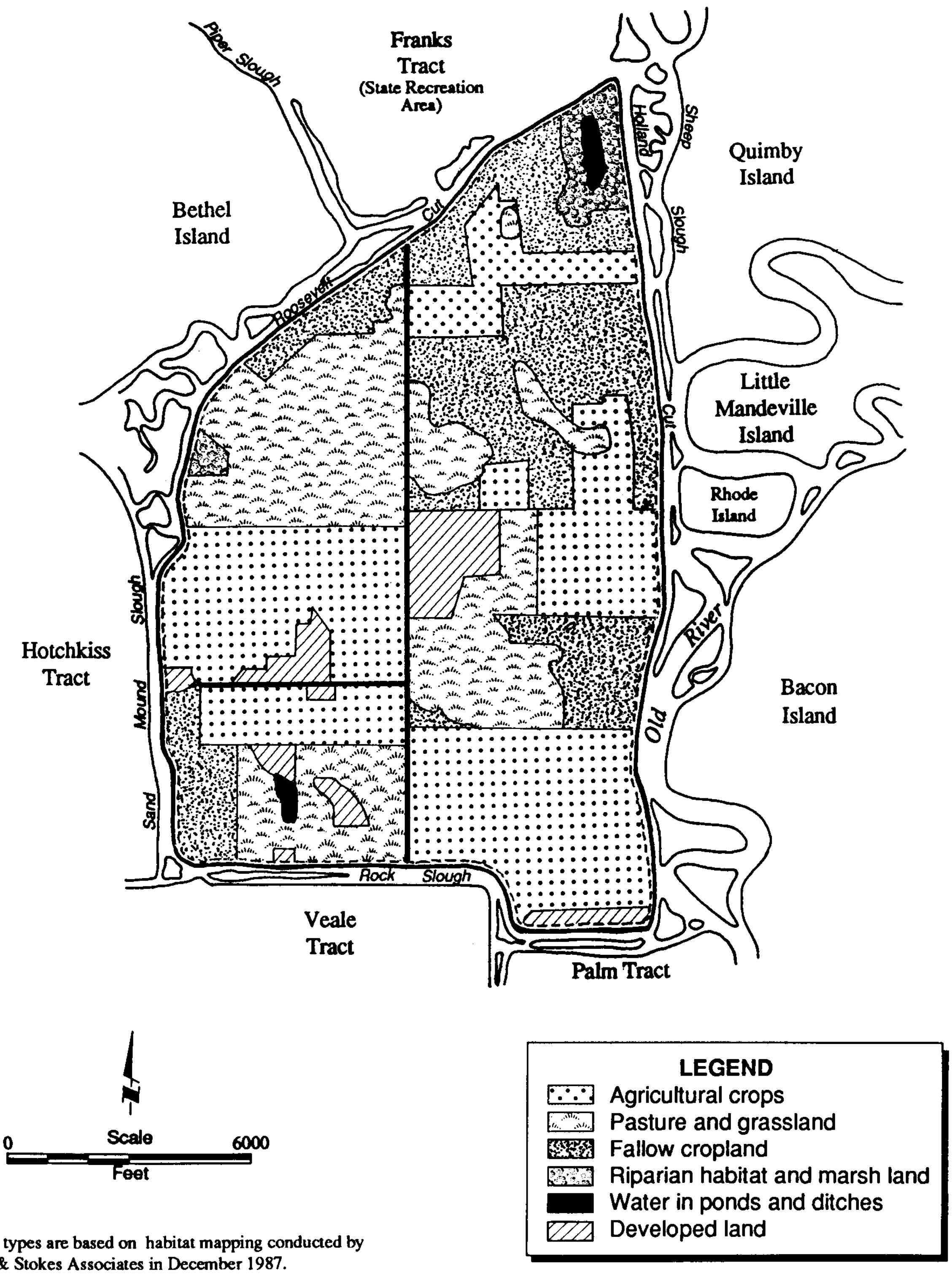
Note: Habitat types are based on habitat mapping conducted by Jones & Stokes Associates in December 1987.

Figure 3G-7
Existing Bouldin Island Habitat Types



Note: Habitat types are based on habitat mapping conducted by Jones & Stokes Associates in December 1987.

Figure 3G-8
Existing Holland Tract Habitat Types in the Project Area for Alternatives 1 and 2



Note: Habitat types are based on habitat mapping conducted by Jones & Stokes Associates in December 1987.

Figure 3G-9
Existing Holland Tract Habitat Types in the Project Area for Alternative 3 and the No-Project Alternative

Chapter 3H. Affected Environment and Environmental Consequences - Wildlife

Chapter 3H. Affected Environment and Environmental Consequences - Wildlife

SUMMARY

This chapter describes wildlife habitats and wildlife use on the DW project islands and the impacts of the DW project alternatives on wildlife. The impact analysis for the reservoir islands provides a description of wildlife values that would be associated with the various flood conditions on the reservoir islands; however, because future habitat conditions are unpredictable, no wildlife values that would compensate for project impacts are assumed to be provided on the reservoir islands. Impacts of the DW project on wildlife are associated with the conversion of existing habitats (primarily agricultural) to reservoir uses on the reservoir islands or to habitat types managed specifically to provide high wildlife habitat values on the habitat islands.

Under Alternatives 1 and 2, the habitat islands (Bouldin Island and Holland Tract) would be managed primarily to offset wildlife impacts resulting from operation of the reservoir islands. Implementation of the HMP developed for the habitat islands would result in creation of seasonal managed wetlands, emergent marshes, seasonal ponds, lakes, herbaceous uplands, riparian woodland and scrub habitats, pastures, and corn and wheat fields that would be managed specifically to provide high wildlife habitat values. In addition to offsetting project impacts on wildlife, implementation of the HMP is expected to benefit many special-status and other wildlife species that currently are not found or are found only irregularly on the DW project islands.

Implementation of Alternative 1 or 2 would result in changes to wildlife habitats on the DW project islands and therefore changes in the use of those islands by wildlife species. In general, flooding the reservoir islands would result in a loss of habitat and implementing the HMP would result in a gain in habitat.

Implementing Alternative 1 or 2 could result in increased incidence of waterfowl disease, which is considered a significant impact on wildlife. Implementing a program for monitoring waterfowl disease in cooperation with DFG would reduce this impact to a less-than-significant level. Significant temporary impacts on state-listed species could occur during construction on the reservoir islands but would be reduced through development and implementation of a mitigation and monitoring plan to avoid these impacts. Use of the Bouldin Island airstrip on hunt days during the waterfowl season under Alternative 1 or 2 could result in disturbance to greater sandhill cranes and wintering waterfowl. This impact would be reduced to a less-than-significant level through implementation of a monitoring program to assess the effects of hunt-day flights on use of Bouldin Island by these species and implementation of actions to reduce any effects identified through monitoring.

Implementation of Alternative 1 or 2 would also result in less-than-significant losses of upland habitats, foraging habitats for wintering waterfowl, upland game species habitats, foraging habitat for Aleutian Canada goose, and wintering habitat for tricolored blackbird, and less-than-significant cumulative losses of riparian and herbaceous habitats. Other less-than-significant impacts would be the potential for disruption of waterfowl use and of greater sandhill crane use of the habitat islands as a result of increased hunting, increases in waterfowl harvest mortality, potential changes in local and regional waterfowl use patterns, and potential effects on wildlife and wildlife habitats resulting from Delta outflow changes. Implementing the HMP would result in beneficial increases in wetland habitats for nongame water and wading birds, waterfowl breeding habitats, foraging and roosting habitat for greater sandhill crane, foraging and nesting habitat for Swainsons hawk, nesting habitat for northern harrier and tricolored blackbird, and suitable habitats for special-status wildlife species, as well as contribute to cumulative increases in wintering waterfowl habitat in the Delta region.

Alternative 3 does not include implementing the HMP, so impacts of reservoir island operations under this alternative on some wildlife habitats would not be offset by created habitats and are considered significant. Significant impacts would be losses of upland habitats, foraging habitats for wintering waterfowl, habitats for upland game species, foraging habitats for greater sandhill crane and Swainson's hawk, and nesting habitat for northern harrier. To offset these impacts, an offsite wildlife habitat mitigation plan is recommended for Alternative 3. Implementation of Alternative 3 would result in the following less-than-significant impacts, as under Alternative 1 or 2: losses of foraging habitat for Aleutian Canada goose and nesting habitat for tricolored blackbird, potential for disruption of waterfowl use as a result of increased hunting, increases in waterfowl harvest mortality, potential changes in local and regional waterfowl use patterns, and potential effects on wildlife and wildlife habitats resulting from Delta outflow changes. Alternative 3 would also contribute to less-than-significant cumulative losses of foraging habitat for wintering waterfowl, herbaceous habitat, and wetland and riparian habitats in the Delta. Implementation of Alternative 3 would result in a beneficial increase in suitable waterfowl breeding habitat.

Implementation of the No-Project Alternative would change wildlife habitat on the DW project islands by converting fallow, herbaceous upland, riparian, and wetland habitats to crops. The effects of the No-Project Alternative would be losses of riparian and wetland habitats, northern harrier nesting habitat, and potential Swainson's hawk foraging habitat. These effects could be reduced through development and implementation of an offsite mitigation plan, but such mitigation would not be required.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

No substantive changes have been made to this chapter since publication of the 1995 DEIR/EIS. In response comments from DFG and DW on the 1995 DEIR/EIS, information about shallow water storage on the reservoir islands has been updated. This minor clarification does not change the conclusions of the analysis of project impacts on wildlife presented below.

INTRODUCTION

This chapter discusses impacts of the DW project on wildlife, most of which would result from habitat changes and changes in hunter use on the DW project islands. The HMP incorporated into the project description for Alternatives 1 and 2 provides for compensation habitat to be established on the habitat islands to offset the effects of reservoir island operations on wildlife species. The impact assessment for Alternatives 1 and 2 is therefore based on the assumption that project implementation would include the establishment of compensation habitat acreages as specified in the HMP. Under Alternative 3, all four DW project islands would be used as reservoirs, and the NBHA on Bouldin Island would be used to provide limited compensation habitat.

The following appendices provide more detailed information on wildlife species, their habitat needs, and the legal status of wildlife species that may be found on the DW project islands:

- Appendix H1, "Wildlife Species Nomenclature";
- Appendix H2, "Wildlife Inventory Methods and Results";
- Appendix H3, "Federal Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Wildlife Species";
- Appendix H4, "California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane"; and
- Appendix H5, "Agency Correspondence regarding the Federal and California Endangered Species Acts".

For background information on existing and anticipated wildlife habitat conditions on the DW project islands, the reader is also referred to the following:

- Chapter 3G, "Vegetation and Wetlands";
- Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands"; and
- Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

AFFECTED ENVIRONMENT

This section describes wildlife habitat conditions on the DW project islands. Wildlife habitat information is based in part on information collected for the 1990 draft EIR/EIS and has been updated to current conditions where these changes would affect the impact analysis.

As a result of land management decisions made since 1988, some changes in agricultural land use and wildlife habitat conditions on the islands have occurred. Some of these changes were made in response to annual fluctuations in agricultural market conditions. Because some of these changes have resulted from project-related actions and influences, information from the 1990 draft EIR/EIS (based on 1988 conditions) provides the most reliable description of typical preproject wildlife habitat conditions on the DW project islands for assessing the impacts of the DW project alternatives.

A detailed description of methods used to identify baseline conditions and results of wildlife and wildlife habitat investigations are presented in Appendix H2, "Wildlife Inventory Methods and Results", and Chapter 3G, "Vegetation and Wetlands". Habitat-type acreages are described in this chapter for the portion of Holland Tract included in Alternatives 1 and 2. Acreages of habitat types on Holland Tract that would be affected with implementation of Alternative 3 and the No-Project Alternative are described in Chapter 3G.

Sources of Information

Information on existing wildlife species occurrence and waste grain availability was collected during surveys of the DW project islands conducted in 1988 (see Appendix H2). Distribution and acreages of wildlife habitats were determined from 1987 aerial photographs of the DW project islands (see Chapter 3G).

Information on wildlife ecology, populations, distribution in the Delta, and use of Delta habitats was obtained from DFG survey data files, technical reports, scientific literature, and contacts with DFG and USFWS biologists, wildlife researchers, farmers, and other individuals knowledgeable of the Delta environment.

General Wildlife Species

General wildlife species include piscivorous (i.e., fish-eating) birds, wading birds, shorebirds, gulls and terns, swallows, blackbirds and starlings, bird species typically associated with riparian woodland and scrub (riparian birds), and bird species typically associated with grassland and agricultural habitats.

Ground surveys to determine the occurrence and relative abundance of general wildlife species on DW project islands were conducted during February-May 1988.

Bacon Island

Bacon Island is the most intensively farmed of the four DW project islands. Most of the island is farmed for potatoes and asparagus. The island supports a moderate diversity and density of wildlife species compared with the other project islands.

Low- to moderate-sized populations of most general wildlife species are found on Bacon Island. The number of gulls observed during ground surveys was higher than on the other project islands; gulls congregated in areas flooded for weed control in winter and spring.

Moderate numbers of raptors, shorebirds (primarily sandpipers), and wading birds were observed during ground surveys. No great egrets, snowy egrets, or great blue herons nest on Bacon Island, and no potential nesting habitat exists. Few piscivorous birds or birds associated with riparian habitats, open water, or grasslands were observed on the island.

Webb Tract

Webb Tract is less intensively farmed than Bacon Island and Bouldin Island but supports more agriculture than Holland Tract. Nearly half the island is farmed for corn and wheat. Approximately 105 acres of open water habitat exists at two blowout ponds located in the northeast quarter of the island. Most of the 106 acres of riparian woodland and scrub and 172 acres of freshwater marsh on Webb Tract surround these ponds.

The number of wading birds observed on Webb Tract during ground surveys was large relative to the numbers observed on the other project islands. The average number of herons and egrets recorded per survey station on Webb Tract was more than twice the number recorded on Bacon Island and four times the number recorded on Bouldin Island and Holland Tract. Most wading birds are found in the weedy marshland area on the north side of the island. No wading bird nesting colonies were found during aerial, ground, and boat surveys of all potential nesting habitats conducted during the nesting season.

More raptors were seen on Webb Tract than on the other islands; however, the number on Webb Tract was only slightly higher than the number on Holland Tract. The most common raptor species are black-shouldered kite, red-tailed hawk, and American kestrel.

Moderate numbers of birds were observed in riparian and wetland habitats on Webb Tract, but the numbers recorded during systematic surveys were undoubtedly low because access was not granted by landowners to a blowout pond that provides high-quality wetland, riparian woodland, and open-water habitats on the eastern portion of the island. Small numbers of other species were observed during surveys, including piscivorous birds, shorebirds, gulls and terns, and blackbirds.

Bouldin Island

Wildlife habitats on Bouldin Island are dominated by agricultural lands that support corn, wheat, and sunflower. Smaller amounts of other habitats exist, including fallow agricultural land and herbaceous upland.

Low to moderate numbers of most bird species were observed on Bouldin Island during field surveys. A large number of gulls was observed; no terns were seen, and no breeding habitat for gulls was found on the island. Large numbers of grassland and agricultural birds, primarily blackbirds and American crows, were observed.

A moderate number of wintering raptors was observed on Bouldin Island. The number of raptors decreased in spring; the only non-special-status raptor species observed during May was red-tailed hawk, but the species did not nest on the island. A moderate number of swallows, primarily cliff swallows, were observed using Bouldin Island.

Small numbers of wading birds, shorebirds, and riparian and marsh birds were observed. No herons or egrets nested on the island. Killdeer were the only shorebirds observed. The most common birds observed in riparian habitats were white-crowned sparrow, house finch, song sparrow, American robin, and black phoebe.

Holland Tract

Holland Tract is the least intensively farmed of the four DW project islands. Agriculture accounts for approximately 31% (974 acres) of the island acreage. Holland Tract supports about 225 acres of herbaceous wetland, most of which is dominated by weedy species that invade fallow agricultural areas. In total, the island supports more woody riparian vegetation (105 acres) than any of the other three project islands, most of which is associated with a blowout pond located at the northeast end of the island. In 1987, DW constructed a shallow 63-acre demonstration wetland pond to evaluate vegetation establishment and growth under proposed operating conditions that would have been present under the original DW proposed project (see Appendix G2, "Vegetation Inventory Methods and Results").

High numbers of shorebirds, raptors, riparian and marsh birds, and blackbirds and starlings were observed on Holland Tract relative to the other project islands. The most common raptors included black-shouldered kite and red-tailed hawk. Raptors were most common in winter and declined to small numbers in April and May. A red-tailed hawk nest was found, and kites were suspected to have nested on the island.

Shorebirds use the Holland Tract demonstration wetland, including an average of 60 sandpipers and 14 dowitchers observed per survey; no nesting by shorebirds was observed. The most common riparian birds included house finch, American robin, song sparrow, and white-crowned sparrow. Large numbers of yellow-headed blackbirds and red-winged blackbirds were observed during winter; blackbird numbers declined during spring, but red-winged blackbirds remained and nested in weedy and marsh areas.

Moderate numbers of gulls, grassland birds, and swallows were observed on Holland Tract during winter. Wading birds were less abundant on Holland Tract than on the other project islands.

Delta Region, Suisun Marsh, and San Francisco Bay

The island area of the Delta consists of approximately 600,000 acres on 60 islands. At least 230 species of birds and 43 species of mammals are found in the Delta (DFG 1987a). The area provides habitat of importance to shorebirds in particular. Thousands of shorebirds use fields flooded for weed control in late summer and fall and fields that flood shallowly from seepage and rainfall in winter.

General wildlife species reported from the Delta are similar to those described for the DW project islands. Wildlife species and populations on different islands vary primarily according to the amounts and types of crops grown and amounts of natural habitats remaining. Rollins (1977) rated the values of several Delta habitats along the proposed route of the Peripheral Canal from most to least valuable. These habitats were riparian woodland, marsh, permanent pasture, cornfields, and asparagus fields.

Suisun Marsh lies between San Francisco Bay and the Delta. The area provides approximately 57,300 acres of wetland and adjacent upland habitat and 27,000 acres of bays and waterways for use by waterfowl and other species (USFWS 1978). Suisun Marsh also supports a variety of general wildlife species characteristic of saltwater and freshwater marsh and herbaceous upland areas.

San Francisco Bay includes 53 square miles of tidal marsh, 15 square miles of diked marsh, and 55 acres of diked ponds (JSA et al. 1979). San Francisco Bay habitats support approximately 200 species of birds and 40 species of mammals (DFG 1987b). Important groups include waterfowl and special-status wildlife species. The bay supports hundreds of thousands of shorebirds during the migratory and winter seasons (Yee et al. 1988), and many nongame birds and mammals use the various marsh habitats.

Waterfowl

Long-Term Trends in Waterfowl Abundance in the Delta

The size of waterfowl populations wintering in the Delta fluctuates between years because of changes in weather, habitat conditions, and flyway populations. Despite annual fluctuation, large populations of waterfowl had used the Delta area in most years until the 1980s. Wintering waterfowl populations in the Delta have declined by approximately 83% since the 1970s (Figure 3H-1). The decline is most pronounced for ducks, but substantial declines are also evident for swans and geese.

Population declines in the Delta during the 1980s and early 1990s reflect the larger waterfowl population decline that has occurred in the Central Valley and Pacific Flyway. The decline is attributable to a variety of factors, the most important of which is probably the prolonged drought in northern breeding areas that resulted in unfavorable land use changes (i.e., intensified farming of former wetland areas and adjacent nesting habitats). Loss of winter habitat is also considered an important factor that has contributed to the population reduction and may prevent future recovery of populations. (Implementation Board of the Central Valley Habitat Joint Venture 1990.) Duck and goose populations have begun to recover in recent years. The wet years of 1993 through 1995 in northern breeding areas provided favorable breeding conditions that resulted in substantially higher production of ducks and geese. Wintering populations of ducks and geese in the Delta and Central Valley, however, are still substantially lower than the average wintering populations for the previous 40 years (Yparraguirre pers. comm.).

Analysis of past population trends is relevant to the DW project because the populations recorded in 1987-1988 were approximately 80% less than those that likely existed in the 1970s. The net result is that numbers reported for individual DW project islands in the following sections are below the numbers that occurred historically and that would likely occur if populations recover to meet management goals. Nonetheless, the survey results provide a valuable indication of the relative abundance of waterfowl on different islands and indicate habitats used by species.

Bacon Island

The estimated total of waterfowl use-days is moderate for Bacon Island. Tundra swans were observed using Bacon Island more than any other island except Webb Tract during the survey period, with an average observed population of about 300 birds. Nearly 90% of the swans were in cornfields flooded for weed control; flooded cornfields made up less than one-third of the island's area.

Geese have a moderate number of use-days on Bacon Island. White-fronted geese arrive in substantial numbers in mid-December to late December and use flooded and unflooded agricultural fields. Snow goose populations vary widely. All snow geese observed on Bacon Island used unflooded, undisked agricultural fields. No Canada geese were observed on Bacon Island.

Few ducks have been observed on Bacon Island. Flocks of pintails were seen twice in flooded potato fields, and mallards were seen in flooded fields and ditches. Only 10 mallards were seen during May surveys, indicating that few birds breed on the island.

Waste Grain Availability. A moderate amount of waste corn is available to waterfowl on Bacon Island (see Appendix H2, "Wildlife Inventory Methods and Results"). Approximately 82,000 pounds of corn are estimated to be available immediately after harvest, but postharvest disking for planting to winter wheat on approximately half the corn acreage reduces availability to approximately 67,500 pounds.

Fields of market potatoes on Bacon Island are not flooded; they are kept in a saturated soil condition for several weeks following harvesting to encourage rotting (Shimasaki pers. comm.). Therefore, these fields provide little food for waterfowl. Seed potatoes are harvested later and cannot be rotted because of cold temperatures; these areas probably provide valuable forage for waterfowl.

Hunting Harvest. No waterfowl or upland game are harvested on Bacon Island.

Webb Tract

Webb Tract supports high numbers of waterfowl use-days. Total waterfowl use observed on Webb Tract is 10 times higher than on any of the other islands. Of the four project islands, Webb Tract has the largest corn acreage and supported the largest number of swans during the midwinter survey period. Swans on Webb Tract use unflooded cornfields and flooded fields.

Webb Tract had the largest number of geese observed during aerial surveys of the four project islands. Three-fourths of the white-fronted geese observed were resting on the eastern blowout pond; the remaining birds were seen in undisked cornfields. The snow goose population averaged 4,700 during December through March, with a peak of 10,000 birds in mid-January. Snow geese were usually seen resting on the eastern blowout pond but were also observed in undisked and flooded cornfields. Several groups of Canada geese were seen; the largest group consisted of approximately 650 birds in an undisked cornfield. The survey data indicate that the eastern blowout pond on Webb Tract is an important resting area for geese in the Delta.

The number of ducks observed on Webb Tract was also high but varied substantially over the survey period. Both mallards and pintails were seen regularly. The largest population, consisting of 20,000 ducks (both pintails and mallards), was found resting on the eastern blowout pond in mid-December. Nearly all ducks on Webb Tract observed during winter were found resting on the eastern blowout pond.

Twenty-seven mallards seen during each of the two May surveys were assumed to be breeding birds; their presence indicates the existence of a moderate-sized breeding population (perhaps 20-50 pairs). Ten mallards (some of which may have been young-of-year) were observed on the eastern blowout pond during a survey conducted in June.

Waste Grain Availability. Webb Tract produces approximately 567,000 pounds of waste corn available for waterfowl and other wildlife, representing more than half the waste corn provided on the DW project islands (see Appendix H2, "Wildlife Inventory Methods and Results"). Wheat also provides seed following harvest in summer and green forage for geese and other wintering birds during late fall and winter.

Hunting Harvest. Harvest rates of ducks and geese are highest on Webb Tract among the four project islands. The harvest represents a small proportion of the total numbers of birds that use the island.

Bouldin Island

Estimated waterfowl use-days are moderate on Bouldin Island. Swan use on Bouldin Island is moderate compared with swan use of other islands; most swans were seen during the surveys in flooded grainfields, with fewer numbers in undisked grainfields.

The number of geese using Bouldin Island is low to moderate, and daily populations vary substantially over winter. A moderate number of white-fronted geese were seen during aerial surveys; the highest count was 1,100 birds in early January. Most white-fronted geese were observed in flooded, disked grainfields and undisked grain stubble.

The few snow geese observed on Bouldin Island used disked cornfields. Canada geese were seen in small numbers in disked and undisked fields, and several flocks were seen in grazed fallow fields during ground surveys. Canada geese may have been slightly undercounted during aerial surveys because they were not easily distinguishable among larger groups of white-fronted and snow geese.

Fowl cholera records show variability in the use of Bouldin Island by geese. In 1986, DFG personnel collected 2,000 dead white-fronted and snow geese, which represented only a portion of the birds using the island at that time (DFG file information).

Overall duck use observed at Bouldin Island is low. The number of ducks observed during surveys declined substantially in early January. Pintails are the most abundant species using the island. During surveys, mallards were observed in ditches and flooded fields. Only four mallards were seen in May, indicating a very small breeding population.

Waste Grain Availability. Approximately 214,000 pounds of waste corn are produced and available for waterfowl use on Bouldin Island (see Appendix H2, "Wildlife Inventory Methods and Results"). Approximately 1,200 acres of wheat, another important source of waste grain for waterfowl, are also grown on the island. Average corn availability shortly after harvest is 87 pounds per acre. Field measurements on the island yield an average of 106 pounds per acre of grain left in the half of the cornfields that are not disked after harvest and 68 pounds per acre in remaining areas disked prior to the planting of winter wheat (JSA 1989).

Wheat is another important crop on Bouldin Island. Approximately half the corn acreage is replanted in wheat following harvest in the fall. Waterfowl, especially Canada and white-fronted geese, graze extensively on green wheat foliage during winter and early spring (Fredrickson et al. 1988, Miller pers. comm.).

Hunting Harvest. Small numbers of ducks and geese are harvested annually by hunters on Bouldin Island. Harvested birds represent only a small proportion of the total number of birds that use the island.

Holland Tract

The estimated total of waterfowl use-days on Holland Tract is low. Few tundra swans were observed at Holland Tract during the surveys. Nearly all birds were detected in flooded fields.

Few geese were observed using Holland Tract. Few or no white-fronted geese were seen during November to March, but numbers increased during April. Snow geese were not recorded on Holland Tract during aerial surveys, but 2,000 birds were seen feeding in an unharvested cornfield near the blowout pond during a ground survey in early February. Several small flocks of Canada geese were seen during December and January; however, nearly all Canada geese recorded during Holland Tract surveys were flying and may not have landed on the island.

Holland Tract supports moderate numbers of ducks. Most ducks were found during surveys in the Holland Tract demonstration wetland and the blowout pond, and the rest were observed in flooded fields. Species seen at the demonstration wetland included American widgeon, mallard, northern pintail, cinnamon teal, ruddy duck, and northern shoveller (JSA 1990).

Waste Grain Availability. Holland Tract produces approximately 67,000 pounds of waste corn for waterfowl. Wheat is the major crop and provides seed during spring and late summer for resident species and green forage for wintering species, especially geese. Corn harvesting is considered nonintensive, and the availability of waste corn for use by wildlife is estimated to be similar to availability on Webb Tract (see Appendix H2, "Wildlife Inventory Methods and Results").

Hunting Harvest. Few ducks, geese, and pheasants are harvested annually by hunters on Holland Tract. The estimated harvest represents only a small proportion of the total numbers that use the island.

Delta Region, Suisun Marsh, and San Francisco Bay

The Delta supports nearly 10% of the waterfowl that winter in the Pacific Flyway. The Delta provides important waterfowl habitat on flooded and unflooded agricultural lands, natural wetlands, and sloughs. Approximately 12,000 acres of agricultural lands are flooded by duck clubs in the Delta (USFWS 1978). Nearly 75% of all tundra swans and more than one-third of all white-fronted geese in the Central Valley winter in the Delta (DFG 1987a). The Delta also supports large populations of snow geese, pintails, and mallards (Gilmer et al. 1982, DFG 1987a).

Suisun Marsh supports more than 57,000 acres of managed wetland and upland. Substantial numbers of waterfowl use Suisun Marsh. The highest use occurs during early fall before the onset of rains, when the availability of shallow-water habitats attract waterfowl. Waterfowl populations at Suisun Marsh decline later in winter when additional flooded habitat is available. Suisun Marsh supported approximately 2% of the waterfowl population observed during the midwinter surveys in December 1973-1976. (USFWS 1978.)

San Francisco Bay provides important habitats for wintering waterfowl (DFG 1987b). The saltwater portions of the bay support a large proportion of the diving ducks wintering in California. Freshwater and brackish areas in the eastern portion of the bay provide important habitats for dabbling ducks and geese.

Upland Game

Upland game species include ring-necked pheasant, mourning dove, California quail, and desert cottontail.

Bacon Island

Low numbers of ring-necked pheasant, California quail, and mourning dove were observed on Bacon Island. The island is farmed intensively and cover is scarce; the number of pheasants observed on Bacon Island was lower than on the other DW project islands. No upland game species are harvested on Bacon Island.

Webb Tract

Webb Tract surveys recorded the highest number of mourning doves among the four islands, a moderate number of pheasants, and no quail. The high number of doves reflects the abundance of woodland perching sites and availability of grain in wheat fields. Among the four project islands, the harvest of pheasants is highest on Webb Tract.

Bouldin Island

Bouldin Island supports moderate numbers of ring-necked pheasants and mourning doves; no quail were seen on the island during surveys. Pheasant numbers are limited by the lack of cover on most parts of the island. Small numbers of pheasants are harvested annually by hunters on Bouldin Island.

Holland Tract

Pheasants and quail are more abundant on Holland Tract than on the other three DW project islands. The higher populations reflect the greater amounts of cover provided for pheasants by fallow areas and for quail by riparian shrubs and trees. Mourning dove populations are also high, presumably because of the abundance of perching sites in trees. Few pheasants, doves, and quail are harvested annually by hunters on Holland Tract.

Special-Status Species

Special-status species include species that are state or federally listed as threatened or endangered, Category 1 or 2 candidates for federal listing, DFG species of special concern, and species fully protected under the California Fish and Game Code. Fourteen special-status species occur or potentially occur on the DW project islands. Additional information regarding the status of the giant garter snake, bald eagle, Aleutian Canada goose, peregrine falcon, Swainson's hawk, and greater sandhill crane on the DW islands is presented in Appendix H3, "Federal Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Wildlife Species", and Appendix H4, "California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane". Table H2-2 in Appendix H2, "Wildlife Inventory Methods and Results", describes the special-status species that occur or have the potential to occur on the DW project islands.

Bacon Island

Northern harrier and burrowing owl were the only special-status species observed on Bacon Island during the surveys. Potential habitat for 10 other special-status species, including Swainson's hawk and tricolored blackbird, exists. Greater sandhill cranes have not traditionally used Bacon Island, and none were observed during surveys. DFG, however, reports a recent isolated observation of a greater sandhill crane on Bacon Island (Wernette pers. comm.).

A small number of northern harriers was observed on Bacon Island. Harriers are not known to nest on Bacon Island because nearly all the island is cultivated and suitable nesting sites are limited. One burrowing owl was observed during surveys. Burrowing owls are not known to nest on Bacon Island because intensive agriculture and levee maintenance activities have minimized the availability of suitable burrows and the presence of ground squirrels that construct burrows.

Bacon Island provides low- to moderate-quality foraging habitat for Swainson's hawks. The nearest known Swainson's hawk nest site is located immediately to the east on Mildred Island, and seven pairs nest within 10 miles of the island. Although no Swainson's hawks were observed during surveys, Swainson's hawks nest within foraging distance and could use the island.

Webb Tract

Northern harrier was the only confirmed special-status species observed on Webb Tract. Webb Tract also supports potential habitat for 12 additional special-status species, including Swainson's hawk, peregrine falcon, and tricolored blackbird.

One sandhill crane (subspecies not identified) was observed during an aerial survey of Webb Tract. Although Webb Tract is not considered an important greater sandhill crane area by Pogson and Lindstedt (1988), it supports suitable foraging habitat, including grainfields, fallow fields, pastures, exotic marshes, and herbaceous uplands. DFG has recently designated Webb Tract as a greater sandhill crane wintering area based on additional sightings.

Webb Tract provides low- to moderate-quality Swainson's hawk foraging habitat. The nearest known nest site is located within 4 miles, and seven pairs nest within 10 miles of the island. Thus, several pairs could forage on Webb Tract. Webb Tract supports a high number of harriers in winter, with an average of 14 birds seen per survey in February. Harriers could nest in densely vegetated wetlands or fallow fields on the island.

Bouldin Island

Greater sandhill crane, Swainson's hawk, and northern harrier were the only special-status species observed on Bouldin Island during surveys. Since surveys were conducted, other special-status species have been observed by JSA biologists; these species include peregrine falcon, Cooper's hawk, ferruginous hawk, and short-eared owl. Bouldin Island also supports potential habitat for five additional special-status species, including tricolored blackbird and Aleutian Canada goose.

Sandhill cranes were regularly observed during October-February, but numbers subsequently declined rapidly and none were seen after early March. All the cranes seen during one October visit were lesser sandhill cranes, but 95% of the birds identified to subspecies in February-March were greater sandhill cranes. Based on additional observations, DFG has designated Bouldin Island as a greater sandhill crane wintering area.

Swainson's hawks have been observed foraging on Bouldin Island during the breeding season and winter. One was observed flying over the island during surveys conducted in May 1988. Pasture, fallow fields, and agricultural fields provide suitable foraging habitat; vegetation in some fallow areas, however, may be too tall and dense to be used for foraging by Swainson's hawks. The nearest known Swainson's hawk nest site is approximately 3 miles north of Bouldin Island, and 10 pairs nest within 10 miles of the island. Thus, several pairs could forage on Bouldin Island.

Bouldin Island supports moderate numbers of harriers during winter and early spring; no birds were seen in May during surveys. Harriers are not known to nest on Bouldin Island.

Holland Tract

Special-status species observed on Holland Tract during the surveys were Swainson's hawk and northern harrier. Although western pond turtles were not observed during surveys, they are known to have been present on Holland Tract; however, the status of pond turtle populations on Holland Tract is unknown. Potential habitat for 12 additional special-status species, including valley elderberry longhorn beetle (VELB), tricolored blackbird, and short-eared owl, also exist on Holland Tract.

One adult Swainson's hawk was observed during surveys of Holland Tract. Suitable nesting habitat on the island exists in trees over 25 years old, but no nests were found. Fallow areas, pasture, grassland, and agricultural fields are suitable for foraging use by Swainson's hawks. The nearest known nest site is approximately 3 miles east of the island. Seven pairs nest within 10 miles of the island, although only two pairs have been located nesting within 9 miles. Thus, although several pairs nest within foraging distance of Holland Tract, it is probably less likely to be used than the other DW project islands.

No greater sandhill cranes were observed on Holland Tract during surveys; however, DFG has recently reported an isolated observation of a greater sandhill crane on the island. Holland Tract provides suitable crane foraging habitat; however, because it is located approximately 7 miles from the nearest important wintering area, the island is not expected to support regular use by greater sandhill cranes.

Holland Tract supported at least four northern harriers throughout the survey period.

Delta Region, Suisun Marsh, and San Francisco Bay

The Delta is known to support seven bird, one reptile, and three insect species state-listed or federally listed as threatened or endangered and four bird, two mammal, one reptile, and two insect species identified as federal candidates for listing (see Appendix H5, "Agency Correspondence regarding the Federal and California Endangered Species Acts"). The Delta area is used only irregularly by small numbers of peregrine falcons and bald eagles. The Delta supports a small number of nesting Swainson's hawk pairs; densities are substantially greater on higher elevation lands north and east of the Delta (Estep pers. comm.). Certain localized areas of the Delta serve as important wintering habitat for the greater sandhill crane (Pogson and Lindstedt 1988) and Aleutian Canada goose (Nelson et al. 1984).

Suisun Marsh and San Francisco Bay provide habitat for six bird species and one mammal listed as threatened or endangered by DFG or USFWS. The salt marsh harvest mouse; California clapper rail; and, to a lesser extent, the California black rail are found primarily in salt marsh habitats. The salt marsh common yellowthroat and Suisun song sparrow subspecies prefer tall emergent vegetation that grows in more brackish conditions.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Impacts on wildlife were evaluated through comparison of wildlife values associated with habitat conditions predicted under the DW project alternatives with existing habitat conditions. Existing wildlife habitats would change as a result of construction of facilities, upgrading of levees, inundation of reservoir islands during water storage and shallow-water management periods, and implementation of the HMP (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). Potential impacts of the project's habitat modifications include changes in populations of general wildlife species, waterfowl, upland game, and special-status species.

Alternatives 1, 2, and 3

The analysis of impacts of the DW project alternatives on the reservoir islands was based on the amounts of Delta water that would be available for storage; the estimated amounts are based on the 70-year hydrologic record for the Delta (see Chapter 3A, "Water Supply and Water Project Operations", and Chapter 3B, "Hydrodynamics"). There is potential for some level of continuing subsidence on the DW project islands even with the cessation of farming activities. As a result, the water storage capacity of the reservoir islands could increase in future years. The rate of subsidence, however, would be substantially less than under existing conditions. Reduced rates of subsidence and increased water storage capacity on the reservoir islands would not be expected to substantially increase or decrease wildlife habitat effects analyzed in this chapter.

A detailed description of the approach used to analyze future habitat conditions on the DW reservoir islands is presented in Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands". Prediction of future vegetation conditions on reservoir islands is based on end-of-month water storage amounts predicted by the DeltaSOS simulations conducted for the 1995 DEIR/EIS. Additional simulations were performed for the updated evaluation of project operations under the proposed project in the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations"; however, the differences in DeltaSOS results in the 1995 DEIR/EIS and 2000 REIR/EIS evaluations of Alternatives 1 and 2 do not affect the conclusions of this chapter. Therefore, the analysis of reservoir island habitat conditions from the 1995 DEIR/EIS remains unchanged and is presented below.

Although reservoir islands will support wildlife habitat, the actual duration and frequency of habitat conditions that would occur on reservoir islands is unpredictable. The general wildlife habitat values that would be associated with each reservoir island operating condition are described below. Because future habitat conditions are unpredictable and cannot be quantified, reservoir islands were assumed in this impact assessment to provide no wildlife values that would offset project impacts. Therefore, for the impact analysis, operation of the reservoir islands was not used to offset or compensate for impacts of the project on wildlife values.

Analysis of future vegetation conditions on habitat islands under Alternatives 1 and 2 is based on habitat types and acreages described in the HMP (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

No-Project Alternative

Island habitat conditions predicted under the No-Project Alternative are based on a feasibility study prepared for DW by The McCarty Company, Diversified Agricultural Services (McCarty pers. comm.). The report, in general, recommends greater crop diversification, with a greater emphasis on perennial crops, for all four DW project islands.

HEP Analysis

This section describes the habitat evaluation procedures (HEP) methodology used to identify preproject and project habitat conditions on the DW islands under the 1990 and 1992 versions of the DW project. The HEP analysis was performed by a team consisting of representatives of SWRCB, USFWS, DFG, and JSA. HEP methodology was not used to evaluate the current DW project; however, the HMP team consulted the HEP results for the earlier versions of the project and conducted an informal, modified HEP evaluation of the current project to assist in identifying habitat types, acreages, and management required on the DW habitat islands to offset project impacts on waterfowl.

HEP Methodology. The HEP methodology is a systematic procedure for assessing the impacts of a project on a set of species (evaluation species) selected to represent wildlife communities that would be affected by the project. The procedure compares the quality and acreages of habitats under preproject and project conditions to determine changes in total habitat value for the evaluation species.

Ten HEP evaluation species were selected to represent the variety of game and nongame species that could be affected positively or negatively by habitat changes that could occur under various project alternatives. Species evaluated in the HEP analysis, the wildlife groups (i.e., guilds) they represent, and the general habitats they use are listed in Table 3H-1.

Per-acre quality of habitats for each species under preproject and project conditions was determined using habitat suitability index (HSI) models developed for each species. The HSI models consisted of:

variables important in determining habitat quality for the species at the project site (e.g., vegetation height, water depth),

habitat suitability ratings for different conditions of each variable (variable values) for the species on a scale from 0.0 to 1.0, and

equations used to combine individual variable suitability ratings to create the HSI value or the overall rating of habitat quality for the species.

Habitat quality was assessed for each of nine 4- to 6-week-long annual periods. The periods were identified to allow tracking of habitat values resulting from substantial changes in habitat conditions that occur at different times of the year and to evaluate habitat quality for each species during its expected period of occupancy at the islands.

Habitat suitability ratings were calculated for each habitat type and subtype present on the islands under preproject and postproject conditions. The models were calibrated through comparison of HSI values for existing and potential habitats (including potential mitigation areas) and adjusted by modification of HSI values for individual variables or modification of the HSI equation. HSI values described the per-acre value of each habitat type. Habitat unit (HU) values (HSI values multiplied by acres) were calculated for each evaluation species to describe the overall habitat value of each habitat type to the species during each of the annual analysis periods. HU values for each habitat type were then added to describe the total value provided in each of the nine annual analysis periods for each species.

Related Documents. Details concerning selection of evaluation species, development of species models, procedures used to conduct HEP analyses, and results of the HEP analysis for the earlier version of the DW project were presented in the 1990 draft EIR/EIS for the DW project and in the following documents:

draft HEP report for the DW project (JSA 1991),

appendices to the draft HEP report for the DW project (JSA 1991), and

draft HEP report for the revised DW project (JSA 1993a).

HMP Development

HMP Objectives. SWRCB staff redesignated the HEP team as the HMP team in November 1993 and instructed the team to develop an HMP for Bouldin Island and Holland Tract that would compensate for project impacts.

The HMP team's primary objective was to design the habitat islands to:

compensate for the loss of foraging habitat on the reservoir islands for Swainson's hawk and greater sandhill crane, which are protected under California Endangered Species Act (see Appendix H4, "California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane");

compensate for foraging habitat for wintering waterfowl; and

mitigate project impacts on jurisdictional waters of the United States, pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899.

The HMP team's secondary planning objectives included creating habitats for upland wildlife species; enhancing habitat for waterfowl breeding, greater sandhill crane roosting, and Swainson's hawk nesting; and providing habitat for other special-status species. Results of the 1990 HEP analysis of preproject conditions were used by the HMP team as a guide to ensure that the HMP team's habitat designs and habitat management guidelines for the habitat islands would compensate for project impacts on wintering waterfowl habitat.

Use of HEP Results. The HMP team assumed that compensation could be achieved for project impacts on wintering waterfowl if white-fronted goose habitat values present under preproject conditions during December (the period of greatest impact) were replaced on the habitat islands. The HEP analysis indicated that between 3,380 and 4,411 HUs for white-fronted goose would need to be replaced on the habitat islands to compensate for project impacts. (Reservoir islands would also provide limited wintering waterfowl foraging habitat; because future habitat conditions on the reservoir islands are unpredictable, however, the HMP team assumed that the reservoir islands would provide no wildlife values that would offset project impacts.)

The HMP team established HSI values for each of the proposed compensation habitats for December. The team designed the HMP for the habitat islands based on these values, as well as other factors to incorporate best management practices for overall wildlife habitat benefits. Following each of several design iterations, a modified HEP analysis was conducted to determine whether compensation was achieved in the overall HMP for the habitat islands. The team's final design provides 4,611 HUs for white-fronted goose during the December analysis period and exceeds the compensation requirement objective for waterfowl. The HMP also meets the other two compensation objectives described above for species protected under the California Endangered Species Act and for jurisdictional wetlands. The plan also represents consensus between SWRCB and DFG regarding adequate mitigation for impacts of reservoir island water storage operations.

Criteria for Determining Impact Significance

SWRCB and the Corps determined that for this analysis an alternative would be considered to have a significant adverse impact on wildlife if it would:

substantially decrease the acreage of herbaceous upland habitats in the Delta region,

decrease the acreage of wetland and riparian habitats on the DW project islands,

decrease forage quality or quantity available to wintering waterfowl on the DW project islands,

substantially disrupt wildlife use patterns in the Delta,

increase the potential for outbreaks of wildlife diseases, or

result in permanent loss of occupied special-status species habitat or direct mortality of special-status species.

An alternative would be considered to have a beneficial impact if it would result in a substantial increase in the quantity or quality of herbaceous upland, wetland, riparian woodland and scrub, wintering waterfowl, or special-status species habitat.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Changes in Wildlife Habitat Conditions and Use

Bacon Island and Webb Tract

Habitat Condition Classes. Five types of habitat conditions are predicted to occur on reservoir islands under the proposed project: full storage, partial storage, shallow storage, nonstorage, and shallow-water wetlands (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands"). The definitions of these habitat conditions are applicable only to the analysis of project impacts on wildlife and vegetation resources. For this analysis, it was assumed that during periods when water was available for storage, water would be simultaneously diverted onto Bacon Island and Webb Tract as a "worst-case" operating scenario. This operating scenario would have the greatest impact on wildlife habitat. DW may, however, sequentially fill reservoir islands. If reservoir islands were sequentially filled, wildlife impacts would be lessened.

The frequency of full-, partial-, and shallow-water-storage periods would increase and the frequency of nonstorage and shallow-water wetland periods would decrease, however, if DW reservoir islands were used for storage of water for transfer or for water banking (see Chapter 2, "Delta Wetlands Project Alternatives"). Although the frequency and magnitude of such activities is uncertain at this time and these activities would require separate authorization, implementation of the HMP would fully compensate for wildlife impacts associated with the operation of the DW project for water transfer or banking.

Tables 3H-2 and 3H-3 present the monthly frequency with which each of the five conditions would be expected to occur on the reservoir islands.

Following are descriptions of the five habitat conditions on the reservoir islands:

Full-storage conditions would completely inundate all portions of reservoir islands except riprapped levee slopes.

Partial-storage conditions would provide shallow to deep water storage pools and exposed island bottoms and riprapped levee slopes above the storage elevation.

Shallow-storage conditions would provide shallow-water habitats similar to shallow-water wetland habitats (see below) except that waterfowl forage availability would be lower.

Nonstorage conditions would occur during periods when no water is stored and water is not used to create shallow-water wetlands.

Shallow-water wetland conditions would occur during periods when no storage occurs and water is diverted onto the reservoir islands to flood vegetation and attract waterfowl and other wetland-associated wildlife. Shallow-water wetlands would be created at DW's discretion. For this analysis, however, it was assumed that DW would create shallow-water wetlands in every year in which no water has been stored for 60 or more consecutive days during the growing season (May through October).

Because water may be stored during any period of the year, populations of less mobile wildlife species, such as some small mammals and reptiles, would be greatly reduced or possibly extirpated from reservoir islands under the DW project alternatives. Consequently, reservoir islands are presumed to provide low-quality foraging habitat for raptors that prey primarily on small mammals.

Full-Storage Conditions. Reservoir islands under full-storage conditions would provide foraging habitat for piscivorous birds, such as pelicans, cormorants, and grebes. The reservoirs would provide low-quality swan, goose, and duck foraging habitat for all species except diving ducks. The reservoir water surface, however, would provide suitable dabbling duck resting habitat. Little or no habitat would be available for use by terrestrial wildlife species.

Full-storage periods that follow shallow-water wetland periods on reservoir islands would provide diving duck foraging habitat. Diving ducks would feed on abundant submerged vegetation at the seasonal pool edges and other areas 3-8 feet deep and on invertebrates that would be attracted by the presence of vegetation. This conclusion is suggested by waterfowl survey data from the demonstration wetland on Holland Tract, which contained several hundred diving ducks, including canvasbacks, ruddy ducks, and lesser scaup, following flooding to a 4-foot depth in January-March 1989 (see Appendix H2, "Wildlife Inventory Methods and Results"). The creation of deep-water habitat favorable to diving ducks would provide conditions similar to the habitat that historically supported large diving duck populations in the Delta. Few diving ducks are expected to nest on reservoir islands.

Partial-Storage Conditions. The greatest range of habitat conditions would exist during partial-storage periods because water depths of the reservoirs under partial-storage conditions may range from a few inches to over 10 feet and portions of island bottoms would be exposed. Portions of reservoirs over 3 feet deep would provide wildlife habitat conditions similar to those described for full storage and shallower areas would provide values similar to, but of poorer quality than, those of shallow-water wetlands (described below).

The rate at which watergrass, smartweed, and other important waterfowl food plants would become reestablished on reservoir islands following complete or partial drawdowns of stored water during the growing season is unknown. Reduction in vegetation density would be expected on the reservoir islands during nonstorage and partial-storage periods as a result of gradual loss of seeds and other plant propagules caused by deterioration associated with inundation, export from the islands during water releases, and periodic disruption of seed production with storage events during the growing season. At DW's discretion, however, reservoir islands may periodically be seeded with watergrass and other waterfowl food plants during spring and summer nonstorage periods to enhance the value of shallow-water wetlands. Partial-storage periods that follow shallow-water wetland periods in which wetlands were seeded, therefore, would be expected to be more productive than in years when reservoir islands are not seeded.

Portions of reservoirs less than 3 feet deep would be suitable for use by foraging swans, geese, and dabbling ducks. The quantity of waterfowl forage that would be available, however, is unpredictable. During partial-storage periods, areas that are exposed following drawdown of water from November through April would remain largely unvegetated.

Saturated and unvegetated portions of exposed reservoir island bottoms would provide suitable foraging habitat for migrant and wintering shorebirds. Herbaceous habitat that may develop above storage pool elevations would be invaded by wildlife species present in the adjacent levee habitats. Populations of species such as voles, gophers, pheasants, grassland songbirds, and raptors would make increased use of the uninundated areas. Populations in these areas, however, would remain below the available carrying capacity because source populations would be low.

Reservoir islands under partial-storage conditions would provide more shallow-water habitats during the nesting seasons for shorebirds and ducks. Because of its irregular availability, this newly available habitat would be discovered and colonized only by small numbers of breeding water birds.

Mudflats and shallow-water areas created during reservoir drawdown periods would be expected to provide foraging areas for red-winged blackbirds and Brewer's blackbirds, and possibly for tricolored blackbirds.

Shallow-Storage Conditions. Shallow-storage conditions would occur when water volumes equal to or less than those used to create shallow-water wetlands are stored on the reservoir islands. Habitat conditions would be similar to those described for shallow-water wetlands (see below) except that the availability of wildlife forage would be lower during storage periods that were not preceded by 60 days of nonstorage.

Nonstorage Conditions. During nonstorage periods that occur after the growing season and follow full-storage and partial-storage events, exposed reservoir island bottoms would remain largely unvegetated. Exposed areas with saturated soils would provide suitable habitat for migrant and wintering shorebirds and blackbirds.

During nonstorage periods in the growing season, herbaceous habitats that would become established on reservoir islands would provide wildlife values similar to those described for partial-storage conditions.

Permanent open-water habitat would be created in reservoir island borrow areas and in the drainage circulation network with implementation of the DW project as a result of seepage. Water depths would range from 2 feet to 4 feet but these areas would probably not be able to support emergent vegetation because of previous storage events on the reservoir islands. Wildlife values associated with borrow areas and the drainage network would be similar to those described for partial storage. These open-water areas would also provide brood habitat for ducks and other water bird species; however, the habitat would be of low quality because it would lack emergent vegetation.

Shallow-Water Wetland Conditions. Approximately 3,700 acres on Bacon Island and 3,850 acres on Webb Tract may be managed as shallow-water wetlands during years when 60 or more consecutive days of nonstorage conditions have occurred during the growing season immediately before any date between September 15 and November 30. This analysis assumes that DW would use its existing riparian water rights, which are available after September 15, to create shallow-water wetlands (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands"). Approximately 60 days of nonstorage during the growing season would be required for watergrass and other waterfowl food plants to develop seed.

DW would construct an inner levee system on the reservoir islands to create wetland cells through which water would be circulated to maintain water quality, which will reduce the likelihood of botulism outbreaks and allow reservoir islands to be rapidly drained to eliminate wetland habitat in the event of an outbreak of botulism, avian cholera, or other water bird disease. The inner levee system and associated water control structures will be designed and managed to allow at least 65% of the reservoir island acreage to be flooded to create shallow-water wetlands. At least 50% of the flooded area would be maintained at an average water depth of 12 inches. In years during which no storage occurs, reservoir islands would be managed as wetlands through winter and would be drawn down by May. In suitable years in which DW does not create shallow-water wetlands, reservoir island conditions would be as described for nonstorage conditions.

Under shallow-water wetland conditions, wildlife values associated with open-water habitats in borrow areas and the drainage circulation network would be as described for nonstorage conditions.

Shallow-water wetlands could be created and managed on the reservoir islands to specifically provide waterfowl foraging habitat. At DW's discretion, shallow-water wetlands would be seeded with waterfowl forage plants. Seeded wetlands would be dominated by watergrass, smartweed, and other wetland waterfowl food plants following seeding of these plants by DW. If reservoir islands are not seeded, herbaceous vegetation would be relatively sparse compared with the vegetation that would be established in dense stands in wetlands following seeding of the islands. Consequently, wildlife values provided by wetlands would be expected to be substantially lower than in years when wetlands are seeded. Dominant plant species in years wetlands were not seeded would be species with seeds that are imported onto the islands in diverted water or species with seeds that are windborne onto the islands. The numbers of swans, geese, and dabbling ducks that would forage in shallow-water wetlands and the period forage would be available would be substantially greater in years when wetlands are seeded than in years when plants become reestablished naturally.

In years during which no storage occurs, areas of herbaceous vegetation not flooded to create shallow-water wetlands would provide nesting habitat for waterfowl; ground-nesting raptors, such as northern harriers and short-eared owls; ring-necked pheasants; and other upland nesting species.

Shallow-water wetlands would provide foraging habitat for wading birds. Herons and egrets would be attracted to feed on larger invertebrates associated with shallow-flooded wetlands. Gulls and terns would also use wetlands to forage on invertebrates. Some shorebird foraging habitat would be provided in shallow-flooded areas (less than 6 inches deep) that were unvegetated or sparsely vegetated. Blackbirds would use shallow marsh areas and herbaceous upland areas for feeding. Swallow nesting sites (e.g., buildings, cement wall overhangs) on reservoir islands are limited. Nesting sites would increase with the construction of pump and siphon stations and recreation facilities, so breeding swallow populations are expected to increase. Migratory swallow populations that use the reservoir islands would be expected to increase in response to increases in flying insects hatched from shallow water bodies and dense vegetation.

Use by General Wildlife Species. Habitat conditions and populations of wildlife species on the reservoir islands under Alternative 1 would differ substantially from those currently present. Use by species groups would depend on season and habitat conditions (i.e., full storage, partial storage, shallow storage, nonstorage, and shallow-water wetland).

Piscivorous Birds. Overall use of the reservoir islands by piscivorous birds (e.g., grebes, cormorants, and pelicans) would increase substantially from the existing low use level. These species would feed in the borrow areas during shallow-storage, nonstorage, and shallow-water wetland periods and in the reservoirs during full-storage and partial-storage periods. Little or no nesting of most of these species would occur on the reservoir islands.

During periods in which the reservoirs are being drawn down, white pelicans and double-crested cormorants would be expected to forage on concentrations of mosquitofish and bullfrog larvae; similar foraging behavior was observed at Dead Horse Island during drawdown of wetlands in July 1988 (JSA 1990).

Wading Birds. Numbers of wading birds would be expected to increase during certain periods. Herons and egrets would be attracted to feed on larger invertebrates in shallow-flooded areas during periods when the reservoir islands are managed as shallow-water wetlands. Although waterfowl hunting would discourage use somewhat, wading birds would become accustomed to hunting activity and would continue to use the area, especially on nonhunt days. During partial-storage periods, suitable habitat would be limited to reservoir margins. Use during the full- and partial-storage periods on the reservoir islands would be substantially lower than under existing conditions.

During nonstorage periods, wading bird use would decrease as the amount of shallow water declined. Nonetheless, substantial numbers of wading birds would forage along the margins of the borrow ponds and interior ditches, where resident fish populations would be concentrated. During this period, the margins of borrow ponds and ditches on the reservoir islands under Alternative 1 would provide a substantially greater amount of habitat than the margins of ditches and sloughs that currently exist on the islands (see Chapter 3G, "Vegetation and Wetlands").

Operations of Alternative 1 would reduce use of the reservoir islands by wading birds below preproject conditions during full-storage and deep-water, partial-storage periods and would be expected to increase use levels during nonstorage, shallow-water wetland, and shallow-storage periods.

Raptors. Raptor use of the reservoir islands would decrease because of habitat changes caused by water storage operations. Most raptors are found on the islands in winter, when they forage for rodents and large insects in fallow grassland and agricultural habitats. Winter flooding of the islands would force most wintering raptors to move elsewhere. Although most migratory raptors are adapted to moving in winter to locate adequate prey populations, it is uncertain whether displacement during winter would increase raptor mortality (Newton 1979).

Raptors would be expected to use unflooded areas on the reservoir islands to a limited extent during some partial-storage, shallow-storage, nonstorage, and shallow-water wetland periods. Rodent populations would be minimal because they would be largely eliminated during full-storage periods.

Shorebirds. Small numbers of shorebirds would use shallowly flooded areas on reservoir islands during spring and fall migration and in winter. Shallowly flooded areas (less than 6 inches deep) with little vegetation cover that may be present under some partial-storage, shallow-storage, nonstorage, and shallow-water wetland periods would be used by shorebirds. No shorebird habitat would exist on the reservoir islands during full-storage periods.

During and following drawdown of stored water, exposure of mudflats could attract thousands of migrant shorebirds; similar wetland drawdown areas on the 180-acre Dead Horse Island were used by hundreds of dowitchers and other shorebirds that fed on worms and other invertebrates in 1988 (JSA 1990). Shorebird habitat areas would decline over time as vegetation became reestablished on island bottoms.

Gulls and Terns. During partial-storage, shallow-storage, and shallow-water wetland periods, gull feeding use of the reservoir islands would probably decline somewhat because of the loss of agricultural waste grain, but this loss would be partially offset by the increased availability of invertebrates in shallowly flooded areas. Gulls currently use agricultural lands for resting and would probably use seasonal pool bottoms similarly. Under full-storage conditions, food availability would decline for gulls; resting use would probably continue on the reservoir islands on calm days or in areas protected from wind.

During discharge periods, gulls would find abundant invertebrate food in the drawdown areas and populations would be expected to increase. After drawdown is completed, overall use would be expected to be higher.

Terns were not recorded on Bacon Island but their numbers there could increase substantially. Caspian terns could breed on islands exposed during partial-storage or drawdown periods; island survey results indicated that they were attracted in spring to the demonstration wetland on Holland Tract (see Chapter 3G, "Vegetation and Wetlands" for a description of the demonstration wetlands). However, in some years, nests would be destroyed as a result of subsequent diversions of water onto the reservoir islands during the breeding season.

Blackbirds and Starlings. During periods in which reservoir islands are managed as shallow-water wetlands and possibly during some shallow-storage periods, blackbird numbers could increase if agricultural foods were replaced by more abundant foods in shallow marsh areas. Red-winged, Brewer's, and possibly tricolored blackbirds would use shallow marsh and upland areas for feeding. Little blackbird habitat would be available during full-storage periods. Many blackbirds would be attracted to mudflats and shallow-water areas during drawdowns and during nonstorage periods in the growing season, when insect populations would be substantial.

Populations of the introduced European starling, a species that is more closely associated with agricultural lands than blackbirds, are expected to decline because of the loss of agricultural foods. The starling decline would be beneficial to native wildlife because it would reduce competition with native cavity-nesting birds (Remsen 1978, Weitzel 1988).

Riparian and Marsh Birds. Existing riparian woodland and scrub and freshwater marsh habitat on reservoir islands would be eliminated by project construction and inundation under project operations. Riparian shrubs and trees would not be expected to colonize interior levee slopes because interior levee slopes will be riprapped.

Grassland and Agricultural Birds. All species in the grassland and agricultural bird group are regionally common. Few bird species currently breed in grassland and agricultural habitats on the reservoir islands. In addition to western meadowlarks, blackbirds, starlings, pheasants, and waterfowl, several species that use grassland and agricultural lands during migration and in winter, including horned lark, American crow, yellow-billed magpie, and water pipit, would use these lands less because of habitat loss resulting from operation of the reservoir islands for water storage.

During some shallow-storage periods and when reservoir islands are managed as shallow-water wetlands, use by migratory species would be expected to increase in years when wetland plants are abundant; savannah sparrows, for example, were abundant in watergrass and smartweed stands during surveys of the Holland Tract demonstration wetland.

Use by Waterfowl. Habitat conditions under Alternative 1 would substantially alter waterfowl populations and seasonal use patterns on reservoir islands. Waterfowl habitat impacts would result from replacement of existing crops and fallow areas by shallow to deeply flooded habitats and shallow-water wetlands. Habitat impacts are described generally in Chapter 3G, "Vegetation and Wetlands".

Approximately 7,530 acres of waterfowl foraging habitat would be created during some shallow-storage periods and periods in which reservoir islands are managed as shallow-water wetlands (JSA 1993a). Waterfowl forage values provided by shallow-water wetlands would diminish substantially following 1 or more years of project operation as a result of seed losses caused by seed deterioration during inundation, seed export from islands during releases, and inundation during the growing season. If DW chooses to periodically seed reservoir islands with watergrass, smartweed, and other important waterfowl food plants during nonstorage periods, overall habitat quality of shallow-water wetlands would be moderate to high for different waterfowl species.

Habitat quality on reservoir islands would decrease substantially for all waterfowl species, except diving ducks, during water storage periods.

Swans. Swans would use the reservoir islands during shallow-water wetland management and some shallow-storage periods to feed on seeds and tubers from marsh plants, although overall foraging habitat value would be less than that of harvested grain fields. Hunting would disturb birds to some extent, but if DW chooses to limit the number of hunting days per week, it would ensure that swans would regularly return to feed in shallow marshland areas. Feeding habitat conditions for swans on the island would decline substantially during storage periods.

Geese. White-fronted geese are expected to use the reservoir islands during some shallow-storage periods and when the islands are managed as shallow-water wetlands, although use there would be lower than in harvested grain fields. Snow geese, in contrast, are more dependent on waste grain (Bellrose 1976) and are expected to make less use of the shallow marsh areas available during shallow-water wetland periods. Canada geese would also not be expected to make extensive use of shallow-water wetlands on the reservoir islands.

Deep flooding during full- and some partial-storage periods would greatly reduce use of the reservoir islands for feeding by geese. The reservoir shorelines under partial-storage conditions would provide a small amount of foraging habitat during this period.

Dabbling Ducks. During some shallow-storage and shallow-water wetland management periods, dabbling duck use of the reservoir islands would increase. The extent of use would depend on the availability of forage. The presence of shallow-water habitat for dabbling ducks in early fall would provide benefits to duck populations because such habitats are often limited in the Central Valley at this time, particularly in dry years (JSA 1993b).

Certain dabbling ducks, including mallards, cinnamon teal, and lesser numbers of gadwalls, would nest in vegetation adjacent to flooded areas during partial-storage, shallow-storage, and shallow-water wetland periods. However, in some years, nests would be destroyed as a result of subsequent diversions of water onto reservoir islands during the nesting season.

Hunting would affect dabbling duck use and distribution on the reservoir islands during the hunting season. If DW chooses to limit the number of days reservoir islands are hunted per week, however, substantial waterfowl use would be maintained on the islands.

Shallow-water habitat at the edges of the reservoirs during partial-storage periods would support moderate numbers of dabbling ducks, as suggested by waterfowl use observed at the Holland Tract demonstration wetland.

During full-storage periods, dabbling duck foraging habitat quality would be substantially reduced; however, dabbling ducks would make extensive use of the reservoir water surfaces for resting. On windy days, such use would be restricted to the windward sides of the islands, which would be protected by levees.

Diving Ducks. Diving ducks currently make little use of the reservoir islands because little suitable habitat exists. Diving species, including scaup, ring-necked duck, ruddy duck, redhead, and canvasback, would be expected to use permanently inundated borrow areas during shallow-storage, nonstorage, and shallow-wetland periods and would use the intermediate-depth portions of the reservoirs during full- and partial-storage periods.

Coots. Coot populations would be expected to increase substantially on the reservoir islands during shallow-water wetland, shallow-storage, and partial-storage periods. Large numbers of coots would be attracted to shallowly flooded areas. An average of 200 birds per day were seen during surveys of the Holland Tract demonstration wetland following deep flooding (see Appendix H2, "Wildlife Inventory Methods and Results"). Coots would also be expected to graze extensively on newly sprouted plants adjacent to reservoir shorelines during the growing season.

Use by Upland Game. The breeding population of ring-necked pheasants on the reservoir islands would decline substantially as a result of periodic inundation of the reservoir islands. At DW's discretion, the reservoir islands may be seeded with watergrass and other waterfowl food plants during nonstorage periods that occur in the growing season. Watergrass seed is an important pheasant food in California (Mallette n.d.); thus, pheasants from surrounding islands may be attracted to feed on watergrass seed during nonstorage and shallow-water wetland periods. The availability of pheasant forage would be expected to be substantially less if islands are not seeded (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands"). The area would be especially attractive to pheasants during fall, when crop harvest would reduce cover on nearby islands. The number of pheasants attracted to the islands in fall would be lower than the number in the current population.

Quail populations on the reservoir islands would decline, and the species may become extirpated from the reservoir islands. Mourning dove populations would be expected to increase during nonstorage and seasonal wetland periods during years in which abundant weed seeds were available.

Use by Special-Status Species

Valley Elderberry Longhorn Beetle. VELB was not found to occur on the reservoir islands; therefore, no impact on this species would occur under any of the operational conditions (see Appendix H3, "Federal Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Wildlife Species").

Giant Garter Snake. Habitat on the reservoir islands is considered marginal for the giant garter snake, and no snakes were observed during ground surveys. Implementation of Alternative 1 would result in creation of variable habitat conditions for the giant garter snake (see Appendix H3). Shallow flooding during partial-storage, shallow-storage, and shallow-water wetland periods would provide low-quality habitat, but very little suitable habitat would be available following deep flooding during some partial- and full-storage periods. The borrow area network could provide suitable habitat during nonstorage, shallow-storage, and shallow-water wetland periods.

Aleutian Canada Goose. Aleutian Canada geese are transitory and are found only in small numbers in the Delta. The last reported observation of Aleutian Canada geese using DW project islands is from 1983, when a small flock was observed on Bouldin Island (Appendix H3). The overall availability of foraging habitat would decline with the loss of corn and other crops of high forage value with implementation of Alternative 1. During shallow-water wetland periods, reservoir islands would provide moderate-quality foraging habitat; however, little suitable foraging habitat would be available during storage and nonstorage periods.

Bald Eagle. Bald eagles do not occur regularly in the Delta and none were observed on DW project islands during surveys. The reservoir islands currently support low-quality bald eagle foraging habitat. During shallow-water wetland periods, reservoir islands would provide moderate foraging habitat when ducks (especially birds injured by hunters) would be common and resident fish would be concentrated in borrow ponds and shallow areas. During storage periods, reservoir islands would provide low-quality foraging habitat along reservoir shorelines, where diving ducks and resting coots would typically congregate (Appendix H3).

Northern Harrier. No suitable nesting habitat for northern harriers currently exists on Bacon Island. Webb Tract currently supports approximately 1,100 acres of moderate-quality nesting habitat and harriers may breed on the island. Moderate-quality habitat consisting of untilled cropland currently exists for winter foraging. Bacon Island and Webb Tract had less than 2% of the Delta-wide total of untilled agricultural land in December 1987. During nonstorage, shallow-storage and shallow-water wetland periods, Alternative 1 operations would create suitable foraging habitat, but potential prey populations for harriers would be low because of previous water storage events. Harriers are wide ranging and, during storage periods, would move to other areas to forage.

Swainson's Hawk. Swainson's hawks are not known to nest on the reservoir islands. Agricultural, fallow, and herbaceous upland habitats present on the islands provide low- to moderate-quality foraging habitat (Appendix H4, "California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane"). Under implementation of Alternative 1, inundated portions of reservoir islands during full-storage, partial-storage, and shallow-water wetland conditions would be unsuitable as Swainson's hawk foraging habitat. Under all project conditions, unflooded areas would provide low-quality foraging habitat as a result of rodent populations would be substantially reduced because of inundation.

Peregrine Falcon. Peregrine falcons do not occur regularly in the Delta and none were observed on the DW project islands during surveys. The reservoir islands currently support low- to moderate-quality foraging habitat for peregrine falcons during winter (Appendix H3, "Federal Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Wildlife Species"). During shallow-water wetland and some partial-storage periods, reservoir islands would attract ducks, shorebirds, and blackbirds, all of which would be potential prey for peregrine falcons. Deep flooding would attract diving ducks and thus provide low- to moderate-quality foraging habitat.

California Black Rail. No suitable black rail habitat currently exists on the reservoir islands, and none would be created. Potentially occupied habitat, however, exists on small islands supporting marsh vegetation located in Delta channels adjacent to the reservoir islands. Black rails that may nest on these islands, therefore, could potentially be affected by construction activities (e.g., levee refurbishment and siphon construction) on the water side of reservoir islands. However, no impacts on this species would occur on the reservoir island interiors under any of the operational conditions.

Greater Sandhill Crane. Greater sandhill cranes do not currently make regular use of Bacon Island or Webb Tract. However, existing corn and wheat fields provide suitable foraging habitat for this species (Appendix H4, "California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane"). Shallow flooding associated with wetland and some partial-storage periods would provide suitable foraging and resting areas on the reservoir islands. The reservoir islands would be unsuitable for greater sandhill cranes during full-storage periods.

Burrowing Owl. Reservoir islands currently support marginal foraging and breeding burrowing owl habitat. Implementation of Alternative 1 would result in the creation of low-quality or unsuitable habitat for burrowing owls on the reservoir islands year round on the island bottoms.

Tricolored Blackbird. The reservoir islands currently provide suitable foraging habitat and low-quality breeding habitat for tricolored blackbirds. Implementation of Alternative 1 would provide low-quality tricolored blackbird habitat during shallow-water wetland and shallow-storage periods and some and partial-storage periods. Reservoir islands would be unsuitable for tricolored blackbirds during full-storage periods.

Bouldin Island and Holland Tract

HMP Implementation. Habitat islands would be managed primarily to offset impacts on wildlife associated with operation of the reservoir islands under

Alternative 1. Implementation of the HMP and mitigation measures would fully offset impacts on wildlife associated with operation of the reservoir islands and would also provide benefits to wildlife that are not required to compensate for project impacts, including development of waterfowl nesting habitat and greater sandhill crane roosting habitat. As previously stated, operation of the reservoir islands for habitat values is not required to compensate for project impacts.

The primary goals of the HMP are to describe habitat island habitats and management requirements necessary to offset impacts of reservoir island operations on state-listed threatened species (i.e., impacts on Swainson's hawk and greater sandhill crane foraging habitat), wintering waterfowl foraging habitat, and jurisdictional wetlands pursuant to Section 404 of the Clean Water Act. Major elements of the HMP include:

- creation of approximately 9,000 acres of agricultural and nonagricultural habitats for species that would be affected by the project,
- creation of Section 404 jurisdictional riparian woodland and scrub and wetland habitats,
- implementation of special habitat management practices that would increase wildlife habitat values beyond those typically associated with created habitats (e.g., specified flooding schedules for seasonal wetlands),
- regulation of hunting and other recreational activities to reduce the effects of human disturbance of wildlife,
- establishment of a closed hunting zone on Bouldin Island to provide greater sandhill crane foraging areas free from hunter disturbance,
- establishment of two additional closed hunting zones (one on each island) to provide waterfowl foraging and resting areas free from hunter disturbance, and
- establishment of a habitat island management oversight committee empowered to consult with DW and DFG to review monitoring data and develop recommendations for changes in habitat island management in future years as long as the primary goals of the HMP are not compromised.

Table 3H-4 summarizes the habitat-type acreages that would be created on the habitat islands under Alternative 1. Fields of corn rotated with wheat, mixed agriculture/seasonal wetlands, seasonal managed wetlands, and pasture/hay fields would be managed during fall and winter specifically to provide high-quality swan, goose, and duck foraging habitat. Seasonal ponds, some seasonal managed wetland, and small grain fields would be managed specifically to provide high-quality duck nesting and brood habitat.

Agricultural lands, seasonal wetland habitats, and herbaceous uplands would be managed during spring, summer, and fall to provide suitable Swainson's hawk habitat.

Habitats managed specifically to provide winter waterfowl foraging habitat and herbaceous uplands would also provide high-quality greater sandhill crane foraging habitat during winter. A portion of seasonal managed wetlands and cornfields on Bouldin Island would be managed specifically to provide crane roosting habitat and high-quality foraging habitat, respectively.

Riparian woodland and scrub habitats established to offset impacts on jurisdictional wetlands under Section 404 of the Clean Water Act (see Chapter 3G, "Vegetation and Wetlands") would provide habitat for a wide diversity of wildlife associated with riparian vegetation, including cavity-nesting species.

To offset the impact of hunting disturbance on foraging waterfowl and greater sandhill cranes, three closed hunting zones, totaling approximately 2,000 acres, would be established on the habitat islands.

Airstrip and Aircraft Restrictions. The Bouldin Island airstrip is located in the easternmost closed hunting zone on the island. Restrictions have been placed on use of the airstrip and aircraft on the habitat islands from September 1 through March 31 to reduce disturbance from airstrip and aircraft operations on waterfowl and greater sandhill cranes using closed hunting zones and other portions of the island. (Airstrip and aircraft use restrictions are detailed in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".) Restrictions include limiting use of the airstrip and island overflights for farming and habitat management operations during the waterfowl hunting season to nonhunt days to prevent disturbance in closed hunting zones during periods of hunter disturbance.

Use of the airstrip and aircraft overflights of the islands for recreational and other uses is also restricted from September 1 through March 31. Restrictions include limiting use of the airstrip to 100 landings and takeoffs during the waterfowl season. Use of the airstrip for landings and takeoffs of fixed-winged aircraft, however, is permitted during hunt days. Consequently, waterfowl, greater sandhill cranes, and other wildlife using Bouldin Island on hunt days could be periodically disturbed by aircraft during periods of hunter disturbance.

Use by General Wildlife Species. Habitat availability and quality would be increased for most wildlife species groups on the habitat islands with implementation of Alternative 1. Table 3H-5 describes habitat island habitats that would be used by the major wildlife species groups on the islands. Details of general wildlife habitat management objectives, habitat descriptions, and habitat management prescriptions for habitat islands are presented in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

The acreages of riparian woodland and scrub, emergent marsh, and seasonal managed wetland habitats would increase substantially with project implementation. Creation of additional acreage of riparian and wetland habitats would primarily benefit piscivorous birds, wading birds, shorebirds, gulls and terns, and riparian and marsh birds.

Acreages of habitats used by upland and agricultural species would decrease with proposed project implementation. Implementation of management prescriptions for these habitats, however, would increase habitat quality above that associated with existing conditions.

Use by Waterfowl. A total of 8,220 acres of suitable agricultural, wetland, and upland waterfowl habitats will be created on the habitat islands (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", and Table 3H-4). Fields of corn rotated with wheat, mixed agriculture/seasonal wetland, seasonal managed wetland, and pasture/hay habitats will be managed specifically to provide high-quality waterfowl foraging habitat. Permanent lakes will provide large bodies of open water for use by waterfowl for resting.

Mixed agriculture/seasonal wetland, seasonal managed wetland, seasonal pond, emergent wetland, permanent lake, and herbaceous upland habitats will provide suitable nesting habitat for mallards, cinnamon teal, and other dabbling ducks. Seasonal pond habitats would be managed specifically to provide high-quality duck brood water. To encourage Canada goose and wood duck nesting, approximately 800 nesting platforms and boxes will also be constructed.

Levels of waterfowl hunting permitted on the habitat islands will be moderate relative to hunting levels on private duck clubs and state and federal waterfowl refuges (see Chapter 3J, "Recreation and Visual Resources"). To ensure wintering waterfowl use during the hunting season, three closed hunting zones have been established (two on Bouldin Island and one on Holland Tract). Approximately 22% of habitat island waterfowl habitats, including both permanent lakes on Bouldin Island, are within the closed hunting zones. Typically, between 15% and 50% of state and federal waterfowl refuges in the Central Valley are designated as closed hunting zones. To reduce human disturbances to waterfowl using closed hunting zones, only spaced-blind hunting, which restricts hunter movement, would be allowed in nearly all areas adjacent to closed hunting zones; free-roam hunting would be allowed on a small area adjacent to the northeast corner of the Holland Tract closed zone.

Use by Upland Game. Approximately 7,926 acres of corn, wheat, small grain, mixed agriculture/seasonal wetland, seasonal managed wetland, pasture/hay, riparian woodland and scrub, and herbaceous upland habitats on the habitat islands will provide foraging and nesting habitat and escape cover for ring-necked pheasants, mourning doves, and quail (Table 3H-4). During fall and winter, up to 3,688 acres of corn, wheat, mixed agriculture/ seasonal wetland, seasonal managed wetland, and pasture/hay habitats would be unsuitable upland game habitat as a result of shallow flooding to attract waterfowl.

Use by Special-Status Species

Swainson's Hawk. A total of 7,539 acres of suitable spring, summer, and fall foraging habitat for Swainson's hawks of poor, fair, and good quality will be developed on the habitat islands (see Appendix G3, "Habitat Management Plan for the Delta Wetlands

Habitat Islands"). Suitable Swainson's hawk foraging habitat will include cornfields, wheat fields, and small grain fields, mixed agriculture/ seasonal wetlands, seasonal managed wetlands, pasture/hay fields, and herbaceous uplands. Portions of nonagricultural habitats would also be mowed to enhance foraging habitat quality.

Approximately 390 acres of existing and created riparian woodland and scrub habitats would provide suitable Swainson's hawk nesting habitat (see Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation").

Greater Sandhill Crane. A total of 7,673 acres of suitable winter foraging habitat for greater sandhill crane of poor, fair, and good quality would be developed on the habitat islands. Suitable habitat would include corn, wheat, and small grain fields; mixed agriculture/seasonal wetlands; seasonal managed wetlands; seasonal ponds; pasture/hay fields; and herbaceous uplands (see Appendix G5).

Three closed hunting zones, totaling 2,008 acres, to be established on the habitat islands (two on Bouldin Island and one on Holland Tract), would provide greater sandhill crane foraging areas free from hunter disturbance during hunt days. A portion of seasonal managed wetlands in one Bouldin Island closed hunting zone would be managed specifically to provide crane roosting habitat. A portion of cornfields near wetlands managed as roosts would be harvested in a manner that would provide optimum crane foraging habitat (see Appendix G3 for a description of the purposes for closed hunting zones on the habitat islands).

Other Special-Status Species. Twenty-two other special-status species occur or could occur on the habitat islands under Alternative 1. Table 3H-6 summarizes habitat island habitats that could be used by these species with implementation of the DW project HMP.

Summary of Project Impacts and Recommended Mitigation Measures

Table 3H-7 summarizes changes in habitat types and acreages from existing conditions to conditions that would occur under Alternative 1.

Impact H-1: Loss of Upland Habitats. Loss of herbaceous upland, exotic marsh, and agricultural habitats on the reservoir islands would reduce the acreage of habitat for western meadowlarks, white-crowned sparrows, and other regionally abundant song birds. Existing upland and agricultural habitats that also provide low to moderate forage value for several breeding and wintering raptor species would also be reduced. As part of the proposed project, implementation of the HMP detailed in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", would offset impacts of reservoir island water storage operations under Alternative 1 by creating fewer, but higher quality, upland habitats. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-2: Increase in Suitable Wetland Habitats for Nongame Water and Wading Birds. Approximately 3,750 acres of additional wetland habitat would be created under Alternative 1 with implementation of the HMP. Seasonal wetlands, emergent marshes, and lakes that would be created on the habitat islands would provide foraging or nesting habitat, or both, for resident and migrant grebes, shorebirds, egrets, herons, gulls, terns, and other wetland-associated birds in the Delta region. During water storage periods, the reservoir islands would also provide foraging and resting habitat for grebes, gulls, terns, cormorants, and other water birds. Although not required to offset impacts, management of the reservoir islands for shallow-water wetlands would provide habitat values for shorebirds, wading birds, and water birds similar to, but of lower quality than, those described for the habitat islands. This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-3: Loss of Foraging Habitats for Wintering Waterfowl. Wintering waterfowl are dependent on agricultural crops, primarily corn and wheat, for forage in the Delta. Water storage operations on the reservoir islands would decrease the amount of agricultural crops on the reservoir islands. However, implementation of Alternative 1 would include intensive management of corn, wheat, mixed agriculture/seasonal wetland, seasonal managed wetland, and pasture/hay habitats on habitat islands specifically to provide high-quality waterfowl forage values. Small grain fields, seasonal ponds, permanent lakes, emergent marshes, and herbaceous uplands would also provide foraging areas for wintering waterfowl on the habitat islands.

Wetland waterfowl foraging habitat would also be created on the reservoir islands during years and seasons in which islands could be managed as shallow-water wetlands. How frequently and for how long islands could be managed as shallow-water wetlands, however, cannot be predicted. The quality of foraging habitat on the reservoir islands would also vary among years when shallow-water wetlands could be created, depending on the types and density of vegetation that becomes reestablished on the reservoir islands following water storage periods.

Results of the modified HEP analysis performed by the HMP team indicate that implementation of the HMP under Alternative 1 would offset impacts of project operations on low- to moderate-quality wintering waterfowl foraging habitats through creation of high-quality foraging habitats on the habitat islands. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-4: Increase in Suitable Breeding Habitats for Waterfowl. Few dabbling ducks and no geese currently successfully nest on the DW project islands. The primary factors limiting duck production are the availability of nesting habitat and availability of suitable brood water for ducklings. Implementation of the HMP under Alternative 1 would include establishment of duck nesting habitats, creation of waterfowl brood ponds, and construction of wood duck nest boxes and goose nesting platforms on the habitat islands. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-5: Loss of Habitats for Upland Game Species. Implementation of Alternative 1 would, as a result of habitat loss associated with operation of the reservoir islands, cause a substantial decline of populations of ring-necked pheasant, the most common upland game species. Implementation of the HMP would provide higher quality habitats on the habitat islands than under existing conditions. Portions of these habitats would be unavailable to pheasants during fall and winter flood periods; however, habitat suitability would be improved during the breeding season, when agricultural lands typically provide unsuitable habitat. Few pheasant hunters currently hunt on the DW project islands and the hunting program under the HMP is expected to focus on waterfowl hunting and to have less emphasis on hunting for upland game species, including pheasant. (See Chapter 3J, "Recreation and Visual Resources", for more details on hunting.)

Other upland game species (mourning dove, California quail, and desert cottontail) are currently present in low numbers and primarily occupy island levees. Upland game birds would use the reservoir islands during nonstorage, shallow-storage, and shallow-water wetland periods. Desert cottontail may become extirpated from Bacon Island (cottontails are not found on Webb Tract [Swanson pers. comm.]) because maximum storage events would completely inundate island interiors, except for riprapped portions of upper levee slopes. Mourning dove and California quail would benefit from the establishment of 154 additional acres of riparian woodland and scrub habitats on the habitat islands. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-6: Increase in Suitable Foraging Habitat for Greater Sandhill Crane. Greater sandhill cranes forage in corn and grain fields, wetlands, pastures, and herbaceous uplands. Implementation of the HMP under Alternative 1 would include replacing the acreage lost as a result of water storage operations of the reservoir islands and creating approximately 645 more acres of greater sandhill crane foraging habitat than required by DFG and the HMP team to compensate for habitat losses (see Appendix H4, "California Endangered Species Act Biological Assessment: Impacts of the Delta Wetlands Project on Swainson's Hawk and Greater Sandhill Crane"). Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-7: Increase in Suitable Roosting Habitat for Greater Sandhill Crane. Greater sandhill cranes currently do not roost on the DW project islands. Suitable roosting sites are a key habitat requirement for wintering greater sandhill cranes, and such sites are limited in the Delta (see Appendix H4). Implementation of the HMP under Alternative 1 would include creation of wetlands managed specifically to provide roosting habitat for greater sandhill cranes. The value of crane foraging habitats that would be created on the habitat islands would also be enhanced with development of roosting habitat because cranes typically forage near roosts. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-8: Increase in Suitable Foraging Habitat for Swainson's Hawk. Implementation of Alternative 1 would result in the loss of 10,048 acres of suitable foraging habitat for Swainson's hawk. DFG guidelines (DFG 1993) were used to determine compensation habitat acreage that would be required to offset project impacts on Swainson's hawk foraging habitat (see Appendix H4). Implementation of the HMP under Alternative 1 would result in replacement of the acreage lost from water storage operations of the reservoir islands and creation of approximately 831 more acres of Swainson's hawk foraging habitat than are required by DFG to compensate for habitat losses. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-9: Increase in Suitable Nesting Habitat for Swainson's Hawk. Implementation of the HMP under Alternative 1 would result in the establishment of approximately 154 additional acres of riparian woodland and scrub habitats. Mature cottonwood and willow trees would provide suitable Swainson's hawk nest sites. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-10: Loss of Foraging Habitat for Aleutian Canada Goose. Aleutian Canada geese could occur irregularly on all four DW project islands because agricultural and herbaceous habitats are suitable, but the species has been observed only on Bouldin Island and generally uses traditional areas elsewhere in the Delta. Therefore, loss of suitable habitat caused by water storage on reservoir islands would not adversely affect the species. Implementation of the HMP under Alternative 1 would offset any possible loss of Aleutian Canada goose habitat on the reservoir islands through creation of suitable habitat on the habitat islands. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-11: Increase in Suitable Nesting Habitat for Northern Harrier. Harriers were observed during the breeding season on Webb and Holland Tracts and may have nested on those islands. Breeding habitat in the past consisted of approximately 2,400 acres of fallow areas that had not been reclaimed for agriculture following past levee breaks on Webb and Holland Tracts. Although much of this habitat may have been eliminated on the two islands by renewed agricultural cultivation, it is assumed for this analysis that implementation of Alternative 1 would eliminate these 2,400 acres of habitat.

Implementation of the HMP under Alternative 1 would include establishment of 3,588 acres of seasonal managed wetlands, seasonal ponds, pasture/ hay fields, emergent marshes, and herbaceous uplands that would be suitable nesting habitat for northern harrier (Table 3H-4). Establishment of these habitats would replace the acreage lost as a result of water storage operations on the reservoir islands and provide 1,188 more acres of suitable nesting habitat for this species than under existing conditions. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-12: Loss of Wintering Habitat for Tricolored Blackbird. Tricolored blackbirds typically forage in marshes and agricultural wetlands and could occur on all four islands during winter, although none were observed during fields surveys. Wintering habitat is abundant in the Delta and Central Valley and is not considered limiting to the species (Beedy pers. comm.). Nonetheless, creation and management of mixed agriculture/seasonal wetland, seasonal managed wetland, seasonal pond, pasture/hay, emergent marsh, and permanent lake habitats on the habitat islands with implementation of the HMP under Alternative 1 would ensure that any possible impacts on wintering tricolored blackbirds would be offset. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-13: Increase in Suitable Nesting Habitat for Tricolored Blackbird. None of the four DW project islands supports nesting colonies of tricolored blackbirds. Also, none of the islands is close enough to suitable or historically used nesting areas to be used for foraging during the nesting season. Most tricolored blackbird colonies are established in tule- and cattail-dominated freshwater marshes (Beedy et al.

1991). Implementation of the HMP would include creation of approximately 175 more acres of emergent freshwater marsh than currently exist on project islands that would be suitable tricolored blackbird nesting habitat. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-14: Increase in Suitable Habitats for Special-Status Wildlife Species. Project impacts were not assessed for most special-status species that could occur on the DW project islands (Table 3H-6) because these species currently are not known to be present or are found only irregularly on the islands. Creation and management of agricultural, upland, wetland, and riparian habitats for wildlife with implementation of the HMP and operation of the reservoir islands under Alternative 1, however, would increase the quantity and quality of suitable habitat for 19 special-status species. (Project impacts on the Aleutian Canada goose, northern harrier, and tricolored blackbird, which are also listed in Table 3H-6, are described above.) Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-15: Temporary Construction Impacts on State-Listed Species. Construction activities associated with refurbishing and enlarging levees, installing project infrastructure, and grading to establish habitat island habitats could result in temporary impacts on state-listed species. Construction activities could affect nesting Swainson's hawks through disturbance or loss of occupied nest trees, disturb roosting greater sandhill cranes, or disturb California black rails nesting in Delta channels adjacent to DW project islands.

Implementation of the construction implementation plan identified in the HMP would offset temporary construction impacts on habitat islands. Temporary construction impacts on state-listed species, however, could occur during construction on the reservoir islands. Therefore, this impact is considered significant.

Implementing Mitigation Measure H-1 would reduce Impact H-15 to a less-than-significant level.

Mitigation Measure H-1: Develop and Implement a Construction Mitigation Plan for the Reservoir Islands. DW shall develop a construction mitigation plan for the reservoir islands following development of detailed project construction schedules, specifications, and plan drawings for construction of project infrastructure, pumps and siphons, enlarged levees, and recreation and other facilities. The plan will be submitted to SWRCB and DFG for approval. Disagreements between DW and DFG during the plan approval process may be submitted to the SWRCB Chief of the Division of Water Rights for resolution.

The construction mitigation and monitoring plan will identify methods to avoid impacts on nesting Swainson's hawks, roosting greater sandhill cranes, and nesting California black rails. These methods shall include conducting preconstruction surveys to locate nesting and roosting sites of these species and may include measures such as avoiding construction during sensitive use periods.

Elements of the plan will identify:

- preconstruction survey protocols to locate Swainson's hawk nest sites and greater sandhill crane roosts on reservoir islands and nesting California black rails on the water side of perimeter levees;

- measures that would be instituted to avoid affecting state-listed wildlife species, including restriction of construction activities to areas at least 200 yards from nesting California black rails;

- construction monitoring methods and schedule to be implemented to ensure compliance with the construction mitigation plan; and

- potential remedial measures to compensate for impacts incurred during construction that are not identified in the HMP.

Following construction, DW shall submit a report describing success of construction impact avoidance measures to the SWRCB Chief of the Division of Water Rights and DFG.

Impact H-16: Disturbance to Greater Sandhill Cranes and Wintering Waterfowl from Aircraft Operations. The Bouldin Island airstrip may be used to ferry hunters to the island or for other recreational uses. Up to 100 takeoffs and landings of fixed-wing aircraft related to such uses are permitted on hunt and nonhunt days during waterfowl hunting season. Use of the airstrip on hunt days would be allowed only between 12:00 p.m. and 2:00 p.m. This estimate of aircraft operations is based on full buildout of the recreation facilities. However, as described in Chapter 2, DW has removed construction of the recreation facilities from its CWA applications. Nevertheless, the analysis of aircraft operations assumes that the facilities would be constructed and operated.

The airstrip is located in the east Bouldin Island closed hunting zone. Closed hunting zones were established on the habitat islands to provide resting and foraging areas for greater sandhill cranes and wintering waterfowl that would be free from hunter disturbance on days when other portions of the habitat islands are hunted. Use of the airstrip on hunt days therefore could result in additional disturbance of these species on hunt days and could reduce habitat values provided by the closed hunting zone. Therefore, this impact is considered significant.

Implementing Mitigation Measure H-2 would reduce Impact H-16 to a less-than-significant level.

Mitigation Measure H-2: Monitor Effects of Aircraft Flights on Greater Sandhill Cranes and Wintering Waterfowl and Implement Actions to Reduce Aircraft Disturbances of Wildlife. DW shall develop a monitoring program in consultation with DFG and the HMAC and implement the program to determine whether airstrip use on hunt days has a deleterious effect on greater sandhill cranes or waterfowl. The plan shall be submitted to SWRCB's Chief of the Division of Water Rights within one year of issuance of project operation permits.

The following will be the major elements of the monitoring plan:

criteria for evaluating monitoring data that would be used to determine whether use of the airstrip on hunt days is having a significant impact on greater sandhill cranes and waterfowl,

criteria for determining appropriate mitigation requirements for offsetting significant impacts based on the level of impact airstrip use has on these species,

a detailed description of monitoring protocols, and

a monitoring schedule that estimates when data would be sufficient to determine whether airstrip use on hunt days has significant impacts on greater sandhill cranes or waterfowl.

If, based on monitoring results, airstrip use on hunt days is found to have a significant impact on greater sandhill cranes or waterfowl, DFG, in consultation with the HMAC, may recommend to SWRCB's Chief of the Division of Water Rights that airstrip use be modified to ensure that the goals for establishment of the closed hunting zone are met. Depending on the level of impact, recommendations could include closing hunting on Bouldin Island during the landing and takeoff period, restricting the number of flights permitted per day, changing the landing and takeoff period to reduce impacts, or closing the use of the airstrip on hunt days. Conversely, if monitoring indicates that there is no significant impact on greater sandhill cranes or wintering waterfowl, DFG, in consultation with the HMAC, could recommend that the proposed initial aircraft use restrictions remain in place or be reduced.

Impact H-17: Potential for Increased Incidence of Waterfowl Diseases. Diseases kill substantial numbers of waterfowl in the Central Valley every year (Tiche 1988). Habitat management changes under Alternative 1 could increase the incidence of disease if habitat conditions are created that favor disease organisms or concentrate birds so that diseases were more easily transmitted. Two important diseases that affect waterfowl in the Delta are botulism and avian cholera. Expected habitat conditions and bird use on the DW islands with implementation of Alternative 1 were analyzed to assess the potential for increases in waterfowl mortality resulting from disease in the Delta.

Botulism develops in waters subject to anaerobic conditions, generally when rotting vegetation depletes oxygen from water. These conditions occur most often in warm, shallow waters and especially in areas with alkaline soils. In general, waterfowl mortality resulting from botulism is minimal in the Delta (Fredrickson et al. 1988). However, the proposed deep flooding of abundant wetland vegetation on the reservoir islands raises concerns regarding botulism potential.

Botulism is not likely to become a problem on the reservoir islands for several reasons. During November-May water storage periods, temperatures are low enough for the water to remain highly oxygenated and vegetation decomposition to occur slowly. June and July are windy months in the Delta and they are the warmest months during water storage periods. Winds would aerate the water, thereby reducing the likelihood that the anaerobic conditions necessary for botulism to develop would occur during this period (Miller pers. comm.). During periods when reservoir islands are managed as shallow-water wetlands, DW would circulate water through wetlands, reducing the likelihood that anaerobic conditions would develop, and would have the capability to drain wetlands rapidly in case an outbreak of botulism were to occur.

Peat soils exposed during water storage drawdown periods on the reservoir islands would quickly dry out and absorb oxygen; this absorption would prevent creation of anaerobic conditions during periods when water is diverted onto the islands. During wetland management periods on both the reservoir and habitat islands, circulation of water through wetland cells would oxygenate the water and reduce the potential for development of botulism (Fredrickson et al. 1988). The incidence of botulism would be expected to be minimal under anticipated project conditions.

Avian cholera is a contagious disease that kills substantial numbers of waterfowl in the Delta annually (Tiche 1988, Gifford pers. comm.). Cholera is more likely to spread when birds concentrate in high numbers and densities in shallow-water areas. Thus, actions that change waterfowl distribution and density patterns may affect the incidence of cholera.

Waterfowl on the reservoir islands would be distributed during shallow-water wetland periods over a large acreage of shallowly flooded area. Hunting during these periods would periodically disturb birds and prevent them from congregating in large numbers. Waterfowl would not make intensive, concentrated use of the deep-water habitats during water storage periods; moderate use by the canvasback and other diving ducks would be expected.

Cholera could become a problem in permanent lakes on Bouldin Island with implementation of the HMP. The risk would be no greater, however, than that currently existing at blowout ponds on Webb and Holland Tracts or in shallow pools in agricultural lands created by the accumulation of rainwater or seepage.

Cholera could also become a problem in cornfields and wheat fields, mixed agriculture/seasonal wetlands, and seasonal managed wetlands on the habitat islands because large numbers of birds would be attracted to the abundant and concentrated foods. Hunting would disturb waterfowl species in hunting zones during October-January and prevent them from concentrating in large numbers on days when hunting is permitted. Large numbers of waterfowl, however, would be expected to concentrate in closed hunting zones.

Waterfowl habitat conditions created on the habitat islands and, during some periods, on the reservoir islands under Alternative 1 would concentrate waterfowl in numbers that could be large enough to increase the incidence of avian cholera. Therefore, this impact is considered significant.

Implementing Mitigation Measure H-3 would reduce Impact H-17 to a less-than-significant level.

Mitigation Measure H-3: Monitor Waterfowl Populations for Incidence of Disease and Implement Actions to Reduce Waterfowl Mortality. DW shall retain a qualified biologist to monitor waterfowl use areas on the DW project islands to locate incidences of waterfowl disease mortalities. DW, in cooperation with DFG and USFWS, shall develop management strategies to be employed in the event of disease outbreaks. On identification of a disease outbreak, DW shall notify DFG and, in cooperation with DFG biologists, implement management strategies to reduce waterfowl mortality. Management actions may include removing carcasses from the DW islands, hazing waterfowl from the islands, or draining waterfowl habitats.

Management strategies will include descriptions of:

- methods used to monitor waterfowl to detect disease outbreaks,
- protocols for determining when and what types of management actions to reduce the incidence of disease would be implemented,
- methods for collecting carcasses and removing them from affected areas,
- potential locations and methods for disposal of collected carcasses, and
- methods to haze waterfowl from reservoir islands.

Impact H-18: Potential Disruption of Waterfowl Use as a Result of Increased Hunting.

Most species of waterfowl quickly learn to identify and avoid hunted areas (Bellrose 1976, Sacramento Valley Waterfowl Habitat Management Committee n.d.). Hunting disturbance can reduce waterfowl use of foraging areas to levels below the areas' potential as determined by foraging habitat quality. During their searches for feeding and resting areas, waterfowl also quickly recognize and use areas that are not being hunted and will use hunting areas that are "rested" regularly from shooting activity. Existing levels of waterfowl hunting are low on the DW project islands and do not substantially affect use of the islands by waterfowl.

No waterfowl hunting restrictions are proposed by DW or are required to offset project impacts on the reservoir islands. DW, however, may limit hunting on the reservoir islands to Wednesdays, Saturdays, and Sundays during the hunting season to preserve hunting quality and reduce bird disturbance. On shooting days, birds would disperse to unhunted portions of the islands or other protected areas. Many birds would likely congregate in closed hunting zones on the habitat islands, Franks Tract, or other unhunted areas elsewhere in the Delta. If DW allows hunting only on specified days, the hunting schedule would permit waterfowl to return to feed on the project islands on nonshooting days.

DW's proposed hunting program for the habitat islands is described in the HMP (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). The hunting program would reduce hunter disturbance to levels that would not substantially disturb waterfowl; elements include allowing hunting only 3 days each week (DW would also select 2 additional hunting days during waterfowl season), establishing over 2,000 acres of closed hunting zones to provide undisturbed waterfowl use areas, restricting the numbers of hunters permitted on islands, and permitting only spaced-blind hunting adjacent to closed hunting zones to reduce disturbance to birds in closed zones. Potential impacts of the hunting program under Alternative 1 were incorporated into the modified HEP analysis conducted for HMP development. The analysis indicated that implementation of the HMP and the hunting program would ensure that waterfowl would use the habitat islands at levels that would offset impacts of Alternative 1 on wintering waterfowl. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-19: Potential Disruption of Greater Sandhill Crane Use of the Habitat Islands as a Result of Increased Hunting. Greater sandhill cranes react to hunting disturbance in much the same way as described for waterfowl under Impact H-18 (Schlorff pers. comm.). Little or no suitable foraging habitat for greater sandhill cranes would exist on the reservoir islands and, therefore, hunting on these islands would not affect greater sandhill crane foraging activities. Waterfowl and upland game hunting would occur on the habitat islands under Alternative 1. Implementation of the HMP, however, would restrict the number of hunting days per week and the number of hunters. One 810-acre closed hunting zone would be established on Bouldin Island that would offset the impact of hunting on crane use of foraging habitat. Two other closed hunting zones, totaling 1,198 acres, would be established to enhance waterfowl use of the habitat islands and would also provide large, undisturbed areas of crane foraging and loafing habitat. This impact is therefore considered less than significant.

Mitigation. No mitigation is required.

Impact H-20: Increase in Waterfowl Harvest Mortality. Existing levels of hunting on the DW project islands and numbers of waterfowl harvested in the Delta are low. Because of this low harvest rate, the Delta provides an unofficial sanctuary area, which has been suggested to be important to maintaining populations of waterfowl, especially the white-fronted goose (Fleskes pers. comm.). The population of white-fronted goose declined in the 1970s but has recovered in recent years (Deuel pers. comm.). A substantial proportion of the entire population winters in the Delta region.

Existing harvest rates on the DW project islands, as derived from known hunting use, are low (Table 3H-8). Implementation of Alternative 1 would result in a substantial increase in waterfowl harvest over existing conditions on the four DW project islands (Table 3H-8). The harvest would increase because more hunters would be present and larger waterfowl populations would be attracted to the islands. Projected harvest levels on the DW project islands would represent 1.2% (approximately 1,612 birds) of the average statewide goose harvest (138,500 birds) and 1.6% (approximately 24,195 birds) of the average statewide duck harvest (1,493,500 birds) during 1984-1987 (Deuel pers. comm.). This estimated harvest level also reflects addition of hunters who would be attracted to the DW project islands but currently hunt other areas. Harvest increases projected under Alternative 1, however, are expected to be partially offset by increased duck production that would occur on the habitat islands with implementation of the HMP. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-21: Potential Changes in Local and Regional Waterfowl Use Patterns. Under Alternative 1, the quality of foraging habitat for swans and white-fronted geese on the habitat islands would be similar to or greater than habitat quality provided on all four of the DW project islands under existing conditions. Duck use of all the DW project islands, however, is expected to be substantially greater under Alternative 1. This level of increase is not likely to cause a noticeable change in waterfowl populations and harvest in other parts of the Delta, in the Central Valley, or at Suisun Marsh because the DW project islands would be hunted and agricultural and seasonal wetland habitats would be flooded on staggered schedules through winter, thereby reducing habitat availability in some periods. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-22: Potential Effects on Wildlife and Wildlife Habitats Resulting from Delta Outflow Changes. Compliance with existing water quality objectives and other requirements would ensure that changes in Delta outflow do not cause salinity changes that would be detrimental to the management of wetlands for wildlife (Wernette pers. comm.) (see Chapters 3A, "Water Supply and Water Project Operations"; 3B, "Hydrodynamics"; and 3C, "Water Quality"). No substantial impacts on wildlife habitats or populations are expected to occur. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

The impacts and mitigation measures of this alternative are the same as those of Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island south of SR 12, and Holland Tract, with secondary uses for wildlife habitat and recreation. Reservoir islands would be managed in fall, winter, and spring as shallow-water wetlands during some nonstorage periods. The portion of Bouldin Island north of SR 12 would be managed as the NBHA. However, in contrast to their use under Alternatives 1 and 2, Bouldin Island and Holland Tract would not be devoted entirely to providing wildlife habitat under Alternative 3.

Changes in Wildlife Habitat Conditions and Use

Bacon Island, Webb Tract, Bouldin Island South of SR 12, and Holland Tract

All wildlife habitat conditions on the reservoir islands under Alternative 3 would be similar to conditions described above under "Impacts and Mitigation Measures of Alternative 1", except that the frequency of these conditions would differ (see Appendix G4, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands").

Impacts on wildlife under Alternative 3 on the reservoir islands would be the same as those described above for reservoir islands under "Impacts and Mitigation Measures of Alternative 1". The magnitudes of beneficial and adverse impacts, however, would be greater because the land area affected by water storage would be increased by approximately 9,327 acres. Table 3H-9 summarizes the acreages of existing foraging habitats for Swainson's hawk, greater sandhill crane, and wintering waterfowl and riparian woodland and scrub habitats that would be affected by implementation of Alternative 3.

North Bouldin Habitat Area

The portion of Bouldin Island north of SR 12 would be managed as the NBHA. Approximately 50 acres of perennial ponds, 330 acres of seasonal managed wetlands, 170 acres of corn, 200 acres of riparian woodland, and 125 acres of herbaceous uplands would be established and managed for wildlife in the NBHA (see Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands").

Wildlife habitat conditions associated with each of the NBHA habitats are the same as those described above for habitat island habitats under "Impacts and Mitigation Measures of Alternative 1". Detailed descriptions of how these habitats would be managed and the wildlife values they provide are presented in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

Impacts on wildlife resulting from development of the NBHA would be similar to those described above for the habitat islands under "Impacts and Mitigation Measures of Alternative 1" for each of the habitat types that would be established (see Appendix G3).

Summary of Project Impacts and Recommended Mitigation Measures

Table 3H-10 compares changes in habitat types and acreages under existing conditions and conditions that would occur under Alternative 3.

