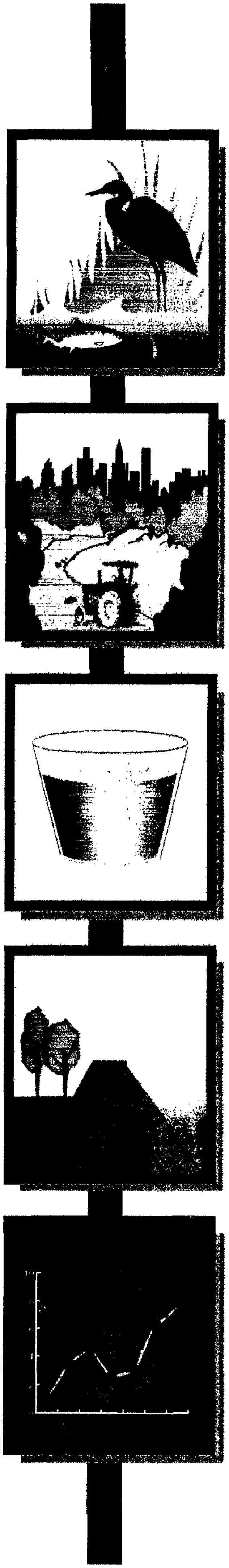

CALFED
BAY-DELTA
PROGRAM

Affected Environment and Environmental Impacts

Riverine Hydraulics & Hydrodynamics

Draft Technical Report
September 1997

CALFED
BAY-DELTA
PROGRAM

ENVIRONMENTAL SETTING - AFFECTED ENVIRONMENT

Bay Delta Hydrodynamics and Riverine Hydraulics

August 27, 1997

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TABLE OF CONTENTS

CALFED Bay-Delta Program
Environmental Setting - Affected Environment
Bay-Delta Hydrodynamics and Riverine Hydraulics

I. SUMMARY

Existing conditions for the CALFED study area are discussed with a focus on those elements of the system that govern the hydraulic and hydrodynamic conditions. The study area includes the Sacramento-San Joaquin Delta Estuary (the Delta), a portion of San Francisco Bay, and those areas of the Sacramento and San Joaquin Rivers that could potentially be affected by the CALFED program. Hydrodynamic conditions addressed in this report include channel discharge, flow velocity, flow depth, and top width of channels at various points throughout the study area. Representative study locations were selected throughout the Delta and river systems. These locations serve as a focal point for identifying potential program-induced changes to hydrodynamic conditions that are discussed in the environmental consequences report. Study locations include 16 channel segments within the Delta, 9 sections along the Sacramento River and its tributaries, and 3 locations along the San Joaquin River. In addition, this report includes a discussion of salinity within the Delta, particle tracking throughout the Delta, and "X2," which is the location of a regulated salinity contour expressed as distance from the Golden Gate bridge.

II. INTRODUCTION

Delta hydrodynamics is the complex interaction of tides, river inflows, and Delta geometry that influence the movement of water in Delta channels. Delta hydrodynamics also depend on diversions, exports from the Delta, and tides. Delta hydrodynamics govern channel flows and Delta outflow dynamics. Channel flows influence water quality (e.g., salinity and dissolved organic carbon), and the movement of fish and entrainment of vulnerable organisms (e.g., larval fish and the organisms on which they feed). Delta outflow dynamics have important effects on salinity intrusion and estuarine habitat and conditions.

The discussion of river hydraulics addresses the movement of water within the principal stream channels of the Sacramento and San Joaquin River regions influenced by operation of the Central Valley Project (CVP) and the State Water Project (SWP). The focus of the discussion is on discharge and its relation to stream velocity, width and depth of the stream, and sediment carrying capacity. Each of these variables has in common a dependence on discharge; that is, if other factors remain the same, a change in discharge will result in a change in the velocity, width, depth, and sediment movement. Temperature and salinity, two additional parameters that relate to river hydraulics, also are discussed. Changes in these water quality parameters depend not only on changes in magnitude of discharge but on differences in the quality of discharges from different sources.

III. SOURCES OF INFORMATION

Sources of information for the historical perspective on the San Francisco Bay-Delta include the California Water Plan Update, Bulletin 160-93 (DWR 1994) and the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995).

Current resources for the flows, velocities, stages, mass fate, central Delta outflow, and salinity in the Delta region are estimated based on hydrodynamic modeling of the Delta region using the Delta simulation computer model (DWRDSM1). Specific information about the modeling effort is contained on the Delta modeling group's web site, http://wwwdelmod.water.ca.gov/. Table 3.1-1 shows key locations in the Delta and their surface area, volume, and mean depth used in the hydrodynamic modeling effort. Representative peak tidal discharges are also provided for reference.

The primary sources of historical information on rivers in the Sacramento and San Joaquin River regions are water resources data reports published by the US Geological Survey (USGS 1994a, 1994b), and the California Water Plan Update (DWR 1994). Historical daily stream flow records for selected USGS stream gaging stations were obtained from the U.S. Geological Survey's "California Surface-Water Data Retrieval" page on the internet at http://h2o.usgs.gov/nwis-w/CA/.

Current resources for river flows were estimated based on computer modeling by the Department of Water Resources (DWR) using the statewide water operations planning model, DWRSIM. Model output reflecting a 1995 level of statewide water demands was obtained from study 1995C06F-SWRCB-469, which was completed by DWR for the State Water Resources Control Board (SWRCB). The data used in this report were obtained from DWR's internet site at http://wwwhydro.water.ca.gov/swrcb.html. Study 1995C06F-SWRCB-469, as well as other studies performed by DWR for the SWRCB, are described in the SWRCB's report Bay/Delta Draft EIR Alternatives Under Consideration (SWRCB 1996). Additional information concerning the assumptions used in the model were obtained from the internet web site referenced above. Detailed information describing the DWRSIM model is also contained in the web site.

Equations relating discharge to average stream velocity, average stream width and stream depth, and sediment loading were developed using data for selected stations from 1967 to the present, obtained from the USGS Water Resources Division (Shiffer, personal communication, 1997).

IV. ENVIRONMENTAL SETTING

4.1 Study Area

The study area for this report includes the Sacramento River and San Joaquin River hydrologic regions and San Francisco Bay. The lowermost portion of the Sacramento River and San Joaquin River regions is the Sacramento-San Joaquin Delta (Figure 4.1-1). The San Francisco Bay (Figure 4.1-2), which includes Suisun, San Pablo, Central,and South bays, extends about 85 miles from the east end of Chipps Island (in Suisan Bay near the city of Antioch)westward and southward to the mouth of Coyote Creek (tributary to South Bay near the City of San Jose). The Golden Gate connects San Francisco Bay to the

Table 3.1-1. Delta channel geometry used in hydrodynamic and water quality modeling.

Location	Channel Number	Surface Area of Channel Segment (acres)	Volume of Channel Segment (acre-ft)	Depth Below MSL* (ft)	Peak Tidal Flow (cfs)
San Joaquin River at Fourteen Mile Slough	22	77.4	2,406	31.1	7,109,000
San Joaquin River at Antioch	51	876.1	21,989	25.1	22,251,000
Old River at Mossdale	54	12.6	102	8.1	206,000
Old River at Fabian Tract	76	28.0	143	5.1	143,000
Old River at Woodward Island	95	56.7	912	16.1	4,233,000
Old River at Franks Tract	121	57.9	585	10.1	873,000
Middle River at Woodward Island	143	30.8	527	17.1	2,975,000
Grant Line Canal	209	21.8	285	13.1	750,000
Victoria Canal	228	34.4	347	10.1	870,000
Delta Cross Channel	365	29.2	470	16.1	1,666,000
Georgiana Slough	366	24.7	348	14.1	586,000
Diversion to Sutter/Steamboat Sloughs	379	10.8	196	18.1	673,000
Miner Slough	388	54.1	762	14.1	761,000
Sacramento River at Rio Vista	430	758.2	19,030	25.1	35,734,000
Mokelumne River, North Fork	362	49.4	993	20.1	1,809,000
Mokelumne River, South Fork	343	51.5	881	17.1	1,808,000

*MSL = Mean Sea Level relative to the National Geodetic Vertical Datum (NGVD) at the Golden Gate.

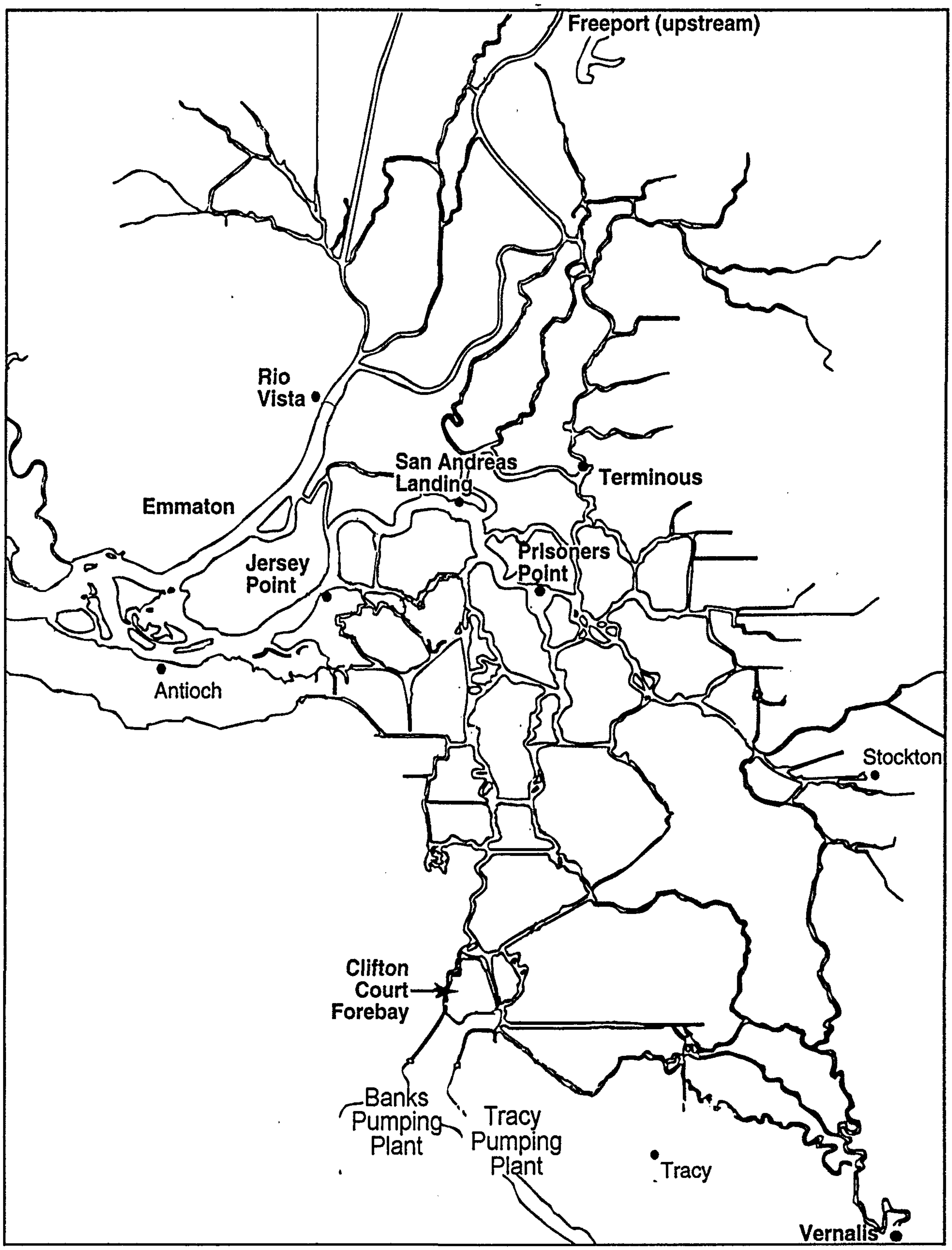


Figure 4.1-1. Sacramento-San Joaquin Delta

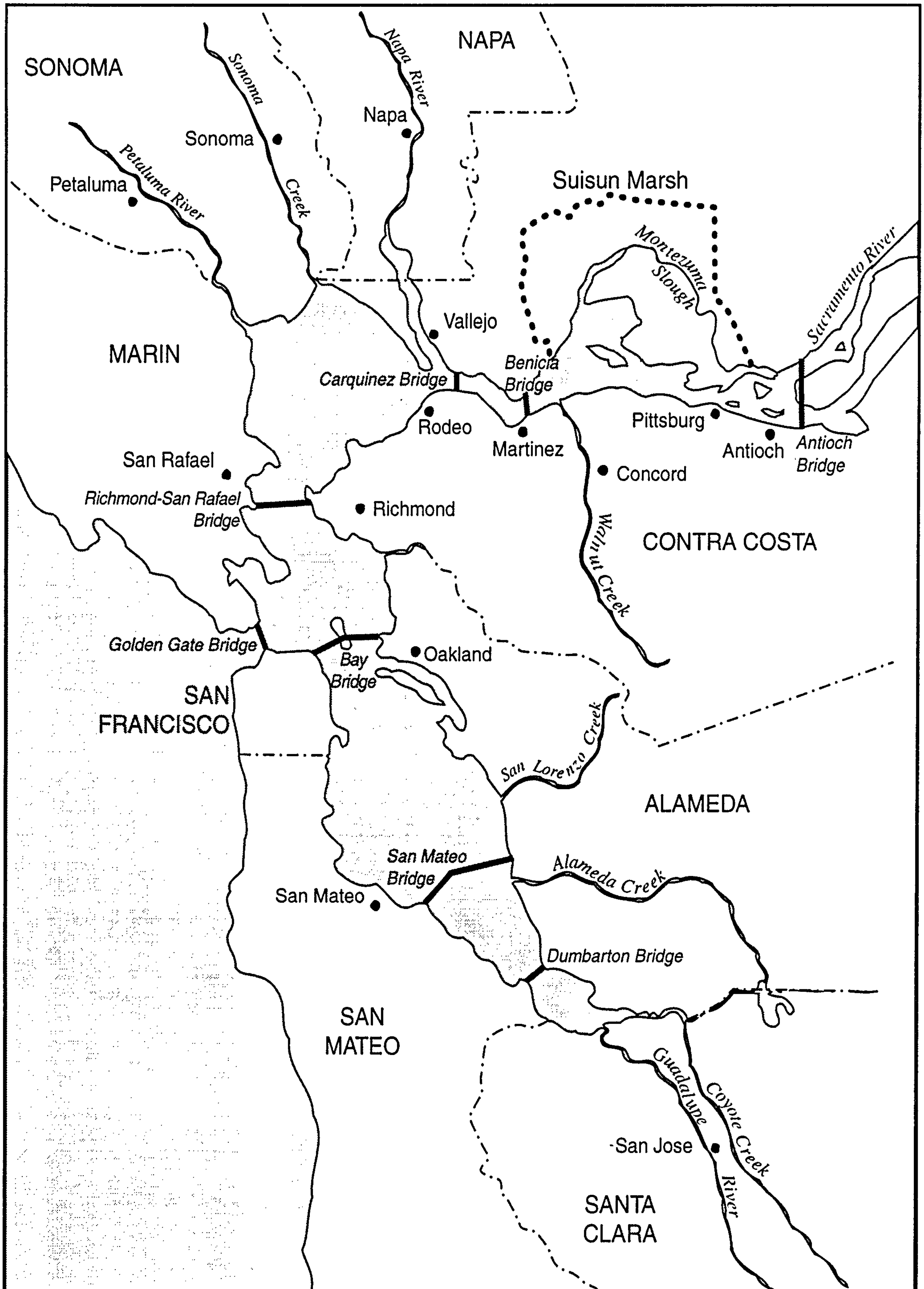


Figure 4.1-2. San Francisco Bay.

Pacific Ocean. The river study area and the locations of points used in the evaluation of river hydraulics are shown on Figure 4.1-3.

Very little of the water that falls as rain or snow within the region flows unregulated out of the Sacramento River and San Joaquin River regions. Instead, this water is intensely managed to extract from it the maximum benefit. The water is managed through a system of storage facilities and conveyances that enable water managers to deliver water at the time and places where it provides the greatest benefits. In the past, these benefits, or beneficial uses, have been broadly classified as municipal and industrial, agricultural, and fish and wildlife. As management capabilities increase and the effects of management decisions on various systems are increasingly understood, beneficial uses have been defined in greater detail. The SWRCB lists 17 specific beneficial uses of water in the Bay-Delta Estuary, each of which is protected. Since stream channels are used as water conveyances, the rules that govern the timing and magnitude of storage and release of water resources determine to a great extent the timing and magnitude of in-stream flows. The principal regulations affecting river and Delta flows are discussed in Section 4.2.

4.2 Regulatory Context

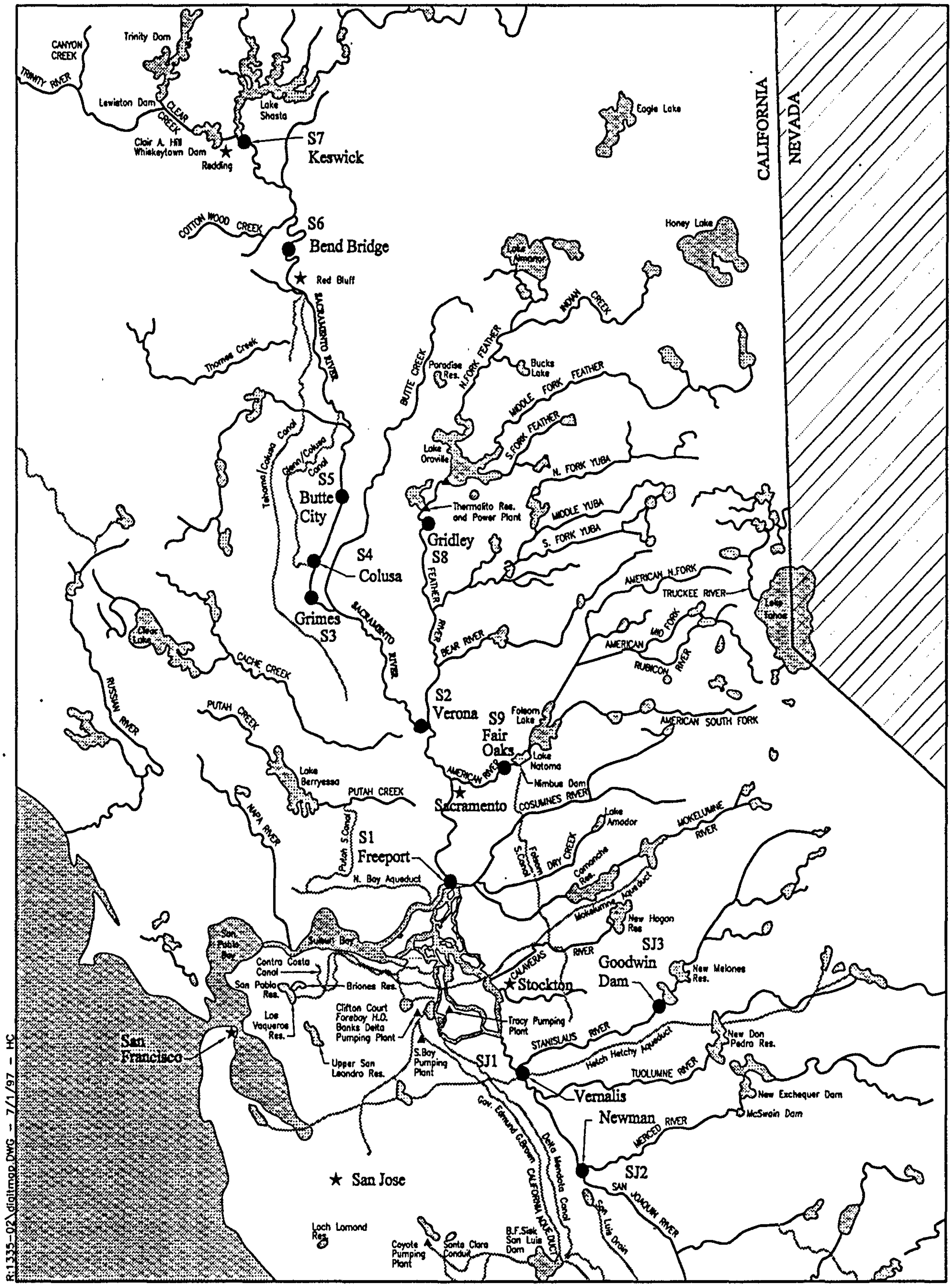
The quantity, quality, and timing of flows in river and Delta channels, particularly during below normal runoff years, increasingly depends on the complex body of laws, regulations, plans, and policies that have evolved to set priorities for allocating the resource among its beneficial users. The following section describes the regulatory context as it pertains to channel flows.

Central Valley Project Improvement Act (CVPIA) of 1992. The CVPIA covers the following primary areas:

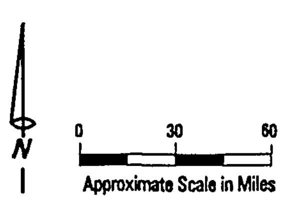
- Limiting on new and renewed CVP contracts;
- Conserving water and other water management actions;
- Transferring water;
- Establishing fish and wildlife restoration actions; and
- Establishing an environmental restoration fund.

Many of the measures in the CVPIA directly affect the flows in rivers and the Delta. Specifically, the CVPIA requires the following:

- At least an 8,000 cubic foot per second (cfs) pulse flow from Keswick Dam for a 5-day period in late April to assist downstream migration of juvenile fall-run chinook salmon and to provide the pulse flow needed in the Delta for Delta smelt and striped bass.
- At least 4,000 cfs releases from Keswick Dam to the Sacramento River from October through March and at least 1,750 cfs releases from Nimbus Dam to the American River from October through February. These releases eliminate flow fluctuations for the spawning, incubation, and rearing of fall-run and late fall-run Chinook salmon and steelhead trout. The Delta Cross Channel gates must be closed during May to reduce entrainment of downstream migrating fall-run Chinook salmon, striped bass eggs and larvae, and other Delta species.
- Two pulse flows from New Melones Reservoir of at least 1,500 cfs from April 24 to May 16, primarily to help move fall-run Chinook salmon molts.



River Hydraulics Study Location Map
Cal Fed Hydraulics



LEGEND:

