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FLOW SCIENCE®

Evaluation of the fate of San Joaquin River flow
Water Years 1964 and 1988

Prepared
for

San Joaquin River Group Authority

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Introduction

Flow Science Incorporated (Flow Science) has been retained by the San Joaquin River Group Authority to evaluate the potential effects of modifying the current salinity standards for the San Joaquin River (SJR) at Vernalis. Flow Science used the Fischer Delta Model (FDM) to simulate the effects of changes in the salinity standard on the ultimate fate of San Joaquin River water entering the Delta between February 1 and April 15. Simulations were performed for a dry water year and for a critically dry water year, when impacts of a change in salinity standards are expected to be most significant.

Presently, the SJR salinity standard at Vernalis, which bears the name "Case 1" for this study, is 0.7 mS/cm (414 mg/L)[1] in April-August, and 1.0 mS/cm (589 mg/L) the remainder of the year. The proposed new standard, called "Case 9" herein, is a salinity of 1.0 mS/cm (589 mg/L) year-round at Vernalis. This document presents modeling results of Sacramento-San Joaquin Delta simulations in which the fate of San Joaquin River water entering the Delta between February 1 and April 15 of each model year was tracked as flows propagated through the Delta.

Model Overview

Flow Science utilized the Fischer Delta Model (FDM)[2] to simulate hydrodynamics and the fate of an added tracer within the Delta for this project. The Fischer Delta Model (FDM)[3] consists of two linked models: a hydrodynamic model and a water quality model. The hydrodynamic model (DELFLO) utilizes the fixed grid method of characteristics to simulate the hydrodynamics of the Delta. The water quality model (DELSAL) uses the Lagrangian method, in which the motions of parcels of water are followed through the Delta. The Lagrangian method uses no grid points, but the computational effort required is equivalent to the use of approximately 2,500 grid points in a finite element numerical model.

The model extends from the downstream boundary in Carquinez Strait, upstream to Sacramento on the Sacramento River, and to Vernalis on the San Joaquin River. It also includes all tidally influenced sloughs and accounts for inflows from all major tributaries, state and federal project exports, riparian diversions, channel depletion, and agricultural returns.

These models describe hydrodynamics and changes in water quality in the Delta as affected by changes in geometry, hydrology, and Delta operations. Changes in hydrology include changes in river flows and diversions and exports within and to the south of the Delta. The models are also designed to allow prediction of the effect of levee breaks, channel gate operations, changes in

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1 Conversions between electrical conductivity (EC) and total dissolved solids (TDS) are based upon historical data from the memorandum "Salinity Unit Conversion Equations", California Department of Water Resources, 1986. Data from the station in the memo nearest the site of interest was used.

2 The model is operated by Flow Science Incorporated for Hugo B. Fischer, Inc.

3 The model is operated by Flow Science Incorporated for Hugo B. Fischer, Inc.

agricultural discharges, and changes in municipal discharges and withdrawals. The model is capable of simulating a partial year, a full year, or multiple years of hydrology.

DELFLO was initially calibrated by comparing model output at 40 stations to observations in the field and to the physical hydraulic model operated by the U. S. Army Corps of Engineers at Sausalito, California. Two conditions were studied: the tide of August 27-28, 1968, with a net Delta outflow of 2,500 cfs, and the tide of September 14-15, 1968, with a net Delta outflow of 17,200 cfs. The values of Manning's "n" for each channel were varied until a satisfactory agreement was obtained between the numerical model and physical model water surface elevations. In most cases, the field and physical model elevations agree within 0.2-feet water surface elevation. DELFLO has also been recalibrated and verified using both extensive flow and stage measurements made by the USGS within the Delta in 1988 and in 1996-1999.

DELSAL, the water quality model, has been calibrated by comparing model output for salinity to field data and verified using measured elemental tracer concentrations in the Delta. The Lagrangian method adopted in the model eliminates numerical dispersion, which is inherent in finite difference and finite element models and is difficult to reconcile with actual dispersion processes in the Delta. The model was designed to simulate salinity changes in the Delta, as affected by physical and hydrologic changes in the Delta, but it can also be used to determine the movement and dispersion of pollutants (or any mass conserving, neutrally buoyant particles) released from point sources. The FDM has also been verified by comparing FDM-computed "source fractions" (computations of the source of water located at specific interior Delta locations) to measured source fractions. Measured source fractions were determined using elemental concentrations measured at specific points in the Delta over a one-year period beginning in March 1996.