Impact H-23: Loss of Upland Habitats. Water storage operations on the reservoir islands under Alternative 3 would result in the loss of approximately 17,529 acres of herbaceous upland, exotic marsh, and agricultural habitats (Table 3H-9). These habitats provide foraging areas for wintering raptors and resident and migrant songbirds associated with herbaceous and agricultural habitats. Therefore, this impact is considered significant.

Implementing Mitigation Measure H-4 would reduce Impact H-23 to a less-than-significant level.

Mitigation Measure H-4: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. DW, in consultation with SWRCB, the Corps, DFG, and USFWS, shall implement an offsite mitigation plan for mitigating impacts on wildlife habitat. Once DW has identified offsite mitigation areas, an HMP team, composed of representatives approved of by SWRCB, shall be established to develop the offsite mitigation plan. No diversion shall be permitted until California Endangered Species Act consultations have been completed; a no-jeopardy opinion has been issued by DFG; and a mitigation plan and mitigation implementation schedule have been approved by SWRCB's Chief of the Division of Water Rights.

Impact H-24: Loss of Foraging Habitats for Wintering Waterfowl. Implementation of Alternative 3 would result in the loss of approximately 19,388 acres of low- to moderate-quality foraging habitats for wintering waterfowl (Table 3H-9). Therefore, this impact is considered significant.

Implementing Mitigation Measure H-4 would reduce Impact H-24 to a less-than-significant level.

Mitigation Measure H-4: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. This mitigation measure is described above.

Impact H-25: Increase in Suitable Breeding Habitats for Waterfowl. Development of the NBHA under Alternative 3 would include establishment of duck nesting habitats, creation of waterfowl brood ponds, and construction of wood duck nest boxes and goose nesting platforms. These actions would increase the suitability of the DW project islands as waterfowl breeding habitat. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact H-26: Loss of Habitats for Upland Game Species. The impacts of water storage operations on upland game species and their habitats are described above under "Impacts and Mitigation Measures of Alternative 1". Implementation of Alternative 3 would result in the loss of 18,678 acres of suitable upland game habitat (i.e., agricultural habitats, riparian woodland and scrub habitats, exotic marshes, and herbaceous uplands). This impact is considered significant.

Implementing Mitigation Measure H-4 would reduce Impact H-26 to a less-than-significant level.

Mitigation Measure H-4: Develop and Implement an Offsite Wildlife Habitat Management Plan. This mitigation measure is described above.

Impact H-27: Loss of Foraging Habitat for Greater Sandhill Crane. Implementation of Alternative 3 would result in the loss of approximately 14,220 acres of foraging habitat for greater sandhill crane (Table 3H-9). This impact is considered significant.

Implementing Mitigation Measure H-4 would reduce Impact H-27 to a less-than-significant level.

Mitigation Measure H-4: Develop and Implement an Offsite Wildlife Habitat Management Plan. This mitigation measure is described above.

Impact H-28: Loss of Foraging Habitat for Swainson's Hawk. Implementation of Alternative 3 would result in the loss of approximately 17,529 acres of foraging habitat for Swainson's hawk (Table 3H-9). This impact is considered significant.

Implementing Mitigation Measure H-4 would reduce Impact H-28 to a less-than-significant level.

Mitigation Measure H-4: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. This mitigation measure is described above.

Impact H-29: Loss of Foraging Habitat for Aleutian Canada Goose. This impact on the reservoir islands is described above under Impact H-10. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-30: Loss of Nesting Habitat for Northern Harrier. Implementation of Alternative 3 would result in the loss of nearly 2,400 acres of potential nesting habitat for northern harrier on Webb and Holland Tracts. The significance of the loss of this habitat is uncertain for several reasons. First, the habitat loss represents a small proportion of the available habitat in the Delta region. Second, high-quality nesting habitat created on the NBHA would partially offset losses elsewhere on the DW project islands. Third, acreages of suitable nesting habitat in the western Delta area are expected to increase as lands are taken out of agricultural production to prevent continued land subsidence (DWR 1988, 1990a). Finally, the harrier is relatively abundant regionally; harrier densities recorded in USFWS breeding bird surveys in the Central Valley are the highest in the United States and Canada (Robbins et al. 1986). Although habitat on Webb and Holland Tracts may not be occupied, implementing Alternative 3 could result in the loss of potential nesting habitat. Therefore, this impact is considered significant.

Implementing Mitigation Measure H-4 would reduce Impact H-30 to a less-than-significant level.

Mitigation Measure H-4: Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. This mitigation measure is described above.

Impact H-31: Loss of Wintering Habitat for Tricolored Blackbird. This impact is described above under Impact H-12. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-32: Temporary Construction Impacts on State-Listed Species. This impact is described above under Impact H-15. This impact is considered significant. Implementing Mitigation Measure H-1 would reduce Impact H-32 to a less-than-significant level.

Mitigation Measure H-1: Develop and Implement a Construction Mitigation Plan for the Reservoir Islands. This mitigation measure is described above under "Impacts of Mitigation Measures of Alternative 1".

Impact H-33: Potential for Increased Incidence of Waterfowl Diseases. This impact is described above under Impact H-17. This impact is considered significant.

Implementing Mitigation Measure H-3 would reduce Impact H-33 to a less-than-significant level.

Mitigation Measure H-3: Monitor Waterfowl Populations for Incidence of Disease and Implement Actions to Reduce Waterfowl Mortality. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact H-34: Potential Disruption of Waterfowl Use as a Result of Increased Hunting. This impact on reservoir islands is described above under Impact H-18. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-35: Increase in Waterfowl Harvest Mortality. This impact is described above under Impact H-20. Waterfowl harvest would be approximately 65% of the harvest predicted under

Alternative 1. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-36: Potential Changes in Local and Regional Waterfowl Use Patterns. This impact is described above under Impact H-21. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact H-37: Potential Effects on Wildlife and Wildlife Habitats Resulting from Delta Outflow Changes. This impact is described above under Impact H-22. This impact is considered less than significant.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Changes in Wildlife Habitat Conditions and Use

Under Section 404(f)(1) of the Clean Water Act, normal farming activities, such as plowing, seeding, cultivating, and maintaining drainage ditches, are exempt from Section 404 permit requirements as long as surface materials are not redistributed by blading or grading to fill a Section 404 jurisdictional wetland area. The No-Project Alternative is thus limited to those farming activities to increase cropping intensity that could be implemented without a Section 404 permit.

Implementation of the No-Project Alternative would involve intensive agricultural use of the DW project islands and would substantially change wildlife habitats on the DW project islands compared with habitats under existing conditions. In general, the impacts would result primarily from conversion of fallow, herbaceous upland, riparian, and wetland habitats to crops (Table 3H-11) (see Chapter 3G, "Vegetation and Wetlands").

Implementation of the No-Project Alternative would result in conversion of large acreages of corn and wheat crops to potatoes, onions, asparagus, and vineyards on Bacon and Bouldin Islands. Substantial acreages of fallow, exotic marsh (i.e., agricultural weeds growing in saturated soils), and pasture habitat on Holland and Webb Tracts would be converted to corn and wheat. Efficiency of harvest for corn and other seed crops would increase; thus, amounts of waste corn per acre left on Holland and Webb Tracts would be expected to decline to the levels measured on Bouldin Island (105 pounds per acre).

Continued agricultural operation would increase subsidence and risk of future flooding (see Chapter 3D, "Flood Control", for more details on subsidence and flooding). Abandonment of operations following flooding would reduce habitat values for most wildlife species.

Use by General Wildlife Species

Conversion of fallow, wetland, herbaceous upland, and riparian habitats on the four DW project islands under the No-Project Alternative would reduce the abundance of many wildlife species that rely on these habitats. The increase in acreages of crops would increase wintering habitat for those species that prefer areas that are bare or that support low vegetation. Abundance of prey species and foraging habitats for raptors would decrease, causing a reduction in use of the islands by wintering raptors. Although the total acreage of corn would decline, the amount of corn that would be managed under an intensive regime would increase from 3,200 acres to 4,200 acres (see Chapter 3G, "Vegetation and Wetlands"). The resulting increase in the acreage flooded for weed control would provide additional habitat for wading birds, shorebirds, and other waterbirds.

Riparian woodland considered jurisdictional wetlands under Section 404 and scrub habitat and marshes that are currently present on the DW project islands would be lost under the No-Project Alternative.

Use by Waterfowl

Overall habitat values for wintering waterfowl under the No-Project Alternative would be similar to or slightly higher than those found under existing conditions. Habitat values would increase despite a decrease in the acreage of corn and the abundance of waste corn left in fields because both the acreage of cornfields flooded for weed control and the total crop acreage would increase.

Use by Upland Game

Habitat values for ring-necked pheasant and desert cottontail would decrease with conversion of fallow fields to crops. Riparian habitats used by mourning dove and quail would also decrease under the No-Project Alternative.

Use by Special-Status Species

Most special-status species that occur or that could occur on the DW project islands would not be affected by implementation of the No-Project Alternative.

Northern harrier nesting habitat on Holland and Webb Tracts would be lost with conversion of fallow lands to crops. Loss of potential Swainson's hawk foraging habitat would also be expected. The reduction in the acreage of corn on Bouldin Island would reduce the amount of potential foraging habitat for greater sandhill cranes that use the island; however, increases of corn on other islands may offset this potential impact.

Summary of Project Impacts and Recommended Mitigation Measures

Loss of Riparian and Wetland Habitats. Up to 136 acres of riparian woodland and scrub habitats and 1,417 acres of wetland habitats could be lost under the No-Project Alternative (Table 3H-11). Impacts on wildlife resulting from the loss of riparian and wetland habitats under the No-Project Alternative would be substantial. Implementing the following measure would reduce this effect of the No-Project Alternative.

Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. DW should develop and implement an offsite mitigation plan that would mitigate impacts on wildlife habitat.

Loss of Northern Harrier Nesting Habitat. A total of 2,400 acres of potential northern harrier nesting habitat would be lost under the No-Project Alternative. Implementing the following measure would reduce this effect of the No-Project Alternative.

Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. This measure is described above.

Loss of Potential Swainson's Hawk Foraging Habitat. Approximately 2,400 acres of suitable Swainson's hawk foraging habitat would be lost under the No-Project Alternative. Implementing the following measure would reduce this effect of the No-Project Alternative.

Develop and Implement an Offsite Wildlife Habitat Mitigation Plan. This measure is described above.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. This section briefly analyzes cumulative impacts for major wildlife issues. The analysis identifies other projects or activities in the Delta region and surrounding areas that may affect those wildlife species and habitats that may also be affected by the DW project. These projects are summarized in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives". Beneficial and negative cumulative effects are identified, and the overall effect of DW project impacts on regional wildlife habitats is described.

Cumulative Impacts, Including Impacts of Alternative 1

Changes in Reservoir Island Storage Conditions

DWR recently installed four additional pumping units at SWP's Banks Pumping Plant near Clifton Court Forebay, increasing total SWP pumping capacity from 6,400 cfs to 10,300 cfs. If SWP export pumping is increased to full capacity in future years, the frequency with which each storage class would occur on the DW project islands would change. Tables 3H-2 and 3H-3 present the storage class frequencies for the reservoir islands under the 1995 DEIR/EIS cumulative scenario for Alternative 1 based on the 70-year hydrologic record for the Delta. In most months the frequency with which full-, partial-, and shallow-storage conditions would occur would be reduced and the occurrence of nonstorage conditions and the opportunity to create shallow-water wetland conditions would be increased.

Foraging Habitat for Wintering Waterfowl

Several other projects proposed for the Delta region may adversely affect waterfowl foraging habitat in the Delta. CALFED's Ecosystem Restoration Program Plan identifies actions to improve habitat conditions in the Delta. Under implementation of the preferred alternative for the Interim South Delta Water Management Program, Clifton Court Forebay would be expanded to encompass existing agricultural land used by waterfowl (DWR 1994). Compensation for impacts of this and other DWR projects, however, has been incorporated into management of Twitchell Island and Sherman Island as habitat islands (DWR 1994). DWR proposals to remove other west Delta islands from row crop agriculture (to prevent subsidence and potential levee failure) would also reduce the availability of waste grain for waterfowl forage (DWR 1988). Compensation for those proposals could also be incorporated into management of Twitchell and Sherman Islands as habitat islands to prevent overall loss of Delta habitat value.

Several other projects could maintain or increase foraging habitat value for wintering waterfowl in the Delta. Levee rehabilitation conducted under the Delta Flood Protection Act (DWR 1990b) would help maintain agricultural production and waste grain availability on protected islands. The Central Valley Habitat Joint Venture (CVHJV), a coalition of state and federal conservation agencies and private organizations, has proposed to augment waterfowl food availability in the Delta by paying farmers to leave land untilled and shallowly flooded for waterfowl. This program could substantially increase waterfowl food availability in the Delta.

The overall effect of proposed projects in the Delta (including implementation of Alternative 1) would be beneficial for wintering waterfowl foraging habitat if identified negative impacts of the projects can be offset through implementation of beneficial projects (e.g., Twitchell and Sherman Island habitat restoration and the DW HMP) that enhance habitat values.

Impact H-38: Cumulative Increase in Foraging Habitat for Wintering Waterfowl in the Delta. Foraging habitat for wintering waterfowl would increase in the Delta as mitigation projects that convert existing land uses to habitat uses (including the DW project) are implemented. This is considered a beneficial cumulative impact.

Mitigation. No mitigation is required.

Herbaceous Habitats

Other projects proposed for the Delta region could alter amounts of herbaceous habitats in the Delta and affect dependent wildlife species. Species of particular importance that use these habitats include Swainson's hawk, northern harrier, and greater sandhill crane. These projects would also affect general wildlife species that use this habitat type.

Water management and flood control projects could reduce amounts of herbaceous habitats in the Delta region, but other projects, including habitat restoration and subsidence control projects, may offset many of those reductions. The South Delta Water Management Program would flood some herbaceous habitats. Compensation for impacts of this project, however, has been incorporated into the Sherman Island Wildlife Management Plan and would result in a net increase in herbaceous habitat acreage. Delta levee rehabilitation projects would temporarily remove herbaceous habitats, but most of these areas are narrow and linear and are not used extensively by special-status species. DWR's proposed program to reduce subsidence by retiring west Delta islands from intensive agriculture would substantially increase amounts of herbaceous habitats in the Delta.

The future amounts of herbaceous habitats in the Delta depend on the extent to which these programs are implemented. The DW project would substantially reduce wildlife habitat values on a small proportion of the acreage of fallow and other herbaceous habitats in the Delta by periodically flooding two islands. This loss would significantly contribute to regional changes in herbaceous habitats. It appears likely that total amounts of herbaceous habitats in the Delta could cumulatively increase as habitat restoration projects are implemented and agricultural lands are retired for subsidence control.

Impact H-39: Cumulative Loss of Herbaceous Habitats in the Delta. Delta levee rehabilitation, water management, and flood control projects could reduce amounts of herbaceous habitat in the Delta region. This cumulative effect may be offset by habitat restoration and subsidence control projects that are separately or jointly implemented with those projects. The DW project would contribute to the loss of herbaceous habitats by flooding the reservoir islands but would compensate for the project's direct losses by creating habitats on the habitat islands. Because it is likely that any cumulative losses of herbaceous habitats in the Delta would be offset by habitat restoration projects, this impact is considered less than significant.

Mitigation. No mitigation is required.

Riparian Habitat

The temporary loss of riparian habitat on the DW project islands could coincide with flood control projects that would disturb riparian vegetation on levees in the Delta. Development of riparian habitat for the DW project on habitat islands and mitigation for other projects would prevent long-term cumulative impacts. Enhancement and creation of riparian habitat are being considered at Prospect Island by the Corps, at Sherman Island by DWR and DFG, and at Franks Tract by California Department of Parks and Recreation (DPR).

Impact H-40: Cumulative Temporary Loss of Riparian Habitat in the Delta. As described for herbaceous habitat in Impact H-39, Delta levee rehabilitation, water management, and flood control projects could reduce amounts of riparian habitat in the Delta region. Losses of riparian vegetation during levee improvement projects is commonly temporary, and any long-term losses would be offset by habitat restoration and subsidence control projects that are separately or jointly implemented with those projects. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impacts of Alternative 2 are the same as those listed above for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

Other projects and activities in the Delta and surrounding regions that may have impacts on wildlife that are similar to those of Alternative 3 are the same as those described in the previous section for Alternative 1.

Changes in Reservoir Island Storage Conditions

Future changes in the frequency of storage condition classes under this alternative are similar to those described for Alternative 1; partial-storage conditions would occur more frequently in some months (see Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives").

Foraging Habitat for Wintering Waterfowl

The loss of late-winter foraging habitat value for wintering waterfowl on the DW project islands under Alternative 3 would be substantial compared with losses associated with other foreseeable projects in the Delta. As discussed previously, the food losses on the DW islands represent a small but important proportion of the total food available to waterfowl in the Delta. The implementation of offsite mitigation, however, could offset losses resulting from implementation of Alternative 3.

Impact H-41: Cumulative Loss of Foraging Habitat for Wintering Waterfowl in the Delta. Implementation of water management and flood control projects (including implementation of Alternative 3) could reduce the amounts of foraging habitat for wintering waterfowl in the Delta region. However, implementing habitat restoration, subsidence control, and habitat compensation projects proposed as part of those projects or as a separate project would offset this loss. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Herbaceous Habitats

The contribution of Alternative 3 to the cumulative impact on herbaceous habitats would be the same as described for Alternative 1.

Impact H-42: Cumulative Loss of Herbaceous Habitats in the Delta. This impact is described above under Impact H-39. This impact is considered less than significant.

Mitigation. No mitigation is required.

Emergent Wetland and Riparian Habitats

Water management and flood control projects could reduce the amounts of emergent wetland and riparian habitats in the Delta region. Alternative 3 would contribute to this impact by reducing emergent wetland and riparian habitats by approximately 72 acres on the DW project islands, but implementation of recommended offsite mitigation could fully compensate for this loss. The creation of a large acreage of seasonal wetland available some years on the DW islands would also benefit some species that prefer dense emergent wetlands. As described above for herbaceous and riparian habitats, cumulative losses of emergent wetland and riparian habitats would be offset by habitat restoration and subsidence control projects proposed for the Delta.

Impact H-43: Cumulative Loss of Wetland and Riparian Habitats in the Delta. Implementation of water management and flood control projects (including implementation of Alternative 3) could reduce the amount of emergent wetland and riparian habitats in the Delta region. However, implementing habitat restoration, subsidence control, and habitat compensation projects proposed as part of those projects or as a separate project would offset this loss. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Cumulative Impacts, Including Impacts of the No-Project Alternative

The No-Project Alternative would not have a significant cumulative impact on wildlife populations or habitats in the Delta.

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Table 3H-1. Characteristics of Evaluation Species Analyzed in the DW HEP Analysis

Species	Wildlife Guilds Represented	General Habitats Used[a]			HEP Analysis Periods (dates)
		Agricultural	Wetland	Herbaceous	
Tundra swan	Waterfowl	XX	XX	--	10/16-4/15
White-fronted goose	Geese	XX	XX	X	10/16-4/15
Northern pintail	Dabbling ducks	XX	XX	--	9/1-4/15
Canvasback	Diving ducks	X	XX	--	10/16-4/15
Ring-necked pheasant	Upland game	XX	--	XX	All year
American kestrel	Raptors	X	--	XX	All year
Black-bellied plover	Shorebirds	X	XX	X	7/15-5/31
Western meadowlark	Resident songbirds	X	--	XX	All year
White-crowned sparrow	Wintering songbirds	X	--	XX	9/1-5/31
California vole	Small mammals	X	--	XX	All year

Note: -- = not applicable.

[a] XX = major use.
X = minor use.

Table 3H-2. Frequency of Habitat Condition Classes on Bacon Island under Alternative 1 and Cumulative Conditions for Alternative 1 (Percentage of Years)

	Alternative 1					Cumulative Alternative 1				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	65.7	13.0	0.0	21.4	0.0	58.6	4.3	0.0	32.9	0.0
June	61.4	15.9	1.4	21.4	0.0	52.9	14.3	0.0	32.9	0.0
July	34.3	21.4	10.0	34.3	0.0	1.4	1.4	0.0	97.1	0.0
August	10.0	5.7	4.3	80.0	0.0	1.4	0.0	0.0	98.6	0.0
September	11.4	1.4	1.4	57.1	28.6	4.3	1.4	2.9	0.0	91.4
October	28.6	2.9	0.0	20.0	48.6	14.3	5.7	0.0	1.4	78.6
November	45.7	1.4	1.4	1.4	50.0	30.0	5.7	0.0	2.9	61.4
December	51.4	7.1	2.9	2.9	35.7	40.0	5.7	0.0	7.1	47.1
January	67.1	5.7	1.4	4.3	21.4	57.1	5.7	0.0	2.9	34.3
February	74.3	5.7	4.3	1.4	14.3	64.3	8.6	2.9	1.4	22.9
March	75.7	7.1	4.3	4.3	8.6	67.1	8.6	2.9	1.4	20.0
April	74.3	2.9	5.7	8.6	8.6	65.7	4.3	7.1	2.9	20.0

Notes: Percentages may not total to 100.0 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record for the Delta. The frequency with which each flood condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3H-3. Frequency of Habitat Condition Classes on Webb Tract under Alternative 1 and Cumulative Conditions for Alternative 1 (Percentage of Years)

	Alternative 1					Cumulative Alternative 1				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	67.1	11.6	0.0	21.4	0.0	58.6	8.6	0.0	32.9	0.0
June	62.9	14.5	1.4	21.4	0.0	55.7	11.4	0.0	32.9	0.0
July	37.1	18.6	10.0	34.3	0.0	1.4	1.4	0.0	97.1	0.0
August	10.0	7.1	7.1	75.7	0.0	1.4	0.0	0.0	98.6	0.0
September	11.4	1.4	1.4	57.1	28.6	4.3	1.4	2.9	0.0	91.4
October	28.6	2.9	0.0	20.0	48.6	14.3	5.7	0.0	1.4	78.6
November	45.7	1.4	1.4	1.4	50.0	31.4	4.3	0.0	2.9	61.4
December	51.4	7.1	2.9	2.9	35.7	40.0	5.7	0.0	7.1	47.1
January	68.6	4.3	1.4	4.3	21.4	57.1	5.7	0.0	2.9	34.3
February	75.7	4.3	4.3	1.4	14.3	64.3	8.6	2.9	1.4	22.9
March	75.7	7.1	4.3	4.3	8.6	67.1	8.6	2.9	1.4	20.0
April	74.3	5.7	5.7	8.6	8.6	65.7	4.3	5.7	4.3	20.0

Notes: Percentages may not total 100.0 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record for the Delta. The frequency with which each flood condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3H-4. Acreages of Habitats to Be Developed on the DW Habitat Islands under Alternative 1

Habitat Type[a]	Bouldin Island		Holland Tract		Habitat Island Totals	
	Total Acres	Percentage of Total Acres	Total Acres	Percentage of Total Acres	Total Acres	Percentage of Total Acres
Corn/wheat	1,629	27	955	31	2,584	29
Small grains	106	2	152	5	258	3
Mixed agriculture/seasonal wetland	1,014	17	631	21	1,645	18
Seasonal managed wetland	1,723	29	393	13	2,116	23
Seasonal pond	66	1	68	2	134	1
Pasture/hay	132	2	72	2	204	2
Emergent marsh[b]	208	3	194	6	402	4
Riparian[b]	170	3	217	7	387	4
Lake[b]	111	2	33	1	144	2
Herbaceous upland[b]	479	8	253	8	732	8
Developed	177	3	58	2	235	3
Canal[b]	70	1	10	0	80	1
Borrow pond	89	1	0	0	89	1
Total	5,974	100	3,036	100	9,010	100

Note: Minor inconsistencies in totals are the result of rounding.

[a] Habitat types and habitat management prescriptions are described in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

[b] Includes existing acres of habitat unaffected by the DW project.

Table 3H-5. Habitat Island Habitats Used by General Wildlife Species

Species Group	Representative Species	Foraging Habitats	Breeding Habitats
Raptors	Red-tailed hawk American kestrel Great horned owl	# Unflooded corn and wheat # Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland # Riparian woodland # Riparian scrub	# Riparian woodland # Riparian scrub
Grassland and agricultural birds	Ring-necked pheasant Western meadowlark	# Unflooded corn and wheat # Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland	# Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland
Small mammals	California vole Deer mouse	# Unflooded corn and wheat # Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland # Riparian woodland # Riparian scrub # Developed	# Unflooded corn and wheat # Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland # Riparian woodland # Riparian scrub # Developed
Furbearers	Raccoon Striped skunk	# Corn and wheat # Small grains # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Pasture/hay # Emergent marsh # Permanent lake shoreline # Herbaceous upland # Riparian woodland # Riparian scrub # Canals # Developed	# Riparian woodland # Riparian scrub # Developed
Migrating and wintering shorebirds	Western sandpiper Dowitcher Long-billed curlew Dunlin	# Shallow-flooded corn and wheat # Shallow-flooded mixed agriculture/seasonal wetland # Shallow-flooded seasonal managed wetland # Seasonal pond # Shallow-flooded and dry pasture/hay # Shallow-flooded emergent marsh # Permanent lake shoreline	Not applicable

Table 3H-5. Continued

Species Group	Representative Species	Foraging Habitats	Breeding Habitats
Breeding shorebirds	American avocet Black-necked stilt	# Shallow-flooded corn and wheat # Shallow-flooded seasonal managed wetland # Seasonal pond # Shallow-flooded emergent marsh # Permanent lake shoreline	# Shallow-flooded seasonal wetland # Seasonal pond # Emergent marsh
Cavity-nesting birds	Nuttall's woodpecker House wren	# Riparian woodland # Riparian scrub	# Riparian woodland # Riparian scrub
Wading birds	Great blue heron Great egret Black-crowned night heron	# Corn and wheat # Small grains # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake shoreline # Herbaceous upland	# Seasonal managed wetland # Emergent marsh # Riparian woodland # Riparian scrub
Migratory and resident songbirds	White-crowned sparrow Yellow warbler Yellow-rumped warbler Savannah sparrow Plain titmouse Bushtit	# Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland # Riparian woodland # Riparian scrub	# Small grains # Unflooded mixed agriculture/seasonal wetland # Unflooded seasonal managed wetland # Pasture/hay # Herbaceous upland # Riparian woodland # Riparian scrub
Wetland songbirds	Marsh wren Red-winged blackbird Yellow-headed blackbird	# Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Herbaceous upland # Canals	# Seasonal managed wetland # Seasonal pond # Emergent marsh # Canals

Table 3H-6. Delta Special-Status Wildlife Species That Occur or Could Occur on the DW Habitat Islands

Species	Legal Status Federal/State[a]	Preferred Habitats	Occurrence in the Delta[b]	Foraging or Roosting Habitats	Breeding Habitats[c]
Valley elderberry longhorn beetle	T/--	Elderberry shrubs in riparian habitats	R	# Elderberry shrubs planted in riparian scrub and riparian woodland habitats	# Elderberry shrubs planted in riparian scrub and riparian woodland habitats
Western pond turtle	C2/SSC	Marshes, streams, and ponds	R	# Seasonal pond # Emergent marsh # Permanent lake # Canal # Borrow pond	# Herbaceous upland
Giant garter snake	T/T	Marshes, streams, and ponds	R	# Seasonal managed wetland # Seasonal pond # Emergent marsh # Permanent lake # Canal # Borrow pond	# Herbaceous upland
American white pelican	--/SSC	Marshes and open water	W	# Seasonal managed wetland # Seasonal pond # Emergent marsh # Permanent lake # Borrow pond	N/A
Double-crested cormorant	--/SSC	Open water for foraging and roosting; valley oaks and cottonwood forests for nesting	NR	# Emergent marsh # Permanent lake # Borrow pond	N/A
White-faced ibis	C2/SSC	Freshwater marshes (rookery sites)	NR	# Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Herbaceous upland	# Emergent marsh # Seasonal pond
Aleutian Canada goose	T/--	Wetland and agricultural habitats	W	# Corn and wheat fields # Small grain # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake # Herbaceous upland	N/A

Species	Legal Status Federal/State[a]	Preferred Habitats	Occurrence in the Delta[b]	Foraging or Roosting Habitats	Breeding Habitats[c]
Black-shouldered kite	--/FP	Riparian habitats for nesting; wetlands and grasslands for foraging	R	# Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Riparian woodland # Riparian scrub # Herbaceous upland	# Riparian woodland # Riparian scrub
Bald eagle	E/E	Streams and lakes	W	# Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Emergent marsh # Riparian woodland # Riparian scrub # Permanent lake	N/A
Northern harrier	--/SSC	Marshes and meadows and seasonal and agricultural wetlands	R	# Corn and wheat fields # Small grain # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake # Herbaceous upland	# Small grain # Seasonal managed wetland # Pasture/hay # Emergent marsh # Herbaceous upland
Sharp-shinned hawk	--/SSC	Riparian habitats	W	# Riparian woodland # Riparian scrub	N/A
Cooper's hawk	--/SSC	Riparian habitats and oak woodlands for nesting	R	# Riparian woodland # Riparian scrub	# Riparian woodland # Riparian scrub
Swainson's hawk	--/T	Agricultural habitats for foraging and riparian habitats for nesting	W	# Corn and wheat fields # Small grain fields # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Pasture/hay # Herbaceous upland	# Riparian woodland # Riparian scrub

Species	Legal Status Federal/State[a]	Preferred Habitats	Occurrence in the Delta[b]	Foraging or Roosting Habitats	Breeding Habitats[c]
Peregrine falcon	E/E	Marshes and seasonal and agricultural wetlands	W	# Corn and wheat fields # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake # Herbaceous upland	N/A
Prairie falcon	--/SSC	Uplands, marshes, and seasonal and agricultural wetlands	W	# Corn and wheat fields # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake # Herbaceous upland	N/A
Greater sandhill crane	--/T	Forages in agricultural habitats and roosts in shallow wetlands	W	# Corn and wheat fields # Small grain # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Herbaceous upland	N/A
California gull	--/SSC	Widespread in winter	NR	# Corn and wheat fields # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake # Herbaceous upland # Borrow pond	N/A
Yellow-billed cuckoo	--/E	Deciduous riparian forests	R	# Riparian woodland # Riparian scrub	# Riparian woodland

Species	Legal Status Federal/State[a]	Preferred Habitats	Occurrence in the Delta[b]	Foraging or Roosting Habitats	Breeding Habitats[c]
Short-eared owl	--/SSC	Marshes and seasonal and agricultural wetlands	R	# Corn and wheat fields # Small grain # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Herbaceous upland	# Small grain # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Herbaceous upland
Long-eared owl	--/SSC	Roosts in riparian habitats; feeds in wetlands, grasslands, and agricultural habitats	W	# Corn and wheat fields # Small grain # Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Riparian woodland # Riparian scrub # Herbaceous upland	N/A
Burrowing owl	--/SSC	Forages in open grassland and agricultural habitats; ground burrows in sparse grassland for nesting	R	# Corn and wheat fields # Small grain # Pasture/hay # Herbaceous upland	# Herbaceous upland
Willow flycatcher	--/SSC	Riparian habitats	M	# Riparian woodland # Riparian scrub	N/A
Yellow warbler	--/SSC	Riparian habitats	M	# Riparian woodland # Riparian scrub	N/A
Tricolored blackbird	C2/SSC	Nonwoody riparian habitats, weedy vegetation, and marshes for breeding; marshes and agricultural wetlands for feeding	R	# Mixed agriculture/seasonal wetland # Seasonal managed wetland # Seasonal pond # Pasture/hay # Emergent marsh # Permanent lake	# Seasonal managed wetland # Seasonal pond # Emergent marsh # Permanent lake

[a] Status definitions:

Federal

E = listed as endangered under the federal Endangered Species Act.

T = listed as threatened under the federal Endangered Species Act.

C2 = Category 2 candidate for federal listing. Category 2 includes species for which USFWS has some biological information indicating that listing may be appropriate but for which further biological research and field study are usually needed to clarify the most appropriate status. Category 2 species are not necessarily less rare, threatened, or endangered than Category 1 species or listed species; the distinction relates to the amount of data available and is therefore administrative, not biological.

-- = no listing status.

State

E = listed as endangered under the California Endangered Species Act.

FP = fully protected under California Fish and Game Code.

T = listed as threatened under the California Endangered Species Act.

SSC = DFG species of special concern.

-- = no listing status.

[b] W = wintering species.
NR = nonbreeding resident.
M = migrant.
R = resident.

[c] N/A = not applicable.

Table 3H-7. Changes in Habitat Acreages from Existing Conditions to Conditions under Alternative 1

Habitat Type[a]	Existing: Reservoir Islands (acres)	Existing: Habitat Islands (acres)	Alternative 1: Reservoir Islands (acres)	Alternative 1: Habitat Islands (acres)	Change from Existing to Alternative 1 Conditions[b]: Acres	Change from Existing to Alternative 1 Conditions[b]: Percentage
Riparian woodland and scrub (same)	109	122	0.0	387	+156	+67.5
Freshwater marsh (emergent marsh)	175	49	0.0[c]	402	+178	+79.9
Exotic marsh (mixed agriculture/seasonal wetland, seasonal managed wetland, and seasonal pond)	814	310	0.0[c]	3,895	+2,771	+246.5
Herbaceous upland (same)	1,367	982	0.0[c]	732	-1,617	-68.8
Corn, wheat, and milo (corn rotated with wheat, and small grains)	3,527	4,193	0.0	2,842	-4,878	-63.2
Pasture (pasture/hay)	61	384	0.0	204	-241	-54.2
Other crops and fallow fields (none)	4,600	2,775	0.0	0	-7,375	-100.0
Sloughs and ditches (canal)	142	158	0.0	80	-220	-73.3
Pond - all year (borrow areas and permanent lake)	107	17	0.0[c]	233	+109	+88.2
Total or average	10,902	8,990	0.0[c]	8,775	-11,117	-55.9

[a] Habitats in parentheses are equivalent habitats to be developed on the habitat islands.

[b] See "Summary of Project Impacts and Recommended Mitigation Measures" for Alternative 1 for a description of how habitat losses would be mitigated.

[c] These habitats would exist on the reservoir islands during some operating years; however, because the areal extent of these habitat types and the frequency with which they would appear are unpredictable, no habitat acreage is credited.

Table 3H-8. Estimated Annual Waterfowl Harvest under Existing Use and Alternative 1

Island	Existing Use			Alternative 1		
	Number of Hunter Use-Days	Number of Birds Harvested[a]		Maximum Number of Hunter Use-Days[b]	Number of Birds Harvested[c]	
		Geese	Ducks		Geese	Ducks
Bacon	0	0	0	2,592	259	3,888
Webb	320	50	350	2,664	266	3,996
Bouldin	150	15	175	7,424	742	11,136
Holland	60	5	25	3,449	345	5,174
Total	530	70	550	16,129	1,612	24,194

[a] See Table H2-12 in Appendix H2, "Wildlife Inventory Methods and Results", for sources of current harvest rates.

[b] See Chapter 3J, "Recreation and Visual Resources", for methods used in calculating estimated numbers of annual hunter use-days.

[c] Average harvest rates are assumed to be 1.5 ducks/hunter/day and 0.1 goose/hunter/day, respectively, under the proposed project.

Table 3H-9. Comparison of Impacts of Alternatives 1, 2, and 3 on Acreages of Suitable Foraging Habitat for Swainson's Hawk, Wintering Raptors, Greater Sandhill Crane, and Wintering Waterfowl

Habitat Type	Increase (+) or Decrease (-) in Foraging Habitat Acres from Existing Conditions								
	Swainson's Hawk and Wintering Raptors			Greater Sandhill Crane			Wintering Waterfowl		
	Alts. 1 and 2[a]	Alt. 3[b]	Additional Acreage Affected under Alt. 3	Alts. 1 and 2[a]	Alt. 3[b]	Additional Acreage Affected under Alt. 3	Alts. 1 and 2[a]	Alt. 3[b]	Additional Acreage Affected under Alt. 3
Exotic marsh	+2,771	-858	858	+2,771	-858	858	+2,771	-858	858
Herbaceous upland	-1,617	-2,251	634	-1,617	-2,251	634	-1,617	-2,251	634
Agriculture	-10,660	-14,420	3,760	-7,406	-11,111	3,705	-12,216	-15,975	3,759
Freshwater marsh	N/A	N/A	N/A	N/A	N/A	N/A	+179	-224	224
Permanent pond	N/A	N/A	N/A	N/A	N/A	N/A	+20	-80	80
Total	-9,508.9	-17,529	5,252	-6,252	-14,220	5,197	-10,863	-19,388	5,555

Note: N/A = not applicable.

[a] See Impacts H-1, H-3, H-6, and H-8 and Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", for a description of how compensation for project impacts on wildlife associated with these habitats would be achieved (regarding habitat quality versus quantity).

[b] See Mitigation Measure H-4 for a description of how compensation for project impacts would be achieved.

Table 3H-10. Changes in Habitat Acreages from Existing Conditions to Conditions under Alternative 3

Habitat Type[a]	Existing Conditions on All Islands (acres)	Alternative 3: Reservoir Islands (acres)	Alternative 3: NBHA (acres)	Change from Existing to Alternative 3 Conditions: Acres	Change from Existing to Alternative 3 Conditions: Percentage
Riparian woodland and scrub (same)	248	0.0	200	-48	-19.4
Freshwater marsh (none)	224	0.0[b]	0.0	-224	-100.0
Exotic marsh (seasonal managed wetland)	1,188	0.0[b]	330	-858	-72.2
Herbaceous upland (same)	2,376	0.0[b]	125	-2,251	-94.7
Agriculture (corn and wheat)	16,424	0.0	170	-16,254	-99.0
Permanent ponds (perennial pond)	130	0.0[b]	50	-80	-61.5
Total or average	20,895	0.0[b]	875	-20,020	-95.8

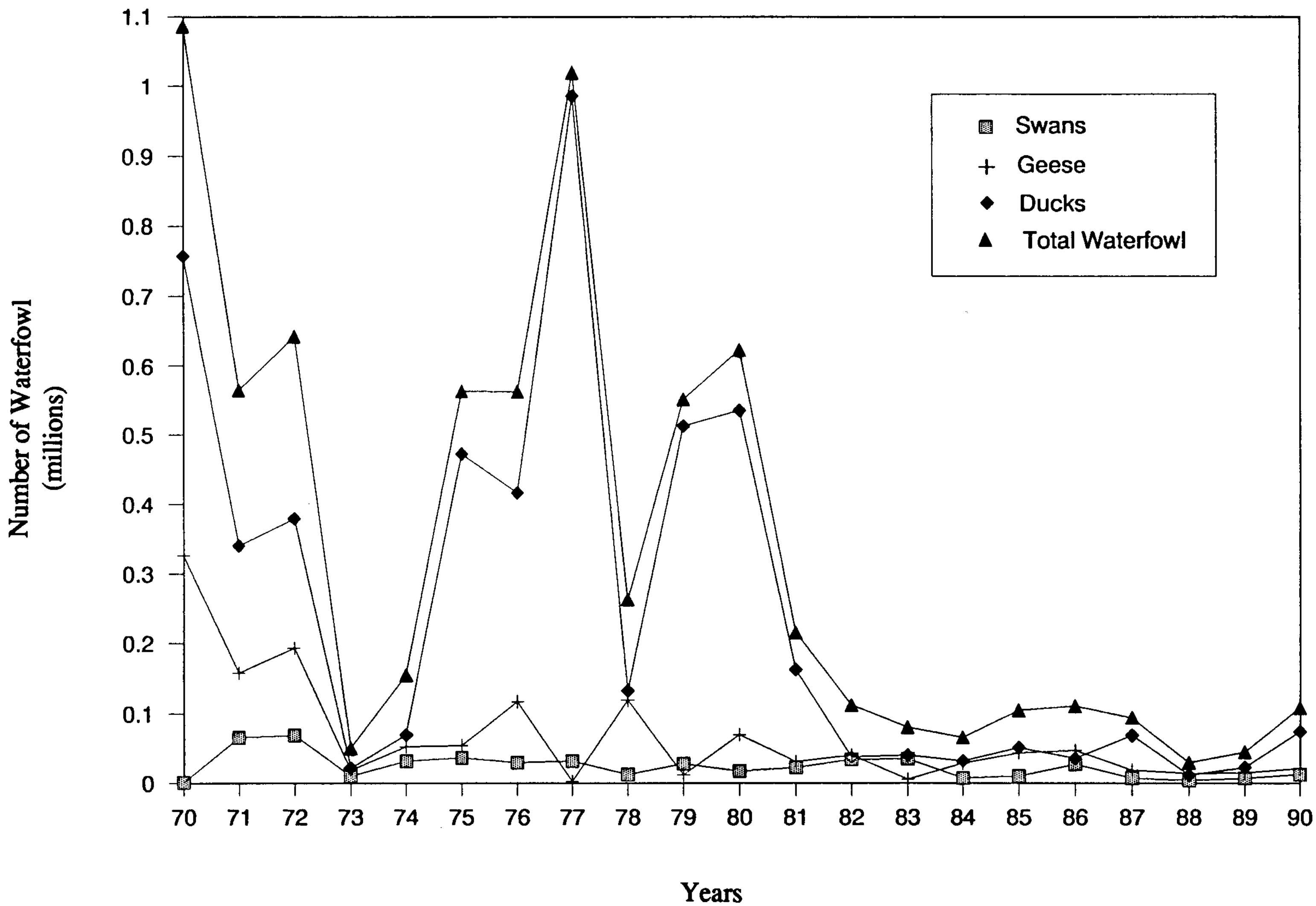
[a] Habitats in parentheses are equivalent habitats that would be developed in the NBHA.

[b] These habitats would exist on the reservoir islands during some operating years; however, because the areal extent of these habitat types and the frequency with which they would appear are unpredictable, no habitat acreage is credited.

Table 3H-11. Predicted Changes in Acreages of Habitat Types under the No-Project Alternative

Habitat Type	Bacon Island		Webb Tract		Bouldin Island		Holland Tract		Total		
	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	No-Project Acreage as Percentage of 1987 Acreage
Riparian woodland and scrub	3	3	106	56	17	7	122	46	248	112	45
Freshwater marsh	3	0	172	16	21	0	28	2	224	18	8
Exotic marsh	30	0	783	40	115	0	323	0	1,251	40	3
Woody non-native and herbaceous upland	528	261	839	220	354	349	569	113	2,290	943	41
Subtotal	564	264	1,900	332	507	356	1,042	161	4,013	1,113	28
Annual grain crops	3,091	3,126	2,695	4,961	4,530	3,329	1,118	3,083	11,434	14,499	127
Perennial crops orchards/vineyards	1,348	1,969	0	0	0	2,097	423	610	1,771	4,676	264
Pasture	0	0	61	0	34	0	571	256	666	256	38
Fallow	355	0	638	0	712	0	785	0	2,490	0	0
Subtotal	4,794	5,095	3,394	4,961	5,276	5,426	2,897	3,949	16,361	19,431	119
Sloughs and ditches	92	92	50	50	118	118	45	45	305	305	100
Ponds	3	3	106	106	9	9	23	23	141	141	100
Developed	86	86	20	20	75	75	243	71	424	252	59
Subtotal	181	181	176	176	202	202	311	139	870	698	80
Total	5,539	5,540	5,470	5,469	5,985	5,984	4,250	4,249	21,244	21,242	100

Note: Minor inconsistencies in totals result from rounding.



Jones & Stokes

Figure 3H-1
Waterfowl Populations Observed in the Annual Midwinter Delta Survey, 1970-1990

Chapter 3I. Affected Environment and Environmental Consequences - Land Use and Agriculture

Chapter 3I. Affected Environment and Environmental Consequences - Land Use and Agriculture

SUMMARY

This chapter discusses impacts of the DW project alternatives on land use and agriculture in the vicinity of the DW project islands. Agriculture is the primary use of the DW project islands and would be affected by DW project implementation. Potential land use impacts of the DW project alternatives include displacement of residences and structures, conflicts with adjacent land uses, effects on Williamson Act contracts, inconsistency with local zoning and land use plans and policies, and inconsistency with general plan principles. Potential agriculture impacts include conversion of prime agricultural lands and conversion of substantial acreages of nonprime agricultural lands to nonagricultural uses.

Implementation of Alternative 1, 2, or 3 would result in two significant and unavoidable land use and agriculture impacts. Conversion of 6,300 acres of prime agricultural land on Webb and Holland Tracts to water storage and habitat, respectively, would be inconsistent with Contra Costa County's and the Delta Protection Commission's (DPC's) land use goals to preserve prime agricultural lands for agricultural production and promote a competitive economy and would therefore be a significant and unavoidable land use impact. Direct conversion of approximately 16,180 acres of agricultural land on the four DW project islands under Alternative 1 or 2, or of 20,345 acres under Alternative 3, including harvested cropland and pasture, short-term fallowed land, and long-term idled lands, is considered to be a significant and unavoidable agriculture impact. Implementation of Alternative 1, 2, or 3 would contribute to the significant and unavoidable cumulative impact of cumulative conversion of prime agricultural land in the Delta.

Implementing Alternative 1, 2, or 3 would result in the less-than-significant land use impact of displacement of residences and structures on reservoir islands. An additional less-than-significant impact, displacement of property owners on habitat islands, would result from implementation of Alternative 1 or 2.

Implementation of the No-Project Alternative would result in an increase in cultivated acreage and agricultural production on the DW islands. Under the No-Project Alternative, there would be no change in the status of onsite structures, Williamson Act contracts, consistency with zoning and general plan designations, or consistency with relevant general plan policies.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

This chapter has been updated to reflect more recent conditions on the project islands and to respond to comments received on the 1995 DEIR/EIS. The description of existing conditions on the DW project islands has been updated to include revisions in land use designations and policies that occurred with the adoption of the Contra Costa County General Plan in 1996; and to revise information on zoning designations for the project islands in response to recent revisions to the zoning code for both San Joaquin and Contra Costa Counties. The analysis of project consistency with adopted plans and policies has been revised in response to comments received on the 1995 DEIR/EIS. The evaluation of project consistency with county general plan policies has been updated in response to comments received from those counties. Additionally, the chapter now includes an analysis of the consistency of the DW project with the goals of the DPC's Land Use and Resource Management Plan for the Primary Zone of the Delta (Delta Protection Commission 1995).

INTRODUCTION

Potential land use issues related to DW project implementation are effects on Williamson Act contracts, displacement of existing dwelling units, and consistency with local zoning and land use plans and policies. Potential agriculture impacts are related to changes in the use of agricultural lands considered to have high production capabilities and changes in regional or statewide crop production.

AFFECTED ENVIRONMENT

This section describes land use and agricultural conditions on the DW project islands. Land use information is based in part on information collected for the 1990 draft EIR/EIS and has been updated to current conditions where these changes would affect the impact analysis. For example, both Contra Costa and San Joaquin Counties updated their general plan policies and designations after 1990. This section therefore uses this updated policy information to represent baseline land use conditions.

Land management decisions made since 1990 have resulted in some changes in agricultural land use on the DW project islands. Some of these changes were made in response to annual fluctuations in agricultural market conditions; others were made in anticipation of DW implementation. For example, changes in agricultural management on Holland and Webb Tracts have resulted in previously fallowed lands being brought into grain production. On Bacon Island, uncertainty concerning the project has led tenant farmers to replace old asparagus stands with wheat and corn crops. Because some of these changes have resulted from project-related actions and influences, information from the 1990 draft EIR/EIS (based on 1988 conditions) provides the most reliable description of typical preproject agricultural land use on the DW project islands for assessing the impacts of the DW alternatives.

The four project islands are located in San Joaquin and Contra Costa Counties (Figure 3I-1). Bacon and Bouldin Islands are in San Joaquin County, and Holland and Webb Tracts are in Contra Costa County.

Sources of Information

Land Use

Current land use plans for San Joaquin County and Contra Costa County were reviewed for information on planned land uses in the DW project area. The 1995 DEIR/EIS used the Contra Costa County General Plan 1990-2005 to estimate baseline land use conditions. Since that time, the County updated and adopted revisions to the general plan in July of 1996. Changes to the land use designations and policies have been reviewed and are reflected in the text of this FEIS. Site visits and aerial photographs were used to determine existing land uses. The plans and policies reviewed for the land use discussion are briefly summarized below.

San Joaquin County General Plan. The San Joaquin County General Plan (SJCGP) (San Joaquin County Community Development Department 1992) contains principles that guide the use of land for residential, commercial, and industrial development and provides limitations and priorities for the use of recreation and agricultural land on Bacon and Bouldin Islands. The plan includes principles that limit development in hazardous areas and that preserve and enhance the county's natural resources.

The SJCGP identifies as priorities the preservation of agricultural resources and retention of agricultural land in areas of periodic flooding. Fragmentation of agricultural land is discouraged outside areas designated for rural residential development. Recreation principles encourage developing recreation facilities to serve regional and statewide residents, protecting the recreation potential of rivers and other natural features, providing public access, and exploring multiple uses of open space. Natural resource principles encourage preserving Delta resources by adhering to water quality standards, supporting programs to improve water quality, retaining riparian vegetation along waterways, prohibiting all actions that would adversely affect the Delta, and designating conservation areas to remain in open space.

Contra Costa County General Plan. Land use on Holland and Webb Tracts is governed by the Contra Costa County General Plan (CCCGP). The CCCGP (Contra Costa County Community Development Department 1996) contains policies that encourage preservation of prime agricultural soils and other resources associated with agriculture. The CCCGP also guides the location and general characteristics of planned communities, industry, and recreational land uses. Water reclamation is encouraged, and recreational uses that are compatible with an area's carrying capacities and environmental constraints are encouraged. CCCGP policies for islands and lowlands of the Sacramento-San Joaquin Delta in Contra Costa County balance the recreation opportunities of the Delta area against the need to allow only low-intensity uses that will not subject large numbers of residents or visitors to flooding.

Delta Protection Commission Resource Management Plan. The DPC was established by the Delta Protection Act of 1992. The commission was created to develop a long-term management plan for the Delta Primary Zone (Figure 3I-1). As stated in the act, the goals of this regional plan are to "protect, maintain and, where possible, enhance and restore the overall quality of the Delta environment, including, but not limited to, agriculture, wildlife habitat, and recreational activities". All local general plans within the Delta Primary Zone are required to be consistent with the DPC's regional plan.

The DPC prepared nine background reports for the regional plan on the following issues: utilities and infrastructure; water; land use and ownership; environment; recreation and access; agriculture; levees, marine patrol, boater education, and safety programs; and plan implementation. After public review of the background reports, the regional plan was completed in July 1994 and adopted in February 1995. Additionally, the commission recommended that water reservoirs that are consistent with other uses in the Delta should be permitted (Aramburu pers. comm.).

Williamson Act Contracts. The California Land Conservation Act of 1965 (commonly known as the Williamson Act) established a voluntary tax incentive program for preserving agricultural land and open-space lands. A property owner enters into a 10-year contract with a county, which places restrictions on the land in exchange for tax savings. The property is taxed according to the income it is capable of generating from agriculture and other compatible uses, rather than its full market value.

Compatible uses under the Williamson Act are determined by the city or county that has jurisdiction. The Williamson Act identifies compatible uses as agricultural production, recreation, and open space. The act also defines "agricultural land" to include land that is:

- devoted to recreational use,
- within a scenic highway corridor,
- a wildlife habitat area,
- a saltpond,
- a managed wetland area, or
- a submerged area.

The San Joaquin County Zoning Code Section 9-2352 (December 20, 1988) states that uses of agricultural land under Williamson Act contracts are limited to "outdoor recreational activities which can be carried out in conjunction with continued agricultural usage of the land" and "[a]ll other uses similar to, comparable to, or no more intensive than, those uses enumerated in subsection (a) which are, in the opinion of the Board [of Supervisors], distinctly and exclusively agricultural based". Section 9-4005.1(c)(11) of the zoning code (December 20, 1988) states that hunting and fishing clubs are allowed in the General Agriculture (AG) zone with a development plan. Finally, Section 9-4005. 2(a)(14) states that water storage facilities are allowed in the AG zone as an "accessory use".

In San Joaquin County, a project is considered consistent with Williamson Act contracts if the county board of supervisors agrees that:

- the recreation portion of the project can be carried out in conjunction with continued agricultural use of the land;

- the proposed uses are similar to, comparable to, or no more intensive than permitted uses of the site and are exclusively agricultural based; and

- a proposed water storage facility would be an accessory use of agricultural land.

In situations in which the land use proposed is not clearly consistent or inconsistent, the Williamson Act provides that compatible uses will be determined by the county or city administering the preserve.

Contra Costa County integrates agricultural land conservation, under the Williamson Act, and zoning. Upon entering into an conservation agreement with a landowner, the county will zone the parcel of land A-4, Agricultural Preserve District. The county describes the production of food and fiber as compatible uses, in addition to other compatible uses consistent with the intent and purpose of the Williamson Act (Drake pers. comm.).

Agriculture

Soil Surveys. Information on soils was obtained from soil surveys prepared by the SCS (now called the Natural Resources Conservation Service [NRCS]). Acreages by soil units on each island were estimated based on planimeter measurements of SCS soil survey maps made by JSA. Soil qualities and limitations are described based on information contained in the soil surveys for Contra Costa and San Joaquin Counties.

Agricultural Land Production Capabilities. Agricultural land production capabilities were assessed using the NRCS land capability classification (LCC) system and California Department of Conservation's (CDC's) important farmland mapping (IFM) system. Information provided by these two systems was supplemented by farmland information contained in the SJCGP open space/conservation element.

The LCC system places soils into eight classes (I-VIII), depending on the limitations to agricultural use imposed by 13 specific soil and climatic criteria. The higher the class, the more restrictive the limitation. Classes I through IV are generally considered lands suitable for cultivation. Class I and II soils are often combined as one definition of prime farmland.

CDC's IFM system identifies four farmland categories: prime land, additional farmland of statewide importance, unique farmland, and additional farmland of local importance. Land must meet 10 specific soil and climatic criteria to qualify for the prime or statewide classes, with the prime class requiring the best of these conditions for agricultural usage. Unique farmland is land that does not qualify for the prime or statewide classes, but because of climatic or other factors, grows one of the top 40 California crops. Farmland of local importance is other farmland that holds economic value for the local economy (CDC 1987).

Crop History and Yields. Crop history information for the DW project islands was generally provided by farmers and farm managers with operations on the islands. Crop acreages were estimated based on land use maps prepared by DWR for 1982 and 1987 crop years and on a field survey conducted by JSA in 1988. Crop yields were estimated using countywide yield data from the San Joaquin and Contra Costa County crop reports produced by the counties' agricultural commissioner's offices. Countywide per-unit estimates for individual crops were modified based on information provided by island farmers and farm managers.

Land Use Conditions

The four DW project islands are used primarily for perennial and annual agricultural production, with some hunting and fishing recreational uses. Bacon and Bouldin Islands are currently used primarily (approximately 80%) for agricultural production or grazing and small portions of these islands are not used (Table 3I-1). In contrast, only about one-half of Holland and Webb Tracts are used for agricultural production and grazing, with a relatively large amount of land unused or fallow (Table 3I-1). The DW project islands are almost entirely designated in local land use plans for agricultural use or uses compatible with agricultural operations (Figure 3I-2).

Bacon Island

Existing Uses and Ownerships. Approximately 80% of Bacon Island is used for agriculture and produced crops such as corn, milo, potato, sunflower, asparagus, and grapes (Table 3I-1). Approximately 20 farmsteads or rural residences are located on the island near the perimeter levees. An additional five or six barracks for migrant farmworkers are also occupied seasonally. Agricultural structures and equipment complexes are located in the northern, central, and southern portions of the island. An airstrip for crop dusting flights is located on the eastern portion of the island.

DW now owns all of Bacon Island, which was previously owned by nine different entities.

Zoning and General Plan Designations. The San Joaquin County zoning designation for Bacon Island is General Agriculture with an 80-acre parcel minimum (AG-80). Uses allowed under this zoning include single-family dwellings, crop production, packing plants, livestock grazing, and other limited agriculture- and livestock-related activities. Development plan approval is required for gas or oil drilling, hunting and fishing clubs, farm worker dwellings, produce stands, poultry operations, nurseries and greenhouses, and labor camps. Other uses may be permitted subject to site approval. Conditional use permits are required for marinas and uses ancillary to marinas, resource recovery operations, and power generating facilities.

The SJCGP designation for Bacon Island is AG. The designation for land along sloughs and rivers surrounding Bacon Island is Open Space/Resource Conservation (Figure 3I-2). Table 3I-2 defines general plan designations.

Williamson Act Contracts. Approximately 4,662 acres of Bacon Island are currently under Williamson Act contracts. As shown in Figure 3I-3, only two parcels on Bacon Island are not under Williamson Act contracts.

Land Uses near Bacon Island. Land on islands surrounding Bacon Island is used primarily for agriculture. Scattered agricultural structures, equipment complexes, and a few rural residences are interspersed throughout the vicinity. San Joaquin County has designated land north, south, and east of Bacon Island on Mandeville Island, Woodward Island, and Lower Jones Tract as AG (Figure 3I-2). Mandeville Island is under Williamson Act contracts. With the exception of Mildred Island, which was flooded in 1983 as the result of a levee breach, Delta land east and south of Bacon Island is also entirely under Williamson Act contracts (Figure 3I-3).

Webb Tract

Existing Uses and Ownerships. Approximately 50% of Webb Tract is in agricultural use, producing mainly corn and wheat crops (Table 3I-1). A small number of agricultural structures and equipment complexes are located on the island, mainly near the perimeter levees. Occupied residences on the island include two trailers located along the northern shore and adjacent to the northern levee, one trailer located in the island interior, and a residence (semipermanently occupied) on the southern portion of the island. A clubhouse is located on high ground at the extreme eastern tip of the island. Webb Tract is entirely owned by DW.

Zoning and General Plan Designations. The Contra Costa County zoning designation for most of Webb Tract is Agriculture (A-2), and the 139.2-acre False River Farms parcel is zoned as Agricultural Preserve District (A-4). This A-4-zoned parcel is under a Williamson Act contract. The Contra Costa County A-2 zoning (5-acre minimum parcel size) allows a variety of agricultural uses, as well as incidental sheds, warehouses, production facilities, produce stands, one single-family detached unit, and other uses allowable by code or use permit. Refuse disposal sites are also allowed in areas zoned A-2 by use permit only. Land uses under A-4 zoning include commercial agricultural production and other uses specifically agreed on by the county and the landowner at the time the zoning was established. Uses allowed by use permit include agriculture-related structures, fruit and vegetable stands, owner or lessee residences, oil and gas drilling, and a variety of other agriculture- and livestock-related uses.

The 1996 CCCGP designation for all of Webb Tract is Delta Recreation and Resources (Figure 3I-2). The CCCGP identifies agriculture and wildlife habitat as the most appropriate uses in this area. Under the CCCGP Delta Recreation and Resources designation, residential density is limited to one unit permitted per 20 acres, and marinas, shooting ranges, duck and other hunting clubs, campgrounds, and other outdoor recreation complexes are allowed through issuance of a land use permit.

Williamson Act Contracts. Webb Tract currently has one parcel under a Williamson Act contract: False River Farms, a 139.2-acre parcel located along the southern portion of Webb Tract (Figure 3I-3).

Land Uses near Webb Tract. Webb Tract is bordered by the San Joaquin River to the north and east, False River and the flooded Franks Tract to the south, and Fishermans Cut to the west. Land use west of Webb Tract on Bradford Island is mainly agriculture with associated farmsteads and structures related to agricultural production. Boating facilities are located on the eastern shoreline of Bradford Island, facing toward Webb Tract. The CCCGP designation for all of Bradford Island is Delta Recreation and Resources (Figure 3I-2).

Land north of Webb Tract across the San Joaquin River is located in Sacramento County. This area has some shoreline development, but most land is in agricultural use with scattered farmsteads and other agriculture-related structures. Land use designations for this area are Recreational and Agricultural Cropland (Figure 3I-2).

Franks Tract, south of Webb Tract across False River, is a state recreation area. The flooded portion of Franks Tract is designated on the CCCGP map as a scenic waterway and the designation for land areas is Recreational. Franks Tract is used primarily for boating and other water-oriented recreation and has no extensively developed areas.

Bradford Island to the west has two parcels under Williamson Act contract totaling approximately 444.4 acres. As described previously, Mandeville Island southeast of Webb Tract is also under Williamson Act contract (Figure 3I-3).

Bouldin Island

Existing Uses and Ownerships. Approximately 76% of Bouldin Island is used for agriculture and produces mainly corn and wheat crops (Table 3I-1). Scattered agricultural structures and equipment complexes are located in the northern, central, and southern portions of the island. Several residences and associated farmstead structures are located north of SR 12. Two residences, one of which is currently occupied, are located south of SR 12 on the eastern side of the island. An airstrip used by crop-dusting operators is located west of these residences. An oil drilling pad is also located in this area. The island also has an old duck club that is unoccupied and is currently used for decoy storage and other similar uses. Bouldin Island is entirely owned by DW.

Zoning and General Plan Designations. The San Joaquin County zoning designation for Bouldin Island is AG-40. Permitted uses under AG-40 zoning are described above under "Bacon Island". As with Bacon Island, the SJCGP map shows the designation for Bouldin Island as AG (Figure 3I-2). The designation for land along sloughs and rivers is Open Space/Resource Conservation.

Williamson Act Contracts. The entire land area of Bouldin Island is under Williamson Act contracts, as shown in Figure 3I-3.

Land Uses near Bouldin Island. The Mokelumne River bounds Bouldin Island to the north and west, and Potato Slough bounds the island to the east and south. Land on islands surrounding Bouldin Island is used primarily for agricultural production. Scattered agricultural structures, equipment complexes, and a few rural residences are also interspersed throughout the vicinity.

Islands surrounding Bouldin Island are designated on the SJCGP map as AG. Land west and northwest of Bouldin Island and the Mokelumne River on Andrus and Tyler Islands is in Sacramento County. General plan designations for those lands in Sacramento County are Recreational and Agricultural Cropland (Figure 3I-2). Staten and Venice Islands, located north and south of Bouldin Island, respectively, are under Williamson Act contracts. Most parcels east of Bouldin Island are also under Williamson Act contracts (Figure 3I-3).

Holland Tract

Existing Uses and Ownership. Approximately 50% of Holland Tract is used for agriculture and produces mainly corn and wheat crops (Table 3I-1). Agricultural structures and equipment complexes are scattered along the southern and western perimeter levees. Onsite residences include a temporary trailer located in the northeast portion of the island near the levee bordering Holland Cut and two residences on the Solomon property in the western portion of the island. An abandoned hog feeding area is located east of the Solomon property residences. This area includes several structures ancillary to hog farming and untilled open space.

Two marinas are located at the southern boundary of Holland Tract on Rock Slough. The Lindquist Landing Marina on the southern boundary features boat docks and other structures ancillary to marina uses. The Holland Riverside Marina, at the southeastern corner of the island, is a large facility with numerous boat docks, covered slips, and ancillary marina uses.

DW owns the majority of Holland Tract parcels. DW does not own the Solomon parcel (857 acres) in the southwestern corner of the site, several small parcels adjacent to the Solomon parcel in the southwestern corner of the island, and the marina parcels along the southeastern perimeter of the island. The marina parcels, the Solomon parcel, and other small parcels would be excluded from Alternatives 1 and 2 (Figure 2-8).

Zoning and General Plan Designations. The Contra Costa County zoning designations for Holland Tract are General Agricultural District (A-2) and Heavy Agricultural District (A-3). Uses allowed under A-2 zoning were discussed above for Webb Tract. The A-3 zone allows uses that are similar to the uses allowed in A-2 zones, with the exception that parcels must consist of at least 10 acres. This designation specifically allows only owners or lessees to reside on the site.

The CCCGP designation for all of Holland Tract is Delta Recreation and Resources (Figure 3I-2).

Williamson Act Contracts. Holland Tract has no parcels under Williamson Act contracts (Figure 3I-3).

Land Uses near Holland Tract. Bethel Island northwest of Holland Tract has extensive shoreline development, consisting mainly of boat docks, marinas, single-family residences, and some retail businesses. General plan designations for this developed area are mainly Single-Family Residential High-Density, with a small amount of Commercial and Multifamily Residential uses permitted. Similar shoreline land uses exist on Hotchkiss Tract, on the western shore of Sand Mound Slough west of Holland Tract. Inland use of these adjacent islands is primarily for agriculture, with a limited amount of rural residential development.

Franks Tract State Recreation Area is north of Holland Tract. Land uses and designations on Franks Tract are discussed above under "Webb Tract" (Figure 3I-2).

Land uses south of Holland Tract on Veale and Palm Tracts are generally agricultural with some farmsteads and agricultural structures. Veale Tract is within the urban limit line for Contra Costa County, so a general plan amendment to rezone the island from agricultural to urban use may be considered in the next 20 years. The designation for most land southwest of Holland Tract is Delta Recreation and Resources (Figure 3I-2).

Palm Tract (approximately 2,554 acres), located south of Holland Tract, is entirely under Williamson Act contracts. As described previously, most of Bacon Island west of Holland Tract is also under contract (Figure 3I-3).

Agriculture Conditions

Bacon Island

Soils. Bacon Island soil types, as identified by the SCS soil survey for San Joaquin County, are presented in Table 3I-3.

Two soils compose an estimated 73% of Bacon Island, according to planimeter measurements of SCS preliminary soils maps. Rindge muck, partially drained with 0-2% slopes, is the dominant soil on Bacon Island, accounting for an estimated 2,547 acres, or 47% of total acreage. Kingile muck, partially drained with 0-2% slopes, accounts for an estimated 1,429 acres, or 26% of total acreage. Both soils have SCS land capability classifications of III, as do all soils on Bacon Island.

Major limitations of the Bacon Island soils include subsidence, a high water table, and slow permeability. Drainage and careful irrigation practices are required for the production of irrigated row and field crops on Bacon Island soils. Fields are irrigated through application of water through siphon pipes from sloughs and channels to a network of canals and ditches on the island. Drainage water is pumped out continually to prevent flooding by the rising water table that is caused by the constant hydrostatic pressure of the water outside the island levees. The shallow water table, in combination with the organic peat soils, creates a soil condition favorable to the outbreak of plant pathogens and destructive nematodes.

Land Production Capabilities. The soils on Bacon Island have been categorized by NRCS as Class III soils because of the limitations imposed by subsidence and high water table. Class III soils can be categorized by NRCS as prime if the soil limitations are easily solved by agricultural practices, as is often the case with drainage systems for Delta soils (Yoha pers. comm.). Virtually all of Bacon Island's soils have been classified as prime because of drainage practices implemented on the island. An estimated 125 acres of Itano silty clay loam have not been classified as prime (Table 3I-3).

CDC's draft IFM map for San Joaquin County indicates that virtually all the soils on Bacon Island are considered to represent prime farmland. Approximately 125 acres have been designated farmland of statewide importance (Table 3I-4).

San Joaquin County prepared its own prime farmland map as part of the open space/conservation element of its general plan (San Joaquin County Community Development Department 1992). San Joaquin County included all lands with SCS Class I and II ratings, as well as lands with Class III ratings and capability units of w2 and w10 (Table 3I-3), within its classification of prime farmlands. According to this definition, all lands on Bacon Island are considered by the county to be prime farmlands.

Crop History and Production Levels. Bacon Island is intensively managed as an agricultural operation by three major growers. A field survey in 1988 found the levees, roads, fields, and ditches to be well maintained. Natural and native vegetation is virtually absent, and virtually all tillable land is in crop production.

Over the past 30 years, a variety of crops have been grown on Bacon Island, including lettuce, corn, celery, carrots, potatoes, milo, asparagus, wheat, barley, onions, grapes, and sunflowers (Gianelli pers. comm.). Estimates of planted acreage are shown in Table 3I-5. As shown, potatoes, asparagus, and corn are the dominant crops produced on Bacon Island. Together, these three crops account for an estimated 78% of the 4,678 acres in agricultural use (including 347 acres of fallow land) on Bacon Island.

Table 3I-6 shows typical yield and production levels for the primary crops grown on Bacon Island based on planted acreage estimates for 1988. Crop acreages vary from year to year, depending on market conditions, the status of federal "set-aside" programs, and pest management concerns. Similarly, per-acre yields vary from season to season based on management practices and weather and pest conditions. The production estimates shown in Table 3I-6 indicate that Bacon Island typically produces the following percentages of the crops produced in San Joaquin County, based on 1987 countywide production levels in tons: corn, 1.3%; sunflower, 3.5%; asparagus (fresh), 7.6%; commercial potatoes, 91.9%; seed potatoes, 52.5%; and grapes (wine), 0.9% (San Joaquin County Office of the Agricultural Commissioner 1988).

Webb Tract

Soils. According to the Soil Survey of Contra Costa County (SCS 1977), Rindge muck is the dominant soil on Webb Tract, accounting for an estimated 4,415 acres (85%) of the island's 5,162 acres (Table 3I-3); Ryde silt loam is the second most common soil found on Webb Tract, accounting for 328 acres. All but an estimated 250 acres (5%) of the island's soils are categorized as Class III soils. Major limitations of the Webb Tract soils include a high water table, rapid permeability, and a moderate soil-blowing hazard. As on the other project islands, careful drainage and irrigation practices are required for the production of irrigated row and field crops.

Land Capabilities. NRCS has identified two Webb Tract soils as prime: Rindge muck and Ryde silt loam. Together, these two soils represent an estimated 4,743 acres (almost 92%) of the island's soils. The CDC IFM system has designated an estimated 4,725 acres on Webb Tract as prime farmland, 130 acres as farmland of statewide importance, and 294 acres as unique farmland (Table 3I-4).

Crop History and Production Levels. Webb Tract was primarily farmed by three growers in 1988. Similar to Holland Tract, and unlike Bacon and Bouldin Islands, Webb Tract has sand hills and upland habitat in its western half. In addition, two blowout ponds are found on Webb Tract, totaling an estimated 106 acres. An estimated 49% of the island is used for crop production, excluding 58 acres of pasture and 611 acres of fallow land.

Crops grown in recent years on Webb Tract include wheat, safflower, corn, and grain sorghum (DWR 1987). Only two crops, wheat and corn, were grown on Webb Tract in 1988 (Table 3I-5); corn was the largest crop grown on Webb Tract, occupying 2,128 acres, an estimated 65% of the island's agricultural acreage. In 1988, wheat was being grown on an estimated 426 acres (13%).

Table 3I-6 shows typical yields and production levels for the primary crops grown on Webb Tract based on planted acreage estimates for 1988. The production estimates shown in Table 3I-6 indicate that Webb Tract typically produces the following percentages of the crops produced in Contra Costa County, based on 1987 countywide production levels in tons: wheat (12.0%) and corn (60.1%) (Contra Costa County Department of Agriculture 1988).

Bouldin Island

Soils. Soils on Bouldin Island, as identified by the preliminary NRCS soil survey of San Joaquin County, are presented in Table 3I-3. Three soils account for an estimated 72% of the soils on Bouldin Island. Similar to Bacon Island, Rindge muck, partially drained, 0-2% slopes, is the dominant soil on Bouldin Island, accounting for an estimated 2,187 acres (38%) of the total acreage of Bouldin Island. Rindge mucky silt loam (0-2% slopes) and Retryde-Peltier complex (0-2% slopes) account for an estimated 19% and 15% of total acreage, respectively. All three soils have NRCS land capability classifications of III.

Major limitations of the Bouldin Island soils are similar to those found on Bacon Island, including subsidence, a high water table, and slow permeability. The discussion of Bacon Island soils describes necessary drainage practices for crop production on Bouldin Island.

Land Capabilities. All but 30 acres of Bouldin Island have been classified by NRCS as Class III soils. Class III soils are usually not considered prime by NRCS or CDC; however, appropriate drainage and irrigation practices may significantly reduce the limitations of the soil and lead to prime designations for some Class III soils. NRCS and CDC have classified all but 50 acres of Bouldin Island's farmlands as prime. An estimated 30 acres of Dello loamy sand have been designated as farmland of statewide importance (Table 3I-3).

The San Joaquin County prime farmlands map, discussed previously for Bacon Island, designates virtually all the soils located on Bouldin Island as prime.

Crop History and Production Levels. Similar to Bacon Island, Bouldin Island is intensively farmed and has well-maintained levees, roads, and ditches; however, adequate drainage is lacking in some areas of the island. Crops grown on Bouldin Island in recent years include wheat, safflower, corn, beans, sunflower, and tomatoes (DWR 1984). As shown in Table 3I-5, corn and wheat are the dominant crops grown on Bouldin Island. These two crops accounted for an estimated 69% of the island's agricultural acreage in 1988. Sunflowers accounted for an estimated 17% of the island's agricultural acreage in 1988.

Table 3I-6 shows typical yields and production levels for the primary crops grown on Bouldin Island based on planted acreage estimates for 1988. The production estimates shown in Table 3I-6 indicate that Bouldin Island typically produces the following percentages of the crops produced in San Joaquin County, based on 1987 countywide production levels in tons: wheat, 2.8%; corn, 4.7%; and sunflower, 16.2% (San Joaquin County Office of the Agricultural Commissioner 1988).

Holland Tract

Soils. Holland Tract soils, as identified by the Soil Survey of Contra Costa County (SCS 1977), are presented in Table 3I-3. Three soils account for an estimated 85% of Holland Tract's 4,031 acres: Rindge muck (34%), Piper loamy sand (28%), and Shima muck (23%). Unlike Bacon Island, Webb Tract, and Bouldin Island, Holland Tract has large areas of Class IV soils, including an estimated 1,108 acres of Piper loamy sand and 420 acres of Piper fine sandy loam. The remaining soils on Holland Tract are categorized as Class III soils. Major limitations of Holland Tract soils include a high water table, low available water capacity, rapid permeability, and moderate soil blowing.

Land Capabilities. NRCS has identified four of Holland Tract's soils as prime: Rindge muck, Ryde silt loam, Egbert mucky clay loam, and Webile muck. Together, these soils represent an estimated 1,556 acres (39%) of the island's soils. The CDC IFM system has designated a similar number of acres as prime on Holland Tract. As shown in Table 3I-4, under the IFM system an estimated 1,575 acres are designated as prime farmland; 2,031 acres are designated as farmland of statewide importance; and 426 acres are designated as unique farmland. Among the four DW project islands, Holland Tract contains the smallest amount of prime farmland.

Crop History and Production Levels. Holland Tract is the least intensively managed island of the four DW project islands. Island flooding, bankruptcies, and land ownership changes have led to neglect and poor agricultural practices on some parcels. In 1988, only 36% of the island was used for crop production, excluding 542 acres of pasture located primarily in the southwest corner of the island, where a year-round grazing operation is located.

Crops grown in recent years on Holland Tract include wheat, safflower, sugar beets, corn, grain sorghums, sunflower, and asparagus (DWR 1987). As shown in Table 3I-5, only three crops were grown on Holland Tract in 1988: wheat, corn, and asparagus. Wheat was the largest crop grown on Holland Tract, representing an estimated 30% of the island's agricultural acreage.

Table 3I-6 shows typical yields and production levels for the primary crops grown on Holland Tract based on planted acreage estimates for 1988. Holland Tract typically produces the following percentages of the crops produced in Contra Costa County, based on 1987 countywide production levels in tons: wheat, 23.5%; corn, 15.4%; and asparagus, 26.6% (Contra Costa County Department of Agriculture 1988).

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Assessment of Land Use Impacts

Land use impacts were assessed based on how construction and operation of the DW project alternatives would benefit or adversely affect existing residences and structures, adjacent land uses, and existing land uses. The DW project alternatives were also evaluated for their consistency with land use designations and policies of the county general plans and zoning ordinances, DPC regional policies, and Williamson Act contracts.

Local agencies were contacted to review potential land use conflicts or inconsistencies. Results of those communications are presented in the sections below on impacts and mitigation measures of the DW project alternatives.

Assessment of Agriculture Impacts

The agricultural resources impact analysis focuses on the conversion of agricultural land and related changes in agricultural production, employment, and income. Findings of significance were made only for the land conversion impacts; the resulting economic effects were evaluated to help determine the significance of the loss of agricultural land. The methodology used to assess agricultural economic effects is described in Chapter 3K, "Economic Conditions and Effects".

Agricultural land conversion impacts were evaluated through comparison between conditions under the DW project alternatives and point-of-reference conditions described in the "Affected Environment" section. Impacts of the DW project alternatives on agricultural resources were determined through estimation of the amount of agricultural land that would be converted to other uses with project implementation and through evaluation of the quality and productive capacity of the converted land, based on the LCC and IFM classification systems and crop yield estimates.

The extent of agricultural land conversion impacts depends on the amount of land on the DW project islands that would be converted to nonagricultural uses. Conversion impacts would begin during construction of project facilities and would continue during the life of the project, which is assumed to be 50 years.

The direct conversion of agricultural land caused by project implementation would not be irreversible. Most project lands could, at some time, be brought back into agricultural production through draining of the islands and clearing of riparian habitat that would be established under the DW project (Simpson pers. comm.). However, once the project is implemented, it may be difficult to return the land to its original state because of the establishment of riparian habitat on the reservoir islands during dry years and on the habitat islands year round (Elliott pers. comm.). Some lands converted for borrow sites and placement of permanent structures (e.g., siphons and pumps) may not be able to be reclaimed for agricultural use. For example, up to 385 acres may be used for borrow areas on the DW project islands over the life of the DW project. No plans are included in the DW project, however, to return DW project lands to agricultural production in the future.

The impact analysis prepared for this chapter evaluated a worst-case scenario by assuming that agricultural lands would be permanently removed from production by implementation of the DW project. This analysis also assumes as a "worst case" that the existing agricultural production conditions could continue indefinitely. In fact, most soils on the DW project islands are limited by subsidence and blowing hazards according to NRCS (SCS 1977, 1988; Simpson pers. comm.) (Table 3I-3). Continued subsidence of the island bottoms may eventually make agricultural production on these islands infeasible (DWR 1990) (see Chapter 3D, "Flood Control", for more detail on subsidence).

Criteria for Determining Impact Significance

The criteria used for determining significance of a land use or agricultural impact are based on the State CEQA Guidelines and professional standards. These criteria are described below.

Land Use Criteria

An alternative is considered to have a significant impact on land use if it would:

- displace existing residences and structures in areas where replacement housing is unavailable and landowners are not willing sellers,
- be incompatible with existing adjacent land uses,
- convert existing land use that involves an extreme change from one land use to a more intensive use,
- cause incompatibilities with existing Williamson Act contracts, or
- conflict with adopted and proposed plans and policies in the project area.

Impacts are considered less than significant if they do not meet any of the criteria listed above.

Agriculture Criteria

Under CEQA, a project will normally have a significant effect on the environment if it will convert prime agricultural land to nonagricultural use or impair the agricultural productivity of prime agricultural land. The State CEQA Guidelines and CEQA, however, do not contain a provision requiring a lead agency to determine whether conversion of nonprime agricultural land is a significant impact.

CEQA allows for economic and social impact discussions in an EIR when the severity of a related physical impact is being measured (i.e., when the physical impact's significance is being determined). By themselves, the economic effects resulting from farmland conversion are not considered significant impacts, and mitigation is not required for economic effects (Chapter 3K, "Economic Conditions and Effects"). Changes in agriculture-related employment and farm income were used only to evaluate the significance of conversion of both prime and nonprime farmlands located on the DW project islands.

Although an estimated 85% of the farmland on the DW project islands has been designated by NRCS and CDC as prime farmland, disagreement exists concerning the quality of island soils. According to the NRCS district conservationist in Stockton (Simpson pers. comm.):

> [The] conclusion is accurate [that the loss of prime agricultural land on the project islands is a significant adverse impact, based on] a strict interpretation of the criteria for prime farmland. However, soil scientists will debate whether peat soils truly fit the theme of the definition of prime farmland since the criteria [do] not specifically address a unique characteristic [of peat soils] - oxidation . . . . it is my opinion that the project does not cause a significant impact to the loss of prime agricultural land as stated.

This opinion, however, does not consider the indirect economic effects that could result from the conversion of DW project island farmlands.

Evaluation of the significance of the farmland conversion impact is further complicated by the fact that the conversion may not be irreversible and that subsidence would continue to impair the productivity of these lands if agricultural uses were to resume in the future.

Although these factors may reduce the severity of the conversion impacts, the conversion of agricultural lands on the DW project islands would be considered a significant impact if:

- agricultural lands on the islands would be retired from production on a long-term basis;
- the conversion of prime and nonprime farmlands on the project islands would result in a substantial loss of jobs and income in agriculture-dependent industries in San Joaquin and Contra Costa Counties; and
- the amount of agricultural land converted by the project, at least temporarily, would be substantial.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands) and management of Bouldin Island and Holland Tract (habitat islands) primarily for wetlands and wildlife habitat. The reservoir islands would be managed primarily for water storage, with wildlife habitat and recreation constituting secondary uses.

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on land use and agriculture presented below assumes that the recreation facilities would be constructed and operated. The information presented in this chapter provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Changes in Land Use Conditions

Bacon Island

Displacement of Residences and Structures. Implementation of Alternative 1 would convert onsite agricultural land uses to water storage operations. This change would require removal or relocation of existing onsite structures and farmsteads on Bacon Island. The major agricultural structures and rural residences on the site are located near the perimeter levees. The structures below the high water level would need to be moved or demolished. Major alteration of the levee interiors could also warrant removal of all agricultural structures and residences adjacent to or on the levees.

For the elimination or relocation of approximately 20 residences, six farm worker barracks, and other agricultural structures, the affected landowners have been or would be compensated for their property as willing sellers. Housing opportunities in the local area are considered sufficient for those affected to be housed.

Conflicts with Adjacent Land Uses. Storage of water and associated recreational uses on Bacon Island would not adversely affect adjacent land uses because the island is buffered by levees and surrounding waterways (see Chapter 3D, "Flood Control", for more detail on levee structure). Thus, implementation of Alternative 1 is not expected to create nuisances that could affect or impair offsite agricultural or nonagricultural land uses.

Implementation of Alternative 1 without appropriate remedial measures could result in flooding of adjacent lands due to seepage from Bacon Island onto surrounding islands. However, DW proposes seepage control measures, including interceptor wells, as part of Alternative 1. As addressed in Chapter 3D, "Flood Control", mitigation has been recommended to reduce significant seepage impacts on neighboring islands to a less-than significant level under Alternative 1.

Effect on Williamson Act Contracts. San Joaquin County has preliminarily determined that Alternative 1 is consistent with the goals of the Williamson Act (Davisson pers. comm.). Submerged areas are considered "agricultural lands" in San Joaquin County under the Williamson Act. Therefore, Alternative 1 would not result in impacts on Williamson Act contract lands on Bacon Island.

Consistency with Zoning and General Plan Designations. Implementation of Alternative 1 would require a development plan for construction of recreation facilities in the AG-80 zone on Bacon Island. The San Joaquin County Department of Planning and Building Inspection staff members could approve the permit if they determine, after reviewing the site and building floor plans, that recreational use of the site is consistent with continued agricultural use (Davisson pers. comm.).

For Alternative 1 to be allowed under the current zoning, the board of supervisors must determine that water storage on Bacon Island is consistent with uses allowed in the AG-80 zone and consistent with uses permitted under zoning ordinance Sections 9-2352 and 9-4005.1. San Joaquin County has preliminarily determined that because Alternative 1 is consistent with the open space and conservation policies of the general plan, the project would be permitted in the AG-80 zone. (Davisson pers. comm.) Therefore, Alternative 1 would not result in impacts on existing zoning and general plan designations.

All four DW project islands are located in the "primary zone" as defined in the Delta Protection Act (Figure 3I-1). The proposed water storage on Bacon Island is consistent with the intent of the Delta Protection Act; Section 29760(b) of the Delta Protection Act directs that the regional plan accomplish the following:

> Permit water reservoir and habitat development that is compatible with other uses.
>
> Preserve and protect riparian and wetlands habitat, and promote and encourage a net increase in both the acreage and values of the resources on public lands and through voluntary cooperative arrangements with private property owners.
>
> Preserve and protect open-space and outdoor recreational opportunities.

Therefore, Alternative 1 is consistent with the Delta Protection Act.

Consistency with General Plan Principles. San Joaquin County's conservation principles encourage protecting and utilizing agricultural resources, supporting intensive agricultural uses, prohibiting fragmentation of agricultural land outside urban expansion areas, and encouraging the implementation of Williamson Act land conservation programs.

San Joaquin County has preliminarily determined that Alternative 1 is consistent with the open space/conservation element of the SJCGP because the project would provide open space, water storage, water supply, and wetlands and fish and wildlife habitat in the county. The SJCGP open space/conservation element is implemented through the AG land use designation. Alternative 1 is considered consistent with the SJCGP principles (Table 3I-7). (Davisson pers. comm.)

An analysis of the consistency of the project with the DPC's Land Use and Resource Management Plan for the Primary Zone of the Delta (Delta Protection Commission 1995) is also included in Table 3I-7. Implementation of the DW project would remove agricultural land on prime soil from production; therefore, the project is not consistent with the DPC's environmental and agriculture principles (Environmental Principle P-1 and Agriculture Principle P-1, Table 3I-7) that direct that the priority land use of areas of prime soil be agriculture. Also, the DPC plan directs that expansion of existing private water-oriented commercial recreational facilities be encouraged over construction of new facilities (Recreation Principle P-2, Table 3I-7); the construction of the new recreation facilities on the DW project islands may be inconsistent with this goal. Although the construction of the recreation facilities has been removed from the proposed project for purposes of the current CWA application, the evaluation of consistency with general plan principles in Table 3I-7 assumes that the recreation facilities would be built and operated. This information provides readers with a complete record of the environmental analysis; it may be used in any subsequent environmental assessment of the recreation facilities.

Webb Tract

Displacement of Residences and Structures. Implementation of Alternative 1 would require relocation or removal of two trailers in the northern portion of Webb Tract, one trailer in the island interior, and the Dinelli residence in the southern portion of the island. The need for removal of residences and structures would result from the proposed reservoir uses or from the proposed levee improvements. The clubhouse on the eastern tip of the island is sited above the proposed high water level and could remain onsite. The affected landowners have been compensated for their property as willing sellers. Housing opportunities in the local area are considered sufficient for those affected to be housed.

Conflicts with Adjacent Land Uses. Storage of water and associated recreational uses on Webb Tract would not adversely affect adjacent land uses because the island is buffered by levees and surrounding waterways (see Chapter 3D, "Flood Control", for more detail on levee structure). Thus, as with Bacon Island, the Webb Tract portion of Alternative 1 would not affect or impair offsite agricultural or nonagricultural land uses.

Implementation of Alternative 1 without appropriate remedial measures could result in flooding of adjacent lands due to seepage from Webb Tract onto surrounding islands. However, DW proposes seepage control measures, including interceptor wells, as part of Alternative 1. As addressed in Chapter 3D, "Flood Control", implementation of Alternative 1 will result in less-than-significant seepage impacts on neighboring islands.

Effect on Williamson Act Contracts. Contra Costa County has preliminarily determined that the water component of Alternative 1 is consistent with the current Williamson Act contract and the existing agricultural use (Drake pers. comm.). Water storage is a compatible use under the Williamson Act. Therefore, Alternative 1 would be compatible with the existing Williamson Act contract on Webb Tract.

Consistency with Zoning and General Plan Designations. Alternative 1 would be consistent with the CCCGP Delta Recreation and Resource land use designation that allows for wildlife habitat and limited recreation. DW would likely need to obtain a land use permit prior to project implementation to construct recreation facilities. Contra Costa County has not completed rezoning the property in this area and would possibly, in cooperation with DW, rezone the property to P-1, public use. P-1 zoning would be consistent with the general plan and with the uses proposed under Alternative 1 (Drake pers. comm.). Further P-1 rezoning would be related solely to the construction and use of the recreation facilities. Lands zoned A-4 would remain in this district as Williamson Act lands. Therefore, water storage on Webb Tract would be consistent with the zoning and general plan designations on the island.

Webb Tract is in the Delta Protection Act "primary zone". The proposed water storage on Webb Tract would be consistent with the intent of the Delta Protection Act to permit water reservoir and habitat development that is compatible with other uses, as described above for Bacon Island.

Consistency with General Plan Principles. Implementation of Alternative 1 would be consistent with the open space and wildlife goals and policies of the CCCGP. However, Alternative 1 is not consistent with the county's agriculture policy to encourage and enhance agriculture, and to maintain and promote a healthy and competitive agricultural economy (Policy 8-G, Table 3I-7). Although the inherent agricultural productivity of the islands would not significantly change as a result of the use of agricultural land for water storage (see "Changes in Agriculture Conditions" below), implementation of Alternative 1 would remove agricultural land in Contra Costa County from production, which is not consistent with this policy. Implementation of Alternative 1 would not be inconsistent with Policy 8-H, which encourages the preservation of prime agricultural land (Table 3I-7) because Contra Costa County does not consider Webb Tract's Class III and IV soils to represent prime farmland.

As described above for Bacon Island, the DW project is inconsistent with some principles outlined in the DPC's Land Use and Resource Management Plan for the Primary Zone of the Delta (Delta Protection Commission 1995); see Table 3I-7 for more information.

Bouldin Island

Displacement of Residences and Structures. Implementation of Alternative 1 would not require removal or relocation of existing onsite structures and farmsteads on Bouldin Island. Structures would not be removed under the HMP, but current property owners would be displaced by the change in land use on the island from agriculture to habitat management. The affected landowners have been or will be compensated for their property as willing sellers.

Conflicts with Adjacent Land Uses. Habitat management on Bouldin Island and associated recreational uses would not adversely affect adjacent land uses because the island is buffered by levees and surrounding waterways. Thus, Alternative 1 is not expected to create substantial nuisances that could affect or impair offsite agricultural or nonagricultural land uses.

Effect on Williamson Act Contracts. Based on a preliminary evaluation by San Joaquin County, Alternative 1 would be consistent with the open space preservation goals of the Williamson Act and is consistent with the SJCGP open space/conservation element and AG land use designation (Davisson pers. comm.). Therefore, Alternative 1 would have no effect on Williamson Act contracts.

Consistency with Zoning and General Plan Designations. San Joaquin County preliminarily determined that open space retention and habitat management on Bouldin Island are consistent with the SJCGP open space/conservation element and the AG land use designation. The County also determined that although not specifically mentioned under the AG-40 zoning definition, the open space value of implementing the HMP is consistent with the intent of the agricultural zoning and would be permitted in the AG-40 zone. (Davisson pers. comm.). Therefore, Alternative 1 is considered consistent with zoning and general plan designations.

Bouldin Island is in the Delta Protection Act "primary zone" (Figure 3I-1). The proposed habitat management on Bouldin Island is consistent with the intent of the Delta Protection Act to permit water reservoir and habitat development that is compatible with other uses, preserves and protects riparian and wetlands habitat, and preserves and protects open space and outdoor recreation opportunities.

Consistency with General Plan Principles. San Joaquin County has preliminarily determined that Alternative 1 is consistent with the open space/conservation element of the SJCGP, which is implemented through the AG land use designation, because it retains valuable open space values and encourages the multiple uses of open space (Davisson pers. comm.). Therefore, Alternative 1 is considered consistent with the SJCGP principles (Table 3I-7).

As described above for Bacon Island, the DW project is inconsistent with some principles outlined in the DPC's Land Use and Resource Management Plan for the Primary Zone of the Delta (Delta Protection Commission 1995); see Table 3I-7 for more information.

Holland Tract

Displacement of Residences and Structures. Implementation of Alternative 1 would not require relocation or removal of existing structures on Holland Tract. Some existing structures would be used for maintenance and operation facilities. Some current property owners within the project area on Holland Tract would be displaced by the change in use of the island from agriculture to habitat management. Lindquist Landing Marina, the Holland Riverside Marina, and the land on the southwest portion of the island would not be within the project area. Any affected landowners have been or will be compensated for their property as willing sellers.

Conflicts with Adjacent Land Uses. Habitat management on Holland Tract and associated recreation uses would not adversely affect adjacent land uses because the island is buffered by levees and surrounding waterways. Thus, Alternative 1 is not expected to create nuisances that could affect or impair offsite agricultural or urban land uses.

Consistency with Zoning and General Plan Designations. The habitat management aspect of Alternative 1 is consistent with the CCCGP Delta Recreation and Resources land use designation. A land use permit for construction of the proposed recreation facilities would be required prior to project implementation. Alternative 1 is considered consistent with the agricultural zoning on Holland Tract because the project would provide uses compatible with agriculture. However, further review and interpretation by the county staff would be required when an application is submitted by DW (Drake pers. comm.). Preliminary evaluation of the land use designations indicates that Alternative 1 would be consistent with current designations. The project would also be consistent with the proposed P-1 zoning as described above for Webb Tract.

Holland Tract is located in the Delta Protection Act "primary zone" (Figure 3I-1). The proposed habitat management on Holland Tract is consistent with the intent of the Delta Protection Act to permit water reservoir and habitat development that is compatible with other uses, preserves and protects riparian and wetlands habitat, and preserves and protects open space and outdoor recreation opportunities.

Consistency with General Plan Principles. Implementation of Alternative 1 would be consistent with the open space and wildlife goals and policies of the CCCGP because Holland Tract would be managed for wildlife habitat (Table 3I-7). However, Alternative 1 is not consistent with the county's agriculture policy to encourage and enhance agriculture, and to maintain and promote a healthy and competitive agricultural economy (Policy 8-G, Table 3I-7). Although the inherent agricultural productivity of the islands would not significantly change as a result of the use of agricultural land for habitat management (see "Changes in Agriculture Conditions" below), implementation of Alternative 1 would remove agricultural land in Contra Costa County from production, which is not consistent with this policy. Implementation of Alternative 1 would not be inconsistent with Policy 8-H, which encourages the preservation of prime agricultural land (Table 3I-7) because Contra Costa County does not consider Holland Tract's Class III and IV soils to represent prime farmland.

As described above for Bacon Island, the DW project is inconsistent with some principles outlined in the DPC's Land Use and Resource Management Plan for the Primary Zone of the Delta (Delta Protection Commission 1995); see Table 3I-7 for more information.

Summary of Project Impacts and Recommended Mitigation Measures

Impact I-1: Displacement of Residences and Structures on Reservoir Islands. Implementation of Alternative 1 would convert onsite agricultural land uses to water storage operations on Webb Tract and Bacon Island. This change would require removal or relocation of existing onsite structures and farmsteads on Bacon Island and Webb Tract. The affected landowners have been or will be compensated for their property as willing sellers, and housing opportunities in the local area are considered sufficient for those affected to be housed. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact I-2: Displacement of Property Owners on Habitat Islands. Implementation of Alternative 1 would not remove structures under the HMP for Bouldin Island and Holland Tract, but current property owners would be displaced by the change in use of the island from agriculture to habitat management. The affected landowners have been or will be compensated for their property as willing sellers. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact I-3: Inconsistency with Contra Costa County General Plan Policy for Agricultural Lands and Delta Protection Commission Land Use Plan Principles for Agriculture and Recreation. Implementation of Alternative 1 would convert 6,300 acres of farmland on Webb and Holland Tracts to water storage and habitat uses, respectively. This conversion, and subsequent loss of agricultural production, is not consistent with the county's and the DPC's agricultural principle to maintain and promote a healthy and competitive agricultural economy (Table 3I-7). Although the inherent agricultural productivity of the islands would not be significantly changed by the use of agricultural land for water storage or habitat management, the proposed use is not consistent with these general plan principles. Additionally, the construction of the new recreation facilities on the DW project islands may be inconsistent with the DPC's recreation principle for private water-oriented commercial recreational facilities (Table 3I-7). This impact is considered significant and unavoidable.

Mitigation. No mitigation is available to reduce this impact to a less-than-significant level.

Changes in Agriculture Conditions

Bacon Island

Implementation of Alternative 1 would convert an estimated 5,403 acres of Class III soils on Bacon Island to nonagricultural use (Table 3I-4). NRCS and CDC have designated all but 125 acres of soil on Bacon Island as prime farmland. An estimated 4,331 acres, excluding 347 acres of short-term fallow land (land that is included as part of a crop rotation plan) were in agricultural use on Bacon Island in 1988. This land represented an estimated 0.7% of harvested acreage in San Joaquin County in 1987 (San Joaquin County

Office of the Agricultural Commissioner 1988). Over the long term, agricultural production on the island may become infeasible even without DW project implementation because of subsidence and resulting increased likelihood of levee failure (DWR 1988).

Agricultural land conversion on Bacon Island would result in the loss of agricultural production on Bacon Island. Estimated crop production on Bacon Island, based on planted acreage in 1988, is shown in Table 3I-6. (See Chapter 3K, "Economic Conditions and Effects", for a discussion of the value of the island's agricultural production.)

As discussed in the "Affected Environment" section, Bacon Island produced virtually all of San Joaquin County's commercial potato crop (91.9%, based on countywide production levels), as well as large percentages of its seed potato (52.5%) and asparagus (7.6%) crops in 1987. The loss of Bacon Island's agricultural production would substantially reduce the countywide production of these crops.

Webb Tract

Implementation of Alternative 1 would convert an estimated 4,912 acres of Class III soils and 250 acres of Class IV soils on Webb Tract to nonagricultural uses. Under the CDC IFM system, an estimated 4,725 acres on Webb Tract are designated as prime farmland (Table 3I-4). In addition, 130 acres have been designated as farmland of statewide importance, and 294 acres have been designated as unique farmland. Implementation of Alternative 1 would convert these lands to nonagricultural uses.

An estimated 2,638 acres, excluding 611 acres of short-term fallow land, were in agricultural use on Webb Tract in 1988. This land represented an estimated 1.3% of acreage harvested in Contra Costa County in 1987 (Contra Costa County Department of Agriculture 1988).

DWR (1988) has identified Holland and Webb Tracts as critical for Delta water quality protection and seeks to reduce agricultural production on these and six other west Delta islands to minimize further subsidence and island flooding hazards. Thus, from the flooding hazard perspective, reduction of cultivated agricultural land on Webb and Holland Tracts may be considered a benefit over the long term. DWR (1990) has judged that loss of cultivated agriculture is inevitable on nearby Sherman Island because of island subsidence and that such loss is more than offset by flood control and wildlife benefits of slowing the rate of subsidence (see Chapter 3D, "Flood Control", for more detail on subsidence and flood control).

Agricultural land conversion would result in the loss of agricultural production on Webb Tract. In 1987, Webb Tract produced 60.1% of Contra Costa County's corn crop and 12.0% of the county's wheat crop. The loss of Webb Tract's agricultural production would substantially reduce the countywide production of these crops.

Bouldin Island

Implementation of Alternative 1 would convert much of Bouldin Island to nonagricultural uses (i.e., wildlife habitat). An estimated 3,864 acres of Class III soils and 30 acres of Class IV soils on Bouldin Island would be converted to nonagricultural uses. (The remaining 1,867 acres of farmland on Bouldin Island would be kept in agricultural use, as described below.) The 3,864 acres of Class III soils that would be converted under Alternative 1 are considered prime farmland by NRCS and CDC.

An estimated 4,395 acres, excluding 685 acres of short-term fallow land, are currently in agricultural use on Bouldin Island. Implementation of Alternative 1 would preempt agricultural production on 3,213 acres (including an estimated 2,780 planted acres and 433 fallowed acres). Under Alternative 1, some portions of Bouldin Island would be planted in grain crops to enhance wildlife habitat. As shown in Table 3I-8, an estimated 1,867 acres would be planted in corn, wheat, barley, and pasture for wildlife habitat, with an estimated 1,195 acres harvested for sale (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

The sale of grain crops planted for wildlife habitat would partially offset the loss of agricultural production on Bouldin Island; however, crop production on the island would be reduced by implementation of Alternative 1. The effect of this alternative on crop production on Bouldin Island includes the net loss of an estimated 2,506 tons of wheat, 7,435 tons of corn, and 770 tons of sunflowers, and the net gain of an estimated 27 tons of barley and 119 acres of harvested pasture. The crop reductions represent 16.2% of San Joaquin County's sunflower crop (based on 1987 countywide production levels), 3.1% of the county's corn crop, and 2.2% of the county's wheat crop. The crop gains would represent a 1.8% increase in the county's barley crop and a 0.4% increase in the county's supply of irrigated pasture.

Holland Tract

Under Alternative 1, portions of Holland Tract would be excluded from the project. Nonproject areas on Holland Tract would include marina properties, the 857-acre Solomon parcel, 263 acres of irrigated pasture, and several small parcels along the levee held by outside interests. An estimated 1,179 acres on Holland Tract within the project area would be planted in grain crops to enhance wildlife habitat, with an estimated 741 acres would be harvested for sale (Table 3I-8).

Implementation of Alternative 1 would convert an estimated 1,733 acres of agricultural soils to nonagricultural uses (excluding 1,120 nonproject acres and 1,179 acres planted in habitat crops). An estimated 1,162 acres of land designated as prime farmland in the CDC IFM system would be converted to nonagricultural uses on Holland Tract under Alternative 1. Additionally, an estimated 357 acres of farmland of statewide importance and 214 acres of unique farmland would be converted under Alternative 1.

An estimated 2,005 acres, excluding 745 acres of short-term fallow land, were used for agriculture on Holland Tract in 1988. An estimated 1,120 of these acres are in the nonproject portion of Holland Tract. Implementation of Alternative 1 would preempt agricultural production on 451 acres (including an estimated 316 planted acres and 135 fallowed acres) and change cropping patterns on much of the remaining farmland within the project area on Holland Tract. As on Bouldin Island, some portions of Holland Tract would be planted in grain crops to enhance wildlife habitat. As shown in Table 3I-8, an estimated 1,179 acres would be planted in corn, wheat, barley, and pasture for wildlife habitat, with an estimated 741 acres harvested for sale.

The harvest and sale of grain crops planted for wildlife habitat would partially offset the loss of agricultural production on Holland Tract; however, crop production on the island would be reduced by implementation of Alternative 1. The effect of this alternative on crop production on Holland Tract includes the net loss of an estimated 374 tons of wheat, 396 tons of asparagus, and 118 acres of harvested pasture, and the net gain of 132 tons of corn and 40 tons of barley. The crop reductions represent 5.3% of Contra Costa County's wheat crop (based on 1987 countywide production levels), 14.7% of the county's asparagus crop, and 2.2% of the county's irrigated pasture. The crop gains would represent a 1.0% increase in the county's corn crop and a 5.2% increase in the county's barley crop.

As described above for Webb Tract, reducing the amount of cultivated agricultural land on Holland Tract may be considered a long-term benefit from a flooding hazard perspective in the west Delta.

Summary of Project Impacts and Recommended Mitigation Measures

Impact I-4: Direct Conversion of Agricultural Land. Implementation of Alternative 1 would convert approximately 16,180 acres of agricultural land, including an estimated 10,065 acres of harvested cropland and pasture, 1,525 acres of short-term fallowed land, and 4,590 acres of long-term idled lands, to nonagricultural uses on the four DW project islands combined. (This total excludes 1,120 acres of nonproject land on Holland Tract and 3,046 acres that would be planted in grains on Bouldin Island and Holland Tract for wildlife habitat.) This impact is considered significant and unavoidable based on the following considerations:

- The conversion of 10,065 harvested acres of agricultural land represents approximately 1.9% of the 535,800 harvested acres (excluding nonirrigated grazing lands) in Contra Costa and San Joaquin Counties in 1987.

- Based on current conditions and management practices, an estimated 15,029 of the 16,180 converted acres have been designated as prime farmland by CDC. This acreage represents 3.1% of the estimated 480,600 acres of prime farmland within the two counties in 1990 (CDC 1992). Additionally, the converted acreage includes an estimated 642 acres designated as farmland of statewide importance and 508 acres designated as unique farmland by CDC.

This conversion of Delta islands to noncultivated uses may be viewed as a benefit because it slows rate of soil loss by reducing the rate of peat oxidation and subsidence problems on reservoir islands over the life of the project; however, under the project, agricultural lands would be retired from production for at least 50 years and there is no certainty that the project islands would be returned to agricultural production at the end of the project.

Alternative 1 would eliminate significant proportions of countywide production of certain agricultural crops in San Joaquin and Contra Costa Counties. On Bacon Island, the project would eliminate 92% of countywide potato production and 53% of countywide seed potato production (based on 1987 production levels) in San Joaquin County. On Bouldin Island, the project would eliminate 16% of San Joaquin County's sunflower crop. On Holland and Webb Tracts in Contra Costa County, Alternative 1 would eliminate the following percentages (net) of countywide production of three crops (based on 1987 production levels): corn, 59%; wheat, 17%; and asparagus, 15%. Although specific effects on individual businesses have not been evaluated as part of this analysis, the proportional extent of these reductions indicates that agricultural service providers may be affected by production reductions related to project implementation.