- ● Study locations
- ~~~ Aqueduct/canal

Figure 4.1-3

downstream and past the Delta pumps and secondarily to benefit Delta smelt; and from May 20 to June 2, primarily to aid Delta smelt and secondarily to benefit striped bass and fall-run Chinook salmon.

- A base flow release of at least 300 cfs from New Melones Reservoir to the Stanislaus River from October through March to improve spawning and rearing conditions for fall-run Chinook salmon.
- A carryover of 100,000 to 115,000 acre-feet in New Melones Reservoir for improved water temperatures and as a contingency against drought.
- No reverse flow in the western Delta in May and June, maximum reverse flow of 1,000 cfs in July, and maximum reverse flow of 2,000 cfs in August, December, and January, specifically to benefit Delta smelt.
- A springtime pulse flow of about 4,500 cfs on the San Joaquin River side of the Delta. (Stanislaus River pulses and releases from other tributaries described above should provide this flow.)
- A pulse flow of at least 18,000 cfs from about April 20 to May 4 in the Sacramento River side of the Delta at Freeport. (The Keswick Dam pulse described above should contribute greatly to this.) From April 20 through May 30, the 14-day running average flow at Freeport should be at least 13,000 cfs, with daily minimums of at least 9,000 cfs.
- Base flows at Chipps Island between 14,000 and 7,700 cfs from May through July.
- Pumping reductions to 1,500 cfs (federal and state combined) from April to May 16 (during the San Joaquin River pulse flows), increased pumping to 4,000 cfs for the remainder of May, and increased pumping to 5,000 cfs for the month of June.

Other CVPIA measures would affect channel hydraulics and hydrodynamics indirectly through habitat improvements. Streambed Alteration Agreements. Fish and Game Code Sections 1601 and 1603 require that any governmental entity or private party altering the bed, bottom, or channel of a river, stream, or lake enter into an agreement with the Department of Fish and Game (DFG) when the project may substantially impact a fish or wildlife resource. DFG may require that the agreement include provisions designed to protect riparian habitat, fisheries, and wildlife.

Porter-Cologne Water Quality Control Act. The Porter-Cologne Act requires the state's nine Regional Water Quality Control Boards to adopt water quality control plans for areas within their regions. The Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995) was prepared in response to the act. The plan is intended to protect beneficial uses of the Bay-Delta Estuary. It identifies water quality standards for salinity (from salt water intrusion and agricultural drainage) and water project operations (flows and diversions), as well as identifies a dissolved oxygen objective. The plan states that "most of the objectives in the plan will be implemented by assigning responsibilities to water rights holders because the factors to be controlled are primarily related to flows and diversions" (SWRCB 1995).

Decision 1485. On April 29, 1976, the SWRCB initiated proceedings leading to the adoption of Water Right Decision 1485 in 1978. Decision 1485 set forth conditions, including water quality standards, export limitations, and minimum flow rates, for SWP and CVP operations in the Delta and superseded all previous water rights decisions for these operations. Decision

1485 established flow and water quality standards to protect three beneficial uses—municipal and industrial water supply, agriculture, and fish and wildlife.

In formulating Decision 1485, the SWRCB asserted that Delta water quality should be at least as good as it would have been if the SWP and CVP had not been implemented. The standards included different levels of protection to reflect variations in hydrologic conditions during different types of water years. Decision 1485 also included water quality standards for Suisun Marsh.

Decision 1485 was overturned in 1984, but it remained in effect pending appeals and was reinstated in 1986 by the Racanelli Decision.

Later in 1986, DWR and the U.S. Bureau of Reclamation (USBR) signed the Coordinated Operation Agreement (COA), obligating the CVP and the SWP to coordinate their operations to meet Decision 1485 standards. The COA helps ensure that the CVP and the SWP will be operated more efficiently during periods of drought than if they were operated independently, and it ensures that each project receives an equitable share of the Central Valley's available water.

Other laws and regulations may indirectly affect Delta hydrodynamics and river hydraulics. These include laws and regulations on the following:

- Water use efficiency;
- Water transfers;
- Releases of water for fish;
- Fish protection;
- Endangered species; and
- Suisun Marsh.

4.3 <u>Other Information</u>

4.3.1 Modeling of River Hydraulics with DWRSIM

DWR has developed computer models to simulate operation of the CVP-SWP network of storage and conveyance facilities. DWRSIM is one of the primary tools used by DWR to plan the operation of the reservoirs and conveyances and to allocate water within the SWP and CVP. A detailed description of DWRSIM can be found on the internet at http://wwwhydro.water.ca.gov.

The output from DWRSIM includes calculated monthly flow volumes in thousands of acre-feet (TAF) that passes a control point defined in the model. These volumes can be converted to an average monthly flow rate (i.e. discharge), expressed in cfs. With a few exceptions, the control points generally represent locations within the storage and conveyance system. Typically, the control points are where diversions, storage, downstream flows, regulatory required flows, or tributary inflows need to be adjusted or evaluated. DWRSIM also contains a module to calculate the X2 location in the Delta Estuary.

For existing conditions, DWRSIM simulates the storage and conveyance facilities as they existed in 1994. The operating assumptions are based on the SWRCB base study 469, which includes D-1485 Delta standards, CVPIA flow criteria, the 1995 WQCP standards, and ESA requirements. The simulation of existing conditions reflects how available water from October 1921 through September 1994 would have been allocated. (This same set of hydrologic inputs is used in simulations of alternative configurations to study the potential effects for a reasonably wide range of inflows). The results of these simulations are used to describe existing hydraulic conditions in the Sacramento River and San Joaquin River regions in the second part of Sections 4.6 and 4.7.

The advantage of using DWRSIM is that it allows us to test the response of the system to the entire range of inflows that have occurred historically. However, when thinking about simulated current conditions, it is important to remember that although the hydrologic input to the DWRSIM model is based on the actual record of precipitation and runoff for water years from 1922 to 1994, the monthly average discharge rates calculated by the model for each control point are not expected to match the historic record. This is because the historic record reflects the configuration and operation of the storage and conveyance system that existed historically, and not the conditions in 1994.

Before flow from the Sacramento River and San Joaquin River discharges to the San Francisco Bay, it passes through the Sacramento-San Joaquin Delta. Channel hydraulic processes in the region upstream of the Sacramento-San Joaquin Delta are dominated by flows toward the Delta. Tidal effects are generally small upstream of the Delta. In the Delta, tidal flows into and out of San Francisco Bay strongly influence the magnitude and direction of flow in Delta channels. Analysis of the combined effects of tidal flows and nontidal flows in the Delta and San Francisco Bay requires different analytical tools from those used to analyze the river flows upstream of the Delta. For this reason, Delta and Bay hydrodynamics are discussed separately from river hydraulics in this report.

4.3.2 Modeling of Delta Hydrodynamics and Water Quality Using DWRDSM1

The DWR's DWRDSM1 model is one of the primary tools used to plan facilities and operations in the Sacramento-San Joaquin Delta. A detailed description of the model can be found on the internet at http://wwwdelmod.water.ca.gov.

The modeling of the Delta using DWRDSM1 includes hydrodynamics (i.e., flows, velocities, and stages), mass tracking studies, and salinity modeling. The hydrodynamic modeling was performed using 16 years of monthly average hydrologic data (October 1975 to September 1991) from DWRSIM study 1995C06F-SWRCB-469. Three months were selected to represent various flow conditions in the Delta: March 1983, representing high inflow conditions; October 1989, representing low inflow/high pumping conditions; and July 1991, representing low inflow/low pumping conditions. DWRDSM1 output included monthly average, minimum, and maximum tidal flows, velocities, and stages for each channel in the modeling network. A subset of the channels was analyzed in this report.

The mass tracking studies were performed for selected locations within the Delta. Mass was continuously released at a particular location and tracked to determine its eventual fate in the Delta. Injection locations included the Sacramento River at Freeport, the San Joaquin River at Vernalis, Terminous, San Andreas Landing, Prisoners Point, the Sacramento River at Rio Vista, and the San Joaquin River at Jersey Point. The fate of released mass was monitored at the following locations: Contra Costa Canal, export locations, trapped on Delta islands, remaining in the Delta channels and waterways, or flowing out of the Delta past Chipps Island. Four months were selected for mass tracking analysis based on fish and wildlife concerns: February 1979, representing high inflow/high pumping conditions; April 1991, representing medium inflow/low pumping conditions; October 1989, representing low inflow/high pumping conditions; and July 1991, representing low inflow/low pumping conditions.

Salinity modeling was also performed for key locations within the Delta. Monthly minimum, maximum, and average tidal-day salinity was simulated for the entire 16-year period. Four locations were selected to represent existing conditions: Emmaton, Jersey Point, Old River at Rock Slough, and Clifton Court Forebay.

4.4 Delta Region

4.4.1 Historical Perspective

Sources of information for the historical perspective on the San Francisco Bay-Delta include the California Water Plan Update, Bulletin 160-93 (DWR 1994) and the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 1995).

The Sacramento-San Joaquin Delta has been the focus for a variety of water-related issues, generating more investigations than any other waterway system in California in the past few decades. Two-thirds of the state's population and millions of acres of agricultural land receive part or all of their water supplies from the Delta system. The Delta provides habitat for many species of fish, birds, mammals, and plants while supporting extensive farming and recreational activities. The following different interest groups have a vital stake in the Delta: farmers, fish and wildlife groups, environmentalists, boaters, people involved with shipping and navigation, and the people and industries that receive water from the Delta and the state's two largest export systems, the SWP and CVP.

During the mid-1800s, the Delta, an area of nearly 750,000 acres, was mostly a tidal marsh, part of an interconnected estuary system that included the Suisun Marsh and San Francisco Bay. The Delta was a great inland lake during the flood season until reclaimed by levees; when the flood waters receded, the network of sloughs and channels reappeared throughout the marsh. Runoff to the Delta comes from over 40 percent of the state's land area, including flows from the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers and their tributaries.

The first surveys of the Delta channels were in 1841 and again in 1849 by Lt. Commander Cadwalader Ringgold of the U.S. Navy. Due to these surveys, trade between the Delta and upstream communities and the San Francisco Bay Area increased. Delta and northern California communities, already experiencing a population boom because of the Gold Rush, expanded even more as travel to the area became easier and less expensive.

In late 1850, when the Swamp Land Act conveyed ownership of all swamp and overflow land, including Delta marshes, from the federal government to the state government, the development of today's Delta began. The California legislature created the Board of Swamp and Overflowed Land in 1861 to manage reclamation projects. The board's authority was transferred to county boards of supervisors in 1866.

Developers first thought Delta lands would be protected from tides and river overflow by levees about 4 feet high and 12 feet wide at the bottom. In the 1870s, small-scale reclamation projects were started on Rough and Ready Island and Roberts Island. However, the peat soils showed their weakness as levee material and would sink, blow away when dry, and develop deep cracks and fissures throughout the levee system. A few years later, developers realized that hand- and horse-powered labor could not maintain the reclaimed Delta islands. Steam-powered dredges were brought in to move large volumes of alluvial soils from the river channels; the alluvial soils were needed to construct the large levees we see today.

Nearly all Delta marshland had been reclaimed by 1930. These new steam-powered dredges were capable of moving material at about half the cost of hand labor. New artificial channels were "cut" at an increased rate, forming linear drainages between islands instead of natural meandering channels. These new cuts were constructed for navigation, to improve circulation, and to provide the material needed for levee construction. Examples of new cuts include the Grant Line Canal, Victoria Canal, Empire Cut, Columbia Cut, and the Delta Cross Channel. The two major navigation waterways include the Stockton Deep Water Channel, completed in 1933 (along the San Joaquin River), and the Sacramento Deep Water Channel, completed in 1963. The Sacramento-San Joaquin Delta Atlas (DWR 1993) identifies the constructed waterways of the Delta.

Today the Delta is about 500,000 acres of rich farmland, much of which is below sea level, is interlaced with hundreds of miles of waterways, and relies on more than 1,000 miles of levees for flood protection. Some of the island interiors are as much as 25 feet below sea level because of the continuing loss of peat soil. Soil loss comes primarily from oxidation, compaction, and wind erosion.

In 1940, water exports from the Delta began after the Contra Costa Canal, a unit of the CVP, was completed. Water was exported at the CVP's Tracy Pumping Plant, supplying the Delta-Mendota Canal in 1951. The SWP began exporting water through the South Bay Aqueduct in 1962 (through an interim connection to the CVP's Delta-Mendota Canal). Due to increased water demand, the SWP began pumping from the South Delta in 1967 (supplying the California Aqueduct) and from the North Delta in late 1987 (supplying the North Bay Aqueduct). The export water is either uncontrolled winter runoff or released from CVP and SWP reservoirs into the Sacramento River system north of the Delta.

To facilitate movement of Sacramento River water to pumping facilities in the South Delta, USBR completed the Delta Cross Channel in 1951. This channel connects the Sacramento River to Snodgrass Slough and the Mokelumne River system. The flow from the Sacramento River is controlled by two 60-foot gates at the Sacramento River near Walnut Grove. Downstream from the Delta Cross Channel, Georgiana Slough also connects the Sacramento River to the Mokelumne River system, moving Sacramento River water into the Central Delta.

Tidal influence is important throughout the Delta. Twice a day, Pacific Ocean tides move through San Francisco Bay and into and out of the Delta. The average incoming and outgoing Delta tidal flow is about 170,000 cfs, much larger than the currently permitted combined SWP and CVP export capability of about 11,000 cfs. Historically, during summers when mountain runoff was small, ocean water intruded into the Delta as far as Sacramento. During the winter and spring, fresh water from heavy rains pushed the salt water back, sometimes past the mouth of San Francisco Bay. Salt water intrusion into the Delta during the summer has been controlled by reservoir releases during what were traditionally the dry months with the addition of Shasta, Folsom, and Oroville dams. Reservoir releases have resulted in dampened peak winter and spring flows and increased summer and fall flows. In very wet years, such as 1969, 1982, 1983, and 1986, reservoirs are unable to control runoff so that during the winter and spring the upper bays became fresh; even at the Golden Gate, the upper several feet of water column consisted of fresh water.

Water that flows through the Delta past Chipps Island to San Francisco Bay is called Delta outflow. The average Delta outflow is about 30,000 cfs or about 21 million acre-feet (maf) per year. Delta inflow, export, and depletions of channel water within the Delta determine the magnitude of this flow. Seasonally, average natural flow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. During the summer months of critically dry years, Delta outflow can be as low as 3,000 cfs. The three major sources of fresh water to the Delta are the Sacramento River, the San Joaquin River, and eastside streams. The Sacramento River (including the Yolo Bypass) contributes about 77 to 85 percent of the fresh water flows, the San Joaquin River contributes roughly 10 to 15 percent, and streams on the east side and the Mokelumne River provide the remainder. In the west, salty water moves into the Delta with the tides, from Suisun and Honker bays. Water is directly exported from the Delta by the CVP, the SWP, and the city of Vallejo. Delta channels are depleted due to crop irrigation, evaporation, and channel seepage. During normal water years, about 10 percent of the water reaching the Delta is withdrawn for local use, 30 percent is withdrawn for export by the CVP and SWP, 20 percent is needed for salinity control, and the remaining 40 percent is Delta outflow in excess of minimum requirements. The excess outflow would occur almost entirely during the season of high inflow.

Today, releases from the upstream storage reservoirs of the SWP and CVP maintain the minimum fresh water Delta outflow. This outflow establishes a hydraulic barrier to prevent ocean water from intruding deep into the Delta and affecting municipal and agricultural water supplies. The hydraulic barrier, where fresh water gradually mixes with ocean water, is generally maintained near Chipps Island. During flood flows, the hydraulic barrier moves out into the Bay.

The Delta has about 700 miles of channels that provide habitat for numerous species of small plants and animals. The organisms form the basis for food chains that support more than 40 species of native and introduced fish. Presently, during all months of the year, water in the Delta channels is generally fresh. Before water development, the Delta water was often salty from summer through late fall, and outflows were higher in winter. Because of the organic nature of Delta islands and annual sediment inflow, Delta waters are high in suspended matter. Often, light only can penetrate 2 feet or less; this high turbidity affects overall Delta productivity.

4.4.2 Current Resource Conditions

4.4.2.1 Flows, Velocities, and Stages

Average flows, velocities, and stages for high inflow, low inflow/high pumping, and low inflow/low pumping conditions are presented in Table 4.4-1 for a number of locations within the Delta. The input hydrology is from DWRSIM, which provides monthly average river inflows and projected exports under predicted 2020 demands. This demand is higher than the current demand; thus, pumping rates and, therefore, flows toward the pumping plants, may be less for existing conditions than those presented in the table.

During periods of high inflow, the Delta Cross Channel is closed for Delta flood protection. Higher flows are observed in locations along the Sacramento River and in the North Delta, while flows in the south Delta are generally lower. Average flow rates range from 0 to 185,000 cfs for high inflow conditions, 30 to 6,200 cfs in low inflow/high pumping conditions and 30 to 2,900 cfs for low inflow/low pumping conditions.

Velocities in the Delta are generally well below the nominal scour velocity of approximately 3 feet per second (fps) except at a few locations in high inflow conditions—Old River at Mossdale, Grant Line Canal, the Diversion to Sutter and Steamboat sloughs, and the Sacramento River at Rio Vista. Since DWRDSM1 provides only cross-sectionally averaged velocity, these results should be considered as indices for comparative purposes.

Maps of the average tidal flows, velocities, and stages throughout the Delta based on modeling are shown in Figures 4.4-1 through 4.4-3 for the high inflow, low inflow/high pumping and low inflow/low pumping conditions, respectively. For high inflow conditions, approximately 40 percent of the inflow from the Sacramento River at Hood is diverted to Steamboat and Sutter sloughs, and 15 percent travels down Georgiana Slough. The remainder continues down the Sacramento River toward the Bay. In the South Delta, about 60 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale and 40 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River toward the Bay, 75 percent is carried by the Grant Line Canal, and 20 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north toward the Bay. The ratio of flow in Old River to flow in Middle River is about 1.5. Water from the central Delta flows out through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). Central Delta water includes inflows from the San Joaquin River and east side streams, as well as Sacramento River flow diverted through Georgiana Slough. False River carries about 35 percent of the central Delta outflow, and Dutch Slough carries about 5 percent. About 60 percent of the total central Delta outflow remains in the main channel of the San Joaquin River.

For low inflow/high pumping conditions, approximately 20 percent of the inflow from the Sacramento River at Hood is diverted to Steamboat and Sutter sloughs, 30 percent is diverted to the Delta Cross Channel, and 20 percent travels down Georgiana Slough. The remainder continues down the Sacramento River toward the Bay. In the South Delta, the

Table 4.4-1. Flows, velocities, and stages at locations within the Delta for existing conditions.

Location		High Flow			Low Inflow/High Pumping			Low Inflow/Low		
Tidal Flow (cfs)	**Loc. Key**	**Avg.**	**Max. Sea-ward**	**Max. Land-ward**	**Avg.**	**Max. Sea ward**	**Max. Land-ward**	**Avg.**	**Max. Sea-ward**	**Max. Land-ward**
San Joaquin River at Fourteen Mile Slough	1	17,464	21,598	11,350	-34	6,032	6,377	99	5,945	6,340
San Joaquin River at Antioch	2	55,602	170,018	110,216	-1,552	148,346	155,223	950	148,752	152,312
Old River at Mossdale	3	24,254	24,292	24,198	1,292	1,650	213	862	1,603	749
Old River at Fabian Tract	4	4,584	4,842	4,136	158	763	1,021	32	993	1,111
Old River at Woodward Island	5	9,275	15,015	1,121	-4,564	5,888	13,191	-981	8,474	11,251
Old River at Franks Tract	6	1,571	5,248	4,010	-295	4,481	3,999	25	4,633	4,026
Middle River at Woodward Island	7	5,669	10,036	2,175	-3,154	4,192	9,915	-848	6,082	8,379
Grant Line Canal	8	15,996	16,513	14,679	1,084	3,632	3,808	525	3,915	3,935
Victoria Canal	9	-3,809	-57	5,911	2,355	5,935	1,049	429	3,211	2,076
Delta Cross Channel	10	0	114	283	3,862	7,756	597	2,677	6,194	528
Georgiana Slough	11	11,201	11,683	10,792	2,241	3,953	903	1,634	3,232	443
Diversion to Sutter/Steamboat Sloughs	12	17,892	18,194	17,443	1,882	5,047	3,422	1,131	4,664	4,292
Miner Slough	13	10,579	11,140	9,757	1,112	4,275	3,392	653	4,084	3,832
Sacramento River at Rio Vista	14	184,780	219,089	132,546	6,158	91,132	82,720	2,900	87,291	86,542
Mokelumne River, North Fork	15	5,951	7,687	2,374	3,018	4,395	1,404	178	4,075	4,332
Mokelumne River, South Fork	16	2,823	5,803	3,845	811	5,206	4,980	153	4,699	4,841
Velocity (fps)	**Loc. Key**	**Avg.**	**Max. Sea-ward**	**Max. Land-ward**	**Avg.**	**Max. Sea ward**	**Max. Land-ward**	**Avg.**	**Max. Sea-ward**	**Max. Land-ward**
San Joaquin River at Fourteen Mile Slough	1	1.05	1.24	0.69	0.00	0.37	0.39	0.01	0.36	0.38
San Joaquin River at Antioch	2	0.92	2.75	1.58	0.06	2.52	2.28	0.10	2.53	2.24
Old River at Mossdale	3	6.86	6.89	6.82	1.14	1.58	0.16	0.76	1.51	0.53
Old River at Fabian Tract	4	2.07	2.18	1.79	0.15	0.70	0.73	0.05	0.71	0.72
Old River at Woodward Island	5	0.90	1.53	0.10	-0.46	0.68	1.32	-0.08	0.89	1.10
Old River at Franks Tract	6	0.27	0.81	0.69	-0.06	0.78	0.82	0.00	0.80	0.81
Middle River at Woodward Island	7	0.81	1.49	0.28	-0.46	0.70	1.44	-0.11	0.92	1.19
Grant Line Canal	8	3.16	3.33	2.80	0.31	1.08	0.93	0.17	1.07	0.94
Victoria Canal	9	-0.80	-0.01	1.30	0.57	1.29	0.29	0.08	0.67	0.49
Delta Cross Channel	10	0.00	0.02	0.05	0.74	1.43	0.11	0.52	1.19	0.10
Georgiana Slough	11	2.83	2.98	2.67	0.82	1.43	0.32	0.61	1.23	0.15
Diversion to Sutter/Steamboat Sloughs	12	4.38	4.49	4.22	0.70	1.76	1.16	0.43	1.64	1.49
Miner Slough	13	2.57	2.78	2.28	0.43	1.49	0.98	0.28	1.43	1.12
Sacramento River at Rio Vista	14	3.04	3.65	2.07	0.13	1.56	1.46	0.08	1.50	1.53
Mokelumne River, North Fork	15	0.99	1.29	0.38	0.55	0.79	0.26	0.37	0.64	0.07
Mokelumne River, South Fork	16	0.39	0.80	0.52	0.12	0.72	0.75	0.05	0.63	0.72
Stage (mllw)	**Loc. Key**	**Avg.**	**Max.**	**Min.**	**Avg.**	**Max.**	**Min.**	**Avg.**	**Max.**	**Min.**
San Joaquin River at Fourteen Mile Slough	1	5.2	7.0	3.8	3.5	5.6	1.7	3.6	5.6	1.8
San Joaquin River at Antioch	2	4.2	6.4	2.2	3.5	6.0	0.9	3.5	6.0	1.0
Old River at Mossdale	3	20.8	20.9	20.8	3.5	4.8	2.4	3.9	5.3	2.5
Old River at Fabian Tract	4	8.0	8.7	7.6	3.0	4.7	1.7	3.5	5.3	1.9
Old River at Woodward Island	5	5.2	7.0	3.8	3.5	5.6	1.6	3.6	5.6	1.7
Old River at Franks Tract	6	5.1	6.7	3.7	3.5	5.4	1.8	3.6	5.4	1.9
Middle River at Woodward Island	7	5.2	7.0	3.8	3.5	5.6	1.6	3.6	5.6	1.7
Grant Line Canal	8	8.1	8.9	7.6	3.0	4.7	1.7	3.6	5.3	1.9
Victoria Canal	9	5.7	7.2	4.6	3.2	5.3	1.5	3.5	5.5	1.7
Delta Cross Channel	10	6.2	7.5	5.1	4.1	5.7	2.5	3.9	5.7	2.3
Georgiana Slough	11	11.1	11.6	10.7	4.1	5.9	2.5	3.9	5.7	2.2
Diversion to Sutter/Steamboat Sloughs	12	13.6	13.9	13.3	4.5	6.2	2.9	4.1	6.0	2.5
Miner Slough	13	9.3	10.3	8.6	3.9	6.3	1.6	3.8	6.2	1.4
Sacramento River at Rio Vista	14	5.0	7.0	3.3	3.5	6.3	0.7	3.5	6.3	0.7
Mokelumne River, North Fork	15	5.5	7.0	4.3	3.7	5.5	2.0	3.7	5.5	2.0
Mokelumne River, South Fork	16	5.4	7.0	4.1	3.6	5.6	1.9	3.6	5.6	1.9

Note: A negative flow or velocity indicates landward direction.

C-002899

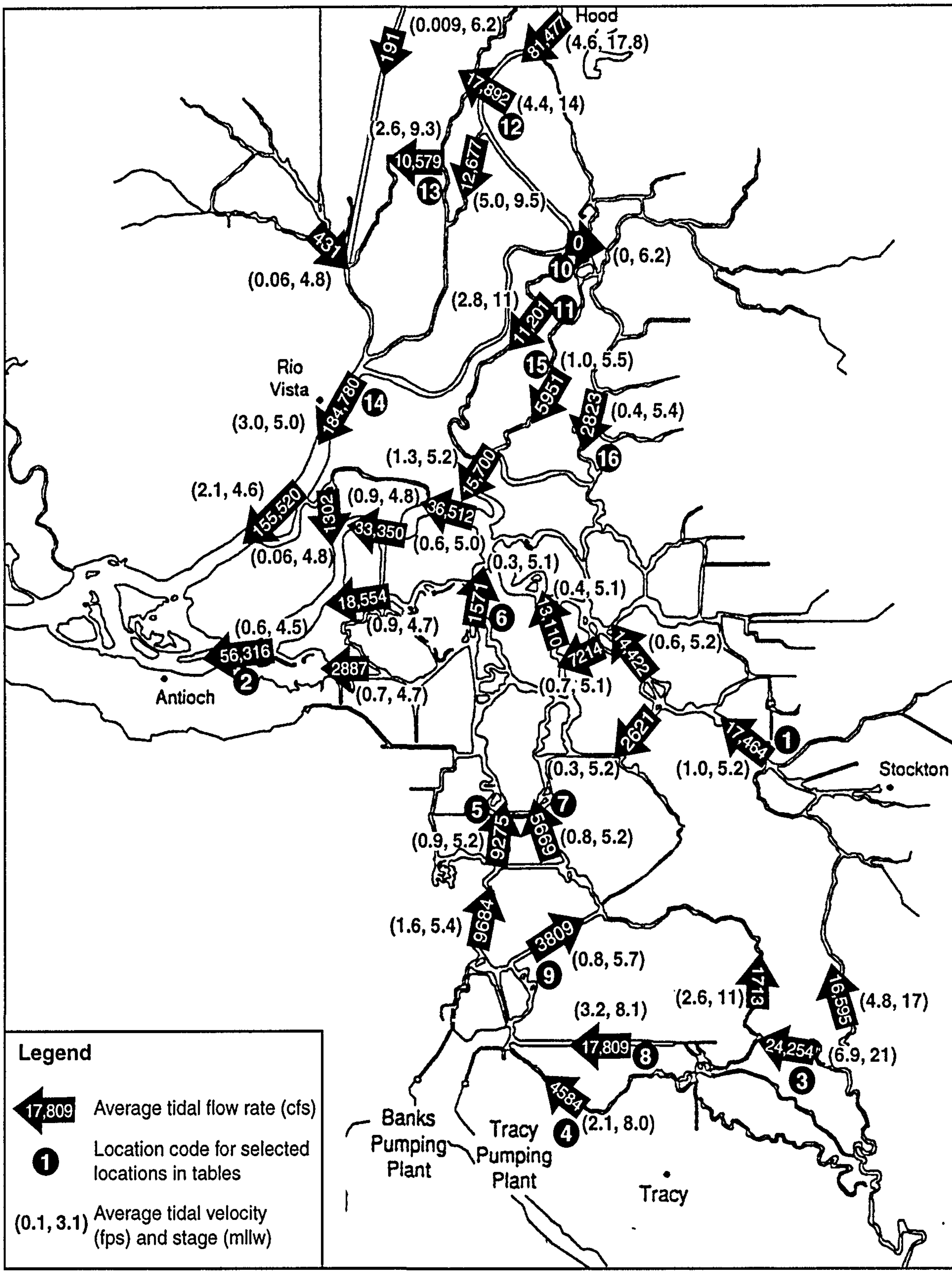


Figure 4.4-1. Average tidal flow rates, velocities, and stages for high flow for existing conditions.

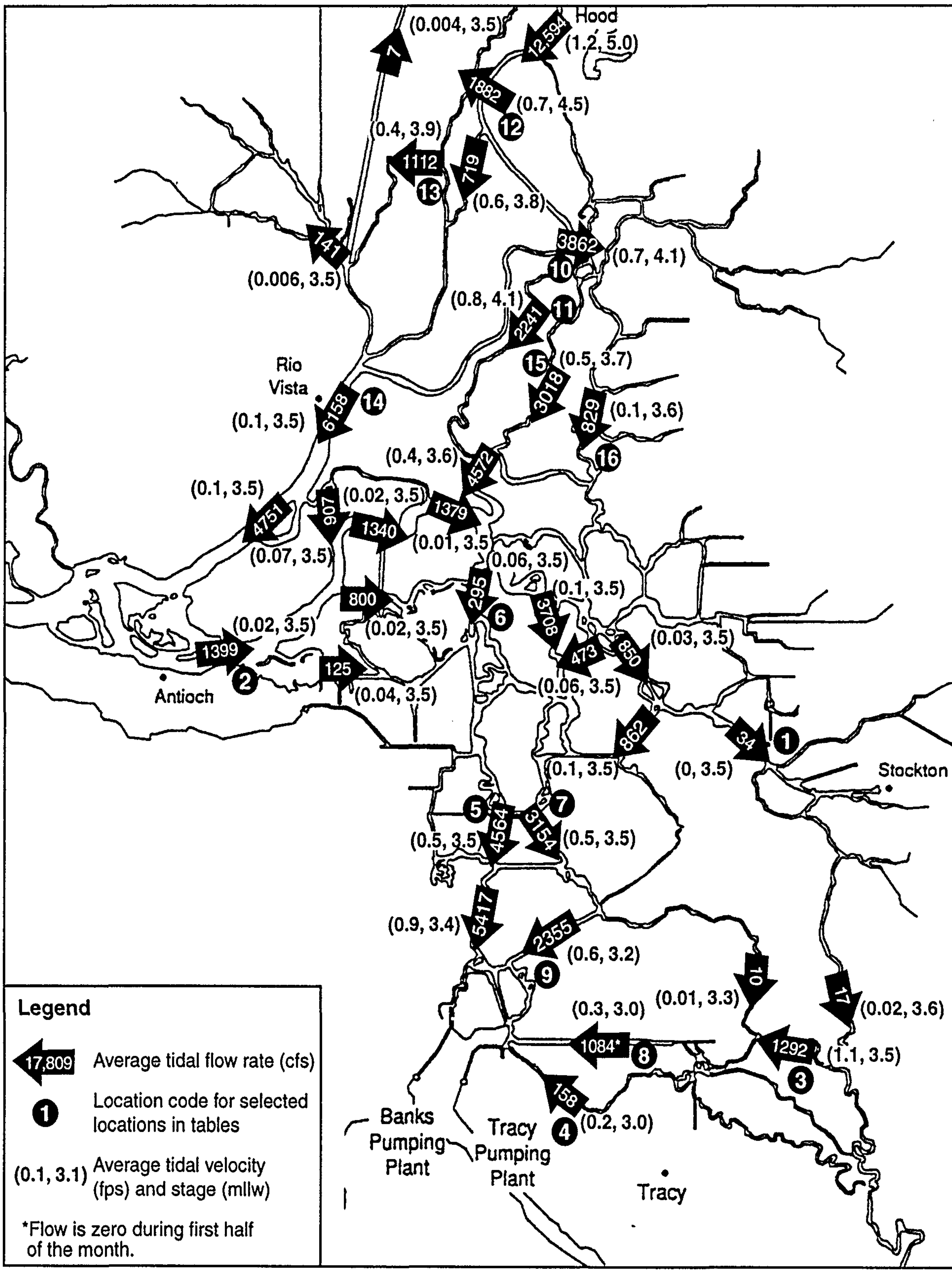


Figure 4.4-2. Average tidal flow rates, velocities, and stages for low flow/high pumping for existing conditions.

C-002901

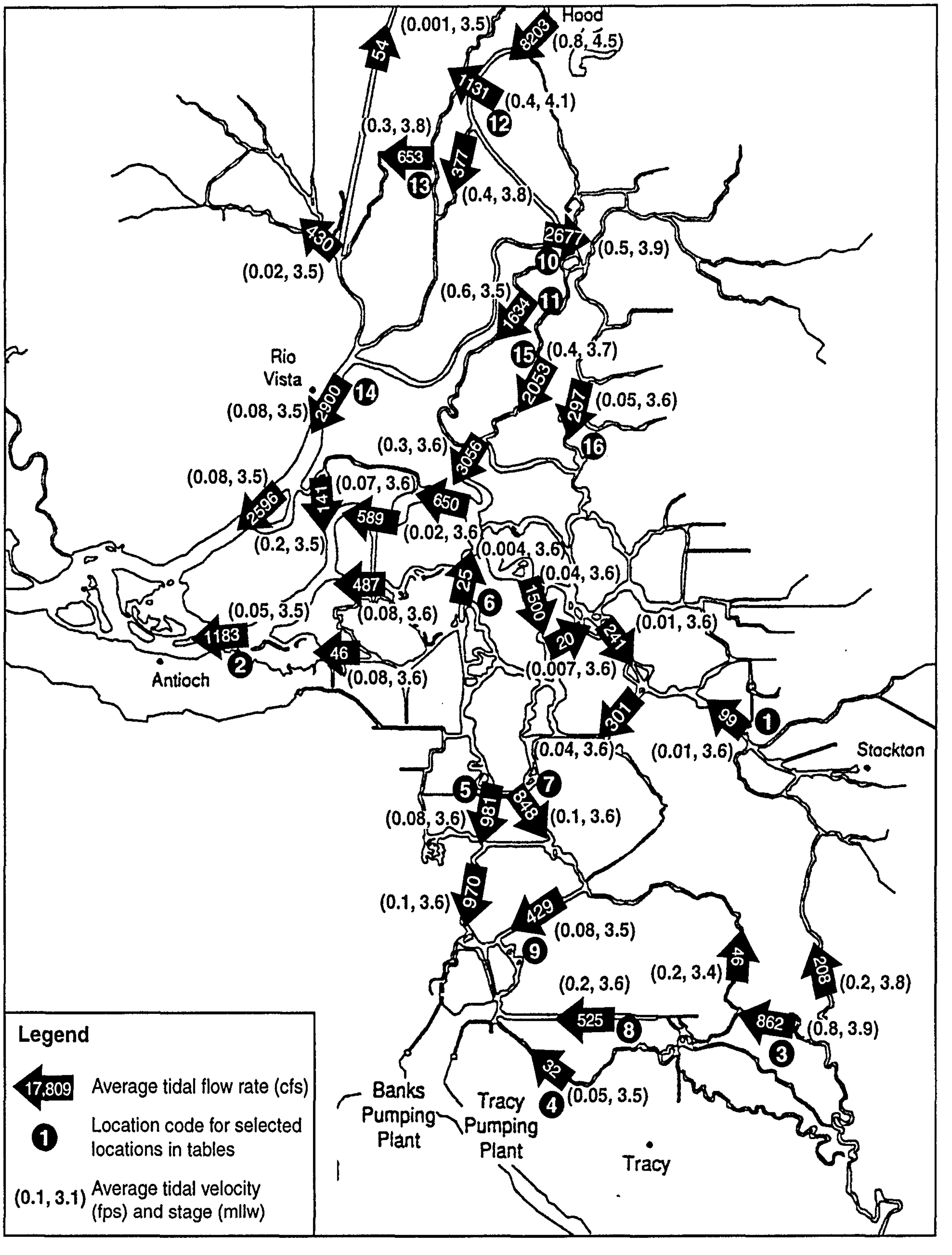


Figure 4.4-3. Average tidal flow rates, velocities, and stages for low flow/low pumping for existing conditions.

C-002902

San Joaquin River experiences reverse flows. Of the flow in Old River at Mossdale, approximately 85 percent is carried by the Grant Line Canal and 10 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy Pumping Plants. The ratio of flow in Old River to flow in Middle River is about 1.5. Much of the water in the central Delta flows south toward the pumping plants. Central Delta water enters Old and Middle River channels at their mouths and flows through Turner, Empire, and Columbia Cuts, which connect the upper San Joaquin River with Middle River. Central Delta water includes inflows from the San Joaquin River and east side streams, as well as Sacramento River flow diverted through the Delta Cross Channel and Georgiana Slough. False River, Dutch Slough, and the San Joaquin River carry water east into the Delta.

For low inflow/low pumping conditions, approximately 20 percent of the inflow from the Sacramento River at Hood is diverted to Steamboat and Sutter sloughs, 35 percent is diverted to the Delta Cross Channel, and 25 percent travels down Georgiana Slough. The remainder continues down the Sacramento River toward the Bay. In the South Delta, about 80 percent of the San Joaquin River inflow at Vernalis, is diverted to Old River near Mossdale and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River toward the Bay, while 60 percent is carried by the Grant Line Canal and 5 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy Pumping Plants. Old River and Middle River carry nearly equal amounts of this flow. Much of the water in the central Delta flows west toward the Bay. Central Delta water enters Old and Middle River channels at their mouths and flows through Turner, Empire, and Columbia Cuts, which connect the upper San Joaquin River with Middle River. Central Delta water includes inflows from the San Joaquin River and east side streams, as well as Sacramento River flow diverted through the Delta Cross Channel and Georgiana Slough. False River, Dutch Slough, and the San Joaquin River carry water west toward the Bay.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are below the nominal scour velocity of 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions are generally below the 3 fps, except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter Sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, Old River at Mossdale, and Grant Line Canal all have average velocities higher than 3 fps. However, Grant Line Canal has average velocity of less than 3 fps in less than 1 percent of the months modeled, the San Joaquin River at Upper Roberts Island in less than 6 percent of the months modeled, the Diversion to Steamboat and Sutter Sloughs, Steamboat Slough, and the Sacramento River at Hood in less than 12 percent of the months modeled, and Old River at Mossdale in less than 18 percent of the months modeled.

4.4.2.2 Transport and Fate of Tracer Mass

The fate of mass released into the Delta at various locations after 30 and 60 days is shown in Table 4.4-2 for a number of flow conditions. The flow conditions are low inflow/high pumping, low inflow/low pumping, high inflow/high pumping, and

Table 4.4-2. Monthly average net Delta outflow (cfs).

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
95%	121,065	147,760	117,955	83,033	58,861	33,383	8,002	5,035	12,604	18,970	33,793	82,059	84,606
90%	101,494	132,725	94,826	67,948	44,155	21,017	8,002	4,889	9,613	15,050	18,587	66,332	54,899
75%	52,141	61,904	49,587	30,166	22,769	11,932	8,002	4,424	3,294	7,676	11,108	17,955	20,964
50%	18,605	31,150	29,323	16,301	11,206	9,882	6,505	4,001	3,008	4,586	5,176	8,831	9,176
25%	10,474	16,710	14,686	10,436	6,896	8,588	4,993	3,497	3,008	4,001	4,504	4,733	4,647
10%	6,001	11,326	11,401	8,036	5,936	6,900	4,001	2,992	3,008	4,001	3,536	4,505	3,497
5%	5,269	10,724	9,215	6,924	5,757	6,816	4,001	2,992	3,008	4,001	3,496	4,225	3,008

medium inflow/low pumping. These flow conditions were chosen based on fisheries and wildlife issues.

Most of the mass released at the San Joaquin River near Vernalis ends up at the export locations for all flow conditions except low inflow/low pumping, where more is on Delta islands due to the decreased demand at the pumps. None of the mass released at Vernalis reaches the Contra Costa Canal or flows past Chipps Island except at high inflow/high pumping conditions, where a small amount flows past Chipps Island within 60 days.

For the mass released at Terminous for low inflow/high pumping and medium inflow/low pumping conditions, most of the mass eventually goes to the exports, very little flows past Chipps Island and flows to the Contra Costa Canal. Some is trapped on Delta islands. For low inflow/low pumping conditions, less mass flows to the exports, and most of the mass is eventually trapped on Delta islands. For high inflow/high pumping conditions, most of the mass flows past Chipps Island.

For the mass released into the Sacramento River at Freeport, for low inflow/high pumping conditions, most of the mass flows past Chipps Island. For low inflow/low pumping conditions, more mass is trapped in Delta islands and remains in Delta channels and waterways after 60 days. For both high and medium inflow conditions, most of the mass flows past Chipps Island, though the mass takes longer to do so under medium flow conditions.

For the mass released in the Sacramento River at Rio Vista and in the San Joaquin River at Jersey Point, for all flow conditions, most of the mass flows past Chipps Island. The mass is quickest to reach Chipps Island in the high inflow case and the slowest under the low inflow/low pumping conditions. Also, under low inflow conditions, more mass is trapped on Delta islands.

For mass released in the San Joaquin River at San Andreas Landing, under high and medium inflow conditions, most of the mass eventually flows past Chipps Island. For the medium inflow case, the mass takes longer to reach Chipps Island, more reaches the export locations, and more is trapped on Delta islands. For low inflow/high pumping conditions, nearly equal amounts of mass reach the export locations as flow past Chipps Island. For low inflow/low pumping conditions, the mass is fairly evenly distributed among reaching the exports, being trapped on Delta islands, flowing past Chipps Island, and remaining in Delta channels after 60 days.

For mass released into the San Joaquin River at Prisoners Point, for low and medium inflow conditions, most of the mass reaches the export locations and more is trapped on Delta islands for low pumping conditions than for high pumping conditions. For high inflow conditions, most of the mass flows past Chipps Island, with a small amount reaching the export locations.

This analysis of the fate of mass released into Delta waterways at various locations is based on DWRDSM1 modeling using predicted 2020 demands and an increased pumping Figure 4.4-2. Average tidal flow rates, velocities, and stages for low flow/high pumping for existing conditions capacity at the export locations. Both of these components would increase the pumping that occurs and, therefore, would increase the mass traveling to the export locations. Therefore, under existing Delta conditions, there would likely be less mass reaching the export locations and more flowing past Chipps Island and becoming trapped on Delta islands.

4.4.2.3 Net Delta Outflow

The Delta is a tidal region with tides causing a zero- to eight-mile back and forth movement of water in the Delta twice each day. The net movement of fresh water through the Delta can be thought of as being superimposed on the tidal flows. The tidal flows into and out of the Delta essentially cancel each other out; thus, an equal amount of water flows into the Delta and then flows back out with no net movement of water through the system. Although the fresh water river flows are small in comparison to the tidal flows, they are the source of "net" movement in and through the Delta.

Net Delta outflow is thought to be the means that fish use to navigate upstream, that fish eggs and larvae use to move through the Delta, and by which dissolved substances, such as salt, are flushed through the Delta. SWRCB has used Delta outflow, Sacramento River flow at Rio Vista, and San Joaquin River flow at Vernalis to create Water Quality Objectives in its water quality control plan (1995). The objectives set minimum flow requirements at these points during specific times of the year.

Net Delta outflow represents the net flow below the San Joaquin River-Sacramento River confluence near Chipps Island moving out of the Delta. Net Delta outflow cannot easily be measured because of the large overshadowing effect of the tidal flows.

Generally, the average tidal flow (ebb or flood) at Chipps Island is about 170,000 cfs. The peak tidal ebb and flood flows are about 320,000 cfs and 310,000 cfs, respectively, the difference accounting for net Delta outflow. In comparison, average winter net Delta outflow is about 32,000 cfs, with summer time flows averaging 6,000 cfs (DWR 1993). Net Delta outflow is the difference between the tidal inflows and tidal plus river outflows (exports and channel depletions).

Table 4.4-3 shows the distribution of monthly averaged net Delta outflow for existing conditions based on DWRSIM modeling. From 1923 through 1994, average annual Delta outflow was 20,700 cfs and ranged from 5,500 cfs to 94,300 cfs. Monthly average flows are frequently as low as 3,000 cfs in the summer and as high as 148,000 cfs in winter (5th and 95th percentiles, respectively).

February typically has the greatest variation of net Delta outflow, ranging from 11,000 cfs to 148,000 cfs for the 5th and 95th percentiles, respectively, in addition to the largest median flow of 31,000 cfs. August has the least variation of net Delta outflow, ranging from 3,000 cfs to 5,000 cfs for the 5th and 95th percentiles, respectively. The low flows are commonly a function of the minimum Delta outflow requirements.

4.4.2.4 Central Delta Outflow

The export pumping plants of the CVP and SWP can cause water in the central southern channels to move upstream toward Clifton Court. Two terms can be used to describe this reverse flow: QWEST and Central Delta Outflow. QWEST represents the flow in the lower San Joaquin River at Jersey Point; Central Delta outflow represents the net flow in the San Joaquin River upstream of Table 4.4-2. Fate of mass released at specific locations for existing conditions. Threemile Slough plus the flow in False River and Dutch Slough. Only central Delta outflow is discussed here.

Central Delta outflow is either downstream in a typical flow pattern or drawn upstream toward the export pumping plants. Reverse flows are a result of high export pumping in

Table 4.4-3. Fate of mass released at specific locations for existing conditions.

	Low Inflow/ High Pumping		Low Inflow/ Low Pumping		High Inflow/ High Pumping		Medium Inflow/ Low Pumping	
Vernalis	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	0%	0%	0%	0%	4%	8%	0%	0%
Contra Costa Canal	0%	0%	0%	0%	1%	1%	0%	0%
Exports	67%	72%	31%	32%	88%	91%	77%	87%
Islands	18%	20%	61%	64%	0%	0%	10%	11%
In Delta	15%	8%	6%	4%	7%	0%	13%	2%
Terminous	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	0%	4%	0%	1%	56%	78%	1%	8%
Contra Costa Canal	1%	3%	1%	3%	1%	1%	0%	0%
Exports	19%	56%	10%	29%	14%	20%	25%	64%
Islands	11%	15%	39%	54%	0%	0%	8%	12%
In Delta	69%	20%	49%	12%	29%	1%	66%	16%
Freeport	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	19%	46%	10%	28%	98%	99%	69%	81%
Contra Costa Canal	1%	2%	1%	3%	0%	0%	0%	0%
Exports	6%	22%	4%	15%	1%	1%	5%	10%
Islands	8%	11%	26%	35%	0%	0%	3%	4%
In Delta	65%	20%	59%	19%	1%	0%	23%	4%
Rio Vista	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	50%	79%	35%	62%	100%	100%	87%	94%
Delta Cross Channel	1%	1%	1%	2%	0%	0%	0%	0%
Exports	2%	5%	2%	5%	0%	0%	2%	3%
Islands	2%	3%	8%	11%	0%	0%	1%	2%
In Delta	45%	12%	55%	19%	0%	0%	10%	1%
Jersey Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	40%	72%	27%	55%	98%	99%	62%	82%
Contra Costa Canal	1%	2%	2%	3%	0%	0%	0%	0%
Exports	7%	9%	6%	9%	1%	1%	8%	10%
Islands	3%	4%	9%	12%	0%	0%	3%	4%
In Delta	49%	13%	56%	20%	1%	0%	27%	4%
San Andreas Landing	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	13%	39%	6%	23%	94%	97%	26%	51%
Contra Costa Canal	2%	3%	3%	5%	0%	0%	0%	0%
Exports	15%	33%	12%	28%	3%	3%	18%	34%
Islands	4%	7%	14%	23%	0%	0%	4%	6%
In Delta	66%	18%	65%	21%	3%	0%	53%	9%
Prisoners Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	2%	10%	1%	6%	74%	87%	6%	16%
Contra Costa Canal	3%	4%	4%	6%	1%	1%	0%	0%
Exports	42%	68%	30%	49%	10%	12%	47%	72%
Islands	5%	8%	21%	31%	0%	0%	4%	6%
In Delta	48%	10%	44%	9%	15%	0%	43%	6%

the southern Delta compared to the low inflows of the San Joaquin River and southern channel capacities. The difference between the exports and the southern Delta inflows are made up from the Sacramento River and east side streams, drawing water across the Delta from the north and west to the south.

Reverse flows appear to occur in every year between 1976 and 1991, except in 1983, which experienced the highest Delta flows on record (66,000 TAF). During the 1976-1977 drought and the 1987-1991 drought, flows were almost always upstream. Frequency analysis of central Delta outflows indicates that approximately 60 percent of the monthly averaged flows are in the upstream direction.

Table 4.4-4 shows the distribution of monthly averaged central Delta outflow for existing conditions based on DWRDSM1 modeling. These flows are based on modeling of the Delta with existing Delta geometry and predicted 2020 demands, which are higher than current demands. Pumping rates will be less for existing conditions and magnitudes of upstream central Delta outflow may be less extreme than those shown in the table.

Central Delta outflows show typical winter and spring characteristic flows and summer and fall characteristic flows. Median flows in mid-winter through spring are downstream, while median flows in summer through fall are upstream. Approximately 70 percent of the central Delta outflows in the late winter through spring are downstream. Flows in April are always downstream. Approximately 70 percent of the central Delta outflows in the summer and fall are in the upstream direction.

4.4.2.5 X2 Position

The X2 position represents the approximate location of the beginning of the entrapment zone, or mixing zone of seawater from the bay and fresh water from the streams. The entrapment zone is an important biological habitat for specific aquatic species. The entrapment zone creates a region where suspended nutrients tend to accumulate, as do phytoplankton, zooplankton, and the eggs and larvae of many fish. When the entrapment zone is located in the warm, shallow waters of Suisun Bay, it appears that food chain dynamics are most favorable. When the entrapment zone is located inland in the narrow river channels with colder water and decreased residence time, ecosystem productivity is diminished. (California State Lands Commission 1991)

The X2 position is the theoretical location of the 2 parts per thousand salinity isohaline. The location of X2 varies in relationship to net Delta outflow and the tidal cycle. The position of X2 is measured in kilometers from the Golden Gate Bridge upstream to the Sacramento River. During high Delta outflows, X2 can be located near Suisun Bay; with low Delta outflows, X2 can be located in the western Delta, sometimes as far upstream as Jersey Point. The tide can move the position of X2 from 3 to 10 kilometers each day (California State Lands Commission 1991). As with other standards, X2 is part of the DWRSIM operation decision structure.

Table 4.4-5 shows the distribution of computed X2 positions obtained from DWRSIM simulation for existing conditions. On a percentile basis, X2 varied from 50 km in February and March to 90 km in September, for the 5th and 95th percentiles, respectively. A minimum X2 of 42 km occurs in March 1983. Maximum X2 of 90 km occurs in August, September, and October in 1929, 1931, and 1933.

Table 4.4-4. Monthly average central Delta outflow (cfs).

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
95%	21,452	40,171	36,355	26,262	13,403	11,968	3,421	40	171	4,371	7,858	22,300	22,090
90%	17,906	35,186	25,580	17,280	6,895	4,191	1,346	-298	-140	3,170	2,552	10,488	11,156
75%	4,301	12,292	12,621	2,912	2,069	2,342	-502	-607	-199	1,318	-197	-821	1,566
50%	-985	2,180	564	1,000	908	153	-2,213	-2,272	-1,588	-454	-1,727	-3,141	-416
25%	-2,844	-472	-1,256	415	-242	-844	-4,770	-3,717	-2,692	-2,073	-3,229	-4,417	-2,350
10%	-4,783	-3,287	-2,533	265	-503	-984	-5,017	-4,540	-3,038	-2,185	-3,737	-4,547	-3,996
5%	-4,904	-3,634	-2,872	106	-591	-1,070	-5,129	-4,654	-3,141	-2,263	-3,898	-4,630	-4,656

Table 4.4-5. Average X2 position (kilometers).

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
95%	84.9	78.6	77.5	79.5	81.0	81.0	85.2	88.7	89.9	87.9	87.7	88.4	88.6
90%	83.6	78.0	75.8	77.8	81.0	81.0	85.2	88.7	89.9	87.9	87.7	86.1	87.7
75%	80.4	74.0	72.1	74.6	78.3	80.6	83.2	86.9	89.3	87.7	86.5	85.9	84.6
50%	74.4	66.8	66.4	69.2	73.5	76.9	80.0	84.7	88.6	85.8	84.3	80.4	78.2
25%	62.5	59.5	58.1	62.1	65.5	72.5	77.2	82.1	86.5	81.0	78.1	71.6	69.6
10%	55.4	51.9	53.3	55.2	58.7	64.7	74.5	81.8	79.5	74.4	73.9	63.7	59.9
5%	52.2	50.7	50.6	52.2	55.8	60.7	73.2	81.7	76.8	73.2	69.6	59.0	55.1

Table 4.4-6. Salinity concentrations at selected locations in the Delta (ppm).

San Joaquin River at Jersey Point

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
95%	1906	1669	1907	1615	397	287	268	374	432	1201	1653	1757	1717
90%	1744	1604	1836	1333	343	264	220	350	414	1170	1451	1711	1617
75%	1575	1453	1711	751	264	169	150	273	328	1049	1130	1523	1191
50%	1368	1285	1509	358	177	148	119	166	208	481	845	1365	342
25%	634	481	392	194	135	115	110	112	110	189	523	1243	145
10%	300	161	120	145	118	113	108	108	107	141	388	728	112
5%	113	116	115	137	116	110	104	106	100	129	335	278	109

Sacramento River at Emmaton

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
95%	1374	1706	1954	1405	207	273	300	452	415	942	1759	1875	1714
90%	1318	1700	1940	1298	194	192	266	422	377	855	1709	1837	1497
75%	1132	1469	1026	282	147	126	147	393	343	640	1508	1737	880
50%	1012	1055	705	165	125	109	107	150	288	375	784	1370	258
25%	619	222	185	129	110	105	104	111	125	184	506	799	116
10%	148	110	105	112	106	104	103	103	111	169	414	418	104
5%	103	105	104	109	104	103	102	102	101	150	336	133	103

Old River at Rock Slough

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
95%	682	657	830	801	386	237	166	181	192	558	635	624	688
90%	660	626	824	644	348	215	156	176	183	530	528	584	619
75%	543	562	774	544	221	158	146	151	158	444	402	493	439
50%	447	451	651	282	190	150	138	139	146	205	295	440	199
25%	294	287	208	218	159	140	131	135	126	131	175	400	144
10%	180	203	125	147	141	116	123	128	115	118	148	262	126
5%	129	160	119	142	126	108	112	124	106	117	141	156	118

Salinity at Clifton Court Forebay

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
95%	467	492	663	643	491	238	219	220	200	403	430	443	547
90%	448	467	641	547	446	211	209	199	186	382	374	398	459
75%	374	429	584	460	275	189	197	193	179	315	302	325	316
50%	315	311	484	307	202	173	187	188	167	186	187	286	197
25%	272	254	193	199	159	154	160	174	146	159	148	265	161
10%	168	193	117	138	107	114	123	143	132	149	139	199	132
5%	136	177	105	118	97	94	103	127	118	144	132	157	109

the watershed washed huge amounts of sediment into stream channels. All of these activities caused changes in the quantity and quality of water reaching the estuary. Additionally, untreated municipal and industrial waste was discharged directly into the estuary.

4.5.2 Current Resource Conditions

San Francisco Bay, which includes Suisun, San Pablo, Central, and South bays, extends about 85 miles from the east end of Chipps Island (in Suisun Bay near the city of Antioch) westward and southward to the mouth of Coyote Creek (tributary to South Bay near the city of San Jose). The Golden Gate connects San Francisco Bay to the Pacific Ocean.

San Francisco Bay has a surface area of about 400 square miles at mean tide. This is about a 40 percent reduction from its original size due to fill. Most of the Bay's shoreline has a flat slope, which causes a relatively large intertidal zone. The volume of water in the Bay changes by about 21 percent from mean higher-high tide to mean lower-low tide. The overall average depth of the Bay is 20 feet, with the Central Bay averaging 43 feet and the South Bay averaging 15 feet (DWR 1986). San Francisco Bay is surrounded by about 130 square miles of tidal flats and marshes.

Delta outflow is the principal source of fresh water in San Francisco Bay. Delta outflows vary greatly according to month and hydrologic year type. During critically dry periods, such as 1928 and 1934, historical Delta outflows have dropped to zero. Present summer outflows are maintained by upstream reservoir releases.

San Francisco Bay receives fresh water inflow from the following other significant sources: the Napa, Petaluma, and Guadalupe rivers, and Alameda, Coyote, Walnut, and Sonoma creeks. The total average inflow of these tributaries is about 350 thousand acre-feet. Stream flow is highly seasonal, with more than 90 percent of the annual runoff occurring during November through April. Many streams often have very little flow during mid- or late-summer.

Below the Delta, the first embayment is Suisun Bay. This bay, which includes Grizzly and Honker bays, is the area where the effects of mixing seaward-flowing fresh water and landward-flowing salt water (driven by tides) are most pronounced. Salt water tends to move landward under river water since it is slightly heavier than fresh water. However, this effect is seen only slightly in the upper Bay and Delta. The complex circulation patterns cause a concentration of small plants, larval fish, and other animals within this zone. This area of concentration is called the entrapment zone, or zone of maximum turbidity, and is a feature of all estuaries that receive significant amounts of fresh water. The location of the entrapment zone in the Suisun Bay and adjacent extensive areas of productive shallow water is considered to be an important ecological feature of the Bay-Delta Estuary complex. This zone moves upstream and downstream in the estuary depending on the amount of fresh water outflows. X2 is used to define the location of the entrapment zone in kilometers from the Golden Gate Bridge. It is Table 4.4-6. Salinity concentrations at selected locations in the Delta (p.m.) thought to be best when located near Suisun Marsh, which occurs during high flows. During low flows, X2 can be as far upstream as Jersey Point.

Adjacent to Suisun Bay is the Suisun Marsh. Suisun Marsh is about 80,000 acres of brackish water containing a significant percentage of the remaining contiguous wetlands in California. This marsh along with the other tidal wetlands around the Bay-Delta Estuary, provide valuable habitat for a variety of plants and animals, especially waterfowl. They also contribute significant amounts of nutrients to the estuarine system.

Below the Carquinez Strait are the San Pablo and central San Francisco bays. Carquinez Strait isolates these bays from the Suisun Bay and the Delta and allows such oceanic conditions as tides to play a leading role in their salinity and circulation. These embayments can become quite fresh, especially at the surface, during extremely high fresh water flows such as happened during February 1986. During these high flows, the entrapment zone can be temporarily relocated in San Pablo Bay. At low fresh water flows and high tides, these embayments are quite saline.

South San Francisco Bay is different from the other parts of the system. This bay is out of the main path of Delta outflows and receives significant flows only from the Sacramento and San Joaquin rivers during high outflow or floods. The South Bay is often saltier than the ocean outside the Golden Gate because of low fresh water flows during most of the year and losses of water through evaporation.

Tides move water from the ocean into the Bay-Delta system through the narrow and deep Golden Gate. Although accurate estimates are difficult to obtain, one estimate is that about a fourth of the Bay water is replaced with new ocean water during each complete tidal cycle. Physical processes that affect the Bay-Delta ecosystem in the ocean include tides, horizontal currents along the coast, which cause up welling of deep oceanic water, temporary and long-term rises in sea level, and changes in ocean temperature. Also, many species of fish and fish-food organisms found in the estuary originate offshore.

4.6 Sacramento River Region

The Sacramento River Hydrologic Region contains the entire drainage area of the Sacramento River and its tributaries and extends almost 300 miles from Collinsville in the Sacramento-San Joaquin Delta, north to the Oregon border. The total land area within the region is 26,960 square miles. Average annual precipitation is 36 inches, and average annual runoff is approximately 22.4 million acre-feet (DWR 1994). The region, including locations of stations referenced in the discussion below, is shown on Figure 4.1-3. Table 4.1-1 is a summary of pertinent information at the selected stations.

4.6.1 Historical Perspective

This discussion of the Sacramento River Region focuses on the river sections most likely impacted by the CALFED program. This includes the Sacramento River below Lake Shasta, the Feather River below Oroville Lake, and the American River below Folsom Lake. The discussion is further divided into the Sacramento River above Keswick, the Sacramento River from Keswick to the Feather River, and the Sacramento River from the Feather River to the Sacramento Delta.

4.6.1.1 Sacramento River above Keswick

The watershed above Keswick, excluding the Goose Lake basin, has an area of 6,468 square miles. The drainage area includes the basins of the upper Sacramento, over the McCloud, and over the Pit River, as well as two smaller tributaries, Squaw Creek and Backbone Creek. Historically, average annual precipitation varies from 60 to 70 inches over most of the watershed.

Most of the flow in the Sacramento River at Keswick is from Shasta Dam, which began operations in December 1943 (U.S. Geologic Survey 1994a,b). Shasta Lake has a storage capacity of approximately 4.5 million acre-feet. Shasta Dam was retrofitted with a temperature control device in 1997. The retrofit was installed by the Bureau of Reclamation in response to the Central Valley Project Improvement Act and is designed to correct a design flaw in the dam that prevented release of deep, cold water from Shasta Lake. The temperature control device allows the temperature of water in the Sacramento River to be regulated for the benefit of migrating fish.

Keswick Dam, about 10 miles downstream of Shasta Dam, was completed in 1950 and has a storage capacity of 23,800 acre-feet. Keswick Reservoir is used to regulate flows into the Sacramento River. About 1.3 million acre-feet of water are diverted annually from Whiskeytown Lake to Keswick Reservoir, which represents about 17 percent of the flows measured in the Sacramento River at Keswick.

Spring Creek also contributes flow to Keswick Reservoir. This flow contains heavy metals contamination from mine drainage, and releases from Spring Creek Debris Dam are metered to achieve water quality objectives in the Sacramento River below Keswick Dam by dilution.

Flows in the Sacramento River just below Keswick Reservoir are measured at USGS gaging station 11370500.

4.6.1.2 Sacramento River: Keswick to the Feather River at Verona

Average annual precipitation in the central Sacramento basin ranges from 15 to 20 inches per year; average annual precipitation ranges up to 60 inches per year in the northern portion of the basin. Between Keswick Reservoir and the confluence with the Feather River at Verona, the Sacramento River receives inflows from more than 31 tributary streams, and there are over 50 established diversions. As a result, there are many opportunities for flows in the river to be modified by local inflows and outflows. The character of the river also changes as the valley floor flattens. The gauge elevation below Keswick Dam is about 480 feet above mean sea level (MSL). At the Bend Bridge gauge near Red Bluff (11377100), the gauge elevation is about 286 feet MSL, a drop of nearly 200 feet in about 40 miles. Between Bend Bridge and the gaging station at Butte City (11389000), the elevation drops another 200 feet in about 80 miles. Within this reach, the river increasingly meanders. Between Butte City and the confluence with the Feather River, the elevation drops about 60 feet over about 55 miles.

Historical topographic maps show that the river has frequently changed its course within a roughly mile-wide meander zone, cutting across old meanders and creating new ones. Below Chico Landing (at Big Chico Creek) the floodplain of the Sacramento River is increasingly constrained by levees. Below Colusa, levees constrain the river to a channel that is typically less than 500 feet wide.

Starting near Butte City, flood flows are diverted to flood bypasses outside the main channel by means of weirs. The flood bypasses allow extreme flows to be diverted and temporarily stored in portions of the floodplain set aside for this purpose. The USGS identifies four flood flow control points between Stony Creek and the Feather River. These control points are an unnamed weir upstream of Butte City, Moulton Weir, Colusa Weir, and Tisdale Weir. The unnamed weir overflows when flow in the Sacramento River exceeds 90,000 cfs; Colusa Weir overflows when flows exceed 30,000 cfs. The overflow is directed into Butte Sink and Sutter Bypass.

The Tisdale Weir discharges to Sutter Bypass through the Tisdale Bypass when flows in the Sacramento River exceed 23,000 cfs. Butte Creek discharges to the Sacramento River between Colusa Weir and Tisdale Bypass. During periods of high flow in the Sacramento River, water from Butte Creek may go to Butte Slough, instead of to the river, ultimately reaching the Sutter Bypass. These controls place an upper limit on the flows in the main channel.

4.6.1.3 Sacramento River from the Feather River Confluence to the Sacramento Delta