Implementation of Alternative 1 would substantially reduce statewide production of two crops, as shown in Table 3I-9. Percentages of sunflower seed for human consumption (31.8%) and seed potatoes (41.2%) grown on the DW islands in 1988 were substantial and would be reduced by project implementation. DW island contributions of the other crops grown on the island were less than 4% of statewide production. For all crops, yields per acre were less on the four project islands in 1988 than the statewide averages.

Loss of production on the four project islands would reduce agricultural employment and income in Contra Costa and San Joaquin Counties, as described in Chapter 3K, "Economic Conditions and Effects". An estimated 290 direct and secondary jobs would be lost in the two counties as a result of project implementation. Most of these jobs would be in the agricultural production and services and food processing sectors. Although the jobs lost would represent a small fraction of the 443,900 jobs in Contra Costa and San Joaquin Counties in 1988, the displaced employment would represent an estimated 1.6% of the agricultural production and service jobs in the two counties in 1988 (California Employment Development Department 1991). Although project construction, operations, and maintenance employment generated by the project would offset this loss, most of the project-related job losses would be in the agricultural sector and in sectors that supply agricultural goods and services. Project-related job growth probably would not offset losses in these specific sectors.

Even though DW project islands could conceivably be returned to agricultural production, the assumed 50-year disruption of production would likely result in permanent effects on employees and industries currently providing services to the project islands. These businesses include agricultural chemical dealers and pesticide applicators, and irrigation equipment and maintenance businesses (Hudson pers. comm.). CEQA and NEPA allow economic effects to be considered when the significance of physical impacts, such as the conversion of agricultural land, is considered (see Chapter 3K).

Mitigation. No reasonable mitigation is available to reduce this impact to a less-than-significant level. It is extremely unlikely that a similar amount of land in the region with similar qualities and productivity could be brought into production to mitigate the effects resulting from the loss of agricultural use of lands on the DW project islands discussed above. Counties in the region of the project are generally losing farmland faster than new land is being brought into production. For example, between 1986 and 1988, approximately 2,600 acres of cropland in Contra Costa County were converted to urban and other uses, while 450 acres of grazing lands and other nonagricultural lands were converted to cropland (CDC 1990). Reclaiming DW project lands to agricultural uses at the conclusion of the project would reduce the long-term impacts on agricultural land and production but would not reduce short-term losses of agricultural production, employment, and income occurring over the 50-year life of the project.

Although DW would not control the use of water discharged from the project islands once it is sold, one of the potential uses of the exported water is for agriculture elsewhere in the state. Also, water from DW project operations sold for urban and environmental uses could reduce or delay losses of water from the agricultural sector that would otherwise be used to fulfill those urban and environmental water needs. These general benefits of Alternative 1 to the agricultural sector, however, would not be guaranteed or continuous. Therefore, intermittent benefits such as these are not a viable mitigation and would not offset the impact of converting agricultural lands on the DW project islands.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Changes in Land Use Conditions

Impacts on land use, including effects on Williamson Act contracts, displacement of existing dwelling units, and consistency with relevant plans and policies, and mitigation measures of Alternative 2 are the same as those of Alternative 1.

Changes in Agriculture Conditions

Impacts on agricultural resources, including agricultural land conversion, production losses, and economic effects, and mitigation measures of Alternative 2 are the same as those of Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage.

Changes in Land Use Conditions

Bacon Island and Webb Tract

The effect of implementation of Alternative 3 on land use for Bacon Island and Webb Tract is the same as that of Alternative 1.

Bouldin Island and Holland Tract

Displacement of Residences and Structures. Flooding Bouldin Island and Holland Tract under Alternative 3 would result in the displacement of residences and structures on those islands. This impact is similar to that described above for Bacon Island and Webb Tract under Alternative 1. The affected landowners have been or would be compensated for their property as willing sellers. Housing opportunities in the local area are considered sufficient for those affected to be housed.

Conflicts with Adjacent Land Uses. Water storage on Holland Tract and water storage and habitat management on Bouldin Island would not adversely affect adjacent land uses as described for Bacon Island and Webb Tract under Alternative 1.

Effect on Williamson Act Contracts. Williamson Act contracts on Bouldin Island would not be affected by water storage use on the south side of SR 12 as described for Bacon Island and Webb Tract under Alternative 1. As described for habitat management on Bouldin Island for Alternative 1, the NBHA north of SR 12 under Alternative 3 would not affect Williamson Act contracts.

Consistency with Zoning and General Plan Designations and Principles. As described for Bacon Island and Webb Tract, water storage on Bouldin Island and Holland Tract would be considered consistent with zoning and general plan designations in San Joaquin and Contra Costa Counties. Habitat management on Bouldin Island north of SR 12 would be consistent with plans and policies as described under Alternative 1.

Water storage on Bouldin Island and Holland Tract would be consistent with the Delta Protection Act. Water storage on Bouldin Island would be consistent with the SJCGP principles as described for Bacon Island. Conversion of farmland to water storage on Holland Tract would be inconsistent with the CCCGP agricultural policy (Policy 8-G) concerning the maintenance and promotion of a healthy and competitive agricultural economy (Table 3I-7). Conversion of farmland and construction of new private recreation facilities is inconsistent with agriculture and recreation principles outlined in the DPC's Land Use and Resource Management Plan for the Primary Zone of the Delta (Table 3I-7).

Summary of Project Impacts and Recommended Mitigation Measures

Impact I-5: Displacement of Residences and Structures on Reservoir Islands. Implementation of Alternative 3 would convert onsite agricultural land uses to water storage operations on all four DW project islands. This change would require removal or relocation of existing onsite structures and farmsteads. The affected landowners have been or would be compensated for their property as willing sellers, and housing opportunities in the local area are considered sufficient for those affected to be housed. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact I-6: Inconsistency with Contra Costa County General Plan Policy for Agricultural Lands and Delta Protection Commission Land Use Plan Principles for Agriculture and Recreation. Implementation of Alternative 3 would convert 6,300 acres of prime agricultural land on Webb and Holland Tracts to water storage use. This conversion is not consistent with the county's and the DPC's agricultural principles to preserve prime agricultural lands for agricultural production and promote a competitive agricultural economy (Table 3I-7). Although the inherent agricultural productivity of the islands would not be significantly changed by use of prime agricultural land for water storage, the proposed use is not consistent with these general plan principles. Additionally, the construction of the new recreation facilities on the DW project islands may be inconsistent with the DPC's recreation principle for private water-oriented commercial recreational facilities (Table 3I-7). This impact is considered significant and unavoidable.

Mitigation. No mitigation is available to reduce this impact to a less-than-significant level.

Changes in Agriculture Conditions

Impacts on agricultural resources, including agricultural land conversion, production losses, and economic effects would be greater under this alternative than under Alternative 1. Under Alternative 3, no crops would be planted on Bouldin Island and Holland Tract as part of an HMP; therefore, agricultural resource impacts caused by land conversion on these islands would not be offset by agricultural production associated with habitat management as under Alternative 1. Additionally, the 1,120 acres on Holland Tract excluded from the project under Alternatives 1 and 2 would be converted to water storage uses under Alternative 3.

Agricultural resource impacts of Alternative 3 on Bacon Island and Webb Tract are the same as those described previously for Alternative 1.

Implementation of Alternative 3 would result in conversion to nonagricultural uses of an estimated 5,761 acres of agricultural land on Bouldin Island, including 5,711 acres designated by CDC as prime farmland (Table 3I-4). Conversion of agricultural land would result in the loss of agricultural production from an estimated 4,395 acres under cultivation in 1988 (this total does not include 685 acres of short-term fallow land) (Table 3I-6). Bouldin Island produces 16.2% of San Joaquin County's sunflower crop (based on 1987 countywide production levels), 4.7% of the county's corn crop, and 2.8% of the county's wheat crop. All agricultural production on Bouldin Island would be lost under Alternative 3.

Implementation of Alternative 3 would result in conversion to nonagricultural uses of an estimated 4,032 acres of agricultural soils on Holland Tract, including 1,575 acres designated by CDC as prime farmland (Table 3I-4). Conversion of agricultural land would result in the loss of agricultural production from an estimated 2,005 acres under cultivation in 1988 (this total does not include an estimated 745 acres of short-term fallowed land but includes 1,120 acres of land excluded from project use under Alternatives 1 and 2). The lost agricultural production on Holland Tract would include an estimated 23.5% of Contra Costa County's wheat crop (based on 1987 production levels), 15.4% of the county's corn crop, 26.6% of the county's asparagus crop, and 10.4% of the county's irrigated pasture.

Under Alternative 3, DW may be required to mitigate habitat losses on DW project islands by leasing or purchasing offsite lands for habitat creation or protection. This offsite mitigation could result in the conversion of an unknown amount of agricultural land.

Summary of Project Impacts and Recommended Mitigation Measures

Impact I-7: Direct Conversion of Agricultural Land. Implementation of Alternative 3 would convert to nonagricultural uses an estimated 20,345 acres of agricultural land on the four DW project islands combined, including an estimated 13,369 acres of harvested cropland and pasture, 2,388 acres of short-term fallowed land, and 4,590 acres of long-term idled lands.

The direct conversion of agricultural land on the project islands includes conversion of an estimated 17,414 acres of land designated as prime farmland by CDC. This acreage represents 3.6% of the estimated 480,600 acres of prime farmland in the two counties in 1990 (CDC 1992). Additionally, the converted acreage includes an estimated 2,211 acres designated as farmland of statewide importance and 720 acres designated as unique farmland by CDC.

The conversion of 13,369 harvested acres of agricultural land represents conversion of approximately 2.5% of the 535,800 harvested acres (excluding nonirrigated grazing lands) in Contra Costa and San Joaquin Counties in 1987. Production losses and economic effects resulting from these production losses, including employment and income effects, would be similar to, but greater than, the effects described previously for Alternative 1.

The direct conversion of agricultural land to nonagricultural uses under Alternative 3 is considered significant and unavoidable based on the above considerations. Although this conversion of Delta islands to noncultivated uses may be viewed as a benefit because it preserves soils with peat oxidation and subsidence problems over the life of the project, project implementation would involve retiring agricultural lands from production for at least 50 years and there is no certainty that the project islands would be returned to agricultural production at the end of the project.

Mitigation. As discussed previously for Alternative 1, no reasonable mitigation is available to reduce this impact to a less-than-significant level. Reclaiming DW project lands to agricultural uses at the conclusion of the project would reduce the long-term impacts on agricultural land and production but would not reduce short-term losses of agricultural production, employment, and income occurring over the 50-year life of the project.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Changes in Land Use Conditions

Under the No-Project Alternative, current use of the four DW project islands would continue as described above under "Affected Environment"; agricultural intensity would increase in currently fallow areas. Implementation of the No-Project Alternative would result in continuation of existing land uses with no change in the status of onsite structures, Williamson Act contracts, or zoning and general plan designations. Land use on the four islands would also continue to be consistent with relevant general plan policies. Therefore, the No-Project Alternative would not result in land use impacts.

Changes in Agriculture Conditions

Under the No-Project Alternative, more intensive agricultural operations would be implemented on the four DW project islands. An agricultural consultant has made general recommendations concerning agricultural practices, land improvements, and cropping patterns that would improve the farming efficiency on the four DW islands (McCarty pers. comm.). Land and drainage improvements under this alternative would be limited to those exempted from regulation under Section 404(f)(1) of the Clean Water Act. No redistribution of soil by grading or blading to fill wetlands would occur.

Based on these recommendations and additional input from DW (Winther pers. comm.), JSA developed a cropping scenario (Table 3I-10) used as the basis for evaluating the impacts of intensified agriculture under the No-Project Alternative. Production projections were prepared based on yield data provided by a variety of sources, as listed at the bottom of Table 3I-10. Average yields for the crops produced on Bacon and Bouldin Islands were assumed to remain the same as existing yields; average yields for the crops produced on Holland and Webb Tracts were assumed to increase because of improvements in drainage and agricultural practices.

The agricultural production projections for this alternative are valid only for the short term. Over the long term, intensive cultivated agriculture would cease on the DW project islands, particularly Holland and Webb Tracts, because of continued subsidence and the threat to Delta water quality (DWR 1990). No information is available concerning the length of time agriculture will remain physically and economically feasible on the project islands; however, intensified agricultural use of the islands will likely increase existing erosion and subsidence problems.

Bacon Island

Implementation of the No-Project Alternative would retain in agricultural use the estimated 5,403 acres of prime agricultural land on Bacon Island. No additional land would be converted to nonagricultural uses. Cultivated land on Bacon Island would increase from an estimated existing 4,331 acres to a projected 4,960 acres (Tables 3I-6 and 3I-10). Over the long term, intensifying agriculture would increase the rate of subsidence and necessitate additional levee protection on the island. (See Chapter 3D, "Flood Control", for more detail on subsidence and levee stability.)

Under the No-Project Alternative, land currently used to grow corn and sunflower would be planted in potatoes, onions, and asparagus (Winther pers. comm.). In addition, set-aside land that currently supports exotic perennial grassland and exotic marsh habitat (see Chapter 3G, "Vegetation and Wetlands", for information on these habitat types) would be converted to use for growing potatoes, onions, and asparagus. Under the cropping scenario presented in Table 3I-10, these changes would increase Bacon Island's production of commercial potatoes by 41% and asparagus by 58%, reintroduce the production of onions, and maintain the existing production levels of seed potatoes and wine grapes.

Webb Tract

Implementation of the No-Project Alternative would retain in agricultural use the estimated 4,725 acres of prime agricultural land on Webb Tract. No additional land would be converted to nonagricultural uses. In the short term, cultivated land on Webb Tract would increase from an estimated existing 2,638 acres to a projected 4,880 acres (Tables 3I-6 and 3I-10). As described above for Bacon Island, all agricultural land on the island may be eliminated over the long term by flooding as subsidence increases and levee protection becomes more difficult.

Under the No-Project Alternative, the irrigation and drainage system on Webb Tract would be improved so that more of the island could be intensively farmed. Under this alternative, much of the fallow cropland (currently not cultivated because of high water tables) and herbaceous upland habitat on the island would be converted to the intensive production of feed grain crops (Winther pers. comm.). Habitat surrounding the two blowout ponds and land that could not be cropped without regrading being conducted on the island would be left in its existing condition. Under the cropping scenario presented in Table 3I-10, agricultural operations on Webb Tract would increase the production of wheat by 413% and the production of corn by 68%.

Bouldin Island

Implementation of the No-Project Alternative would retain in agricultural use the estimated 5,711 acres of prime agricultural land on Bouldin Island. No additional land would be converted to nonagricultural uses. Cultivated land on Bouldin Island would increase from an estimated existing 4,395 acres to a projected 5,200 acres (Tables 3I-6 and 3I-10). As described above for Bacon Island, increased subsidence and decreased levee stability over the long term may cause cessation of agricultural production on Bouldin Island.

Under the No-Project Alternative, drainage on Bouldin Island would be improved to make areas currently fallow because of high water tables available for agricultural use. Drainage improvements would make the island suitable for a cropping pattern similar to that of Bacon Island. (Winther pers. comm.) Under the cropping scenario presented in Table 3I-10, agricultural operations on Bouldin Island would shift from the production of wheat, corn, and sunflower to the intensive production of onions, asparagus, potatoes, and wine grapes.

Holland Tract

Implementation of the No-Project Alternative would retain in agricultural use the estimated 1,575 acres of prime agricultural land on Holland Tract. No additional land would be converted to nonagricultural uses. Cultivated land on Holland Tract would increase in the short term from an estimated existing 2,005 acres in 1988 to a projected 3,680 acres (Tables 3I-6 and 3I-10). As described above for Bacon Island, intensifying agriculture would hasten subsidence and threaten levee protection, eventually causing the loss of all agricultural land on the island.

To implement intensive agriculture under the No-Project Alternative on Holland Tract, a number of physical improvements would be required to improve the island's agricultural efficiency. Many of the island's drainage ditches would require reconditioning to improve irrigation and drainage practices. Existing fallow lands would be converted to wheat and corn production. In addition, existing areas of annual grassland and exotic perennial grassland would be converted to orchards or vineyards. (Winther pers. comm.) Under the cropping scenario presented in Table 3I-10, agricultural operations on Holland Tract would increase the production of wheat by 136% and corn by 293%, introduce the production of wine grapes, and maintain the existing production of asparagus and pasture.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in Cultivated Acreage and Agricultural Production on the DW Project Islands. Implementing the No-Project Alternative would increase the amount of land in agricultural production on the DW project islands from approximately 13,350 under existing conditions to approximately 18,720 acres. Increasing crop production would contribute to an increase in agricultural employment in Contra Costa and San Joaquin Counties. Also, irrigation and drainage systems would be improved on the DW project islands to provide for long-term agricultural production. Increasing agricultural production on the DW project islands under the No-Project Alternative would benefit agriculture-related industries.

CUMULATIVE IMPACTS

Cumulative Impacts, Including Impacts of Alternative 1

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. The following discussion considers only those project effects that may contribute cumulatively to impacts on land use and agriculture in the project vicinity.

Changes in Land Use Conditions

Implementation of Alternative 1 would not contribute to cumulative impacts on land use, including changes in Williamson Act contracts, a substantial reduction in regional housing supply, or incompatibilities with adjacent land uses. Implementation of Alternative 1 would, however, contribute to the regional conversion of agricultural land as described below. The DW project, in conjunction with other projects that convert agricultural land to other uses (see Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives"), would not be consistent with general plan principles that promote the retention and production of agricultural land as described above under "Impacts and Mitigation Measures of Alternative 1".

Changes in Agriculture Conditions

The list of related projects evaluated for cumulative impacts (Appendix 2) includes a number of projects that would convert agricultural lands to nonagricultural uses. Agricultural land conversions could occur through the urban development of Delta islands, additional water storage projects on Delta islands encouraged by the DW project, levee improvement and flood control projects, or subsidence-reduction programs (DWR 1990). The cumulative amount of agricultural land that would ultimately be converted by related projects is not known but is expected to be relatively large.

DWR's West Delta Water Management Program, DWR's North Delta Flood Control Plan, and CCWD's Los Vaqueros Project are examples of water resource projects that would convert agricultural lands to nonagricultural uses.

Conversion of land from agricultural to managed wildlife habitat on Sherman and Twitchell Islands is the primary focus of the West Delta program. DWR has successfully purchased 5,000 of the 10,000-acre Sherman Island to implement the West Delta mitigation program. By the end of 1995, it is projected that a total of 8,000 acres of Sherman Island will have been purchased (Brown pers. comm.). Purchased lands would be converted from intensive agriculture to slow the rate of subsidence and potentially reduce the likelihood of levee failure; therefore, this conversion could increase protection of Delta water quality (DWR 1990). DWR has purchased approximately 3,000 of the 3,600 acres on Twitchell Island and will convert this land to wetlands and riparian wildlife habitat if mitigation agreements are successfully negotiated with USFWS and DFG (Turner pers. comm.). Virtually all the lands on Sherman and Twitchell Islands have been mapped as prime farmland by CDC.

The Los Vaqueros Project converted approximately 2,200 acres of agricultural land in dryland farming and grazing to other uses (e.g., reservoir, recreation facilities) (CCWD and Reclamation 1992). The Los Vaqueros project and future developments in the region would have significant cumulative impacts on regional agricultural resources, including the conversion of prime and nonprime agricultural lands to nonagricultural uses. No mitigation measures are available to the lead agencies (CCWD and Reclamation) to reduce this cumulative impact; mitigation for agricultural land conversion is within the purview and jurisdiction of local land use agencies (CCWD 1993).

Implementation of Alternative 1 would involve direct conversion to nonagricultural uses of an estimated 15,154 acres (9,267 acres in San Joaquin County and 5,887 acres in Contra Costa County) of prime agricultural land. The California Department of Food and Agriculture (DFA) has recently begun monitoring projects that would convert agricultural land to nonagricultural uses. According to DFA (1988b), between July 1, 1987, and October 13, 1988, applications were filed in San Joaquin and Contra Costa Counties for projects (including the DW project) that would convert approximately 52,200 acres of agricultural land to nonagricultural uses. The 15,154 acres of prime farmland converted by the DW project would represent approximately 29% of all agricultural land being considered for conversion in the two-county area during the period when applications for the project were first sought.

Impact I-8: Cumulative Conversion of Agricultural Land. The cumulative conversion of prime agricultural land by the DW project and related projects is considered a significant and unavoidable impact on agricultural production. For example, cumulative conversions of the DW project and the possible DWR projects on Sherman and Twitchell Islands could total more than 30,000 acres, or more than 5% of the total agricultural acreage mapped on Delta islands by Madrone Associates (1980). These cumulative conversions would result in similar, but greater, economic effects than those described for conversions under the DW project.

Mitigation. No reasonable mitigation is available to reduce this impact to a less-than-significant level. It is extremely unlikely that a similar amount of land in the region with similar qualities and productivity could be brought into production to mitigate the effects resulting from the cumulative loss of agricultural land. Counties in the DW project region are generally losing farmland faster than new land is being brought into production. For example, between 1986 and 1988, approximately 2,600 acres of cropland in Contra Costa County were converted to urban and other uses, while 450 acres of grazing lands and other nonagricultural lands were converted to cropland (CDC 1988).

Cumulative Impacts, Including Impacts of Alternative 2

Implementation of Alternative 2 would not contribute to any cumulative land use impacts. The contribution of Alternative 2 to cumulative impacts on agriculture would be the same as that described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

Implementation of Alternative 3 would not contribute to any cumulative land use impacts. The contribution of Alternative 3 to cumulative impacts on agriculture would be the same as that described for Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Implementing the No-Project Alternative would not contribute to cumulative changes in regional land uses and agricultural production.

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Table 3I-1. Generalized Land Use Acreages on the Delta Wetlands Project Islands

Land Use	Bacon Island	Webb Tract	Bouldin Island	Holland Tract
Agricultural land and pastureland	4,439	2,756	4,565	2,112
Fallow agricultural land	355	638	712	785
Agriculture-related structures, farmsteads, and exposed earth (includes marinas on Holland Tract)	86	20	75	243
Sloughs and ditches	92	50	118	45
Other natural or unmanaged land (e.g., fallow agricultural land, open space)	567	2,005	515	1,064
Total	5,539	5,469	5,985	4,249

Notes: Based on habitat map, dated October 24, 1988, by JSA.

Although agricultural production on the DW project islands may have changed since 1988, these conditions were determined to best represent typical preproject agricultural land use.

Table 3I-2. Selected General Plan Designations and Definitions for the Delta Wetlands Project Islands and Vicinity

Designation	Definition
San Joaquin County	
General agriculture	These are areas suitable for agriculture outside areas planned for urban development where the soils are capable of producing a wide variety of crops and/or supporting grazing, parcel sizes are generally large enough to support commercial agricultural activities (20-acre minimum parcel size), and a commitment to commercial agriculture in the form of Williamson Act contracts and/or capital investments exists.
Open space/resource conservation	Open spaces are areas best suited for the continuation of commercial agricultural and productive uses, the enjoyment of scenic beauty and recreation, the protection and use of natural resources, and protection from natural hazards. Open space/resource conservation areas include waterways; riparian habitat and woodlands; wetlands and vernal pools; significant oak groves and other heritage trees; habitat for rare, threatened, or endangered species; substantial groundwater recharge areas; significant mineral resource areas; and floodways.
Contra Costa County	
Delta recreation and resources	These areas include islands and adjacent lowlands of the Sacramento-San Joaquin Delta within the 100-year floodplain appropriate primarily for agriculture and wildlife habitat, with limited recreation uses allowed that do not conflict with the predominant agricultural and habitat uses.
Water	This designation includes water in the Sacramento-San Joaquin estuary; the San Francisco-San Pablo Bay; and all large inland bodies of water, such as reservoirs. Uses allowed in the “water” designation areas include transport facilities associated with adjacent heavy industrial plants, such as ports and wharves, and water-oriented recreation uses, such as boating and fishing.
Parks and recreation	This designation includes all publicly owned city, district, county, regional, and state park facilities. Appropriate uses in the designation are passive and active recreation-oriented activities and ancillary commercial uses, such as snack bars and restaurants.
Single-family residential - high density	This designation includes easily developed land near transportation and shopping facilities (maximum density allowed is five to seven units per acre) and boat harbors, launching facilities, and ancillary uses. This is the designation for land on Bethel Island and along San Mound Slough.
Multifamily residential - low density	This designation includes land near transportation and shopping facilities. This land is a transition between residential and commercial uses, with a suburban atmosphere and landscaped areas at a density of seven to 12 units per acre.
Local commercial	This land allows for the continued maintenance of the existing commercial core along Bethel Island Road at both ends of the bridge.

Table 3I-2. Continued

Designation	Definition
Marina commercial	In the Bethel Island area, commercial uses are tied directly to water-oriented businesses and activities, such as boat sales, repairs, and storage; fishing supplies; and waterskiing.

Sources: San Joaquin County Community Development Department 1991, 1992; Contra Costa County Community Development Department 1991.

Table 3I-3. Estimated Acreages of Soil Types on the Delta Wetlands Project Islands

Soils	Land Capability Classes[a]	Soil Limitations	Typical Uses	Bacon Island		Bouldin Island		All Islands	
				Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
San Joaquin County soils									
Peltier mucky clay loam, partially drained, 0 to 2 percent slopes	IIIw-5	Subsidence, high water table, slow permeability	Irrigated row and field crops	0	0.0	12	0.2	12	0.0
Retryde-Peltier complex, 0 to 2 percent slopes	IIIw-2	Subsidence, high water table, slow permeability	Irrigated row and field crops	65	1.2	889	15.0	954	4.7
Venice mucky silt loam, overwash, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table	Irrigated row and field crops	0	0.0	200	3.5	200	1.0
Piper sandy loam, partially drained, 0 to 2 percent slopes	IVw-4	Subsidence, low available water capacity, high water table, weakly cemented substratum	Irrigated row and field crops	0	0.0	30	0.5	30	0.1
Shima muck, partially drained, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table	Irrigated row and field crops	0	0.0	19	0.3	19	0.1
Dello loamy sand, partially drained, 0 to 2 percent slopes	IIIw-4	Low available water capacity, severe hazard of soil blowing, high water table	Irrigated row and field crops	0	0.0	20	0.3	20	0.1
Rindge muck, partially drained, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table	Irrigated row and field crops	2,547	47.1	2,187	38.0	4,734	23.3
Kingile muck, partially drained, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table, slow permeability	Irrigated row and field crops	1,429	26.4	157	2.7	1,586	7.8
Kingile-Retryde complex, partially drained, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table, slow permeability	Irrigated row and field crops	459	8.5	0	0.0	459	2.3
Retryde clay loam, partially drained, 0 to 2 percent slopes	IIIw-2	Subsidence, high water table	Irrigated row and field crops	379	0.0	80	1.4	459	2.3
Valdez silt loam, partially drained, 0 to 2 percent slopes	IIIw-2	Subsidence, high water table	Irrigated row and field crops	0	0.0	451	7.8	451	2.2
Rindge mucky silt loam, overwash, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table	Irrigated row and field crops	92	1.7	1,095	19.0	1,187	5.8
Venice muck, partially drained, 0 to 2 percent slopes	IIIw-10	Subsidence, high water table	Irrigated row and field crops	58	1.1	267	5.0	325	1.6
Retryde silty clay loam, organic substratum, 0 to 2 percent slopes	IIIw-2	Subsidence, high water table	Irrigated row and field crops	249	4.6	354	6.1	603	3.0
Itano silty clay loam, partially drained, 0 to 2 percent slopes	IIIw-2	Subsidence, high water table, acidity	Irrigated row and field crops	125	2.0	0	0.0	125	0.6
Subtotal for Bacon and Bouldin Islands				5,403	100.0	5,761	100.0	11,164	54.8

Table 3I-3. Continued

Soils	Land Capability Classes[a]	Soil Limitations	Typical Uses	Bacon Island Acres	Bacon Island Percent of Total	Bouldin Island Acres	Bouldin Island Percent of Total	All Islands Acres	All Islands Percent of Total
Contra Costa County soils									
Rindge muck	IIIw-10	High water table, rapid permeability, moderate soil blowing hazard	Irrigated row crops	4,415	86.0	1	34.0	5,785	28.4
Piper fine sandy loam	Ive-9	High water table, low available water capacity, rapid permeability, moderate soil blowing hazard	Dryland pasture, small grains, volunteer hay	241	5.0	420	10.4	661	3.2
Piper loamy sand	Ivw-4	High water table, low available water capacity, rapid permeability, moderate soil blowing hazard	Irrigated pasture, alfalfa, row crops	9	0.0	1,108	27.5	1,117	5.5
Ryde silt loam	IIIw-2	High water table	Irrigated row and field crops	328	6.0	59	1.5	387	1.9
Egbert mucky clay loam	IIIw-2	High water table	Irrigated field crops and wildlife habitat	0	0.0	14	0.3	14	0.1
Shima muck	IIIw-10	High water table, moderate soil blowing hazard	Irrigated row and field crops	191	2.0	932	23.1	1,033	5.1
Kingile muck	IIIw-10	High water table, moderate soil blowing hazard	Irrigated row and field crops	38	0.7	15	0.4	53	0.3
Webile muck	IIIw-10	High water table, moderate soil blowing hazard	Irrigated row and field crops	0	0.0	113	2.8	113	0.6
Merritt loam	IIIw-2	High water table	Irrigated row and field crops	30	1.0	0	0.0	30	0.1
Subtotal for Holland and Webb Tracts				5,162	100.0	4,031	100.0	9,193	45.2
Total								20,357	100.0

Note: Acreage totals may not correspond with acreages shown elsewhere in this report because of measurement error, rounding error, and water bodies not surveyed on the islands. Acreages by soil units were estimated based on planimeter measurements performed by JSA.

[a] Soils are categorized by NRCS (formerly SCS) according to eight classes (I-VIII) depending on the limitations to agricultural use imposed by specific soil and climatic criteria. The higher the class, the more restrictive the limitation. Soils in Class III have more limitations and hazards than those in Classes I and II. They require more difficult or complex conservation practices when cultivated. Soils in Class IV have greater limitations and hazards than those in Class III and require more difficult or complex measures when cultivated. Capability classes are divided into subclasses and capability units. Subclass symbols include “w” for wetness and “e” for erosion problems. Capability unit symbols include “2" for wetness problems; “4" for coarse texture, low water-holding capacity; “5" for fine textures, tillage problems; “9" for low fertility, acidity, or toxics problems; and “10" for very coarse textured substratum.

Sources: SCS 1977 and 1988.

Table 3I-4. Estimated Acreages of Soils in Important Farmland Mapping Categories on the Delta Wetlands Project Islands

	Bacon Island		Webb Tract		Bouldin Island		Holland Tract		All Islands	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Totak	Acres	Percent of Total
San Joaquin County soils										
Prime farmland	5,278	97.7			5,711	99.1			11,114	54.6
Farmland of statewide importance	125	2.3			50	0.9			50	0.2
Contra Costa County soils										
Prime farmland			4,725	91.8			1,575	39.1	6,300	31.0
Farmland of statewide importance			130	2.5			2,031	50.4	2,161	10.6
Unique farmland			294	5.7			426	10.6	720	3.5
Total	5,403	100.0	5,149	100.0	5,761	100.0	4,032	100.0	20,345	100.0

Note: Acreage totals may not correspond to acreages shown in other tables of this report because of measurement error, rounding error, and the presence of water bodies within island perimeters. Acreages were estimated based on planimeter measurements performed by JSA.

Source: CDC 1988 and 1992.

Table 3I-5. Agricultural Land Use on the Delta Wetlands Project Islands

Agricultural Land Use	Bacon Island		Webb Tract		Bouldin Island		Holland Tract[a]		All Islands	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Wheat			426	13.1	1,139	22.4	835	30.4	2,400	15.2
Milo	82	1.8							82	0.5
Corn (field)	757	16.2	2,128	65.5	2,368	46.6	226	8.2	5,479	34.8
Sunflower	186	4			855	16.8			1,041	6.6
Asparagus	1,043	22.3					402	14.6	1,445	9.2
Potatoes	1,836	39.2							1,836	11.7
Vineyard	272	5.8							272	1.7
Unknown crops	155	3.3	26	0.8					181	1.1
Pasture			58	1.8	33	0.6	542	19.7	633	4
Fallow (short term)	347	7.4	611	18.8	685	13.5	745	27.1	2,388	15.2
Idle (cropped in past but not at time of survey)									0	0
Total	4,678	100	3,249	100	5,080	100	2,750	100	15,757	100

Notes: Acreages were calculated during JSA's 1988 survey.

Idle land was not identified in the 1988 survey.

Inconsistencies in acreages are the result of rounding.

[a] Acreage includes 1,120 acres excluded from the project under Alternatives 1 and 2.

Table 3I-6. Estimated Crop Production on the Delta Wetlands Project Islands

	Bacon Island			Webb Tract			Bouldin Island			Holland Tract[a]			All Islands		
Crops	Acres Planted in 1988	Yield (tons per acre)	Total Yield (tons)	Acres Planted in 1988	Yield (tons per acre)	Total Yield (tons)	Acres Planted in 1988	Yield (tons per acre)	Total Yield (tons)	Acres Planted in 1988	Yield (tons per acre)	Total Yield (tons)	Acres Planted in 1988	Yield (tons per acre)	Total Yield (tons)
Wheat				426	2.0	852	1,139	2.8	3,189	835	2.0	1,670	2,400	2.4	5,711
Corn (field)	994	3.3	3,280	2,154	1.6	3,446	2,368	4.8	11,366	226	1.5	339	5,742	3.2	18,431
Sunflower	186	0.9	167				855	0.9	770				1,041	0.9	937
Asparagus	1,043	1.5	1,565							402	1.5	603	1,445	1.5	2,168
Potatoes															
Commercial	1,486	15.0	22,290										1,486	15.0	22,290
Seed	350	12.0	4,200										350	12.0	4,200
Vineyard	272	7.0	1,904										272	7.0	1,904
Pasture				58	N/A	N/A	33	N/A	N/A	542	N/A	N/A	633	N/A	N/A
Total	4,331			2,638			4,395			2,005			13,369		

Notes: N/A = not applicable.

Acreage planted in milo and unknown crops in 1988 was assumed to be planted in corn for the purposes of this table.

Although the project site's agricultural production may have changed since 1988, these conditions were determined to best represent typical preproject agricultural land use.

[a] Acreage and yield includes production of acreage excluded from the project under Alternatives 1 and 2.

Sources: Acreages of planted crops were obtained during JSA's 1988 island survey.

Average yields: San Joaquin County Office of the Agricultural Commissioner 1988; Contra Costa County Department of Agriculture 1988; Shimasaki, Wilkerson, and Winther pers. comms.

Principle/Policy		Consistency
SAN JOAQUIN COUNTY GENERAL PLAN		
Agriculture Principles		
III. To protect agricultural lands needed for the continuation of commercial agricultural enterprises, small-scale farming operations, and the preservation of open space.	Consistent:	The proposed project would protect agricultural lands for the preservation of open space. Both water storage and habitat management are open space uses.
1. The following agricultural land use categories shall be established to promote a range of agricultural activities and preserve open space: General Agriculture, Limited Agriculture, and Agriculture-Urban Reserve.	Consistent:	The proposed project would be consistent with the General Agriculture designation on Bouldin and Bacon Islands.
5. Agricultural areas shall be used principally for crop production, ranching, and grazing. All agricultural support activities and nonfarm uses shall be compatible with agricultural operations and shall satisfy the following criteria: (a) The use requires a location in an agricultural area because of unusual site area requirements, operational characteristics, resource orientation, or because it is providing a service to the surrounding agricultural area; (b) The operational characteristics of the use will not have a detrimental impact on the management or use of surrounding agricultural properties; (c) The use will be sited to minimize any disruption to the surrounding agricultural operations; and (d) The use will not significantly impact transportation facilities, increase air pollution, or increase fuel consumption.	Consistent:	Water storage and habitat management are both compatible nonfarm uses. Both proposed uses require location in the Delta area, and neither would have a detrimental effect on surrounding agricultural properties or would result in significant air and transportation impacts (see Chapters 3E, “Utilities and Highways”; 3L, “Traffic”; and 3O, “Air Quality”).
6. All lands designated for agricultural uses and those lands designated for nonagricultural use but not needed for development for 10 years shall be placed in an agricultural preserve and shall be eligible for Williamson Act contracts. Parcels eligible for Williamson Act contracts shall be 20 or more acres in size in the case of prime land or 40 or more acres in the case of nonprime land.	Consistent:	The proposed project would be consistent with existing Williamson Act contracts in San Joaquin County.

Principle/Policy		Consistency
7. There shall be no further fragmentation of land designated for agricultural use, except in the following cases: (a) Parcels for homesites may be created, provided that the General Plan density is not exceeded. (b) A parcel may be created for the purpose of separating existing dwellings on a lot, provided the Development Title regulations are met. (c) A parcel may be created for a use granted by a permit in the AG zone, provided that conflicts with surrounding agricultural operations are mitigated.	Consistent:	The proposed project would not lead to fragmentation of existing parcels.
Open Space Principles		
I. To preserve open space land for the continuation of commercial agricultural and productive uses, the enjoyment of scenic beauty and recreation, the protection and use of natural resources, and for protection from natural hazards.	Consistent:	The proposed project would provide recreation opportunities, flood control, and protection of natural resources in the Delta.
4. Areas with serious development constraints, such as the Delta, should be predominantly maintained as open space.	Consistent:	The proposed project would maintain the islands in water storage and habitat management, consistent with the county's open space definition.
6. The County shall consider waterways, levees, and utility corridors as major elements of the open space network and shall encourage their use for recreation and trails in appropriate areas.	Consistent:	The proposed project would promote recreational use along levees.
Recreation Principles		
II. To protect the diverse resources upon which recreation is based, such as waterways, marsh lands, wildlife habitats, unique land and scenic features, and historical and cultural sites.	Consistent:	The proposed project would involve management of the habitat islands to protect and restore wildlife habitat.

Principle/Policy		Consistency	
III.	To ensure the preservation of the Delta and the opportunity for the public to learn about and enjoy this unique recreation resource.	Consistent:	The proposed project would provide new recreation opportunities in the Delta. Recreation facilities on the DW project islands may or may not be publicly accessible; however, the proposed project would provide opportunities and improve the setting for waterfowl hunting, bird watching, and other recreation activities in the Delta by enhancing the regional habitat value for wildlife in the Delta (see Chapter 3H, "Wildlife").
	7. Natural features shall be preserved in recreation areas, and opportunities to experience natural settings shall be provided.	Consistent:	Implementation of the proposed project would provide recreation opportunities in resource management areas in the Delta.
	15. The recreational values of the Delta, the Mokelumne River, and the Stanislaus River shall be protected.	Consistent:	Same as above.
	19. Development in the Delta islands shall generally be limited to water-dependent uses, recreation, and agricultural uses.	Consistent:	Under the proposed project, the islands would be managed for recreation, wildlife, and water storage.
Vegetation and Wildlife Principles			
II.	To provide undeveloped open space for nature study, protection of endangered species, and preservation of wildlife habitat.	Consistent:	Habitat management under the proposed project would provide open space for nature study, protection of endangered species, and preservation of wildlife habitat.
	1. Resources of significant biological and ecological importance in San Joaquin County shall be protected. These include wetlands; riparian areas; rare, threatened, and endangered species and their habitats as well as potentially rare or commercially important species; vernal pools; significant oak groves; and heritage trees.	Consistent:	Habitat management under the proposed project would establish and protect wetlands, riparian areas, and habitats for listed species.
	7. The County shall support feeding areas and winter habitat for migratory waterfowl.	Consistent:	Same as above.
	14. The County shall support the establishment and maintenance of ecological preserves and accessibility to areas for nature study.	Consistent:	Same as above.

Principle/Policy		Consistency	
CONTRA COSTA COUNTY GENERAL PLAN			
Conservation Principles			
8-2.	Areas that are highly suited to prime agricultural production shall be protected and preserved for agriculture, and standards for protecting the viability of agricultural land shall be established.	Inconsistent:	Implementation of the proposed project would remove agricultural land in Contra Costa County from production. The inherent agricultural productivity of the islands would not change because of the use of prime agricultural land for water storage and habitat management. Project implementation would not be consistent with the county's policy of preserving lands for agricultural production.
8-3.	Watersheds, natural waterways, and areas important for the maintenance of natural vegetation and wildlife populations shall be preserved and enhanced.	Consistent:	The project would enhance and preserve habitat values on Holland Tract.
Agriculture Principles			
8-G.	To encourage and enhance agriculture, and to maintain and promote a healthy and competitive agricultural economy.	Inconsistent:	Implementation of the proposed project would remove agricultural land in Contra Costa County from production; this is not consistent with the county's goal to promote a competitive agricultural economy.
8-H.	To conserve prime productive agricultural land outside the Urban Limit Line exclusively for agriculture.	Consistent:	Implementation of the proposed project would remove agricultural land in Contra Costa County from production; however, Contra Costa County does not consider the Class III and IV soils in Holland and Webb Tracts to represent prime farmland. Therefore, the conversion of farmlands on these islands is not considered inconsistent with the county's policy of preserving prime agricultural lands for agricultural production.
8-38.	Agricultural operations shall be protected and enhanced through encouragement of Williamson Act contracts to retain designated areas in agricultural use.	Consistent:	The proposed project will not affect existing Williamson Act contracts on DW islands.
8-39.	A full range of agriculturally related uses shall be allowed and encouraged in agricultural areas.	Consistent:	Water storage and habitat management are considered agriculture-related uses.
8-45.	Efforts to assure an adequate, high quality, and fairly priced water supply to irrigated agricultural areas shall be supported.	Consistent:	A purpose of the proposed project is to increase the availability of high-quality water through the Delta.

Principle/Policy		Consistency	
8-46.	Maintenance and reconstruction of Delta levees shall be encouraged to assure the continued availability of valuable agricultural land protected by the existing network of levees and related facilities.	Consistent:	The proposed project would enhance the existing levee system on the water storage islands.
Vegetation and Wildlife Principles			
8-D.	To protect ecologically significant lands, wetlands, and plant and wildlife habitats.	Consistent:	A purpose of the proposed project is to increase the extent and value of wildlife habitat in the Delta.
8-F.	To encourage the preservation and restoration of the natural characteristics of the San Francisco Bay/Delta estuary and adjacent lands, and recognize the role of Bay vegetation and water area in maintaining favorable climate, air and water quality, and fisheries and migratory waterfowl.	Consistent:	Same as above.
8-17.	The ecological value of wetland areas, especially the salt marshes and tidelands of the bay and Delta, shall be recognized. Existing wetlands in the county shall be identified and regulated. Restoration of degraded wetland areas shall be encouraged and supported whenever possible.	Consistent:	Same as above.
Open Space Principles			
9-2.	Historic and scenic features, watersheds, natural waterways, and areas important for the maintenance of natural vegetation and wildlife populations shall be preserved and enhanced.	Partially inconsistent:	The proposed project would affect scenic waterways along the project islands. In other areas, however, the proposed project would enhance wildlife habitat. See Chapters 3J, "Recreation and Visual Resources", and 3G, "Vegetation", for more information on these effects of the proposed project.
9-25.	Maintenance of the scenic waterways of the county shall be ensured through public protection of the marshes and riparian vegetation along the shorelines and Delta levees, as otherwise specified in this plan.	Inconsistent:	Riparian habitat on Delta levees will be affected by the proposed project. See Chapter 3J, "Recreation and Visual Resources", for an analysis of impacts on scenic waterways.
9-36.	As a unique resource of statewide importance, the Delta shall be developed for recreation use in accordance with the state environmental goals and policies. The recreational value of the Delta shall be protected and enhanced.	Consistent:	A purpose of the proposed project is to provide regional recreation opportunities.

Principle/Policy		Consistency
LAND USE AND RESOURCE MANAGEMENT PLAN FOR THE PRIMARY ZONE OF THE DELTA		
Environmental Principles		
P-1. The priority land use of areas of prime soil shall be agriculture. If commercial agriculture is no longer feasible due to subsidence or lack of adequate water supply or water quality, land uses which protect other beneficial uses of Delta resources, and which would not adversely affect agriculture on surrounding lands, or viability or cost of levee maintenance, may be permitted. If temporarily taken out of agriculture production due to lack of adequate water supply or water quality, the land shall remain reinstatable to agricultural production for the future.	Partially inconsistent:	Implementation of the proposed project would remove agricultural land from production; however, the proposed project would not affect agricultural activities on surrounding land, and the land could be returned to agricultural use if project operations were terminated.
P-2. Agricultural and land management practices shall minimize subsidence of peat soils. Local governments shall support study of agricultural methods which minimize subsidence and assist in educating landowners and managers as to the value of utilizing these methods.	Consistent:	Implementation of the Delta Wetlands Project would minimize subsidence on Webb Tract, Holland Tract, Bacon Island, and Bouldin Island.
P-3. Lands managed primarily for wildlife habitat shall be managed to provide several inter-related habitats. Deltawide habitat needs should be addressed in development of any wildlife habitat plan. Appropriate programs, such as "Coordinated Resource Management and Planning" and "Natural Community Conservation Planning" should ensure full participation by local government and property owner representatives.	Consistent:	Habitat management under the proposed project would provide open space, protection of endangered species, and preservation of wildlife habitat. Bouldin Island and Holland Tract would be managed to provide breeding and foraging habitat for several wildlife species groups.

Principle/Policy			
Utilities and Infrastructure Policies			
P-2.	New houses built in the Delta agricultural areas shall continue to be served by independent potable water and wastewater treatment facilities. Uses which attract a substantial number of people to one area, including any expansions to the Delta communities, recreational facilities, or businesses, shall provide adequate infrastructure improvements or pay to expand existing facilities, and not overburden the existing limited community resources. New or expanded construction of wastewater disposal systems shall ensure highest feasible standards are met. Independent treatment facilities shall be monitored to ensure no cumulative adverse impact to groundwater supplies.	Consistent:	Drinking water for recreation facilities would be imported as needed or supplied using onsite treatment subject to county and state standards. Sewer disposal would comply with the requirements of the CVRWQCB. A private solid waste collection agency certified to operate in Contra Costa and San Joaquin Counties would be contracted to serve the recreation facilities.
Land Use			
P-6.	Subsidence control shall be a key factor in evaluating land use proposals.	Consistent:	Implementation of the proposed project would not accelerate subsidence.
P-7.	Structures shall be set back from levees and areas which may be needed for future levee expansion	Consistent:	The proposed project would improve levees on all four project islands. Although recreational facilities would be located adjacent to the levee crest, they would not interfere with future levee expansion
Agriculture			
P-1.	Commercial agriculture in the Delta shall be supported and encouraged as a key element in the State's economy and in providing the food supply needed to sustain the increasing population of the State, the Nation, and the world.	Inconsistent:	Implementation of the proposed project would result in land being removed from agricultural production.
P-8.	Encourage management of agricultural lands which maximize wildlife habitat seasonally and year-round, through techniques such as sequential flooding in fall and winter, leaving crop residue, creation of mosaic of small grains and flooded areas, controlling predators, controlling poaching, controlling public access, and others.	Consistent:	Agricultural fields on the habitat islands will be managed to maximize wildlife habitat values. Requirements specified in the Habitat Management Plan call for the provision of high-value foraging habitat for wintering waterfowl through creation of fields of corn rotated with wheat, mixed agriculture/seasonal wetland, seasonal managed wetland, and pasture/hay fields.

Principle/Policy		Consistency	
Water			
P-1.	Salinity levels in Delta waters shall ensure full agricultural use of Delta agricultural lands, provide habitat for aquatic life, and meet requirements for drinking water and industrial uses.	Consistent:	The Delta Wetlands Project would not result in conflicts with the 1995 WQCP requirements for agricultural water quality. The final operations criteria and other reasonable prudent measures adopted as part of the Endangered Species Act consultation process include restrictions on project operations to minimize effects on aquatic habitat and fish. Project effects on drinking water quality would be reduced to a less-than-significant level through the implementation of the mitigation measures.
P-2.	Design, construction, and management of any flooding program to provide seasonal wildlife habitat on agricultural lands shall incorporate "best management practices" to minimize mosquito breeding opportunities and shall be coordinated with the local vector control district. Each of the four vector control districts in the Delta provides specific wetland/mosquito management criteria to landowners within their district.	Consistent:	Implementation of the proposed project would result in the need for a significant increase in abatement levels on Delta Wetlands Project islands. Coordination with responsible MADs and implementation of appropriate abatement practices would offset the creation of potential mosquito production sources under the Delta Wetlands Project alternatives.
P-3.	Water agencies at local, state, and federal levels shall work together to ensure that adequate Delta water quality standards are set and met and that beneficial uses of State waters are protected consistent with the CALFED agreement.	Consistent:	Implementation of the Delta Wetlands Project would require ongoing consultation with water agencies at the state, federal, and local levels.
Recreation and Access			
P-2.	To minimize impacts to agriculture and to wildlife habitat, local governments shall encourage expansion of existing private water-oriented commercial recreational facilities over construction of new facilities. Local governments shall ensure any new recreational facilities will be adequately supervised and maintained.	Inconsistent:	Implementation of the Delta Wetlands Project would include the construction of several new private recreation facilities in the Delta.

Principle/Policy		Consistency	
Levees			
P-1.	Delta levees shall be maintained to protect human life, to provide flood protection, to protect private and public property, to protect historic structures and communities, to protect riparian and upland habitat, to promote interstate and intrastate commerce, to protect water quality in the state and federal water projects, and to protect recreational use of the Delta area. Delta levee maintenance and rehabilitation shall be given priority over other uses of the levee areas. To the extent levee integrity is not jeopardized, other uses, including support of vegetation for wildlife habitat, shall be allowed.	Consistent:	Levee improvements on the project reservoir islands would include raising and widening existing levees to bear the stresses of interior water storage of up to 6 feet. Levee improvements for both habitat and reservoir islands would be designed to meet or exceed state-recommended criteria for levees outlined in DWR Bulletin 192-82.

Sources: San Joaquin County Community Development Department 1992, Contra Costa County Community Development Department 1991. Delta Protection Commission 1995.

Table 3I-8. Projected Crop Production on the Delta Wetlands Project Islands under Alternatives 1 and 2

	Bouldin Island				Holland Tract[a]				Total		
Crop	Acres Planted	Acres Harvested[b]	Yield (tons per acre)	Total Yield (tons)	Acres Planted	Acres Harvested[b]	Yield (tons per acre)	Total Yield (tons)	Acres Planted	Acres Harvested[b]	Total Yield (tons)
Corn	1,222	819	4.8	3,931	716	480	1.5	720	1,938	1,299	4,651
Wheat[c]	487	244	2.8	683	353	177	2.0	354	840	421	1,037
Barley	26	13	2.1	27	38	19	2.1	40	64	32	67
Pasture	132	119	N/A	N/A	72	65	N/A	N/A	204	184	N/A
Total	1,867	1,195			1,179	741			3,046	1,936	

Note: Represents acreages of crops planted for wildlife habitat. No crops would be planted on Bacon Island and Webb Tract.

[a] Excludes crops grown on 1,120 acres on nonproject Holland Tract lands.

[b] Represents acreages of crops that would be harvested and sold.

[c] Includes spring and winter wheat.

Sources: Planted acreage projections: HMP (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). Average yield projections: Shimasaki, Wilkerson, and Winther pers. comms.; San Joaquin County Office of the Agricultural Commissioner 1988; Contra Costa County Department of Agriculture 1988.

Table 3I-9. Estimated Effect of Alternative 1 on Regional and Statewide Crop Production

Crops	Net Loss of Production[a]			Regional Production[b]			Statewide Production[c]			Percentage of Regional Production		Percentage of State Production	
	Acres Harvested	Yield (tons per acre)	Total Yield (tons)	Acres Harvested	Yield (tons per acre)	Total Yield (tons)	Acres Harvested	Yield (tons per acre)	Total Yield (tons)	Acres Harvested	Total Yield	Acres Harvested	Total Yield
Wheat	1,691	2.4	4,098	44,790	2.7	121,090	624,251	2.5	1,563,000	3.8	3.4	0.3	0.3
Corn[d]	4,365	3.1	13,663	54,940	4.7	255,900	193,144	4.4	846,500	7.9	5.3	2.3	1.6
Sunflower, seed[e]	1,041	0.9	937	5,670	0.8	4,740	3,505	0.8	2,950	18.4	19.8	29.7	31.8
Asparagus	1,307	1.5	1,961	19,840	1.5	28,990	37,267	1.7	62,100	6.6	6.8	3.5	3.2
Potatoes[f]				1,990	16.7	33,250				92.3	79.7		
Commercial	1,486	15.0	22,290				46,699	17.1	796,600			3.2	2.8
Seed	350	12.0	4,200				669	15.2	10,200			52.3	41.2
Vineyard[g]	272	7.0	1,904	31,400	6.8	213,000	328,609	7.0	2,307,600	0.9	0.0	0.1	0.1

[a] Represents the net decrease (change between preproject production levels and production levels under the HMP) in agricultural production on the four project islands under Alternative 1. Based on planted acreage in 1988.

[b] Represents production in Contra Costa and San Joaquin Counties in 1987.

[c] Represents statewide production in 1988.

[d] Numbers for the project islands and state represent field corn only. Numbers for the region include fresh and field corn.

[e] Numbers for the project islands and the state represent sunflower seeds for human consumption. They do not include sunflower planting seed. Regional numbers include sunflowers harvested for all purposes.

[f] Regional numbers represent potatoes harvested for all purposes.

[g] Number represent vine grapes only.

Sources: Tables 3I-6 and 3I-8; California Department of Food and Agriculture 1988a; San Joaquin County Office of the Agricultural Commissioner 1988; Contra Costa County Department of Agriculture 1988.

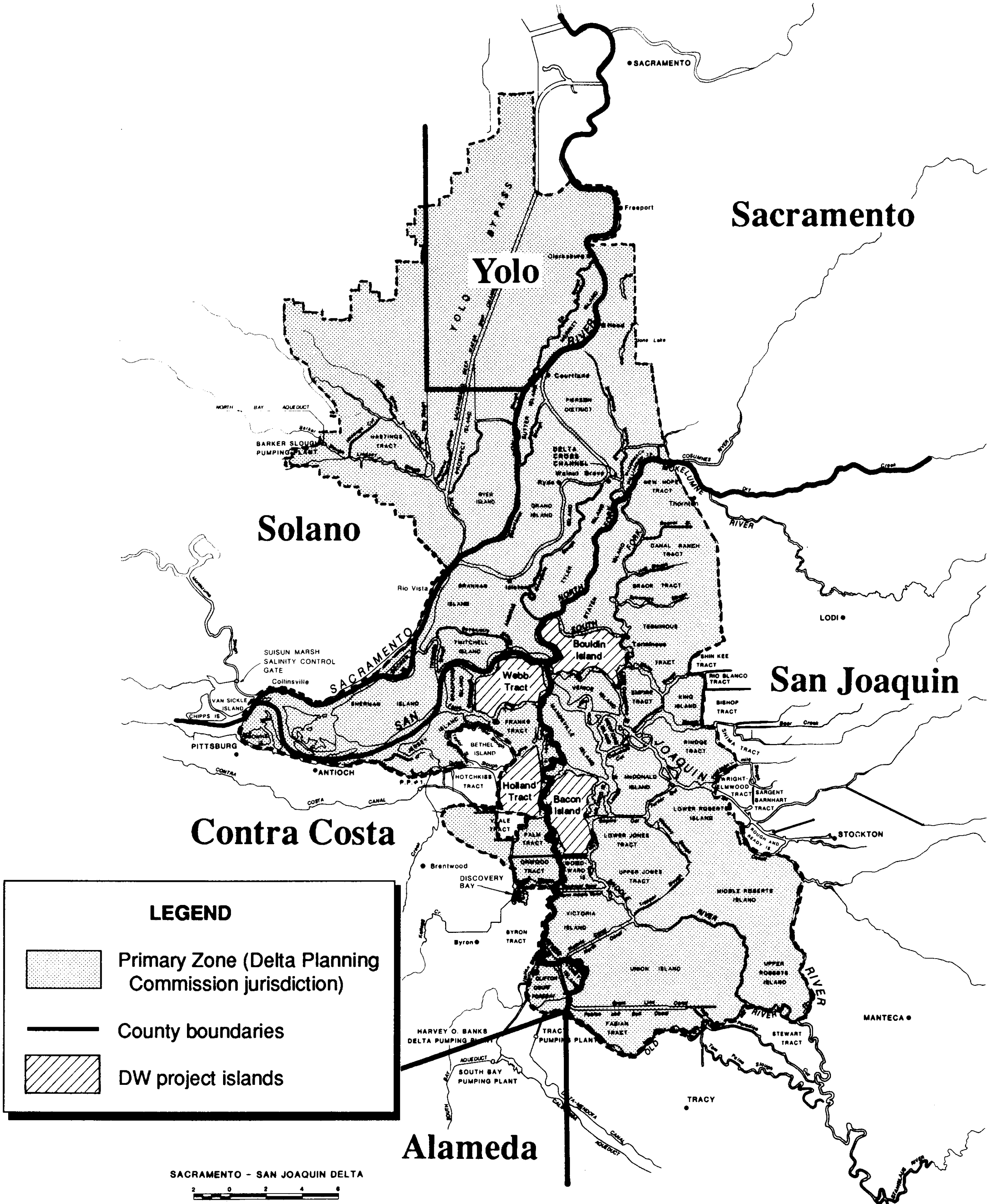
Table 3I-10. Projected Crop Production on the Delta Wetlands Project Islands under the No-Project Alternative

	Bacon Island			Webb Tract			Bouldin Island			Holland Tract			All Islands		
Crop	Acres Planted	Yield (tons per acre)	Total Yield (tons)	Acres Planted	Yield (tons per acre)	Total Yield (tons)	Acres Planted	Yield (tons per acres)	Total Yield (tons)	Acres Planted	Yield (tons per acres)	Total Yield (tons)	Acres Planted	Yield (tons per acre)	Total Yield (tons)
Wheat				1,560	2.8	4,368				1,410	2.8	3,948	2,970	2.8	8,316
Corn (field)				3,260	4.0	13,040				800	4.0	3,200	4,060	4.0	16,240
Onion	600	24.0	14,400				630	24.0	15,120				1,230	24.0	29,520
Asparagus	1,650	1.5	2,475				1,730	1.5	2,595	400	1.5	600	3,780	1.5	5,670
Potatoes															
Commercial	2,090	15.0	31,350				2,560	15.0	38,400				4,650	15.0	69,750
Seed	350	12.0	4,200					12.0	0				350	12.0	4,200
Vineyard	270	7.0	1,890				280	7.0	1,960	530	7.0	3,710	1,080	7.0	7,560
Pasture	__			60	N/A	N/A	__			540	N/A	N/A	600	N/A	N/A
Total	4,960			4,880			5,200			3,680			18,720		

Note: N/A = not applicable.

Sources: Planted acreage projections: Winther and McCarty pers. comms.

Average yield projections: Shimaski, Wilkerson, and Williams pers. comms.



Source: California Department of Water Resources 1993.

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Figure 3I-1
Counties of and Delta Planning Commission Jurisdiction in the Delta Wetlands Project Region

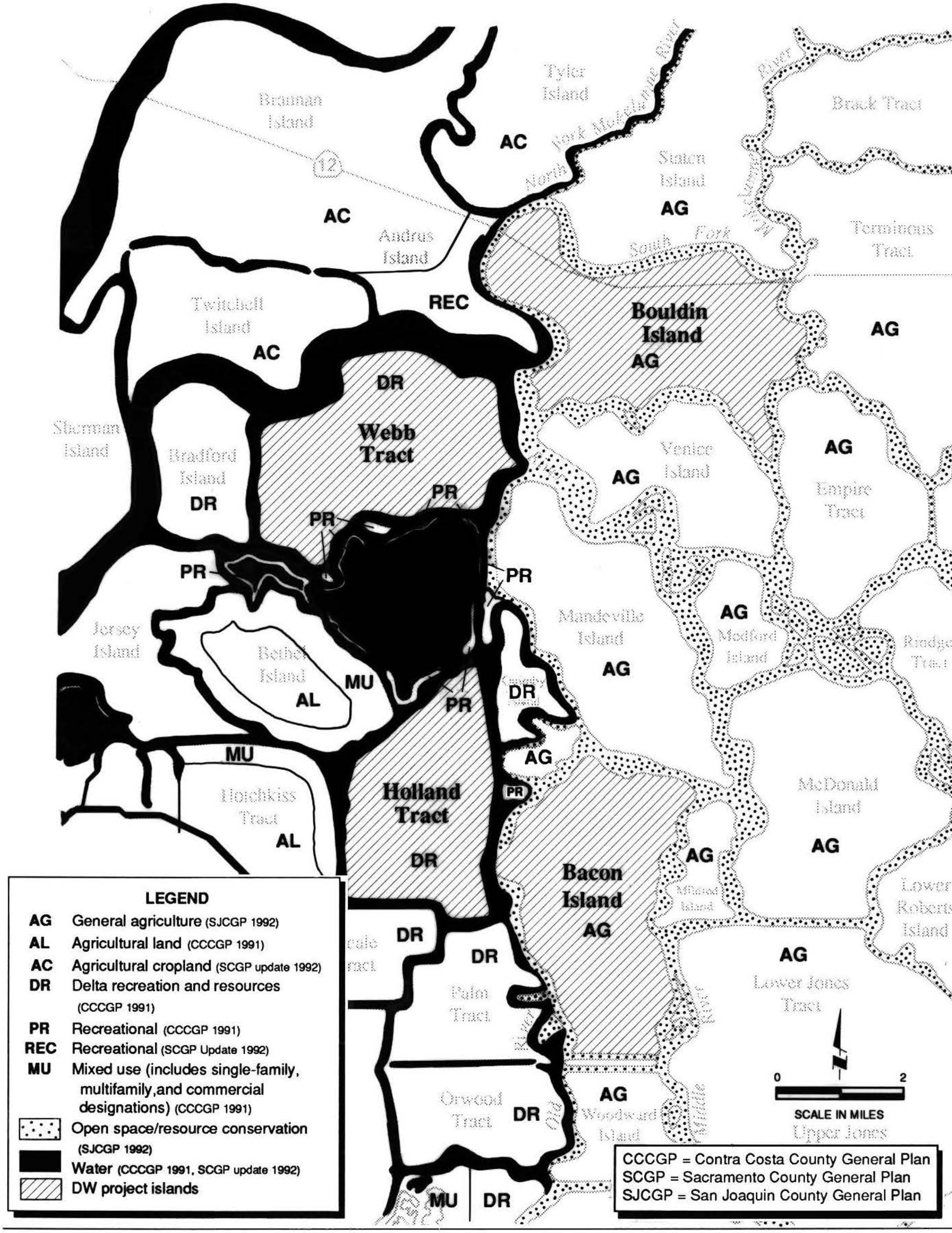
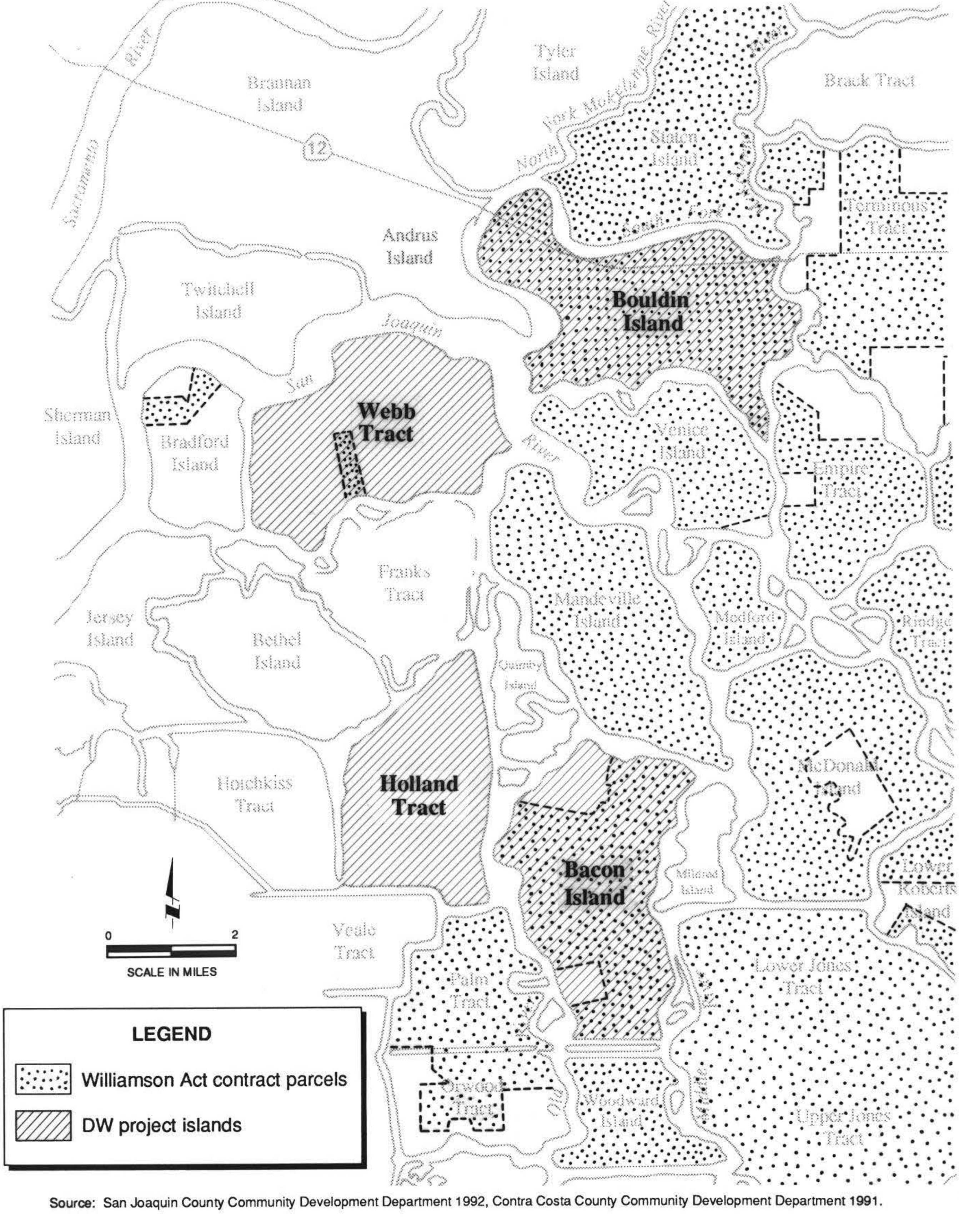


Figure 3I-2
County General Plan Designations for the Delta Wetlands Project Islands and Vicinity



Source: San Joaquin County Community Development Department 1992, Contra Costa County Community Development Department 1991.

Figure 3I-3
Williamson Act Contract Lands in the Delta Wetlands Project Vicinity

Chapter 3J. Affected Environment and Environmental Consequences - Recreation and Visual Resources

Chapter 3J. Affected Environment and Environmental Consequences - Recreation and Visual Resources

SUMMARY

The demand for recreation opportunities in the Delta is expected to increase, primarily as a result of growth of major population centers such as Sacramento, Stockton, Tracy, Pittsburg, and the Bay Area. This chapter discusses the changes in recreational hunting, fishing, and boating in the Delta and the changes in visual resources that could result from implementing the DW project alternatives.

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. However, it is anticipated that DW would subsequently apply for CWA and Rivers and Harbors Act permits for some or all of these recreation facilities. The analysis of impacts on recreation and visual resources in this chapter assumes that the maximum number of recreation facilities would be constructed and operated on all four project islands and that a facility of the maximum size would be built at every proposed location. These full build-out conditions result in a worst-case analysis of project impacts. The information in this chapter provides readers with a complete record of the environmental analysis; it may be used in subsequent environmental assessment of the recreation facilities.

Hunting recreation use-days in the Delta would increase by approximately 21% with implementation of Alternative 1 or 2 or by approximately 13% with implementation of Alternative 3. All three alternatives would increase boating recreation use-days in the Delta by approximately 5% . All three alternatives also would increase recreation use-days for other recreational uses in the Delta. These impacts are considered beneficial. All three alternatives would also contribute to the beneficial cumulative impacts of an increase in recreation opportunities in the Delta and enhancement of waterfowl populations and increased hunter success in the Delta. Enhancement of waterfowl habitat on the DW habitat islands under Alternatives 1 and 2 could result in the less-than-significant impact of decreased hunter success outside the project area.

Implementation of Alternative 1, 2, or 3 would increase boat use in Delta channels and alter boating conditions (e.g., necessitate speed restrictions) on waterways adjacent to the DW project islands. These factors could detract from the quality of the recreation experience for boaters and anglers in the project vicinity. This impact is considered significant and unavoidable. A 50% reduction in the number of new boat slips in Delta channels is recommended as mitigation of this impact. However, even with implementation of this mitigation measure, project effects on boating conditions are still considered significant and unavoidable. Chapter 3L, "Traffic and Navigation", describes issues related to waterway traffic and safety in more detail.

Under the No-Project Alternative, an intensive for-fee hunting program would be operated on the DW project islands. This program would generate approximately 12,000 additional recreation use-days, resulting in a 17% increase over the existing hunting recreation use-days in the Delta. Implementation of the No-Project Alternative would also contribute to a cumulative increase in recreation opportunities in the Delta and enhancement of waterfowl populations and increased hunter success.

Visual resource issues include potential changes in the visual quality of the DW project islands and potential conflicts with local visual resource policies and designations that would result from DW project implementation. Under

Alternatives 1, 2, and 3, introducing pumps, siphons, and recreation facilities into the existing landscape; removing vegetation; and placing rock revetment on levees around the reservoir islands would result in a significant and unavoidable impact on the quality of views of Bacon Island and Webb Tract from adjacent waterways and from the Santa Fe rail line along the south side of Bacon Island. Under Alternative 3, these project features would also result in a significant and unavoidable impact on the quality of views of Bouldin Island and Holland Tract from adjacent waterways. Mitigation measures of partially screening pump and siphon stations and designing project features to blend with the surrounding environment would reduce these impacts, but not to a less-than-significant level. Under Alternative 1 or 2, the reduction in the quality of views of Bouldin Island and Holland Tract from adjacent waterways would be a significant impact, but implementing the mitigation measures listed above would reduce this impact to a less-than-significant level. No significant cumulative impacts on visual resources are expected to result from implementation of any DW project alternative.

The management of DW islands as wildlife habitat under Alternative 1 or 2 would enhance views of Bouldin Island from SR 12 and would increase the visual quality of views of island interiors and the DW project vicinity for recreationists using the DW project islands. These impacts are considered beneficial.

Implementation of Alternative 1, 2, or 3 could result also in a reduction of the visual quality of views of the Bacon Island and Webb Tract interiors from island levees and a potential conflict with the Bacon Island Road scenic designation. These impacts are considered less than significant. Additional less-than-significant impacts would result from implementation of Alternative 3: the views south of SR 12 would be altered because of construction of a new levee parallel to the highway, and the quality of views of Holland Tract from the island levees would be reduced.

Views of the islands would not substantially change under the No-Project Alternative.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

In an effort to reduce adverse effects of increased recreational boating use in the Delta attributable to the proposed project, the EIR/EIS lead agencies and the project proponent developed a new mitigation measure for the final environmental document which requires DW to reduce the total number of outward (channel-side) boat slips proposed on the DW islands by 50%. Additionally, information regarding recreation use in the Delta and on the DW project islands has been updated in response to comments received on the 1995 DEIR/EIS and 2000 REIR/EIS.

AFFECTED ENVIRONMENT

Sources of Information

Recreation

Regional information on existing Delta recreation was obtained from reference materials of DWR and the California State Lands Commission (SLC). Additional information about Delta recreation was published by the Delta Protection Commission after the 1995 DEIR/EIS was issued. Information on existing recreation use of the DW project islands was collected from project island property owners and managers.

Maximum recreation use estimates for hunting on habitat islands under the DW project were derived from California hunting regulations (i.e., the lengths of the hunting seasons) and the HMP hunting program described in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands". Estimates of hunter participation on habitat islands were determined based on hunter use data obtained from state and federal refuges in or near the Delta. Information on the hunting program on reservoir islands under the DW project was provided by DW. Information on the hunting program for the No-Project Alternative was also obtained from DW.

Estimates of recreational boating associated with the DW project were based on the potential use of recreation facilities at project buildout. Each recreation facility would include a maximum of 30 boat slips in the adjacent Delta channel to accommodate temporary and permanent boat docking for private guests. Temporary boat docking includes use of a boat berth on a daily or weekly basis, whereas permanent boat docking applies to use of a boat berth over a long period of time, usually more than 12 months (Burkes pers. comm.). Boater use estimates were obtained from the California Department of Boating and Waterways, a marina and harbors organization, and commercial marina operators in the Delta.

Visual Resources

The visual resources in the Delta region and on the DW project islands were evaluated based on site assessment and aerial photographs. The relevant county general plans were reviewed for applicable policies and guidelines for visual resource management.

Recreation Conditions

The primary unit of measurement of recreation use is the recreation use-day, which represents participation by one individual in a recreational activity during any portion of a 24-hour period. Participation in hunting, fishing, or boating by one individual during a 24-hour period represents one recreation use-day. Participation in all three activities during a 24-hour period represents 3 recreation use-days.

Recreational Uses in the Region

The Delta is generally bounded by the cities of Sacramento, Stockton, Tracy, and Pittsburg. Delta recreation is supported by these major population centers and the Bay Area in general. Recreation use in the Delta exceeds 12 million user days annually (SLC 1991; DWR 1990a, 1993; DWR and Reclamation 1990). Boating is the most popular recreation activity in the Delta, accounting for approximately 2,016,000 annual recreation visits (Table 3J-1). Fishing (not including boating) is the next most popular activity, attracting an estimated 1,800,000 recreation visits. Hunting accounts for approximately 72,000 recreation visits. (DWR 1990a.)

The demand for recreation opportunities in the Delta is expected to increase primarily as a result of increased population. Higher incomes, increased numbers of retirees, and shorter workweeks will probably also influence the demand for new recreation opportunities. (DWR 1990a.)

After the 1995 DEIR/EIS was issued, the California Department of Parks and Recreation completed a recreation survey of the Delta for the Delta Protection Commission and the California Department of Boating and Waterways (California Department of Parks and Recreation 1997). The report outlines current recreation facilities and activities in the Delta and identifies needed improvements for Delta recreationists. The report found that the lack of public lands and facilities limits the use of the Delta for recreation. The report describes boating and fishing in the Delta, including an evaluation of facilities, equipment and locations used.

Although power boats remain the most common boating vessel used by Delta recreationists, the increased popularity of personal watercraft in recent years has changed the character of water-based recreation in the Delta. Fishing from a boat continues to be the most popular fishing activity in the Delta.

In its comments on the 2000 REIR/EIS (Aramburu pers. comm.), the Delta Protection Commission reported that hunting has continued to decline in California with the number of resident hunting licenses issued down 61% between 1970 and 1998, and the number of State duck stamps down 58% in the same period. Fishing has remained popular in the Delta and throughout California, with a slight decrease (8%) in the same period.

Public recreation opportunities in the Delta are limited because facilities are insufficient; the demand for parking, boat launch ramps, camp units, and picnic areas exceeds the supply. Other difficulties related to Delta recreation include limited access to recreation sites and minimal coordination between recreational jurisdictions. (DWR 1990a, SLC 1991.)

Approximately 120 commercial recreation facilities exist in the Delta, including at least 100 marinas (Figure 3J-1). Delta marinas provide services to regional boaters that include temporary and permanent boat berthing, mooring, and dry storage (Nunes pers. comm.). Most marinas operate at 50%-90% capacity. Other commercial facilities include resorts, restaurants with guest docks, and recreational vehicle parks (DWR 1990a, 1993). Also in the Delta are approximately 23 public recreation facilities that include areas or facilities for boat launching, camping, fishing access, swimming, and picnicking (SLC 1991). Brannan Island State Park is one of the largest public recreation areas in the Delta. Attendance records show that the park is usually full during May-September with numerous people being turned away. (DWR 1990a.)

Some hunting in public areas in the Delta is conducted from boats in waterways and on small unnamed Delta islands (Weinstein pers. comm.). The state owns 15,000 acres in Suisun Marsh at the western edge of the Delta, including approximately 6,000 acres of public hunting areas at Grizzly Island Wildlife Area. The state also owns the Lower Sherman Island Wildlife Area north of Antioch near the confluence of the Sacramento and San Joaquin Rivers, which has 3,300 acres open to hunting. No other state-managed or federally managed wildlife areas for hunting exist in the Delta but DFG may create a hunting program on Twitchell Island (Chapin pers. comm.).

On many privately owned Delta islands, owners and their guests hunt waterfowl on agricultural lands (Winther pers. comm.). Most of the private hunting clubs in the Delta are small, accommodating between eight and 16 hunters on a typical shoot day. At least one club occasionally has 30 hunters in a day. (Dennis, Luckey, Zuckerman pers. comms.) Landowners manage private hunting clubs on Delta islands that in some cases are no longer in agricultural production (Zuckerman pers. comm.). Approximately 200 people have private memberships with Delta hunting clubs (Weinstein pers. comm.).

Existing Recreational Uses on the DW Project Islands

This section describes the existing recreational uses on the DW project islands. Recreational use information, in part, is based on information collected for the 1990 draft EIR/EIS and has been updated to current conditions where these changes would affect the impact analysis.

Bacon Island

Hunting. No waterfowl hunting takes place on Bacon Island. Pheasant hunting is permitted by invitation only and is limited primarily to onsite workers and their families. No fees are charged. Pheasant hunting is allowed daily during a 3-week hunting period, typically from mid-November to mid-December. The California Fish and Game Commission annually establishes pheasant hunting season, so the specific dates change annually. On opening day, typically 30-35 hunters use Bacon Island, but for the rest of the season hunting participation declines to three or four hunters per day. The total number of hunting recreation use-days per season is estimated at 100 (Table 3J-2). (Shimasaki pers. comm.)

Hunters on Bacon Island are primarily San Joaquin County residents, and most of the remaining hunters come from Contra Costa and Santa Barbara Counties (Shimasaki pers. comm.).

Fishing and Boating. Approximately 90% of the fishing on Bacon Island takes place adjacent to the county road, which is the only means of public access. Although there are no designated public access areas along the roadway for fishing, members of the public fish Middle River from the island perimeter levee adjacent to Bacon Island Road. No other areas of Bacon Island are accessible to the public. Therefore, fishing from other parts of the island (i.e., away from the county roadway) is limited to relatives and employees of property owners, and trespassers in those areas are asked to leave. (Shimasaki pers. comm.)

Between the middle of November and the latter part of January, approximately 20 anglers per day fish on weekends and between two and four per day fish on weekdays from the levee adjacent to Bacon Island Road. These numbers are generally lower during the rest of the year. Total fishing activity is estimated at 3,120 recreation use-days per year on Bacon Island (Table 3J-2). Anglers using Bacon Island originate primarily from San Joaquin County and the East Bay. Although there are no marinas or boat docks on Bacon Island, about 35% of the anglers use boats to gain access to Delta waterways adjacent to Bacon Island. The remaining anglers (approximately 65%) fish from the levee adjacent to the county road. (Shimasaki pers. comm.)

Webb Tract

Hunting. No public hunting takes place on Webb Tract; hunting is limited to family and friends of the owners and no hunting fees are charged. Waterfowl hunting is allowed on Wednesdays, Saturdays, and Sundays in December and January following the corn harvest. Use averages between 10 and 15 hunters per day. Waterfowl hunting use is estimated at 320 recreation use-days per season. (Dinelli pers. comm.)

There is some private pheasant hunting, limited to friends and family of property owners, with no fees charged. Pheasant hunting is allowed daily from November 12 through December 1. An average of 15 hunters participate per day, for a total of about 320 recreation use-days per season. Estimated hunting recreation use-days on Webb Tract total 640 (Table 3J-2). Most hunters come from Contra Costa County. (Dinelli pers. comm.)

Fishing and Boating. Written permission from the property owners is required for fishing on Webb Tract. Anglers occasionally fish the northern blowout pond on Webb Tract. Fishing activity on Webb Tract totals approximately 90 recreation use-days per year (Table 3J-2). All anglers on Webb Tract live in Contra Costa County. No boating activity originates from Webb Tract. (Dinelli pers. comm.)

Bouldin Island

Hunting. Waterfowl hunting on Bouldin Island is limited to invited guests, and no hunting fees are charged. Most waterfowl hunting is for ducks; some geese are also hunted. Waterfowl hunting is permitted over a 59-day period, which typically occurs from the third week of October to mid-January. Waterfowl seasons are established annually by the Pacific Flyway Committee, so specific dates vary among years. Hunting is allowed on Wednesdays, Saturdays, and Sundays on Bouldin Island, with approximately six people hunting per day, for a total of approximately 150 hunting recreation use-days per season. Hunting facilities on the island consist of a building used to store waterfowl hunting equipment. (Wilkerson pers. comm.)

Pheasant hunting on Bouldin Island is also limited to invited guests, with no fees charged. Hunting is permitted on Wednesdays, Saturdays, and Sundays over a 30-day period. Approximately six people hunt per day, for a total of about 60 hunting recreation use-days per season. Total hunting recreation use-days on Bouldin Island are estimated at 210 (Table 3J-2). (Wilkerson pers. comm.)

Approximately 90% of the hunters on Bouldin Island are residents of San Joaquin County that make day trips to the area (Wilkerson pers. comm.).

Fishing and Boating. Onsite workers who fish from levees account for most of the fishing on Bouldin Island. Written permission is needed for others visiting the island. Most fishing occurs from October to March on weekends and weekday afternoons. Fishing activity averages two anglers per day, for a total of about 360 fishing recreation use-days per season. All anglers are San Joaquin County residents. No boating originates from Bouldin Island. (Wilkerson pers. comm.)

Holland Tract

Hunting. One ownership on Holland Tract accommodates for-fee hunting, which constitutes approximately 80% of the waterfowl hunting on this property. The remainder consists of hunting by friends and family of the landowner. Waterfowl hunting is permitted at two hunting clubs on Wednesdays, Saturdays, and Sundays during the waterfowl season. Approximately two people hunt per day, for a total of about 50 hunting recreation use-days per season for waterfowl. (Frelier pers. comm.)

Other property owners on Holland Tract either do not allow hunting or allow only limited hunting to members of their immediate families. Total waterfowl hunting per season on these properties totals about 10-15 recreation use-days. (Lindquist pers. comm.)

Pheasant hunting takes place primarily on the west side of Holland Tract. Hunters are charged a fee to visit the island. Approximately 20% of all hunting is nonfee hunting that is limited to friends and family of the landowner. The island generates approximately 30 hunting recreation use-days per season for pheasant. Total hunting recreation use-days on Holland Tract are estimated at 95 (Table 3J-2). (Frelier pers. comm.)

Most hunters on Holland Tract originate from the Bay Area. An estimated 80% of the hunters make day trips, and approximately 20% stay overnight in the local area. Approximately half the overnight users stay in hotels, and the other half stay in campgrounds. (Frelier pers. comm.) Hunting facilities on Holland Tract consist of a building used as a clubhouse (Cochrell pers. comm.).

Fishing and Boating. Most fishing on Holland Tract originates from two marinas on the south end of the island. Marina tenants generate an estimated 4,000 fishing recreation use-days per year. Fishing activities associated with the launch ramp (day-use boaters) account for another 4,500-7,700 fishing recreation use-days annually. Fishing from the levees accounts for approximately 200 fishing recreation use-days per year. Total fishing on Holland Tract thus ranges from 8,700 to 11,900 recreation use-days annually (Table 3J-2). Bay Area anglers account for approximately 75% of this activity. (Cochrell pers. comm.)

Two marinas located on Holland Tract presently support recreational boating near the island. The larger marina, located on the southeastern corner of the island, accommodates 235 boats more than 26 feet long and 100 boats less than 20 feet long. Boat slip occupancy at this marina averages approximately 85%, with the summer months being especially busy (Cochrell pers. comm.). Boat slips account for an estimated 24,100 boating recreation use-days per season.

The larger marina also has other facilities, including a fuel dock, a snack shack, a launch ramp, and a 500-foot guest dock. The launch ramp is used by day-use boaters. From May 1 through October 1, approximately 100-150 boats are launched per weekend day. During midweek, 25-50 boats are launched per day. The launch ramp generates an estimated additional 22,750-38,500 boating recreation use-days per season at Holland Tract. (Cochrell pers. comm.)

Most launch ramp use is related to waterskiing, which accounts for 18,200-30,800 recreation use-days per season. To avoid double counting, these waterskiing days are not included in Table 3J-2. Approximately 20% of the launch ramp boating activity is related to fishing (Cochrell pers. comm.).

The other marina on Holland Tract, located on the south shore, has a 21-berth capacity. Total boating generated by this facility is estimated at 1,500 recreation use-days per season. (Cochrell pers. comm.)

Total boating activity generated by all facilities on Holland Tract is approximately 56,225 recreation use-days (Table 3J-2). Approximately 80% of the boaters on Holland Tract come from the Bay Area, about 10% from Contra Costa County, and about 10% from other areas in the Delta (Cochrell pers. comm.).

Visual Resources

Visual quality can be described as the overall impression that is retained after one drives through, walks through, or flies over an area (U.S. Bureau of Land Management [BLM] 1980). Both natural and human-made features that make up a landscape contribute to its perceived image and visual quality. Visual quality is influenced by a wide range of landscape characteristics, including geologic, hydrologic, botanical, wildlife, recreational, and urban features.

Judgments of visual quality must be made in the context of a regional frame of reference (SCS 1978). The same landform or visual resource appearing in different geographic areas could have a different visual quality and sensitivity in each setting. For example, a small hill may be an important visual element on a flat landscape but have little importance in mountainous terrain.

Visual resource sensitivity is determined by the extent of the public's concern for a particular view or landscape, the number of viewers, and the frequency and duration of views. Visual sensitivity is higher for views seen by people who are driving for pleasure, people engaged in recreational activities, and homeowners; visual sensitivity tends to be lower for views seen by people driving to and from work or as part of their work (USFS 1974, Federal Highway Administration 1983, SCS 1978).

Terminology and Standards for Visual Resource Analyses

The visual character and quality in the vicinity of the DW project islands are evaluated using criteria established by the Federal Highway Administration (1983) for visual landscape relationships. These criteria are intactness, vividness, and unity. They are defined as follows:

- **Intactness** is the visual integrity of the natural and constructed landscape and its freedom from encroaching elements. This factor can be present in well-kept urban and rural landscapes as well as natural settings.

- **Vividness** is the visual power or memorability of landscape components that combine in striking or distinctive visual patterns.

Unity is the visual coherence, composition, and harmony of the landscape considered as a whole. It frequently attests to the careful design of individual components in the landscape. (Unity is most frequently used to describe the cohesiveness of built elements in an urban environment.)

The appearance of the landscape is described in this chapter using these criteria and descriptions of the dominance of elements of form, line, color, and texture. These elements are the basic components used to describe visual character and quality for most visual assessments. The criteria for identifying importance of views are related in part to the position of the viewer relative to the resource. An area of the landscape that is visible from a particular location (e.g., an overlook) or series of points (e.g., a road, trail, or waterway) is defined as a viewshed. (USFS 1974, Federal Highway Administration 1983.)

Relevant Policies on Visual Resources

Contra Costa County Visual Resource Policies. Preserving the scenic resources of Contra Costa County is an important general plan goal. The scenic vistas are major contributors to the perception that the county is a desirable place to live and work. Preserving the quality of visually sensitive features of the landscape reinforces the rural landscape character and balances the effects of development. (Contra Costa County Community Development Department [CCCCDD] 1991.)

The open space element of the county general plan identifies goals for preserving and protecting areas of high scenic value, including scenic qualities of the shorelines and other elements of the Bay and Delta systems, and scenic ridges, hillsides, and rock outcroppings. The transportation and circulation element of the county general plan designates scenic routes that have rural and natural scenic qualities that should be protected. The land use element identifies goals and policies for development and project design that reinforce the aesthetic character of the county, encourage the uniqueness of its communities, and enhance scenic quality.

San Joaquin County Visual Resource Policies. The river corridors, groves of valley oak trees, wetlands in the Delta, and sloping foothills and ridges of the Diablo Range and the Sierra Nevada are the key visual resources in the San Joaquin County landscape. The Delta waterways and marshlands are considered important visual features because they provide a contrasting visual element to the large tracts of agricultural land that are common in the county. (San Joaquin County Community Development Department [SJCCDD] 1992.)

San Joaquin County has designated as scenic routes roads that lead to recreation areas, exhibit scenery with agricultural or rural values or topographic interest, provide access to historical sites, or offer views of waterways (SJCCDD 1992). The general plan also identifies some Delta waterways as Significant Recreation Resource Areas; protection and maintenance of these areas for high-quality recreation is an important general plan goal (Figure 3J-2).

The land use element and open space and recreation element of the general plan include several policies for protecting, enhancing, and mitigating effects of development on visual resources in the county, including Delta waterways (SJCCDD 1992).

Visual Resources in the Delta Region

The Delta is an extensive, largely agricultural region linking the Central Valley and the Bay Area. Views in the Delta are dominated by flat, open agricultural land and sloughs and rivers that are bordered by levees. Scattered trees occasionally break the horizon, but typical views encompass agricultural fields. The Delta waterways are important visual features because they contribute to the visual character of the region by enhancing the vividness of views in the Delta. Because few roads traverse the Delta islands, the unique Delta landscape is accessible primarily by boat.

The visual resources associated with the four DW project islands are typical of the region. Views of the project islands from levee roads have some variety in form, line, color, and texture but are not unique to the region. The sensitivity of the visual resources of the four islands varies from island to island based on the wide variability in access to and travel patterns on the islands. The character of the views changes with the season, time of day, and weather, but the quality of the views is relatively uniform.

Bacon Island. Bacon Island is accessible only on its eastern side by a local levee road, Bacon Island

Road. Views from the road toward the Bacon Island interior are dominated by intensely farmed agricultural open space with scattered woody vegetation, farm buildings, and rural residences. Mt. Diablo can be seen to the west from Bacon Island Road, providing a background visual element that enhances the vividness of the viewshed from Bacon Island Road. Except for the utility lines that run along the perimeter of Bacon Island, the views of the island from the road are generally intact. The views are not vivid, however, and are common for the region. The overall visual quality of the island bottom from Bacon Island Road is considered moderate.

San Joaquin County has designated Bacon Island Road as a scenic route because of its recreational access and use characteristics and its visual relationship to the adjacent waterway (Figure 3J-2) (SJCCDD 1992). The road carries a low volume of traffic, and the remainder of the island is largely inaccessible to the public. The visual resources on this island as viewed from Bacon Island Road are considered moderately sensitive because of the small number of visitors traveling the designated scenic route and the inaccessibility of the rest of the island interior.

Views of the Bacon Island levees from adjacent waterways consist of a variety of forms and colors created by changing elevations between the water level and the levee and by textural differences between the water, the marsh, and the riparian vegetation along the water side of the levees. The views from the waterways are vivid and relatively intact but are common to the region. The overall visual quality of the island viewsheds from the water is considered moderate.

A portion of Middle River along the east side of Bacon Island and a portion of Connection Slough bordering the island to the north are considered "significant resource areas for recreation" by San Joaquin County and are frequently used by boaters and anglers (Figure 3J-2) (SJCCDD 1992). Views of the island perimeter levees from these waterways are therefore considered highly sensitive.

The Santa Fe Railways Amtrak line immediately south of Bacon Island runs eight passenger trains per day between Stockton and Richmond, California (Colbert pers. comm.). Views of the Bacon Island southern exterior levee from the train are similar to views of the levee from the adjacent waterway along the south side of Bacon Island (Santa Fe Cut). Views of Bacon Island from the railway are considered highly sensitive.

Webb Tract. Interior views of Webb Tract are dominated by agriculture, but the intensity of agricultural production on this island is low compared with that of Bacon Island. Webb Tract has more natural vegetation and high visual variability because of the scattered woody vegetation and blowout ponds. Views of the island bottom from the levee tops are vivid and intact because the visual resources vary and present a natural setting free from encroaching elements. The overall visual quality of resources on Webb Tract is therefore considered high.

Public access is more limited on Webb Tract than on any of the other project islands. No bridges provide access to the island; it is accessible only by ferry. The number of visitors to the island is low; thus, the visual sensitivity of the Webb Tract landscape as viewed from perimeter levees and other parts of the island interior is considered low.

Views of Webb Tract from adjacent waterways are similar to those described above for Bacon Island. The views are generally intact and vivid, but are common to the region. The overall visual quality of the landscape from the waterways is moderate.

Contra Costa County has designated all the waterways surrounding Webb Tract as scenic waterways (Figure 3J-2) (CCCCDD 1991). The general plan policies include maintenance or protection of the marshes and riparian vegetation along the shorelines and Delta levees, consistent with safety and other general plan policies. The Webb Tract perimeter levees as viewed from these waterways are therefore considered a highly sensitive visual resource.

Bouldin Island. Public access to the interior of Bouldin Island is limited to travelers crossing the island on SR 12. Views from SR 12 toward the interior of Bouldin Island are dominated by intensely farmed agricultural open space with scattered woody vegetation, farm buildings, and rural residential units. Utility lines cross the highway, detracting from the intactness of views of the island. The overall visual quality of Bouldin Island is considered moderate because the visual resources are somewhat intact but are not especially vivid, and because the views are common to the region.

Because Bouldin Island is visible to people from SR 12 and many of the viewers are recreationists in the Delta, visual sensitivity for part of the viewer group could be high. The duration of views for viewers along SR 12 is brief, however, because there are no vista points or rest areas on Bouldin Island from which to prolong the views. Therefore, the overall visual sensitivity is considered moderate for views of the island along SR 12.

A study by Caltrans found that the visual resources along the Bouldin Island section of SR 12 did not qualify this road section for eligibility for State Scenic Highway designation (Hatfield pers. comm., Caltrans 1992). Similarly, SR 12 on Bouldin Island has not been designated as a scenic roadway by San Joaquin County (SJCCDD 1992). Figure 3J-3 shows a typical view along SR 12 on Bouldin Island. The views of Bouldin Island are not especially vivid and are common to the region, and SR 12 across the island is not considered eligible for designation as a scenic route. Therefore, the overall visual quality of Bouldin Island is considered moderate for views from SR 12.

Views of Bouldin Island from adjacent waterways are similar to those described above for Bacon Island. The overall visual quality of the landscape from the waterways is moderate; these views are generally intact and vivid but are common to the region. Potato Slough south of Bouldin Island is considered a resource area for recreation (SJCCDD 1992), so the south perimeter levee is commonly viewed by boaters and anglers. The Bouldin Island east perimeter levee is visible from marina facilities across Little Potato Slough on Terminous Tract, both north and south of SR 12. Views of these perimeter levees from the waterways are considered highly sensitive because many recreationists use these waterways.

Holland Tract. Public access to Holland Tract is limited to Holland Tract Road along the south levee. Views of Holland Tract from the road consist of agriculture fields and some fallow areas with established woody vegetation along the levee and toward the center of the island (Figure 3J-4). This vegetation adds somewhat to the variety and texture of views and generally enhances the vividness of views of the island. The overall visual quality of resources on Holland Tract is considered moderate because the views are generally common to the region.

One small bridge at the southwest corner of Holland Tract provides access across Rock Slough to the marinas located on the southern levee; other parts of Holland Tract are inaccessible to the public. Furthermore, Holland Tract Road has no special local or state scenic corridor designation. Visual sensitivity of the Holland Tract landscape from the road is therefore considered moderate.

Views of Holland Tract from adjacent waterways include developed marina facilities on the southern and eastern side of the island and vegetated levees in other areas. The marina facilities that border Holland Tract for about 2/3 mile include covered and uncovered boat berths. Small ancillary buildings and covered berths are constructed partly using wood siding. Wood pilings in the water adjacent to one of the marinas are connected by a low narrow ridge of automobile tires. Because these view components generally disrupt the intactness and unity of views in marina areas, visual quality is low along the water side of the levees in the marina areas.

Views of Holland Tract from adjacent waterways away from the marinas are similar to those described above for the other DW project islands. The views are generally intact and somewhat vivid but are common to the region; therefore, the overall visual quality of the landscape from the waterways is moderate.

Old River, which borders the eastern side of Holland Tract, and Roosevelt Cut and the flooded Franks Tract waters north of Holland Tract are designated as scenic waterways by Contra Costa County (Figure 3J-2) (CCCCDD 1991). The county general plan policies include maintenance or protection of the marshes and riparian vegetation along the shorelines and Delta levees, consistent with safety and other general plan policies. Furthermore, these waters are frequented by boaters and anglers. The view of Holland Tract levees from these waterways is therefore considered highly sensitive.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Assessment of Recreation Impacts

The DW project is expected to increase opportunities for recreation in the Delta. As described above, DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on recreation presented below assumes that the recreation facilities would be constructed and operated. Recreation impacts were evaluated through comparison of changes in hunting, fishing, and boating use that would occur under the DW project alternatives with the point-of-reference conditions described above under "Affected Environment". Estimates of existing recreation use in the Delta (Table 3J-2) also provided a point of comparison to use in assessing the significance of changes in hunting, fishing, and boating that would occur under the DW project alternatives.

The hunting schedule on the DW project islands is based partially on California hunting regulations that determine the length of the hunting seasons (DFG 1993). Since the late 1980s, DFG has implemented changes to the hunting regulations that have resulted in a split duck-hunting season. No proposals currently exist to change current hunting regulations. It is therefore assumed that existing regulations would persist in future years.

Assessment of Visual Resource Impacts

Visual resource impacts were determined through evaluation of the effects a project alternative would have on views and potential viewer groups. These evaluations were based on the visual sensitivity of a site and the changes to visual quality of a viewshed that would result from implementation of a project alternative.

Criteria for Determining Impact Significance

Recreation Criteria

This analysis is based on the assumption that increased recreation opportunities in the Delta constitute beneficial impacts. An alternative is considered to have a beneficial impact on recreation if it would provide facilities for recreational use, create habitat for hunting use, or otherwise facilitate greater recreational use. An alternative is considered to have a significant impact on recreation if it would result in a decrease in recreation use-days in the Delta or a reduction in the quality of existing recreation experiences in the Delta.

Impacts on fisheries, wildlife, traffic, public health, and air quality that may result from increased recreation use are addressed, respectively, in the following chapters:

- Chapter 3F, "Fishery Resources";
- Chapter 3H, "Wildlife";
- Chapter 3L, "Traffic and Navigation";
- Chapter 3N, "Mosquitos and Public Health"; and
- Chapter 3O, "Air Quality".

Changes in economic conditions that may occur as a result of increased recreation use are addressed in Chapter 3K, "Economic Conditions and Effects".

Visual Resource Criteria

According to the State CEQA Guidelines, visual resource impacts are generally considered significant if the project will "have a substantial, demonstrable negative aesthetic effect" or if it will "conflict with adopted environmental plans and goals of the community where it is located". Based on these guidelines and professional standards and practices, a project alternative is considered to have a significant impact on visual resources if it would:

- substantially reduce the vividness, intactness, or unity of high-quality or highly sensitive views;
- substantially reduce the visual quality of highly sensitive views from designated scenic roads or waterways; or
- conflict with adopted visual resource policies identified from the general plans for Contra Costa and San Joaquin Counties or with scenic resource designations by other public agencies.

A project is considered to have a beneficial impact on visual resources if it would improve the visual quality of views or if it would provide new viewing opportunities in the project area.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands) and management of Bouldin Island and Holland Tract (habitat islands) primarily for wildlife habitat. Reservoir islands would be managed primarily for water storage, with wildlife habitat and recreation constituting secondary uses.

Changes in Recreation Conditions

Overview of Recreation Associated with the DW Project

DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on recreation assumes that the recreation facilities would be constructed and operated as described below.

Implementation of Alternative 1 would include development of recreation facilities along the four DW project island perimeter levees. (Figures 2-7 and 2-8 in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", depict a conceptual recreation facility.) These facilities would be run as a private operation and would provide year-round recreation opportunities at the DW project islands.

Each recreation facility would include living quarters for as many as 80 people. Parking lots would be constructed at each facility along levee roads to allow for vehicle access. A floating boat dock and gangway adjacent to each facility would provide boat access to island interiors along a network of ditches and canals. A similarly sized floating boat dock would be constructed on the slough or river side of the island levees to provide temporary and permanent boat berthing for members who would likely boat, waterski, and fish in Delta channels beyond the DW project islands.

A general schedule of recreation facility use can be determined based on various factors. Boating and waterskiing in Delta channels would be expected to occur primarily during the warmer months of the year (mid-May to mid-September). Participation in sport fishing can be predicted to occur primarily during February-November based on the expected presence of different fish species in the Delta. Participation in waterfowl and upland game hunting on the DW project islands would take place mostly during October-January based on California hunting regulations (DFG 1993). There would be some hunting during the first half of September for mourning dove. Figure 3J-5 depicts the expected schedule of participation in fishing and hunting at and near the DW project islands. The figure shows that recreation facility members and their guests would have reasons and opportunities to use the facilities throughout the year.

Other recreation activities at the DW project islands could include but would not be limited to birdwatching, photography, skeet and trap shooting, relaxing, walking, nature study, windsurfing, swimming, and canoeing. Recreationists could participate in these activities for a fee or at the invitation of DW. Many of these activities could take place throughout the year, weather permitting. Participation in these activities may result in incremental increases in existing regional recreation use-days (Table 3J-1). It is also possible that implementation of the DW project would cause local shifts of people who currently participate in these secondary recreation activities in other parts of the Delta.

Recreation Program for Alternative 1

Bacon Island and Webb Tract. Bacon Island and Webb Tract could each have a maximum of 11 recreation facilities under Alternative 1 (Figures 2-2 and 2-3 in Chapter 2, "Delta Wetlands Project Alternatives").

During years when water is not stored on reservoir islands during the growing season, Bacon Island and/or Webb Tract could be managed to create shallow-water habitats to attract waterfowl (Chapter 3H, "Wildlife", and Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands"). In years when shallow-water habitats are created, the reservoir islands would be available for waterfowl hunting during October-January until appropriative water becomes available in the Delta for diversion onto reservoir islands. Unless reservoir islands were seeded to create forage for waterfowl, the shallow-water habitats created on Bacon Island and Webb Tract would probably have marginal quality as foraging habitat and would not be expected to provide an exceptional hunting experience (see Chapter 3H, "Wildlife").

During years when appropriative water is available in the Delta for storage on reservoir islands, Bacon Island and/or Webb Tract would be managed as a water storage facility. Waterfowl hunting would be conducted from boats, floating blinds, and on foot from perimeter levees. During water storage, the reservoirs would provide resting habitat for some waterfowl, but the foraging habitat would be extremely limited. The reservoir islands would not be expected to attract large numbers of waterfowl; consequently, hunter participation would be low. (Appendix G2 provides further detail on storage condition classes.) Because of the uncertainty of waterfowl habitat availability, the recreation facilities on reservoir islands would likely be used more by members who enjoy boating and fishing and less by members who hunt.

The reservoir islands could also be used for temporary storage of water owned by parties other than DW. The water storage could occur as a result of water transfers and water banking. These storage occurrences could increase the uncertainty of availability of shallow-water wetlands for wintering waterfowl and therefore increase the uncertainty of recreational uses. Actions taken by other parties to use the DW reservoir islands for water storage, however, are speculative and beyond the scope of this EIR/EIS.

As described above, other recreation activities would be expected to occur on the DW project islands; the reservoir island interiors could be used for canoeing, windsurfing, and swimming during deep-water storage periods.

Bouldin Island and Holland Tract. Habitat islands would be managed primarily to provide wildlife habitat to compensate for habitat losses on the four DW project islands. Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", describes the HMP under which the habitat islands would be managed. Bouldin Island and Holland Tract could have a maximum of 10 and six recreation facilities, respectively, under Alternative 1 (Figures 2-7 and 2-8 in Chapter 2, "Delta Wetlands Project Alternatives").

Implementation of the HMP as part of Alternative 1 would result in the creation of high-quality wintering waterfowl foraging habitat on the habitat islands that would be managed primarily to enhance the value of waterfowl habitat in the Delta. HMP implementation would provide 3,055 acres of spaced-blind hunting areas and 3,743 acres of free-roam hunting areas on habitat islands (Table 20 in Appendix G3). The hunting program under the HMP would allow hunting on Wednesdays, Saturdays, and Sundays during the hunting seasons prescribed by DFG (1993) (Figure 3J-5). Two additional hunting days would be allowed during the waterfowl seasons to compensate for hunting days that may fall on holidays.

The Bouldin Island airstrip will be available for use by hunters and other recreationists to fly to the island. Restrictions have been placed on fixed-wing and helicopter use of the airstrip during the waterfowl season to reduce disturbances to wildlife (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

Recreation facilities on habitat islands would also be expected to provide opportunities for recreationists to participate in the full range of other recreation activities described above.

Hunting

Bacon Island and Webb Tract. As described above, hunting would occur on the reservoir islands during shallow-water wetland and storage periods.

A total of 3,694 acres on Bacon Island and 3,836 acres on Webb Tract could be managed as shallow-water wetlands during nonstorage periods (Table 3J-3) (JSA 1993). This acreage could be hunted for waterfowl every day of the week during the hunting seasons at estimated densities up to one hunter per 30 acres. (JSA 1993, DFG 1993, Forkel pers. comm.)

The quality of the hunting would depend on the availability of foraging habitat for waterfowl. Unless DW seeds the islands during nonstorage periods, the availability of waterfowl forage plants would diminish over time. Large numbers of waterfowl would not be expected to visit the reservoir islands unless forage were available.

Predicting when the islands would be available for hunting during shallow-water wetland periods is difficult because DW may fill reservoir islands in a sequence that changes each year to maximize the opportunity for creating shallow-water wetlands. However, DW may divert water simultaneously and at the same rate onto each island, minimizing the frequency with which shallow-water wetlands would be created. (Chapter 3N, "Mosquitos and Public Health", and Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands", describe each management regime and the expected changes in vegetation conditions.) The selected management regime would also influence the frequency of occurrence of storage condition classes. This analysis is based on the assumption that either management regime could occur; consequently, the percentages of project years when islands would be in a shallow-water wetland condition or a storage condition represent an average of the two regimes (Tables 3J-3 and 3J-4). (Methods used to derive percentages are described in Chapter 3N and Appendix G2.) The values shown for annual maximum hunter use-days in Tables 3J-3 and 3J-4 therefore are adjusted to account for unpredictable year-to-year storage conditions under Alternative 1.

Prediction of future conditions on reservoir islands is based on end-of-month water storage amounts predicted by the DeltaSOS simulations conducted for the 1995 DEIR/EIS. Additional simulations were performed for the updated evaluation of project operations under the proposed project in the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations"; however, the differences in DeltaSOS results in the 1995 DEIR/EIS and 2000 REIR/EIS evaluations of Alternatives 1 and 2 do not affect the conclusions of this chapter. Therefore, the analysis of reservoir island habitat conditions and the resulting estimates of hunting recreational user-days from the 1995 DEIR/EIS remains unchanged and is presented below.

Waterfowl Hunting under the Shallow-Water Wetland Condition. Table 3J-3 shows that Bacon Island and Webb Tract could support 4,119 and 4,729 maximum hunter use-days, respectively. The maximum hunter use-days calculated in Table 3J-3 for the shallow-water wetland condition are adjusted to account for the possible marginal quality of wetlands on reservoir islands and the low hunter attendance that would result from probable low numbers of waterfowl. Therefore, it is assumed that hunter participation would average 30% of capacity during the hunting seasons on reservoir islands. Under Alternative 1, Bacon Island and Webb Tract may support a total of approximately 2,660 annual recreation use-days for waterfowl hunting under the shallow-water wetland condition during any project year (Table 3J-3).

Waterfowl Hunting under Water Storage Conditions. All of Bacon Island and Webb Tract would be managed for full, partial, or shallow storage in some years. Totals of 5,539 acres on Bacon Island and 5,470 acres on Webb Tract could be hunted for waterfowl every day of the week during water storage periods during the hunting seasons at densities of up to one hunter per 30 acres (Table 3J-4) (JSA 1993, DFG 1993).

Because Clifton Court Forebay is a large open-water area, hunter use data for the forebay provide an indicator of the level of hunting that could be expected at the DW reservoir islands. Waterfowl hunting season use reports were obtained for the Clifton Court Forebay Waterfowl Public Shoot Area for four waterfowl hunting seasons during the middle 1970s and early 1980s. The reports provide data on total acreages, maximum quotas of hunters allowed, numbers and types of waterfowl killed per shoot day, and total attendance per day during the waterfowl hunting season. Average attendance at the Clifton Court Forebay Public Shoot Area during the four hunting seasons was 27% of capacity. Results of the hunting reports are summarized in Table 3J-5.

Clifton Court Forebay is operated as a public shooting area, whereas access to the privately owned recreation facilities on the DW reservoir islands would be limited to members and their guests. Hunter participation at public waterfowl hunting areas such as Clifton Court Forebay would be expected to exceed participation on the DW reservoir islands under water storage conditions.

Furthermore, the DW reservoir islands might not support the level of participation in waterfowl hunting that has occurred in the past at Clifton Court Forebay. Hunter use data (Table 3J-5) may represent the high level of waterfowl hunting in California during the 1970s, when the number of waterfowl hunting permits issued statewide was much higher than during any subsequent period. The level of participation in waterfowl hunting in California is less than half that of the 1970s, and waterfowl hunting is not expected to approach the levels seen during the 1970s. (Becker pers. comm.)

As described previously, waterfowl would congregate to rest on the open water during storage periods. Waterfowl hunting would occur during storage periods from boats with blinds, scull boats, and floating blinds and on foot from perimeter levees. (A scull boat is a small boat that can be maneuvered by one passenger using a single oar.) Most hunting would likely occur from motorized boats with blinds (camouflage). Scull boating requires special equipment and skills, and few hunters participate. Stationary floating blinds would provide the least desirable opportunities for hunting on open water because they cannot be moved to better hunting areas. (Wernette pers. comm.) Overall, the specialized nature of open-water hunting would lead to low levels of hunting on the DW reservoir islands during storage periods.

Table 3J-4 shows that Bacon Island and Webb Tract could support a maximum of 9,038 and 8,299 hunter use-days, respectively. The maximum numbers of hunter use-days calculated in Table 3J-4 have been adjusted to account for the predicted low levels of hunting on reservoir islands during storage periods. As described above, low hunter attendance would be expected because of the unpredictable schedule of water storage periods and because the hunting areas at the DW reservoir islands would be private rather than public. Furthermore, hunter participation at the DW reservoir islands would probably not approach the level of hunting documented at Clifton Court Forebay during the late 1970s. The specialized nature of open water hunting would also contribute to low hunting levels. Therefore, it is assumed that hunter participation during storage periods would average 15% of capacity during the hunting seasons on reservoir islands. This percentage was applied to the maximum numbers of hunter use-days for Bacon Island and Webb Tract, leading to the estimate that approximately 2,600 annual recreation use-days for waterfowl hunting may result from operation of Alternative 1 during storage periods during any project year (Table 3J-4).

Upland Game Hunting. Herbaceous habitats could become established on exposed island bottoms during periods when reservoir islands are managed to provide shallow-water habitat; these habitats could provide forage for mourning dove and possible nesting opportunities for ring-necked pheasant during some years. Habitat for these upland game species, however, would be nonexistent on reservoir islands under full storage conditions, and water storage on the islands would limit establishment of breeding habitat for doves or pheasants. (See Chapter 3H, "Wildlife", for more detail on predicted changes to upland game habitat.) Incidental hunting for these upland game species may occur on reservoir islands during September, before the start of the waterfowl hunting seasons (Figure 3J-5). The numbers of recreation use-days associated with this activity would be very low and would not alter this impact analysis; therefore, they were not included.

Incidental upland game hunting could also occur during November-December, concurrent with part of the waterfowl hunting seasons. No assumptions were made regarding numbers of hunters who may participate in upland game hunting to avoid double counting of hunters who would likely also be hunting waterfowl.

Bouldin Island and Holland Tract. A total of 2,122 acres on Bouldin Island and 933 acres on Holland Tract would be managed as spaced-blind hunting zones under the HMP for hunting waterfowl (Table 3J-6). The blinds occupied by hunters would be at a maximum density of one blind per 50 acres, and each blind could accommodate four hunters at a time; therefore, maximum hunter density would be one hunter per 12.5 acres. Hunting would occur on Wednesdays, Saturdays, and Sundays during the hunting seasons (Figure 3J-5) (DFG 1993).

A total of 2,331 acres on Bouldin Island and 1,308 acres on Holland Tract would be managed as free-roam hunting zones under the HMP for hunting waterfowl and upland game during the October-January hunting seasons (Table 3J-6). Maximum hunter density would be one hunter per 60 acres, and hunting could occur on Wednesdays, Saturdays, and Sundays during the hunting seasons (Figure 3J-5) (DFG 1993).

An additional 104 acres are designated only for upland game hunting on Bouldin Island; when these are added to the 2,331 free-roam acres, a total of 2,435 free-roam acres are available for mourning dove hunting during September (Figure 3J-5). The 104 free-roam acres were deleted from Table 3J-6 for October-January to avoid double counting of hunters who would probably also hunt waterfowl. (See Tables 19, 20, and 21 in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", for more detail on the HMP hunting program.)

Table 3J-6 shows that Bouldin Island and Holland Tract could support a maximum of 8,632 and 4,011 hunter use-days, respectively. Contacts with private hunting club owners and public refuge managers were made to determine the average hunter participation as a percentage of capacity. As described previously under "Recreational Uses in the Region", private hunting clubs in the Delta are small and participation is generally limited to landowners and their guests. Participants hunt frequently and attendance patterns are different from those at large refuges. Furthermore, maximum density cannot be calculated because the clubs generally operate on hundreds of acres that could accommodate many more hunters. (Zuckerman pers. comm.)

Although the DW hunting program would be private, information obtained from managers of public refuges located in the Sacramento Valley, Butte Basin, and west of the Delta at Grizzly Island is assumed to provide a reasonable indication of the level of hunting participation anticipated on Bouldin Island and Holland Tract. This assumption is based on the fact that Alternative 1 would create high-quality wintering waterfowl foraging habitat in the Delta at a scale comparable to that of the public refuges. The waterfowl habitat at the DW habitat islands would be expected to attract an abundance of several waterfowl game species; therefore, hunter participation would likely be similar to that on the inland public refuges.

Waterfowl hunting season reports were obtained from five public refuges for the 1993-1994 hunting season. Hunting season reports are not maintained for Lower Sherman Island Wildlife Area. The reports did not provide data on upland game hunting. Results of the hunting reports are summarized in Table 3J-7.

The values that are over 100% in Table 3J-7 indicate that as hunters checked out during shoot days in October and January when the demand for hunting was high, other hunters entered the refuges. Average attendance at the public refuges during the 1993-1994 hunting season was 86% of capacity. This figure was applied to the maximum hunter use-days for Bouldin Island and Holland Tract in Table 3J-6 to show that approximately 10,870 total annual recreation use-days for hunting would be generated during any project year under Alternative 1.

Fishing and Boating

Implementation of Alternative 1 would increase recreation use-days related to fishing and boating in the Delta. Each private recreation facility would include a 30-berth boat dock constructed on the channel side of the project island perimeter levees to accommodate temporary and permanent boat docking for private guests (see Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives", for conceptual design of the recreation facilities). As described previously under "Recreation Program for Alternative 1", a total of 38 recreation facilities could be constructed at the DW project islands over the life of the project. The recreation facilities would provide overnight accommodations for boaters and other recreationists. If there is low demand for facilities, DW may construct fewer facilities and/or smaller facilities.

Delta boating use attributable to the DW project would originate from the recreation facility boat docks. Assuming 70% occupancy of the boat slips, implementing Alternative 1 would provide permanent boat docking in Delta waterways for 798 boats. Contra Costa County and San Joaquin County have 38,330 and 22,870 registered boats, respectively (Nunes pers. comm.). If none of the boats docked at the DW project facilities are existing registered boats, the DW project could add approximately 800 registered boats to the two-county area. This would represent a 1%-2% increase over the existing number of boats in the area. Recreational boat use would be highest during summer weekends and lowest during winter. Table 3J-8 shows the average weekend and weekday boat use by season estimated for Alternative 1. Based on an estimate of three boaters per boat, it is estimated that an annual increase of 100,620 boater recreation use-days would be generated by Alternative 1 (Table 3J-9). This represents a 5% increase over the 2,016,000 existing boater recreation use-days in the Delta (Table 3J-2).

It is possible that some anglers and boaters in the Delta are limited by the lack of public facilities with boat launch areas. (The shortage of public recreation facilities in the Delta is described under "Recreational Uses in the Region".) As described previously in this section, the DW project recreation facilities would be private and would provide mooring for members with boats. It is assumed that implementation of the DW project would not contribute to relieving the demands on public recreation facilities for access to Delta waterways.

Other Recreational Uses

Implementation of Alternative 1 would likely increase participation of recreationists on the DW project islands in recreational uses other than hunting, fishing, and boating. The proposed recreation facilities would accommodate recreationists interested in birdwatching, photography, nature study, walking, relaxing, skeet and trap shooting, swimming, and other activities. The reservoir island interiors could be used for canoeing, windsurfing, and swimming during deep-water storage periods. Other recreational uses would occur year round but most frequently during summer. Estimated recreation use-days for these other uses generated by the DW project are shown in Table 3J-10. Other recreational use was estimated as a relative percentage of boater use-days by season. Implementation of Alternative 1 would generate approximately 38,560 recreation use-days related to these other uses.

Summary of Project Impacts and Recommended Mitigation Measures

Impact J-1: Increase in Recreation Use-Days for Hunting in the Delta. Implementation of Alternative 1 would result in the creation of 7,530 acres of low- to medium-quality shallow-water wetland waterfowl habitat on reservoir islands during some years (JSA 1993). The quality of the wetland habitat for waterfowl on reservoir islands would be dependent on forage availability. All the reservoir island acreage, approximately 11,000 acres, would be in a water-storage condition in some years; waterfowl would rest on the open water and possibly forage in shallow areas around the storage pool edges.

A total of 8,219 acres of high-quality wintering waterfowl compensation habitat would be created on the habitat islands (Table 15 in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). Some of the waterfowl habitat would also support upland game. The combined habitats for waterfowl and upland game would support approximately 16,130 annual hunting recreation use-days in the Delta (Table 3J-11). This figure represents a net increase of approximately 15,080 hunter use-days over existing conditions on the DW project islands (Tables 3J-2 and 3J-11).

The net increase of 15,080 hunter use-days generated by Alternative 1 represents a 21% increase over the 72,000 existing hunting recreation use-days in the Delta (Tables 3J-2 and 3J-11).

The increase in number of hunters in the project vicinity could detract from the quality of the recreation experience for some people; however, most other recreational uses (e.g., boating and fishing) occur primarily during summer and would not be affected by increases in hunting on the DW project islands during the hunting season. Also, the benefits of having new areas in the Delta for hunting use outweigh possible annoyances that could result from hunters being concentrated in the project area during hunting season.

This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact J-2: Change in Regional Hunter Success outside the Project Area. Implementation of Alternative 1 would include establishment of 8,219 acres of wintering waterfowl compensation habitat on the habitat islands (Table 15 in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). As described in Chapter 3H, "Wildlife", establishment of these wetland areas is expected to result in some redistribution of regional waterfowl populations to the habitat islands. This redistribution may cause a decrease in hunter success outside the project area. This scenario may occur especially in areas where wintering waterfowl habitat management and waterfowl hunting are secondary to other uses; the resultant waterfowl foraging habitat may be less than optimal.

However, during hunt days on the habitat islands, waterfowl would disperse to other areas in the Delta where they could be hunted. Waterfowl may also disperse to forage in adjacent areas as the food source diminishes during winter on habitat islands. Therefore, potentially decreased hunter success in some areas would likely be offset by increased hunter success in hunted areas relatively close to the DW project islands. Additionally, implementation of the HMP as part of Alternative 1 would include establishment of waterfowl breeding habitat that would be expected to increase numbers of waterfowl in the region. (Appendix G3 includes details on the proposed waterfowl habitats.)

This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-3: Increase in Recreation Use-Days for Boating in the Delta. Implementation of Alternative 1 would result in a net increase of 100,620 annual boater use-days at project build out. This increase represents a 5% increase over existing boater use-days in the Delta. Sport fishing would occur primarily during February-November (Figure 3J-4), and most boating would occur during the warmer months (Table 3J-8). Although the DW project would not contribute to relieving demands for public access to Delta waterways, implementing Alternative 1 would facilitate greater boating and fishing use in the Delta. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact J-4: Change in the Quality of the Recreational Boating Experience in Delta Channels. Implementation of Alternative 1 would increase boat use in Delta channels and alter existing boating conditions on waterways adjacent to the DW project islands. The State Division of Boating and Waterways requires that boats traveling within 200 yards upstream or downstream of boat docks maintain speeds of less than 5 mph. If DW recreation facilities were all constructed in waterways that do not have existing speed restrictions, the presence of the facilities would necessitate speed restrictions being established on more than 8 miles of Delta waterways. Because recreational uses such as waterskiing require higher boat speeds, introducing boat speed restrictions in Delta waterways could reduce the availability of areas that support those uses. Also, the increase in the number of boaters in the project vicinity could detract from the quality of the recreation experience for some people (see Chapter 3L, "Traffic and Navigation", for more information on waterway traffic and boater safety).

Implementation of Mitigation Measure RJ-1 would reduce impact J-4, but not to a less-than-significant level.

Mitigation Measure RJ-1: **Reduce the Number of Outward Boat Slips Located at Recreation Facilities**. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. With the implementation of this mitigation measure the number of permanent docking spaces provided by the recreation facilities would decline from 1140 to 570 slips. Using the methodology described above, this would reduce the number of boats that are provided permanent docking space from 798 to 400. A reduction in the number of boats originating from project recreation facilities would lessen adverse impacts on changes in the quality of the recreational boating experience in Delta channels, but not to a less-than-significant level.

Impact J-5: Increase in Recreation Use-Days for Other Recreational Uses in the Delta. Implementation of Alternative 1 would increase participation in Delta recreational activities other than hunting, fishing, and boating. Because the DW project facilities would be private, they would not contribute to meeting public demands for facilities to support these activities. However, implementing Alternative 1 would support approximately 38,560 recreation use-days for other recreational activities in the Delta and would provide accommodations to support these activities. This figure represents an increase of less than 1% over the existing 5,136,000 recreation use-days for relaxing, sightseeing, camping, picnicking, photography, and bicycling in the Delta (Table 3J-1). This impact is considered beneficial.

Mitigation. No mitigation is required.

Changes in Visual Resources

DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on visual resources assumes that the recreation facilities would be constructed and operated.

Alternative 1 would introduce recreation facilities and ancillary boat docks, pump and siphon stations, levee improvement material, and wetland habitat into the viewsheds of the four project islands. The dominant visual character on the four islands would change from agricultural open space to open water or a combination of upland, riparian, and wetland vegetation. Implementation of the DW project would provide new opportunities for members of recreation facilities on the DW project islands to view habitat island interiors and other areas in the project vicinity. The impacts for each DW project island are described below.

Bacon Island

Implementation of Alternative 1 would result in the conversion of land in agricultural use on Bacon Island to water storage. Intake siphons and discharge pumps and recreation facilities would encroach on the existing visual features on the interior and exterior levee slopes and would be visible from Bacon Island Road. Perimeter levees around Bacon Island would be strengthened and improved. Vegetation would be removed from levee slopes and replaced with rock revetment. These changes would reduce the vividness and intactness of views of the levee slopes from the road.

The existing visual quality on Bacon Island is considered moderate, however, because the agricultural landscape is common to the region, and the visual sensitivity is considered moderate because access to the island interior is limited to a few viewers who use Bacon Island Road.

As described above under "Visual Resources in the Delta Region", Bacon Island Road is designated as a scenic route because of its recreational access and its visual relationship to the adjacent waterway (Figure 3J-2) (SJCCDD 1992). Bacon Island Road would be reconstructed on the improved levee on the east side of the island and one new intake siphon and up to four new recreation facilities would be constructed adjacent to the designated scenic roadway. Vegetation on the levee would be removed and replaced with rock revetment during levee improvement. Built elements introduced into the viewshed would encroach on the designated scenic corridor and would reduce the intactness and unity of views of Bacon Island from Bacon Island Road. The road would, however, continue to provide access to recreation areas and views of the adjacent waterway; therefore, implementation of Alternative 1 would not be expected to conflict with the scenic corridor designation.

Implementation of Alternative 1 would not likely change views from the road of Middle River, flooded Mildred Island, and Lower Jones Tract; furthermore, viewing opportunities may be slightly enhanced as a result of improvements being made to the Bacon Island Road levee.

Views of the island from adjacent waterways would be affected by improvements to perimeter levees, construction of the siphon and pump stations, and construction of boat docks for the proposed recreation facilities. During project construction, existing vegetation would be removed from the perimeter levees, the levees would be raised, and rock revetment would be placed along the exterior slopes. The levees would be kept clear of most vegetation during project operation to facilitate levee inspections. These changes to the levees would be highly visible to boaters and anglers on adjacent waterways.

As described previously, two significant resource areas for recreation are designated along the Bacon Island eastern and northern perimeter levees (Figure 3J-2) (SJCCDD 1992). The DW project would change the character of the levee slopes from vegetated to unvegetated with the addition of rock revetment. The project would also introduce recreation facilities (e.g., boat docks and access ramps) along the exterior levee slopes in the designated resource areas. These resource areas are considered visually sensitive by San Joaquin County, as indicated in the county general plan. Implementing Alternative 1 would substantially reduce the vividness, intactness, and unity of views from the waterways adjacent to Bacon Island.

Many Amtrak passengers have a northward view from the south side of Bacon Island across the tops of the levees. As described above, implementing Alternative 1 would reduce the quality of views of the levee slopes by introducing recreation facilities and altering levee materials and design in the viewshed. A discharge pump station would also be constructed along the south side island levee. Views from the Santa Fe rail line would therefore be substantially altered under Alternative 1.

Webb Tract

Implementing Alternative 1 would change the land use of the island floor of Webb Tract from agriculture to open water or wetland vegetation. As described for Bacon Island, the island levee slopes would be modified and siphon and pump stations and recreation facilities would be constructed around the levee perimeters. Introduction of these elements would reduce the vividness and intactness of views of the island interior from perimeter levees, affecting the overall visual quality of the Webb Tract viewshed. However, access to the interior of Webb Tract is limited and few people view the island interior. Therefore, changes to the aesthetic conditions on Webb Tract would be relatively inconsequential.

Webb Tract is surrounded by waterways designated as scenic by Contra Costa County (Figure 3J-2). Strengthening and improving perimeter levees and constructing boat docks for recreation facilities would introduce built elements into this generally intact landscape. Vegetation would be removed and replaced with rock revetment. The siphon and pump stations would also be highly visible to boaters and anglers. These changes to the existing levees would not be easily absorbed into the natural landscape. The visual quality of views of Webb Tract from the designated scenic waterways surrounding the island would be substantially reduced.

Bouldin Island

Implementation of Alternative 1 would change the land use of island floor of Bouldin Island from agricultural production to wildlife habitat. The habitat elements would generally improve the vividness of views of the island from SR 12, the only access route on Bouldin Island. (See Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", for detailed descriptions of habitats.)

Potato Slough, bordering the south side of Bouldin Island, is designated as a significant resource area for recreation by the county (Figure 3J-2) (SJCCDD 1992). Construction of boat docks associated with the proposed recreation facilities on the south side of the island would be visible from the slough. Introduction of these built elements into the viewshed from the waterway would reduce the intactness of those views. The island perimeter levees would otherwise be maintained in a manner similar to existing practices.

Holland Tract

Changes to visual resources on Holland Tract would be similar to those described for Bouldin Island. Views of the island interior from the county road would likely improve in vividness because the variety of landscapes on the island bottom would increase in areas managed for habitat. Although the island perimeter levees would not be substantially altered under Alternative 1, boat docks constructed for recreation facilities in designated scenic waterways on the north and east sides of Holland Tract would encroach on the existing views from the waterways (Figure 3J-2).

Summary of Project Impacts and Recommended Mitigation Measures

Impact J-6: Reduction in the Quality of Views of the Reservoir Island Interiors from Island Levees. Implementation of Alternative 1 would result in the conversion of the Bacon Island and Webb Tract interiors from agricultural use to open water or shallow-water wetland vegetation. Levee improvements would include replacing vegetation on interior levee slopes with rock revetment. DW project facilities along levees would include recreation facilities and intake siphons and discharge pumps. These project features would reduce the vividness and intactness of interior island views from existing island roads. However, views of the island interiors are not highly sensitive because low numbers of viewers are present on the reservoir islands. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-7: Potential Conflict with the Scenic Designation for Bacon Island Road. Implementation of Alternative 1 would include introduction of recreation facilities and a siphon station facility into the Bacon Island Road viewshed, which would change the views from the designated scenic corridor. Levee improvements would include removal of vegetation and placement of rock revetment on levee slopes. However, Bacon Island Road would continue to provide access to recreation areas and views of the adjacent waterway, and these criteria are the basis for the Bacon Island Road scenic designation. Levee improvements and the introduction of project facilities into the roadway scenic corridor would not affect the county designation. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-8: Reduction in the Quality of Views of the Reservoir Islands from Adjacent Waterways and from the Santa Fe Railways Amtrak Line. Implementation of Alternative 1 would result in construction of recreation facilities and siphon and pump stations along Bacon Island and Webb Tract levees. Perimeter levees would be strengthened and improved and vegetation would be removed and replaced with rock revetment. These changes would substantially reduce the intactness and unity of highly sensitive views of these island levees from adjacent waterways, including waterways around Bacon Island and Webb Tract that are designated as scenic. Views from the Santa Fe rail line along the south side of Bacon Island would be similarly affected. Although facility design features described below under Mitigation Measures J-1 and J-2 would reduce the intensity of this impact, these features would not restore the quality of views of exterior island levees. Therefore, this impact is considered significant and unavoidable.

Implementing Mitigation Measures J-1, J-2, and RJ-1 would reduce Impact J-8, but not to a less-than-significant level.

Mitigation Measure J-1: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas. Concurrent with implementation of Alternative 1, DW shall, consistent with flood control and levee or facility maintenance requirements, establish screening that could consist of native trees, shrubs, landscape berms, and ground covers between the project facilities and designated scenic waterways. Landscape berms near structures will provide partial screening and will better connect the buildings visually to the site and the area. Screening vegetation shall be planted in locations and at a density that would provide at least a 50% visual screen after 5 years.

Mitigation Measure J-2: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape. DW shall require that pump and siphon station structures and recreation facilities be painted in earth tones to blend with the surrounding landscape. Rock revetment material shall be selected to blend with the surrounding landscape and minimize glare. DW shall limit structure heights and emphasize horizontal features in its design. Boat docks and related structures shall be constructed of natural-appearing materials with subdued, earth-tone colors to blend in with the surrounding environment.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under Impact J-4.

Impact J-9: Enhanced Views of Bouldin Island from SR 12. Implementation of Alternative 1 would involve management of Bouldin Island for wildlife habitat, which would enhance the vividness of views from SR 12. This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact J-10: Reduction in the Quality of Views of the Habitat Islands from Adjacent Waterways. Implementation of Alternative 1 would not include removal of vegetation from exterior levee slopes on the habitat islands, and the changes in the visual quality would be considerably less severe than for the reservoir islands. Construction of boat docks and related structures associated with the proposed recreation facilities, however, would reduce the quality of views of island levees from designated scenic and significant waterways. Constructing the boat docks and related structures would reduce the unity and intactness of the highly sensitive views from adjacent channels by introducing a built element into a generally intact landscape. Therefore, this impact is considered significant.

Implementing Mitigation Measures J-1, J-2, and RJ-1 would reduce Impact J-10 to a less-than-significant level.

Mitigation Measure J-1: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas. This mitigation measure is described above.

Mitigation Measure J-2: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape. This mitigation measure is described above.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under Impact J-4.

Impact J-11: Increase in Viewing Opportunities and the Quality of Views of Island Interiors and the DW Project Vicinity for Recreation Facility Members. Implementation of Alternative 1 would provide increased access to the DW project area. Recreation facilities on reservoir islands would provide opportunities for members to view open water and wetland areas at or near reservoir islands while they relax or enjoy recreation activities such as boating or fishing in the Delta.

A complex mosaic of wildlife habitats would be established within the interiors of the habitat islands, which would greatly enhance the vividness of views of the island interiors from the surrounding levees. (See Appendix G3, "Habitat Management Plan for the

Delta Wetlands Habitat Islands", for detailed descriptions of habitats.) Recreation facility members would benefit from these enhanced views.

This impact is considered beneficial.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

Changes in Recreation Conditions

The recreation program under this alternative is the same as under Alternative 1. Hunter use-days under Alternative 2 for the habitat islands are the same as for Alternative 1, as shown in Table 3J-6. Hunter use-days under Alternative 2 for the shallow-water wetland condition and for water storage conditions on reservoir islands are shown in Tables 3J-12 and 3J-13, respectively. Implementation of Alternative 2 would result in a net increase of approximately 15,150 total annual hunting recreation use-days in the Delta (Tables 3J-2 and 3J-11). The slight variation in hunter use-days between this alternative and Alternative 1 is attributable to minor variations in the flooding regimes for the reservoir islands. As for Alternative 1, the 1995 DEIR/EIS simulations of reservoir conditions under Alternative 2 are used in the analysis of hunting recreation use-days. Boater and other recreation use-days under Alternative 2 are the same as for Alternative 1, as shown in Tables 3J-9 and 3J-10. Impacts and mitigation measures under this alternative are the same as under Alternative 1.

Changes in Visual Resources

Impacts on visual resources and mitigation measures under this alternative are the same as under Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation.

Changes in Recreation Conditions

Recreation Program for Alternative 3

Although the DW project islands would be used for water storage under this alternative, the NBHA north of SR 12 on Bouldin Island would be managed as a wildlife habitat area and would not be used for water storage. The NBHA encompasses 875 acres, most of which would be available for waterfowl and upland game hunting during the hunting seasons. (Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands", includes proposed acres by habitat type for the NBHA.)

Under Alternative 3 the four islands could have a total maximum of 40 recreation facilities. (Figures 2-10 and 2-11 in Chapter 2 depict DW project facilities on Bouldin Island and Holland Tract for Alternative 3.) The recreation program for the DW project islands under Alternative 3, except for the NBHA, would be the same as that described for Bacon Island and Webb Tract under Alternative 1.

Hunting

Bacon Island, Webb Tract, Bouldin Island (south of SR 12), and Holland Tract may support approximately 9,700 annual recreation use-days for waterfowl hunting during any project year under Alternative 3 (Tables 3J-14 and 3J-15).

The NBHA (north of SR 12) would provide 808 acres of habitat for mourning dove hunting during September (Figure 3J-5, Table 3J-14). This acreage includes 325 acres of riparian woodland, annual grassland, and fallow levee slope habitats that are considered suitable for upland game but not for waterfowl.

During October-January, 550 acres of habitat would be available for waterfowl hunting (Table 3J-14); some of this acreage would also be available for pheasant and dove hunting. The 550 acres do not include the 325 acres of habitat that is suitable only for upland game because inclusion may result in double counting of hunters who would probably also hunt waterfowl.

Hunting would take place at the NBHA on Wednesdays, Saturdays, and Sundays during the hunting seasons at a density of one hunter per 30 acres (JSA 1993, DFG 1993, Forkel pers. comm.). The NBHA could support 909 maximum hunter use-days. If hunter attendance averaged 86% of capacity during the hunting seasons, the NBHA would support approximately 780 annual hunter use-days (Table 3J-14). Addition of these days to the 9,700 hunter use-days for reservoir islands results in approximately 10,480 annual recreation use-days for hunting generated during any project year under Alternative 3 (Table 3J-11).

Implementation of this alternative would require implementation of an offsite mitigation plan (Chapter 3G, "Vegetation and Wetlands"). If a hunting program is implemented at any offsite areas, the number of hunter use-days could be greater than the number predicted for Alternative 3.

Fishing and Boating

Implementation of Alternative 3 would increase recreation use-days related to fishing and boating in the Delta. As described previously under "Recreation Program for Alternative 3", a total of 40 recreation facilities could be constructed at the DW project islands over the life of the project. The boating facilities at these recreation facilities would be the same as those described under Alternative 1.

Delta boating use attributable to the DW project would originate from the recreation facility boat docks. Assuming 70% occupancy of the boat slips, implementing Alternative 3 would provide permanent boat docking in Delta waterways for 840 boats. Table 3J-8 shows the average weekend and weekday boat use by season estimated for Alternative 3. Based on an estimate of three boaters per boat, it is estimated that an annual increase of approximately 105,820 boater recreation use-days would be generated by Alternative 1 (Table 3J-9). This represents a 5% increase over the 2,016,000 existing boater recreation use-days in the Delta (Table 3J-2).

Other Recreational Uses

Implementation of Alternative 3 would likely increase recreationists' participation in recreational uses other than hunting, fishing, and boating. The proposed recreation facilities would accommodate these recreationists as described under Alternative 1. Estimated recreation use-days for these other uses generated by the DW project are shown in Table 3J-10. Implementation of Alternative 3 would generate approximately 40,590 recreation use-days related to these other uses.

Summary of Project Impacts and Recommended Mitigation Measures

Impact J-12: Increase in Recreation Use-Days for Hunting in the Delta. Implementation of Alternative 3 would result in the creation of 13,662 acres of shallow-water wetland habitat on the four DW project islands in some operating years (Table 3J-14) (JSA 1993). This habitat would provide low- to medium-quality waterfowl foraging habitat, the quality depending on forage availability. A total of 550 acres of high-quality wintering waterfowl foraging habitat in the NBHA would be available for hunting. A total of 20,280 acres on the four DW project islands would be used for water storage in some years (Table 3J-15); waterfowl would rest on the open water and possibly forage in shallow areas around the storage pool edges.

The DW project islands could support approximately 10,480 annual recreation use-days in the Delta for waterfowl and upland game hunting (Table 3J-11). This figure represents a net increase of approximately 9,440 hunter use-days over existing conditions on the DW project islands (Tables 3J-2 and 3J-11).

The net increase of 9,440 hunter use-days generated by Alternative 3 represents a 13% increase over the 72,000 existing hunting recreation use-days in the Delta (Table 3J-2).

This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact J-13: Increase in Recreation Use-Days for Boating in the Delta. Implementation of Alternative 3 would result in a net increase of 105,816 annual boater use-days at project build out. This increase represents a 5% increase over existing boating use-days in the Delta.

This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact J-14: Change in the Quality of the Recreational Boating Experience in Delta Channels. Implementation of Alternative 3 would increase boat use in Delta channels and alter existing boating conditions on waterways adjacent to the DW project islands. This impact is described above under Impact J-4.

Implementation of Mitigation Measure RJ-1 would reduce Impact J-14 but to a less-than-significant level.

Mitigation Measure RJ-1: **Reduce the Number of Outward Boat Slips Located at Recreation Facilities**. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. With the addition of this mitigation measure, the number of permanent docking spaces provided by the recreation facilities under Alternative 3 would decline from 1200 to 600 slips. Using the methodology described above, this would reduce the number of boats that are provided permanent docking space from 840 to 420. A reduction in the number of boats originating from the project's recreation facilities would lessen adverse impacts on changes in the quality of the recreational boating experience in Delta channels, but not to a less-than-significant level.

Impact J-15: Increase in Recreation Use-Days for Other Recreational Uses in the Delta. Implementation of Alternative 3 would increase participation in other recreational activities in the Delta. Implementing Alternative 3 would support approximately 40,590 recreation use-days for other recreational activities in the Delta and would provide accommodations to support these activities. This impact is considered beneficial.

Mitigation. No mitigation is required.

Changes in Visual Resources

Bacon Island and Webb Tract

Impacts on visual resources of Bacon Island and Webb Tract and mitigation measures under this alternative are the same as under Alternative 1.

Bouldin Island

Under Alternative 3, the southern viewshed from SR 12 as it crosses Bouldin Island would be substantially altered by construction of a new levee parallel to the south side of the highway. The proposed levee would be approximately 10-12 feet higher than the roadway and would greatly restrict southern views from the highway in much the same way a soundwall does along highways in urban settings. Woody trees or shrubs would not be permitted to grow on the levee; DSOD levee safety standards require that the levee slopes be maintained in herbaceous vegetation to allow levee inspections to be conducted. A viewer traveling along SR 12 with a viewing height of 5 feet or more above the roadway would be able to see the top several hundred feet of Mt. Diablo, approximately 25 miles southwest of Bouldin Island.

The existing visual quality on Bouldin Island is considered moderate, however, because the visual resources are somewhat intact but the agricultural landscape is common to the region. The visual sensitivity is considered moderate because the views for recreationists along this section of SR 12 are brief in duration.

North of SR 12, agricultural open space would be replaced by a mosaic of woody riparian vegetation and freshwater marsh as wildlife habitat. This riparian vegetation would partially enclose the northern views from the highway but would add variation to the visual sequence observed by viewers traveling along the highway.

The Bouldin Island perimeter levees south of SR 12 would be strengthened and improved as described previously for Bacon Island and Webb Tract under Alternative 1. Intake siphons and discharge pumps would be constructed on the levees that would be visible from adjacent waterways. Recreation facilities would also be constructed along the levees. These changes would degrade existing views by introducing built elements and removing vegetation from a generally intact landscape.

As described previously, access to views of the interior of Bouldin Island is limited to SR 12 across the island. Under Alternative 3, members of private recreation facilities on Bouldin Island would have new opportunities to view areas of open water and wetlands within the island interior and in the Delta in the vicinity of the project islands. Although the quality of views of open water and wetland habitat would generally be comparable to existing views of agricultural open space, the increased accessibility of the island for recreation and relaxation is considered a beneficial aspect of Alternative 3.

San Joaquin County has designated Potato Slough along the southern perimeter of the island as a significant resource area for recreation (Figure 3J-2) (SJCCDD 1992). The Bouldin Island northeastern perimeter levee is also visible from a marina on Terminous Tract. Views of Bouldin Island from these recreation areas and waterways are considered highly sensitive. Implementing Alternative 3 would substantially reduce the vividness, intactness, and unity of views from designated waterways adjacent to Bouldin Island.

Holland Tract

Visual impacts of Alternative 3 on Holland Tract are similar to those described for Bacon Island and Webb Tract under Alternative 1. Views of the island floor from levee roads would change as land use changes from agriculture to open water or wetland vegetation, levee slopes are modified, and siphon and pump stations are constructed. Access to the interior of Holland Tract is limited to a levee road along the south edge of the island and views of the island interior from the road are moderate. As described for Bouldin Island, private recreation facilities on Holland Tract would provide new opportunities for members of facilities to view open water and wetland areas within the island interior and in the Delta in the vicinity of the project islands.

Waterways north and east of Holland Tract are designated as scenic by Contra Costa County (Figure 3J-2) (CCCCDD 1991). As described above for Bouldin Island, improvement of the perimeter levees and construction of boat docks for recreation facilities would alter views of Holland Tract from adjacent waterways. The siphon and pump stations would be highly visible to boaters and anglers. These changes to the existing levees would not be easily absorbed into the natural landscape and would substantially reduce the visual quality of sensitive views of Holland Tract from surrounding designated scenic waterways.

Summary of Project Impacts and Recommended Mitigation Measures

Impact J-16: Reduction in the Quality of Views of Bacon Island and Webb Tract Interiors from Island Levees. This impact is described above under Impact J-6. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-17: Potential Conflict with the Scenic Designation for Bacon Island Road. This impact is described above under Impact J-7. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-18: Reduction in the Quality of Views of Bacon Island and Webb Tract from Adjacent Waterways and from the Santa Fe Railways Amtrak Line. This impact is described above under Impact J-8. This impact is considered significant and unavoidable.

Implementing Mitigation Measures J-1, J-2, and RJ-1 would reduce Impact J-18, but not to a less-than-significant level.

Mitigation Measure J-1: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure J-2: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact J-19: Change in Views Southward from SR 12. Implementation of Alternative 3 would substantially alter the viewshed south from SR 12 as it crosses Bouldin Island as a result of construction of a new levee parallel to the highway. The views along this section of SR 12 are common to the region and the visual quality and the view sensitivity are considered moderate.

As described previously, Caltrans determined that the visual resources along the Bouldin Island section of SR 12 did not render it eligible for State Scenic Highway designation (Caltrans 1992, Hatfield pers. comm.). Neither has San Joaquin County designated this portion of SR 12 as scenic.

Furthermore, enhancement of habitat north of SR 12 would increase the vividness of views north of the highway.

Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-20: Reduction in the Quality of Views of Holland Tract from the Island Levee. Implementation of Alternative 3 would result in the conversion of land use of the island floor from agriculture to open water or wetland vegetation. Perimeter levees would be improved and composition of interior slope materials would change as a result of removal of vegetation and placement of rock revetment.

Project facilities would include recreation facilities and intake siphons and discharge pumps, which would combine to reduce the vividness and intactness of interior island views from Holland Tract Road. Because the agricultural nature of Holland Tract is common to the region, the visual quality is considered moderate. The visual sensitivity is moderate because of limited access along the south side of the island. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact J-21: Reduction in the Quality of Views of Bouldin Island and Holland Tract from Adjacent Waterways. Implementation of Alternative 3 would include construction of recreation facilities and siphon and pump stations along Bouldin Island and Holland Tract levees. Vegetation on levee slopes would be replaced with rock revetment. These changes would substantially reduce the high quality of views from adjacent waterways and other recreation areas that are designated as scenic and sensitive by San Joaquin and Contra Costa Counties. Although facility design features are available to reduce the intensity of this impact, these features would not restore the quality of views of exterior island levees. Therefore, this impact is considered significant and unavoidable.

Implementing Mitigation Measures J-1, J-2, and RJ-1 would reduce Impact J-21, but not to a less-than-significant level.

Mitigation Measure J-1: Partially Screen Proposed Recreation Facilities and Pump and Siphon Stations from Important Viewing Areas. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure J-2: Design Levee Improvements, Siphon and Pump Stations, and Recreation Facilities and Boat Docks to Be Consistent with the Surrounding Landscape. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact J-22: Increase in Opportunities for Recreation Facility Members to View Reservoir Island Interiors and Other Areas in the DW Project Vicinity. Implementation of Alternative 3 would provide increased access to the DW project area. Recreation facilities on the project islands would provide opportunities for members to view open water and wetland areas at or near the islands while they relax or enjoy recreation activities such as boating or fishing in the Delta. Members of recreation facilities located in the NBHA would benefit from the increased variation of habitat types created in this area. This impact is considered beneficial.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The No-Project Alternative would result in the conversion of nonagricultural lands to agricultural uses and changes in the types of crops farmed on the DW project islands. Impacts on vegetation under this alternative are described in Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands". The cropping scenario for this alternative is summarized in Table 3I-10 in Chapter 3I, "Land Use and Agriculture".

The agriculture production projections for this alternative may be valid only for the short term. Over the long term, intensively cultivated agriculture could cease on the project islands because of continued island subsidence and increased threats to Delta water quality (DWR 1990b). Under the No-Project Alternative, the DW island interiors could subside an additional 6-10 feet over the next 40 years (HLA 1989). (See Chapter 3D, "Flood Control", for more details on subsidence and levee stability.)

Changes in Recreation Conditions

Hunting

Under the No-Project Alternative, an intensive for-fee hunting program would be operated on the DW project islands. Acres of habitat referenced in this section are summarized in Table G2-10 in Appendix G2.

A total of 20,526 acres of habitat would be available for mourning dove hunting during September on the DW project islands (Table 3J-16, Figure 3J-5). This acreage includes 112 acres of riparian woodland that is considered suitable for upland game but not for waterfowl. During October-January, 20,878 acres of habitat would be available for waterfowl hunting; some of this acreage would also provide suitable upland game habitat. The 112 acres of riparian woodland are excluded from the 20,878 acres to avoid double counting of hunters who would probably also hunt waterfowl.

Upland game or waterfowl could be hunted on Wednesdays, Saturdays, and Sundays during the hunting seasons at a density of one hunter per 45 acres (DFG 1993; Forkel and Winther pers. comms.). The DW project islands could support 21,745 annual maximum hunter use-days (Table 3J-16). Attendance is expected to average 60% of capacity during the hunting seasons (Forkel and Winther pers. comms.). The DW project islands could support approximately 13,050 annual recreation use-days for hunting of upland game and waterfowl (Tables 3J-11 and 3J-16).

Waterfowl would continue to forage in agricultural fields on the DW project islands; the No-Project Alternative would not, however, include enhancement or management of habitat areas specifically to benefit wintering waterfowl. Therefore, the No-Project Alternative is not expected to result in any discernible or actual redistribution of regional waterfowl populations to the DW project islands, and hunter success elsewhere in the Delta would not be affected.

Fishing and Boating

Fishing and boating access and use under this alternative are the same as described above under "Existing Recreational Uses on the DW Project Islands".

Under the No-Project Alternative, no new boat docks or other recreation facilities would be constructed. Therefore, no new boat use would be generated from the DW project islands. Fishing and boating access and use would not substantially change under the No-Project Alternative.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in Recreation Use-Days for Hunting in the Delta. Implementation of the No-Project Alternative would result in the conversion of non-agricultural lands to agricultural uses on the DW project islands. DW would secondarily manage the islands for hunting. The DW project islands could temporarily support approximately 13,050 annual recreation use-days in the Delta for hunting of waterfowl and upland game (Tables 3J-11 and 3J-16). This level of hunting could be sustained until subsidence of island interiors required removal of land from agricultural production sometime during the next several decades.

The approximate 12,000 additional recreation use-days generated under the No-Project Alternative represent a 17% increase over the 72,000 existing hunting recreation use-days in the Delta during the period when this level of hunting could be sustained (Table 3J-2).

Changes in Visual Resources

Implementation of the No-Project Alternative would generally result in the continuation of existing land uses; agricultural intensity on the islands would increase as areas that are currently fallow are converted to agricultural use. Views of the islands (interior and exterior) would not substantially change under the No-Project Alternative. Increasing agricultural use on Holland and Webb Tracts could reduce the vividness of interior island views, but because of the low number of viewers on Holland and Webb Tracts, these changes are considered inconsequential.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. The following discussion considers only those impacts that may contribute cumulatively to impacts on recreation and visual resources in the vicinity of the DW project islands.

Cumulative Impacts, Including Impacts of Alternative 1

Changes in Recreation Conditions

Agricultural Land Conversion Projects and DWR Programs. Agricultural lands are being acquired in the Delta by various government agencies and other groups for conversion to nonagricultural uses (Table 3J-17). Most of these projects involve management of wetland habitat. These projects are being planned independent of one another and are at different stages in the environmental review process. (Delta Protection Commission 1994.) Implementation of these wetland enhancement projects concurrent with the DW project would reduce the amount of waste grain available for waterfowl forage. Projects that convert agricultural land, however, would be expected to maintain or augment wetland habitat for waterfowl in the Delta, including areas for forage. (See Chapter 3H, "Wildlife", for further details.)

It is unknown what recreation opportunities would be created by the cumulative implementation of agricultural land conversion projects. It can be assumed that the government agencies purchasing land in the Delta would promote project objectives that involve management of public land for recreation. Acquisition of Sherman Island as part of the DWR West Delta Water Management Program would include among its objectives provisions for additional recreation opportunities (DWR and Reclamation 1990). DFG may implement a hunting program on Twitchell Island (Chapin pers. comm.). Implementation of agency projects that involve conversion of agricultural land would probably result in an overall enhancement of recreation opportunities for activities such as birdwatching, nature study, relaxing, and hiking. Opportunities for fishing and boating would likely be enhanced if new boat launch areas are provided.

Other recreation development projects in the Delta are approved for construction. Tower Park Marina near SR 12 between Bouldin Island and Terminous Tract has planned 1,000 new recreational vehicle campsites to be built over 10 years. A new marina has been planned at Walnut Grove. (Delta Protection Commission 1994.)

DWR is preparing an interim north Delta water management program that will address a variety of project alternatives that would increase Delta channel capacity to improve flows, thereby reducing flooding. The water management program will include among its objectives plans to reduce fishery impacts, enhance recreation opportunities, and enhance wildlife habitat. The DWR interim program will be a revision of its North Delta Program published in the early 1990s (Roberts pers. comm.).

DWR is also preparing the EIR/EIS for the South Delta Water Management Program, which will include among its objectives plans to improve water flows, increase recreation opportunities, and reduce fishery impacts. This document will be a revision of the South Delta Water Management Program prepared in the early 1990s (DWR and Reclamation 1990).

Changes in Waterfowl Use Patterns and Waterfowl Populations in the Delta. As described previously under "Impacts and Mitigation Measures of Alternative 1", Alternative 1 would be expected to result in some redistribution of regional waterfowl populations in the Delta to the DW habitat islands, which could result in localized decreases in hunter success. However, the hunting program on the DW project islands would encourage dispersal of waterfowl to other areas in the Delta on hunt days at the DW project islands. Additionally, the staggered schedule for flooding agricultural fields and seasonal wetland habitat on the DW habitat islands in winter would reduce habitat availability in some periods. (See Chapter 3H, “Wildlife”, for further details.)

Other projects in the Delta that convert agricultural land to wetland habitat could provide improved habitat conditions for waterfowl. It is unknown whether increased breeding habitat would be created outside the DW project islands. As described in Chapter 3H (and Table 3J-17), some Delta projects would augment or replace waterfowl forage areas, thereby attracting waterfowl to areas outside the DW project islands. Hunter success would likely be maintained and could improve throughout the Delta.

Changes in Reservoir Island Storage Conditions. DWR recently installed four additional pumping units at SWP's Banks Pumping Plant near Clifton Court Forebay, increasing total SWP pumping capacity from 6,400 cfs to 10,300 cfs. If SWP export pumping is increased to full capacity in future years, the frequency with which each storage class would occur on the DW project islands would change. In most months the frequency with which full-, partial-, and shallow-storage conditions would occur would be reduced and the occurrence of nonstorage conditions and the opportunity to create shallow-water wetland conditions would be increased. Tables in Chapter 3N, “Mosquitos and Public Health”, and Appendix G2, “Prediction of Vegetation on the Delta Wetlands Reservoir Islands”, show the frequency with which each storage class would occur based on the 1995 DEIR/EIS analysis of cumulative project operations and the 70-year hydrologic record for the Delta.

The potential increase in SWP export pumping would have a minor effect on estimated annual hunter use-days shown in Table 3J-11 for Alternatives 1, 2, and 3. Hunter use-days would increase by 1.22% for Alternative 1, would decrease by 0.18% for Alternative 2, and would increase by 1.78% for Alternative 3. These magnitudes of change would be negligible and would not affect the impact analyses in this chapter.

Offsite Reservoir Management Effects. Water stored in the Delta under the DW project may be purchased by the SWP or CVP and used to substitute for water otherwise to be released from upstream reservoirs such as Folsom, Oroville, or Shasta Lakes, or from San Luis Reservoir, south of the Delta. It is possible that use of DW water by the SWP or CVP could result in different reservoir storage patterns at these or other reservoirs and higher reservoir pool elevations during the recreation season. Higher pool elevations could support higher recreational use levels or improved recreational experiences at these reservoirs. Because of the uncertainty about the identity of water purchasers and their use of DW water, it is not possible at this time to predict which upstream reservoir might be affected or the extent of effects. Furthermore, instream flow requirements would likely result in protection of river-based recreation downstream of these reservoirs.

Impact J-23: Increase in Recreation Opportunities in the Delta. Implementation of Alternative 1 concurrent with other agricultural conversion projects and the DWR water management programs may result in an increase in recreation opportunities throughout the Delta. Although the schedule of the North Delta Water Management Program EIR/EIS is unknown and the alternatives have yet to be determined, the document would include objectives to enhance Delta recreation as an ancillary effect.

Implementation of agricultural conversion projects by state and federal agencies would be expected to include provisions for public access and new opportunities for recreation in the Delta. Implementation of Alternative 1 would provide waterfowl habitat of varying quality and new recreation facilities for use by hunters, anglers, boaters, and other recreationists.

The proposed DWR water management programs would include channel and levee improvements that may improve access for boaters and anglers. Implementation of these water management programs may also improve fishery conditions and support increased fishing in the Delta.

This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact J-24: Enhancement of Waterfowl Populations and Increased Hunter Success in the Delta. Implementation of Alternative 1 concurrent with other proposed agricultural conversion projects throughout the Delta would be expected to reduce available waste grain for waterfowl foraging habitat. Projects that result in the conversion of agricultural land used by waterfowl for foraging would be required to compensate for the loss of wintering waterfowl foraging habitat. Twitchell and Sherman Islands, for example, will be managed as habitat islands to compensate for DWR projects that remove agricultural land from production. (See Chapter 3H, "Wildlife", for further details.) The overall effect of proposed projects in the Delta, including the DW project, would be beneficial for waterfowl foraging habitat. This analysis assumes that adverse impacts of agricultural conversion projects would be mitigated or otherwise offset through implementation of other beneficial projects. Because Delta projects are expected to enhance or maintain habitat values overall, waterfowl would be expected to continue to use the Delta. Hunter success, therefore, may increase throughout the Delta. This impact is considered beneficial.

Mitigation. No mitigation is required.

Changes in Visual Resources

The visual character of the Delta is changing as conversion of farmland to wetland habitat or urban uses increases throughout the Delta region. Implementation of Alternative 1 would involve changing the visual character of the DW project islands as a result of the land use conversion to wetland habitat. However, the visual changes to Delta islands, including the DW project islands, would not result in substantial changes to existing regional visual quality, and these changes could increase the vividness of views in the Delta by providing landscapes more varied than those of existing agriculture lands. Alternative 1 would therefore not contribute to cumulative impacts on visual resources in the Delta.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impacts associated with this alternative would be the same as those described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

The cumulative impacts associated with this alternative would be the same as those described for Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Similar to cumulative impacts of Alternative 1, implementation of the No-Project Alternative would contribute to increased recreation opportunities and an increase in potential waterfowl foraging habitat in the Delta and would not contribute to any cumulative visual impacts. The contribution of the No-Project Alternative to recreation opportunities in the Delta, however, would be less than that described for Alternative 1.

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Table 3J-1. Annual Participation in Delta Recreational Activities

Activity	Percent Participation by Visitation	Total Participation by Visitation
Boating	16.9	2,016,000
Fishing	15.1	1,800,000
Relaxing	12.1	1,440,000
Driving for pleasure	12.0	1,440,000
Sightseeing	11.0	1,320,000
Overnight camping	8.0	960,000
Picnicking	7.0	840,000
Swimming	7.0	840,000
Waterskiing	5.0	600,000
Photography	3.0	360,000
Bicycling	1.0	120,000
Dirt biking	0.8	96,000
Hunting	0.6	72,000
Flying	0.3	36,000
Total	100.0	11,940,000

Note: Boating includes motorboating, sailing, canoeing, kayaking, and rowing. Motorboating separately accounts for approximately 15% of total visitation.

Source: DWR 1990a.

Table 3J-2. Annual Estimated Number of Recreation Use-Days
on the Delta Wetlands Project Islands and in the Delta

	Hunting	Fishing[f]	Boating[f]	Total
DW Project Islands				
Bacon Island[a]	100	3,120	0	3,220
Webb Tract[b]	640	90	0	730
Bouldin Island[c]	210	360	0	570
Holland Tract[d]	95	10,300	56,225	66,620
Total	1,045	13,870	56,225	71,140
Delta Region[e]	72,000	1,800,000	2,016,000	3,888,000

[a] Shimasaki pers. comm.

[b] Dinelli pers. comm.

[c] Wilkerson pers. comm.

[d] Frelier, Lindquist, and Cochrell pers. comms.

[e] DWR 1990a.

[f] The fishing and boating recreation use-days on Holland Tract consist of recreation originating from existing marinas. These facilities would not be included in the project boundaries and would not be directly affected by the project.

Table 3J-3. Estimated Maximum Number of Hunter Use-Days for the Shallow-Water Wetland Condition on the Reservoir Islands under Alternative 1

	Acres of Shallow-Water Wetlands[a]	Hunter Density (acres per hunter)[b]	Maximum Number of Hunters	Maximum Allowable Hunting Days[c]	Average Percent Frequency of Shallow-Water Wetland Condition[d]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[e]	Estimated Annual Hunter Use-Days[f]
Bacon Island								
October	3,694	30	123	9	47	521		
November	3,694	30	123	30	49	1,810		
December	3,694	30	123	31	36	1,374		
January	3,694	30	123	16	21	414		
Subtotal						4,119	30	1,236
Webb Tract								
October	3,836	30	128	9	57	656		
November	3,836	30	128	30	52	1,995		
December	3,836	30	128	31	39	1,546		
January	3,836	30	128	16	26	532		
Subtotal						4,729	30	1,419
Total								2,655

[a] JSA 1993 (also see Chapter 3N, "Mosquitos and Public Health", for a description of the shallow-water wetland condition on reservoir islands).

[b] JSA 1993, Forkel pers. comm.

[c] DFG 1993 (Figure 3J-4).

[d] Values based on averages of maximum and minimum acreages of available shallow-water wetlands during project years. Methods used to derive percentages are described in Chapter 3N, "Mosquitos and Public Health", and Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands".

[e] Estimate of 30% based on possible marginal quality of waterfowl foraging habitat that would attract low numbers of waterfowl; consequently, hunter attendance would be significantly lower than on habitat islands.

[f] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated number of days at culmination of the buildout. (Forkel pers. comm.)

Table 3J-4. Estimated Maximum Number of Hunter Use-Days for Full-, Partial-, and Shallow-Storage Conditions on the Reservoir Islands under Alternative 1

	Total Island Acreage	Hunter Density (acres per hunter)[a]	Maximum Number of Hunters	Maximum Allowable Hunting Days[b]	Average Percent Frequent of Full-, Partial-, and Shallow-Storage Conditions[c]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[d]	Estimated Annual Hunter Use-Days[e]
Bacon Island								
October	5,539	30	185	9	32	532		
November	5,539	30	185	30	49	2,714		
December	5,539	30	185	31	63	3,606		
January	5,539	30	185	16	74	2,186		
Subtotal						9,038	15	1,356
Webb Tract								
October	5,470	30	182	9	30	492		
November	5,470	30	182	30	47	2,571		
December	5,470	30	182	31	56	3,165		
January	5,470	30	182	16	71	2,071		
Subtotal						8,299	15	1,245
Total								2,601

[a] JSA 1993, Forkel pers. comm.

[b] DFG 1993 (Figure 3J-4).

[c] Values based on averages of maximum and minimum acreages of available shallow-water wetlands during project years. Methods used to derive percentages are described in Chapter 3N and Appendix G2.

[d] Participation in hunting is predicted to be half of that estimated for reservoir islands during shallow-water wetland periods.

[e] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated number of days at culmination of the buildout. (Forkel pers. comm.)

Table 3J-5. Hunter Participation as a Percentage of Capacity
at Clifton Court Forebay Waterfowl Public Shoot Area for Some Years

	Average Percentage				
	October	November	December	January	October-January
1975-1976	17	22	36	36	28
1978-1979	30	23	36	41	33
1980-1981	30	19	33	34	29
1981-1982	24	17	13	14	17
All years	25	20	30	31	27

Notes: Prior to the 1982-1983 hunting season, hunters would enter and exit the Clifton Court Forebay Public Shoot Area through a check station operated by a DFG employee; use of this check station system ensured accurate reporting of hunter use data. A self-registration system was implemented at Clifton Court Forebay at the beginning of the 1982-1983 hunting season. Implementation of the self-registration system coincided with a sharp reduction in hunter use data that endured during subsequent hunting seasons. The significant drop in hunter use data is assumed to be attributable to hunters failing to register and fill out day-use permits (Gifford pers. comm.). The recreation analysis relies on the accuracy of hunter use data for Clifton Court Forebay collected prior to the 1982-1983 season.

The drop in hunter attendance during the 1981-1982 hunting season corresponds with the beginning of a 12-year drought across the Canadian prairies, which provide breeding habitat for migrating waterfowl during the summer. The drought noticeably affected the size of waterfowl populations, which in turn affected hunter success and attendance during the drought years. The drought abated before the 1993-1994 hunting season and waterfowl populations have been recovering. Hunter participation has increased throughout California during the past 2 years in response to increasing numbers of waterfowl. (Becker pers. comm.)

Source: Gifford pers. comm.

Table 3J-6. Estimated Maximum Number of Hunter Use-Days on the Habitat Islands under Alternative 1

	Spaced-Blind Acres[a]	Spaced-Blind Hunter Density (acres per hunter)[b]	Free-Roam Acres[a]	Free-Roam Hunter Density (acres per hunter)[b]	Maximum Number of Hunters	Maximum Allowable Hunting Days[c]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[d]	Estimated Annual Hunter Use-Days[e]
Bouldin Island									
September	0	0	2,435	60	41	7	287		
October	2,122	12.5	2,331	60	209	5	1,043		
November	2,122	12.5	2,331	60	209	13	2,712		
December	2,122	12.5	2,331	60	209	14	2,921		
January	2,122	12.5	2,331	60	209	8	1,669		
Subtotal							8,632	86	7,424
Holland Tract									
September	0	0	1,308	60	22	7	153		
October	933	12.5	1,308	60	96	5	482		
November	933	12.5	1,308	60	96	13	1,254		
December	933	12.5	1,308	60	96	14	1,350		
January	933	12.5	1,308	60	96	8	772		
Subtotal							4,011	86	3,449
Total									10,873

[a] See Table 20 in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", for detailed summary of hunting zone acreage by habitat type.

[b] From Tables 19 and 21 in Appendix G3.

[c] DFG 1993 (Figure 3J-4), also from Table 19 in Appendix G3.

[d] Estimate of 86% from Table 3J-7.

[e] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated number of days at culmination of the buildout. (Forkel pers. comm.)

Table 3J-7. Hunter Participation as a Percentage of Capacity at Selected Wildlife Refuges during 1993-1994

	Average Percentage				
	October	November	December	January	October-January
Grizzly Island Wildlife Area[a]	66	47	74	64	63
Sacramento National Wildlife Refuge[b]	109	56	74	106	86
Gray Lodge Wildlife Area[b]	96	18	72	106	73
Delevan National Wildlife Refuge[b]	127	79	94	130	108
Colusa National Wildlife Refuge[b]	115	47	105	136	101
All refuges	103	49	84	108	86

[a] Becker pers. comm.

[b] Rollins pers. comm.

Table 3J-8. Average Daily Boat Use by Season Estimated for Alternatives 1 and 3
(Boats Used per Day)

	Hunting Season (Nov-Jan)		Winter/Spring (Feb-May)		Summer (Jun-Aug)		Fall (Sep-Oct)	
	Alt. 1	Alt.3	Alt. 1	Alt. 3	Alt. 1	Alt. 3	Alt. 1	Alt. 3
Average Weekend Use								
Bacon Island	12	12	23	23	92	92	58	58
Webb Tract	12	12	23	23	92	92	58	58
Bouldin Island	11	11	21	21	84	84	53	53
Holland Tract	7	8	13	17	51	67	32	42
Total	42	43	80	84	319	335	201	211
Average Weekday Use								
Bacon Island	7	7	12	12	46	46	23	23
Webb Tract	7	7	12	12	46	46	23	23
Bouldin Island	6	6	11	11	42	42	21	21
Holland Tract	4	5	7	8	25	34	13	17
Total	24	25	42	43	159	168	80	84

Notes: Average use estimates are based on conversation with DW, commercial marina operators, and personnel of the State Division of Boating and Waterways.

The figures are for recreational boats used for at least 4 hours in a day.

Table 3J-9. Summary of Estimated Annual Boater Use-Days Generated from the Delta Wetlands Project Islands under Alternatives 1, 2, and 3 and the No-Project Alternative

	Bacon Island	Webb Tract	Bouldin Island	Holland Tract[a]	Total
Alternative 1	29,178	29,178	26,580	72,155	157,091
Alternative 2	29,178	29,178	26,580	72,155	157,091
Alternative 3	29,178	29,178	26,580	77,351	162,287
No-Project Alternative	0	0	0	56,225	56,225

[a] Figures for Holland Tract under Alternatives 1, 2, and 3 include the 56,225 existing boating use-days generated by the Holland Tract Marina. This facility would not be affected by implementation of the DW project.

Table 3J-10. Summary of Estimated Annual Use-Days for Other Recreation on the Delta Wetlands Project Islands under Alternatives 1, 2, and 3

	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	Total
Alternative 1	11,137	11,137	10,157	6,098	38,530
Alternative 2	11,137	11,137	10,157	6,098	38,531
Alternative 3	11,137	11,137	10,157	8,118	40,552

Notes: "Other recreation use" refers to recreation activities, other than hunting, fishing, and boating, conducted at the DW project islands. Such activities could include, but are not limited to, birdwatching, photography, skeet and trap shooting, relaxing, walking, nature study, windsurfing, swimming, and canoeing.

No data were available for other recreation uses on the DW project islands under existing conditions or the No-Project Alternative.

Table 3J-11. Summary of Estimated Total Number of Hunter Use-Days on the Delta Wetlands Project Islands under Alternatives 1, 2, and 3 and the No-Project Alternative

	Shallow-Water Wetland Condition[a]	Full-, Partial- and Shallow- Storage Condition[b]	Total Estimated Annual Hunter Use-Days[c]
Alternative 1			
Bacon Island	1,236	1,356	2,592
Webb Tract	1,419	1,245	2,664
Bouldin Island			7,424
Holland Tract			3,449
Total			16,129
Alternative 2			
Bacon Island	1,270	1,356	2,626
Webb Tract	1,446	1,247	2,693
Bouldin Island			7,424
Holland Tract			3,449
Total			16,192
Alternative 3			
Bacon Island	1,257	1,367	2,624
Webb Tract	1,429	1,268	2,697
Bouldin Island (south of SR 12)	1,282	1,096	2,378
Bouldin Island (NBHA)			782
Holland Tract	1,136	862	1,998
Total			10,479
No-Project Alternative			
Bacon Island			3,404
Webb Tract			3,371
Bouldin Island			3,682
Holland Tract			2,590
Total			13,047

[a] From Tables 3J-3, 3J-12, and 3J-14.

[b] From Tables 3J-4, 3J-13, and 3J-15.

[c] Values for habitat islands under Alternatives 1 and 2 from Table 3J-6. Value of 782 for NBHA from Table 3J-14. Values for No-Project Alternative from Table 3J-16.

Table 3J-12. Estimated Maximum Number of Hunter Use-Days for the Shallow-Water Wetland Condition on the Reservoir Islands under Alternative 2

	Acres of Shallow-Water Wetlands[a]	Hunter Density (acres per hunter)[b]	Maximum Number of Hunters	Maximum Allowable Hunting Days[c]	Average Percent Frequency of Shallow-Water Wetland Condition[d]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[e]	Estimated Annual Hunter Use-Days[f]
Bacon Island								
October	3,694	30	123	9	54	598		
November	3,694	30	123	30	50	1,847		
December	3,694	30	123	31	36	1,374		
January	3,694	30	123	16	21	414		
Subtotal						4,233	30	1,270
Webb Tract								
October	3,836	30	128	9	65	748		
November	3,836	30	128	30	52	1,995		
December	3,836	30	128	31	39	1,546		
January	3,836	30	128	16	26	532		
Subtotal						4,821	30	1,446
Total								2,716

[a] JSA 1993 (see also Chapter 3N, "Mosquitos and Public Health", for a description of the shallow-water wetland condition on reservoir islands).

[b] JSA 1993, Forkel pers. comm.

[c] DFG 1993 (Figure 3J-4).

[d] Values based on averages of maximum and minimum acreages of available shallow-water wetlands during project years. Methods used to derive percentages are described in Chapter 3N and Appendix G2.

[e] Estimate of 30% based on possible marginal quality of waterfowl foraging habitat that would attract low numbers of waterfowl; consequently, hunter attendance would be significantly lower than on habitat islands.

[f] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated numbers of days of culmination of the buildout. (Forkel pers. comm.)

Table 3J-13. Estimated Maximum Number of Hunter Use-Days for Full-, Partial-, and Shallow-Storage Conditions on the Reservoir Islands under Alternative 2

	Total Island Acreage	Hunter Density (acres per hunter)[a]	Maximum Number of Hunters	Maximum Allowable Hunting Days[b]	Average Percent Frequency of Full-, Partial-, and Shallow-Storage Conditions[c]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[d]	Estimated Annual Hunter Use-Days[e]
Bacon Island								
October	5,539	30	185	9	32	532		
November	5,539	30	185	30	49	2,714		
December	5,539	30	185	31	62	3,549		
January	5,539	30	185	16	76	2,245		
Subtotal						9,040	15	1,356
Webb Tract								
October	5,470	30	182	9	29	476		
November	5,470	30	182	30	47	2,571		
December	5,470	30	182	31	56	3,165		
January	5,470	30	182	16	72	2,100		
Subtotal						8,312	15	1,247
Total								2,603

[a] JSA 1993, Forkel pers. comm.

[b] DFG 1993 (Figure 3J-4).

[c] Values based on averages of maximum and minimum acreages of available shallow-water wetlands during project years. Methods used to derive percentages are described in Chapter 3N and Appendix G2.

[d] Participation in hunting is predicted to be half of that estimated for reservoir islands during shallow-water wetland periods.

[e] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated number of days at culmination of the buildout. (Forkel pers. comm.)

Table 3J-14. Estimated Maximum Number of Hunter Use-Days for the Shallow-Water Wetland Condition on the Delta Wetlands Project Islands under Alternative 3

	Acres of Shallow-Water Wetlands[a]	Huntable Acres in NBHA[b]	Hunter Density (acres per hunter)[c]	Maximum Number of Hunters	Maximum Allowable Hunting Days[d]	Average Percent Frequency of Shallow-Water Wetland Condition[e]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[f]	Estimated Annual Hunter Use-Days[g]
Bacon Island									
October	3,694		30	123	9	52	576		
November	3,694		30	123	30	50	1,847		
December	3,694		30	123	31	36	1,374		
January	3,694		30	123	16	20	394		
Subtotal							4,191	30	1,257
Webb Tract									
October	3,836		30	128	9	60	690		
November	3,836		30	128	30	52	1,995		
December	3,836		30	128	31	39	1,546		
January	3,836		30	128	16	26	532		
Subtotal							4,763	30	1,429
Bouldin Island South of SR 12									
October	3,440		30	115	9	64	660		
November	3,440		30	115	30	56	1,926		
December	3,440		30	115	31	33	1,173		
January	3,440		30	115	16	28	514		
Subtotal							4,273	30	1,282
Bouldin Island NBHA									
September		808	30	27	7		189		
October		550	30	18	5		90		
November		550	30	18	13		234		
December		550	30	18	14		252		
January		550	30	18	8		144		
Subtotal							909	86	782
Holland Tract									
October	2,692		30	90	9	66	533		
November	2,692		30	90	30	62	1,669		
December	2,692		30	90	31	42	1,168		
January	2,692		30	90	16	29	416		
Subtotal							3,786	30	1,136
Total									5,886

Table 3J-14. Continued

[a] JSA 1993 (see also Chapter 3N, “Mosquitos and Public Health”, for a description of the shallow-water wetland condition on reservoir islands).

[b] From Appendix G2. The total of 808 acres includes cornfields, riparian woodland, annual grassland, fallow levee slopes, and seasonal managed wetlands. Cornfields and seasonal managed wetlands will not be flooded until after September 15, at the end of mourning dove hunting season in September (Figure 3J-4). The total of 550 acres includes cornfields, perennial ponds, seasonal managed wetlands, and ditches.

[c] JSA 1993, Forkel pers. comm.

[d] DFG 1993 (Figure 3J-4).

[e] Values based on averages of maximum and minimum available shallow-water wetlands during project years. Methods used to derive percentages are described in Chapter 3N and Appendix G2.

[f] Estimate of 30% based on possible marginal quality of waterfowl foraging habitat that would attract low numbers of waterfowl; consequently, hunter attendance would be significantly lower than on habitat islands. Estimate of 86% for NBHA based on similarity of this habitat to habitat on Bouldin Island and Holland Tract for Alternatives 1 and 2 (Table 3J-6).

[g] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated numbers of days at culmination of the buildout. (Forkel pers. comm.)

Table 3J-15. Estimated Maximum Number of Hunter Use-Days for Full-, Partial-, and Shallow-Storage Conditions on the Delta Wetlands Project Islands under Alternative 3

	Total Island Acreage	Hunter Density (acres per hunter)[a]	Maximum Number of Hunters	Maximum Allowable Hunting Days[b]	Average Percent Frequency of Full-, Partial-, and Shallow-Storage Conditions[c]	Estimated Annual Maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[d]	Estimated Annual Hunter Use-Days[e]
Bacon Island								
October	5,539	30	185	9	31	515		
November	5,539	30	185	30	49	2,714		
December	5,539	30	185	31	63	3,606		
January	5,539	30	185	16	77	2,275		
Subtotal						9,110	15	1,367
Webb Tract								
October	5,470	30	182	9	29	476		
November	5,470	30	182	30	47	2,571		
December	5,470	30	182	31	58	3,278		
January	5,470	30	182	16	73	2,130		
Subtotal						8,455	15	1,268
Bouldin Island South of SR 12								
October	5,023	30	167	9	26	392		
November	5,023	30	167	30	42	2,110		
December	5,023	30	167	31	57	2,959		
January	5,023	30	167	16	69	1,848		
Subtotal						7,309	15	1,096
Holland Tract								
October	4,248	30	142	9	24	306		
November	4,248	30	142	30	36	1,529		
December	4,248	30	142	31	54	2,370		
January	4,248	30	142	16	68	1,541		
Subtotal						5,746	15	862
Total								4,593

[a] JSA 1993, Forkel pers. comm.

[b] DFG 1993 (Figure 3J-4).

[c] Values based on averages of maximum and minimum acreages of available shallow-water wetlands during project years. Methods used to derive percentages are described in Chapter 3N and Appendix G2.

[d] Participation in hunting is predicted to be half that estimated for reservoir islands during shallow-water wetland periods.

[e] Annual hunter use-days would increase gradually during a 5- to 15-year buildout period. The values presented here represent the estimated numbers of days at culmination of the buildout. (Forkel pers. comm.)

Table 3J-16. Estimated Maximum Number of Hunter Use-Days on the Delta Wetlands Project Islands under the No-Project Alternative

	Acres of Waterfowl Habitat[a]	Acres of Upland Game Habitat[a]	Hunter Density (acres per hunter)[b]	Maximum Number of Hunters	Maximum Allowable Hunting Days[b,c]	Estimated Annual maximum Hunter Use-Days	Estimated Annual Participation as a Percentage of Capacity[d]	Estimated Annual Hunter Use-Days
Bacon Island								
September		5,359	45	119	7	833		
October	5,451		45	121	5	605		
November	5,451		45	121	13	1,573		
December	5,451		45	121	14	1,694		
January	5,451		45	121	8	968		
Subtotal						5,673	60	3,404
Webb Tract								
September		5,277	45	117	7	819		
October	5,393		45	120	5	600		
November	5,393		45	120	13	1,560		
December	5,393		45	120	14	1,680		
January	5,393		45	120	8	960		
Subtotal						5,619	60	3,371
Bouldin Island								
September		5,782	45	128	7	896		
October	5,902		45	131	5	655		
November	5,902		45	131	13	1,703		
December	5,902		45	131	14	1,834		
January	5,902		45	131	8	1,048		
Subtotal						6,136	60	3,682
Holland Tract								
September		4,108	45	91	7	637		
October	4,132		45	92	5	460		
November	4,132		45	92	13	1,196		
December	4,132		45	92	14	1,288		
January	4,132		45	92	8	736		
Subtotal						4,317	60	2,590
Total								13,047

[a] See Table G2-10 in Appendix G2 for a detailed breakdown of habitat types. Waterfowl habitat excludes riparian woodland and developed land. Upland game habitat excludes freshwater marsh, sloughs, ditches, other open water, and developed land.

[b] Forkel and Winther pers. comms.

[c] DFG 1993 (Figure 3J-4).

[d] Forkel and Winther pers. comms.

Table 3J-17. Proposed and Planned Agricultural Land Conversion Projects in the Delta

Project Location or Name	Responsible Agency or Group	Existing Uses	Proposed Uses	Acreage Acquired	Acreage Pending Acquisition	Total
Twitchell Island[a]	DWR	Agriculture, gas wells, one power line, marina	Managed wetland habitat	2,965	588	3,553
Sherman Island[a]	DWR	Agriculture, public boat launch ramp, marinas, residential	Managed wetland habitat	1,037	9,465	10,502
Stone Lakes Wildlife Refuge[b]	USFWS	Agriculture, wildlife habitat	Managed wetland and wildlife habitat, environmental education, wildlife-oriented recreation, hunting		22,000[c]	22,000
Medford Island[a]	Private	Agriculture	Mitigation bank approved by DFG	1,215		1,215
Prospect Island[a]	Trust for Public Lands, Reclamation, DFG	Agriculture	Managed wetland habitat	1,228		1,228
Palm Tract Mitigation[a]	Western Area Power Administration, Transmission Agency of Northern California	Agriculture	Agriculture and managed wetland habitat	1,213		1,213
Yolo Basin Wetlands[a]	DFG	Agriculture and fallow	Managed wetland and wildlife habitat	3,470		3,470
Port of Sacramento Mitigation Bank[a]	Yolo and Solano Counties	Unknown	Unknown	420		420
Central Valley Habitat Joint Venture Implementation Plan[a, d]	USFWS, DFG, Audubon Society, The Nature Conservancy, California Waterfowl Association, Trust for Public Lands, Defenders of Wildlife, Ducks Unlimited	Agriculture	Restored wetland waterfowl habitat, management of agricultural lands for wintering waterfowl		About 20,000	About 20,000
DW habitat islands				9,120		9,120
DW reservoir islands				11,008		11,008
Total				31,676	52,053	83,729

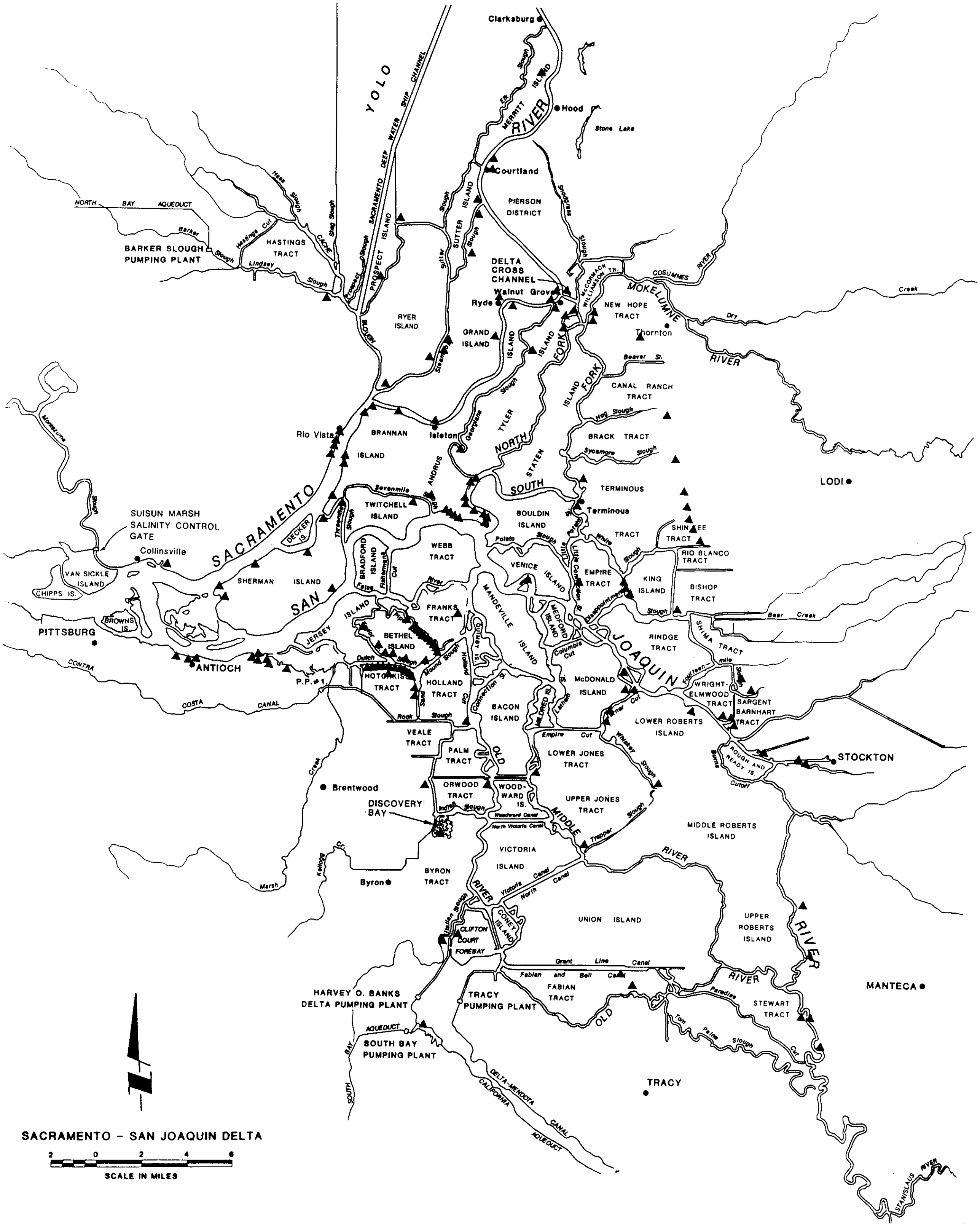
Table 3J-17. Continued

[a] Delta Protection Commission 1994.

[b] USFWS 1991.

[c] Some of this acreage may remain in private landholding.

[d] The plan goal is to restore 20,000 acres of former wetlands to permanent wetlands by acquisition of fee title or conservation easements.



Map source: Adapted from California Department of Water Resources 1993.

Figure 3J-1
Existing Recreational Facilities in the Delta Wetlands Project Vicinity

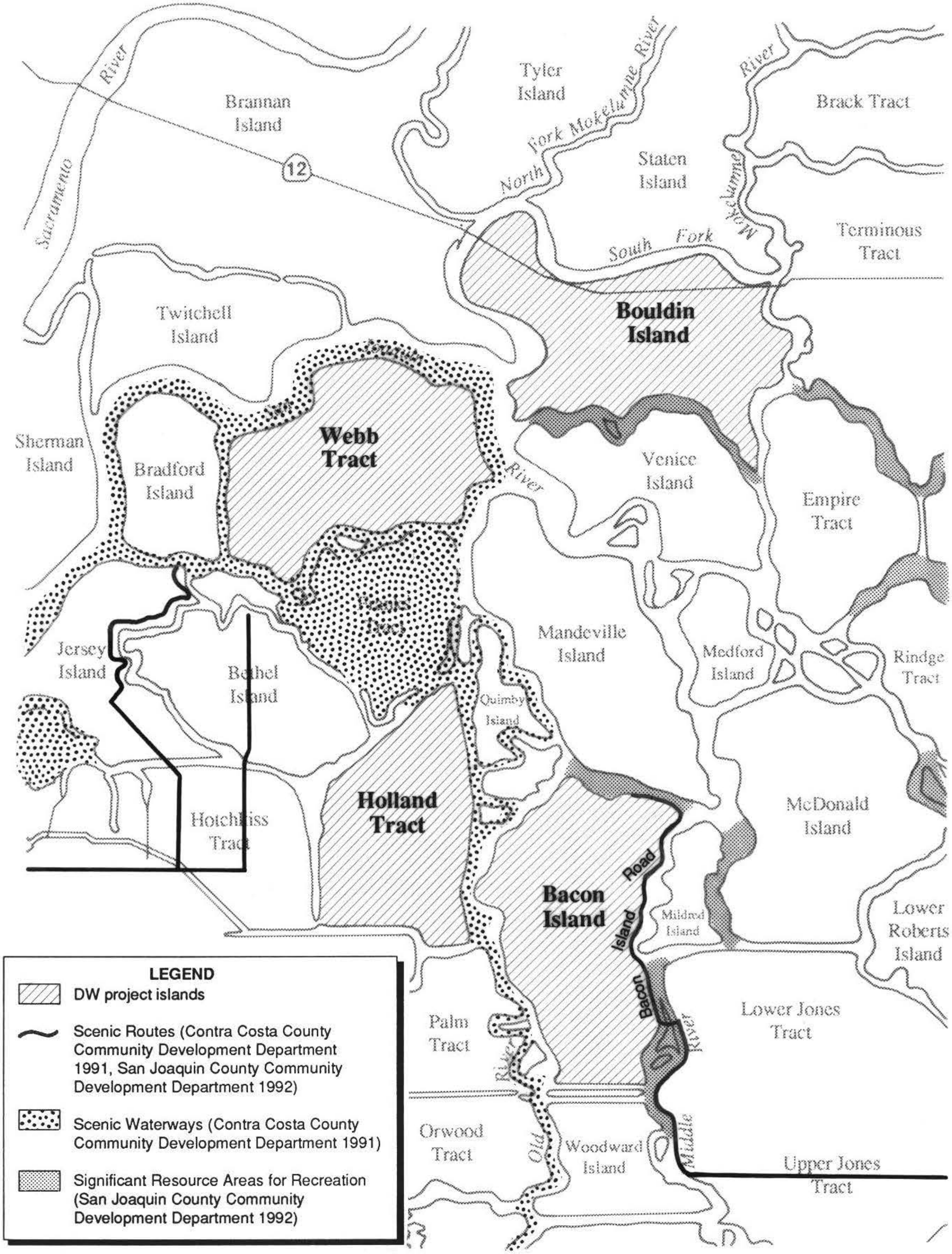


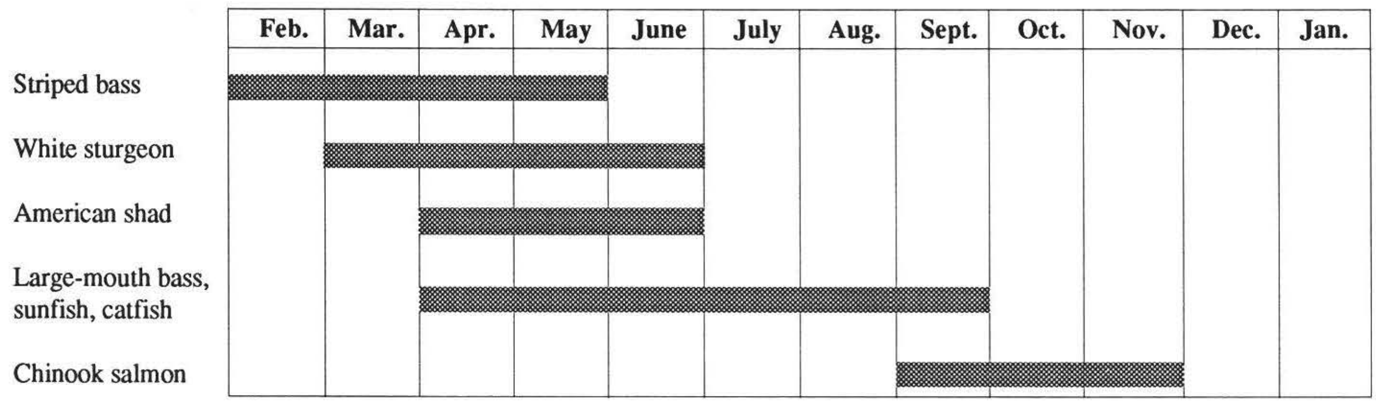
Figure 3J-2
Designated Scenic Waterways and Scenic Routes in the Delta Wetlands Project Vicinity

Figure 3J-3
Typical View along SR 12 on Bouldin Island

Jones & Stokes

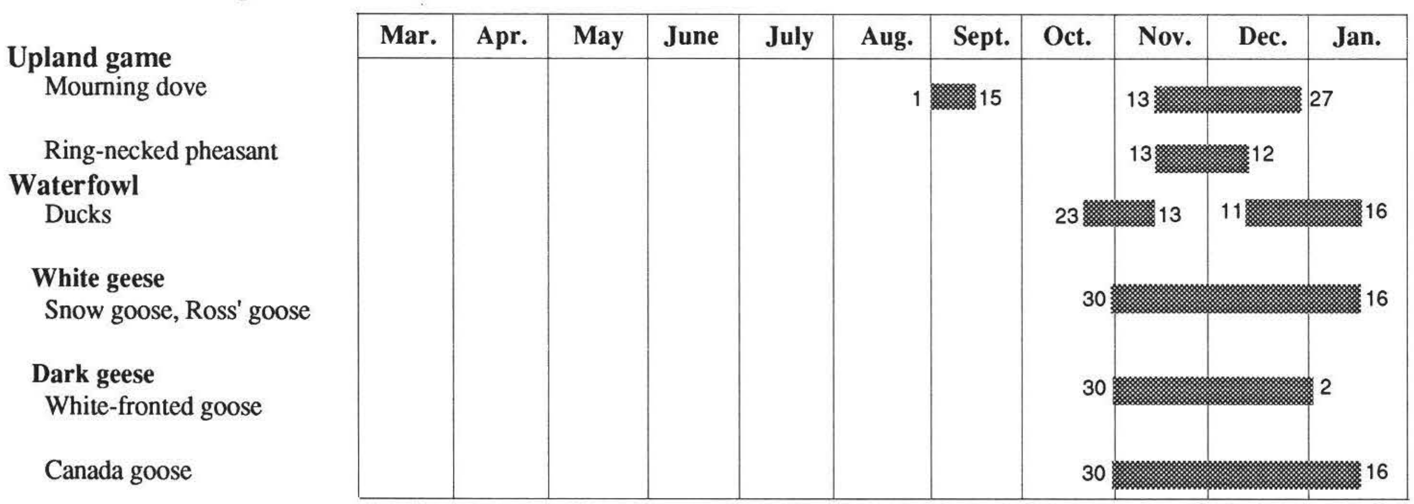
Figure 3J-4
Typical View of Holland Tract from Holland Tract Road

General Sport Fishing Schedule in the Delta



Notes: Minor amounts of fishing occur in the Delta during December-February for resident species, including large-mouth bass, sunfish, and catfish. The schedule is based on the expected presence of different fish species in the Delta.

Selected Hunting Seasons in California



Note: Numbers at ends of bars represent dates in months when the hunting seasons begin and end.

Source: California Department of Fish and Game 1993.

Jones & Stokes

Figure 3J-5
Expected Schedule of Participation in Fishing and Hunting

Chapter 3K. Economic Conditions and Effects

Chapter 3K. Affected Environment and Environmental Consequences - Economic Conditions and Effects

SUMMARY

This chapter discusses the economic effects of the DW project. Following are the types of economic effects that could be associated with implementation of the DW project alternatives:

- *changes in employment and income resulting from changes in agricultural and recreational uses of the DW project islands;*
- *changes in employment and income resulting from construction, operations, and maintenance activities associated with project implementation; and*
- *changes in fiscal conditions (public revenues and public costs) resulting from project implementation.*

Because economic effects are not considered environmental impacts under CEQA and NEPA, no conclusions are made in this chapter regarding the significance of these economic effects and no mitigation for economic effects is identified.

Under Alternative 1 or 2, the conversion of lands currently farmed on the DW islands would result in adverse effects on agriculture-related employment and income; however, project-related recreation expenditures and project construction, operation, and maintenance activities would generate a net increase in employment and income within the two-county region. The construction and operation of the project also would generate additional property tax revenues within Contra Costa and San Joaquin Counties.

Implementing Alternative 3 would have a beneficial effect on the regional economy at buildout of the project. Net employment and income benefits would be greater than those described for Alternatives 1 and 2 because of increased construction, operation, and maintenance employment and expenditures required to expand water storage capabilities to all four DW islands.

Implementing the No-Project Alternative would result in increases in local employment and income in the agricultural sector. However, these effects may be short term because of erosion and subsidence problems associated with agricultural production on the islands. No information is available concerning the length of time agriculture will remain physically and economically feasible on the project islands; however, intensified agricultural use of the islands likely will become more costly to maintain over the long term. Recreation on the project islands would increase slightly from existing levels under this alternative because for-fee hunting (day use only) on the four islands would be expanded, which would benefit local economies.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

To meet the NEPA requirement that an EIS comply with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations, information has been added to this chapter to address effects on these populations. Additionally, the estimates of gross revenues from annual water sales that were reported in the 1995 DEIR/EIS for Alternatives 1, 2, and 3 have been corrected in response to a comment on the 1995 DEIR/EIS; the modified results are calculated based on average discharges rather than average diversions.

The evaluation of economic effects of the alternatives was not revised in the 2000 REIR/EIS, so the results presented in this chapter represent conditions as identified in the 1995 DEIR/EIS. The 2000 REIR/EIS evaluation of the proposed project (Alternative 1 or 2), as restricted by the FOC, biological opinion RPMs, and stipulated agreements between DW and other parties to the SWRCB's water right hearing, indicated that discharges under Alternative 1 or 2 would be lower than estimated in the 1995 DEIR/EIS. Reductions in project yield could reduce the gross revenues from water sales that are reported below for Alternatives 1 and 2; however, such changes would not alter the conclusion that the project's fiscal effects would be beneficial.

INTRODUCTION

Under NEPA and CEQA, economic and social effects alone are not considered environmental impacts.

Similarly, NEPA requires discussion of economic impacts to the extent to which they are interrelated with environmental impacts (NEPA regulations, 40 CFR 1508.14).

Under CEQA, economic and social effects can be discussed in an EIR at the option of the lead agency. CEQA (State CEQA Guidelines Section 15131) allows for economic and social impact discussions in an EIR when the agency is:

- tracing the chain of cause and effect from a project's economic and social effects to physical changes caused by those effects (with the focus of the analysis on the physical changes),
- determining the significance of physical changes caused by a project (e.g., economic or social effects may be used to assess the severity of a project-related physical change), or
- making CEQA findings relating to the feasibility of mitigating project impacts (the economic information must be in the EIR or added to the record in some other manner).

This chapter's discussion of economic effects of the DW project alternatives has been included in this document to help assess the severity of physical impacts related to the conversion of agricultural land, as discussed in Chapter 3I, "Land Use and Agriculture". The change in agriculture-related employment and income was used with other factors to assess the significance of the project's agricultural land conversion impacts.

For public disclosure purposes, this chapter also discusses economic effects related to the construction, operation, and maintenance of the project's water storage and recreation facilities. As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of the project's economic effects assumes that the recreation facilities would be constructed and operated. Fiscal effects of the project in Contra Costa and San Joaquin Counties are also discussed, as well as the indirect economic effects of the project on adjacent landowners, recreationists, and Delta water users.

The economic effects discussed in this chapter are not considered environmental impacts under NEPA and CEQA. Accordingly, no conclusions are made regarding the significance of economic effects and no mitigation for these effects is required.

The discussion of economic effects in this chapter includes several terms that may not be familiar to all readers. The following are definitions of key terms as they are used in this discussion:

Direct employment. Employment generated in businesses that are part of the DW project (i.e., agriculture; recreational uses; and construction, operations, and maintenance of project facilities).

Secondary employment. Indirect or induced employment, defined as follows:

- **Indirect employment**. Employment generated in businesses supplying goods and services related to DW project operations.

- **Induced employment**. Employment generated as a result of consumer spending by employees who are directly and indirectly affected by DW project operations.

Full-time equivalent (FTE) employment. A unit for measuring employment in terms of number of jobs, where one job equals 40 hours of work per week. The actual number of employee jobs supported by a business may differ based on how total work hours are divided among employees.

Final demand. Sum of all purchases for final use or consumption.

Employment multiplier. The number of jobs associated with a $1 million change in final demand in a specified industry and a specified region.

Income. The earnings of households associated with a given industry, consisting of employee compensation (salary and wages) and proprietors' earnings (profit and dividends) but excluding proprietor contributions to welfare and pension funds. Income is classified as direct or secondary, as follows:

- **Direct income**. Earnings of households generated in businesses that are part of DW project operations.

- **Secondary income**. Earnings of households generated in businesses supplying goods and services related to DW project operations (indirect income) and generated as a result of spending by employees directly and indirectly affected by DW project operations (induced income).

Income multiplier. The amount of income associated with a dollar change in final demand in a specified industry and a specified region.

Direct economic effects. Changes in the earnings of households generated by DW project operations and changes in fiscal conditions (property and sales tax revenues and public costs) associated with DW project operations.

Secondary economic effects. Changes in the earnings of households and in fiscal conditions (property and sales tax revenues and public costs) associated with changes in businesses supplying goods and services related to DW project operations and with spending by employees directly and indirectly affected by DW project operations.

ECONOMIC CONDITIONS

This section describes conditions on the DW project islands as they existed in 1987 and 1988 when the environmental permitting process for the DW project was initiated. This section also describes the point of reference (or baseline) under CEQA for measuring the economic changes expected to be caused by the DW project's physical impacts. All dollar amounts in this chapter have been adjusted for inflation to 1993 dollars to allow for comparison with dollar amounts estimated for conditions with the DW project.

As discussed in Chapter 3I, "Land Use and Agriculture", some changes in agricultural land use and related employment and income on the islands have occurred since 1988; however, some of these changes have resulted from project-related actions and influences. (Changes include portions of fallowed lands on Holland and Webb Tracts being brought back into grain production, and some of Bacon Island's asparagus stands being converted to wheat and corn crops.) The 1987-1988 point of reference (with adjustments to 1993 dollars to account for inflation) is used to describe baseline economic conditions because it provides the best basis for comparing project effects on conditions existing at the time of DW's initial application to the Corps and SWRCB.

Sources of Information

Employment

Existing employment generated by agricultural use of the islands was estimated based on the estimated gross value of agricultural production on the islands. Existing direct and secondary employment was estimated by applying employment multipliers provided by the U.S. Bureau of Economic Analysis' Regional Input-Output Modeling System (RIMS II) (1987) to estimates of production. Modeled estimates rather than actual employment data were used to ensure consistency with employment estimates prepared for the DW project alternatives and because collecting accurate baseline employment information from numerous landowners and tenant farmers is difficult. All agricultural yield and economic data referred to in this section include data on 1,120 acres on Holland Tract that would not be included in the project under Alternatives 1 and 2, but would be included under Alternative 3.

The effects of interindustry linkages and the impacts induced by household spending were estimated using RIMS multipliers. RIMS multipliers for industrial sectors for the project vicinity were obtained for an area that approximates the economic impacts of production changes on the economy of San Joaquin and Contra Costa Counties.

Existing employment generated by recreational use of the islands was estimated based on the recreational use estimates in Chapter 3J, "Recreation and Visual Resources". These estimates were used with recreation spending profiles to estimate existing spending associated with recreational use of the islands. RIMS employment multipliers for industrial sectors were then used to estimate direct and secondary employment associated with existing levels of spending. All recreation use numbers and economic data referred to in this section exclude the marinas on Holland Tract, which would not be directly affected by the project. The boat slip occupancy rate of Holland Tract's largest marina reportedly averages 85%, with summer months being especially busy (Cochrell pers. comm.). Increased boat traffic generated by the project would likely have minor economic effects on the marinas because occupancy of the marinas is already high.

Overall employment effects of the project were compared to estimates of employment in San Joaquin and Contra Costa Counties provided by the California Employment Development Department.

Income

Income generated by existing agricultural use of the four project islands was estimated in much the same way described above for employment. The RIMS income multipliers were applied to estimates of the gross value of agricultural production on the islands to provide estimates of direct and secondary income generated by the islands throughout San Joaquin and Contra Costa Counties. Similarly, income associated with existing recreational uses of the islands was estimated using RIMS income multipliers with estimates of recreation spending.

Fiscal Conditions

Information on property tax revenues generated by the islands was provided by landowners through the project proponent (Williams pers. comm.).

Existing Employment

Agriculture

Agriculture is the primary economic activity on the four project islands, using an estimated 65% of the islands' total acreage in 1987-1988. The average gross value of the agricultural output of the four DW project islands (excluding the output of 1,120 nonproject acres on Holland Tract) is shown in Table 3K-1 (in 1993 dollars). Agricultural operations on the project islands generate three kinds of employment in the local and regional economy. First, direct employment is generated on the project islands through crop-related cultivation and harvesting activities. The expenditures on goods and services related to onsite agricultural operations indirectly generate additional employment in businesses supplying goods and services. Employment is also induced throughout the region as a result of consumer spending by employees who are directly and indirectly affected by onsite agricultural operations. The indirect and induced effects are referred to throughout the remainder of this chapter as the secondary economic effects of the project. RIMS employment multipliers for the crops produced on the project islands are shown in Table 3K-2.

Agricultural use of the four islands generates an estimated 290 FTE direct and secondary jobs in San Joaquin and Contra Costa Counties (Table 3K-2). The majority of these jobs are generated by the agricultural output of Bacon Island. Bacon Island, with its extensive production of labor-intensive vegetable crops, generates an estimated 221 direct and secondary jobs. Webb Tract, Bouldin Island, and Holland Tract, which primarily produce grain crops that require relatively less labor, generate an estimated 8, 34, and 26 direct and secondary jobs, respectively.

Recreation

A small number of jobs are currently generated within San Joaquin and Contra Costa Counties by recreational use of the islands. The primary recreational activities on the project islands are hunting on Bouldin Island and Webb Tract and fishing on Bacon Island. As shown in Table 3K-3 under "Existing Conditions", the islands generate an estimated 3,852 days of use (visitor days) by recreationists from outside of the two-county area, excluding fishing and boating recreation days on Holland Tract originating from existing marinas that would not be directly affected by the project. (A visitor day is defined as participation by one individual in a recreational activity during any portion of a 24-hour period.)

Employment is generated by the expenditures of visitors in eating and drinking places, lodging places, and retail establishments. The total estimated annual expenditure for nonlocal visitors to the islands is approximately $119,600 (Table 3K-3). Based on RIMS employment multipliers for the appropriate industrial sectors, it is estimated that current spending generates very little direct and secondary employment (an estimated four jobs) in San Joaquin and Contra Costa Counties because of the small number of nonlocal recreationists visiting the islands (see Table 3K-4 under "Existing Conditions"). RIMS employment multipliers for components of recreation spending are shown in Table 3K-4.

Existing Income Generated by Use of the DW Islands

Agriculture

Together, the four islands produce crops worth an estimated $11.6 million (1993 dollars), based on market prices (Table 3K-1). In terms of crop value Bacon Island is, by far, the greatest producer. Bacon Island's production of asparagus, potatoes, and wine grapes generates an estimated $8.2 million annually. Webb Tract, Bouldin Island, and Holland Tract, which produce lower value grain crops, generate average gross crop values of $0.5 million, $1.9 million, and $1.0 million, respectively.

The direct and secondary income generated by the agricultural output of the four islands is shown in Table 3K-2. Together, the islands generate an estimated $6.7 million in income throughout San Joaquin and Contra Costa Counties. Bacon Island generates an estimated $5.1 million, or 76%, of this total.

Recreation

Recreational use of the project islands (excluding the commercial marina on Holland Tract that would not be affected by the project) generates a small amount of income within San Joaquin and Contra Costa Counties. Income is currently generated by expenditures on lodging, food, and retail goods by nonlocal visitors to the project islands. Based on an estimated $119,600 in local spending and RIMS income multipliers, an estimated $68,200 (in 1993 dollars) in direct and secondary income is generated in San Joaquin and Contra Costa Counties (Table 3K-4).

Existing Fiscal Conditions

Public Revenues

Bacon and Bouldin Islands, located in San Joaquin County, and Holland and Webb Tracts, located in Contra Costa County, generate property and sales tax revenues for these two counties and for cities and districts within the two-county area.

Property tax revenues generated by the islands are limited by Williamson Act contracts, which govern

51% of the total project area (99% on Bacon and Bouldin Islands in San Joaquin County and 1% on Webb Tract in Contra Costa County). Williamson Act legislation enables counties and cities to designate agricultural preserves and to offer preferential taxation based on a property's agricultural use value, rather than on market value, effectively reducing the property tax payments required of landowners under Williamson Act contracts.

During the 1987-1988 tax year, landowners on Holland and Webb Tracts made property tax payments totaling approximately $125,000 ($158,000 in 1993 dollars), or an average of $13.50 ($17.10 in 1993 dollars) per acre. Bacon and Bouldin Islands generated $137,000 ($174,000 in 1993 dollars) in property tax revenues, or $12.30 ($15.60 in 1993 dollars) per acre, during the same year (Williams pers. comm.). These revenues are allocated to counties and districts in which the islands are located. Counties received from 35% to 40% of each property tax dollar generated by properties in unincorporated areas during the 1987-1988 tax year.

Property taxes generated by the project area have changed little since the 1987-1988 tax year and have actually decreased in dollars adjusted for inflation. Property tax payments on lands on Holland and Webb Tracts within the project area totaled approximately $127,000 ($14.94 per acre) on an assessed value of $11.8 million during the 1993-1994 tax year. Property tax payments for properties on Bacon and Bouldin Islands totaled $139,000 ($13.79 per acre) on an assessed value of $11.0 million. Property taxes paid on lands within the project area averaged approximately 1.2% of assessed value during the 1993-1994 tax year. (Forkel pers. comm.)

Agricultural operations on the islands generate sales tax revenues through the purchase of such production inputs as fertilizer, pesticides, herbicides, fuel, and equipment in the local area. Purchases are spread throughout the region, including the communities of Rio Vista, Brentwood, Lodi, and Stockton. These communities receive sales tax revenues equaling 1% of the purchase price of goods purchased within their communities. Based on the value of agricultural production on the islands, it is estimated that annual sales tax revenues generated by purchases in local areas probably would not exceed $25,000 (assuming that local retail purchases equal 20% of gross production value). Retail spending generated by direct and secondary employment associated with agricultural production on the islands could generate an additional $15,000 in local sales tax revenues.