Freeport lies just within the legal boundary of the Delta. The drainage area upstream of the USGS gaging station at Freeport (11425500) is listed as "indeterminate," but the drainage area of the Sacramento River above Sacramento, 11 miles to the north, is 23,502 square miles. Historically, average annual precipitation over this reach of the Sacramento River ranges from 8 to 19 inches.

The historical average annual flow is 16.7 million acre-feet at Freeport, which is more than twice the average annual flow measured in the Sacramento River above the confluence with the Feather River. The maximum mean monthly discharge measured for the period of record was 71,340 cfs (March 1986); the minimum mean monthly discharge was 4,494 cfs (October 1977).

The flow data for this station do not account for the upstream flood overflows that bypass the Sacramento River, such as flows into the Colusa Basin, the Sutter Basin, the Sutter Bypass, and the Yolo Bypass. Flood flows from the Sacramento River, Feather River, and Sutter Bypass the Sacramento area by spilling over the Fremont Weir at Verona into the Yolo Bypass. Overflows occur at this point when Sacramento River flows, as measured at Verona (USGS Station 11425500) exceed 55,000 cfs. Sacramento River overflows also may enter the Yolo Bypass just north of Sacramento by spilling over the Sacramento Weir.

The two major tributaries to the Sacramento River in the lower reach of the Sacramento River are the Feather River (which also includes flows from the Yuba River) and the American River. The combined flows of the Feather River and Sutter Bypass enter the river near Verona. The American River joins the Sacramento River north of Sacramento. Smaller contributions are made by the Cross Canal, draining the area from the Feather River east to Auburn and Roseville and the Colusa Basin Drain, which drains the west side of the Sacramento Valley from about Willows south to Knights Landing.

4.6.1.4 Feather River

The Feather River drains a large portion of the east side of the Sacramento Valley and is a major contributor to Sacramento River flows, typically contributing about 25 percent of Sacramento River flows, as measured at Freeport. Its upper watershed consists of the West Branch and the North, Middle, and South forks. The Feather River drains approximately 3,624 square miles above Oroville. Average annual precipitation over the drainage area ranges from 80 inches in the upper watershed to 15 inches near the mouth.

The USGS operates a gaging station on the Feather River near Gridley (11407150). The station is downstream from Oroville Dam but upstream of the Yuba River.

Oroville Dam is operated in part to control downstream flooding. The capacity of the reservoir is 3.5 million acre-feet. Prior to construction of the dam, the maximum instantaneous flow in the Feather River below the dam was 230,000 cfs (March 19, 1907). In the period from 1969 to the present, following the construction of Oroville, the maximum instantaneous flow was 153,800 cfs (February 18, 1986). The maximum mean monthly flow in the Feather River near Gridley was 37,860 cfs (January 1970). The minimum mean monthly flow was 804 cfs (April 1991).

4.6.1.5 American River

The American River drains approximately 1,895 square miles. Average annual precipitation in the American River watershed ranges from 17 inches near its confluence with the Sacramento River to nearly 65 inches in the headwaters. Historically, the river's flows have contributed approximately 15 percent to Sacramento River flows.

Folsom Lake is the primary regulating facility on the American River. The lake has a storage capacity of 1.0 million acre-feet. The Bureau of Reclamation began operating the dam in February 1955 as an integrated component of the CVP. Just downstream of Folsom Dam is Nimbus Dam, which also began operating in 1955. Lake Natoma (formed by Nimbus Dam) acts as a re-regulating reservoir for diurnal fluctuations from Folsom Powerplant. The USGS has operated a gaging station on the American River at Fair Oaks (11446500) since 1904. The station is about half a mile downstream of Nimbus Dam.

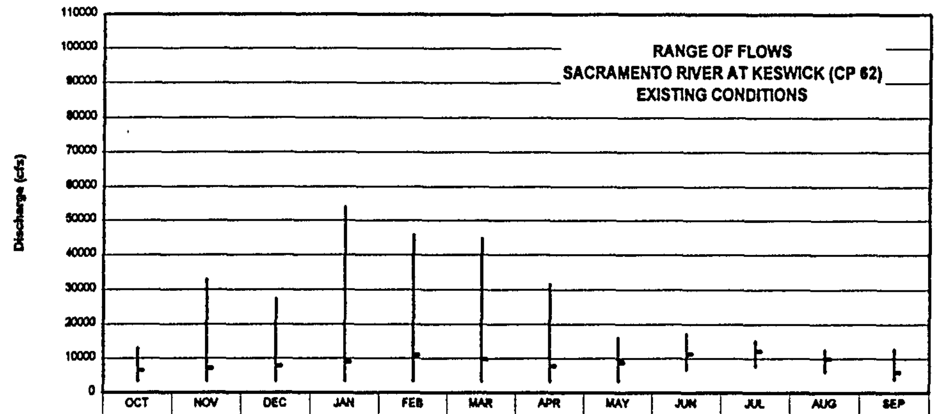
There are also more than 19 other major reservoirs within the upper American River watershed, with capacities ranging from approximately 1,000 acre-feet to 270,000 acre-feet.

4.6.2 Current Resource Conditions

Nine locations have been selected as the focal points for analyzing current hydraulic conditions in the Sacramento River region (Figure 4.1-3). The locations were selected based on their locations relative to the principal hydraulic features in the region.

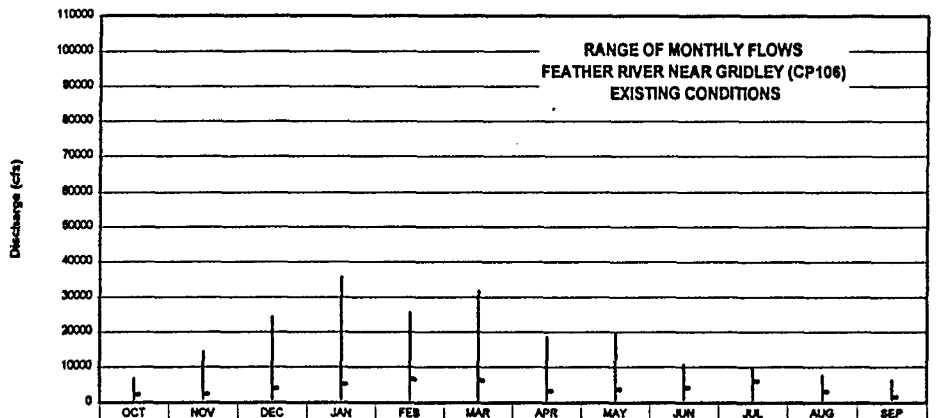
Figures 4.6-1 through 4.6-3 illustrate the ranges in simulated average monthly flows for current conditions at each of the nine control points in the Sacramento River Region. The vertical scale is the same for all the graphs to facilitate comparison of control points. The endpoints of the bars represent the minimum and maximum flow that occurred during the 73-year simulation period. The average flow for each month is shown by the tick marks. The discharge values are shown in the table beneath each graph. Figure 4.6-1 compares the stations that are farthest upstream—the Sacramento River at Keswick, the Feather River near Gridley, and the American River at Fair Oaks. The greatest ranges in flows occur from November through March and April. The average flows hover within a relatively narrow range over the entire year. However, the height of the bars above the averages from November through March and April reflects the fact that extremely high flows are relatively uncommon. The increase in average flows and narrower range of flows during the summer reflects releases from storage to meet the relatively high and constant demand during this period. Average summer flows are comparable to average winter flows in the upper reaches of the Sacramento River and tributaries.

Figure 4.6-2 shows similar graphs of the range of flow conditions at points midway between Keswick and the Feather River. Although the maximum flows generally increase downstream, the patterns in these two graphs



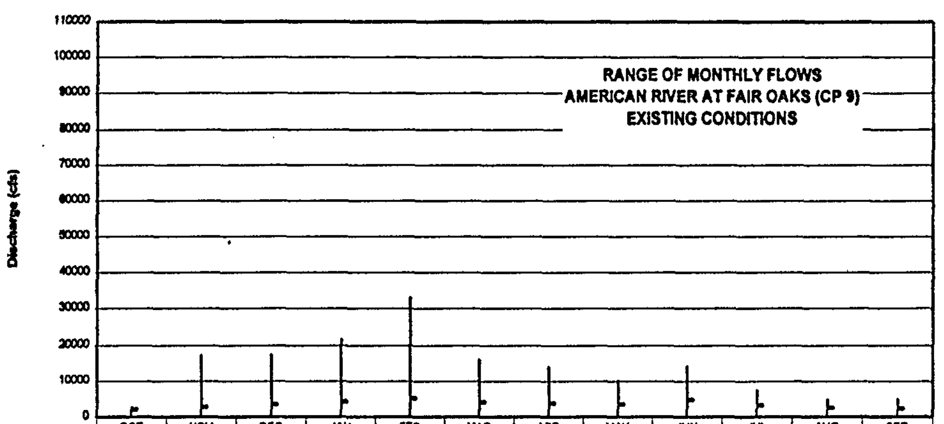
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	13271	33174	27502	54093	45870	44871	32065	16329	17377	15337	12718	13041
Minimum	3253	3243	3253	3253	3241	3253	3243	3253	6606	7626	6034	3832
- Average	6603	7126	7866	8861	11036	9791	7848	8734	11377	12100	9607	6050

Month



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	7010	14453	24363	35828	25551	31828	18738	19608	10772	9728	7741	6604
Minimum	894	908	894	894	900	748	758	748	1008	828	748	756
- Average	2358	2403	4086	5204	6554	6310	3378	3773	4218	6001	3155	1630

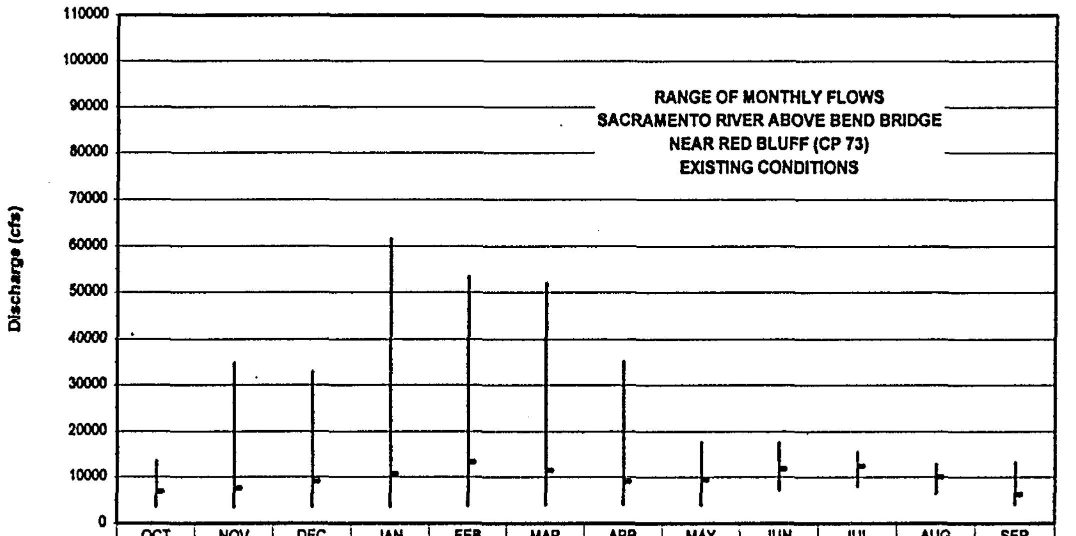
Month



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	2787	17411	17630	21891	33077	16312	14286	10327	14402	7611	4928	4874
Minimum	504	571	537	504	504	407	289	283	655	504	504	504
- Average	1968	2866	3432	4228	5186	4082	3731	3464	4722	3171	2374	2218

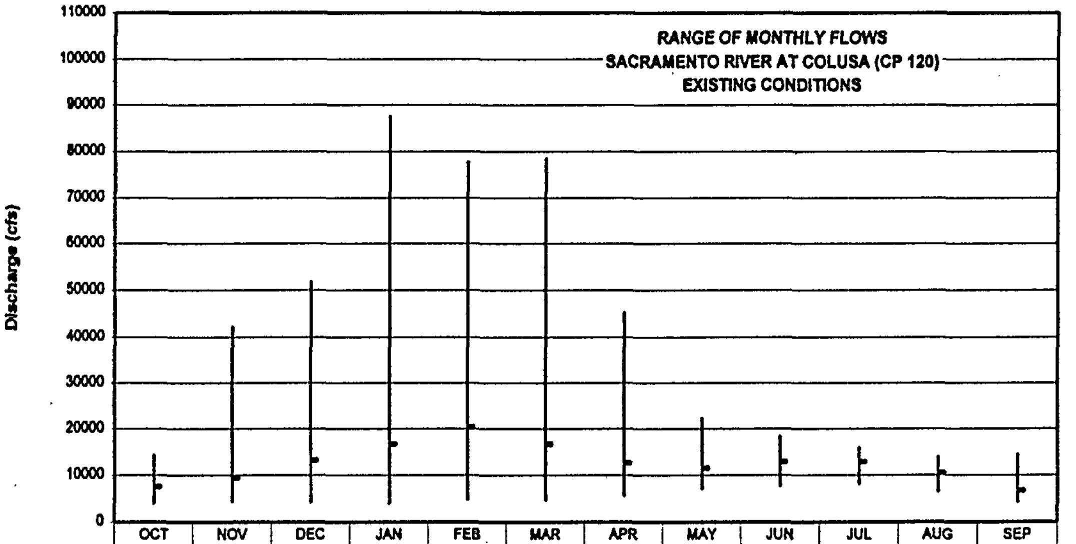
Month

FIGURE 4.6-1 RANGE OF FLOWS AT THREE UPSTREAM POINTS IN THE SACRAMENTO RIVER REGION, EXISTING CONDITONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	13564	34939	33064	61736	53478	52141	35241	17760	17629	15597	13011	13327
Minimum	3399	3428	3432	3383	3619	3968	3949	3854	7092	7839	6310	4000
-Average	6814	7596	9059	10685	13270	11531	9041	9433	11798	12377	10002	6235

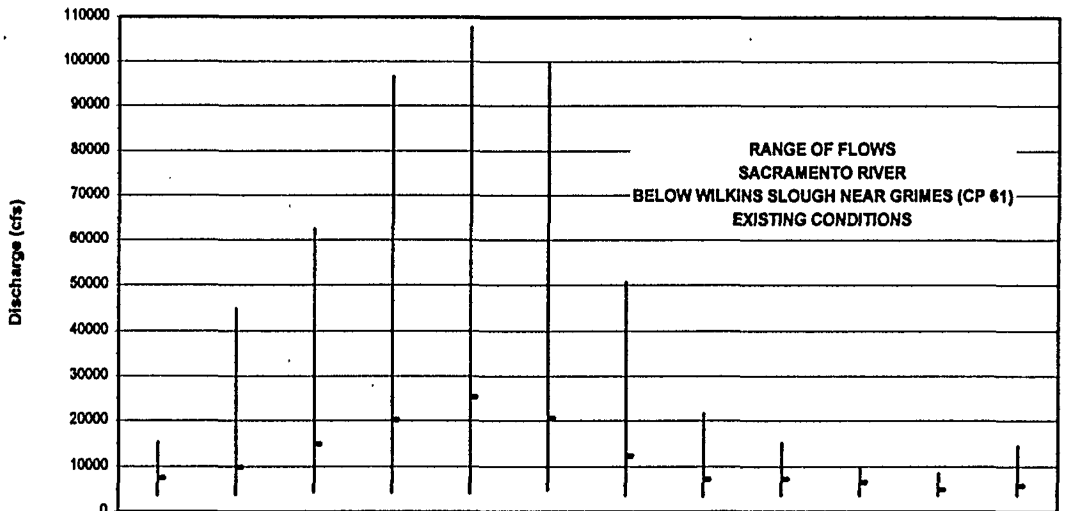
Month



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	14475	42384	51897	87742	77840	78618	45342	22346	18486	16117	14100	14621
Minimum	4001	4369	4261	3952	4808	4668	5546	7026	7680	8067	6408	4302
-Average	7595	9411	13190	16719	20311	16670	12587	11482	12907	12930	10457	6722

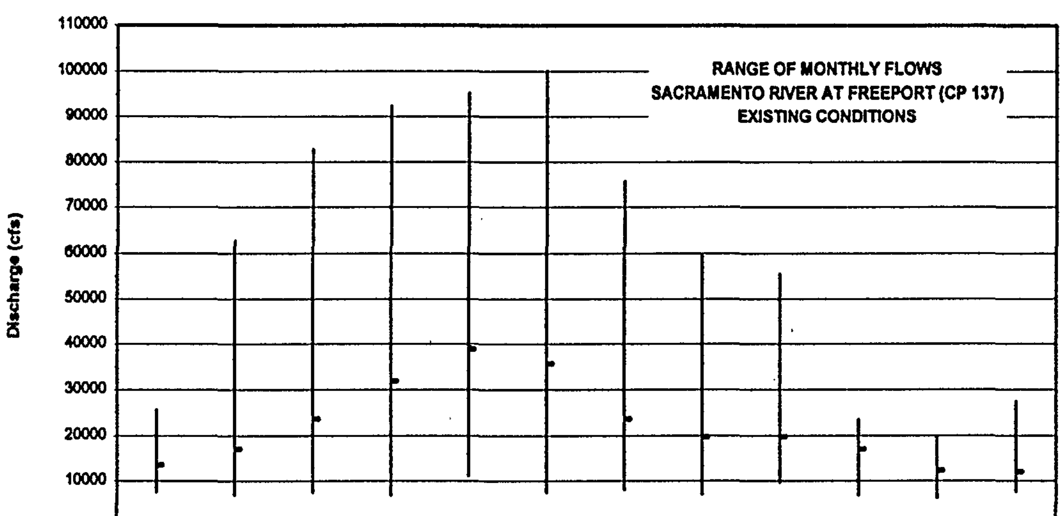
Month

FIGURE 4.6-2 RANGE OF FLOWS, SACRAMENTO RIVER BETWEEN KESWICK AND WILKINS SLOUGH, EXISTING CONDITIONS



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	15450	44922	62680	96736	107874	99891	50854	21696	15293	9791	8717	14638
Minimum	3497	3664	4294	4098	3997	4716	3496	3302	3496	3497	3497	3496
-Average	7514	9865	14914	20199	25281	20557	12352	7188	7243	6522	4879	5764

Month



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	25664	62803	82944	92670	95486	100200	75844	59557	55576	23485	19793	27494
Minimum	7579	6924	7465	6847	11002	7546	8067	6993	9579	6863	6164	7613
-Average	13515	17024	23582	31844	38893	35698	23595	19646	19763	17060	12312	11982

Month

FIGURE 4.6-3 RANGE OF FLOWS, SACRAMENTO RIVER, WILKINS SLOUGH AND FREEPORT, EXISTING CONDITIONS are similar to the pattern for Keswick. The minimum and average flows at Bend Bridge are nearly the same as at Keswick, while they increase by 25 to 50 percent during the wet season between Bend Bridge and Colusa. Average wet season flows begin to exceed average dry season flows in the Sacramento River below Bend Bridge.

Figure 4.6-3 compares the range of flows on the Sacramento River at Freeport with the range of flows just above the confluence with the Feather River below Wilkins Slough. Although average flows are significantly higher at Freeport than at Wilkins Slough, reflecting the contributions of the Feather River and American River, maximum (simulated) flows during the peak winter months of January and February are actually higher at Wilkins Slough than at Freeport. This is due to diversion of flood flows into the Yolo Bypass and to operation of Oroville Dam for flood control.

The average velocity in a stream bears a relationship to discharge (Leopold and Maddock 1953), which can be described by an equation of the form $V = aQ^b$, where V is the cross-section average velocity (fps), Q is the rate of discharge (cfs), and a and b are constants that depend on the geometry of the stream. Similar equations can be used to describe other hydraulic parameters, such as stream depth, width, and sediment load as a function of discharge. For example the equation for depth (D) as a function of discharge is given by $D = cQ^e$, where c and e are constants. The equation for stream width (W) as a function of discharge is given by $W = fQ^g$, where f and g are constants.

Measured values of average velocity, stream width and cross-sectional area recorded for the nine USGS gaging stations in the Sacramento River study area were plotted against measured discharge to obtain equations of this type that best fit the plotted data. The plotted data and the equations used to fit the data are presented in Appendix A. In some cases, more than one equation, or other types of equations were needed to fit the data as closely as possible. A description of the procedures used to obtain the equations is included in Appendix A.

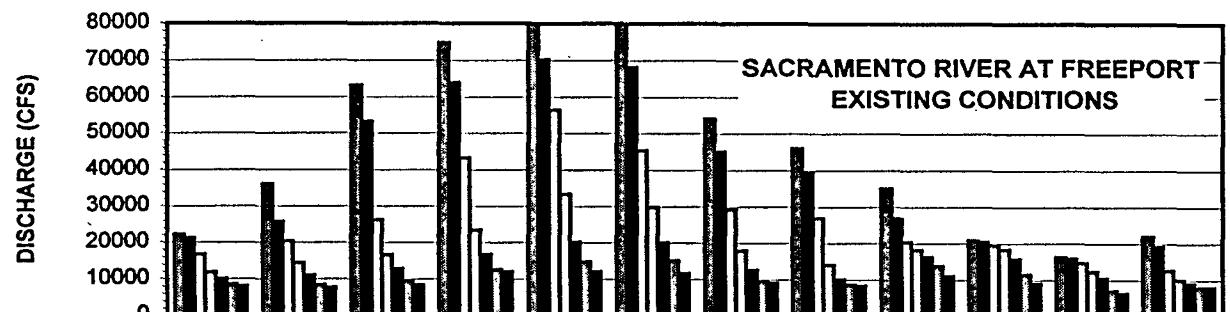
The equations were used to estimate the mean velocity, stream width, and mean depth corresponding to the simulated average monthly discharges at each control point. The results of these calculations, for February and September, are presented in Table 4.6-1. The maximum, minimum, and average discharge values in the table correspond to the values for the selected months plotted in the graphs on Figures 4.6-1 through 4.6-3. Similar calculations could be performed to show the range of these parameters for the other months of the year.

February was selected to represent wet season flows because average flows are highest in that month (see Figures 4.6-1 through 4.6-3). September was selected to represent dry season flows because average flows are lowest during that month.

As can be seen in Table 4.6-1, the discharges for the Sacramento River for the stations at Butte City and Colusa and at Verona and below Wilkins Slough are the same. This is because the simulated discharge for DWRSIM control point 61 were used to estimate the discharge at both Wilkins Slough and Verona, and the output for control point 120 was used to estimate the discharge at both Butte City and Colusa. The equations relating velocity, top width, and average depth to discharge depend on the local channel geometry, so the calculated values of these parameters differ even though the same discharges were used in the calculations.

TABLE 4.6-1 SUMMARY OF EXISTING CONDITIONS, STATIONS IN THE SACRAMENTO RIVER REGION

FLOW CONDITIONS BASED ON 73-YEAR HYDROLOGIC RECORD	CP#137, GS4476.5, SAC. R @ FREEPORT	CP#61, GS4255, SAC. R. @ VERONA	CP#61, GS3905, SAC. R. BLW WILKINS SLOUGH NR. GRIMES	CP#120, GS3890, SAC. R. @ BUTTE CITY	CD#120, SAC. R. @ COLUSA	CD#73, SAC. R. ABV. BEND BRIDGE	CP#62, GS3705, SAC R. @ KESWICK	CP#9, GS 4465, AM. R. @ FAIR OAKS	CP#106, GS4071.5, FEA. R. NR. GRIDLEY
Location Map Station >	S1	S2	S3	S4	S5	S6	S7	S8	S9
FEBRUARY									
Discharge (cfs)									
Maximum	95090	107874	107874	78056	78056	53694	46186	33005	24884
Minimum	11632	3997	3997	4808	4808	3619	3241	504	900
Average	38605	25227	25227	20257	20257	13198	10966	5168	6194
Mean Velocity (fps)									
Maximum	4.26	4.48	5.81	6.13	4.86	6.24	7.25	6.04	4.24
Minimum	1.34	1.67	2.25	1.42	2.26	4.16	1.94	0.70	0.34
Average	2.60	3.02	3.82	3.02	3.35	5.06	3.63	2.32	1.84
Top Width (feet)									
Maximum	621	839	375	509	389	569	629	462	317
Minimum	564	460	213	459	269	335	429	260	275
Average	596	536	292	484	326	382	516	358	299
Mean Depth (feet)									
Maximum	36.2	30.6	49.7	25.5	40.1	14.7	10.1	12.2	9.9
Minimum	16.2	5.2	8.3	7.4	7.9	2.6	3.9	2.7	9.1
Average	25.6	15.5	22.6	14.0	18.5	7.0	5.8	6.3	9.3
SEPTEMBER									
Discharge (cfs)									
Maximum	27494	14638	14638	14621	14621	13327	13041	4790	6420
Minimum	7999	4437	4437	6016	6016	6117	6000	504	756
Average	12722	6689	6689	7630	7630	7159	6974	1865	1613
Mean Velocity (fps)									
Maximum	2.15	2.54	3.27	2.54	3.07	5.06	3.96	2.23	1.90
Minimum	1.09	1.73	2.32	1.59	2.40	4.50	2.66	0.70	0.29
Average	1.41	1.97	2.61	1.81	2.56	4.61	2.87	1.37	0.57
Top Width (feet)									
Maximum	587	512	266	478	312	382	530	354	299
Minimum	555	464	217	463	278	353	471	260	273
Average	567	480	233	467	286	359	482	311	282
Mean Depth (feet)									
Maximum	22.5	11.2	16.8	12.1	15.4	7.0	6.1	6.1	9.3
Minimum	14.0	5.5	8.8	8.2	9.1	3.8	4.7	2.7	9.1
Average	16.8	7.1	11.0	9.1	10.5	4.3	5.0	4.4	9.2



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	22154	36041	63203	74754	79951	79955	54030	45935	35036	20873	16221	21905
10 percent	21159	25740	53344	63987	70267	68190	45096	39390	26876	20443	15899	19145
25 percent	16686	20284	26201	43229	56467	45327	29208	26867	20284	19435	14702	12621
50 percent	11807	14386	16573	23452	33329	29827	17864	14100	18150	18296	12344	10083
75 percent	10067	10924	12751	16735	20131	20102	12638	10067	16285	15694	10539	9075
90 percent	8525	8329	9348	12575	14733	15145	9546	8698	13818	11427	7110	7983
95 percent	8011	7606	8376	11989	12104	11654	9068	8379	11061	8997	6310	7959

MONTH

FIGURE 4.6-4 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, EXISTING CONDITONS

4.7 San Joaquin River Region

The San Joaquin River region includes the Central Valley south of the watershed of the American River. It is generally drier than the Sacramento Valley, and flows into the Delta from the San Joaquin River are considerably lower than those into the Delta from the Sacramento River. The region is also subject to extreme variations in flow, as exemplified by flooding that occurred during the spring of 1996.

4.7.1 Historical Perspective

The drainage area of the San Joaquin River above Vernalis is 13,356 square miles, including 2,100 square miles of drainage contributed by James Bypass. Inflows from the Merced (farthest upstream), Tuolumne, and Stanislaus rivers historically contribute over 60 percent of the flows in the San Joaquin River, as measured at Vernalis. Average annual precipitation in the lower reach of the river ranges from 10 to 12 inches per year.

The USGS has operated a gaging station on the San Joaquin River near Vernalis (11303500) since 1922, although complete records are available only back to 1930. The instantaneous maximum recorded at the station was 79,000 cfs, observed on December 9, 1950; the lowest daily mean flow was 19 cfs, on August 10, 1961. The maximum mean monthly discharge was 40,040 cfs (March), and the minimum mean monthly discharge was 804 cfs (April).

The drainage area of the watershed of the San Joaquin River above the confluence with the Merced River is 9,520 square miles. However, except for flood periods, tributaries south of the Merced River contribute virtually no flow to the San Joaquin River. The drainage area of the Merced River above Stevenson, near the San Joaquin River, is 1,273 square miles. A gaging station is located on the San Joaquin River near Newman (11274000), about 650 feet downstream from the confluence of the Merced River. The maximum mean monthly discharge measured at the Newman station from 1944 to 1994 was 24,170 (March), and the minimum monthly mean was 25.2 cfs. The average monthly flow during the same period ranged from 481 cfs (August) to 2,841 cfs (March).

The drainage area of the Tuolumne River above Modesto is 1,884 square miles. Mean monthly discharge ranges from 331 cfs (August) to 1852 cfs (March), as recorded at the Modesto gaging station (11290000).

The drainage area of the Stanislaus River above Ripon, near the San Joaquin River, is approximately 1,075 square miles. Historically, Stanislaus River flows account for approximately 22 percent of the San Joaquin River flows at Vernalis. Most of the water is from snowmelt, with the highest monthly flows occurring in May and June. The USGS has operated a gaging station on the Stanislaus River below Goodwin Dam (11302000) since 1957. The instantaneous maximum flow for the period of record was 40,200 cfs, on December 24, 1964; the minimum daily mean flow was 0.12 cfs, recorded on February 8, 1975. The watershed above Goodwin Dam has an area of 986 square miles.

4.7.2 Current Resource Conditions

Three locations have been selected to represent the range of hydraulic conditions in the San Joaquin River Region. The most important of these is the San Joaquin River at Vernalis. Vernalis lies just inside the legal boundary of the Delta, but it is widely used as a monitoring point for Delta inflows and standards. The San Joaquin River at Newman was chosen to characterize the upstream portion of the river. The Stanislaus River below Goodwin Dam was selected to represent the basin margin.

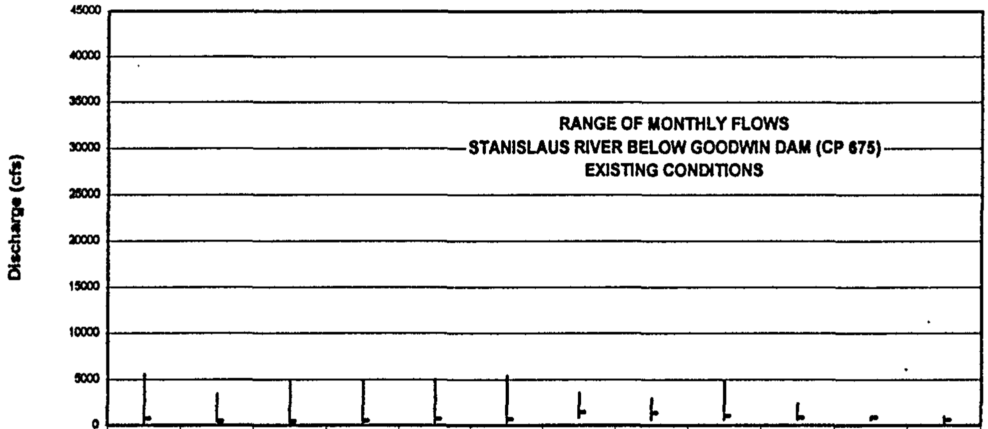
The output from the simulation of existing conditions at the selected control points in the San Joaquin River Region was subjected to the same type of analysis as described for control points in the Sacramento River Region. Figure 4.7-1 presents plots of the average and extreme monthly discharges. The data are plotted at less than half the scale used to plot the Sacramento River data. The pattern shown in the graphs of the data is consistent between points in the San Joaquin River Region but differs noticeably from the pattern of flows in the Sacramento River region. Maximum flows remain significantly above the average at all three stations during May, June, and July. In fact, the maximum flows during these months at Vernalis are roughly equivalent to the maximum flows during this time on the Sacramento River at Colusa. August clearly represents the low flow period at the San Joaquin stations, with flows just maintained above minimum flow requirements at Vernalis. Average April flows are maintained by pulse flow requirements at Vernalis. As in the Sacramento River region, the highest average flows occur from January through March, but the magnitudes of the flows are roughly the same as the American River at Fair Oaks and the Feather River near Gridley during this period.

Table 4.7-1 presents the summary data expressed in terms of estimated average stream velocities, top width, and mean depth for February and August. February represents the period of highest average flows and relatively high peak flows. August is the lowest flow period. Average stream velocities during February calculated for Vernalis, the lowest point in the San Joaquin River region, span a range comparable to the stream velocities at the highest stations evaluated in the Sacramento River Region (i.e., Keswick, Feather River at Gridley, and American River at Fair Oaks).

Figure 4.7-2 shows the distribution of flow frequencies for the San Joaquin River at Vernalis. The data are plotted at the same scale used to plot the data for Sacramento River stations to illustrate the relative size of the flows. As described for Sacramento River stations, the results indicate that the average winter flows are skewed by infrequent elevated flows. The medians are nearly the same in the low flow months of July, August, September, and November, reflecting the effects of releases to maintain minimum stream flows during these months.

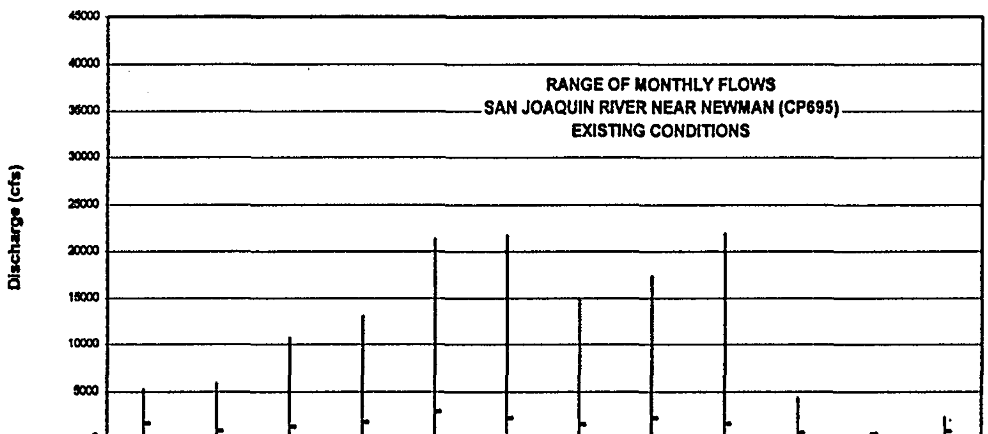
4.8 SWP and CVP Service Areas Outside Central Valley

These areas are beyond the scope of this report.



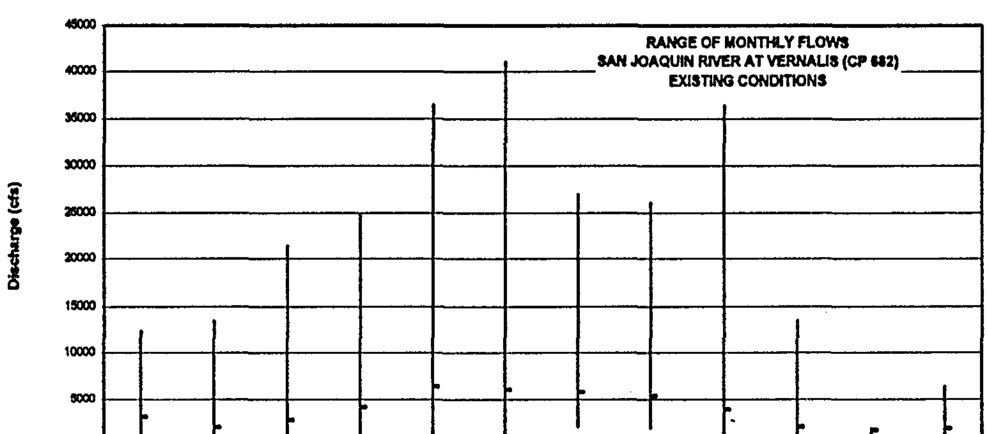
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	5627	3512	4679	5009	5078	5497	3630	3058	4990	2621	980	1092
Minimum	276	319	244	211	216	308	823	802	555	553	563	286
- Average	748	471	455	537	720	667	1462	1366	1059	878	864	586

Month



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	5302	5999	10783	13157	21409	21761	14974	17451	21999	4424	983	2370
Minimum	472	367	358	309	306	589	353	380	303	309	342	467
- Average	1643	840	1269	1805	2935	2244	1529	2228	1613	634	520	807

Month



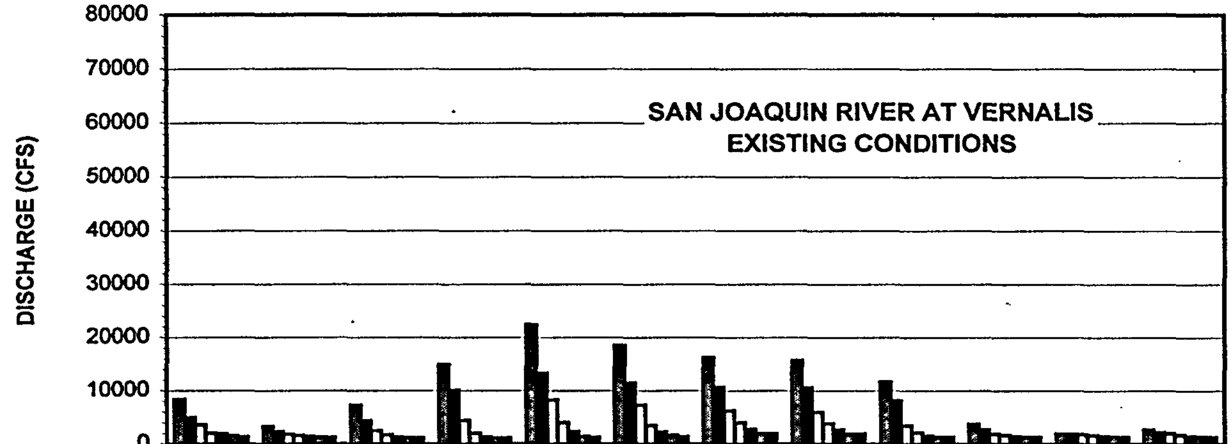
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Maximum	12442	13545	21500	24867	36534	41114	27024	26136	36451	13580	1919	6504
Minimum	1252	1176	1122	1090	1152	1204	1963	1870	1260	1136	1155	1160
- Average	3106	1983	2749	4147	6428	6063	5796	5369	3909	2017	1643	1832

Month

FIGURE 4.7-1 RANGE OF FLOWS AT THREE STATIONS IN SAN JOAQUIN RIVER REGION, EXISTING CONDITIONS

TABLE 4.7-1 SUMMARY OF EXISTING CONDITIONS FOR STATIONS IN THE SAN JOAQUIN RIVER REGION

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	CP#682, GS3035, SAN. JOAQ. R @ VERNALIS	CP#695, GS2740, SAN. JOAQ. R. NR. NEWMAN	CP#675, GS3020, SAN. JOAQ. R. BLW. GOODWIN DAM, NEAR KNIGHTS LANDING
Location Map Station >	SJ1	SJ2	SJ3
FEBRUARY			
Discharge (cfs)			
Maximum	36534	21409	5078
Minimum	972	306	216
Average	6410	2917	738
Mean Velocity (fps)			
Maximum	3.17	3.64	4.27
Minimum	1.42	0.89	1.12
Average	2.15	1.88	2.01
Top Width (feet)			
Maximum	512	261	151
Minimum	247	140	88
Average	294	195	105
Mean Depth (feet)			
Maximum	20.8	25.4	7.9
Minimum	2.8	2.4	2.2
Average	9.7	8.4	3.5
AUGUST			
Discharge (cfs)			
Maximum	1919	683	960
Minimum	1106	342	732
Average	1626	520	878
Mean Velocity (fps)			
Maximum	1.65	1.16	2.27
Minimum	1.46	0.92	2.00
Average	1.59	1.06	2.18
Top Width (feet)			
Maximum	263	157	109
Minimum	250	142	105
Average	259	151	108
Mean Depth (feet)			
Maximum	4.3	3.8	3.9
Minimum	3.0	2.6	3.5
Average	3.9	3.3	3.7



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7221	14897	22353	18534	16174	15672	11630	3669	1893	2672
10 percent	4902	2333	4349	10064	13274	11459	10688	10581	8151	2654	1867	2202
25 percent	3545	1849	2521	4375	8265	7237	6201	5936	3428	1870	1805	1949
50 percent	2000	1630	1691	2017	3997	3415	3983	3822	2134	1675	1675	1697
75 percent	1919	1412	1317	1350	2287	2277	2807	2683	1563	1447	1496	1479
90 percent	1522	1294	1171	1155	1430	1665	1983	1890	1331	1311	1366	1361
95 percent	1334	1237	1138	1132	1260	1369	1983	1870	1304	1278	1295	1287

MONTH

FIGURE 4.7-2 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, EXISTING CONDITONS

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APPENDIX A

LIST OF TABLES

LIST OF FIGURES

APPENDIX A
Development of Rating Curves for Hydraulic Parameters at SelectedControl Points in the Sacramento and San Joaquin River Systems.

Measurements of gage height, average velocity, stream width, and channel cross-sectional area were obtained from the US Geological Survey for the period 1967 to 1997 for selected stream gage locations. Gage height is the height of water in the stream, in feet, measured in a gage set at a fixed depth in the stream channel, usually the deepest point. The gage height can be converted to the corresponding elevation of the water surface by adding the gage height to the elevation of the gage datum. Average stream velocity is a calculation based on a number of measurements, and is reported in units of feet per second (fps) by the US Geological Survey. The stream width is the width, in feet, of the wetted portion of the channel. The cross-sectional area of the channel, in square feet, is determined from soundings along the stream cross-section. The average stream depth is a calculated value, determined by dividing the cross-sectional area by the stream width.

It has been observed that in natural, graded streams, average stream depth, average velocity, and stream width tend to follow a relation to discharge of the form $y=ax^b$, where "y" is the average stream depth, average velocity, or stream width; "x" is the discharge, and "a" and "b" are constants. The relation does not necessarily hold in engineered stream channels, where the bed of the stream is not able to adjust naturally to discharge.

It was desired for this study to find mathematical expressions that would allow conversion of simulated discharge values to depths, velocities, and stream widths that would reasonably approximate observed values over the range of the observed values. Figures A-1 through A-12 are graphs showing the measured and calculated data and the plots of the equations that were found to fit the data reasonably well. The equations are shown on the graphs were used to calculate the estimated values of depth, velocity and stream width used in the river hydraulics study. In most cases, a single equation fit the data adequately, but in some cases, two, or even three equations were needed to adequately fit the data. Data from most of the study locations could be reasonably approximated by one to three power equations of the form y=axb, but linear equations of the form y=ax + b were used to fit the depth and width data for the Feather River near Gridley (Figure A-8; USGS Station 11407150).

The data for some parameters at some of the stations indicate an abrupt change in the value of the dependent variable over a narrow range of discharge. For example, discontinuities appear to occur at about 40,000 cfs and about 105,000 cfs in the depth and width graphs for the Sacramento River above Bend Bridge (Figure A-6; USGS Station 1137100). The discontinuities suggest that the channel geometry changes at the elevations corresponding to the river stage at these discharges. Flood stage occurs in the range of about 40,000 cfs (27 ft) at this station. The variability in the width and average depth measurements shown in Figures A-6b and A-6d probably reflect the difficulty in measuring the hydraulic parameters as the river exceeds flood stage and widens rapidly as it flows onto the floodplain above the main channel.

Gage height data at some of the stations were adjusted by a constant before fitting the data with a power equation to achieve the best correlation to the data. The rationale for doing this is that the when discharge is zero, average stream depth must also be zero. In practice, the zero point on the gage does not necessarily correspond to the depth at which discharge is zero. By adjusting the gage height values by a constant value, the resulting fit of the power curve to the data could generally be improved. The constant is then subtracted from the intermediate calculated values to obtain the estimated gage heights for the station. The data plotted on the graphs show the fit obtained for the intermediate values, and would need to be readjusted by the constant to reflect the estimated gage height.

Table A-1 shows the resulting coefficients for each of the gage stations. Coefficients for multiple curves are provided when needed. The table also includes the station name, period of analysis, elevation datum of the gage, and the range of discharge within the equations are assumed to be valid.

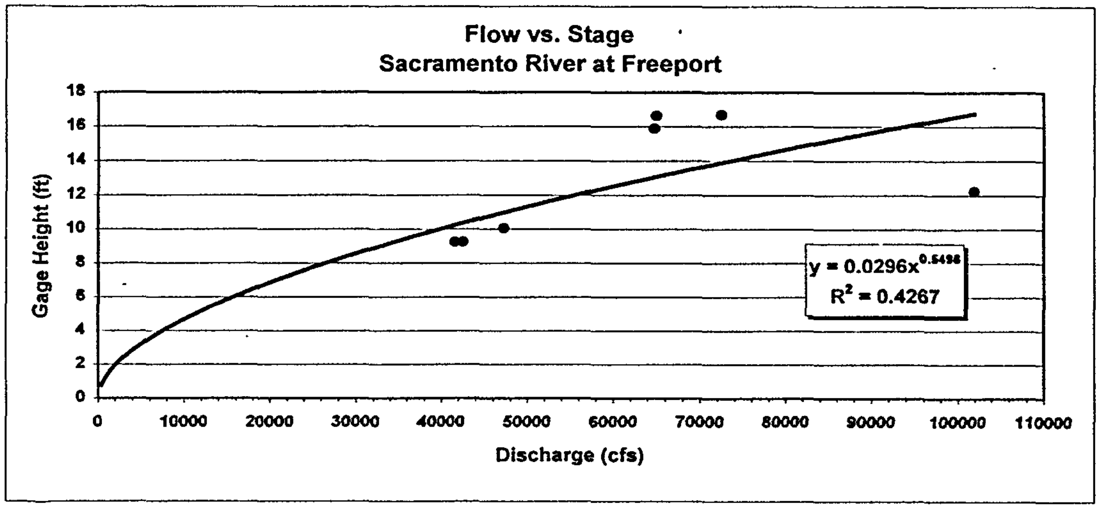

FIGURE A-1a Discharge vs. Gage Height (Measured, 1989-1997)

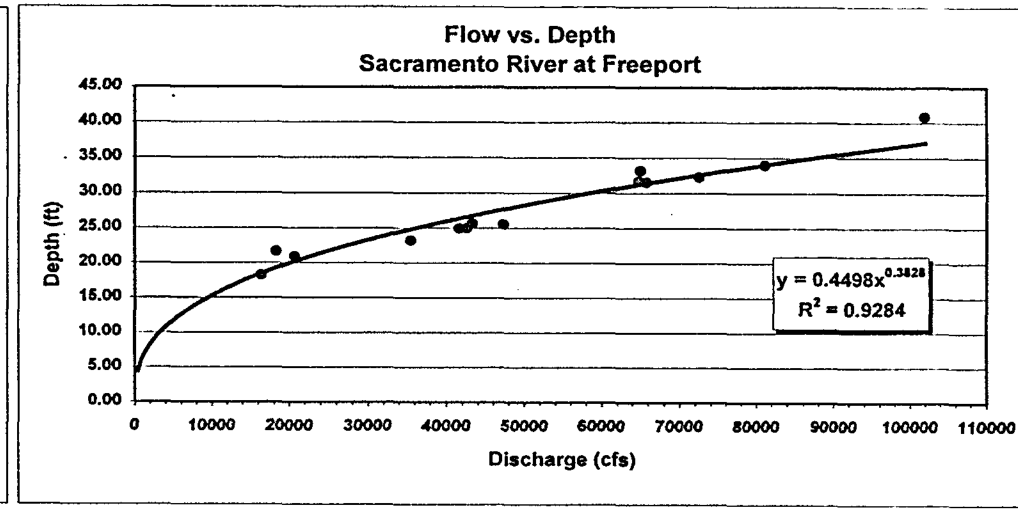

FIGURE A-1b Discharge vs. Average Depth (Calculated, 1989-1997)

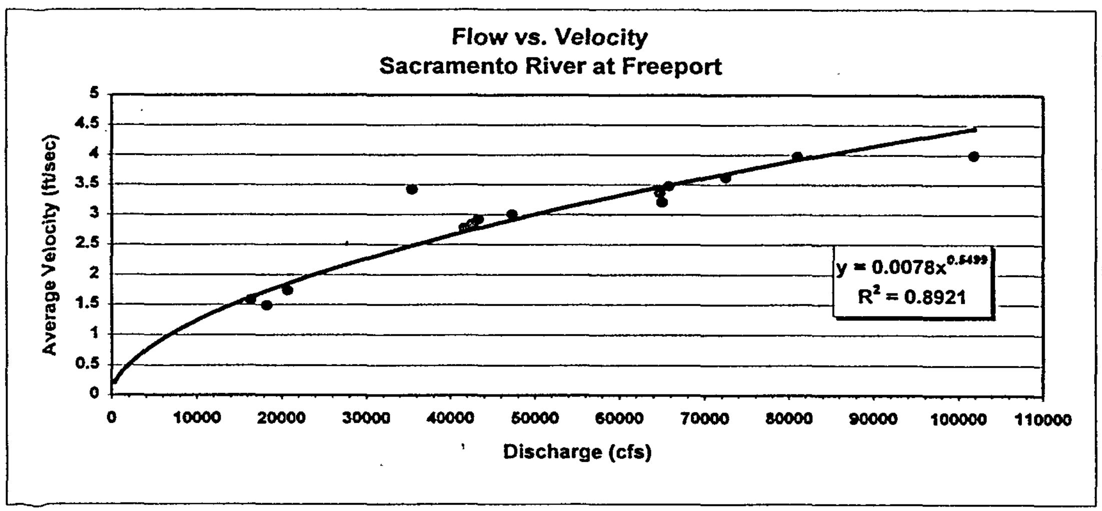

FIGURE A-1c Discharge vs. Average Velocity (Calculated, 1989-1997)

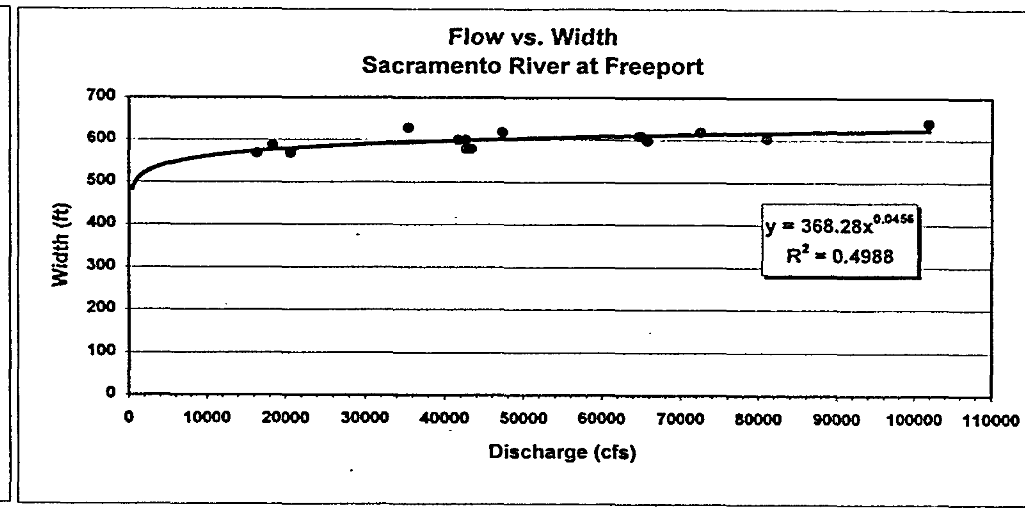

FIGURE A-1a Discharge vs. Top Width (Measured, 1989-1997)

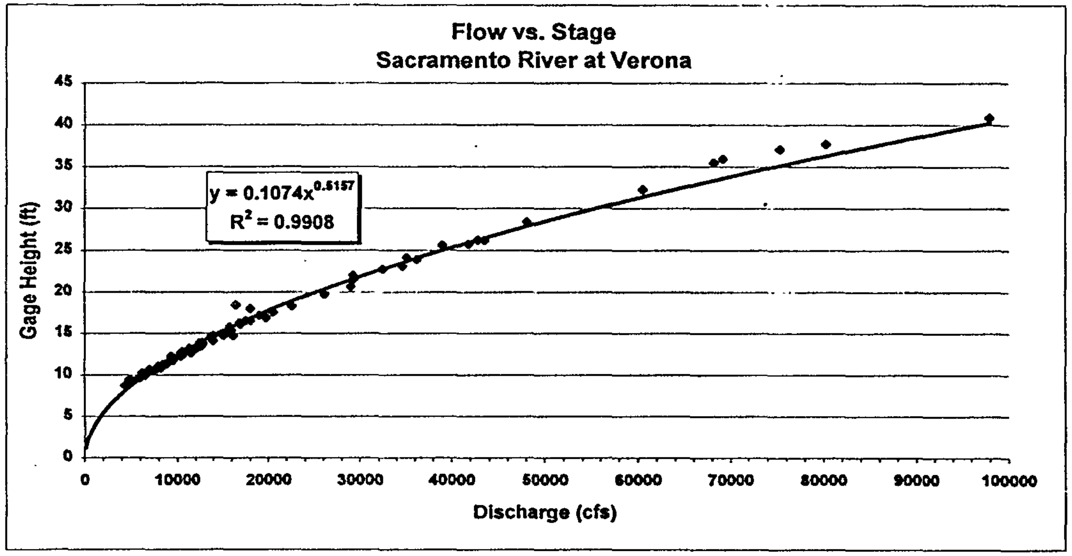

FIGURE A-2a Discharge vs. Gage Height (Measured, 1987-1997)

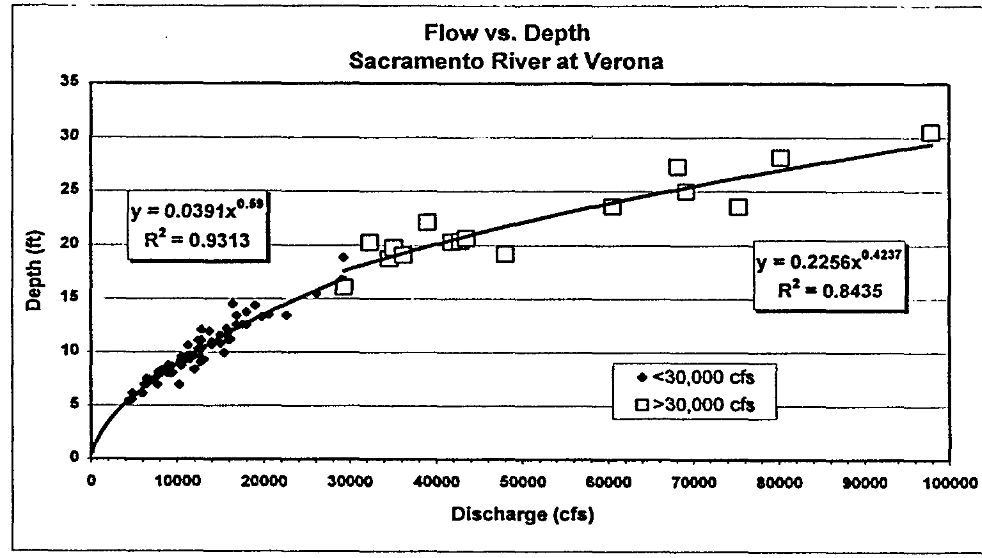

FIGURE A-2b Discharge vs. Average Depth (Calculated, 1987-1997)

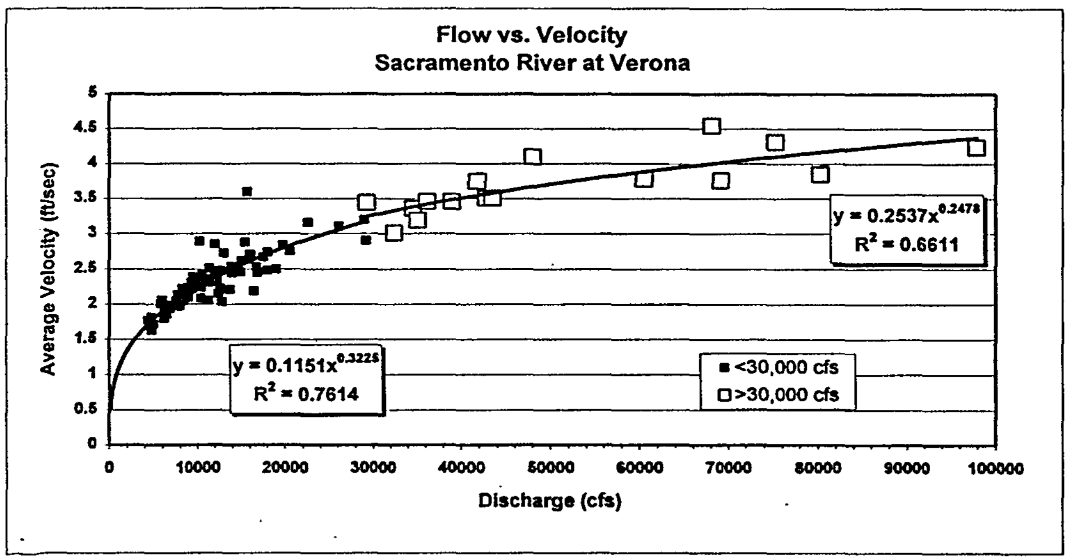

FIGURE A-2c Discharge vs. Average Velocity (Calculated, 1987-1997)

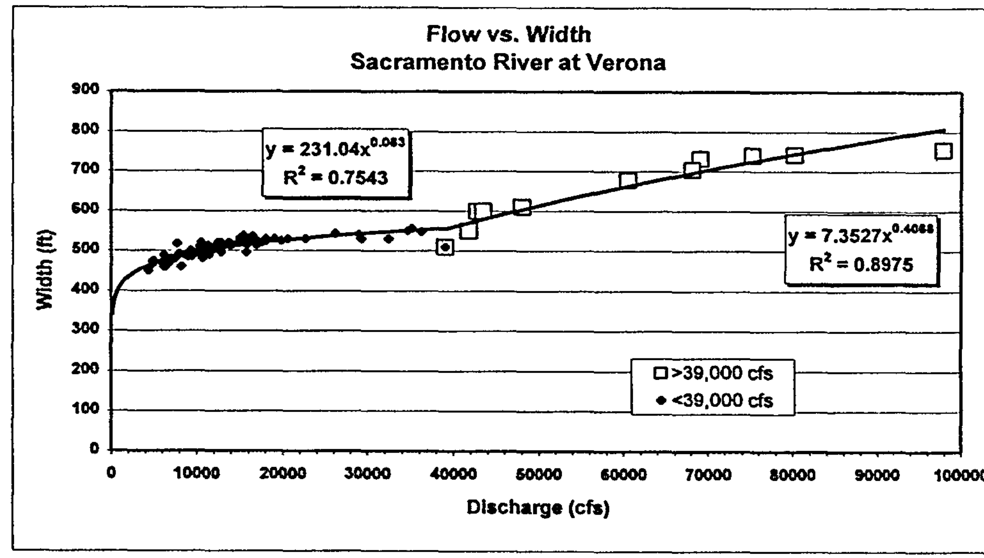

FIGURE A-2d Discharge vs. Top Width (Measured, 1987-1997)

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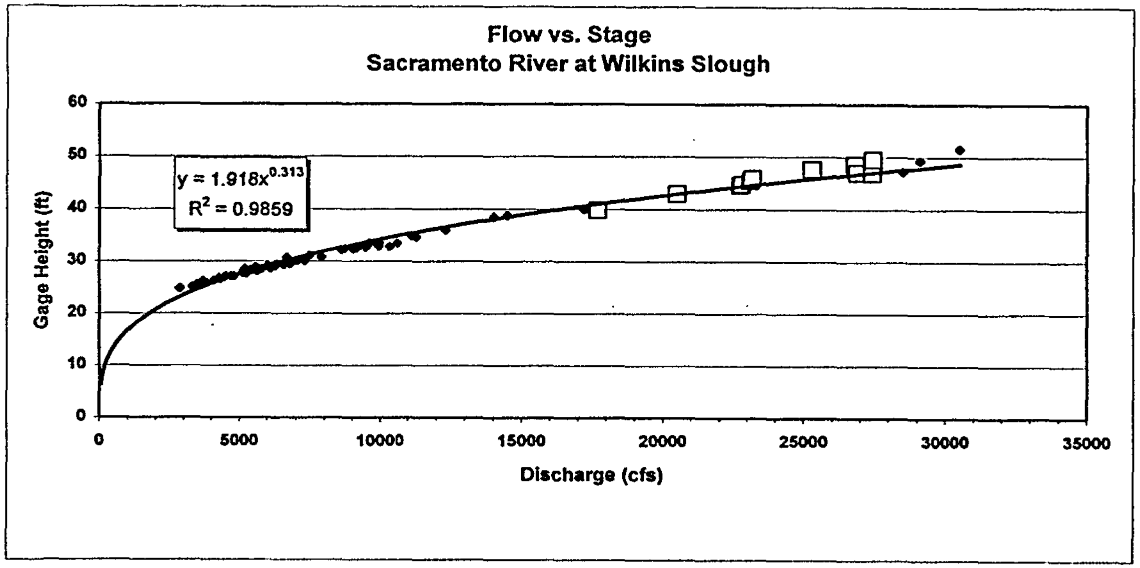

FIGURE A-3a Discharge vs. Gage Height (Measured, 1987-1997)

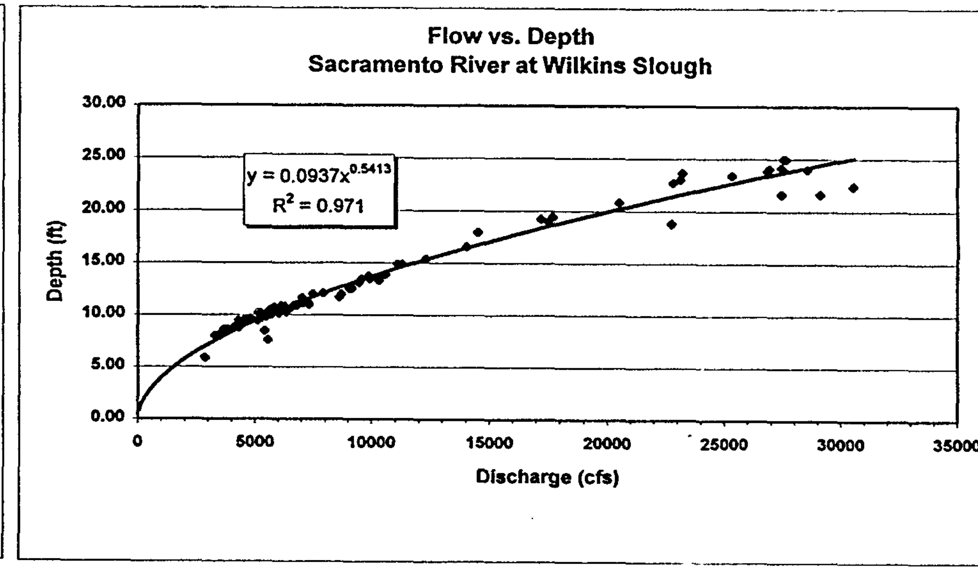

FIGURE A-3b Discharge vs. Average Depth (Calculated, 1987-1997)

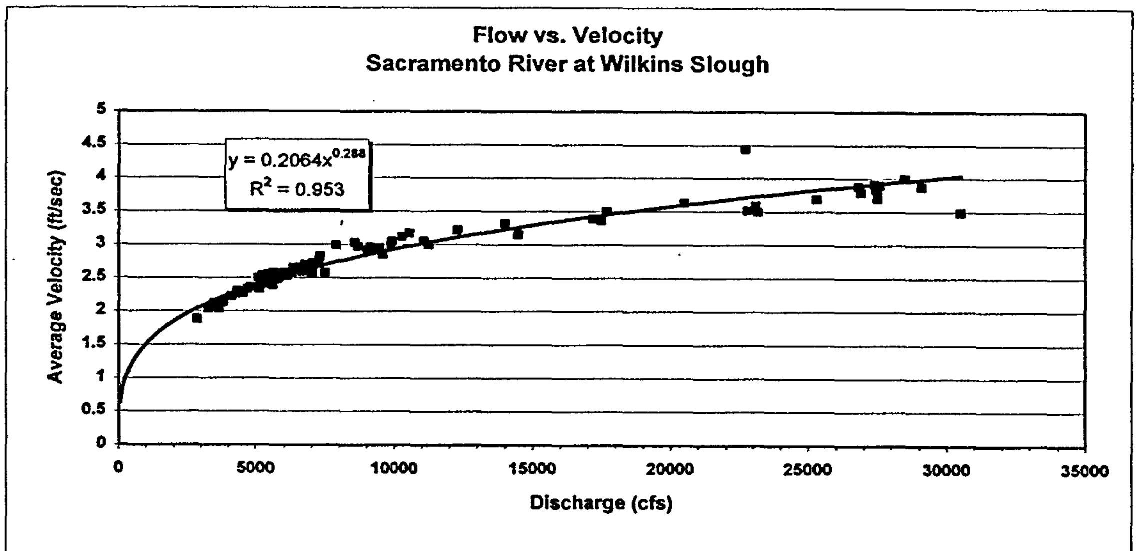

FIGURE A-3c Discharge vs. Average Velocity (Calculated, 1987-1997)

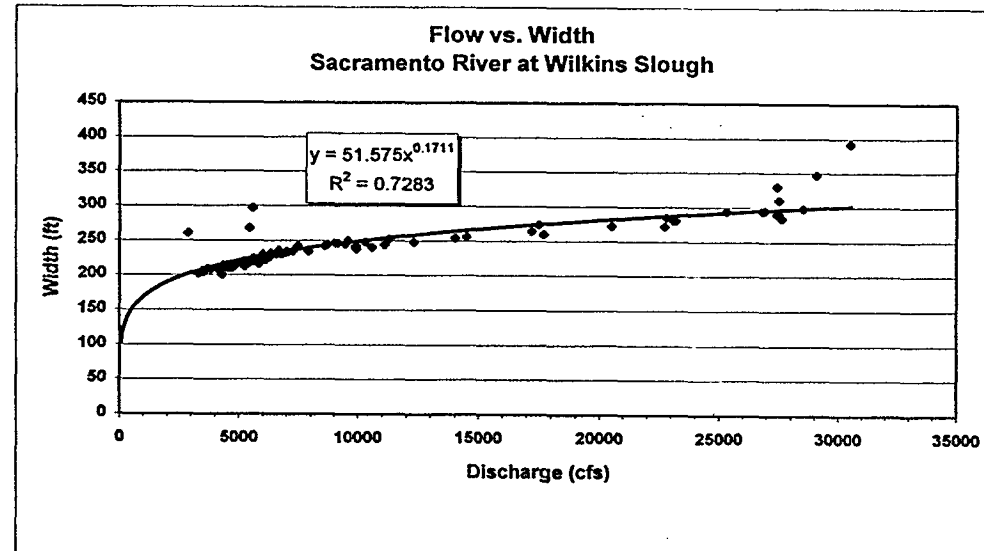

FIGURE A-3d Discharge vs. Top Width (Measured, 1987-1997)

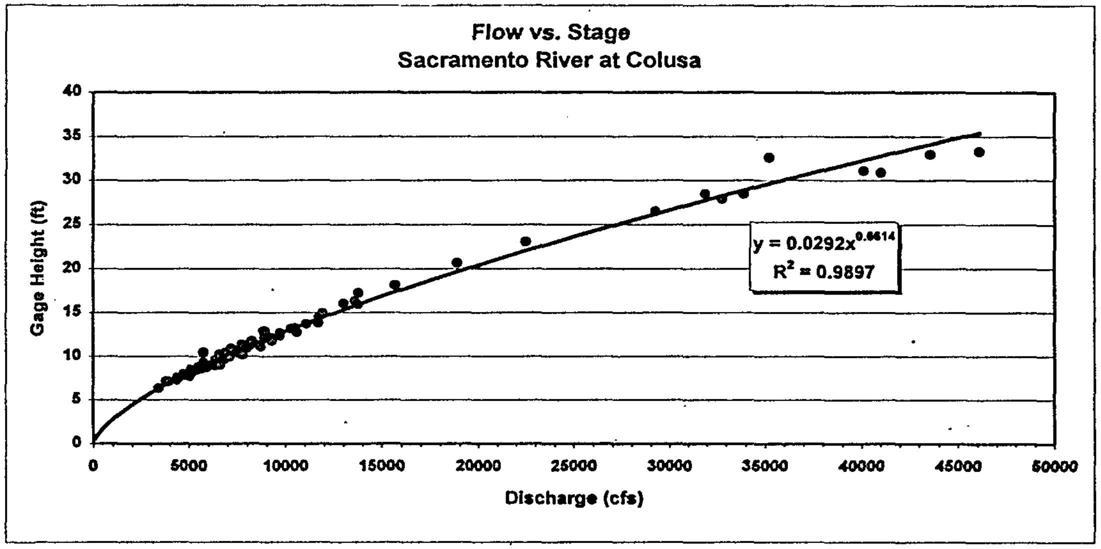

FIGURE A-4a Discharge vs. Gage Height (Measured, 1987-1997)

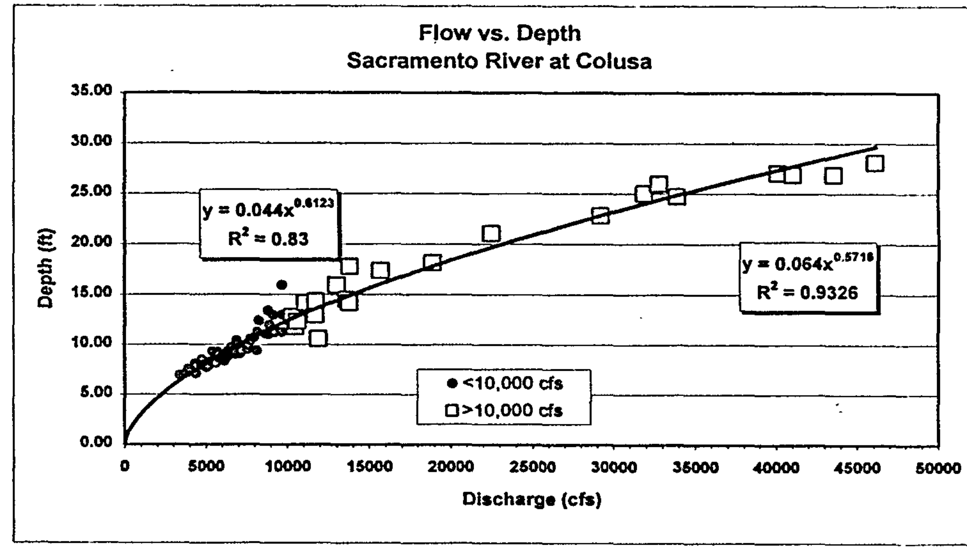

FIGURE A-4b Discharge vs. Average Depth (Calculated, 1987-1997)

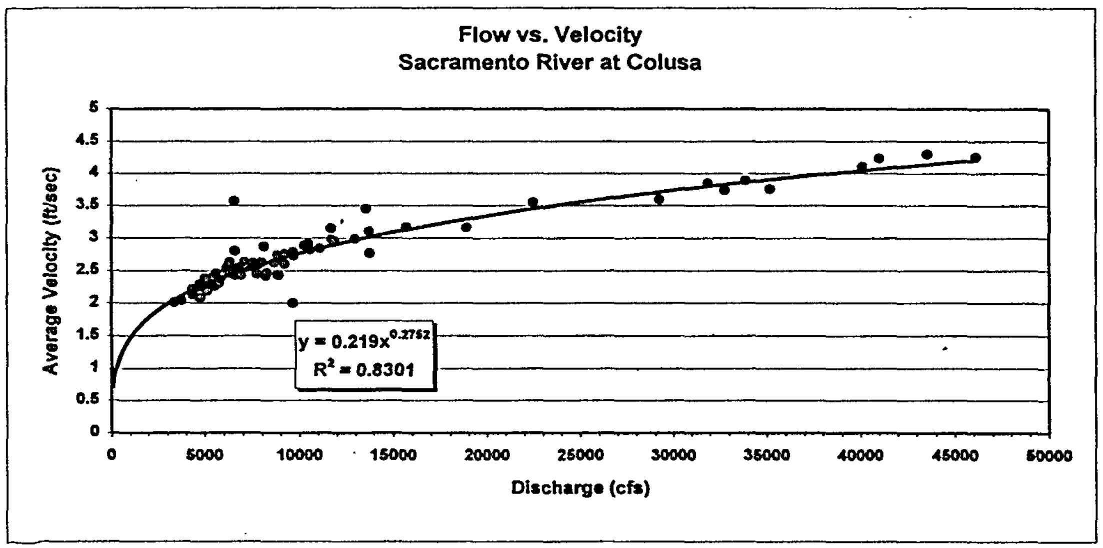

FIGURE A-4c Discharge vs. Average Velocity (Calculated, 1987-1997)

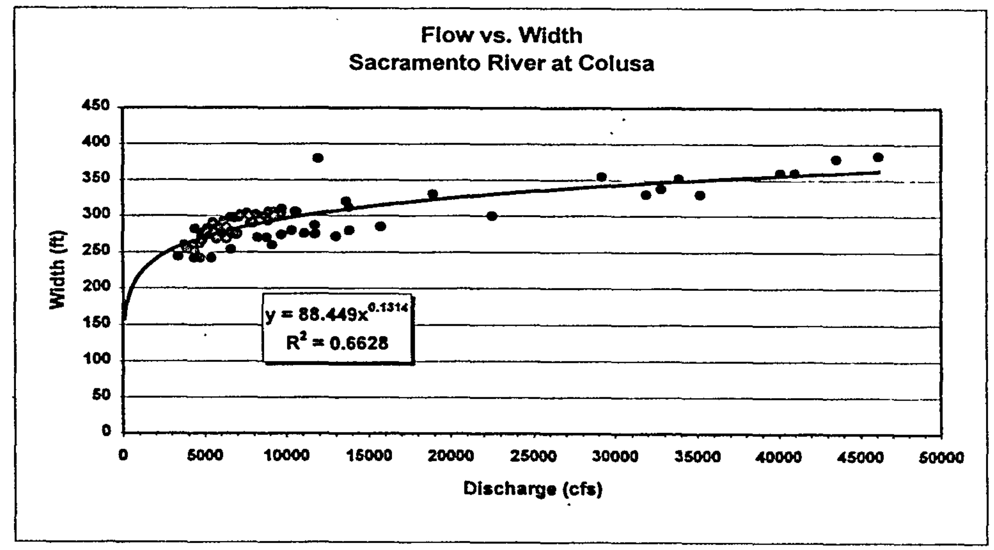

FIGURE A-4d Discharge vs. Top Width (Measured, 1987-1997)

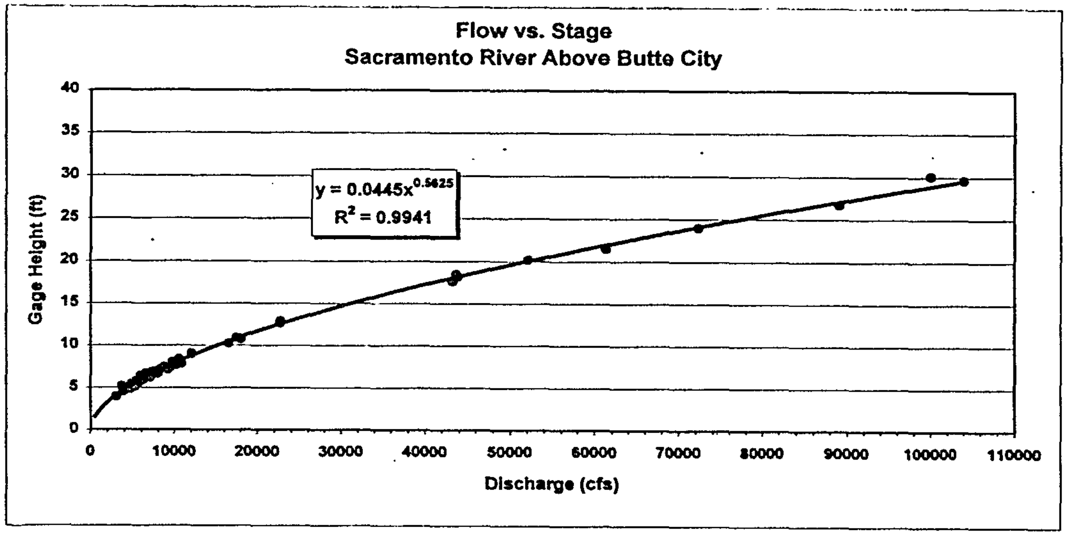

FIGURE A-5a Discharge vs. Gage Height (Measured, 1987-1995)

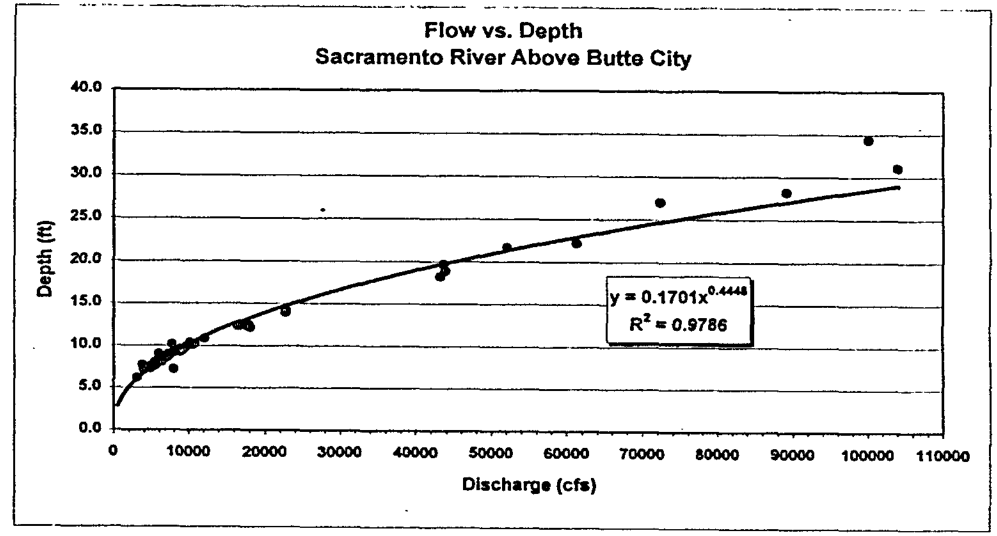

FIGURE A-5b Discharge vs. Average Width (Calculated, 1987-1995)

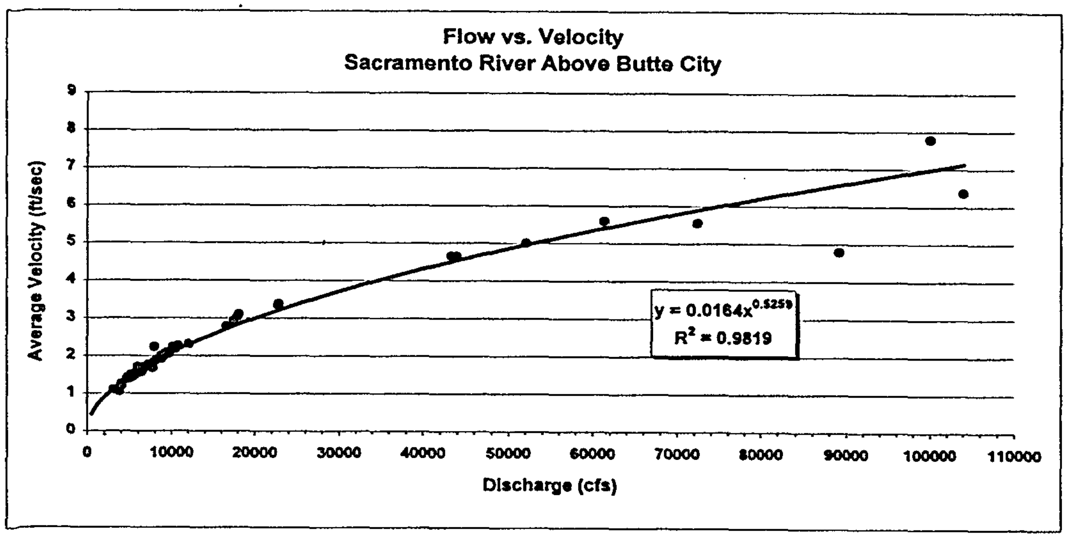

FIGURE A-5c Discharge vs. Average Velocity (Calculated, 1987-1995)

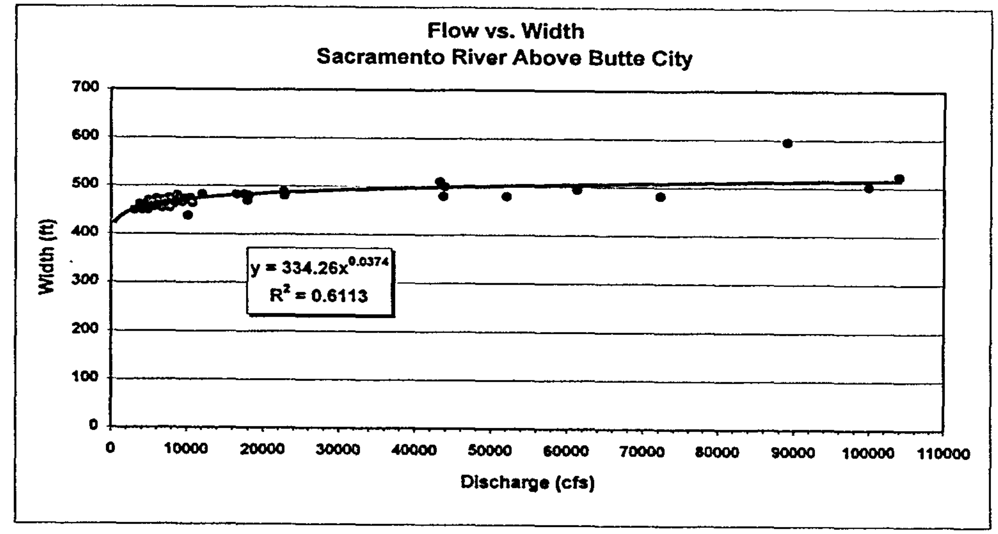

FIGURE A-5d Discharge vs. Top Width (Measured, 1987-1995)

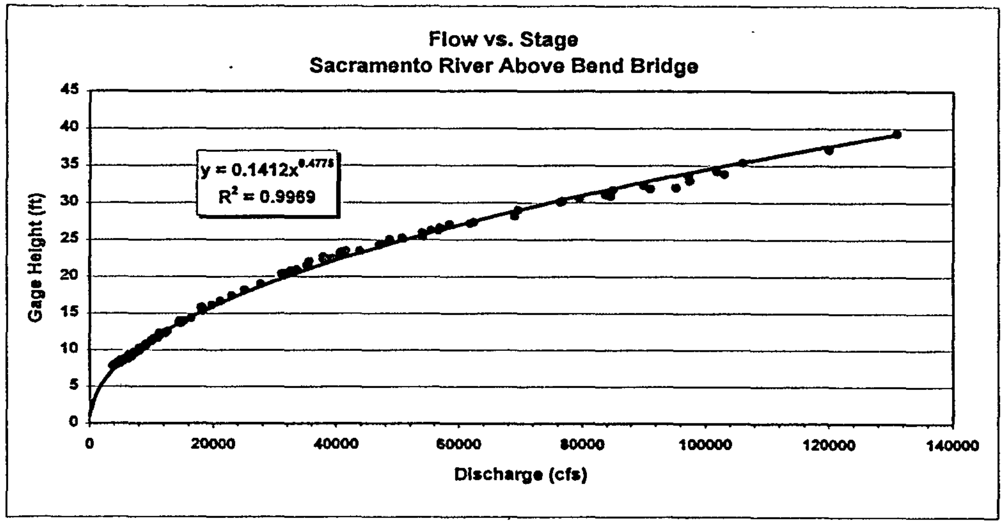

FIGURE A-6a Discharge vs. Gage Height (Measured, 1988-1997)

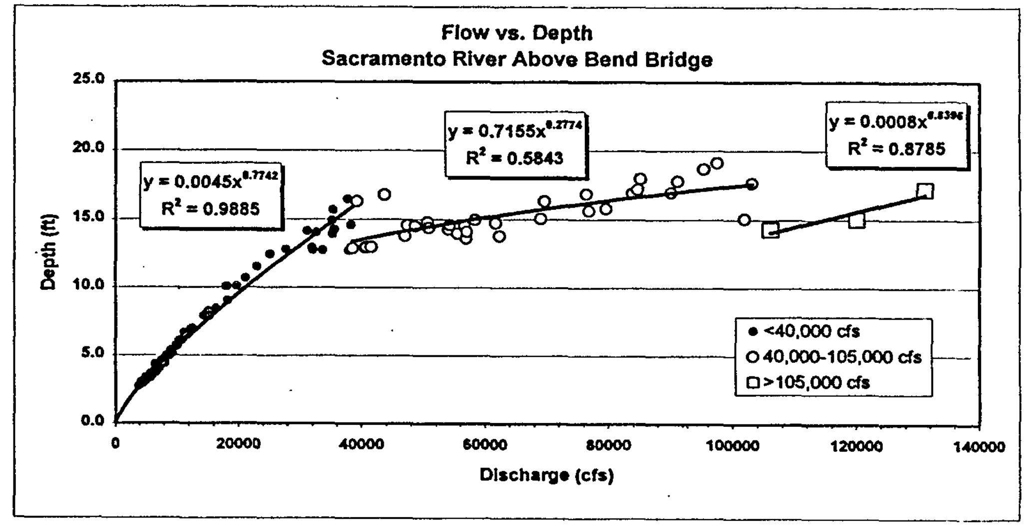

FIGURE A-6b Discharge vs. Average Depth (Calculated, 1988-1997)

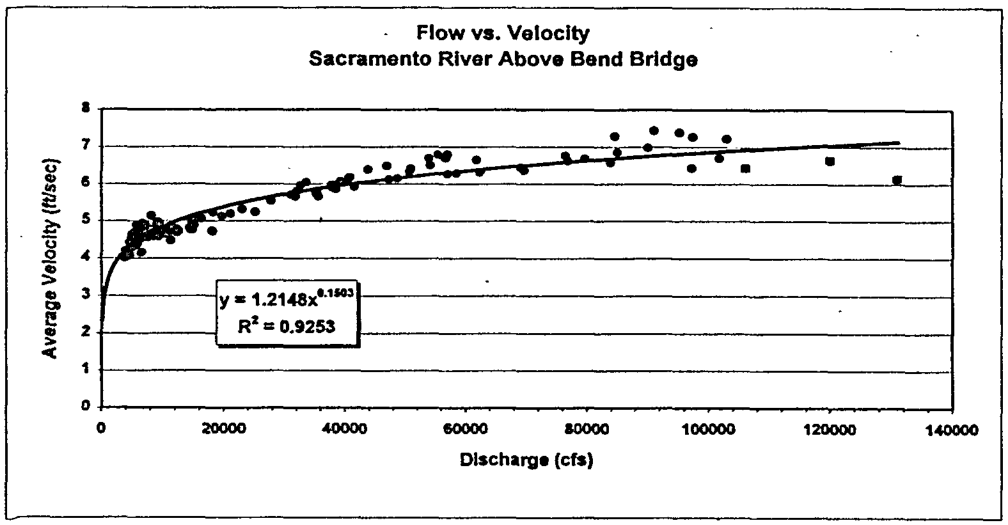

FIGURE A-6c Discharge vs. Average Velocity (Calculated, 1988-1997)

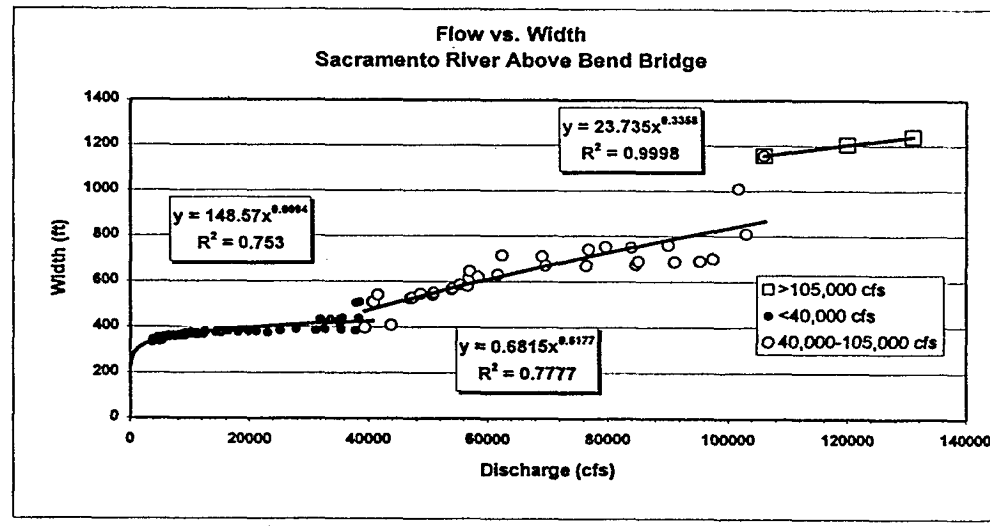

FIGURE A-6d Discharge vs. Top Width (Measured, 1988-1997)

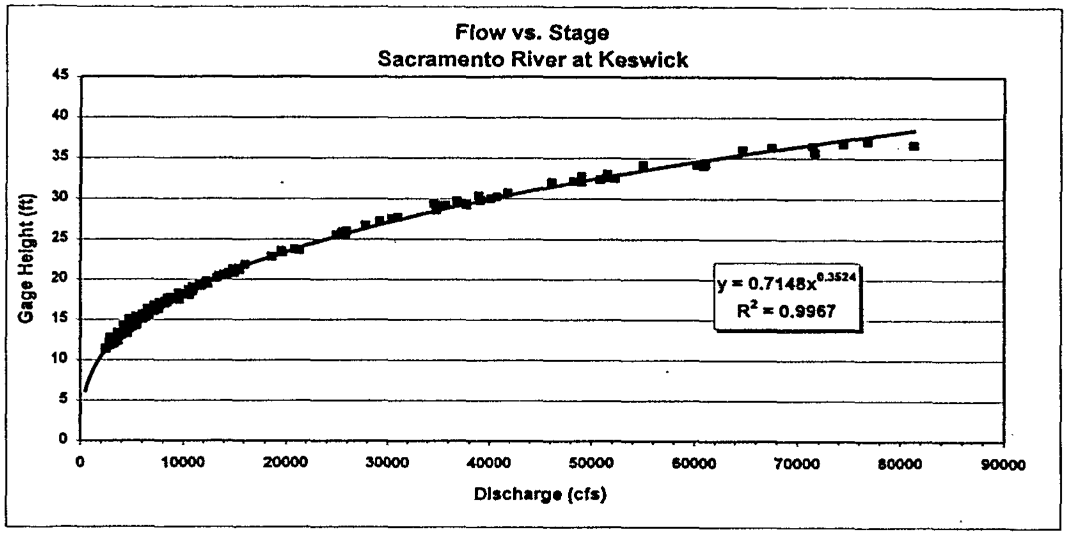

FIGURE A-7a Discharge vs. Gage Height (Measured, 1973-1997)

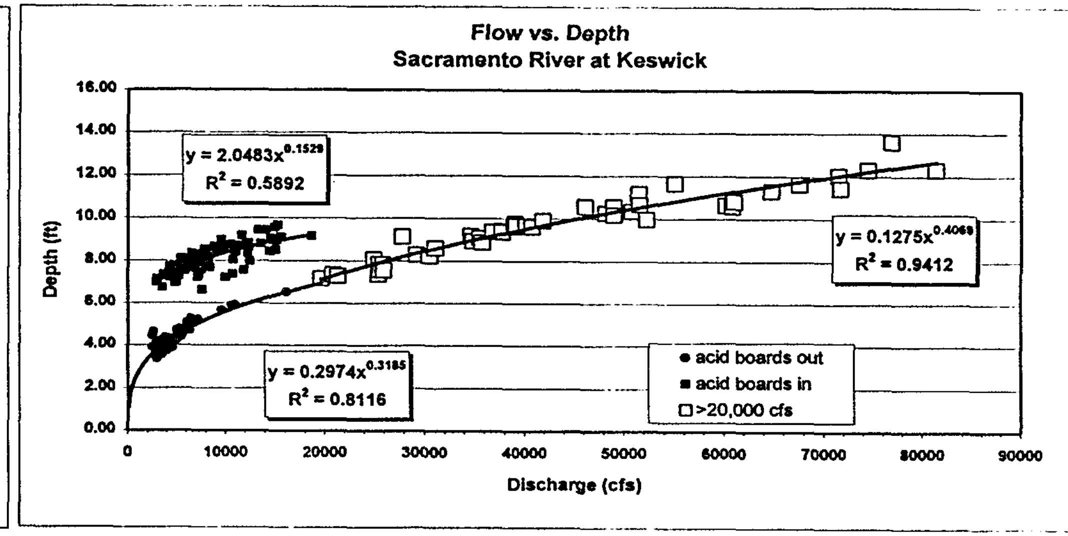

FIGURE A-7b Discharge vs. Average Depth (Calculated, 1973-1997)

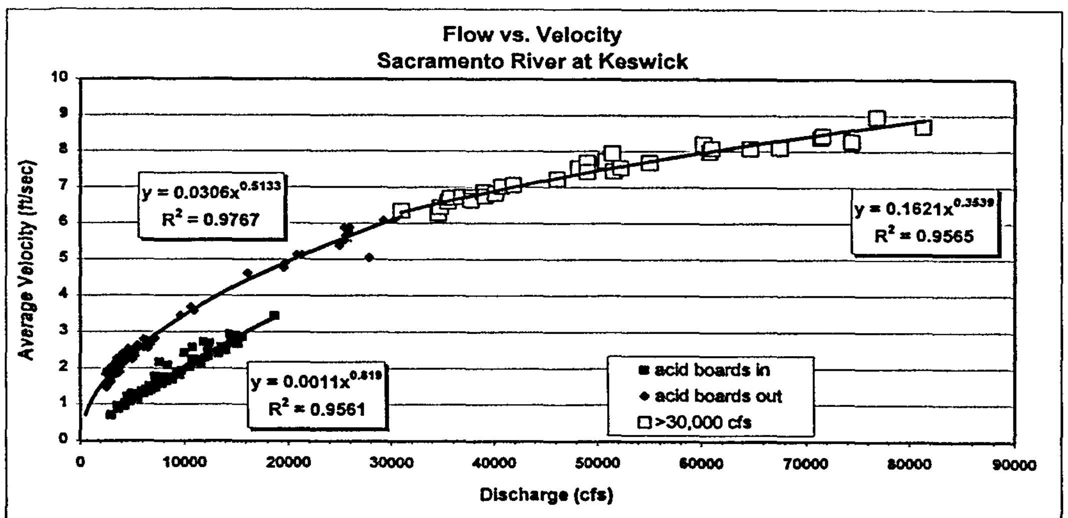

FIGURE A-7c Discharge vs. Average Velocity (Calculated, 1973-1997)

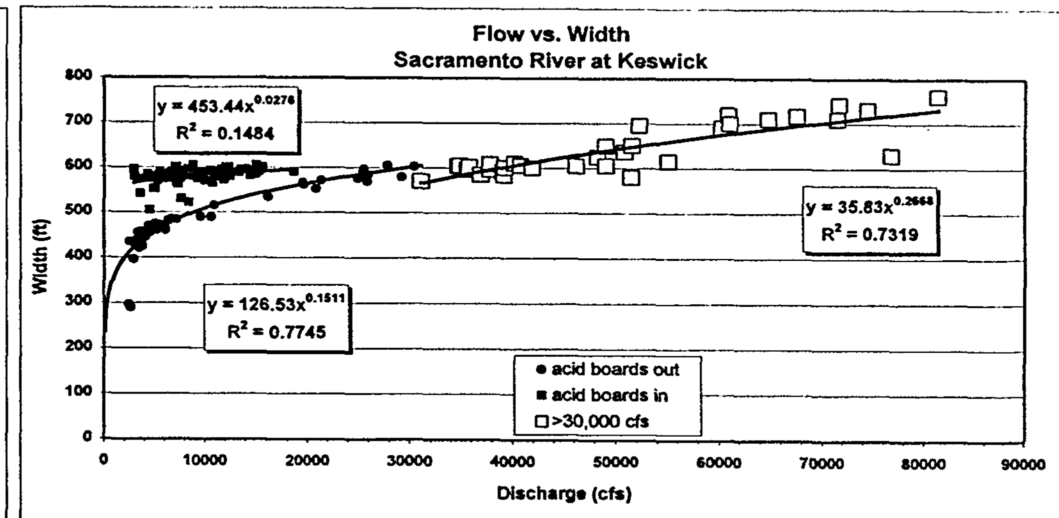

FIGURE A-7d Discharge vs. Top Width (Measured, 1973-1997)

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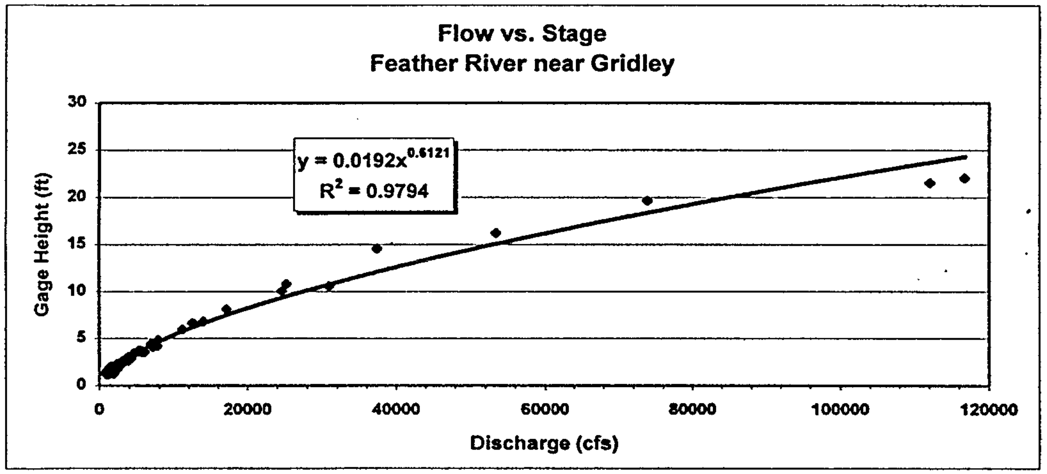

FIGURE A-8-a Discharge vs. Gage Height (Measured, 1987-1997)

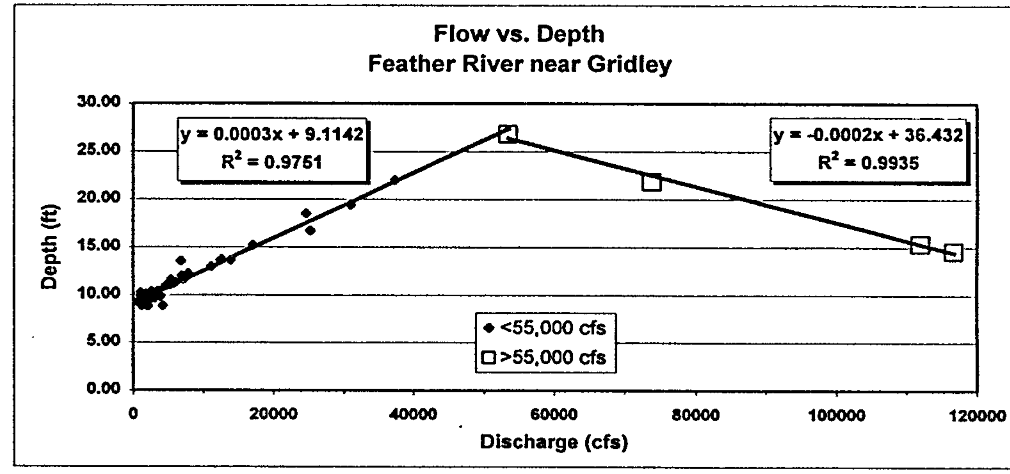

FIGURE A-8-b Discharge vs. Average Depth (Calculated, 1987-1997)

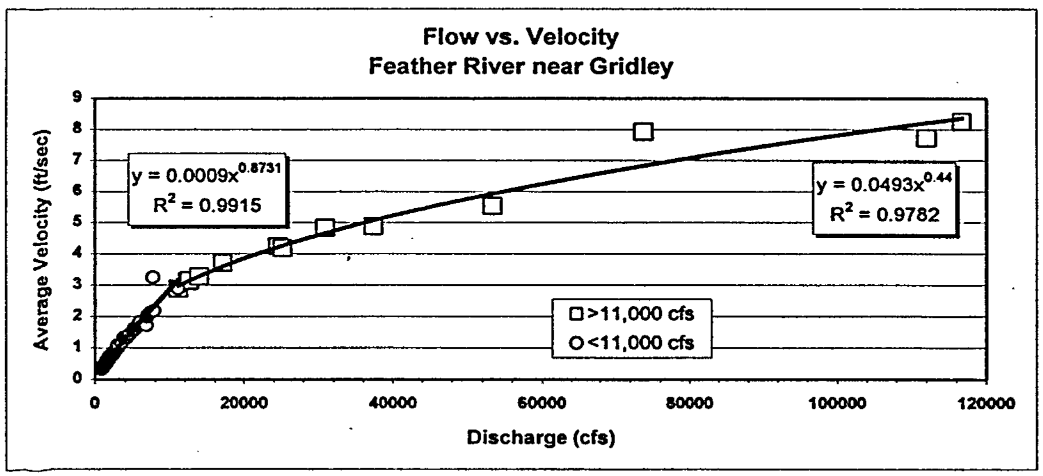

FIGURE A-8-c Discharge vs. Average Velocity (Calculated, 1987-1997)

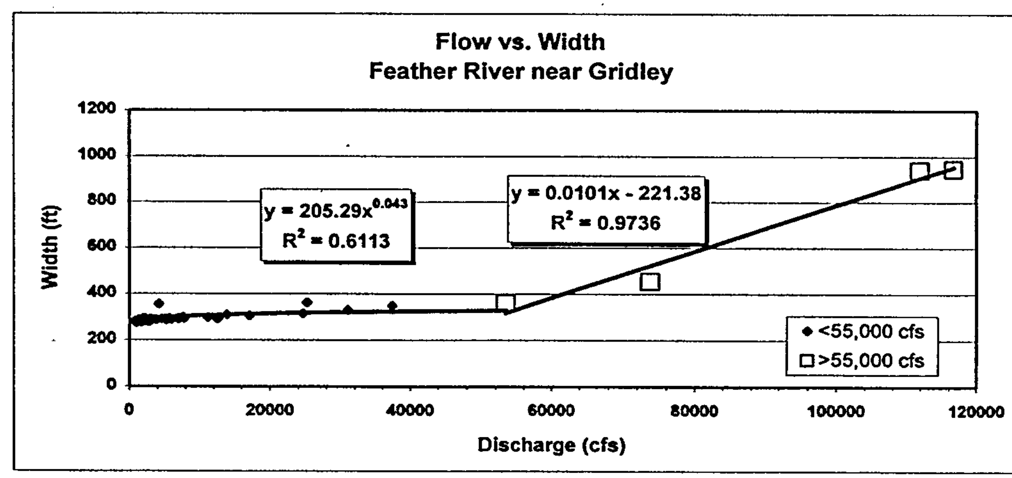

FIGURE A-8-d Discharge vs. Top Width (Measured, 1987-1997)

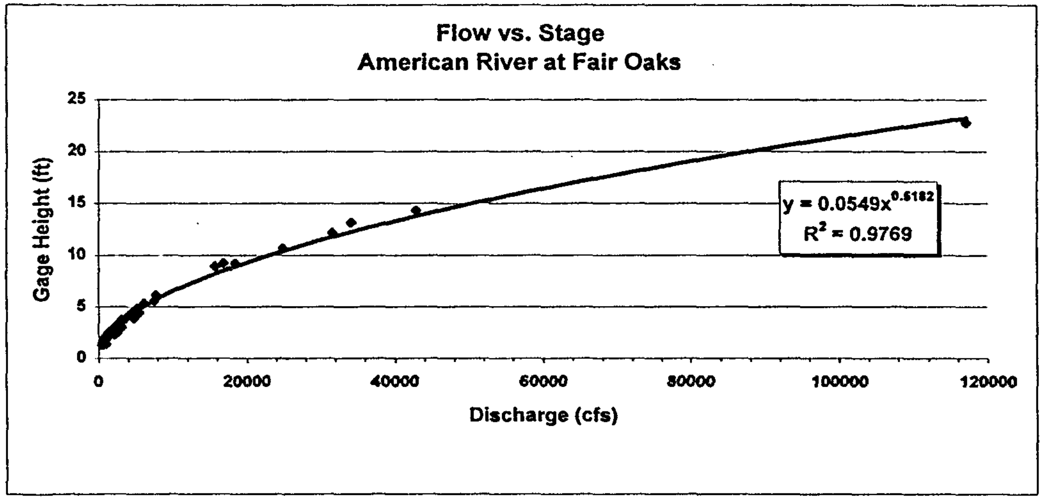

FIGURE A-9a Discharge vs. Gage Height (Measured, 1987-1995)

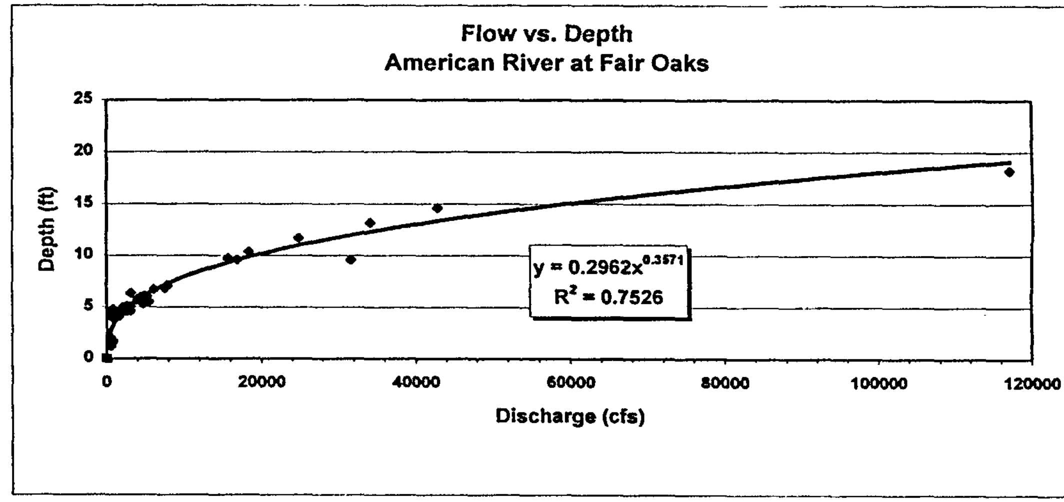

FIGURE A-9b Discharge vs. Average Depth (Calculated, 1987-1995)

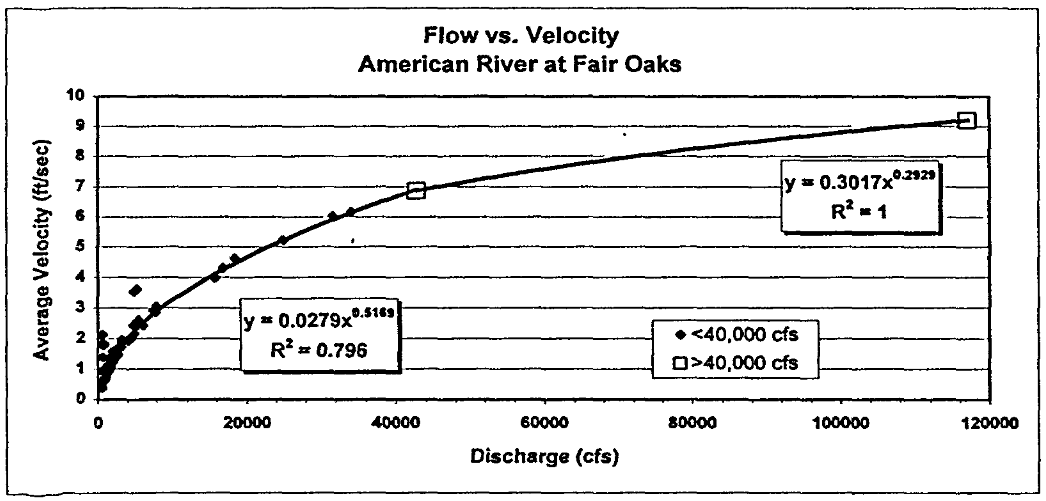

FIGURE A-9c Discharge vs. Average Velocity (Calculated, 1987-1995)

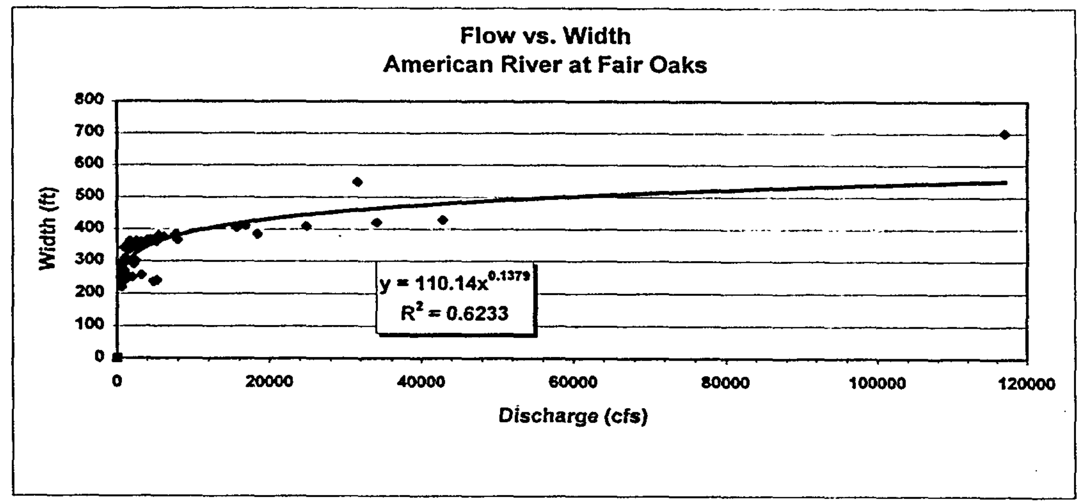

FIGURE A-9d Discharge vs. Top Width (Measured, 1987-1995)

C —0 0 2 9 4 0

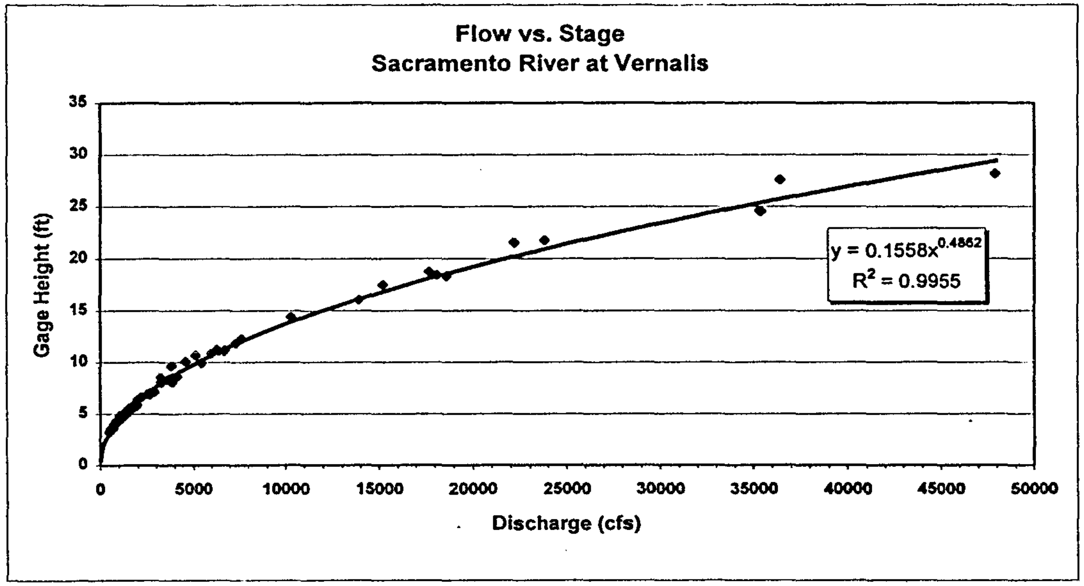

FIGURE A-10a Discharge vs. Gage Height (Measured, 1988-1997)

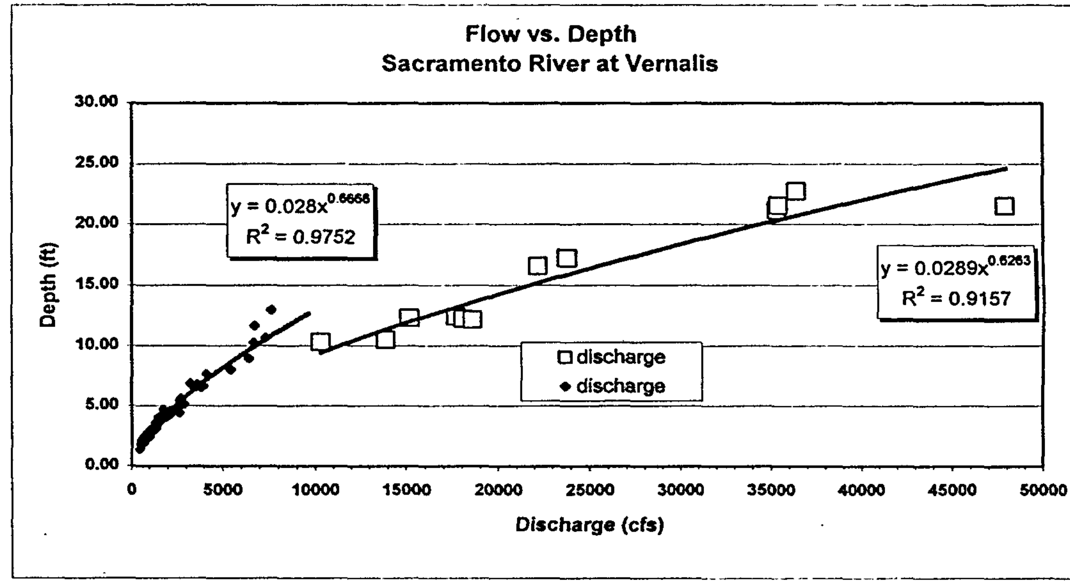

FIGURE A-10b Discharge vs. Average Depth (Calculated, 1988-1997)

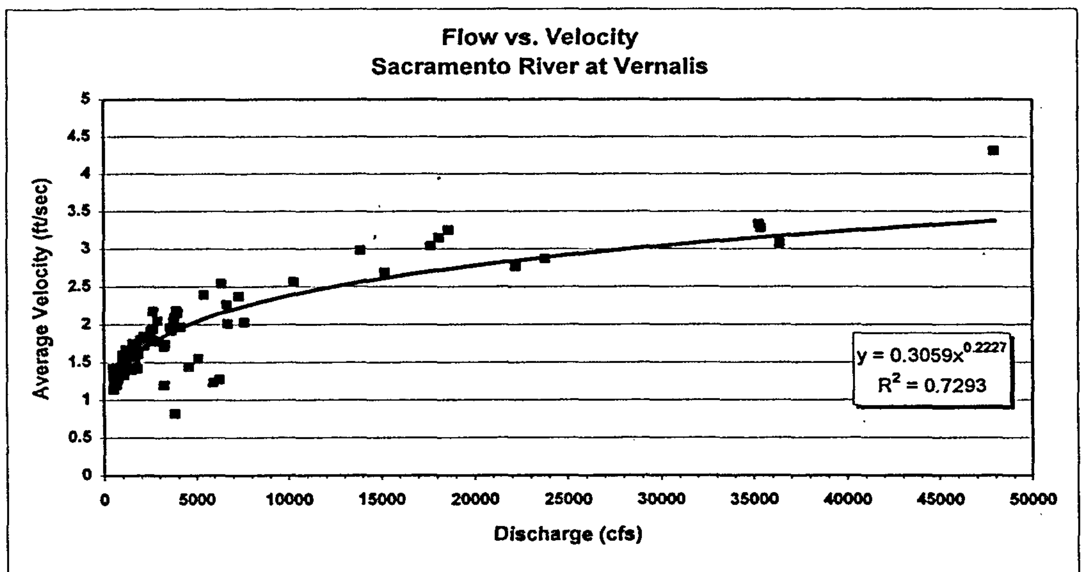

FIGURE A-10c Discharge vs. Average Velocity (Calculated, 1988-1997)

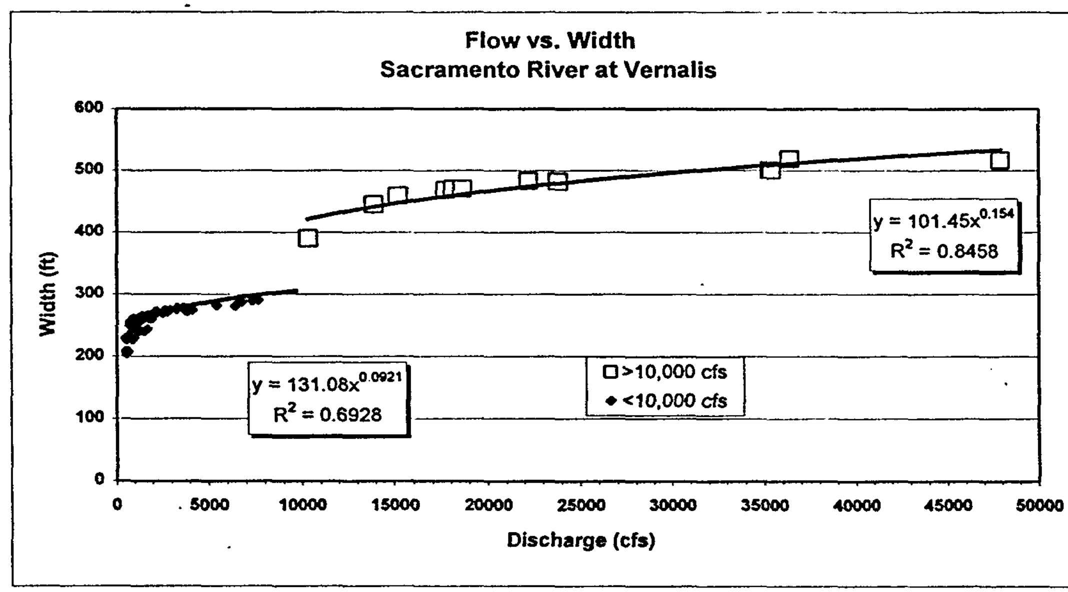

FIGURE A-10d Discharge vs. Top Width (Measured, 1988-1997)

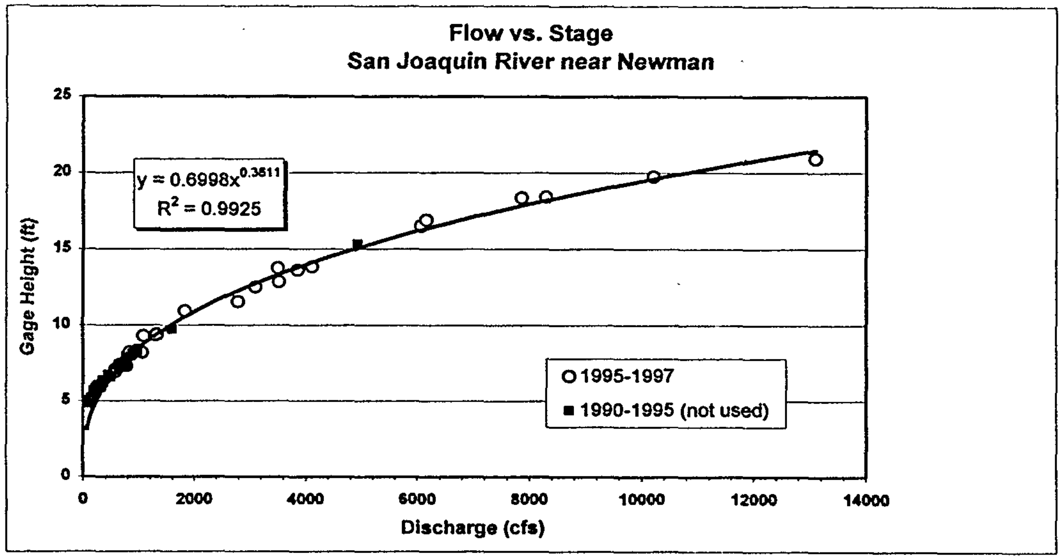

FIGURE A-11a Discharge vs. Gage Height (Measured, 1995-1997)

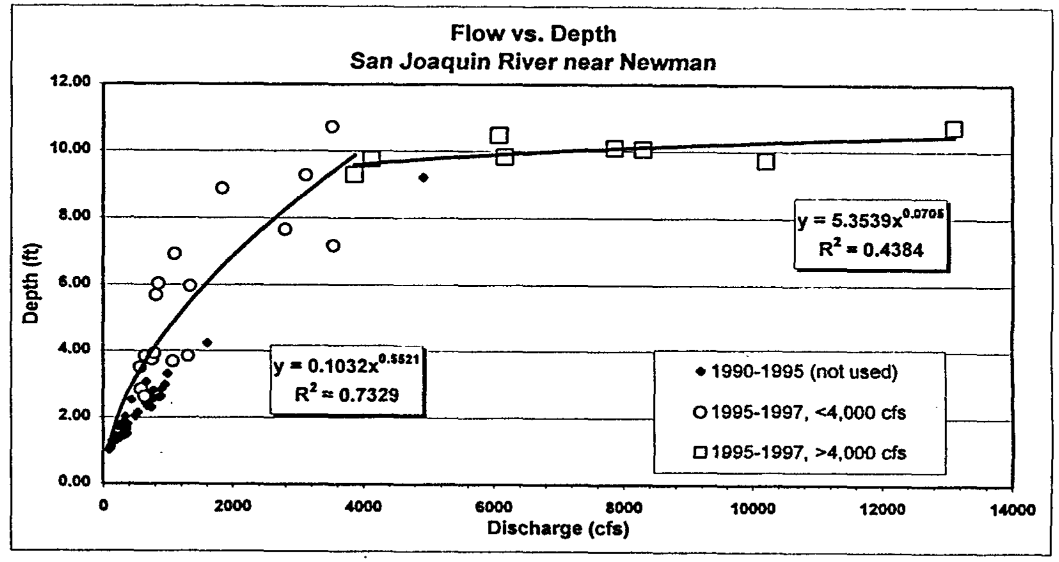

FIGURE A-11b Discharge vs. Average Depth (Calculated, 1995-1997)

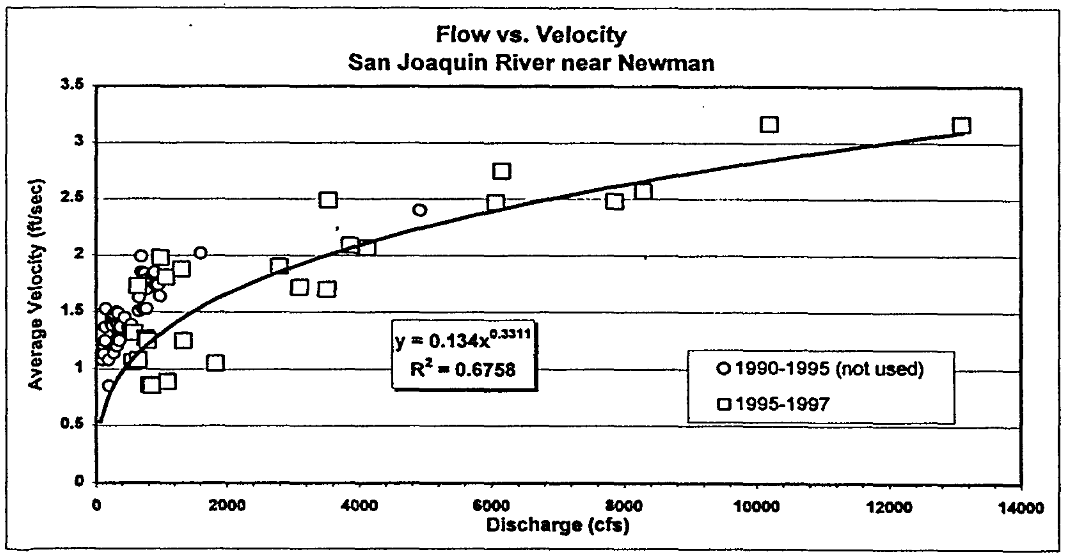

FIGURE A-11c Discharge vs. Average Velocity (Calculated, 1995-1997)

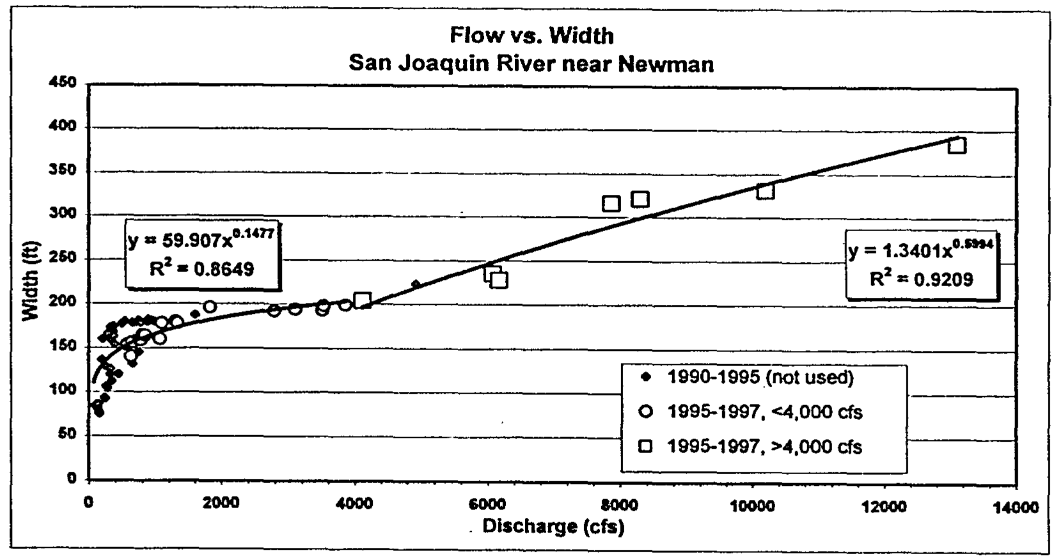

FIGURE A-11d Discharge vs. Top Width (Measured, 1995-1997)

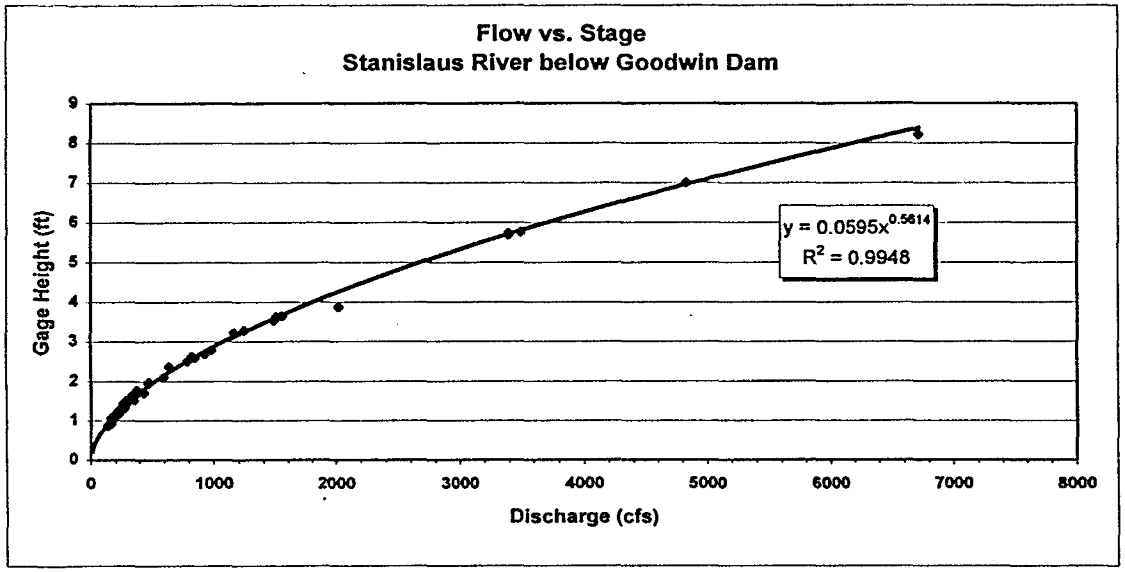

FIGURE A-12a Discharge vs. Gage Height (Measured, 1989-1997)

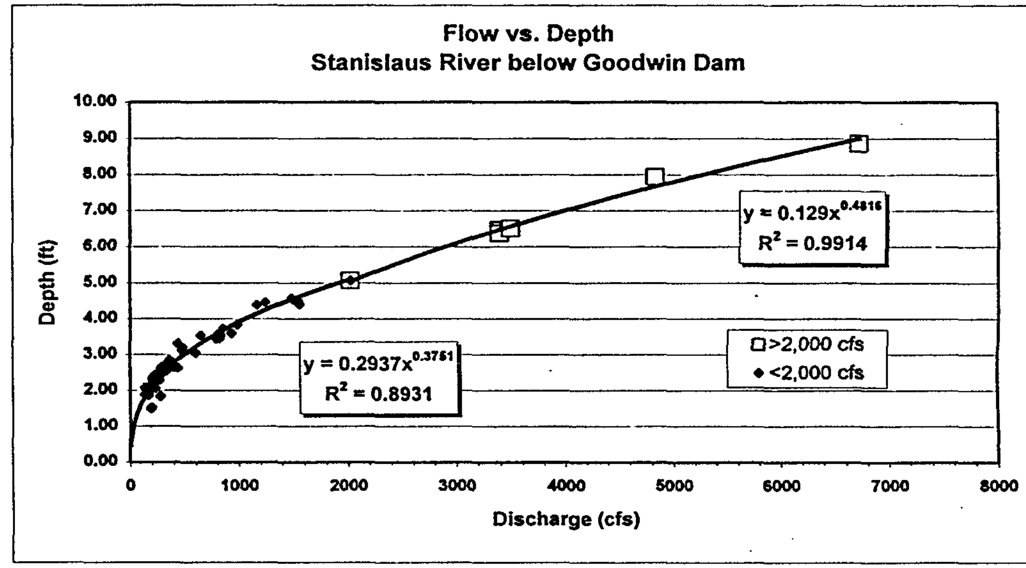

FIGURE A-12b Discharge vs. Average Depth (Calculated, 1989-1997)

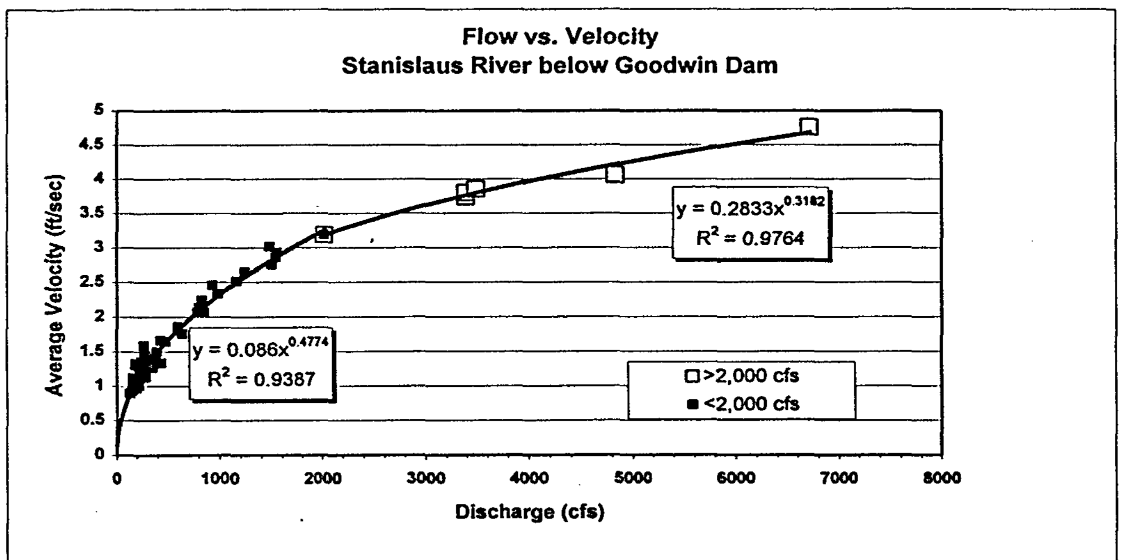

FIGURE A-12c Discharge vs. Average Velocity (Calculated, 1989-1997)

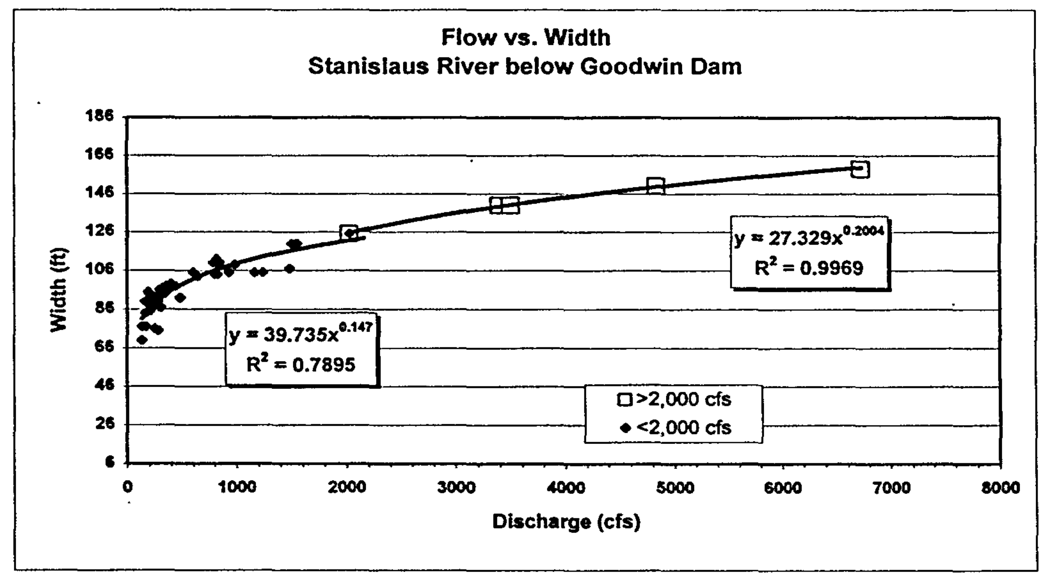

FIGURE A-12d Discharge vs.Top Width (Measured, 1989-1997)

Table A-1 Coefficients and Exponents for Calculating Stream Velocity, Depth, and Width

USGS Station	Description	Period used for analysis	Elevation Datum	Flow Range	Stage			Depth Correction	Flow Range	Average Depth			Flow Range	Width			Flow Range	Velocity		
				(cfs)	coef	exp	R^2		(cfs)	coef	exp	R^2	(cfs)	coef	exp	R^2	(cfs)	coef	exp	R^2
11446500	American River at Fair Oaks	1987-95	71.53	0 - 120,000	0.055	0.52	0.98	-3.1	0-120,000	0.30	0.36	0.75	0-120,000	110	0.14	0.62	0-40,000	0.028	0.52	0.80
"	"	"	"														40,000-120,000	0.30	0.29	1.00
11370500	Sacramento River at Keswick, Boards In	1973-97	479.81	0 - 19,000	0.71	0.35	1.00	5.0	0 - 19,000	2.0	0.15	0.59	0 - 19,000	453	0.028	0.15	0 - 19,000	0.001	0.82	0.96
"	Sacramento River at Keswick, Boards Out	1973-97	479.81	0 - 82,000	0.71	0.35	1.00	5.0	0 - 20,000	0.30	0.32	0.81	0 - 30,000	127	0.15	0.77	0 - 30,000	0.031	0.51	0.98
"	"	"	"						20,000-82,000	0.13	0.41	0.94	30,000-82,000	36	0.27	0.73	30,000-82,000	0.16	0.35	0.96
11377100	Sacramento River above Bend Bridge	1988-97	285.77	0 - 135,000	0.14	0.48	1.00	7.0	0-40,000	0.00	0.77	0.99	0-40,000	149	0.10	0.75	0-135,000	1.21	0.15	0.93
"	"	"	"						40,000-105,000	0.72	0.28	0.58	40,000-105,000	0.68	0.62	0.78				
"	"	"	"						105,000-135,000	0.00	0.84	0.88	105,000-135,000	24	0.34	1.00				
11389500	Sacramento River at Colusa	1987-97	-2.95	0-46,000	0.029	0.66	0.99	-33	0-10,000	0.04	0.61	0.83	0-46,000	88	0.13	0.66	0-46,000	0.22	0.28	0.83
"	"	"	"						10,000-46,000	0.06	0.57	0.93								
11389000	Sacramento River at Butte City	1987-95	-2.92	0-105,000	0.045	0.56	0.99	-64	0-105,000	0.17	0.44	0.98	0-105,000	334	0.04	0.61	0-105,000	0.016	0.53	0.98
11390500	Sacramento River below Wilkins Slough	1987-97	-3.00	0 - 30,000	1.92	0.31	0.99	0.0	0-30,000	0.094	0.54	0.97	0-30,000	52	0.17	0.73	0-30,000	0.21	0.29	0.95
11447650	Sacramento River at Freeport	1989-97	sea level	0-100,000	0.030	0.55	0.43	-100	0-100,000	0.45	0.38	0.93	0-100,000	368	0.05	0.50	0-100,000	0.008	0.55	0.89
11425500	Sacramento River at Verona	1987-97	-3.00	0-100,000	0.11	0.52	0.99	0.0	0-30,000	0.039	0.59	0.93	0-39,000	231	0.08	0.75	0-30,000	0.12	0.32	0.76
"	"	"	"						30,000-100,000	0.23	0.42	0.84	39,000-100,000	7.4	0.41	0.90	30,000-100,000	0.25	0.25	0.66
11302000	Stanislaus River below Goodwin Dam	1989-97	252.83	0 - 7,000	0.060	0.56	0.99	-7.0	0-2,000	0.29	0.38	0.89	0-2,000	40	0.15	0.79	0-2,000	0.086	0.48	0.94
"	"	"	"						2,000-7,000	0.13	0.48	0.99	2,000-7,000	27	0.20	1.00	2,000-7,000	0.28	0.32	0.98
11303500	San Joaquin River at Vernalis	1988-97	sea level	0 - 50,000	0.16	0.49	1.00	-4.0	0-10,000	0.028	0.67	0.98	0-10,000	131	0.09	0.69	0-50,000	0.31	0.22	0.73
"	"	"	"						10,000-50,000	0.029	0.63	0.92	10,000-50,000	101	0.15	0.85				
11274000	San Joaquin River near Newman	1995-97	sea level	0-13,000	0.70	0.36	0.99	-42.0	0-4,000	0.10	0.55	0.73	0-4,000	60	0.15	0.86	0-13,000	0.13	0.33	0.68
"	"	"	"						4,000-13,000	5.35	0.07	0.44	4,000-13,000	1.3	0.60	0.92				
"	"	"	"							linear coef.	intercept									
11407150	Feather River near Gridley	1987-97	-2.91	0-120,000	0.019	0.61	0.98	-73.5	0-55,000	0.00	9.11	0.98	0-55,000	205.29	0.043	0.61	0-11,000	0.00	0.87	0.99
"	"	"	"							linear coef.	intercept			linear coef.	intercept					
"	"	"	"						55,000-120,000	0.00	36.43	0.99	55,000-120,000	0.010	-221.38	0.97	11,000-120,000	0.05	0.44	0.98

CALFED
BAY-DELTA
PROGRAM

ENVIRONMENTAL IMPACTS/CONSEQUENCES

Bay Delta Hydrodynamics and Riverine Hydraulics

August 27, 1997

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(continued)

Page

TABLE OF CONTENTS
(continued)

LIST OF TABLES

LIST OF TABLES
(continued)

LIST OF FIGURES

LIST OF FIGURES

CALFED Bay-Delta Program
Environmental Impacts/Consequences
Bay-Delta Hydrodynamics and Riverine Hydraulics

1.0 INTRODUCTION

The CALFED Bay-Delta Program (Program) was established in 1995 to develop a long-term solution to the problems affecting the Bay-Delta estuary. The main objectives of the Program are to restore ecological health, to provide good quality water to all beneficial uses, to reduce the mismatch between Bay-Delta water supplies and those beneficial uses dependent on the Bay-Delta system, and to reduce the risks associated with catastrophic breaching of Delta levees.

To meet these objectives, CALFED began a three phase program to "fix" the Bay-Delta system. Phase I, completed in September 1996, identified the problems facing the Bay-Delta system, developed the Program goals and objectives, and designed three alternatives solutions. Phase II, currently underway and the basis of this report, involves the environmental review of the three alternatives and preparation of a Programmatic EIR/EIS. Phase II is expected to identify a Preferred Alternative.

Among the problems facing the Bay-Delta system, many are dependent on the hydrodynamics of the estuary and the upstream river hydraulics. Fresh water inflows repel sea water intrusion, improve water quality, provide important flow cues for anadromous fish, and help maintain adequate aquatic habitat for estuary species. Heavy exports can draw migratory fish out of river channels, increase entrainment of aquatic species, and change migratory flow cues.

Phase I identified three primary alternatives: 1) existing through-Delta conveyance, 2) modified through-Delta conveyance, and 3) dual Delta conveyance. Each alternative consists of four common elements including water use efficiency, ecosystem restoration, levee system integrity, and water quality. Each alternative also includes a range of upstream water storage options resulting in 17 different configurations. Delta conveyance and water storage provide the primary differences between alternatives and form the basis of this impacts analysis.

This report summarizes the environmental consequences to the Bay-Delta hydrodynamics and Riverine hydraulics associated with the three CALFED alternatives. Specific parameters and conditions were selected for analysis that are important for defining the state of the estuary and the tributary rivers, and for identifying potential impacts. The selected hydrodynamic parameters are compared between alternatives under a variety of conditions and their impacts are discussed.

This report summarizes potential significant impacts and mitigation measures for each Program alternative and for the various configurations identified within each alternative. The report includes a discussion of the methods of analysis and the criteria used for evaluating the significance of potential impacts. The main body of the report provides a discussion of the potential changes in the hydrodynamic conditions throughout the study area for each alternative configuration.

2.0 SUMMARY

This section summarizes potential significant impacts, possible mitigation measures, and potential unavoidable impacts. An detailed explanation of significance as well as adverse and beneficial impacts is provided in Section IV.

Built into the CALFED alternatives are two basic assumptions:

1. The importance of a unit of water is not fixed, but, varies according to the flow rate, the time of year, and the water year type. Water can be diverted during high flow periods with relatively little impact on the ecosystem and can be released at other times to produce greater benefits.

2. A comprehensive ecosystem restoration program will improve ecosystem functions and the recovery of Bay-Delta species that are currently threatened, endangered, or of special concern. In addition, improved flow management can not only reduce the impacts of diversions on the environment during critical periods, but can enhance flows during periods of time which produce the greatest benefit to the ecosystem health.

If these assumptions are correct, it should be possible to change how water is managed to take advantage of the time value and restore ecosystem health. However, the complex interrelationship between the movement of water and ecosystem health makes it difficult to define adverse and beneficial changes simply on the basis of changed flow conditions.

Generally, it is accepted that increased fresh water flow through the Delta is beneficial and a decrease in fresh water flow can be adverse if it causes a degradation in water quality and ecosystem habitat. On the other hand, a diversion of fresh water flows in the winter when high flows exist is assumed to be beneficial if it is later used to augment flow or supplies during a critical period. Adverse flow changes can be defined as a change that causes a degradation of water quality and ecosystem habitat, increases the risk of flooding or reduces navigability. Beneficial impacts enhance water quality, ecosystem habitat and navigability, and reduce the risk of flooding.

In order to conduct a systematic analysis of Delta hydrodynamics and Riverine hydraulics, and provide useful results, adverse has been defined as a long-term or substantial decrease in flow, especially during low flow conditions. Adverse is also defined as the increase in flow at or near flood stage. Beneficial effects were only identified; the degree to which the benefits occur was not evaluated. Therefore, in addition to evaluating a range of flow conditions, the analysis also focuses on identifying potential adverse conditions.

Technical reports addressing the potential impacts on ecosystem health, fish and wildlife, water quality, and flooding as a result of changed hydrodynamics and river hydraulics have been prepared separately. The results of this report are used to assess the impacts on these other areas.

2.1 Summary of Potential Significant Impacts

Table 2.1-1 summarizes the potential impacts for the Delta, Bay, Sacramento River, and San Joaquin River. For the Delta region, changes associated with each alternative configuration as compared to the No Action Alternative were assessed separately for the north, central, and south Delta. Changes in the Delta region were evaluated by flows, salinity, and mass fate. Additionally, the effect of the alternatives on net Delta outflow was evaluated. Changes in the rivers were evaluated by flows and the related hydraulic variables (depth, width, and velocity).

The adverse effects on flow patterns in the Delta were assessed as follows:

Negligible—Decreases in flows within the region were minor or nonexistent for all flow conditions (i.e., high inflow, low inflow/high pumping, low inflow/low pumping).
Small change—Flows within the region decreased slightly in two or more flow conditions or decreased moderately in one flow condition.
Moderate change—Flows within the region decreased moderately in two or more flow conditions or decreased substantially in one flow condition.
Large change—Flows substantially decreased in two or more flow conditions.

In the central Delta, special attention was given to central Delta outflow, which is defined as the net flow in the San Joaquin River upstream of Threemile Slough plus the flow in False River and Dutch Slough. For central Delta outflow, increased reverse flows are defined as adverse, and reduced reverse flows are considered beneficial. Central Delta flows were assessed by the categories given above as well as the following:

Negligible—Increases in reverse flow are less than 10 percent throughout most of the year, or increases are greater than 10 percent with a frequency of 25 percent in one season of the year.
Small Change—Increases in reverse flow are greater than 10 percent with a frequency of 10 percent in three of the four seasons in a year, or increases greater than 10 percent with a frequency of 25 percent in two seasons of the year, or increases greater than 10 percent with a frequency of 50 percent in only one season of the year.
Moderate Change—Increases in reverse flow are greater than 10 percent with a frequency of 25 percent in three seasons of a year, or increases having a frequency of 50 percent in two seasons of the year.
Large Change—Increases in reverse flow are greater than 10 percent throughout most of the year with a frequency of 50 percent or more.

For Delta salinity, increases in salinity were defined as adverse effects and decreases in salinity as beneficial effects. Of the two locations used to assess salinity in the southern Delta, Rock

Table 2.1-1.Summary of Environmental Consequences

	ALTERNATIVE AND CONFIGURATION																
	1			2					3								
LOCATION	A	B	C	A	B	C	D	E	A	B	C	D	E	F	G	H	I
North Delta Region																	
• Flows						U		O	O	O	O	O	O	O	O	O	U
• Salinity at Emmaton				O	O	U	O		O	O	O	O	O	O	O	O	U
• Mass Fate						U	O	O	O	O	O	O	O	O	O	O	U
Central Delta Region																	
• Flows		O	O			U			O	O	O	O	O	O	O		U
• Salinity						U			O	O	O	O	O	O	O	O	U
• Mass Fate						U	O	O	O	O	O	O	O	O	O	O	U
South Delta Region																	
• Flows						U			O	O	O	O	O	O	O		U
• Salinity		O	O			U			λ	λ	λ	λ	λ	λ	λ	λ	U
• Mass Fate						U			O	O	O	O	O	O	O	O	U
Net Delta Outflow		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Bay Region						U											U
Sacramento River @ Freeport																	
• Flooding Potential			O		O		O	O		O		O	O	O	O	O	O
• Low Flows																	
San Joaquin River @ Vernalis																	
• Flooding Potential																	
• Low Flows																	

IMPACT ASSESSMENT CATEGORIES	
Symbol	Rating
	Negligible
O	Small Change
O	Moderate Change
O	Large Change
λ	Significant Impacts
U	Unknown
	Beneficial Effect

Slough was given primary consideration because it is assumed to be more representative of area wide conditions than Clifton Court Forebay. The adverse effects on salinity in the Delta were assessed as follows:

Negligible—Increases in salinity of less than 10 percent throughout most of the year, or increases greater than 10 percent with a frequency of 25 percent in one season of the year.

Small Change—Increases in salinity are greater than 10 percent with a frequency of 10 percent in three of the four seasons in a year, or increases are greater than 10 percent with a frequency of 25 percent in two seasons of the year, or increases are greater than 10 percent with a frequency of 50 percent in only one season of the year.

Moderate Change—Increases in salinity are greater than 10 percent with a frequency of 25 percent in three seasons of a year, or increases greater than 10 percent with a frequency of 50 percent in two seasons of the year.

Large Change—Increases in salinity are greater than 10 percent throughout most of the year with a frequency of 50 percent or more.

Net Delta outflow represents the net fresh water movement through the Delta and out to the Bay, excluding tides. The adverse effects on net Delta outflow were assessed as follows:

Negligible—Decreases in net Delta outflow are less than 10 percent throughout most of the year, or changes are greater than 10 percent with a frequency of 25 percent in one season of the year.

Small Change—Decreases in net Delta outflow are greater than 10 percent with a frequency of 10 percent in three of the four seasons in a year, or decreases are greater than 10 percent with a frequency of 25 percent in two seasons of the year, or decreases are greater than 10 percent with a frequency of 50 percent in only one season of the year.

Moderate Change—Decreases in net Delta outflow are greater than 10 percent with a frequency of 25 percent in three seasons of a year, or decreases are greater than 10 percent with a frequency of 50 percent in two seasons of the year.

Large Change—Decreases in net Delta outflow are greater than 10 percent throughout most of the year with a frequency of 50 percent or more.

For the mass tracking study, increased mass trapped on Delta islands and a slower travel time of mass were defined as adverse effects. The adverse effects on the fate of mass released into the Delta were assessed as follows:

Negligible—Increases in mass trapped on Delta islands and increases in travel time of mass were minor or nonexistent for all flow conditions (i.e., high inflow/high pumping, medium inflow/low pumping, low inflow/high pumping, low inflow/low pumping).

Small change—Increases in mass trapped on Delta islands or increases in travel time were small in two or more flow conditions or moderate in one flow condition.

Moderate change—Increases in mass trapped on Delta islands or increases in travel time were moderate in two or more flow conditions or substantial in one flow condition.

Large change—Increases in mass trapped on Delta islands or increases in travel time were substantial in two or more flow conditions.

In the Bay region, impacts were assumed to be negligible; therefore, no further impact assessment categories were defined.

River flows were assessed at the Sacramento River at Freeport and the San Joaquin River at Vernalis. For flows in the rivers, changes associated with each alternative configuration as compared to the No Action Alternative were assessed as follows:

Negligible—Flow discharges are generally within 1 percent of the No Action Alternative; flow velocities generally within 1 percent of the No Action Alternative.

Small Change—Flow discharges are generally within 2 to 5 percent of the No Action Alternative; flow velocities generally within 1 to 2.5 percent of the No Action Alternative.

Moderate Change—Flow discharges are generally within 5 to 15 percent of the No Action Alternative; flow velocities are generally within 2.5 to 7 percent of the No Action Alternative.

Large Change—Flow discharges are generally more than 15 percent different from the No Action Alternative; flow velocities are generally more than 7.5 percent different from the No Action Alternative.

The potential impacts of the alternatives on Delta hydrodynamics and Riverine hydraulics can be summarized by alternative as follows:

Alternative 1

Alternative 1 relies on reoperation of the SWP and CVP and existing Delta channel configurations to meet the goals of CALFED. There are three configurations of Alternative 1. Configuration 1A relies on reoperation of the SWP and CVP. Configuration 1B includes reoperation and increased pumping capacity at the Banks Pumping Plant. Configuration 1C includes south Delta improvements, increased pumping plant capacity, and north and south Delta surface storage.

Generally, Alternative 1 causes small to negligible impacts on Bay-Delta hydrodynamics and Riverine hydraulics. As shown in Table 2.1-1, Alternative 1 causes negligible impacts in the north Delta region, small to negligible impacts in the central Delta region, negligible and beneficial impacts in the south Delta with regard to flow and mass fate, and negligible impacts in both the Sacramento and San Joaquin river systems. The primary adverse impacts from Alternative 1 are a result of the increased pumping plant capacity, which draws more water to the south Delta export pumps and increases salinity in the southern region.

In the south Delta region, flow circulation patterns are improved as a result of the south Delta improvements in Configuration 1C. The south Delta improvements do not allow San Joaquin

River water to flow directly to the export pumps via Old River; therefore, upstream flows in the San Joaquin River between Prisoners Point and the head of Old River are virtually eliminated. However, Delta channel flows toward the export pumps in Old River and Middle River increase and cause frequent increases in salinity of greater than 10 percent throughout most of the year.

Alternative 1 reduces net Delta outflow and increases reverse central Delta flow a small percentage of the time in proportion to the increased exports. The increase in exports and the corresponding changes in net and central Delta outflow occur mostly in the fall, once surplus water is available in excess of the defined flow requirements.

Impacts on the Bay from Alternative 1 are assumed to be negligible for two reasons: 1) the effect of net Delta outflow on Bay hydrodynamics is small in comparison to tidal influences, and 2) only small changes were observed in the position of X2.

Alternative 1 causes negligible impacts on river hydraulics in both the Sacramento River region and in the San Joaquin River region (Table 2.1-1). Alternative 1 does not appear to cause any flood or navigational impacts in either the Sacramento River region or the San Joaquin River region.

Reoperation of the SWP and CVP facilities allows more efficient timing of storage and flow releases in an effort to take advantage of the time-value of water. Under Alternative 1, reoperation increases exports and Sacramento River flows in July and reduces exports and Sacramento River flows in August. South Delta storage creates an additional increase in Sacramento River flows during the fall and winter to fill the added storage. Storage south of the Delta (i.e., the extra water taken in the fall and winter) allows further reductions in exports during July and August. North Delta storage reduces Sacramento River flows during the winter and increases flows during the summer and fall. Presumably, high winter flows are diverted, stored, and released later during dry periods.

Alternative 2

The emphasis of Alternative 2 is on in-Delta modifications and conveyance, such as channel and habitat improvements, and increased fresh water diversion from the Sacramento River into the north Delta region. Four potential conveyance options and three storage options differentiate five Alternative 2 configurations. Configurations 2A and 2C include only south Delta improvements. Configurations 2B and 2E include south Delta improvements, north Delta surface storage, and south Delta surface storage. Configuration 2D includes south Delta improvements and south Delta surface storage.

Generally, Alternative 2 creates beneficial impacts in the northern, central, and southern Delta regions (Table 2.1-1). In-Delta modifications and increased diversions substantially increase north Delta inflows and reduce reverse flows in the central Delta. Although a strong cross-Delta flow pattern remains and south Delta channel flows toward the export pumps increase, mostly beneficial impacts occur due to the extra fresh water flows from Sacramento River.

Some small and moderate adverse impacts occur for Alternative 2 (Table 2.1-1). Specifically, salinity at Emmaton is increased as a result of more Sacramento River flow entering the northern Delta and, therefore, not flowing pass Emmaton. Frequent increases in salinity of greater than 10 percent occur in the fall and winter. The fate of mass released at Freeport and Terminous is similarly affected: mass remains in the Delta channels for a longer period of time.

Configurations 2A and 2B include the south Delta improvements, which improve the circulation patterns as discussed for Alternative 1. These improvements eliminate upstream flows in a portion of the San Joaquin River and minimize the draw of river water out of the San Joaquin River channel, which improves flow conditions for migratory fish species.

Alternative 2 has a small impact on net Delta outflow (Table 2.1-1). Alternative 2 reduces net Delta outflow during the fall and early winter a small percentage of the time. The increase in exports and corresponding changes in net Delta outflow occur once surplus water is available in excess of the defined flow requirements.

Impacts on the Bay are assumed to be negligible for Alternative 2 for two reasons: 1) the effect of net Delta outflow on Bay hydrodynamics is small in comparison to tidal influences, and 2) only small changes were observed in the position of X2.

Alternative 2 causes negligible to small impacts on river hydraulics in Sacramento River region and negligible impacts on river hydraulics in San Joaquin River region (Table 2.1-1). Alternative 2 does not appear to cause any flood or navigational impacts in either the Sacramento River region or the San Joaquin River region.

Reoperation of CVP and SWP facilities under Alternative 2, similar to Alternative 1, allows more efficient timing of storage and flow releases in order to take advantage of the time-value of water. Exports and Sacramento River flows are increased in July and reduced in August; exports and Sacramento River flows are increased during the fall and winter to fill storage south of the Delta. North Delta storage reduces Sacramento River flows during the winter and increases flows during the summer and fall to supply increased exports. Overall for Alternative 2, in-Delta modifications have a much greater impact on Delta hydrodynamics than reoperation and storage; therefore, potential impacts from reoperation and storage are rendered negligible.

Alternative 3

The emphasis of Alternative 3 is on dual-Delta conveyance and includes channel improvements and new storage configurations. A combination of seven conveyance and two storage options differentiate nine Alternative 3 configurations. Configurations 3A and 3C include south and north Delta improvements with an isolated facility. Configurations 3B and 3D include south and north Delta improvements, an isolated facility, and both north and south Delta storage. Configurations 3E through 3I include variations on channel improvements, isolated facility types, and storage components.