Public Costs

Levee maintenance activities by the local reclamation districts are the most substantial public cost on the DW project islands; they are discussed in Chapter 3D, "Flood Control". Otherwise, the project islands currently require few public services and therefore generate relatively minor costs to the counties and districts serving the project islands, with the exception of mosquito abatement costs. The primary public services currently required by the project islands include police and fire protection services and county road maintenance services. The islands are sparsely populated, have few structures, and generate few calls for fire department or sheriff services. Road maintenance costs to the counties are minor because all roads, with the exception of Bacon Island Road on Bacon Island, are privately maintained.

As described in Chapter 3N, "Mosquitos and Public Health", Bouldin Island and Holland Tract annually generate numerous service calls for the San Joaquin County Mosquito Abatement District and the Contra Costa Mosquito Abatement District, respectively. Mosquito problems on Bouldin Island are generally related to the flooding of cornfields and the proximity of human activities associated with nearby marinas, campgrounds, and urban developments. Mosquito problems on Holland Tract are related to portions of the island outside the project area. No significant mosquito abatement problems are currently generated by Bacon Island and Webb Tract.

An additional but highly variable public cost at the federal level is related to commodity crop deficiency payments and set-aside programs. Payments to farmers under federal subsidy programs vary from year to year, depending on federally determined crop target prices, national average prices, and qualifying crops. Wheat and corn both qualified as subsidized crops in 1987, generating commodity crop deficiency payments for growers of the crops on the project islands. In 1988, these crops accounted for 50% of the acreage on the four project islands (Table 3I-5) and almost 8% of the wheat and corn acreage harvested in Contra Costa and San Joaquin Counties in 1987 (Table 3I-9 in Chapter 3I, "Land Use and Agriculture"). Information concerning the amount of payments made to farmers on the DW project islands in 1987 is not readily available.

Government payments to farmers in Contra Costa County under all programs totaled $299,000 ($380,000 in 1993 dollars) during 1987. These payments averaged $6,600 per farm ($8,400 in 1993 dollars) over the 45 farms in the county that received government payments. Payments to farms in San Joaquin County totaled approximately $7.6 million ($9.7 million in 1993 dollars) during 1987, averaging $27,000 ($34,000 in 1993 dollars) over the 284 farms in San Joaquin County receiving payments in 1987. (U.S. Bureau of the Census 1989.)

METHODOLOGY FOR ASSESSMENT OF ECONOMIC EFFECTS

Analytical Approach

The economic analysis focuses on the direct and secondary economic changes that would occur in the region as a result of implementation of the DW project. For this analysis, the region is defined as a two-county area consisting of San Joaquin and Contra Costa Counties. The analysis uses two measures of economic activity, employment and income, to characterize the economic changes generated by the DW project alternatives.

As discussed at the beginning of this chapter, economic effects of projects are not normally considered impacts on the physical environment and therefore are not considered significant impacts and do not require mitigation under NEPA and CEQA. Because economic effects are not considered environmental impacts, no criteria for determining the significance of economic effects have been included in this chapter. Economic effects, however, can be used to judge the significance of physical impacts. For this analysis, the magnitude and severity of economic effects resulting from project implementation were identified and used to help characterize the socioeconomic effects resulting from the conversion of agricultural lands to water storage and recreation facilities.

The secondary, offsite economic effects that would be generated by the supply and sale of water stored on the four islands were not evaluated as part of this analysis because it is too remote and speculative to identify the ultimate uses and users of DW project water. Additionally, accurately identifying the price and availability of alternative water supplies for the ultimate users of DW project water is not possible. Without this information, accurately estimating the secondary, offsite economic effects of the supply and sale of DW project water is not possible. Gross revenue generated for the project proponents by the sale of water was estimated based on DW's estimate of the market value of project water and on the expected yield of the project alternatives. Estimates of gross revenues generated by water sales have been included for informational purposes only. These estimates do not necessarily represent the economic value of project water to end users of the water.

Following are brief descriptions of the methodologies used to project the economic effects of the DW project alternatives. All dollar figures in this chapter have been adjusted to 1993 dollars.

Effects on Agricultural Employment and Income

Employment and income effects generated by the loss of agricultural use of the project islands under the DW project alternatives were evaluated based on the existing (1987-1988) cropping patterns and agricultural production described in Chapter 3I, "Land Use and Agriculture". The gross value of each island's agricultural production was estimated using average prices in San Joaquin County over a 5-year period (1988-1992) for each crop produced on the DW project islands (Table 3K-1). For some crops, prices were modified based on information provided by farmers on the islands. Crop prices fluctuate, sometimes dramatically, from year to year because of local, national, and international market and weather conditions. A 5-year price average was used to smooth out price levels that may have fluctuated dramatically. Employment and income multipliers from the RIMS model were used to project total direct and secondary employment and income generated within San Joaquin and Contra Costa Counties by current agricultural production on the DW project islands (Table 3K-2).

This analysis is based on the assumption that the existing agricultural production on the four DW islands could continue indefinitely. In fact, most soils on the four islands are limited by long-term subsidence and erosion hazards, according to NRCS (formerly SCS) (Table 3I-3). Continued subsidence of the island bottoms and increased likelihood of levee failure could eventually make agricultural production on these islands infeasible (DWR 1990). (See Chapter 3D, "Flood Control", and Chapter 3I, "Land Use and

Agriculture".) This analysis also assumed that the mix of crops grown on the DW project islands in 1987 would continue in the future. Subsidence, levee maintenance costs, and market factors could substantially affect future crop mixes (although they have not affected crop mixes between 1987 and 1994).

Effects on Recreation-Related Employment and Income

Estimates of employment and income effects generated by recreation were largely based on the changes in recreational use of the DW project islands under each of the project alternatives projected in Chapter 3J, "Recreation and Visual Resources". Analysis of the economic effects of changes in recreation visitation associated with the DW project alternatives focused on changes in final demand for recreation goods and services. The analysis evaluated effects resulting from changes in hunting, boating, and other recreational uses of the DW project islands (refer to Chapter 3J).

As described above, DW has removed construction of recreation facilities from its CWA permit applications. However, it is anticipated that DW would subsequently apply for CWA and Rivers and Harbors Act permits for some or all of these recreation facilities. Therefore, the estimates of recreation-related employment and income presented in this chapter assume that the facilities would be constructed over the next 20 years.

The approach used to assess changes in final recreation demands involved the following steps:

1. Estimate the number of recreation-related visitor days on the islands under existing conditions and the DW project alternatives (refer to Chapter 3J).

2. Estimate the proportion of total recreation use accounted for by nonlocal visitors (i.e., visitors from counties other than San Joaquin and Contra Costa Counties). Recreation expenditures by nonlocals represent exports from the two-county region and hence sales to final demand. Conversely, expenditures by locals do not directly affect sales to final demand because the expenditures would go to other sectors within the regional economy if not spent on recreation goods and services; however, substitution of recreation days from other areas in the region was assumed not to occur under the DW project because of the unique nature of the "recreation package" offered by the DW project. The onsite lodging facilities and marinas, year-round recreation opportunities, and club membership cost would all differentiate the project-related recreation from other recreation opportunities within the region. These factors would limit the amount of recreation substitution that would occur under the DW project.

3. Estimate recreation expenditures per day by nonlocal visitors to the islands.

4. Aggregate annual changes in final demand for recreational goods and services in the region into three industrial classes: eating and drinking places, lodging establishments, and retail trade.

Expenditures by visitors to the DW project islands were estimated based on studies of daily spending by recreationists in California (USFWS and U.S. Bureau of the Census 1993) and nationwide (Propst et al. 1992), updated to 1993 dollars, weighted for the types of recreation expected on the DW project islands under project operations, and revised for application to the industrial classes identified above in step 4. Visitors who would use the islands under the DW project alternatives were assumed to be club members with access to clubhouse facilities who thus would not spend money on local lodging.

Changes in visitation associated with each project alternative were estimated based on information presented in Chapter 3J, "Recreation and Visual Resources". Proportions of visitors to each island from counties outside the region were estimated based on information provided by island landowners concerning the residence of current visitors. As discussed in Chapter 3J (refer to "Existing Recreation Use on the DW Project Islands"), approximately 80% of hunters visiting the islands under the DW project alternatives were assumed to be visitors to the two-county region.

Expenditures considered in this analysis include grocery purchases, restaurant and lodging expenditures (for existing and no-project conditions), purchases of miscellaneous retail goods, expenditures on miscellaneous recreation services, and gasoline expenditures. These expenditures were aggregated into three industrial classes: eating and drinking places (grocery and restaurant purchases), lodging establishments, and retail trade (miscellaneous retail and gasoline expenditures). The estimates of expenditures made within each industrial class were used in conjunction with the RIMS employment and income multipliers for each industrial class to estimate the total direct and secondary employment and income generated by the project alternatives. The employment and income generated by expenditures on onsite club memberships were implicitly included in the projections of operations- and maintenance-related employment and income.

Employment and Income Effects of Project Construction, Operations, and Maintenance

Employment and income effects generated by the construction, operation, and maintenance of the water storage and recreation facilities were evaluated based on projections of direct employment requirements provided by DW (Forkel pers. comm.). Total direct and secondary regional employment effects for each project-related activity, including employment related to the operation and maintenance of recreation facilities, were projected based on the relationship of direct employment to secondary employment suggested by the appropriate RIMS employment multipliers. Total direct and secondary income was then projected based on the RIMS relationship of total employment to total income for the appropriate industrial sectors.

Effects on Minority and Low-Income Populations

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations, requires each federal agency (in this case, the Corps) to identify and avoid disproportionately high and adverse effects on minority and low-income populations when implementing its programs, policies, and activities that affect human health or the environment.

Executive Order 12898 applies to this project because Corps approval has been requested and the DW project islands are the resident and employment location of minority and low-income populations. Surrounding areas containing minority and low-income populations may also be affected by the project. Potential environmental, human health, and socioeconomic effects on minority and low-income populations are discussed below.

The environmental and economic effects of Alternatives 1, 2, and 3 under each resource topic, described in Chapters 3A through 3O, were reviewed and evaluated to determine whether they could potentially result in disproportionately high impacts on minority or low-income populations. Environmental impacts considered include water supply, hydrodynamic, water quality, and flood control effects; effects on utilities, highways, traffic levels, land use, recreation, visual resources, and cultural resources; and impacts on fishery resources, vegetation and wetlands, and wildlife (refer to Table S-1).

Fiscal Effects

Fiscal effects were evaluated based on projections of construction and operations and maintenance expenditures provided by DW (Forkel pers. comm.). Order-of-magnitude estimates of property and sales tax revenue generated by project operations were compared with estimates of existing revenues to evaluate changes in public revenues generated by the project. Public costs for local governments potentially generated by the project were qualitatively evaluated.

ECONOMIC EFFECTS OF ALTERNATIVE 1

Employment Effects

Agriculture

Implementation of Alternative 1 would preempt existing agricultural operations on the four project islands, resulting in the loss of an estimated 280 direct and secondary jobs in San Joaquin and Contra Costa Counties. (An estimated nine jobs would continue to be generated by agricultural use of 1,120 acres on Holland Tract excluded from the project under Alternatives 1 and 2.) Although some agricultural use may be incidental to the management of the habitat islands, the employment generated by agricultural use would be relatively small and would be included in employment projections for project operations. The loss of employment generated by the agricultural use of Bacon Island would represent the largest loss among the four islands; agricultural operations on Bacon Island currently generate an estimated 221 direct and secondary jobs, or 76% of all jobs generated by agricultural use of the DW project islands (Table 3K-2). Employment groups sustaining the most severe job losses would include onsite farmworkers and employees who work for local suppliers of agricultural goods (e.g., farm equipment, seed, fertilizers, pesticides, gasoline) and services. The loss of agricultural employment would probably occur within 3 years of necessary project permits being granted.

Recreation

Based on the projections of recreation-related expenditures shown in Table 3K-3 and the RIMS employment multipliers shown in Table 3K-4, it is estimated that implementation of Alternative 1 would generate approximately 91 secondary jobs within San Joaquin and Contra Costa Counties at buildout of the project's recreation facilities. This total excludes recreation-related employment on the project islands that is included under "Project Construction, Operations, and Maintenance" below.

Project Construction, Operations, and Maintenance

Implementation of Alternative 1 would directly generate temporary, construction-related employment and permanent, operations-related employment. Both types of employment would generate secondary employment within San Joaquin and Contra Costa Counties.

Temporary employment would be generated by earthwork and levee improvements and other related improvements required for the water storage operations. Temporary employment would also be generated by the construction of onsite hunting and recreation facilities. Employment related to the construction of the water storage facilities would probably occur over a 1.5-year period following the granting of necessary project permits. Employment related to the construction of recreation-related facilities would probably occur over a longer period as facilities are constructed to meet the demand for onsite recreation pursuant to the limitations of the permit conditions imposed by the lead agencies and of the HMP (refer to Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). DW expects buildout of all recreation facilities within 20 years (Forkel pers. comm.); this rate of development was used to estimate annual employment and income generated by construction of recreation-related facilities.

According to estimates provided by DW, construction of water storage facilities would directly generate 309 person-years of construction employment, or 206 FTE jobs spread over 1.5 years. Person-years of construction employment represent the number of years of full-time employment generated by construction activities; FTE employment represents the number of permanent, full-time jobs generated by the ongoing operations of the DW project. Construction of recreation facilities would directly generate an estimated 420 person-years of employment, or an average of 22 FTE jobs over the 20-year construction period.

Total direct and secondary employment generated by the construction activities was projected using RIMS employment multipliers (Table 3K-5). Total direct and secondary temporary employment generated by Alternative 1 within San Joaquin and Contra Costa Counties was projected to total 344 FTE jobs over the 1.5-year construction period for water storage facilities and an average of 37 FTE jobs annually over the 20-year construction period for recreation facilities.

Based on DW estimates, operations and maintenance of the water storage and recreation facilities would directly generate a total of 155 permanent FTE jobs. Approximately 75 of these jobs would be related to the annual operations and maintenance of the water storage facilities (i.e., 34 employees for the maintenance of facilities and equipment and 41 employees for levee and island maintenance activities), while the remainder would be related to operation and maintenance of the recreation facilities.

A projected 315 permanent direct and secondary jobs would be generated by operations and maintenance of Alternative 1 (Table 3K-5). These jobs would be generated over the buildout period beginning with the operation of the water storage facilities, reaching a maximum, permanent level at buildout of the recreation facilities. The employment total includes a projected 13 secondary jobs in the regional economy that would be generated by annual expenditures for major maintenance of recreation facilities.

Net Employment Effects

Table 3K-5 presents a summary of the employment effects under Alternative 1. A projected 406 permanent jobs (excluding the nine agriculture-related jobs generated by the continued agricultural use of 1,120 acres on Holland Tract) would be generated within the region with the expenditures of project-related recreationists and the operation and maintenance of water storage and recreation facilities. This gain in employment would offset the loss of an estimated 284 jobs currently generated by onsite agricultural operations and recreation-related activities. Implementation of Alternative 1 would result in the projected net gain of 122 permanent FTE jobs in San Joaquin and Contra Costa Counties at full buildout and operation of onsite recreation facilities. Project-related job losses would occur primarily in agriculture-dependent industries, while job gains would occur in levee maintenance, equipment maintenance, and recreation-dependent industries.

The regional economy would also benefit from temporary employment in the construction industry and subsequent construction-related spending in the regional economy. Implementation of Alternative 1 would generate a projected 344 direct and secondary FTE jobs over the 1.5-year water project construction period. An additional 37 FTE jobs would be generated annually over the 20-year recreation facility construction period.

Income Effects

Agriculture

Implementation of Alternative 1 would result in the loss of existing agricultural production and the subsequent loss of income generated by the agricultural production on the four project islands. (Nonproject areas on Holland Tract would remain in agricultural production and would continue to produce agricultural income.) As discussed in the "Affected Environment" section, the islands currently produce an estimated $11.6 million in agricultural output, generating an estimated $6.7 million in direct and secondary income in San Joaquin and Contra Costa Counties (Table 3K-2). All agricultural income other than the estimated $217,600 generated by the continued agricultural use of 1,120 acres on Holland Tract would be lost as a result of implementation of Alternative 1.

Recreation

The spending of recreationists visiting the project islands under Alternative 1 would generate new income in San Joaquin and Contra Costa Counties. Nonlocal visitors to the DW project islands are projected to spend approximately $3.1 million annually in the two-county area at buildout of the onsite recreation facilities (Table 3K-3). Based on the RIMS income multipliers shown in Table 3K-4, this spending would generate approximately $1.8 million in direct and secondary income in San Joaquin and Contra Costa Counties.

Project Construction, Operations, and Maintenance

Alternative 1 would generate income in San Joaquin and Contra Costa Counties during both the construction and operation phases of the project. The construction of the water storage and recreation facilities would generate income through wages paid to construction workers and the earnings of contractors. The purchase of construction inputs and the subsequent spending by workers and contractors would generate secondary income in the regional economy. RIMS income multipliers were used to project total income generated by project construction.

The analysis summarized in Table 3K-6 estimates that approximately $14.3 million in income would be generated annually by construction activities on the four DW project islands over the expected 1.5-year water storage construction period. Additionally, construction of recreation facilities is projected to generate $1.5 million in income annually over the 20-year construction period. The island-by-island generation of construction-related direct and secondary income is presented in Table 3K-6.

The operation and maintenance of the water storage and recreation facilities would generate annual income through payments to employees, management earnings, contractor payments, and subsequent household and business expenditures in the regional economy. RIMS income multipliers were used to project total income generated by the operation and maintenance of Alternative 1. Approximately $11.4 million in direct and secondary income would be generated annually in San Joaquin and Contra Costa Counties by the operation and maintenance of Alternative 1 (Table 3K-6). This income would be generated over the buildout period, beginning with the operation of the water storage facilities and reaching a permanent, maximum level at the projected buildout date for the recreation facilities.

The operation of Alternative 1 would also generate revenue through the sale of water. This revenue would be received by DW, which is located in Contra Costa County. A portion of this revenue would be spent in the local area on operation and maintenance of water storage facilities, as discussed above. A portion of this revenue may also be returned to the local economy through other expenditures and taxes. Although there is no way to estimate the price DW will ultimately receive for its water, DW expects to receive $200-$250 per acre-foot of delivered water (Forkel pers. comm.). Based on this price and the projected average annual project discharges of 188 TAF (refer to Appendix A3, "DeltaSOS Simulations of the Delta Wetlands Project Alternatives"), it is estimated that $38-$47 million in gross revenues would be generated annually by water sales.

Net Income Effects

A projected $13.3 million in annual, permanent income (excluding the estimated $217,600 in income generated by the continued agricultural use of 1,120 acres on Holland Tract) would be generated in the region by the spending of project-related recreationists and the operation and maintenance of water storage and recreation facilities (Table 3K-6). This gain in income would offset the loss of an estimated $6.5 million in income currently generated by onsite agricultural operations and recreation-related activities. Implementation of Alternative 1 would thus result in the projected net gain of approximately $6.8 million in annual income in San Joaquin and Contra Costa Counties. The loss in annual income to workers in agriculture-related and other industries in the two-county area would be adverse; however, workers in construction, equipment maintenance, and recreational retail and service industries would benefit from the generation of income under Alternative 1.

The beneficial regional economic effect of the gain in permanent, annual income would be enhanced by the generation of substantial temporary, construction-related income within the region. The construction of water storage facilities would generate a projected annual $14.3 million in direct and secondary regional income over the expected 1.5-year construction period. Additionally, construction of recreation facilities would generate annual regional income of $1.5 million over the expected 20-year construction period.

Effects on Minority and Low-Income Populations

None of the environmental impacts identified for the project alternatives would affect a specific population group. Many of the effects would occur on the DW project islands either during construction or during project operations. The population currently residing or working on the DW project islands, which primarily comprises Hispanic farmworkers, would presumably relocate prior to the beginning of construction activities on the islands. Most of the remaining environmental effects would be broadly spread throughout the Delta or the San Joaquin/Contra Costa County region and would not disproportionately affect a specific ethnic or income group. Additionally, mitigation would reduce the effects of most of the environmental impacts to less-than-significant levels.

None of the significant and unavoidable environmental impacts of the project would result in disproportionate effects on minority or low-income populations residing on the DW project islands, in the Delta, or within the larger region. However, the project would result in employment losses caused by the conversion of agricultural land. The effect on agricultural workers related to the conversion of agricultural land are discussed below under "Socioeconomic Effects".

Human Health Effects

The potential human health effects of the project alternatives regarding effects on minority or low-income populations primarily relate to increases in mosquito populations, increases in the potential exposure of people to wildlife species that transmit diseases, and reductions in air quality. These potential human health effects are described in Chapter 3N, "Mosquitos and Public Health", and Chapter 3O, "Air Quality".

Implementing Alternative 1 would result in an increase in mosquito breeding habitat on the DW project islands and probably an increase in mosquito production during certain times of the year. This impact would occur during project operations and would not affect the existing residents of the DW project islands, who would presumably relocate prior to commencement of project construction activities. Residents of nearby islands, many of whom are Hispanic farmworkers, could be adversely affected by exposure to larger mosquito populations; however, implementing Mitigation Measure N-1 would ensure coordination of DW project activities with mosquito abatement districts, reducing the potential for mosquito population management problems, and would reduce this impact to a less-than-significant level.

The populations of wildlife species known to serve as hosts of wildlife-transmitted diseases affecting humans could increase on the habitat islands under Alternative 1 (see Chapter 3N). This potential impact could occur during project operations, after the islands' current populations have relocated. The potential change in risk to public health associated with exposure to wildlife species on the habitat islands is considered less than significant.

Implementation of Alternative 1 would result in reduced regional air quality during both the construction and operations phases of the project. As described in Chapter 3O, "Air Quality", construction would result in significant increases in emissions of ROG, NO_x, and PM10; operations would cause significant increases in emissions of ROG and NO_x. Although mitigation measures could reduce adverse air quality impacts, they would not reduce impacts to less-than-significant levels. Reductions in regional air quality could adversely affect human health within the San Joaquin Valley Unified Air Pollution Control District and the Bay Area Air Quality Management District. These adverse effects would be experienced by all ethnic and income groups within these districts and, while adverse, would not disproportionately affect a specific ethnic group or low-income population within these districts.

Socioeconomic Effects

Implementing Alternative 1 would directly result in the loss of agricultural jobs generated by farming on the DW project islands and the displacement of many of the islands' residents.

DW currently leases land on the islands (excluding the land on the Solomon parcel on Holland Tract) to tenant farmers. Many of the islands' residences and farmworker camps are used by employees of the three farm operations that lease land on the islands. Onsite agricultural employment levels vary from year to year, but information provided by the islands' current farmers (Machado, Robertson, and Campbell pers. comms.) indicates that farming on the DW project islands annually generates the following numbers of jobs:

- Bacon Island, 171 (including 138 seasonal jobs),
- Webb Tract, 10 (including seasonal jobs),
- Bouldin Island, 20 (including seasonal jobs), and
- Holland Tract, 5 (including seasonal jobs).

The seasonal jobs range in duration, but can include 6-7 months of work per year (Robertson pers. comm.). Except for a few workers on Bouldin Island and four to six workers of Japanese descent on Bacon Island, virtually all of the permanent and seasonal workers on the DW project islands are Hispanic (Machado, Robertson, and Campbell pers. comms.).

Many of the permanent farmworkers live in residences on the islands and some of the migrant farmworkers periodically reside in converted barracks in farmworker camps on Bacon and Bouldin Islands. Bacon Island's population averages 20-30 farmworkers and family members residing in 12 single-family housing units, but its population can grow to 150 during the high season, with migrant workers staying in two farmworker camps (Campbell pers. comm.). Webb Tract is currently unoccupied except for a caretaker trailer that houses two people (Machado pers. comm.). Bouldin Island's resident population averages about 30, with farmworkers living in single-family units and a farmworker camp (Machado pers. comm.). Except for the families residing in the two residences on the Solomon parcel, Holland Tract is occupied by only two persons living in a foreman's trailer (Machado pers. comm.).

Most of the farmworkers working and residing on the DW project islands earn from \$4.35 to \$8 per hour (Machado, Robertson, and Campbell pers. comms.). Some workers hired during the harvesting season are paid on a piecemeal basis. Employees work up to 60 hours per week during the high season; permanent employees work an average of approximately 50 hours per week (Campbell pers. comm.). Based on average wages and work hours, permanent employees earn an estimated $10,000-$15,000 per year. Foremen and other supervisorial employees can earn $20,000-$30,000 per year, but these employees represent a small fraction of total employment.

Under Alternative 1, commercial farming would cease on the DW properties. Farm jobs would be lost or transferred to new locations if tenant farmers are able to relocate their operations. Most of the farmworkers and their families residing on the DW project islands would need to relocate because housing would be eliminated by the project. Under Alternatives 1 and 2, some farmworkers could be reemployed on the habitat islands to assist with the production of habitat crops. It is also possible that displaced workers could be employed in jobs related to project operations or maintenance that require an equivalent level of skill and provide a level of pay that is similar to or greater than that of positions normally filled by farm employees.

Although the project would ultimately generate more jobs than it would eliminate, many displaced farmworkers and their households could suffer disproportionately high, adverse socioeconomic effects as a result of project implementation. No mitigation has been identified to reduce or eliminate these disproportionate socioeconomic effects.

Fiscal Effects

Public Revenue Effect

As discussed in the "Affected Environment" section, the DW project islands currently generate property tax and sales tax revenues for San Joaquin and Contra Costa Counties and nearby communities and districts. Under Alternative 1, property tax revenues generated by the four islands would increase. Most of the project site is currently under Williamson Act contracts and is taxed based on its agricultural production value. Under Alternative 1, the Williamson Act contracts would remain in effect, but the appraised values of the project properties would no longer be based on their agricultural production value.

The construction of water storage and recreation facilities would constitute new construction to the land and trigger a reappraisal of the properties. The appraised value of the land, with improvements, would be based on either the construction cost of the project or the potential income stream generated by the project (Miller pers. comm.). Either appraisal method would generate property values above current values, generating greater property tax revenue for the counties and districts in which the islands are located. Property tax revenue would also increase if properties are not kept in their Williamson Act status because the assessed values of properties would approximate their new market values with project facilities.

Based on DW's estimated cost for construction of water storage and recreation facilities (Forkel pers. comm.), the assessed value of the project area could increase from $22.8 million to approximately $158 million. Property tax revenue generated by use of the islands could increase from an estimated $266,000 to a projected $1.9 million. This revenue would be allocated among Contra Costa and San Joaquin Counties and a number of special districts.

Sales tax revenue generated by use of the islands would likely increase under Alternative 1 because of the increase in regional income associated with project-related employment and expenditures. Under Alternative 1, the loss of retail sales tax revenue generated by purchases of agricultural supplies and expenditures by agricultural workers would be at least partially offset by the purchase of seed and fertilizer for the onsite wildlife habitat plantings; purchases of materials and supplies for project operations and maintenance; and purchases of food, fuel, and other retail goods by recreationists and onsite workers.

Public Cost Effect

Public costs for levee maintenance on the DW project islands would be substantially reduced under Alternative 1 because DW would be directly paying for levee maintenance on the project islands (see Chapter 3D, "Flood Control"). Other than levee maintenance, few public services, except mosquito abatement services, are currently required by the four DW project islands. Under Alternative 1, no additional public services would be required, with the exception of potential increases in mosquito abatement costs. As discussed in Chapter 3N, "Mosquitos and Public Health", mosquito abatement problems may increase on the four DW project islands because of increased mosquito habitat. The potential increase in service calls for the two mosquito abatement districts serving the islands is difficult to predict because of the many variables that could affect the need for abatement treatments (i.e., future urban uses on or near the islands, climatic conditions, or annual water management on the islands). The mitigation measures described in Chapter 3N would help reduce potential costs to the San Joaquin County and Contra Costa County Mosquito Abatement Districts.

The recreational use of the islands could generate a slightly greater number of sheriff calls and may require increased maintenance of county roads leading to the islands. The net effect of Alternative 1 on road maintenance costs is not clear. Wear and tear on roads caused by recreationists visiting the islands may actually be less than wear currently being caused by heavy agricultural vehicles (see Chapter 3L, "Traffic"). Increased costs to the counties and other public service providers currently serving the islands should be minimal.

Net Fiscal Effects

The net fiscal effect of Alternative 1 would likely be beneficial. This conclusion is based on the following considerations:

- increased public revenue would be generated by higher assessed valuations on the DW project islands,
- public levee maintenance costs may be substantially reduced because DW would be providing levee maintenance for the project islands,
- other public costs would be minimal, and
- costs of federal commodity crop deficiency payments would be eliminated.

Indirect Effects

Indirect Offsite Effects on Recreation

The availability of recreation opportunities on the DW project islands could indirectly affect the recreational use of other sites in the region through the redistribution of Delta waterfowl populations and hunters. These issues were evaluated in Chapter 3J, "Recreation and Visual Resources", which states that the offsite effects on waterfowl hunting would be less than significant. Thus, Alternative 1 is not expected to result in adverse indirect, offsite economic effects on operators of other Delta recreational facilities.

Indirect Effects on Adjacent Landowners

Seepage onto adjacent islands caused by the storage of water on the DW project islands could decrease property values and increase pumping costs for landowners on adjacent islands; however, project-related seepage would be controlled and should not result in increased costs or lower property values for adjacent landowners. This issue is addressed in Chapter 3D, "Flood Control", and Appendix D2, "Levee Design and Maintenance Measures".

Summary of Economic Effects of Alternative 1

Based on the analysis presented above, Alternative 1 would be expected to have a beneficial effect on the regional economy at buildout of the project. The conversion of lands currently farmed on the DW islands would result in adverse effects on agriculture-related employment and income; however, project-related recreation expenditures and project construction, operation, and maintenance activities would generate a net increase in employment and income within the two-county region. The construction and operation of the project would also generate additional property tax revenues within Contra Costa and San Joaquin Counties.

ECONOMIC EFFECTS OF ALTERNATIVE 2

The effects of Alternative 2 on regional employment, income, and fiscal conditions would be virtually the same as the effects described for Alternative 1, as summarized in Tables 3K-5 and 3K-6. Regional economic effects would be beneficial under Alternative 2, although farmworkers and agriculture-dependent industries would be adversely affected under this alternative.

Under Alternative 2, revenue generated for DW by the sale of project water would be higher than under

Alternative 1. Based on the projected annual average project discharges of 202 TAF and DW's estimated water market prices of $200-$250 per acre-foot, revenue generated by water sales would range from $40 million to $51 million under Alternative 2.

The effects of Alternative 2 on minority and low-income populations would be the same as the effects of Alternative 1.

ECONOMIC EFFECTS OF ALTERNATIVE 3

Under Alternative 3, net economic effects would be similar to, but generally greater than, effects under Alternative 1 because of increased recreation use and spending and increased construction, operation, and maintenance employment and expenditures required to expand water storage capabilities to all four DW islands. Effects on agriculture-related employment and income would be greater than under Alternatives 1 and 2 because 1,120 acres of agricultural land on Holland Tract, excluded from the project under Alternatives 1 and 2, would be converted to water storage uses under Alternative 3.

Employment Effects

As shown in Table 3K-5, agriculture-related employment would be reduced by an estimated nine additional jobs relative to Alternative 1 because of the conversion of an additional 1,120 acres of agricultural land on Holland Tract. Recreation-related employment would increase by approximately one FTE job compared with employment under Alternatives 1 and 2. Operation and maintenance of water storage and recreation facilities under Alternative 3 would generate a projected 36 more direct and secondary jobs than would be generated by operation and maintenance activities under Alternative 1.

Under Alternative 3, construction of water storage facilities would generate a projected 732 direct and secondary FTE jobs over the 1.5- to 2.5-year construction period, compared with 344 FTE jobs under Alternatives 1 and 2. Employment generated by construction of recreation facilities would be slightly less than employment generated under Alternatives 1 and 2 if all recreation facilities planned under Alternative 3 are constructed.

Income Effects

Regional income generated by recreation spending and construction, operation, and maintenance of water storage facilities would be greater under Alternative 3 than under Alternative 1, more than offsetting reduced agriculture-related income. Regional income associated with operation and maintenance of water storage and recreation facilities would total approximately $1.1 million more than under Alternative 1. Regional income generated by construction of water storage facilities under Alternative 3 would total approximately $16.1 million more than under Alternative 1 (Table 3K-6).

Because water storage would be increased under Alternative 3, revenue generated for DW by sales of project water would increase under this alternative. Based on an average annual discharge of 302 TAF of delivered water and water prices of $200-$250 per acre-foot, annual revenue from water sales would range from $60 million to $76 million, compared with $38 million to $47 million under Alternative 1.

Effects on Minority and Low-Income Populations

The effects of Alternative 3 on minority and low-income populations would be the same as the effects of Alternative 1, except that under Alternative 3, all four DW project islands would be used for water storage and there would be no opportunity for displaced farmworkers to be reemployed to assist with the production of habitat crops as under Alternatives 1 and 2.

Fiscal Effects

Under Alternative 3, higher project construction costs would generate a higher assessed value and increased property tax revenue for local agencies. Based on DW's estimated construction cost for this alternative, Alternative 3 would generate $3.6 million in property tax payments at buildout of all facilities, compared with a projected $1.9 million in property tax revenue under Alternative 1.

Public costs generated by Alternative 3 would likely be similar to those described for Alternative 1.

Indirect Effects

The potential indirect effects of Alternative 3 on adjacent landowners and other waterfowl clubs in the Delta region would be similar to those described for Alternative 1.

Under Alternative 3, DW would likely be required to mitigate habitat losses on project islands by leasing or purchasing offsite lands for habitat creation or protection. This offsite mitigation could result in the conversion of an unknown amount of agricultural land, resulting in additional agricultural economic effects.

Summary of Economic Effects of Alternative 3

Alternative 3 would have a beneficial effect on the regional economy at buildout of the project. Net employment and income benefits would be greater than those described for Alternative 1. As under Alternative 1, the conversion of lands currently farmed on the DW islands, and the potential conversion of offsite agricultural lands, would result in adverse effects on agriculture-related employment and income; however, project-related recreation expenditures and project construction, operation, and maintenance activities would generate a net increase in employment and income within the two-county region. The construction and operation of the project would also generate additional property tax revenue within Contra Costa and San Joaquin Counties.

ECONOMIC EFFECTS OF THE NO-PROJECT ALTERNATIVE

Employment and income impacts generated by intensified agricultural use of the project islands under the No-Project Alternative were evaluated based on the cropping patterns and agricultural production projections described in Chapter 3I, "Land Use and Agriculture". The methodology used to evaluate direct and secondary economic effects associated with agricultural use of the DW islands was similar to the methodology used to determine existing employment and income.

The methodology used to evaluate recreation-related employment and income changes under the No-Project Alternative was identical to the methodology used for the evaluation of Alternative 1. The recreational usage of the project islands would increase from existing levels because of the expansion of for-fee hunting (day use only) to the four islands (refer to Chapter 3J, "Recreation and Visual Resources").

The economic effects resulting from the intensified agricultural use of the project islands should be considered short-term effects because of erosion and subsidence problems associated with agricultural production on the islands described in Chapter 3I, "Land Use and Agriculture". Over the long term, continued agricultural use of the DW islands may be infeasible because of increased costs of soil management and levee maintenance. (No information is available concerning the length of time agriculture will remain physically and economically feasible on the project islands; however, intensified agricultural use of the islands will likely increase existing erosion and subsidence problems.)

Employment Effects

As described in Chapter 3I, "Land Use and Agriculture", implementation of the No-Project Alternative would result in more land being brought into production on all islands, generating increased production of vegetable crops on Bacon and Bouldin Islands and grain crops on Holland and Webb Tracts (Table 3K-7). The increased production would require additional labor inputs, which in turn would increase the total direct and secondary employment generated by agricultural use of the islands.

Agricultural production under the No-Project Alternative would generate a projected 828 direct and secondary jobs in San Joaquin and Contra Costa Counties, representing an almost 200% increase over existing island-related agricultural employment (Table 3K-8). Approximately 91% of total direct and secondary employment would be generated by the agricultural output of Bacon and Bouldin Islands.

Under the No-Project Alternative, recreational use of the project island by nonlocal recreationists would increase from an estimated existing 3,852 visitor days to a projected 13,455 visitor use-days (refer to Chapter 3J, “Recreation and Visual Resources”, for a description of recreational use effects), generating increased visitor expenditures within the region by a projected $372,300 (Table 3K-3). This increase in visitor expenditures would increase direct and secondary employment currently generated by the recreational use of the project islands from approximately four to 15 FTE jobs (Table 3K-4).

A projected 843 permanent direct and secondary jobs would be generated within the region under the No-Project Alternative (Table 3K-5). This projected employment level represents a net increase of 550 regional jobs over the estimated existing level of employment generated by use of the islands. The net increase in regional employment under the No-Project Alternative is considered a beneficial economic effect.

Income Effects

Under the No-Project Alternative, the value of the agricultural output generated by the islands and the resulting income would increase substantially over existing levels. The gross value of the agricultural output of the four islands would increase from an existing $11.6 million to a projected $31.1 million under the No-Project Alternative (Table 3K-7). The projected increase in production on Bouldin Island would account for a large percentage of the overall increase. The average gross value of Bouldin Island’s output would increase from an existing $1.9 million to a projected $13.4 million as production shifts from grain crops to vegetable crops.

The direct and secondary income generated within San Joaquin and Contra Costa Counties by the agricultural output of the four islands would increase from an existing $6.7 million to a projected $19.1 million under the No-Project Alternative (Table 3K-8). Production on Bacon and Bouldin Islands would generate approximately 91% of total income under this alternative.

Under the No-Project Alternative, the increase in recreational spending would lead to a slight increase in the regional income generated by the recreational use of the project islands. Direct and secondary income generated by the expenditures of visitors to the islands would increase from an estimated $68,000 to a projected $270,000 (Table 3K-4).

A projected $19.3 million in annual direct and secondary income would be generated under the No-Project Alternative (Table 3K-6). This projected income level represents a net increase of $12.6 million in regional income over the estimated existing level of income generated by use of the islands. The net increase in regional income under the No-Project Alternative is considered a beneficial economic effect.

Fiscal Effects

Property values on the DW islands may increase as improvements are made to drainage systems and more land is brought into production, resulting in higher property tax revenue. Based on the increased agricultural production under the intensified use of the islands, property tax revenue could increase from approximately $267,000 to $715,000 under the No-Project Alternative.

Sales tax revenue may also increase relative to existing levels because of increased purchases of agricultural goods and services in the local area. Road maintenance costs also may rise with increased road wear caused by the transportation of agricultural products to and from the DW islands.

Public costs for levee maintenance and emergency repair would continue at existing levels or would increase because of further subsidence under the No-Project Alternative. Also, federal commodity crop deficiency payments may increase if crops produced under this alternative qualify for price supports.

Implementation of the No-Project Alternative would likely hasten erosion and subsidence problems associated with agricultural use of the project islands. This may ultimately reduce the fiscal benefits of the No-Project Alternative as agricultural production declines and levee maintenance and repair costs increase.

CUMULATIVE ECONOMIC EFFECTS OF THE ALTERNATIVES

Effects on Agricultural Employment and Income

Implementation of any of the DW project alternatives (except the No-Project Alternative) would contribute to the regional conversion of agricultural land. The DW project alternatives, in conjunction with other projects that convert agricultural land to other uses, would reduce employment and income for farmworkers and agriculture-dependent industries within the region.

As discussed in Chapter 3I, "Land Use and Agriculture", several projects in the Delta could convert agricultural lands to nonagricultural uses in the Delta region. These projects include DWR's North Delta and West Delta Programs. In addition, agricultural land conversions could occur through the development of new recreational uses on Delta islands and through additional habitat restoration and water storage projects on Delta islands encouraged by the DW project. The cumulative amount of agricultural land ultimately converted by related projects is not known but is expected to be relatively large.

Similar to the DW project alternatives, these projects would likely generate some employment and income from recreational uses and from project construction, operation, and maintenance activities. Employment and income in agricultural sectors, however, would be reduced by these projects.

The cumulative loss of agricultural land would result in the loss of substantial direct and secondary agricultural employment and the loss of income generated by agricultural production; however, current public expenditures on commodity crop deficiency payments could decline. The cumulative loss of agricultural employment and income is considered an adverse economic effect resulting from the cumulative conversion of agricultural land.

Effects on Recreation-Related Employment and Income

As described in Chapter 3J, "Recreation and Visual Resources", a number of projects are being planned (mostly by public agencies) in the Delta that would involve management of wetland habitat. Many of these projects would presumably result in increased recreational opportunities for activities such as hunting, bird watching, and hiking. Although it is unknown whether hunting programs would be implemented on publicly acquired land in the Delta, regional hunter success on privately held land would be expected to increase as waterfowl are provided with better foraging in areas managed for wetland values.

Under all DW project alternatives, employment and income related to recreational use of the DW islands would increase. Enhanced recreational use of other private and public lands in the Delta would also lead to increased recreational spending in the region, generating increased regional employment and income. The cumulative effects on recreation generated by planned projects in conjunction with the DW project are expected to be beneficial because of the cumulative increase in recreational spending and related employment and income. The cumulative effects on recreation-related employment and income are therefore considered beneficial.

CITATIONS

References to the Code of Federal Regulations (CFR) are not included in this list. CFR citations in text refer to title and section (e.g., 40 CFR 1508.14 refers to Title 40 of the CFR, Section 1508.14).

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Table 3K-1. Estimated Average Gross Value of Crops Grown on the Delta Wetlands Islands

Crops	Bacon Island			Webb Tract			Bouldin Island			Holland Tract[a]			All Islands		
	Total Yield (tons)	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value
Wheat				852 tons	113	96,276	3,189 tons	113	360,357	1,670 tons	113	188,710	5,711 tons	113	645,343
Corn (field)	3,280	108	354,240	3,446 tons	108	372,168	11,366 tons	108	1,227,528	339 tons	108	36,612	18,431 tons	108	1,990,548
Sunflower	167	400	66,800				770 tons	400	308,000				937 tons	400	374,800
Asparagus (fresh)	1,565	1,288	2,015,720							603 tons	1,288	776,664	2,168 tons	1,288	2,792,384
Potato	22,290	198	4,413,420										22,290 tons	198	4,413,420
CommercialSeed	4,200	204	856,800										4,200 tons	204	856,800
Wine grape (crushed)	1,904	265	504,560										1,904 tons	265	504,560
Pasture				58 acres	96/acre	5,568	33 acres	96/acre	3,168	542 acres	96/acre	52,032	633 acres	96/acre	60,768
Total			8,211,540			474,012			1,899,053			1,054,018			11,638,623

[a] Crop yield and production value includes production from 1,120 acres excluded from the project under Alternatives 1 and 2.

Notes: Prices and production values are shown in 1993 dollars.

Estimated total yields based on acreage planted in 1987. Refer to Chapter 3I, “Land Use and Agriculture”.

Prices represent 5-year (1988-1992) averages for San Joaquin County modified by information provided by farmers on the islands (Forkel pers. comm.).

Table 3K-2. Estimated Existing (1988) Employment and Income Generated in San Joaquin and Contra Costa Counties by Agricultural Use of the Delta Wetlands Islands

	Multipliers[a]		Bacon Island						Bouldin Island			Holland Tract[b]			All Islands		
Crop	Income	Employment	Existing Value of Production ($1,000)	Income ($1,000)	Employment (FTE)	Existing Value of Production ($1,000)	Income ($1,000)	Employment (FTE)	Existing Value of Production ($1,000)	Income ($1,000)	Employment (FTE)	Existing Value of Production ($1,000)	Income ($1,000)	Employment (FTE)	Existing Value of Production ($1,000)	Income ($1,000)	Employment (FTE)
Crop																	
Wheat	0.4168	18.0				96.3	40.1	1.7	360.4	150.2	6.5	188.7	78.6	3.4	645.4	268.9	11.6
Corn	0.3983	17.1	354.2	141.1	6.1	372.2	148.2	6.4	1,227.5	488.9	21.0	36.6	14.6	0.6	1,990.5	792.8	34.1
Sunflower	0.4655	19.9	66.8	31.1	1.3				308.0	143.4	6.1				374.8	174.5	7.4
Asparagus	0.6353	27.6	2,015.7	1,280.6	55.6							776.7	493.4	21.4	2,792.4	1,774.0	77.0
Potato	0.6353	27.6	5,270.2	3,348.2	145.5										5,270.2	3,348.2	145.5
Wine grape	0.5936	25.6	504.6	299.5	12.9										504.6	299.5	12.9
Pasture	0.4655	19.9	___	___	___	5.5	2.6	0.1	3.2	1.5	0.1	52.0	24.2	1.0	60.8	28.3	1.2
Totals			8,211.5	5,100.5	221.4	474.0	190.9	8.2	1,899.1	784.0	33.7	1,054.0	610.8	26.4	11,638.7	6,686.2	289.7

Notes: Income and production values are shown in 1993 dollars.

Refer to Table 3K-1 for estimated average gross value of crops.

FTE = full-time equivalent.

[a] Income multipliers represent the direct, indirect, and induced change in income resulting from each additional dollar of output delivered to final demand. Income includes employee compensation and proprietors' earnings, minus proprietor contributions to welfare and pension funds. Employment multipliers represent the direct, indirect, and induced change in the number of FTE jobs generated by each additional $1 million of output delivered to final demand. (U.S. Bureau of Economic Analysis 1987.)

[b] Includes estimated production value, employment, and income generated by production of 1,120 acres excluded from the project under Alternatives 1 and 2.

Table 3K-3. Predicted Expenditures in San Joaquin and Contra Costa Counties by Recreationists Visiting the Delta Wetlands Project Islands

Project Alternative	Nonlocal Visitors to Site (visitor days per year)[a]	Visitor Expenditures ($)						Total Spending by Island
		Eating and Drinking Places		Lodging Places		Retail Establishments		
		Spending per Day[b]	Total Spending	Spending per Day[b]	Total Spending	Spending per Day[b]	Total Spending	
Existing Conditions (1988)								
Bacon Island	2,576	$7.99	$20,582	$5.32	$13,704	$17.74	$45,698	$79,984
Webb Tract	584	7.99	4,666	5.32	3,107	17.74	10,360	18,133
Bouldin Island	456	7.99	3,643	5.32	2,426	17.74	8,089	14,158
Holland Tract	236	7.99	1,886	5.32	1,256	17.74	4,187	7,329
Total	3,852		30,777		20,493		68,334	119,604
Alternative 1								
Bacon Island	34,326	5.84	200,464	0.00	0	18.94	650,134	850,598
Webb Tract	34,383	5.84	200,797	0.00	0	18.94	651,214	852,011
Bouldin Island	35,329	5.84	206,321	0.00	0	18.94	669,131	875,452
Holland Tract	20,381	5.84	119,025	0.00	0	18.94	386,016	505,041
Total	124,419		726,607		0		2,356,495	3,083,102
Alternative 2								
Bacon Island	34,353	5.84	200,622	0.00	0	18.94	650,646	851,268
Webb Tract	34,406	5.84	200,931	0.00	0	18.94	651,650	852,581
Bouldin Island	35,329	5.84	206,321	0.00	0	18.94	669,131	875,452
Holland Tract	20,381	5.84	119,025	0.00	0	18.94	386,016	505,041
Total	124,469		726,899		0		2,357,443	3,084,342
Alternative 3								
Bacon Island	34,351	5.84	200,610	0.00	0	18.94	650,608	851,218
Webb Tract	34,410	5.84	200,954	0.00	0	18.94	651,725	852,679
Bouldin Island	31,918	5.84	186,401	0.00	0	18.94	604,527	790,928
Holland Tract	24,993	5.84	145,959	0.00	0	18.94	473,367	619,326
Total	125,672		733,924		0		2,380,227	3,114,151
No-Project Alternative								
Bacon Island	5,219	10.77	56,209	3.15	16,440	22.64	118,158	190,807
Webb Tract	2,769	10.77	29,822	3.15	8,722	22.64	62,690	101,234
Bouldin Island	3,234	10.77	34,830	3.15	10,187	22.64	73,218	118,235
Holland Tract	2,233	10.77	24,049	3.15	7,034	22.64	50,555	81,638
Total	13,455		144,910		42,383		304,621	491,914

Table 3K-3. Continued

Notes: Expenditures are in 1993 dollars.

[a] See Table 3J-8. Excludes the visitor days of residents of the two-county area (20% of total recreation user days) for all alternatives and existing conditions. Local recreationists visit and spend in the local area, but these expenditures do not result in changes in final demand for services in the two-county area. Recreation user days include days spent hunting, boating, and participating in other recreation activities.

[b] Spending-per-day estimates are based on studies of daily spending by recreationists in California (USFWS and U.S. Bureau of the Census 1993) and nationwide (Propst et al. 1992), updated to 1993 dollars and revised for application to the industrial classes in this table. These spending estimates represent average expenditures per visitor day. Because not all recreationists would use lodging places during a trip, the estimated average daily expenditures for lodging represent only a portion of the daily cost of a lodging place and therefore are lower than may be expected. Visitors to the DW project islands are assumed to use onsite lodging facilities under Alternatives 1, 2, and 3.

Table 3K-4. Projected Income and Employment Generated in San Joaquin and Contra Costa Counties by Recreational Use of the Islands under the Delta Wetlands Project Alternatives

	Multipliers[a]		Bacon Island			Webb Tract			Bouldin Island			Holland Tract			All Islands		
Expenditure Type	Income	Employment	Projected Spending ($1,000)[b]	Income ($1,000)	Employment (FTE)	Projected Spending ($1,000)[b]	Income ($1,000)	Employment (FTE)	Projected Spending ($1,000)[b]	Income ($1,000)	Employment (FTE)	Projected Spending ($1,000)[b]	Income ($1,000)	Employment (FTE)	Projected Spending ($1,000)[b]	Income ($1,000)	Employment (FTE)
Existing Conditions (1988)																	
Eating and drinking places	0.4526	35.1	20.6	9.3	0.7	4.7	2.1	0.2	3.6	1.6	0.1	1.9	0.9	0.1	30.8	13.9	1.1
Lodging	0.5000	37.7	13.7	6.9	0.5	3.1	1.6	0.1	2.4	1.2	0.1	1.2	0.6	0.1	20.4	10.3	0.8
Retail purchases	0.6427	28.0	45.7	29.4	1.3	10.4	6.7	0.3	8.1	5.2	0.2	4.2	2.7	0.1	68.4	44.0	1.9
Total			80.0	45.6	2.5	18.2	10.4	0.6	14.1	8.0	0.4	7.3	4.2	0.3	119.6	68.2	3.8
Alternative 1																	
Eating and drinking places	0.4526	35.1	200.5	90.7	7.0	200.8	90.9	7.0	206.3	93.4	7.2	119.0	53.9	4.2	726.6	328.9	25.4
Lodging	0.5000	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retail purchases	0.6427	28.0	650.1	417.8	18.2	651.2	418.5	18.2	669.1	430.0	18.7	386.0	248.1	10.8	2,356.4	1,514.4	65.9
Total			850.6	508.5	25.2	852.0	509.4	25.2	875.4	523.4	25.9	505.0	302.0	15.0	3,083.0	1,843.3	91.3
Alternative 2																	
Eating and drinking places	0.4526	35.1	200.6	90.8	7.0	200.9	90.9	7.1	206.3	93.4	7.2	119.0	53.9	4.2	726.8	329.0	25.5
Lodging	0.5000	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retail purchases	0.6427	28.0	650.7	418.2	18.2	651.7	418.8	18.2	669.1	430.0	18.7	386.0	248.1	10.8	2,357.5	1,515.1	65.9
Total			851.3	509.0	25.2	852.6	509.7	25.3	875.4	523.4	25.9	505.0	302.0	15.0	3,084.3	1,844.1	91.4
Alternative 3																	
Eating and drinking places	0.4526	35.1	200.6	90.8	7.0	200.9	90.9	7.1	186.4	84.4	6.5	145.9	66.0	5.1	733.8	332.1	25.7
Lodging	0.5000	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retail purchases	0.6427	28.0	650.6	418.1	18.2	651.7	418.8	18.2	604.5	388.5	16.9	473.4	304.3	13.3	2,380.2	1,529.7	66.6
Total			851.2	508.9	25.2	852.6	509.7	25.3	790.9	472.9	23.4	619.3	370.3	18.4	3,114.0	1,861.8	92.3
No-Project Alternative																	
Eating and drinking places	0.4526	35.1	56.2	25.4	2.0	29.8	13.5	1.0	34.8	15.7	1.2	24.0	10.9	0.8	144.8	65.5	5.0
Lodging	0.5000	37.7	16.4	1.6	0.6	8.7	4.4	0.3	10.2	1.7	0.4	7.0	1.2	0.3	42.3	8.9	1.6
Retail purchases	0.6427	28.0	118.2	76.0	3.3	62.7	40.3	1.8	73.2	47.0	2.0	50.6	32.5	1.4	304.7	195.8	8.5
Total			190.8	103.0	5.9	101.2	58.2	3.1	118.2	64.4	3.6	81.6	44.6	2.5	491.8	270.2	15.1

Note: Income and spending are shown in 1993 dollars.

FTE = full-time equivalent.

[a] Income multipliers represent the direct, indirect, and induced change in income resulting from each additional dollar of output delivered to final demand (net spending). Income includes employee compensation and proprietors' earnings, minus proprietor contributions to welfare and pension funds. Employment multipliers represent the direct, indirect, and induced change in the number of FTE jobs generated by each additional $1 million of output delivered to final demand (net spending).

[b] Represents spending by nonlocal visitors to the islands. See Table 3K-3.

Table 3K-5. Comparison of Employment Estimated to Be Generated under the Delta Wetlands Project Alternatives (FTE)

	1988 Existing Conditions					Alternatives 1 and 2[a]					Alternative 3[a]					No-Project Alternative				
Employment Generator	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands
Annual Employment																				
Agriculture	221	8	34	26	289	0	0	0	9	9	0	0	0	0	0	368	33	391	36	828
Recreation	3	1	0	0	4	25	25	26	15	91	25	25	24	18	92	6	3	4	2	15
Operations and maintenance[b]	0	0	0	0	0	95	89	63	68	315	95	89	80	87	351	0	0	0	0	0
Total annual employment	224	9	34	26	293	120	114	89	92	415	120	114	104	105	443	374	36	395	38	843
Temporary Employment																				
Water project construction[c]	0	0	0	0	0	134	121	74	15	344	134	121	368	109	732	0	0	0	0	0
Recreation facilities construction[d]	0	0	0	0	0	10	10	10	7	37	10	8	8	10	36	0	0	0	0	0

Notes: Employment figures represent the number of annual FTE direct and secondary jobs generated within San Joaquin and Contra Costa Counties. Estimates and projections are based on employment multipliers from the Regional Input-Output Modeling System (U.S. Bureau of Economic Analysis 1987).

[a] Agricultural employment includes estimated employment generated by production of 1,120 acres on Holland Tract excluded from the project under Alternatives 1 and 2, but included in the project under Alternative 3.

[b] Represents direct and secondary employment generated by the operation and maintenance of water and recreation facilities. These employment estimates represent the number of FTE direct and secondary jobs generated by operation and maintenance of facilities located on the DW project islands; these employment totals do not necessarily represent the number of persons who would actually be hired to work on the islands and within the region.

[c] Represents direct and secondary FTE employment generated per year by construction of water project facilities. Employment generated by the construction of water facilities is expected to last 1.5 years (2.5 years for construction of facilities on Bouldin Island under Alternative 3).

[d] Represents direct and secondary FTE employment generated per year by construction of recreation facilities. Employment generated by construction of recreation facilities is expected to last 20 years.

Table 3K-6. Comparison of Income Estimated to Be Generated under the Delta Wetlands Project Alternatives ($1,000)

	1988 Existing Conditions					Alternatives 1 and 2[a]					Alternative 3[a]					No-Project Alternative				
Employment Generator	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands	Bacon Island	Webb Tract	Bouldin Island	Holland Tract	All Islands
Annual Income																				
Agriculture	5,100.5	190.9	784.0	610.8	6,686.2	0.0	0.0	0.0	217.6	217.6	0.0	0.0	0.0	0.0	0.0	8,475.3	769.4	9,010.3	838.7	19,093.7
Recreation	45.6	10.4	8.0	4.2	68.2	508.5	509.4	523.4	302.0	1,843.3	508.9	509.7	472.9	370.3	1,861.8	103.0	58.2	64.4	44.6	270.2
Operations and maintenance[b]	0.0	0.0	0.0	0.0	0.0	3,446.8	3,229.1	2,285.8	2,467.2	11,428.9	3,446.8	3,229.1	2,902.6	3,156.5	12,735.0	0.0	0.0	0.0	0.0	0.0
Total annual income	5,146.1	201.3	792.0	615.0	6,754.4	3,955.3	3,738.5	2,809.2	2,986.8	13,489.8	3,955.7	3,738.8	3,375.5	3,526.8	14,596.8	8,578.3	827.6	9,074.7	883.3	19,363.9
Temporary Income																				
Water project construction[c]	0.0	0.0	0.0	0.0	0.0	5,549.9	5,011.5	3,064.9	621.2	14,247.5	5,549.9	5,011.5	15,241.5	4,514.4	30,317.3	0.0	0.0	0.0	0.0	0.0
Recreation facilities construction[d]	0.0	0.0	0.0	0.0	0.0	414.2	414.2	414.2	289.9	1,532.5	414.2	331.3	331.3	414.2	1,491.0	0.0	0.0	0.0	0.0	0.0

Notes: Income is shown in thousands of 1993 dollars.

Income figures represent the annual direct and secondary income generated within San Joaquin and Contra Costa Counties.

Estimates and projections are based on income multipliers from the Regional Input-Output Modeling System (U.S. Bureau of Economic Analysis 1987).

[a] Income generated by recreation would be slightly higher under Alternative 2 than under Alternative 1. Agricultural income includes estimated income generated by production of 1,120 acres on Holland Tract excluded from the project under Alternatives 1 and 2, but included in the project under Alternative 3.

[b] Represents direct and secondary income generated by the operation and maintenance of water and recreation facilities.

[c] Represents direct and secondary income generated per year during the construction of water project facilities. Construction of water facilities is expected to require 1.5 years (2.5 years for construction of facilities on Bouldin Island under Alternative 3).

[d] Represents direct and secondary income generated per year during the construction of recreation facilities. Construction of all recreation facilities is expected to last 20 years.

Table 3K-7. Projected Average Gross Value of Crops Grown on the Delta Wetlands Islands under the No-Project Alternative

	Bacon Island			Webb Tract			Bouldin Island			Holland Tract			All Islands		
Crop	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value	Total Yield	Price per Unit	Total Gross Value
Wheat				4,368 tons	113	493,584				3,948 tons	113	446,124	8,316 tons	113	939,708
Corn (field)				13,040 tons	108	1,408,320				3,200 tons	108	345,600	16,240 tons	108	1,753,920
Onion	14,400 tons	182	2,620,800				15,120 tons	182	2,751,840				29,520 tons	182	5,372,640
Asparagus (fresh)	2,475 tons	1,288	3,187,800				2,595 tons	1,288	3,342,360	600 tons	1,288	772,800	5,670 tons	1,288	7,302,960
Potato															
Commercial	31,350 tons	198	6,207,300				38,400 tons	198	7,603,200				69,750 tons	198	13,810,500
Seed	4,200 tons	204	856,800										4,200 tons	204	856,800
Wine grape (crushed)	1,890 tons	265	500,850				1,960 tons	265	519,400	3,710 tons			7,560 tons	135	1,020,250
Pasture				60 acres	$96/acre	5,760				540 acres	$96/acre	51,840	600 acres	$96/acre	57,600
Total			13,373,550			1,907,664			14,216,800			1,616,364			31,114,378

Notes: Gross values are shown in 1993 dollars.

Projected total yields are based on assumptions for cropping under intensified agriculture under the No-Project Alternative. Refer to Chapter 3I, “Land Use and Agriculture”.

Prices represent 5-year (1988-1992) averages for San Joaquin County, modified by information provided by farmers on the DW islands (Forkel pers. comm.).

Table 3K-8. Projected Income and Employment Generated in San Joaquin and Contra Costa Counties by Agricultural Use of the Delta Wetlands Islands under the No-Project Alternative

	Multipliers[a]		Bacon Island			Webb Tract			Bouldin Island			Holland Tract			All Islands		
Crops	Income	Employment	Projected Value of Production	Income ($1,000)	Employment (FTE)	Projected Value of Production	Income ($1,000)	Employment (FTE)	Projected Value of Production	Income ($1,000)	Employment (FTE)	Projected Value of Production	Income ($1,000)	Employment (FTE)	Projected Value of Production	Income ($1,000)	Employment (FTE)
Wheat	$0.4168	18.0				$493.6	$205.7	8.9				$446.1	$185.9	8.0	$939.7	$391.7	16.9
Corn	0.3983	17.1				1,408.3	560.9	24.1				345.6	137.7	5.9	1,753.9	698.6	30.0
Onions	0.6353	27.6	$2,620.8	$1,665.0	72.3				$2,751.8	$1,748.2	75.9				5,372.6	3,413.2	148.3
Asparagus	0.6353	27.6	3,187.8	2,025.2	88.0				3,342.4	2,123.4	92.3	772.8	491.0	21.3	7,303.0	4,639.6	201.6
Potatoes	0.6353	27.6	7,064.1	4,487.8	195.0				7,603.2	4,830.3	209.8				14,667.3	9,318.1	404.8
Wine grapes	0.5936	25.6	500.8	297.3	12.8				519.4	308.3	13.3				1,020.2	605.6	26.1
Pasture	0.4655	19.9				5.8	2.7	0.1				51.8	24.1	1.0	57.6	26.8	1.1
Total			$13,373.5	$8,475.3	368.1	$1,907.7	$769.4	33.1	$14,216.8	$9,010.3	391.3	$1,616.3	$838.7	36.3	$31,114.3	$19,093.6	828.8

Notes: Income and production values are shown in 1993 dollars.

FTE = full-time equivalent.

[a] Income multipliers represent the direct, indirect, and induced change in income resulting from each additional dollar of output delivered to final demand. Income includes employee compensation and proprietors' earnings, minus proprietor contributions to welfare and pension funds. Employment multipliers represent the direct, indirect, and induced change in the number of FTE generated by each additional $1 million of output delivered to final demand. (U.S. Bureau of Economic Analysis 1987.)

[b] Refer to Table 3K-7 for projected average gross value of crops.

Chapter 3L. Affected Environment and Environmental Consequences - Traffic and Navigation

Chapter 3L. Affected Environment and Environmental Consequences - Traffic and Navigation

SUMMARY

This chapter assesses the impacts of the DW project alternatives on traffic congestion, traffic circulation and access, and safety on roads and waterways in the project area during construction and operation of the DW project alternatives. Impacts of the DW project alternatives on the physical roadway structure are assessed in Chapter 3E, "Utilities and Highways".

As described in Chapter 2, "Delta Wetlands Project Alternatives", DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. However, it is anticipated that DW would subsequently apply for CWA and Rivers and Harbors Act permits for some or all of these recreation facilities. The analysis of impacts on traffic and navigation assumes that the recreation facilities would be constructed and operated. The information in this chapter provides readers with a complete record of the environmental analysis; it may be used in subsequent environmental assessment of the recreation facilities.

Implementation of Alternative 1, 2, or 3 would result in significant and unavoidable impacts on vehicle and boat traffic and congestion during project operation. The primary source of vehicle and boat traffic during project operation would be summer recreation use of the DW project facilities. Reducing the number of new boat slips associated with the Delta Wetlands recreation facilities would reduce vehicle and boat traffic generated by the project, but not to a less-than-significant level. Increased boat-traffic congestion would contribute to waterway safety problems in Delta channels. Clear posting of waterway intersections, speed zones, and potential boating hazard areas, as well as enforcement of boating regulations, would reduce potential safety problems near proposed recreation facilities to a less-than-significant level.

Project construction under Alternative 1, 2, or 3 could also result in the creation of significant safety conflicts on Delta roadways and waterways. The addition of construction vehicles to roadway traffic and the use of large barges in Delta waterways would affect vehicle and boat safety. Clearly marking roadway intersections with poor visibility in the DW project vicinity, marking and lighting barges at the DW project islands, and notifying the U.S. Coast Guard of construction activities would mitigate these construction-related impacts to less-than-significant levels.

Reducing agricultural vehicle traffic on Delta roadways during DW project operation would reduce safety conflicts between agricultural vehicles and other traffic. This is considered a beneficial impact of Alternatives 1, 2, and 3. Additionally, implementation of Alternative 1, 2, or 3 would result in less-than-significant impacts on peak-hour traffic and circulation during project construction and on waterway navigation conditions during project operations.

In combination with future traffic increases from other sources, the increase in traffic generated by Alternative 1, 2, or 3 would contribute to a significant cumulative impact on traffic congestion on Delta roadways. Implementing Caltrans' route concepts for SR 4 and SR 12 would reduce this impact to a less-than-significant level. Increased safety problems on Delta waterways as a result of increasing recreation use, combined with recent funding cutbacks for marine patrol services in the Delta, would constitute a significant and unavoidable cumulative impact.

Under the No-Project Alternative, peak-hour traffic volumes would slightly increase because of increased agricultural production. Agricultural vehicle traffic on Delta roadways would also increase, creating potential safety

conflicts on roads in the DW project vicinity. Clearly marking intersections with poor visibility in the vicinity of agricultural operations would not be required, but could reduce this effect. Circulation on Delta roadways could be decreased by the addition of more slow-moving agricultural vehicles. Restricting agricultural vehicles from using Delta highways during peak hours would reduce this effect of the No-Project Alternative, but implementation of this measure would not be required.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

This chapter has been revised to include updated information about existing conditions in the Delta, including:

- use of the ferry serving Webb Tract and funding sources for the Delta Ferry Authority,
- commercial and transit purposes of Delta waterways, and
- fog conditions on Delta roads and channels.

The impact analysis has been revised to include an analysis of traffic volumes for Jersey Island Road, the approach road to the Webb Tract Ferry.

Mitigation measures for project effects on roadway and waterway traffic and safety have been revised in response to recommendations made by the local counties, the California Department of Boating and Waterways, and the California Department of Transportation (Caltrans). Lastly, in an effort to reduce roadway and waterway traffic associated with increased recreational boating use in the Delta attributable to the proposed project, the EIR/EIS lead agencies and the project proponent developed a new mitigation measure for the final environmental document that requires DW to reduce the total number of outward (channel-side) boat slips proposed on the DW islands by 50%.

AFFECTED ENVIRONMENT

This section describes the existing roadway and waterway system and traffic conditions on and in the vicinity of the DW project islands. Information on the roadway system and traffic conditions is based, in part, on information collected for the 1990 draft EIR/EIS. Where conditions have not changed, this information has been used to describe current conditions. The description of the roadway and waterway system and traffic conditions has been updated, however, to reflect changes in traffic access.

Sources of Information

Information on the current traffic environment in the DW project vicinity was compiled from various sources. The main source of information used for roadway traffic is Caltrans. Information on waterway traffic and safety comes from data, reports, and conversations with the California Department of Boating and Waterways, the State Lands Commission, San Francisco Estuary Project, SWRCB, the Delta Protection Commission, and Delta marina operators.

Existing Roadway System

The Delta is served by a network of county roads, private roads, and state highways. SR 12, Interstate 5 (I-5), SR 4, and SR 160 serve the project vicinity. In addition, ferries provide transportation between islands that do not have bridges. Transportation facilities in the DW project area are described below and are shown in Figure 3L-1.

Bacon Island

Bacon Island Road, the only public road to Bacon Island, provides access from SR 4 to Bacon Island from the east. As it approaches Bacon Island, Bacon Island

Road is a narrow, two-lane, east-west road with no shoulder and speeds posted at 15-30 miles per hour (mph) at sharp turns. Access to Bacon Island via Bacon Island Road is provided by the Bacon Island bridge over Middle River. At the time that the 1995 DEIR/EIS was prepared, the bridge was a one-lane facility with signals on the east and west approaches and carried very little traffic. San Joaquin County obtained funding and necessary approvals to construct a new Bacon Island bridge; construction began in April 1994 and has been completed (Vidad pers. comm.).

On Bacon Island, Bacon Island Road is a narrow, winding, north-south levee road with a posted speed limit of 25 mph. Bacon Island Road provides access to the Bullfrog Landing Marina and agricultural properties on the island. The public portion of Bacon Island Road ends at the north end of Bacon Island at a bridge to Mandeville Island. Beyond the bridge, a private dirt/gravel road extends to the western edge of Bacon Island.

SR 4 provides access between Bacon Island Road, Stockton, and the Sierra Nevada foothills to the east, and Brentwood and Antioch to the west. SR 4 is a two-lane, east-west highway with wide shoulders and a two-way left-turn lane east of the San Joaquin River but without a two-way left-turn lane across most of the Delta. SR 4 is a levee-top road at its intersection with Bacon Island Road.

Webb Tract

There are no roads providing access to Webb Tract; the Jersey-Bradford-Webb ferry, operated by the Delta Ferry Authority, provides ferry service to Webb Tract and Bradford Island from Jersey Island. Jersey Island Road provides access to the ferry on Jersey Island. Jersey Island Road is mostly unpaved and winds along the levee with scarcely enough room for two vehicles to pass in some areas.

The Delta Ferry Authority operates the Jersey-Bradford-Webb ferry each hour from 8:00 a.m. to 5:00 p.m., Monday through Friday during fall, winter, and spring, and Friday through Tuesday during summer. During fiscal year 1998-1999, the total number of passengers using the ferry was 21,938 (California Office of the Controller 2000). Based on this figure, average use for that year is estimated to have been approximately 85 passenger trips per day. The ferry system is funded through the Delta Ferry Authority. The Delta Ferry Authority is composed of Contra Costa County, Webb Tract Reclamation District, and Bradford Reclamation District. Each reclamation district provides approxi-mately $50,000 per year in funding for the ferry service (Heringer pers. comm.), while Contra Costa County collects approximately $15,000 per year in local funds to support the ferry service (Cutler pers. comm.) The Delta ferry authority collects these monies to fund operation of the ferry.

Although there are no roads providing access to Webb Tract, private interior roads exist on Webb Tract to provide a way for vehicles to circulate once they are on the island.

Bouldin Island

SR 12 crosses the north side of Bouldin Island from east to west, providing access to Fairfield and Napa to the west and extending to Lodi and the foothills to the east. On the island, SR 12 is a narrow-shouldered, two-lane highway across the island bottom, at 10-15 feet below water level in the exterior channels. In addition to SR 12, several narrow private interior roads provide access to agricultural operations on the island.

At the east end of Bouldin Island, SR 12 crosses Little Potato Slough on a two-lane swing bridge that has an approximately 35-foot clearance for boats. The speed limit is 55 mph on this segment of SR 12 (Simon pers. comm.). Access to the private dirt levee roads on Bouldin Island north and south of SR 12 is available approximately 0.25 mile west of the bridge. At the west end of the island, SR 12 crosses the Mokelumne River on a swing bridge.

Holland Tract

Just north of the town of Brentwood in Contra Costa County, the east-west Delta Road turns north; crosses Rock Slough on a narrow, one-lane wooden bridge; and becomes Holland Tract Road. Holland Tract Road is a narrow, two-lane levee road that enters the southwest corner of Holland Tract. Since 1991, access northward on the west levee has been blocked by a locked gate. To the east, the county road runs along the southern levee to the Holland Tract Marina, located at the southeast corner of the island. At the marina, the county road ends at a locked gate. In 1993, the Contra Costa County Department of Public Works abandoned responsibility for those sections of Holland Tract Road along the east and west perimeter levees beyond the locked gates; these are now private roads (Figure 3L-1). The posted speed limit is 35 mph on the public access portion of Holland Tract Road on the southern perimeter levee and is 25 mph at the marina. Additionally, private interior roads provide access to agricultural operations on the island.

Existing Traffic Conditions

Traffic level of service (LOS) was evaluated along four two-lane highway segments in the DW project vicinity. Three of these segments are on SR 4 and one is on SR 12. These roadway segments were chosen for evaluation because they are located at the major access points to each island.

LOS criteria for two-lane highways address mobility and accessibility concerns. The primary measures of LOS are amount of delay, speed, and capacity utilization. Two-lane highway capacities vary depending on terrain and the degree of passing restrictions. The LOS ranges for two-lane highways, shown in Table 3L-1, are given in terms of a constant ideal capacity of 2,800 total passenger cars per hour.

Existing traffic volumes (Table 3L-2) and LOS ranges (Table 3L-1) were used to determine existing LOS on these project vicinity roadways (Table 3L-3). The roadway segments evaluated are on flat terrain and have no-passing zones on 20% of the roadway lengths, as determined during field observations. SR 12 on Bouldin Island currently operates at LOS D, indicating some delay in traffic operations. Narrow shoulders, passing restrictions, and heavy truck traffic (14%) all contribute to the LOS on SR 12. SR 4 in the project vicinity operates in the LOS C-D range. Caltrans considers LOS D, E, and F to be unacceptable. Therefore, existing LOS is acceptable on SR 4 east of Tracy Boulevard and is unacceptable on all other roadway segments analyzed.

Waterway Traffic and Safety

Boat-related recreational activity in the Delta has increased over recent years. The number of registered boats in California is approximately 841,300 (California Department of Motor Vehicles 1995). Of these, approximately 38,330, or 4.6%, are registered in Contra Costa County, and 22,780, or 2.7%, are registered in San Joaquin County. The Delta supports approximately 140 commercial and public recreation facilities (see Figure 3J-1 in Chapter 3J, "Recreation and Visual Resources"). There are more than 80 public and private marinas in Contra Costa and San Joaquin Counties. Because of population growth in the Sacramento and Stockton areas and the Bay Area, the number of recreational boat users has grown considerably. Boating is the primary recreational activity in the Delta and makes up approximately 17% of the Delta's total recreational use (see Chapter 3J, "Recreation and Visual Resources"). Boating traffic in the Delta also includes commercial, residential, and emergency service traffic. Fisherman's Cut and False River, for example, are used to transport large barges, tugs, cranes, and other types of equipment. Bradford Island residents use the channels as a "freeway" to commute to work and to shopping locations. Police and fire services also use the waterways for emergency response to various locations in the Delta.

Boat traffic congestion is found along Delta waterways and is often found at and around launch ramps and boat berthing areas. The California Department of Boating and Waterways requires that boats traveling within 200 yards upstream or downstream of boat docks maintain speeds of less than 5 mph. Restricted speeds, combined with boats moving into and out of waterways, create boat congestion on days of heavy recreational use (e.g., summer and holiday weekends).

A study of boating safety in the Delta shows that most safety problems on waterways are a result of:

- boaters having limited knowledge and experience,
- boats traveling at excessive speeds that create large wakes, and
- a lack of uniformity existing in signs regulating boat speeds and other boater information.

Boaters and enforcement agencies also agree that obscured visibility at intersecting waterways and the operation of vessels by boaters under the influence of alcohol and/or drugs contribute to unsafe waterway conditions and boating accidents. In 1993, 743 boating accidents occurred on California waterways. Of these, 36 and 34 boating accidents occurred in Contra Costa County and San Joaquin County, respectively. Figure 3L-2 shows the locations of accidents reported in the Delta between 1981 and 1985. (California Department of Boating and Waterways 1986.)

Fog is common during the winter months throughout the Delta. Fog may sometimes settle low on bodies of water (i.e., Delta channels) when there is little or no wind, creating a dense fog condition in that localized area. Marine navigation in the Delta can be difficult during periods of dense fog. However, according to the U.S. Coast Guard, the level of boating activity and the need for search and rescue efforts during the winter months is relatively low compared with the need in summer months (Undieme pers. comm.). Boaters who use the Delta in the winter are generally experienced in boating, carry navigational equipment, and are familiar with marine navigation in foggy weather (Undieme pers. comm.).

Air Traffic from Bouldin Island

A small private airstrip is located on the east side of Bouldin Island, south of SR 12, and runs generally east-west. The airstrip is currently used for agricultural activities on Bouldin Island, Holland Tract, and Webb Tract. The airstrip is currently used primarily for aerial application of wheat and corn seed, urea fertilizer, and herbicides. Some aerial observation flights are also made from the airstrip. Most of the agricultural flights are made from mid-November through mid-March. However, corn herbicide is applied in late spring or early summer, so a few flights are made during that time. Approximately 750 landings and takeoffs (a landing and a takeoff in combination are counted as one) occur annually from the airstrip, with more than 80% of those flights occurring during the period of mid-November to mid-March.

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

In this analysis, impacts on roadway traffic and waterway traffic were assessed. As described above, DW has removed construction of recreation facilities from its CWA permit applications, and USACE will not include the construction of such facilities in permits issued for the project at this time. Nevertheless, the analysis of impacts on roadway traffic and waterway traffic assumes that the recreation facilities would be constructed and operated. The methods and assumptions used in this analysis are described below.

Roadway Traffic

Impacts related to congestion, circulation, and access were analyzed for this chapter; they are the major indicators of traffic conditions in a given area. Safety impacts were also analyzed because of the potentially dangerous conditions associated with the addition of large construction or agricultural vehicles to semirural roadways.

There are two periods of impact assessed in this chapter: construction, which is temporary, and operation, which is long term. In both cases, impacts were analyzed through comparison between LOS for each DW project alternative and future (2010) without-project LOS. It should be noted that the No-Project Alternative includes intensified agricultural activities and is not the same as future without-project conditions. Future without-project conditions represent traffic levels that would exist in 2010 if the DW project were not implemented and the intensified agricultural activities associated with the No-Project Alternative did not occur. Future without-project conditions are used as a basis for comparison in order to determine the increment of change directly related to implementation of the DW project. If, for example, traffic levels related to an earlier year were used for comparison, it would not be possible to determine which portions of estimated changes in traffic levels under a DW project alternative were attributable to the DW project and which were attributable to other unrelated activities.

Construction Impacts. Construction impacts consist of impacts related to traffic congestion, safety, circulation, and access occurring during the estimated 1.5-year project construction period (the construction period is assumed to be approximately 2.5 years long under Alternative 3 on Bouldin Island). The construction period may be longer than 1.5 calendar years (see Chapter 3D, "Flood Control"), but the shorter period is assumed in the traffic analysis to represent total construction days and to estimate a worst-case traffic scenario in which all construction traffic would occur in a short time frame. Although existing farming activities would gradually be phased out over the period of construction, under the worst-case scenario, it is assumed that some of the existing farming activities would still be conducted throughout the construction period. Because construction-related impacts would occur only during the period of construction, they are considered short-term impacts. Construction-related congestion impacts were analyzed through comparison between LOS for the period of DW project construction and future without-project LOS. Construction-related safety, circulation, and access impacts were analyzed qualitatively.

Operation Impacts. Operation-related impacts consist of impacts on traffic congestion, safety, and circulation during the life of the DW project (access to the DW project islands is expected to be a potential issue only during construction). Congestion was analyzed through comparison between LOS during operation of the DW project and future without-project LOS. Operation-related safety and circulation impacts were analyzed qualitatively.

Future without-project LOS was determined in two different ways. For the segment of SR 12 west of Terminous and the segment of SR 4 east of Tracy Boulevard, LOS was supplied by Caltrans (Chalk pers. comm.). For all other roadway segments, LOS was calculated using future without-project volumes and an assumed capacity of 2,800 cars per hour to determine the volume-to-capacity (V/C) ratio (Transportation Research Board 1985). For Jersey Island Road, LOS was calculated using an assumed capacity of 500 cars per hour to determine the V/C ratio. The V/C ratio is defined as the ratio of the volume of cars traveling on a roadway to the maximum capacity of that roadway. Table 3L-1 was then used to determine LOS based on the calculated V/C ratio. It was assumed that roadways analyzed are on flat terrain and that no passing is allowed on 20% of the length of the roadways.

LOS under the DW project was calculated the same way that future without-project LOS was calculated. However, the volumes used were the totals of the future-year without-project volumes supplied by Caltrans plus the number of trips that would be generated by the DW project alternatives.

Trip Generation and Distribution. Trips generated by the DW project alternatives are shown in Table 3L-4. Sources of traffic under existing conditions and the No-Project Alternative are recreationists and agricultural operations. Sources of traffic under Alternatives 1, 2, and 3 are recreationists, agricultural operations, and project maintenance activities. Vehicle travel between recreation facilities and the Bouldin Island airstrip was not included in the sources of traffic. Although agricultural and recreation-related traffic would not peak during the same months, all sources of traffic were combined to make this a worst-case analysis. Peak-hour trips are vehicle trips made during the hour of the day with the greatest traffic volume. Commonly, an approximately 10:1 relationship exists between daily traffic and peak-hour volumes. Therefore, it was assumed that 10% of daily trips would operate during the peak hour. For a more detailed breakdown of trip generation, see Appendix L1, "Estimated Trip Generation".

Agriculture- and construction-related trip generation estimates were provided by the project proponent, and recreation-related trip generation was calculated for existing conditions and Alternatives 1 and 3 and the No-Project Alternative as described below. Recreation-related trip generation for Alternative 2 would be almost identical to recreation-related trip generation for Alternative 1.

Vehicle and boat trip generation was estimated for recreation-related use for all seasons of recreational activity (Table 3L-5). These estimates, described in the following sections, were used to determine the season with the greatest amount of recreational trip generation.

Under existing conditions and the No-Project Alternative, the hunting season would be the peak recreation season (see Chapter 3J, "Recreation and Visual Resources"). Therefore, trips generated by recreational activities under existing conditions and the No-Project Alternative were estimated based on estimates of hunting activities during the hunting season. Under Alternatives 1 and 3, summer would be the peak recreation season (see Chapter 3J). Boating, fishing, hunting, and other miscellaneous recreational activities were included in the analysis of trip generation for recreation, as described below. However, because summer is the peak recreation season assessed for the traffic analysis for Alternatives 1 and 3, hunting is not included as a source of recreation-related trips for the peak use impact assessment for these alternatives because hunting would not occur during summer.

Existing Conditions and the No-Project Alternative. Hunting-related vehicle trips were estimated for existing conditions and the No-Project

Alternative using the number of annual hunter use-days expected on the DW project islands (Table 3J-2 in Chapter 3J, "Recreation and Visual Resources"). One hunter use-day represents participation by one individual in hunting activities for any portion of a 24-hour period. The following assumptions were used to determine annual hunting-related vehicle trips:

- Hunters would not stay overnight; therefore, each hunter use-day represents one hunter.

- Vehicle occupancy would be two people per vehicle.

- Each vehicle would make two trips (one trip to the island and one trip back).

The annual number of vehicle trips was then divided by the number of days that hunting is or would be allowed in a year, giving the average number of recreation-related vehicle trips occurring per day during the hunting season. The number of days hunting would be allowed during the year was assumed to be the same for existing conditions and the No-Project Alternative, as shown for the No-Project Alternative in Table 3J-16.

Alternatives 1 and 3. Hunting-related vehicle trip generation for Alternatives 1 and 3 was estimated in the same manner as for existing conditions. However, the DW project alternatives would include lodging facilities for hunters; therefore, the number of hunters was estimated based on the following assumptions: an overnight hunter accounts for two hunter use-days, 70% of the hunters would stay overnight at the project facilities, and the remaining 30% of the hunters would come for day use only. Also, it was assumed that 10% of the hunters using Webb Tract would travel by private boats and would not use the ferry.

Estimates of annual hunter use-days shown in Table 3J-11 in Chapter 3J were used for the trip generation analysis for Alternatives 1 and 3. These numbers represent the maximum amount of hunting that would occur during the approximately 5- to 15-year period following project start-up. After this initial period, hunting activity on the DW project islands is expected to decrease. These maximum numbers were used for a worst-case analysis. Additionally, the number of days that hunting would be allowed in future years under each alternative was taken from Tables 3J-3, 3J-4, 3J-12, 3J-13, 3J-14, 3J-15, and 3J-16 in Chapter 3J. Depending on the alternative and the island under consideration, the number of days on which hunting would be allowed varied from 47 to 86 days per year.

Hunting also would result in boating on the interior of the project islands under Alternatives 1 and 3. Trip generation for hunting-related boating was estimated based on the number of hunters expected to use the project islands each day, assuming an occupancy of two people per boat. This activity is not considered a part of pleasure boating activities, which would take place in the Delta on the exterior of the DW project islands. Additionally, hunting-related boat trips would be much shorter in duration, and boats used for hunting are smaller than pleasure boats.

Boating activity associated with Alternatives 1 and 3 would result in both vehicle traffic and boat traffic. Trip generation for boating-related boats and vehicles for Alternatives 1 and 3 was estimated for each season using peak-use estimates for each season. Boating activity is the largest source of vehicle trip generation under Alternatives 1 and 3 during the summer. Boat berths that would be constructed under the DW project alternatives are projected to have an average boat occupancy rate of 70% (see Chapter 3J, "Recreation and Visual Resources"). Estimates of the percentage of docked boats that are used on a peak day were used to estimate the total number of boats that would be used per peak day for each season under Alternatives 1 and 3. Estimates were based on the assumptions that each boat would complete two trips each day, and that the occupancy rate would be three people per boat.

The numbers of boating-related vehicle trips under Alternatives 1 and 3 were calculated based on the numbers of boaters (assuming three boaters per boat), the number of peak-day boat trips, and an occupancy rate of two people per car. Therefore, the number of boating-related vehicle trips would be 1.5 times the number of boat trips during every season except hunting season. Because 5% of the hunters are assumed to engage in pleasure boating, 5% of the hunting-related vehicle trips were subtracted from the boating-related vehicle trips during the hunting season.

Generation of vehicle trips related to other recreational activities under Alternatives 1 and 3 was estimated for each season using the number of recreationists other than boaters or hunters expected to use each island. This number was estimated in relation to the number of boaters expected to use the islands. See Chapter 3J, "Recreation and Visual Resources", for further explanation of this estimate. It was assumed that 90% of these recreationists would drive to the islands or, in the case of Webb Tract, to the ferry. A vehicle occupancy of two people per car was assumed.

It should be noted that all trips referred to in this chapter and in Chapter 3O, "Air Quality", are one-way trips. It should also be noted that the vehicle-to-boat trips included in this analysis are not vehicle trips made to the ferry, but are vehicle trips made to private boats. However, all vehicle trips made "directly" to Webb Tract are actually vehicle trips made to the Jersey-Bradford-Webb ferry, which would transport the vehicles and passengers to Webb Tract. These vehicle trips should not be confused with vehicle trips made to private boats going to Webb Tract.

Also, harvest vehicle trips are distinguished from nonharvest agricultural trips by the fact that harvest trips are made to deliver harvested crops. Nonharvest agricultural trips include all other agricultural trips.

Table 3L-4 shows peak-hour trip generation for existing conditions; Alternatives 1, 2, and 3; and the No-Project Alternative. Trips generated by the DW project were assigned to roadway segments based on the following trip distribution assumptions:

- # 50% of all trips generated by the DW project approach the project area from the west, and the other half approach it from the east;
- # 100% of all DW project trips generated by Bacon Island use Bacon Island Road;
- # 100% of all DW project trips generated by Bouldin Island use SR 12 west of Terminous; and
- # 50% of all DW project trips generated by Bacon Island, Webb Tract, and Holland Tract use SR 4 east of Tracy Boulevard, SR 4 south of Cypress Road, and SR 4 south of Delta Road.

The first assumption listed above is based on the understanding that there are population centers and appropriate work forces located to both the east and west of the DW project site and the assumption that it is equally likely that recreationists and DW workers would come from one direction as from the other. All the other assumptions listed above follow from the first assumption.

Waterway Traffic and Safety

The number of boat trips expected to occur per day during construction and operation of the DW project are shown in Table L1-2 of Appendix L1, "Estimated Trip Generation". The numbers of boat trips expected to occur per day under existing conditions and the No-Project Alternative are shown in Tables L1-1 and L1-3 of Appendix L1, respectively. Boat trip estimates are based on the proposed recreation facility design (see Figures 2-7 and 2-8 in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives") and projected use of the facilities (see Chapter 3J, "Recreation and Visual Resources"). The analysis addresses project effects on waterway traffic, safety, and navigability in Delta waterways during construction and operation. Waterway traffic and safety would be affected by changes in boat use in the Delta and changes in the condition of channels adjacent to the DW project islands.

Criteria for Determining Impact Significance

Traffic Congestion

An alternative is considered to have a significant impact if it would cause a roadway segment to go from one LOS under future without-project conditions to a lower LOS during construction or operation of the project (e.g., from LOS B to LOS C). Additionally, an alternative is considered to have a significant impact if it would add 25 or more vehicle trips to the peak-hour volume on a roadway segment with an already unacceptable LOS (estimated for future without-project conditions). This 25-trip threshold is based on the San Joaquin County Congestion Management Plan (San Joaquin County Council of Governments 1991), which states that a project would have a significant impact if it would result in the addition of 250 or more trips to the daily traffic volume. Using the 10:1 ratio for daily to peak-hour traffic volume, a 25-trip peak-hour volume threshold was derived from the daily threshold. Although this criterion is designed for use with general plans and general plan amendments, it is appropriate for use on other types of projects as well (VanDenburgh pers. comm.). Although not all roadways assessed in this analysis are located in San Joaquin County, this criterion was considered appropriate for use on all the roadways analyzed. According to the San Joaquin County General Plan, an

LOS of E or F is an unacceptable LOS on all state highways in the Delta portion of San Joaquin County. Furthermore, an LOS of D, E, or F is unacceptable on all other San Joaquin County roadways in the Delta (San Joaquin County Community Development Department 1992). According to the Contra Costa County Transportation Authority, unacceptable LOS on non-freeway segments of SR 4 in Contra Costa County is LOS F (Engelmann pers. comm.). All roadway segments located in Contra Costa County analyzed in this chapter are non-freeway segments of SR 4.

Conversely, an alternative is considered to have a beneficial impact if it would cause a roadway segment to go from one LOS under future without-project conditions to a higher LOS during construction or operation of the project. Additionally, an alternative is considered to have a beneficial impact if it would remove 25 or more vehicle trips from the peak-hour volume on a roadway segment with an already unacceptable LOS.

Traffic Safety

An alternative is considered to have a significant impact if it would result in the operation of additional large trucks or other equipment on Delta roadways during construction or operation, compared with future without-project conditions. Conversely, an alternative is considered to have a beneficial impact if it would result in the removal of any large trucks or other equipment from operation on Delta roadways during construction or operation, compared with future without-project conditions.

Traffic Circulation and Access

An alternative is considered to have a significant impact if it would limit access to the project site or along haul routes during construction. An alternative is also considered to have a significant impact if it would alter circulation patterns on highways in the project vicinity during construction or operation.

Waterway Traffic and Safety

An alternative is considered to have a significant impact on waterway traffic or safety if it would:

substantially increase boat traffic on waterways in the DW project vicinity during construction or operation,

adversely affect boat navigation in Delta waterways by altering physical conditions in a channel,

involve the permanent placement of an obstruction greater than one-third the width of the channel in waterways surrounding the DW project islands during construction or operation, or

increase the potential for boating accidents to occur in waterways surrounding the DW project islands during project construction or operation.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands) and management of Bouldin Island and Holland Tract (habitat islands) primarily for wildlife habitat. Reservoir islands would be managed primarily for water storage, with wildlife habitat and recreation constituting secondary uses. The impacts of Alternative 1 on traffic conditions in the DW project area are described below. In cases in which an impact is designated as significant, mitigation is recommended if available.

Level of Service on Delta Roadways

Traffic generated during construction under Alternative 1 would consist of vehicles carrying workers to the project sites and trucks bringing materials to the project sites. The sources of traffic generated during operation of Alternative 1 are recreation, agriculture, and project maintenance activities. See Table L1-2 in Appendix L1 for estimates of the number of trips that would be generated on each island during construction and operation of Alternative 1.

Alternative 1 involves the potential sale of water stored on the reservoir islands. If water sales do occur, water would be transferred through existing pipelines and aqueducts to the purchaser. Therefore, implementation of Alternative 1 would not generate traffic associated with transport of water.

Bacon Island

Construction. As shown in Table 3L-6, the estimated peak-hour volume on Bacon Island Road at the Bacon Island bridge during construction under Alternative 1 is 241 and under future without-project conditions is 234. As shown in Table 3L-7, this roadway would operate at LOS A under future without-project conditions and during construction under Alternative 1.

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during construction under Alternative 1 is 1,109 and under future without-project conditions is 1,100. As shown in Table 3L-7, the LOS on this roadway segment would be D under future without-project conditions and during construction under Alternative 1.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on Bacon Island Road at the Bacon Island bridge during operation of Alternative 1 is 290 and under future without-project conditions is 234. As shown in Table 3L-7, the LOS on this roadway segment would be A under future conditions with and without Alternative 1.

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during operation of Alternative 1 is 1,171 and under future without-project conditions is 1,100. As shown in Table 3L-7, the LOS on this roadway segment would be D under future conditions with and without Alternative 1.

Webb Tract

Construction. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during construction under Alternative 1 is 2,741 and under future without-project conditions is 2,732. As shown in Table 3L-7, the LOS on this roadway segment would be E under future without-project conditions and during construction under Alternative 1.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during operation of Alternative 1 is 2,803 and under future without-project conditions is 2,732. As shown in Table 3L-7, the LOS on this roadway segment would be E under future without-project conditions and F under Alternative 1 conditions.

Bouldin Island

Construction. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during construction under Alternative 1 is 2,903 and under future without-project conditions is 2,900. As shown in Table 3L-7, the LOS on this roadway segment would be F under future without-project conditions and during construction under Alternative 1.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during operation of Alternative 1 is 2,949 and under future without-project conditions is 2,900. As shown in Table 3L-7, the LOS on this roadway segment would be F under future conditions with and without Alternative 1.

Holland Tract

Construction. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during construction under Alternative 1 is 2,847 and under future without-project conditions is 2,838. As shown in Table 3L-7, the LOS on this roadway segment would be F under future without-project conditions and during construction under Alternative 1.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during operation of Alternative 1 is 2,909 and under future without-project conditions is 2,838. As shown in Table 3L-7, the LOS on this roadway segment would be F under future conditions with and without Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-1: Increase in Traffic on Delta Roadways during Project Construction. Implementation of Alternative 1 would slightly increase peak-hour volumes during project construction. However, the increase in volume would be less than 25 trips on all roadways analyzed. Furthermore, the LOS letter grade would not be affected on any of the roadways analyzed. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact L-2: Increase in Traffic on Delta Roadways during Project Operation. Implementation of Alternative 1 would increase peak-hour volumes during project operation. As shown in Table L1-2 of Appendix L1, the majority of trips generated under Alternative 1 would be generated by summer recreationists (e.g., boaters). The increase in peak-hour volume would be more than 25 trips on all roadways analyzed. Of these roadways, two have unacceptable LOS under future without-project conditions, including SR 12 west of Terminous and SR 4 south of Delta Road (see Table 3L-7). Therefore, implementation of Alternative 1 would result in the addition of more than 25 peak-hour trips to roadway segments with already unacceptable LOS under future without-project conditions. Additionally, LOS would be reduced by a letter grade, from E to F, on SR 4 south of Cypress Road; and from A to B, on Jersey Island Road north of Dutch Slough Road. Therefore, this impact is considered significant and unavoidable.

Implementation of Mitigation Measure RJ-1 would reduce impact L-2 but not to a less-than-significant level".

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. Projected boat use at the Delta Wetlands Project islands would contribute substantially to increases in boating-related vehicle traffic on Delta roadways. With the implementation of this mitigation measure the number of projected peak season (June-August) boating-related vehicle trips under Alternative 1 would decline from 1680 to 840 trips per day. This reduction in boating-related vehicle trips would greatly reduce the magnitude of this impact. However, changes in traffic on Delta roadways would still exceed the peak-hour significance criteria.

Safety on Delta Roadways

Under Alternative 1, traffic safety on Delta roadways would be adversely affected by the addition of large, slow-moving vehicles. Large vehicle traffic generated during construction under Alternative 1 would consist of trucks carrying materials to the project sites as well as agricultural vehicle traffic associated with concurrent agricultural activities. Large vehicle traffic generated during operation of Alternative 1 would consist solely of agricultural vehicle traffic. The issue of safety on Delta roadways was assessed qualitatively for this chapter. See Table L1-2 in Appendix L1 for the number of large vehicle trips generated on each island during construction and operation of Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-3: Creation of Safety Conflicts on Delta Roadways during Project Construction. Implementation of Alternative 1 would slightly increase traffic during project construction (Table 3L-6). A portion of this increase would consist of large trucks transporting materials to the DW project islands. As explained above under "Criteria for Determining Impact Significance", an alternative is considered to have a significant impact if it would result in the addition of large trucks or other equipment to Delta roadways. This criterion is quite stringent because of the great potential for safety conflicts on these roadways. Although agricultural activities would taper off from current levels throughout the construction period, under the worst-case scenario, it is assumed that all existing agricultural traffic levels would continue throughout the construction period. Therefore, because construction vehicles would be added to traffic on Delta roadways, this impact is considered significant.

Implementing Mitigation Measure L-1 would reduce Impact L-3 to a less-than-significant level.

Mitigation Measure L-1: Clearly Mark Intersections with Poor Visibility in the DW Project Vicinity. Before beginning construction at any of the DW project sites, visibility at intersections in the project vicinity shall be visually assessed. If visibility is poor at any intersection, highly visible signs shall be posted at all approaches to the intersection stating that construction activity is taking place and that drivers should be aware of construction vehicles traveling on roads in the area.

A construction contractor and a representative of the San Joaquin County Department of Public Works shall visually assess visibility at intersections along Bacon Island Road, SR 4 from I-5 to Bacon Island Road, SR 4 from Bacon Island Road to the San Joaquin County line, and SR 12 from I-5 to the west end of Bouldin Island.

A construction contractor and a representative of the Contra Costa County Department of Public Works shall visually assess visibility at intersections along SR 4 from the Contra Costa County line to SR 160, Jersey Island Road from Cypress Road to the Jersey-Bradford-Webb ferry, Cypress Road from SR 4 to Jersey Island Road, Delta Road from SR 4 to Holland Tract Road, Holland Tract Road from Delta Road to its end, Byron Highway from SR 4 to Delta Road, and SR 12 from the west end of Bouldin Island to SR 160.

Impact L-4: Reduction in Safety Conflicts on Delta Roadways during Project Operation. Farm vehicles and trucks transporting agricultural products occasionally cause traffic congestion on Delta roadways. The congestion is most apparent when these relatively slow-moving vehicles operate on high-speed roadways. The congestion is most frequent during harvest season, when the number of farm vehicles and transport trucks operating on public roads reaches a peak. For example, in 1988, more than 400 truckloads of corn left Bouldin Island on SR 12 during the corn harvest (Wilkerson pers. comm.). Additionally, operation of these vehicles on public roadways can increase the frequency of traffic accidents.

Implementation of Alternative 1 would result in a reduction in agricultural vehicle traffic on Delta roadways during project operation (see Tables L1-1 and L1-2 in Appendix L1, "Estimated Trip Generation"). Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Circulation on and Access to Delta Roadways

During construction of Alternative 1, circulation on and access to Delta roadways could be adversely affected by road closures or detours. During operation of Alternative 1, circulation and access could be adversely affected by increased peak-hour traffic volumes, as discussed above under "Level of Service on Delta Roadways". The issues of circulation on and access to Delta roadways are assessed qualitatively in this chapter.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-5: Change in Circulation on or Access to Delta Roadways during Project Construction. Because most of the construction activity would take place on the interior side of the levees, implementation of Alternative 1 would not cause traffic conflicts, detours, or lane closures during construction on the DW project islands. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact L-6: Change in Circulation on Delta Roadways during DW Project Operation. Implementation of Alternative 1 would not involve any alterations to the existing roadway network in the project vicinity. Therefore, implementation of this alternative would not change circulation patterns on Delta roadways. This impact is considered less than significant.

Mitigation. No mitigation is required.

Waterway Traffic and Safety

Waterway Traffic and Circulation

During operation of Alternative 1, waterway traffic would increase and could adversely affect boat circulation on Delta waterways. Under Alternative 1, an estimated 560 boats would originate from the DW project recreation facilities on a peak summer day. Assuming two trips per boat, implementation of Alternative 1 would increase peak boating use by 1,116 boat trips. Bacon Island and Webb Tract would each generate 323 boat trips; Bouldin Island and Holland Tract would generate 294 and 176 boat trips, respectively (Table 3L-5). There are no current studies to document boat-trip generation for the entire Delta (Delta Protection Commission 1995). However, as described in Chapter 3J, "Recreation and Visual Resources", implementing Alternative 1 is projected to increase average annual boating in the Delta by 5%. Therefore, the increase in peak-day boat trips under Alternative 1 is assumed to be proportional to the estimated increase in annual boating recreation use.

Construction of new boat facilities would increase restrictions on existing boat use on waterways adjacent to the DW project islands. As described in the "Affected Environment" section, boat speeds are restricted to 5 mph within 200 yards upstream or downstream of boat docks. If all DW recreation facilities were constructed in waterways that do not have existing speed restrictions, the facilities would require restrictions on over 8 miles of Delta waterways. Restricted speeds, combined with boats moving into and out of waterways, create boat congestion on days of heavy recreation use. Therefore, implementing the DW project would contribute to boat traffic congestion adjacent to the DW project islands.

Navigation

During construction under Alternative 1, large barges loaded with rock would be transported to the DW project islands. These barges are most likely to be loaded directly from a quarry located on the water (e.g., the San Rafael rock quarry on San Pablo Bay). Additionally, a barge would be permanently moored at the DW project islands to assist offloading and placement of rock. Because of their size, barges could obstruct more than one-third the width of a channel. Therefore, use of barges would contribute to navigation and safety issues on Delta waterways during construction.

The proposed design of the recreation facilities includes a 36-berth floating boat dock and a gangway that extends 40 feet into the adjacent channels (see Appendix 2, Figures 2-7 and 2-8). To minimize effects on navigability of these waterways, DW would design and construct all floating boat docks and gangways in accordance with the recommended standards of the 1991 Department of Boating and Waterways' Layout, Design and Construction Handbook for Small Craft Boat Launching Facilities. In compliance with Corps recommendations for boat facilities, floating boat docks would not extend more than one-third the horizontal distance across the channel and a navigation channel of not less than 100 feet would be maintained at all times.

Water discharged from the reservoir islands into adjacent channels would not adversely affect navigation in those locations. Pumps would include an expansion chamber to slow the speed of water entering the Delta channels. The cross-sectional area at the point of discharge would be 30 square feet, resulting in an exit velocity of 3.33 feet per second. By the time water has moved a few feet past the pump exit, the velocity would slow to well below scour velocity (see Chapter 3B, "Hydrodynamics"), and with a pump spacing of 25 feet and a channel water depth of approximately 12 feet, the water velocity would slow to 0.33 feet per second by the time it reaches the surface. At this speed, water entering the Delta channels would not affect navigation of even small boats on the water surface. Appendix 2 describes the pump design in more detail.

Water storage on the Delta Wetlands reservoir islands could increase fog on the project islands during the winter months but would not substantially affect existing fog conditions in the adjacent channel waters or in other parts of the Delta (Bohnak pers. comm.). Therefore, increased fog on the Delta Wetlands reservoir islands would not affect boater navigation in adjacent channels.

Safety

Implementation of Alternative 1 would adversely affect boating safety on Delta waterways by increasing boat traffic, contributing to congestion, and adversely affecting navigation during project construction. The introduction of more boats to waterways surrounding the DW project islands would increase the potential for accidents. As described above, excessive speeds, large wakes, boaters with limited knowledge and experience, and a lack of uniformity in signs regulating boat speeds and other boating information contribute to safety problems on Delta waterways. As shown in Figure 3L-2, areas most prone to accidents include Little Potato Slough near Terminous, the southern end of Holland Tract near Palm Tract, areas along the southern portion of Bacon Island, and areas in the vicinity of Franks Tract along the Piper Slough.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-7: Increase in Boat Traffic and Congestion on Delta Waterways during DW

Project Operation. Implementation of Alternative 1 would result in the addition of 1,116 boat trips on a peak summer day to waterways in the DW project vicinity. Based on estimated recreation use, it is estimated that boat trips would increase by approximately 5% over existing conditions. Also, construction of the recreation facilities would restrict boat speeds on up to approximately 8 miles of Delta waterways. Restricted speeds, combined with boats moving into and out of waterways at the DW facilities, would create boat congestion on days of heavy recreational use. Therefore, this impact is considered significant and unavoidable.

Implementation of Mitigation Measure RJ-1 would reduce impact L-7, but not to a less-than-significant level.

Mitigation Measure RJ-1: **Reduce the Number of Outward Boat Slips Located at Recreation Facilities**. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. Implementation of this mitigation measure would reduce the projected number of peak season (June-August) boat trips under Alternative 1 from 1116 to 560 trips per day. Therefore, adverse impacts on boat traffic and congestion that would result from project implementation would be greatly reduced. However, increased boat traffic is still considered significant with implementation of this mitigation measure.