Alternative 3 creates the greatest impacts on Bay-Delta hydrodynamics and riverine hydraulics (Table 2.1-1). Flows, salinity, and mass fate are all substantially affected by Alternative 3. Beneficial impacts on flows are also observed in the northern and central Delta regions. Although this alternative allows the greatest increase in exports, the reduction in the south Delta diversions creates a more natural downstream flow condition through the Delta.

The impact of Alternative 3 on flows and mass fate range from small to large, with some beneficial impacts (Table 2.1-1). In general, due to the isolated facility, there is a substantial decrease in flow from the Sacramento River through the Delta. Additionally, mass released into the Delta tends to remain in the Delta channels longer. In the central Delta, the isolated facility reduces the frequency of reverse flows, producing beneficial impacts. The reduction in reverse flows helps to reduce salinity intrusion and improve water quality.

Large adverse impacts are observed in the northern and southern Delta regions due to the increase in salinity. The isolated facility allows greater exports which reduce Sacramento River flows downstream of the new diversion and cause a frequent increase in salinity at Emmaton throughout the year. The isolated facility also substantially reduces cross-Delta fresh water flows and causes a frequent increase in salinity in the south Delta throughout the year. Furthermore, potential impacts on the south Delta are determined significant because increases in salinity at Rock Slough are as much as 100 to 200 percent over the No Action Alternative. In the central Delta, the combination of reduced exports and fresh water inflows results in a small adverse impact on central Delta salinity (Table 2.1-1).

Alternative 3 has a moderate impact on net Delta outflow (Table 2.1-1). Alternative 3 frequently reduces net Delta outflow by 10 percent or more during the fall, winter, and spring. The increase in exports and corresponding changes in net Delta outflow occur once surplus water is available in excess of the defined flow requirements. Unlike the other alternatives, Alternative 3 allows increased exports and reduces net Delta outflow during the spring about 25 percent of the time.

Impacts on the Bay are assumed to be negligible for Alternative 3 for two reasons: 1) the effect of net Delta outflow on Bay hydrodynamics is small in comparison to tidal influences, and 2) only small changes were observed in the position of X2.

Alternative 3 causes negligible to small impacts on river hydraulics in Sacramento River region and negligible impacts on river hydraulics in San Joaquin River region (Table 2.1-1). Alternative 3 does not appear to cause any flood or navigational impacts in either the Sacramento River region or the San Joaquin River region.

Reoperation enhances the value of water by changing the timing of when it can be stored and used later for beneficial purposes. Under Alternative 3, substantially less water is released upstream of the Delta and exported in July and August, while more water flows down the Sacramento River and is exported in the fall. North Delta storage reduces Sacramento River flows during the winter and increases flows during the fall to supply the increased exports. Reoperation will create a similar effect as those described for Alternative 1; however, the isolated facility has such a large impact on Delta hydrodynamics that any potential impacts from storage and reoperation are rendered negligible.

2.2 Summary of Mitigation Strategies

The potential impacts discussed in this document are based on computer model simulations of programmatic alternatives. As the planning process progresses, the model simulations will be refined. As site-specific alternatives emerge, even more detailed design and analysis information will become available. For example, if Alternative 3 is selected for further analysis and design, it may be possible to develop specific mitigation strategies to avoid potentially significant low flow and associated salinity problems in the south Delta. In general, it is expected that mitigation will include revised operating scenarios to reduce water quality problems that may occur during low flow conditions.

2.3 Summary of Potentially Significant Unavoidable Impacts

The impacts that have the greatest potential to be significant are the simulated reductions of low flows in the south Delta area, primarily associated with Alternative 3. As mentioned above, if Alternative 3 is selected for further analysis and design, it may be possible to develop specific mitigation strategies for these problems. In general, it is expected that mitigation will include revised operating scenarios to reduce water quality problems that may occur during low flow conditions.

The isolated facility in Alternative 3 reduces the amount of fresh water entering the Delta from the Sacramento River via the Delta Cross Channel and flowing to the export pumps at Clifton Court Forebay. Without the flushing effects of fresh water from the Sacramento River, salts tend to build up in the southern Delta. Increases in salinity also were seen in the central Delta (analyzed at Jersey Point), though not as significantly as in the south Delta.

3.0 ASSESSMENT METHODS

The assessment of potential impacts resulting from the implementation of CALFED alternatives are analyzed using the Department of Water Resources' operations planning model (DWRSIM) and Bay-Delta hydrodynamic model (DWRDSM1). Due to their design and purpose, each model provides a different set of results and simulates only selected components of the CALFED alternatives.

DWRSIM is used to plan the operation of reservoirs and conveyances to allocate water within the State Water Project (SWP) and Central Valley Project (CVP). For evaluation of the CALFED alternatives, DWRSIM uses the same sequence of hydrologic inputs, representing historic inflows for the period from October 1921 through September 1994. In this study, DWRSIM is used to evaluate river hydraulics, Delta inflows, and Delta outflows. The monthly average flows calculated by DWRSIM for the Sacramento River at Freeport and for the San Joaquin River at Vernalis are used as input to the Delta hydrodynamic model.

DWRDSM1 is much more time consuming and data intensive than DWRSIM. To accurately simulate the tidal effects on Bay-Delta hydrodynamics, DWRDSM1 uses a fifteen minute time-step and outputs daily results. As a result, only 16 years of model simulations were completed to evaluate in-Delta hydrodynamic changes (January 1976 to December 1991). Tidal average results were provided by DWR for this analysis.

As noted previously, the three CALFED alternatives consist of: 1) existing through-Delta conveyance, 2) modified through-Delta conveyance, and 3) dual delta conveyance (i.e., isolated facility). The alternatives also include a range of upstream water storage options and in-Delta habitat and channel improvements, resulting in 17 different alternative configurations. With the exception of the isolated facility, DWRSIM cannot simulate in-Delta modifications. DWRDSM1 cannot address upstream modifications except in the form of inflows to the Delta.

3.1 Delta Region

Hydrodynamic impacts of the alternatives on the Delta are evaluated based on in-Delta modifications and on changes in operations of the SWP and CVP that affect the Delta. Operational changes include reoperation for improved flow timing, increased exports, or additional storage. In-Delta conveyance modifications include channel enlargement, barriers, flow control structures, habitat improvements, and increased export capacity. The following potential impacts on the Delta are evaluated with DWRDSM1: 1) Effects on monthly average flows, velocities, and stages in Delta channels; 2) Changes in the fate of mass released at particular locations within the Delta; 3) Effects on monthly average central Delta outflow; and 4) Changes in monthly average salinity. The following potential impacts on the Delta are evaluated using DWRSIM: 1) Effects on monthly average net Delta outflow; and 2) Changes in the X2 location.

The strategy for analyzing hydrodynamic conditions within the Delta can be summarized as follows:

1. Analyze changes in hydrodynamic conditions resulting from modifications in the Delta for appropriate alternative configurations using the DWRDSM1 model with a 16-year monthly average inflow record. The inflow and pumping record is equivalent to the No Action Alternative with increased Banks Pumping Plant capacity. Storage was not included.
2. Use DWRSIM to evaluate Delta inflow and outflow changes associated with alternative storage configurations. Use the relationship between Sacramento River flows and Delta inflow to estimate the impact of storage configurations on Delta hydrodynamics.

A summary of the alternative configurations for DWRDSM1 are provided in Table 3.1-1. Specific information about the DWRDSM1 CALFED modeling effort can be found at http://wwwdelmod. water.ca.gov. These configurations are intended to represent the range of modifications being considered in this programmatic analysis. The DWRSIM modeling effort is discussed in Section 3.3.

3.1.1 Flow, Velocity, and Stage

In order to determine effects of the alternatives on flow patterns, velocities, and

Table 3.1-1. *Alternative configurations evaluated using DWRDSM1 model.*

Alternative	Configuration	Description
No Action	n/a	Existing Delta geometry with predicted 2020 demands.
1	A	Existing Delta geometry with CVP-SWP improvements (10,300 cfs pumping) and predicted 2020 demands.
	C	South Delta improvements, CVP-SWP improvements (10,300 cfs pumping), and predicted 2020 demands.
2	B	North and south Delta improvements, a 10,000 cfs Hood Intake, CVP-SWP improvements (10,300 cfs pumping), and predicted 2020 demands.
	D	Mokelumne River floodway, east and south Delta habitats, a 10,000 cfs Hood Intake, CVP-SWP improvements (10,300 cfs pumping), and predicted 2020 demands.
	E	Mokelumne River floodway, Tyler Island, east, and south Delta habitats, CVP-SWP improvements (10,300 cfs pumping), and predicted 2020 demands.
3	E	North Delta improvements, a 15,000 cfs isolated facility, CVP-SWP improvements (10,300 cfs pumping), and predicted 2020 demands.

Table 3.1-2. Inflows and pumping for representative periods used in DWRDSM1 modeling.

Conditions	Month(s)	Sacramento River Flow TAF	San Joaquin River Flow TAF	East Side Streams Flow TAF	Yolo Bypass Flow TAF	SWP Pumping TAF	CVP Pumping TAF
High Inflow	Mar-83	5,038	2,528	679	6,979	313	171
Low Inflow/High Pumping	Oct-89	783	81	6	0	285	264
Low Inflow/Low Pumping	Jul-91	556	80	8	3	46	90
High Inflow/High Pumping	Feb-79	2,319	515	119	35	303	236
Medium Inflow/Low Pumping	Apr-81	1,018	218	33	3	163	163
Average	8/75 to 9/91	1,300	287	68	218	289	202
Minimum	8/75 to 9/91	393	54	0	0	5	3
Maximum	8/75 to 9/91	5,100	2,528	746	6,979	633	283

- Low inflow/low pumping, represented by July 1991.

These flow conditions were selected based on fish and wildlife concerns. The locations at which mass was released into the Delta are shown in Figure 3.1-1. Monitoring locations for released mass include the following: Contra Costa Canal, export locations, Delta islands, Delta channels and waterways, and the Delta past Chipps Island. The effect of the alternatives on mass fate was evaluated by comparing the change in distribution of mass among these endpoints after 30 and 60 days.

3.1.3 Central Delta Outflow and Salinity

Central Delta outflow and salinity were evaluated using frequency analysis. Figure 3.1-1 shows a representation of central Delta outflow and locations where salinity is evaluated.

The frequency analysis consists of evaluating long-term and substantial changes caused by CALFED alternatives. Long-term and substantial changes, or trends, are assessed by comparing distributions of the model results. The distributions are presented by percentiles on a monthly basis. Trends are defined as frequent changes in any given month or in adjacent months or seasons. Results are discussed on the basis of trends rather than individual changes. The long-term and substantial trends are used to define adverse impacts, which in turn are used to identify potential significant impacts.

Central Delta outflow represents the net flow in the San Joaquin River upstream of Threemile Slough plus the flow in False River and Dutch Slough. Central Delta outflow is evaluated by observing the frequency of increases or decreases in reverse flows. Reverse flows are considered to be detrimental to aquatic species and degrade water quality in the central and southern Delta. An adverse change to central Delta outflow is defined as the long-term or substantial increase in reverse flows.

Salinity was evaluated at four locations in the Delta region: Emmaton, Jersey Point, Rock Slough, and Clifton Court Forebay. Salinity standards are defined at these locations; these standards are used in DWRSIM to determine the allocation of water supply. Salinity is evaluated by observing the magnitude and frequency of changes between alternatives. An adverse change in salinity is defined as the long-term, or substantial, increase in salinity.

3.1.4 Net Delta Outflow and X2 Position

The effects of changes in SWP and CVP operations on net Delta outflow and position of X2 were evaluated using frequency analysis. Figure 3.1-1 shows the location of net Delta outflow. The position of X2 varies from Suisun Marsh to Jersey Point and is not shown on the figure.

Net Delta outflow represents the net fresh water movement through the Delta and out to the Bay, excluding tides. Net Delta outflow is evaluated by observing the magnitude and frequency of changes in net Delta outflow between alternatives. Minimum flow standards apply to net Delta outflow; therefore, changes in flows that increase the frequency of minimum flows near the standards are evaluated. An adverse change in net Delta outflow is defined as the

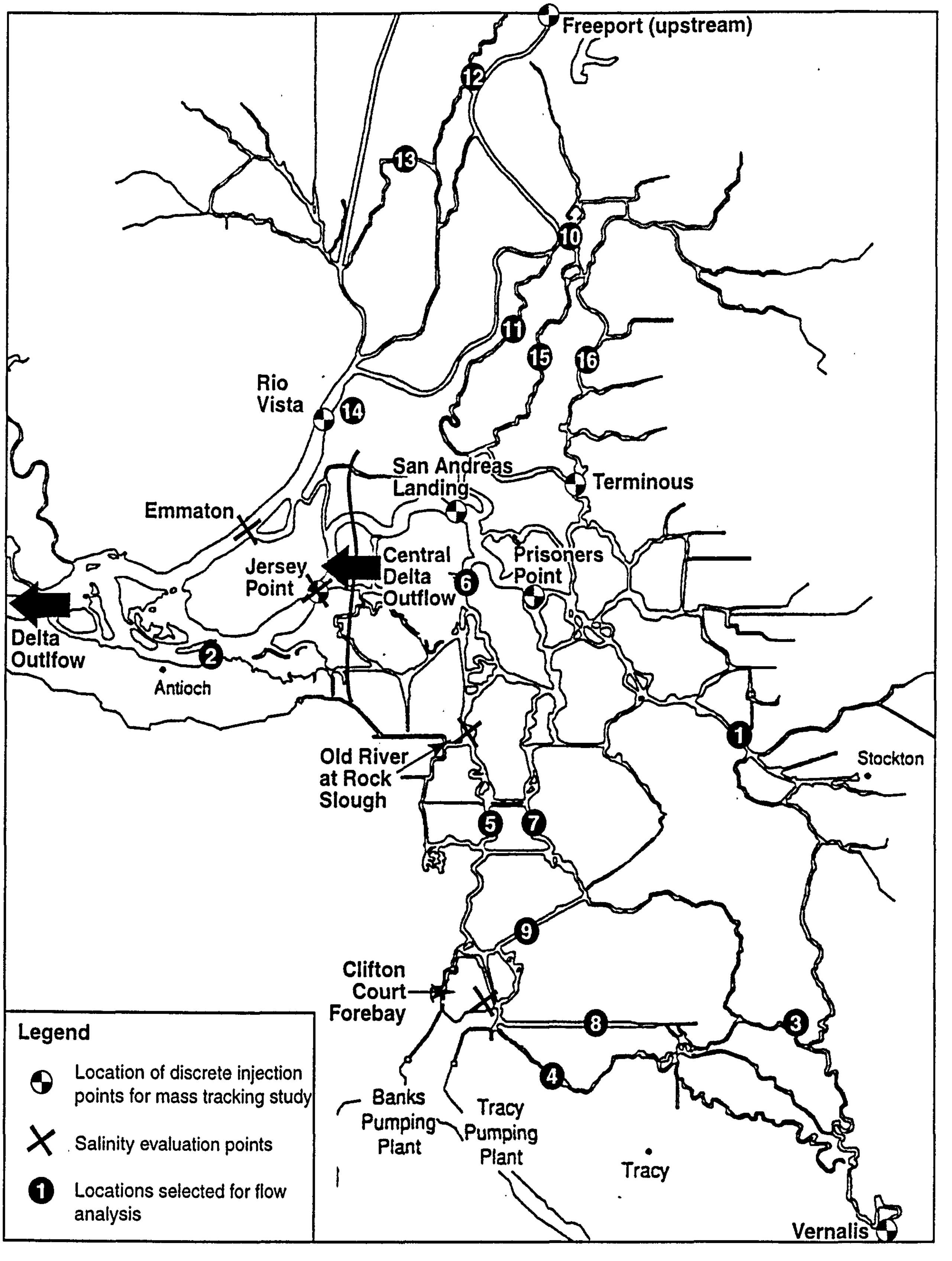

Figure 3.1-1. Key locations used in Delta Hydrodynamic Analysis.

long-term, or substantial, decrease in outflow, particularly in flows near the minimum flow standards.

The X2 position is the location in kilometers of the 2 parts-per-thousand isohaline. The impact analysis consists of comparing X2 position percentiles between alternatives. The differences between the frequency distributions are used to assess potential impacts. For X2 position, changes greater then 1 kilometer are identified and discussed.

3.1.5 Storage and Reoperation

To evaluate the potential effects of additional storage and reoperation on Delta hydrodynamics, changes in Sacramento River inflows were used to predict the impact on the Delta.

A relationship exists between Sacramento River flows at Freeport and inflows to the Delta. This relationship shows that the rate of Delta inflow through Georgiana Slough and the Delta Cross Channel are dependent on the magnitude of Sacramento River flows. Figure 3.1-2 shows the flow in Georgiana Slough and the Delta Cross Channel versus the flow in the Sacramento River at Freeport.

As shown on the figure, Georgiana Slough flows range from 15 to 20 percent of the Sacramento River flows when the Delta Cross Channel is closed. With the Delta Cross Channel open, Georgiana Slough flows vary from 10 to 20 percent of the Sacramento River flows. Delta inflows vary from 30 to 60 percent of the Sacramento River flows. The Delta Cross Channel is generally open when the flows in the Sacramento River are below 30,000 cfs.

With the Delta Cross Channel closed, there is essentially a one-for-one relationship between Georgiana Slough flows and Sacramento River flows for flows above 30,000 cfs. In other words, a 10 percent change in the Sacramento River flow would result in a 10 percent change in flow into the Delta via Georgiana Slough. The relationship is not as clearly defined for flows below 30,000 cfs. With the Delta Cross Channel open, the relationship shown on the figure can be used to determine the change in Delta inflow based on the change in Sacramento River flow. For example, if the Sacramento River flow is 10,000 cfs, a 20 percent drop (to 8,000 cfs) would be expected to reduce Delta inflow by 15 percent. If the Sacramento River flow is 30,000 cfs, a 20 percent drop (to 24,000 cfs) would reduce Delta inflow by 10 percent.

3.2 Bay Region

Since the components of the alternatives are focused on the Sacramento and San Joaquin river systems and the Delta, impacts on flows in San Francisco Bay will be minimal. Therefore, evaluation of the hydrodynamic impacts of the alternatives on the Bay focuses on salinity.

A key factor in the health of the Bay-Delta is the relationship between salinity and the ecology of the estuary. During the dry season, salt water from the Pacific Ocean moves landward within the Bay; during the wet winter season, salt water moves seaward, driven by the increased discharge of fresh water. The principal sources of fresh water to the Bay-Delta are the Sacramento River and San Joaquin River. Between winter and summer, salinity can vary by as much as 10 parts-per-thousand in many parts of the Bay.

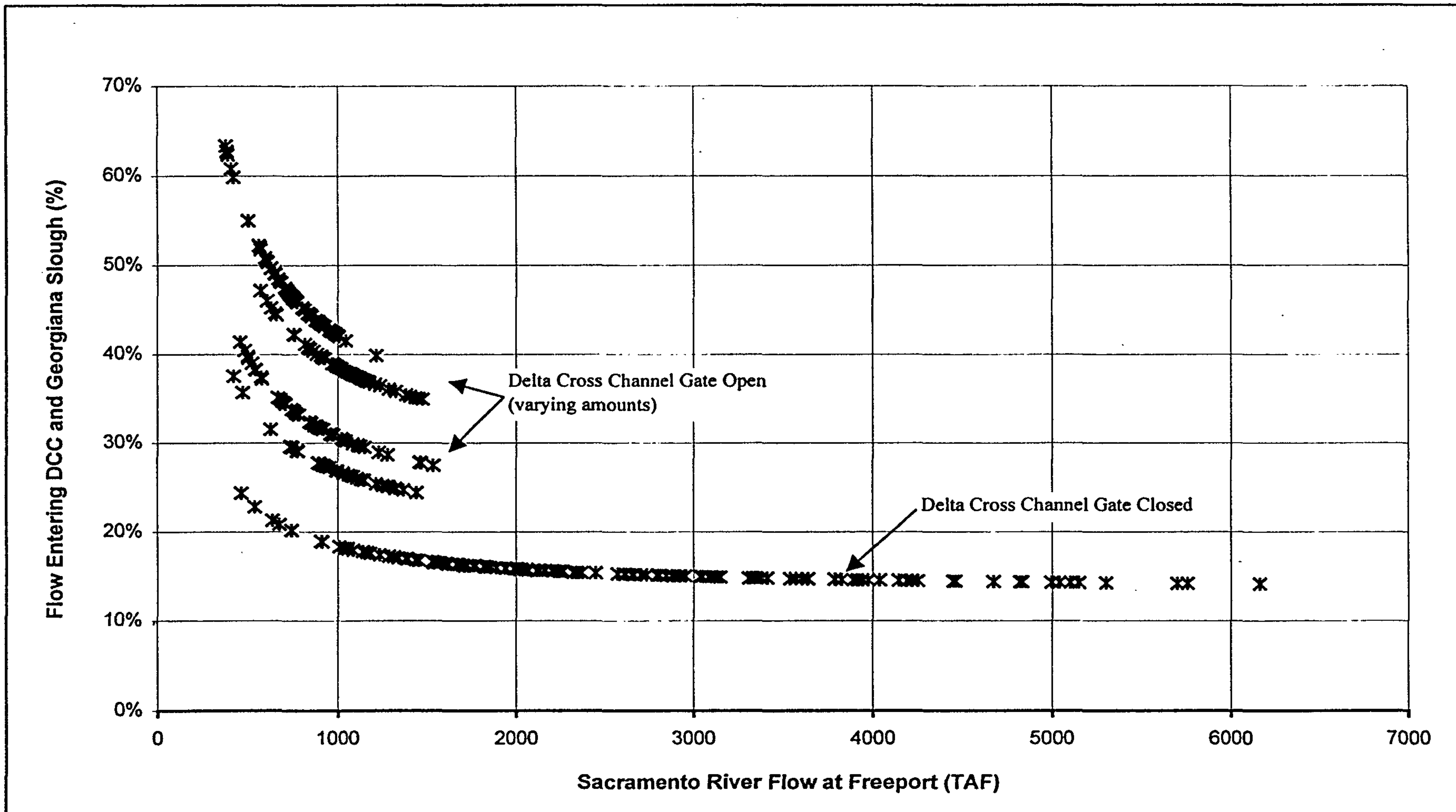

Figure 3.1-2. Flow in Georgiana Slough and the Delta Cross Channel versus Flow in the Sacramento River at Freeport

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Delta outflow is the major factor influencing seasonal and yearly variations in salinity, which in turn affects where aquatic species live within the Bay-Delta system. Most of the variations in the Bay are caused by the variations of fresh water discharge from the Delta and by the mixing of fresh water with seawater. Peak spring Delta outflows are thought to be important for maintaining the health of the Bay-Delta.

Although little is known about the effect of salinity on estuarine habitats, the X2 position is used in the decision making process to control fresh water flows and salinity. In this analysis, X2 and net Delta outflow are used to qualitatively discuss potential impacts on the Bay system from the CALFED alternatives.

3.3 Sacramento and San Joaquin River Regions

Potential changes in hydraulic conditions in the Sacramento and San Joaquin rivers were evaluated using the DWRSIM computer model. A set of model runs was prepared to simulate existing conditions, the No Action Alternative, and a range of potential storage and operating conditions. The alternative configurations are identified in Table 3.3-1.

The model runs provide a preliminary assessment of the magnitude of changes that would be expected for each alternative and configuration. The hydraulic effects of some configurations are expected to be similar to other configurations. In these cases, one set of modeling assumptions has been used to represent alternative configurations that would have similar hydraulic impacts. Differences between such configurations are discussed in qualitative terms.

The output from DWRSIM consists of calculated monthly flow volumes representing the amount of water in thousands of acre-feet that passes a control point defined in the model. These volumes can be readily converted to an average monthly flow rate (i.e. discharge), expressed in cubic feet per second. With a few exceptions, the control points generally represent actual locations along channels within the storage and conveyance system.

Nine locations in the Sacramento River system and three locations in the San Joaquin River system have been selected as the focal points for analyzing hydraulic changes in the rivers. These locations were selected based on the following primary goals:

- Provide adequate regional geographic coverage to support programmatic decisions;
- Assess potential changes in flow conditions at locations that are most likely to be affected by program alternatives.
- Identify potential changes at critical flow points in the system, such as the Sacramento River at Freeport and the San Joaquin River at Vernalis, at which points the rivers flow into the Delta.

The list of study locations is provided in Table 3.3-2 and a reference map showing the locations is presented in Figure 3.3-1.

Some of the control points in the DWRSIM model correspond reasonably well to locations with gaging stations. At these points, a historic record of discharge and other parameters is often available. The U.S. Geological Survey maintains a network of gaging stations and publishes the

Table 3.3-1. Alternative configurations evaluated using DWRSIM model.

Alternative Configuration	Run	Description
Existing Condition	469	SWRCB 1995 WQCP Study
No Action, 1A, 1B	472	CALFED Benchmark Study
2A,2C	472B	Benchmark + SDI
2D	498	Benchmark + SDI + SDSS
1C, 2B, 2E	510	Benchmark + SDI + SDSS + NDSS
3A, 3C	475	Benchmark + SDI + 5,000 cfs IF
3B, 3D-3I	500	Benchmark + SDI + SDSS + NDSS + 5,000 cfs IF

Benchmark Study includes WQCP objectives, ESA requirements, CVPIA flow recomendations, and predicted 2020 demands.

SDI = South Delta Improvements

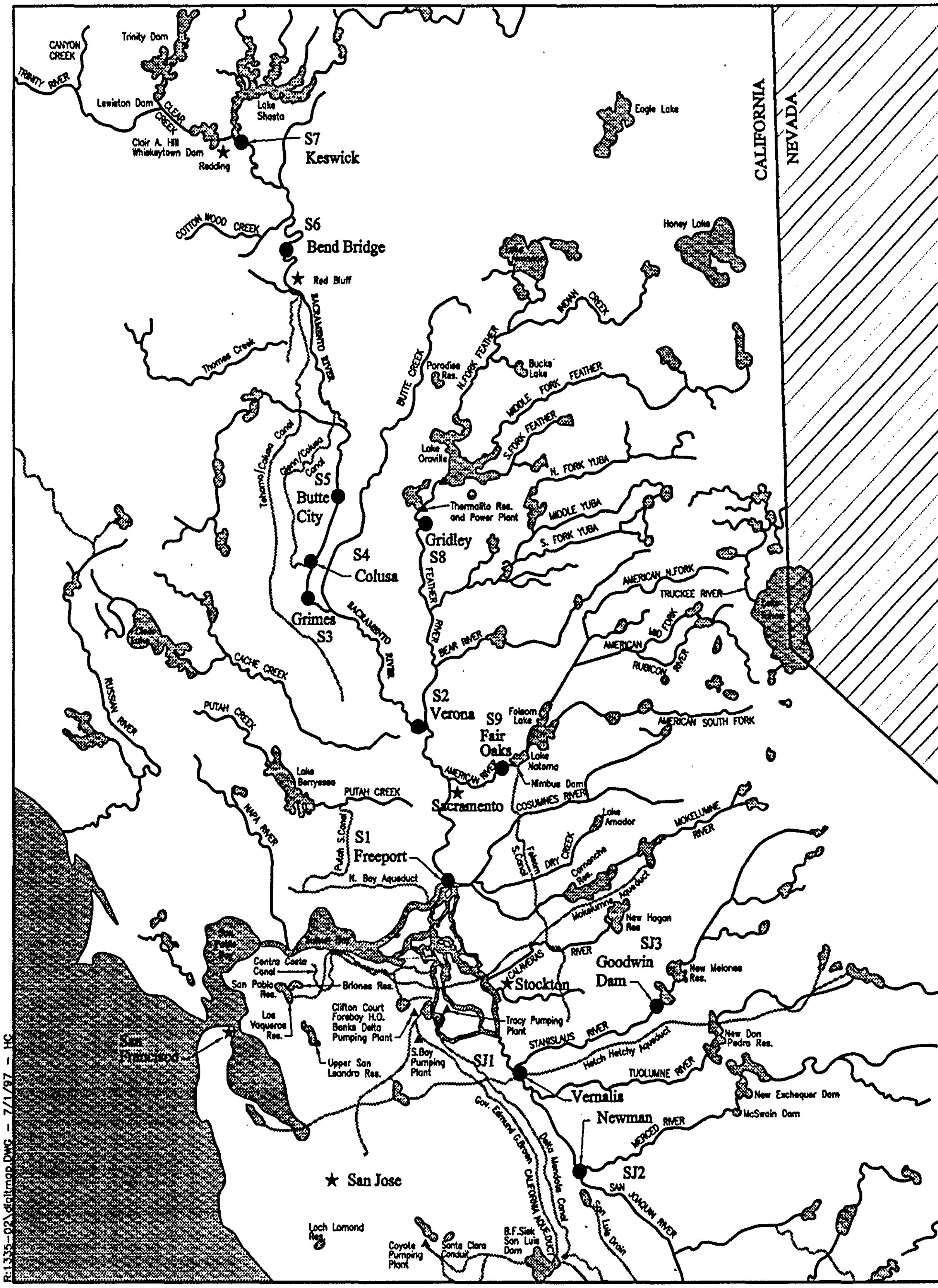
SDSS = South of Delta Surface Storage

NDSS = North of Delta Surface Storage

IF = Isolated Facility

Table 3.3-2 Station Information

Study Location	DWRSIM Control Point	USGS Station ID	Description	Station Location	Gage Elevation (msl)	Watershed Area (sq. miles)	Flood Thresholds	Maximum Daily Mean Discharge (cfs)	Minimum Monthly Discharge (cfs)	Maximum Monthly Discharge (cfs)	10% Exceeds (cfs)	90% Exceeds (cfs)	Minimum Mean Discharge (cfs)	Maximum Mean Discharge (cfs)	Period of Record for Statistics
S1	137	11447650	Sacramento River at Freeport	630 feet downstream from drawbridge at Freeport; 11 mi. south of Sacramento	sea level	not determined	flood flows bypass station through spill to Yolo Bypass	115000	4494 (10/78)	79040 (2/83)	52800	8740	12470 (October)	38570 (February)	1949-1994
S2	61	11425500	Sacramento River at Verona (DA 15 at Wilkins Slough)	1.5 mi downstream from Feather River; 19.1 mi. upstream from Sacramento	-3.00	21251	flood stage 41.3 ft; above 55,000 cfs, overflows to Yolo Bypass	92300	4725 (10/78)	71340 (3/83)	44200	7360	10680 (October)	32660 (February)	1946-1994
S3	61	11390500	Sacramento River below Wilkins Slough near Grimes (DA 15 at Wilkins Slough)	5.8 mi. southeast of Grimes; 62.9 mi upstream of Sacramento	-3.00	12926	flood stage 52.7 ft; above 23,000 cfs overflows into Sutter Bypass	32600	3330 (10/78)	29490 (3/83)	21500	5000	6665 (October)	16150 (February)	1946-1994
S4	120	11389500	Sacramento River at Colusa (North of Delta Storage Release)	60 ft downstream from highway bridge at Colusa; 89.4 mi. upstream from Sacramento	-2.95	12090	flood stage 70 ft; above 30,000 cfs overflows into Butte Sink and Sutter Bypass	51300	3219 (10/78)	44450 (3/83)	23100	5310	6636 (October)	18750 (February)	1946-1994
S5	120	11389000	Sacramento River at Butte City (North of Delta Storage Release)	0.5 mi. south of Butte City; 115.8 mi. upstream from Sacramento	-2.92	12080	above 90,000 cfs, overbank flow into Butte basin.	158000	3323 (10/78)	104500 (2/58)	23300	5280	6641 (October)	24850 (February)	1946-1994
S6	73	11377100	Sacramento River above Bend Bridge near Red Bluff (Sacramento River at Cottonwood Creek)	2.7 mi upstream from Bend Bridge	285.77	8900	flood stage 27 ft	127000	3935 (10/78)	75830 (3/83)	18800	5370	6901 (October)	18140 (February)	1964-1994
S7	62	11370500	Sacramento River at Keswick, Boards In (Sacramento River at Keswick)	1.6 mi. downstream from Keswick	479.81	6468		79700	2847 (12/78)	47170 (3/83)	14600	3910	6328 (October)	12330 (July)	1964-1994
S8	106	11407150	Feather River near Gridley (Feather River below Oroville-Thermalito Complex)	2.7 mi east of Gridley	-2.91	3676		146000	804 (4/91)	37860 (1/70)	8990	1050	2377 (October)	7180 (January)	1969-1994
S9	9	11446500	American River at Fair Oaks (American River at Lake Natomas)	2100 ft downstream from Nimbus dam	71.53	1888		131000	252 (12/78)	31140 (2/86)	7500	2480	1899 (October)	5209 (February)	1956-1994
SJ1	682	11303500	San Joaquin River at Vernalis	2.6 mi downstream from Stanislaus River	sea level	13536		70000	92.8 (7/77)	40040 (3/83)	11700	638	1311 (August)	7504 (May)	1924-1994
SJ2	695	11274000	San Joaquin River near Newman (San Joaquin and Merced Rivers	650 feet downstream from Merced River	sea level	9520		30300	25.2 (10/78)	24170 (3/83)	3590	211	481 (August)	2841 (March)	1944-1994
SJ3	675	11302000	Stanislaus River below Goodwin Dam (Stanislaus River Below Goodwin Dam, near Knights Landing)	0.9 mi. downstream from Goodwin Dam	252.83	986		6330	132 (1/90)	4905 (3/86)	1250	149	368 (September)	1096 (March)	1924-1994



River Hydraulics Study Location Map
Cal Fed Hydraulics

N

0 30 60
Approximate Scale in Miles

LEGEND:

● Study locations

Aqueduct/canal

Figure 3.3-1

measured parameters. Although the DWRSIM runs used in this analysis use input data representing the actual hydrologic record for water years 1922 through 1994, historic discharges are not expected to correlate well with the existing condition model simulation. This is because the existing conditions simulation is based on the existing configuration and current rules of operation of the system, which may be far different from historic conditions.

Discharge measurements reported at gaging stations are based on an empirical "rating curve" for the control section that relates the discharge to the height of water (i.e. stage) in the stream. The rating curve is developed by directly measuring the water velocity as it passes through the control section for a number of different depth conditions. Discharge (cfs) is then calculated from the product of the average velocity of the water (fps) and the cross-sectional area (square feet) of the stream. However, the velocity of water in a stream is not uniform. Discharge measurement is accomplished by measuring the velocity in many small vertical segments of a stream cross section, calculating the average velocity in the segment and multiplying by the area of the segment to get discharge. The total discharge in the cross section is then calculated as the sum of the segment discharges. Since DWRSIM only simulates discharge, an additional method is need to evaluate velocity, top width, and depth for the impacts analysis.

The average velocity at a stream bears a relationship to discharge (Leopold and Maddock 1953), which can be described by an equation $V = aQ^b$, where V is the cross-section average velocity (fps), Q is the rate of discharge (cfs), and a and b are constants that depend on the geometry of the stream.

Similar equations can be used to describe other hydraulic parameters, such as stream depth, width, and sediment load as a function of discharge. The equation for depth (D) as a function of discharge is given by $D = cQ^e$, where c and e are constants. The equation for stream width (W) as a function of discharge is given by $W = fQ^g$, where f and g are constants.

Although more complex equations have been developed to describe some of these relationships, the equations above were used in this analysis because they provide a convenient method of estimating the velocity, depth, stream width, and sediment load from model results. The constants in these equations were determined by finding the equation that best fit the measured data at each gaging station used in the analysis. A more detailed description of the method used to estimate hydraulic parameters is presented in Appendix A. The constants used in the analysis are presented in Table 3.3-3. Extremes in discharge can cause erosion and sedimentation that can alter the geometry of an alluvial stream channel.

Therefore, the resulting empirical relationships derived from the data are only expected to approximate actual conditions.

After using the simulated monthly average discharge data from the DWRSIM runs to obtain the corresponding hydraulic parameters, the differences between alternative configurations were evaluated in two ways: 1) regionally; and 2) impact on Delta inflow.

3.3.1 Regional Analysis

For the regional analysis, the minimum, maximum, and average discharge, mean channel velocity, channel depth and channel width were calculated by month for the 72-year simulation period. The data were evaluated for each of the locations shown in Table 3.3-3, for both high and low flow conditions. The month with the highest average discharge for existing conditions was selected to represent high flows, which, for both rivers, is the month of February. The month with the lowest average discharge for existing conditions was selected to represent low flows, which is the month of August for the Sacramento River and the month of September for the San Joaquin River. For each river, data tables were prepared for each study location, showing flow conditions for each alternative configuration.

3.3.2 Delta Inflow Analysis

Because of the importance of inflow into the Delta, a more comprehensive analysis was conducted for the Sacramento River at Freeport and the San Joaquin River at Vernalis. Charts were prepared for each location showing the range of discharge by month associated with each alternative. In addition, a frequency analysis was conducted for monthly flows. The results of this analysis show how flows with various probabilities of being exceeded in a given month would be affected by each alternative configuration. Probabilities of being exceeded of 5, 10, 25, 50, 75, 90, and 95 percent were calculated for each month and each configuration. A 5 percent probability flow is expected to be equaled or exceeded in a given month once in a 20-year period.

4.0 SIGNIFICANCE CRITERIA

The environmental consequences of a program may be either adverse or beneficial. The significance of adverse impacts must be judged with respect to their context and intensity. The general context for this programmatic analysis is regional. Site specific impacts of program components would be assessed at the next tier of environmental analysis.

This document has been prepared to support programmatic decisions by identifying possible changes in hydrodynamic conditions that have the potential to be significant at the program level. The analysis includes an evaluation of potential program-induced regional changes to flow conditions throughout the Sacramento River and San Joaquin River systems and throughout the Delta. Some discussion of the Bay also is included.

Built into the CALFED alternatives are two basic assumptions: 1) The importance of a unit of water is not fixed, but, varies according to the flow rate, the time of year, and the water year type. Water can be diverted during high flow periods with relatively little impact on the ecosystem and can be released at other times to produce greater benefits; and 2) A comprehensive ecosystem restoration program will improve ecosystem functions and the recovery of Bay-Delta species that are currently threatened, endangered, or of special concern. Improved flow management can not only reduce the impacts of diversions on the environment during critical periods, but can enhance flows during periods of time which produce the greatest benefit to the ecosystem health. If these assumptions are correct, it should be possible to change how water is managed to take advantage of the time value and restore ecosystem health. However, the complex interrelationship between the movement of water and

Table 3.3-3 Coefficients and Exponents for Calculating Stream Velocity, Depth, and Width

USGS Station	Description	Period used for analysis	Elevation Datum	Flow Range	Stage			Depth Correction	Flow Range	Average Depth			Flow Range	Width			Flow Range	Velocity		
				(cfs)	coef	exp	R^2		(cfs)	coef	exp	R^2	(cfs)	coef	exp	R^2	(cfs)	coef	exp	R^2
11446500	American River at Fair Oaks	1987-95	71.53	0 - 120,000	0.055	0.52	0.98	-3.1	0-120,000	0.30	0.36	0.75	0-120,000	110	0.14	0.62	0-40,000	0.028	0.52	0.80
"	"	"	"														40,000-120,000	0.30	0.29	1.00
11370500	Sacramento River at Keswick, Boards In	1973-97	479.81	0 - 19,000	0.71	0.35	1.00	5.0	0 - 19,000	2.0	0.15	0.59	0 - 19,000	453	0.028	0.15	0 - 19,000	0.001	0.82	0.96
"	Sacramento River at Keswick, Boards Out	1973-97	479.81	0 - 82,000	0.71	0.35	1.00	5.0	0 - 20,000	0.30	0.32	0.81	0 - 30,000	127	0.15	0.77	0 - 30,000	0.031	0.51	0.98
"	"	"	"						20,000-82,000	0.13	0.41	0.94	30,000-82,000	36	0.27	0.73	30,000-82,000	0.16	0.35	0.96
11377100	Sacramento River above Bend Bridge	1988-97	285.77	0 - 135,000	0.14	0.48	1.00	7.0	0-40,000	0.00	0.77	0.99	0-40,000	149	0.10	0.75	0-135,000	1.21	0.15	0.93
"	"	"	"						40,000-105,000	0.72	0.28	0.58	40,000-105,000	0.68	0.62	0.78				
"	"	"	"						105,000-135,000	0.00	0.84	0.88	105,000-135,000	24	0.34	1.00				
11389500	Sacramento River at Colusa	1987-97	-2.95	0-46,000	0.029	0.66	0.99	-33	0-10,000	0.04	0.61	0.83	0-46,000	88	0.13	0.66	0-46,000	0.22	0.28	0.83
"	"	"	"						10,000-46,000	0.06	0.57	0.93								
11389000	Sacramento River at Butte City	1987-95	-2.92	0-105,000	0.045	0.56	0.99	-64	0-105,000	0.17	0.44	0.98	0-105,000	334	0.04	0.61	0-105,000	0.016	0.53	0.98
11390500	Sacramento River below Wilkins Slough	1987-97	-3.00	0 - 30,000	1.92	0.31	0.99	0.0	0-30,000	0.094	0.54	0.97	0-30,000	52	0.17	0.73	0-30,000	0.21	0.29	0.95
11447650	Sacramento River at Freeport	1989-97	sea level	0-100,000	0.030	0.55	0.43	-100	0-100,000	0.45	0.38	0.93	0-100,000	368	0.05	0.50	0-100,000	0.008	0.55	0.89
11425500	Sacramento River at Verona	1987-97	-3.00	0-100,000	0.11	0.52	0.99	0.0	0-30,000	0.039	0.59	0.93	0-39,000	231	0.08	0.75	0-30,000	0.12	0.32	0.76
"	"	"	"						30,000-100,000	0.23	0.42	0.84	39,000-100,000	7.4	0.41	0.90	30,000-100,000	0.25	0.25	0.66
11302000	Stanislaus River below Goodwin Dam	1989-97	252.83	0 - 7,000	0.060	0.56	0.99	-7.0	0-2,000	0.29	0.38	0.89	0-2,000	40	0.15	0.79	0-2,000	0.086	0.48	0.94
"	"	"	"						2,000-7,000	0.13	0.48	0.99	2,000-7,000	27	0.20	1.00	2,000-7,000	0.28	0.32	0.98
11303500	San Joaquin River at Vernalis	1988-97	sea level	0 - 50,000	0.16	0.49	1.00	-4.0	0-10,000	0.028	0.67	0.98	0-10,000	131	0.09	0.69	0-50,000	0.31	0.22	0.73
"	"	"	"						10,000-50,000	0.029	0.63	0.92	10,000-50,000	101	0.15	0.85				
11274000	San Joaquin River near Newman	1995-97	sea level	0-13,000	0.70	0.36	0.99	-42.0	0-4,000	0.10	0.55	0.73	0-4,000	60	0.15	0.86	0-13,000	0.13	0.33	0.68
"	"	"	"						4,000-13,000	5.35	0.07	0.44	4,000-13,000	1.3	0.60	0.92				
"	"	"	"							linear coef.	intercept									
11407150	Feather River near Gridley	1987-97	-2.91	0-120,000	0.019	0.61	0.98	-73.5	0-55,000	0.00	9.11	0.98	0-55,000	205.29	0.043	0.61	0-11,000	0.00	0.87	0.99
"	"	"	"							linear coef.	intercept			linear coef.	intercept					
"	"	"	"						55,000-120,000	0.00	36.43	0.99	55,000-120,000	0.010	-221.38	0.97	11,000-120,000	0.05	0.44	0.98

ecosystem health makes it difficult to define adverse and beneficial changes simply on the basis of changed flow conditions.
Generally, it is accepted that increased fresh water flow through the Delta is beneficial and a decrease in fresh water flow can be adverse if it causes a degradation in water quality and ecosystem habitat. On the other hand, a diversion of fresh water flows in the winter when high flows exist is assumed to be beneficial if it is later used to augment flow or supplies during a critical period. An adverse flow change is a change that causes a degradation of water quality or ecosystem habitat, increases the risk of flooding, or reduces navigability. Beneficial impacts enhance water quality, ecosystem habitat and navigability, and reduce the risk of flooding.

In order to conduct a systematic analysis of Delta hydrodynamics and riverine hydraulics, and provide useful results, a definition of adverse and beneficial impacts is needed. Adverse has been defined as a long-term or substantial decrease in flow, especially during low flow conditions. Adverse is also defined as the increase in flow at or near flood stage. Therefore, in addition to evaluating a range of possible flow conditions and scenarios, the analysis also focuses on identifying potential adverse conditions on the basis of the above definition.

Adverse Impacts
Two situations may occur that could cause program-induced changes in hydrodynamic conditions to be considered ***adverse***:

- If a program alternative were to cause a long-term or substantial decrease in low flows within the rivers or Delta, as compared to the No Action Alternative, which could degrade water quality, fish habitat, or navigability.

- If a program alternative were to cause a long-term or substantial increase in high flows within the rivers or Delta, as compared to the No Action Alternative, which could increase the likelihood of flooding.

The significance of impacts will be assessed with respect to the degree to which either of these changes occur, as evidenced by changes in various hydraulic indicators. Hydraulic indicators addressed in this report include channel discharge, velocity, depth, and top width in the rivers. In addition, flow, velocity, stage, net Delta outflow, and central Delta outflow, salinity, and mass tracking were also evaluated within the Delta.

Beneficial Effects
Program-induced changes in hydrodynamic conditions that would be ***beneficial*** are the reverse of the adverse effects:

- If a program alternative were to cause an increase in low flows within the rivers or Delta, as compared to the No Action Alternative, which could enhance water quality, fish habitat, or navigability.

- If a program alternative were to cause a decrease in high flows within the rivers or Delta, as compared to the No Action Alternative, which could decrease the likelihood of flooding.

Beneficial effects are identified without consideration of their degree or significance.

5.0 ENVIRONMENTAL IMPACTS/CONSEQUENCES

5.1 No Action Alternative

5.1.1 Summary of No Action Effects

In the Delta region, separate modeling studies from existing conditions were not performed to evaluate the effects of the No Action Alternative on flows, velocities, stages, mass fate, central Delta outflow, and salinity; however, no substantial effects on these are anticipated. Based on modeling studies performed to date, no substantial effects on the Delta are expected for the No Action Alternative.

For the Sacramento River region, for the No Action Alternative, DWRSIM was configured to simulate the projected water resources demands associated with the base year 2020. Since the streams are part of the conveyance system that brings water to pumping facilities in the Delta, the additional spills needed to meet the higher demand results in slightly higher flows in Sacramento Region streams. The percentage increase of in-stream flows are largest in reaches below major dams such as Shasta and Oroville.

No substantial changes in flows are observed in the San Joaquin River relative to existing conditions as a result of the No Action Alternative. During low flow periods, minimum flow requirements control in-stream flows. Differences are in the range of 1 percent.

5.1.2 Comparison to Existing Conditions

5.1.2.1 Delta Region

5.1.2.1.1 Flow, Velocity, and Stage

For the No Action Alternative, Delta geometry is the same as for existing conditions. Therefore, the same modeling simulation was used to represent both existing conditions and the No Action Alternative. The existing conditions in the Delta are described in the Delta Hydrodynamics and Riverine Hydraulics Affected Environment Technical Report. Some changes in exports are likely for the No Action Alternative due to predicted 2020 demand.

5.1.2.1.2 Mass Fate

For the No Action Alternative, Delta geometry is the same as for existing conditions. Therefore, the same modeling simulation was used to represent both existing conditions and the No Action Alternative. The existing conditions in the Delta are described in the Delta Hydrodynamics and Riverine Hydraulics Affected Environment Technical Report. Some changes in exports are likely for the No Action Alternative due to predicted 2020 demand.

5.1.2.1.3 Net Delta Outflow

Using DWRSIM modeling, differences in net Delta outflows between the No Action Alternative and existing conditions were evaluated. For the No Action Alternative, average annual Delta outflow was 20,000 cfs and ranged from 5,600 cfs to 92,000 cfs. In comparison, the average annual Delta outflow for existing conditions was 20,700 cfs and ranged from 5,500 cfs to 94,300 cfs. Monthly average outflows for the No Action Alternative are similar to outflows for existing conditions.

Table 5.1-1 shows the distribution of monthly averaged net Delta outflow for the No Action Alternative by percentiles. The 10th percentile indicates the value where 10 percent of the numbers are equal to or less than the indicated value. The 90th percentile indicates the value where 90 percent of the numbers are equal to or less than the indicated value. The 90th percentile also can be used to indicate that 10 percent of the numbers are greater than the indicated value. The 50th percentile (median) represents a measure of central tendency.

February typically has the largest variation of net Delta outflow, ranging from 11,000 cfs (10th percentile) to 133,000 cfs (90th percentile); in addition to the largest median flow of 31,000 cfs. August has the smallest variation of net Delta outflow, ranging from 3,000 cfs to 5,000 cfs for the 10th and 90th percentiles, respectively. These outflows at these percentiles are similar to those estimated for existing conditions.

Table 5.1-1 presents two methods used in this report to analyze the differences between Alternatives 1, 2, and 3, and the No Action Alternative. The first method uses the difference between the distributions of values and the second method uses the distribution of the differences between the values for the alternatives. The difference in distributions is determined by subtracting the corresponding percentile values for the No Action Alternative from the values for existing conditions. For example, the 90th percentile January net Delta outflow for the No Action Alternative is subtracted from the 90th percentile January net Delta outflow for existing conditions to obtain a negative 3 percent difference in the two distributions, which is shown in Table 5.1-1. This approach shows the change in the percentiles between alternatives and indicates what range of values have experienced changes. The distribution of differences is determined by first calculating the actual differences between the net Delta outflows for the alternatives, creating a new distribution of the differences, and then calculating percentiles of the new distribution. This approach shows the distribution of actual changes in net Delta outflow that occurred. For example, the January data in Table 5.1-1 suggest that 60 percent of the outflows under the No Action Alternative are less than outflows under existing conditions. The data also suggest that about 25 percent of the outflows for the No Action Alternative are reduced by 10 percent or more from existing conditions. The advantage of this approach is that it provides the magnitude and frequency of the changes that occurred. In both methods, negative values indicate that Alternative 1 net Delta outflows are less than outflows under existing conditions.

Analysis of the distribution of differences suggests that the No Action Alternative reduces net Delta outflow about 40 percent of the time in 7 of the 12 months. Most of these differences occur in the fall and winter. June experiences substantial reductions (changes greater than 10 percent) about 50 percent of the time. In the winter, substantial decreases occur about 10 to 20 percent of the time. In late

Table 5.1-1 Net Delta outflow: differences between No Action Alternative and existing conditions.

Existing Conditions

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
90%	101494	132725	94826	67948	44155	21017	8002	4889	9613	15050	18587	66332	54899
80%	74529	77249	62234	44024	24925	13760	8002	4567	5028	9371	12214	39764	26542
70%	34134	57904	43192	24489	21399	11112	8002	4242	3075	6427	9741	15697	16059
60%	27228	49797	35126	19827	14065	10272	8002	4001	3025	5403	7562	10396	11336
50%	18605	31150	29323	16301	11206	9882	6505	4001	3008	4586	5176	8831	9176
40%	13271	24931	21816	13001	10308	9273	6505	4001	3008	4056	4564	6470	6991
30%	11114	20235	17360	11125	7696	8843	4993	3497	3008	4001	4504	5035	5199
20%	7149	13274	13255	10043	6749	8228	4993	3497	3008	4001	4504	4524	4504
10%	6001	11326	11401	8036	5936	6900	4001	2992	3008	4001	3536	4505	3497

No Action Alternative

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
90%	98397	132113	91592	66950	43726	20836	8002	5116	8820	14078	19202	63873	53787
80%	73212	75531	60243	43311	25117	13710	8002	4889	4887	9423	11061	36320	25420
70%	30845	55138	40694	23208	20105	10393	8002	4616	3260	6252	8783	15655	15520
60%	24203	44003	33919	19841	14159	9058	8002	4329	3012	5452	6806	9631	10957
50%	17581	31186	27209	16503	11206	7983	6505	4001	3008	4912	5058	7253	8002
40%	11170	24229	22369	13014	10275	7341	6505	4001	3008	4066	4504	5852	6672
30%	9690	18507	16690	11085	7797	6890	4993	3497	3008	4001	4504	4775	5221
20%	6782	12493	12178	10043	6720	6625	4993	3497	3008	4001	4504	4505	4504
10%	6001	11398	10259	8094	5978	5953	4001	2992	3008	4001	3496	4505	3497

Difference in Distributions (a)

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
90%	-3%	0%	-3%	-1%	-1%	-1%	0%	5%	-8%	-6%	3%	-4%	-2%
80%	-2%	-2%	-3%	-2%	1%	0%	0%	7%	-3%	1%	-9%	-9%	-4%
70%	-10%	-5%	-6%	-5%	-6%	-6%	0%	9%	6%	-3%	-10%	0%	-3%
60%	-11%	-12%	-3%	0%	1%	-12%	0%	8%	0%	1%	-10%	-7%	-3%
50%	-6%	0%	-7%	1%	0%	-19%	0%	0%	0%	7%	-2%	-18%	-13%
40%	-16%	-3%	3%	0%	0%	-21%	0%	0%	0%	0%	-1%	-10%	-5%
30%	-13%	-9%	-4%	0%	1%	-22%	0%	0%	0%	0%	0%	-5%	0%
20%	-5%	-6%	-8%	0%	0%	-19%	0%	0%	0%	0%	0%	0%	0%
10%	0%	1%	-10%	1%	1%	-14%	0%	0%	0%	0%	-1%	0%	0%

Distribution of Differences (b)

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
90%	4%	3%	0%	2%	1%	0%	0%	14%	4%	4%	2%	3%	3%
80%	1%	0%	0%	1%	1%	0%	0%	8%	0%	1%	0%	1%	1%
70%	0%	-1%	-2%	1%	1%	0%	0%	5%	0%	0%	0%	0%	0%
60%	-1%	-1%	-2%	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%
50%	-2%	-2%	-4%	0%	0%	-9%	0%	0%	0%	0%	0%	0%	0%
40%	-4%	-4%	-4%	0%	0%	-16%	0%	0%	0%	0%	0%	-1%	-1%
30%	-7%	-5%	-6%	0%	0%	-21%	0%	0%	-1%	0%	-1%	-8%	-2%
20%	-13%	-8%	-9%	-1%	-1%	-25%	0%	0%	-1%	-2%	-6%	-14%	-6%
10%	-22%	-14%	-13%	-4%	-2%	-30%	0%	0%	-4%	-12%	-21%	-24%	-15%

a) The difference in distributions is determined by subtracting the corresponding percentile values for the No Action Alternative from the percentile values for existing conditions. For example, the 90% January value for the No Action Alternative is subtracted from the 90% January value for existing conditions to obtain a -3% difference in the two distributions. This approach shows the change in the percentiles between alternatives and indicates the magnitude or range of values where changes have taken place.

b) The distribution of differences is determined by first calculating the actual differences in net Delta outflow between alternatives, creating a new distribution of the differences, and then calculating percentiles for the new distribution. This approach shows the distribution of actual changes in net Delta outflow that occurred. For example, January data suggest that 60% of the flows under the No Action Alternative are less than flows under existing conditions and about 20% of the flows are greater than for existing conditions. This approach also indicates the magnitude of the changes that occurred. For example, January data suggest that about 25% of the No Action flows are reduced by 10% or more from existing conditions.

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summer through mid-winter, net Delta outflow increases
slightly 5 to 10 percent of the time.

5.1.2.1.4 Central Delta Outflow

For the No Action Alternative, Delta geometry is the same as for existing conditions. Therefore, the same modeling simulation was used to represent both existing conditions and the No Action Alternative. The existing conditions in the Delta are described in the Delta Hydrodynamics and Riverine Hydraulics Affected Environment Technical Report. Some changes in exports are likely for the No Action Alternative due to predicted 2020 demand.

5.1.2.1.5 X2 Position

The comparison of X2 position between the No Action Alternative and existing conditions is based on DWRSIM modeling and shows very little differences. The No Action Alternative tends to move the average X2 location slightly upstream, on the order of tenths of kilometers.

5.1.2.1.6 Salinity

For the No Action Alternative, Delta geometry is the same as for existing conditions. Therefore, the same modeling simulation was used to represent both existing conditions and the No Action Alternative. The existing conditions in the Delta are described in the Delta Hydrodynamics and Riverine Hydraulics Affected Environment Technical Report. Some changes in exports are likely for the No Action Alternative due to predicted 2020 demand.

5.1.2.1.7 Storage and Reoperation

As discussed in Section 3, the current modeling does not include simulation of Delta hydrodynamics with the reoperation of SWP and CVP facilities and new storage configurations. As a result, the evaluation of potential impacts on Delta hydrodynamics from the reoperation of SWP and CVP facilities and new storage is based on changes in flows occurring in the Sacramento River at Freeport and their relationship to changes in Delta Cross Channel flows.

Table 5.1-2 lists the monthly distributions of differences for Sacramento River flows between the No Action Alternative and existing conditions. Overall, Sacramento River flows increase slightly compared to existing conditions, while the monthly distributions indicate a shift in the timing of flows. Flows increase by 10 percent or more in July, August, September, and October about 20 to 30 percent of the time and decrease in June about 45 percent of the time. A small but observed trend of decreasing flows occur during the fall and winter. The changes in Delta Cross Channel flows parallel changes in the Sacramento River, although to a lesser degree. Delta Cross Channel flows are reduced in June and increased in July through October as observed for Sacramento River flows.

Figure 5.1-1 shows the relationship between changes in Sacramento River flows and changes in the Delta Cross Channel flows. The figure demonstrates a linear relationship between the percent changes in Sacramento River flows and the percent changes in Delta Cross Channel flows, with a ratio of 3:2. For example, a change of 20 percent in the Sacramento

Table 5.1-2. Distribution of differences in Sacramento River and Delta Cross Channel flows between No Action Alternative and existing conditions.

Sacramento River at Freeport													
Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
90%	2%	7%	2%	2%	6%	2%	16%	40%	23%	17%	3%	7%	12%
80%		2%		1%	1%		10%	32%	20%	12%	1%	1%	4%
70%				1%	1%		4%	21%	12%	5%	1%		1%
60%						-5%	2%	8%	8%	2%			
50%						-8%	1%	4%	3%	1%			
40%						-13%		2%	1%	1%			
30%	-1%	-1%	-1%			-15%					-1%		
20%	-2%	-4%	-5%	-1%		-17%				-1%	-2%	-2%	-3%
10%	-6%	-9%	-13%	-1%	-4%	-22%	-3%	-8%	-3%	-3%	-8%	-9%	-9%
Delta Cross Channel													
Percentile	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Overall**
90%	3%	5%	2%	1%	4%	1%	10%	24%	13%	10%	2%	4%	7%
80%		1%		1%	1%		7%	19%	11%	6%	1%		2%
70%				1%	1%		3%	13%	7%	3%			1%
60%						-3%	2%	5%	5%	1%			
50%						-5%		3%	2%	1%			
40%						-9%		1%					
30%		-1%	-1%			-11%							
20%	-1%	-4%	-4%			-12%					-2%	-2%	-2%
10%	-4%	-7%	-10%	-1%	-2%	-16%	-2%	-6%	-2%	-2%	-6%	-8%	-6%

Zero percent shown as blank spaces; boxed values represent changes greater than 10 percent.

Negative values indicate decreased flow, while positive values indicate increased flow.

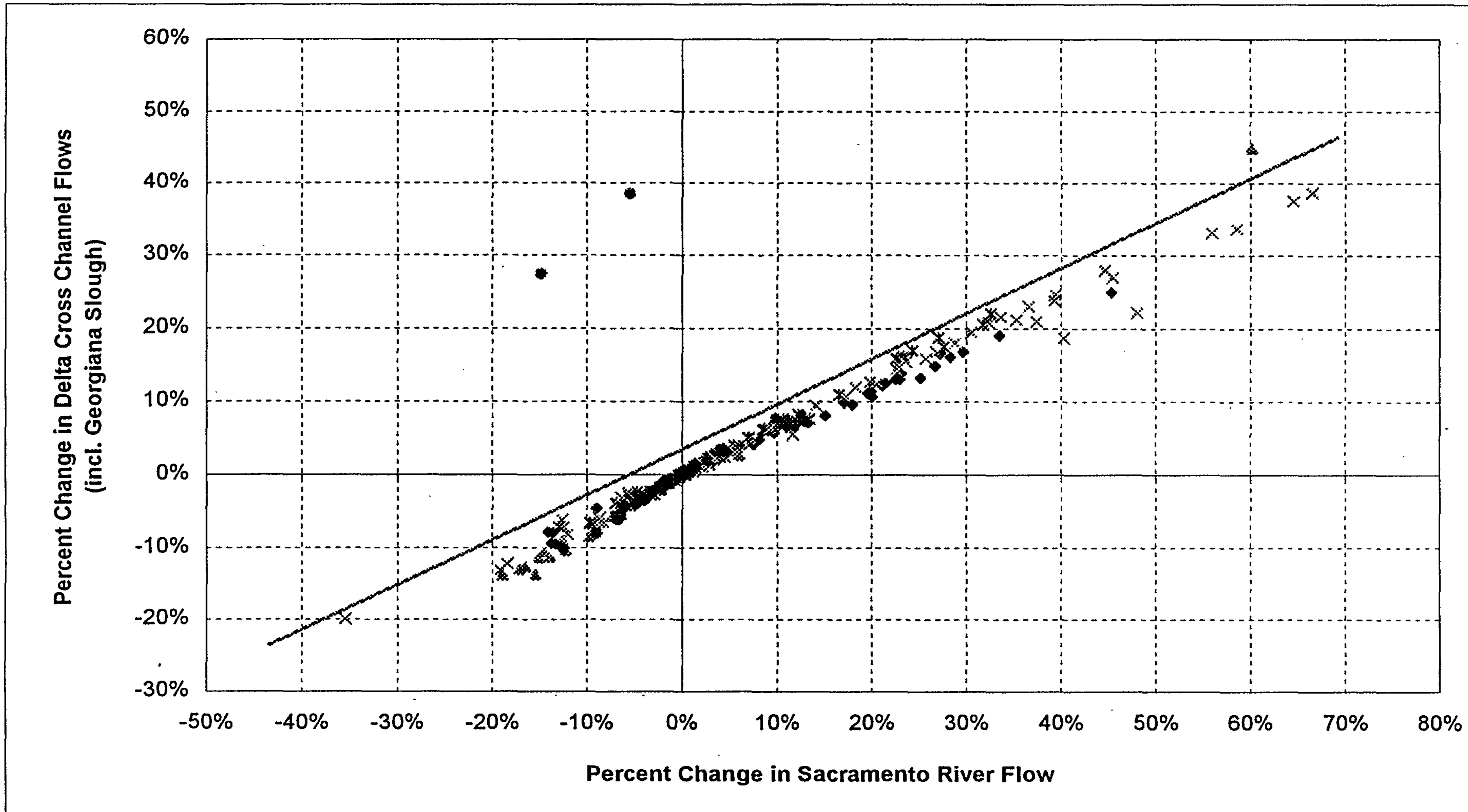


Figure 5.1-1. Percent change in Sacramento River flow versus percent change in Delta Cross Channel flow.

River flow corresponds to approximately a 13 percent change in the Delta Cross Channel flow. The two outliers on Figure 5.1-1 also demonstrate the impact of opening the cross channel gates when they were originally closed: changes in Delta Cross Channel flows can jump 30 to 40 percent.

Relating these results to changes in net Delta outflow and exports demonstrates that the storage and reoperation component of the No Action Alternative will increase Delta channel flows toward the export pumps throughout most of the year except in the spring. In April and May, exports and Sacramento River flows remain about the same between the No Action Alternative and existing conditions. In June, exports and Sacramento River flows are substantially reduced for the No Action Alternative. During the summer, the increased Sacramento River flows appear to provide the extra flows needed for the increased exports. During the fall and winter, the increased exports are apparently made up by reduced net Delta outflow. Based on this analysis, the reoperation of SWP and CVP facilities and new storage may cause an increase in cross Delta flows from the north to the south during the summer and an increase in the frequency of reverse flows in the central and southern Delta during the fall and winter for the No Action Alternative.

5.1.2.2 Bay Region

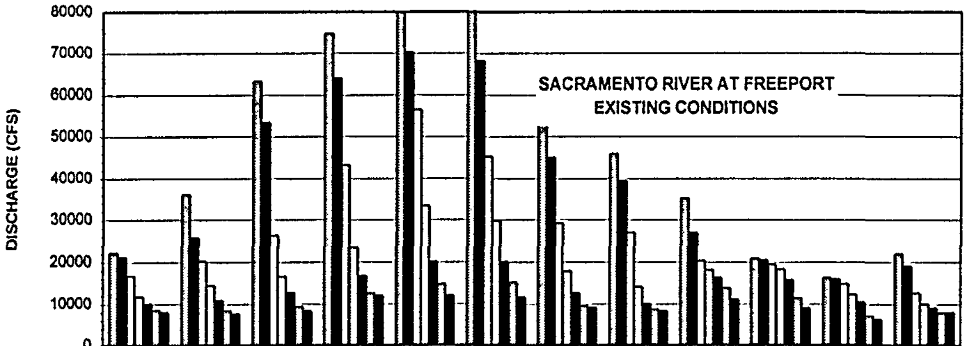
The No Action Alternative will reduce fresh water flow to the Bay by 3 percent or more in 25 percent of the months. Most of these differences occur in the fall and winter. If the average fall and winter Delta outflow is 30,000 cfs, then the No Action Alternative reduces net Delta outflow by 900 cfs. The amount of fresh water flowing to the Bay from the Delta will be reduced accordingly.

Seasonally, the No Action Alternative has more impact on the Bay during fall and winter. Maintaining net Delta outflow is more critical during spring and summer when municipal and agricultural demands are high and fresh water discharge is needed for fish migrations.

5.1.2.3 Sacramento River Region

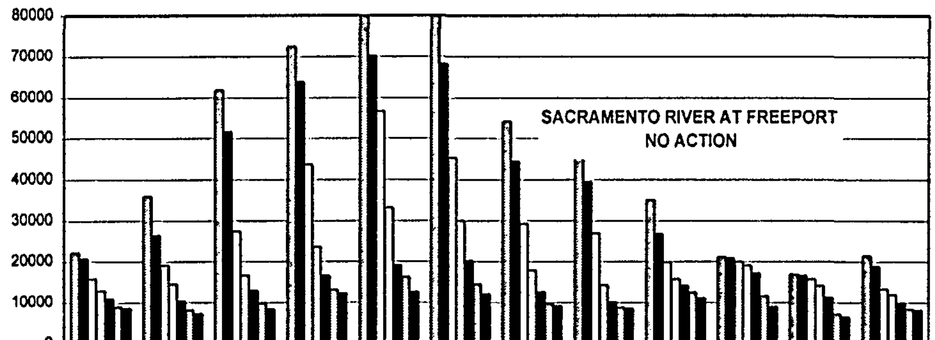
For the No Action Alternative, the demand for water would continue to increase without any modifications to the current supply. Flows in the Sacramento River were modeled using DWRSIM with predicted 2020 demands. Figure 5.1-2 illustrates the projected frequency of flows for the Sacramento River at Freeport for both existing conditions and No Action Alternative. As shown on Figure 5.1-2, the highest flows in December and January, i.e. those that are equaled or exceeded in only 5 out of every 100 years, would be reduced by 2 to 3 percent for the No Action Alternative as compared to existing conditions. For most months, low flows actually would be greater for the No Action Alternative, as compared to existing conditions, by 2 to 3 percent. These differences in river flows between the No Action Alternative and existing conditions are not considered significant. Therefore, No Action flow conditions in the Sacramento River at Freeport are not expected to be substantially different than for existing conditions.

The DWRSIM model results suggest that more substantive changes may occur at

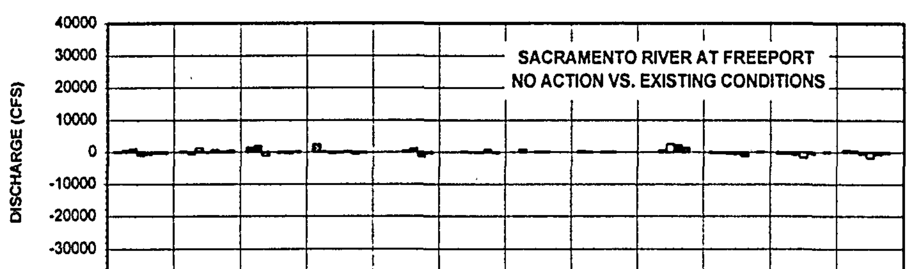


	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	22154	36041	63203	74754	79851	79855	54030	45935	35036	20873	16221	21905
10 percent	21159	25740	53344	63967	70267	68190	45096	39390	26676	20443	15699	19145
25 percent	16686	20284	26201	43229	56467	45327	29208	26867	20284	19436	14702	12621
50 percent	11807	14366	16573	23452	33329	29627	17864	14100	18150	18296	12344	10063
75 percent	10067	10924	12751	16735	20131	20102	12636	10067	16285	15694	10539	9075
90 percent	8525	8329	9348	12575	14733	15145	9546	8696	13818	11427	7110	7963
95 percent	8011	7606	8376	11969	12104	11654	9068	8379	11061	8997	6310	7959

MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	22131	35941	61915	72431	79851	79855	54030	45668	35036	21113	16745	21326
10 percent	20601	26479	51513	63916	70267	68190	44417	39358	26916	20782	16465	18843
25 percent	15727	19125	27453	43684	56467	45245	29208	26949	19763	19939	15682	13310
50 percent	12881	14503	16573	23631	33095	29990	17814	14231	15663	19012	14084	11966
75 percent	10880	10302	12978	16540	19086	20216	12571	10051	14050	17077	11222	9682
90 percent	8860	8147	9791	13112	16205	14494	9626	8724	12483	11524	7133	8336
95 percent	8519	7193	8333	12259	12529	12042	9089	8457	11078	8916	6457	8033



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	23	101	1288	2322	0	0	0	267	0	-241	-524	578
10 percent	358	-739	1831	72	0	0	679	33	-40	-338	-566	303
25 percent	960	1160	-1252	-456	0	81	0	-81	521	-504	-980	-689
50 percent	-1073	-118	0	-179	234	-163	50	-130	2487	-716	-1740	-1862
75 percent	-813	622	-228	195	1044	-114	67	16	2235	-1382	-683	-807
90 percent	-335	182	-442	-537	-1473	651	-81	-26	1334	-98	-23	-353
95 percent	-507	413	42	-270	-425	-387	-20	-78	-17	81	-146	-74

MONTH

FIGURE 5.1-2 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, EXISTING CONDITIONS AND NO ACTION other upstream locations on the Sacramento River system. For example, model results suggest that average September flows at Keswick Reservoir and at Cottonwood Creek, would be about 15 percent higher for No Action Alternative, as compared to existing conditions. At the Keswick location, the average mean velocity in September would increase by about 13 percent. Data for No Action Alternative at other locations in the system are presented in the comparison of alternatives, Section 5.4.

5.1.2.4 San Joaquin River Region

Flows in the San Joaquin River also were modeled using DWRSIM with predicted 2020 demands. Figure 5.1-3 illustrates the projected frequency of flows for the San Joaquin River at Vernalis for existing conditions and No Action Alternative. As shown on Figure 5.1-3, the flows for No Action Alternative for almost all months and frequencies are similar to existing conditions, with differences generally being less than 1 percent. These differences in river flows between no action and existing conditions are not considered significant. Therefore, No Action Alternative hydrodynamic flow conditions in the San Joaquin River at Vernalis are not expected to be substantially different than for existing conditions.

The DWRSIM model results suggest that similar results can be found at other locations within the San Joaquin River system. At the two other locations studied on the San Joaquin River, model results suggest that flows for No Action Alternative generally would be within a percentage point of those for existing conditions. Data for No Action Alternative at these locations are presented in the comparison of alternatives Section 5.5.

5.2 Delta Region

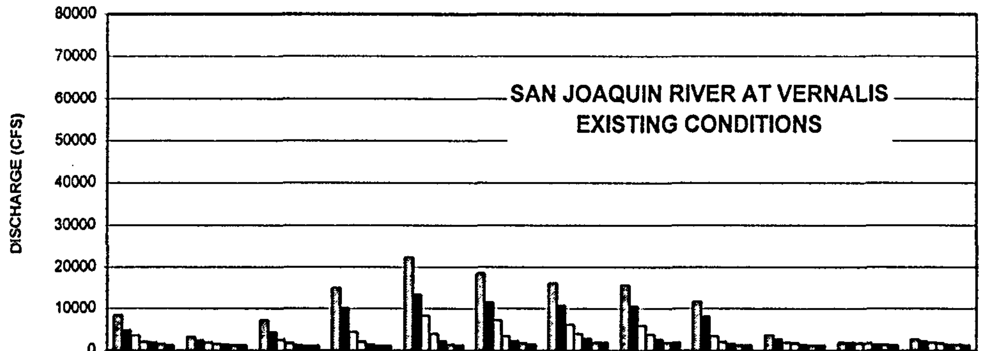
5.2.1 Summary of Regional Effects by Alternative

A summary of the potential hydrodynamic effects of Alternatives 1, 2, and 3 on the Delta is presented in Table 5.2-1. The summary is presented by the alternatives' effects on the following: flow, velocity, and stage; mass fate; net Delta outflow; central Delta outflow; X2 position; and salinity. The summary is further broken down by alternative configuration. The potential effects were determined based on the modeling studies performed to date. The potential effects of those configurations that were not modeled were estimated by their similarity to other configurations.

5.2.2 Comparison of Program Actions to No Action Alternative

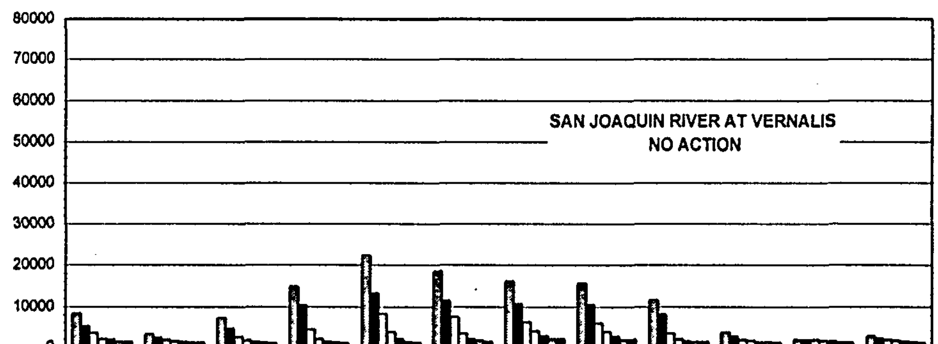
5.2.2.1 Alternative 1

The three components of Alternative 1 are reoperation of the SWP and CVP; CVP-SWP improvements (including a new intake at Clifton Court Forebay, fish screens, and increased pumping plant capacity to 10,300 cfs); and south Delta modifications (including flow and fish control structures and channel modifications to increase conveyance capacity). The hydrodynamic effects of Alternative 1 on the Delta are evaluated by its effects on the following: flow, velocity, and stage; mass fate; net Delta outflow;central Delta outflow; X2 position; and salinity.

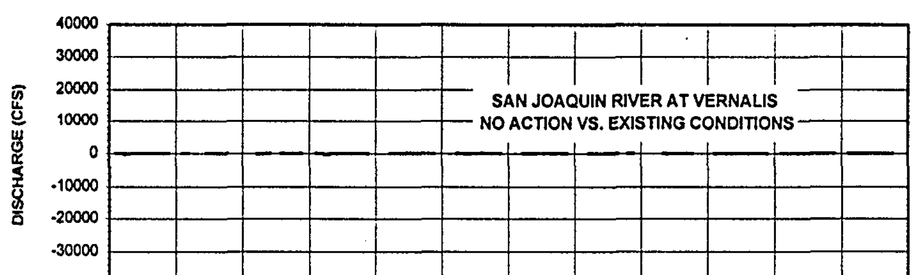


	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7221	14897	22353	18534	16174	15672	11630	3669	1893	2672
10 percent	4902	2333	4349	10064	13274	11459	10688	10581	8151	2654	1867	2202
25 percent	3545	1849	2521	4375	8265	7237	6201	5936	3428	1870	1805	1949
50 percent	2000	1830	1891	2017	3897	3415	3983	3622	2134	1875	1675	1897
75 percent	1919	1412	1317	1350	2287	2277	2807	2683	1563	1447	1496	1479
90 percent	1522	1294	1171	1155	1430	1665	1983	1890	1331	1311	1366	1361
95 percent	1334	1237	1138	1132	1260	1368	1983	1870	1304	1278	1295	1287

MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7237	14829	22364	18550	16184	15681	11636	3688	1887	2672
10 percent	5230	2346	4625	10409	13270	11459	10688	10581	8154	2651	1854	2202
25 percent	3545	1933	2521	4375	8193	7432	6201	5936	3428	1870	1805	1933
50 percent	2000	1613	1708	2000	3763	3415	3983	3622	2134	1859	1675	1897
75 percent	1903	1412	1317	1350	2017	2065	2807	2683	1563	1431	1480	1479
90 percent	1444	1294	1171	1156	1430	1665	1983	1903	1331	1308	1272	1361
95 percent	1334	1247	1125	1122	1260	1368	1983	1870	1328	1262	1213	1297



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	0	0	-16	68	-11	-16	-10	-10	-7	0	7	0
10 percent	-329	-13	-276	-345	4	0	0	0	-3	3	13	0
25 percent	0	-84	0	0	72	-195	0	0	0	0	0	17
50 percent	0	17	-16	16	234	0	0	0	0	16	0	0
75 percent	16	0	0	0	270	211	0	0	0	16	16	0
90 percent	78	0	0	0	0	0	0	-13	0	3	94	0
95 percent	0	-10	13	10	0	0	0	0	-24	16	81	-10

MONTH

FIGURE 5.1-3 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, EXISTING CONDITIONS AND NO ACTION

Table 5.2-1. Summary of Potential Effects of Alternatives on Delta.

Category	Alternative 1			Alternative 2				
	1A	1B	1C	2A	2B	2C	2D	2E
Flow, Velocity, and Stage	• No substantial effects	• No substantial effects	• Reduces reverse flows in San Joaquin River between Vernalis and Disappointment Slough • Changes in stage and velocity in areas near flow control structures	• Similar to 2B	• Improves circulation of flows • Reduces reverse flows in San Joaquin River • Increases flows in Mokelumne River and Old River near Woodward Island • Changes in stage and velocity in areas near flow control structures	• No substantial effects in north Delta • Decreased flow through south Delta	• Improves circulation of flows • Reduces reverse flows in San Joaquin River • Increases flows in Mokelumne River • More flow carried by Old River due to channel improvements • Decreased velocity and increased minimum stage in channels with setback levees • Changes in stage and velocity in areas near flow control structures	• No substantial effects
Mass Fate	• No substantial effects	• No substantial effects	• No substantial effects	• Similar to 2B with reduced mass reaching exports	• For lower flow conditions, no significant effects except at low pumping conditions where more mass injected at Vernalis becomes trapped on Delta islands and less reaches the exports • For higher flow conditions, substantially more mass injected in north Delta remained in the Delta after 60 days	• Potentially more mass injected in central Delta reaching exports	• For lower flow conditions, mass injected at Freeport and Terminous remains in the Delta longer before reaching the endpoints • For higher flow conditions, substantially more mass injected in north remained in Delta after 60 days	• For lower flow conditions, mass injected at Freeport and Terminous remains in the Delta longer before reaching the endpoints • For higher flow conditions, no substantial effects
Net Delta Outflow	• No substantial effects	• Similar to 1C	• Decreases outflow in late summer, fall, and winter about 25% of the time. No change in spring and summer. • Increases the frequency of flows in the 4,000 to 6,500 cfs range. No change in the 3,000 to 4,000 cfs range.	• Decreases outflow in late summer and fall about 25% of the time. No change in spring and summer. • Increases the frequency of flows in the 4,000 cfs to 6,500 cfs range. No change in the 3,000 to 4,000 cfs range.	• Similar to 1C	• Similar to 2A	• Decreases outflow in late summer, fall and winter about 25% of the time. No change in spring and summer. • Increases the frequency of flows in the 4,000 cfs to 6,500 cfs range. No change in the 3,000 to 4,000 cfs range.	• Similar to 2B
Central Delta Outflow	• No substantial effects	• Similar to 1C	• No change in the frequency of reverse flows. However, increases magnitude of reverse flows and decreases magnitude of downstream flows.	• Similar to 2B	• Substantially reduces the frequency and magnitude of reverse flows. • Reverse flows remain in July and August about 25% of the time.	• unknown	• Substantially reduces the frequency and magnitude of reverse flows. • Reverse flows remain in July and August about 25% of the time.	• Substantially reduces the frequency and magnitude of reverse flows. • Reverse flows remain in July and August only about 10% of the time.
X2 Position	• No substantial effects	• Similar to 1C	• Moves the average seaward location 1 to 5 kilometers upstream in late summer and fall about 25% of the time.	• Moves the average seaward location 1 to 3 kilometers upstream in late summer and fall about 25% of the time.	• Similar to 1C	• unknown	• Moves the average seaward location 1 to 3 kilometers upstream in late summer and fall about 25% of the time.	• Similar to 2B
Salinity	• No substantial effects	• Similar to 1C	• No change at Jersey point and Emmaton. • Increases salinity at Rock Slough in the spring about 75% of the time. • Increases salinity at Clifton Court Forebay throughout the year about 50% of the time.	• Similar to 2B	• Substantially reduces salinity at Jersey Point throughout the year. • Increases salinity at Emmaton in the summer and fall about 75% of the time. • Increases salinity at Rock Slough in the spring about 50% to 75% of the time. • Increases salinity at Clifton Court Forebay in May through August about 50% of the time and in the winter about 25% of the time.	• unknown	• Substantially reduces salinity at Jersey Point throughout the year. • Increases salinity at Emmaton in the summer and fall about 75% of the time. • Increases salinity at Rock Slough similar to 2B. • Increases salinity at Clifton Court Forebay similar to 2B.	• Substantially reduces salinity at Jersey Point throughout the year. • Increases salinity at Emmaton in the summer about 75% of the time. • Increases salinity at Rock Slough in the spring about 75% of the time. • Increases salinity at Clifton Court Forebay similar to 2B.

Category	Alternative 3								
	3A	3B	3C	3D	3E	3F	3G	3H	3I
Flow, Velocity, and Stage	• Similar to 3E but flows through Delta reduced to a lesser degree	• Similar to 3E but flows through Delta reduced to a lesser degree	• Same as 3A	• Same as 3B	• Less flow down Sacramento River at Rio Vista and through Delta toward pumps • Reduces reverse flows in San Joaquin River • Decreased velocity in channels with setback levees • Changes in stage and velocity in areas near flow control structures	• Similar to 3E	• Similar to 3E but flows through Delta reduced to a lesser degree	• Similar to 2E with reduced flows through Delta	• Similar to 2C with reduced flows through Delta
Mass Fate	• Similar to 3E	• Similar to 3E	• Same as 3A	• Same as 3B	• Reduces mass reaching exports from all locations except Freeport • For low flow conditions, increases travel time through Delta for mass injected in south and central Delta	• Similar to 3E	• Similar to 3E	• Similar to 2E except isolated facility reduces mass reaching exports from all locations except Freeport	• Similar to 2C except isolated facility reduces mass reaching exports from all locations except Freeport
Net Delta Outflow	• Decreases outflow in late summer and fall about 25% of the time. Decreases outflow in the spring about 25% of the time (April and May). No change in July and August. • Increases the frequency of flows in the 4,000 cfs to 6,500 cfs range. Negligible change in the 3,000 to 4,000 cfs range.	• Decreases outflow in the late summer, fall, and winter about 25% of the time. Decreases outflow in the spring about 25% of the time. No change in July and August. • Increases number of months with flows in the 4,000 cfs to 5,000 cfs range. Negligible change in the 3,000 to 4,000 cfs range.	• Similar to 3A	• Similar to 3B	• Similar to 3B	• Similar to 3B	• Similar to 3B	• Similar to 2D	• Similar to 3B
Central Delta Outflow	• Similar to 3E	• Similar to 3E	• Similar to 3E	• Similar to 3E	• Reverse flows are not	• Similar to 3E	• Similar to 3E	• Similar to 3E	• unknown
X2 Position	• Moves the average seaward location 1 to 4 kilometers upstream in late summer and fall about 25% of the time. Moves the average landward location 1 to 3 kilometers upstream in winter and spring.	• Moves the average seaward location 1 to 7 kilometers upstream in late summer and fall about 40% of the time. Moves the average landward location 1 to 5 kilometers upstream in winter and spring about 40% of the time.	• Similar to 3A	• Similar to 3B	• Similar to 3B	• Similar to 3B	• Similar to 3B	• Similar to 2D	• Similar to 3B
Salinity	• Similar to 3E	• Similar to 3E	• Similar to 3E	• Similar to 3E	• Increases salinity at Jersey Point in the winter and spring about 50% of the time. Reduces salinity at Jersey Point during the remaining times of year. • Substantially increases salinity at Emmaton throughout the year about 50% of the time, more so in summer and fall. • I. Substantially increases salinity at Rock Slough throughout the year. Rock Slough salinities increase in winter and spring about 90% of the time. • Substantially reduces salinity at Clifton Court Forebay.	• Similar to 3E	• Similar to 3E.	• Similar to 3E	• unknown.

5.2.2.1.1 Flow, Velocity, and Stage

DWRDSM1 modeling was performed for Configurations 1A and 1C to evaluate differences in monthly average flows, velocities, and stages between Alternative 1 and the No Action Alternative. A comparison of flows, velocities, and stages between Configurations 1A and 1C and the No Action Alternative for a number of locations within the Delta is presented in Tables 5.2-2, 5.2-3, and 5.2-4 for high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively. These numbers are based on modeling of the Delta with Delta geometry changes appropriate for the respective alternatives, predicted 2020 demands, and the increased pumping capacity of the Banks Pumping Plant of 10,300 cfs. In general, there are only small changes in flows in the north Delta and moderate changes in the south Delta for Alternative 1.

Configurations 1A and 1B

Configuration 1A involves reoperating existing facilities. Average tidal flows, velocities, and stages throughout the Delta, based on DWRDSM1 modeling, are shown in Figures 5.2-1 through 5.2-3 for the high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

For high inflow conditions, there are no substantial differences in flows between Configuration 1A and the No Action Alternative. For Configuration 1A, more of the Sacramento River inflow remains in the river, with approximately 15 percent diverted to Steamboat and Sutter Sloughs and 5 percent diverted to Georgiana Slough. In the south Delta, similar to the No Action Alternative, 60 percent of the San Joaquin River inflow at Vernalis for Configuration 1A is diverted to Old River near Mossdale and 40 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 10 percent travels down Middle River, while 65 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. As for the No Action Alternative, for Configuration 1A, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north, and the ratio of flow in Old River to flow in Middle River is about 1.5. Flow in the central Delta is distributed similarly to the No Action Alternative, with False River carrying about 35 percent of the central Delta outflow, Dutch Slough carrying about 5 percent, and the main channel of the San Joaquin River carrying the remaining 60 percent.

For low inflow/high pumping conditions, there are also no substantial differences in flows between Configuration 1A and the No Action Alternative. For Configuration 1A, as in the No Action Alternative, approximately 20 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter Sloughs, 30 percent is diverted to the Delta Cross Channel, and 20 percent travels down Georgiana Slough. The remainder continues down the Sacramento River. In the south Delta, the San Joaquin River experiences reverse flow like in the No Action Alternative. Of the flow in Old River at Mossdale, approximately 85 percent is carried by the Grant Line Canal and 15 percent is carried by Old River toward the pumping plants. Reverse flows occur in Middle River at

Table 5.2-2. Flows, velocities, and stages at locations within the Delta for high inflow conditions.

Location		No Action Alternative			Configuration 1A				Configuration 1C				Configuration 2B				Configuration 2D				Configuration 2E				Configuration 3E			
Tidal Flow (cfs)	Loc. Key	Avg.	Max. Sea-ward	Max. Land-ward	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*
San Joaquin River at Fourteen Mile Slough	1	17,464	21,598	11,350	17,872	21,993	11,787	2%	17,762	21,914	11,801	2%	17,671	21,760	11,877	1%	17,645	20,563	13,136	1%	17,550	20,168	13,610	0%	17,645	21,469	11,960	1%
San Joaquin River at Antioch	2	55,602	170,018	110,216	56,535	170,441	109,068	2%	56,721	169,340	108,256	2%	61,470	169,471	101,305	11%	62,303	163,821	94,583	12%	77,546	170,976	72,368	39%	60,668	171,819	103,141	9%
Old River at Mossdale	3	24,254	24,292	24,198	23,800	23,836	23,749	-2%	23,909	23,964	23,839	-1%	23,914	23,968	23,844	-1%	23,995	24,042	23,929	-1%	24,004	24,056	23,933	-1%	23,941	23,992	23,890	-1%
Old River at Fabian Tract	4	4,584	4,842	4,136	4,495	4,743	4,023	-2%	4,853	5,104	4,367	6%	4,836	5,078	4,356	5%	4,539	4,776	4,169	-1%	4,528	4,753	4,132	-1%	4,620	4,892	4,267	1%
Old River at Woodward Island	5	9,275	15,015	1,121	9,715	15,316	402	5%	10,097	17,817	3,790	9%	10,077	17,369	3,569	9%	8,321	15,381	5,250	-10%	8,391	14,938	5,206	-10%	13,502	17,918	5,129	46%
Old River at Franks Tract	6	1,571	5,248	4,010	1,622	5,247	3,982	3%	1,592	5,130	3,929	1%	1,617	5,057	3,965	3%	1,655	6,377	5,469	5%	1,903	6,457	5,598	21%	1,956	4,896	3,641	25%
Middle River at Woodward Island	7	5,669	10,036	2,175	5,989	10,245	1,628	6%	5,746	11,407	4,210	1%	5,668	10,987	4,136	0%	4,125	9,541	7,227	-27%	3,814	8,940	7,502	-33%	8,929	12,257	3,064	58%
Grant Line Canal	8	15,996	16,513	14,679	15,749	16,284	14,405	-2%	15,486	16,068	14,214	-3%	15,447	16,010	14,186	-3%	15,736	16,298	14,730	-2%	15,711	16,257	14,665	-2%	15,673	16,314	14,780	-2%
Victoria Canal	9	-3,809	-57	5,911	-4,111	-518	6,136	8%	-3,280	1,199	5,784	-14%	-3,260	1,174	5,634	-14%	-1,306	1,844	2,717	-66%	-1,204	1,990	2,552	-68%	-6,529	-3,230	7,522	71%
Delta Cross Channel	10	0	114	283	0	114	283	NA	0	110	279	NA	0	46	108	NA	0	23	59	NA	0	172	185	NA	0	121	301	NA
Georgiana Slough	11	11,201	11,683	10,792	11,194	11,678	10,785	0%	11,198	11,670	10,809	0%	10,166	10,635	9,863	-9%	10,117	10,634	9,738	-10%	39,842	47,259	35,306	256%	10,330	10,821	9,919	-8%
Diversion to Sutter/Steamboat Sloughs	12	17,892	18,194	17,443	17,893	18,195	17,445	0%	17,891	18,194	17,442	0%	16,140	16,477	15,640	-10%	16,152	16,498	15,627	-10%	14,059	14,699	13,167	-21%	16,353	16,683	15,863	-9%
Miner Slough	13	10,579	11,140	9,757	10,579	11,141	9,759	0%	10,578	11,138	9,754	0%	9,459	10,073	8,557	-11%	9,470	10,057	8,573	-10%	8,047	8,792	6,958	-24%	9,596	10,202	8,709	-9%
Sacramento River at Rio Vista	14	184,780	219,089	132,546	184,786	218,874	132,641	0%	184,774	219,388	132,383	0%	177,886	213,229	124,453	-4%	177,961	216,699	124,914	-4%	155,961	192,257	98,245	-16%	178,707	212,879	125,896	-3%
Mokelumne River, North Fork	15	5,951	7,687	2,374	5,951	7,683	2,366	0%	5,943	7,618	2,394	0%	7,393	10,498	1,024	24%	7,676	8,886	5,541	29%	2,960	4,152	1,094	-50%	3,964	6,567	2,077	-33%
Mokelumne River, South Fork	16	2,823	5,803	3,845	2,824	5,795	3,866	0%	2,823	5,699	3,854	0%	3,008	5,888	2,884	7%	2,689	6,003	3,661	-5%	2,625	8,655	9,832	-7%	1,743	5,026	4,965	-38%
Velocity (fps)	Loc. Key	Avg.	Max. Sea-ward	Max. Land-ward	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*
San Joaquin River at Fourteen Mile Slough	1	1.05	1.24	0.69	1.07	1.26	0.71	2%	1.06	1.26	0.71	2%	1.05	1.25	0.71	1%	1.1	1.2	0.8	1%	1.04	1.17	0.80	0%	1.05	1.23	0.71	1%
San Joaquin River at Antioch	2	0.92	2.75	1.58	0.93	2.76	1.57	2%	0.94	2.75	1.55	2%	1.01	2.76	1.45	10%	1.0	2.7	1.4	11%	1.26	2.83	1.04	37%	1.00	2.79	1.48	8%
Old River at Mossdale	3	6.86	6.89	6.82	6.80	6.82	6.76	-1%	6.77	6.80	6.72	-1%	6.77	6.81	6.73	-1%	6.8	6.9	6.8	-1%	6.83	6.86	6.79	0%	6.79	6.82	6.75	-1%
Old River at Fabian Tract	4	2.07	2.18	1.79	2.02	2.13	1.74	-2%	2.07	2.21	1.79	0%	2.07	2.19	1.79	0%	2.0	2.1	1.8	-2%	2.00	2.11	1.76	-3%	1.95	2.09	1.77	-6%
Old River at Woodward Island	5	0.90	1.53	0.10	0.94	1.56	0.04	5%	0.98	1.79	0.34	9%	0.98	1.73	0.32	8%	0.8	1.5	0.5	-11%	0.80	1.43	0.47	-12%	1.29	1.77	0.45	43%
Old River at Franks Tract	6	0.27	0.81	0.69	0.28	0.81	0.68	3%	0.28	0.79	0.67	2%	0.28	0.78	0.67	4%	0.3	1.0	0.9	8%	0.33	1.02	0.90	22%	0.33	0.75	0.62	24%
Middle River at Woodward Island	7	0.81	1.49	0.28	0.85	1.52	0.21	5%	0.82	1.67	0.55	2%	0.81	1.60	0.54	0%	0.6	1.3	1.0	-28%	0.54	1.24	0.99	-34%	1.25	1.76	0.39	54%
Grant Line Canal	8	3.16	3.33	2.80	3.13	3.30	2.76	-1%	3.04	3.23	2.69	-4%	3.02	3.21	2.68	-4%	3.1	3.3	2.8	-2%	3.07	3.23	2.79	-3%	3.00	3.19	2.76	-5%
Victoria Canal	9	-0.80	-0.01	1.30	-0.86	-0.10	1.34	7%	-0.69	0.23	1.24	-14%	-0.68	0.22	1.19	-15%	-0.3	0.4	0.6	-65%	-0.26	0.39	0.54	-68%	-1.30	-0.60	1.54	62%
Delta Cross Channel	10	0.00	0.02	0.05	0.00	0.02	0.05	NA	0.00	0.02	0.05	NA	0.00	0.01	0.02	NA	0.0	0.0	0.0	NA	0.00	0.03	0.03	NA	0.00	0.02	0.05	NA
Georgiana Slough	11	2.83	2.98	2.67	2.83	2.97	2.67	0%	2.83	2.97	2.68	0%	2.66	2.79	2.53	-6%	2.6	2.8	2.6	-7%	3.37	3.97	2.99	19%	2.69	2.85	2.52	-5%
Diversion to Sutter/Steamboat Sloughs	12	4.38	4.49	4.22	4.38	4.49	4.22	0%	4.38	4.49	4.22	0%	4.09	4.22	3.91	-7%	4.1	4.2	3.9	-6%	3.73	3.94	3.46	-15%	4.13	4.25	3.95	-6%
Miner Slough	13	2.57	2.78	2.28	2.57	2.78	2.28	0%	2.57	2.78	2.28	0%	2.36	2.60	2.05	-8%	2.4	2.6	2.1	-8%	2.09	2.38	1.72	-18%	2.39	2.62	2.08	-7%
Sacramento River at Rio Vista	14	3.04	3.65	2.07	3.04	3.65	2.07	0%	3.04	3.65	2.07	0%	2.93	3.55	1.95	-4%	2.9	3.5	2.0	-3%	2.59	3.24	1.54	-15%	2.94	3.56	1.97	-3%
Mokelumne River, North Fork	15	0.99	1.29	0.38	0.99	1.28	0.38	0%	0.99	1.27	0.38	0%	1.23	1.80	0.16	25%	1.3	1.5	0.9	28%	0.47	0.67	0.17	-52%	0.66	1.11	0.33	-33%
Mokelumne River, South Fork	16	0.39	0.80	0.52	0.39	0.79	0.52	0%	0.39	0.78	0.52	0%	0.42	0.84	0.38	7%	0.4	0.8	0.5	-5%	0.35	1.16	1.29	-10%	0.24	0.67	0.68	-38%
Stage (mllw)	Loc. Key	Avg.	Max.	Min.	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*
San Joaquin River at Fourteen Mile Slough	1	5.2	7.0	3.8	5.3	7.1	3.8	0%	5.3	7.0	3.9	0%	5.3	7.0	4.0	2%	5.3	6.5	4.4	1%	5.5	6.6	4.8	6%	5.3	7.0	4.0	2%
San Joaquin River at Antioch	2	4.2	6.4	2.2	4.2	6.4	2.2	0%	4.2	6.4	2.2	0%	4.2	6.4	2.2	0%	4.2	6.4	2.2	-1%	4.2	6.4	2.1	0%	4.2	6.4	2.2	0%
Old River at Mossdale	3	20.8	20.9	20.8	20.6	20.7	20.5	-1%	20.8	20.9	20.7	0%	20.8	20.9	20.7	0%	20.7	20.8	20.6	-1%	20.7	20.7	20.6	-1%	20.7	20.8	20.7	0%
Old River at Fabian Tract	4	8.0	8.7	7.6	8.0	8.7	7.6	0%	8.6	9.3	8.0	7%	8.6	9.2	8.1	7%	8.1	8.7	7.7	1%	8.2	8.8	7.8	3%	8.7	9.3	8.2	9%
Old River at Woodward Island	5	5.2	7.0	3.8	5.2	7.0	3.9	0%	5.3	7.0	4.0	1%	5.3	7.0	4.1	2%	5.3	6.5	4.4	2%	5.5	6.7	4.7	6%	5.4	6.9	4.1	3%
Old River at Franks Tract	6	5.1	6.7	3.7	5.1	6.7	3.7	0%	5.1	6.6	3.8	0%	5.1	6.7	3.9	2%	5.1	6.2	4.2	1%	5.3	6.4	4.5	5%	5.1	6.7	3.9	2%
Middle River at Woodward Island	7	5.2	7.0	3.8	5.2	7.0	3.8	0%	5.2	7.0	3.9	1%	5.3	7.0	4.0	2%	5.2	6.5	4.4	1%	5.5	6.7	4.7	6%	5.3	7.0	4.0	3%
Grant Line Canal	8	8.1	8.9	7.6	8.1	8.9	7.6	-1%	8.3	9.1	7.7	2%	8.3	9.1	7.7	2%	8.2	8.8	7.8	1%	8.4	9.0	7.9	3%	8.7	9.3	8.2	7%
Victoria Canal	9	5.7	7.2	4.6	5.7	7.2	4.7	1%	5.7	7.2	4.6	0%	5.7	7.2	4.7	1%	5.4	6.7	4.5	-4%	5.6	6.9	4.8	-1%	6.2	7.3	5.2	10%
Delta Cross Channel	10	6.2	7.5	5.1	6.2	7.5	5.1	0%	6.2	7.5	5.1	0%	6.4	6.9	6.0	3%	6.6	6.8	6.4	6%	6.4	6.8	6.2	4%	5.7	7.2	4.5	-8%
Georgiana Slough	11	11.1	11.6	10.7	11.1	11.7	10.7	0%	11.1	11.6	10.7	0%	10.4	10.9	9.9	-7%	10.4	10.9	10.0	-7%	6.4	6.8	6.2	-42%	10.4	11.0	10.0	-6%
Diversion to Sutter/Steamboat Sloughs	12	13.6	13.9	13.3	13.6	13.9	13.3	0%	13.6	13.9	13.3	0%	12.6	13.0	12.3	-7%	12.6	13.0	12.3	-7%	11.3	11.7	11.1	-17%	12.7	13.1	12.4	-6%
Miner Slough	13	9.3	10.3	8.6	9.3	10.3	8.6	0%	9.3	10.3	8.6	0%	8.8	9.8	8.0	-6%	8.7	9.8	8.0	-6%	8.0	9.1	7.1	-14%	8.8	9.8	8.1	-5%
Sacramento River at Rio Vista	14	5.0	7.0	3.3	5.0	7.0	3.3	0%	5.0	7.0	3.3	0%	5.0	7.0	3.2	-1%	4.9	7.0	3.2	-2%	4.8	6.9	3.0	-4%	5.0	7.0	3.2	-1%
Mokelumne River, North Fork	15	5.5	7.0	4.3	5.5	7.0	4.3	0%	5.5	6.9	4.3	0%	5.6	6.7	4.7	2%	5.6	6.3	5.1	2%	6.3	6.7	6.0	15%	5.4	6.9	4.2	-2%
Mokelumne River, South Fork	16	5.4	7.0	4.1	5.4	7.0	4.1	0%	5.4	7.0	4.2	0%	5.4	6.8	4.3	0%	5.5	6.1	5.0	1%	6.1	6.4	5.9	13%	5.3	7.0	4.0	-1%

*Represents the percent difference between the average value of the alternative and the average value of the No Action Alternative.

Note: A negative flow or velocity indicates landward direction.

Table 5.2-3. Flows, velocities, and stages at locations within the Delta for low inflow/high pumping conditions.

Location		No Action Alternative			Configuration 1A				Configuration 1C				Configuration 2B				Configuration 2D				Configuration 2E				Configuration 3E			
Tidal Flow (cfs)	Loc. Key	Avg.	Max. Sea-ward	Max. Land-ward	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*
San Joaquin River at Fourteen Mile Slough	1	-34	6,032	6,377	-51	6,050	6,371	50%	1,268	7,494	5,063	3629%	1,270	7,355	5,043	3635%	1,289	6,174	3,944	3691%	1,270	6,200	3,963	3635%	1,268	6,832	4,762	3629%
San Joaquin River at Antioch	2	-1,552	148,346	155,223	-1,522	146,898	154,849	-2%	-1,504	145,791	154,428	-3%	1,308	144,267	151,290	-16%	1,341	137,747	146,793	-14%	712	137,355	147,033	-54%	912	147,280	151,988	-41%
Old River at Mossdale	3	1,292	1,650	213	1,311	1,609	868	1%	0	88	104	-100%	0	87	103	-100%	0	99	79	-100%	0	97	78	-100%	0	114	134	-100%
Old River at Fabian Tract	4	158	763	1,021	160	742	466	1%	-294	158	771	86%	-292	154	738	85%	-11	809	735	-93%	-11	786	698	-93%	-17	969	1,022	-89%
Old River at Woodward Island	5	-4,564	5,888	13,191	-4,534	6,377	14,756	-1%	-5,540	8,208	18,174	21%	-5,504	7,815	17,652	21%	-4,855	8,035	17,489	6%	-4,844	7,782	16,937	6%	-650	9,350	11,307	-86%
Old River at Franks Tract	6	-295	4,481	3,999	-305	4,020	3,980	3%	-385	3,644	4,176	31%	-370	3,555	4,059	25%	-537	4,731	5,162	82%	-499	4,610	4,996	69%	62	4,071	3,868	-79%
Middle River at Woodward Island	7	-3,154	4,192	9,915	-3,144	4,618	10,758	0%	-3,398	5,636	11,977	8%	-3,432	5,222	11,499	9%	-2,439	6,418	11,102	-23%	-2,448	6,234	10,648	-22%	-582	6,683	8,085	-82%
Grant Line Canal	8	1,084	3,632	3,808	1,102	3,699	1,581	2%	340	3,593	3,164	-69%	340	3,461	3,051	-69%	-47	3,075	2,931	-96%	-49	2,994	2,812	-95%	-54	3,517	4,052	-95%
Victoria Canal	9	2,355	5,935	1,049	2,364	6,053	1,159	0%	2,220	6,309	2,094	-6%	2,224	6,106	1,985	-6%	1,195	3,793	1,674	-49%	1,200	3,658	1,620	-49%	383	4,629	2,500	-84%
Delta Cross Channel	10	3,862	7,756	597	3,872	7,744	755	0%	3,881	7,683	863	0%	0	88	130	-100%	0	63	105	-100%	0	194	191	-100%	0	243	233	-100%
Georgiana Slough	11	2,241	3,953	903	2,244	3,941	990	0%	2,245	3,909	1,043	0%	903	3,351	1,641	-60%	781	3,888	2,546	-65%	9,018	26,024	4,645	302%	1,363	3,739	989	-39%
Diversion to Sutter/Steamboat Sloughs	12	1,882	5,047	3,422	1,879	5,019	3,421	0%	1,879	5,006	3,422	0%	783	3,851	3,933	-58%	827	3,771	3,960	-56%	1,263	5,222	4,751	-33%	936	4,053	3,825	-50%
Miner Slough	13	1,112	4,275	3,392	1,110	4,271	3,391	0%	1,110	4,271	3,396	0%	447	3,784	3,811	-60%	476	3,776	3,767	-57%	752	3,904	3,859	-32%	539	3,861	3,726	-52%
Sacramento River at Rio Vista	14	6,158	91,132	82,720	6,144	91,270	83,003	0%	6,135	91,512	83,389	0%	2,429	90,099	89,390	-61%	2,636	93,822	92,889	-57%	3,245	83,987	84,852	-47%	2,972	90,251	88,354	-52%
Mokelumne River, North Fork	15	3,018	4,395	1,404	3,022	4,444	1,370	0%	3,021	4,532	1,268	0%	4,283	8,966	4,733	42%	5,003	6,937	1,782	66%	-41	3,080	3,803	-99%	13	4,623	5,002	-100%
Mokelumne River, South Fork	16	829	4,786	4,412	836	4,883	4,433	1%	845	4,944	4,501	2%	1,327	5,416	4,123	60%	1,258	6,173	5,111	52%	136	10,334	12,093	-84%	-26	5,004	4,821	-97%
Velocity (fps)	Loc. Key	Avg.	Max. Sea-ward	Max. Land-ward	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*
San Joaquin River at Fourteen Mile Slough	1	0.00	0.37	0.39	0.00	0.37	0.39	NA	0.08	0.46	0.32	NA	0.08	0.45	0.32	NA	0.08	0.38	0.25	NA	0.08	0.38	0.25	NA	0.08	0.41	0.30	NA
San Joaquin River at Antioch	2	0.06	2.52	2.28	0.06	2.50	2.27	0%	0.06	2.48	2.27	0%	0.10	2.47	2.22	80%	0.10	2.40	2.15	84%	0.09	2.39	2.15	68%	0.10	2.52	2.23	71%
Old River at Mossdale	3	1.14	1.58	0.16	1.15	1.52	0.67	1%	0.00	0.07	0.10	-100%	0.00	0.07	0.10	-100%	0.00	0.08	0.07	-100%	0.00	0.08	0.07	-100%	0.00	0.09	0.14	-100%
Old River at Fabian Tract	4	0.15	0.70	0.73	0.15	0.71	0.44	-1%	-0.25	0.12	0.57	61%	-0.24	0.11	0.55	59%	0.00	0.59	0.57	-97%	0.00	0.57	0.55	-97%	0.00	0.66	0.79	-99%
Old River at Woodward Island	5	-0.46	0.68	1.32	-0.45	0.72	1.42	-2%	-0.55	0.91	1.76	20%	-0.55	0.86	1.71	19%	-0.50	0.86	1.77	9%	-0.50	0.84	1.72	9%	-0.04	0.98	1.08	-90%
Old River at Franks Tract	6	-0.06	0.78	0.82	-0.06	0.70	0.82	0%	-0.07	0.65	0.80	19%	-0.07	0.63	0.83	14%	-0.09	0.89	0.98	50%	-0.08	0.87	0.99	38%	0.01	0.72	0.78	-78%
Middle River at Woodward Island	7	-0.46	0.70	1.44	-0.45	0.75	1.51	-1%	-0.48	0.90	1.68	6%	-0.49	0.83	1.62	7%	-0.35	0.98	1.61	-24%	-0.35	0.96	1.56	-23%	-0.06	1.02	1.12	-86%
Grant Line Canal	8	0.31	1.08	0.93	0.31	1.08	0.41	1%	0.11	1.01	0.81	-66%	0.11	0.97	0.78	-66%	-0.01	0.78	0.76	-98%	-0.01	0.76	0.74	-98%	0.00	0.88	1.05	-100%
Victoria Canal	9	0.57	1.29	0.29	0.57	1.34	0.30	0%	0.54	1.43	0.52	-6%	0.54	1.39	0.50	-5%	0.29	0.92	0.41	-49%	0.29	0.90	0.40	-49%	0.07	1.01	0.59	-88%
Delta Cross Channel	10	0.74	1.43	0.11	0.74	1.42	0.14	0%	0.74	1.41	0.16	0%	0.00	0.02	0.02	-100%	0.00	0.01	0.02	-100%	0.00	0.04	0.04	-100%	0.00	0.05	0.05	-100%
Georgiana Slough	11	0.82	1.43	0.32	0.82	1.43	0.35	0%	0.82	1.42	0.37	0%	0.31	1.15	0.69	-62%	0.25	1.30	1.06	-70%	0.89	2.49	0.47	8%	0.49	1.31	0.41	-41%
Diversion to Sutter/Steamboat Sloughs	12	0.70	1.76	1.16	0.70	1.75	1.16	0%	0.70	1.75	1.16	0%	0.31	1.39	1.36	-55%	0.33	1.40	1.37	-52%	0.49	1.98	1.65	-30%	0.37	1.45	1.32	-47%
Miner Slough	13	0.43	1.49	0.98	0.43	1.49	0.98	0%	0.43	1.49	0.98	0%	0.21	1.34	1.11	-51%	0.22	1.33	1.10	-48%	0.32	1.45	1.13	-25%	0.24	1.36	1.09	-44%
Sacramento River at Rio Vista	14	0.13	1.56	1.46	0.13	1.56	1.47	0%	0.13	1.56	1.48	0%	0.07	1.54	1.58	-48%	0.07	1.61	1.63	-45%	0.09	1.46	1.49	-36%	0.08	1.54	1.56	-41%
Mokelumne River, North Fork	15	0.55	0.79	0.26	0.55	0.79	0.25	0%	0.55	0.80	0.23	0%	0.79	1.70	0.79	45%	0.90	1.29	0.30	65%	0.00	0.57	0.65	-100%	0.01	0.81	0.87	-98%
Mokelumne River, South Fork	16	0.13	0.70	0.68	0.13	0.69	0.68	1%	0.13	0.70	0.69	2%	0.21	0.82	0.58	64%	0.20	0.96	0.74	54%	0.03	1.59	1.78	-74%	0.00	0.71	0.75	-99%
Stage (mllw)	Loc. Key	Avg.	Max.	Min.	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*
San Joaquin River at Fourteen Mile Slough	1	3.5	5.6	1.7	3.5	5.6	1.7	0%	3.5	5.5	1.7	0%	3.6	5.4	1.9	2%	3.6	5.0	2.4	2%	3.6	4.9	2.5	2%	3.6	5.5	1.9	2%
San Joaquin River at Antioch	2	3.5	6.0	0.9	3.5	6.0	0.9	0%	3.5	6.0	0.9	0%	3.5	6.0	0.9	0%	3.5	6.0	0.9	0%	3.5	5.9	0.9	0%	3.5	5.9	1.0	0%
Old River at Mossdale	3	3.5	4.8	2.4	3.4	4.6	2.4	-1%	3.2	4.8	1.8	-7%	3.3	4.8	1.9	-6%	3.4	4.9	2.1	-3%	3.4	4.8	2.1	-3%	3.6	5.3	1.8	3%
Old River at Fabian Tract	4	3.0	4.7	1.7	3.0	4.3	1.7	-1%	3.5	4.6	2.4	17%	3.6	4.6	2.5	18%	3.4	4.7	2.2	12%	3.4	4.7	2.2	12%	3.6	5.2	1.9	18%
Old River at Woodward Island	5	3.5	5.6	1.6	3.5	5.4	1.6	0%	3.4	5.3	1.7	-1%	3.5	5.3	1.8	1%	3.4	4.7	2.3	-1%	3.4	4.6	2.4	-1%	3.6	5.4	1.8	4%
Old River at Franks Tract	6	3.5	5.4	1.8	3.5	5.4	1.8	0%	3.5	5.4	1.9	0%	3.6	5.3	2.0	1%	3.6	4.9	2.5	1%	3.6	4.8	2.5	1%	3.6	5.3	2.0	2%
Middle River at Woodward Island	7	3.5	5.6	1.6	3.5	5.5	1.6	0%	3.5	5.4	1.7	0%	3.6	5.4	1.8	2%	3.6	4.9	2.4	2%	3.5	4.8	2.4	1%	3.6	5.4	1.8	3%
Grant Line Canal	8	3.0	4.7	1.7	3.0	4.3	1.7	-1%	3.2	4.6	1.8	4%	3.2	4.6	1.9	6%	3.4	4.7	2.2	11%	3.4	4.6	2.2	10%	3.6	5.2	1.9	17%
Victoria Canal	9	3.2	5.3	1.5	3.2	4.9	1.5	-1%	3.2	4.7	1.6	-2%	3.2	4.7	1.8	0%	3.4	4.7	2.2	6%	3.4	4.6	2.3	5%	3.6	5.2	1.8	11%
Delta Cross Channel	10	4.1	5.7	2.5	4.1	5.8	2.5	0%	4.1	5.7	2.5	0%	4.4	5.3	3.8	7%	4.4	5.0	4.0	9%	3.8	4.5	3.2	-8%	3.6	5.5	1.9	-11%
Georgiana Slough	11	4.1	5.9	2.5	4.1	5.9	2.5	0%	4.1	5.9	2.5	0%	3.9	5.8	2.1	-7%	3.9	5.7	2.2	-6%	3.8	4.7	3.1	-8%	3.9	5.8	2.1	-6%
Diversion to Sutter/Steamboat Sloughs	12	4.5	6.2	2.9	4.5	6.2	2.8	0%	4.5	6.2	2.8	0%	4.0	6.0	2.0	-11%	4.0	6.1	2.1	-11%	4.2	5.4	3.3	-6%	4.0	6.1	2.1	-9%
Miner Slough	13	3.9	6.3	1.6	3.9	6.3	1.6	0%	3.9	6.3	1.6	0%	3.7	6.2	1.2	-5%	3.7	6.2	1.2	-5%	3.8	6.1	1.7	-3%	3.7	6.3	1.3	-4%
Sacramento River at Rio Vista	14	3.5	6.3	0.7	3.5	6.4	0.7	0%	3.5	6.4	0.7	0%	3.5	6.3	0.6	0%	3.5	6.3	0.6	-1%	3.5	6.3	0.7	-1%	3.5	6.3	0.7	0%
Mokelumne River, North Fork	15	3.7	5.5	2.0	3.7	5.5	2.0	0%	3.7	5.5	2.0	0%	3.8	5.3	2.5	4%	3.8	4.9	2.9	4%	3.8	4.7	3.1	2%	3.6	5.4	2.0	-2%
Mokelumne River, South Fork	16	3.6	5.6	1.9	3.6	5.6	1.9	0%	3.6	5.6	1.9	0%	3.7	5.4	2.2	2%	3.8	4.5	3.1	4%	3.7	4.3	3.3	3%	3.6	5.5	1.9	0%

*Represents the percent difference between the average value of the alternative and the average value of the No Action Alternative.

Note A negative flow or velocity indicates landward direction

Table 5.2-4. Flows, velocities, and stages at locations within the Delta for low inflow/low pumping conditions.

Location		No Action Alternative			Configuration 1A				Configuration 1C				Configuration 2B				Configuration 2D				Configuration 2E				Configuration 3E			
Tidal Flow (cfs)	Loc. Key	Avg.	Max. Sea-ward	Max. Land-ward	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*
San Joaquin River at Fourteen Mile Slough	1	99	5,945	6,340	69	6,065	6,356	-30%	412	6,278	5,850	316%	394	6,092	5,672	298%	127	4,928	5,181	28%	122	4,928	5,089	23%	131	5,762	6,181	32%
San Joaquin River at Antioch	2	950	148,752	152,312	680	148,097	152,301	-28%	652	147,294	152,041	-31%	986	144,740	150,990	4%	1,322	138,268	146,304	39%	2,235	138,745	145,573	135%	1,215	147,681	151,716	28%
Old River at Mossdale	3	862	1,603	749	892	1,547	452	3%	554	1,399	401	-36%	573	1,385	315	-34%	846	1,582	490	-2%	843	1,563	418	-2%	830	1,535	528	-4%
Old River at Fabian Tract	4	32	993	1,111	49	875	888	53%	113	963	750	253%	115	942	696	259%	40	746	714	25%	39	731	699	22%	31	917	910	-3%
Old River at Woodward Island	5	-981	8,474	11,251	-1,331	8,409	11,319	36%	-1,565	9,429	13,260	60%	-1,560	9,149	12,609	59%	-1,122	9,582	13,823	14%	-1,116	9,259	13,374	14%	-686	9,074	11,621	-30%
Old River at Franks Tract	6	25	4,633	4,026	-11	4,302	4,031	-56%	4	4,102	4,203	-84%	-10	4,035	4,202	-60%	-126	5,112	5,047	404%	-93	4,989	5,000	272%	27	4,079	3,913	8%
Middle River at Woodward Island	7	-848	6,082	8,379	-1,094	6,051	8,392	29%	-1,217	6,484	9,114	44%	-1,196	6,308	8,519	41%	-821	8,173	9,428	-3%	-851	7,834	9,070	0%	-632	6,488	8,384	-25%
Grant Line Canal	8	525	3,915	3,935	509	3,848	4,019	-3%	190	3,559	3,242	-64%	203	3,435	2,999	-61%	480	3,020	3,018	-9%	474	2,938	2,935	-10%	443	3,668	3,909	-16%
Victoria Canal	9	429	3,211	2,076	624	4,262	2,208	45%	569	4,340	2,485	33%	564	4,096	2,482	31%	269	2,835	2,104	-37%	282	2,732	2,011	-34%	277	4,634	2,425	-35%
Delta Cross Channel	10	2,677	6,194	528	2,875	6,398	313	7%	2,872	6,399	213	7%	996	7,677	5,006	-63%	1,609	7,952	3,593	-40%	1,346	5,790	2,752	-50%	2,474	6,592	1,837	-8%
Georgiana Slough	11	1,634	3,232	443	1,730	3,336	540	6%	1,731	3,335	523	6%	1,712	3,157	99	5%	1,345	3,335	1,069	-18%	5,268	18,888	5,394	222%	1,641	3,245	493	0%
Diversion to Sutter/Steamboat Sloughs	12	1,131	4,664	4,292	1,228	4,704	4,182	9%	1,227	4,676	4,194	8%	1,015	4,442	4,496	-10%	995	4,223	4,499	-12%	700	5,040	5,332	-38%	1,027	4,588	4,333	-9%
Miner Slough	13	653	4,084	3,832	710	4,110	3,772	9%	710	4,104	3,769	9%	589	3,880	3,887	-10%	576	3,718	3,848	-12%	408	3,759	4,153	-38%	590	4,046	3,871	-10%
Sacramento River at Rio Vista	14	2,900	87,291	86,542	3,251	87,739	86,251	12%	3,253	87,672	86,245	12%	2,830	85,516	85,589	-2%	2,664	89,718	89,664	-8%	1,242	80,090	86,305	-57%	2,529	86,894	87,437	-13%
Mokelumne River, North Fork	15	2,053	3,649	385	2,192	3,824	593	7%	2,194	3,873	541	7%	1,580	6,414	5,408	-23%	2,264	3,637	548	10%	375	2,381	2,194	-82%	1,036	4,066	2,372	-50%
Mokelumne River, South Fork	16	297	4,459	4,603	351	4,605	4,592	18%	347	4,609	4,536	17%	272	4,428	5,429	-8%	448	5,776	5,598	51%	1	10,403	12,112	-100%	309	4,946	4,592	4%
Velocity (fps)	Loc. Key	Avg.	Max. Sea-ward	Max. Land-ward	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*	Avg.	Max. Sea-ward	Max. Land-ward	% Diff*
San Joaquin River at Fourteen Mile Slough	1	0.01	0.36	0.38	0.01	0.37	0.39	-22%	0.03	0.38	0.36	211%	0.03	0.37	0.36	200%	0.01	0.31	0.33	0%	0.01	0.30	0.32	0%	0.01	0.35	0.37	22%
San Joaquin River at Antioch	2	0.10	2.53	2.24	0.09	2.52	2.24	-5%	0.09	2.51	2.23	-5%	0.10	2.48	2.22	1%	0.10	2.41	2.14	7%	0.12	2.42	2.13	23%	0.10	2.52	2.23	5%
Old River at Mossdale	3	0.76	1.51	0.53	0.78	1.48	0.35	3%	0.44	1.15	0.29	-42%	0.46	1.14	0.23	-40%	0.73	1.46	0.36	-4%	0.73	1.43	0.31	-4%	0.72	1.45	0.41	-5%
Old River at Fabian Tract	4	0.05	0.71	0.72	0.06	0.69	0.68	15%	0.10	0.76	0.49	80%	0.10	0.73	0.46	85%	0.05	0.55	0.59	-15%	0.04	0.54	0.58	-19%	0.05	0.67	0.70	-11%
Old River at Woodward Island	5	-0.08	0.89	1.10	-0.12	0.89	1.10	42%	-0.14	0.98	1.26	75%	-0.14	0.95	1.21	75%	-0.10	0.99	1.38	26%	-0.10	0.96	1.34	26%	-0.05	0.95	1.11	-42%
Old River at Franks Tract	6	0.00	0.80	0.81	0.00	0.75	0.81	-50%	0.00	0.72	0.86	-100%	0.00	0.71	0.86	-50%	-0.01	0.95	0.98	175%	-0.01	0.93	0.97	25%	0.01	0.72	0.79	50%
Middle River at Woodward Island	7	-0.11	0.92	1.19	-0.14	0.93	1.20	34%	-0.16	0.98	1.26	55%	-0.16	0.95	1.19	54%	-0.10	1.23	1.39	-1%	-0.11	1.18	1.34	6%	-0.07	0.99	1.16	-33%
Grant Line Canal	8	0.17	1.07	0.94	0.16	1.06	0.96	-4%	0.06	0.98	0.75	-66%	0.06	0.94	0.70	-64%	0.14	0.80	0.74	-15%	0.14	0.78	0.72	-16%	0.14	1.00	0.93	-15%
Victoria Canal	9	0.08	0.67	0.49	0.13	0.91	0.51	53%	0.12	0.93	0.57	48%	0.12	0.89	0.56	48%	0.05	0.66	0.50	-36%	0.06	0.64	0.48	-31%	0.04	1.00	0.57	-52%
Delta Cross Channel	10	0.52	1.19	0.10	0.56	1.23	0.06	7%	0.56	1.22	0.04	7%	0.18	1.41	1.02	-66%	0.29	1.45	0.74	-44%	0.26	1.10	0.55	-50%	0.48	1.29	0.33	-7%
Georgiana Slough	11	0.61	1.23	0.15	0.64	1.26	0.19	6%	0.64	1.26	0.19	6%	0.64	1.22	0.04	5%	0.48	1.14	0.44	-20%	0.52	1.82	0.55	-14%	0.61	1.20	0.20	0%
Diversion to Sutter/Steamboat Sloughs	12	0.43	1.64	1.49	0.47	1.65	1.45	8%	0.47	1.64	1.45	8%	0.40	1.65	1.57	-8%	0.40	1.64	1.57	-8%	0.28	1.92	1.89	-34%	0.40	1.60	1.51	-9%
Miner Slough	13	0.28	1.43	1.12	0.30	1.44	1.10	7%	0.30	1.44	1.10	7%	0.26	1.40	1.14	-6%	0.26	1.36	1.12	-7%	0.21	1.40	1.22	-25%	0.26	1.42	1.13	-7%
Sacramento River at Rio Vista	14	0.08	1.50	1.53	0.08	1.50	1.52	8%	0.08	1.50	1.52	8%	0.08	1.47	1.51	0%	0.07	1.55	1.57	-4%	0.05	1.39	1.51	-34%	0.07	1.49	1.54	-8%
Mokelumne River, North Fork	15	0.37	0.64	0.07	0.40	0.67	0.10	7%	0.40	0.68	0.09	7%	0.31	1.22	0.91	-17%	0.41	0.66	0.09	10%	0.07	0.44	0.38	-81%	0.19	0.72	0.43	-48%
Mokelumne River, South Fork	16	0.05	0.63	0.72	0.06	0.65	0.71	16%	0.06	0.65	0.70	14%	0.05	0.70	0.77	6%	0.08	0.90	0.82	59%	0.01	1.60	1.78	-73%	0.05	0.70	0.71	0%
Stage (mllw)	Loc. Key	Avg.	Max.	Min.	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*	Avg.	Max.	Min.	% Diff*
San Joaquin River at Fourteen Mile Slough	1	3.6	5.6	1.8	3.6	5.6	1.7	0%	3.6	5.6	1.7	0%	3.6	5.5	1.9	0%	3.6	5.0	2.4	0%	3.6	4.9	2.5	1%	3.6	5.5	1.8	0%
San Joaquin River at Antioch	2	3.5	6.0	1.0	3.5	6.0	1.0	0%	3.5	6.0	1.0	0%	3.5	6.0	0.9	0%	3.5	6.0	0.9	-1%	3.5	6.0	0.9	-1%	3.5	6.0	1.0	0%
Old River at Mossdale	3	3.9	5.3	2.5	3.8	5.2	2.5	-1%	4.3	5.3	3.8	10%	4.2	5.2	3.8	9%	3.8	4.9	2.8	-1%	3.8	4.9	2.8	-1%	3.9	5.2	2.6	1%
Old River at Fabian Tract	4	3.5	5.3	1.9	3.5	5.1	1.9	-1%	4.1	5.3	3.3	16%	4.0	5.2	3.2	14%	3.6	4.9	2.3	1%	3.6	4.9	2.4	2%	3.6	5.2	2.0	2%
Old River at Woodward Island	5	3.6	5.6	1.7	3.6	5.5	1.7	-1%	3.6	5.5	1.6	-1%	3.6	5.4	1.7	-1%	3.6	4.8	2.4	-1%	3.6	4.8	2.4	0%	3.6	5.4	1.8	0%
Old River at Franks Tract	6	3.6	5.4	1.9	3.6	5.4	1.9	0%	3.6	5.4	1.9	0%	3.6	5.3	2.0	0%	3.6	4.9	2.4	0%	3.6	4.8	2.5	1%	3.6	5.4	2.0	0%
Middle River at Woodward Island	7	3.6	5.6	1.7	3.6	5.6	1.7	0%	3.6	5.5	1.6	0%	3.6	5.4	1.8	0%	3.6	4.9	2.4	0%	3.6	4.9	2.4	1%	3.6	5.5	1.8	0%
Grant Line Canal	8	3.6	5.3	1.9	3.6	5.2	1.9	1%	3.6	5.5	1.4	1%	3.6	5.4	1.5	1%	3.6	4.9	2.4	1%	3.7	4.9	2.5	3%	3.7	5.4	2.1	4%
Victoria Canal	9	3.5	5.5	1.7	3.5	5.3	1.6	-1%	3.5	5.3	1.5	-1%	3.5	5.2	1.6	-1%	3.6	4.9	2.3	1%	3.6	4.8	2.4	1%	3.6	5.2	1.8	1%
Delta Cross Channel	10	3.9	5.7	2.3	3.9	5.7	2.3	1%	3.9	5.7	2.3	1%	3.9	5.3	2.8	1%	3.9	5.2	2.7	0%	3.8	4.6	3.1	-3%	3.9	5.6	2.2	-1%
Georgiana Slough	11	3.9	5.7	2.2	4.0	5.7	2.3	1%	4.0	5.8	2.3	1%	3.9	5.5	2.5	0%	3.9	5.5	2.6	-1%	3.8	4.7	3.0	-4%	3.9	5.7	2.2	-1%
Diversion to Sutter/Steamboat Sloughs	12	4.1	6.0	2.5	4.2	6.0	2.5	1%	4.2	6.0	2.5	1%	4.1	5.8	2.6	-1%	4.1	5.8	2.6	-2%	4.0	5.0	3.1	-4%	4.1	5.9	2.4	-1%
Miner Slough	13	3.8	6.2	1.4	3.8	6.2	1.4	1%	3.8	6.2	1.4	1%	3.7	6.2	1.4	-1%	3.7	6.2	1.4	-1%	3.7	6.0	1.6	-2%	3.8	6.2	1.4	0%
Sacramento River at Rio Vista	14	3.5	6.3	0.7	3.5	6.3	0.7	0%	3.5	6.3	0.7	0%	3.5	6.3	0.7	0%	3.5	6.3	0.6	-1%	3.5	6.3	0.7	-1%	3.5	6.3	0.7	0%
Mokelumne River, North Fork	15	3.7	5.5	2.0	3.7	5.5	2.0	0%	3.7	5.5	2.0	0%	3.7	5.3	2.3	0%	3.7	4.9	2.6	0%	3.7	4.7	3.0	1%	3.7	5.5	2.0	-1%
Mokelumne River, South Fork	16	3.6	5.6	1.9	3.6	5.6	1.9	0%	3.6	5.6	1.9	0%	3.6	5.4	2.1	0%	3.7	4.5	3.0	1%	3.7	4.3	3.3	2%	3.6	5.6	1.9	0%

*Represents the percent difference between the average value of the alternative and the average value of the No Action Alternative.

Note: A negative flow or velocity indicates landward direction

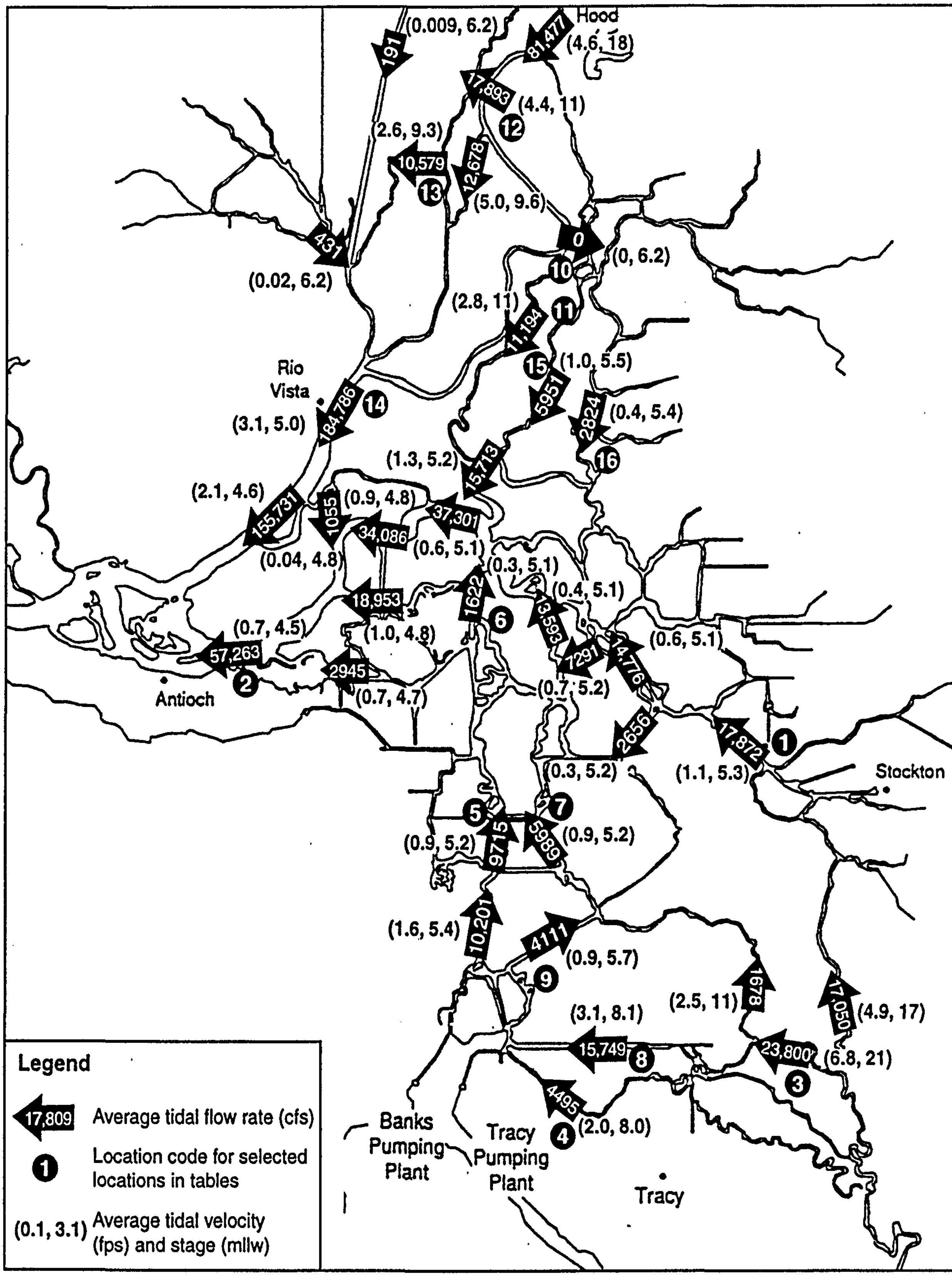


Figure 5.2-1. Average tidal flow rates, velocities, and stages for high flow conditions for Alternative 1A.

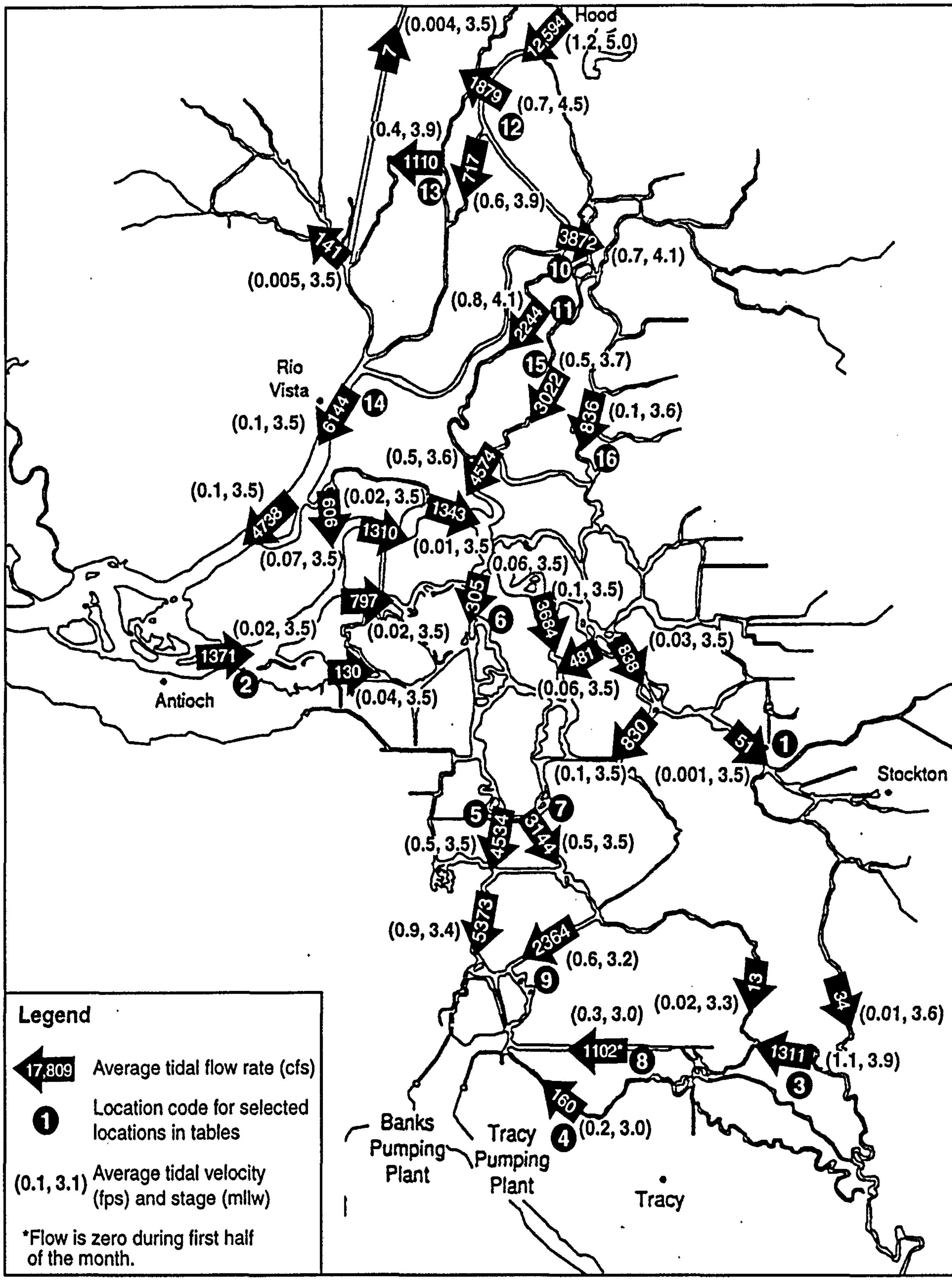


Figure 5.2-2. Average tidal flow rates, velocities, and stages for low flow/high pumping for Alternative 1A.

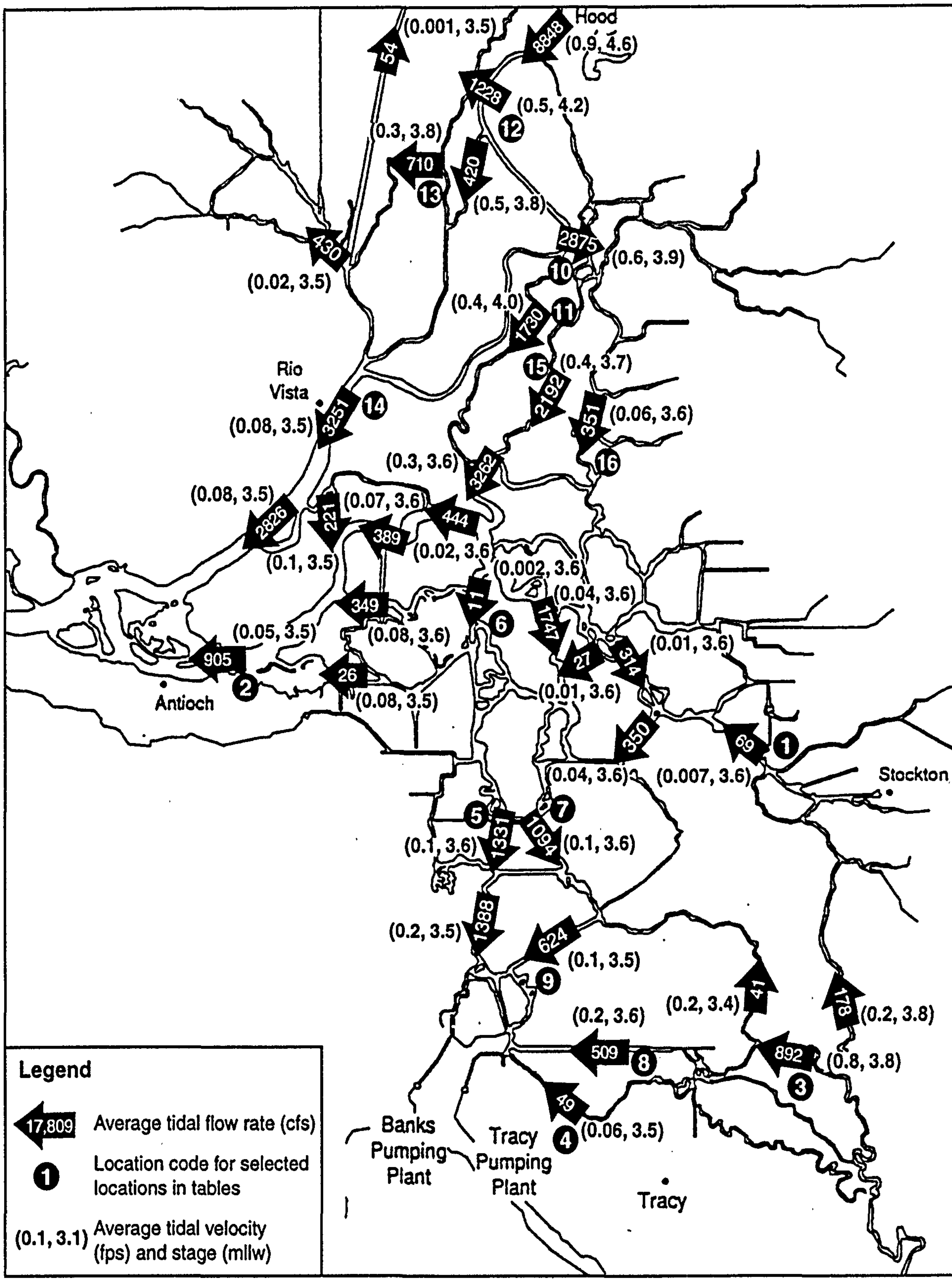


Figure 5.2-3. Average tidal flow rates, velocities, and stages for low flow/low pumping for Alternative 1A.

Upper Roberts Island. Similar to the No Action Alternative, for Configuration 1A, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants, and the ratio of flow in Old River to flow in Middle River is about 1.5. Water flows into the Delta in the San Joaquin River at Antioch, and most of the water in the central Delta flows south toward the pumping plants. Central Delta water enters Old River and Middle River channels at their mouths and flows through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River.

For low inflow/low pumping conditions, there are also no substantial differences in flows between Configuration 1A and the No Action Alternative. For Configuration 1A, approximately 20 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs, 35 percent is diverted to the Delta Cross Channel, and 20 percent travels down Georgiana Slough. The remainder continues down the Sacramento River. Flows in the south Delta are also similar to the No Action Alternative. Of the San Joaquin River inflow at Vernalis, about 80 percent is diverted to Old River near Mossdale, and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River, while 60 percent is carried by the Grant Line Canal and 5 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants, and the ratio of flow in Old River to flow in Middle River is about 1. Similar to the No Action Alternative, water in the central Delta generally flows west. Some central Delta water enters Old River and Middle River channels at their mouths and flows through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River.

There are no substantial differences in velocities and stages between Configuration 1A and the No Action Alternative. Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the nominal scour velocity of approximately 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions for Configuration 1A are generally below 3 fps except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter Sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, Old River at Mossdale, and Grant Line Canal all have average velocities higher than 3 fps. However, the Grant Line Canal and Sacramento River at Rio Vista have average velocities above 3 fps in less than 1 percent of all months modeled, the San Joaquin River at Upper Roberts Island in less than 6 percent of the months modeled, the diversion to Steamboat and Sutter sloughs, Steamboat slough, and the Sacramento River at Hood in less than 13 percent of the months modeled, and Old River at Mossdale in less than 20 percent of the months modeled. This is consistent with the No Action Alternative.

Configuration 1B is similar to Configuration 1A, with the addition of operable barriers, flow control measures, and fish screens. Thus, flows and velocities in the Delta will be similar to Configuration 1A except in the immediate vicinity of the barriers and flow control measures while they are operating. The barrier at the head of Old River will prevent flow reversal in the San Joaquin River.

Configuration 1C

Configuration 1C involves south Delta modifications that improve the circulation of flow and reduce reverse flows in the south Delta. Average tidal flows, velocities, and stages throughout the Delta based on DWRDSM1 modeling are shown in Figures 5.2-4 through 5.2-6 for the high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

For high inflow conditions, differences in the average flows between Configuration 1C and the No Action Alternative are generally insignificant. For Configuration 1C, similar to the No Action Alternative, approximately 40 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs and 15 percent travels down Georgiana Slough. The remainder continues down the Sacramento River. Flows in the south Delta are also similar to the No Action Alternative. Of the San Joaquin River inflow at Vernalis, about 60 percent is diverted to Old River near Mossdale, and 40 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River, while 65 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north, and the ratio of flow in Old River to flow in Middle River is about 2. As in the No Action Alternative, for Configuration 1C water from the central Delta flows out of the Delta through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). False River carries about 35 percent of the central Delta outflow, Dutch Slough carries about 5 percent, and about 60 percent remains in the main channel of the San Joaquin River.

For low inflow/high pumping conditions, flows for Configuration 1C are similar to flows for the No Action Alternative, except near the operable barriers. Similar to the No Action Alternative, approximately 20 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs, 30 percent is diverted to the Delta Cross Channel, and 20 percent travels down Georgiana Slough. The remainder continues down the Sacramento River. In the south Delta, however, a flow control structure at Old River at Mossdale limits flow down the Old River, which eliminates reverse flow in the San Joaquin River upstream of Disappointment Slough. Therefore, water in Middle River at Upper Roberts Island is reversed and flow in Grant Line Canal is reduced. Similar to the No Action Alternative, for Configuration 1C, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping

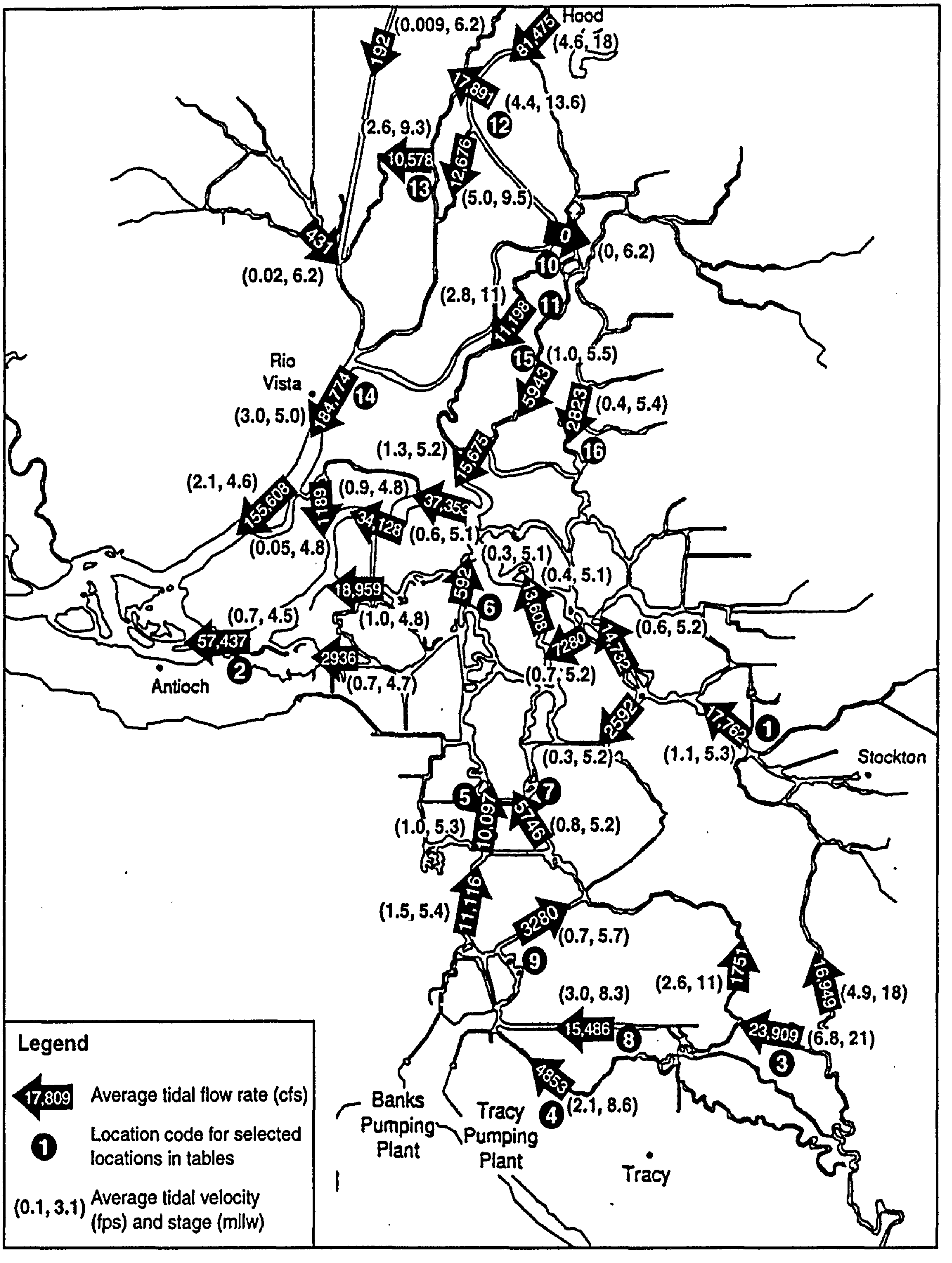


Figure 5.2-4. Average tidal flow rates, velocities, and stages for high flow conditions for Alternative 1C.

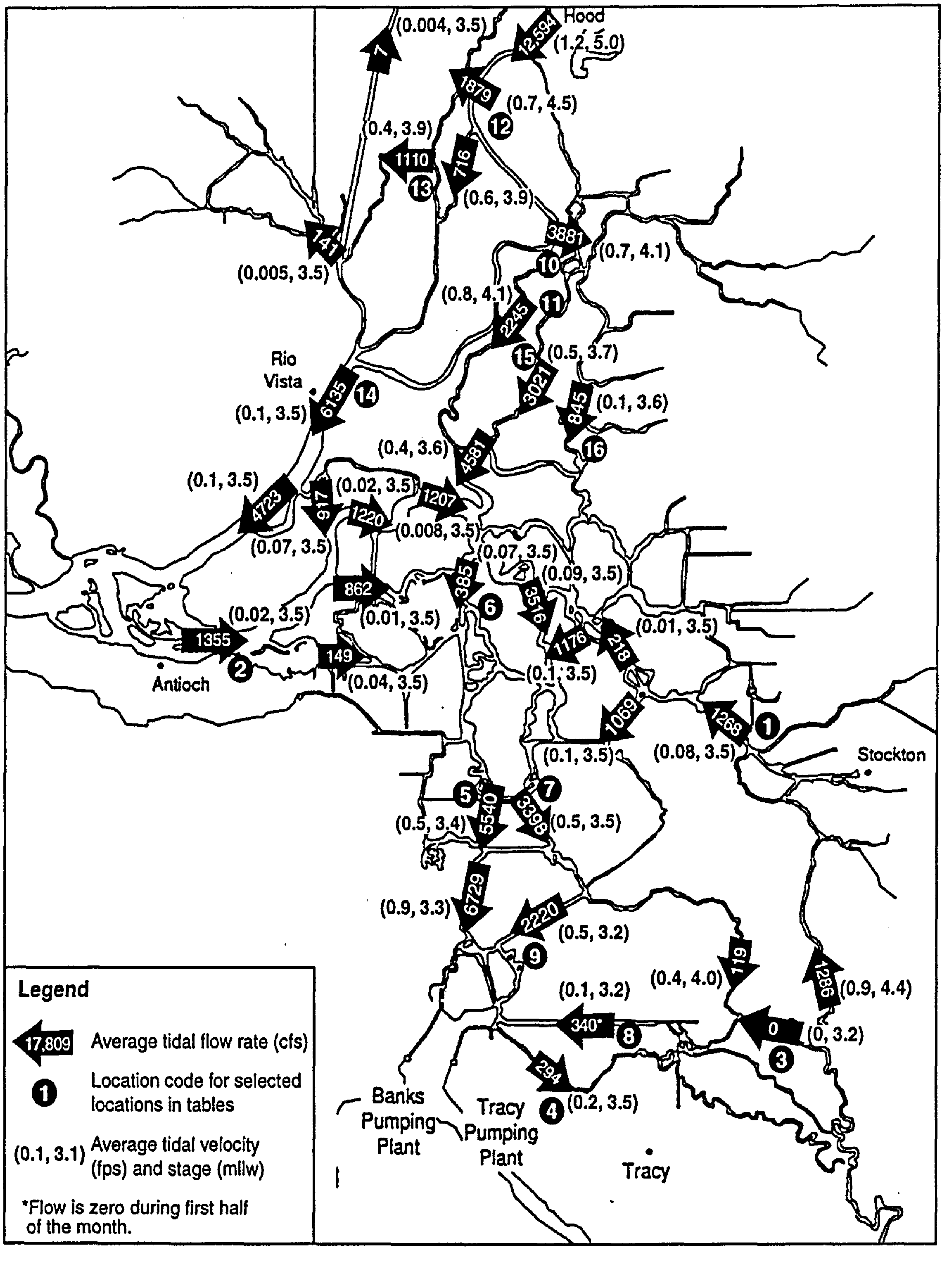


Figure 5.2-5. Average tidal flow rates, velocities, and stages for low flow/high pumping conditions for Alternative 1C.

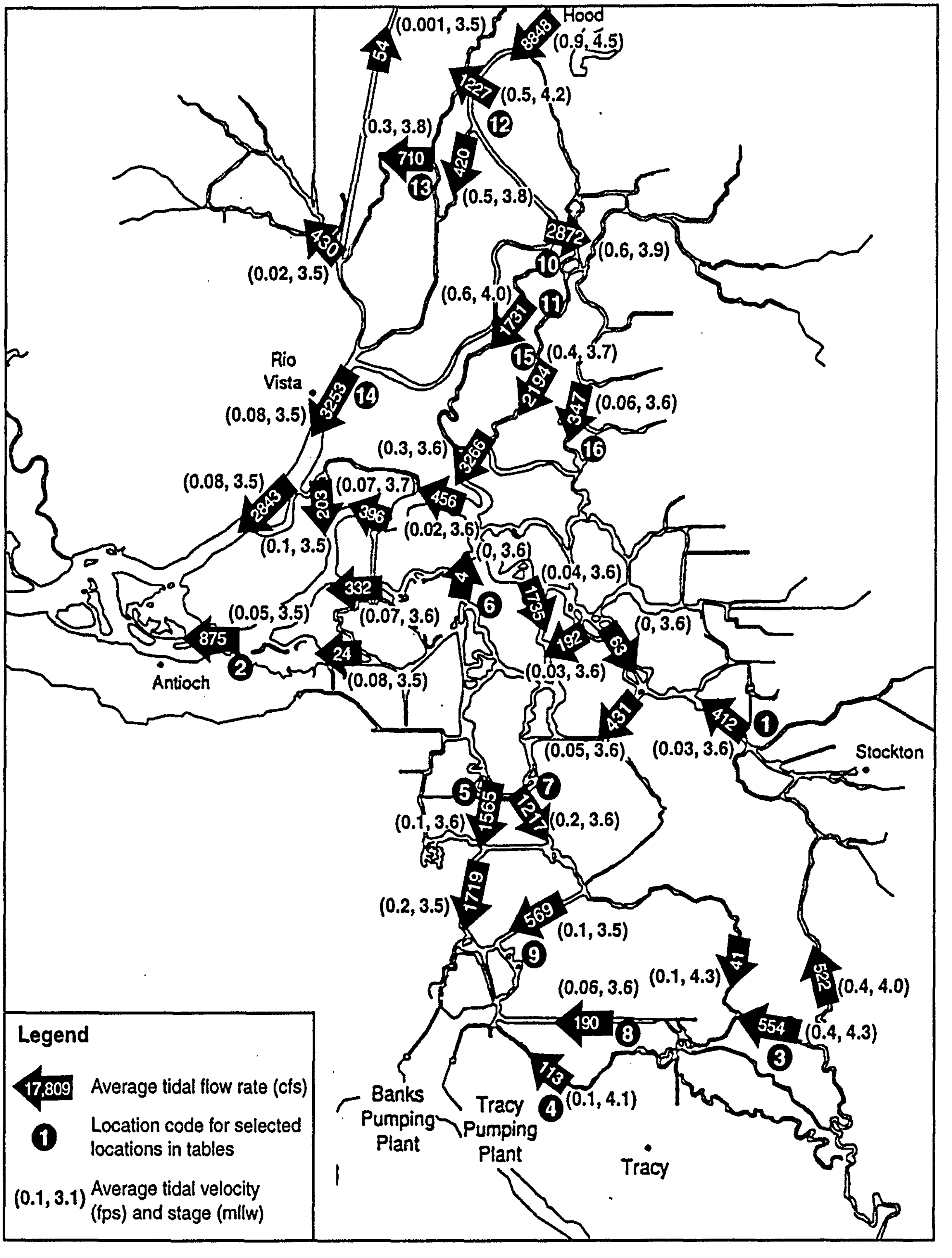


Figure 5.2-6. Average tidal flow rates, velocities, and stages for low flow/low pumping conditions for Alternative 1C.

plants, and the ratio of flow in Old River to flow in Middle River is about 1.5. Also similar to the No Action Alternative, water in the San Joaquin River at Antioch flows into the Delta, and most of the water in the central Delta flows south toward the pumping plants. Central Delta water enters Old and Middle River channels at their mouths and flows through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River. False River, Dutch Slough, and the San Joaquin River carry water east into the Delta.

For low inflow/low pumping conditions, approximately 20 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter Sloughs, 35 percent is diverted to the Delta Cross Channel, and 20 percent travels down Georgiana Slough, similar to the No Action Alternative. In the south Delta, of the San Joaquin River inflow at Vernalis, more flow is directed down the San Joaquin River for Configuration 1C, than in the No Action Alternative (about 50 percent is diverted to Old River and 50 percent remains in the San Joaquin River channel). Thus, more flow is carried to the pumps via Old River and less is carried via Grant Line Canal. Of the flow diverted to Old River, approximately 35 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. Water in Middle River at Upper Roberts Island flows upstream toward the head of Middle River. As for the No Action Alternative, for Configuration 1C, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants, though slightly more water is carried by Old River than Middle River (a ratio of 1.5). Similar to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water flows from the San Joaquin River to Middle River through Turner, Empire, and Columbia cuts. False River, Dutch Slough, and the San Joaquin River carry water westward.

There are no substantial differences in velocities and stages between Configuration 1C and the No Action Alternative except in areas near the flow control structures. For low inflow/high pumping conditions, the flow control barriers were operating and large changes in velocity and stage were observed in the San Joaquin River and Middle River near Upper Roberts Island.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the nominal scour velocity of approximately 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions are generally below the nominal scour velocity of approximately 3 fps except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter Sloughs, Steamboat slough, San Joaquin River at Upper Roberts Island, and Old River at Mossdale all have average velocities higher than 3 fps. However, the San Joaquin River at Upper Roberts Island has average velocities above 3 fps in less than 7 percent of all months modeled, the Diversion to Steamboat and Sutter Sloughs, Steamboat slough, and the Sacramento River at Hood in less than 12 percent of the months modeled, and Old River at Mossdale in less than 15 percent of the months modeled. This is generally consistent with the No Action Alternative.

5.2.2.1.2 Mass Fate

Using DWRDSM1 modeling, the fate of mass released into the Delta waterways at various locations was analyzed. The mass fate is presented in Tables 5.2-5, 5.2-6, 5.2-7, and 5.2-8 for high inflow/high pumping, medium inflow/low pumping, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

Mass fate for Configuration 1A is based on the same modeling study as the No Action Alternative; therefore, the tables show no differences between the mass fate for Configuration 1A and the No Action Alternative. Modeling of both indicates that the number of months with Delta outflows in the 3,000 cfs to 4,000 cfs range do not change. The number of months with flows between 4,000 cfs and 6,500 cfs 1A and the No Action Alternative, the percentage of mass reaching the pumps may be smaller.

Configuration 1B is similar to Configuration 1A, with the addition of operable barriers, flow control measures, and fish screens. Thus, mass fate in the Delta will be similar to Configuration 1A.

For high inflow/high pumping conditions, medium inflow/low pumping conditions and low inflow/high pumping conditions, the fate of mass released at all locations under Configuration 1C is similar to the fate of mass under the No Action Alternative. For low inflow/low pumping conditions, mass released at all locations has a similar fate as that for the No Action Alternative except for mass released at Vernalis. Less mass released at Vernalis reaches the pumps and more is trapped on Delta islands.

5.2.2.1.3 Net Delta Outflow

Using DWRSIM modeling, differences in monthly average net Delta outflows between Alternative 1 and the No Action Alternative were evaluated. Net Delta outflow represents the net fresh water flow out of the Delta into the Bay, excluding tides. Under Alternative 1, net Delta outflows are reduced as a result of the increased export capacity in the CVP-SWP improvements and the north and south Delta surface storage. The higher export capacity increases the number of months with flows in the range of the minimum flow requirements (3,000 cfs to 8,000 cfs) specified in the State Water Resources Control Board (SWRCB) Water Quality Control Plan (WQCP) (SWRCB 1995).

Table 5.2-9 shows the distribution of the differences in net Delta outflow between Alternative 1 configurations and the No Action Alternative. The primary changes occur in late summer through winter (September through March), resulting in less Delta outflow about 25 percent of the time. The magnitude of changes during this time period range from zero to more than 40 percent. The differences in net Delta outflow from April through August are negligible. The largest percent reductions occur when Delta outflow is relatively small, most often just above the required outflow. When the Delta outflow is large, as during winter high flows, percent reductions are typically small.

Table 5.2-5. Fate of mass released at specific locations for high inflow/high pumping conditions.

	No Action		Alternative 1				Alternative 2						Alternative 3	
			1A		1C		2B		2D		2E		3E	
Vernalis	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	4%	8%	0%	0%	4%	9%	7%	9%	9%	12%	11%	13%	80%	87%
Contra Costa Canal	1%	1%	0%	0%	1%	1%	1%	1%	0%	0%	0%	0%	1%	1%
Exports	88%	91%	67%	72%	88%	90%	88%	90%	82%	87%	83%	86%	11%	11%
Islands	0%	1%	18%	20%	1%	0%	1%	1%	0%	1%	0%	1%	1%	1%
In Delta	7%	0%	15%	8%	7%	0%	4%	0%	8%	0%	5%	0%	9%	0%
Terminous	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	56%	78%	0%	4%	57%	77%	63%	75%	80%	88%	66%	75%	99%	100%
Contra Costa Canal	1%	1%	1%	3%	1%	1%	1%	1%	0%	0%	1%	1%	0%	0%
Exports	14%	20%	19%	56%	15%	21%	19%	24%	7%	11%	13%	21%	0%	0%
Islands	0%	0%	11%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
In Delta	29%	1%	69%	20%	27%	1%	17%	0%	13%	0%	20%	4%	1%	0%
Freeport	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	98%	99%	19%	46%	98%	99%	76%	76%	76%	76%	96%	97%	80%	79%
Contra Costa Canal	0%	0%	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	1%	1%	6%	22%	1%	1%	0%	0%	0%	1%	1%	2%	21%	21%
Islands	0%	0%	8%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
In Delta	1%	0%	65%	20%	1%	0%	24%	23%	24%	23%	3%	1%	0%	0%
Rio Vista	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	100%	100%	50%	79%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Contra Costa Canal	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	0%	0%	2%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Islands	0%	0%	2%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
In Delta	0%	0%	45%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Jersey Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	99%	99%	40%	72%	98%	99%	100%	100%	99%	99%	100%	100%	100%	100%
Contra Costa Canal	0%	0%	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	1%	1%	7%	9%	1%	1%	0%	0%	1%	1%	0%	0%	0%	0%
Islands	0%	0%	3%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
In Delta	0%	0%	49%	13%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
San Andreas Landing	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	94%	97%	13%	39%	94%	96%	99%	99%	94%	96%	99%	99%	100%	100%
Contra Costa Canal	0%	0%	2%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	3%	3%	15%	33%	4%	4%	1%	1%	3%	3%	1%	1%	0%	0%
Islands	0%	0%	4%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
In Delta	3%	0%	66%	18%	2%	0%	0%	0%	3%	0%	0%	0%	0%	0%
Prisoners Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	74%	87%	2%	10%	75%	86%	84%	88%	81%	85%	89%	91%	100%	100%
Contra Costa Canal	1%	1%	3%	4%	1%	1%	0%	1%	1%	1%	0%	0%	0%	0%
Exports	10%	12%	42%	68%	11%	13%	10%	11%	10%	14%	7%	9%	0%	0%
Islands	0%	0%	5%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
In Delta	15%	0%	48%	10%	13%	0%	6%	0%	8%	0%	4%	0%	0%	0%

Table 5.2-6. Fate of mass released at specific locations for medium inflow/low pumping conditions.

	No Action		Alternative 1				Alternative 2						Alternative 3	
			1A		1C		2B		2D		2E		3E	
Vernalis	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	0%	0%	0%	0%	0%	2%	1%	4%	2%	7%	3%	8%	8%	67%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	77%	87%	77%	87%	76%	84%	78%	84%	70%	81%	73%	81%	0%	1%
Islands	10%	11%	10%	11%	8%	11%	8%	10%	7%	10%	7%	9%	8%	13%
In Delta	13%	2%	13%	2%	16%	3%	13%	1%	21%	2%	17%	2%	83%	19%
Terminous	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	1%	8%	1%	8%	3%	16%	7%	25%	24%	54%	7%	20%	15%	80%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	25%	64%	25%	64%	35%	62%	41%	60%	18%	34%	19%	37%	0%	0%
Islands	8%	12%	8%	12%	7%	11%	8%	11%	4%	5%	4%	7%	10%	11%
In Delta	66%	16%	66%	16%	55%	11%	43%	4%	54%	7%	70%	35%	75%	9%
Freeport	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	69%	81%	69%	81%	69%	81%	55%	60%	54%	60%	55%	78%	60%	69%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	5%	10%	5%	10%	8%	12%	3%	4%	3%	4%	7%	13%	27%	27%
Islands	3%	4%	3%	4%	3%	4%	2%	2%	2%	2%	4%	4%	3%	3%
In Delta	23%	4%	23%	4%	19%	3%	40%	33%	41%	34%	34%	4%	10%	1%
Rio Vista	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	87%	94%	87%	94%	86%	93%	94%	98%	93%	97%	94%	98%	96%	99%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	2%	3%	2%	3%	3%	4%	1%	1%	1%	2%	1%	1%	0%	0%
Islands	1%	2%	1%	2%	1%	2%	1%	1%	1%	1%	1%	1%	1%	1%
In Delta	10%	1%	10%	1%	9%	1%	4%	0%	4%	0%	4%	0%	3%	0%
Jersey Point	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	62%	82%	62%	82%	60%	79%	88%	94%	86%	92%	92%	95%	93%	98%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	8%	10%	8%	10%	13%	15%	3%	4%	6%	6%	3%	3%	0%	0%
Islands	3%	4%	3%	4%	3%	3%	2%	2%	2%	2%	1%	2%	2%	2%
In Delta	27%	4%	27%	4%	24%	3%	7%	0%	7%	0%	3%	0%	5%	0%
San Andreas Landing	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	26%	51%	26%	51%	27%	51%	65%	80%	49%	71%	71%	84%	83%	97%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	18%	34%	18%	34%	28%	38%	15%	16%	16%	22%	11%	13%	0%	0%
Islands	4%	6%	4%	6%	4%	5%	3%	3%	3%	3%	2%	3%	2%	2%
In Delta	53%	9%	53%	9%	40%	6%	17%	0%	33%	3%	16%	1%	15%	1%
Prisoners Point	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days	30 days	60 days
Chipps Island	6%	16%	6%	16%	8%	20%	23%	36%	23%	39%	30%	43%	63%	95%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	47%	72%	47%	72%	56%	69%	52%	58%	40%	53%	40%	50%	0%	0%
Islands	4%	6%	4%	6%	5%	7%	4%	6%	3%	5%	3%	5%	3%	3%
In Delta	43%	6%	43%	6%	31%	4%	21%	1%	33%	2%	27%	2%	35%	2%

Table 5.2-7. Fate of mass released at specific locations for low inflow/high pumping conditions.

	No Action		Alternative 1				Alternative 2						Alternative 3	
			1A		1C		2B		2D		2E		3E	
Vernalis	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	3%	0%	1%
Contra Costa Canal	0%	0%	0%	0%	1%	2%	0%	2%	1%	2%	1%	2%	1%	3%
Exports	67%	72%	67%	72%	47%	74%	45%	72%	29%	67%	31%	68%	12%	29%
Islands	18%	20%	18%	20%	13%	17%	14%	18%	12%	17%	12%	17%	13%	21%
In Delta	15%	8%	15%	8%	39%	7%	41%	8%	58%	12%	55%	10%	75%	45%
Terminous	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	0%	4%	0%	4%	1%	6%	0%	4%	4%	20%	0%	3%	0%	4%
Contra Costa Canal	1%	3%	1%	3%	2%	3%	1%	3%	1%	2%	0%	1%	0%	1%
Exports	19%	58%	19%	58%	29%	62%	27%	58%	8%	36%	6%	23%	0%	4%
Islands	10%	15%	10%	15%	10%	15%	10%	16%	4%	8%	5%	9%	15%	27%