Impact L-8: Change in Navigation Conditions on Delta Waterways Surrounding the DW Project Islands during Project Operation. Implementation of Alternative 1 would result in the construction of recreation facilities with floating boat docks and gangways that would extend into the channels. However, the floating boat docks and gangways would not extend more than one-third the horizontal distance across the channel and a navigation channel of not less than 100 feet would be maintained at all times. Additionally, the boat docks and gangways would be constructed in accordance with recommended standards of the 1991 Department of Boating and Waterways' Layout, Design and Construction Handbook for Small Craft Boat Launching Facilities. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact L-9: Creation of Safety Conflicts on Delta Waterways during Project Construction. Implementation of Alternative 1 would result in a barge being permanently moored at the DW project island where construction is occurring. This barge would have a crane on it and would be moored using long pilings that fit through openings in the base of the barge and are sunk into the riverbed (Stewart pers. comm.). Tugboats would transport barges loaded with rock to the permanently moored barge for offloading and placement. Because of its size and the length of time that would located in adjacent channels, the barge is considered an obstruction and is a cause for safety concerns during construction. Therefore, this impact is considered significant.

Implementing Mitigation Measure L-2 would reduce Impact L-9 to a less-than-significant level.

Mitigation Measure L-2: Clearly Mark the Barge and Notify the U.S. Coast Guard of Construction Activities. The construction contractor shall ensure that the barge is well marked and lit in accordance with Title 14 of the California Code of Regulations, Section 7000 *et seq*. Additionally, the construction contractor shall contact the U.S. Coast Guard 2 weeks before construction begins so that a notice to mariners may be issued by the U.S. Coast Guard alerting boaters to the presence of the barge and to construction activities occurring in the area. The contractor must inform the Coast Guard of the location and type of activity, whether night operations will be taking place, and whether there will be lights and buoys (Pisel pers. comm.). These safety measures are common practice for contractors performing work in marine environments (Stewart pers. comm.).

Impact L-10: Increase in the Potential for Safety Problem on Waterways Surrounding the DW Project Islands. Implementation of Alternative 1 would adversely affect boating safety on Delta waterways by increasing boat traffic, contributing to congestion, and adversely effecting navigation during project construction. Therefore, this impact is considered significant.

Implementing Mitigation Measure L-3 would reduce Impact L-10 to a less-than-significant level.

Mitigation Measure L-3: Clearly Post Waterway Intersections, Speed Zones, and Potential Hazards in the DW Project Vicinity. Prior to operation of the DW recreation facilities, intersections shall be assessed for speed requirements, poor visibility, and any unposted areas or potential hazards with respect to boating. If poor visibility conditions or any potential boating hazards exist, these areas shall be marked with buoys, waterway markers, and information signs in accordance with the California uniform waterway marking system or federal lateral waterway system. Speed requirements shall be posted and enforced in accordance with local and state laws and ordinances. Regulations for boating activities proposed by local agencies must be submitted to, reviewed, and approved by the California Department of Boating and Waterways in accordance with the California Harbors and Navigation Code before they are adopted and implemented.

Air Traffic from Bouldin Island

Under Alternative 1, the Bouldin Island airstrip would be available for maintenance and recreational activity on the DW project islands. Hunters and other recreationists could fly to the island, and DW would use the airstrip for habitat maintenance (e.g., seed dispersal and application of herbicide and pesticide). The HMP places restrictions on timing and frequency of takeoffs and landings from the airstrip during the waterfowl season (September 1 to March 31) to reduce disturbances to wildlife (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands"). During other times of the year, no restrictions would be placed on use of the airstrip. However, DW anticipates that the use of the airstrip would average up to 300 takeoffs and landings throughout the rest of the year, with approximately 50% of those flights occurring during summer. Combined with the limit of 100 takeoffs and landings during the hunt season, the number of flights generated from the airstrip under Alternative 1 would be less than current levels for agricultural activities. Although the season of peak airstrip use may change from existing conditions, implementing the DW project would not substantially change operation of the airstrip. Therefore, no adverse effects on existing air traffic would occur.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

The impacts and mitigation measures of Alternative 2 are the same as those described for Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. The Bouldin Island airstrip would not be operated under this alternative.

The peak-hour volumes for some roadways under Alternative 3 vary slightly from those estimated for Alternative 1. These variations would not affect LOS for any roadway. Impacts and mitigation measures relating to roadway safety, circulation and access, and waterway traffic and safety under this alternative are the same as under Alternative 1.

Level of Service on Delta Roadways

Traffic sources during construction and operation of Alternative 3 would be the same as those described for Alternative 1. Trip generation under Alternative 3 was estimated in the same manner and using the same assumptions as trip generation under Alternative 1.

Bacon Island

Construction. As shown in Table 3L-6, the estimated peak-hour volume on Bacon Island Road at the Bacon Island bridge during construction under Alternative 3 is 241 and under future without-project conditions is 234. As shown in Table 3L-7, the LOS on this roadway segment would be A under future without-project conditions and during construction under Alternative 3.

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during construction under Alternative 3 is 1,114 and under future without-project conditions is 1,100. As shown in Table 3L-7, the LOS on this roadway segment would be D under future without-project conditions and during construction under Alternative 3.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on Bacon Island Road at the Bacon Island bridge during operation of Alternative 3 is 290 and under future without-project conditions is 234. As shown in Table 3L-7, the LOS on this roadway segment would be A under future conditions with and without Alternative 3.

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during operation of Alternative 3 is 1,177 and under future without-project conditions is 1,100. As shown in Table 3L-7, the LOS on this roadway segment would be D under future conditions with and without Alternative 3.

Webb Tract

Construction. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during construction under Alternative 3 is 2,746 and under future without-project conditions is 2,732. As shown in Table 3L-7, the LOS on this roadway segment would be E under future without-project conditions and during construction under Alternative 3.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during operation of Alternative 3 is 2,809 and under future without-project conditions is 2,732. As shown in Table 3L-7, the LOS on this roadway segment would be E under future without-project conditions and F under Alternative 3 conditions.

Bouldin Island

Construction. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during construction under Alternative 3 is 2,916 and under future without-project conditions is 2,900. As shown in Table 3L-7, the LOS on this roadway segment would be F under future without-project conditions and during construction under Alternative 3.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during operation of Alternative 3 is 2,950 and under future without-project conditions is 2,900. As shown in Table 3L-7, the LOS on this roadway segment would be F under future conditions with and without Alternative 3.

Holland Tract

Construction. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during construction under Alternative 3 is 2,852 and under future without-project conditions is 2,838. As shown in Table 3L-7, the LOS on this roadway segment would be F under future without-project conditions and during construction under Alternative 3.

Operation. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during operation of Alternative 3 is 2,915 and under future without-project conditions is 2,838. As shown in Table 3L-7, the LOS on this roadway segment would be F under future conditions with and without Alternative 3.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-11: Increase in Traffic on Delta Roadways during Project Construction. Implementation of Alternative 3 would slightly increase peak-hour volumes during project construction. However, the increase in volume would be less than 25 trips on all roadways analyzed. Furthermore, the LOS letter grade would not be affected on any of the roadways analyzed. Therefore, this impact is considered less than significant.

Mitigation. No mitigation is required.

Impact L-12: Increase in Traffic on Delta Roadways during Project Operation. Implementation of Alternative 3 would increase peak-hour volumes during project operation. As shown in Table L1-2 in Appendix L1, summer recreationists would generate the majority of the vehicle trips estimated for Alternative 3. The increase in peak-hour volume would be more than 25 trips on all roadways analyzed. Of these roadways, two have unacceptable LOS under future without-project conditions, including SR 12 west of Terminous and SR 4 south of Delta Road (see Table 3L-7). Therefore, implementation of Alternative 3 would result in the addition of more than 25 peak-hour trips to roadway segments with already unacceptable LOS under future without-project conditions. Additionally, LOS would be reduced by a letter grade, from E to F, on SR 4 south of Cypress Road and from A to B on Jersey Island Road north of

Dutch Slough Road. This impact is considered significant and unavoidable.

Implementation of Mitigation Measure RJ-1 would reduce impact L-12, but not to a less-than-significant level.

Mitigation Measure RJ-1: **Reduce the Number of Outward Boat Slips Located at Recreation Facilities**. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. Projected boat use at the Delta Wetlands Project islands would contribute substantially to increases in boating-related vehicle traffic on Delta roadways. With the implementation of this mitigation measure the number of projected peak season (June-August) boating-related vehicle trips under Alternative 3 would decline from 1765 to 882 trips per day. This reduction in boating-related vehicle trips would greatly reduce the magnitude of this impact. However, changes in traffic on Delta roadways would still exceed the peak-hour significance criteria.

Safety on Delta Roadways

The roadway safety impacts and mitigation measures of Alternative 3 are the same as those described for Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-13: Creation of Safety Conflicts on Delta Roadways during Project Construction. This impact is described above under Impact L-3. This impact is considered significant. Implementing Mitigation Measure L-1 would reduce Impact L-10 to a less-than-significant level.

Mitigation Measure L-1: Clearly Mark Intersections with Poor Visibility in the DW Project Vicinity. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact L-14: Reduction in Safety Conflicts on Delta Roadways during Project Operation. This impact is described above under Impact L-4. This impact is considered beneficial.

Mitigation. No mitigation is required.

Circulation on and Access to Delta Roadways

The circulation impacts and mitigation measures of Alternative 3 are the same as those described for Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-15: Change in Circulation on or Access to Delta Roadways during Project Construction. This impact is described above under Impact L-5. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact L-16: Change in Circulation on Delta Roadways during Project Operation. This impact is described above under Impact L-6. This impact is considered less than significant.

Mitigation. No mitigation is required.

Waterway Traffic and Safety

The waterway traffic and safety impacts and mitigation measures of Alternative 3 are the same as those described for Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact L-17: Increase in Boat Traffic and Congestion on Delta Waterways during DW Project Operation. Implementation of Alternative 3 would result in addition of 1,175 boat trips on a peak summer day to waterways in the DW project vicinity. This impact is described above under Impact L-7 and is considered significant and unavoidable.

Implementation of Mitigation Measure RJ-1 would reduce impact L-17, but not to a less-than-significant level.

Mitigation Measure RJ-1: **Reduce the Number of Outward Boat Slips Located at Recreation Facilities**. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. Implementation of this mitigation measure would reduce the projected number of peak season (June-August) boat trips under Alternative 3 from 1175 to 590 trips per day. Therefore, adverse impacts on boat traffic and congestion that would result from project implementation would be greatly reduced. However, increased boat traffic is still considered significant.

Impact L-18: Change in Navigation Conditions on Delta Waterways Surrounding the DW Project Islands during Project Operation. This impact is described above under Impact L-8. This impact is considered less than significant.

Mitigation. No mitigation is required.

Impact L-19: Creation of Safety Conflicts on Delta Waterways during Project Construction. This impact is described above under Impact L-9. This impact is considered significant. Implementing Mitigation Measure L-2 would reduce Impact L-19 to a less-than-significant level.

Mitigation Measure L-2: Clearly Mark the Barge and Notify the U.S. Coast Guard of Construction Activities. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact L-20: Increase in the Potential for Safety Problem on Waterways Surrounding the DW Project Islands. This impact is described above under Impact L-10. This impact is considered significant. Implementing Mitigation Measure L-3 would reduce Impact L-20 to a less-than-significant level.

Mitigation. L-3: Clearly Post Waterway Intersections, Speed Zones, and Potential Hazards in the DW Project Vicinity. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

Operation of the No-Project Alternative consists of intensified agricultural activity with some increase in recreational use compared with existing conditions. Because implementation of the No-Project Alternative would not include development of recreation facilities and boat docks and would not require construction activities, traffic and safety on Delta waterways would not change from existing conditions. Therefore, waterway traffic and safety are not discussed for the No-Project Alternative.

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Level of Service on Delta Roadways

Traffic sources during operation of the No-Project Alternative would include increased agricultural and recreational activity compared with future without-project conditions. Trip generation under the No-Project Alternative was estimated in the same manner and using the same assumptions as trip generation under Alternative 1.

Bacon Island

As shown in Table 3L-6, the estimated peak-hour volume on Bacon Island Road at the Bacon Island bridge during operation of the No-Project Alternative is 257 and under future without-project conditions is 234. As shown in Table 3L-7, the LOS on this roadway segment would be A under future conditions with and without the No-Project Alternative.

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during operation of the No-Project Alternative is 1,127 and under future without-project conditions is 1,100. As shown in Table 3L-7, the LOS on this roadway segment would be C/D under future conditions with and without the No-Project Alternative.

Webb Tract

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during operation of the No-Project Alternative is 2,759 and under future without-project conditions is 2,732. As shown in Table 3L-7, the LOS on this roadway segment would be E under future conditions with and without the No-Project Alternative.

Bouldin Island

As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during operation of the No-Project Alternative is 2,920 and under future without-project conditions is 2,900. As shown in Table 3L-7, the LOS on this roadway segment would be F under future conditions with and without the No-Project Alternative.

Holland Tract

As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during operation of the No-Project Alternative is 2,865 and under future without-project conditions is 2,838. As shown in Table 3L-7, the LOS on this roadway segment would be F under future conditions with and without the No-Project Alternative.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in Traffic on Delta Roadways. Implementation of the No-Project Alternative would increase peak-hour volumes during project operation. As shown in Table L1-2, the majority of trips generated by Alternative 1 are recreation related. The increase in peak-hour volume would be slightly more than 25 trips on three of the roadways analyzed: SR 4 east of Tracy Boulevard, SR 4 south of Cypress Road, and SR 4 south of Delta Road. Of these roadways, only SR 4 south of Delta Road has an unacceptable LOS under future without-project conditions (see Table 3L-7). Therefore, implementation of the No-Project Alternative would result in the addition of more than 25 peak-hour trips to a roadway segment with an already unacceptable LOS under future without-project conditions. However, LOS would not be reduced by a letter grade on any roadway.

Safety on Delta Roadways

Under the No-Project Alternative, traffic safety on Delta roadways would be adversely affected by the addition of agricultural vehicle traffic, which tends to be large and slow moving. See Table L1-2 in Appendix L1 for the number of agricultural vehicle trips expected to be generated on each island during operations under the No-Project Alternative. The issue of safety on Delta roadways is assessed qualitatively in this chapter.

Summary of Project Impacts and Recommended Mitigation Measures

Creation of Safety Conflicts on Delta Roadways. Implementation of the No-Project Alternative would result in an increase in agricultural vehicle traffic on Delta roadways (see Tables L1-1 and L1-3 in Appendix L1, "Estimated Trip Generation"). Implementing the following measure would reduce this effect of the No-Project Alternative.

Clearly Mark Intersections with Poor Visibility in the Vicinity of Agricultural Operations. Visibility at intersections in the vicinity of intensified agricultural operations shall be assessed. If visibility is poor at any intersection, highly visible signs shall be posted at all approaches to the intersection stating that drivers should be aware of agricultural vehicles traveling on roads in the area.

A representative of the San Joaquin County Department of Public Works should assess visibility at intersections along Bacon Island Road, SR 4 from I-5 to Bacon Island Road, SR 4 from Bacon Island Road to the San Joaquin County line, and SR 12 from I-5 to the west end of Bouldin Island.

A representative of the Contra Costa County Department of Public Works should assess visibility at intersections along SR 4 from the Contra Costa County line to SR 160, Jersey Island Road from Cypress Road to the Jersey-Bradford-Webb ferry, Cypress Road from SR 4 to Jersey Island Road, Delta Road from SR 4 to Holland Tract Road, Holland Tract Road from Delta Road to its end, Byron Highway from SR 4 to Delta Road, and SR 12 from the west end of Bouldin Island to SR 160.

Circulation on and Access to Delta Roadways

Circulation on and access to Delta roadways could be adversely affected by increased agricultural traffic volumes under the No-Project Alternative. See Table L1-2 in Appendix L1 for the number of agricultural vehicle trips generated on each island during operations under the No-Project Alternative. The issues of circulation on and access to Delta roadways are assessed qualitatively in this chapter.

Summary of Project Impacts and Recommended Mitigation Measures

Decrease in Circulation on Delta Roadways. Implementation of the No-Project Alternative would slightly affect peak-hour volumes on Delta roadways. Although the overall number of trips added to Delta roadways is small, many of these trips would be made by agricultural vehicles, which tend to be large and slow moving. Therefore, it is possible that implementation of this alternative could negatively affect circulation on Delta roadways, although access to project islands is not expected to be affected. Implementing the following measure would reduce this effect of the No-Project Alternative.

Restrict Agricultural Vehicle Operators from Using Delta Highways during Peak Hours. Drivers of agricultural vehicles associated with agricultural activities on the DW islands operating at speeds lower than the posted speed limit on Delta highways should be restricted from using Delta highways during peak hours, from approximately 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m. on weekdays.

CUMULATIVE IMPACTS

Cumulative impacts are defined as the impacts of all reasonably foreseeable future projects; this means that all traffic growth occurring between the present and a future period is included in the impact assessment. Cumulative traffic growth is represented by the change in traffic levels from existing conditions to future with-project conditions. This is different from the previous assessment of “direct” impacts (construction- and operation-related impacts of the DW project alternatives), which was based on a comparison between future without-project and future with-project conditions.

For the cumulative impact assessment, future with-project traffic volumes and LOS were compared with existing traffic volumes and LOS. The increment of growth in traffic volumes from existing conditions to future without-project volumes represents the contribution of all reasonably foreseeable future projects, whereas the increment of growth from future without-project volumes to future with-project volumes represents only the contribution of the project. Future traffic conditions are based on information from Caltrans district and county transportation planners and engineers.

In the assessment of direct impacts of the DW project alternatives, congestion and circulation were addressed separately. Under cumulative conditions, including operation of any DW project alternative, traffic volumes would increase and assessment of circulation problems would be encompassed by the analysis of congestion. Therefore, there is no separate assessment of circulation in the cumulative impact analysis. Furthermore, safety on Delta waterways during construction is not an issue because construction is not assessed as part of cumulative conditions. As in the direct impact analysis, although agricultural and recreation-related traffic would not be present during the same months, all sources of traffic were combined to make the cumulative impact analysis a worst-case analysis.

Cumulative Impacts, Including Impacts of Alternative 1

Level of Service on Delta Roadways

Bacon Island. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during operation of Alternative 1 is 1,109. As shown in Table 3L-2, the peak-hour volume under existing conditions is 725.

As shown in Table 3L-7, the LOS on this roadway segment would be D under Alternative 1. As shown in Table 3L-3, existing LOS on this segment is C.

Webb Tract. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during operation of Alternative 1 is 2,741. As shown in Table 3L-2, the peak-hour volume on SR 4 south of Cypress Road under existing conditions is 1,400.

As shown in Table 3L-7, the LOS on this roadway segment would be E under Alternative 1. As shown in Table 3L-3, existing LOS on this segment is D.

Bouldin Island. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during operation of Alternative 1 is 2,949. As shown in Table 3L-2, the peak-hour volume on SR 12 west of Terminous under existing conditions is 1,300.

As shown in Table 3L-7, the LOS on this roadway segment would be F under Alternative 1. As shown in Table 3L-3, existing LOS on this segment is D.

Holland Tract. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during operation of Alternative 1 is 2,909. As shown in Table 3L-2, the peak-hour volume on SR 4 south of Delta Road under existing conditions is 1,600.

As shown in Table 3L-7, the LOS on this roadway segment would be F under Alternative 1. As shown in Table 3L-3, existing LOS on this segment is D.

Impact L-21: Increase in Traffic on Delta Roadways during Operation of Future Projects, Including the DW Project. Peak-hour volumes would increase during operation of future projects, including Alternative 1. The increase in volumes would be enough to degrade LOS on each of the roadways analyzed. Alternative 1 would contribute approximately 3% of the cumulative traffic increase on SR 4 east of Tracy Boulevard and approximately 1% of the cumulative traffic increases on the other roadways.

On three of the segments, SR 4 south of Cypress Road, SR 12 west of Terminous, and SR 4 south of Delta Road, LOS is reduced by at least one full letter grade. Therefore, this impact is considered significant.

Implementing Mitigation Measures L-4 and RJ-1 would reduce Impact L-21 to a less-than-significant level.

Mitigation Measure L-4: Implement Caltrans' Route Concepts for SR 4 and SR 12. Caltrans' route concepts for SR 12 across Bouldin Island and SR 4 in Contra Costa County are for four-lane highways in 2010 (Cowell and Johnson pers. comms.). This widening would include the sections of SR 4 south of Cypress Road and south of Delta Road and SR 12 west of Terminous. Caltrans has initiated preliminary design and environmental compliance work for the widening of SR 12 on Bouldin Island (O'Conner pers. comm.). The portion of SR 4 between the San Joaquin County line and I-5 would remain a two-lane highway because of the narrow bridges along that portion of the route. Table 3L-8 describes improvements in V/C ratio and LOS that would result from implementation of Caltrans' route concepts.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation for Alternative 1".

Safety on Delta Roadways

Impact L-22: Reduction in Safety Conflicts on Delta Roadways during Operation of Future Projects, Including the DW Project. Operation of reasonably foreseeable future projects, including Alternative 1, would result in a reduction in agricultural vehicle traffic on Delta roadways compared with existing conditions (Tables L1-1 and L1-2 in Appendix L1, "Estimated Trip Generation"). Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Waterway Traffic and Safety

Impact L-23: Cumulative Increase in Safety Problems on Delta Waterways. Speeding, unsafe vessel operation, lack of proper safety equipment (life jackets), and alcohol-related incidents continue to be major problems on Delta waterways. Additionally, recent cutbacks in funding for marine patrol services provided by the five Delta counties have limited enforcement of safety regulations in the Delta (Delta Protection Commission 1995). Implementation of Alternative 1, combined with increasing recreational use of the Delta by residents of growing regional population centers and limited resources for safety improvements in the Delta, could adversely affect boating safety on Delta waterways. This impact is considered significant and unavoidable.

Implementing Mitigation Measures L-5 and RJ-1 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure L-5: Develop and Enforce a Boater Safety Program for DW Private Boat Users. Working with the Coast Guard and local government marine patrols, DW should develop and enforce boater safety rules for private boat users on the DW project islands. These rules could include requiring that all boaters attend a boater education and safety course, restricting open alcohol containers from the boat docks, and rigidly enforcing boat speed restrictions near the DW recreation facilities. To support this program, DW should sponsor boater education and safety courses for private boaters and post all safety rules.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation for Alternative 1".

Cumulative Impacts, Including Impacts of Alternative 2

Although there may be a slight variation in traffic estimates for Alternatives 1 and 2, cumulative impacts of future projects including Alternative 2 would be the same as cumulative impacts of future projects including Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

The methods and rationale used to assess cumulative impacts of future projects including Alternative 3 are the same as those used to assess cumulative impacts of future projects including Alternative 1.

Level of Service on Delta Roadways

Bacon Island. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during operation of Alternative 3 is 1,177. As shown in Table 3L-2, the peak-hour volume on SR 4 east of Tracy Boulevard under existing conditions is 725.

As shown in Table 3L-7, the LOS on this roadway segment would be D under Alternative 3 conditions. As shown in Table 3L-3, existing LOS on this segment is C.

Webb Tract. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during operation of Alternative 3 is 2,909 As shown in Table 3L-2, the peak-hour volume on SR 4 south of Cypress Road under existing conditions is 1,400.

As shown in Table 3L-7, the LOS on this roadway segment would be F under Alternative 3 conditions. As shown in Table 3L-3, existing LOS on this segment is D.

Bouldin Island. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during operation of Alternative 3 is 2,950. As shown in Table 3L-2, the peak-hour volume on SR 12 west of Terminous under existing conditions is 1,300.

As shown in Table 3L-7, the LOS on this roadway segment would be F under Alternative 3 conditions. As shown in Table 3L-3, existing LOS on this segment is D.

Holland Tract. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during operation of Alternative 3 is 2,915. As shown in Table 3L-2, the peak-hour volume on SR 4 south of Delta Road under existing conditions is 1,600.

As shown in Table 3L-7, the LOS on this roadway segment would be F under Alternative 3 conditions. As shown in Table 3L-3, existing LOS on this segment is D.

Summary of Increase in Traffic. Peak-hour volumes would increase during operation of reasonably foreseeable future projects, including Alternative 3. The increase in volumes is enough to degrade LOS on each of the roadways analyzed. Alternative 3 would contribute 3% of the traffic increase on SR 4 east of Tracy, 1% of the traffic increase on SR 4 south of Cypress Road, 0.5% of the traffic increase on SR 12 west of Terminous, and 1% of the traffic increase on SR 4 south of Delta Road.

On four of the segments, SR 4 east of Tracy Boulevard, SR 4 south of Cypress Road, SR 12 west of Terminous, and SR 4 south of Delta Road, LOS is reduced by at least one letter grade.

The cumulative impact on level of service under Alternative 3 would be the same as under Alternative 1. The same mitigation measures would apply (but would not reduce the impact to a less-than-significant level).

Safety on Delta Roadways

The cumulative impact on Delta roadway safety under Alternative 3 would be the same as under Alternative 1.

Waterway Traffic and Safety

The cumulative impact on waterway traffic and safety under Alternative 3 would be the same as under Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

The methods and rationale used to assess cumulative effects of future projects including the No-Project Alternative are the same as those used to assess cumulative impacts of future projects including Alternative 1.

Level of Service on Delta Roadways

Bacon Island. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 east of Tracy Boulevard during operation of the No-Project Alternative is 1,127. As shown in Table 3L-2, the peak-hour volume on SR 4 east of Tracy Boulevard under existing conditions is 725.

As shown in Table 3L-7, the LOS on this roadway segment would be D under the No-Project Alternative. As shown in Table 3L-3, existing LOS on this segment is C.

Webb Tract. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Cypress Road during operation of the No-Project Alternative is 2,759. As shown in Table 3L-2, the peak-hour volume on SR 4 south of Cypress Road under existing conditions is 1,400.

As shown in Table 3L-7, the LOS on this roadway segment would be E under the No-Project Alternative. As shown in Table 3L-3, existing LOS on this segment is D.

Bouldin Island. As shown in Table 3L-6, the estimated peak-hour volume on SR 12 west of Terminous during operation of the No-Project Alternative is 2,920. As shown in Table 3L-2, the peak-hour volume on SR 12 west of Terminous under existing conditions is 1,300.

As shown in Table 3L-7, the LOS on this roadway segment would be F under the No-Project Alternative. As shown in Table 3L-3, existing LOS on this segment is D.

Holland Tract. As shown in Table 3L-6, the estimated peak-hour volume on SR 4 south of Delta Road during operation of the No-Project Alternative is 2,865. As shown in Table 3L-2, the peak-hour volume on SR 4 south of Delta Road under existing conditions is 1,600.

As shown in Table 3L-7, the LOS on this roadway segment would be F under the No-Project Alternative. As shown in Table 3L-3, existing LOS on this segment is D.

Increase in Traffic on Delta Roadways during Operation of Future Projects, Including the No-Project Alternative. Peak-hour volumes would increase during operation of reasonably foreseeable future projects, including the No-Project Alternative. The increase in volumes is enough to degrade LOS on each of the roadways analyzed. The No-Project Alternative would contribute 5% of the traffic increase on SR 4 east of Tracy, 1.5% of the traffic increase on SR 4 south of Cypress Road, 1% of the traffic increase on SR 12 west of Terminous, and 2% of the traffic increase on SR 4 south of Delta Road.

On four of the segments, SR 4 east of Tracy Boulevard, SR 4 south of Cypress Road, SR 12 west of Terminous, and SR 4 south of Delta Road, LOS would be reduced by at least one letter grade.

Implementing the following measure would reduce this effect of the No-Project Alternative. As described above, however, funding does not exist for implementation of this measure.

Implement Caltrans' Route Concepts for SR 4 and SR 12. This measure is described above under Mitigation Measure L-4.

Safety on Delta Roadways

Creation of Safety Conflicts on Delta Roadways during Operation of Future Projects, Including the No-Project Alternative. Operation of reasonably foreseeable future projects, including the No-Project Alternative, would cause an increase in agricultural vehicle traffic on Delta roadways during operation, compared with existing conditions (Tables L1-1 and L1-2 in Appendix L1, "Estimated Trip Generation"). Implementing the following measure would reduce this effect of the No-Project Alternative.

Clearly Mark Intersections with Poor Visibility in the Vicinity of Agricultural Operations. This measure is described above under "Impacts and Mitigation Measures of the No-Project Alternative".

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Table 3L-1. Level of Service Criteria for General Two-Lane Highway Segments (Volume-to-Capacity Ratio)

LOS	Percentage Time Delay	Average Speed (mph)[a]	Volume-to-Capacity Ratio[b] by Percentage of Roadway with No-Passing Zones					
			0%	20%	40%	60%	80%	100%
Level Terrain								
A	# 30	$ 58	0.15	0.12	0.09	0.07	0.05	0.04
B	# 45	$ 55	0.27	0.24	0.21	0.19	0.17	0.16
C	# 60	$ 52	0.43	0.39	0.36	0.34	0.33	0.32
D	# 75	$ 50	0.64	0.62	0.60	0.59	0.58	0.57
E	> 75	> 45	1.00	1.00	1.00	1.00	1.00	1.00
F			>1.00	>1.00	>1.00	>1.00	>1.00	>1.00
Rolling Terrain								
A	# 30	$ 57	0.15	0.10	0.07	0.05	0.04	0.03
B	# 45	$ 54	0.26	0.23	0.19	0.17	0.15	0.13
C	# 60	$ 52	0.42	0.39	0.35	0.32	0.30	0.28
D	# 75	$ 49	0.62	0.57	0.52	0.48	0.46	0.43
E	> 75	> 40	0.97	0.94	0.92	0.91	0.90	0.90
F			>0.97	>0.94	>0.92	>0.91	>0.90	>0.90
Mountainous Terrain								
A	# 30	$ 56	0.14	0.09	0.07	0.04	0.02	0.01
B	# 45	$ 54	0.25	0.20	0.16	0.13	0.12	0.10
C	# 60	$ 49	0.39	0.33	0.28	0.23	0.20	0.16
D	# 75	$ 45	0.58	0.50	0.45	0.40	0.37	0.33
E	> 75	> 35	0.91	0.87	0.84	0.82	0.80	0.78
F			>0.91	>0.87	>0.84	>0.82	>0.80	>0.78

Notes: LOS A: Represents unrestricted operation.
LOS B: Generally may be described as smooth and stable.
LOS C: Although still stable, approaches the range where instability can occur because of small changes in traffic flow.
LOS D: Vehicles must frequently change speeds to avoid conflicts.
LOS E: Represents capacity operation; considerable delay is experienced and speeds are greatly reduced.
LOS F: Represents over-capacity flows with heavy congestion and considerable reductions in speed.

Table 3L-1. Continued

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[a] Average travel speed of all vehicles for highways with design speed $ 60 mph; for highways with lower design speeds, reduce speed by 4 mph for each 10-mph reduction in design speed below 60 mph; assumes that speed is not restricted to lower values by regulation.

[b] Ratio of flow rate to an ideal capacity of 2,800 passenger cars per hour in both directions.

Source: Transportation Research Board 1985.

Table 3L-2. Existing Traffic Volumes on Roadways in the Project Vicinity

Location	Average Daily Traffic	Peak-Hour Volume
Bacon Island		
Bacon Island Road at the Bacon Island Road bridge	550	55
Lower Jones Road north of Cook Road	300	30
SR 4 east of Tracy Boulevard	5,900	725
Webb Tract		
Jersey Island Road north of Dutch Slough Road	200	20
Cypress Road west of Jersey Island Road	6,917	591
SR 4 south of Cypress Road	11,800	1,400
Bouldin Island		
SR 12 west of Terminous	12,200	1,300
Holland Tract		
Delta Road east of Byron Highway	537	60
SR 4 south of Delta Road	13,000	1,600

Note: These are actual volumes supplied by the sources listed below.

Sources: Caltrans 1988; Chalk, Redic, and Chahal pers. comms.

Table 3L-3. Existing Levels of Service on Major Roadway Segments in the Project Vicinity

Location	Volume-to-Capacity Ratio	Peak-Hour LOS
SR 4 east of Tracy Boulevard	0.36	C
SR 4 south of Cypress Road	0.50	D
SR 12 west of Terminous	0.61	D
SR 4 south of Delta Road	0.57	D

Source: Information on SR 4 east of Tracy Boulevard and SR 12 from Chalk pers. comm. Information on other segments taken from the range of volume-to-capacity ratios and LOS shown in Table 3L-1 for roadways with level terrain and having no-passing zones on 20% of the roadway length.

Table 3L-4. Trip Generation for the Delta Wetlands Project Islands (Peak Hour)

Condition and Location	Existing Conditions	Alternative 1 or 2	Alternative 3	No-Project Alternative
Construction				
Bacon Island	N/A	7	7	N/A
Webb Tract	N/A	9	9	N/A
Bouldin Island	N/A	3	16	N/A
Holland Tract	N/A	1	11	N/A
Total		20	43	
Operation and Maintenance				
Bacon Island	4	56	56	23
Webb Tract	4	55	55	19
Bouldin Island	3	49	50	20
Holland Tract	1	31	42	12
Total	12	191	203	74

Notes: Numbers have been rounded to the nearest number of trips.

N/A = not applicable.

Peak-hour trip generation is based on daily vehicle trip generation shown in Appendix L1. Peak-hour trip generation is generally equal to approximately 10% of daily trip generation. Therefore, the peak-hour trip generation shown in this table is equal to the daily vehicle trip generation shown in Appendix L1 divided by 10.

Sources: Construction trip generation: Stewart and Forkel pers. comms.; other trip generation: Forkel pers. comm.

Table 3L-5. Trip Generation Estimates for Recreational Vehicles and Boats by Season (Trips per Day) for Alternatives 1 and 3

		Bacon Island		Webb Tract		Bouldin Island		Holland Tract	
Vehicle or Boat Type	Season	Alternative 1	Alternative 3	Alternative 1	Alternative 3	Alternative 1	Alternative 3	Alternative 1	Alternative 3
Hunting-related vehicles	Nov-Jan	18	18	17	17	93	22	43	14
	Feb-May	0	0	0	0	0	0	0	0
	Jun-Aug	0	0	0	0	0	0	0	0
	Sep-Oct	0	0	0	0	0	0	0	0
Boating-related vehicles	Nov-Jan	68	68	68	68	58	62	36	50
	Feb-May	277	277	277	277	252	252	151	202
	Jun-Aug	485	485	485	485	441	441	265	353
	Sep-Oct	347	347	347	347	315	315	189	252
Other recreation-related vehicles	Nov-Jan	2	2	2	2	2	2	1	2
	Feb-May	8	8	8	8	8	8	5	6
	Jun-Aug	36	36	36	36	33	33	20	26
	Sep-Oct	16	16	16	16	14	14	9	11
Total recreation-related vehicles	Nov-Jan	88	88	87	87	153	85	80	65
	Feb-May	286	286	286	286	260	260	156	208
	Jun-Aug	521	521	521	521	474	474	284	379
	Sep-Oct	362	362	362	362	329	329	198	263
Hunting-related boats	Nov-Jan	18	18	18	18	93	22	43	14
	Feb-May	0	0	0	0	0	0	0	0
	Jun-Aug	0	0	0	0	0	0	0	0
	Sep-Oct	0	0	0	0	0	0	0	0
Boating-related boats	Nov-Jan	46	46	46	46	42	42	25	34
	Feb-May	185	185	185	185	168	168	101	134
	Jun-Aug	323	323	323	323	294	294	176	235
	Sep-Oct	231	231	231	231	210	210	126	168
Other recreation-related boats	Nov-Jan	0	0	0	0	0	0	0	0
	Feb-May	0	0	0	0	0	0	0	0
	Jun-Aug	0	0	0	0	0	0	0	0
	Sep-Oct	0	0	0	0	0	0	0	0
Total recreation-related boats	Nov-Jan	64	64	65	65	135	64	68	47
	Feb-May	185	185	185	185	168	168	101	134
	Jun-Aug	323	323	323	323	294	294	176	235
	Sep-Oct	231	231	231	231	210	210	126	168

Notes: Although 10% of other recreationists would boat to the project islands, these boat trips are not included in this analysis because their origin is unknown.
Hunting-related boat trips would be on the interior of the project islands and would be of much shorter duration than boating-related boat trips, which would be taken on the exterior of the islands. Hunting-related boat trips would be taken in small outboard-engine fishing boats, whereas boating-related boat trips would be taken in larger inboard-engine boats.

Sources: Anderson, Boyce, Camper, Cochrell, Holmes, Ruth, Wagner, Williams, and Winther pers. comms.

Table 3L-6. Projected 2010 Traffic Volumes on Roadways near the Delta Wetlands Project Islands with and without the Project

Location	Future without Project		Future with Project				
			Construction		Operation		
	Average Daily Traffic	Peak-Hour Volume	Alternatives 1 or 2	Alternative 3	Alternatives 1 or 2	Alternative 3	No-Project Alternative
Bacon Island							
Bacon Island Road at the Bacon Island Road bridge	2,336	234	241	241	290	290	257
Lower Jones Road north of Cook Road	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 east of Tracy Boulevard	9,000	1,100	1,109	1,114	1,171	1,177	1,127
Webb Tract							
Jersey Island Road north of Dutch Slough Road	200	20	26	26	75	75	39
Cypress Road west of Jersey Island Road	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 south of Cypress Road	24,164	2,732	2,741	2,746	2,803	2,809	2,759
Bouldin Island							
SR 12 west of Terminous	24,000	2,900	2,903	2,916	2,949	2,950	2,920
Holland Tract							
Delta Road east of Byron Highway	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 south of Delta Road	21,013	2,838	2,847	2,852	2,909	2,915	2,865

Notes: N/A = not available.
Operational volumes are equal to without-project volumes plus the estimated number of trips generated by the proposed project under the worst-case assumption that recreation, operations and maintenance, and agricultural traffic would all travel during the same peak hour.

[a] The No-Project Alternative includes increased agricultural and recreational activities compared with existing conditions.

Source: Holland Tract and Webb Tract future without-project volumes from Johnson pers. comm.; Bacon and Bouldin Island future without-project volumes from Reed and Chalk pers. comms.

Table 3L-7. Projected Volume-to-Capacity Ratios and Levels of Service on Roadways near the Delta Wetlands Project Islands, with Existing Roadway Configuration, with and without the Project

		Future with Project				
		Construction		Operation		
Location	Future without Project	Alternatives 1 or 2	Alternative 3	Alternatives 1 or 2	Alternative 3	No-Project Alternative
Bacon Island						
Bacon Island Road at the Bacon Island Road bridge	0.08 (A)	0.09 (A)	0.09 (A)	0.10 (A)	0.10 (A)	0.09 (A)
Lower Jones Road north of Cook Road	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 east of Tracy Boulevard	0.56 (D)	0.57 (D)	0.57 (D)	0.60 (D)	0.60 (D)	0.57 (D)
Webb Tract						
Jersey Island Road north of Dutch Slough Road	0.04(A)	0.05(A)	0.05(A)	0.15(B)	0.15(B)	0.08(A)
Cypress Road west of Jersey Island Road	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 south of Cypress Road	0.98 (E)	0.98 (E)	0.98 (E)	1.00 (F)	1.00 (F)	0.99 (E)
Bouldin Island						
SR 12 west of Terminous	1.29 (F)	1.29 (F)	1.30 (F)	1.31 (F)	1.31 (F)	1.30 (F)
Holland Tract						
Delta Road east of Byron Highway	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 south of Delta Road	1.01 (F)	1.02 (F)	1.02 (F)	1.04 (F)	1.04 (F)	1.02 (F)

Notes: N/A = not available.

Numbers in table represent volume-to-capacity ratio. Letters in parentheses represent the corresponding level of service.

These estimates are based on the future traffic volumes with and without the proposed project shown in Table 3L-5 using the existing road facilities.

Source: Information on SR 4 east of Tracy Boulevard and SR 12 from Chalk pers. comm. Information on other segments estimated based on Tables 3L-5 and 3L-3.

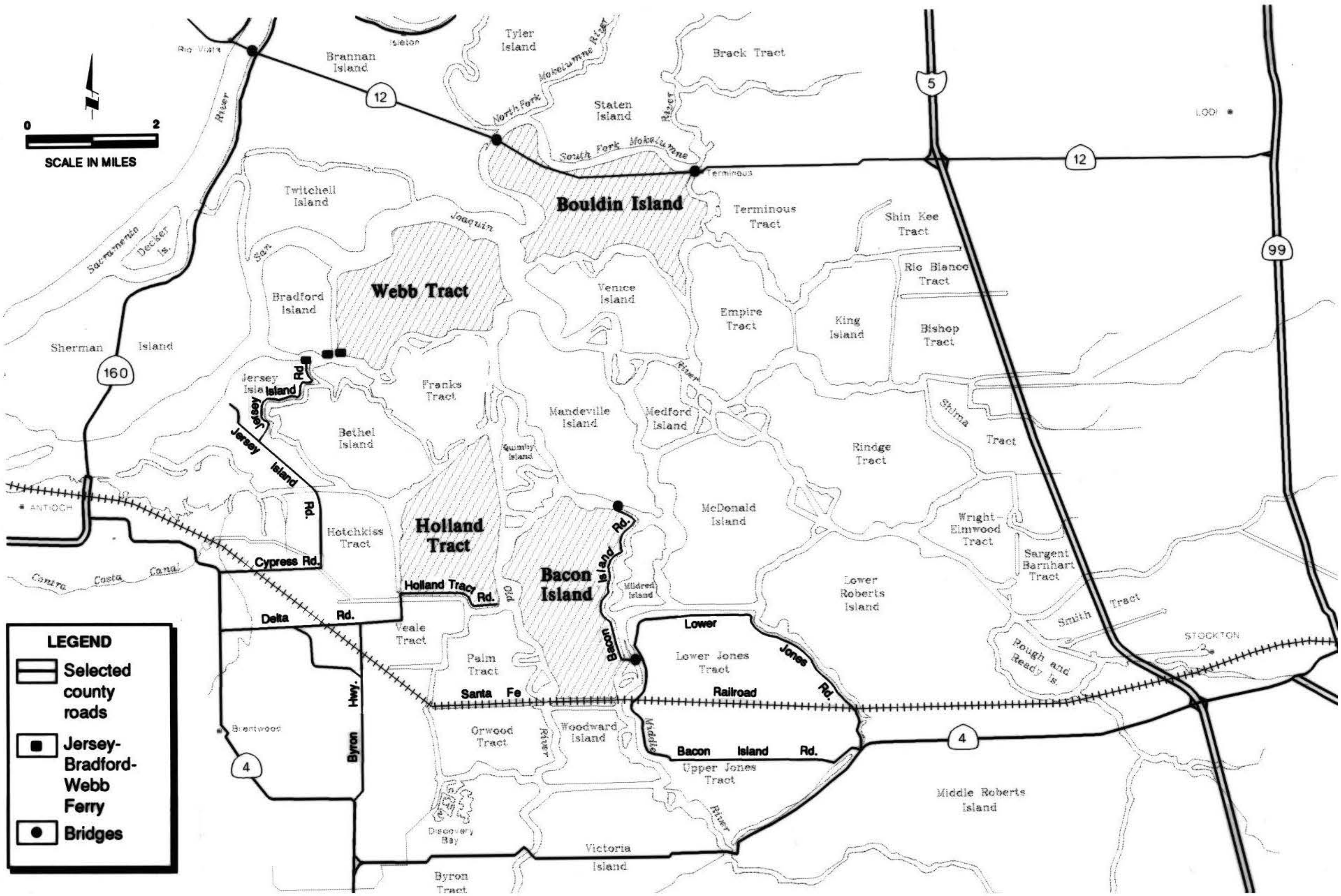
Table 3L-8. Projected Volume-to-Capacity Ratios and Levels of Service on Roadways near the Delta Wetlands Project Islands, with Improved Roadway Configuration, with and without the Project

		Future with Project				
		Construction		Operation		
Location	Future without Project	Alternatives 1 or 2	Alternative 3	Alternative 1 or 2	Alternative 3	No-Project Alternative
Bacon Island						
Bacon Island Road at the Bacon Island Road bridge	0.08 (A)	0.09 (A)	0.09 (A)	0.10 (A)	0.10 (A)	0.09 (A)
Lower Jones Road north of Cook Road	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 east of Tracy Boulevard	0.54 (C/D)	0.54 (C/D)	0.55 (C/D)	0.57 (C/D)	0.58 (C/D)	0.55 (C/D)
Webb Tract						
Jersey Island Road north of Dutch Slough Road	0.04(A)	0.05(A)	0.05(A)	0.15(B)	0.15(B)	0.08(A)
Cypress Road west of Jersey Island Road	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 south of Cypress Road	0.49 (D)	0.49 (D)	0.49 (D)	0.50 (D)	0.50 (D)	0.50 (D)
Bouldin Island						
SR 12 west of Terminous	0.48 (B)	0.48 (B)	0.49 (B)	0.49 (B)	0.49 (B)	0.49 (B)
Holland Tract						
Delta Road east of Byron Highway	N/A	N/A	N/A	N/A	N/A	N/A
SR 4 south of Delta Road	0.51 (D)	0.51 (D)	0.51 (D)	0.52 (D)	0.52 (D)	0.51 (D)

Notes: N/A = not available.

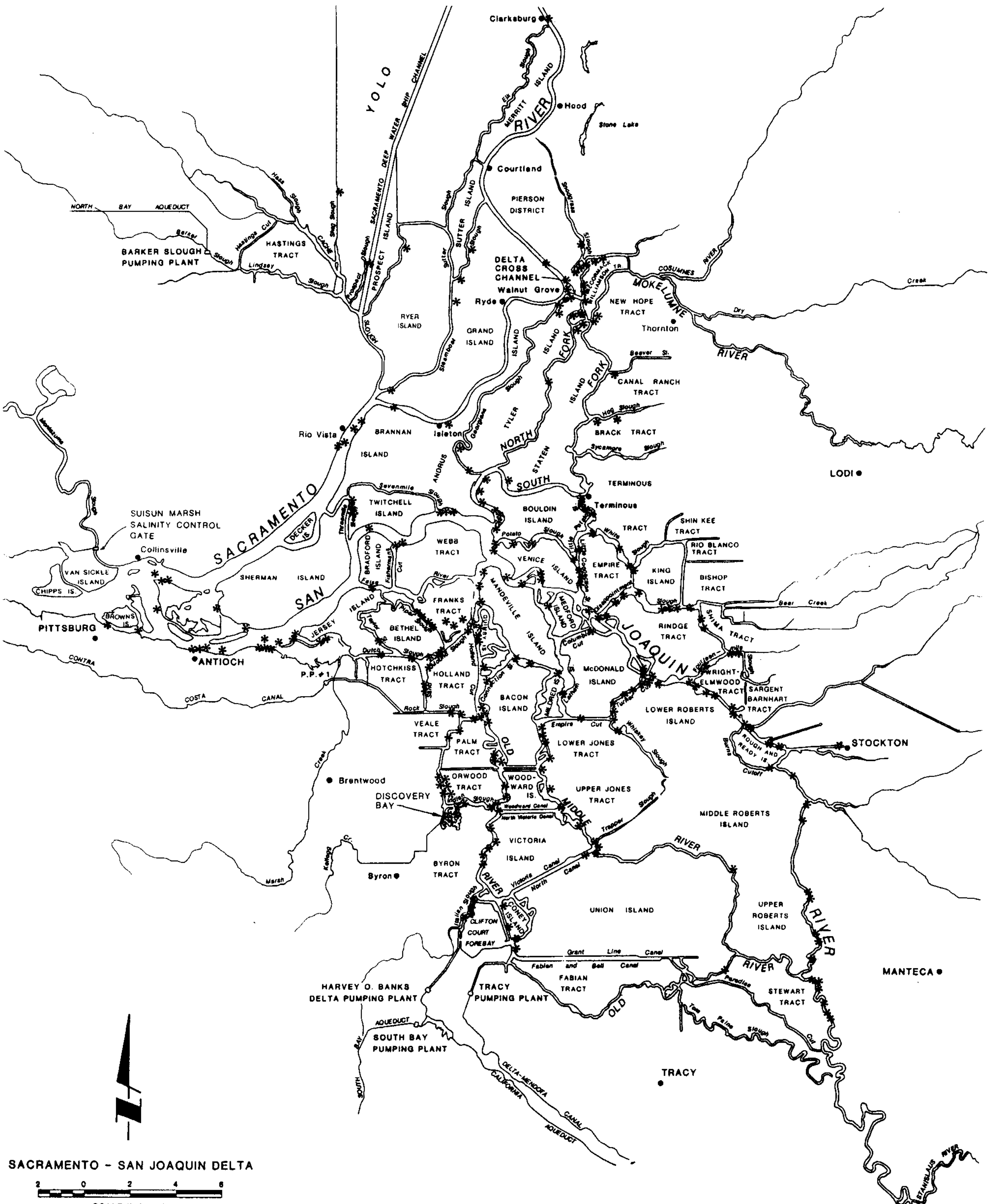
1. Numbers in table represent volume-to-capacity ratio. Letters in parentheses represent the corresponding level of service.
2. These estimates are based on the future traffic volumes with and without the proposed project shown in Table 3L-5 using the improved roadway configuration.
3. Improvement to four lanes on SR 12 west of Terminous, SR 4 south of Delta Road, and SR 4 south of Cypress Road are Caltrans concepts but are not currently programmed or funded.
4. Full widening has not been planned for SR 4 east of Tracy Boulevard; however, Caltrans has proposed constructing passing lanes at selected locations and new bridges at Old and Middle Rivers (west of Tracy Boulevard).

Source: Information on SR 4 east of Tracy Boulevard and SR 12 from Chalk pers. comm. Information on other segments estimated based on Tables 3L-5 and 3L-3.



Jones & Stokes

Figure 3L-1
Highways and County Roads in the Delta Wetlands Project Vicinity



Source: California Department of Boating and Waterways 1986.

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Figure 3L-2
Reported Accidents in the Sacramento-San Joaquin Delta, 1981-1985

Chapter 3M. Affected Environment and Environmental Consequences - Cultural Resources

Chapter 3M. Affected Environment and Environmental Consequences - Cultural Resources

SUMMARY

This chapter discusses laws and regulations applicable to protection of cultural resources on the DW project islands, presents the results of research of the prehistory and history of the DW project vicinity, and describes cultural resources identified or potentially present on the DW project islands.

Several cultural resource issues are associated with the DW project islands. Bacon Island contains historic-period archaeological sites and architectural properties, most of which represent early 20th century agricultural development and use. Bacon Island resources represent a cohesive record of agricultural development in the Delta; the island has been determined eligible for listing in the National Register of Historic Places (NRHP) as a historic district. Webb Tract contains several areas of Piper soils, where prehistoric burials may be present; therefore, the sites may be important to Native Americans. One of the historic sites identified on Bouldin Island has been determined eligible for NRHP listing. Three of the prehistoric archaeological sites identified on Holland Tract may have importance to Native Americans as prehistoric burial sites and have been determined eligible for NRHP listing; additional archaeological resources may also be present in the Piper soils on the island.

Implementation of the DW project alternatives could result in several significant impacts: demolition of the historic district on Bacon Island and disturbance of prehistoric buried resources that may be present on Webb Tract, the archaeological site on Bouldin Island that has been determined eligible for NRHP listing, and intact burials and buried prehistoric resources possibly present on Holland Tract. Implementation of Alternative 3 would result in the additional significant impact of damage or destruction of prehistoric resources on Holland Tract as a result of inundation.

Although measures to document and preserve information about the resources are recommended to reduce the impact on the NRHP-eligible district on Bacon Island, this impact would remain significant and unavoidable. Impacts on Webb Tract prehistoric resources and Bouldin Island historic-period resources can be reduced to a less-than-significant level through preparation of a historic properties management plan (HPMP) providing for treatment and monitoring of these resources, and preparation of a data recovery plan for resources on Bouldin Island. Disturbance of intact burials and buried resources, if present, on Holland Tract under Alternatives 1 and 2 could be avoided with design of habitat management and enhancement activities to prevent such disturbance and preparation of an HPMP. Mitigation measures are available to recover or protect some of the Holland Tract cultural values that would be lost as a result of implementation of Alternative 3, but this impact would remain significant and unavoidable.

Implementation of the DW project alternatives would result in cumulative impacts on historic-period resources. Destruction of the resources on Bacon Island that have been determined eligible for NRHP listing as a historic district would add to the loss of this historic resource type in the Delta. This impact is considered significant and unavoidable. Effects of the DW project would not significantly contribute to the overall loss of prehistoric resources in the Delta and are considered to be less than significant.

Under the No-Project Alternative, damage to known and unknown prehistoric sites could result from continued agricultural activities on the DW islands. The adverse effects of continued agricultural activities on historic and prehistoric resources on the DW project islands is typical of the effects of land management in the region. Therefore, implementing the No-Project Alternative would contribute to cumulative effects on cultural resources in the Delta.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

Since the 1995 DEIR/EIS was issued, the Corps, SWRCB, DW, the State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation (ACHP) have entered into a Programmatic Agreement (PA) under Section 106 of the National Historic Preservation Act (NHPA). The PA identifies mitigation required to address potential effects of the DW project on prehistoric and historic resources. Before issuing the PA, the SHPO determined which cultural resources are eligible for listing on the NRHP and concurred with the findings of project effects on those resources presented in the 1995 DEIR/EIS and related documents. This chapter has been updated to present the results of those findings and describe the conditions of the PA. However, because the requirements of the PA are consistent with the mitigation measures recommended in the 1995 DEIR/EIS, completion of the Section 106 consultation process did not change the impact conclusions and mitigation measures presented in this chapter.

AFFECTED ENVIRONMENT

For purposes of the cultural resource analysis of this EIR/EIS, the area of potential effect (APE) for Alternatives 1 and 2 is the entire project site, except the southwest quarter of Holland Tract (Figure 2-1). The APE for Alternative 3 consists of all four islands, including the southwest quarter of Holland Tract. This section describes the results of research of the prehistory and history of the DW project islands and discusses present conditions on the islands. For a more detailed discussion of the prehistory and history of the project area, see Appendix M1, "Cultural Context of the Delta Wetlands Project Islands".

Applicable Laws and Regulations

In addition to meeting CEQA and NEPA requirements, the DW project is required to comply with Section 106 of the NHPA of 1966, as amended, and with its implementing regulations, 36 CFR 800. Section 106 requires that federal agencies take into account the effects of their actions on properties that has been determined eligible for listing in or that are already listed in the NRHP. The DW project is considered a federal undertaking because of the necessity for a federal permit (Department of the Army permit, issued by the Corps under Section 404 of the Clean Water Act). To determine whether an undertaking could affect properties eligible for NRHP listing, cultural sites (including archaeological, historical, and architectural properties) must first be inventoried and evaluated for eligibility for NRHP listing.

The Section 106 review process is implemented using a five-step procedure: identifying and evaluating historic properties, assessing the effects of the undertaking on properties that are eligible for NRHP listing, consulting with the SHPO and other agencies for the development of an agreement document that addresses the treatment of historic properties, receiving ACHP comments on the agreement or results of consultation, and proceeding with the project according to the conditions of the agreement.

Evidence of compliance with the process is available for review at the Corps' Sacramento office. The steps necessary to comply with Section 106 usually are adequate to satisfy the requirements of NEPA and CEQA regarding cultural resources.

Section 106 compliance for the DW project is described below under "Programmatic Agreement for Section 106 Compliance".

Section 7052 of the California Public Health and Safety Code and Section 5097 of the Public Resources Code provide for the protection of Native American remains and identify special procedures to be followed when Native American burials are found. When remains are found, the Native American Heritage Commission (NAHC) and the county coroner must be notified. The NAHC provides guidance concerning the most likely Native American descendants and the treatment of human remains and associated artifacts. Compliance with the provisions of these laws is separate from the requirements of CEQA and NEPA.

Previous Research

Before research was conducted for the DW project, cultural resource investigations in the project area were limited. In 1943, two prehistoric archaeological sites (assigned the numbers CA-CCo-146 and -147 by the California Archaeological Inventory) were recorded in the southwest portion of Holland Tract. CA-CCo-146 was partially excavated by Elsasser in 1954 after burials were uncovered (Elsasser 1954). In the early 1970s, a site believed to be CA-CCo-146 was excavated by the University of California, Davis, after burials were inadvertently discovered by the landowner. In 1985, a small portion of the southern part of Holland Tract was surveyed, but no additional resources were discovered (Hampson 1985).

Previous historic research within the project area was also limited. In the late 1970s, a study of the Delta waterways, which included some resources in the project area, was conducted (Paterson et al. 1978). In 1980, resources in the project area were discussed in an ethnic survey project conducted by the State Office of Historic Preservation (Fujita 1980). This study identified the resources on Bacon Island as being of historic and ethnic importance.

In 1989, cultural resource inventories were initiated for the DW project for compliance with CEQA, NEPA, and NHPA by PAR Environmental Services (PAR) under contract to JSA. PAR conducted archival research and reconnaissance-level field surveys, recorded architectural properties and archaeological resources for all four islands, and made preliminary recommendations regarding the significance of the resources identified (Maniery and Syda 1989).

In 1992, JSA retained PAR to evaluate the historic-period archaeological and architectural resources within the project area for their eligibility for listing in the NRHP. BioSystems Analysis was requested to evaluate the prehistoric resources for NRHP eligibility. These evaluative studies were completed in 1993. In April 1994, the SHPO concurred that CA-CCo-147 and CA-CCo-678 were eligible for listing in the NRHP and that CA-CCo-146 and CA-CCo-594 were not eligible for listing (Widell pers. comm). Later in that same year, the SHPO concurred that the Bacon Island Rural Historic District was eligible for NRHP listing (Widell pers. comm.). See the section below entitled "Determination of Resource Significance" for additional information about the SHPO's determination of eligibility for these resources.

Cultural Context

The following is a summary of the cultural context of the DW project area. This information is extracted from a more complete discussion provided in Appendix M1.

Prehistory

In the Delta, among areas of greatest prehistoric archaeological sensitivity are those where Piper soils are located. Piper soils represent relic sand hills that once stood above the level of the surrounding tule marshes. Because of their elevation above the frequently inundated peat soils, these sand mounds were often used by prehistoric peoples for village and burial sites. Surface evidence of prehistoric sites in this setting is scarce because Piper soils are often covered with peat. Many more sites probably exist on the islands than have been discovered to date.

The earliest recognized use of the Delta region dates from approximately 2500 B.C. to 1000 B.C. and is known as the Early Horizon. Burials from this period have been found in the lower levels of indurated Piper sand mounds.

Middle Horizon sites, dating from approximately 1000 B.C. to A.D. 500, have also been found in the Delta. Sites dating to this period often contain substantial living refuse (midden). Middle Horizon burials are found primarily in flexed positions.

The period between A.D. 500 and the arrival of the Spanish in central California has been named the Late Horizon. This period is characterized by large village sites, increasing evidence of acorn and nut processing, the introduction and use of the bow and arrow, and the use of clam shell disc beads as the primary medium of exchange. During the last part of the period, cremation became a common mortuary practice.

Ethnography

The DW project area is situated at the interface of three different ethnolinguistic groups that used the region before European contact: the Plains Miwok, the Bay Miwok, and the Northern Valley Yokuts. Levy (1978) places Holland Tract within the boundaries of the Plains Miwok; however, settlement and territorial boundaries of the Plains Miwok have long been the subject of controversy in California ethnography. The following summarizes ethnographic information for the three groups.

The tribelet was the largest political unit of the Miwok. The Plains Miwok had about 28 such divisions (Bennyhoff 1977). Within each tribelet were several more or less permanently inhabited settlements and a larger number of seasonal campsites (Levy 1978). The Plains Miwok are thought to have numbered about 11,000; their population density was probably the highest of any group in aboriginal California, averaging over 10 persons per square mile (Baumhoff 1963). The Plains Miwok were subject to missionization in the early part of the nineteenth century, and converts from the westernmost Delta began appearing in baptismal records of Mission San Jose in 1811.

The Bay Miwok were the first of the Eastern Miwok peoples to be missionized, with converts coming from the Saclan tribelet to Mission San Francisco in 1794 (Levy 1978). The Bay Miwok aboriginal population is estimated to have been about 1,700.

The Yokuts had miniature tribes of approximately 300 people, with most of the members of a tribe congregated in one principal settlement with a headman. No precise idea of the size of the aboriginal population of the Northern Yokuts can be arrived at from Spanish accounts; however, two estimates place the total at 25,100 (Cook 1955) and 31,404 (Baumhoff 1963). The native population was not evenly distributed but was clustered in a narrow strip of land bordering the San Joaquin River and its main tributaries (Wallace 1978). The Yokuts were profoundly affected by diseases brought by Euroamericans and by being removed to the missions on the coast.

All three groups occupied large multiple-family villages. The preferred location for settlement was on elevated terraces near streams. Most settlements were inhabited permanently, except during a period of several weeks each year during the fall acorn harvest. Acorns were a staple augmented by various seeds, nuts, roots, berries, and greens. Fishing was very important in both the Miwok and Northern Valley Yokuts economies (Bennyhoff 1977, Levy 1978).

History

Until the Gold Rush of the 1840s and 1850s, the Delta was a network of waterways and natural islands of sand and peat. The Swamp and Overflow Land Act of 1850 opened the Delta for speculation by land developers (Thompson and West 1879). Land ownership of the Delta islands and development of reclamation districts began in the 1850s; however, it was not until the late 1860s that massive efforts were initiated to seriously reclaim the land for farming.

The initiation of reclamation of Bouldin Island in the 1870s brought recognition of the richness of the peat soils and their value for agricultural purposes. Reclamation efforts went hand in hand with extensive construction of ditch systems and pump stations around the islands as a means of draining water, leading to even more acres being planted in crops. Agriculture on Bouldin Island was successful in the 1880s and grew in importance into the 1900s.

The first attempts to commercially grow asparagus were made on Bouldin Island in 1892, and the venture led to the fame of the Delta as the "asparagus capital" of the world. Asparagus, potatoes, beans, and grains were the primary crops grown on the islands before 1900 (Chan 1986). In 1910, farming on the islands focused on potatoes and onions (Sierra Art and Engineering Company 1910).

In the 1880s and early 1890s, most farming was conducted by Chinese laborers. By the late 1890s, Japanese immigrants were steadily arriving in America and joining the Chinese work force. They were aided in their endeavor to find work by George Shima, a fellow immigrant who arrived in America in 1889 and began working as a laborer at a potato farm along the coast (Fujita 1980, Hata and Hata 1986). By 1894, Shima had begun to experiment with potato growing in the Delta on land he leased at Staten Island, and by 1909, Shima was known as the Potato King (Yoshimura 1981).

As early as 1900, Delta farmers devised a series of camps to facilitate cultivation of vast fields on the islands, and Shima's holdings were no exception. The camps functioned as autonomous units. Each had its own housing, cooking facilities, barn, sheds, horses, and farm implements. In addition, large warehouses used for packing, storing, and processing crops were located on tops of levees near the landing or wharf (Chan 1986, Paterson et al. 1978).

By 1917, Shima had 17 camps on Webb Tract, 12 on Holland Tract, and 12 on Bacon Island, as well as headquarters on Webb Tract and Bacon Island (Widdows 1917). Shima operated the camps under a lease with the California Delta Farms Company, of which he was a shareholder. In addition, Shima maintained a residence at camp no. 1 on Bacon Island, and his headquarters office for the Delta was located in camp no. 3 on Bacon Island (Fujita 1980). Following completion of reclamation of Bouldin Island in 1918, 37 camps were also built around the perimeter of that island (Budd and Widdows 1926).

Today, Bacon Island, Bouldin Island, and Webb Tract are still used primarily for agriculture. Portions of Holland and Webb Tracts and Bouldin Island are used for grazing sheep and cattle, and there are hunting clubs and two marinas on Holland Tract.

Research Methods

The inventory phase of the cultural resources investigation consisted of archival research, field surveys, site recordation, and preliminary assessments of resource significance.

Prefield research was conducted at the following repositories:

- the Northwest Information Center at Sonoma State University and the Central Information Center at California State University, Stanislaus;
- the State Office of Historic Preservation;
- the NAHC;
- California State Library; and
- Reclamation's Sacramento office.

Census materials, maps, and written histories were checked to identify landing sites, agricultural operations and camps, and other activity sites on the islands. County offices were also contacted for information they might have on cultural resources in the project area. In addition, several Japanese American organizations, including the National Japanese American Historical Society, Japanese American Historical Museum, Japanese American Citizens League, and Haggin Pioneer Museum were contacted for information.

Following the archival research, a reconnaissance-level field survey of the project area was conducted. In consultation with the lead state and federal agencies, a sampling strategy was developed for the inventory. Areas believed to have little potential for archaeological resources because they would have been seasonally inundated were subjected to a 20% sample survey. Areas with high potential for prehistoric archaeological materials, such as the Piper sand mounds, were subjected to a 100% survey. Areas identified during archival research as having potential for historic or prehistoric remains were also surveyed completely.

Areas to be sample surveyed were selected to provide representative coverage of the entire project area. Researchers walked transects 20-30 meters apart (20 meters on Piper soils) across each of the areas selected for survey. Approximately 100 acres of Piper sand mounds on Holland Tract could not be surveyed because they are not owned by or under control of DW.

An architectural survey was also conducted by PAR. This work included identifying and recording all potentially historic structures on the four islands. For each structure built before 1946, the structure was photographed and numbered, its physical location was mapped, and a California Historic Site Inventory form was completed. Because many of the structures had the potential for archaeological deposits, California Archaeological Inventory forms were also completed for some of these resources.

Following the inventory, PAR conducted significance evaluations, including archival and oral history research and archaeological test excavations of the historic-period resources. BioSystems Analysis conducted test excavations and evaluated the significance of prehistoric resources. Determination of eligibility and effect reports were prepared and submitted to the SHPO for concurrence. Documentation of this consultation is available for review at the Corps' Sacramento office.

Inventory Findings

The archival research and field surveys of the DW project islands revealed the presence of many cultural resources. The following section summarizes PAR's report (Maniery and Syda 1989) and describes the resources identified and recorded on the four islands. The following discussion does not include descriptions of isolated artifacts and features. For a complete listing of resources identified on each island, see Tables M2-1 through M2-4 in Appendix M2, "Cultural Resource Survey Information for the Delta Wetlands Project Islands".

Resources with archaeological deposits or the potential for archaeological deposits were assigned trinomials by the California Archaeological Inventory. Locations where only architectural remains were found are identified with numbers assigned during the survey. Enumeration of isolated artifacts varies for different Information Centers of the California Archaeological Inventory. Isolated artifacts found on Bacon and Bouldin Islands were assigned isolated artifact numbers by the Central California Information Center. These resources are denoted with an "I" in Tables M2-3 and M2-4 in Appendix M2. Isolated artifacts are not numbered by the Northwest Information Center, so the numbers assigned during the survey are used.

Bacon Island

Resources on Bacon Island consist of historic-period archaeological sites and architectural properties; no records or evidence of prehistoric sites have been found. The resources identified on Bacon Island are listed in Table M2-1 in Appendix M2.

Most of the historic resources on Bacon Island are related to agricultural development and use. Bacon Island once had 12 main work camps, at least two auxiliary camps, a headquarters, and associated landings all built by George Shima between 1915 and 1918. Standing historic structures were identified at 10 of the main work camps, one of the auxiliary camps, and the bridge tender's residence. Identified buildings included bunk, boarding, and foremen's houses; kitchens; sheds; wash houses; lavatory facilities; offices; and barns. The majority of the structures are of Craftsman design, characterized by steep- or low-pitched, end- and side-gabled roofs, exposed rafters, porches supported by square columns, multipane or single-pane windows, and paneled doors.

The remains of the 1870-1910 site of Day's Landing is also present on the island. This site is also the location of Shima's labor camp no. 5.

Webb Tract

Five of the seven resources identified on Webb Tract are isolated historic-period features or artifacts. Two resources are architectural/archaeological sites. No prehistoric resources have been found on the tract. Table M2-2 in Appendix M2 lists the resources on Webb Tract.

Site number CA-CCo-584H on Webb Tract consists of a large one-story, Craftsman-style house with a low-pitched and gabled roof, exposed rafters, and multipane windows. The site is located on top of a sand mound, and a historic artifact scatter is associated with the structure. CA-CCo-584H marks the location of camp no. 1. A second Craftsman-style structure (CA-CCo-583H), built about 1915, is located at the ferry terminus of the Jersey-Bradford-Webb ferry and is used by the ferry operator.

The remaining resources on Webb Tract include two isolated cement pads and three locations with isolated fragments of glass or ceramic material. The remaining labor camps have been bulldozed or dismantled and no longer exist.

Although no prehistoric resources have been identified, Webb Tract contains several areas of Piper sandy loam soils. These high-sensitivity areas for prehistoric resources were examined in detail during the field survey, and no surface evidence of prehistoric resources was found. However, burials have reportedly been removed from Piper sand mounds on the tract (Maniery pers. comm.). Subsurface sampling or testing is not practicable, given the acreage (approximately 330 acres of Piper sand) involved.

Bouldin Island

Thirteen historic-period resources were identified on Bouldin Island, consisting of five historic sites and eight isolated features or artifacts, representing two landings, six camps, and a pumping station. No records or evidence of prehistoric sites have been found on the island. Table M2-3 in Appendix M2 lists the resources identified on Bouldin Island.

The five archaeological sites include CA-SJo-205H and -207H, which are trash scatters with 1920-era artifacts located in plowed fields. These two sites have been severely damaged by plowing activities, and the precise location of their origin could not be ascertained. Site CA-SJo-206H is an intact trash deposit near the location of historic labor camp no. 25. Site CA-SJo-208H is the historic location of Schultz Landing, dated to about 1873, and was also used by Shima as labor camp no. 1 during the 1920s. Structural foundations and historic artifacts were found at this location.

CA-SJo-209H is still used by the Bouldin Farming Company and is the site of the 1920s camp No. 21. Two Craftsman-style boarding houses with exposed rafters, pitched and gabled roofs, louvers, recessed porches, and paneled doors are situated on the top and sides of the levees. Bulldozed foundation slabs and modern structures are also present at the site.

Some historic locations on the island are represented by an isolated concrete foundation with no associated historic material. Others have been virtually destroyed through agricultural use.

Holland Tract

Prehistoric Resources. Four prehistoric archaeological sites and three isolated artifacts have been identified on Holland Tract (Table M2-4 in Appendix M2). Two of the resources (CA-CCo-146 and -147) were recorded previously. CA-Co-146 was recorded in the southwest corner of the island, and CA-CCo-147 was recorded about 1,000 feet north. Both sites were located on Piper sand mounds. Although CA-CCo-147 was reportedly destroyed (Cook and Elsasser 1956), PAR relocated and rerecorded the site during its survey. Cultural materials noted during the field survey included animal and human bone fragments; shell, obsidian, and chert flakes; and stone implements. Local landowners reported that approximately 70% of the site was washed away during the 1980 flood, although sand extraction is also said to have contributed to the mound's reduced size.

Some confusion exists about the location and condition of CA-CCo-146. CA-CCo-146 was excavated in 1954 by Elsasser after a landowner reported finding burials (Elsasser 1954, Hampson 1985). Elsasser removed four burials from the site, including an infant buried with many ceremonial artifacts. A report prepared by Cook and Elsasser (1956) indicated that following the 1954 excavation, a farmer leveled the mound for agricultural use. The area where CA-CCo-146 was plotted was surveyed by PAR, but no cultural materials were identified at that location.

Subsequent to PAR's survey, earthmoving work conducted by reclamation district personnel uncovered disarticulated human remains and a single artifact east of the recorded locations for both CA-CCo-146 and -147. PAR staff examined the find and supervised its reburial. No midden or other cultural material was observed at the location. Because it was not determined whether the materials represented an archaeological site, this resource was not recorded and was subsequently referred to as the "unrecorded resource".

Information obtained recently from the University of California, Davis, supports the theory that CA-CCo-146 was misplotted originally and that the unrecorded resource is actually the remnants of CA-CCo-146 (BioSystems Analysis 1993). This site was excavated by the University of California, Davis, in 1973 after burials were uncovered by the landowner. Several burials were excavated and are curated at the University of California, Davis. Given the uncertainty regarding the location of CA-CCo-146, a new trinomial (CA-CCo-678) was assigned to this location.

In addition to the previously recorded sites, PAR identified and recorded two new sites (CA-CCo-593 and -594). CA-CCo-593 is a prehistoric occupation site on a Piper sand mound near the center of the tract. The top of the mound was plowed in the past, exposing burned and unburned human remains. During PAR's examination, shell beads, chipped and ground stone tool implements, obsidian and chert flakes, animal bone fragments, disarticulated human remains, and charcoal were noted on the surface of the site.

CA-CCo-594, situated in the north-central portion of Holland Tract, consists of the remaining portion (approximately 5%) of a Piper sand mound. Most of the site was removed while the mound was being excavated for use in levee reconstruction and repair work. A few pieces of chipped stone, a bone fragment, and one stone implement were found in this location.

In 1989, following the inventory, CA-CCo-147 and CA-CCo-593 were damaged by unauthorized excavations by a Native American determined by the NAHC to be the most likely descendant. These excavations were reportedly conducted to locate human remains.

Additional archaeological resources that were not identified during the survey may be present on Holland Tract. Buried deposits and human remains have been found in Piper sands on Holland Tract and other islands. In many cases, no cultural materials are found above these deposits and burials, making their discovery problematic. Subsurface sampling or testing is not practicable, given the acreage (approximately 220 acres of Piper sand) involved.

In addition, approximately 100 acres of Piper sand mounds on the southwest portion of the island could not be surveyed because DW does not own or control this parcel, and access was not granted to conduct surveys. Undiscovered resources may be present on this parcel.

Historic-Period Resources. Of the 12 work camps on Holland Tract in 1917, only the remnants of two (CA-CCo-585H and -586H) remain (Table M2-4). CA-CCo-585H consists of Craftsman-style buildings among modern structures. These structures are used seasonally as a duck hunting club. CA-CCo-586H marks the 1917 location of camp no. 5. Other sites have been bulldozed and destroyed. The 1980 flood reportedly damaged many of the historic structures on the perimeter of the island, leading to their demolition (Hampson 1985). Concrete pads and pier blocks are all that remain at these locations.

Determination of Resource Significance

There are three sets of criteria for assessing cultural resource significance: NRHP eligibility criteria, CEQA significance criteria, and NEPA significance criteria. Following is the definition of the NRHP criteria for eligibility:

> The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects of state and local importance that possess integrity of location, design, setting, materials, workmanship, feeling and association, and that:
>
> A. are associated with events that have made a contribution to the broad pattern of our history;
>
> B. are associated with the lives of people significant in our past;
>
> C. embody the distinct characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> D. have yielded, or are likely to yield, information important in prehistory or history (36 CFR 60.6).

Under CEQA, important cultural resources are described as:

- being associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage;
- being associated with the lives of persons important in our past;
- embodying the distinctive characteristics of a type, period, region, or method of construction, or representing the work of an important creative individual, or possessing high artistic values; or
- having yielded or likely to yield information important in prehistory or history (State CEQA Guidelines Section 15064.5).

Determination of resource significance for NEPA includes resources considered significant by:

- inclusion in the records of recognized organizations, such as the NRHP, National Historic Landmarks, Points of Historical Interest, Native American Heritage Commission sacred lands files, and city and county registers;
- public groups, such as Native American groups and historical societies; and
- technical and professional groups and individuals.

Section 106 of the NHPA, NEPA, and CEQA require consideration of effects of projects on traditional cultural values. Resources with contemporary or sacred values to Native Americans are considered significant. Because this project also requires compliance with Section 106 of the NHPA, the impact assessment uses the NRHP significance criteria to assess project effects.

Bacon Island

PAR's 1989 research and inventory found that the resources on Bacon Island represent a cohesive record of agricultural development in the Delta. For this reason, PAR recommended, and the SHPO concurred, that Bacon Island was eligible for NRHP listing as a district under 36 CFR 60.4 criteria of (a) historic events, (b) significant people, (c) architecturally distinctive structures, and (d) important sources of information.

PAR's study further recommended that additional work be conducted to determine the boundaries, contributing elements, and period of significance of the potential historic district. In 1992, PAR conducted the additional archival and oral history research and prepared a determination of NRHP eligibility for the Bacon Island historic district. The following is extracted from PAR's report (PAR 1993a).

Ten labor camps on the island and one bridge tender's residence remain on Bacon Island. A total of 105 buildings were associated with the camps. In addition to the buildings, two pump houses, siphons, canals, agricultural fields, and a modern farming headquarters are present. Five of the camps appear to have archaeological elements, and two other archaeological sites exist on the island.

Given the general theme of the island (agriculture), the condition of the existing camps, and the water conveyance and pumping system, PAR recommended that the resources on Bacon Island meet the NRHP's definition of district. The cultural landscape, water system, camp architecture and layout, and pump house locations are all integral parts of the operation of Bacon Island. The association of the island and the camps with Japanese farmworkers and other ethnic groups qualifies the district as being eligible for listing in the NRHP under Criterion A. The involvement of George Shima in island reclamation, camp construction, and ongoing farming operations qualifies the district as being eligible for listing in the NRHP under Criterion B.

Bacon Island resources are an intact example of architectural styles (vernacular Craftsman) and camp layout once found throughout the Delta, making the district eligible for listing in the NRHP under Criterion C. Finally, seven known archaeological sites are present on the island, and these sites contain material that is important to ongoing research on Japanese-American culture. Therefore, it has been determined that the district meets NRHP eligibility Criterion D (Widell pers. comm).

Webb Tract

Six of the seven resources recorded on Webb Tract are not potentially eligible for NRHP listing because of their lack of research potential, isolated nature, or common occurrence throughout the Delta region (Maniery and Syda 1989). PAR suggested that CA-CCo-584H was potentially eligible for NRHP listing and recommended that further work be conducted to determine the extent and integrity of the subsurface deposits and the site's research potential.

In 1992, PAR conducted a test excavation at CA-CCo-584H and determined that most of the artifacts dated to circa 1950s to 1970s. Some older materials were located but only in disturbed contexts. This site was recommended as not meeting the criteria for NRHP eligibility (PAR 1993b); the SHPO concurred with this recommendation (Widell pers. comm).

Bouldin Island

In 1989, PAR suggested that CA-SJo-206H and CA-SJo-208H were potentially eligible for listing in the NRHP and that further investigations of the subsurface integrity and research potential of the resources be conducted. In 1992, PAR conducted test excavations at the two sites to determine whether they were eligible for listing in the NRHP. Few artifacts were found at CA-SJo-206H and most dated to post-1940. Given the paucity of the remains and their recent age, the site did meet the criteria for NRHP eligibility (PAR 1993b); the SHPO concurred with the finding (Widell pers. comm.).

CA-SJo-208H contained two intact refuse features with 1920s bottles, ceramics, and metal. PAR recommended that materials from this site have the potential to address research questions, and the SHPO concurred that the site is thus eligible for listing in the NRHP under Criterion D (PAR 1993b, Widell pers. comm).

Holland Tract

PAR recommended that CA-CCo-147, -593, and -594 are potentially eligible for NRHP listing under Criterion D because of their potential to yield information important in reconstructing prehistoric lifeways and economic exchange patterns and in answering questions concerning the development of prehistoric culture in the Delta. The standing structures on the tract are not unique in the Delta region and are not considered potentially eligible for NRHP listing. Other resources on the island consist of isolated prehistoric artifacts or historic cement foundations and are not eligible for NRHP listing.

Subsequent to the completion of PAR's report, human remains and cultural materials believed to mark the location of CA-CCo-146 were identified. Because consultation with lead state and federal agencies regarding which sites required further evaluative studies, this site was added to those recommended by PAR for additional work. At that time, it was decided that no further work was necessary at CA-CCo-594 because too little of the site remained for it to be eligible for NRHP listing. The SHPO concurred with this finding (Widell pers. comm).

In 1992, BioSystems Analysis conducted test excavations at CA-CCo-147, CA-CCo-593, and CA-CCo-678. BioSystems Analysis determined that CA-CCo-147 contained intact subsurface deposits and intact burials. BioSystems Analysis recommended and the SHPO concurred that CA-CCo-147 is eligible for listing in the NRHP and is also important because of the values that Native Americans place on burials (BioSystems Analysis 1993, Widell pers. comm).

CA-CCo-593 consisted of a shallow disturbed deposit with few artifacts and disarticulated human remains. This site was not recommended for listing in the NRHP and the SHPO concurred with that finding (Widell pers. comm). However, the site may contain intact burials with importance to Native Americans.

CA-CCo-678 does not contain intact archaeological deposits and does not meet NRHP eligibility Criterion D for its archaeological value. However, intact human remains that have importance to Native Americans have been found at this site; therefore, it was determined that this site met NRHP eligibility criteria (Widell pers. comm).

In addition to the known sites on Holland Tract, additional buried resources on the 100-acre parcel that were not surveyed may exist. Given the scarcity of these types of resources and the fact that they often contain burials, these resources are likely to be significant.

Programmatic Agreement for Section 106 Compliance

In compliance with Section 106, a Programmatic Agreement (PA) among the Corps, SWRCB, the SHPO, the ACHP, and Delta Wetlands Properties regarding the implementation of the Delta Wetlands Project was drafted in December 1997. The PA calls for an inventory of the remaining unsurveyed area of the APE, and the evaluation of any properties recorded as a result of this survey for NRHP eligibility. The PA also calls for the development and implementation of a Historic Properties Management Plan (HPMP), which, among other tasks, will call for the development of monitoring plans and data recovery plans as necessary. Other subjects addressed in the PA include procedures for: changes in the undertaking or APE; inadvertent discovery of cultural materials or human remains during project implementation; participation of interested parties; review, consultation, and coordination among the USACE, SWRCB, the SHPO, and the ACHP; curation and disposition of cultural and human remains; and dispute resolution. Appended to the PA are outlines for the HPMP and Data Recovery Plan(s).

IMPACT ASSESSMENT METHODOLOGY

Analytical Approach and Impact Mechanisms

Impacts could result from the following elements of the DW project alternatives:

neglect of historic properties, resulting in their deterioration or destruction;

demolition of buildings or structures;

placement of fill for levee construction and periodic replenishment and other components of construction (e.g., sand borrowing and construction of siphons and pumps) that affect historic properties;

flooding of islands for water storage resulting in the wet/dry cycling and saturation of cultural materials and human remains;

wave erosion of the archaeological sites during flooded periods;

ground disturbance related to habitat management or enhancement activities that could disturb historic properties; and

presence of hunters and others increasing the potential for vandalism of archaeological sites on the islands.

Criteria for Determining Impact Significance

Section 106 of the NHPA, NEPA, and CEQA describe the criteria for impact assessment for cultural resources. Under Section 106, three possible findings of effect can be made: no effect, no adverse effect, and adverse effect. ACHP regulations define an undertaking as having an effect on historic property when the undertaking:

> may alter the characteristics of the property that may qualify the property for inclusion in the NRHP, including alteration of the property's location, setting, or use. An undertaking may have an adverse effect when the effect on a historic property may diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Adverse effects on historic properties include, but are not limited to:
>
> # physical destruction or alteration of all or part of the property;
>
> # isolation of the property from or alteration of the property's setting when that character contributes to the property's qualification for the NRHP;
>
> # introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting;
>
> # neglect of a property resulting in its deterioration or destruction; and
>
> # transfer, lease, or sale of the property (36 CFR 800.9).

Note that these are the ways in which adverse effects can occur; not all these elements would result from implementation of the DW project alternatives.

Under CEQA, an impact is considered significant if the project may cause substantial adverse change in the significance of an important cultural resource as defined in Pub. Res. Code Section 5020.1(j) and 5024.1.

Impacts would be significant under NEPA if a project would diminish the integrity of a resource's location, design, setting, materials, workmanship, feeling, or association or cause the loss or destruction of significant scientific, cultural, or historical resources (40 CFR 1508.27).

Section 106 of the NHPA, NEPA, and CEQA require consideration of effects of projects on traditional cultural values. Significant impacts would occur if areas with contemporary or sacred values to Native Americans would be adversely affected by the project.

An impact would be considered beneficial if it would result in the protection, stabilization, or restoration of cultural properties listed or eligible for listing in the NRHP or sites determined to be important under CEQA.

Less-than-significant impacts would occur if sites determined ineligible for listing in the NRHP or sites not considered important under CEQA were affected by the project.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands) and management of Bouldin Island and most of Holland Tract (habitat islands) primarily as wildlife habitat.

This section describes the impacts of Alternative 1 on cultural resources and outlines mitigation measures that may avoid, minimize, rectify, reduce, or compensate for the predicted impacts. Determination of which mitigation measures would be required has been made by the lead state and federal agencies in consultation with the SHPO as part of the determination and eligibility and effect process, as required by Section 106 of the NHPA. The NAHC and appropriate Native American groups have been consulted. Implementation of the selected mitigation measures will be ensured through the execution of the PA. Signatories to the PA are DW, the Corps, SWRCB, the SHPO, and ACHP. The PA requires that an HPMP be prepared to outline the specific mitigation for each site affected by the project.

Prehistoric Resources

Bacon Island

No NRHP-eligible prehistoric resources are present on Bacon Island. Therefore, no impacts are anticipated.

Webb Tract

No NRHP-eligible prehistoric resources have been identified on Webb Tract; however, 335 acres of Piper sands that could contain buried resources are present on the tract. In addition, burials have reportedly been uncovered on Webb Tract in the past.

Bouldin Island

No NRHP-eligible prehistoric resources are present on Bouldin Island. Therefore, no impacts are anticipated.

Holland Tract

CA-CCo-593, a prehistoric archaeological site, is within the APE for Alternative 1. The site consists of a shallow disturbed deposit with few artifacts and disarticulated human remains. This site is not eligible for listing in the NRHP under Criterion D for its archaeological value. Although no intact burials were found at CA-CCo-593, their presence cannot be ruled out, given the amount of disarticulated skeletal materials observed during the survey and test excavation. If intact human remains are present at the site, they may have importance to Native Americans. In addition, Piper sands on Holland Tract could contain buried resources.

Summary of Project Impacts and Recommended Mitigation Measures

Impact M-1: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Webb Tract. Because the value of archaeological resources often depends on their integrity, project activities that disturb buried resources could render them insignificant. If significant buried resources are present on Webb Tract and they are disturbed by implementation of the alternative, such disturbance would be considered a significant impact. Implementing Mitigation Measure M-1 would reduce Impact M-1 to a less-than-significant level.

Mitigation Measure M-1: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract. Prior to implementation of Alternative 1, the project applicant shall prepare an HPMP that will specify notification procedures in the event of discovery of cultural materials or human remains in the archaeologically sensitive Piper sand deposits. The HPMP will include a monitoring plan to address impacts resulting from inadvertent discovery of cultural resources and human remains, and will outline treatment and management requirements for these resources. Treatment of archaeological resources usually consists of data recovery excavations designed to retrieve important information that would be lost as a result of project implementation. If human remains are identified, consultation with the NAHC will be required for development of appropriate mitigation measures.

Impact M-2: Disturbance of Intact Burials at CA-CCo-593 (If Present) on Holland Tract. Ground-disturbing activities, such as plowing and planting, associated with habitat management or enhancement could uncover previously undiscovered burials at CA-CCo-593. Disturbance of intact burials would be considered a significant impact.

Implementing Mitigation Measure M-2 would reduce Impact M-2 to a less-than-significant level.

Mitigation Measure M-2: Design Habitat Management and Enhancement Activities to Prevent Disturbance of CA-CCo-593 on Holland Tract. Prior to implementation of Alternative 1, the project applicant shall prepare an HPMP that considers the possibility that intact human remains exist at CA-CCo-593. The HPMP will specify that no deep plowing (more than 18 inches deep) or planting of invasive vegetation will be permitted on the site. Currently, the HMP calls for the area to be planted in herbaceous grasses (see Appendix H3, "Habitat Management Plan for the Delta Wetlands Habitat Islands").

Impact M-3: Disturbance of Intact Burials in CA-CCo-593 (If Present) Resulting from Vandalism on Holland Tract. Implementation of Alternative 1 could result in disturbance of intact burials, if they are present at CA-CCo-593, as a result of increased visitation and the potential for pot hunting and vandalism. Disturbance of intact burials would be considered a significant impact. Implementing Mitigation Measure M-3 would reduce Impact M-3 to a less-than-significant level.

Mitigation Measure M-3: Prepare an HPMP to Address Disturbance of Human Remains at CA-CCo-593 on Holland Tract. Prior to project implementation, the project applicant shall prepare an HPMP that specifies the notification procedures that will be followed if intact human remains are discovered at CA-CCo-593. The HPMP will include a monitoring plan to address impacts resulting from inadvertent discovery of human remains, pot hunting, and vandalism and will outline treatment and management requirements for human remains should they be discovered. Consultation with the NAHC will also be outlined in the HPMP. Treatment could include measures such as ceasing ground-disturbing activities on the site, fencing the site to prevent access, and increasing monitoring of the site. If the burials cannot be protected, treatment could include removing them from the site and reburying them elsewhere.

Impact M-4: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Holland Tract. Piper sands on Holland Tract could contain buried resources. Ground-disturbing activities, such as plowing and planting associated with habitat management or enhancement, could uncover previously undiscovered resources on Holland Tract. Because the value of archaeological resources often depends on their integrity, project activities that disturb buried resources could render them insignificant. If significant buried resources are present and they are disturbed by implementation of Alternative 1, such disturbance would be considered a significant impact. Implementing Mitigation Measure M-4 would reduce Impact M-4 to a less-than-significant level.

Mitigation Measure M-4: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Holland Tract. Prior to project implementation, the project applicant shall prepare an HPMP that will specify notification procedures in the event of discovery of cultural materials or human remains in the archaeologically sensitive Piper sand deposits. The HPMP will include a monitoring plan to address impacts resulting from inadvertent discovery of cultural resources and human remains and will outline treatment and management requirements for these resources. Treatment of archaeological resources usually consists of data recovery excavations designed to retrieve important information that would be lost as a result of project implementation. If human remains are identified, consultation with the NAHC will be required for development of appropriate mitigation measures.

Historic-Period Resources

Bacon Island

Historic resources on Bacon Island constitute the Bacon Island Rural Historic District, an NRHP-eligible property. Findings indicate that 10 labor camps and one bridge tender's residence, totaling 106 buildings, are contributing elements to the district. In addition, there are two pump houses, siphons, canals, agricultural fields, and a modern farming headquarters on Bacon Island. Five of the camps appear to have archaeological elements, and two other archaeological sites on the island that are not associated with labor camps exist.

Because properties on Bacon Island are eligible for NRHP listing as a historic district, the effect of implementation of Alternative 1 on the district as a whole must be assessed. The definition of an NRHP district implicitly recognizes that the importance of the whole is greater than the sum of its contributing parts. By definition, the loss of a single contributing element within an NRHP district has a deleterious effect on the integrity and research potential of the remaining contributing elements and on the district as a whole. If a project component affects one contributing element of the district, it affects the entire district.

The majority of NRHP-eligible resources on Bacon Island will be affected by reconstruction of the levees and inundation. Most of the structures lie on the perimeters of the islands in areas that would be disturbed by reconstruction of levees. Structures on the sides or near the bases of levees would be subject to significant impacts resulting from fill placement.

Webb Tract

No historic-period resources eligible for NRHP listing are present on Webb Tract. Therefore, no impacts are anticipated.

Bouldin Island

One historic archaeological site (CA-SJo-208H) on Bouldin Island has been determined eligible for listing in the NRHP under Criterion D.

Holland Tract

No historic-period resources eligible for NRHP listing are present on Holland Tract. Therefore, no impacts are anticipated.

Summary of Project Impacts and Recommended Mitigation Measures

Impact M-5: Demolition of the NRHP-Eligible Historic District on Bacon Island. Although a small number of buildings may be preserved, most of the NHRP-eligible district will be demolished and inundated. This impact is considered significant and unavoidable. Mitigation measures can be implemented to recover some of the historical values that would be lost as a result of Alternative 1 implementation. Implementing Mitigation Measures M-5 through M-8 would reduce Impact M-5, but not to a less-than-significant level.

Mitigation Measure M-5: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island. Prior to project implementation, the project applicant shall prepare an HPMP that will outline how significant archaeological materials should be treated. The HPMP will require preparation of a data recovery plan that specifies how important archaeological data will be recovered.

Mitigation Measure M-6: Prepare a Video-tape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island. Prior to project implementation, the project applicant shall prepare a video that captures some of the qualities that make the historic district significant. This production should be prepared to meet the technical requirements for airing on the Public Broadcasting System (PBS), as specified in the PBS producers' handbook. To meet PBS requirements, the video must be at least 27 minutes long.

Mitigation Measure M-7: Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools. Prior to project implementation, the project applicant shall produce a popular publication to disseminate historical information on the NRHP-eligible historic district on Bacon Island to the public. This document should combine historical photographs with information gathered from historical research and interviews to describe the history of Bacon Island. The publication should be prepared for use by schools, historical societies, local museums, and the general public.

Mitigation Measure M-8: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island. Prior to project implementation, the project applicant shall complete architectural and engineering documentation for contributing elements in the NRHP-eligible historic district, consisting of measured drawings, photographs, and written data. These are used to preserve information about a historic building, site, structure, or object that may be demolished or subject to loss of historical integrity. Documentation may be included in the Historic American Building Survey and the Historic American Engineering Record Collections in the Library of Congress.

Impact M-6: Disturbance of Archaeological Site CA-SJo-208H on Bouldin Island. Archaeological site CA-SJo-208H could be affected by activities related to implementation of Alternative 1. Because the value of archaeological resources often depends on their integrity, project activities that disturb significant buried resources could render them insignificant. This impact is considered significant. Implementing Mitigation Measure M-9 would reduce Impact M-6 to a less-than-significant level.

Mitigation Measure M-9: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bouldin Island. Prior to project implementation, the project applicant shall prepare an HPMP that will outline how significant archaeological materials should be treated. The HPMP will require that a data recovery plan be prepared that specifies how important archaeological data will be recovered.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

The impacts and mitigation measures of this alternative are the same as those of Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation.

This section describes the impacts of Alternative 3 on cultural resources and outlines mitigation measures that may avoid, minimize, rectify, reduce, or compensate for the predicted impacts. Determination of which mitigation measures will be required has been made by the lead state and federal agencies in consultation with the SHPO as part of the determination of eligibility and effect process, as required by Section 106 of the NHPA. The NAHC and appropriate Native American groups have been and will continue to be consulted. Implementation of the selected mitigation measures will be ensured through the execution of a PA. A single PA covering all historic properties on the four islands that would be affected by the project has been prepared. Signatories to the PA are DW, the Corps, SWRCB, the SHPO, and ACHP. The PA requires that an HPMP be prepared to outline the specific mitigation for each site affected by the project.

Prehistoric Resources

Bacon Island

As described above under "Impacts and Mitigation Measures of Alternative 1", no prehistoric resources eligible for NRHP listing exist on Bacon Island; therefore, no impacts are anticipated.

Webb Tract

The effect of implementation of Alternative 3 on prehistoric resources on Webb Tract would be identical to that described above under "Impacts and Mitigation Measures of Alternative 1".

Bouldin Island

As described above under "Impacts and Mitigation Measures of Alternative 1", no prehistoric resources eligible for NRHP listing exist on Bouldin Island; therefore, no impacts are anticipated.

Holland Tract

Three prehistoric archaeological sites (CA-CCo-147, CA-CCo-593, and CA-CCo-678) on Holland Tract are eligible for NRHP listing under Criterion D or have other values that make them significant. CA-CCo-147 and CA-CCo-678 contain intact human remains and have been determined eligible for NRHP listing. No intact burials were found at CA-CCo-593; however, their presence cannot be ruled out, given the amount of disarticulated skeletal materials observed during the survey and test excavation.

Of the three sites, only CA-CCo-147 appears to retain a substantial archaeological deposit. CA-CCo-593 is shallow and disturbed. If CA-CCo-678 had a cultural deposit, most of it was removed during leveling of the mound. Piper sands on Holland Tract could contain buried resources. If buried resources are present, activities associated with implementation of Alternative 3 would result in significant impacts.

Approximately 100 acres of Piper sand mounds have not been surveyed because they are not owned or under the control of the project applicant, and the current owner did not permit the area to be surveyed. Additional significant resources could be present on this parcel.

These resources could be affected by several different mechanisms, including flooding of islands for water storage, resulting in wet/dry cycling and saturation of cultural materials and human remains; wave erosion of archaeological deposits during flooded periods; and presence of hunters and others, increasing the potential for vandalism on the islands.

Summary of Project Impacts and Recommended Mitigation Measures

Impact M-7: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Webb Tract. This impact is described above under Impact M-1. This impact is considered significant. Implementing Mitigation Measure M-1 would reduce Impact M-7 to a less-than-significant level.

Mitigation Measure M-1: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact M-8: Damage or Destruction of Known Archaeological Sites Resulting from Inundation, Wave Action and Erosion, or Vandalism on Holland Tract. Sites on Holland Tract could be affected by implementation of Alternative 3 because of inundation, wave action and erosion, or vandalism. These sites contain significant archaeological materials and/or burials with importance to Native Americans. Because the value of archaeological resources often depends on their integrity, project activities that disturb the resources could render them insignificant. Project activities could also disturb burials. Therefore, this impact is considered significant and unavoidable.

No mitigation is available to reduce this impact to a less-than-significant level because the sites contain values (i.e., human remains important to Native Americans) that are not amenable to mitigation through data recovery. Mitigation measures are available that would recover or protect some of the cultural values that would be lost as a result of project implementation. Implementing Mitigation Measures M-10 through M-14 would reduce Impact M-8, but not to a less-than-significant level.

Mitigation Measure M-10: Prepare an HPMP and Conduct Data Recovery Excavations (Only Appropriate for CA-CCo-147) for Archaeological Materials on Holland Tract. Prior to implementation of Alternative 3, the project applicant shall prepare an HPMP that will outline how significant archaeological materials should be treated. The HPMP will require that a data recovery plan be prepared that specifies how important archaeological data will be recovered from CA-CCo-147. Data recovery could include removal of burials.

Mitigation Measure M-11: Cap Archaeological Sites on Holland Tract. Where appropriate, prior to implementation of Alternative 3, the project applicant shall cap archaeological sites to protect sites from pot hunting and vandalism.

Mitigation Measure M-12: Construct Fencing or Other Barriers to Prevent Site Access on Holland Tract. Where appropriate, prior to implementation of Alternative 3, the project applicant shall construct fences or other barriers to restrict access to archaeological sites and help protect sites from pot hunting and vandalism.

Mitigation Measure M-13: Construct Levees or Beach Slopes around Archaeological Sites to Decrease Wave Action and Erosion on Holland Tract. Where appropriate, prior to implementation of Alternative 3, the project applicant shall construct levees or beach slopes around sites to reduce the potential for wave action and erosion.

Mitigation Measure M-14: Prepare an HPMP to Provide for the Long-Term Monitoring of Known Archaeological Sites on Holland Tract. Prior to implementation of Alternative 3, the project applicant shall prepare an HPMP that includes a monitoring plan to identify impacts on intact burials that could result from inundation, wave action and erosion, and vandalism. The HPMP will address treatment of intact burials in known sites that are inadvertently discovered during project construction and implementation. The HPMP will include notification procedures to be followed when intact burials are identified and will outline treatment and management requirements for human remains, should they be discovered. Treatment could include removing the burials from the site and reburying them elsewhere.

Impact M-9: Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Holland Tract. Piper sands on Holland Tract could contain buried resources. Inundation, wave action and erosion, and vandalism could uncover previously undiscovered resources on Holland Tract. Because the value of archaeological resources often depends on their integrity, activities associated with implementation of Alternative 3 that disturb buried resources could render them insignificant. If significant buried resources are present and they are disturbed by the project, such disturbance would be considered a significant impact. Implementing Mitigation Measure M-4 would reduce Impact M-9 to a less-than-significant level.

Mitigation Measure M-4: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Holland Tract. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact M-10: Disturbance of Unknown Resources on Unsurveyed Portions of Holland Tract. Approximately 100 acres of Piper sand mounds have not been surveyed because they are not owned or under the control of the project applicant, and the current owner did not permit the area to be surveyed. Ground-disturbing activities, inundation, wave action and erosion, and vandalism associated with implementation of Alternative 3 could uncover previously undiscovered resources on Holland Tract. Because the value of archaeological resources often depends on their integrity, project activities that disturb buried resources could render them insignificant. If significant buried resources are present and they are disturbed by the project, such disturbance would be considered a significant impact. Implementing Mitigation Measure M-15 would reduce Impact M-10 to a less-than-significant level.

Mitigation Measure M-15: Survey Unsurveyed Portions of Holland Tract and Determine Eligibility for NRHP Listing and Appropriate Treatment. Prior to implementation of Alternative 3, the project applicant shall survey the unsurveyed portions of Holland Tract to identify potentially significant cultural resources. If potentially significant cultural resources are identified, their significance and appropriate treatment will be determined in accordance with the stipulations of the PA. If significant resources are identified during the survey, mitigation measures similar to those specified for the known resources would be implemented.

Historic-Period Resources

Bacon Island

The effect of implementation of Alternative 3 on historic-period resources on Bacon Island would be identical to that described above under "Impacts and Mitigation Measures of Alternative 1".

Webb Tract

As described above under "Impacts and Mitigation Measures of Alternative 1", no historic-period resources eligible for NRHP listing exist on Webb Tract; therefore, no impacts are anticipated.

Bouldin Island

The effect of implementation of Alternative 3 on historic-period resources on Bouldin Island would be identical to that described above under "Impacts and Mitigation Measures of Alternative 1".

Holland Tract

As described above under "Impacts and Mitigation Measures of Alternative 1", no historic-period resources eligible for NHRP listing exist on Holland Tract; therefore, no impacts are anticipated.

Summary of Project Impacts and Recommended Mitigation Measures

Impact M-11: Demolition of the NRHP-Eligible Historic District on Bacon Island. This impact is described above under Impact M-5. This impact is considered significant and unavoidable. Implementing Mitigation Measures M-5 through M-8 would reduce Impact M-11, but not to a less-than-significant level. These mitigation measures are described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure M-5: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island.

Mitigation Measure M-6: Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island.

Mitigation Measure M-7: Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools.

Mitigation Measure M-8: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island.

Impact M-12: Disturbance of Archaeological Site CA-SJo-208H on Bouldin Island. This impact is described above under Impact M-6. This impact is considered significant. Implementing Mitigation Measure M-9 would reduce Impact M-12 to a less-than-significant level.

Mitigation Measure M-9: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bouldin Island. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The shift from current agricultural practices to more intensive agriculture on the DW project islands under the No-Project Alternative would barely alter existing conditions. On Bacon and Bouldin Islands and Webb Tract, changing crop types and weed management practices would have little effect on cultural resources. On Holland Tract, any intensification of activities that affected Piper soils could increase the extent and severity of disturbance of prehistoric resources. Reintroduction of hog feeding could affect the Piper sand mounds if animals are concentrated in those areas.

If the DW project does not proceed, cultural resources on the islands would nonetheless be disturbed, primarily by continued agricultural activity. Activities that would continue to affect the resources include grazing, plowing and planting, and levee construction and replenishment. The following describes the impacts that would result from implementation of the No-Project Alternative.

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Under strictly agricultural operations, mitigation of impacts on cultural resources would not be required under Section 106 of the NHPA, which applies only if federal funds or permits are required by a project. With the discovery of Native American burials on the Holland Tract sites, however, the California Public Health and Safety Code and the Public Resources Code apply, and the NAHC has the right to request appropriate reinterment of the remains. If agreement between the landowner and the NAHC cannot be reached, the landowner is nonetheless required to reinter the human remains and items associated with Native American burials with appropriate dignity on the property in a location not subject to further subsurface disturbance. Any disturbance or removal of human remains without authority of law is a felony under the California Public Health and Safety Code.

Prehistoric Resources

Bacon Island

As described above under "Impacts and Mitigation Measures of Alternative 1", no prehistoric resources eligible for NRHP listing exist on Bacon Island; therefore, no impacts are anticipated.

Webb Tract

No prehistoric resources eligible for NRHP listing have been identified on Webb Tract; however, 335 acres of Piper sands that could contain buried resources are present on the tract. In addition, burials have reportedly been uncovered on Webb Tract in the past.

Bouldin Island

As described above under "Impacts and Mitigation Measures of Alternative 1", no prehistoric resources eligible for NRHP listing exist on Bouldin Island; therefore, no impacts are anticipated.

Holland Tract

Three prehistoric archaeological sites (CA-CCo-147, CA-CCo-593, and CA-CCo-678) on Holland Tract are eligible for NRHP listing under Criterion D or have other values that make them significant. CA-CCo-147 and CA-CCo-678 contain intact human remains and are eligible for NRHP listing. No intact burials were found at CA-CCo-593; however, their presence cannot be ruled out, given the amount of disarticulated skeletal materials observed during the survey and test excavation.