In Delta	69%	20%	69%	20%	59%	14%	61%	18%	84%	34%	89%	63%	84%	64%
Freeport	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	19%	46%	19%	46%	20%	46%	19%	46%	19%	39%	7%	36%	19%	43%
Contra Costa Canal	1%	2%	1%	2%	1%	2%	1%	2%	0%	1%	1%	2%	0%	1%
Exports	6%	22%	6%	22%	10%	24%	8%	21%	3%	10%	3%	20%	24%	27%
Islands	8%	11%	8%	11%	8%	11%	6%	9%	4%	6%	6%	9%	6%	8%
In Delta	65%	20%	65%	20%	61%	17%	66%	21%	73%	44%	84%	34%	50%	22%
Rio Vista	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	50%	79%	50%	79%	50%	78%	49%	80%	49%	77%	40%	76%	51%	79%
Contra Costa Canal	0%	1%	0%	1%	1%	1%	0%	1%	0%	1%	0%	1%	0%	1%
Exports	3%	5%	3%	5%	4%	7%	3%	5%	3%	7%	2%	5%	1%	2%
Islands	2%	3%	2%	3%	2%	3%	3%	3%	2%	3%	3%	4%	2%	3%
In Delta	45%	12%	45%	12%	43%	11%	45%	11%	46%	12%	55%	14%	46%	14%
Jersey Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	40%	72%	40%	72%	40%	70%	42%	73%	39%	69%	47%	77%	40%	72%
Contra Costa Canal	1%	2%	1%	2%	1%	2%	1%	1%	1%	1%	1%	1%	1%	2%
Exports	7%	9%	7%	9%	9%	12%	8%	10%	9%	14%	6%	9%	2%	5%
Islands	3%	4%	3%	4%	3%	4%	3%	4%	3%	4%	3%	3%	3%	5%
In Delta	49%	13%	49%	13%	46%	12%	46%	12%	48%	12%	44%	9%	54%	17%
San Andreas Landing	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	13%	39%	13%	39%	14%	40%	15%	45%	9%	31%	15%	47%	13%	46%
Contra Costa Canal	2%	4%	2%	4%	2%	3%	2%	3%	1%	3%	1%	2%	1%	3%
Exports	15%	33%	15%	33%	21%	35%	20%	30%	10%	31%	10%	25%	2%	8%
Islands	4%	7%	4%	7%	4%	6%	4%	6%	3%	6%	3%	5%	4%	6%
In Delta	66%	18%	66%	18%	59%	16%	60%	17%	77%	30%	71%	21%	81%	37%
Prisoners Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	3%	10%	3%	10%	3%	11%	4%	13%	5%	16%	5%	18%	3%	19%
Contra Costa Canal	3%	4%	3%	4%	3%	4%	3%	4%	2%	3%	2%	3%	1%	4%
Exports	42%	68%	42%	68%	49%	68%	52%	67%	31%	61%	32%	61%	3%	21%
Islands	5%	8%	5%	8%	6%	9%	6%	9%	4%	8%	4%	8%	4%	9%
In Delta	48%	10%	48%	10%	39%	8%	35%	7%	58%	12%	56%	10%	89%	47%

Table 5.2-8. Fate of mass released at specific locations for low inflow/low pumping conditions.

	No Action		Alternative 1				Alternative 2						Alternative 3	
			1A		1C		2B		2D		2E		3E	
Vernalis	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Contra Costa Canal	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Exports	31%	32%	31%	32%	4%	18%	5%	17%	22%	23%	22%	23%	20%	20%
Islands	61%	63%	61%	63%	69%	78%	70%	79%	68%	72%	68%	72%	69%	73%
In Delta	6%	4%	6%	4%	26%	4%	25%	3%	10%	6%	10%	6%	11%	6%
Terminous	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	0%	1%	0%	1%	0%	2%	0%	1%	2%	12%	0%	1%	0%	2%
Contra Costa Canal	1%	3%	1%	3%	2%	3%	1%	3%	1%	4%	0%	1%	1%	3%
Exports	10%	30%	10%	30%	14%	33%	11%	27%	2%	19%	1%	9%	1%	11%
Islands	39%	54%	39%	54%	38%	51%	41%	57%	15%	29%	22%	39%	40%	61%
In Delta	49%	12%	49%	12%	49%	11%	47%	12%	80%	37%	76%	50%	58%	23%
Freeport	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	10%	28%	10%	28%	10%	28%	9%	27%	8%	21%	2%	19%	7%	25%
Contra Costa Canal	1%	3%	1%	3%	1%	3%	1%	3%	1%	2%	1%	3%	1%	2%
Exports	4%	15%	4%	15%	6%	17%	6%	17%	1%	7%	0%	11%	12%	17%
Islands	26%	35%	26%	35%	26%	34%	23%	32%	14%	20%	19%	29%	23%	32%
In Delta	59%	19%	59%	19%	57%	18%	61%	22%	77%	50%	78%	38%	57%	24%
Rio Vista	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	35%	62%	35%	62%	35%	62%	32%	62%	31%	60%	22%	54%	31%	62%
Contra Costa Canal	1%	2%	1%	2%	1%	2%	1%	1%	1%	2%	1%	1%	1%	2%
Exports	2%	5%	2%	5%	3%	6%	3%	5%	1%	5%	0%	3%	1%	2%
Islands	8%	11%	8%	11%	8%	11%	8%	11%	8%	12%	11%	17%	8%	12%
In Delta	55%	19%	55%	19%	54%	19%	56%	20%	59%	21%	66%	25%	59%	22%
Jersey Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	27%	55%	27%	55%	27%	55%	28%	58%	28%	56%	32%	63%	30%	61%
Contra Costa Canal	2%	3%	2%	3%	2%	3%	2%	3%	2%	3%	1%	2%	2%	3%
Exports	6%	9%	6%	9%	8%	11%	6%	9%	4%	10%	3%	7%	2%	4%
Islands	9%	12%	9%	12%	8%	16%	8%	11%	8%	11%	7%	10%	8%	11%
In Delta	56%	20%	56%	20%	55%	20%	55%	20%	59%	20%	56%	18%	58%	21%
San Andreas Landing	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	6%	23%	6%	23%	7%	23%	7%	27%	5%	20%	8%	31%	8%	32%
Contra Costa Canal	3%	5%	3%	5%	3%	5%	3%	8%	2%	4%	2%	4%	2%	5%
Exports	12%	28%	12%	28%	16%	31%	15%	26%	4%	21%	3%	17%	2%	10%
Islands	14%	23%	14%	23%	13%	21%	13%	20%	10%	20%	9%	17%	11%	21%
In Delta	65%	21%	65%	21%	61%	19%	62%	22%	80%	35%	77%	31%	76%	31%
Prisoners Point	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**	**30 days**	**60 days**
Chipps Island	1%	6%	1%	6%	1%	6%	2%	8%	2%	9%	2%	11%	1%	7%
Contra Costa Canal	4%	6%	4%	6%	4%	6%	4%	6%	3%	5%	4%	5%	2%	7%
Exports	30%	49%	30%	49%	35%	52%	36%	50%	15%	43%	15%	43%	7%	24%
Islands	21%	31%	21%	31%	21%	29%	21%	28%	18%	28%	17%	26%	17%	37%
In Delta	44%	9%	44%	9%	38%	8%	36%	8%	62%	15%	61%	14%	72%	25%

Table 5.2-9. Change in monthly average net Delta outflow (cfs) by percentile.

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
NO ACTION ALTERNATIVE													
95%	119,237	145,470	115,269	82,072	57,358	33,211	8,002	5,325	12,076	17,649	33,309	82,348	81,584
90%	98,397	132,113	91,592	66,950	43,726	20,836	8,002	5,116	8,820	14,078	19,202	63,873	53,787
75%	46,058	59,564	47,148	30,267	23,094	10,856	8,002	4,798	3,496	7,205	10,285	17,955	19,921
50%	17,581	31,186	27,209	16,503	11,206	7,983	6,505	4,001	3,008	4,912	5,058	7,253	8,002
25%	7,872	13,721	15,288	10,352	6,993	6,890	4,993	3,497	3,008	4,001	4,504	4,586	4,810
10%	6,001	11,398	10,259	8,094	5,978	5,953	4,001	2,992	3,008	4,001	3,496	4,505	3,497
5%	5,370	10,944	9,150	7,099	5,767	5,714	4,001	2,992	3,008	4,001	3,496	3,497	3,008
ALTERNATIVE 1 - Configuration 1C													
95%	12%	7%	11%	8%	3%	1%				3%	2%	9%	4%
90%	6%	3%	4%	4%	2%							3%	1%
75%													
50%	-4%	-1%	-2%									-1%	
25%	-24%	-9%	-7%	-2%	-1%				-5%	-9%	-17%	-15%	-4%
10%	-33%	-15%	-17%	-9%	-3%	-2%			-18%	-24%	-33%	-30%	-18%
5%	-35%	-20%	-20%	-15%	-4%	-4%			-22%	-28%	-46%	-38%	-27%
ALTERNATIVE 2 - Configurations 2A, 2C													
95%	20%	9%	7%	1%	1%					1%		19%	5%
90%	12%	8%	3%		1%							5%	1%
75%	3%	1%	1%										
50%													
25%	-2%			-1%					-1%	-14%	-17%	-9%	
10%	-20%	-4%	-3%	-3%	-2%	-4%			-27%	-25%	-28%	-20%	-12%
5%	-22%	-6%	-5%	-4%	-3%	-5%			-30%	-29%	-31%	-23%	-22%
Configurations 2B, 2E													
95%	12%	7%	11%	8%	3%	1%				3%	2%	9%	4%
90%	6%	3%	4%	4%	2%							3%	1%
75%													
50%	-4%	-1%	-2%									-1%	
25%	-24%	-9%	-7%	-2%	-1%				-5%	-9%	-17%	-15%	-4%
10%	-33%	-15%	-17%	-9%	-3%	-2%			-18%	-24%	-33%	-30%	-18%
5%	-35%	-20%	-20%	-15%	-4%	-4%			-22%	-28%	-46%	-38%	-27%
Configuration 2D													
95%	9%	5%	3%	5%	2%	1%				1%		6%	3%
90%	5%	2%		1%	1%							3%	
75%													
50%	-1%	-1%	-1%									-1%	
25%	-12%	-5%	-4%	-1%	-1%				-3%	-5%	-17%	-14%	-2%
10%	-20%	-10%	-8%	-3%	-2%	-2%			-16%	-23%	-28%	-22%	-13%
5%	-21%	-10%	-10%	-4%	-4%	-5%			-22%	-30%	-32%	-25%	-22%
ALTERNATIVE 3 - Configurations 3A, 3C													
95%	25%	13%	7%	1%	3%	6%		4%		3%	7%	34%	14%
90%	19%	9%	5%		2%	3%		2%		1%		28%	5%
75%	7%	2%	2%			1%						20%	
50%				-3%									
25%	-11%	-1%	-3%	-13%	-10%	-4%			-11%	-14%	-18%	-19%	-6%
10%	-24%	-7%	-11%	-19%	-26%	-11%			-32%	-27%	-32%	-30%	-22%
5%	-29%	-12%	-24%	-21%	-31%	-22%		-1%	-40%	-38%	-40%	-35%	-29%
Configurations 3B, 3D, 3E, 3F, 3G, 3H, 3I													
95%	14%	12%	3%	2%	4%	8%		3%		3%	8%	27%	7%
90%	7%	3%		1%	3%	4%		2%		2%	5%	20%	3%
75%			-1%		1%	1%						3%	
50%	-6%	-3%	-3%	-4%	-1%							-2%	
25%	-25%	-11%	-16%	-13%	-14%	-2%			-9%	-12%	-16%	-27%	-12%
10%	-31%	-18%	-25%	-22%	-27%	-12%			-23%	-27%	-46%	-33%	-27%
5%	-40%	-27%	-29%	-25%	-38%	-22%		-1%	-38%	-44%	-55%	-39%	-33%

Zero percent shown as blank spaces; boxed values represent changes greater than 10 percent. Negative values indicate decreased flow, while positive values indicate increased flow.

C-003008

To evaluate the storage component of Configuration 1C, net Delta outflow was compared to Configurations 2A and 2C (Table 5.2-9). The storage component tends to increase the number of months with reduced outflow and the magnitude of the decreases (up to 20 percent), especially during February and March.

To further analyze the critical (low) net Delta outflow, changes in outflow in the range of the WQCP minimum flow requirements (3,000 cfs to 8,000 cfs) are examined more closely. Figure 5.2-7(a) shows the distribution of net Delta outflows in the lower outflow range. This analysis indicates that the number of months with Delta outflows in the 3,000 cfs to 4,000 cfs range do not change. The number of months with flows between 4,000 cfs and 6,500 cfs will increase by 3 percent (from 226 months to 250 months). The number of months with flows greater than 6,500 cfs decreases by approximately the same amount.

5.2.2.1.4 Central Delta Outflow

DWRDSM1 modeling was used to evaluate the effects of Alternative 1 on monthly average central Delta outflow. Central Delta outflow is defined as the total flow in the San Joaquin River upstream from Threemile Slough plus the flow in False River and Dutch Slough. Figure 5.2-8 (a) shows the frequency distributions for Configurations 1A and 1C and the No Action Alternative. Alternative 1 did not affect the number of months with reverse flows (shown as negative). However, the figure suggest an increase in the magnitude of upstream flows; the number of months in the -5,000 to -2,500 cfs range decreased while the number of months in the <-5,000 cfs range increased.

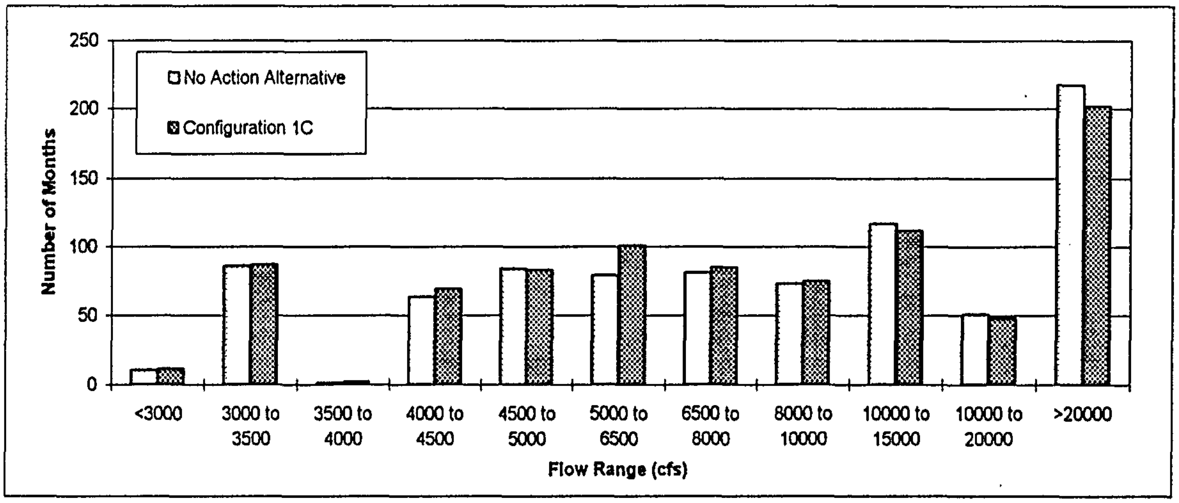
Table 5.2-10 shows the distribution of central Delta outflows by month. The distribution does not appear to change when compared to the No Action Alternative. Of those flows originally in the upstream direction, about half increased in magnitude; the maximum increase is around 3,600 cfs, with an average of 1,200 cfs. Of those flows originally in the downstream direction, about half decreased in flow; the maximum decrease is around 3,500 cfs, with an average of 350 cfs.

The current modeling of Configuration 1A used in this analysis involved CVP-SWP improvements although the improvements are not included in CALFED Configuration 1A. CVP-SWP improvements include an increased pumping capacity; however, the effects of increased pumping on central Delta outflow are likely to be small.

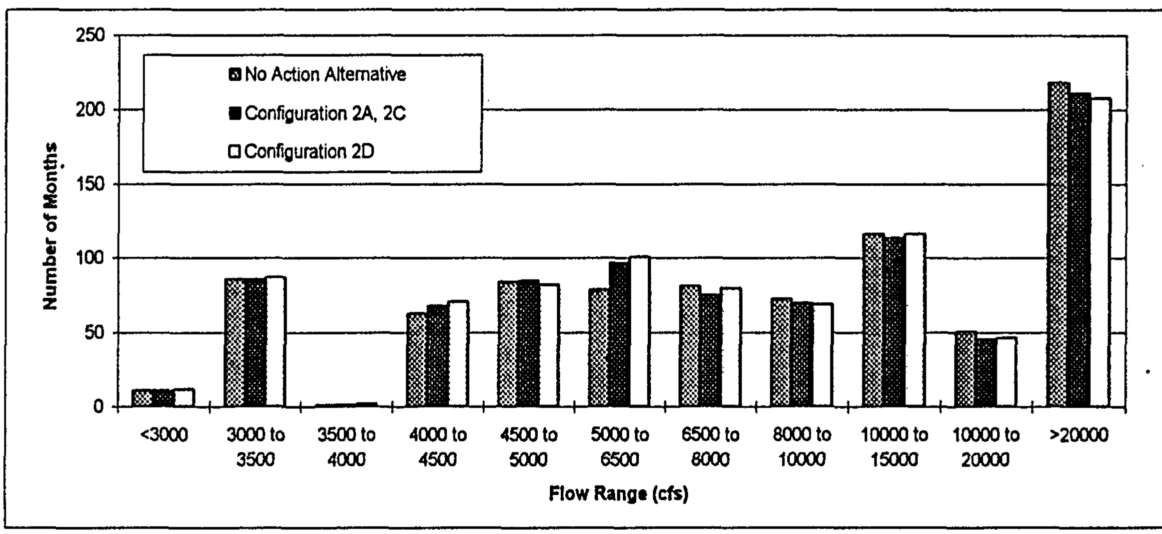
Configuration 1B is similar to Configuration 1A, with the addition of operable barriers, flow control measures, and fish screens. The barrier at the head of Old River will reduce reverse flows in the San Joaquin River.

5.2.2.1.5 X2 Position

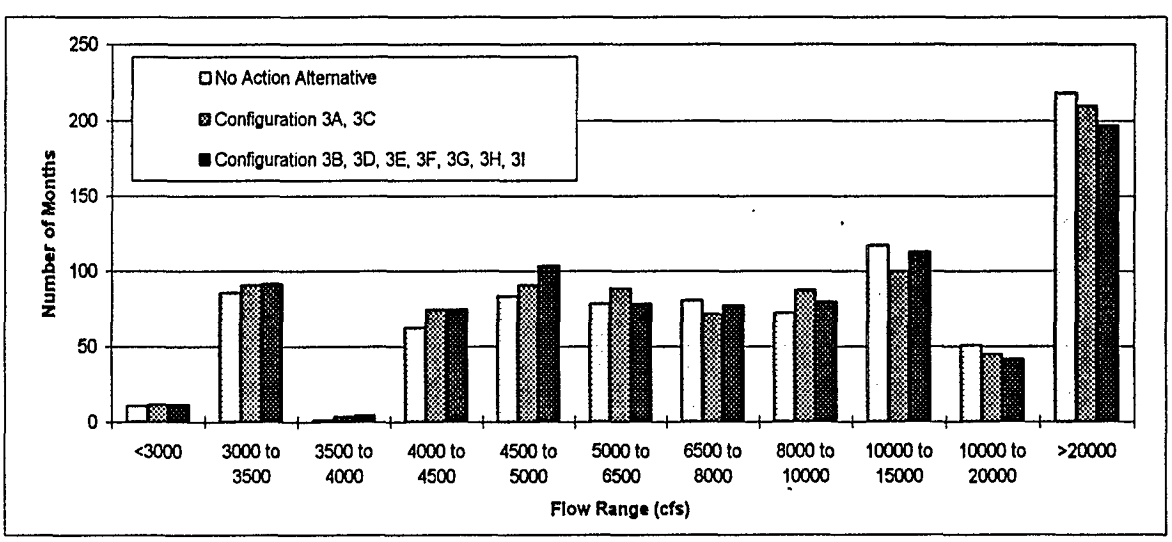
DWRSIM modeling was used to evaluate the effects of Alternative 1 on X2 location. The X2 position is defined as the location of the 2 parts-per-thousand isohaline. Table 5.2-11 shows the distribution of X2 position. Potential impacts are assessed by identifying relative changes in the X2 position greater than or equal to 1 kilometer (km). Differences greater than 1 km are



(a) Alternative 1

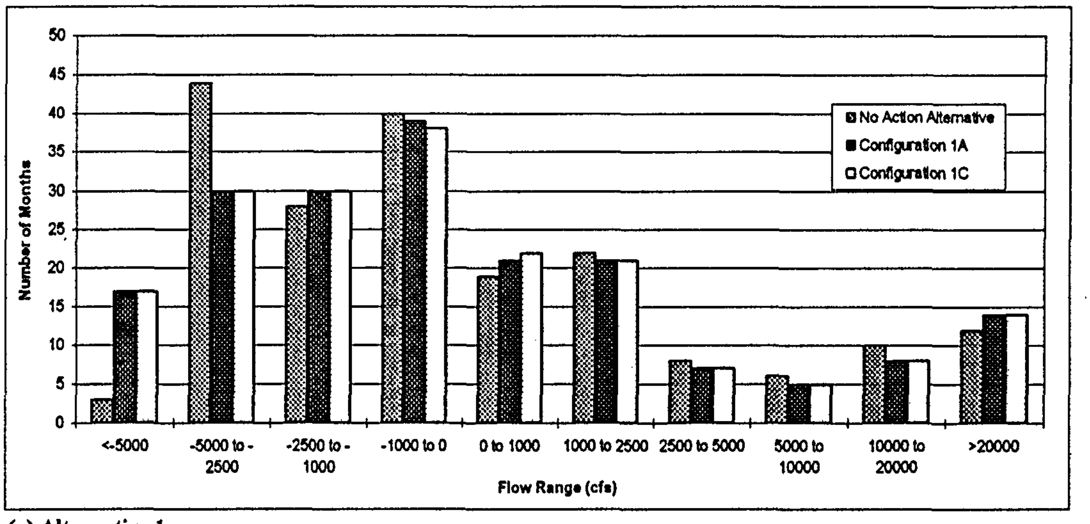


(b) Alternative 2

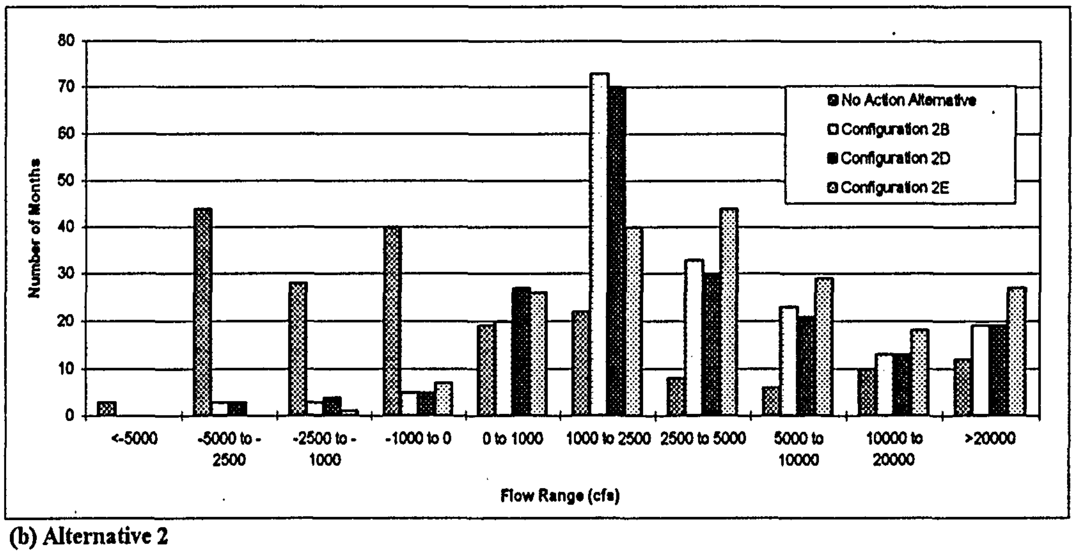


(c) Alternative 3

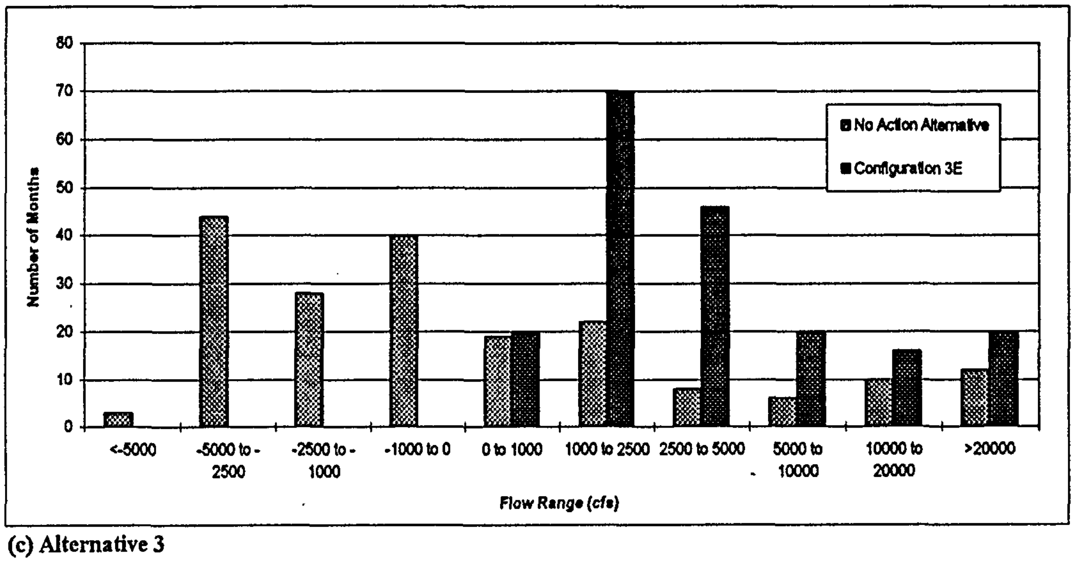
Figure 5.2-7. Frequency distribution of net Delta outflow for each alternative.



(a) Alternative 1



(b) Alternative 2



(c) Alternative 3

Figure 5.2-8. Frequency distribution of central Delta outflow for each alternative.

Table 5.2-10. Monthly averaged central Delta outflow (cfs) by percentile.

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
NO ACTION ALTERNATIVE													
95%	21452	40171	36355	26262	13403	11968	3421	40	171	4371	7858	22300	22090
90%	17906	35186	25580	17280	6895	4191	1346	-298	-140	3170	2552	10488	11156
75%	4301	12292	12621	2912	2069	2342	-502	-607	-199	1318	-197	-821	1566
50%	-985	2180	564	1000	908	153	-2213	-2272	-1588	-454	-1727	-3141	-416
25%	-2844	-472	-1256	415	-242	-844	-4770	-3717	-2692	-2073	-3229	-4417	-2350
10%	-4783	-3287	-2533	265	-503	-984	-5017	-4540	-3038	-2185	-3737	-4547	-3996
5%	-4904	-3634	-2872	106	-591	-1070	-5129	-4654	-3141	-2263	-3898	-4630	-4656
ALTERNATIVE 1 - Configuration 1A													
95%	22340	41245	37968	26163	12892	10878	3278	747	-173	2816	7475	24061	22503
90%	18445	35899	26401	17079	6540	3473	1172	540	-181	1781	2275	10441	11707
75%	2998	12697	12362	2561	2082	2346	425	-389	-425	1167	-560	-1477	1496
50%	-1632	1824	506	1000	870	160	-1736	-1075	-1477	-1639	-1731	-3679	-569
25%	-3472	-646	-1212	409	-238	-842	-6236	-2236	-2470	-2317	-4068	-5130	-2439
10%	-5579	-2879	-3336	257	-505	-980	-7409	-4071	-3058	-2774	-5956	-5726	-4748
5%	-6257	-3148	-4335	106	-599	-1069	-7629	-4675	-3188	-3409	-7197	-5972	-5734
Configuration 1C													
95%	22363	41275	38000	26188	12913	10937	3274	733	-173	2816	7557	24086	22528
90%	18463	35927	26429	17102	6533	3549	1158	529	-181	1775	2335	10459	11725
75%	3035	12712	12378	2526	2009	2370	443	-382	-422	1182	-542	-1444	1478
50%	-1617	1828	513	1006	861	165	-1723	-1064	-1466	-1633	-1712	-3660	-565
25%	-3455	-639	-1205	408	-241	-834	-6197	-2220	-2451	-2319	-4043	-5102	-2434
10%	-5543	-2868	-3312	257	-506	-972	-7356	-4052	-3034	-2774	-5881	-5687	-4722
5%	-6233	-3139	-4276	106	-600	-1060	-7576	-4657	-3159	-3418	-7073	-5920	-5699
ALTERNATIVE 2 - Configuration 2B													
95%	30328	50094	46259	34717	21485	16714	5725	1574	3410	10911	15937	32139	30782
90%	25228	44342	34961	25630	14930	7804	3286	1392	1844	6468	7741	18504	19375
75%	11479	20055	19316	9979	8342	6183	2103	1181	1559	2244	2149	2173	6298
50%	3606	6042	7268	5252	3120	1220	369	1019	1241	1915	1687	1562	2172
25%	2043	3735	3413	3371	2353	993	-1792	550	1131	1747	1473	1122	1228
10%	1515	3507	2863	2982	2050	895	-3077	-89	1058	1404	861	563	682
5%	1198	3440	2533	2860	1918	777	-3269	-890	1005	923	751	388	-141
Configuration 2D													
95%	30281	49965	46208	34700	21421	16453	5448	1534	3239	10659	15881	32133	30789
90%	25195	44232	34911	25630	14682	7545	3091	1452	1715	6307	7698	18429	19383
75%	11301	19992	19279	9655	8136	5955	2007	1313	1516	2159	2102	2084	6046
50%	3299	5883	7109	5093	2911	970	416	947	1173	1777	1587	1457	2048
25%	1958	3511	3114	3133	2145	710	-2367	572	1060	1567	1391	879	1128
10%	1231	3266	2640	2764	1834	610	-3568	-519	973	1130	640	321	527
5%	917	3217	2298	2647	1695	506	-3763	-1254	922	601	483	119	-524
Configuration 2E													
95%	43860	72775	64461	50964	28873	20802	6959	2316	5710	13137	24623	46338	46450
90%	38116	64855	51519	36758	18398	8480	4372	2185	2688	7880	13752	32849	28126
75%	20630	30395	28728	11417	8437	6279	3731	2094	1371	3077	3187	2858	8785
50%	4083	10762	13213	9238	5714	3762	1572	1714	731	1270	1542	1181	3688
25%	2999	7033	6724	5995	3934	2933	65	1438	292	773	1269	530	1337
10%	2485	5867	4690	4777	3727	2653	-880	436	169	645	770	397	548
5%	1995	5504	4173	4568	3556	2388	-964	-229	46	348	639	327	188
ALTERNATIVE 3 - Configuration 3E													
95%	29537	49824	45502	34920	22626	18795	7427	3126	6133	13198	16174	31329	30372
90%	24415	43763	34186	26004	16081	9054	4542	2819	3649	8850	9375	19677	20001
75%	13844	19396	18575	10164	8452	6278	3528	2518	1334	3202	2741	2982	6273
50%	4205	5231	6759	5278	3117	1201	1772	1604	715	1970	1665	1622	2709
25%	2783	2952	4115	3373	2332	968	1453	1347	527	1298	1323	1300	1398
10%	1587	2634	2197	2992	2046	889	1380	1276	478	1209	952	971	1000
5%	1488	2597	1823	2868	1909	774	1361	1246	435	1130	872	857	759

Central Delta includes the lower San Joaquin River upstream from Three Mile Slough plus False River and Dutch Slough. Negative values (boxed) are upstream flows.

Table 5.2-11. Changes in X2 position (km) using differences in percentiles.

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Overall
NO ACTION ALTERNATIVE													
90%	83.6	78.0	75.8	77.8	81.0	81.0	85.2	88.7	89.9	87.9	87.7	86.1	87.7
80%	81.3	75.1	73.7	75.0	79.8	81.0	83.5	87.0	89.3	87.8	86.5	86.1	85.8
70%	79.5	72.4	71.1	73.8	77.7	80.1	83.1	86.9	89.3	87.6	86.5	85.0	83.0
60%	76.9	70.2	68.1	71.2	74.7	79.3	81.3	84.9	88.6	87.1	86.1	83.2	80.9
50%	74.4	66.8	66.4	69.2	73.5	76.9	80.0	84.7	88.6	85.8	84.3	80.4	78.2
40%	72.0	63.2	63.4	67.5	70.5	75.9	78.7	83.1	88.0	85.7	81.4	78.4	75.4
30%	66.4	60.5	60.3	64.3	66.7	73.7	77.7	82.7	87.5	83.2	79.0	74.1	72.3
20%	59.1	55.8	56.8	60.8	64.6	70.8	76.5	82.0	84.1	79.6	76.7	68.6	66.9
10%	55.4	51.9	53.3	55.2	58.7	64.7	74.5	81.8	79.5	74.4	73.9	63.7	59.9
ALTERNATIVES 1 AND 2 - Configurations 1C, 2B, 2E													
90%	0.10	0.16	0.08	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80%	1.36	0.66	0.20	0.02	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.10
70%	1.72	1.68	-0.02	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.30
60%	2.26	0.84	1.60	0.84	0.10	0.08	0.00	0.00	0.00	0.20	0.10	0.78	0.40
50%	2.40	1.60	0.70	0.50	-0.10	0.00	0.00	0.00	0.00	0.00	0.80	2.20	0.95
40%	3.52	-0.32	1.06	0.28	0.10	0.00	0.00	0.02	-0.08	0.00	1.80	2.52	1.00
30%	1.62	0.98	0.62	0.80	0.06	0.10	0.00	0.00	0.12	0.98	2.76	4.16	0.75
20%	1.22	1.42	0.36	0.52	0.50	0.04	0.00	0.00	1.34	3.02	3.42	1.22	0.60
10%	0.72	0.22	0.36	0.54	0.42	0.50	0.18	0.00	1.86	1.40	2.50	0.50	0.90
ALTERNATIVE 2 - Configurations 2A, 2C													
90%	0.00	0.12	0.08	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80%	1.14	0.22	-0.06	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70%	0.54	0.56	0.06	-0.06	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.45
60%	0.00	-0.14	0.52	1.00	0.00	0.08	0.00	0.00	0.00	0.00	-0.08	1.04	0.10
50%	0.20	0.30	0.40	0.00	-0.20	0.00	0.00	0.00	0.00	0.00	0.70	1.90	0.60
40%	-0.26	-0.08	-0.10	0.00	0.00	0.00	0.00	0.02	-0.08	0.00	1.46	1.08	0.30
30%	0.14	-0.02	-0.06	0.12	-0.12	0.00	0.00	0.00	0.00	1.64	2.22	1.26	0.35
20%	0.58	0.02	-0.22	0.16	0.18	0.00	0.00	0.00	1.26	3.28	2.04	0.62	0.20
10%	-0.10	-0.08	0.08	0.00	0.34	0.60	0.20	0.08	3.28	2.12	1.52	0.78	0.10
Configuration 2D													
90%	0.02	0.14	0.10	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80%	1.32	0.48	0.08	0.02	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.10
70%	1.32	1.36	0.26	0.24	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.30
60%	1.56	0.18	0.98	1.08	0.10	0.08	0.00	0.00	0.00	0.00	0.02	0.64	0.10
50%	1.00	0.60	0.40	0.10	-0.10	0.00	0.00	0.00	0.00	0.30	0.70	2.00	0.50
40%	1.16	-0.14	1.02	0.20	0.10	0.00	0.00	0.02	-0.08	0.00	1.64	1.90	0.50
30%	0.40	0.34	0.16	0.24	0.00	0.06	0.00	0.00	0.06	1.64	1.80	2.76	0.50
20%	0.72	0.86	0.18	0.36	0.24	0.04	0.00	0.00	1.26	2.42	2.60	0.94	0.30
10%	0.50	0.12	0.24	0.12	0.34	0.56	0.18	0.08	1.30	1.10	2.70	0.74	0.20
ALTERNATIVE 3 - Configurations 3A, 3C													
90%	1.84	0.86	1.30	1.04	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.32	0.00
80%	2.02	0.00	0.52	-0.04	0.40	0.00	0.00	0.00	0.00	-0.12	0.00	-0.06	0.60
70%	0.24	-0.42	0.00	0.54	0.56	0.00	0.00	0.00	0.00	0.10	0.00	-0.10	1.15
60%	0.66	-0.46	0.54	2.80	1.68	0.16	-0.06	0.00	0.08	0.38	0.38	1.02	0.10
50%	0.00	0.20	0.30	1.30	0.80	0.30	0.10	0.10	0.00	1.60	2.10	2.30	0.90
40%	-0.50	-0.32	0.06	0.28	2.66	0.64	0.28	0.00	0.10	0.00	3.12	0.46	0.80
30%	0.30	-0.12	-0.24	0.40	1.14	1.18	0.42	0.00	0.40	2.52	1.56	1.16	1.20
20%	0.68	0.08	-0.18	0.32	0.74	1.54	0.54	0.00	3.62	3.48	2.10	0.98	0.30
10%	-0.10	-0.10	-0.02	0.08	0.42	0.66	0.22	0.08	1.88	1.66	1.94	0.78	0.00
Configurations 3B, 3D-3I													
90%	2.26	0.50	2	1.12	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.86	0.00
80%	2.62	1.32	1.46	0.86	0.68	0.00	0.00	0.00	0.00	-0.12	0.00	0.04	0.60
70%	2.84	2.08	1.50	0.54	0.62	0.00	0.00	0.00	0.00	0.10	0.00	1.02	1.55
60%	1.76	2.04	2.06	2.80	1.68	0.16	0.02	0.00	0.08	0.38	0.38	2.52	0.40
50%	1.50	1.50	1.20	1.80	1.00	0.30	0.10	0.10	0.00	1.60	2.10	2.90	1.20
40%	1.92	-0.42	1.02	0.34	3.14	0.68	0.50	0.02	0.12	0.00	3.74	1.24	1.40
30%	1.82	1.02	0.56	2.00	2.14	1.38	0.42	0.00	0.40	2.40	3.04	3.40	1.70
20%	0.92	1.42	0.46	0.80	0.98	1.28	0.40	0.00	3.62	3.16	2.90	0.74	1.10
10%	0.50	0.22	0.24	0.48	0.50	0.76	0.20	0.08	0.70	1.38	2.48	0.12	0.60

Changes shown are the differences in the distributions of X2 position between the configuration and the No Action Alternative.
Boxed values represent positive increases greater than 1 kilometer.
Positive values indicate a move eastward toward the Delta. Negative values indicate a move westward toward the Bay.

shaded in the table. The same general patterns of change observed in net Delta outflow are observed in the X2 position; that is, upstream movements in the X2 position tend to occur in the fall when Delta outflow tends to decrease.

In an effort to place some measure of significance on these changes, the magnitude of change is compared to the hydrologic range of X2 positions under the No Action alternative. For example, the X2 position ranges from 80 to 90 km in September (the 10 and 90 percentiles, respectively), which means the X2 position varies by 10 km. Thus, a 1 km change is 10 percent of a 10 km range in the X2 position.

Based on the difference in percentiles approach, under Alternative 1, the western positions of X2 (lowest No Action values in Table 5.2-11) move upstream from 1.3 to 4.2 km during the late summer and fall. The changes in September are 13 to 19 percent of the hydrologic range in X2 position. The changes in December are 10 to 19 percent of the hydrologic range in X2 position. In January, the X2 position tends to move eastward from 1.2 to 3.5 km. The range in the position of X2 in January is 30 km, which represents 4 to 13 percent of the natural variability in X2 positions. The eastern X2 positions (highest No Action values in Table 5.2-11) do not change from the No Action Alternative.

5.2.2.1.6 Salinity

DWRDSM1 modeling was used to evaluate the effects of Alternative 1 on salinity. Salinity for the No Action Alternative is based on the same modeling study as Configuration 1A; therefore, Configuration 1C is compared to Configuration 1A.

Salinity was analyzed at four locations: the San Joaquin River at Jersey Point, the Sacramento River at Emmaton, Old River at Rock Slough, and Clifton Court Forebay. Tables 5.2-12 through 5.2-15 show the percentiles for the differences in salinity between Configuration 1C and the No Action Alternative. The table identifies increases greater than 10 percent by shading. The effects of Alternative 1 on salinity can be summarized as follows:

Jersey Point. No substantial change in salinity is observed at Jersey Point.

Emmaton. No substantial change in salinity is observed at Emmaton.

Old River. Configuration 1C increases salinity in April, May, and June about 50 percent of the time, with increases in magnitude ranging from 10 to 30 percent.

Clifton Court. Configuration 1C substantially affects the salinity at Clifton Court Forebay. On average, about 50 percent of the monthly salinities increased 10 percent or more. Essentially no decreases in salinity are observed.

These results suggest that Configuration 1C will increase salinity in the south Delta presumably due to increased flow in Old River toward the export pumps. Configuration 1C also increases the amount of saline water entering the south Delta from the Bay. These results are analogous to reduced net Delta outflow and increased upstream flows in the central Delta also seen with Alternative 1.

Table 5.2-12. Changes in salinity on San Joaquin River at Jersey Point.

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
Salinity (mg/L) for Configuration 1A													
95%	1906	1669	1907	1615	397	287	268	374	432	1201	1653	1757	1717
90%	1744	1604	1836	1333	343	264	220	350	414	1170	1451	1711	1617
75%	1575	1453	1711	751	264	169	150	273	328	1049	1130	1523	1191
50%	1368	1285	1509	358	177	148	119	166	208	481	845	1365	342
25%	634	481	392	194	135	115	110	112	110	189	523	1243	145
10%	300	161	120	145	118	113	108	108	107	141	388	728	112
5%	113	116	115	137	116	110	104	106	100	129	335	278	109
ALTERNATIVE 1 - Configuration 1C													
95%					1%	1%	2%	8%	3%	2%	2%	2%	3%
90%	-1%				1%	1%	1%	7%	3%	2%	1%	1%	2%
75%	-1%	-1%	-1%	-1%			1%	4%	3%	1%	1%		1%
50%	-2%	-2%	-2%	-2%	-1%			1%	2%				
25%	-3%	-3%	-2%	-2%	-2%	-1%		1%	1%	-1%		-1%	-2%
10%	-3%	-3%	-3%	-3%	-3%	-1%			1%	-1%	-1%	-2%	-3%
5%	-4%	-3%	-3%	-3%	-5%	-2%				-1%	-1%	-2%	-3%
ALTERNATIVE 2 - Configuration 2B													
95%	-6%	-5%							10%		-17%	-27%	
90%	-9%	-19%		-6%					5%	-6%	-21%	-28%	
75%	-39%	-36%	-42%	-27%	-6%	-5%		-5%		-21%	-32%	-33%	-10%
50%	-58%	-51%	-61%	-52%	-33%	-14%	-8%	-28%	-24%	-31%	-45%	-49%	-38%
25%	-68%	-68%	-72%	-70%	-59%	-35%	-25%	-39%	-37%	-42%	-47%	-64%	-54%
10%	-73%	-73%	-74%	-71%	-67%	-51%	-42%	-46%	-46%	-52%	-55%	-67%	-69%
5%	-74%	-75%	-74%	-74%	-78%	-54%	-47%	-49%	-48%	-54%	-60%	-68%	-73%
Configuration 2D													
95%	-9%			-5%					9%		-25%	-31%	
90%	-11%	-20%		-7%					5%	-11%	-29%	-32%	
75%	-40%	-38%	-44%	-28%	-6%					-22%	-39%	-37%	-10%
50%	-61%	-54%	-61%	-53%	-32%	-12%	-7%	-27%	-24%	-35%	-50%	-53%	-40%
25%	-70%	-68%	-72%	-70%	-53%	-34%	-22%	-39%	-38%	-46%	-55%	-65%	-58%
10%	-74%	-73%	-74%	-72%	-61%	-51%	-41%	-45%	-46%	-58%	-60%	-68%	-70%
5%	-76%	-75%	-74%	-76%	-65%	-53%	-46%	-48%	-48%	-59%	-64%	-69%	-73%
Configuration 2E													
95%	-9%	-6%	-7%	-10%	-5%					-15%	-38%	-37%	
90%	-24%	-25%	-8%	-13%	-7%					-20%	-42%	-42%	
75%	-53%	-51%	-51%	-37%	-12%	-6%				-33%	-50%	-46%	-18%
50%	-62%	-57%	-66%	-63%	-34%	-17%	-8%	-30%	-30%	-60%	-58%	-53%	-51%
25%	-66%	-69%	-68%	-70%	-58%	-35%	-23%	-44%	-56%	-70%	-62%	-60%	-63%
10%	-72%	-70%	-71%	-76%	-65%	-56%	-44%	-54%	-67%	-71%	-65%	-65%	-70%
5%	-74%	-71%	-73%	-81%	-69%	-57%	-50%	-57%	-69%	-71%	-68%	-66%	-72%
ALTERNATIVE 3 - Configuration 3E													
95%	20%	16%	6%	12%	25%	41%	51%	41%	49%	6%	-19%	-6%	43%
90%	15%			6%	16%	35%	45%	40%	46%		-25%	-13%	35%
75%	-10%	-25%	-23%		5%	26%	42%	32%	8%	-18%	-38%	-19%	
50%	-50%	-35%	-57%	-38%	-6%		33%		-18%	-57%	-51%	-43%	-29%
25%	-65%	-62%	-64%	-53%	-31%	-9%		-29%	-47%	-75%	-62%	-56%	-55%
10%	-72%	-69%	-65%	-62%	-47%	-34%	-24%	-42%	-59%	-78%	-70%	-64%	-67%
5%	-73%	-69%	-67%	-69%	-50%	-36%	-32%	-46%	-62%	-78%	-71%	-66%	-71%

Zero percent shown as blank spaces; shaded values represent increases greater than 10 percent.
Negative values represent decreases in salinity, while positive values represent increases in salinity.

Table 5.2-13. Changes in salinity on Sacramento River at Emmaton.

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
Salinity (mg/L) for Configuration 1A													
95%	1374	1706	1954	1405	207	273	300	452	415	942	1759	1875	1714
90%	1318	1700	1940	1298	194	192	266	422	377	855	1709	1837	1497
75%	1132	1469	1026	282	147	126	147	393	343	640	1508	1737	880
50%	1012	1055	705	165	125	109	107	150	288	375	784	1370	258
25%	619	222	185	129	110	105	104	111	125	184	506	799	116
10%	148	110	105	112	106	104	103	103	111	169	414	418	104
5%	103	105	104	109	104	103	102	102	101	150	336	133	103
ALTERNATIVE 1 - Configuration 1C													
95%							1%	2%	4%	4%	1%	1%	2%
90%								2%	3%	3%	1%	1%	1%
75%								1%	1%	2%			
50%	-1%	-1%	-1%	-1%						1%		-1%	
25%	-2%	-2%	-2%	-2%	-1%	-1%				-1%	-1%	-1%	-1%
10%	-2%	-3%	-3%	-2%	-2%	-1%	-2%	-1%	-1%	-2%	-2%	-2%	-2%
5%	-3%	-3%	-4%	-3%	-2%	-1%	-4%	-1%	-1%	-3%	-2%	-2%	-3%
ALTERNATIVE 2 - Configuration 2B													
95%	44%	27%	33%	10%		6%	7%	20%	9%	22%	32%	50%	35%
90%	43%	24%	32%				6%	18%	9%	21%	29%	48%	30%
75%	34%	20%	21%					14%		16%	19%	45%	16%
50%	20%	16%	13%					7%		8%	14%	30%	
25%		5%		-14%	-9%						5%	17%	
10%				-21%	-21%				-7%			6%	-6%
5%	-9%			-22%	-26%				-9%			-6%	-12%
Configuration 2D													
95%	37%	21%	27%	5%				10%		13%	19%	41%	29%
90%	33%	17%	26%					9%		12%	18%	38%	19%
75%	26%	13%	13%					5%		7%	11%	36%	9%
50%	10%	6%	7%								8%	22%	
25%				-16%	-11%				-12%			10%	
10%	-11%	-5%	-7%	-25%	-23%	-5%			-14%	-5%			-12%
5%	-15%	-6%	-12%	-28%	-28%	-6%	-5%		-15%	-6%		-7%	-15%
Configuration 2E													
95%	8%			5%			6%	16%		19%	22%	12%	15%
90%	7%							15%		18%	19%	11%	12%
75%	5%							14%		13%	13%	10%	
50%				-7%						6%	10%	8%	
25%		-5%	-5%	-16%	-12%							5%	
10%		-6%	-15%	-28%	-23%				-7%				-7%
5%	-11%	-8%	-18%	-33%	-29%	-7%	-2%	0%	-9%			-8%	-19%
ALTERNATIVE 3 - Configuration 3E													
95%	61%	37%	37%	15%	11%	16%	23%	24%	22%	74%	70%	53%	53%
90%	59%	35%	37%	10%	8%	13%	20%	23%	19%	73%	58%	50%	39%
75%	40%	21%	36%	7%	7%	9%	17%	17%		51%	37%	42%	24%
50%	27%	16%	17%			5%	13%	5%	-13%	28%	32%	19%	9%
25%	8%	7%							-22%	22%	21%	8%	
10%				-9%	-7%		-5%	-8%	-26%	8%		6%	-7%
5%				-12%	-13%		-8%	-11%	-29%				-14%

Zero percent shown as blank spaces; shaded values represent increases greater than 10 percent.
Negative values represent decreases in salinity, while positive values represent increases in salinity.

Table 5.2-14. Changes in salinity on Old River at Rock Slough.

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
Salinity (mg/L) for Configuration 1A													
95%	682	657	830	801	386	237	166	181	192	558	635	624	688
90%	660	626	824	644	348	215	156	176	183	530	528	584	619
75%	543	562	774	544	221	158	146	151	158	444	402	493	439
50%	447	451	651	282	190	150	138	139	146	205	295	440	199
25%	294	287	208	218	159	140	131	135	126	131	175	400	144
10%	180	203	125	147	141	116	123	128	115	118	148	262	126
5%	129	160	119	142	126	108	112	124	106	117	141	156	118
ALTERNATIVE 1 - Configuration 1C													
95%						5%	17%	31%	16%	6%			17%
90%							16%	28%	12%	5%			13%
75%		-5%					14%	24%	5%		0%		
50%	-8%	-7%					9%	19%					
25%	-9%	-11%						13%					
10%	-11%	-11%	-5%									-5%	-6%
5%	-11%	-11%	-5%	-5%	-5%							-5%	-9%
ALTERNATIVE 2 - Configuration 2B													
95%							19%	26%	5%		-14%	-24%	16%
90%	-6%	-11%					17%	25%			-17%	-33%	7%
75%	-29%	-46%	-45%	-18%			14%	21%			-23%	-39%	
50%	-58%	-54%	-65%	-54%	-24%	-6%	7%	13%	-5%	-35%	-35%	-55%	-26%
25%	-69%	-71%	-79%	-64%	-44%	-25%			-19%	-55%	-47%	-62%	-55%
10%	-71%	-75%	-80%	-78%	-53%	-30%	-7%		-32%	-58%	-56%	-64%	-69%
5%	-72%	-76%	-80%	-80%	-59%	-33%	-10%		-36%	-60%	-60%	-66%	-76%
Configuration 2D													
95%							23%	31%	5%		-13%	-20%	19%
90%		-9%		-6%			21%	29%			-17%	-27%	6%
75%	-24%	-41%	-43%	-20%	-8%		19%	23%			-20%	-35%	
50%	-53%	-50%	-64%	-54%	-21%	-10%	8%	16%	-5%	-34%	-33%	-52%	-24%
25%	-66%	-68%	-78%	-64%	-44%	-23%			-17%	-56%	-47%	-61%	-55%
10%	-69%	-72%	-79%	-78%	-53%	-29%	-5%		-30%	-58%	-58%	-63%	-67%
5%	-69%	-74%	-79%	-80%	-58%	-31%	-8%		-33%	-60%	-61%	-65%	-75%
Configuration 2E													
95%						5%	28%	32%			-16%	-25%	22%
90%	-10%	-12%		-6%			26%	31%			-18%	-35%	6%
75%	-28%	-43%	-45%	-21%	-8%		22%	26%		-7%	-26%	-40%	
50%	-54%	-52%	-66%	-55%	-20%	-11%	12%	17%	-5%	-40%	-40%	-53%	-28%
25%	-64%	-67%	-77%	-67%	-46%	-24%			-23%	-70%	-51%	-59%	-58%
10%	-67%	-71%	-78%	-79%	-56%	-31%	-5%		-37%	-73%	-65%	-62%	-70%
5%	-69%	-73%	-79%	-80%	-62%	-34%	-8%		-41%	-74%	-70%	-63%	-74%
ALTERNATIVE 3 - Configuration 3E													
95%	41%	24%	192%	109%	175%	219%	222%	128%	124%	98%	24%	80%	177%
90%	34%	20%	97%	75%	149%	203%	201%	121%	109%	79%	18%	40%	130%
75%	17%			37%	81%	198%	154%	101%	80%	25%	7%	-7%	66%
50%	-16%	-3%	-30%	-7%	14%	74%	104%	64%	64%	-9%	-22%	-24%	
25%	-36%	-36%	-44%	-23%			49%	44%	50%	-57%	-39%	-39%	-24%
10%	-41%	-45%	-51%	-30%	-16%	-14%	-7%	12%	37%	-65%	-57%	-44%	-44%
5%	-47%	-46%	-52%	-36%	-24%	-24%	-13%		25%	-67%	-65%	-46%	-52%

Zero percent shown as blank spaces; shaded values represent increases greater than 10 percent.
Negative values represent decreases in salinity, while positive values represent increases in salinity.

Table 5.2-15. Changes in salinity at Clifton Court Forebay.

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Overall
					Salinity (mg/L) for Configuration 1A								
95%	467	492	663	643	491	238	219	220	200	403	430	443	547
90%	448	467	641	547	446	211	209	199	186	382	374	398	459
75%	374	429	584	460	275	189	197	193	179	315	302	325	316
50%	315	311	484	307	202	173	187	188	167	186	187	286	197
25%	272	254	193	199	159	154	160	174	146	159	148	265	161
10%	168	193	117	138	107	114	123	143	132	149	139	199	132
5%	136	177	105	118	97	94	103	127	118	144	132	157	109
					ALTERNATIVE 1 - Configuration 1C								
95%	21%	29%	27%	23%	25%	39%	16%	36%	36%	24%	44%	26%	35%
90%	20%	24%	21%	15%	21%	34%	13%	34%	30%	22%	40%	23%	29%
75%	8%	14%	7%	6%	14%	29%	8%	28%	26%	17%	34%	18%	19%
50%					6%	16%		11%	19%	8%	23%	14%	7%
25%						5%			12%		7%	11%	
10%			-6%	-6%					6%			6%	
5%			-6%	-7%					5%				
					ALTERNATIVE 2 - Configuration 2B								
95%		6%	17%	14%	14%	26%	5%	31%	31%	22%	27%	7%	24%
90%			10%	6%	10%	21%		27%	24%	18%	25%		18%
75%	-6%	-16%	-18%	-7%	6%	13%		22%	16%	5%	19%	-7%	6%
50%	-35%	-36%	-51%	-29%	-3%	7%		8%	7%	-11%		-26%	
25%	-49%	-55%	-70%	-49%	-9%					-47%	-27%	-33%	-32%
10%	-53%	-62%	-71%	-67%	-23%				-5%	-49%	-43%	-40%	-53%
5%	-56%	-62%	-71%	-70%	-31%		-5%		-9%	-49%	-50%	-46%	-63%
					Configuration 2D								
95%	7%	7%	16%	14%	14%	23%		25%	33%	23%	24%	9%	23%
90%			9%	6%	10%	18%		21%	26%	20%	23%	7%	18%
75%		-12%	-16%	-10%	5%	12%	0%	15%	19%	6%	16%	-5%	6%
50%	-30%	-35%	-48%	-26%	-2%	6%	-7%	6%	11%	-7%		-23%	-5%
25%	-46%	-54%	-68%	-50%	-12%		-11%			-47%	-30%	-32%	-30%
10%	-51%	-59%	-69%	-67%	-22%		-13%			-49%	-42%	-38%	-51%
5%	-52%	-60%	-69%	-70%	-31%		-15%	-8%	-5%	-49%	-49%	-42%	-60%
					Configuration 2E								
95%		5%	15%	14%	15%	24%		25%	33%	22%	24%	5%	22%
90%			10%	6%	10%	19%		21%	26%	18%	21%		16%
75%	-7%	-16%	-17%	-10%	5%	12%		16%	17%	6%	13%	-7%	6%
50%	-31%	-37%	-50%	-28%	-4%	6%	-6%	6%	9%	-8%		-23%	-5%
25%	-44%	-53%	-68%	-50%	-12%		-9%			-54%	-36%	-32%	-33%
10%	-49%	-59%	-68%	-68%	-22%		-13%		-6%	-62%	-50%	-39%	-56%
5%	-52%	-59%	-69%	-70%	-31%		-15%	-7%	-10%	-64%	-58%	-45%	-64%
					ALTERNATIVE 3 - Configuration 3E								
95%	-22%	-26%			18%	15%		-21%	-11%	38%	16%	-27%	11%
90%	-24%	-34%		-10%	8%	11%	-17%	-29%	-24%	18%	12%	-28%	
75%	-40%	-43%	-29%	-33%	-15%		-37%	-42%	-31%	-5%	7%	-34%	-24%
50%	-61%	-55%	-66%	-55%	-24%	-22%	-45%	-46%	-40%	-24%	-8%	-46%	-43%
25%	-68%	-70%	-77%	-66%	-38%	-32%	-49%	-47%	-44%	-59%	-38%	-53%	-56%
10%	-72%	-74%	-78%	-74%	-50%	-35%	-51%	-49%	-46%	-68%	-61%	-61%	-70%
5%	-73%	-74%	-78%	-76%	-52%	-39%	-53%	-53%	-49%	-70%	-69%	-65%	-74%

Zero percent shown as blank spaces; shaded values represent increases greater than 10 percent.
Negative values represent decreases in salinity, while positive values represent increases in salinity.

5.2.2.1.7 Storage and Reoperation

Potential impacts on Delta hydrodynamics from the reoperation of the SWP and CVP facilities and from new storage are evaluated using DWRSIM. Potential impacts on Delta hydrodynamics are qualitatively assessed by relating observed changes in the Sacramento River to changes in Delta flows. DWRSIM was used to model the storage components of Configuration 1C. Configuration 1C includes south Delta improvements, north Delta surface storage, and south Delta surface storage. This section evaluates the potential impacts of adding north and south Delta storage to the SWP and CVP systems.

Table 5.2-16 lists the monthly distributions of differences in Sacramento River flows between the No Action Alternative and Configuration 1C. Generally, Configuration 1C reduces Sacramento River flows during the winter and increases flows during the summer and fall. Overall, there appears to be a slight increase in the Sacramento River flows. Changes in Delta Cross Channel flows parallel changes in the Sacramento River, though the changes are smaller for the Delta Cross Channel.

To isolate the impact of storage, Configuration 1C, which includes south Delta improvements and north and south Delta storage, was compared to Configurations 2A and 2C, which include south Delta improvements but do not include storage, and Configuration 2D, which includes south Delta improvements and south Delta storage only. The comparison shows that the south Delta improvements create most of the substantial changes in Sacramento River flows in July and August. Adding south Delta storage (Configuration 2D) allows for increased exports and thus requires increased Sacramento River flows in the summer through winter. Adding north Delta storage (Configuration 1C) reduces Sacramento River flows in the winter and increases flows during the summer and fall. Presumably, high winter flows are stored in the new reservoirs and released later during dry periods. The same pattern of change occurs for the Delta Cross Channel flows (Table 5.2-17) as observed for the Sacramento River flows. The percent changes in Delta Cross Channel flows are about two-thirds of the percent changes observed in Sacramento River flows (excluding changes in the cross channel gate position).

Relating these results to changes in net Delta outflow and exports demonstrates that the storage components of Alternative 1 will increase Delta channel flows toward the export pumps throughout summer, fall and winter. During the summer and fall, both increased Sacramento River flows (and Delta Cross Channel flows) and reduced net Delta outflow provide the extra water needed for increased exports. During the winter, the increased exports are apparently made up by reduced net Delta outflow.

5.2.2.2 Alternative 2

Alternative 2 is the through-Delta conveyance alternative with extensive channel and habitat improvements. This alternative consists of four conveyance options and three storage components to make up five configurations. The hydrodynamic effects of Alternative 2 on the Delta are evaluated by its effects on the following: flow, velocity, and stage; mass

Table 5.2-16. Distribution of differences for Sacramento River flows by percentile.

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
ALTERNATIVE 1 - Configuration 1C													
90%	4%	13%	13%	4%	5%	5%	21%	43%	14%	28%	26%	19%	18%
80%	2%	3%	3%	1%	1%		18%	22%	10%	17%	9%	5%	7%
70%							17%	12%	2%	8%	2%	1%	1%
60%							11%			3%	1%		
50%							6%	-1%		1%			
40%	-1%							-9%					
30%	-4%	-5%					-5%	-17%	-2%			-3%	-1%
20%	-8%	-8%	-7%				-12%	-25%	-7%		-3%	-6%	-6%
10%	-16%	-11%	-12%	-12%	-1%	-1%	-23%	-28%	-17%	-4%	-6%	-11%	-13%
ALTERNATIVE 2 - Configurations 2A and 2C													
90%	3%	2%	3%		1%		19%	1%	2%	4%	4%	4%	4%
80%	1%						18%			2%	1%	2%	1%
70%							16%	-1%		1%			
60%							8%	-4%					
50%							3%	-9%					
40%								-13%					
30%							-1%	-19%					
20%							-3%	-25%	-5%				
10%							-11%	-27%	-14%				-4%
Configurations 2B and 2E													
90%	4%	13%	13%	4%	5%	5%	21%	43%	14%	28%	26%	19%	18%
80%	2%	3%	3%	1%	1%		18%	22%	10%	17%	9%	5%	7%
70%							17%	12%	2%	8%	2%	1%	1%
60%							11%			3%	1%		
50%							6%	-1%		1%			
40%	-1%							-9%					
30%	-4%	-5%					-5%	-17%	-2%			-3%	-1%
20%	-8%	-8%	-7%				-12%	-25%	-7%		-3%	-6%	-6%
10%	-16%	-11%	-12%	-12%	-1%	-1%	-23%	-28%	-17%	-4%	-6%	-11%	-13%
Configuration 2D													
90%	7%	6%	10%	1%	2%	1%	18%	16%	9%	16%	9%	14%	11%
80%	3%	2%	3%		1%		17%	4%	4%	6%	3%	3%	2%
70%							14%		1%	2%	1%		
60%													
50%							-2%	-8%					
40%							-5%	-18%					
30%							-9%	-22%					
20%							-14%	-26%	-6%		-1%		-1%
10%		-5%		-1%	-1%		-25%	-30%	-14%	-7%	-5%	-3%	-10%
ALTERNATIVE 3 - Configurations 3A and 3C													
90%	4%	3%	5%	35%	37%	35%			10%	15%	9%	16%	17%
80%	2%	1%	2%	28%	28%	25%	-7%		6%	11%	4%	13%	7%
70%			1%	22%	15%	19%	-14%	-2%	2%	6%	2%	5%	2%
60%				14%	8%	12%	-15%	-17%		2%		2%	
50%				1%	2%	3%	-18%	-22%		1%			
40%							-19%	-28%					
30%							-22%	-29%	-6%		-1%		
20%							-23%	-30%	-12%	-5%	-6%		-6%
10%	-1%	-4%	-2%		-1%	-3%	-26%	-31%	-18%	-12%	-9%		-18%
Configurations 3B and 3D-3I													
90%	15%	17%	16%	42%	39%	30%	9%	17%	12%	41%	31%	51%	31%
80%	5%	10%	4%	32%	26%	11%	-1%		9%	26%	19%	17%	15%
70%	2%			22%	17%	8%	-9%	-2%	3%	23%	12%	10%	6%
60%				8%	6%	5%	-19%	-8%		18%	6%	5%	1%
50%				1%	2%		-20%	-18%		14%	2%	1%	
40%		-2%	-1%				-22%	-26%		3%			
30%	-5%	-7%	-4%			-1%	-24%	-30%	-4%				-5%
20%	-8%	-9%	-7%	-4%	-2%	-5%	-28%	-31%	-9%		-5%	-2%	-10%
10%	-15%	-14%	-12%	-12%	-7%	-10%	-32%	-33%	-17%	-10%	-13%	-6%	-21%

Table 5.2-17. Distribution of differences for Delta Cross Channel flows by percentile.

Percentile	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
ALTERNATIVE 1 - Configuration 1C													
90%	19%	10%	9%	3%	4%	3%	15%	27%	10%	16%	16%	27%	14%
80%	3%	2%	3%	1%	1%		13%	14%	6%	12%	5%	10%	6%
70%	1%						12%	8%	1%	5%	2%	3%	1%
60%							7%			2%		1%	
50%							4%	-1%		1%			
40%								-6%					
30%	-1%	-4%					-3%	-12%	-2%				
20%	-4%	-7%	-6%				-9%	-18%	-4%		-2%	-2%	-3%
10%	-9%	-10%	-10%	-10%	-1%		-16%	-19%	-11%	-3%	-4%	-7%	-10%
ALTERNATIVE 2 - Configuration 2A, 2C													
90%	3%	2%	2%		1%		14%		1%	2%	3%	2%	3%
80%	1%						13%			1%		1%	
70%							12%	-1%					
60%							6%	-2%					
50%							2%	-6%					
40%								-8%					
30%							-1%	-13%					
20%							-2%	-15%	-3%				
10%							-8%	-19%	-8%				-3%
Configuration 1C													
90%	19%	10%	9%	3%	4%	3%	15%	27%	10%	16%	16%	27%	14%
80%	3%	2%	3%	1%	1%		13%	14%	6%	12%	5%	10%	6%
70%	1%						12%	8%	1%	5%	2%	3%	1%
60%							7%			2%		1%	
50%							4%	-1%		1%			
40%								-6%					
30%	-1%	-4%					-3%	-12%	-2%				
20%	-4%	-7%	-6%				-9%	-18%	-4%		-2%	-2%	-3%
10%	-9%	-10%	-10%	-10%	-1%		-16%	-19%	-11%	-3%	-4%	-7%	-10%
Configuration 2D													
90%	5%	4%	8%	1%	1%		13%	10%	6%	9%	7%	11%	8%
80%	2%	2%	2%				13%	2%	3%	4%	2%	2%	2%
70%							10%			1%			
60%													
50%							-1%	-4%					
40%							-3%	-13%					
30%							-7%	-14%					
20%							-10%	-18%	-4%		-1%		-1%
10%	-1%	-4%		-1%	-1%		-18%	-21%	-8%	-4%	-3%	-2%	-7%
ALTERNATIVE 3 - Configuration 3A, 3C													
90%	-4%	-6%	-5%	-1%		1%	-11%	-6%	-62%	-59%	-18%		-2%
80%	-6%	-7%	-7%	-3%			-20%	-18%	-63%	-61%	-53%	-8%	-7%
70%	-8%	-8%	-9%	-5%	-3%	-3%	-25%	-24%	-64%	-63%	-55%	-9%	-10%
60%	-10%	-9%	-11%	-7%	-7%	-7%	-27%	-26%	-65%	-64%	-56%	-11%	-14%
50%	-16%	-11%	-13%	-8%	-9%	-10%	-29%	-29%	-67%	-64%	-57%	-16%	-18%
40%	-18%	-13%	-14%	-11%	-11%	-12%	-30%	-34%	-67%	-66%	-58%	-19%	-23%
30%	-20%	-15%	-15%	-11%	-12%	-13%	-30%	-34%	-68%	-67%	-59%	-21%	-30%
20%	-21%	-18%	-17%	-15%	-15%	-15%	-31%	-35%	-69%	-68%	-60%	-22%	-57%
10%	-23%	-20%	-20%	-19%	-22%	-18%	-32%	-36%	-71%	-69%	-60%	-24%	-64%
Configuration 3B, 3D-3I													
90%	8%	-3%	-5%	1%	2%	4%	-5%	-5%	-62%	-56%	-18%	16%	
80%	-1%	-7%	-7%			-4%	-17%	-14%	-62%	-59%	-50%	6%	-7%
70%	-7%	-8%	-9%	-3%	-3%	-9%	-23%	-21%	-64%	-60%	-53%	-4%	-11%
60%	-10%	-10%	-12%	-6%	-8%	-12%	-27%	-24%	-65%	-61%	-54%	-8%	-15%
50%	-14%	-13%	-14%	-10%	-10%	-13%	-29%	-27%	-66%	-62%	-56%	-12%	-19%
40%	-18%	-15%	-16%	-11%	-12%	-13%	-30%	-33%	-67%	-63%	-57%	-15%	-24%
30%	-20%	-18%	-18%	-16%	-14%	-16%	-31%	-34%	-68%	-64%	-58%	-20%	-31%
20%	-21%	-20%	-21%	-19%	-18%	-17%	-31%	-34%	-69%	-65%	-59%	-21%	-56%
10%	-25%	-24%	-24%	-22%	-24%	-19%	-32%	-36%	-71%	-67%	-60%	-24%	-63%

C-003021

fate; net Delta outflow; central Delta outflow; X2 position; and salinity.

5.2.2.2.1 Flow, Velocity, and Stage

DWRDSM1 modeling was performed on Configurations 2B, 2D, and 2E to evaluate differences in monthly average flows, velocities, and stages between Alternative 2 and the No Action Alternative. A comparison of flows, velocities, and stages between Configurations 2B, 2D, and 2E and the No Action Alternative for a number of locations within the Delta is presented in Tables 5.2-2, 5.2-3, and 5.2-4 for high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively. These numbers are based on modeling of the Delta with Delta geometry changes appropriate for the respective alternatives, predicted 2020 demands, and the increased pumping capacity of the Banks Pumping Plant of 10,300 cfs. In general, Alternative 2 increases flows through the Delta from the Sacramento River in the north to the export locations in the south.

Configurations 2A and 2B

Configurations 2A and 2B include North and South Delta improvements and a 10,000 cfs Hood intake. These alternatives improve conveyance and circulation of flow and reduce reverse flows in the Delta. For Configuration 2B, average tidal flows, velocities, and stages throughout the Delta, based on DWRDSM1 modeling, are shown in Figures 5.2-9 through 5.2-11 for the high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

For high inflow conditions, differences in the average flows between Configurations 2B and the No Action Alternative are generally small, except at locations with channel modifications. For Configuration 2B, approximately 35 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs and 10 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 2B, approximately 20 percent of the Sacramento River flow is diverted to the Hood intake and subsequently travels down the Mokelumne River, where flows in the North Fork have approximately doubled due to setback levees. In the south Delta, the flow split between the San Joaquin River and Old River is the same as for the No Action Alternative (about 60 percent is diverted to Old River near Mossdale and 40 percent remains in the San Joaquin River channel and flows past Stockton). Of the flow diverted to Old River, approximately 5 percent travels down Middle River, while 65 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. As for the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north, and the ratio of flow in Old River to flow in Middle River is about 1.2. Also similar to the No Action Alternative, water from the central Delta flows out of the Delta through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). False River carries about 35 percent of the central Delta outflow, Dutch Slough carries about 5 percent, and the main channel of the San Joaquin River carries the remaining 60 percent.

For low inflow/high pumping conditions for Configuration 2B, there is generally an increase in Sacramento River water flowing into the Delta. For Configuration 2B,

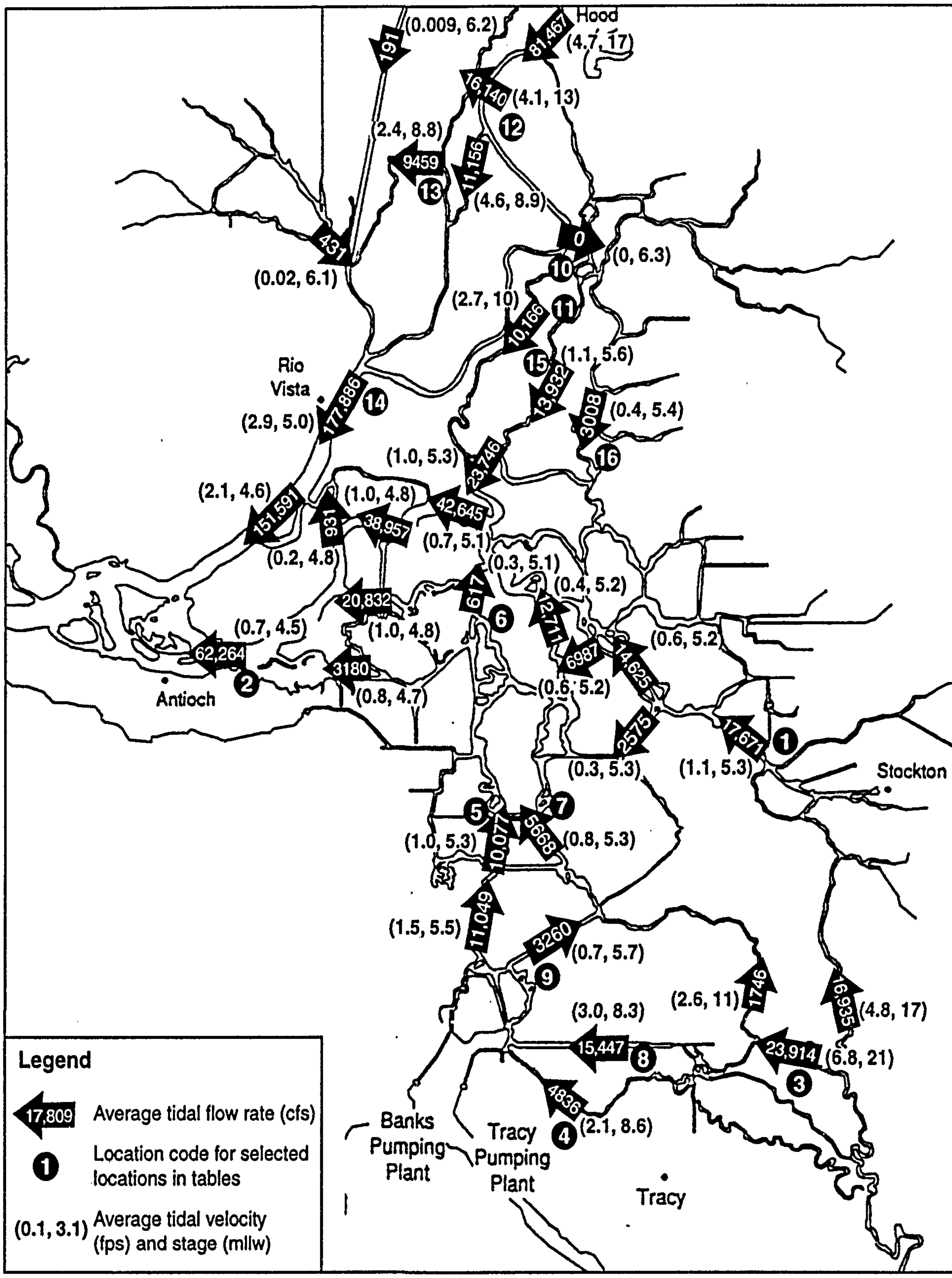


Figure 5.2-9. Average tidal flow rates, velocities, and stages for high flow conditions for Alternative 2B.

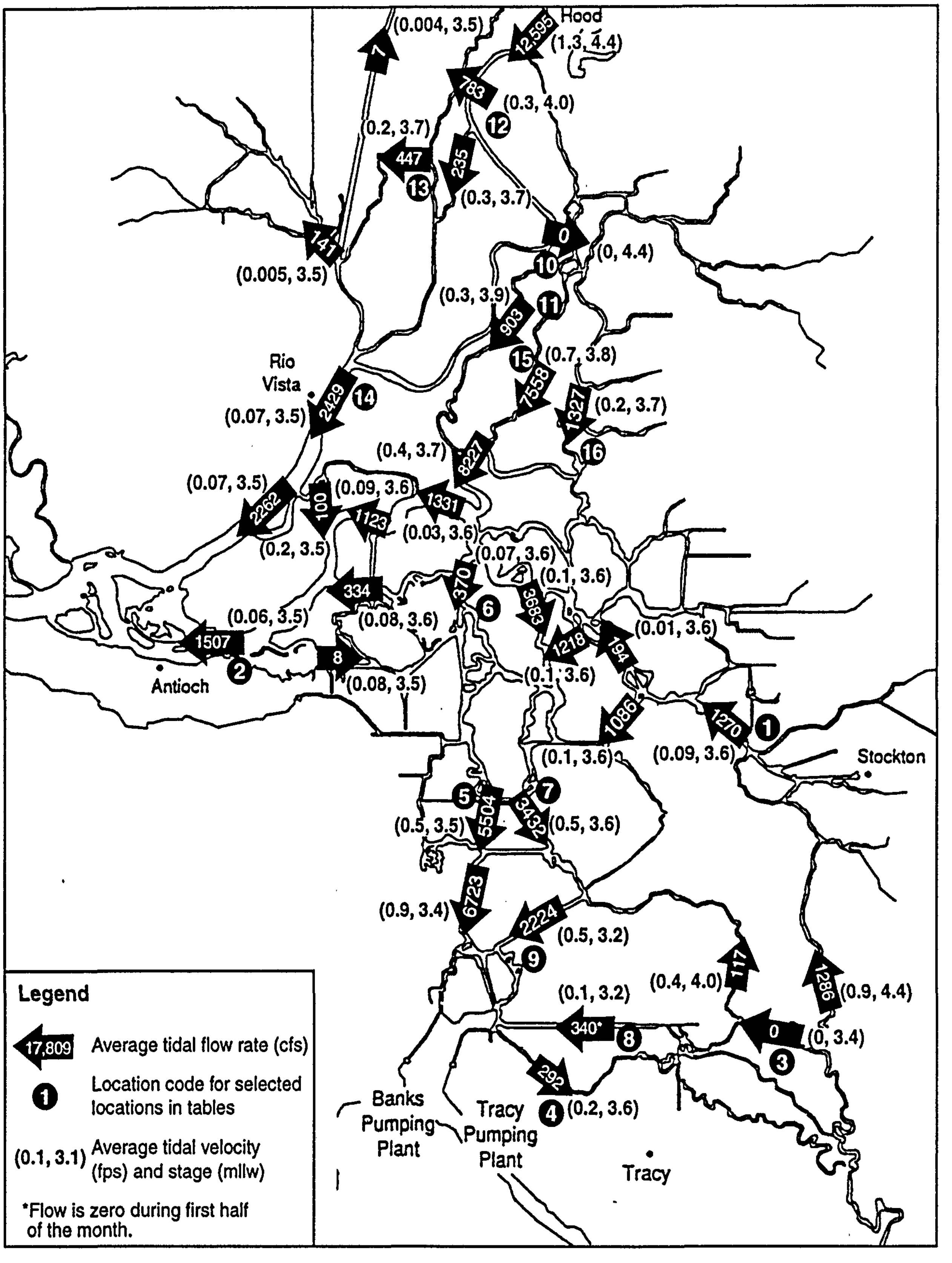


Figure 5.2-10. Average tidal flow rates, velocities, and stages for low flow/high pumping conditions for Alternative 2B.

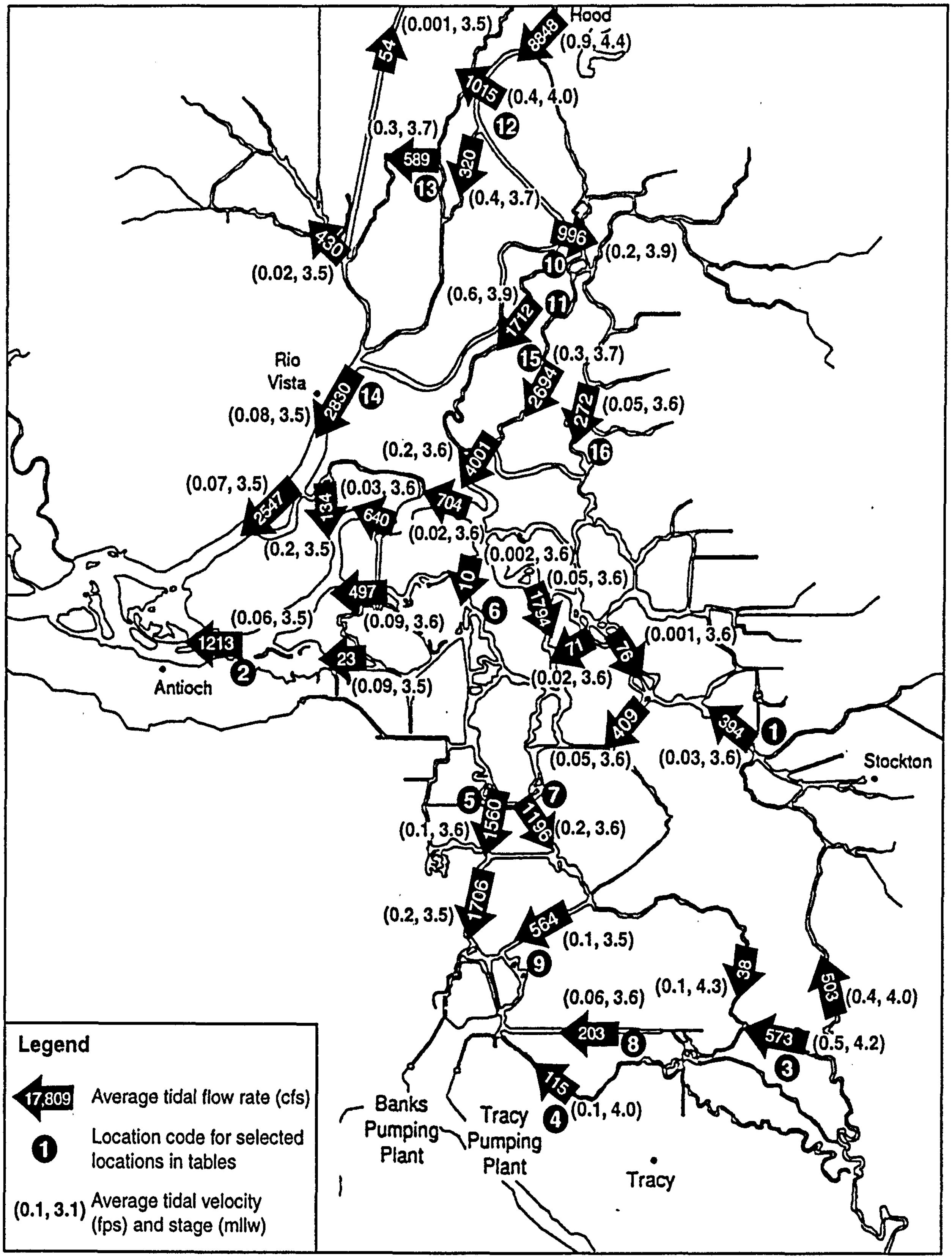


Figure 5.2-11. Average tidal flow rates, velocities, and stages for low flow/low pumping conditions for Alternative 2B.

approximately 10 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter Sloughs and 5 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 2B, approximately 60 percent of the Sacramento River flow is diverted to the Hood intake and subsequently travels down the improved channels of the Mokelumne River, where the flows are more than double those of the No Action Alternative. In the south Delta, a flow control structure at Old River at Mossdale limits flow down Old River, which eliminates reverse flow in the San Joaquin River between Prisoners Point and the head of Old River. Therefore, the flow down the San Joaquin River is increased, flow in Old River at Fabian Tract is reversed, and flow down the Grant Line Canal is reduced. Similar to the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants, and the ratio of flow in Old River to flow in Middle River is about 1.5. Contrary to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water enters Old River and Middle River channels at their mouths. Flows through the Turner, Empire, and Columbia cuts, which connect the San Joaquin River with Middle River, are increased with Configuration 2B. Dutch Slough carries water into the Delta, while False River and the San Joaquin River carry water westward.

For low inflow/low pumping conditions, the results are similar to the low inflow/high pumping conditions but less extreme due to the reduced demand at the pumps. For low inflow/low pumping conditions, approximately 15 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs, 10 percent is diverted to the Delta Cross Channel, and 20 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 2B, approximately 30 percent of the Sacramento River water is diverted to the Hood intake and subsequently travels down the Mokelumne River. In the south Delta, more flow remains in the San Joaquin River (about 50 percent is diverted to Old River near Mossdale and 50 percent remains in the San Joaquin River channel and flows past Stockton). Of the flow diverted to Old River, approximately 35 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. Water in Middle River at Upper Roberts Island flows upstream toward the head of Middle River. Similar to the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy Pumping Plants. The ratio of flow in Old River to flow in Middle River (about 1.5) is slightly higher for Configuration 2B than for the No Action Alternative. As with the No Action Alternative, most of the water in the central Delta flows west. Central Delta water flows from the San Joaquin River to Middle River through Turner, Empire, and Columbia cuts and to Old River at its mouth. False River, Dutch Slough, and the San Joaquin River carry water westward.

There are no substantial differences in the velocities and stages between Configuration 2B and the No Action Alternative, except in areas near flow control structures. During low inflow/high pumping conditions, the flow control structures were operating and large changes in velocity and stage were observed in the San Joaquin River and Middle River near Upper Roberts Island.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the nominal scour velocity of approximately 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions are generally below the nominal scour velocity of approximately 3 fps, except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, and Old River at Mossdale all have average velocities higher than 3 fps. However, the San Joaquin River at Upper Roberts Island has average velocities above 3 fps in less than 6 percent of the months modeled, the diversion to Steamboat and Sutter sloughs and Steamboat Slough in less than 10 percent of the months modeled, and the Sacramento River at Hood and Old River at Mossdale in less than 16 percent of the months modeled. This is generally consistent with the No Action Alternative.

The hydrodynamic effects of Configuration 2A will be the same as presented above, except that Configuration 2A does not include CVP-SWP improvements. The main hydrodynamic effect of the CVP-SWP improvements is that the source of water for the Tracy Pumping Plant may be the Clifton Court Forebay instead of Old River.

Configuration 2C

Configuration 2C involves three isolated intakes in the Delta and has not currently been modeled to determine the hydrodynamic effects on the Delta. Since Configuration 2C does not have any geometry changes to the north Delta, there should be no hydrodynamic effects in the north Delta. Hydrodynamic effects are likely to be localized to the area of the proposed intakes—Rock Slough, the San Joaquin River near Turner Cut, and the San Joaquin River near Lathrop. The intakes will allow operational flexibility, and the operating criteria will control the impacts to the Delta.

Configuration 2D

Configuration 2D improves circulation of flow and reduces reverse flows in the Delta via a Mokelumne River Floodway, East and South Delta habitats, and a 10,000-cfs Hood Intake. Average tidal flows, velocities, and stages throughout the Delta, based on DWRDSM1 modeling, are shown in Figures 5.2-12 through 5.2-14 for the high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

During high inflow conditions, differences in average flows between Configuration 2D and the No Action Alternative are generally small, except in locations where channel modifications occurred. For Configuration 2D, approximately 35 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs and 10 percent is diverted to Georgiana Slough. These diversions are slightly less than the diversions for the No Action Alternative. Additionally, for Configuration 2D, approximately 20 percent of the Sacramento River flow is diverted to the Hood intake and subsequently travels down the Mokelumne River. Hence, the flow in the South Fork of the Mokelumne River is increased. In the south Delta, as for the No

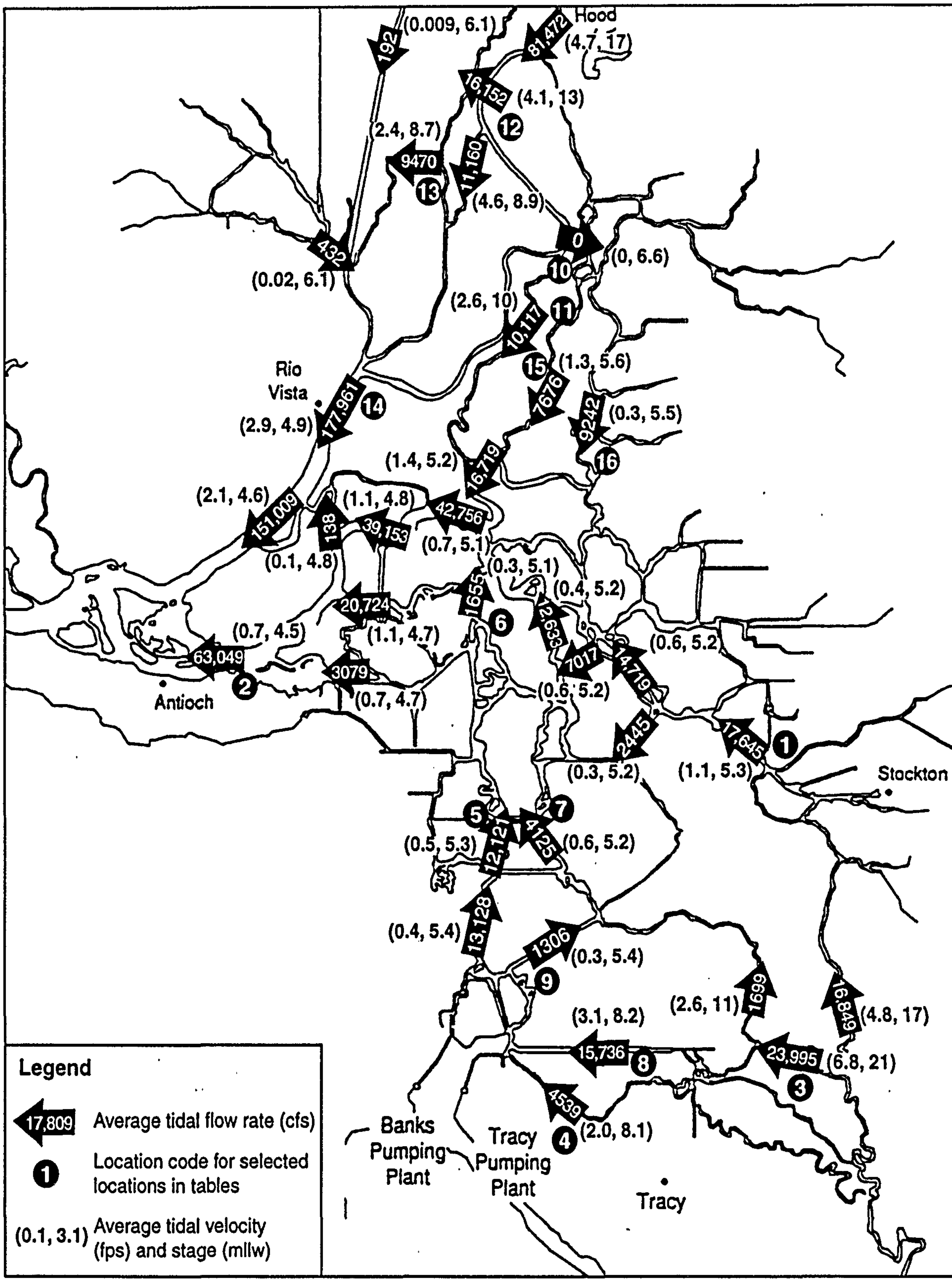


Figure 5.2-12. Average tidal flow rates, velocities, and stages for high flow conditions for Alternative 2D.

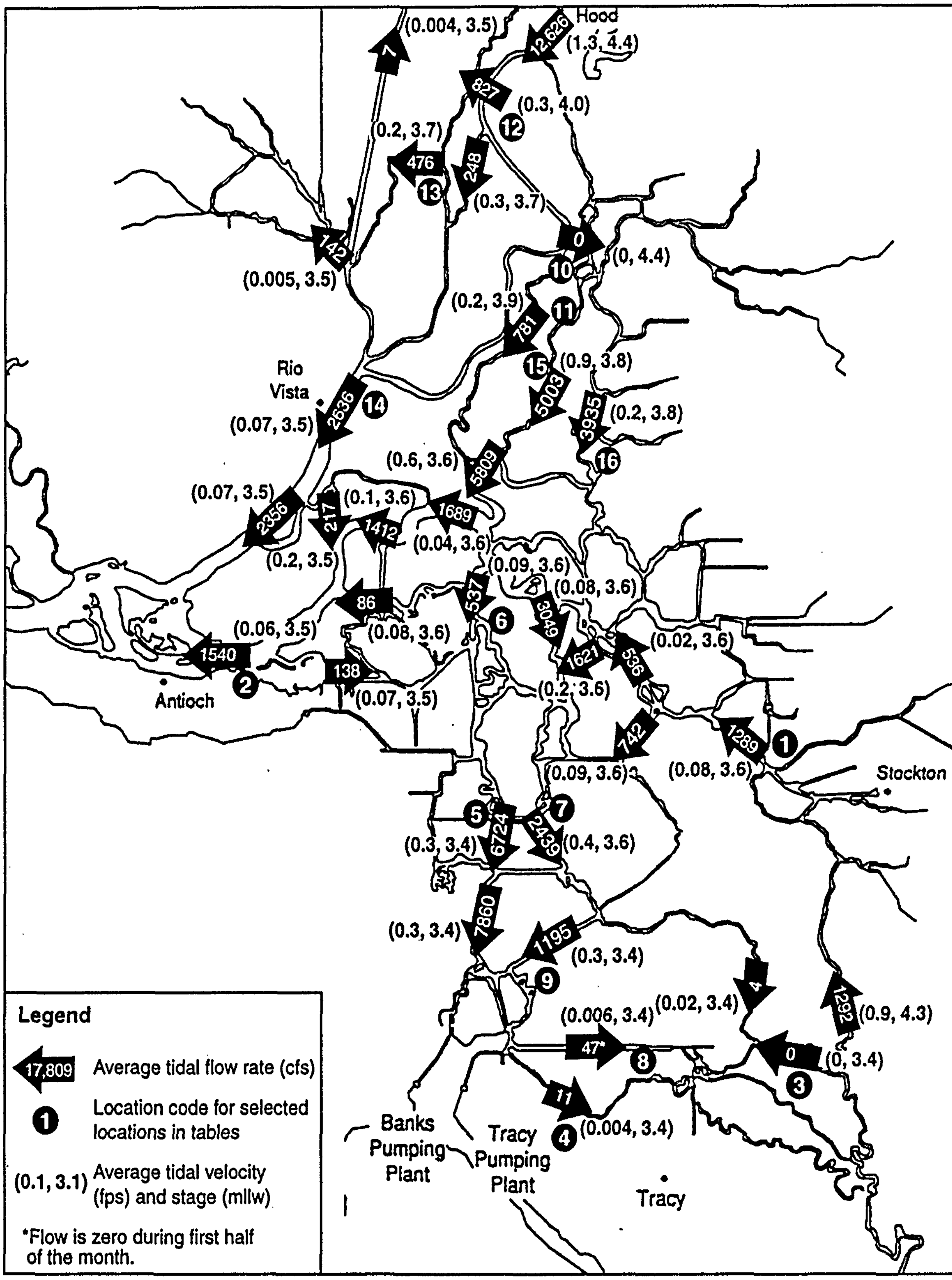


Figure 5.2-13. Average tidal flow rates, velocities, and stages for low flow/high pumping conditions for Alternative 2D.

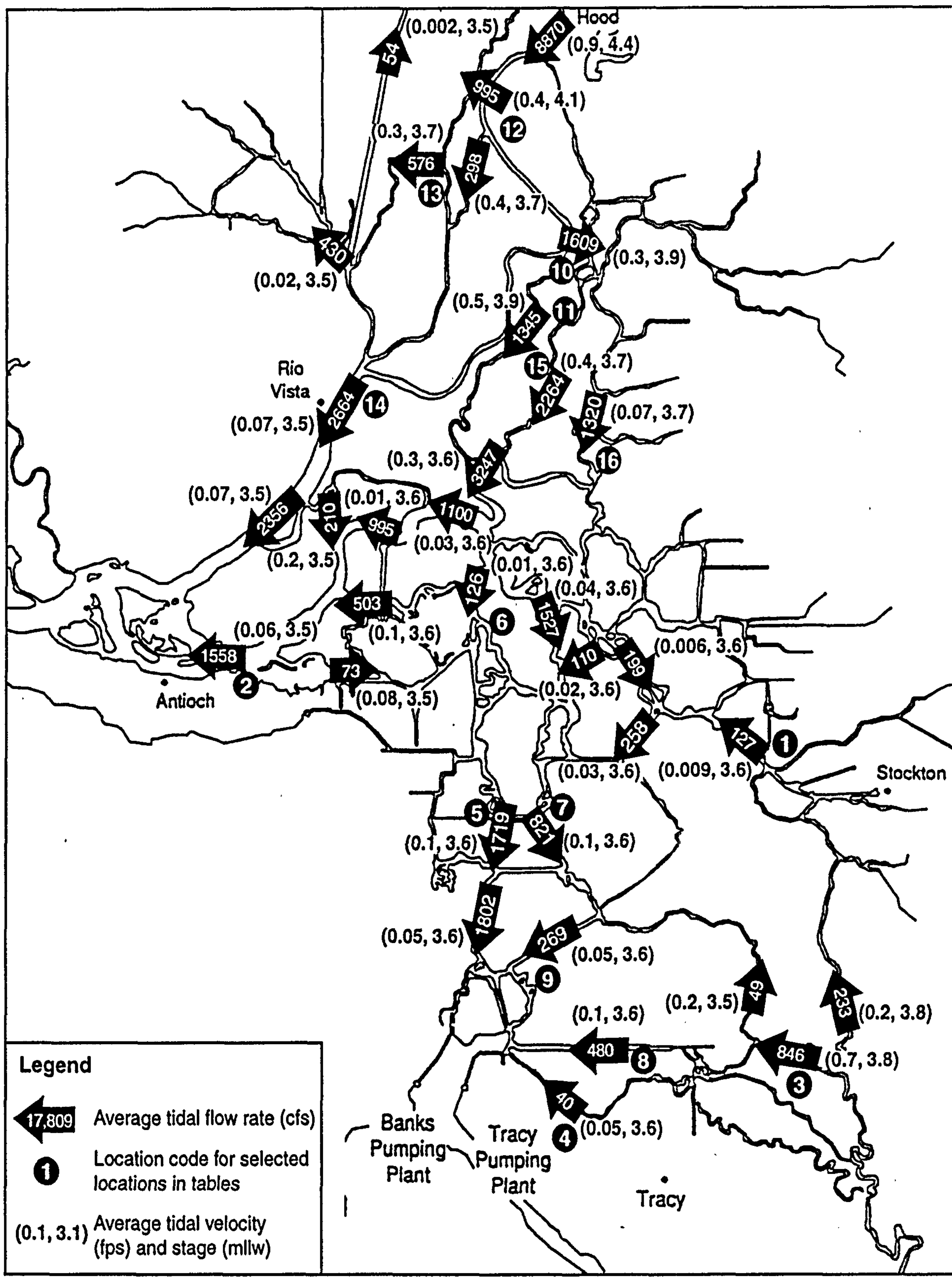


Figure 5.2-14. Average tidal flow rates, velocities, and stages for low flow/low pumping conditions for Alternative 2D.

Action Alternative, about 60 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale, and 40 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River, while 65 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north. The ratio of flow carried north from the south Delta in Old River to Middle River is about 3, which is an increase over the No Action Alternative due to setback levees. As for the No Action Alternative, water from the central Delta flows out of the Delta through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). False River carries about 35 percent of the central Delta outflow, Dutch Slough carries about 5 percent, and about 60 percent remains in the main channel of the San Joaquin River.

For low inflow/high pumping, the hydrodynamic effects of Configuration 2D are similar to the effects of Configurations 2A and 2B, except in the areas with setback levees. There is generally an increase in Sacramento River water flowing through the Delta to the pumps and a decrease in San Joaquin River water flowing to the pumps. For Configuration 2D, approximately 10 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter Sloughs and 5 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 2D, approximately 70 percent of the Sacramento River flow is diverted to the Hood intake and subsequently travels down the Mokelumne River. Thus, there is an increase in flow down the South Fork of the Mokelumne River. In the south Delta, of the San Joaquin River inflow at Vernalis, no water is diverted to Old River near Mossdale due to the operable barrier at the head of Old River, eliminating reverse flow in the San Joaquin River. Water in Old River at Fabian Tract and Middle River at Upper Roberts Island is reversed. Contrary to the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants. The ratio of flow in Old River to flow in Middle River, approximately 3, is higher for Configuration 2D. Most of the water in the central Delta flows west. Central Delta water enters Old River and Middle River channels at their mouths and through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River. Dutch Slough carries water into the Delta, while False River and the San Joaquin River carry water westward.

For low inflow/low pumping conditions, the hydrodynamic effects of Configuration 2D are similar to those for low inflow/high pumping, but to a lesser degree due to the reduced demand at the pumps. For low inflow/low pumping conditions, approximately 15 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs, 20 percent is diverted to the Delta Cross Channel, and 20 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 2D, approximately 40 percent of the Sacramento River water is diverted to the Hood intake and subsequently travels down the Mokelumne

River. In the south Delta, similar to the No Action Alternative, about 80 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent is diverted down Middle River, 60 percent is carried by the Grant Line Canal, and 5 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants. The ratio of flow in Old River to flow in Middle River (about 2.3) is higher due to setback levees. Similar to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water enters Old and Middle River channels at their mouths and through Turner, Empire, and Columbia Cuts, which connect the upper San Joaquin River with Middle River. False River and the San Joaquin River carry water west while Dutch Slough conveys water into the Delta.

In most of the Delta, there are no substantial differences in velocities or stages between Configuration 2D and the No Action Alternative. However, in locations with setback levees, the velocity decreased and minimum stages increased. In Old River and the South Fork of the Mokelumne River, the velocities decreased by up to a factor of 4 and the minimum stages almost doubled in the channels with setback levees. Also, in areas near flow control structures, changes in velocities and stages were observed. During low inflow/high pumping conditions, the flow barriers were operating and the velocity in the San Joaquin River near Upper Roberts Island increased while the velocities in Grant Line Canal and Old River at Fabian Tract decreased substantially. A slower velocity will decrease sediment transport and increase sedimentation in the channel.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the nominal scour velocity of approximately 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions are generally below the nominal scour velocity of approximately 3 fps except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter Sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, Old River at Mossdale, and the Grant Line Canal all have average velocities higher than 3 fps. However, Grant Line Canal has an average velocity above 3 fps in less than 1 percent of the months modeled, the San Joaquin River at Upper Roberts Island in less than 6 percent of the months modeled, the Diversion to Steamboat and Sutter Sloughs and Steamboat Slough in less than 10 percent of the months modeled, and the Sacramento River at Hood and Old River at Mossdale in less than 17 percent of the months modeled. This is generally consistent with the No Action Alternative.

Configuration 2E

Configuration 2E includes Tyler Island, East, and South Delta habitats and the Mokelumne River Floodway, which improve circulation of flow and reduces reverse flows in the Delta. Average tidal flows, velocities, and stages throughout the Delta based on DWRDSM1 modeling are shown in Figures 5.2-15 through 5.2-17 for the high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

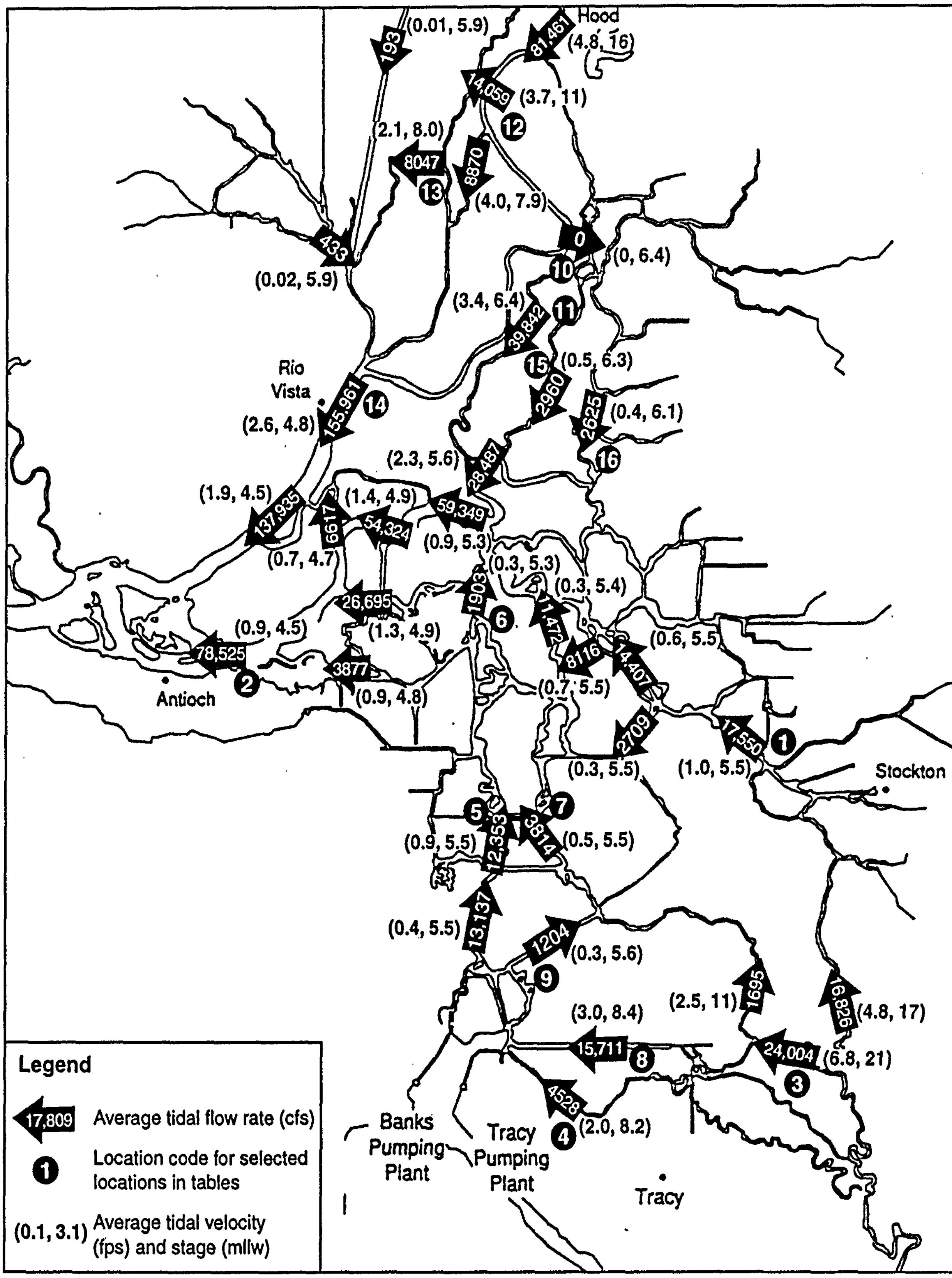


Figure 5.2-15. Average tidal flow rates, velocities, and stages for high flow conditions for Alternative 2E.

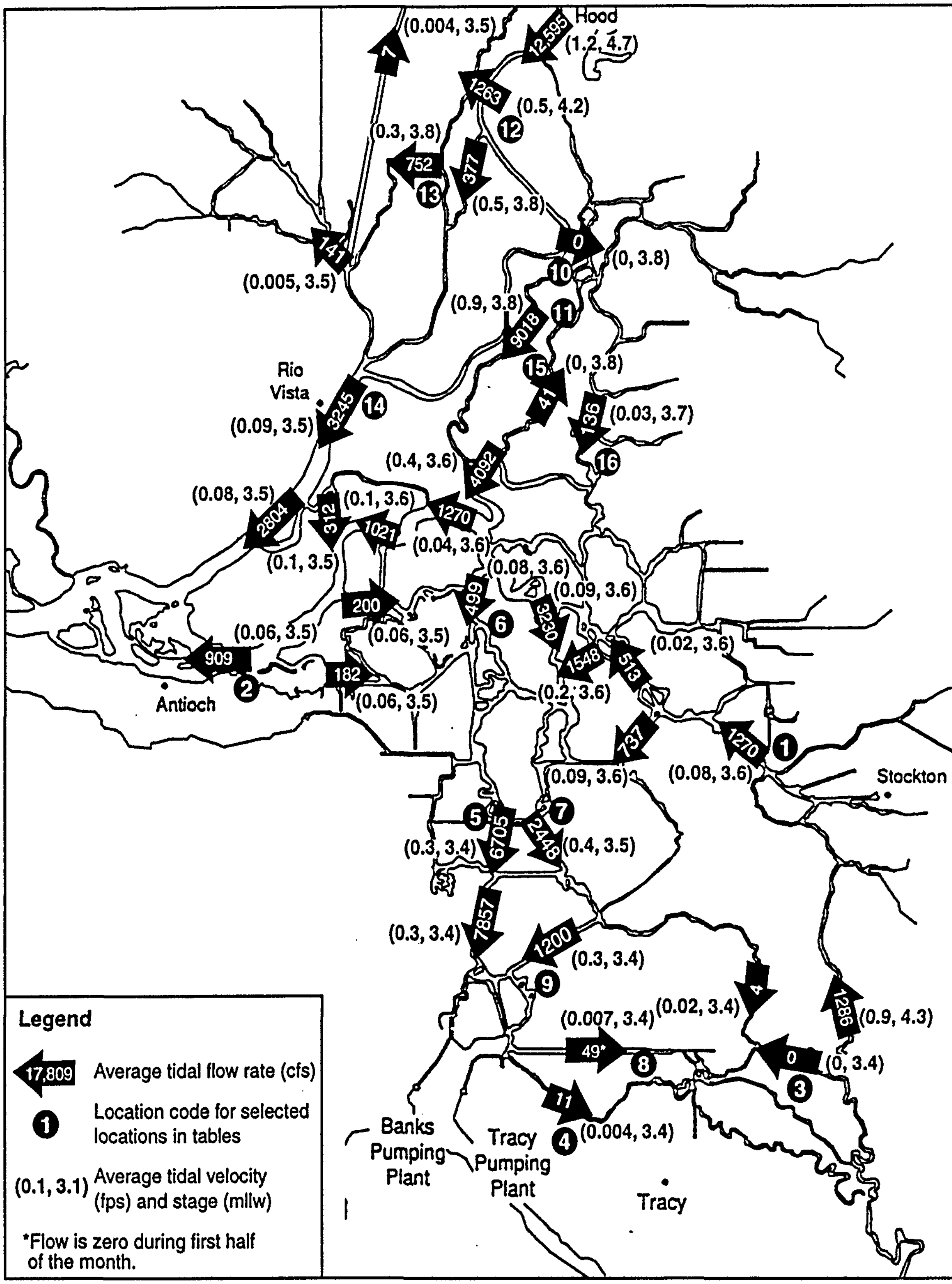


Figure 5.2-16. Average tidal flow rates, velocities, and stages for low flow/high pumping conditions for Alternative 2E.

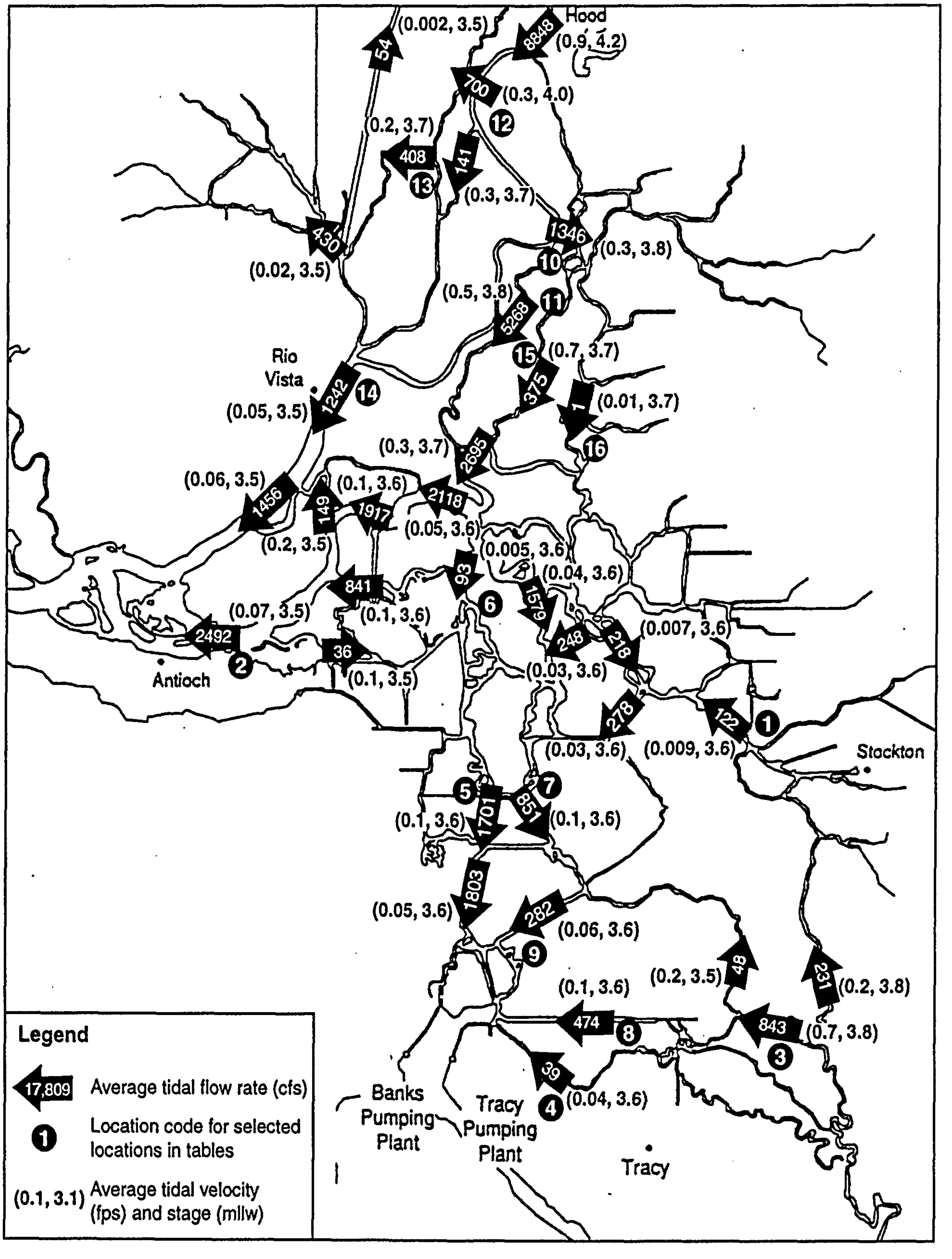


Figure 5.2-17. Average tidal flow rates, velocities, and stages for low flow/low pumping conditions for Alternative 2E.

For high inflow conditions, differences in the average flows between Configurations 2E and the No Action Alternative are mostly in the north Delta. There is a large increase in flow down Georgiana Slough (50 percent of the Sacramento River flow) due to the increased capacity at Tyler Island. Therefore, less Sacramento River flow is diverted to Steamboat and Sutter Sloughs (30 percent of the Sacramento River flow), less flow travels down the Sacramento River, and more water flows into the Central Delta and out to the Bay via the San Joaquin River near Antioch. In the south Delta, similar to the No Action Alternative, about 60 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale and 40 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River while 65 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north. The ratio of flow in Old River to flow in Middle River is about 3, which is higher for Configuration 2E due to setback levees. Similar to the No Action Alternative, water from the central Delta flows out of the Delta through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). False River carries about 30 percent of the central Delta outflow, Dutch Slough carries about 5 percent, and about 65 percent remains in the main channel of the San Joaquin River.

For low inflow/high pumping conditions for Configuration 2E, there is again a large increase in flow through Georgiana Slough (70 percent of the Sacramento River flow) and consequently less Sacramento River flow diverted to Steamboat and Sutter Sloughs (15 percent of the Sacramento River flow) and less flow traveling down the Sacramento River. In the south Delta, of the San Joaquin River inflow at Vernalis, a flow control structure at Old River at Mossdale limits flow down Old River, which eliminates reverse flow in the San Joaquin River. Therefore, the flow down the San Joaquin River is increased and flows in Old River at Fabian Tract, Grant Line Canal, and Middle River at Upper Roberts Island are reversed. Similar to the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy Pumping Plants. The ratio of flow in Old River to flow in Middle River is about 3, which is higher due to setback levees. As for the No Action Alternative, most of the water in the central Delta flows toward the pumping plants. Central Delta water enters Old River and Middle River channels at their mouths and through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River. Dutch Slough and False River carry water into the Delta, while the San Joaquin River carries water westward.

For low inflow/low pumping conditions, the results in the north Delta are similar to the low inflow/high pumping conditions but less extreme due to the reduced demand at the pumps. For low inflow/low pumping conditions, approximately 10 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs and 15 percent is diverted to the Delta Cross Channel. These diversions are less than the diversions for the No Action Alternative. More flow is diverted to Georgiana Slough (60 percent of the Sacramento River flow) for Configuration 2E than for the No Action Alternative. In the south Delta, similar to the No Action Alternative, about 80 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent is diverted down Middle River, 55 percent is carried by the Grant Line Canal, and 5 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants. The ratio of flow in Old River to flow in Middle River (about 2) is increased. Similar to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water enters Old River and Middle River channels at their mouths and through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River. False River and the San Joaquin River carry water west, while Dutch Slough moves water into the Delta.

There are no substantial differences in velocities or stages between Configuration 2E and the No Action Alternative, except in the channels with setback levees or nearby habitats. In Old River and the South Fork of the Mokelumne River, the velocities decreased by up to a factor of 4 in the channels with setback levees. A slower velocity will decrease sediment transport and will increase sedimentation in the channel. Minimum stages in channels with setback levees increased by almost a factor of 1. Also, in Georgiana Slough at high inflow conditions the stage is considerably less for Configuration 2E than for the No Action Alternative. Velocities and stages also changed in the areas near flow control structures while they were operating. During low inflow/high pumping conditions, the velocity in the San Joaquin River near Upper Roberts Island increased, while the velocities in Grant Line Canal and Old River at Fabian Tract decreased substantially.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the nominal scour velocity of approximately 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions are generally below 3 fps, except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter sloughs, Steamboat Slough, Georgiana Slough, San Joaquin River at Upper Roberts Island, and Old River at Mossdale all have average velocities higher than 3 fps. However, the San Joaquin River at Upper Roberts Island, Georgiana Slough, the Diversion to Steamboat and Sutter sloughs, and Steamboat Slough have average velocities of less than 3 fps in less than 7 percent of the months modeled and the Sacramento River at Hood and Old River at Mossdale in less than 17 percent of the months modeled. This is generally consistent with the No Action Alternative.

5.2.2.2.2 Mass Fate

Using DWRDSM1 modeling, the fate of mass released into the Delta waterways at various locations was analyzed. The mass fate is presented in Tables 5.2-5, 5.2-6, 5.2-7, and 5.2-8 for high inflow/high pumping, medium inflow/low pumping, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

For high inflow/high pumping conditions and mass released at Freeport, Configurations 2B and 2D substantially more mass remained in the Delta after 60 days. Also, for mass released at Terminous, slightly more flows past Chipps Island for there were no major differences between the mass fate for Configuration 2E and the No Action Alternative.

For medium inflow/low pumping conditions, all Alternative 2 configurations, and injections at Jersey Point, San Andreas Landing, and Prisoners Point, the percent mass flowing past Chipps Island is larger and the percent mass reaching the export locations is smaller than those for the No Action Alternative. For the injection of mass at Freeport, more mass remains in the Delta after 60 days for Configurations 2B and 2D. For Configuration 2E, more mass released at Terminous remains in the Delta and less reaches the pumps after 60 days.

For low inflow/high pumping conditions, there is no significant difference between the fate of mass under Configuration 2B and the fate of mass under the No Action Alternative. For Configurations 2D and 2E for injections at Terminous and Freeport, mass remains in the Delta longer due to the habitat improvements. Also at Terminous, less mass flows to the exports and more flows past Chipps Island.

For low inflow/low pumping conditions for Configuration 2B, more mass released at Vernalis is trapped on Delta islands and less reaches the exports. For Configurations 2D and 2E for injections at Terminous and Freeport, mass remains in the Delta longer due to the habitat improvements. Also at Terminous, less mass flows to the exports and more flows past Chipps Island.

The mass fate of Configuration 2A will be the same as presented above except that Configuration 2A does not include CVP-SWP improvements. The main effect of the CVP-SWP improvements is reduced pumping so less mass may end up at the export locations.

Configuration 2C involves three isolated intakes in the Delta and has not currently been modeled to determine the hydrodynamic effects on the Delta. There are likely to be small changes in mass fate from the No Action Alternative, and the operating criteria will control the fate of mass in the Delta.

5.2.2.2.3 Net Delta Outflow

Using DWRSIM modeling, differences in monthly average net Delta outflows between Alternative 2 and the No Action Alternative were evaluated. Net Delta outflow represents the net fresh water movement through the Delta and out to the Bay, excluding tides. Net Delta outflows are reduced as a result of the increased export capacity in the CVP-SWP improvements. The increased export capacity increases the number of months with flows in the range of the WQCP minimum flow requirements (3,000 cfs to 8,000 cfs).

Table 5.2-9 shows the distribution of the differences in net Delta outflow between Alternative 2 configurations and the No Action Alternative. Configurations 2A and 2C add south Delta improvements to the No Action Alternative. Overall, these two configurations tend to reduce net Delta outflow. The primary changes occur in late summer through fall (September through January), resulting in less Delta outflow about 25 percent of the time. The magnitude of changes during this period range from zero to a little more than 30 percent. The differences in net Delta outflow from February through August are small (less than 10 percent), and these months have about an equal number of increases as decreases.

When Alternative 2 includes south Delta surface storage (Configuration 2D), the potential impacts to net Delta outflow are similar to those described in Configuration 2A and 2C, with one exception—there are slightly larger decreases in net Delta outflow in the winter.

To further analyze the critical low net Delta outflows, changes in the range of the WQCP minimum flow standards are examined more closely. Figure 5.2-7(b) shows the distribution of net Delta outflows in the lower outflow range. This analysis indicates that for both Alternative 2 configurations, the number of months with flows in the minimum flow ranges is increased. Both configurations show negligible change in the 3,000 cfs to 4,000 cfs range. The number of months with flows between 4,000 cfs and 6,500 cfs increased by 3 percent (same as Alternative 1). The number of months with flows greater than 6,500 cfs decreases by the same amount.

Since the reoperation and storage components of Configurations 1C, 2B, and 2E are the same, the effects of Configurations 2B and 2E on net Delta outflow would be similar to those described for Configuration 1C.

5.2.2.2.4 Central Delta Outflow

DWRDSM1 modeling was used to evaluate the effects of Alternative 2 on monthly average central Delta outflow. Central Delta outflow includes the net flow in the San Joaquin River upstream of Threemile Slough plus the flow in False River and Dutch Slough. Alternative 2 showed a dramatic reduction in upstream flows in the central Delta region for each of the three configurations modeled. All of the configurations that include increased diversions from the Sacramento River into the central Delta help to reduce or eliminate upstream central Delta flows.

Figure 5.2-8(b) shows a frequency distribution for Configurations 2B, 2D, and 2E and the No Action Alternative. This analysis shows that Configurations 2B and 2D, which include a 10,000 cfs Hood diversion from the Sacramento River into the central Delta, reduce the number of months with upstream central Delta flows from 60 percent to about 6 percent. Configuration 2E, which includes the Tyler Island habitat improvement, reduces the number of months with upstream flows to about 4 percent.

Table 5.2-10 shows the distribution of monthly averaged central Delta outflows for Alternative 2. These results show a substantial improvement in central Delta flows by reducing the frequency that upstream flows occur. Upstream flows are eliminated in all months except July and August.

The hydrodynamic effects of Configuration 2A will be the same as those presented above for Configuration 2B, except that Configuration 2A does not include the CVP-SWP improvements (10,300 cfs pumping capacity). The main effect of the CVP-SWP improvements on central Delta outflow is to increase the magnitude of upstream flows and to reduce the magnitude of downstream flows.

Configuration 2C involves three isolated intakes in the Delta and has not currently been modeled to determine the hydrodynamic effects on the Delta. Hydrodynamic effects are likely to be localized to the area of the proposed intakes: Rock Slough, the San Joaquin River near Turner Cut, and the San Joaquin River near Lathrop. The intakes will allow operational flexibility and the operating criteria will control the impacts to the Delta.

5.2.2.2.5 X2 Position

DWRSIM modeling was used to evaluate effects of Alternative 2 on X2 location. The X2 position indicates the location in kilometers from the Golden Gate of the 2 parts-per-thousand isohaline. Table 5.2-11 shows the distribution of percentiles for X2 location. Potential impacts are assessed by identifying relative changes in X2 greater than or equal to 1 kilometer (km). Differences greater than 1 km are shaded in the table.

All configurations modeled under Alternative 2 show similar changes in the X2 position. However, Configurations 2B, 2D, and 2E tend to move the X2 position eastward in January, which was not observed under Configurations 2A and 2C. The X2 position does not appear to be sensitive to adding storage. All Alternative 2 configurations show similar monthly changes when compared to the No Action Alternative, suggesting that the increased capacity of the SWP-CVP improvements has more effect on X2 than storage.

During the fall and winter, the western positions of X2 move upstream from 1.1 to 3.3 km. This corresponds to a 5 percent and a 33 percent change when compared to the hydrologic range in the X2 positions. Changes in January range from 3 to 6 percent of the natural variability of X2 position.

The changes in X2 position parallel changes in net Delta outflow; eastward movements in the X2 position tend to occur in the fall when decreases in Delta outflow tend to occur. Changed positions of X2 during the late winter and spring (March, April, May and June) are negligible compared to the No Action Alternative.

5.2.2.2.6 Salinity

DWRDSM1 modeling was used to evaluate the effects of Alternative 2 on monthly average salinity. Tables 5.2-12 through 5.2-15 show the percentiles for the differences in salinity between Alternative 2 and the No Action Alternative. Increases greater than 10 percent are shaded in the table. Salinity was evaluated at four locations: Jersey Point, Emmaton, Old River at Rock Slough, and Clifton Court Forebay. Generally, the effects on salinity are similar for all of the Alternative 2 configurations, and can be summarized as follows:

Jersey Point. A substantial improvement in salinity is observed at Jersey Point. Decreases in salinity of 10 percent or more are observed 75 percent of the time. Median decreases are about 40 to 50 percent. Essentially no increases in salinity are observed. Decreases in salinity of up to 70 percent from the No Action Alternative are possible.

Emmaton. Under Configuration 2B, salinity at Emmaton appears to increase substantially. On average, about 65 percent of the monthly salinities increased by more than 10 percent. Most of the increases occur in July through December. Configurations 2A, 2D and 2E also show decreases in salinity in the late fall and winter.

Old River. Alternative 2 increases salinity in April and May about 50 percent of the time, with increases ranging from 10 to 30 percent. However, for the remaining months, Alternative 2 reduces salinity on Old River. The summer through winter months show decreases in salinity of 10 percent or more 50 to 100 percent of the time.

Clifton Court. Alternative 2 appears to improve salinity at Clifton Court Forebay. Overall, there tends to be about as many decreases as increases in salinity. However, the decreases are greater in magnitude than the increases. The increases occur mostly in the late spring and summer; the decreases occur mostly in the fall and winter.

These results indicate that Alternative 2 decreases salinity in the central and southern Delta region. The channel improvements and habitat improvements that increase the flow of Sacramento River water into the central and south Delta substantially reduce salinity. Somewhat moderate improvements are observed at Clifton Court Forebay. With the increase in cross Delta flows, and corresponding decrease in Sacramento River flows, salinity is increased on the Sacramento River at Emmaton.

Since channel improvements are included in both Configurations 2A and 2B, these configurations may have a similar effect on salinity to Configurations 2D and 2E.

Configuration 2C does not include improved cross Delta flows from the Sacramento River, and as a result, would be expected to show increased salinity in the southern Delta region similar to 3E.

5.2.2.2.7 Storage and Reoperation

Potential impacts on Delta hydrodynamics from the reoperation of the SWP and CVP facilities and from new storage are evaluated using DWRSIM. Potential impacts on Delta hydrodynamics are qualitatively assessed by relating observed changes in the Sacramento River to changes in Delta flows. DWRSIM was used to model reoperation and additional storage components of Configurations 2A, 2B, 2C, 2D, and 2E. Configurations 2B and 2E include south Delta improvements, north Delta surface storage, and south Delta surface storage. Configuration 2D includes south Delta improvements and south Delta surface storage. Configurations 2A and 2C include only south Delta improvements. This section evaluates the potential impacts of reoperation and adding north and south Delta storage to the SWP and CVP systems. Table 5.2-16 shows the difference in distributions of Sacramento River flow between each of these configurations and the No Action Alternative. For all Alternative 2 configurations, changes in Delta Cross Channel flows (Table 5.2-17) parallel changes in the Sacramento River flows.

The results show that, overall, Configurations 2A and 2C cause little change in Sacramento River flows. However, there are some changes in July and August. The monthly distributions suggest that reoperation of the SWP and CVP facilities in Configurations 2A and 2C will increase Sacramento River flows in July and reduce flows in August. July flows increase by 10 percent or more about 40 percent of the time and August flows decrease by 10 percent or more about 50 percent of the time. Increased exports in the fall are made up mostly from reduced net Delta outflow with little coming from increased Sacramento River flows.

Similar patterns in Sacramento River flows to Configurations 2A and 2C are experienced with Configuration 2D except that adding south Delta storage allows increased exports and results in increased Sacramento River flows in the summer through winter. These increases are relatively small, with only a small percentage have changes greater than 10 percent.

Since Configurations 2B and 2E have the same storage components as Configuration 1C, the results for these configurations are the same. Configurations 2B and 2E reduce Sacramento River flows during the winter and increase flows in the summer and fall.

This analysis indicates that the impact of reoperation and storage on Delta hydrodynamics is small. Furthermore, Alternative 2 also includes in-Delta channel improvements and a new Hood Diversion which allows substantially more flow into the north Delta from the Sacramento River. Based on the analyses in previous sections, the in-Delta modifications have a more substantial impact on Delta flows; therefore, reoperation and new storage will likely have little observable effect.

5.2.2.3 Alternative 3

Alternative 3 involves the dual Delta conveyance option including north and south Delta channel improvements, CVP-SWP improvements, and various forms of an isolated facility. A combination of seven conveyance configurations and two storage options differentiate nine variations of this alternative. The hydrodynamic effects of Alternative 3 on the Delta are evaluated by its effects on the following: flow, velocity, and stage; mass fate; net Delta outflow; central Delta outflow; X2 position; and salinity.

5.2.2.3.1 Flow, Velocity, and Stage

DWRDSM1 modeling was performed for Configuration 3E to evaluate the effects of Alternative 3 on monthly average flows, velocities, and stages in the Delta. A comparison of flows, velocities, and stages between Configuration 3E and the No Action Alternative for a number of locations within the Delta is presented in Tables 5.2-2, 5.2-3, and 5.2-4 for high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively. These numbers are based on modeling of the Delta with Delta geometry changes appropriate for the respective alternatives, predicted 2020 demands, and the increased pumping capacity of the Banks Pumping Plant of 10,300 cfs. In general, Alternative 3 reduces flow through the Delta, especially for low inflow/high pumping conditions. This is due to the diversion of water to the isolated facility from the Sacramento River at Hood.

Configurations 3A and 3B

Configurations 3A and 3B use a combination of through-Delta conveyance and an isolated facility to move water from the Sacramento River in the north Delta to the pumping plants in the south Delta. The hydrodynamic effects on the Delta of Configurations 3A and 3B will be similar to the effects of Configuration 3E, except the flows through the Delta will be reduced to a lesser degree than for Configuration 3E. This is due to the fact that the isolated facility for Configurations 3A and 3B has a smaller capacity than the isolated facility for Configuration 3E; thus, Configurations 3A and 3B rely more on through-Delta conveyance than Configuration 3E.

Configurations 3C and 3D

Configurations 3C and 3D are identical to Configurations 3A and 3B, except that the isolated facility is a pipe instead of an open channel. Therefore, the hydrodynamic effects of Configurations 3C and 3D on the Delta will be the same as the effects of Configurations 3A and 3B.

Configuration 3E

For Configuration 3E, the isolated facility will allow flexibility in the system by providing an alternative intake diversion point. Operating criteria of the isolated facility will control the effects on the Delta. Average tidal flows, velocities, and stages throughout the Delta based on DWRDSM1 modeling are shown in Figures 5.2-18 through 5.2-20 for the high inflow, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

For high inflow conditions, differences in the average flows between Configuration 3E and the No Action Alternative are mostly in the north Delta. For Configuration 3E, diversions from the Sacramento River are similar to the diversion for the No Action Alternative: approximately 35 percent is diverted to Steamboat and Sutter sloughs, and 15 percent travels down Georgiana Slough. For Configuration 3E, there is an increase in flow down the Mokelumne River due to setback levees. In the south Delta, similar to the No Action Alternative, about 60 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale, and 40 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent travels down Middle River, while 65 percent is carried by the Grant Line Canal and 20 percent is carried by Old River toward the pumping plants. As for the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels north, and the ratio of flow in Old River to flow in Middle River is about 1.5; however, there is an increase in flow down the Old River and Middle River for Configuration 3E. Similar to the No Action Alternative, water from the central Delta flows out of the Delta through the San Joaquin River and through Franks Tract and connecting channels (False River and Dutch Slough). False River carries about 35 percent of the central Delta outflow, Dutch Slough carries about 5 percent, and the main channel of the San Joaquin River carries the remaining 60 percent.

For low inflow/high pumping conditions for Configuration 3E, there is less movement of water through the Delta toward the pumps. For Configuration 3E, approximately 10 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs and 10 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 3E, approximately 65 percent of the Sacramento River flow is diverted at Hood to the isolated facility. There is a decrease in flow down the Mokelumne River due to the closure of the Delta Cross Channel and

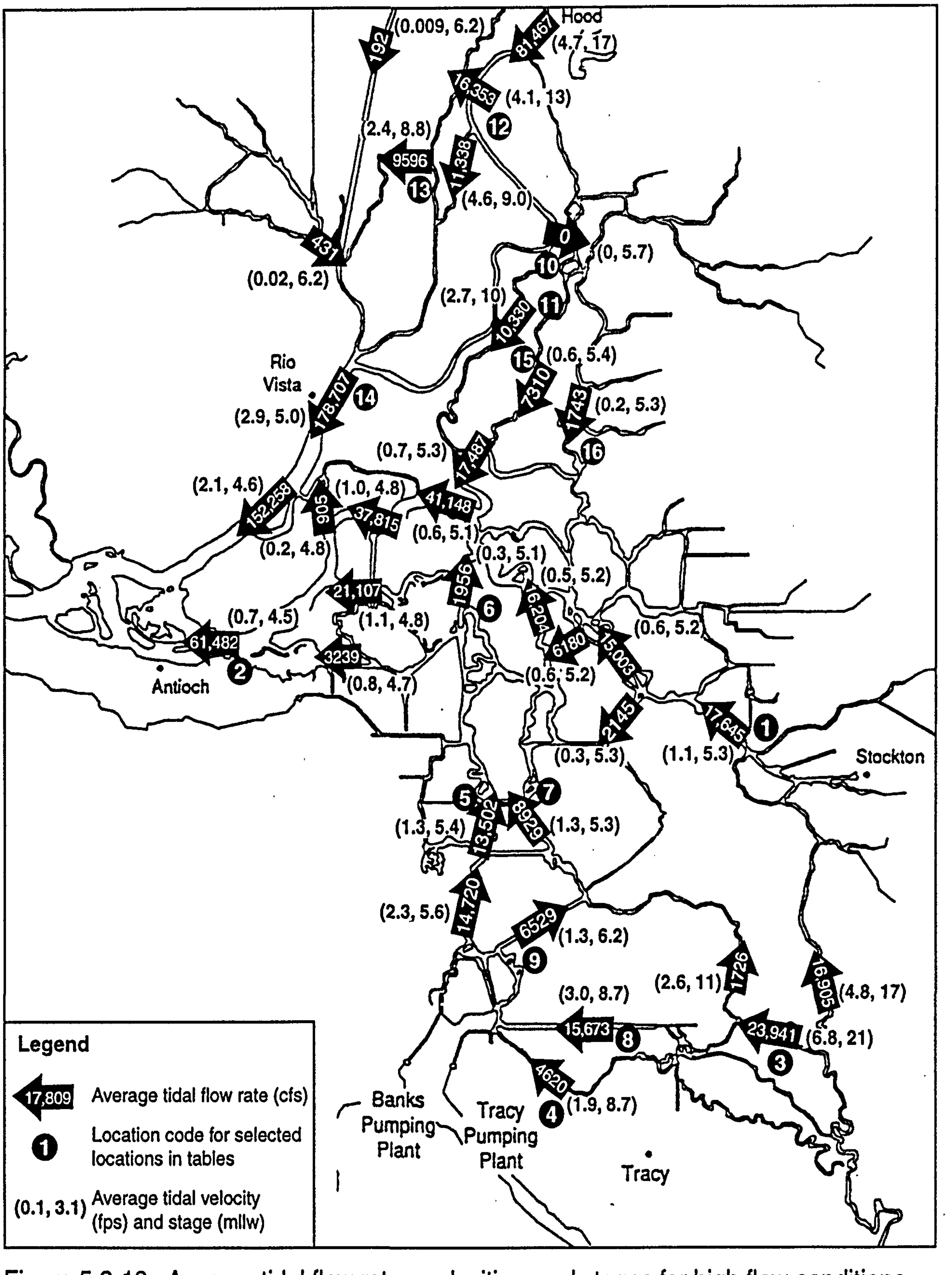


Figure 5.2-18. Average tidal flow rates, velocities, and stages for high flow conditions for Alternative 3E.

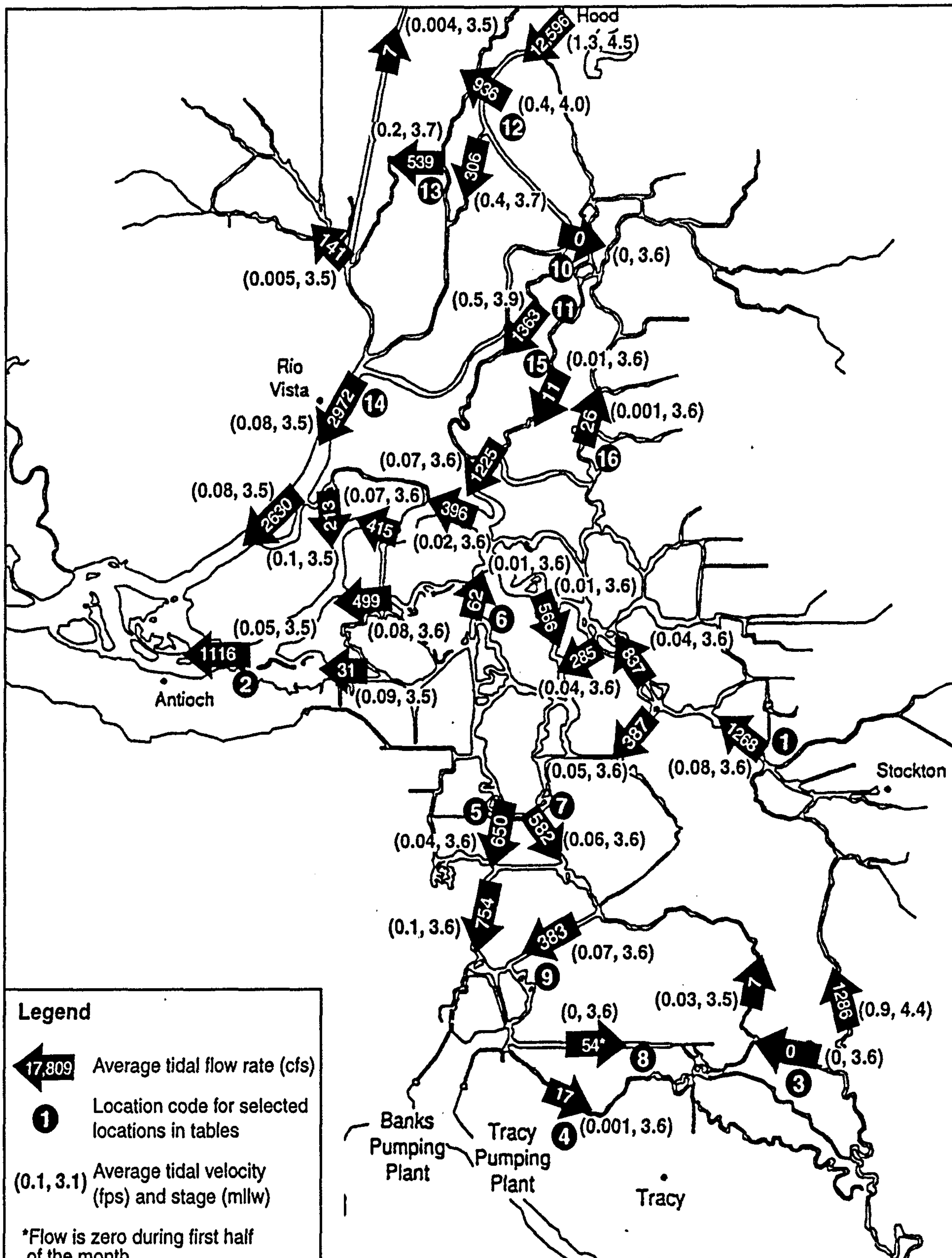


Figure 5.2-19. Average tidal flow rates, velocities, and stages for low flow/high pumping conditions for Alternative 3E.

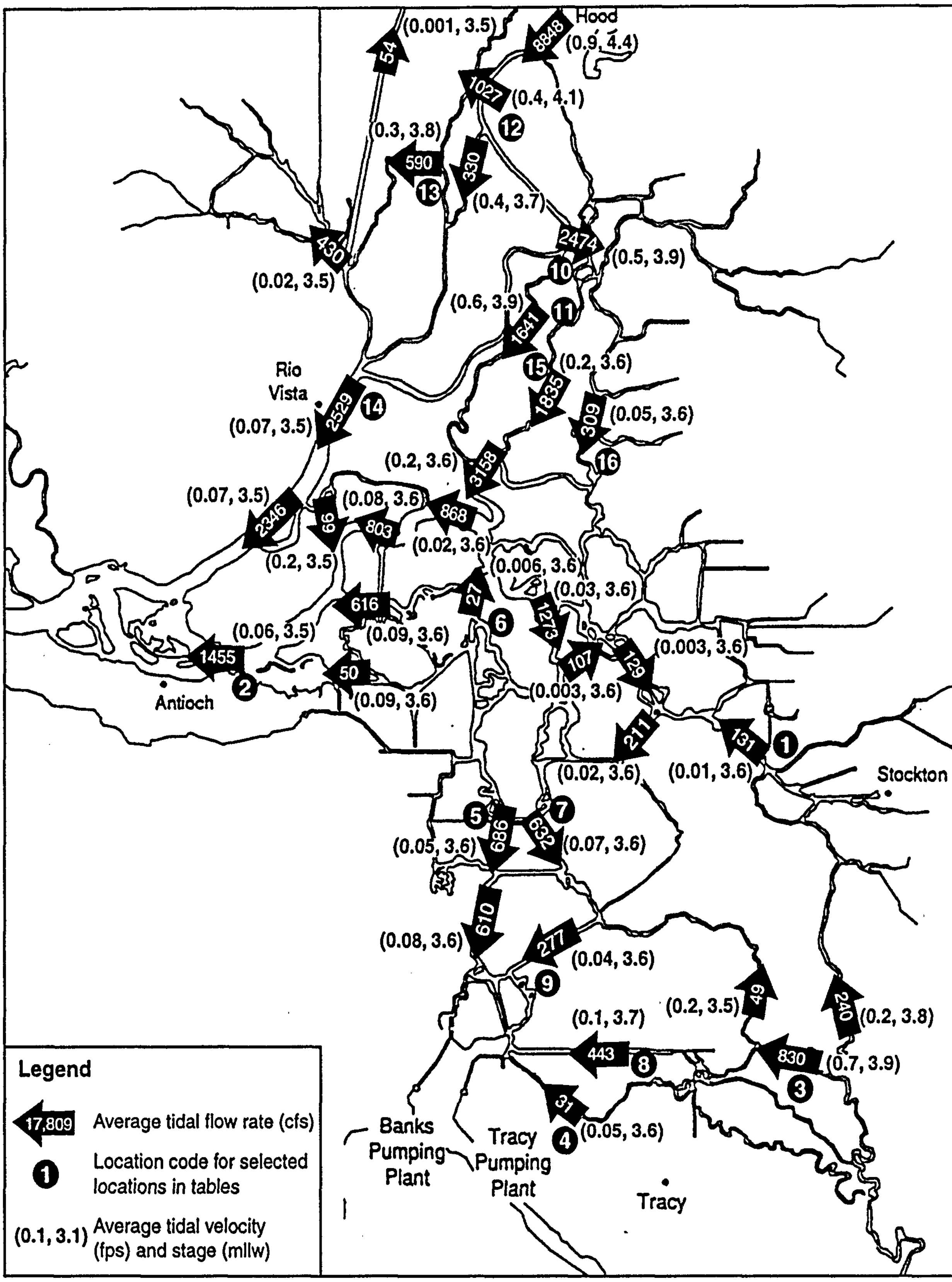


Figure 5.2-20. Average tidal flow rates, velocities, and stages for low flow/low pumping conditions for Alternative 3E.

less flow traveling down the Sacramento River. In the south Delta, a flow control structure at Old River at Mossdale limits flow down the Old River, which eliminates reverse flow in the San Joaquin River. Therefore, the flow down the San Joaquin River is increased, flow in Old River at Fabian Tract is reversed, and flow down the Grant Line Canal is reversed. As for the No Action Alternative, water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants. The ratio of flow in Old River to flow in Middle River is smaller, about 1, and there is less flow traveling via Old and Middle Rivers toward the pumps. Contrary to the No Action Alternative, most of the water in the central Delta flows out of the Delta. Central Delta water enters Old and Middle River channels at their mouths and through Turner, Empire, and Columbia cuts, which connect the upper San Joaquin River with Middle River. Dutch Slough, False River, and the San Joaquin River carry water westward.

For low inflow/low pumping conditions, the hydrodynamic effects of Configuration 3E are similar to the effects presented for low inflow/high pumping. For low inflow/low pumping conditions, approximately 15 percent of the inflow from the Sacramento River is diverted to Steamboat and Sutter sloughs, 30 percent is diverted to the Delta Cross Channel, and 20 percent is diverted to Georgiana Slough. These diversions are less than the diversions for the No Action Alternative. Additionally, for Configuration 3E, approximately 30 percent of the Sacramento River water is diverted at Hood to the isolated facility. In the south Delta, similar to the No Action Alternative, about 80 percent of the San Joaquin River inflow at Vernalis is diverted to Old River near Mossdale, and 20 percent remains in the San Joaquin River channel and flows past Stockton. Of the flow diverted to Old River, approximately 5 percent is diverted down Middle River, 55 percent is carried by the Grant Line Canal, and 5 percent is carried by Old River toward the pumping plants. Water in Victoria Canal, Old River north of Victoria Island, and Middle River travels south toward the Delta export locations at the Banks and Tracy pumping plants, and the ratio of flow in Old River to flow in Middle River is about 1. Also, similar to the No Action Alternative, most of the water in the central Delta flows west. Central Delta water enters Old River and Middle River channels at their mouths and through Turner and Empire cuts, which connect the upper San Joaquin River with Middle River. False River, Dutch Slough, and the San Joaquin River carry water westward.

There are no substantial differences in velocities and stages between Configuration 3E and the No Action Alternative, except in channels with setback levees. In the Mokelumne River, the velocities decreased by up to a factor of 5 in the channels with setback levees. Velocities and stages also changed in the areas near flow control structures while they were operating. During low inflow/high pumping conditions, the velocity in the San Joaquin River near Upper Roberts Island increased, while the velocities in Grant Line Canal and Old River at Fabian Tract decreased substantially. A slower velocity will decrease sediment transport and will increase sedimentation in the channel.

Average velocities in the Delta for both low inflow/high pumping conditions and low inflow/low pumping conditions are well below the nominal scour velocity of approximately 3 fps at all locations within the Delta. Average velocities in the Delta for high inflow conditions are generally below the nominal scour velocity of approximately 3 fps except on the outskirts. The Sacramento River at Hood, diversion to Steamboat/Sutter sloughs, Steamboat Slough, San Joaquin River at Upper Roberts Island, and Old River at Mossdale all have average velocities higher than 3 fps. However, the San Joaquin River at Upper Roberts Island, the diversion to Steamboat and Sutter sloughs, and Steamboat Slough have average velocities of less than 3 fps in less than 9 percent of the months modeled and the Sacramento River at Hood and Old River at Mossdale in less than 17 percent of the months modeled. This is generally consistent with the No Action Alternative.

Configuration 3F

Configuration 3F involves a chain of lakes that would convey Sacramento River water from the Delta Cross Channel in the north Delta to Clifton Court Forebay in the south Delta. This chain of lakes would operate as an isolated facility, not subject to tidal influences. Therefore, the hydrodynamic effects of Configuration 3F on the Delta would be similar to the effects of Configuration 3E.

Configuration 3G

Configuration 3G is similar to Configuration 3E, except that the Sacramento Deep Water Ship Channel and a West Delta Tunnel are used to convey water from the Sacramento River in the north Delta to the pumping plants in the south Delta. The effects of Configuration 3G will be similar to the effects of Configuration 3E. However, the capacity of the isolated facility of Configuration 3G is smaller than the capacity of the isolated facility of Configuration 3E; therefore, the flow through the Delta will be larger than shown for Configuration 3E.

Configuration 3H

Configuration 3H is similar to Configuration 2E, except that it has an East Delta isolated facility. The hydrodynamic effects of Configuration 3H will be similar to the effects of Configuration 2E except that the isolated facility increases the flexibility of the system by providing an alternative intake diversion point. When flow is diverted to the isolated facility, flows through the Delta will be reduced.

Configuration 3I

Configuration 3I is similar to Configuration 2C, except that the 15,000 cfs northern intake is extended to be like the isolated facility of Configuration 3E. The hydrodynamic effects of Configuration 3I will be similar to the effects of Configuration 2C.

5.2.2.3.2 Mass Fate

Using DWRDSM1 modeling, the fate of mass released into the Delta waterways at various locations was analyzed. The mass fate is presented in Tables 5.2-5, 5.2-6, 5.2-7, and 5.2-8 for high inflow/high pumping, medium inflow/low pumping, low inflow/high pumping, and low inflow/low pumping conditions, respectively.

For high inflow/high pumping conditions and at Vernalis and Terminous, substantially more mass released flows past Chipps Island and less reaches the exports for

Configuration 3E than for the No Action Alternative. Substantially more mass released at Freeport reaches the exports for Configurations 3E than for the No Action Alternative.

For medium inflow/low pumping conditions, Configuration 3E reduced the mass reaching the exports to zero except for mass released at Freeport. This is due to the isolated facility, which takes in water at Hood and diverts it directly to the export locations. For low inflow/high pumping conditions, the mass released at all locations except Freeport that reaches export locations is reduced, and more of the mass released at Vernalis, Terminous, San Andreas Landing, and Prisoners Point remains in the Delta after 60 days. For low inflow/low pumping conditions, the mass released at all locations except Freeport that reaches export locations is reduced, and more of the mass released at Terminous, San Andreas Landing, and Prisoners Point remains in the Delta after 60 days.

Configurations 3A and 3B use a combination of through-Delta conveyance and an isolated facility to move water from the Sacramento River in the north Delta to the pumping plants in the south Delta. The fate of mass in the Delta for Configurations 3A and 3B will be similar to the fate of mass for Configuration 3E.

Configurations 3C and 3D are identical to Configurations 3A and 3B, except that the isolated facility is a pipe instead of an open channel. Therefore, the mass fate for Configurations 3C and 3D will be the same as the mass fate for Configurations 3A and 3B.

Configuration 3F involves a chain of lakes that would convey Sacramento River water from the Delta Cross Channel in the north Delta to Clifton Court Forebay in the south Delta. This chain of lakes would operate as an isolated facility, not subject to tidal influences. Therefore, the mass fate for Configuration 3F would be similar to the effects of Configuration 3E.

Configuration 3G is similar to Configuration 3E except that the Sacramento Deep Water Ship Channel and a West Delta Tunnel are used to convey water from the Sacramento River in the north Delta to the pumping plants in the south Delta. The mass fate for Configuration 3G will be similar to the mass fate for Configuration 3E.

Configuration 3H is similar to Configuration 2E, except that it has an East Delta isolated facility. The mass fate of Configuration 3H will be similar to the mass fate of Configuration 2E, except that the isolated facility will allow more mass released at Freeport to reach the exports. When flow is diverted to the isolated facility, flows through the Delta will be reduced, increasing the travel time of mass through the Delta.

Configuration 3I is similar to Configuration 2C except that the 15,000 cfs northern intake is extended to be like the isolated facility of Configuration 3E. The mass fate for Configuration 3I will be similar to the mass fate for Configuration 2C.

5.2.2.3.3 Net Delta Outflow

Using DWRSIM modeling, the effect of Alternative 3 on monthly average net Delta outflow was evaluated. Net Delta outflow represents the net fresh water movement through the Delta and out to the Bay, excluding tides. Alternative 3 reduces net Delta outflow more than the other two alternatives. Table 5.2-9 shows the distribution of the differences in net Delta outflow between Alternative 3 and the No Action Alternative. The same general pattern of reductions are observed for fall through mid-winter, as described in the previous alternatives. However, from mid-winter through spring, this alternative showed a greater number of months with reduced Delta outflow. Alternative 3 is the only one that shows substantial reductions in outflow during April, May, and June.

Frequency analysis of the differences in monthly net Delta outflow indicates that approximately 30 percent of the outflows for Alternative 3 are reduced by 2.5 percent or more. However, about 15 percent of the monthly outflows are increased by 2.5 percent or more, resulting in a net decrease of 15 percent.

Configurations 3A and 3C show the impacts of adding the 5,000 cfs isolated facility. Comparing net Delta outflow for Configurations 3A and 3C to net Delta outflow for Configurations 2A and 2C indicates that the isolated facility decreases outflow in spring. Approximately 30 percent of the total March, April, May, and June months showed a decrease in outflow. Approximately 25 percent of the time outflows are increased during winter.

Adding north and south surface storage (Configurations 3B and 3D through 3I) tends to increase the magnitude of reduced outflows but does not substantially change the number of months when decreases occur except in the spring. The effect of Configurations 3B and 3D through 3I are similar to those found for Configuration 1C.

To further analyze the critical (low) net Delta outflow, changes in outflow in the range of the WQCP minimum flow requirements (3,000 cfs to 8,000 cfs) are examined more closely. Figure 5.2-7(c) shows the distribution of net Delta outflows in the lower outflow range. This figure shows that all modeled Alternative 3 configurations modeled increase the number of months with flows below 6,500 cfs. Configurations 3A and 3C increased the number of months with flows between 4,000 cfs and 6,500 cfs by about 3 percent and configurations 3B and 3D through 3I increased the number of months with flows between 4,000 cfs and 6,500 cfs by about 4 percent.

5.2.2.3.4 Central Delta Outflow

DWRDSM1 modeling was used to evaluate the effects of Alternative 3 on monthly average central Delta outflow. Central Delta outflow is defined as the flow in the San Joaquin River upstream of Threemile Slough plus the flow in False River and Dutch Slough. As with Alternative 2, those options that allow more Sacramento River water to be diverted into the central Delta reduce average monthly upstream flows in the central Delta region. Unlike Alternative 2, Configuration 3E appears to eliminate upstream flows entirely.

Figure 5.2-8(c) shows the frequency distribution for Configuration 3E and the No Action Alternative. It demonstrates that the number of months with flows in the upstream direction (negative) are reduced to zero. The number of months with downstream (positive) flows increased in all flow ranges.

Table 5.2-10 shows the distribution of monthly average central Delta outflows. The results confirm that all central Delta flows are downstream, even in July and August, which are typically the critical months for reverse flows. Minimum downstream flows for this alternative are around 400 cfs.

Configurations 3A and 3B use a combination of through-Delta conveyance and an isolated facility to move water from the Sacramento River in the north Delta to the pumping plants in the south Delta. The effect of Configuration 3A on central Delta outflow will be similar to the effect of Configuration 2A with the following exceptions: 2A includes a 10,000 cfs Hood intake, which is not included in 3A, and 3A includes a 5,000 cfs isolated facility, which is not included in 2A. The operating criteria of the isolated facility will control effects on the Delta, and, while it is operational, flows through the Delta will be reduced. Configurations 3C and 3D are identical to Configurations 3A and 3B, except that the isolated facility is a pipe instead of an open channel. Therefore, the effects of Configurations 3C and 3D on central Delta outflow will be the same as the effects of Configurations 3A and 3B.

Configuration 3F involves a chain of lakes that would convey Sacramento River water from the Delta Cross Channel in the north Delta to Clifton Court Forebay in the south Delta. This chain of lakes would operate as an isolated facility, not subject to tidal influences. Therefore, the effects of Configuration 3F on central Delta outflow would be similar to 3E.

Configuration 3G is similar to Configuration 3B, except that the Sacramento Deep Water Ship Channel and a West Delta Tunnel convey water from the Sacramento River in the north Delta to the pumping plants in the south Delta. The effects of Configuration 3G on central Delta outflow will be similar to the effects of Configuration 3B.

Configuration 3H is similar to Configuration 2E, except that it has an east Delta isolated facility. The effects of Configuration 3H on central Delta outflow will be similar to the effects of Configuration 2E, except that the isolated facility increases the flexibility of the system by providing an alternative intake diversion point. When flow is diverted to the isolated facility, central Delta outflow will be reduced.

Configuration 3I is similar to Configuration 2C except that the 15,000 cfs northern intake is extended to be like the isolated facility of Configuration 3E. The effects of Configuration 3I on central Delta outflow will be similar to the effects of Configuration 2C.

5.2.2.3.5 X2 Position

DWRSIM modeling was performed to evaluate the effects of Alternative 3 on X2 location. The X2 position indicates the location in kilometers from the Golden Gate of the 2 parts-per-thousand isohaline. Table 5.2-11 shows the distribution of X2 position. Potential impacts are assessed by identifying relative changes in X2 position greater than or equal to 1 km. Although not indicated in Table 5.2-11, eastward movements in X2 during the fall range from 1 to 7 km and eastward movements during the winter and spring range from 1 to 5 km.

As shown by the shaded values in Table 5.2-11, the changes in X2 position parallel changes in net Delta outflow; movements in the X2 position tend to occur when decreases in net Delta outflow occur. Alternative 3 appears to move the position of X2 eastward during the spring, which is not observed in Alternative 1 or 2.

Based on the difference in percentiles method, under Configurations 3A and 3C, the western position of X2 tends to move upstream during the fall about 1.0 to 3.5 km. During the spring, the position of X2 moves upstream from 1.1 to 2.8 km.

Configurations 3B and 3D-3I appear to cause the most change of any configuration in both western and eastern locations of X2. Configurations 3B and 3D-3I move the location of X2 eastward from 1.0 to 3.7 km in the fall and from 1.0 to 3.1 km in the winter and spring. These changes represent 5 to 35 percent of the natural variability in X2 position during the fall, and 5 to 15 percent of the natural variability in X2 position in the winter and spring.

5.2.2.3.6 Salinity

DWRDSM1 modeling was used to evaluate the effects of Alternative 3 on monthly average salinity. Salinity for the No Action Alternative is based on the same modeling study as Configuration 1A; therefore, Configuration 3E is compared to Configuration 1A. Salinity is evaluated at four locations: Jersey Point, Emmaton, Old River at Rock Slough, and Clifton Court Forebay. Tables 5.2-12 through 5.2-15 show the percentiles of the difference in salinity between Configuration 3E and the No Action Alternative. Changes greater than 10 percent are shaded on the table. The effects of Configuration 3E on salinity at each location can be summarized as follows:

Jersey Point. Under Configuration 3E, the there is a moderate improvement in salinity, though not as large as found for Alternative 2. During summer and winter, salinity is reduced by 10 percent or more about 75 percent of the time. However, increases in salinity occur in all months except August and September.

Emmaton. Salinity at Emmaton appears to increase substantially under Alternative 3. Salinity increased by more than 10 percent in about 50 percent of the total months. Generally, increases occur throughout the year. The few decreases that do occur are mostly in June.

Old River. Alternative 3 substantially increases salinity on Old River. There are about as many increases as decreases in salinity; however, the increases are greater in magnitude. Most of the increases occur in winter and spring. Summer and fall show a greater number of decreases in salinity.

Clifton Court. Alternative 3 appears to improve salinity at Clifton Court substantially. There are only a few increases in salinity under Configuration 3E. Improvements in salinity occur throughout the year.

This analysis indicates that Configuration 3E will substantially improve the salinity conditions at Clifton Court Forebay as a result of the isolated facility. However, Configuration 3E increases salinity at the other three locations.

Configurations 3A, 3B, 3C, 3D, 3F, 3G and 3H will all likely have similar effects on salinity as Configuration 3E. The configurations isolate and convey Sacramento River water to the south Delta exports. These configurations bring fresher water to the export pumps but reduce the fresh water in the Delta.

5.2.2.3.6 Storage and Reoperation

Potential impacts on Delta hydrodynamics from the reoperation of the SWP and CVP facilities and from new storage are evaluated using DWRSIM. Potential impacts on Delta hydrodynamics are qualitatively assessed by relating observed changes in the Sacramento River to changes in Delta flows. DWRSIM was used to model reoperation and additional storage components of Configurations 3A through 3I. Configurations 3A and 3C include south Delta improvements with an isolated facility. Configurations 3B and 3D-3I include south Delta improvements, an isolated facility, and both north and south Delta storage. This section evaluates the potential impacts of reoperation and adding north and south Delta storage to the SWP and CVP systems. Table 5.2-16 shows the difference in distributions of Sacramento River flow between each of these configurations and the No Action Alternative.

The results for all Alternative 3 configurations show that the reoperation for an isolated facility substantially reduces Sacramento River flows in July and August. There is an increase in Sacramento River flows during the fall for a small percentage of the time and a substantial increase in Sacramento River flows during the spring (unlike the other alternatives). This corresponds to a substantial decrease in net Delta outflow and an increase in exports during the spring, when flow restrictions usually limit south Delta pumping. For Configurations 3B and 3D-3I, which include south and north Delta surface storage, the observed changes in Sacramento River flows are larger than for Configurations 3A and 3C, which do not include storage.

Table 5.2-17 shows the changes in Delta Cross Channel flows as a result of the isolated facility and new storage. Substantial reductions in Delta Cross Channel flows occur in every month of the year almost 100 percent of the time. During the summer and fall the Delta Cross Channel flows are reduced as much as 70 percent. During the winter and spring Delta Cross Channel flows are reduced up to 25 percent. The results suggest a substantial decrease in cross Delta flows from the northern inflows to the southern exports. Based on the analysis in previous sections, the isolated facility has a large impact on Delta hydrodynamics; therefore, potential impacts from the storage components of Alternative 3 are likely to be insignificant.

5.2.3 Comparison of Program Actions to Existing Conditions

Since there are no substantial differences in the Delta between existing conditions and the No Action Alternative, the comparison of the effects of the alternatives to existing conditions is the same as the comparison of the effects of the alternatives to the No Action Alternative.

5.3 Bay Region

5.3.1 Summary of Regional Effects by Alternative

No potential substantial effects on the Bay have been determined for Alternatives 1, 2, and 3.

5.3.2 Comparison of Program Actions to No Action Alternative

5.3.2.1 Alternative 1

Under Alternative 1, fresh water flows to the Bay will be reduced as a result of the increased export capacity in the CVP-SWP improvements. The primary changes in net Delta outflow occur in late summer through winter (September through March), resulting in less Delta outflow about 25 percent of the time. The magnitude of changes range from zero to more than 40 percent. The differences in net Delta outflow from April through August are negligible.

During late summer and fall, Alternative 1 causes the average western X2 location to move upstream. X2 moves upstream from 1 to 5 kilometers about 25 percent of the time.

5.3.2.2 Alternative 2

Configurations 2A and 2C reduce fresh water flows to the Bay. The primary reductions will occur in late summer through fall (September through January) about 25 percent of the time. The magnitude of changes range from zero to a little more than 30 percent. The differences in fresh water inflows in February through August are small (less than 10 percent).

Under Configuration 2D, the potential impacts are similar to those described in Configuration 2A and 2C, except fresh water flows are slightly decreased in late fall and winter (December through March).

During late summer and fall, this alternative causes the average western X2 location to move upstream. X2 moves upstream from 1 to 3 kilometers about 25 percent of the time.

5.3.2.3 Alternative 3

Alternative 3 reduces fresh water inflow to the Bay more than Alternative 1 or 2. Also, unlike Alternatives 1 and 2, Alternative 3 reduces fresh water inflow during the spring (April to June). Approximately 30 percent of fresh water inflows are reduced by 10 percent or more when compared to the No Action Alternative. Alternative 3 also increases fresh water flow about 25 percent of the time in winter.

During late summer and fall, this alternative causes the average western X2 location to move upstream from 1 to 7 kilometers. The average eastern X2 location moves farther upstream by 1 to 5 kilometers in winter. The median X2 location moves farther upstream by 1 to 3 kilometers in spring.

5.3.3 Comparison of Program Actions to Existing Conditions

The effects of the alternatives on the Bay in comparison to existing conditions will be similar to their effects in comparison to the No Action Alternative described in the previous section.

5.4 Sacramento River Region

5.4.1 Summary of Regional Effects by Alternative

On a regional basis, the impacts of the alternatives on flows in the Sacramento River region are generally minimal. The most substantial changes occur in the dry season at Bend Bridge for Configurations 3A and 3C, and on the Feather River in the wet season for Configurations 1C, 2B, 2E, 3B, and 3D-3I and in the dry season for

Configurations 1C, 2A, 2B, 2C, 2E, 3A, and 3C.

For the Delta inflow analysis, the impact of the alternatives on the Sacramento River at Freeport was evaluated. During the wet season, average stream flows are relatively unaffected by any of the alternative configurations. Maximum wet season flows increase in configurations where there is an off-stream storage element but decrease in configurations that do not include storage. Minimum wet season flows decrease with configurations that include an isolated facility.

As for average wet season flows, dry season average stream flows in the Sacramento River at Freeport are relatively unaffected by any of the alternatives. The changes in maximum dry season flows are negligible for all of the alternatives. The changes in minimum dry season flows at Freeport are also negligible except for the configurations that include an isolated facility.

5.4.2 Comparison of Program Actions to No Action Alternative

Tables 5.4-1 through 5.4-9 present summary statistics (averages, maximums, and minimums) representing discharge, mean stream velocity, stream top width, and mean depth at nine locations within the Sacramento River region based on DWRSIM modeling. Each table presents the results evaluated at one location for each of the modeled alternative configurations. High flow conditions are represented by the February data, and low flow conditions are represented by September data. In addition to presenting nominal values of flow, velocity, width, and depth, the summary tables show the percent difference in the summary statistical values relative to the No Action Alternative. For convenience, the tables also show the percent difference of the values for the No Action Alternative relative to existing conditions.

Due to the functional relationship between discharge and the secondary variables (velocity, top width, and depth), the magnitudes of the changes in these variables are generally reflective of, but not proportional to, the magnitudes of changes in discharge. In addition, the magnitude of the velocity, top width, and depth are also a function of the channel geometry at a specific location and will change because the channel geometry varies even if the discharge remains fixed over a given reach of a stream.

Many of the common elements of the alternatives do not have the potential to cause changes in river hydraulics. For example, Delta habitat improvements would have no impacts on stream flows outside the Delta. None of the proposed configurations would modify stream channels. The only way in which the proposed configurations might potentially affect river hydraulics is through changes in stream flows. Stream flows may be altered by changes in the magnitude or timing of diversions or inflows.

The common elements that have the potential for altering stream flows include the increased pumping capacity at the Banks Pumping Plant, increased storage, and isolated conveyance facilities.

Although the Banks Pumping Plant takes water from the Delta, the pattern of storage and releases upstream of the Delta might

TABLE 5.4-1 SUMMARY OF ALTERNATIVES, CP # 137, SACRAMENTO RIVER AT FREEPORT (USGS 11447650)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	95486	95090	-0.41%	110953	16.68%	91705	-3.56%	101374	6.61%	90138	-5.21%	110143	15.83%
Minimum	11002	11632	5.73%	11758	1.08%	11596	-0.31%	10714	-7.89%	10498	-9.75%	10930	-6.04%
Average	38893	38605	-0.74%	37669	-2.43%	38605	SC***	38731	0.33%	38641	0.09%	38101	-1.31%
Mean Velocity (fps)													
Maximum	4.25	4.24	-0.23%	4.76	12.45%	4.29	1.26%	4.53	7.00%	4.25	0.31%	4.59	8.43%
Minimum	1.29	1.33	3.11%	1.39	4.03%	1.38	3.23%	1.32	-1.16%	1.30	-2.26%	1.29	-3.37%
Average	2.59	2.58	-0.41%	2.63	1.96%	2.67	3.35%	2.67	3.53%	2.67	3.40%	2.56	-0.72%
Top Width (feet)													
Maximum	620	620	-0.02%	628	1.31%	622	0.43%	625	0.89%	622	0.35%	624	0.67%
Minimum	562	563	0.25%	566	0.52%	566	0.45%	564	0.09%	563	SC***	562	-0.28%
Average	595	595	-0.03%	598	0.43%	598	0.54%	598	0.56%	598	0.54%	595	-0.06%
Mean Depth (feet)													
Maximum	36.8	36.8	-0.16%	38.5	4.68%	35.8	-2.69%	37.2	1.12%	35.6	-3.33%	38.9	5.77%
Minimum	16.1	16.5	2.15%	16.3	-1.19%	16.2	-1.71%	15.7	-4.65%	15.6	-5.39%	16.1	-2.35%
Average	26.1	26.1	-0.28%	25.5	-2.37%	25.7	-1.44%	25.7	-1.32%	25.7	-1.41%	25.9	-0.50%
SEPTEMBER													
Discharge (cfs)													
Maximum	27494	27494	SC***	27393	-0.37%	27494	SC***	27494	SC***	27494	SC***	27393	-0.37%
Minimum	7613	7999	5.08%	7999	SC***	8016	0.21%	8067	0.84%	7445	-6.93%	7680	-3.99%
Average	11982	12722	6.17%	12789	0.53%	12520	-1.59%	12772	0.40%	12688	-0.26%	12671	-0.40%
Mean Velocity (fps)													
Maximum	2.14	2.14	SC***	2.21	3.16%	2.21	3.37%	2.21	3.37%	2.21	3.37%	2.14	-0.20%
Minimum	1.06	1.08	2.76%	1.12	3.43%	1.12	3.55%	1.13	3.91%	1.08	-0.58%	1.06	-2.22%
Average	1.35	1.40	3.35%	1.45	3.71%	1.43	2.50%	1.45	3.63%	1.45	3.26%	1.40	-0.22%
Top Width (feet)													
Maximum	586	586	SC***	589	0.50%	589	0.52%	589	0.52%	589	0.52%	586	-0.02%
Minimum	553	554	0.23%	556	0.45%	556	0.45%	557	0.48%	555	0.11%	553	-0.18%
Average	564	566	0.27%	569	0.50%	568	0.40%	569	0.49%	568	0.46%	566	-0.02%
Mean Depth (feet)													
Maximum	22.9	22.9	SC***	22.5	-1.62%	22.6	-1.49%	22.6	-1.49%	22.6	-1.49%	22.9	-0.14%
Minimum	14.0	14.3	1.91%	14.1	-1.64%	14.1	-1.57%	14.1	-1.33%	13.7	-4.31%	14.1	-1.54%
Average	16.7	17.1	2.31%	16.8	-1.39%	16.7	-2.19%	16.8	-1.44%	16.8	-1.68%	17.0	-0.15%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-2 SUMMARY OF ALTERNATIVES, CP # 61 NAVIGATION CP (NCP), DA15 ADJST (USGS 11425500 - SACRAMENTO RIVER AT VERONA)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	107874	107874	SC***	107874	SC***	107874	SC***	107874	SC***	107874	SC***	107874	SC***
Minimum	3997	3997	SC***	3997	SC***	3997	SC***	3997	SC***	3997	SC***	3493	-12.61%
Average	25281	25227	-0.21%	23642	-6.28%	25190	-0.14%	25136	-0.36%	25227	SC***	23732	-5.92%
Mean Velocity (fps)													
Maximum	4.48	4.48	SC***	4.48	SC***	4.48	SC***	4.48	SC***	4.48	SC***	4.48	SC***
Minimum	1.67	1.67	SC***	1.67	SC***	1.67	SC***	1.67	SC***	1.67	SC***	1.60	-4.25%
Average	3.03	3.02	-0.07%	2.96	-2.07%	3.02	-0.05%	3.02	-0.12%	3.02	SC***	2.97	-1.95%
Top Width (feet)													
Maximum	839	839	SC***	839	SC***	839	SC***	839	SC***	839	SC***	839	SC***
Minimum	460	460	SC***	460	SC***	460	SC***	460	SC***	460	SC***	455	-1.11%
Average	536	536	-0.02%	533	-0.54%	536	-0.01%	536	-0.03%	536	SC***	533	-0.51%
Mean Depth (feet)													
Maximum	30.6	30.6	SC***	30.6	SC***	30.6	SC***	30.6	SC***	30.6	SC***	30.6	SC***
Minimum	5.2	5.2	SC***	5.2	SC***	5.2	SC***	5.2	SC***	5.2	SC***	4.8	-7.65%
Average	15.5	15.5	-0.13%	14.9	-3.76%	15.4	-0.08%	15.4	-0.21%	15.5	SC***	14.9	-3.54%
SEPTEMBER													
Discharge (cfs)													
Maximum	14638	14638	SC***	14520	-0.80%	14638	SC***	14638	SC***	14638	SC***	14520	-0.80%
Minimum	3496	4437	26.92%	3496	-21.21%	4437	SC***	4437	SC***	4437	SC***	4437	SC***
Average	5764	6689	16.03%	6672	-0.25%	6672	-0.25%	6672	-0.25%	6739	0.75%	6705	0.25%
Mean Velocity (fps)													
Maximum	2.54	2.54	SC***	2.53	-0.26%	2.54	SC***	2.54	SC***	2.54	SC***	2.53	-0.26%
Minimum	1.60	1.73	7.99%	1.60	-7.40%	1.73	SC***	1.73	SC***	1.73	SC***	1.73	SC***
Average	1.88	1.97	4.91%	1.97	-0.08%	1.97	-0.08%	1.97	-0.08%	1.98	0.24%	1.97	0.08%
Top Width (feet)													
Maximum	512	512	SC***	512	-0.07%	512	SC***	512	SC***	512	SC***	512	-0.07%
Minimum	455	464	2.00%	455	-1.96%	464	SC***	464	SC***	464	SC***	464	SC***
Average	474	480	1.24%	480	-0.02%	480	-0.02%	480	-0.02%	480	0.06%	480	0.02%
Mean Depth (feet)													
Maximum	11.2	11.2	SC***	11.2	-0.47%	11.2	SC***	11.2	SC***	11.2	SC***	11.2	-0.47%
Minimum	4.8	5.5	15.10%	4.8	-13.12%	5.5	SC***	5.5	SC***	5.5	SC***	5.5	SC***
Average	6.5	7.1	9.17%	7.1	-0.15%	7.1	-0.15%	7.1	-0.15%	7.1	0.44%	7.1	0.15%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-3 SUMMARY OF ALTERNATIVES, CP # 61 NAVIGATION CP (NCP), DA15 ADJST (USGS 11390500 - SACRAMENTO RIVER BELOW WILKINS SLOUGH N

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	107874	107874	SC***	107874	SC***	107874	SC***	107874	SC***	107874	SC***	107874	SC***
Minimum	3997	3997	SC***	3997	SC***	3997	SC***	3997	SC***	3997	SC***	3493	-12.61%
Average	25281	25227	-0.21%	23642	-6.28%	25190	-0.14%	25136	-0.36%	25227	SC***	23732	-5.92%
Mean Velocity (fps)													
Maximum	5.81	5.81	SC***	5.81	SC***	5.81	SC***	5.81	SC***	5.81	SC***	5.81	SC***
Minimum	2.25	2.25	SC***	2.25	SC***	2.25	SC***	2.25	SC***	2.25	SC***	2.16	-3.81%