Of the three sites, only CA-CCo-147 appears to retain a substantial archaeological deposit. CA-CCo-593 is shallow and disturbed. If CA-CCo-678 had a cultural deposit, most of it was removed during leveling of the mound. Piper sands on Holland Tract could contain buried resources. If buried resources are present, activities associated with implementation of the No-Project Alternative would adversely affect those resources.

Approximately 100 acres of Piper sand mounds have not been surveyed because they are not owned or under the control of the project applicant, and the current owner did not permit the area to be surveyed. Additional significant resources could be present on this parcel.

Summary of Project Impacts and Recommended Mitigation Measures

Disturbance of Buried Resources (If Present) in the Archaeologically Sensitive Piper Sands on Webb Tract as a Result of Agricultural Activities. No prehistoric resources eligible for NRHP listing have been identified on Webb Tract; however, approximately 335 acres of Piper sands on Webb Tract could contain significant buried resources. Because the value of archaeological resources often depends on their integrity, continued agricultural activities under the No-Project Alternative that disturb buried resources could render them insignificant. Implementing the following measure would reduce this effect of the No-Project Alternative.

Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Webb Tract. This measure is described above as Mitigation Measure M-1.

Damage to Known and Unknown Prehistoric Sites Resulting from Agricultural Activities on Holland Tract. There are three significant known prehistoric cultural resources on Holland Tract that would be disturbed by continued agricultural activities under the No-Project Alternative. The proximity of site CA-CCo-147 to corrals and salt blocks results in heavy use by cattle, leading to disturbance of the site. Plowing of CA-CCo-678 and CA-CCo-593 has exposed cultural materials and would continue to disturb the sites and possibly uncover human remains. Activities that have rendered CA-CCo-594 ineligible for listing in the NRHP (i.e., sand extraction) could further adversely affect CA-CCo-678, -147, and -593.

Additionally, Piper sands on Holland Tract could contain buried resources. If buried resources are present, continued agricultural activities could adversely affect those resources.

The integrity of the sand mounds that are known to contain or that potentially contain Native American burials and artifacts is threatened by the continued use by cattle and sand extraction. Continued deflation of peat soils caused by agricultural operations would increase the exposure of the Piper sand mounds, thereby increasing the potential for erosion of the margins, especially when combined with trampling by cattle. Implementing the following measure would reduce this effect of the No-Project Alternative.

Prepare an HPMP to Provide for the Long-Term Monitoring of Known and Unknown Archaeological Sites on Holland Tract. If the No-Project Alternative is selected, the project applicant should prepare an HPMP that includes a monitoring plan to identify impacts on intact burials that could result from agricultural activities, such as plowing, grazing, and sand extraction. The HPMP would address treatment of intact burials that are inadvertently discovered in known sites during agricultural activities. The HPMP would include notification procedures to be followed when intact burials are identified, and would outline treatment and management requirements for human remains, should they be discovered. Treatment could include removing the burials from the site and reburying them elsewhere.

Historic-Period Resources

Bacon Island

As described above under "Impacts and Mitigation Measures of Alternative 1", PAR has suggested that resources on Bacon Island are eligible for NRHP listing as a historic district. The majority of NRHA-eligible resources on Bacon Island will be affected by the continued deterioration of structures, modifications that are not consistent with their historic character, and possible demolition.

Webb Tract

As described above under "Impacts and Mitigation Measures of Alternative 1", no historic-period resources eligible for NRHP listing exist on Webb Tract; therefore, no impacts are anticipated.

Bouldin Island

One historic archaeological site (CA-SJo-208H) on Bouldin Island is eligible for listing in the NRHP under Criterion D. This site will not be affected by continued agricultural activities.

Holland Tract

As described above under "Impacts and Mitigation Measures of Alternative 1", no historic-period resources eligible for NRHP listing exist on Holland Tract; therefore, no impacts are anticipated.

Summary of Project Impacts and Recommended Mitigation Measures

Damage to Historic Structures Resulting from Agricultural Practices on Bacon Island. Under the No-Project Alternative, an indirect effect of agriculture on cultural resources results from the use of historic structures as boarding houses. Normal wear and tear and modification of the structures without concern for their historic integrity could reduce their significance. Continued use of the structures in this manner probably would result in a need for replacement, perhaps accompanied by demolition of the historic structures. Occupation of the historic structures provides some protection because they are less vulnerable to vandalism. Implementing the following measure would reduce this effect of the No-Project Alternative.

Prepare an HPMP to Provide for the Long-Term Maintenance and Protection of Historic Properties on Bacon Island. If the No-Project Alternative is selected, the project applicant should prepare an HPMP addressing the effects of continued agricultural use on the historic structures on Bacon Island.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. The following discussion considers only those impacts that may contribute cumulatively to impacts on cultural resources in the vicinity of the DW project islands.

Cumulative Impacts, Including Impacts of Alternative 1

Prehistoric Resources

Impact M-13: Destruction of or Damage to Prehistoric Archaeological Sites in the Delta. Fourteen prehistoric sites have been found near the DW project site. Many of these have been adversely affected by agricultural activities, leveling, and sand extraction occurring in the Delta. The effects of the DW project would not contribute to the overall loss of prehistoric resources in the Delta because the single prehistoric archaeological site within the APE for the

DW project is not eligible for listing in the NRHP. This impact is considered less than significant.

Mitigation. No mitigation is required.

Historic-Period Resources

Impact M-14: Destruction of or Damage to the NRHP-Eligible Historic Districts Representing Agricultural Labor Camp Systems in the Delta. During the last 25 years, the majority of agricultural labor camps in the Delta have been demolished or modified or have deteriorated. The resources on Bacon Island represent one of the last intact agricultural labor camp systems in the Delta. The destruction of the resources on Bacon Island that are eligible for NRHP listing as a historic district would add to the loss of this historic resource type in the Delta. This impact is considered significant and unavoidable. Implementing Mitigation Measures M-5 through M-8 would reduce Impact M-14, but not to a less-than-significant level. These mitigation measures are described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure M-5: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island.

Mitigation Measure M-6: Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island.

Mitigation Measure M-7: Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools.

Mitigation Measure M-8: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island.

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impacts of Alternative 2 are the same as those of Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

Prehistoric Resources

Impact M-15: Destruction of or Damage to Prehistoric Archaeological Sites in the Delta. Fourteen prehistoric sites have been found near the DW project site. Many of these have been adversely affected by agricultural activities, leveling, and sand extraction occurring in the Delta. The effects of the DW project would contribute to the overall loss of prehistoric resources in the Delta. Because implementing Alternative 3 would result in significant and unavoidable effects on prehistoric resources on Holland Tract, this cumulative impact is considered significant and unavoidable.

Although no mitigation to reduce this impact to a less-than-significant level exists, implementing the following mitigation measures will reduce the magnitude of this cumulative impact. These mitigation measures are described above under "Impacts and Mitigation Measures of Alternative 1" and "Impacts and Mitigation Measures of Alternative 3".

Mitigation Measure M-4: Prepare an HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive Areas on Holland Tract.

Mitigation Measure M-11: Cap Archaeological Sites on Holland Tract.

Mitigation Measure M-12: Construct Fencing or Other Barriers to Prevent Site Access on Holland Tract.

Mitigation Measure M-13: Construct Levees or Beach Slopes around Archaeological Sites to Decrease Wave Action and Erosion on Holland Tract.

Mitigation Measure M-14: Prepare an HPMP to Provide for the Long-Term Monitoring of Known Archaeological Sites on Holland Tract.

Mitigation Measure M-15: Survey Unsurveyed Portions of Holland Tract and Determine Eligibility for NRHP Listing and Appropriate Treatment.

Historic-Period Resources

Impact M-16: Destruction of or Damage to the NRHP-Eligible Historic Districts Representing Agricultural Labor Camp Systems in the Delta. This cumulative impact is described above under Impact M-14. This impact is considered significant and unavoidable. Implementing Mitigation Measures M-5 through M-8 would reduce Impact M-16, but not to a less-than-significant level. These mitigation measures are described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure M-5: Prepare an HPMP and a Data Recovery Plan for Archaeological Deposits on Bacon Island.

Mitigation Measure M-6: Prepare a Videotape of Public Broadcasting System Quality of the NRHP-Eligible Historic District on Bacon Island.

Mitigation Measure M-7: Prepare a Popular Publication on Bacon Island Resources for Use by Museums, Cultural Centers, and Schools.

Mitigation Measure M-8: Complete Historic American Building Survey/Historic American Engineering Record Forms, Including Photographic Documentation, That Preserve Information about the NRHP-Eligible District on Bacon Island.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Destruction of or Damage to Prehistoric Archaeological Sites and Historic Resources in the Delta. Direct effects of the No-Project Alternative contribute to the cumulative destruction of or damage to prehistoric archaeological sites and historic resources in the Delta. Under the No-Project Alternative, known and unknown prehistoric resources on the DW project islands would continue to be disturbed by agricultural activities, including grazing, plowing, and planting. Additionally, use of historic structures as boarding houses or for other agricultural support activities could increase wear and tear on the structures. Implementing the following measures would reduce this cumulative effect. These measures are described above under "Impacts and Mitigation Measures of the No-Project Alternative".

Prepare and HPMP to Provide for the Long-Term Monitoring and Treatment of Archaeologically Sensitive areas on Webb Tract.

Prepare an HPMP to Provide for the Long-Term Monitoring of Known and Unknown Archaeological Sites on Holland Tract.

Prepare an HPMP to Provide for the Long-Term Maintenance and Protection of Historic Properties on Bacon Island.

CITATIONS

References to the Code of Federal Regulations (CFR) are not included in this list. CFR citations in text refer to title and section (e.g., 36 CFR 60.6 refers to Title 36 of the CFR, Section 60.6).

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Chapter 3N. Affected Environment and Environmental Consequences - Mosquitos and Public Health

Chapter 3N. Affected Environment and Environmental Consequences - Mosquitos and Public Health

SUMMARY

This chapter discusses public health concerns related to transmission of disease by mosquitos and wildlife vectors in the Delta, describes mosquito control and abatement practices on the DW project islands, and assesses potential impacts of the DW project alternatives on mosquito production levels, mosquito abatement requirements, and transmission of diseases by wildlife.

The potential for creation of mosquito breeding habitat on the reservoir islands under Alternative 1, 2, or 3 was assessed for five habitat condition classes: full storage, partial storage, shallow storage, nonstorage, and shallow-water wetland. Shallow-water wetland conditions would have the greatest potential for producing problem numbers of mosquitos. The impact analysis presented in this chapter assumes, as a worst-case analysis, that water would be stored and released on the reservoir islands in a manner that would create the largest acreage of shallow-water wetlands during mosquito breeding seasons. Under Alternative 1 or 2, seasonal and permanent wetland and seasonal flooded agricultural habitats that would be created on the habitat islands and managed for wildlife would also provide potential mosquito breeding sites during flood periods.

Implementing Alternative 1, 2, or 3 could result in the need for a significant increase in abatement levels on the DW project islands. Coordination with responsible mosquito abatement districts (MADs) and implementation of appropriate abatement practices would offset the creation of potential mosquito production sources under the DW project alternatives. The DW project would also contribute to the cumulative increase in mosquito abatement needs resulting from implementation of future projects in the Delta that benefit mosquito breeding conditions (e.g., projects for wetland habitat restoration) or that increase human populations near existing mosquito production areas (e.g., residential housing and marina developments). This cumulative impact is considered significant and unavoidable.

Implementing Alternative 1, 2, or 3 would also result in the beneficial impact of reducing or eliminating the need for mosquito abatement activities during full-storage periods on the reservoir islands.

Exposure of people to wildlife species that transmit diseases could increase on the habitat islands under Alternatives 1 or 2. However, this impact is considered less than significant because wildlife-transmitted diseases are not considered a significant risk to public health in the Delta, and the increase in risk under Alternative 1 or 2 would be minor.

The No-Project Alternative would benefit mosquito abatement needs by eliminating habitats considered problem mosquito production sources. However, increased corn production under the No-Project Alternative, primarily on Holland and Webb Tracts, could result in a substantial increase in mosquito production during the fall flooding. Coordination with responsible MADs and implementation of appropriate abatement practices would offset the effects of fall flooding practices under the No-Project Alternative.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

No substantive changes have been made to this chapter since the 1995 DEIR/EIS was published. Public health issues associated with changes in drinking water quality are discussed in Chapter 3C, "Water Quality".

Simulations of DW project operations that were performed for the updated evaluation of project operations under the proposed project in the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations", may change the predictions of mosquito breeding habitat on the reservoir islands. However, the difference between project operations presented in the 1995 DEIR/EIS and in the 2000 REIR/EIS do not affect the conclusions of this chapter. Therefore, the analysis of mosquito breeding habitat on reservoir islands from the 1995 DEIR/EIS remains unchanged and is presented below.

INTRODUCTION

This chapter discusses impacts of the DW project on mosquito production levels; disease transmission by mosquito, tick, and wildlife vectors; and mosquito abatement efforts. These impacts would result from water storage operations on the DW reservoir islands and wildlife habitat management activities associated with management of the DW habitat islands. The HMP incorporated into the project description for Alternatives 1 and 2 provides for compensation habitat to be developed on the habitat islands to offset the effects of DW reservoir island operations on wildlife and on lands considered jurisdictional wetlands under Section 404 of the Clean Water Act. The impact assessment for Alternatives 1 and 2 is therefore based on the assumption that project implementation would include the establishment of compensation habitat acreages specified in the HMP. Under Alternative 3, all four DW project islands would be used as reservoirs, and the NBHA on Bouldin Island would be used to provide limited compensation habitat.

The following chapters and appendices provide more detailed information on existing habitat conditions on the DW project islands that affect the likelihood of disease transmission by vectors and provide information on predicted future habitat conditions for each alternative:

- Chapter 3G, "Vegetation and Wetlands";
- Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands";
- Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands";
- Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives"; and
- Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation".

The 1990 draft EIR/EIS on the DW project did not address mosquitos or other public health issues. This chapter was added to this document in response to comments on the 1990 draft EIR/EIS from MADs and others.

AFFECTED ENVIRONMENT

This section describes conditions affecting production of mosquitos, and disease transmission by mosquitos and other vectors on the DW project islands. Information on habitat conditions that govern the production of mosquitos is based in part on information collected for the 1990 draft EIR/EIS and has been updated to current conditions where these changes would affect the impact analysis.

As a result of land management decisions made since 1988, some changes in agricultural land use and vegetation conditions on the islands have occurred. Some of these changes were made in response to annual fluctuations in agricultural market conditions. Because some of the changes resulted from project-related actions and influences, information from the 1990 draft EIR/EIS (based on 1988 conditions) provides the most reliable description of typical preproject habitat conditions to use in assessing the impacts of the DW project alternatives.

Sources of Information

Information on mosquito ecology, control methods, existing levels of abatement, and midge production was collected from documents issued by MADs, mosquito ecology and abatement literature, and contacts with the San Joaquin County MAD (SJCMAD) and the Contra Costa MAD (CCMAD). DHS provided information on the status of Lyme disease, bubonic plague, and rabies in the Delta region.

Status of Mosquito Control in the Delta

Mosquito Breeding Conditions in the Delta

All species of mosquitos require standing water to complete the growth cycle; therefore, any body of standing water represents a potential mosquito breeding site. Mosquitos are produced year round on Delta islands, but mosquito production diminishes substantially during the cool season (typically late October through April) (Lucchesi and Kramer pers. comms.).

Water quality affects the productivity of a potential mosquito breeding site. Typically, water bodies with poor circulation, higher temperatures, and higher organic content (and therefore with poor water quality) produce greater numbers of mosquitos than water bodies having good circulation, lower temperatures, and lower organic content (Collins and Resh 1989). Additionally, irrigation and flooding practices may influence the level of mosquito production associated with a water body. Typically, water bodies with water levels that slowly increase or recede produce greater numbers of mosquitos than water bodies with water levels that are stable or that rapidly fluctuate.

Among the habitat types on the DW project islands and in the Delta, two general classes of habitats, open-water and flooded habitats, can provide suitable conditions for mosquito production.

Open-Water Habitats. Open-water habitats on the DW project islands include perennially inundated ditches, sloughs, and ponds (Table 3N-1). The shallow edges of sloughs, ditches, and ponds are typically lined with riparian or marsh vegetation.

Sloughs and ponds that have good water quality (good circulation, low temperatures, and low organic content) usually do not provide optimum breeding habitat for mosquitos. Permanent bodies of open water with these characteristics typically sustain stable nutrient content and support rich floral and faunal species diversity, including mosquito predators and pathogens. Wave action across larger bodies of water in the Delta physically retards mosquito production by inhibiting egg laying and larval survival (USFWS 1992).

Mosquito larvae prefer stagnant water and the protected microhabitats provided by stems of emergent vegetation. Therefore, if not properly maintained, ditches can be major producers of mosquitos. Periodic dredging of ditches substantially reduces mosquito production by enhancing water circulation and preventing encroachment of emergent vegetation into ditch channels (Lucchesi pers. comm.).

Open-water habitats existing on the DW islands support established populations of mosquitofish (*Gambusia affinis*) and other mosquito predator populations, including predacious insects such as backswimmers and dragonflies, that assist in suppressing mosquito production at these sites by feeding on mosquito larvae at the water's surface (Lucchesi and Kramer pers. comms.).

Flooded Habitats. Flooded habitats on the DW project islands and in the Delta include exotic and freshwater marshes and agricultural lands that may seasonally retain surface water (Table 3N-1). These habitats are inundated by subsurface or surface irrigation or exist at the edges of ditches, sloughs, and ponds.

Mosquitos are adapted to breed during periods of temporary flooding and can complete their life cycles before water evaporates and predator populations become well established (USFWS 1992). Water management practices associated with agriculture and creation of seasonal wetlands for waterfowl use result in the types of flooding that can produce problem numbers of mosquitos (USFWS 1992, Kramer and Lucchesi pers. comms.).

Delta agricultural lands flooded to pre-irrigate fields, control weeds, or attract migrating and wintering waterfowl typically produce problem numbers of mosquitos from May through October. For example, substantial increases in mosquito production have been recorded in agricultural fields on Bouldin Island that are flooded in late summer to control weeds (Lucchesi pers. comm.). Mosquito production can be reduced substantially if fields are not flooded until the end of October, when temperatures usually drop enough to curtail mosquito production (Kramer and Lucchesi pers. comms.).

Most crop irrigation does not produce appreciable numbers of mosquitos because water is typically applied rapidly and removed from fields (USFWS 1992). Irrigated pastures, however, are typically nutrient rich and are irrigated for 7-10 days. This environment is conducive to production of large numbers of mosquitos and provides sufficient time for them to complete their life cycles. Therefore, irrigation of pastures may result in a severe mosquito problem if the pastures are flooded at any time from May through October (Kramer pers. comm.).

Mosquito Abatement Districts

The DW project islands are located in two MADs. Bouldin and Bacon Islands are within the jurisdiction of SJCMAD, and Holland and Webb Tracts are within the jurisdiction of CCMAD. Both MADs receive most of their revenue from property taxes and are responsible for controlling mosquitos as pest species and as disease vectors (Kramer and Lucchesi pers. comms.).

California law dictates that if a mosquito source exists as a result of human-made conditions, the party responsible for those conditions is liable for the cost of abatement. The law is enforced at the discretion of the responsible MAD (California Health and Safety Code Sections 2200-2294). In 1993, CCMAD implemented a policy that would require landowners to either provide abatement or enter into a service contract with the district if abatement costs exceed $500 per mosquito production source (Kramer and Waletzko pers. comms.). Although SJCMAD does not charge landowners for abatement, the district maintains an option to do so if funding for the MAD declines (Lucchesi pers. comm.).

CCMAD has adopted the California Mosquito and Vector Control Association's draft Wetlands Policy Statement as its policy for wetland creation and restoration projects. Elements of this policy directly applicable to the DW project instruct MADs to:

> participate in all levels of wetlands planning in order to identify and minimize all real or potential public health impacts created by mosquitoes and other vectors; work cooperatively with all responsible participants on any wetlands project to achieve as many of the stated goals of the project as possible; and provide the necessary information to ensure that any mosquito or other vector surveillance and control funds are provided for in the necessary Operation and Maintenance Plan of all wetlands projects. (Waletzko pers. comm.)

SJCMAD has not adopted specific policies or guidelines for wetland creation and restoration projects; however, general abatement policies are codified in Division 15 of the SJCGP (Lucchesi pers. comm.).

Mosquito Species of Concern

On Delta islands, SJCMAD and CCMAD are primarily concerned with controlling seven species of mosquitos that can transmit malaria and several types of encephalitis or cause a substantial nuisance in surrounding communities.

The floodwater mosquito (*Aedes melanimon*) and the pasture mosquito (*Aedes nigrormaculis*) are the primary nuisance species produced on the DW project islands. These mosquitos commonly breed in irrigated pastures and seasonal wetlands and may travel several miles from breeding areas in search of hosts (Kramer and Lucchesi pers. comms.). Floodwater mosquitos are potential vectors of California encephalitis, and both species are potential vectors of western equine encephalitis and St. Louis encephalitis (Bohart and Washino 1978).

The encephalitis mosquito (*Culex tarsalis*) breeds in almost any freshwater pond. Birds appear to be the primary hosts of this species, but domestic animals and humans serve as occasional hosts (Bohart and Washino 1978). This species is the primary carrier in California of western equine encephalitis, St. Louis encephalitis, and California encephalitis and is considered the most important disease vector in the state (Sacramento-Yolo County Mosquito Abatement and Vector Control District 1990).

The western malaria mosquito (*Anopheles freeborni*) is the primary vector of malaria in the western United States. Algal mats that form in stagnant water are the preferred egg-laying habitat for this species (Stroh pers. comm.). Depending on ambient temperatures, development from the egg to the adult stage may take 12-20 days. In the Delta region, the western malaria mosquito may migrate up to 5 miles from production areas (Bohart and Washino 1978).

The mosquito *Aedes dorsalis* breeds in intertidal marshes, which are not found on the DW project islands. *A. dorsalis* can travel up to 20 miles from breeding areas, however, and can become a major pest in the project area if large numbers move inland (Bohart and Washino 1978, Kramer pers. comm.). This species is a suspected vector of California encephalitis (Bohart and Washino 1978).

The cool-weather mosquito (*Culiseta inornata*) is most abundant in fall and spring (Bohart and Washino 1978). This species feeds primarily on domestic animals and has been identified as a vector of western equine encephalitis. It is not considered an important public health vector, however, because humans are not preferred hosts and the species has not been found to carry western equine encephalitis in California.

House mosquitos (*Culex pipiens*) usually breed in waters with a high content of organic material and generally do not travel far from breeding sites (Bohart and Washino 1978, Sacramento-Yolo County Mosquito Abatement and Vector Control District 1990). Although birds are their primary hosts, house mosquitos will bite people. They are the primary vector of St. Louis encephalitis outside the western United States but are not considered a problem vector of St. Louis encephalitis in California (Bohart and Washino 1978).

Mosquito Control Methods

SJCMAD and CCMAD use a combination of various abatement procedures to control mosquitos, each of which may have maximum effectiveness under different habitat conditions or periods of the mosquito life cycle (Kramer and Lucchesi pers. comms.).

Criteria for Determining the Need for Control at a Mosquito Source. According to MADs, state laws and regulations require that mosquitos be controlled if diseases transmitted by mosquitos are identified in or near human populations, or if surveillance of mosquito populations for the incidence of mosquito-transmitted diseases indicates the likelihood of transmission (USFWS 1992). The decision to control mosquitos as a nuisance to human populations is at the discretion of each MAD. Factors influencing this decision may include the number of service calls received from a given locality, the proximity of mosquito sources to population centers, the availability of funds for abatement, the density of mosquito larvae present in a mosquito production source, and the number of adult mosquitos captured per night in light traps (USFWS 1992, Waletzko and Lucchesi pers. comms.).

Once a recurring mosquito production source has been identified, abatement schedules are often adopted and maintained for that source (USFWS 1992, Waletzko pers. comm.). SJCMAD and CCMAD monitor larval and adult mosquito populations at known mosquito production sources to determine when problems may occur and when treatment should take place (Kramer and Lucchesi pers. comms.).

Biological Control. Mosquitofish are the primary biological control used by SJCMAD and CCMAD. Populations of mosquitofish bred in captivity are stocked in open water and flooded habitats; additionally, naturalized populations of mosquitofish in Delta waters enter DW island waters through irrigation and drainage ditches. Mosquito larvae, however, are not the preferred food item so biological controls are not effective in most situations unless they are used as part of an integrated mosquito control program (Kramer pers. comm.). Additionally, if emergent vegetation is established in dense stands, it can provide an ideal substrate for mosquito production and physically prevent mosquitofish from feeding on mosquito larvae (USFWS 1992, Kramer pers. comm.).

Source Reductions. Source reductions are management actions that physically eliminate environmental conditions necessary for mosquito production. These actions include dewatering ponded areas, improving drainage on cultivated fields, removing emergent vegetation from drainage ditches, and improving water circulation (USFWS 1992). SJCMAD and CCMAD have ongoing programs of source reduction (Kramer and Lucchesi pers. comms.).

Pesticides. Pesticides that are designed to control mosquito larvae or adults are available to SJCMAD and CCMAD. However, because of public concerns regarding environmental effects, SJCMAD and CCMAD have reduced their reliance on these chemicals as part of their abatement programs (Kramer and Lucchesi pers. comms.).

SJCMAD uses several types of organophosphorus and pyrethrum pesticides to control adult mosquitos in populated areas and at mosquito production sources

(Lucchesi pers. comm.). Controlling mosquitos in larval stages, however, is the preferred method because mosquitos are removed before they can reproduce and because treating larvae is less costly than treating adults (USFWS 1992).

Bacillus thuringiensis israelensis (Bti) is a bacterial larvicide that, although expensive, is a preferred method of treatment in wetlands where removal of nontarget species may be a concern (USFWS 1992). Bti is effective only against first and second larval instar stages and does not work well in the organic soils common in the project area (Kramer pers. comm.).

Methoprene is sometimes used by CCMAD to control larvae on irrigated pastures (Kramer pers. comm.). Methoprene is a growth-regulating chemical that mimics insect juvenile hormone in mosquito larvae and prevents larvae from developing into adults. Methoprene usually dissipates from the environment within 48 hours after application (Sacramento-Yolo County Mosquito Abatement and Vector Control District 1990).

Rapidly dissipating petroleum-based oils are also used to control larvae. These oils form an impenetrable film on water surfaces, preventing larvae from obtaining oxygen. SJCMAD and CCMAD frequently use oils to control larvae on irrigated pastures (Kramer and Lucchesi pers. comms.).

Ecological Control. Ecological control methods take advantage of ecological relationships to reduce the population size or production rate of mosquitos. Ecological control methods include designing irrigation systems to rapidly supply and remove water, manipulating water levels in wetlands, and maintaining constant water quality. (Collins and Resh 1989.)

Mosquito Habitat Conditions on the DW Project Islands

Potential mosquito breeding habitats existing on the DW project islands include grain and seed croplands, exotic and freshwater marshes, irrigated pastures, ditches and sloughs, and ponds. Except for permanent ponds, these habitats provide suitable mosquito breeding sites only during periods when surface water is present. Other habitat types on the DW project islands, including riparian woodlands, herbaceous uplands, perennial croplands, fallow fields, and developed lands, typically do not produce substantial numbers of mosquitos (Table 3N-1).

Bacon Island

Most of Bacon Island is intensively farmed, primarily to produce potatoes and asparagus (see Table 3G-4 in Chapter 3G, "Vegetation and Wetlands"). There is no irrigated pasture on the island, less than 2% of the island is open-water habitat, and less than 1% is marsh (Table 3N-1).

In recent years, SJCMAD has treated approximately 3.5 acres of ponds receiving tailwater from potato processing on Bacon Island to control house mosquitos (Figure 3N-1). SJCMAD treats tailwater ponds with Bti and oil when the ponds are receiving discharge and stocks the ponds with mosquitofish during nondischarge periods (mosquitofish cannot survive in water discharged from potato-processing plants). (Lucchesi pers. comm.)

SJCMAD receives a few service requests per year from resorts near Bacon Island during holiday periods when resort visitation is greatest. Generally, however, SJCMAD does not consider Bacon Island a problem mosquito-production area because most of the island is farmed to produce crops that are cultivated in a manner that typically does not promote mosquito production (Lucchesi pers. comm.).

Webb Tract

Approximately 49% of Webb Tract is farmed to produce corn and small grain crops. Approximately 17% of the island is marsh, 3% is open water, and 1% is irrigated pasture (Table 3N-1). The remainder of the island consists mostly of riparian upland habitat types.

CCMAD does not consider Webb Tract a problem mosquito production source and has not implemented mosquito control measures on the island in recent years (Waletzko pers. comm.).

Bouldin Island

The agricultural land on Bouldin Island (nearly 76% of the island) is farmed to produce corn, wheat, and sunflowers. Open-water and marsh habitats constitute approximately 4% of the island (Table 3N-1).

Mosquito production on Bouldin Island generates service calls to SJCMAD when the mosquitos move east from the island to Tower Park Marina at Terminous (Lucchesi pers. comm.). During the past 5 years, SJCMAD has averaged five to seven service calls per year, primarily during August and September. During September 1992, however, the district received 18 service requests. SJCMAD attributes the increase to earlier-than-normal flooding of harvested wheat fields for weed control during warm fall weather (Lucchesi pers. comm.).

SJCMAD believes that water management practices associated with corn cultivation on Bouldin Island from late summer through October create habitat suitable for producing problem numbers of mosquitos (Lucchesi pers. comm.). The year before corn is planted, fields are generally shallow-flooded from about mid-September to October 1 for pre-irrigation and weed control, and they are drained by the end of December. Flooding before the onset of cooler weather (usually by November 1) creates conditions conducive to producing large numbers of pasture and western malaria mosquitos. SJCMAD annually treats these areas to control mosquito production and stocks fields with mosquitofish immediately after they are flooded (Lucchesi pers. comm.).

In fall 1992, approximately 1,000 acres on Bouldin Island were flooded and treated by SJCMAD with aerial applications of Bti (Wilkerson and Lucchesi pers. comms.). Adulticides were applied around the perimeters of some breeding areas to remove adult mosquitos before they could breed, and at Tower Park Marina on adjacent Terminous Tract to alleviate mosquito nuisances (Figure 3N-1) (Lucchesi pers. comm.).

Holland Tract

Approximately 18% of the project area on Holland Tract is farmed in corn and wheat, 11% is irrigated pasture, and approximately 3% is open-water and freshwater marsh habitats (Table 3N-1).

Floodwater, pasture, *Aedes dorsalis*, and encephalitis mosquitos are the most prevalent species of mosquitos on the island. CCMAD considers irrigated pastures to be major and recurring mosquito production sources on Holland Tract (Kramer pers. comm.). CCMAD does not consider the project area for Alternatives 1 and 2 on Holland Tract to be a problem mosquito production source. During 1989-1991, however, CCMAD spent approximately $37,000 and 58 work days annually to inspect mosquito production sources and to control mosquitos on approximately 520 acres of irrigated pastures located in the southwestern quadrant of Holland Tract (Figure 3N-1). These pastures are frequently flooded for 7-10 days and produce large numbers of floodwater and pasture mosquitos (Waletzko pers. comm.). If monitoring of production sources indicates that larvae densities exceed CCMAD's established mosquito production standards, pastures are treated with oil or methoprene (Kramer pers. comm.).

Mosquitos typically migrate north from Holland Tract and frequently cause nuisance problems in the Oakley area to the west and the Discovery Bay area to the south (Kramer pers. comm.). From 1989 through 1991, CCMAD averaged 68 mosquito service request calls per year from locations within a 5-mile radius of Holland Tract (Waletzko pers. comm.).

Other Public Health Concerns

Other public health concerns on the DW project islands include midge production and the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife and other animals. However, as described below, none of these public health concerns are considered a risk to public health in the Delta.

Midge Production

Midges are nonbiting insects that breed in ponded water and, as adults, are similar in appearance to mosquitos. Large populations of midges can be a nuisance to humans and have been known to swarm in large numbers, causing traffic accidents along SR 4 by reducing driver visibility (Stroh pers. comm.).

No public agency is responsible for controlling midge production, and the control of midges is not explicitly mandated by state law. If midges become a significant nuisance or pose a safety hazard, however, the owner of the land where midges are produced may be held liable for midge control under current state health and safety codes (Lucchesi pers. comm.).

Lyme Disease

Lyme disease is transmitted to humans by some species of ticks. In California, incidences of Lyme disease are most frequently reported from the coastal foothill region. Lyme disease is rare in the Sacramento and San Joaquin Valleys and is considered by DHS to be a very low risk to public health in the Delta area. (Reilly pers. comm.)

Bubonic Plague

Bubonic plague is transmitted to humans by fleas that have fed on ground squirrels and other rodents infected with the plague bacteria. The plague in California occurs mostly in the foothill regions of the Sierra Nevada and coastal ranges at elevations above 4,000 feet. Incidence of bubonic plague in the Central Valley is very rare and the plague is considered by DHS to be a very low risk to public health in the Delta area (Reilly pers. comm.).

Rabies

Rabies is a viral disease of mammals that is, except under unusual circumstances, transmitted through the bite of an infected animal. In the Delta, skunks, gray foxes, and bats are the main carriers of the disease. Rabies is endemic throughout California but is not considered by DHS to be a high risk in the Delta area (Reilly pers. comm.).

IMPACT ASSESSMENT METHODOLOGY

Changes in mosquito abatement requirements for the DW project islands were evaluated through comparison of predictions of future mosquito breeding conditions under the DW project alternatives with existing mosquito abatement requirements. Predictions of future mosquito breeding conditions are based on predicted future habitat conditions, which are described in Appendices G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands", and G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

The risks to public health associated with midge production and transmission of Lyme disease, bubonic plague, and rabies are low, and risk levels are not expected to substantially change with implementation of the DW project alternatives. These public health concerns, therefore, are not considered to be potential impacts of the DW project alternatives.

Analytical Approach and Impact Mechanisms

Impact mechanisms include habitat-type conversions and changes in water management practices resulting from project implementation. Proposed management of reservoir islands and creation of wetland, pasture, and cornfield habitats on the habitat islands may increase or decrease the amount of potential breeding habitat for mosquitos, wildlife-borne diseases, or other pests. Changes in the timing of water application and withdrawal on the DW project islands may increase or decrease the amount of potential breeding habitat for mosquitos or other pests. Changes in land and water management may increase the presence of wildlife species, particularly migratory waterfowl, that are hosts for transmittable diseases.

The following were used to predict future mosquito breeding conditions and abatement requirements for the DW project islands:

- literature on mosquito ecology and control methods;
- contacts with SJCMAD and CCMAD personnel knowledgeable about the mosquito ecology, mosquito control problems, and mosquito control history of Delta islands; and
- information on acreages of habitat types and flood conditions to be created on the DW project islands (see Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands", and Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives").

In the analysis, the growing season for vegetation and the breeding periods for mosquitos were assumed to extend from May through October (Lucchesi and Kramer pers. comms.). Additionally, predictions of the frequency and extent of water storage, nonstorage, and shallow-flooding conditions on the reservoir islands under the DW project alternatives were essential to the analysis of mosquito breeding potential. Although farming will cease on the DW project islands, potential exists for some level of continuing subsidence on these islands. As a result, the water storage capacity of the reservoir islands could increase in future years. The rate of subsidence, however, would be substantially less than under existing conditions. Reduced rates of subsidence and increased water storage capacity on the reservoir islands would not be expected to substantially increase or decrease the level of mosquito production from levels predicted in this analysis.

Although additional water associated with water transfers may be banked on the reservoir islands, the frequency and magnitude of nonproject water-banking activities is unknown and is not included in this analysis (see Chapter 2, "Delta Wetlands Project Alternatives"). Increased periods and depths of inundation that would be associated with water banking activities, however, may reduce mosquito production levels during banking periods (see "Full Storage" and "Partial Storage" below, under "Mosquito Breeding Conditions").

Reservoir Islands

The frequencies of future periods of water storage, nonstorage, and shallow flooding on Bacon Island and Webb Tract are difficult to predict because conditions would vary with water availability in the Delta. Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives", presents the 1995 DEIR/EIS results of simulations of water storage operations under the DW project alternatives based on Delta flows recorded over the 70-year period from 1922 to 1991. Additional simulations were performed for the updated evaluation of project operations under the proposed project in the 2000 REIR/EIS, as described in Chapter 3A, "Water Supply and Water Project Operations"; however, the differences in DeltaSOS results in the 1995 DEIR/EIS and 2000 REIR/EIS evaluations of Alternatives 1 and 2 do not affect the conclusions of this chapter.

The simulations presented in Appendix G4 are used to predict the frequency of island flooding conditions in future years. The future availability of water for storage, however, may not follow simulated storage frequencies.

Sequence of Water Storage Operations. Prediction of future conditions on a particular reservoir island is further complicated because DW may sequentially fill the reservoir islands and, when feasible, rotate the sequence of island flooding between years to maximize the opportunity for creating shallow-water wetland habitats (see Chapter 2, "Delta Wetlands Project Alternatives"). Alternately, DW may simultaneously fill the reservoir islands when water is available for diversion onto both islands. The analysis of mosquito breeding conditions is based on the assumption that the reservoir islands would be sequentially filled to provide the greatest opportunity to create shallow-water wetlands and thus, as a worst-case scenario, the greatest potential for creating mosquito breeding habitat. In the assumed order of sequential filling for Alternatives 1 and 2, Bacon Island (having the greatest storage capacity) would be filled to capacity before water is diverted to Webb Tract, and Webb Tract would be emptied before water is released from Bacon Island. Under Alternative 3, the order of diversion would be Bacon Island, Webb Tract, Bouldin Island, and Holland Tract; these islands would be emptied in the reverse order.

Definitions of Habitat Condition Classes for the Reservoir Islands. Based on mosquito production potentials associated with different ranges of reservoir water volumes, reservoir volumes were divided into the five habitat condition classes: full storage, partial storage, shallow storage, nonstorage, and shallow-water wetland. Descriptions of these habitat condition classes are given in Appendix G2, "Prediction of Vegetation on the Delta Wetlands Reservoir Islands". However, the mosquito production analysis assumes sequential diversions, with the reservoir islands filled to storage capacity, and the vegetation analysis assumes simultaneous diversions, with "full storage", as defined in Appendix G2, being achieved before full storage capacity is filled. Therefore, the total storage volume when all reservoir islands are at full storage would be greater for this analysis than that described in Appendix G2. For this analysis, the reservoir islands would be completely inundated at a total storage volume of 189 TAF under Alternative 1 or 2 and 396 TAF under Alternative 3.

Habitat Islands

Water management to maintain lake, permanent wetland, seasonal wetland, and agricultural habitats on Bouldin Island and Holland Tract under Alternatives 1 and 2 is described in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands". The annual sequence of water management on the habitat islands would be followed according to predetermined flooding schedules established in April of each operating year.

No-Project Alternative

Predictions of island conditions under the No-Project Alternative are based on the results of a feasibility study prepared for DW by The McCarty Company, Diversified Agricultural Services (McCarty pers. comm.). This report outlines island-by-island recommendations for intensifying the production and yield of various crops. Diversifying crops and emphasizing perennial crops are general recommendations for all islands.

Criteria for Determining Impact Significance

For this analysis, an alternative would be considered to have a significant impact on mosquito abatement if habitat changes would necessitate increasing levels of mosquito abatement programs in order to maintain mosquito populations at preproject levels. Habitat changes that could result in a substantial decline of available mosquito breeding habitat or greater efficiency of CCMAD or SJCMAD abatement programs are considered to be beneficial impacts.

An alternative would also be considered to result in a significant impact if it would substantially increase potential exposure of people to wildlife-transmitted diseases considered a high health risk in the Delta area by DHS.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Impacts of Alternative 1 were analyzed for the period during which potential problem numbers of mosquitos could be produced on the DW project islands (May 1 through October 31) (Kramer and Lucchesi pers. comms.). As stated above, because DW may rotate the sequence of filling the reservoir islands, the analysis was conducted for the project operating regime that would create the greatest potential for production of problem numbers of mosquitos.

Mosquito Breeding Conditions

Bacon Island and Webb Tract

Tables 3N-2 and 3N-3 present the monthly frequency with which each flood habitat condition class would occur on the reservoir islands during the mosquito breeding season based on the 1995 DEIR/EIS analysis of DW project operations. Mosquito breeding conditions would be the same on Bacon Island and Webb Tract for each habitat condition class, but the frequency with which each class occurs on each island may differ. The frequency of full-, partial-, and shallow-storage periods would be expected to increase, and nonstorage and shallow-water wetland periods would be expected to decrease on both islands, however, if the DW reservoir islands were used for storage of water for transfer or for water banking (see Chapter 2, "Delta Wetlands Project Alternatives"). Because the frequency and magnitude of such activities is uncertain at this time and these activities would require separate authorization, their impacts on mosquito production and abatement are not assessed in this document.

Full Storage. During full-storage periods, mosquito production on the reservoir islands would be minimal. At full storage, water depths would exceed 10 feet over most of the islands and, because the water level would be at the riprapped levee slopes, reservoir edges would lack emergent vegetation that could be used as breeding areas by problem numbers of mosquitos. As described above, deep, open-water habitats are poor mosquito breeding areas because the wave action generated over large water bodies disrupts the ability of larvae to penetrate the water surface and because vegetation necessary for egg laying and cover for larvae is lacking.

Water would be diverted onto the reservoir islands as it becomes available in the Delta and would be discharged into the Delta during periods of water demand. Consequently, reservoir water would be circulated and water levels would fluctuate as water is diverted or discharged. Periods of good water circulation and rapid changes in water levels on the reservoir islands would probably disrupt mosquito production during some full-storage periods (USFWS 1992, Lucchesi pers. comm.).

Partial Storage. Partial-storage conditions would provide shallow to deep water storage pools, exposed island bottoms, and above-water riprapped levee slopes. Reservoir island habitat conditions will vary more under partial-storage conditions than under other storage conditions because, during partial-storage periods, a greater range of reservoir sizes and water depths can occur. Partial-storage reservoir conditions would range from saturated soils at shorelines to water depths of over 10 feet. Portions of the reservoir with depths over 3 feet would not encourage breeding of problem numbers of mosquitos because habitat conditions would be similar to those described for full-storage periods.

Mosquito production could occur in shallow-water areas near the edges of the reservoir in a partial-storage condition. During May partial-storage periods in most years, however, little or no vegetation would be present to provide egg-laying sites or cover for larvae, or to break up wave action in shallow water areas because previous storage or flooding to create shallow-water wetlands would have removed vegetation from island bottoms.

The rate at which herbaceous vegetation would become reestablished on islands following complete or partial drawdowns of the reservoir is unknown. Vegetation density during nonstorage and partial-storage periods is expected to be reduced as a result of gradual loss of seeds and other plant propagules because of deterioration from inundation, export from the islands during water releases, and periodic disruption of seed production by water storage during the growing season. To enhance the value of shallow-water wetlands, DW may choose to periodically seed islands during spring and summer nonstorage periods with watergrass and other food plants for waterfowl.

For partial-storage periods, the potential for substantial mosquito production is greatest during July and August. In years when July and August partial-storage periods follow one or more months of nonstorage, dense vegetation could become reestablished on the island bottoms. Shallow and relatively stable storage pools present during these months in some years, coupled with dense vegetation and high ambient temperatures, would create optimal mosquito breeding conditions.

Mosquito breeding conditions on portions of island bottoms exposed during partial-storage periods would be the same as those described below for nonstorage conditions.

Shallow Storage. Shallow storage occurs when stored water volumes are equal to water volumes used to create shallow-water wetlands. Mosquito breeding conditions under shallow storage would be similar to those described for partial storage except that the reservoir area available for breeding would be smaller. Shallow storage that occurs after nonstorage during the growing season would create vegetation conditions similar to those of shallow-water wetland periods (described below).

Nonstorage. Nonstorage periods follow complete water releases from the reservoir islands and precede fall planned flooding to create seasonal wetlands. Islands would be constructed with a drainage system to allow the lowest portions of island bottoms to drain. Drainage would reduce ponding in depressions at elevations above the elevation of the drawdown pool, eliminating potential sites for mosquito production. Some level of mosquito production, however, may occur in undrained pools, small pools that result from seepage onto the island, and areas with saturated soils.

Following drawdown, some mosquito production may occur in saturated areas. Mosquito breeding conditions, however, would not be optimal because most areas of the island bottoms would lack sufficient vegetation. During periods of nonstorage from April through October, plants would be expected to germinate within the first 30 days of nonstorage, although bare ground would be the predominant condition. Vegetation would grow rapidly following germination. Substantial mosquito production may occur in small pools or areas of saturated soils that are revegetated.

Permanent open-water habitat in borrow areas and in the drainage circulation network would be created under Alternative 1. Conditions in this habitat would be less than favorable for mosquito production because water depths would range between 2 feet and 4 feet, and insufficient time would exist for emergent vegetation to become established before subsequent deep-water storage would occur.

Shallow-Water Wetlands. Shallow-water wetland conditions would occur during periods when no storage occurs and water is diverted onto the reservoir islands to flood vegetation and attract waterfowl and other wetland-associated wildlife. Shallow-water wetlands would be created at DW's discretion. For this analysis, however, it was assumed that DW would create shallow-water wetlands each year in which no water had been stored for 60 or more consecutive days during the growing season (May through October). Approximately 3,700 acres on

Bacon Island and 3,850 acres on Webb Tract could be managed as shallow-water wetlands (JSA 1993).

Shallow-water wetlands would be managed until the first water storage period or through April if no storage occurs. Wetlands would be flooded between September and November (flooding dates would vary with vegetation maturity) to create shallow-water wetlands. As described in Chapter 2, DW will construct an inner levee system on the reservoir islands. Open-water habitats in borrow areas and the drainage circulation network would be as described for nonstorage conditions. Higher elevation fields around the perimeters of islands would be filled first and the water allowed to flow through weirs to lower elevation fields and toward island interiors. This procedure would provide some water circulation, improving water quality and reducing the potential for substantial mosquito production. In addition, the network of inner levees, the drainage circulation network, pumps, and other water control structures associated with the project would allow rapid drainage of shallow-water wetlands for mosquito control.

Problem numbers of mosquitos could be produced for as long as 60 days when seasonal wetlands are flooded on September 1. If DW does not seed the islands, mosquito breeding conditions would be less than optimal because vegetation would be sparse and water would have greater wave action than in shallow-water wetlands that are seeded (see Chapter 3G, "Vegetation and Wetlands").

Bouldin Island and Holland Tract

Habitats would be created and managed on Bouldin Island and Holland Tract primarily to offset project impacts on Swainson's hawks, greater sandhill cranes, wintering waterfowl, and jurisdictional waters of the United States. Seven habitat types that could potentially produce problem numbers of mosquitos would be created on the habitat islands: seasonal managed wetland and mixed agriculture/seasonal wetland, corn rotated with wheat, pastures/hayfields, seasonal ponds, permanent lakes, emergent marsh, and borrow ponds.

A detailed description of how the habitat islands would be designed and managed is contained in DW's habitat management plan, presented in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

Tables 3N-4 and 3N-5 present the acreage of each habitat type that would be flooded during the mosquito breeding season (May 1-October 31). Up to 25% of each seasonal wetland area and agricultural field may be left dry. Acreages of each habitat type differ between islands; however, mosquito breeding conditions associated with each habitat type are the same.

Seasonal Managed Wetlands and Mixed Agriculture/Seasonal Wetland. Approximately 3,760 acres of seasonal managed wetlands and mixed agriculture/seasonal wetland habitat would be developed on the habitat islands. These habitat types would be managed under identical flood regimes, and watergrass and smartweed are expected to be the dominant plant species. However, narrow strips of corn would be planted throughout mixed agriculture/seasonal wetland habitats.

Wetland areas would consist of a minimum of 65 acres and would be designed to allow rapid drawdown or flooding if necessary to control mosquito production. Additionally, water would be circulated through wetlands to maintain water quality and inhibit mosquito production.

These wetland habitats would be slowly flooded through fall and winter to average depths of 12 inches and would be slowly drawn down from early spring through May. When first flooded, wetland areas would support dense stands of emergent vegetation. After 6-8 weeks of flooding, most vegetation is expected to fall over and become submerged because of wave action and waterfowl foraging. Flooding of these habitats potentially could produce problem numbers of mosquitos from September 1 through October 31. Wetlands that remain flooded from May 1 to May 30, however, would lack emergent vegetation. This condition, in combination with wave action, would be expected to substantially reduce the potential for production of problem numbers of mosquitos.

Corn Rotated with Wheat. Approximately 2,585 acres of corn rotated with wheat would be developed on each island. Each cornfield and wheat field would consist of at least 65 acres and would be designed to allow rapid drawdown or flooding if necessary to control mosquito production. Additionally, water would also be circulated through fields to maintain water quality and inhibit mosquito production.

Fields would be slowly flooded through fall and winter to depths averaging 12 inches and would be slowly drawn down from early winter through April 15. Between 50% and 67% of fields would be harvested in 120-foot-wide strips. Unharvested corn and wheat would be allowed to remain standing until wave action, root deterioration, and waterfowl foraging caused stalks and stems to fall over. Cornfields and wheat fields potentially could produce problem numbers of mosquitos from September 1 through October 31. Some mosquito production may occur during summer irrigation periods; however, production levels would be similar to those associated with corn and wheat irrigation practices elsewhere in the Delta.

Pasture/Hay. Approximately 205 acres of pasture/ hay fields would be maintained on the habitat islands. Pastures would be shallow-flooded after the mosquito breeding season from November to February. During irrigation periods from May through early summer, however, substantial numbers of mosquitos could be produced if flood irrigation water is allowed to remain on fields for more than 3 days.

Seasonal Ponds. Approximately 134 acres of small, 2- to 10-acre seasonal ponds would be created to provide brood water for ducks from February through July. Between 70% and 100% of pond area would be flooded to depths of 6-12 inches.

Seasonal ponds could potentially produce substantial numbers of mosquitos because they would be flooded during periods of high ambient temperatures, would support emergent vegetation, and would be flooded to depths favored by mosquitos. Mosquito production levels, however, would be reduced because ponds would be initially flooded during periods of cold ambient temperature. Mosquito predator populations would become established before the mosquito breeding period begins.

Permanent Lakes. Two permanent lakes of 50 acres and 60 acres would be created on Bouldin Island. Lakes would be excavated and maintained with groundwater inflow and supplemented with irrigation as needed to maintain desired water levels. Lakes would be excavated to permanently maintain open-water areas and stands of emergent vegetation along shorelines and island edges.

Mosquitos are adapted to breed in habitats that are not ecologically stable. Immediately following lake construction, permanent ponds could potentially produce substantial numbers of mosquitos, but over time, mosquito predator populations would become established. Because lakes would be open-water areas and seasonally stable lake levels would be maintained, lake environments would stabilize and mosquito production would be expected to decline.

Permanent lakes are being constructed to provide values similar to those of lakes that would be inundated on Webb Tract. The existing lakes on Webb Tract do not produce mosquitos in sufficient numbers to require abatement (Kramer pers. comm.). If lakes constructed on Bouldin Island can be maintained in an ecological condition similar to lakes on Webb Tract, production of problem numbers of mosquitos would be unlikely after the lakes have stabilized.

Emergent Marsh. Approximately 400 acres of permanent emergent marsh would be created on Bouldin Island and Holland Tract. Marshes would be dominated by tule and cattail and would be flooded all year to depths ranging from 12 inches to 36 inches. To maintain between 40% and 70% in open-water areas, the marshes would be drawn down every few years to remove emergent vegetation.

Immediately following marsh construction or maintenance drawdown periods, marshes could potentially produce substantial numbers of mosquitos. Following maintenance drawdown periods, marshes would be rapidly reflooded, reducing the likelihood that substantial numbers of mosquitos would be produced during these periods (see Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation"). Because stable water levels and open water areas would be maintained, marsh environments would stabilize and mosquito production would be expected to decline. Substantial numbers of mosquitos, however, could be produced in dense stands of emergent vegetation, such as cattail and tule. This vegetation would protect larvae from wave action and predators, such as mosquitofish.

Borrow Ponds. Approximately 90 acres of borrow ponds may be created on Bouldin Island to provide borrow material for inner levee and perimeter levee maintenance and repair. Borrow ponds would be recharged with groundwater and surface runoff, so water levels would fluctuate seasonally. Borrow ponds would not be expected to produce problem numbers of mosquitos because periodic excavations would gradually deepen ponds and steepen shorelines. Steep shorelines would not support extensive stands of emergent vegetation.

Changes in the Need for Mosquito Abatement

Bacon Island and Webb Tract

Potential for Increase in Adult Mosquito Populations. The highest potential for production of problem numbers of mosquitos on the reservoir islands would occur in certain years when islands support partial-storage, shallow-storage, or shallow-water wetland conditions from June through October. These years would include periods when partial- and shallow-storage pool shorelines and shallow-water wetlands are heavily vegetated. Substantial mosquito production would not be expected during May because full-storage, partial-storage, shallow-storage, and shallow-water wetland conditions that would exist through winter would remove vegetation from the islands.

Potential for Increase in Mosquito Abatement Levels. The potential for an increase in mosquito abatement levels would fluctuate among years and would depend on the availability of water for storage on the reservoir islands. The greatest potential for increased need for abatement would be expected from September 1 to October 31 in years when islands could be managed as shallow-water wetlands (Tables 3N-2 and 3N-3).

Bouldin Island and Holland Tract

Potential for Increase in Adult Mosquito Populations. Creating permanent lakes, emergent marshes, and borrow ponds would result in a short-term impact on mosquito production because permanent wetlands tend to develop and maintain mosquito predator populations. Mosquito production will stabilize once natural predator/ prey ratios reach equilibrium. However, the time required for newly created or restored permanent wetlands to mature is unpredictable (USFWS 1992).

Although mosquito production in permanent wetlands may stabilize at lower levels as the wetland ecosystems evolve, these sites may have the potential for long-term impacts because the definition of a mosquito production problem can be independent of the number of mosquitos produced. For example, if the human population adjacent to an existing mosquito production source were increased, the number of service calls to the responsible MAD from residents could increase without a change in existing mosquito production levels.

Seasonal wetlands, including flooded cornfields and wheat fields, have the highest potential to produce problem numbers of mosquitos from September 1 through October 31 because they duplicate habitat conditions most preferred by the species. Seasonal wetlands simulate water conditions that are associated with natural intermittent flood events and to which most species of mosquitos have adapted. Seasonal wetlands flooded from May 1 to May 31 would not be expected to produce problem numbers of mosquitos because most emergent vegetation would have been removed as a result of wave action and waterfowl forage activities.

Potential for Increase in Mosquito Abatement Levels. With implementation of Alternative 1, approximately 3,695 acres of potential mosquito breeding habitat would be created on the habitat islands during peak flood periods (i.e., October 16-31) (Tables 3N-4 and 3N-5). This represents approximately 2,100 more acres of potential mosquito habitat than were treated by MADs in 1991 (Holland Tract) and 1992 (Bouldin Island). Therefore, mosquito production might increase enough to require higher levels of mosquito abatement than are currently required.

Summary of Project Impacts and Recommended Mitigation Measures

Impact N-1: Reduction or Elimination of Mosquito Abatement Activities during Full-Storage Periods on the Reservoir Islands. Implementation of Alternative 1 would substantially reduce mosquito production and, subsequently, the need for abatement on the reservoir islands during full-storage periods. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

Impact N-2: Increase in Abatement Levels on the Habitat Islands and during Partial-Storage, Shallow-Storage, or Shallow-Water Wetland Periods on the Reservoir Islands. Implementation of Alternative 1 would result in an increase in mosquito breeding habitat on both the reservoir and habitat islands, at least during certain times of the year. Therefore, an increase in mosquito production would likely occur on the habitat islands and, during some years, on the reservoir islands under partial-storage, shallow-storage, or shallow-water wetland conditions.

Substantially more people would be exposed to mosquitos as a result of the recreation programs for hunting, boating, and other uses on the DW project islands than are exposed under existing conditions (see Chapter 3J, "Recreation and Visual Resources", for details on the recreation program). Increased exposure of people to mosquitos would result in an increased need for abatement. Therefore, this impact is considered significant.

Implementing Mitigation Measure N-1 would reduce Impact N-2 to a less-than-significant level.

Mitigation Measure N-1: Coordinate Project Activities with SJCMAD and CCMAD. DW, DFG, and the HMAC shall consult and coordinate with SJCMAD and CCMAD during design, implementation, and operations phases of the project. DW will be responsible for coordination with MADs regarding mosquito control measures for the reservoir islands, and DW, DFG, and the HMAC will be responsible for coordination regarding the habitat islands. Consultation and coordination with SJCMAD and CCMAD shall include the following actions:

- Consult with SJCMAD and CCMAD during the project design phase to incorporate design elements of the reservoir and habitat islands to reduce the mosquito production potential of the project. Measures considered should include designing water delivery and drainage systems to allow for rapid manipulation of water levels on the habitat islands. The project design for the reservoir islands allows for the rapid manipulation of water levels in water storage areas.

- Permit SJCMAD and CCMAD personnel unrestricted access to the DW project islands to monitor or control mosquito populations.

- Regularly consult with SJCMAD and CCMAD to identify mosquito management problems, mosquito monitoring and abatement procedures, and opportunities to adjust operations to reduce mosquito production during problem periods.

- Consult with SJCMAD and CCMAD to identify annual mosquitofish stocking requirements.

- If it is necessary for SJCMAD and CCMAD to increase mosquito monitoring and control programs beyond preproject levels, consult with SJCMAD and CCMAD to identify opportunities for DW to share costs or otherwise participate in implementing mosquito abatement programs.

Incidence of Wildlife-Transmitted Diseases Affecting Humans

Public health issues of concern in the proposed DW project area include the transmission of human diseases, such as rabies, bubonic plague, and Lyme disease, by wildlife and other animals. Wildlife species that could transmit these diseases to humans are not expected to be present on the reservoir islands because their habitats would be eliminated as a result of water storage. However, habitats created on the habitat islands may increase the populations of wildlife species known to serve as hosts of wildlife-transmitted diseases. People using the habitat islands for recreation may experience increased exposure or closer proximity to these wildlife populations. However, such exposure would still not be considered a risk to public health in the Delta (Lucchesi and Reilly pers. comms.).

Summary of Project Impacts and Recommended Mitigation Measures

Impact N-3: Increase in Potential Exposure of People to Wildlife Species That Transmit Diseases. Under Alternative 1, the populations of wildlife species known to serve as hosts of wildlife-transmitted diseases affecting humans could increase on the habitat islands. Increased recreational use of these areas would increase the potential exposure of people to these species. However, transmission of wildlife-transmitted diseases such as Lyme disease, bubonic plague, and rabies is not now considered a significant risk to public health in the Delta, and the increase in risk under Alternative 1 would be minor. Therefore, the potential change in risk to public health from exposure to wildlife species on the habitat islands is considered less than significant.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

The potential for mosquito production for each habitat condition class on the reservoir islands under Alternative 2 would be the same as described for Alternative 1. However, the 1995 DEIR/EIS assessment of DW project operations under Alternative 2 indicates that the frequency of each habitat condition class may differ (Tables 3N-6 and 3N-7). The habitat islands would be managed as described for Alternative 1.

The frequency with which mosquito breeding habitat would be created on Bacon Island would probably be increased because partial-storage, shallow-storage, and shallow-water wetland periods would increase. The frequency of these habitat conditions on Webb Tract would probably decrease from May through August but increase during September and October, when the island could be managed for shallow-water wetlands.

Although the frequency of creation of mosquito habitat would differ, impacts and mitigation measures under Alternative 2 are generally the same as those under Alternative 1. The impact associated with the incidence of wildlife-transmitted diseases would also be the same under Alternative 2.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 would include storage of water on all four DW project islands, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area (the NBHA) and would not be used for water storage.

Mosquito Breeding Conditions

The potential for mosquito production for each habitat condition class on the reservoir islands would be the same as described for Alternative 1. However, the frequency of occurrence of each class may differ (Tables 3N-8, 3N-9, 3N-10, and 3N-11).

Approximately 3,440 acres on Bouldin Island and 2,690 acres on Holland Tract during nonstorage periods could be flooded in fall to create shallow-water wetlands (JSA 1993). Although more acreage would be flooded under Alternative 3 than under Alternative 1 or 2, mosquito production levels would be expected to be lower because periodic inundation would result in lowered vegetation density and increased wave action.

On the portion of Bouldin Island north of SR 12 that would be managed as a wildlife habitat area, approximately 50 acres of perennial ponds, 330 acres of seasonal wetlands, and 170 acres of corn would be created on existing agricultural croplands.

Mosquito production associated with perennial ponds would be similar to that described for permanent lakes on the habitat islands under Alternatives 1 and 2. Seasonal wetlands and cornfields in the habitat area would be designed and managed as described for seasonal wetlands and cornfields on the habitat islands. Mosquito production would be the same.

Changes in the Need for Mosquito Abatement

The potential for an increase in mosquito abatement levels would depend on the availability of water for storage on the reservoir islands and would therefore fluctuate between years. The greatest potential for increased need for abatement would be expected to occur from September 1 to October 31 in years when the islands could be managed for shallow-water wetlands.

Impacts and the mitigation measure for the reservoir islands under Alternative 3 are similar to those described under Alternative 1.

Summary of Project Impacts and Recommended Mitigation Measures

Impact N-4: Reduction or Elimination of Mosquito Abatement Activities during Full-Storage Periods on the Reservoir Islands. This impact is described above under Impact N-1. This impact is considered beneficial.

Mitigation. No mitigation is required.

Impact N-5: Increase in Abatement Levels during Partial-Storage, Shallow-Storage, or Shallow-Water Wetland Periods on the Reservoir Islands and in the NBHA. This impact is similar to Impact N-2, described above. This impact is considered significant.

Implementing Mitigation Measure N-1 would reduce Impact N-5 to a less-than-significant level.

Mitigation Measure N-1: Coordinate Project Activities with SJCMAD and CCMAD. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Incidence of Wildlife-Transmitted Diseases Affecting Humans

Wildlife species that could transmit diseases to humans are not expected to be present on the reservoir islands under Alternative 3 because their habitats would be substantially reduced as a result of water storage. Habitats created on the NBHA may increase the populations of these species in that area , but that increase would be negligible relative to the reduction in populations resulting from water storage. Therefore, implementing Alternative 3 would not affect the incidence of wildlife-transmitted diseases affecting humans.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

The No-Project Alternative would increase the acreage of land cultivated for annual grains, perennial crops, orchards, and vineyards. Irrigated pasture and marsh habitats would be reduced by 1,764 acres and acreage of open-water habitats would be similar to existing acreage (Table 3N-12).

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the EIR/EIS lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Mosquito Breeding Conditions

Bacon Island and Webb Tract

Existing marsh habitats (34 acres) and irrigated pastures (61 acres) would be eliminated from Bacon Island and Webb Tract, respectively, and marsh habitats would be reduced by 899 acres (94.1%) on Webb Tract under the No-Project Alternative (Table 3N-12). Although SJCMAD and CCMAD currently do not consider either island to be a significant mosquito production source (Lucchesi and Waletzko pers. comms.), conversion of these habitats to agricultural uses could reduce the potential for future mosquito production problems on these islands (Kramer pers. comm.).

Bouldin Island and Holland Tract

Implementing the No-Project Alternative would eliminate existing marsh habitats and irrigated pastures (170 acres) on Bouldin Island. Marsh habitat and irrigated pastures on Holland Tract would be reduced by 285 acres (99.3%) and 315 acres (55.1%), respectively (Table 3N-12). Both islands support problem mosquito production sources that require frequent monitoring and treatment by SJCMAD and CCMAD (Lucchesi and Waletzko pers. comms.).

Changes in the Need for Mosquito Abatement

Potential for Reduction of Existing Mosquito Breeding Habitat

Implementing the No-Project Alternative could result in lower levels of mosquito abatement by eliminating habitats that have the potential to produce problem numbers of mosquitos and reducing or eliminating habitats currently identified by SJCMAD and CCMAD as problem mosquito production sources (Figure 3N-1).

Potential for an Increase in Adult Mosquito Populations as a Result of Increased Corn Production

An increase of 127% in annual grain production, and specifically an increase in corn cultivation, primarily on Holland and Webb Tracts (Table 3N-12), could result in increased mosquito production during the fall pre-irrigation and weed control periods. As a result, higher levels of mosquito abatement may be required.

Summary of Project Impacts and Recommended Mitigation Measures

Reduction in Mosquito Abatement Activities on the DW Project Islands. Implementation of the No-Project Alternative would reduce mosquito production by eliminating habitats that have the potential to produce problem numbers of mosquitos. Subsequently, the need for abatement on the DW project islands would be reduced.

Increase in Mosquito Production Levels as a Result of Increased Corn Production. Implementation of the No-Project Alternative could involve increased fall flooding to control weeds in cornfields, which could result in substantial increases in mosquito production. Implementing the following mitigation measure would reduce this effect of the No-Project Alternative.

Coordinate Project Activities with SJCMAD and CCMAD. DW should notify SJCMAD and CCMAD of proposed fall cornfield flooding schedules at least 2 months in advance. Additionally, DW should allow SJCMAD and CCMAD to have access to the DW islands to monitor mosquito production, control mosquitos, and conduct other related abatement activities.

Incidence of Wildlife-Transmitted Diseases Affecting Humans

Under the No-Project Alternative, populations of wildlife species that could transmit diseases to humans are not expected to increase. Increased agricultural production may reduce populations by disturbing or eliminating their habitats through plowing and vegetation removal. Therefore, implementing the No-Project Alternative would not affect the incidence of wildlife-transmitted diseases affecting humans.

CUMULATIVE IMPACTS

This section briefly analyzes cumulative impacts related to mosquito production and abatement issues. The analysis identifies other projects or activities in the Delta region and surrounding areas that may affect mosquito production conditions that may also be affected by the DW project. These projects are summarized in Appendix 2, "Supplemental Description of the Delta Wetlands Project Alternatives". Beneficial and negative cumulative effects are identified, and the overall effect of DW project impacts on regional habitats is described.

Cumulative Impacts, Including Impacts of Alternative 1

Changes in Reservoir Island Storage Conditions

DWR recently installed four additional pumping units at SWP's Banks Pumping Plant near Clifton Court Forebay, increasing total SWP pumping capacity from 6,400 cfs to 10,300 cfs. If SWP export pumping is increased to full capacity in future years, the frequency with which each storage class would occur on the DW project islands would change. Tables 3N-2 and 3N-3 present the storage class frequencies for the reservoir islands under this cumulative scenario for Alternative 1, as reported in the 1995 DEIR/EIS. In most months the frequency with which full-, partial-, and shallow-storage conditions would occur would be reduced and the occurrence of nonstorage conditions and the opportunity to create shallow-water wetland conditions would be increased. Consequently, the availability of mosquito breeding habitat would generally be reduced from May through August and would be increased during September and October under Alternative 1.

Impact N-6: Increase in Abatement Levels during Partial-Storage, Shallow-Storage, or Shallow-Water Wetland Periods on the Reservoir Islands under Cumulative Conditions. If SWP export pumping is increased to full capacity in future years, the availability of mosquito breeding habitat would generally be reduced from May through August and increased during September and October. As described under Impact N-2, increased need for abatement is considered a significant impact.

Implementing Mitigation Measure N-1 would reduce Impact N-6 to a less-than-significant level.

Mitigation Measure N-1: Coordinate Project Activities with SJCMAD and CCMAD. This impact is described above under "Impacts and Mitigation Measures of Alternative 1".

Related Future Projects

Related future projects that may contribute cumulatively to impacts on mosquito abatement programs described in this chapter include wetland habitat restoration programs that would increase mosquito breeding habitat within mosquito flight ranges of SJCMAD or CCMAD jurisdictional boundaries.

DWR has proposed projects to develop seasonal and permanent wetland habitats on Sherman Island and Twitchell Island in the west Delta (DWR 1990). Implementing these projects would create up to 10,000 acres of wetlands on Sherman Island and 3,600 acres on Twitchell Island in Sacramento County. Without mitigation, these projects could significantly increase MAD abatement requirements if mosquito production on restored wetlands results in a greater potential for disease transmittal by mosquitos or an increase in the number of service requests to MADs.

Additionally, mosquito abatement programs may be affected by projects that increase human populations near existing mosquito production areas. Residential housing developments are proposed for Hotchkiss Tract and Bethel Island west of Holland Tract. Service calls generated from new developments could substantially increase abatement costs to MADs.

Impact N-7: Cumulative Increase in Mosquito Abatement Needs Resulting from Implementation of Future Projects, Including the DW Project. Implementing future projects that benefit mosquito breeding conditions (e.g., wetland habitat restoration projects) or that increase human populations near existing mosquito production areas (e.g., residential housing and marina developments) contribute to the need for mosquito abatement in the DW project area. Mitigation should be implemented for each project during the project evaluation and approval process to minimize the cumulative effects on mosquito abatement. However, because there is no guarantee that mitigation measures would be implemented for other future projects, this impact is considered significant and unavoidable.

Mitigation. No mitigation is available to reduce this impact to a less-than-significant level.

Cumulative Impacts, Including Impacts of Alternative 2

As shown on Tables 3N-6 and 3N-7, the changes in frequencies with which habitat condition classes for the reservoir islands could occur under the cumulative scenario for Alternative 2 would be similar to the changes in frequencies shown for Alternative 1 (i.e., the availability of mosquito breeding habitat on the reservoir islands would generally be reduced from May through August and increased during September and October).

The cumulative impacts associated with this alternative would be the same as those described for cumulative conditions with Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

As shown on Tables 3N-8 through 3N-11, the frequencies with which habitat condition classes for the reservoir islands could occur under the cumulative scenario for Alternative 3 would be similar to changes in frequencies shown for cumulative conditions with Alternative 1 (i.e., the availability of mosquito breeding habitat on the reservoir islands would generally be reduced from May through August and increased during September and October).

The cumulative impacts associated with this alternative would be the same as those described for cumulative impacts with Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

Cumulative Increase in Mosquito Abatement Needs Resulting from Implementation of Future Projects, Including the No-Project Alternative. Implementing future projects that benefit mosquito breeding conditions (e.g., wetland habitat restoration projects) or that increase human populations near existing mosquito production areas (e.g., residential housing and marina developments) contribute to the need for mosquito abatement in the DW project area. The No-Project Alternative could contribute to this cumulative effect by increasing mosquito production levels on the four DW project islands during fall flooding.

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Table 3N-1. Acreages of Wetlands and Other Potential Mosquito Breeding Sites on the Delta Wetlands Project Islands

	Bacon Island[a]		Webb Tract[a]		Bouldin Island[a]		Holland Tract[a, b]		All Islands[a]	
Habitat Type[c]	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total	Acres	Percentage of Total
Canals and ditches	91.8	1.66	49.7	0.91	118.1	1.97	39.4	1.26	299.0	1.49
Ponds	1.5	0.03	105.7	1.93	0.0	0.00	16.6	0.53	123.8	0.62
Freshwater marsh	2.7	0.05	172.0	3.14	21.1	0.35	27.8	0.89	223.6	1.11
Exotic marsh	30.4	0.55	783.3	14.32	114.7	1.92	195.5	6.24	1,123.9	5.58
Irrigated pasture	0.0	0.00	61.0	1.12	34.2	0.57	349.8	11.16	445.0	2.21
Cropland[d]	3,091.5	55.81	2,694.7	49.27	4,530.3	75.69	550.9	17.57	10,867.4	53.99
Other habitat types[e]	2,321.5	41.91	1,602.6	29.30	1,166.6	19.49	1,955.2	62.36	7,045.9	35.00
Totals	5,539.4	100	5,469.0	100	5,985.0	100	3,135.2	100	20,128.6	100

[a] Acreages are derived from Table 3G-4 in Chapter 3G, "Vegetation and Wetlands".

[b] Acreages are not provided for the portion of Holland Tract that would be included under Alternative 3. Habitat acreages for Alternative 3 are presented in Table 3G-4 in Chapter 3G, "Vegetation and Wildlife".

[c] Habitat types are defined in Chapter 3G, "Vegetation and Wetlands".

[d] Includes corn, wheat, milo, potato, and sunflower crops.

[e] Other habitat types include developed areas and riparian, upland, fallow, and other cropland habitats.

Table 3N-2. Frequency of Habitat Condition Classes on Bacon Island under Alternative 1 and Cumulative Conditions for Alternative 1 (Percentage of Years)

	Alternative 1					Cumulative Alternative 1				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	74.3	4.3	1.4	20.0	0.0	67.1	0.0	1.4	31.4	0.0
June	70.0	8.7	0.0	21.4	0.0	64.3	2.9	0.0	32.9	0.0
July	45.7	11.4	8.6	34.3	0.0	2.9	0.0	0.0	97.1	0.0
August	15.7	2.9	5.7	75.7	0.0	1.4	0.0	0.0	98.6	0.0
September	11.4	2.9	0.0	61.4	24.3	4.3	4.3	0.0	0.0	91.4
October	30.0	1.4	0.0	22.9	45.7	18.6	1.4	0.0	2.9	77.1

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, “Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives”. The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-3. Frequency of Habitat Condition Classes on Webb Tract under Alternative 1 and Cumulative Conditions for Alternative 1 (Percentage of Years)

	Alternative 1					Cumulative Alternative 1				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	48.6	15.9	1.4	34.3	0	45.7	11.4	1.4	41.4	0
June	37.1	21.7	2.9	38.6	0	35.7	11.4	4.3	48.6	0
July	7.1	22.9	1.4	68.6	0	1.4	0	0	98.6	0
August	2.9	5.7	0	91.4	0	1.4	0	0	98.6	0
September	8.6	2.9	0	37.1	51.4	2.9	1.4	0	0	95.7
October	22.9	5.7	0	7.1	64.3	11.4	2.9	0	1.4	84.3

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives". The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-4. Flooded Habitat Acreages by Date on Bouldin Island under Alternatives 1 and 2 during the Mosquito Breeding Season

	Acres by Management Period[b]							
	5/1-5/15	5/16-5/30	6/1-7/30	8/1-8/30	9/1-9/15	9/16-9/30	10/1-10/15	10/16-10/31
Seasonal managed wetland and mixed agriculture/seasonal wetland	432	432	0	0	432	432	686	1,446
Corn rotated with wheat	0	0	0	0	102	204	509	712
Pasture/hay[c]	0	0	0	0	0	0	0	0
Seasonal ponds	66	66	66	0	0	0	0	0
Permanent lakes	111	111	111	111	111	111	111	111
Emergent marsh	208	208	208	208	208	208	208	208
Borrow ponds	89	89	89	89	89	89	89	89
Total	906	906	474	408	942	1,044	1,603	2,632

[a] Habitat types are described in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

[b] Acreages are derived from Table 3 in Appendix G3.

[c] Approximately 205 acres of pasture/hay would be flooded on habitat islands for wildlife after the mosquito breeding season. Mosquito breeding habitat, however, would be created during spring and summer irrigation periods.

Table 3N-5. Flooded Habitat Acreages by Date on Holland Tract under Alternatives 1 and 2 during the Mosquito Breeding Season

	Acres by Management Period[b]							
	5/1-5/15	5/16-5/30	6/1-7/30	8/1-8/30	9/1-9/15	9/16-9/30	10/1-10/15	10/16-10/31
Seasonal managed wetland and mixed agriculture/seasonal wetland	100	100	0	0	100	100	258	416
Corn rotated with wheat	0	0	0	0	60	119	298	418
Pasture/hay[c]	0	0	0	0	0	0	0	0
Seasonal ponds	68	68	68	0	0	0	0	0
Permanent lakes	33	33	33	33	33	33	33	33
Emergent marsh	194	194	194	194	194	194	194	194
Borrow ponds	0	0	0	0	0	0	0	0
Total	395	395	295	227	397	446	783	1,061

[a] Habitat types are described in Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

[b] Acreages are derived from Table 3 in Appendix G3.

[c] Approximately 205 acres of pasture/hay would be flooded on habitat islands for wildlife after the mosquito breeding season. Mosquito breeding habitat, however, would be created during spring and summer irrigation periods.

Table 3N-6. Frequency of Habitat Condition Classes on Bacon Island under Alternative 2 and Cumulative Conditions for Alternative 2 (Percentage of Years)

	Alternative 2					Cumulative Alternative 2				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	54.3	7.1	1.4	37.1	0.0	44.3	2.9	0.0	52.9	0.0
June	30.0	7.1	2.9	60.0	0.0	20.0	1.4	0.0	78.6	0.0
July	15.7	7.1	37.1	40.0	0.0	2.9	0.0	0.0	97.1	0.0
August	4.3	2.9	8.6	84.3	0.0	1.4	0.0	0.0	98.6	0.0
September	11.4	2.9	0.0	57.1	28.6	4.3	4.3	0.0	0.0	91.4
October	30.0	1.4	0.0	14.2	54.3	18.6	1.4	0.0	1.4	78.6

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, “Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives”. The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-7. Frequency of Habitat Condition Classes on Webb Tract under Alternative 2 and Cumulative Conditions for Alternative 2 (Percentage of Years)

	Alternative 2					Cumulative Alternative 2				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	38.6	11.4	0	50.0	0	28.6	7.1	1.4	62.9	0
June	17.1	10.0	0	72.9	0	11.4	2.9	0	85.7	0
July	2.9	4.3	2.9	90.0	0	1.4	0	0	98.6	0
August	1.4	1.4	1.4	95.7	0	1.4	0	0	98.6	0
September	8.6	2.9	0	10.0	78.6	2.9	1.4	0	0	95.7
October	20.0	5.7	0	4.3	75.7	11.4	2.9	0	1.4	84.3

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives". The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-8. Frequency of Habitat Condition Classes on Bacon Island under Alternative 3 and Cumulative Conditions for Alternative 3 (Percentage of Years)

	Alternative 3					Cumulative Alternative 3				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	62.9	4.3	1.4	31.4	0	47.1	2.9	0	50.0	0
June	48.6	2.9	0	48.6	0	21.4	8.6	1.4	68.6	0
July	31.4	38.6	0	30.0	0	5.7	7.1	0	87.1	0
August	11.4	10.0	1.4	77.1	0	1.4	0	0	98.6	0
September	11.4	5.7	0	54.3	28.6	4.3	4.3	0	7.1	84.3
October	30.0	1.4	0	15.7	52.9	18.6	1.4	0	1.4	78.6

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives". The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-9. Frequency of Habitat Condition Classes on Webb Tract under Alternative 3 and Cumulative Conditions for Alternative 3 (Percentage of Years)

Month	Alternative 3 Full Storage	Alternative 3 Partial Storage	Alternative 3 Shallow Storage	Alternative 3 Nonstorage	Alternative 3 Shallow-Water Wetland	Cumulative Alternative 3 Full Storage	Cumulative Alternative 3 Partial Storage	Cumulative Alternative 3 Shallow Storage	Cumulative Alternative 3 Nonstorage	Cumulative Alternative 3 Shallow-Water Wetland
May	54.3	4.3	0	41.4	0	42.9	4.3	0	52.9	0
June	32.9	4.3	0	62.9	0	18.6	2.9	0	78.6	0
July	18.6	4.3	0	77.1	0	2.9	0	1.4	95.7	0
August	2.9	2.9	0	94.3	0	1.4	0	0	98.6	0
September	8.6	2.9	0	12.9	75.7	2.9	1.4	0	2.9	92.9
October	21.4	5.7	0	4.3	68.6	11.4	2.9	0	1.4	84.3

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives". The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-10. Frequency of Habitat Condition Classes on Bouldin Island under Alternative 3 and Cumulative Conditions for Alternative 3 (Percentage of Years)

	Alternative 3					Cumulative Alternative 3				
Month	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	42.9	5.8	0	51.4	0	32.9	2.9	0	67.1	0
June	18.6	7.2	1.4	72.9	0	11.4	5.8	0	82.9	0
July	4.3	5.7	0	90.0	0	1.4	0	0	98.6	0
August	1.4	1.4	0	97.1	0	1.4	0	0	98.6	0
September	4.3	1.4	1.4	5.7	87.1	1.4	0	0	0	98.6
October	17.1	1.4	1.4	2.9	77.1	5.7	0	0	1.4	92.9

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives". The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

Table 3N-11. Frequency of Habitat Condition Classes on Holland Tract under Alternative 3 and Cumulative Conditions for Alternative 3 (Percentage of Years)

Month	Alternative 3					Cumulative Alternative 3				
	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland	Full Storage	Partial Storage	Shallow Storage	Nonstorage	Shallow-Water Wetland
May	20.0	7.2	1.4	71.4	0	12.9	8.6	1.4	77.1	0
June	10.0	4.3	0	85.7	0	7.1	0	0	92.9	0
July	2.9	1.4	0	95.7	0	1.4	0	0	98.6	0
August	1.4	0	0	98.6	0	0	0	0	100.0	0
September	1.4	0	0	2.9	95.7	1.4	0	0	0	98.6
October	11.4	1.4	4.3	1.4	81.4	4.3	0	1.4	1.4	92.9

Note: Percentages may not total 100 because of rounding.

Frequencies were estimated based on the 70-year hydrologic record presented in Appendix G4, "Simulated End-of-Month Water Storage on Reservoir Islands for the Delta Wetlands Project Alternatives". The frequency with which each habitat condition class would occur in future years, however, is unpredictable. Frequencies do not include periods when reservoir islands may be used for water transfers or banking. If reservoir islands are used to transfer or bank water, the frequency of storage periods could be expected to increase and the frequency of nonstorage and shallow-water wetland periods could be expected to decrease.

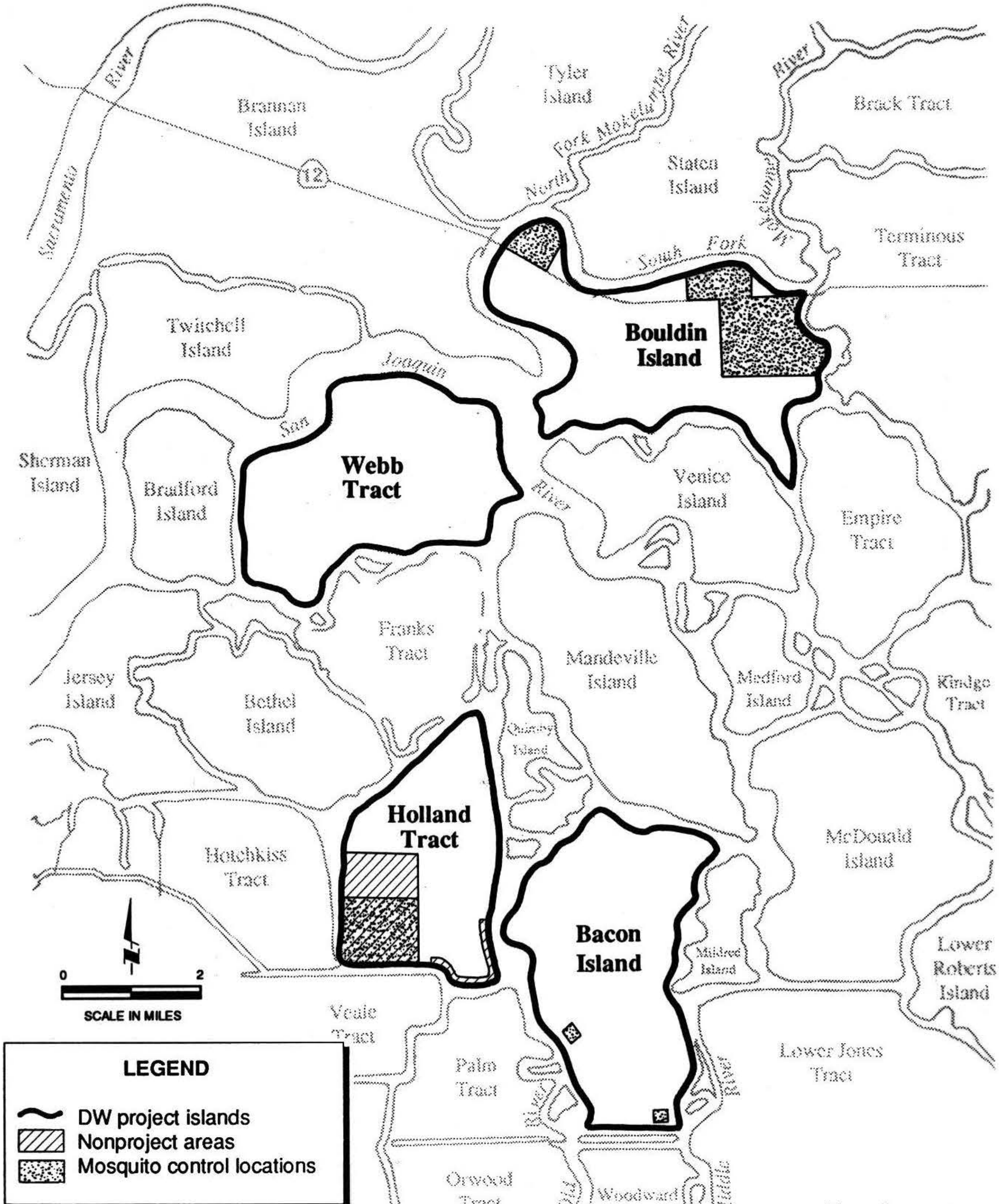
Table 3N-12. Predicted Changes in Acreages of Habitat Types under the No-Project Alternative

	Bacon Island		Webb Tract		Bouldin Island		Holland Tract		Total		
Habitat Type[a]	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	1987 Acreage	No-Project Acreage	Estimated Change between 1987 and No-Project Acreages
Ditches and sloughs	92	92	50	50	118	118	45	45	305	305	0
Ponds	2	2	106	106	0	0	23	23	131	131	0
Freshwater marsh	3	0	172	16	21	0	28	2	224	18	-206
Exotic marsh	30	0	783	40	115	0	259	0	1,188	40	-1,148
Irrigated pasture	0	0	61	0	34	0	571	256	666	256	-410
Crops, orchards, vineyards	4,439	5,095	2,695	4,961	4,530	5,426	1,541	3,693	13,205	19,175	5,970
Fallowed lands	355	0	638	0	712	0	785	0	2,490	0	-2,490
Other habitat types[b]	617	351	965	296	455	440	998	230	3,035	1,317	-1,718
Total	5,539	5,540	5,470	5,469	5,985	5,984	4,250	4,249	21,244	21,242	

Notes: Minor discrepancies in totals are the result of rounding.

[a] Habitat types are defined in Chapter 3G, “Vegetation and Wetlands”.

[b] Includes developed lands and riparian and upland habitats.



Note: The nonproject areas on Holland Tract are included in the DW Project for Alternative 3 and the No-Project Alternative.

Source: Lucchesi and Kramer pers. comms.

Jones & Stokes

Figure 3N-1
Mosquito Control Locations on the Delta Wetlands Project Islands, 1991-1992

Chapter 3O. Affected Environment and Environmental Consequences - Air Quality

Chapter 3O. Affected Environment and Environmental Consequences - Air Quality

SUMMARY

This chapter discusses air quality on and near the DW project islands and analyzes the impacts on air quality conditions in project area air basins that could result from implementation of the DW project alternatives. The pollutants studied for this analysis are carbon monoxide (CO), ozone precursors (reactive organic gases [ROG] and oxides of nitrogen [NO_x]), and particulate matter smaller than 10 microns in diameter (PM10).

Construction and operation under Alternative 1, 2, or 3 would result in significant increases in emissions of ROG and NO_x, and construction under Alternative 1, 2, or 3 would result in significant increases in PM10. The following mitigation measures would reduce construction impacts, but not to less-than-significant levels: perform routine maintenance on construction equipment, require borrow sites to be chosen closest to fill locations, prohibit unnecessary idling of construction equipment engines, and implement construction practices that reduce generation of particulate matter. Recreation-generated vehicle and boat trips would be the primary source of air pollutant emissions during project operations. Reducing the number of new boat slips associated with the Delta Wetlands recreation facilities would reduce emissions associated with boat and vehicle traffic generated by the project, but not to a less-than-significant level. To further reduce project operation impacts, DW should coordinate with the local air districts to implement measures that would reduce or offset DW project air emissions. Because the feasibility and effectiveness of those measures are not known, these impacts are considered significant and unavoidable.

Implementation of Alternative 1, 2, or 3 would result in increases in CO emissions during project construction and operation. Because the project area is a CO attainment area under state and federal standards, these changes in CO generation are considered less than significant. However, mitigation measures are recommended for the construction period to reduce the quantity of CO generated.

Under DW project operation, the reduction in agriculture-related activities would result in a beneficial decrease in PM10 emissions.

Operation of the No-Project Alternative includes intensified agricultural activity with some increase in recreational uses. Implementation of the No-Project Alternative would result in increases in CO, ROG, NO_x, and PM10 emissions.

Implementation of Alternative 1, 2, or 3 in conjunction with cumulative development and increased recreational use of the Delta would contribute to the cumulative production of ozone precursors (ROG and NO_x) and CO in the Delta. This cumulative impact is considered significant and unavoidable.

CHANGES MADE TO THIS CHAPTER FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

In an effort to reduce roadway and waterway traffic associated with increased recreational boating use in the Delta attributable to the proposed project, the EIR/EIS lead agencies and the project proponent developed a new mitigation measure for the final environmental document that requires DW to reduce the total number of outward (channel-side) boat slips proposed on the DW islands by 50%. This mitigation measure has been incorporated into this chapter to recreation-generated emissions. No other changes have been made to the chapter.

AFFECTED ENVIRONMENT

Sources of Information

All information on air quality used in this analysis was collected in preparation of the 1995 DEIR/EIS; the 1990 draft EIR/EIS did not contain a chapter on air quality. This section describes the air quality environment in the DW project vicinity at the time that the 1995 DEIR/EIS was prepared. The information used to describe these existing air quality conditions was derived from many sources, including the California Air Resources Board (ARB), the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD), and the Bay Area Air Quality Management District (BAAQMD). Federal and state ambient air quality standards are described below for each pollutant to provide the context for the discussion of existing air quality conditions in the project area.

Information on sulfur dioxide was not included in this chapter because sulfur dioxide is emitted primarily by industrial sources and is not considered to be a pollutant of concern in the DW project area, which is in attainment with state and federal standards for sulfur dioxide. Nitrogen dioxide is included in the group of pollutants discussed in this chapter as NO_x. Nitrogen dioxide is usually not discussed separately from other NO_x compounds in analyses of nonindustrial projects because high nitrogen dioxide concentrations are most often associated with industrial combustion sources.

Regional Geography, Topography, and Climate

Two of the DW project islands, Bacon and Bouldin Islands, are located in San Joaquin County, which is in the San Joaquin Valley Air Basin (SJVAB); the other two project islands, Holland and Webb Tracts, are in Contra Costa County, which is in the San Francisco Bay Area Air Basin (SFBAAB).

The project islands are all located in the Delta, a flat, sea-level area with moderate temperatures and rainfall. The Delta is upwind from major population centers in the Sacramento Valley Air Basin and the SJVAB. Pollutants generated in the Delta are transported to these areas, which already tend to experience high levels of pollution. The Delta, in turn, receives pollutant transport from the Bay Area.

Carbon Monoxide

Federal and State Air Quality Standards

CO is a public health concern because it combines readily with hemoglobin, reducing the amount of oxygen transported to the bloodstream. CO binds to hemoglobin 200-250 times more strongly than oxygen. Thus, relatively low concentrations of CO can significantly affect the amount of oxygen in the bloodstream. Both the cardiovascular system and the central nervous system can be affected when 2.5%-4.0% of the hemoglobin in the bloodstream is bound to CO rather than to oxygen. The state and federal ambient air quality standards have been set at levels to keep CO from combining with more than 1.5% of the blood's hemoglobin (EPA 1979, ARB 1982). CO is of concern primarily during winter, when vehicle-related emissions are greatest and atmospheric stability allows the buildup of high CO concentrations.

State and federal CO standards have been set for both 1-hour and 8-hour averaging times. The average CO level measured over any 1-hour period is not to exceed the 1-hour standards, and the average CO level measured over any 8-hour period is not to exceed the 8-hour standards. The state 1-hour CO standard is 20 parts per million (ppm), and the federal 1-hour standard is 35 ppm. The state and federal 8-hour standards are both 9 ppm. State CO standards are phrased as values not to be exceeded. Federal CO standards are phrased as values not to be exceeded more than once per year.

Existing Air Quality Conditions

Air Quality Monitoring Data. Within the SJVAB, only the metropolitan area of Fresno is a non-attainment area for CO under both federal and state standards. The metropolitan areas of Bakersfield, Modesto, and Stockton are nonattainment areas under federal standards. The remaining portions of the SJVAB, including Bacon and Bouldin Islands, are in attainment under state and federal CO standards.

Within the SFBAAB, only the urban portion of Santa Clara County is a nonattainment area for CO under state standards. The remaining portions of the SFBAAB, including Holland and Webb Tracts, are in attainment of the state CO standards. All urban portions of all counties in the SFBAAB are nonattainment areas for CO under federal standards. The remaining portions of the SFBAAB, including the DW project area, are in attainment under the federal CO standards. The BAAQMD has submitted a request to redesignate federal CO nonattainment areas in the SFBAAB as CO maintenance areas (Marshall pers. comm.).

Table O1-1 in Appendix O1, "Air Quality Monitoring Data and Pollutant Emissions under Existing Conditions and the Delta Wetlands Project Alternatives", shows air quality monitoring data for CO for 1989-1993. Data are included for all monitoring stations in Contra Costa and San Joaquin Counties; however, few of the monitoring stations are located near the DW project area. Only the Delta monitoring stations, at Bethel Island Road and Pittsburg in Contra Costa County, are discussed in this chapter.

As shown in Table O1-1, the highest 1-hour CO concentration at the Bethel Island Road station during 1989-1993 was 5.0 ppm and occurred in 1993. The highest 8-hour CO concentration was 3.9 ppm and occurred in the same year. There were no days with CO concentrations over the state and federal standard of 9.0 ppm at this station during this period.

The highest 1-hour CO concentration at the Pittsburg station during 1989-1993 was 12.0 ppm and occurred in 1989. The highest 8-hour CO concentration was 4.8 ppm and occurred in the same year. There were no days with CO concentrations over the state and federal standard of 9.0 ppm at this station during this period.

Existing Emissions on the DW Project Islands. As shown in Table 3O-1, approximately 1,554 pounds of CO are being emitted each day on the DW project islands as a result of existing agricultural and recreational activities (see Appendix O1 for more detailed information regarding existing CO emissions). This estimate was derived using the methods described below for estimating project-related emissions.

Ozone

Federal and State Air Quality Standards

Ozone is a public health concern because it is a respiratory irritant that increases human susceptibility to respiratory infections. Ozone can cause significant damage to leaf tissues of crops and natural vegetation and can damage many materials by acting as a chemical oxidizing agent.

Ozone is of concern primarily during summer when high temperatures, the presence of sunlight, and an atmospheric inversion layer induce photochemical reactions that convert ROG and NO_x into ozone. Because ozone is not emitted directly into the atmosphere, but is created by reactions of these ozone precursors in the presence of sunlight, emissions of ROG and NO_x are estimated in this chapter as a way of assessing potential for ozone generation.

State and federal standards for ozone have been set for a 1-hour averaging time. The state 1-hour ozone standard is 0.09 ppm, not to be exceeded. The federal 1-hour ozone standard is 0.12 ppm, not to be exceeded more than three times in any 3-year period.

Existing Air Quality Conditions

Air Quality Monitoring Data. The SJVAB and SFBAAB are both nonattainment areas for ozone under state standards. The SJVAB is also a nonattainment area for ozone under federal standards. SFBAAB is an ozone maintenance area under federal standards (Marshall pers. comm.).

Table O1-2 in Appendix O1 shows air quality monitoring data for ozone for 1989-1993. As shown in Table O1-2, the highest 1-hour ozone concentration at the Bethel Island Road station in this 4-year period was 0.12 ppm and occurred in 1990. There were 29 days with ozone concentrations over the state standard of 0.09 ppm at this station during this period. The federal standard of 0.12 ppm was not exceeded at this station during 1989-1993.

The highest 1-hour ozone concentration at the Pittsburg station during 1989-1993 was 0.13 ppm and occurred once in 1993. There were 16 days with ozone concentrations over the state standard of 0.09 ppm at this station during this 5-year period.

Existing Emissions on the DW Project Islands. As shown in Table 3O-1, approximately 116 pounds of ROG and 459 pounds of NO_x, the ozone precursors, are being emitted each day on the DW project islands as a result of existing agricultural and recreational activities (see Appendix O1 for more detailed information regarding existing ROG and NO_x emissions). These estimates were derived using the methods described below for estimating project-related emissions.

PM10

Federal and State Air Quality Standards

At one time, the federal and state particulate matter standards applied to a broad range of particle sizes. The high-volume samplers used at most monitoring stations were most effective in collecting particles smaller than 30 microns in diameter (1 micron is equal to about 0.00004 inch) (Powell 1980). Health concerns associated with suspended particles focus on those particles small enough to reach deep into the lungs when inhaled. Few particles larger than 10 microns in diameter reach the lungs. Consequently, both the federal and state air quality standards for particulate matter were revised to apply only to these small particles (generally designated as PM10).

State standards for inhalable particulate matter have been set for two periods, a 24-hour average and an annual geometric mean of the 24-hour values; federal standards have been set for a 24-hour average and an annual arithmetic mean of the 24-hour values. (See Appendix O1, "Air Quality Monitoring Data and Pollutant Emissions under Existing Conditions and the Delta Wetlands Project Alternatives", for a description of the geometric and arithmetic means.) The state PM10 standards are 50 micrograms per cubic meter (Fg/m^3) as a 24-hour average and 30 Fg/m^3 as an annual geometric mean. The federal PM10 standards are 150 Fg/m^3 as a 24-hour average and 50 Fg/m^3 as an annual arithmetic mean.

Existing Air Quality Conditions

Air Quality Monitoring Data. The SJVAB and the SFBAAB are both nonattainment areas for PM10 under state standards. The SJVAB is also a nonattainment area for PM10 under federal standards, and the SFBAAB is an unclassified area, with pending redesignation as a nonattainment area, under federal standards (Marshall pers. comm.).

Table O1-3 in Appendix O1 shows air quality monitoring data for PM10 for 1989-1993. As shown in Table O1-3, the highest 24-hour PM10 concentration at the Bethel Island Road station during this 5-year period was 141.0 Fg/m^3 and occurred in 1990. There were 30 days with PM10 concentrations over the state standard of 50 Fg/m^3. The federal standard was not exceeded at this station during this period.

The Pittsburg station is not designed to monitor for PM10 concentrations.

Existing Emissions on the DW Project Islands. As shown in Table 3O-1, approximately 32,143 pounds of PM10 are being emitted each day on the DW project islands as a result of existing agricultural and recreational activities (see Appendix O1 for more detailed information regarding existing PM10 emissions). This estimate was derived using the methods described below for estimating project-related emissions.

Air Quality Management Programs

State

The California Clean Air Act requires that an air quality attainment plan be prepared for areas that violate air quality standards for CO, sulfur dioxide, nitrogen dioxide, or ozone. No locally prepared attainment plans are required for areas that violate state PM10 standards. PM10 attainment issues are being addressed by the ARB. The air quality attainment plan requirements established by the California Clean Air Act are based on the severity of air pollution problems caused by locally generated emissions. Upwind air pollution control districts are required to establish and implement emission control programs commensurate with the extent of pollutant transport to downwind districts.

The SJVUAPCD's 1991 Air Quality Attainment Plan was approved by the ARB in January 1992. The BAAQMD prepared a Clean Air Plan that was approved in 1991 and submitted an update of its air quality attainment plan to the ARB in 1994. This update has been verbally approved by ARB and written approval is expected by January 1996.

Federal

The federal Clean Air Act mandated the establishment of ambient air quality standards and requires areas that violate those standards to prepare and implement plans to achieve the standards. These plans are called State Implementation Plans (SIPs). A separate SIP must be prepared for each nonattainment pollutant. Although the SFBAAB is currently awaiting redesignation of its CO nonattainment areas as CO maintenance areas, it does have a SIP for CO. This SIP is not truly applicable, however, because the CO standards included in that plan have already been achieved (Marshall pers. comm.). SIPS for CO, ozone, and PM10 have been prepared for the SJVAB but they have not yet been approved by EPA (Stagnaro pers. comm.).

Consistency with Local Air Quality Management Programs

According to the BAAQMD, there are no aspects of the DW project that would cause it to be inconsistent with the BAAQMD's 1991 Clean Air Plan or the 1994 update (Steinberger and Marshall pers. comms.). According to the SJVUAPCD, the DW project would not be inconsistent with the SJVUAPCD 1991 Air Quality Attainment Plan if the project includes all the mitigation measures for construction-related PM10 emissions outlined in Rule 8020 of SJVUAPCD Regulation 8 (Stagnaro pers. comm.). Rule 8020 requires that the following actions be taken to minimize PM10 emissions at construction sites (SJVUAPCD 1993):

- All disturbed areas of a construction site, including storage piles of fill dirt and other bulk materials that are not being actively used for a period of 7 days or more shall be stabilized using water, chemical dust stabilizers, or planting of vegetation. Application of the stabilizing material must effectively stabilize the disturbed area and limit visible dust emissions.

- Appropriate dust control measures must be utilized during land preparation, demolition, excavation, or extraction. Appropriate dust control measures may consist of effective application of water or pre-soaking.

- Visible dust emissions from onsite unpaved roads and offsite unpaved access roads must be effectively limited using water or chemical dust stabilizers or suppressants.

- Mud and dirt must be removed from paved public roads, including shoulders, adjacent to the construction site. The use of dry rotary brushes or blower devices for this purpose is expressly prohibited. Additionally, the use of paved access aprons, gravel strips, and wheel washers is strongly encouraged to minimize the need for removal of mud and dirt from paved public roads.

- All areas used for storage of construction vehicles, equipment, and materials shall comply with the measures described above.

Because the actions described above have been included in construction mitigation for each of the DW project islands where appropriate, the project would not be inconsistent with the SJVUAPCD 1991 Air Quality Attainment Plan.

Conformity with State Implementation Plans

Projects involving federal funding or federal approval are required to show conformity with EPA's general conformity rule if they would result in emission of over a certain amount of nonattainment pollutants. These pollutant threshold levels, called "de minimis" emission levels, vary from pollutant to pollutant and depend on the attainment status of individual air basins. As discussed above, pollutants for which the DW project area is in nonattainment are ozone (formed by ROG and NO_x in the presence of sunlight) and PM10. According to EPA, the applicable de minimis levels for this project are 100 tons per year (tpy) of ROG, 50 tpy of NO_x, and 70 tpy of PM10. Tables 3O-2 and 3O-3 show the results of conformity screening for Alternatives 1 and 3, respectively.

IMPACT ASSESSMENT METHODOLOGY

Under existing conditions, emissions are generated by agricultural and recreational activities. Under Alternatives 1, 2, and 3, emissions would be generated during activities associated with construction of facilities (i.e., transport of employees and materials to the islands, rock placement, and earthmoving) and operation (i.e., discharge pump operation, recreational activities, and agricultural activities). Under the No-Project Alternative, emissions would be generated by agricultural and recreational activities that would be expected to occur on the islands if the DW project is not implemented.

Analytical Approach and Impact Mechanisms

This section describes the methods used to estimate CO, ROG, NO_x, and PM10 emissions generated by construction, operation, and agricultural activities under the DW project alternatives, as well as under existing conditions. Maintenance activities, consisting of boat and maintenance vehicle trips to the project islands, were assessed in preliminary stages of the analysis. Few vehicle and boat trips are associated with maintenance, and in general, these constitute a minor component of pollutant emissions associated with the DW project. Because vehicle and boat trips are the only activities associated with emissions during maintenance, maintenance-related emissions contribute a negligible fraction of operation-related emissions, and therefore are not considered further in this chapter. The methods described below were designed to estimate pollutant emissions for the worst-case scenario, under which all activities assessed for a given condition would occur simultaneously.

Construction-Related Emissions

Construction-related emissions were calculated only for Alternatives 1 and 3 because project-related construction does not occur under existing conditions and would not occur under the No-Project Alternative. Additionally, emissions generated during construction under Alternative 2 would be the same as the emissions generated during construction under Alternative 1.

The average amount of CO, ROG, NO_x, and PM10 that would be emitted on each island during each day of construction was calculated based on the average number of vehicle and boat trips expected to take place per day, as well as the number of hours of rock placement and the number of cubic yards of earth moved per day during the construction period (Forkel and Stewart pers. comms.). It should be noted that the boat trips included in this analysis are not ferry trips, but are trips made by private boats. Additionally, all trips referred to in this chapter, as well as in the traffic chapter, are one-way trips, rather than round trips.