Average	3.83	3.82	-0.06%	3.75	-1.85%	3.82	-0.04%	3.82	-0.10%	3.82	SC***	3.76	-1.74%
Top Width (feet)													
Maximum	375	375	SC***	375	SC***	375	SC***	375	SC***	375	SC***	375	SC***
Minimum	213	213	SC***	213	SC***	213	SC***	213	SC***	213	SC***	208	-2.28%
Average	292	292	-0.04%	289	-1.10%	292	-0.02%	292	-0.06%	292	SC***	289	-1.04%
Mean Depth (feet)													
Maximum	49.7	49.7	SC***	49.7	SC***	49.7	SC***	49.7	SC***	49.7	SC***	49.7	SC***
Minimum	8.3	8.3	SC***	8.3	SC***	8.3	SC***	8.3	SC***	8.3	SC***	7.8	-7.04%
Average	22.6	22.6	-0.12%	21.8	-3.45%	22.6	-0.08%	22.6	-0.19%	22.6	SC***	21.9	-3.25%
SEPTEMBER													
Discharge (cfs)													
Maximum	14638	14638	SC***	14520	-0.80%	14638	SC***	14638	SC***	14638	SC***	14520	-0.80%
Minimum	3496	4437	26.92%	3496	-21.21%	4437	SC***	4437	SC***	4437	SC***	4437	SC***
Average	5764	6689	16.03%	6672	-0.25%	6672	-0.25%	6672	-0.25%	6739	0.75%	6705	0.25%
Mean Velocity (fps)													
Maximum	3.27	3.27	SC***	3.26	-0.23%	3.27	SC***	3.27	SC***	3.27	SC***	3.26	-0.23%
Minimum	2.16	2.32	7.11%	2.16	-6.64%	2.32	SC***	2.32	SC***	2.32	SC***	2.32	SC***
Average	2.50	2.61	4.38%	2.61	-0.07%	2.61	-0.07%	2.61	-0.07%	2.61	0.22%	2.61	0.07%
Top Width (feet)													
Maximum	266	266	SC***	266	-0.14%	266	SC***	266	SC***	266	SC***	266	-0.14%
Minimum	208	217	4.16%	208	-4.00%	217	SC***	217	SC***	217	SC***	217	SC***
Average	227	233	2.58%	233	-0.04%	233	-0.04%	233	-0.04%	233	0.13%	233	0.04%
Mean Depth (feet)													
Maximum	16.8	16.8	SC***	16.8	-0.44%	16.8	SC***	16.8	SC***	16.8	SC***	16.8	-0.44%
Minimum	7.8	8.8	13.77%	7.8	-12.11%	8.8	SC***	8.8	SC***	8.8	SC***	8.8	SC***
Average	10.2	11.0	8.38%	11.0	-0.14%	11.0	-0.14%	11.0	-0.14%	11.1	0.41%	11.0	0.14%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-4 SUMMARY OF ALTERNATIVES, CP 120, N. OF DELTA STORAGE RELEASE (SAC. RIV. AT COLUSA USGS 11389500)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	77840	78056	0.28%	75752	-2.95%	78074	0.02%	77894	-0.21%	76490	-2.01%	75752	-2.95%
Minimum	4808	4808	SC***	2863	-40.45%	4808	SC***	4808	SC***	4808	SC***	3403	-29.21%
Average	20311	20257	-0.27%	18672	-7.82%	20221	-0.18%	20167	-0.44%	20257	SC***	18762	-7.38%
Mean Velocity (fps)													
Maximum	4.86	4.86	0.08%	4.82	-0.82%	4.86	SC***	4.86	-0.06%	4.84	-0.56%	4.82	-0.82%
Minimum	2.26	2.26	SC***	1.96	-13.29%	2.26	SC***	2.26	SC***	2.26	SC***	2.05	-9.07%
Average	3.36	3.35	-0.07%	3.28	-2.22%	3.35	-0.05%	3.35	-0.12%	3.35	SC***	3.28	-2.09%
Top Width (feet)													
Maximum	389	389	0.04%	387	-0.39%	389	SC***	389	-0.03%	388	-0.27%	387	-0.39%
Minimum	269	269	SC***	252	-6.58%	269	SC***	269	SC***	269	SC***	258	-4.44%
Average	326	326	-0.03%	322	-1.06%	325	-0.02%	325	-0.06%	326	SC***	322	-1.00%
Mean Depth (feet)													
Maximum	40.0	40.1	0.16%	39.4	-1.70%	40.1	0.01%	40.0	-0.12%	39.6	-1.15%	39.4	-1.70%
Minimum	7.9	7.9	SC***	5.8	-27.19%	7.9	SC***	7.9	SC***	7.9	SC***	6.4	-19.07%
Average	18.6	18.5	-0.15%	17.7	-4.55%	18.5	-0.10%	18.5	-0.25%	18.5	SC***	17.7	-4.29%
SEPTEMBER													
Discharge (cfs)													
Maximum	14621	14621	SC***	14503	-0.80%	14621	SC***	14621	SC***	14621	SC***	14503	-0.80%
Minimum	4302	6016	39.84%	4958	-17.60%	6016	SC***	6016	SC***	5983	-0.56%	6016	SC***
Average	6722	7630	13.50%	7613	-0.22%	7613	-0.22%	7613	-0.22%	7680	0.66%	7647	0.22%
Mean Velocity (fps)													
Maximum	3.07	3.07	SC***	3.06	-0.22%	3.07	SC***	3.07	SC***	3.07	SC***	3.06	-0.22%
Minimum	2.19	2.40	9.67%	2.28	-5.19%	2.40	SC***	2.40	SC***	2.40	-0.15%	2.40	SC***
Average	2.48	2.56	3.55%	2.56	-0.06%	2.56	-0.06%	2.56	-0.06%	2.57	0.18%	2.57	0.06%
Top Width (feet)													
Maximum	312	312	SC***	312	-0.11%	312	SC***	312	SC***	312	SC***	312	-0.11%
Minimum	266	278	4.51%	271	-2.51%	278	SC***	278	SC***	277	-0.07%	278	SC***
Average	282	286	1.68%	286	-0.03%	286	-0.03%	286	-0.03%	287	0.09%	286	0.03%
Mean Depth (feet)													
Maximum	15.4	15.4	SC***	15.3	-0.46%	15.4	SC***	15.4	SC***	15.4	SC***	15.3	-0.46%
Minimum	7.4	9.1	22.79%	8.1	-11.18%	9.1	SC***	9.1	SC***	9.0	-0.34%	9.1	SC***
Average	9.7	10.5	8.06%	10.5	-0.13%	10.5	-0.13%	10.5	-0.13%	10.5	0.40%	10.5	0.13%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-5 SUMMARY OF ALTERNATIVES, CP 120, NORTH OF DELTA STORAGE RELEASE (USGS 11389000 - SACRAMENTO RIVER AT BUTTE CITY)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	77840	78056	0.28%	75752	-2.95%	78074	0.02%	77894	-0.21%	76490	-2.01%	75752	-2.95%
Minimum	4808	4808	SC***	2863	-40.45%	4808	SC***	4808	SC***	4808	SC***	3403	-29.21%
Average	20311	20257	-0.27%	18672	-7.82%	20221	-0.18%	20167	-0.44%	20257	SC***	18762	-7.38%
Mean Velocity (fps)													
Maximum	6.13	6.13	0.15%	6.04	-1.56%	6.13	0.01%	6.13	-0.11%	6.07	-1.06%	6.04	-1.56%
Minimum	1.42	1.42	SC***	1.08	-23.86%	1.42	SC***	1.42	SC***	1.42	SC***	1.18	-16.61%
Average	3.02	3.02	-0.14%	2.89	-4.19%	3.01	-0.09%	3.01	-0.23%	3.02	SC***	2.90	-3.95%
Top Width (feet)													
Maximum	509	509	0.01%	509	-0.11%	509	SC***	509	SC***	509	-0.08%	509	-0.11%
Minimum	459	459	SC***	450	-1.92%	459	SC***	459	SC***	459	SC***	453	-1.28%
Average	484	484	SC***	483	-0.30%	484	SC***	484	-0.02%	484	SC***	483	-0.29%
Mean Depth (feet)													
Maximum	25.5	25.5	0.12%	25.2	-1.32%	25.5	0.01%	25.5	-0.09%	25.3	-0.90%	25.2	-1.32%
Minimum	7.4	7.4	SC***	5.9	-20.59%	7.4	SC***	7.4	SC***	7.4	SC***	6.3	-14.25%
Average	14.0	14.0	-0.12%	13.5	-3.56%	14.0	-0.08%	14.0	-0.20%	14.0	SC***	13.5	-3.35%
SEPTEMBER													
Discharge (cfs)													
Maximum	14621	14621	SC***	14503	-0.80%	14621	SC***	14621	SC***	14621	SC***	14503	-0.80%
Minimum	4302	6016	39.84%	4958	-17.60%	6016	SC***	6016	SC***	5983	-0.56%	6016	SC***
Average	6722	7630	13.50%	7613	-0.22%	7613	-0.22%	7613	-0.22%	7680	0.66%	7647	0.22%
Mean Velocity (fps)													
Maximum	2.54	2.54	SC***	2.53	-0.42%	2.54	SC***	2.54	SC***	2.54	SC***	2.53	-0.42%
Minimum	1.34	1.59	19.29%	1.44	-9.68%	1.59	SC***	1.59	SC***	1.59	-0.29%	1.59	SC***
Average	1.69	1.81	6.89%	1.80	-0.12%	1.80	-0.12%	1.80	-0.12%	1.81	0.35%	1.81	0.12%
Top Width (feet)													
Maximum	478	478	SC***	478	-0.03%	478	SC***	478	SC***	478	SC***	478	-0.03%
Minimum	457	463	1.26%	460	-0.72%	463	SC***	463	SC***	463	-0.02%	463	SC***
Average	465	467	0.47%	467	SC***	467	SC***	467	SC***	467	0.02%	467	SC***
Mean Depth (feet)													
Maximum	12.1	12.1	SC***	12.1	-0.36%	12.1	SC***	12.1	SC***	12.1	SC***	12.1	-0.36%
Minimum	7.0	8.2	16.09%	7.5	-8.25%	8.2	SC***	8.2	SC***	8.1	-0.25%	8.2	SC***
Average	8.6	9.1	5.79%	9.1	-0.10%	9.1	-0.10%	9.1	-0.10%	9.1	0.29%	9.1	0.10%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-6 SUMMARY OF ALTERNATIVES, CP 73, SAC. RIV. AT COTTONWOOD CR. (USGS 11370500 - SAC. R. ABOVE BEND BRIDGE)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	53478	53694	0.40%	54126	0.80%	53712	0.03%	53532	-0.30%	53478	-0.40%	53244	-0.84%
Minimum	3619	3619	SC***	3619	SC***	3619	SC***	3619	SC***	3619	SC***	3619	SC***
Average	13270	13198	-0.54%	13198	SC***	13162	-0.27%	13108	-0.68%	13270	0.55%	13216	0.14%
Mean Velocity (fps)													
Maximum	6.24	6.24	0.06%	6.25	0.12%	6.24	SC***	6.24	-0.05%	6.24	-0.06%	6.24	-0.13%
Minimum	4.16	4.16	SC***	4.16	SC***	4.16	SC***	4.16	SC***	4.16	SC***	4.16	SC***
Average	5.06	5.06	-0.08%	5.06	SC***	5.05	-0.04%	5.05	-0.10%	5.06	0.08%	5.06	0.02%
Top Width (feet)													
Maximum	568	569	0.25%	572	0.50%	569	0.02%	568	-0.19%	568	-0.25%	566	-0.52%
Minimum	335	335	SC***	335	SC***	335	SC***	335	SC***	335	SC***	335	SC***
Average	382	382	-0.05%	382	SC***	381	-0.03%	381	-0.07%	382	0.05%	382	0.01%
Mean Depth (feet)													
Maximum	14.7	14.7	0.11%	14.7	0.22%	14.7	SC***	14.7	-0.08%	14.7	-0.11%	14.6	-0.23%
Minimum	2.6	2.6	SC***	2.6	SC***	2.6	SC***	2.6	SC***	2.6	SC***	2.6	SC***
Average	7.0	7.0	-0.42%	7.0	SC***	7.0	-0.21%	6.9	-0.53%	7.0	0.42%	7.0	0.11%
SEPTEMBER													
Discharge (cfs)													
Maximum	13327	13327	SC***	13327	SC***	13327	SC***	13327	SC***	13327	SC***	13327	SC***
Minimum	4000	6117	52.94%	4689	-23.35%	6117	SC***	6117	SC***	4000	-34.62%	6100	-0.27%
Average	6235	7159	14.82%	7058	-1.41%	7126	-0.47%	7126	-0.47%	6235	-12.91%	7210	0.70%
Mean Velocity (fps)													
Maximum	5.06	5.06	SC***	5.06	SC***	5.06	SC***	5.06	SC***	5.06	SC***	5.06	SC***
Minimum	4.23	4.50	6.59%	4.33	-3.92%	4.50	SC***	4.50	SC***	4.23	-6.19%	4.50	-0.04%
Average	4.52	4.61	2.10%	4.60	-0.21%	4.61	-0.07%	4.61	-0.07%	4.52	-2.06%	4.62	0.11%
Top Width (feet)													
Maximum	382	382	SC***	382	SC***	382	SC***	382	SC***	382	SC***	382	SC***
Minimum	339	353	4.31%	344	-2.61%	353	SC***	353	SC***	339	-4.14%	353	-0.03%
Average	354	359	1.38%	359	-0.14%	359	-0.05%	359	-0.05%	354	-1.36%	359	0.07%
Mean Depth (feet)													
Maximum	7.0	7.0	SC***	7.0	SC***	7.0	SC***	7.0	SC***	7.0	SC***	7.0	SC***
Minimum	2.8	3.8	38.95%	3.1	-18.61%	3.8	SC***	3.8	SC***	2.8	-28.03%	3.8	-0.21%
Average	3.9	4.3	11.30%	4.3	-1.09%	4.3	-0.36%	4.3	-0.36%	3.9	-10.15%	4.4	0.54%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-7 SUMMARY OF ALTERNATIVES, CP 62, KESWICK RESERVOIR (USGS 11370500 - SACRAMENTO RIVER AT KESWICK)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	45970	46186	0.47%	46618	0.94%	46204	0.04%	46024	-0.35%	44619	-3.39%	45735	-0.97%
Minimum	3241	3241	SC***	3241	SC***	3241	SC***	3241	SC***	3241	SC***	3241	SC***
Average	11038	10966	-0.65%	10966	SC***	10930	-0.33%	10894	-0.66%	10984	0.16%	11002	0.33%
Mean Velocity (fps)													
Maximum	7.24	7.25	0.17%	7.28	0.33%	7.25	0.01%	7.24	-0.12%	7.17	-1.21%	7.23	-0.35%
Minimum	1.94	1.94	SC***	1.94	SC***	1.94	SC***	1.94	SC***	1.94	SC***	1.94	SC***
Average	3.64	3.63	-0.34%	3.63	SC***	3.62	-0.17%	3.61	-0.34%	3.63	0.08%	3.63	0.17%
Top Width (feet)													
Maximum	628	629	0.13%	631	0.25%	629	0.01%	629	-0.09%	623	-0.92%	627	-0.26%
Minimum	429	429	SC***	429	SC***	429	SC***	429	SC***	429	SC***	429	SC***
Average	517	516	-0.10%	516	SC***	516	-0.05%	515	-0.10%	516	0.02%	516	0.05%
Mean Depth (feet)													
Maximum	10.1	10.1	0.19%	10.1	0.38%	10.1	0.02%	10.1	-0.14%	9.9	-1.39%	10.0	-0.40%
Minimum	3.9	3.9	SC***	3.9	SC***	3.9	SC***	3.9	SC***	3.9	SC***	3.9	SC***
Average	5.8	5.8	-0.21%	5.8	SC***	5.7	-0.10%	5.7	-0.21%	5.8	0.05%	5.8	0.10%
SEPTEMBER													
Discharge (cfs)													
Maximum	13041	13041	SC***	13041	SC***	13041	SC***	13041	SC***	13041	SC***	13041	SC***
Minimum	3832	6000	56.58%	4521	-24.65%	6000	SC***	6000	SC***	6000	SC***	6000	SC***
Average	6050	6974	15.28%	6874	-1.45%	6941	-0.48%	6941	-0.48%	7008	0.48%	7025	0.72%
Mean Velocity (fps)													
Maximum	3.96	3.96	SC***	3.96	SC***	3.96	SC***	3.96	SC***	3.96	SC***	3.96	SC***
Minimum	2.11	2.66	25.88%	2.30	-13.52%	2.66	SC***	2.66	SC***	2.66	SC***	2.66	SC***
Average	2.67	2.87	7.57%	2.85	-0.74%	2.87	-0.25%	2.87	-0.25%	2.88	0.25%	2.89	0.37%
Top Width (feet)													
Maximum	530	530	SC***	530	SC***	530	SC***	530	SC***	530	SC***	530	SC***
Minimum	440	471	7.01%	451	-4.19%	471	SC***	471	SC***	471	SC***	471	SC***
Average	472	482	2.17%	481	-0.22%	482	-0.07%	482	-0.07%	482	0.07%	482	0.11%
Mean Depth (feet)													
Maximum	6.1	6.1	SC***	6.1	SC***	6.1	SC***	6.1	SC***	6.1	SC***	6.1	SC***
Minimum	4.1	4.7	15.35%	4.3	-8.62%	4.7	SC***	4.7	SC***	4.7	SC***	4.7	SC***
Average	4.8	5.0	4.63%	5.0	-0.46%	5.0	-0.15%	5.0	-0.15%	5.0	0.15%	5.0	0.23%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-8 SUMMARY OF ALTERNATIVES, CP 106 FEATHER R. BELOW OROVILLE-THERMOLITO, (USGS 11407150 - FEATHER R. NR. GRIDLEY)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	25551	24884	-2.61%	45447	82.63%	23642	-4.99%	31205	25.40%	23642	-4.99%	45447	82.63%
Minimum	900	900	SC***	900	SC***	900	SC***	900	SC***	900	SC***	900	SC***
Average	6554	6194	-5.49%	6986	12.79%	6284	1.45%	6176	-0.29%	6194	SC***	7112	14.83%
Mean Velocity (fps)													
Maximum	4.29	4.24	-1.16%	5.52	30.35%	4.14	-2.23%	4.68	10.47%	4.14	-2.23%	5.52	30.35%
Minimum	0.34	0.34	SC***	0.34	SC***	0.34	SC***	0.34	SC***	0.34	SC***	0.34	SC***
Average	1.93	1.84	-4.81%	2.04	11.08%	1.86	1.27%	1.84	-0.25%	1.84	SC***	2.08	12.83%
Top Width (feet)													
Maximum	318	317	-0.11%	326	2.62%	317	-0.22%	320	0.98%	317	-0.22%	326	2.62%
Minimum	275	275	SC***	275	SC***	275	SC***	275	SC***	275	SC***	275	SC***
Average	300	299	-0.24%	300	0.52%	299	0.06%	299	-0.01%	299	SC***	301	0.60%
Mean Depth (feet)													
Maximum	9.9	9.9	-0.20%	10.5	6.26%	9.8	-0.38%	10.1	1.92%	9.8	-0.38%	10.5	6.26%
Minimum	9.1	9.1	SC***	9.1	SC***	9.1	SC***	9.1	SC***	9.1	SC***	9.1	SC***
Average	9.3	9.3	-0.12%	9.3	0.26%	9.3	0.03%	9.3	SC***	9.3	SC***	9.3	0.30%
SEPTEMBER													
Discharge (cfs)													
Maximum	6504	6420	-1.29%	6504	1.31%	6504	1.31%	6504	1.31%	6504	1.31%	7092	10.47%
Minimum	756	756	SC***	756	SC***	756	SC***	756	SC***	756	SC***	756	SC***
Average	1630	1613	-1.03%	1798	11.46%	1395	-13.54%	1630	1.04%	1428	-11.46%	1714	6.25%
Mean Velocity (fps)													
Maximum	1.92	1.90	-1.13%	1.92	1.14%	1.92	1.14%	1.92	1.14%	1.92	1.14%	2.07	9.08%
Minimum	0.29	0.29	SC***	0.29	SC***	0.29	SC***	0.29	SC***	0.29	SC***	0.29	SC***
Average	0.57	0.57	-0.90%	0.63	9.93%	0.50	-11.93%	0.57	0.91%	0.51	-10.08%	0.60	5.44%
Top Width (feet)													
Maximum	299	299	-0.06%	299	0.06%	299	0.06%	299	0.06%	299	0.06%	301	0.43%
Minimum	273	273	SC***	273	SC***	273	SC***	273	SC***	273	SC***	273	SC***
Average	282	282	-0.04%	283	0.47%	280	-0.62%	282	0.04%	281	-0.52%	283	0.26%
Mean Depth (feet)													
Maximum	9.3	9.3	-0.03%	9.3	0.03%	9.3	0.03%	9.3	0.03%	9.3	0.03%	9.3	0.22%
Minimum	9.1	9.1	SC***	9.1	SC***	9.1	SC***	9.1	SC***	9.1	SC***	9.1	SC***
Average	9.2	9.2	SC***	9.2	0.06%	9.2	-0.07%	9.2	SC***	9.2	-0.06%	9.2	0.03%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.4-9 SUMMARY OF ALTERNATIVES, CP 9, LAKE NATOMA & FOLSOM SOUTH DIV (USGS 11446500-AMERICAN R. AT FAIR OAKS)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	33077	33005	-0.22%	32951	-0.16%	33005	SC***	33005	SC***	33005	SC***	33005	SC***
Minimum	504	504	SC***	504	SC***	504	SC***	504	SC***	504	SC***	504	SC***
Average	5186	5168	-0.35%	5114	-1.05%	5168	SC***	5168	SC***	5204	0.70%	5168	SC***
Mean Velocity (fps)													
Maximum	6.05	6.04	-0.11%	6.04	-0.08%	6.04	SC***	6.04	SC***	6.04	SC***	6.04	SC***
Minimum	0.70	0.70	SC***	0.70	SC***	0.70	SC***	0.70	SC***	0.70	SC***	0.70	SC***
Average	2.32	2.32	-0.18%	2.30	-0.54%	2.32	SC***	2.32	SC***	2.33	0.36%	2.32	SC***
Top Width (feet)													
Maximum	463	462	-0.03%	462	-0.02%	462	SC***	462	SC***	462	SC***	462	SC***
Minimum	260	260	SC***	260	SC***	260	SC***	260	SC***	260	SC***	260	SC***
Average	358	358	-0.05%	358	-0.14%	358	SC***	358	SC***	358	0.10%	358	SC***
Mean Depth (feet)													
Maximum	12.2	12.2	-0.08%	12.2	-0.06%	12.2	SC***	12.2	SC***	12.2	SC***	12.2	SC***
Minimum	2.7	2.7	SC***	2.7	SC***	2.7	SC***	2.7	SC***	2.7	SC***	2.7	SC***
Average	6.3	6.3	-0.12%	6.3	-0.37%	6.3	SC***	6.3	SC***	6.3	0.25%	6.3	SC***
SEPTEMBER													
Discharge (cfs)													
Maximum	4974	4790	-3.72%	4790	SC***	4790	SC***	4790	SC***	4790	SC***	4790	SC***
Minimum	504	504	SC***	504	SC***	504	SC***	504	SC***	504	SC***	504	SC***
Average	2218	1865	-15.91%	1798	-3.60%	1849	-0.90%	1865	SC***	1916	2.70%	1748	-6.31%
Mean Velocity (fps)													
Maximum	2.27	2.23	-1.94%	2.23	SC***	2.23	SC***	2.23	SC***	2.23	SC***	2.23	SC***
Minimum	0.70	0.70	SC***	0.70	SC***	0.70	SC***	0.70	SC***	0.70	SC***	0.70	SC***
Average	1.50	1.37	-8.57%	1.34	-1.88%	1.36	-0.47%	1.37	SC***	1.39	1.39%	1.32	-3.31%
Top Width (feet)													
Maximum	356	354	-0.52%	354	SC***	354	SC***	354	SC***	354	SC***	354	SC***
Minimum	260	260	SC***	260	SC***	260	SC***	260	SC***	260	SC***	260	SC***
Average	319	311	-2.36%	310	-0.50%	311	-0.12%	311	SC***	312	0.37%	308	-0.89%
Mean Depth (feet)													
Maximum	6.2	6.1	-1.34%	6.1	SC***	6.1	SC***	6.1	SC***	6.1	SC***	6.1	SC***
Minimum	2.7	2.7	SC***	2.7	SC***	2.7	SC***	2.7	SC***	2.7	SC***	2.7	SC***
Average	4.6	4.4	-6.00%	4.3	-1.30%	4.3	-0.32%	4.4	SC***	4.4	0.96%	4.3	-2.30%

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

need to be altered to compensate for the increased pumping. The amount of the increase in pumping capacity would be relatively small, approximately 3,000 cfs relative to current capacity, but actual monthly pumping rates would not necessarily be at capacity. Pumping rates would depend on a variety of factors, including the demand level, available surplus, and Delta flow and water quality requirements. Also, the locations of the upstream releases might vary. Increased pumping capacity at the Banks Pumping Plant is an element of all of the configurations except 1A and the No Action Alternative.

An isolated through-Delta conveyance facility to the Delta below Freeport, as with increased pumping capacity at the Banks Pumping Plant, could only indirectly result in changes in stream flows. Two of the DWRSIM studies evaluated in this report were configured to include a 5,000 cfs capacity isolated conveyance facility. This element is included in simulations corresponding to all of the configurations of Alternative 3.

Off-stream storage could result in modifications in stream flows both directly, as a result of diversions to or returns from storage, or indirectly, as a result of compensating spills or diversions elsewhere in the system. Three of the DWRSIM studies used in preparation of this report simulated operation of surface storage facilities (such as a new or expanded reservoir). All three studies (representing Configurations 1C, 2B, and 2E; Configuration 2D; and Configurations 3B, 3D to 3I, respectively), assumed a 2 million-acre-feet (MAF) south of Delta surface storage facility with a 3,500 cfs inlet/outlet. Two of the studies (representing Configurations 1C, 2B, 2E and 3B, 3D to 3I) simulated 3 MAF north of Delta storage with a 5,000 cfs capacity inlet/outlet.

Among the assumptions of the simulations was the requirement that in each water year, diversions to the north of Delta surface storage facility are not permitted until a monthly flushing volume of at least 550 TAF occurs at the facilities diversion point. The target flushing volume is roughly equivalent to a monthly average flow rate of about 9,000 cfs. The diversion point for north of Delta surface storage is assumed in DWRSIM to be at CP#120 (near Colusa or Butte City). Based on the results of simulating the No Action Alternative at CP#120, the flow target would be exceeded in about 90 percent of water years during June and July, in about 75 percent of water years during May, and in 25 to 50 percent of water years during the rest of the year. Preliminary sensitivity analysis performed by CALFED indicates that the rate of filling of a north of Delta surface storage facility is quite sensitive to the target flushing rate assumption.

5.4.2.1 Alternative 1

The hydraulic impacts of Alternative 1 on Sacramento River flows are evaluated on a regional basis and with respect to Delta inflow. The analysis is based on DWRSIM modeling. Because Alternative 1 does not involve increased storage, there is expected to be little difference between the hydrodynamic conditions in the Sacramento River associated with Alternative 1 configurations and those for the No Action Alternative.

5.4.2.1.1 Regional Analysis

Configurations 1A and 1B

Configurations 1A and 1B involve reoperation of the system and CVP-SWP improvements, respectively. In both cases, flows in the Sacramento River are expected to be essentially the same as they would be under the No Action Alternative. As discussed in Section 5.1.2.3, there would be some changes with respect to existing conditions as a result of increasing demands for water. These projected changes are illustrated in Tables 5.4-1 through 5.4-9.

Configuration 1C

Configuration 1C involves south Delta modifications that improve circulation of flow and reduce reverse flows in the south Delta. Average February flows at the four study locations in the reach from Butte City to Verona are projected to be between 6 and 8 percent lower than for the No Action Alternative. The corresponding reduction in mean velocity at these locations would be between 2 and 4 percent. At Freeport, the average flow discharge for February is projected to be about 2.4 percent lower than for the No Action Alternative, with a corresponding reduction in mean velocity of 1.3 percent. Average flow discharges at the seven locations along the Sacramento River (excluding the two tributary stations) are within about 1 percent of no action conditions for September.

5.4.2.1.2 Delta Inflow Analysis

Flows in the Sacramento River at Freeport represent the bulk of the inflow from the Sacramento River region to the Delta. Table 5.4-1 presents the summary statistics evaluated for the Sacramento River at Freeport. Figure 5.4-1 presents the summary statistics graphically. Each bar represents a different alternative configuration. The heights of the bars correspond with the maximum discharge for the corresponding month.

Wet Season Flows. The summary table shows that average wet season stream flows at Freeport are relatively unaffected by any of the Alternative 1 configurations. However, larger differences can be seen in the extreme flows. Maximum wet season flows increase in Configuration 1C, which has an off-stream storage element. There are no substantial differences in minimum wet season flows for the Alternative 1 configurations.

Dry Season Flows. As with wet season flows, the average dry season stream flows at Freeport are relatively unaffected by any of the Alternative 1 configurations. This suggests that in most water years, the hydraulic effects of Alternative 1 on the lower portion of the basin would be small. The changes in maximum and minimum dry season flows at Freeport are negligible for all of the Alternative 1 configurations.

Flow Frequency Analysis. Figure 5.4-2 shows the frequency distribution for Configuration 1C, by month, of projected flows at Freeport and the changes in the discharges at selected exceedence levels relative to the No Action Alternative. Configuration 1C includes both north and south of Delta storage. Wet season changes are more apparent, with the higher flows tending to decrease by 5 to 10 percent. Dry season flows tend to increase about 10 percent relative to the No Action Alternative.

5.4.2.2 Alternative 2

The hydraulic impacts of Alternative 2 on Sacramento River flows are evaluated on a regional basis and with respect to Delta inflow. The analysis is based on DWRSIM modeling.

5.4.2.2.1 Regional Analysis

Configurations 2A and 2C

Tables 5.4-1 through 5.4-9 present descriptive statistics for February and September for Alternatives 2A and 2C. Statistics are provided for discharge, mean velocity, top width, and mean depth.

Comparing the percent differences for Configurations 2A and 2C in Tables 5.4-1 through 5.4-9 shows negligible changes in discharge, velocity, width, and depth, with one exception. Table 5.4-8 shows the result for the Feather River below Oroville. These data suggest that the maximum discharge and maximum velocity are reduced in February, while the average discharge and average velocity are reduced in September.

Configuration 2D

The percent differences for Configuration 2D in Tables 5.4-1 through 5.4-9 generally show negligible changes in discharge, velocity, width, and depth. However, there are obvious changes at Freeport and on the Feather River in February. Table 5.4-1 shows that the maximum discharge is increased and the minimum decreased by about 7 percent. Corresponding changes occur in velocity and stage. Table 5.4-8 shows an increase in maximum discharge of 25 percent and an increase in maximum velocity of 20 percent, with a corresponding change in stage.

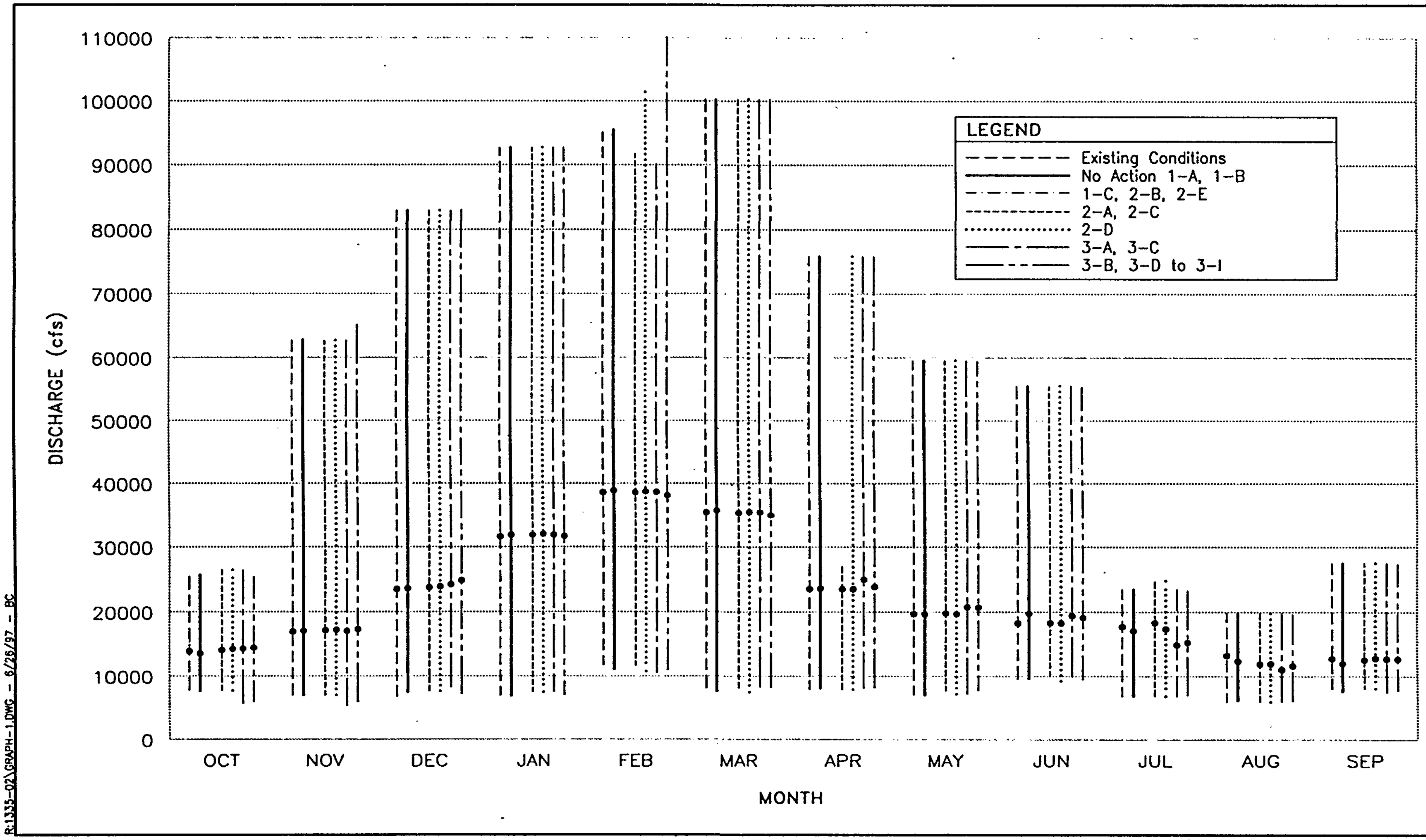
5.4.2.2.2 Delta Inflow Analysis

Flows in the Sacramento River at Freeport represent the bulk of the inflow from the Sacramento River region to the Delta. Table 5.4-1 presents the summary statistics evaluated for the Sacramento River at Freeport. Figure 5.4-1 presents the summary statistics graphically. Each bar represents a different alternative configuration. The heights of the bars correspond with the maximum discharge for the corresponding month.

Wet Season Flows. The summary table shows that average wet season stream flows at Freeport are relatively unaffected by any of the Alternative 2 configurations. However, larger differences can be seen in the extreme flows. The maximum wet season flow increases slightly for Configuration 2D and decreases slightly for Configurations 2A and 2C. The minimum wet season flow, which increases under the No Action Alternative relative to existing conditions, decreases with Configuration 2D.

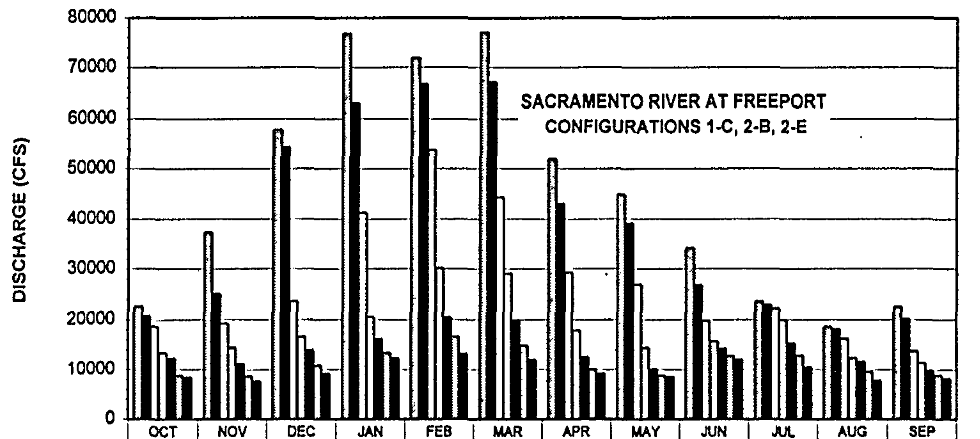
Dry Season Flows. As with wet season flows, the average dry season stream flows at Freeport are relatively unaffected by any of the Alternative 2 configurations. This suggests that in most water years, the hydraulic effects of the alternatives on the lower portion of the basin would be small. The changes in the maximum and minimum dry season flows at Freeport are negligible for all of the Alternative 2 configurations.

Flow Frequency Analysis. Figure 5.4-3 presents a frequency distribution of discharge in the Sacramento River at



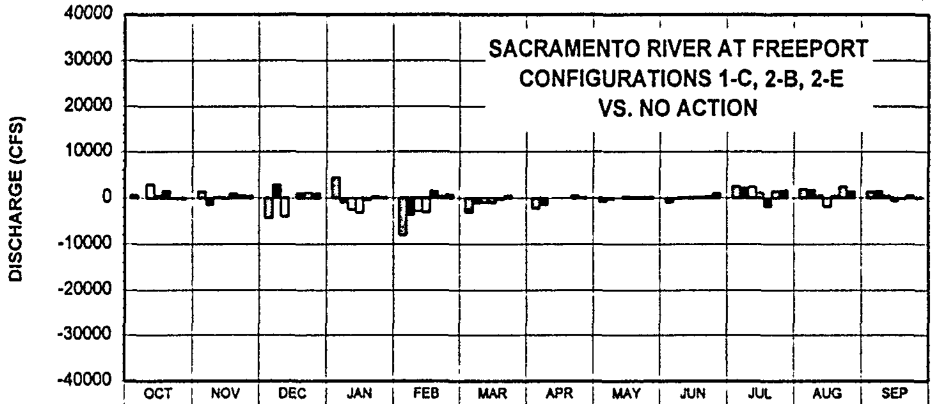
Range of Monthly Flows in the
Sacramento River at Freeport

Figure 5.4- 1



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	22593	37231	57697	76751	71941	76962	51899	44975	34166	23585	18583	22590
10 percent	20743	25118	54252	63083	66673	67084	43053	39163	26795	22951	18101	20237
25 percent	18557	19259	23615	41293	53694	44383	29208	26949	19780	22216	16166	13713
50 percent	13385	14386	16573	20590	30142	29047	17814	14442	15747	20020	12344	11344
75 percent	12312	11142	13954	16150	20509	19923	12571	10132	14201	15337	11612	9730
90 percent	8756	8605	10880	13411	16580	14910	10040	8831	12809	12939	9472	8816
95 percent	8376	7559	9169	12298	13188	12016	9129	8571	12023	10438	7771	8127

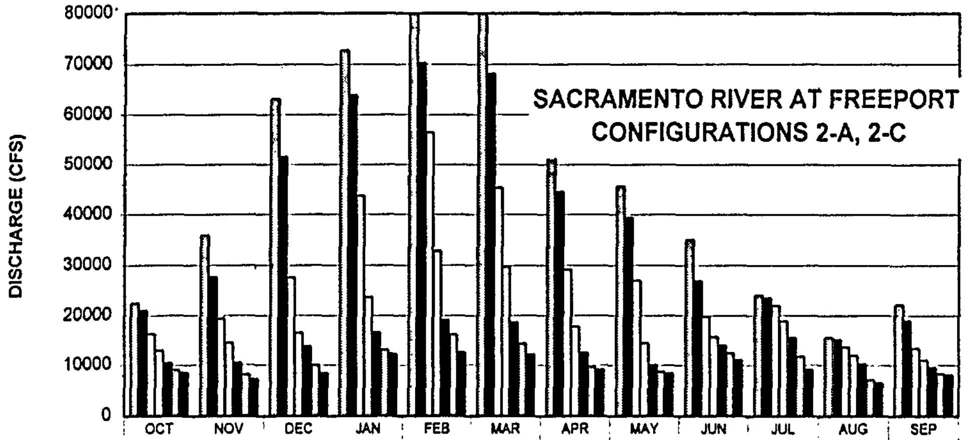
MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	462	1291	-4219	4320	-8009	-2992	-2131	-693	-871	2472	1838	1264
10 percent	-59	-1361	2739	-833	-3594	-1106	-1365	-195	-121	2170	1636	1395
25 percent	2830	134	-3838	-2391	-2773	-862	0	0	17	2277	504	403
50 percent	504	-118	0	-3041	-2953	-943	0	211	84	1008	-1740	-622
75 percent	1431	840	976	-390	1422	-293	0	81	151	-1740	390	-151
90 percent	-104	457	1090	299	375	416	413	107	326	1415	2339	481
95 percent	-143	366	836	39	659	-26	40	114	944	1522	1314	94

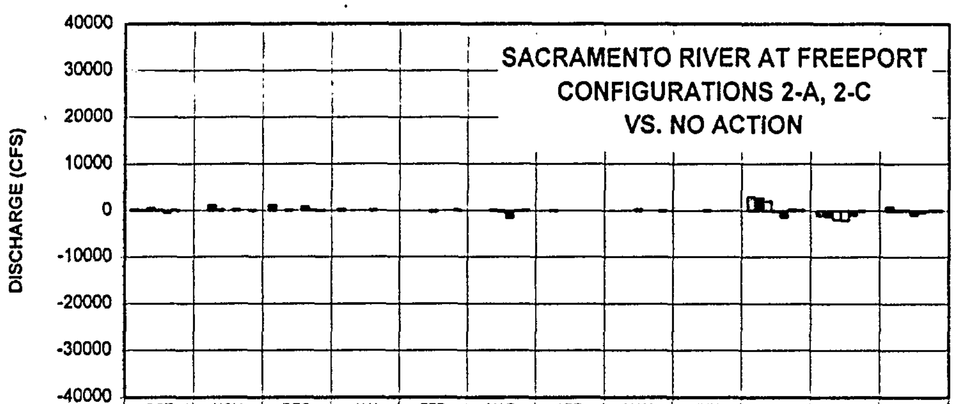
MONTH

FIGURE 5.4-2 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, CONFIGURATIONS 1-C, 2-B, 2-E



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	22392	35941	63125	72705	79951	79955	54030	45668	35036	24067	15720	22177
10 percent	20980	27672	51513	63916	70267	68190	44522	39358	26916	23524	15190	18970
25 percent	16312	19343	27550	43716	56467	45392	29208	26949	19763	22005	13726	13428
50 percent	12995	14503	16589	23631	32843	29746	17814	14491	15730	18898	12019	11075
75 percent	10457	10520	13775	16654	19086	18638	12571	10035	14066	15646	10246	9529
90 percent	9043	8164	9957	13108	16205	14423	9626	8724	12497	11807	7094	8376
95 percent	8486	7253	8405	12259	12665	12152	9078	8385	11102	9134	6447	8073

MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	260	0	1210	273	0	0	0	0	0	2953	-1025	850
10 percent	179	1193	0	0	0	0	104	0	0	2742	-1275	128
25 percent	585	218	98	33	0	146	0	0	0	2065	-1935	118
50 percent	114	0	16	0	-252	-244	0	260	67	-114	-2065	-891
75 percent	-423	218	797	114	0	-1578	0	-16	17	-1431	-976	-353
90 percent	182	17	166	-3	0	-72	0	0	13	283	-39	40
95 percent	-33	61	72	0	137	111	-10	-72	24	218	-10	40

MONTH

FIGURE 5.4-3 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, CONFIGURATIONS 2-A, 2-C

Freeport for Configurations 2A and 2C. This figure shows the wide range of flows experienced in the winter and the narrow range in the fall. February flows range from 12,700 to 80,000 cfs between the 95th and 5th percentiles, respectively. August flows range from 6,400 to 15,700 cfs between the 95th and 5th percentiles, respectively. In comparison, the No Action Alternative flows range from 12,500 to 80,000 cfs in February and from 6,400 to 16,700 cfs in August. In general, the differences for these configurations are small. Wet season changes are negligible. The changes that do occur represent roughly 10 percent increases of above-median flows during July and nearly compensating decreases in upper range flows in August. These are considered moderate differences in discharge by the criteria defined in Section 2.1. The differences in low flows during the dry season due to implementation of Configurations 2A and 2C would be negligible.

Figure 5.4-4 presents a frequency distribution of discharge in the Sacramento River at Freeport for Configuration 2D, which includes the components of Configurations 2A and 2C plus south of Delta surface storage. This figure shows the wide range of flows experienced in winter and the narrow range in fall. February flows range from 12,300 to 79,000 cfs between the 95th and 5th percentiles, respectively. August flows range from 6,500 to 18,500 cfs between the 95th and 5th percentiles, respectively. In comparison, the No Action Alternative flows range from 12,500 to 80,000 cfs in February and from 6,400 to16,700 cfs in August. The variability in discharge is slightly greater for Configuration 2D than for Configurations 2A and 2C. Negligible to small changes in the higher flows occur from October through January. The distribution of dry season changes in flow are similar to those for Configurations 2A and 2C but indicate a small to moderate shift toward lower middle range flows during July and August. Negligible increases in the smallest five percent of dry season flows would occur.

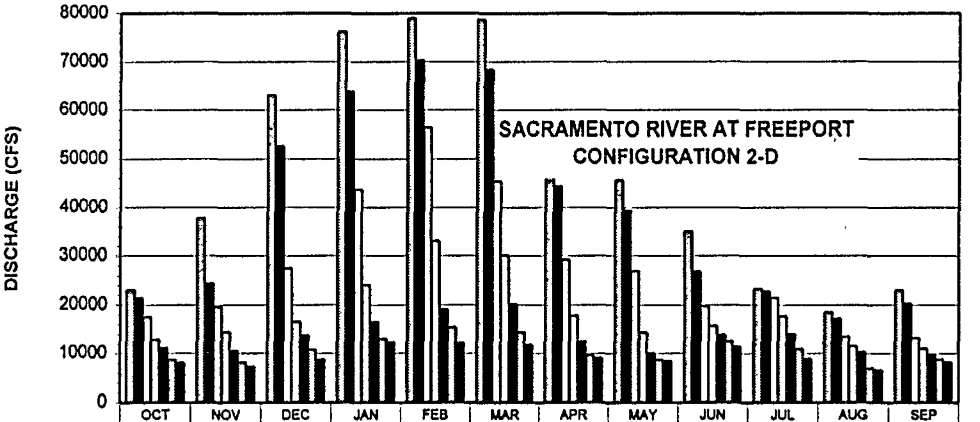
Figure 5.4-5 shows flow frequencies for Configurations 1-C, 2B and 2E, which include both north and south of Delta storage. Wet season changes are more pronounced than for Configuration 2D. Generally, a small to moderate decrease would occur in flows between November and February, while there would be a small to moderate increase in middle-level flow in October. The timing of the decrease in the higher flows is variable, so that December and January actually show small increases in the highest five percent of flows, which might occasionally result in a small adverse impact. Dry season flows tend to increase about 10 percent relative to the No Action Alternative, and moderate to large increases in the lowest five to ten percent of flows would occur in July and August. This would probably be considered a beneficial impact.

5.4.2.2.3 Regional Analysis

Configurations 3A and 3C

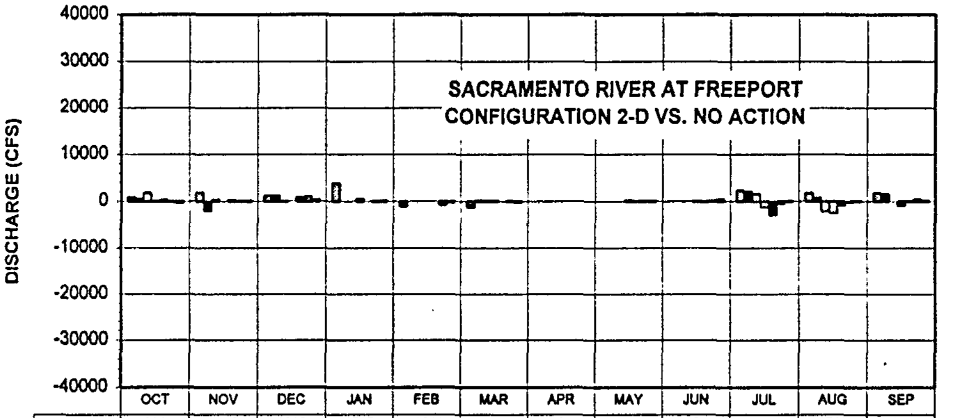
Tables 5.4-1 through 5.4-9 present descriptive statistics for February and September for Configurations 3A and 3C. Statistics are provided for discharge, mean velocity, top width, and mean depth.

The percent differences for Configurations 3A and 3C in Tables 5.4-1 through 5.4-9 show changes on the Sacramento River at



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	23026	37776	63125	76169	78906	78706	54030	45668	35036	23406	18511	23061
10 percent	21361	24432	52736	63916	70267	68417	44414	39358	26916	22821	17249	20368
25 percent	17532	19528	27550	43716	56467	45392	29208	26949	19780	21500	13531	13276
50 percent	12930	14537	16605	24135	33095	30153	17814	14442	15764	17744	11580	11075
75 percent	11141	10588	13840	16540	19086	20216	12571	10100	13982	14149	10311	9781
90 percent	8789	8191	10792	13157	15485	14540	9643	8763	12624	11010	6964	8803
95 percent	8155	7331	8721	12406	12284	11911	9099	8496	11539	8987	6557	8174

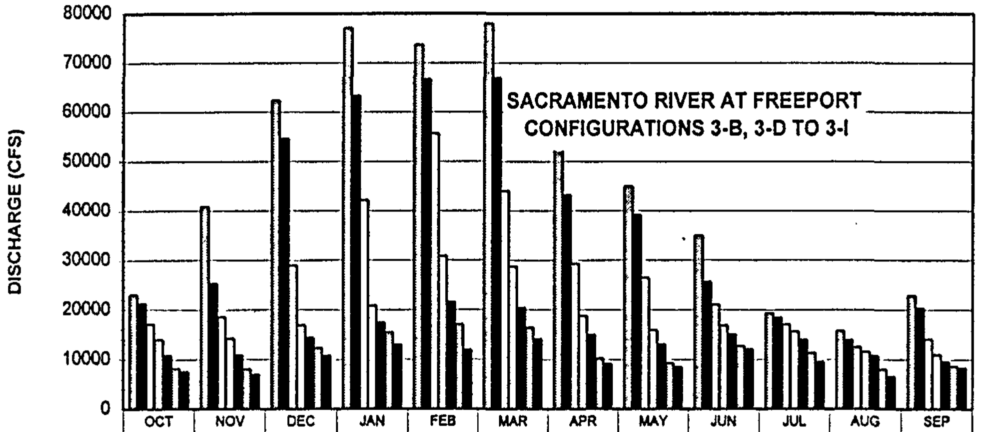
MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	894	1835	1210	3737	-1044	-1249	0	0	0	2293	1766	1734
10 percent	559	-2047	1223	0	0	228	-3	0	0	2039	784	1526
25 percent	1805	403	98	33	0	146	0	0	17	1561	-2131	-34
50 percent	49	34	33	504	0	163	0	211	101	-1269	-2505	-891
75 percent	260	286	862	0	0	0	0	49	-67	-2927	-911	-101
90 percent	-72	44	1002	46	-720	46	17	39	141	-514	-169	467
95 percent	-364	138	387	146	-245	-130	10	39	460	72	101	141

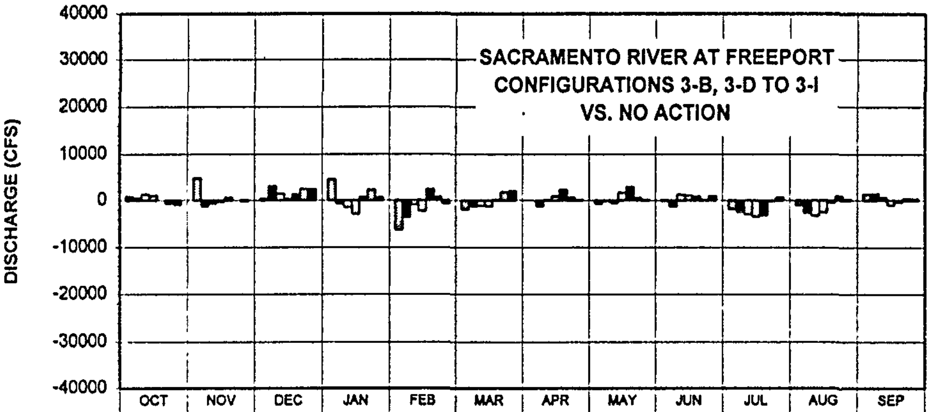
MONTH

FIGURE 5.4-4 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, CONFIGURATION 2-D



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	22925	40804	62263	77083	73699	78042	54030	44975	34983	19263	15740	22752
10 percent	21240	25219	54606	63216	66673	66954	43224	39244	25595	18355	13857	20305
25 percent	17028	18486	28917	42188	55567	44058	29309	26412	21007	16995	12474	13949
50 percent	13922	14184	16865	20801	30808	28754	18738	15889	16755	15548	11563	10991
75 percent	10864	10907	14328	17304	21517	20378	14907	12962	14940	13922	10783	9512
90 percent	8197	8131	12285	15356	16969	16319	10275	9322	12645	11345	8041	8712
95 percent	7605	7011	10776	12894	11862	14081	9196	8503	12053	9556	6665	8305

MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	794	4864	348	4651	-6252	-1913	0	-693	-54	-1851	-1005	1425
10 percent	439	-1260	3093	-699	-3594	-1236	-1193	-114	-1321	-2427	-2609	1462
25 percent	1301	-639	1464	-1496	-900	-1187	101	-537	1244	-2944	-3188	639
50 percent	1041	-319	293	-2830	-2287	-1236	924	1659	1092	-3464	-2521	-975
75 percent	-16	605	1350	764	2431	163	2336	2911	891	-3155	-439	-370
90 percent	-664	-17	2495	2244	763	1825	649	598	161	-179	908	376
95 percent	-914	-182	2443	634	-666	2039	108	46	975	641	208	272

MONTH

FIGURE 5.4-5 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, CONFIGURATIONS 3-B, 3-D TO 3-I

Freeport, on the Sacramento River at Cottonwood, and on the Feather River below Oroville. On the Sacramento River at Freeport in February, both the maximum and minimum discharge decreased by 5 percent and 10 percent, respectively. There is also a corresponding decrease in velocity and stage. In September, the minimum discharge decreased by 7 percent with a decrease in velocity and stage of 4 percent and 3 percent, respectively. Upstream from Freeport on the Sacramento River at Cottonwood (Table 5.4-6), the minimum discharge decreased by 35 percent and the average decreased by 13 percent in September. Both velocity and stage decreased in relationship to discharge. On the Feather River below Oroville (Table 5.4-8), the average discharge decreased by 12 percent and the average velocity by 9 percent in September.

5.4.2.3 Alternative 3

The hydraulic impacts of Alternative 3 on Sacramento River flows are evaluated on a regional basis and with respect to Delta inflow. The analysis is based on DWRSIM modeling.

Configurations 3B and 3D-3I

September for Configurations 3B and 3D-3I. Statistics are provided for discharge, mean velocity, top width, and mean depth.

The percent differences for Configurations 3B and 3D-3I in Tables 5.4-1 through 5.4-9 show the greatest change from all the other configurations. Based on these tables, most of the changes occur in February rather than September. Statistics for the Sacramento River at Freeport show an increase in the maximum discharge of 16 percent, with a decrease in the minimum discharge of 6 percent. Both velocity and stage changed accordingly in relationship to discharge. Upstream on the Sacramento River at Verona, decreases in the minimum and average discharge are observed in February. The changes observed at Verona are also found on the Sacramento River below Wilkins. Upstream on the Sacramento River at Colusa, the same pattern of change is observed but to a greater magnitude. The minimum discharge was reduced by 29 percent with the corresponding change in velocity and stage. The maximum and average discharges are also reduced. The patterns of change observed at Colusa are also found on the Sacramento River at Butte City. Large changes also are observed on the Feather River below Oroville. The maximum discharge increased by 83 percent, and the average discharge increased by 15 percent. The corresponding changes in velocity and stage occur in relationship to discharge. The maximum and average velocity increased by 62 and 12 percent, respectively. On the Feather River, increases in maximum and average discharge also are found in September.

5.4.2.3.1 Delta Inflow Analysis

Flows at the Sacramento River at Freeport represent the bulk of the inflow from the Sacramento River region to the Delta. Table 5.4-1 presents the summary statistics evaluated for the Sacramento River at Freeport. Figure 5.4-1 presents the summary statistics graphically. Each bar represents a different alternative configuration. The heights of the bars correspond with the maximum discharge for the corresponding month.

Wet Season Flows. The summary table shows that average wet season stream flows at Freeport are relatively unaffected by any of the Alternative 3 configurations. However, larger differences can be seen in the extreme flows. The maximum wet season flow increases for Configurations 3B and 3D-3I, which include an off-stream storage element. The maximum wet season flows decreases for Configurations 3A and 3C, which do not include storage. The minimum wet season flow, which increases under the No Action Alternative relative to existing conditions, decreases with all Alternative 3 configurations. The decrease roughly compensates for the increase of the No Action Alternative and would make the minimum flow 1 to 3 percent lower than under existing conditions.

Dry Season Flows. As with wet season flows, the average dry season stream flows at Freeport are relatively unaffected by any of the alternatives. This suggests that in most water years, the hydraulic effects of the alternatives on the lower portion of the basin would be small. The change in the maximum dry season flow at Freeport is negligible for all of the Alternative 3 configurations.

The change in the minimum dry season flow at Freeport is small. The magnitude of the difference is about the same but in the opposite direction as the difference between the No Action Alternative and existing conditions. As a result, the minimum dry season flow would be about the same as under existing conditions.

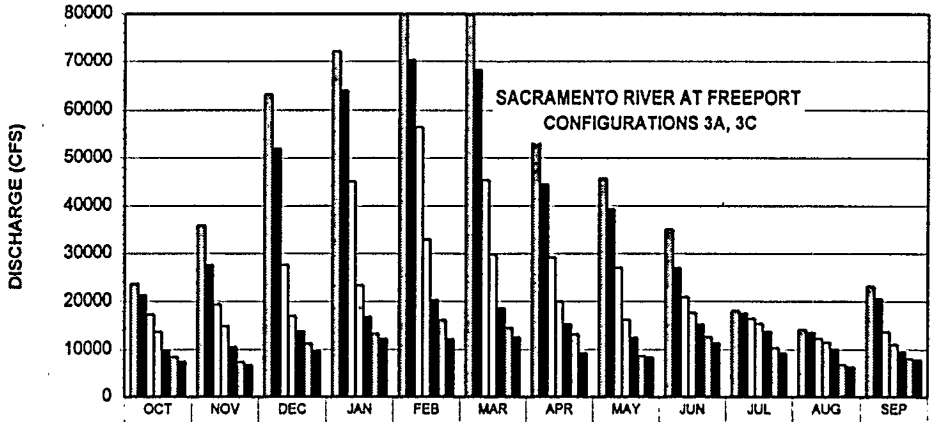
Flow Frequency Analysis. Figure 5.4-5 shows the flow frequencies for Configurations 3B and 3D to 3I. These configurations include north and south of Delta storage and an isolated conveyance facility. The wet season changes are similar to those shown for Configurations 1C, 2B, and 2E. Small and moderate increases in five percent of the flows in January and November, respectively. Otherwise, between October and January, increases in high flows would be negligible. Large increases in the lowest five to ten percent of flows would occur in December and January. High flows during February decrease moderately. During the dry season small to moderate increases would occur in the lowest five to ten percent of flows, which would probably be a beneficial effect. Moderate to large decreases would occur in middle range flows in July and August.

The change in the maximum dry season flow at Freeport is negligible for all of the Alternative 3 configurations.

Figure 5.4-6 shows flow frequencies for Configurations 3A and 3C, which include an isolated conveyance facility but no storage. Changes in wet season flows are negligible to small, but large decreases would occur in most of the flows during July and August. The decreases are in the range of fifteen to twenty-five percent for flows above the 25th percentile. Negligible decreases would occur in the lowest five percent of dry season flows.

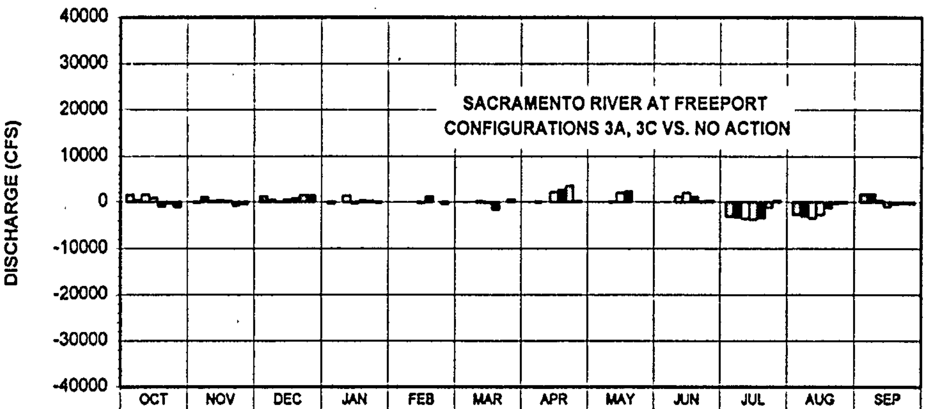
5.4.3 Comparison of Program Actions to Existing Conditions

For all alternatives including the No Action Alternative, the demand for water will continue to increase. Flows in the Sacramento River were modeled using DWRSIM for existing conditions with current demand and for all alternatives (including no action) with future demand for



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	23660	35820	63125	72148	79951	79955	54030	45668	35036	18088	14136	23061
10 percent	21260	27548	51943	63916	70267	68190	44488	39358	26916	17587	13515	20594
25 percent	17304	19343	27550	45050	56467	45392	29208	27014	20957	16442	12279	13663
50 percent	13743	14890	17077	23322	32915	29827	19982	16264	17696	15402	11498	11075
75 percent	9921	10554	13824	16833	20293	18638	15310	12425	15226	13759	10067	9529
90 percent	8522	7391	11303	13326	16209	14510	13179	8711	12671	10409	6860	8114
95 percent	7511	6749	9713	12198	12187	12536	9290	8431	11344	9293	6411	7757

MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	1529	-121	1210	-283	0	0	0	0	0	-3025	-2609	1734
10 percent	459	1069	429	0	0	0	71	0	0	-3194	-2950	1751
25 percent	1578	218	98	1366	0	146	0	65	1193	-3497	-3383	353
50 percent	862	387	504	-309	-180	-163	2168	2033	2033	-3611	-2586	-891
75 percent	-960	252	846	293	1206	-1578	2739	2374	1176	-3318	-1155	-353
90 percent	-338	-756	1513	215	4	16	3553	-13	188	-1116	-273	-222
95 percent	-1008	-444	1379	-62	-342	494	202	-26	266	377	-46	-276

MONTH

FIGURE 5.4-6 FLOW FREQUENCIES, SACRAMENTO RIVER AT FREEPORT, CONFIGURATIONS 3-A, 3-C

TABLE 5.5-1 SUMMARY OF ALTERNATIVES, CP # 682, SAN JOAQUIN RIVER AT VERNALIS (USGS 11303500)

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	36534	36534	SC***	36534	SC***	36534	SC***	36534	SC***	36534	SC***	36534	SC***
Minimum	1152	972	-15.63%	972	SC***	972	SC***	972	SC***	972	SC***	972	SC***
Average	6428	6410	-0.28%	6410	SC***	6428	0.28%	6410	SC***	6428	0.28%	6428	0.28%
Mean Velocity (fps)													
Maximum	3.17	3.17	SC***	3.17	SC***	3.17	SC***	3.17	SC***	3.17	SC***	3.17	SC***
Minimum	1.47	1.42	-3.71%	1.42	SC***	1.42	SC***	1.42	SC***	1.42	SC***	1.42	SC***
Average	2.16	2.15	-0.06%	2.15	SC***	2.16	0.06%	2.15	SC***	2.16	0.06%	2.16	0.06%
Top Width (feet)													
Maximum	512	512	SC***	512	SC***	512	SC***	512	SC***	512	SC***	512	SC***
Minimum	251	247	-1.55%	247	SC***	247	SC***	247	SC***	247	SC***	247	SC***
Average	294	294	-0.03%	294	SC***	294	0.03%	294	SC***	294	0.03%	294	0.03%
Mean Depth (feet)													
Maximum	20.8	20.8	SC***	20.8	SC***	20.8	SC***	20.8	SC***	20.8	SC***	20.8	SC***
Minimum	3.1	2.8	-10.71%	2.8	SC***	2.8	SC***	2.8	SC***	2.8	SC***	2.8	SC***
Average	9.7	9.7	-0.19%	9.7	SC***	9.7	0.19%	9.7	SC***	9.7	0.19%	9.7	0.19%
AUGUST													
Discharge (cfs)													
Maximum	1919	1919	SC***	1919	SC***	1919	SC***	1919	SC***	1919	SC***	1919	SC***
Minimum	1155	1106	-4.23%	1106	SC***	1106	SC***	1106	SC***	1106	SC***	1106	SC***
Average	1643	1626	-0.99%	1626	SC***	1626	SC***	1626	SC***	1626	SC***	1626	SC***
Mean Velocity (fps)													
Maximum	1.65	1.65	SC***	1.65	SC***	1.65	SC***	1.65	SC***	1.65	SC***	1.65	SC***
Minimum	1.47	1.46	-0.96%	1.46	SC***	1.46	SC***	1.46	SC***	1.46	SC***	1.46	SC***
Average	1.59	1.59	-0.22%	1.59	SC***	1.59	SC***	1.59	SC***	1.59	SC***	1.59	SC***
Top Width (feet)													
Maximum	263	263	SC***	263	SC***	263	SC***	263	SC***	263	SC***	263	SC***
Minimum	251	250	-0.40%	250	SC***	250	SC***	250	SC***	250	SC***	250	SC***
Average	259	259	-0.09%	259	SC***	259	SC***	259	SC***	259	SC***	259	SC***
Mean Depth (feet)													
Maximum	4.3	4.3	SC***	4.3	SC***	4.3	SC***	4.3	SC***	4.3	SC***	4.3	SC***
Minimum	3.1	3.0	-2.84%	3.0	SC***	3.0	SC***	3.0	SC***	3.0	SC***	3.0	SC***
Average	3.9	3.9	-0.66%	3.9	SC***	3.9	SC***	3.9	SC***	3.9	SC***	3.9	SC***

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

TABLE 5.5-2 SUMMARY OF ALTERNATIVES, CP #675 STANISLAUS RIVER MOUTH & RETURN FLOW (USGS 11302000 - STANISLAUS RIVER BELOW GOODWIN

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	5078	5078	SC***	5078	SC***	5078	SC***	5078	SC***	5078	SC***	5078	SC***
Minimum	216	216	SC***	216	SC***	216	SC***	216	SC***	216	SC***	216	SC***
Average	720	738	2.50%	738	SC***	738	SC***	738	SC***	738	SC***	738	SC***
Mean Velocity (fps)													
Maximum	4.27	4.27	SC***	4.27	SC***	4.27	SC***	4.27	SC***	4.27	SC***	4.27	SC***
Minimum	1.12	1.12	SC***	1.12	SC***	1.12	SC***	1.12	SC***	1.12	SC***	1.12	SC***
Average	1.98	2.01	1.18%	2.01	SC***	2.01	SC***	2.01	SC***	2.01	SC***	2.01	SC***
Top Width (feet)													
Maximum	151	151	SC***	151	SC***	151	SC***	151	SC***	151	SC***	151	SC***
Minimum	88	88	SC***	88	SC***	88	SC***	88	SC***	88	SC***	88	SC***
Average	105	105	0.36%	105	SC***	105	SC***	105	SC***	105	SC***	105	SC***
Mean Depth (feet)													
Maximum	7.9	7.9	SC***	7.9	SC***	7.9	SC***	7.9	SC***	7.9	SC***	7.9	SC***
Minimum	2.2	2.2	SC***	2.2	SC***	2.2	SC***	2.2	SC***	2.2	SC***	2.2	SC***
Average	3.5	3.5	0.93%	3.5	SC***	3.5	SC***	3.5	SC***	3.5	SC***	3.5	SC***
AUGUST													
Discharge (cfs)													
Maximum	960	960	SC***	992	3.39%	960	SC***	960	SC***	960	SC***	960	SC***
Minimum	553	732	32.35%	732	SC***	732	SC***	732	SC***	732	SC***	748	2.22%
Average	894	878	-1.82%	878	SC***	878	SC***	878	SC***	878	SC***	878	SC***
Mean Velocity (fps)													
Maximum	2.27	2.27	SC***	2.31	1.60%	2.27	SC***	2.27	SC***	2.27	SC***	2.27	SC***
Minimum	1.75	2.00	14.31%	2.00	SC***	2.00	SC***	2.00	SC***	2.00	SC***	2.02	1.05%
Average	2.20	2.18	-0.87%	2.18	SC***	2.18	SC***	2.18	SC***	2.18	SC***	2.18	SC***
Top Width (feet)													
Maximum	109	109	SC***	110	0.49%	109	SC***	109	SC***	109	SC***	109	SC***
Minimum	101	105	4.21%	105	SC***	105	SC***	105	SC***	105	SC***	105	0.32%
Average	108	108	-0.27%	108	SC***	108	SC***	108	SC***	108	SC***	108	SC***
Mean Depth (feet)													
Maximum	3.9	3.9	SC***	3.9	1.26%	3.9	SC***	3.9	SC***	3.9	SC***	3.9	SC***
Minimum	3.1	3.5	11.08%	3.5	SC***	3.5	SC***	3.5	SC***	3.5	SC***	3.5	0.83%
Average	3.8	3.7	-0.69%	3.7	SC***	3.7	SC***	3.7	SC***	3.7	SC***	3.7	SC***

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent. NA=Simulation data not available.

TABLE 5.5-3 SUMMARY OF ALTERNATIVES, CP #695, SAN JOAQUIN AND MERCED RIVERS CONFLUENCE (USGS 11274000 - SAN JOAQUIN RIVER NEAR NEW

FLOW CONDITIONS BASED ON 72-YEAR HYDROLOGIC RECORD	EXISTING CONDITIONS	ALTERNATIVE CONFIGURATIONS											
		NO ACTION, 1-A, 1-B		1-C, 2-B, 2-E		2-A, 2-C		2-D		3-A, 3-C		3-B, 3-D TO 3-I	
	Value	Value	% Diff*	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff**	Value	% Diff*
FEBRUARY													
Discharge (cfs)													
Maximum	21409	21409	SC***	21409	SC***	21409	SC***	21409	SC***	21409	SC***	21409	SC***
Minimum	306	306	SC***	324	5.88%	324	5.88%	324	5.88%	324	5.88%	306	SC***
Average	2935	2917	-0.61%	2917	SC***	2935	0.62%	2917	SC***	2935	0.62%	2935	0.62%
Mean Velocity (fps)													
Maximum	3.64	3.64	SC***	3.64	SC***	3.64	SC***	3.64	SC***	3.64	SC***	3.64	SC***
Minimum	0.89	0.89	SC***	0.91	1.91%	0.91	1.91%	0.91	1.91%	0.91	1.91%	0.89	SC***
Average	1.88	1.88	-0.20%	1.88	SC***	1.88	0.20%	1.88	SC***	1.88	0.20%	1.88	0.20%
Top Width (feet)													
Maximum	261	261	SC***	261	SC***	261	SC***	261	SC***	261	SC***	261	SC***
Minimum	140	140	SC***	141	0.85%	141	0.85%	141	0.85%	141	0.85%	140	SC***
Average	195	195	-0.09%	195	SC***	195	0.09%	195	SC***	195	0.09%	195	0.09%
Mean Depth (feet)													
Maximum	25.4	25.4	SC***	25.4	SC***	25.4	SC***	25.4	SC***	25.4	SC***	25.4	SC***
Minimum	2.4	2.4	SC***	2.5	3.21%	2.5	3.21%	2.5	3.21%	2.5	3.21%	2.4	SC***
Average	8.5	8.4	-0.34%	8.4	SC***	8.5	0.34%	8.4	SC***	8.5	0.34%	8.5	0.34%
AUGUST													
Discharge (cfs)													
Maximum	683	683	SC***	683	SC***	683	SC***	683	SC***	683	SC***	683	SC***
Minimum	342	342	SC***	342	SC***	342	SC***	342	SC***	342	SC***	342	SC***
Average	520	520	SC***	520	SC***	520	SC***	520	SC***	520	SC***	520	SC***
Mean Velocity (fps)													
Maximum	1.16	1.16	SC***	1.16	SC***	1.16	SC***	1.16	SC***	1.16	SC***	1.16	SC***
Minimum	0.92	0.92	SC***	0.92	SC***	0.92	SC***	0.92	SC***	0.92	SC***	0.92	SC***
Average	1.06	1.06	SC***	1.06	SC***	1.06	SC***	1.06	SC***	1.06	SC***	1.06	SC***
Top Width (feet)													
Maximum	157	157	SC***	157	SC***	157	SC***	157	SC***	157	SC***	157	SC***
Minimum	142	142	SC***	142	SC***	142	SC***	142	SC***	142	SC***	142	SC***
Average	151	151	SC***	151	SC***	151	SC***	151	SC***	151	SC***	151	SC***
Mean Depth (feet)													
Maximum	3.8	3.8	SC***	3.8	SC***	3.8	SC***	3.8	SC***	3.8	SC***	3.8	SC***
Minimum	2.6	2.6	SC***	2.6	SC***	2.6	SC***	2.6	SC***	2.6	SC***	2.6	SC***
Average	3.3	3.3	SC***	3.3	SC***	3.3	SC***	3.3	SC***	3.3	SC***	3.3	SC***

*Percent Difference Compared to Existing Conditions. **Percent Difference Compared to No Action. SC=Small Change (magnitude of difference less than 0.01 percent.
NA=Simulation data not available.

2020. Figure 5.1-2 in Section 5.1.2.3 illustrates the projected frequency of flows for the Sacramento River at Freeport for both existing conditions and the No Action Alternative. As shown on Figure 5.1-2, the highest flows in December and January, i.e. those that are equaled or exceeded in only 5 out of every 100 years, would be reduced by 2 to 3 percent for the No Action Alternative as compared to existing conditions. For most months, low flows would actually be greater for No Action as compared to existing conditions, by 2 to 3 percent. Additional discussion of the difference between the No Action Alternative and existing conditions can be found in Section 5.1.2.3. Comparisons of hydraulic conditions associated with other alternatives and those associated with existing conditions can found in Tables 5.4-1 through 5.4-9 for Freeport plus eight other locations on the Sacramento River system.

5.5 San Joaquin River Region

5.5.1 Summary of Regional Effects by Alternative

No discernable changes in San Joaquin River flows at Vernalis occur as a result of any of the modeled program actions.

5.5.2 Comparison of Program Actions to No Action Alternative

The hydraulic impacts of the alternatives on San Joaquin River flows are evaluated on a regional basis and with respect to Delta inflow. The analysis is based on DWRSIM modeling.

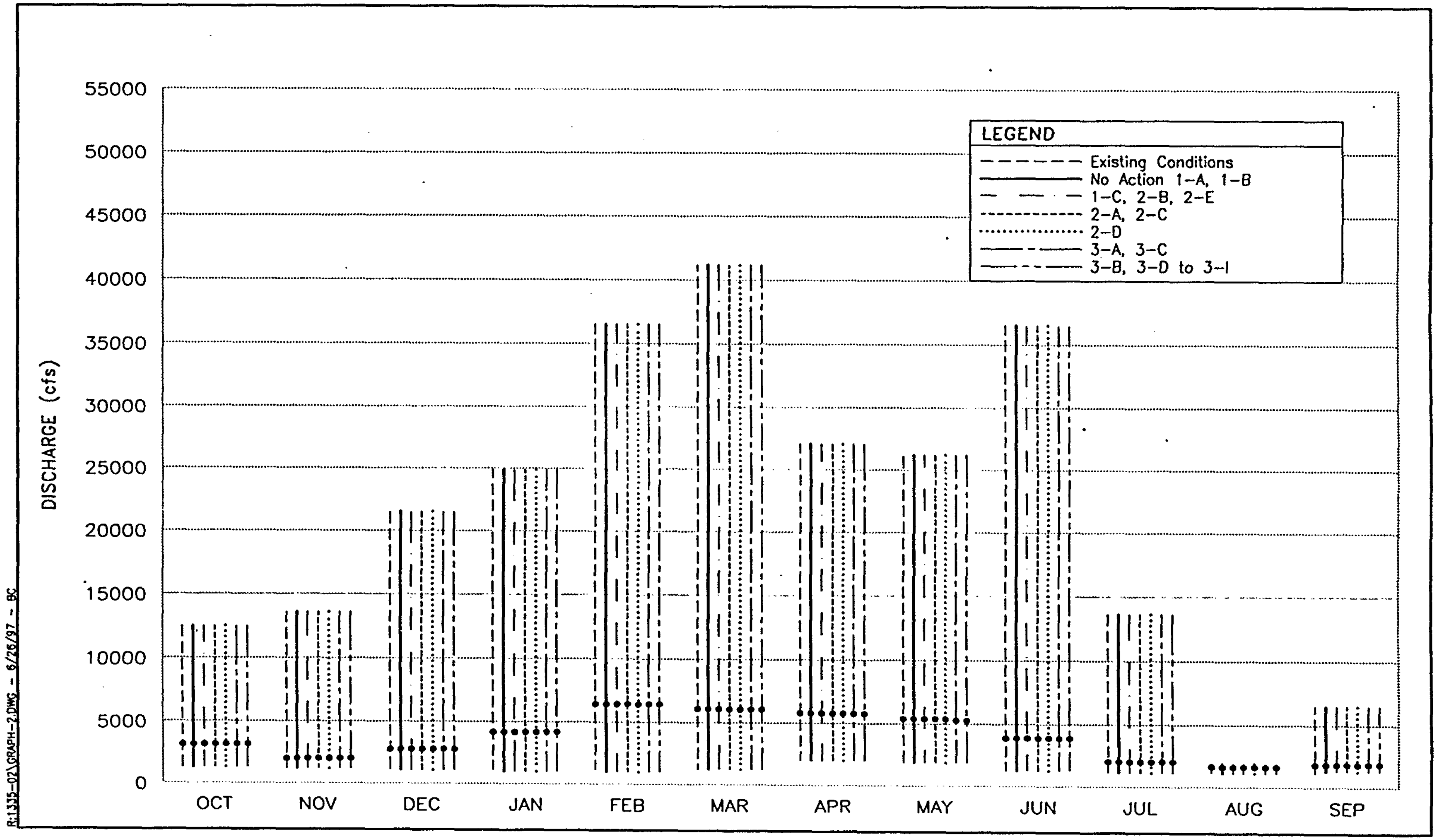
5.5.2.1 Regional Analysis

Tables 5.5-1 through 5.5-3 present summar statistics (averages, maximums, and minimums) representing discharge, mean stream velocity, stream top width, and mean depth at three locations within the San Joaquin River Region. Each table presents the results evaluated at one location. Figure 5.5-1 presents the discharge statistics from the tables graphically. The tables are similar to those presented in Section 5.4.2.1 for the Sacramento River Region. Each table includes summary statistics for each of the modeled alternative configurations. High inflow conditions are represented by the February data, and low flow conditions are represented by August data.

The tables indicate that negligible changes would occur in average and maximum flows for all alternative configurations relative to the No Action Alternative. Wet season minimum flows would be slightly (less than 6 percent) higher on the San Joaquin River below the confluence with the Merced (USGS Station 11274000) under configurations that do not include north of Delta surface storage. However, no change is observed at Vernalis.

5.5.2.2 Delta Inflow Analysis

The San Joaquin River at Vernalis represents a much smaller inflow to the Delta than the Sacramento River. Figures 5.5-2 through 5.5-6 present frequency distributions, by month, of projected flows at Vernalis, and the changes in the discharges at selected exceedence levels relative to the No Action Alternative. Based on the small magnitudes of the changes at each percentile level shown in the lower



Range of Monthly Flows in the San Joaquin River at Vernalis

Figure 5.5-1

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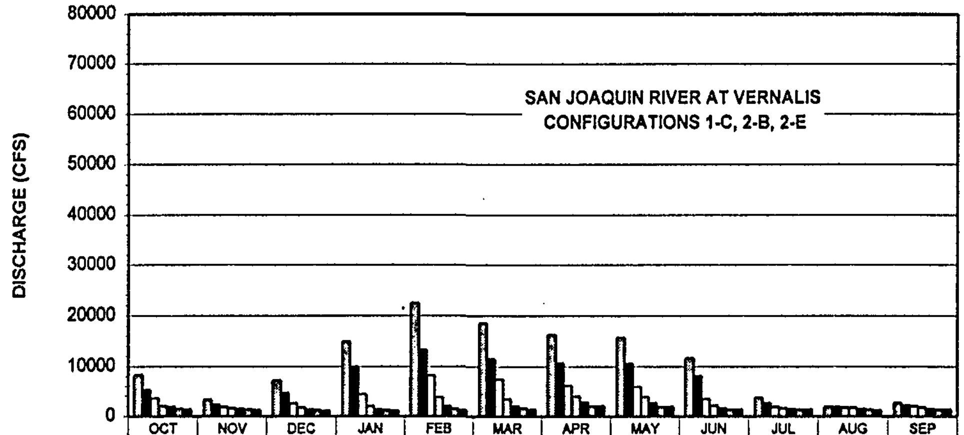
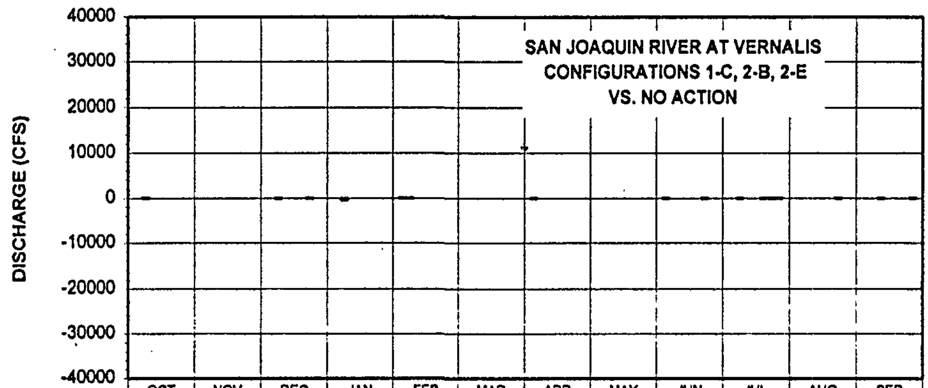


	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7228	14829	22374	18550	16191	15672	11646	3669	1887	2672
10 percent	5312	2346	4645	10002	13274	11459	10688	10581	8151	2667	1854	2202
25 percent	3545	1933	2521	4375	8175	7432	6201	5936	3428	1870	1805	1949
50 percent	2000	1613	1708	2000	3763	3415	3983	3822	2134	1659	1675	1697
75 percent	1903	1412	1317	1350	2017	2065	2807	2683	1563	1447	1480	1479
90 percent	1444	1294	1174	1155	1430	1665	1983	1903	1344	1311	1275	1361
95 percent	1334	1247	1125	1122	1260	1369	1983	1870	1314	1278	1213	1304

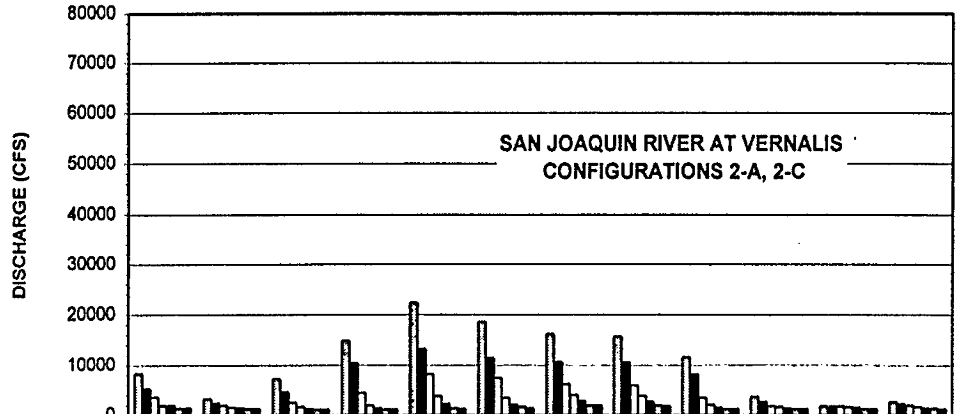
MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	0	0	-10	0	11	0	7	-10	10	0	0	0
10 percent	81	0	20	-407	4	0	0	0	-3	16	0	0
25 percent	0	0	0	0	-18	0	0	0	0	0	0	17
50 percent	0	0	0	0	0	0	0	0	0	0	0	0
75 percent	0	0	0	0	0	0	0	0	0	16	0	0
90 percent	0	0	3	0	0	0	0	0	13	3	3	0
95 percent	0	0	0	0	0	0	0	0	-13	16	0	7

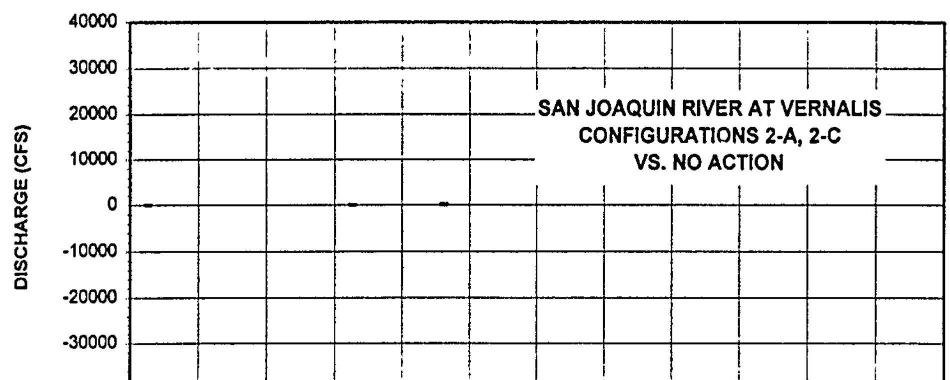
MONTH

FIGURE 5.5-2 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, CONFIGURATIONS 1-C, 2-B, 2-E



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7237	14829	22385	18550	16184	15672	11646	3669	1887	2672
10 percent	5282	2346	4625	10483	13270	11459	10688	10581	8151	2667	1854	2202
25 percent	3545	1933	2521	4375	8193	7432	6201	5936	3428	1870	1805	1933
50 percent	2000	1613	1708	2000	3763	3415	3983	3822	2134	1659	1675	1697
75 percent	1903	1412	1317	1350	2287	2065	2807	2683	1563	1447	1480	1479
90 percent	1444	1294	1171	1155	1430	1665	1983	1903	1331	1306	1272	1361
95 percent	1343	1237	1125	1122	1260	1369	1983	1870	1328	1262	1207	1304

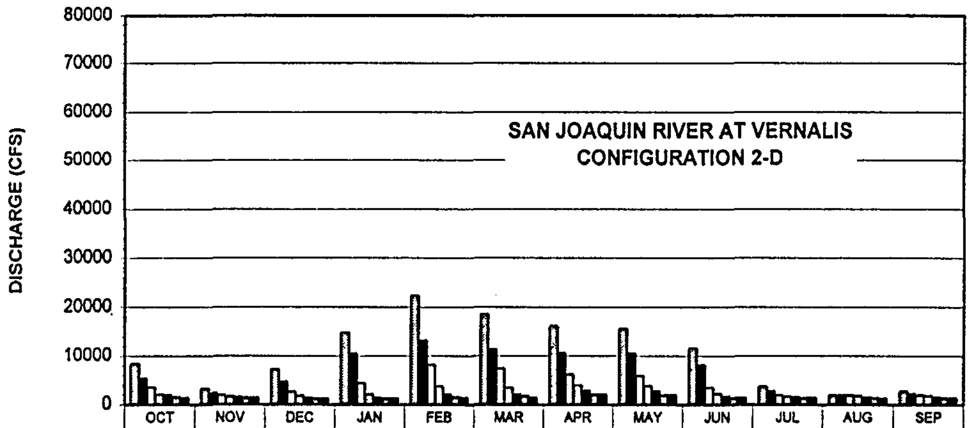
MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	0	0	0	0	22	0	0	-10	10	0	0	0
10 percent	52	0	0	75	0	0	0	0	-3	16	0	0
25 percent	0	0	0	0	0	0	0	0	0	0	0	0
50 percent	0	0	0	0	0	0	0	0	0	0	0	0
75 percent	0	0	0	0	270	0	0	0	0	16	0	0
90 percent	0	0	0	0	0	0	0	0	0	0	0	0
95 percent	10	-10	0	0	0	0	0	0	0	0	-7	7

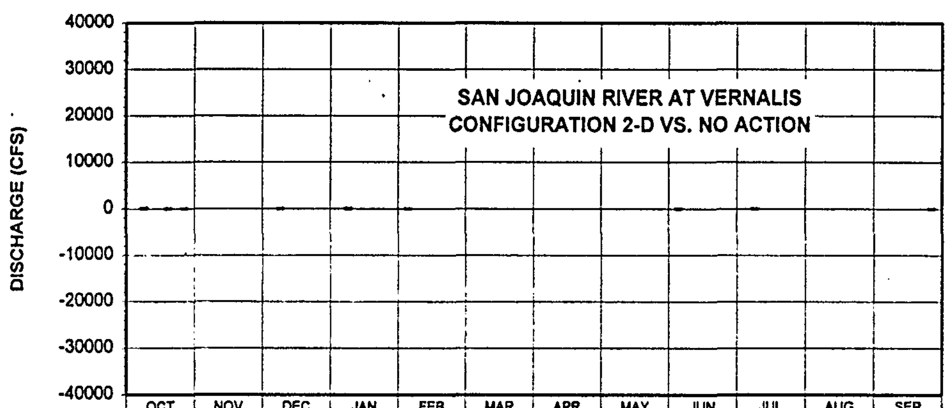
MONTH

FIGURE 5.5-3 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, CONFIGURATIONS 2-A, 2-C



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7228	14829	22374	18540	16184	15672	11646	3669	1887	2672
10 percent	5390	2346	4645	10500	13270	11459	10688	10581	8151	2667	1854	2202
25 percent	3545	1933	2521	4375	8175	7432	6201	5936	3428	1870	1805	1933
50 percent	2000	1613	1708	2000	3763	3415	3983	3822	2134	1659	1675	1697
75 percent	1919	1412	1317	1350	2017	2065	2807	2683	1563	1431	1480	1479
90 percent	1444	1294	1171	1155	1430	1665	1983	1903	1331	1308	1272	1361
95 percent	1343	1247	1125	1122	1260	1369	1983	1870	1328	1262	1213	1304

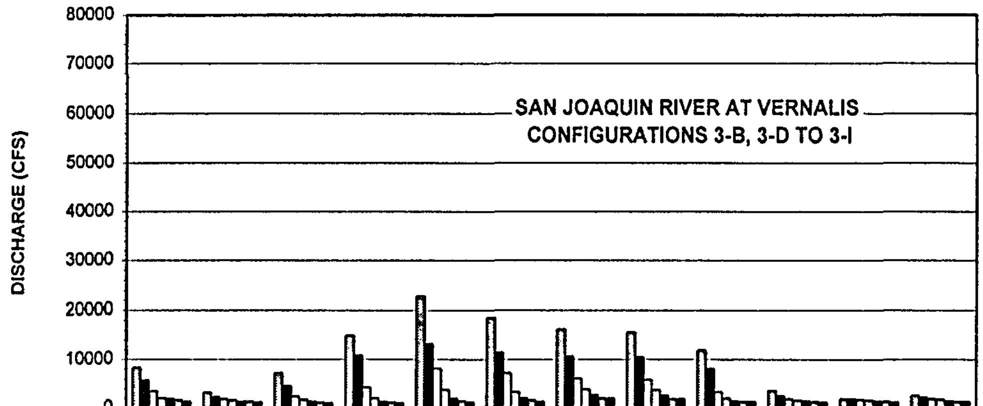
MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	0	0	-10	0	11	-10	0	-10	10	0	0	0
10 percent	159	0	20	91	0	0	0	0	-3	16	0	0
25 percent	0	0	0	0	-18	0	0	0	0	0	0	0
50 percent	0	0	0	0	0	0	0	0	0	0	0	0
75 percent	16	0	0	0	0	0	0	0	0	0	0	0
90 percent	0	0	0	0	0	0	0	0	0	0	0	0
95 percent	10	0	0	0	0	0	0	0	0	0	0	7

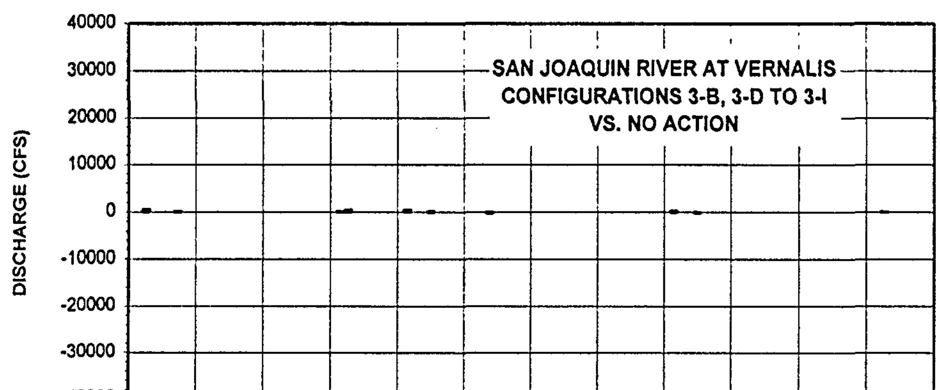
MONTH

FIGURE 5.5-4 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, CONFIGURATION 2-D



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7228	14946	22900	18550	16184	15672	11959	3669	1887	2665
10 percent	5803	2346	4645	10893	13274	11459	10688	10594	8154	2667	1854	2259
25 percent	3545	1933	2521	4375	8193	7237	6201	5936	3428	1870	1805	1949
50 percent	2000	1613	1708	2000	3889	3415	3983	3822	2017	1675	1675	1714
75 percent	1919	1412	1317	1350	2017	2065	2807	2683	1563	1447	1480	1479
90 percent	1587	1294	1174	1155	1430	1665	1983	1903	1344	1311	1301	1365
95 percent	1334	1247	1138	1122	1260	1369	1983	1870	1328	1278	1213	1304

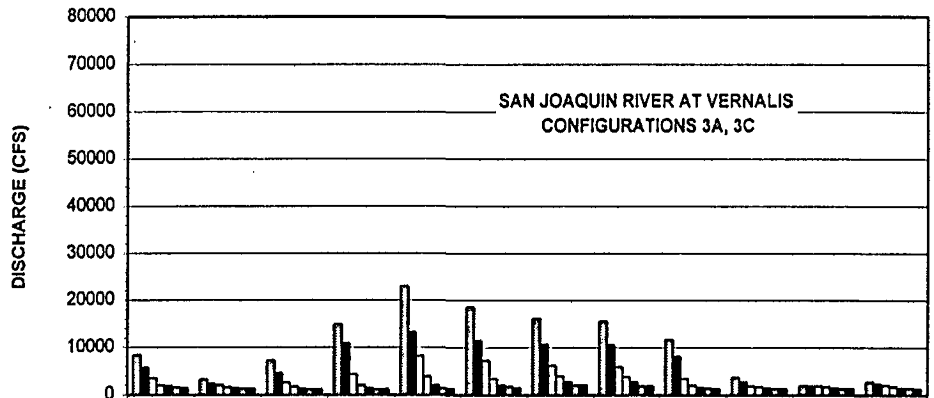
MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	0	0	-10	117	537	0	0	-10	323	0	0	-7
10 percent	572	0	20	485	4	0	0	13	0	16	0	57
25 percent	0	0	0	0	0	-195	0	0	0	0	0	17
50 percent	0	0	0	0	126	0	0	0	-118	16	0	17
75 percent	16	0	0	0	0	0	0	0	0	16	0	0
90 percent	143	0	3	0	0	0	0	0	13	3	29	3
95 percent	0	0	13	0	0	0	0	0	0	16	0	7

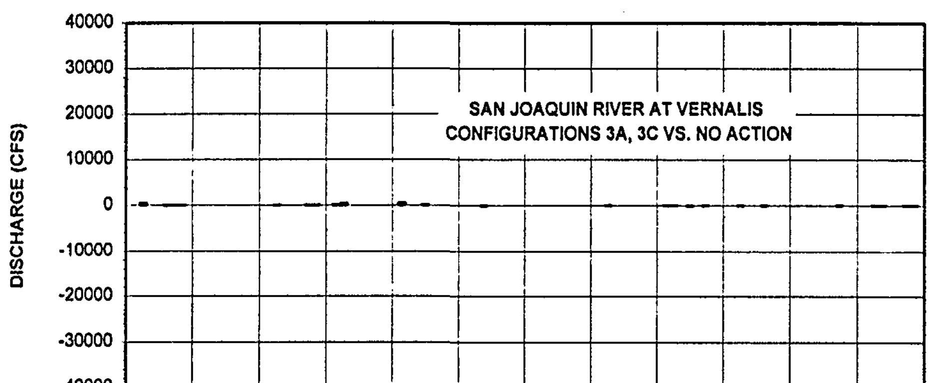
MONTH

FIGURE 5.5-5 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, CONFIGURATIONS 3-B, 3-D TO 3-I



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	8333	3247	7237	14946	22915	18540	16184	15672	11646	3669	1887	2665
10 percent	5819	2346	4645	10893	13270	11459	10688	10594	8157	2667	1854	2232
25 percent	3545	1933	2521	4375	8193	7237	6201	5936	3428	1870	1805	1949
50 percent	2000	1613	1708	2000	3889	3415	3983	3822	2000	1659	1675	1697
75 percent	1919	1412	1317	1350	1999	2065	2807	2683	1563	1447	1480	1479
90 percent	1574	1294	1174	1155	1430	1665	1983	1903	1344	1308	1301	1365
95 percent	1350	1247	1138	1122	1260	1369	1983	1870	1321	1262	1213	1314

MONTH



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5 percent	0	0	0	117	551	-10	0	-10	10	0	0	-7
10 percent	589	0	20	485	0	0	0	13	3	16	0	30
25 percent	0	0	0	0	0	-195	0	0	0	0	0	17
50 percent	0	0	0	0	126	0	0	0	-134	0	0	0
75 percent	16	0	0	0	-18	0	0	0	0	16	0	0
90 percent	130	0	3	0	0	0	0	0	13	0	29	3
95 percent	16	0	13	0	0	0	0	0	-7	0	0	17

MONTH

FIGURE 5.5-6 FLOW FREQUENCIES, SAN JOAQUIN RIVER AT VERNALIS, CONFIGURATIONS 3-A, 3-C graphs, the effects of the alternatives on discharge are negligible.

5.5.3 Comparison of Program Actions to Existing Conditions

Flows in the San Joaquin River were modeled using DWRSIM for both existing conditions with current demand and for all alternatives (including no action) with future demand for the year 2020. Figure 5.1-2 illustrates the projected frequency of flows for the San Joaquin River at Vernalis for both existing conditions and the No Action Alternative. As shown on Figure 5.1-2, the model results suggest that there will be very little difference between the No Action Alternative and existing conditions for the San Joaquin River at Vernalis. Comparisons of hydrodynamic conditions associated with other alternatives and those associated with existing conditions can found in Tables 5.5-1 through 5.5-3 for Vernalis plus two other locations in the San Joaquin River system. Under no circumstances have any substantial changes associated with any alternatives been identified for the San Joaquin River system, whether compared to the No Action Alternative or existing conditions.

5.6 SWP and CVP Service Areas Outside Central Valley

These areas are beyond the scope of our report.

6.0 REFERENCES

Leopold, L.B., and T. Maddock. 1953. Hydraulic geometry of stream channels and some physiographic implications. U.S. Geological Survey Professional Paper 252. 57 pp.

State Water Resources Control Board (SWRCB). 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Environmental Report. California Environmental Protection Agency. Sacramento, California. May 1995.