The total number of hours of rock placement that would take place and the total amount of earth that would need to be moved on each DW project island were each divided by 375, to represent the average amount of these activities that would take place on each day of construction during the 1.5-year construction period. It was assumed that there would be 250 days of construction each year, for a total of 375 construction days in a 1.5-year period, except on Bouldin Island under Alternative 3, in which case the construction period was assumed to be 2.5 years, or 625 days.

The average number of hours of rock placement expected to occur per day was multiplied by emission rates for cranes taken from the EPA document Compilation of Air Pollution Emission Factors, also known as AP-42 (EPA 1985), to calculate the average amount of each pollutant emitted by rock placement cranes during each day of construction on each DW project island (see Tables O1-8 through O1-15 in Appendix O1). A similar process was applied to the average number of cubic yards of earth moved per day on each island. The average number of vehicle and boat trips expected to occur each day on each island was multiplied by emission rates taken from AP-42 to calculate the average amount of each pollutant emitted by construction vehicles and boats during each day of construction on each island (see Tables O1-8 through O1-15 in Appendix O1).

In addition to combustion-related emissions of PM10, PM10 emissions generated through construction-related ground disturbance were estimated through multiplication of the total acreage of each DW project island by a ground-disturbance PM10 emission rate taken from AP-42. It was assumed that an estimate based on each acre being disturbed once would approximate the actual practice of some acres being disturbed numerous times and others being left undisturbed.

Operation-Related Emissions

Three different activities, water pumping, recreation, and agriculture, are associated with operation of the DW project. The methods used to assess pollutant emissions resulting from these activities are described below.

Pumping. Emissions generated during pumping were calculated only for Alternatives 1 and 3 because discharge pumping of stored water is not conducted under existing conditions and would not occur under the No-Project Alternative. Although the amount of discharge under Alternative 2 would be slightly different from the amount of discharge under Alternative 1, Alternative 2 is similar enough to Alternative 1 that little variation in pumping emissions is expected to occur. It should be noted that the project's pumps are likely to be electrically powered but may instead be diesel fueled. This analysis assesses the worst-case scenario (i.e., that the pumps would be diesel fueled). If electric pumps are used, no pollutant emissions would be generated by pumping.

The average amount of CO, ROG, NO_x, and PM10 emitted each day by diesel pumps discharging water from the DW project islands was calculated based on the total DW discharge for export reported in the 1995 DEIR/EIS and shown in Tables 3A-6 and 3A-10 of Chapter 3A, "Water Supply and Water Project Operations", for Alternatives 1 and 3, respectively. As reported in the 2000 REIR/EIS, incorporating the FOC into the proposed project operations reduced the frequency and average quantity of water storage operations under Alternatives 1 and 2. No changes have been made to the assessment of emissions from pumping activities because the reduction in emissions from pumping activities attributable to less frequent water storage operations would be minor. Therefore, the assessment presented in this chapter may slightly overestimate emissions associated with project operations under Alternatives 1 and 2.

The total discharge for export reported in the 1995 DEIR/EIS was multiplied by an average fuel consumption rate per acre-foot of water pumped to calculate the total amount of fuel needed to pump water from each island annually (Forkel pers. comm.). This annual amount of fuel consumption was divided by 365 to represent the amount of fuel needed to pump the average volume each day. Although the amount of water pumped per day would vary from year to year and month to month, in order to determine an average amount of emissions generated per day, pumping was assumed to be evenly distributed throughout the year. The average daily fuel consumption for pumping was then multiplied by diesel fuel combustion emission rates taken from AP-42 to calculate the average amount of each pollutant emitted on each island during each day of discharge (see Tables O1-8 through O1-15 in Appendix O1). It should be noted that although there would be a minimal amount of water storage on the habitat islands under Alternatives 1 and 3, the amount of pumping would not be sufficient to cause a noticeable effect on discharge-related emissions.

Operation of the siphon booster pumps was not included in this analysis because these pumps are small and would only be used in the event that gravity fails to successfully divert water onto the DW project islands. Emissions from the booster pumps are expected to be minimal, especially when compared with emissions generated during discharge.

Recreation. Recreation-related air pollutant emissions were calculated for existing conditions, Alternative 1, Alternative 3, and the No-Project Alternative. Recreation-related emissions for Alternative 2 would be almost identical to recreation-related emissions for Alternative 1.

The impact analysis compared recreation-related emissions estimated for the peak recreation season under each alternative with emissions for the peak season under existing conditions. Trip generation estimates for recreation-related vehicle and boat use for all seasons of recreational activity (see Table 3L-5 in Chapter 3L, "Traffic and Navigation") were used to determine the season with the greatest amount of recreational trip generation. The trip generation estimates are described in the following sections.

Under existing conditions and the No-Project Alternative, the hunting season would be the peak recreation season (see Chapter 3J, "Recreation and Visual Resources"). Therefore, peak emissions generated by recreational activities under existing conditions and the No-Project Alternative were estimated based on estimates of hunting activities during the hunting season. Under Alternatives 1 and 3, summer would be the peak recreation season (see Chapter 3J). Boating, fishing, hunting, and other miscellaneous recreational activities were included in the analysis of trip generation for recreation, as described below. However, because summer is the peak recreation season assessed for the air quality impact analysis for Alternatives 1 and 3, hunting is not included as a source of recreation-related emissions for the peak use impact assessment for these alternatives because hunting would not occur during summer.

Existing Conditions and the No-Project Alternative. Hunting-related vehicle trips were estimated for existing conditions and the No-Project Alternative using the number of annual hunter use-days expected on the DW project islands (Table 3J-2 in Chapter 3J, "Recreation and Visual Resources"). One hunter use-day represents participation by one individual in hunting activities for any portion of a 24-hour period. The following assumptions were used to determine annual hunting-related vehicle trips:

- Hunters would not stay overnight; therefore, each hunter use-day represents one hunter.
- Vehicle occupancy would be two people per vehicle.
- Each vehicle would make two trips (one trip to the island and one trip back).

The annual number of vehicle trips was then divided by the number of days that hunting is or would be allowed in a year, giving the average number of recreation-related vehicle trips occurring per day during the hunting season. The number of days hunting would be allowed during the year was assumed to be the same for existing conditions and the No-Project Alternative, as shown for the No-Project Alternative in Table 3J-16. To calculate recreation-related emissions for existing conditions and the No-Project Alternative, the average number of vehicle trips expected to occur during the hunting season was multiplied by automobile emission rates taken from AP-42 (see Tables O1-4 through O1-7 and O-16 through O-19 in Appendix O1).

Alternatives 1 and 3. Hunting-related vehicle trip generation for Alternatives 1 and 3 was estimated in the same manner as for existing conditions. However, the DW project alternatives would include lodging facilities for hunters; therefore, the number of hunters was estimated based on the following assumptions: an overnight hunter accounts for two hunter use-days, 70% of the hunters would stay overnight at the project facilities, and the remaining 30% of the hunters would come for day use only. Also, it was assumed that 10% of the hunters using Webb Tract would travel by private boats and would not use the ferry.

Estimates of annual hunter use-days shown in Table 3J-11 in Chapter 3J were used for the trip generation analysis for Alternatives 1 and 3. These numbers represent the maximum amount of hunting that would occur during the approximately 5- to 15-year period following project start-up. After this initial period, hunting activity on the DW project islands is expected to decrease. These maximum numbers were used for a worst-case analysis. Additionally, the number of days that hunting would be allowed in future years under each alternative was taken from Tables 3J-3, 3J-4, 3J-12, 3J-13, 3J-14, 3J-15, and 3J-16 in Chapter 3J. Depending on the alternative and the island under consideration, days on which hunting would be allowed varied from 47 to 86.

Hunting also would result in boating on the interior of the project islands under Alternatives 1 and 3. Trip generation for hunting-related boating was estimated based on the number of hunters expected to use the project islands each day, assuming an occupancy of two people per boat. This activity is not considered a part of pleasure boating activities, which would take place in the Delta on the exterior of the DW project islands. Additionally, hunting-related boat trips would be much shorter in duration, and boats used for hunting are smaller than pleasure boats.

Boating activity associated with Alternatives 1 and 3 would result in both vehicle traffic and boat traffic. Trip generation for boating-related boats and vehicles for Alternatives 1 and 3 was estimated for each season using peak-use estimates for each season. Boat berths that would be constructed under the DW project alternatives are projected to have an average boat occupancy rate of 70% (see Chapter 3J, "Recreation and Visual Resources"). Estimates of the percentage of docked boats that are used on a peak day were used to estimate the total number of boats that would be used per peak day for each season under Alternatives 1 and 3. Estimates were based on the assumptions that each boat would complete two trips each day, and that the occupancy rate would be three people per boat.

The numbers of boating-related vehicle trips under Alternatives 1 and 3 were calculated based on the numbers of boaters (assuming three boaters per boat), the number of peak-day boat trips, and an occupancy rate of two people per car. Therefore, the number of boating-related vehicle trips would be 1.5 times the number of boat trips during every season except hunting season. Because 5% of the hunters are assumed to engage in pleasure boating, 5% of the hunting-related vehicle trips were subtracted from the boating-related vehicle trips during the hunting season.

Generation of vehicle trips related to other recreational activities under Alternatives 1 and 3 was estimated for each season using the number of recreationists other than boaters or hunters expected to use each island. This number was estimated in relation to the number of boaters expected to use the islands. See Chapter 3J, “Recreation and Visual Resources”, for further explanation of this estimate. It was assumed that 90% of these recreationists would drive to the islands or, in the case of Webb Tract, to the ferry. A vehicle occupancy of two people per car was assumed.

To calculate recreation-related emissions for Alternatives 1 and 3, the number of vehicle and boat trips expected to occur during summer under each alternative was multiplied by automobile and boat emission rates taken from AP-42 (see Tables O1-8 through O1-15 in Appendix O1).

Agriculture. Agricultural emissions were calculated for existing conditions and conditions under Alternative 1 and the No-Project Alternative. Agricultural emissions under Alternative 2 would be identical to agricultural emissions under Alternative 1. No agricultural use of the DW project islands is expected to occur under Alternative 3; therefore, no agricultural emissions were estimated for that alternative.

Agricultural emission calculations were divided into two categories: emissions generated by agricultural equipment, nonharvest vehicles, and agricultural boats and emissions generated by harvest vehicles. Agricultural equipment is used for activities such as harvesting and tilling. Harvest vehicles are used to deliver harvested crops. Nonharvest vehicles are used for all other farm-related trips. It should be noted that the boat trips included in this analysis are not ferry trips but are trips made by private boats. See Tables O1-4 through O1-19 for calculations of agricultural emissions.

Existing Conditions. To calculate emissions generated by agricultural equipment, nonharvest vehicles, and agricultural boats under existing conditions, the average daily gas and diesel consumption by agricultural equipment, nonharvest vehicles, and agricultural boats on the DW project islands was multiplied by fuel-combustion emission rates taken from AP-42. It was assumed that agricultural activities are conducted approximately 250 days per year on the DW project islands (Forkel pers. comm.). Therefore, the total amount of gas and diesel fuel consumed annually by agricultural equipment, nonharvest vehicles, and agricultural boats on each island under existing conditions was divided by 250, giving the estimated average amount of fuel consumed per day.

In addition to the emission calculations described above, further calculations were needed to determine the quantity of PM10 that would be generated through ground disturbance caused by agricultural equipment. This quantity was estimated by multiplying the total acreage farmed under existing conditions by a ground-disturbance factor, then multiplying by a ground-disturbance PM10 emission rate taken from AP-42. The ground-disturbance factor is equal to the average number of times an acre of active farmland is expected to be disturbed per year, which was assumed to be five, representing tilling, seeding, two episodes of weeding, and harvesting. It should be noted that ground disturbance is the greatest source of PM10 emissions in the project area under any condition.

To calculate emissions generated by harvest vehicles under existing conditions, the average daily number of existing harvest vehicle trips occurring on the DW project islands was multiplied by emission rates taken from AP-42.

No-Project Alternative. To calculate all emissions, including ground-disturbance PM10 emissions, generated by agricultural equipment, nonharvest vehicles, and agricultural boats under the No-Project Alternative, the quantities of such emissions under existing conditions were multiplied by a production factor. This production factor is equal to the amount of agricultural production expected to occur under the No-Project Alternative divided by the amount of agricultural production occurring under existing conditions. The amount of agricultural production expected to occur under the No-Project Alternative was taken from Table 3I-10 and the amount of agricultural production occurring under existing conditions was taken from Table 3I-6 in Chapter 3I, “Land Use and Agriculture”. For more information on the agricultural analysis, see Chapter 3I.

To calculate emissions generated by harvest vehicles under Alternative 1, the quantity of such emissions under existing conditions was multiplied by the acreage factor discussed below.

Alternative 1. To calculate all emissions, including ground-disturbance PM10 emissions, generated by agricultural equipment, nonharvest vehicles, and agricultural boats under Alternative 1, the quantities of such emissions under existing conditions were multiplied by an acreage factor. An acreage factor is used for this calculation rather than a production factor because no information was available regarding the amount of crop production expected to occur under Alternative 1. This acreage factor is equal to the number of acres expected to remain in conventional agricultural use under Alternative 1, which is 1,120 acres on Holland Tract, divided by the number of acres farmed under existing conditions on Holland Tract. There would be no land used for conventional agriculture on the other islands under Alternative 1. The number of acres expected to remain in conventional agricultural use under Alternative 1 was taken from the text of Chapter 3I, and the number of acres farmed under existing conditions on Holland Tract was taken from Table 3I-6.

An additional type of agriculture, habitat-related farming, would take place under Alternative 1; this agricultural use does not currently occur and would not occur under the No-Project Alternative. Habitat-related farming would be an additional source of ground-disturbance PM10 emissions. Because habitat-related farming would not be very intensive, vehicle emissions associated were considered negligible and were not included in this analysis. The following information on the amount and type of habitat-related farming that would take place under Alternative 1 was taken from Appendix G3, "Habitat Management Plan for the Delta Wetlands Habitat Islands".

The most intensive types of habitat-related farming activity were considered: corn and wheat in rotation, small grains, pasture, and seasonal wetland. For corn and wheat rotation and small grains, it was assumed that the ground would be disturbed approximately three times a year for tilling, seeding, and harvesting. For pasture, it was assumed that the ground would rarely be disturbed. For seasonal wetland, it was assumed that the ground would be disturbed approximately once each year for disking and seeding. To determine habitat-related farming PM10 emissions, the acreages that would be used for these various purposes were multiplied by the number of disturbances expected per year and the product was then multiplied by a ground-disturbance PM10 emission factor taken from AP-42.

To calculate emissions generated by harvest vehicles under Alternative 1, the quantity of such emissions under existing conditions was multiplied by the acreage factor discussed above.

Local Permitting Requirements

The DW project would involve the use of several discharge pumps to move water from the islands to destinations determined by purchasers. These pumps are likely to be electrically powered but may be diesel fueled. This analysis assumes the worst-case scenario (i.e., that the pumps are diesel fueled).

The SJVUAPCD requires that a permit be obtained for any engine over 50 brake horsepower (bhp) that is fueled by diesel or natural gas unless that pump is portable and would be used for less than 6 months consecutively in the same spot (Stagnaro pers. comm.). Such a portable pump would need to be registered with the SJVUAPCD in accordance with its portable equipment registration rule. Discharge pumps for the project include both permanently installed 200-hp pumps and portable 200-hp pumps that would not be used for more than 6 months consecutively in the same spot (Forkel pers. comm.). Portable pumps used on Bacon and Bouldin Islands would need to be registered with the SJVUAPCD and permits would be needed for the permanent pumps on Bacon and Bouldin Islands. If electricity is used to power these pumps instead of diesel fuel, neither registration nor permitting would be required.

The BAAQMD does not require permits for internal combustion engines of less than 250 hp unless they would emit more than 150 pounds per day (ppd) of any pollutant. All discharge pumps for the DW project would have 200-hp engines; however, the discharge pumps on Holland and Webb Tracts would each emit 107 ppd of NO_x under Alternative 3, for a total of 214 ppd (see Appendix O1, Table O1-14). Under Alternative 1, there would be no discharge pumps on Holland Tract, but approximately 143 ppd of NO_x would be emitted by discharge pumps on Webb Tract (see Appendix O1, Table O1-10). Because pump-related NO_x emissions would exceed the 150-ppd limit under Alternative 3, permits from the BAAQMD would be required for those pumps on Holland and Webb Tracts under Alternative 3 (Carter pers. comm.).

Criteria for Determining Impact Significance

Significant Impacts

Because project-related pollution cannot be quantified in terms of concentration (ppm), it is quantified in terms of absolute amount (ppd). Therefore, significance must be determined based on threshold quantities in ppd, as determined by the air districts, rather than on state and federal standards, which are expressed in ppm.

New Source Review (NSR) thresholds represent the absolute amount of a pollutant that a new source is allowed to emit. In the SJVUAPCD, formal thresholds have not yet been developed. In the interim, the following thresholds are being used to assess significance: 55 ppd of ROG, 55 ppd of NO_x, and 82 ppd of PM10 (Stagnaro pers. comm.). In the BAAQMD, the established thresholds of significance are 150 ppd of ROG, 150 ppd of NO_x, and 150 ppd of PM10 (BAAQMD 1985).

Because of the proximity of the four islands, the most conservative set of pollutant thresholds, those recommended for use by the SJVUAPCD, are used for determining impact significance. Therefore, to constitute a significant impact, a project alternative must generate more ROG, NO_x, or PM10 than is generated under existing conditions by an amount exceeding 55 ppd of ROG, 55 ppd of NO_x, or 82 ppd of PM10. These thresholds have been applied in this analysis to the total amount of each pollutant generated on all four islands. Because the project area is a CO attainment area under state and federal standards, generation of CO during either construction or operation is not considered significant. However, an assessment of the quantity of CO generated by the project is included in the impact section for informational purposes.

Beneficial Impacts

For a project alternative to result in a beneficial impact, it must generate less ROG, NO_x, or PM10 than is generated under existing conditions by an amount exceeding 55 ppd of ROG, 55 ppd of NO_x, or 82 ppd of PM10. As described above, because the project area is a CO attainment area under state and federal standards, reduction in CO generation during either construction or operation is considered less than significant.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 1

Alternative 1 involves storage of water on Bacon Island and Webb Tract (reservoir islands), with Bouldin Island and Holland Tract (habitat islands) managed primarily as wildlife habitat. Reservoir islands would be managed primarily for water storage, with wildlife habitat and recreation constituting incidental uses. Although DW has removed construction of recreation facilities from its CWA permit applications, the analysis of impacts on air quality presented below assumes that the recreation facilities would be constructed and operated. The impacts of Alternative 1 on air quality conditions in the project area are described below. In cases in which an impact is designated as significant, mitigation is recommended if available. Tables O1-8 through O1-11 of Appendix O1 show CO, ROG, NO_x, and PM10 emissions for Alternative 1 in detail.

Carbon Monoxide Emissions

On Bacon Island, implementation of Alternative 1 would generate 164 ppd of CO during the 1.5-year construction period and 4,848 ppd of CO during an average year of operation. On Webb Tract, implementation of Alternative 1 would generate 308 ppd of CO during the 1.5-year construction period and 4,848 ppd of CO during an average year of operation. On Bouldin Island, implementation of Alternative 1 would generate 356 ppd of CO during the 1.5-year construction period and 4,379 ppd of CO during an average year of operation. On Holland Tract, implementation of Alternative 1 would generate 68 ppd of CO during the 1.5-year construction period and 2,738 ppd of CO during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Impact O-1: Increase in CO Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 1 would generate 897 ppd of CO on all four project islands during the construction period. Under existing conditions, there would be no construction-related emissions; however, daily operational emissions would continue. Although existing farming activities would gradually be phased out over the period of construction, under the worst-case scenario, existing farming activities would still be conducted. Therefore, under the worst-case scenario, there would be an increase in CO emissions of 897 ppd for all four project islands during project construction. As explained in the section on significance criteria, because the project area is a CO attainment area under state and federal CO standards, this impact is considered less than significant.

Implementing Mitigation Measures O-1, O-2, and O-3 is not required but would reduce the quantity of CO generated during construction under Alternative 1.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment. During construction under Alternative 1, the primary source of CO emissions and other pollutants, including ROG and NO_x, is the exhaust generated by earthmoving equipment and other construction and transport vehicles. Therefore, DW shall require construction crews to perform routine maintenance of earthmoving equipment, as well as all other construction and transport vehicles. Routine maintenance involves oil changes and tuneups performed at least as frequently as recommended by the manufacturers. This measure shall be included as a condition of the construction contract and shall be enforced through weekly inspection by the project proponent.

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations. The project applicant shall require construction crews to take borrow material from appropriate sites located closest to intended fill locations. This measure would reduce the overall amount of equipment and vehicle operation, thereby reducing exhaust emissions of CO and other pollutants, including ROG, NO_x, and PM10. This measure would also reduce the amount of PM10 emitted into the air by vehicles traveling over unpaved or dusty surfaces, which is the main source of PM10 emissions during construction. This measure shall be included as a condition of the construction contract and shall be enforced through weekly inspection by DW.

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines. DW shall prohibit construction crews from leaving construction equipment or other vehicle engines idling when not in use for more than 5 minutes. This measure would reduce the amount of CO and other pollutants, including ROG, NO_x, and PM10, emitted in engine exhaust. This measure shall be included as a condition of the construction contract and shall be enforced through weekly inspection by DW.

Impact O-2: Increase in CO Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 1 would generate 16,813 ppd of CO on all four project islands during an average year of operation. Under existing conditions, approximately 1,568 ppd of CO are generated. The difference between Alternative 1 emissions and existing CO emissions is 15,245 ppd. This increase in CO emissions would result from pumping and recreational activities being increased under Alternative 1. As explained in the significance criteria section, because the project area is a CO attainment area under state and federal standards, this impact is considered less than significant.

Mitigation. No mitigation is required.

Ozone Precursor Emissions

On Bacon Island, implementation of Alternative 1 would generate 45 ppd of ROG and 281 ppd of NO_x during the 1.5-year construction period, and 931 ppd of ROG and 1,918 ppd of NO_x during an average year of operation. On Webb Tract, implementation of Alternative 1 would generate 96 ppd of ROG and 516 ppd of NO_x during the 1.5-year construction period, and 931 ppd of ROG and 1,918 ppd of NO_x during an average year of operation. On Bouldin Island, implementation of Alternative 1 would generate 139 ppd of ROG and 1,053 ppd of NO_x during the 1.5-year construction period, and 837 ppd of ROG and 1,614 ppd of NO_x during an average year of operation. On Holland Tract, implementation of Alternative 1 would generate 23 ppd of ROG and 141 ppd of NO_x during the 1.5-year construction period, and 512 ppd of ROG and 1,009 ppd of NO_x during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Impact O-3: Increase in ROG Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 1 would generate 304 ppd of ROG on all four project islands during the construction period. Therefore, under the worst-case scenario, there would be an increase in ROG emissions of 304 ppd for all four project islands during project construction. This increase is greater than the 55-ppd threshold for ROG in the project area. Therefore, this impact is considered significant.

Implementing Mitigation Measures O-1, O-2, and O-3 (described above) would decrease construction-related ROG emissions, but only by less than 5% (Sacramento Metropolitan Air Quality Management District [SMAQMD] 1994). This reduction is not large enough to reduce Impact O-3 to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Impact O-4: Increase in NO_x Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 1 would generate 1,991 ppd of NO_x on all four project islands during the construction period. Therefore, under the worst-case scenario, there would be an increase in NO_x emissions of 1,991 ppd for all four project islands during project construction. This increase is greater than the 55-ppd threshold for NO_x in the project area. Therefore, this impact is considered significant.

Implementing Mitigation Measures O-1, O-2, and O-3 (described above) would reduce construction-related NO_x emissions, but only by less than 5% (SMAQMD 1994). This reduction is not large enough to reduce Impact O-4 to a less-than-significant level. Therefore, this impact is significant and unavoidable.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Impact O-5: Increase in ROG Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 1 would generate 3,210 ppd of ROG on all four project islands during an average year of operation. Under existing conditions, approximately 116 ppd of ROG are generated. The difference between Alternative 1 and existing ROG emissions is 3,094 ppd. This increase in ROG emissions would be generated by pumping and recreational activities associated with Alternative 1. This increase is more than the 55-ppd threshold for ROG in the project area. Therefore, this impact is considered significant and unavoidable.

Implementing Mitigation Measures RJ-1 and O-4 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. The reduction in the number of boating-related vehicle trips and reduction in boat use that would accompany implementation of the proposed mitigation measure would also reduce projected emissions from automobile and boat engines. Therefore, the increase in ROG emissions attributable to project operations would be lessened, but not to a less-than-significant level.

Mitigation Measure O-4: Coordinate with Local Air Districts to Reduce or Offset Emissions. DW shall coordinate with the SJVUAPCD and the BAAQMD to implement measures to reduce or offset ROG and NO_x emissions of DW project operations. These measures may include implementing an air emissions offset program or a reduction credit program, as described below.

Preliminary discussions with the local air districts (Stagnaro and Marshall pers. comms.) indicate that emission offset programs may be available to DW. For example, emission reduction credits (ERCs) for stationary sources can be purchased from stationary source owners who shut down or install more emission controls than are required by their SJVUAPCD permits. Credits may also be obtained from the BAAQMD emissions bank. ERCs could be purchased from stationary source owners in the SJVAB for a price agreed upon between the source owner and DW. Another option, mobile source ERCs, can be obtained by retiring (purchasing and destroying) older vehicles. DW would be responsible for retiring the vehicles or could hire a third party to perform that function.

Impact O-6: Increase in NO_x Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 1 would generate 6,459 ppd of NO_x for all four project islands during an average year of operation. Under existing conditions, approximately 459 ppd of NO_x are generated. The difference between Alternative 1 and existing NO_x emissions is 6,000 ppd. This increase in NO_x emissions would be generated by pumping and recreational activities associated with Alternative 1. This increase is more than the 55-ppd threshold for NO_x in the project area. Therefore, this impact is considered significant and unavoidable.

Implementing Mitigation Measures RJ-1 and O-4 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. Delta Wetlands shall reduce the total number of outward (channel-side) boat slips proposed on the Delta Wetlands islands by 50%. The reduction in the number of boating-related vehicle trips and reduction in boat use that would accompany implementation of the proposed mitigation measure would also reduce emissions from automobile and boat engines. Therefore, the increase in NO_x emissions attributable to project operations would be lessened, but not to a less-than-significant level.

Mitigation Measure O-4: Coordinate with Local Air Districts to Reduce or Offset Emissions. This mitigation measure is described above.

PM10 Emissions

On Bacon Island, implementation of Alternative 1 would generate 1,802 ppd of PM10 during the 1.5-year construction period and 10 ppd of PM10 during an average year of operation. On Webb Tract, implementation of Alternative 1 would generate 1,800 ppd of PM10 during the 1.5-year construction period and 10 ppd of PM10 during an average year of operation. On Bouldin Island, implementation of Alternative 1 would generate 2,014 ppd of PM10 during the 1.5-year construction period and 4,331 ppd of PM10 during an average year of operation. On Holland Tract, implementation of Alternative 1 would generate 1,374 ppd of PM10 during the 1.5-year construction period and 2,635 ppd of PM10 during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Impact O-7: Increase in PM10 Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 1 would generate 6,990 ppd of PM10 on all four project islands during the construction period. Therefore, under the worst-case scenario, there would be a 6,990-ppd increase in PM10 emissions for all four project islands during project construction. This increase is greater than the 82-ppd threshold for PM10 in the project area. Therefore, this impact is considered significant.

Implementing Mitigation Measures O-1, O-2, and O-3 (described above) would reduce construction-related PM10 emissions by less than 5%. Implementing Mitigation Measure O-5 (described below) would result in a reduction of approximately 37%. (SMAQMD 1994.) The combination of these reductions would not be enough to reduce Impact O-7 to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Mitigation Measure O-5: Implement Construction Practices That Reduce Generation of Particulate Matter. DW shall require construction crews to implement the following measures throughout the construction period to reduce generation of particulate matter at and in the vicinity of construction sites:

- # Use appropriate dust control measures, including effective application of water or pre-soaking, during land preparation and excavation.
- # Cover or water all soil transported offsite to prevent excessive dust release.
- # Sprinkle all disturbed areas, including soil piles left for more than 2 days, onsite unpaved roads, and offsite unpaved access roads, with water to sufficiently control windblown dust and dirt. Watering shall be conducted once during the morning work hours and once during afternoon work hours. The frequency of watering shall be increased to control dust if wind speeds exceed 15 mph.
- # Sweep roads, including shoulders, adjacent to the project at least daily to remove silt accumulated from construction activities. The use of dry rotary brushes or blower devices for this purpose is expressly prohibited. Additionally, the use of paved access aprons, gravel strips, and wheel washers is strongly encouraged to minimize the need for removal of silt from paved public roads.
- # Limit construction vehicle speeds to 15 mph on unpaved surfaces.
- # Prohibit dust-producing construction activities when wind speeds reach or exceed 20 mph.
- # All areas used for storage of construction vehicles, equipment, and materials shall comply with the measures described above.

These measures shall be included as a condition of the construction contract and shall be enforced through weekly inspection by the project proponent.

Impact O-8: Decrease in PM10 Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 1 would generate 6,987 ppd of PM10 on all four project islands during an average year of operation. Under existing conditions, approximately 32,143 ppd of PM10 are generated. The difference between Alternative 1 and existing PM10 emissions is 25,156 ppd. This decrease in PM10 emissions would result from agricultural activities being decreased under Alternative 1. This agriculture-related decrease in PM10 emissions is more than enough to offset the increase in PM10 emissions generated by pumping and recreational activities associated with Alternative 1. Emission levels related to agricultural activities are much higher for PM10 than for other pollutants because PM10 is generated by ground disturbance as well as by fuel combustion. Furthermore, ground disturbance emits a far greater amount of PM10 than combustion does. This decrease is far greater than the 82 ppd threshold for PM10 in Alternative 1. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 2

The only difference between Alternative 2 and Alternative 1 is the quantity and frequency of water diversions and discharges. As explained in the methodology section of this chapter, pollutant emissions generated under Alternative 2 would be identical to those under Alternative 1 for all activity categories, except pumping, where there would be a slight difference. Operation-related impacts under Alternative 2 would be significant, as under Alternative 1. It is expected that, even with the slight difference in pumping emissions, Alternatives 1 and 2 would result in the same number of unavoidable impacts. Construction-related impacts and mitigation measures of Alternative 2 would be the same as those of Alternative 1.

IMPACTS AND MITIGATION MEASURES OF ALTERNATIVE 3

Alternative 3 involves storage of water on Bacon Island, Webb Tract, Bouldin Island, and Holland Tract, with secondary uses for wildlife habitat and recreation. The portion of Bouldin Island north of SR 12 would be managed as a wildlife habitat area and would not be used for water storage. The impacts of Alternative 3 on air quality in the project area are described below. In cases in which an impact is designated as significant, mitigation is recommended if available. Tables O1-12 through O1-15 of Appendix O1 show CO, ROG, NO_x, and PM10 emissions for Alternative 3 in detail.

Carbon Monoxide Emissions

On Bacon Island, implementation of Alternative 3 would generate 164 ppd of CO during the 1.5-year construction period and 4,840 ppd of CO during an average year of operation. On Webb Tract, implementation of Alternative 3 would generate 308 ppd of CO during the 1.5-year construction period and 4,840 ppd of CO during an average year of operation. On Bouldin Island, implementation of Alternative 3 would generate 1,112 ppd of CO during the 2.5-year construction period and 4,402 ppd of CO during an average year of operation. On Holland Tract, implementation of Alternative 3 would generate 258 ppd of CO during the 1.5-year construction period and 3,526 ppd of CO during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Impact O-9: Increase in CO Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 3 would generate 1,842 ppd of CO for all four project islands during the construction period. Therefore, under the worst-case scenario, there would be a 1,842-ppd increase in CO emissions for all four project islands during project construction. As explained above under "Criteria for Determining Impact Significance", because the project area is a CO attainment area under state and federal standards, this impact is considered less than significant.

Implementing Mitigation Measures O-1, O-2, and O-3 is not required but would reduce the quantity of CO generated during construction under this alternative. These mitigation measures are described above under "Impacts and Mitigation Measures of Alternative 1".

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Impact O-10: Increase in CO Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 3 would generate 17,608 ppd of CO on all four project islands during an average year of operation. Under existing conditions, approximately 1,554 ppd of CO would be generated. The difference between Alternative 3 and existing CO emissions is 16,054 ppd. This increase would result from CO emissions generated by pumping and recreational activities associated with Alternative 3. As explained in the section on significance criteria, because the project area is a CO attainment area under state and federal standards, this impact is considered less than significant.

Mitigation. No mitigation is required.

Ozone Precursor Emissions

On Bacon Island, implementation of Alternative 3 would generate 45 ppd of ROG and 281 ppd of NO_x during the 1.5-year construction period, and 928 ppd of ROG and 1,882 ppd of NO_x during an average year of operation. On Webb Tract, implementation of Alternative 3 would generate 96 ppd of ROG and 516 ppd of NO_x during the 1.5-year construction period, and 928 ppd of ROG and 1,882 ppd of NO_x during an average year of operation. On Bouldin Island, implementation of Alternative 3 would generate 427 ppd of ROG and 3,131 ppd of NO_x during the 2.5-year construction period, and 845 ppd of ROG and 1,721 ppd of NO_x during an average year of operation. On Holland Tract, implementation of Alternative 3 would generate 69 ppd of ROG and 244 ppd of NO_x during the 1.5-year construction period, and 677 ppd of ROG and 1,398 ppd of NO_x during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Impact O-11: Increase in ROG Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 3 would generate 637 ppd of ROG for all four project islands during the construction period. Therefore, under the worst-case scenario, there would be an 637-ppd increase in ROG emissions for all four project islands during project construction. This increase is greater than the 55-ppd threshold for ROG in the project area. Therefore, this impact is considered significant.

Implementing Mitigation Measures O-1, O-2, and O-3 (described above under "Impacts and Mitigation Measures of Alternative 1") would reduce construction-related ROG emissions, but only by less than 5% (SMAQMD 1994). This reduction is not large enough to reduce Impact O-11 to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Impact O-12: Increase in NO_x Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 3 would generate 4,172 ppd of NO_x on all four project islands during the construction period. Therefore, under the worst-case scenario, there would be a 4,172-ppd increase in NO_x emissions for all four project islands during project construction. This increase is greater than the 55-ppd threshold for NO_x in the project area. Therefore, this impact is considered significant.

Implementing Mitigation Measures O-1, O-2, and O-3 would reduce construction-related NO_x emissions, but only by less than 5% (SMAQMD 1994). This reduction is not large enough to reduce Impact O-12 to a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Impact O-13: Increase in ROG Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 3 would generate 3,378 ppd of ROG on all four project islands during an average year of operation. Under existing conditions, approximately 116 ppd of ROG are generated. The difference between Alternative 3 and existing ROG emissions is 3,262 ppd. This increase in ROG emissions would be generated by pumping and recreational activities associated with Alternative 3. This increase is greater than the 55-ppd threshold for ROG in the project area. Therefore, this impact is considered significant and unavoidable.

Implementing Mitigation Measures RJ-1and O-4 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation for Alternative 1".

Mitigation Measure O-4: Coordinate with Local Air Districts to Reduce or Offset Emissions. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Impact O-14: Increase in NO_x Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 3 would generate 6,883 ppd of NO_x on all four project islands during an average year of operation. Under existing conditions, approximately 459 ppd of NO_x are generated. The difference between Alternative 3 and existing NO_x emissions is 6,424 ppd. This increase in NO_x emissions would be generated by pumping and recreational activities associated with Alternative 3. This increase is greater than the 55-ppd threshold for ROG in the project area. Therefore, this impact is considered significant and unavoidable.

Implementing Mitigation Measures RJ-1 and O-4 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation for Alternative 1".

Mitigation Measure O-4: Coordinate with Local Air Districts to Reduce or Offset Emissions. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

PM10 Emissions

On Bacon Island, implementation of Alternative 3 would generate 1,802 ppd of PM10 during the 1.5-year construction period and 8 ppd of PM10 during an average year of operation. On Webb Tract, implementation of Alternative 3 would generate 1,800 ppd of PM10 during the 1.5-year construction period and 8 ppd of PM10 during an average year of operation. On Bouldin Island, implementation of Alternative 3 would generate 1,438 ppd of PM10 during the 2.5-year construction period and 8 ppd of PM10 during an average year of operation. On Holland Tract, implementation of Alternative 3 would generate 1,385 ppd of PM10 during the 1.5-year construction period and 8 ppd of PM10 during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Impact O-15: Increase in PM10 Emissions on the DW Project Islands during Construction. As shown in Table 3O-1, implementation of Alternative 3 would generate 6,425 ppd of PM10 for all four project islands during the construction period. Therefore, under the worst-case scenario, there would be a 6,425-ppd increase in PM10 emissions for all four project islands during project construction. This increase is greater than the 82-ppd threshold for PM10 in the project area. Therefore, this impact is considered significant.

Implementing Mitigation Measures O-1, O-2, and O-3 would reduce construction-related PM10 emissions by less than 5%. Implementing Mitigation Measure O-5 would result in a reduction of approximately 37%. (SMAQMD 1994.) The combination of these reductions would not be enough to reduce Impact O-15 a less-than-significant level. Therefore, this impact is considered significant and unavoidable.

Mitigation Measure O-1: Perform Routine Maintenance of Construction Equipment

Mitigation Measure O-2: Choose Borrow Sites Close to Fill Locations

Mitigation Measure O-3: Prohibit Unnecessary Idling of Construction Equipment Engines

Mitigation Measure O-5: Implement Construction Practices That Reduce Generation of Particulate Matter

Impact O-16: Decrease in PM10 Emissions on the DW Project Islands during Project Operation. As shown in Table 3O-1, implementation of Alternative 3 would generate 31 ppd of PM10 for all four project islands during an average year of operation. Under existing conditions, approximately 32,143 ppd of PM10 are generated. The difference between Alternative 3 and existing PM10 emissions is 32,112 ppd. This great decrease in PM10 emissions would result from the discontinuation of agricultural activities under Alternative 3. This agriculture-related decrease in PM10 emissions is much more than enough to offset the relatively minor increase in PM10 emissions generated by pumping and recreational activities associated with Alternative 3. Emission levels related to agricultural activities are much higher for PM10 than for other pollutants because PM10 is generated by ground disturbance as well as by fuel combustion. Furthermore, ground disturbance emits a far greater amount of PM10 than combustion does. This decrease is greater than the 82-ppd threshold for PM10 in the project area. Therefore, this impact is considered beneficial.

Mitigation. No mitigation is required.

IMPACTS AND MITIGATION MEASURES OF THE NO-PROJECT ALTERNATIVE

Because the No-Project Alternative would not involve any construction, only operational impacts are discussed in this section. Operation of the No-Project Alternative includes intensified agricultural activity with some increase in recreational uses compared with existing conditions. Tables O1-16 through O1-19 of Appendix O1 show CO, ROG, NO_x, and PM10 emissions for the No-Project Alternative in detail.

The project applicant would not be required to implement mitigation measures if the No-Project Alternative were selected by the lead agencies. However, mitigation measures are presented for impacts of the No-Project Alternative to provide information to the reviewing agencies regarding the measures that would reduce impacts if the project applicant implemented a project that required no federal or state agency approvals. This information would allow the reviewing agencies to make a more realistic comparison of the DW project alternatives, including implementation of recommended mitigation measures, with the No-Project Alternative.

Carbon Monoxide Emissions

On Bacon Island, implementation of the No-Project Alternative would generate 1,561 ppd of CO during an average year of operation. On Webb Tract, implementation of the No-Project Alternative would generate 984 ppd of CO during an average year of operation. On Bouldin Island, implementation of the No-Project Alternative would generate 1,106 ppd of CO during an average year of operation. On Holland Tract, implementation of the No-Project Alternative would generate 563 ppd of CO during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in CO Emissions on the DW Project Islands. As shown in Table 3O-1, implementation of the No-Project Alternative would generate 4,215 ppd of CO on all four project islands during an average year of operation. Under existing conditions, approximately 1,554 ppd of CO are generated. The difference between estimated emissions for the No-Project Alternative and existing CO emissions is 2,661 ppd. This increase in emissions is attributable to the increase in recreational and agricultural activities associated with the No-Project Alternative.

Ozone Precursor Emissions

On Bacon Island, implementation of the No-Project Alternative would generate 89 ppd of ROG and 271 ppd of NO_x during an average year of operation. On Webb Tract, implementation of the No-Project Alternative would generate 84 ppd of ROG and 345 ppd of NO_x during an average year of operation. On Bouldin Island, implementation of the No-Project Alternative would generate 95 ppd of ROG and 389 ppd of NO_x during an average year of operation. On Holland Tract, implementation of the No-Project Alternative would generate 48 ppd of ROG and 194 ppd of NO_x during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in ROG Emissions on the DW Project Islands. As shown in Table 3O-1, implementation of the No-Project Alternative would generate 315 ppd of ROG for all four project islands during an average year of operation. Under existing conditions, approximately 116 ppd of ROG are generated. The difference between estimated ROG emissions under the No-Project Alternative and existing conditions is 199 ppd. This increase in emissions is attributable to the increase in recreational and agricultural activities associated with the No-Project Alternative.

Increase in NO_x Emissions on the DW Project Islands. As shown in Table 3O-1, implementation of the No-Project Alternative would generate 1,198 ppd of NO_x on all four project islands during an average year of operation. Under existing conditions, approximately 459 ppd of NO_x are generated. The difference between estimated NO_x emissions under the No-Project Alternative and existing conditions is 739 ppd. This increase in emissions is attributable to the increase in recreational and agricultural activities associated with the No-Project Alternative.

PM10 Emissions

On Bacon Island, implementation of the No-Project Alternative would generate 26,432 ppd of PM10 during an average year of operation. On Webb Tract, implementation of the No-Project Alternative would generate 26,835 ppd of PM10 during an average year of operation. On Bouldin Island, implementation of the No-Project Alternative would generate 12,271 ppd of PM10 during an average year of operation. On Holland Tract, implementation of the No-Project Alternative would generate 16,105 ppd of PM10 during an average year of operation.

Summary of Project Impacts and Recommended Mitigation Measures

Increase in PM10 Emissions on the DW Project Islands. As shown in Table 3O-1, implementation of the No-Project Alternative would generate 81,643 ppd of PM10 for all four project islands during an average year of operation. Under existing conditions, approximately 32,143 ppd of PM10 are generated. The difference between estimated PM10 emissions under the No-Project Alternative and existing conditions is 49,500 ppd. This increase in emissions is attributable to the increase in agricultural activities that would be associated with the No-Project Alternative. Recreation vehicles would contribute a negligible amount of PM10 under the No-Project Alternative. The reason that this increase in PM10 emissions would be so great is that PM10 emission levels generated by ground disturbance (i.e., agricultural activities) tend to be very high because of the intensity of such activity and the ease with which dust is lifted by such activity.

CUMULATIVE IMPACTS

Cumulative impacts are the result of the incremental impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions. The following discussion considers those impacts that may contribute cumulatively to impacts on air quality in the vicinity of the DW project islands.

Cumulative Impacts, Including Impacts of Alternative 1

Because prevailing winds blow many pollutants from the Delta into the Central Valley, air pollutants generated by the DW project and other Delta projects would contribute to air quality problems existing throughout the Central Valley area and would add to pollutant levels in the Delta. Mobile sources are the primary cause of cumulative ozone precursor and CO emissions in the region, and agricultural activity is the primary cause of PM10 emissions in the Delta area.

Boat and automobile traffic associated with recreational use of the four DW project islands would be the principal source of air pollutants during project operations (see Appendix O1, "Air Quality Monitoring Data and Pollutant Emissions under Existing Conditions and the Delta Wetlands Project Alternatives"). Implementing Alternative 1 would reduce agricultural production on the DW project islands, thereby reducing PM10 emissions during project operations. Therefore, the cumulative analysis focuses on present and future projects or conditions that would contribute to CO, ROG, and NO_x emissions in the vicinity of the DW project islands.

Current and planned recreation facilities in the Delta generate boat and automobile traffic in the vicinity of the DW project islands. The Delta currently supports more than 120 commercial recreation facilities (marinas), 20 public facilities, and approximately 20 private recreation associations (DWR 1993). Recreation areas support boat launching, boat docking, fishing, camping, and other activities (see Chapter 3J, "Recreation and Visual Resources"). Figure 3J-1 in Chapter 3J shows existing Delta recreational facilities located in the vicinity of the DW project islands. Future marina and recreation development will most likely occur to support population growth in the Sacramento, Stockton, and Bay Area regions. Currently, few new or expanded recreation facilities (i.e., marinas) are planned in the vicinity of the DW project islands. Recently approved or proposed recreation development projects include the expansion of the Harbor Marina and the Willow Berm Marina on Andrus Island in Sacramento County (Sacramento County Department of Environmental Review and Assessment 1995a, 1995b), approved development of recreational vehicle sites at the Tower Park Marina on Terminous Tract in San Joaquin County (Keranen pers. comm.), and proposed development of a 25-berth marina on the north end of Bethel Island and possible expansion of marina facilities on the south end of Holland Tract in Contra Costa County (Drake pers. comm.). Implementation of recreation facilities proposed under Alternative 1, in addition to existing recreational and residential development and other new recreation projects in the Delta, would increase cumulative mobile source emissions generated by automobile and boat traffic.

Impact O-17: Increase in Cumulative Production of Ozone Precursors and CO in the Delta. Implementation of Alternative 1 in conjunction with cumulative development and increased recreation use in the Delta would increase the production of ozone precursors (ROG and NO_x) and CO over existing levels. This impact is considered significant and unavoidable.

Implementing Mitigation Measures RJ-1 and O-4 would reduce this impact, but not to a less-than-significant level.

Mitigation Measure RJ-1: Reduce the Number of Outward Boat Slips Located at Recreation Facilities. This mitigation measure is described above under "Impacts and Mitigation for Alternative 1".

Mitigation Measure O-4 : Coordinate with Local Air Districts to Reduce or Offset Emissions. This mitigation measure is described above under "Impacts and Mitigation Measures of Alternative 1".

Cumulative Impacts, Including Impacts of Alternative 2

The cumulative impacts of this alternative would be the same as those described for Alternative 1.

Cumulative Impacts, Including Impacts of Alternative 3

The cumulative impacts of this alternative would be the same as those described for Alternative 1.

Cumulative Impacts, Including Impacts of the No-Project Alternative

By increasing recreational and agricultural activities on the DW project islands, implementation of the No-Project Alternative would contribute to air pollutant emissions in the project vicinity.

Increase in Cumulative Production of Ozone Precursors, CO, and PM10 in the Delta. Implementation of the No-Project Alternative in conjunction with existing recreational and agricultural uses would increase cumulative emissions of CO, ROG, and NO_x and levels of PM10 generated in the Delta.

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Table 3O-1. Pollutant Emissions under Existing Conditions and Delta Wetlands Project Alternatives (Pounds per Day)

		Alternative 1, 2020		Alternative 3, 2020		
Pollutant	Existing Conditions 1993	Construction	Operation	Construction	Operation	No-Project Alternative, 2020
CO	1,554	897	16,813	1,842	17,608	4,215
ROG	116	304	3,210	637	3,378	315
NO_x	459	1,991	6,459	4,172	6,883	1,198
PM10	32,143	6,990	6,987	6,425	31	81,643

Notes: Emissions under Alternative 2 would be almost identical to those shown for Alternative 1.

Construction emissions would continue during the period of construction, which is 1.5 years, except on Bouldin Island under Alternative 3, in which case it is 2.5 years.

Sources: Appendix O1 of the 1995 DEIR/EIS, Tables O1-4 through O1-19.

Table 3O-2. Total Pollutant Emissions Used for Conformity Screening for Alternative 1 (Tons per Year)

	San Joaquin County					Contra Costa County				
	Existing Conditions	Alternative 1 Construction	Alternative 1 Operation	Construction Minus Existing	Operation Minus Existing	Existing Conditions	Alternative 1 Construction	Alternative 1 Operation	Construction Minus Existing	Operation Minus Existing
ROG	8	23	55	15	47	6	15	46	9	40
NO_x	31	167	128	136	97	26	82	114	56	88
PM10	2,113	477	331	(1,636)	(1,782)	604	397	544	(207)	(60)

Notes: Emissions under Alternative 2 would be almost identical to those shown for Alternative 1.

These quantities were calculated from the daily emission values shown in Appendix O1, based on assumptions of 250 days per year of agricultural activity; 365 days per year of water pumping and boating; and 47 or 86 days per year of hunting, depending on alternative and island.

De minimis thresholds for this project are 100 tons per year of ROG, 50 tons per year of NO_x, and 70 tons per year of PM10. See text for further explanations.

Table 3O-3. Total Pollutant Emissions Used for Conformity Screening for Alternative 3 (Tons per Year)

	San Joaquin County					Contra Costa County				
	Existing Conditions	Alternative 3 Construction	Alternative 3 Operation	Construction Minus Existing	Operation Minus Existing	Existing Conditions	Alternative 3 Construction	Alternative 3 Operation	Construction Minus Existing	Operation Minus Existing
ROG	8	59	84	51	76	6	21	76	15	70
NO_x	31	426	195	395	164	26	95	180	69	154
PM10	2,113	405	3	(1,708)	(2,110)	604	398	3	(206)	(601)

Notes: These quantities were calculated from the daily emission values shown in Appendix O1, based on assumptions of 250 days per year of agricultural activity; 365 days per year of water pumping and boating; and 47 or 86 days per year of hunting, depending on alternative and island.

De minimis thresholds for this project are 100 tons per year of ROG, 50 tons per year of NO_x, and 70 tons per year of PM10. See text for further explanations.

Chapter 4. Permit and Environmental Review and Consultation Requirements

Chapter 4. Permit and Environmental Review and Consultation Requirements

This chapter provides preliminary information on the major requirements for permitting and environmental review and consultation for implementation of the DW project. Certain state and federal regulations require issuance of permits prior to project implementation; other regulations require agency consultation but may not require issuance of any entitlements prior to project implementation. Some information in this chapter and the accompanying table has been updated based on comments received on the 1995 DEIR/EIS.

INTRODUCTION

Table 4-1 provides a preliminary list of federal, state, and local permits and approvals that may be required for the DW project alternatives. Preparation of this document has proceeded concurrently with environmental review and consultation required by federal and state environmental laws other than NEPA and CEQA. Table 4-2 lists these environmental review and consultation requirements. The following sections describe the major state and federal laws that specify permitting and environmental review and consultation requirements. Not every permit or environmental review presented in Tables 4-1 and 4-2 is described.

CLEAN WATER ACT, SECTION 404 (33 USC 1344)

Under Section 404 of the Clean Water Act, a Department of the Army permit must be obtained from the Corps for the discharge of dredged or fill material into waters of the United States, including wetlands. The Corps reviews applications for permits in accordance with Section 404 guidelines, which have been established by the Corps and EPA. The guidelines require that "no discharge of dredged or fill materials shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative doesn't have other significant adverse environmental consequences". The Corps must also determine that the project is not contrary to the public interest (33 CFR 323.6).

An alternatives analysis was prepared and submitted to EPA and the Corps in partial compliance with EPA's Section 404(b)(1) guidelines (40 CFR 230.10[a], [b], and [d]) (see Appendix 4, "Section 404[b][1] Alternatives Analysis for the Delta Wetlands Project"). The information from the 1995 DEIR/EIS was used to complete compliance with the Section 404(b)(1) requirements and will be used during the Corps' public interest review.

To issue a permit under Section 404, the Corps must ensure that the discharge will not violate the state's water quality standards. Therefore, in California, the proponent of any activity that may result in a discharge to a surface water of the United States must obtain water quality certification or a waiver of certification from SWRCB (pursuant to Section 401 of the Clean Water Act).

RIVERS AND HARBORS ACT OF 1899, SECTION 10 (33 USC 403)

Section 10 of the Rivers and Harbors Act of 1899 prohibits work affecting the course, location, conditions or capacity of navigable waters of the United States without a permit from the Corps. Examples of activities requiring a permit from the Corps are the construction of any structure in or over any navigable water; excavation or deposition of materials in such waters; and various types of work performed in such waters, including placement of fill and stream channelization.

The project applicant has submitted to the Corps a joint Department of the Army permit application pursuant to Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. The Corps' compliance with Section 404 of the Clean Water Act and NEPA will also satisfy requirements under Section 10 of the Rivers and Harbors Act.

ENDANGERED SPECIES ACT (16 USC 1531 ET SEQ.)

Section 7 of the Endangered Species Act of 1973, as amended, requires federal agencies, in consultation with USFWS and NMFS, to ensure that their actions do not jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of the critical habitat of these species. The required steps in the Section 7 consultation process are as follows:

Agencies must request information from USFWS and NMFS on the existence in a project area of listed species or species proposed for listing.

Following receipt of the USFWS/NMFS response to this request, agencies generally prepare a biological assessment (BA) to determine whether any listed species or species proposed for listing are likely to be affected by a proposed action.

Agencies must initiate formal consultation with USFWS and NMFS if the proposed action would affect listed species.

USFWS and NMFS must prepare a biological opinion to determine whether the action would jeopardize the continued existence of listed species or adversely modify their critical habitat.

If a finding of jeopardy or adverse modifications is made in the biological opinion, USFWS and NMFS must recommend reasonable and prudent alternatives that would avoid jeopardy and the federal agency must modify project approval to ensure that listed species are not jeopardized and that their critical habitat is not adversely modified (unless an exemption from this requirement is granted).

The Section 7 consultation process for the DW project has been completed with the Sacramento Endangered Species Office of USFWS and with NMFS.

In 1997, the USFWS and NMFS issued no-jeopardy opinions regarding effects of the DW project on federally listed fish species. A thorough description of the process and outcome of the Section 7 consultation for the DW project is provided in the section entitled "Regulatory Compliance History" in Chapter 1 of this FEIS Volume.

FISH AND WILDLIFE COORDINATION ACT (16 USC 661 ET SEQ.)

The Fish and Wildlife Coordination Act requires federal agencies to consult with USFWS and state fish and game agencies before undertaking or approving projects that control or modify surface water (water projects). This consultation is intended both to promote the conservation of wildlife resources by preventing their loss or damage and to provide for the development and improvement of wildlife resources in connection with water projects. Federal agencies undertaking water projects are required to include recommendations made by USFWS and state fish and game agencies in project reports, give full consideration to these recommendations, and include in project plans measures to reduce impacts on wildlife.

The Corps' compliance with the Fish and Wildlife Coordination Act (for permit review) is achieved by USFWS and DFG comments being obtained and, where possible, concerns being resolved through the CEQA/ NEPA process (Elder pers. comm.).

NATIONAL HISTORIC PRESERVATION ACT (16 USC 470 ET SEQ.)

Section 106 of the National Historic Preservation Act requires federal agencies to evaluate the effects of federal undertakings on historical, archeological, and cultural resources. Agencies are required to identify historical or archeological properties near proposed project sites, including properties listed in the NRHP and those properties that the agency and the SHPO agree are eligible for listing in the NRHP. If the project is determined to have an adverse effect on NRHP-listed properties or those eligible for listing in the NRHP, the agencies are required to consult with the

SHPO and the ACHP to develop alternatives or mitigation measures to allow the project to proceed.

Section 106 consultation with the SHPO has been completed for the DW project. A programmatic agreement (PA) outlining the steps and timing of compliance with Section 106 and addressing the project's potential effect on cultural resources has been signed by the ACHP, the SHPO, the Corps, SWRCB, and the project applicant.

AMERICAN INDIAN RELIGIOUS FREEDOM ACT OF 1978

This legislation sets forth the policy of the U.S. Department of the Interior to protect and preserve the observance of traditional Native American religions. The act requires federal agencies to evaluate their policies and procedures to ensure compliance with this policy.

Beginning in 1992 (before the beginning of any construction activities that could have project-related impacts on Native American resources), the Corps and SWRCB contacted local tribal representatives for input regarding the treatment of Native American cultural resources that may be affected by project construction and operation. This consultation process was coordinated with compliance with Section 106 of the NHPA.

FARMLANDS PROTECTION POLICY ACT

Memoranda from the U.S. Council on Environmental Quality to heads of agencies dated August 30, 1976, and August 11, 1980, and the Farmlands Protection Policy Act of 1981 require agencies preparing EISs to include farmland assessments designed to minimize adverse impacts on prime and unique farmlands. As described in Chapter 3I, "Land Use and Agriculture", implementation of the DW project alternatives would cause losses of farmland acreage in areas in Contra Costa and San Joaquin Counties.

The environmental analysis of the DW project alternatives includes a thorough discussion of impacts on prime and unique farmlands. The analysis includes an evaluation of farmlands using CDC and NRCS (formerly SCS) classifications and an evaluation of the project's effects on prime and unique farmlands as determined by the CDC's Farmland Mapping and Monitoring Program.

EXECUTIVE ORDERS 11988 (FLOODPLAIN MANAGEMENT) AND 11990 (PROTECTION OF WETLANDS)

Executive Order 11988 requires federal agencies to prepare floodplain assessments for proposed actions located in or affecting floodplains. If an agency proposes to conduct an action in a floodplain, it must consider alternatives to avoid adverse effects and incompatible development in the floodplain. If the only practicable alternative involves siting in a floodplain, the agency must minimize potential harm to or in the floodplain and explain why the action is proposed in the floodplain. The DW project involves compatible construction in a floodplain.

Executive Order 11990 requires federal agencies to prepare wetland assessments for proposed actions located in or affecting wetlands. Agencies must avoid undertaking new construction in wetlands unless no practicable alternative is available and the proposed action includes all practicable measures to minimize harm to wetlands. Chapter 3G, "Vegetation and Wetlands", and Appendix G5, "Summary of Jurisdictional Wetland Impacts and Mitigation", describe impacts on wetlands and mitigation measures for reducing significant impacts.

UNIFORM RELOCATION ASSISTANCE AND REAL PROPERTY ACQUISITION POLICIES ACT (42 USC 4601 ET SEQ.)

This act provides for a uniform policy and equitable treatment of persons displaced as a direct result of programs or projects undertaken by a Federal Agency. Under the provisions of this act, displaced individuals shall be reimbursed and provided with relocation planning assistance coordination, and advisory services. This reimbursement may consist of reasonable moving expenses, costs incurred to search for a replacement business or farm, and actual reasonable expenses necessary to reestablish a displaced farm.

Implementation of Delta Wetlands Project would require the relocation of 20 residences and six farm worker barracks on Bacon Island and three trailers and one residence on Webb Tract. Bacon Island's farm worker camps are used by employees of the three farm operations that lease land on the islands. The tenants on the Delta Wetlands Project islands are aware of the proposed project and have been kept informed throughout the NEPA/CEQA process. Delta Wetlands would give tenants no less than 6 months after the project is approved to find new housing. These individuals may be eligible for some form of assistance provided under this act.

WATER COMMISSION ACT (CALIFORNIA WATER CODE SECTION 1000 ET SEQ.)

The Water Commission Act establishes a system of state-issued permits and licenses to appropriate water. SWRCB is responsible for administering appropriative water rights. Within its authority, SWRCB approves diversions of water to beneficial uses and changes in the purpose of use, points of diversion, and places of use of water.

CALIFORNIA ENDANGERED SPECIES ACT (CALIFORNIA FISH AND GAME CODE SECS. 2050 ET SEQ.)

The California Endangered Species Act requires a state lead agency to consult formally with DFG when a proposed action may affect state-listed endangered or threatened species. The provisions of the California Endangered Species Act and the federal Endangered Species Act will often be activated simultaneously. The assessment of project effects on species listed under both the California and federal Endangered Species Acts is addressed in USFWS's and NMFS's biological opinions. However, for those species listed only under the California Endangered Species Act, SWRCB must formally consult with DFG, and DFG must issue a biological opinion separate from USFWS's biological opinion. For this project, there are two species (Swainson's hawk and greater sandhill crane) listed only under the California Endangered Species Act. A separate BA was prepared for these species. DFG issued a no-jeopardy opinion in 1998 on project effects on state-listed fish, wildlife, and plant species. As a private applicant, DW must also comply with the take prohibitions of the California Endangered Species Act by obtaining an "incidental take" management permit pursuant to Section 2081. DW has requested that DFG issue a Section 2081 agreement for the DW project. A thorough description of the California Endangered Species Act consultation process for the DW project is provided in the section entitled "Regulatory Compliance History" in Chapter 1 of this FEIS Volume.

CITATIONS

References to the Code of Federal Regulations (CFR) and the U.S. Government Code (USC) are not included in this list. CFR and USC citations in text refer to title and section (e.g., 33 CFR 323.6 refers to Title 33 of the CFR, Section 323.6).

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Table 4-1. Permits and Approvals That May Be Required for the Delta Wetlands Project Alternatives

Agency and Requirements	Agency Authority	Project Activities Subject to Requirements
FEDERAL		
U.S. Army Corps of Engineers		
Department of the Army permit pursuant to Section 404 of the Clean Water Act	The Corps issues permits for discharge of dredged or fill materials into waters of the United States, including wetlands; permits are issued following public interest review and analyses according to EPA's Section 404(b)(1) guidelines	Construction activities; location of siphon, pump, and recreation facilities; and other activities requiring the discharge of dredged or fill material into waters of the United States, including wetlands
Department of the Army permit pursuant to Section 10 of the Rivers and Harbors Act of 1899	The Corps issues permits for activities in or affecting navigable waters of the United States	Construction of intake structures, fish screens, discharge pumps, boat docks, or other facilities affecting navigable Delta waters
STATE		
California Department of Fish and Game		
Streambed alteration agreement	DFG enters into agreements with project applicants proposing changes in conditions of rivers, streams, lakes, or other regulated areas	Construction of intake structures, fish screens, discharge pumps, boat docks, or other facilities within regulated areas
California Department of Water Resources, Division of Safety of Dams		
Approval of plans and specifications	DOSD reviews and grants approval of plans and specifications for construction of reservoirs where the barrier will exceed 6 feet in height to ensure that no threat to life or property could occur because of seepage, earth movement, or other types of reservoir-induced dam failures	Designing and constructing water impoundment facilities (on Bouldin Island for Alternative 3)
Notice of completion and statement of actual cost; certificate of approval to impound water	DOSD evaluates the safety of newly constructed reservoirs and grants approval to initiate storage operations	Storage of water in a reservoir (on Bouldin Island for Alternative 3)
California State Water Resources Control Board		
Permit to appropriate and store water	SWRCB issues permit to allow the appropriation of unappropriated water from surface sources and grants approval to divert water to storage or for direct diversion and to change purpose of use	Diversion of Delta water, storage of appropriated water, and later discharge of water for sale as export or outflow
Statement of riparian water diversion and use	SWRCB requires submittal of a statement for applicants wishing to divert water under a riparian claim	Diversion of Delta water for circulation on the islands to provide wetlands and wildlife habitat benefits
Water quality certification pursuant to Section 401 of the Clean Water Act	SWRCB certifies that an applicant for a Department of the Army permit pursuant to Section 404 of the Clean Water Act complies with the state's water quality standards	Same as for Department of Army permit pursuant to Section 404 of the Clean Water Act

Agency and Requirements	Agency Authority	Project Activities Subject to Requirements
Regional Water Quality Control Board		
Construction Storm Water Permit (Order No. 99-08-DWQ)	The RWQCB, under the SWRCB, ensures compliance with National Pollutant Discharge Elimination System requirements pursuant to Section 402 of the Clean Water Act	Clearing, grading, filling, and excavation activities extending over 5 acres or more
Issuance of or waiver from discharge requirements	RWQCB may set waste discharge requirements for any proposed activity that would discharge waste into surface waters, projects that affect groundwater quality, and projects from which waste would be discharged in a diffused manner; waivers are also granted based on project sponsor's water quality control plans (RWQCB waste discharge requirements constitute NPDES permits where such permits are required)	Any earthmoving activities, such as grading, excavating, and other construction; discharge of water from dewatering activities into storm drains and creeks; and discharge of wastewater from conveyance cleaning
State Lands Commission		
Land use lease	The SLC grants a lease to use state-owned lands, including tidelands and submerged lands	Use of state-owned land for construction or siting of project facilities, such as boat docks, in tidelands and submerged lands
Dredging permit	The SLC issues a permit to parties proposing to dredge or deposit material on state-owned lands as elements of various projects	Construction of diversion and discharge facilities, if state-owned lands are dredged or altered
California Department of Transportation		
Encroachment permit	Caltrans issues encroachment permits for projects affecting areas within the rights-of-way (ROWs) of state-owned roadways	Activities that may affect SR 12
Department of Transportation, Division of Aeronautics		
State airport permit	Caltrans issues special use airport permits for airports not open to the general public, access to which is controlled by the owner in support of commercial activities, public service operations, and/or personal use	Operational activities of the airport on Bouldin Island that include agricultural and private commercial activities
REGIONAL AND LOCAL AGENCIES AND UTILITIES		
Bay Area Air Quality Management District		
Authority to construct/permit to operate	BAAQMD issues permits based on emission estimates and subsequent tests performed at the construction facility	Installation and subsequent operation of internal combustion equipment that generates any pollutant in excess of 150 pounds/day or is greater than 250 hp in size
San Joaquin Valley Unified Air Pollution Control District		
Authority to construct/permit to operate	SJVUAPCD issues permits based on the size of stationary or portable internal combustion engines proposed for use	Use, during construction and operation of the project, of stationary or portable internal combustion engines over 50 hp, if fueled by diesel or natural gas

Agency and Requirements	Agency Authority	Project Activities Subject to Requirements
Contra Costa County		
Sewer permit	The sanitary district approves and issues permits to ensure conformance with sanitary standards and sanitary sewer work related to the repair, construction, reconstruction, or abandonment of any building sewers, connections, or discharge to a district sewer system.	Construction of recreation facilities
Land use permit	The community development department issues permits to allow special zoning considerations or waive existing zoning regulations regarding the way that a property is to be used.	Construction of Delta Wetlands reservoir islands and recreation facilities
Building permit	County planning department issues permits for all permanent structures	Construction of pump stations and recreation facilities
Road encroachment permit and design approval	County public works department issues permits and approves designs for construction within the ROWs of any county-maintained roads	Construction of conveyance facilities within the ROWs of county-maintained roads
Grading permit	County planning department and public works department issues permits for grading activities associated with construction activities	Grading of project site
San Joaquin County		
Use permit	The county issues permits for construction of recreation facilities and for the opening of a new airport or the modification of an existing airport.	Construction of recreation facilities and the operational activities of the airport on Bouldin Island that include agricultural, recreational, and private commercial activities
Building permit	County planning department issues permits for all permanent structures	Construction of pump stations and recreation facilities
Road encroachment permit and design approval	County public works department issues permits and approves designs for construction within the ROWs of any county-maintained roads	Construction of conveyance facilities within the ROWs of county-maintained roads
Grading permit	County planning department and public works department issues permits for grading activities associated with construction activities	Grading of project site
Reclamation Districts		
Access easement and permission to cross levees	Individual reclamation districts grant easements and regulate access to levees under district jurisdiction	Construction of conveyance and related facilities on reclamation district lands

Table 4-2. Other Environmental Review and Consultation Requirements

Agency and Requirements	Agency Authority	Project Activities Initiating Review and Consultation Requirements
FEDERAL		
U.S. Fish and Wildlife Service		
Consultation pursuant to Section 7 of the Endangered Species Act	Federal agencies must consult with USFWS when their actions may affect species listed under the Endangered Species Act	Corps approval of the project because the Corps has determined that the project may affect species listed under the Endangered Species Act
Fish and Wildlife Coordination Act	Federal agencies must consult with USFWS when undertaking projects that control or modify surface water	Corps approval of the project; consultation will be achieved through the Corps' NEPA process in approving the project
National Marine Fisheries Service		
Consultation pursuant to Section 7 of the Endangered Species Act	Federal agencies must consult with NMFS when their actions may affect anadromous or marine species listed under the Endangered Species Act	Corps approval of the project because the Corps has determined that the project may affect species listed under the Endangered Species Act
Environmental Protection Agency		
Clean Water Act and National Environmental Policy Act	EPA has oversight responsibility to ensure that federal and state agencies comply with the provisions of the Clean Water Act and NEPA	Need for a Department of the Army permit under Section 404 of the Clean Water Act and for preparation of an EIS under NEPA
Federal Aviation Administration		
Completion requirement of Form 7480-1 for change in use approval	FAA requires that all persons notify FAA prior to change in the status or use of a civil or joint-use airport	Operational activities of the airport on Bouldin Island, including agricultural and private commercial activities
STATE		
California Department of Fish and Game		
Consultation pursuant to the California Endangered Species Act	State lead agencies must consult with DFG when their actions may affect species listed under the California Endangered Species Act	SWRCB approval of the project because SWRCB has determined that the project may affect species only listed under the California Endangered Species Act (Swainson's hawk and greater sandhill crane)
Fish and Wildlife Coordination Act	Federal agencies must consult with state fish and game agencies when undertaking projects that control or modify surface water	Corps approval of the project; consultation will be covered through the Corps' NEPA and SWRCB's CEQA process in approving the project

Agency and Requirements	Agency Authority	Project Activities Initiating Review and Consultation Requirements
Office of Historic Preservation and Advisory Council on Historic Preservation		
Archaeological survey review (Archaeological Resource Protection Act, National Historic Preservation Act); PA for project effects on archaeological resources on the project site	The SHPO reviews and comments on any archaeological surveys; if resources are identified, the SHPO must be consulted to determine the eligibility for nomination to the National Register of Historic Places. The Advisory Council on Historic Preservation must concur with the PA.	Archaeological survey conducted and determinations of eligibility and effect prepared; PA circulated and signed by the project applicant, SWRCB, the Corps, the SHPO, and the Advisory Council on Historic Preservation
Native American Heritage Commission		
Consultation with certain Native Americans in compliance with California Public Resources Code Section 5097.98 and California Health and Safety Code Section 7050.5	The commission identifies persons who may be likely descendants of Native Americans whose remains may be found and requires that consultation with identified persons be initiated	Plans for physical alteration of a known cultural resource site that has a likely potential for containing remains of Native Americans
REGIONAL AND LOCAL AGENCIES		
Contra Costa and San Joaquin Counties		
Conformance with general plan	County planning department reviews local agency projects for conformity with the general plan	Project effects on land use

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Chapter 6. Glossary of Technical Terms

Chapter 6. Glossary of Technical Terms

Note: All acronyms used in the text are defined under "List of Acronyms" found after the Table of Contents and Lists of Tables and Figures in the front of this document.

Acre-foot. The quantity of water that would cover 1 acre to a depth of 1 foot (43,560 cubic feet or 326,700 gallons).

Actual exports. Actual exports are the least of the following: the amount specified by the export limits (i.e., as percentage of inflow), available water (i.e., water available after outflow requirements are met), and permitted export pumping rate.

Adulticides. Mosquito pesticides that target adult-stage mosquitos.

Agricultural yield. A measurement of the level of crop production for a given area, generally given in tons or tons per acre.

Allowable export. The amount of water allowable for export under the 1995 WQCP; the lesser of the amount specified by the export limits (i.e., percentage of total Delta inflow) and the amount remaining after outflow requirements are met (i.e., available water).

Anadromous species. Fishes that mature in marine waters and migrate to fresh water to spawn.

Anticorrosion coating. The coating of pipelines with paint, epoxy, or other materials to prevent contact of dissimilar metals. The barrier prevents establishment of a corrosion current and corrosion of the pipe.

Appropriative water rights. Water rights held in the form of conditional permits or licenses from SWRCB, which allow the diversion of a specified amount of water from a source for reasonable and beneficial use during all or a portion of the year. In California, previously issued appropriative water rights are superior to and take precedence over newly granted rights. SWRCB's authorizations contain terms and conditions to protect prior water right holders, including Delta and upstream riparian water users, and to protect the public interest in fish and wildlife resources. To a varying degree, SWRCB reserves jurisdiction to establish or revise certain permit or license terms and conditions for salinity control, protection of fish and wildlife, protection of vested water rights, and coordination of terms and conditions between the major water supply projects.

Aquifer. A porous soil or geological formation lying between impermeable strata that contains groundwater; yields groundwater to springs and wells.

Available water. Under the 1995 WQCP, total Delta inflow less Delta outflow requirements.

Bearing capacity. The maximum load that a structure can support, divided by its effective bearing area (the part of the structure that carries the load).

Bending load. The result when the opposite ends of an item are forced together (as when a sheet of paper is folded). Pipelines can be subject to this type of load.

Biological oxygen demand (BOD). A measure of rapidly oxidized or decayed organic materials.

Blowout ponds. Small lakes on Webb and Holland Tracts scoured in the island bottoms by inrushing floodwaters caused by levee failures in 1950 on Webb Tract and in 1980 on both islands.

Borrow area. An excavated area or pit created by the removal of earth material to be used as fill in a different location.

Bti (*Bacillus thuringiensis israelensis*). A bacterial larva that consumes first and second larval instar stages of mosquitos.

Buttress. To steady a structure by providing greater resistance to lateral forces to prevent failure. Also, an exterior pier, often sloped, used to steady a structure in this manner. See also “toe berm”.

Calibration. See “model calibration”.

Candidate species (*also* **candidate threatened or endangered species**). Taxa (species or subspecies) of plants and animals currently being considered for listing to be protected as special-status species by USFWS.

Carriage water. Delta outflow beyond the basic outflow required to meet water quality standards. The additional Delta outflow required (carriage water) is a function of Delta export pumping and south Delta inflow, and is necessary to maintain acceptable chloride concentrations in export water as Delta exports are increased.

Carryover storage. The amount of stored water remaining at the end of the water year (end of September) in San Luis Reservoir (for CVP and SWP) or on the Delta Wetlands reservoir islands.

Cathodic protection system. A process used to prevent pipeline corrosion by passing an electric current through the pipe. When dissimilar metals (the pipeline and soil minerals) are placed in solution together, a corrosion current is established. The cathodic protection system creates an opposite current to minimize corrosion.

Central Delta water. Used in the DeltaSOQ model to represent the source of export water from the central Delta, which includes a mixture of water from the Sacramento, Mokelumne, and Cosumnes Rivers; seawater intrusion from the western Delta; and some portion of the Sacramento River that does not flow directly to the export locations.

Central Valley Project (CVP). The federal water project in California's Central Valley operated by Reclamation.

Channel depletion. The water removed from Delta channels by diversions for irrigation and by open-water evaporation.

Color. A variable of water that reflects its organic content (primarily humic and fulvic acids).

Confirmation. See "model confirmation".

Conjunctive use. A term used to describe operation of a groundwater basin in coordination with a surface water system.

Consumptive use. Loss of water on the Delta Wetlands Project islands and other Delta islands through crop ET and open-water evaporation and use for shallow-water management for wetlands and wildlife habitat. Rainfall and channel depletion supply the consumptive-use water.

Conveyance. The flow capacity of a channel related to the hydraulic radius, used to describe the flow in channels.

Conveyance capacity. The volume of water that can be transported by a canal, aqueduct, or ditch. Conveyance capacity is generally measured in cfs.

Cubic feet per second (cfs). A measure of a moving volume of water, sometimes shortened to "second-feet".

Cultural resource. Any building, site, district, structure, object, data, or other material significant in history, architecture, archaeology, or culture.

DailySOS. A daily operations model used to confirm the adequacy of the analysis completed using DeltaSOS (which simulates the effects of regulatory standards and water management projects on the Delta on a monthly basis).

DAYFLOW. DWR's database of daily hydrologic conditions, including measured Delta inflows and exports, estimated consumptive use, and net Delta outflow. The daily data have been compiled for each water year (October 1 to September 30) beginning with 1930 and are updated annually. USGS and DWR streamflow gages are the sources of inflow measurements for the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras Rivers. Yolo Bypass and several miscellaneous inflows between Sacramento and Stockton are also estimated from available streamflow gages. CVP and SWP operations records are the source of export pumping data.

DAYFLOW provides an accounting of historical Delta boundary (systemwide) hydrology that is used for evaluating flow-related conditions in the Delta.

Delta Cross Channel (DCC). An existing gated structure and channel connecting the Sacramento River at Walnut Grove to the North Fork of the Mokelumne River. The facility was constructed as part of the CVP to control movement of Sacramento River water into the central Delta and to the south-Delta export pumps. Operating criteria currently require the gates to be closed for specific periods to keep downstream migrating fish in the Sacramento River and to prevent flooding of the central Delta.

Delta Drainage Water Quality model (DeltaDWQ). A model developed for the 1995 DEIR/EIS analysis to estimate how much the Delta Wetlands islands contribute to EC, DOC, Cl^-, and Br^- levels at Delta channel locations and in Delta diversions and exports under no-project conditions and under project operations.

Delta exports. The water pumped from the Delta to south-of-Delta users by DWR at Banks Pumping Plant and by Reclamation at the CVP Tracy Pumping Plant, and the amount diverted by CCWD at its Rock Slough and Old River intakes.

Delta in-balance/in-excess conditions. Conditions in the Delta, designated by DWR and Reclamation, that help determine when the Delta Wetlands Project may divert water for storage on its designated reservoir islands. When conditions are "in balance", all Delta inflow is required to meet Delta objectives and satisfy diversions by CCWD, the CVP, the SWP, and Delta riparian and senior appropriative water users. Delta Wetlands would not be allowed to divert water when the Delta is designated as being "in balance" because no additional water would be available for diversion by the Delta Wetlands Project under new water rights; Delta Wetlands reservoir releases may be necessary to increase exports when the Delta is in balance. When DWR and Reclamation determine that Delta conditions are "in excess" and other terms and conditions are met, the Delta Wetlands Project would be allowed to divert available excess water for storage under new appropriative water rights.

Delta-Mendota Canal (DMC). The major conveyance facility of the CVP, which carries water from the Delta to as far south as the southern San Joaquin Valley.

Delta outflow criteria. Minimum water quality or flow standards for the Delta and Suisun Marsh, such as those required by the 1995 WQCP.

Delta standards. A general term referring to all applicable water quality objectives; flow requirements; and other restrictions on diversions, exports, channel flows, or gate operations.

Delta Standards and Operations Simulation model (DeltaSOS). A computer spreadsheet model developed by Jones & Stokes that simulates the effects of regulatory standards and water management projects on the Delta.

Delta Standards, Operations, and Quality model (DeltaSOQ). A modified version of the DeltaSOS model that incorporates equations that predict the water quality of agricultural drainage and Delta Wetlands reservoir island storage. This model also incorporates equations that predict the effects of agricultural drainage and Delta Wetlands discharges on EC levels and DOC concentrations in Delta channels and exports.

Design response spectrum. The specified range of ground motion in response to seismic activity that is assumed for an analysis based on historical data and local soil conditions.

Direct economic effects. Changes in the earnings of households generated by Delta Wetlands Project operations and changes in fiscal conditions (property and sales tax revenues and public costs) associated with Delta Wetlands Project operations.

Direct employment. Employment generated in businesses that are part of the Delta Wetlands Project (i.e., agriculture; recreational uses; and construction, operations, and maintenance of project facilities).

Direct fishery effects. Mortality of fish attributable to Delta Wetlands diversions, including entrainment in Delta Wetlands diversions and losses resulting from changes in habitat.

Direct income. Earnings of households generated in businesses that are part of Delta Wetlands Project operations.

Disinfection byproducts (DBP). A class of chemicals created during chlorination or other oxidation treatment processes used to disinfect municipal water supplies. Organic content and chloride (Cl^-) and bromide (Br^-) concentrations are the primary variables that influence the formation of DBP compounds.

Dissolved oxygen (DO). Oxygen dissolved in water that is available to supply oxidation and respiration requirements.

Diversions. Water diverted at control points, including reservoir control points. Diversions typically represent basin irrigation diversions, water transfers, municipal diversions, and exports.

Drawdown. The lowering of the water level of a reservoir or other body of water as a result of the withdrawal of water.

DWRSIM. DWR's operations planning model, used to estimate possible effects of increased demands, new facilities, or new standards on SWP operations.

Dynamic and static stability. The stability of levees under seismic movement or without seismic movement.

Eight-River Index. The sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake.

Electrical conductivity (EC). A general measure of dissolved minerals (i.e., salinity); the most commonly measured variable in Delta waters.

Employment multiplier. The number of jobs associated with a $1 million change in final demand in a specified industry and a specified region.

Endangered species. Any plant or animal species or subspecies whose survival is threatened with extinction and that is included in the federal or state list of endangered species.

Entrainment. The process in which fish are drawn into water diversion facilities along with water drawn from a channel or other water body by siphons and/or pumps. Entrainment loss includes all fish not salvaged (i.e., eggs, larvae, juveniles, and adults that pass through the fish screens, are impinged on the fish screens, or are eaten by predators).

Entrapment zone. An area or zone of the Bay-Delta estuary where riverine current meets upstream-flowing estuarine currents and variations in flow interact with particle settling to trap particles. The entrapment zone generally corresponds to a surface salinity range of 2 to 10 mS/cm conductance. The entrapment zone is an important aquatic habitat region associated with high levels of biological productivity.

Erosion. A combination of processes (e.g., wind or tidal action) in which the materials of the earth's surface are loosened, dissolved, or worn away and transported from one place to another by natural agents.

Ethnography. The comprehensive, descriptive study of a particular culture.

Evapotranspiration (ET). Loss of water from the earth's surface by evaporation from soil or water and by transpiration from plants.

Evolutionarily Significant Unit (ESU). A distinctive group of Pacific salmon or steelhead.

Exotic. Not native to the region in which it is found; refers to vegetation and wildlife species.

Export limits. A specification in the 1995 WQCP. Delta exports are limited to a percentage of total Delta inflow (generally 35% during February-June and 65% during July-January).

Exports. The water pumped from the Delta to south-of-Delta users by DWR at Banks Pumping Plant and by Reclamation at the CVP Tracy Pumping Plant, and the amount diverted by CCWD at its Rock Slough and Old River intakes.

Factor of safety for slope stability (FS). A calculated number representing the degree of safety of a slope against instability. The FS is expressed mathematically as the ratio of stabilizing effects (forces or moments) and destabilizing effects acting on a potentially unstable soil mass in a slope. When the FS is greater than 1, the soil mass in the slope is, in theory, stable; when FS is less than 1, the slope is, in theory, unstable. For a given slope geometry and soil conditions, a calculated FS is associated with a unique slope failure configuration. The most critical failure configuration is associated with the minimum FS calculated in a slope stability analysis. Several agencies (such as the Association of State Dam Safety Officials and USACE) have developed criteria that provide different design FSs stipulated for various slope conditions, e.g., under long-term loading, shortly after construction, etc. These FSs are typically above 1 and are recommended or required for various conditions, including consideration of uncertainties in design and risks to life and property.

Fallow. *adj*. Relating to farmland that is not in active use for the growing of crops. *v*. To remove land from active crop production.

Farmland conversion. The process or result of changing land from agricultural use to a different (generally more intensive) land use.

Farmland of statewide importance. Land with a good combination of physical and chemical features for the production of agricultural crops.

Final demand. Sum of all purchases for final use or consumption.

Firm storage capacity. An amount equivalent to guaranteed storage capacity. Utility rates usually vary based on guarantee of service. The first priority is to meet firm demands; consequently, this demand is most expensive. Demands that can be met with less reliability are less expensive.

Freeboard. The vertical distance between a design maximum water level and the top of a structure such as a levee, dike, floodwall, or other control surface. The freeboard is a safety margin intended to accommodate unpredictable rises in water level.

Full-time equivalent (FTE) employment. A unit for measuring employment in terms of number of jobs, where one job equals 40 hours of work per week. The actual number of employee jobs supported by a business may differ based on how total work hours are divided among employees.

Future permitted export pumping capacity. A capacity that may be established for the SWP in the future. If new permit conditions are established for the SWP, the permitted export pumping rate of the SWP pumps would be increased to the physical export pumping capacity of 10,300 cfs. If that occurs, the combined permitted export pumping rate of the SWP and CVP pumps could then equal up to 14,900 cfs or 14,500 cfs.

Gas field. An area that contains closely contiguous reservoirs of commercially valuable gas.

General plan designation. A specified land use (e.g., agricultural, residential, or commercial) established for a given area by the local governing city or county in its general plan, as required by California law (California Government Code Sections 65300 et seq.).

Geotechnical. Of or pertaining to the practical application of geologic science to civil engineering problems.

Habitat evaluation procedures (HEP). A method for analyzing impacts on wildlife resources that models the preproject and postproject quality and quantity of habitats for a set of species selected to represent all wildlife.

Habitat suitability index (HSI). A rating of the overall quality of a habitat for a species calculated using a model that combines ratings of different individual habitat variables.

Habitat unit (HU). A unit of habitat value determined by multiplying habitat acreages for different areas by each area's habitat suitability index.

Historical conditions. The combination of measured inflows and exports, estimated channel depletion and Delta outflow, simulated channel flows, and measured or simulated EC and other water quality variables.

Historical Delta flows. Measured Delta inflows and exports, estimated Delta outflow, and simulated net channel flows corresponding to the inflows and exports.

Hydraulic conductivity. A measure of the capacity of a porous medium to transmit water, often expressed in centimeters per second. The hydraulic conductivity is equal to the rate of flow of water through a cross section of one unit area under a unit hydraulic gradient.

Hydraulic gradient. The rate of change in total hydraulic head per unit distance of flow measured at a specific point and in a given direction, often resulting from frictional effects along the flow path.

Hydraulic head. The force exerted by a column of liquid expressed as the height of the liquid above the point at which the pressure is measured (the force of the liquid column being directly proportional to its height).

Hydraulic radius. Channel cross-section area divided by the perimeter of the channel; used in this document to mean the effective depth of water in a channel.

Hydraulics. Study of the practical effects and control of moving water; used to refer to the relationship between channel geometry and flow, velocity, and depth of water.

Hydrology. General description of the movement of water in the atmosphere, on the earth surface, in the soil, and in the ground; used in this document to refer to rainfall and streamflow conditions.

Hydrostatic pressure. The pressure of water at a given depth caused by the weight of the fluid above it.

Income. The earnings of households associated with a given industry, consisting of employee compensation (salary and wages) and proprietor's earnings (profit and dividends) but excluding proprietor contributions to welfare and pension funds. Income is classified as direct or secondary (see "Direct income" and "Secondary income").

Income multiplier. The amount of income associated with a dollar change in final demand in a specified industry and a specified region.

Indirect employment. Employment generated in businesses supplying goods and services related to Delta Wetlands Project operations.

Indirect fishery effects. Mortality of fish attributable to other diversions that results from Delta Wetlands effects on Delta flow conditions.

Induced employment. Employment generated as a result of consumer spending by employees who are directly and indirectly affected by Delta Wetlands Project operations.

Inflow. The rate (cfs) or volume (TAF) of total streamflow entering the Delta from the Sacramento and San Joaquin Rivers, Yolo Bypass, and the eastside streams.

Intactness. The visual integrity of the natural and constructed landscape and its freedom from encroaching elements.

Interceptor-well system. A seepage-control system that would consist of actively pumped wells installed in the exterior levees of the Delta Wetlands reservoir islands in locations where substantial seepage to adjacent islands is predicted to occur.

Internal inspection. The process of evaluating pipeline stresses from within the pipeline. A robotic device commonly called a "pig" is sent along the inside of the pipeline. The pig measures the shape of the pipeline, noting where the pipeline shape is abnormal (i.e., oval instead of round) and where the pipeline has ripples that indicate that the pipeline is bent or stressed.

Interruptible demand/interruptible supply. An assumed additional demand for, and supply of, SWP water above the specified monthly demands. Interruptible supply is simulated in DWRSIM as 84 TAF/month, or 1,400 cfs/month. DWRSIM assumes that additional SWP deliveries are made to meet interruptible demand when there is unused export capacity and available water in the Delta. Interruptible delivery made when there is surplus water in the Delta, Banks Pumping Plant has excess capacity, and San Luis Reservoir is full.

Joint point of diversion. Allowance of CVP and SWP export pumping at either the Banks or Tracy pumping plants.

Kilovolt (kV). A metric unit of energy equal to 1,000 volts.

Leaching. The removal of soluble substances from soil by percolating water.

Levee crest. The top of a levee.

Level of service (LOS). A measurement of the relative amount of traffic congestion at an intersection or on a roadway. The scale of measurement ranges from "A" to "F", with "A" representing the least congestion and "F" the most congestion.

Liquefaction. The process in which loose saturated soils lose strength when subject to seismic activity (i.e., shaking).

Local water supply. In the DWRSIM model, the assumed amount of captured rainfall in areas south of the Delta that can be used to satisfy CVP and SWP demands.

Midges. Nonbiting insects that breed in ponded water and, as adults, are similar in appearance to mosquitos and can be a nuisance to humans when the insects swarm.

Midwater trawl index. The sum of the weighted catch of fish of four monthly samples (September-December) from numerous locations in the Delta and Suisun Bay. The index is assumed to be a measure of abundance when considered in relation to the catch for all other years of the sampling record (1967-1995). In the Bay-Delta estuary, the index has been developed for striped bass, American shad, delta smelt, Sacramento splittail, longfin smelt, and other species.

Mitigation. Methods to avoid, reduce, rectify, eliminate, or compensate for adverse project impacts.

Mixing. Exchange of mass between two volumes; used in this document to refer to the movement of salt or fish from one location to another caused by the tidal movement of water within the Delta channels.

Mixing zone. A localized region surrounding a discharge pipe (or diffuser) where initial mixing and dilution of a discharge with the channel water occurs.

Model calibration. Adjustments made to a model (i.e., equations or coefficient values) to provide results that more closely follow observed data; used especially during initial model development and testing.

Model confirmation. Comparative testing of model results with measured data to determine the adequacy of model simulations for describing the observed behavior of the modeled variables; used especially during model application to conditions different from those used to calibrate the model.

Mosquito abatement districts (MADs). Agencies responsible for controlling mosquitos as disease vectors and as a nuisance to humans.

Municipal Water Quality Investigations (MWQI) program. A program conducted by the DWR Division of Planning and Local Assistance that collects data on a wide variety of water quality variables in Delta inflows and exports. These data constitute some of the baseline water quality information used in this document.

National Register of Historic Places (NRHP). A register of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, and culture, maintained by the Secretary of the Interior.

Natural Resources Conservation Service land capability classification system. The land classification system that places soils into eight classes (I-VIII) according to the limitations on agricultural use imposed by 13 specific soil and climatic criteria. The higher the class, the more restrictive the limitation. Classes I through IV are generally considered lands suitable for cultivation. Class I and II soils are defined as prime farmland.

Net flow. Long-term average of flows in a channel; used to describe the magnitude and direction of flow in a channel after flows during a tidal cycle are averaged.

Nonattainment area. An area that does not meet state and/or federal air pollution standards.

Nongame fish. Fish species not considered sport fishes by anglers; nongame fish are generally found near the lower end of the food chain.

Nonproject levees. Levees constructed and maintained by local landowners and reclamation districts.

Null zone. An area in a column of water where vertical velocity and net horizontal velocity near the bottom are zero during incoming (flood) and outgoing (ebb) tides.

Outflow. The water flowing out of the Delta into San Francisco Bay.

Outflow requirements. Specifications for the Delta in the 1995 WQCP that encompass water quality protection for agricultural and municipal and industrial uses, Suisun Marsh, and fish habitat. In standard DWR calculations of Delta operations (using DWRSIM), "outflow" represents the difference between inflow and exports; the outflow term therefore includes in-Delta consumptive use.

Overtopping. Passing of water over the top of a levee as a result of wave runup or surge action.

Passive-flow relief-well system. A system of wells that passively relieve elevated hydrostatic pressures in an aquifer by allowing flow to the surface. (Hydrostatic pressure is the pressure exerted by a liquid, such as water, at rest.)

Peak flow. The maximum discharge of a stream during a specified period of time.

Peak-hour trips. The number of traffic trips made during the hour of the day with the most traffic. Also referred to as peak-hour volume.

Peat soils. Acidic, humus-rich soils that contain a large amount of unconsolidated, semicarbonized, partially decomposed plant debris formed in an anaerobic, water-saturated environment.

Permeability. The capacity of a porous rock, sediment, or soil for transmitting a fluid.

Permitted pumping rate. A rate that may be established by USACE. USACE does not require a permit under Section 404 of the CWA for current SWP export pumping. However, USACE would require a permit if SWP export pumping were to exceed a maximum 3-day average rate of 6,680 cfs. Therefore, the maximum combined export pumping rate that does not require a USACE permit is 11,280 cfs (6,680 cfs for the SWP pumps and 4,600 cfs for the CVP pumps). The restrictions for the period of December 15 to March 15, as interpreted by DWR, allow a combined rate of 11,700 cfs in December and March and a combined maximum 3-day average rate of 12,700 cfs in January and February. (See also "future permitted export pumping capacity".)

Phreatic. Of or pertaining to groundwater.

Phreatic surface. The surface of a body of unconfined groundwater at atmospheric pressure.

Physical export pumping capacity. The SWP export pumps have a maximum physical pumping capacity of 10,300 cfs and the CVP export pumps have a maximum physical pumping capacity of 4,600 cfs, for a combined physical export pumping capacity of 14,900 cfs. At times, the canal capacity for the CVP is reduced to 4,200 cfs, reducing the combined physical export pumping capacity to 14,500 cfs.

Piezometer. A sandpipe monitoring well used to measure the depth to the groundwater surface in the aquifer.

Pipeline balancing. The process that gas utilities use to balance the customer loads (demands) with the available supplies of natural gas. Inflows to the system must be balanced on a continuous basis against outflows from the system.

Piscivorous birds. Fish-eating birds, including cormorants, herons, egrets, grebes, and mergansers.

Planimeter. An instrument for measuring the area of a plane surface by tracing its boundary lines.

Plankton. The usually microscopic animal and plant life floating or drifting in bodies of water, used as food by fish.

Pollutant concentration. Concentration of any toxic or potentially toxic contaminant, expressed in ppt, ppm, or ppb.

Prehistory. The period of time before written history, or the study of cultures before written history or of more recent cultures lacking formal historical records.

Prime farmland. Land with the best combination of physical and chemical features for the production of agricultural crops.

Project yield. Average annual water discharged for export from the Delta Wetlands Project islands. Reported in TAF/yr.

PROSIM. Reclamation's operations planning model, used to estimate possible effects of increased demands, new facilities, or new standards on CVP operations.

QWEST. A calculated flow parameter representing net flow between the central Delta and the western Delta. QWEST criteria have previously been considered for protection of central Delta fish.

Ramping of exports. Gradual change in export pumping that may be required to moderate the effects of rapid changes.

Reclamation. Extensive drainage of low-lying marshy lands for potential practical use.

Recreation use-day. A standard unit of use consisting of a visit by one individual to an area for recreation purposes during any portion of a 24-hour period.

Recruitment. The increase in population of an organism caused by natural reproduction or immigration.

Resident species. A species that carries out its entire life cycle within a given region.

Reverse flow. The Delta outflow condition existing when in-Delta diversions or high Delta exports, in combination with low Delta inflow, cause net seaward flow to reverse so that San Francisco Bay water is moved toward the central and south Delta.

Riparian. Living on or adjacent to a water body, such as a river, lake, or pond.

Riparian habitat. Woody vegetation (trees and shrubs) that grows in soils saturated for a substantial portion of the year, especially on the edges of open water bodies (e.g., lakes, rivers, or ditches) or on levees.

Riparian water rights. Correlative entitlements to water that are held by owners of land bordering natural watercourses. California requires a statement of diversion and use of natural flows on adjacent riparian land under a riparian right.

Riprap. A stone covering used to protect soil or surfaces from erosion by water or the elements.

Rock revetment. A stone covering used to protect soil or surfaces from erosion by water or the elements.

Sacramento Valley Four-River Index (or Sacramento Valley 40-30-30 water-year hydrologic classification index). The sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; and American River, total inflow to Folsom Reservoir.

Safe yield. The rate at which or amount that an aquifer may be pumped without exceeding recharge and incurring overdraft.

Salinity. Salt measured in ppt, TDS, EC units, or mg/l.

Salvage. Removal of fish from screens on diversion structures and the subsequent return of the fish to the water body.

San Joaquin Valley Four-River Index (or San Joaquin Valley 60-20-20 water-year hydrologic classification index). The sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake.

Secondary economic effects. Changes in the earnings of households and in fiscal conditions (property and sales tax revenues and public costs) associated with changes in businesses supplying goods and services related to Delta Wetlands Project operations and with spending by employees directly and indirectly affected by Delta Wetlands Project operations.

Secondary employment. Indirect or induced employment.

Secondary income. Earnings of households generated in businesses supplying goods and services related to Delta Wetlands Project operations (indirect income) and generated as a result of spending by employees directly and indirectly affected by Delta Wetlands Project operations (induced income).

Sediment. Fragmented mineral or organic material transported or deposited by air, water, or ice.

Seepage. A slow movement of water through permeable soils caused by increases in the hydraulic head. (See also "hydraulic head".)

Seepage flux. The rate of flow of water across a given line or surface, typically expressed in gpm or cfs.

Seismicity. The frequency, intensity, and distribution of earthquake activity in a given area.

Settlement. The sinking of surface material as a result of compaction of soils or sediment caused by an increase in the weight of overlying deposits or by pressure resulting from earth movements.

Shear load. The result when force is applied perpendicular to or on opposite sides of an item (as when a sheet of paper is cut with scissors). Pipelines can be subject to this type of load.

Simulated Disinfection System (SDS). A method of determining THM formation potential. This laboratory analytical method was developed to simulate municipal water treatment facilities' actual disinfection process (and THM concentrations) more closely than other methods; it uses a much lower chlorine (Cl_2) dose and much less contact time.

Simulation. The application of a mathematical representation or model to analyze a theoretical or physical process.

Slope deformations. Changes in the shape or size of a slope.

Smolt. A juvenile chinook salmon or steelhead that has undergone physiological change enabling it to survive in saltwater.

South-of-Delta delivery deficit. Unmet demand, that is, total demand for CVP and SWP water minus total CVP and SWP deliveries. Total deliveries are calculated based on water exported from the Delta and the change in San Luis Reservoir storage. (When San Luis Reservoir storage drops, that amount is added to Delta exports to determine total CVP and SWP deliveries. When San Luis Reservoir storage increases, that amount is subtracted from Delta exports to determine total CVP and SWP deliveries.)

South-of-Delta demands. Demands for CVP and SWP contractors that export water from the Delta.

Spawning. Laying of eggs, especially by fish.

Special Multipurpose Applied Research Technology Station (SMARTS). A test facility at the DWR Bryte facility in West Sacramento that conducts a variety of peat-soil-flooding water-quality experiments under controlled static or continuous water-flow conditions.

Special-status species. Those species listed as threatened or endangered by the state and federal governments or identified as possibly warranting such protection.

Species. The basic category of biological classification intended to designate a single kind of animal or plant.

Splash berm. An extended area of facing on an island levee designed to protect against erosion of the levee crest by wave splash and runup.

Stage. Water surface elevation; the elevation above mean sea level (msl) datum.

State Historic Preservation Officer. The official in each state authorized by the state at the request of the Secretary of the Interior to implement the NHPA.

State Water Project (SWP). The water project operated by DWR that delivers water from the Sacramento Valley to southern California.

Stratigraphy. The composition, characteristics, distribution, and age relation of layered rocks and soils.

Subsidence. A local or regional sinking of the ground. In the Delta, this results primarily from peat soil being converted into gas.

Surplus Delta outflow. Outflow in excess of the amount required to meet all monthly water demands, protect Delta salinity standards, and comply with the export/inflow objectives of the 1995 WQCP.

Suspended sediment (SS). Sediments or other particulates that adsorb chemicals and block light transmission through water; a general indicator of surface erosion and runoff.

Take. A term used in Section 9 of the federal Endangered Species Act that includes harassment of and harm to a species, entrainment, directly and indirectly caused mortality, and actions that adversely modify or destroy habitat.

Threatened species. A species that is likely to become endangered in the foreseeable future and is included in the federal or state list of threatened species.

Tidal excursion. The distance between the most upstream position and most downstream position of a floating object that is released from a location at mean tide and tracked over a complete tidal cycle.

Tidal flow. Flow caused by tidal changes in stage and hydraulic gradient; describes the fluctuating flows in a channel caused by the tide.

Tidal hydraulics or tidal hydrodynamics. Water movements caused by tidal forces; used to describe the movement of water caused by tidal stage variations in San Francisco Bay.

Tidal prism. The volume of water that moves past a location as the result of a change in tidal stage; used in this document to refer to the change in volume between low tide and high tide, estimated as the upstream water surface area times the change in tidal stage.

Toe berm. The section projecting at the base of a dam, levee, or retaining wall.

Total dissolved solids (TDS). A measure of the total concentration of disintegrated organic and inorganic material or salt in water.

Transport. Movement of mass from one location to another; used in this document to refer to the movement of salt or fish from one location to another caused by net flows.

Trihalomethane (THM). A class of carcinogenic substances, including chloroform ($CHCl_3$) and bromoform ($CHBr_3$), formed from chlorination of drinking-water supplies.

Trihalomethane formation potential (THMFP). The potential for creation of THMs during chlorination or other oxidation treatment processes used for disinfection of municipal water supplies; an index of the maximum possible THM concentrations that could be produced by maximum chlorination of Delta water.

Turbidity. The reduction of light transmission in water caused primarily by the suspension of clays, silts, and other fine materials.

Ultraviolet absorbance (UVA). A physical measurement used in the study of humic acids and THM precursors, often found to be linearly related to DOC concentration. UVA may provide a measure of the humic and fulvic acid portion of total DOC in a water sample; this portion of total DOC is thought to be the precursor for THM.

Unbundled rates. The individual rates for separate service components of a particular utility. For example, natural gas utilities can be broken down into separate service components such as gas procurement, transportation, storage, and delivery with distinct rate schedules for each service. Deregulation of the utility industry has allowed this unbundling of the services to promote market competition.

Unimpaired flow. Natural tributary inflow without storage or diversions.

Unique farmland. Land with soils of lesser quality than the soils of prime farmland or farmland of statewide importance, used for the production of the state's leading cash crops.

Unity. The visual coherence, composition, and harmony of the landscape considered as a whole.

Vernalis Adaptive Management Plan (VAMP). Multiyear program for studying the survival of salmon smolts from the San Joaquin River; uses pulse flows and export restrictions.

Vividness. The visual power or memorability of landscape components that combine in visual patterns.

Volume-to-capacity (V/C) ratio. The ratio of the number of vehicles using a roadway or intersection to the maximum number of vehicles that could use the roadway or intersection.

Waste grain. Grain left in fields as residue after harvesting, which is often eaten by wildlife species.

Water demand. A monthly schedule of water deliveries specified at a point of diversion in an operations model analysis.

Waterfowl use-day. A standard unit for measuring use of an area by waterfowl; one waterfowl use-day represents use of an area by ducks, geese, and/or swans for foraging or nesting during any portion of a 24-hour period.

Water right. A grant, permit, decree, appropriation, or claim to the use of water for beneficial purposes. California has a dual system of water rights. riparian and appropriative. *Riparian water rights* are held by owners of land bordering a surface water source. *Appropriative water rights* allow the exclusive diversion of a specified amount of water from a source for a reasonable and beneficial use. (See also "riparian water rights" and "appropriative water rights".)

Water Right Decision-1485 (D-1485). SWRCB's decision of August 1978 specifying water quality standards for the Delta and Suisun Marsh.

Water Treatment Plant (WTP) model. An EPA model used for the 1995 DEIR/EIS to estimate THM concentrations at a typical water treatment plant that may use Delta exports containing water released from the Delta Wetlands Project islands. The model consists of a series of subroutines that simulate removal of organic THM precursor compounds and formation of THM. A more detailed description of the operation of the WTP model is provided in Appendix C5 of the 1995 DEIR/EIS. The model predicts total THM concentration, then estimates the relative concentrations of each of the four types of THM molecules by using separate regression equations for each type of THM molecule.

Wetlands. Areas supporting vegetation typical of soils that are saturated for a major portion of the year.

Wheeling. Use of SWP or CVP Delta pumping facilities to pump and convey water for another party.

Williamson Act contract. A 10-year contract between a landowner and a county, established under the authority of the California Land Conservation Act of 1965, which places restrictions on the use of the private land in exchange for tax savings.

Wind fetch. An area of water over which wind blows, generating waves.

X2. The location in the Bay-Delta estuary of the 2-ppt-TDS isohaline 1 meter off the bottom; an isohaline is a line connecting all points of equal salinity.

Yield. An annual quantity of water that can be delivered to a service area from a water project on a specified delivery schedule.

Yield acceleration. Pseudostatic horizontal force that will give a calculated factor of safety of 1 in slope-stability analyses. (See "factor of safety for slope stability".)

Chapter 7. Final EIS Distribution List

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