The FDM has been successfully applied to the transport of total dissolved solids (TDS) and other neutral buoyant tracers in the Sacramento-San Joaquin Delta for over twenty years. The model has undergone continuous improvement over the years.

Study Design

Water years 1964 and 1988 were modeled in this study. Water year 1964 was a dry year in both the Sacramento and San Joaquin River basins, while 1988 was a critically dry year in both basins[4]. These years were selected as representative of hydrologic conditions in which the proposed SJR salinity changes are likely to have the largest effect.

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4 A dry water year is defined as having a water year index below 6.5 million acre-feet (Sacramento Valley) or below 2.5 million acre-feet (San Joaquin Valley). A critically dry water year is defined as having a water year index below 5.4 million acre-feet (Sacramento Valley) or below 2.1 million acre-feet (San Joaquin Valley) according to California Department of Water Resources criteria. 1964 was a dry year in both basins, while 1988 was a critically dry water year in both basins. See DWR's Chronological Sacramento and San Joaquin Valley Water year Hydrologic Classification Indices, available at cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.

Four different scenarios were modeled for this study. The four scenarios stem from two basic configurations: a baseline case, called "Case 1", and the new SJR salinity standard case, called "Case 9". Each of these two cases was then modified to reflect implementation of the South Delta Improvement Plan (SDIP)[5]. The resulting four scenarios (Case1, Case9, Case1-SDIP, and Case9-SDIP) were modeled for both water years 1964 and 1988.

Flow Science's previous modeling for the San Joaquin River Group Authority included yet another alteration of the "Case 1" and "Case 9" scenarios-simulation of a modified Head of Old River Barrier (HORB) schedule (Flow Science, February 2005). The modified HORB schedule is the same as the standard HORB schedule during the spring barrier installation; the only difference in barrier configuration and operations occurs in November. Since the purpose of the current modeling is to track San Joaquin River flows entering the Delta between February 1 and April 15, the modified HORB scenarios were not simulated in this study.

Input data for the model were obtained from several sources. Dan Steiner provided river and export flow rates based on CALSIM II simulations of these water years. The tracer concentrations in all rivers was set to zero, except San Joaquin River flows entering the Delta from February 1 to April 15 were simulated as having a "tracer" concentration of 1,000,000 ppm. Gates and barriers were modeled according to current barrier operations based on information obtained from DWR[6]. Table 1 below summarizes the barrier operation schedules for both 1964 and 1988 for the HORB, the Old River Barrier at Tracy (ORB), the Middle River Barrier (MRB), and the Grant Line Canal Barrier (GLCB). The table shows the dates that the barriers were in place.

Table 1: Barrier Operations for Modeled Scenarios, water years 1964 and 1988

	All scenarios
HORB[a]	Apr. 16-May 15, Sep. 16-Sep. 30
ORB[b]	Apr. 16-Sep. 30
MRB[c]	Same as ORB
GLCB[d]	Same as ORB

a. HORB was simulated as spanning the full channel width at elevation 10 feet (all elevations reference NGVD29).
b. ORB was simulated as spanning the full channel width at elevation 4 feet.
c. MRB was simulated as spanning the full channel width at elevation 3 feet.
d. GLCB was simulated as spanning the full channel width at elevation 3.5 feet.

5 SDIP CALSIM II simulations performed by DWR are preliminary and may change at a later date. Currently, the SDIP simulations include changes in export pumping rates from the Banks and Tracy Pumping Plants and changes in flow rates to the Sacramento and Mokelumne Rivers.

6 Emails from Andy Chu, Senior Water Resources Engineer, California Department of Water Resources, 1/13/05; Mark Holderman, Chief-Temporary Barriers Project, California Department of Water Resources, 1/27/05.

Several additional assumptions were made, as follows:

- No culverts or notches were placed in the barriers (HORB, ORB, MRB, and GLCB).

- Clifton Court Forebay gates were assumed to be open all of WY64 because CCFB did not exist in WY64. Historical CCFB gate operations were used for WY88.

- The Delta Cross Channel Barrier (DXC) was simulated as open from the first of each month until the month's "open days" quota is spent, where the number of open days were specified by the CALSIM II modeling. This is in accordance with DWR's modeling practices[7].

- All CCWD diversions are assumed to be through Rock Slough Pumping Plant #1 (i.e., no Old River diversions).

- Monthly data from CALSIM II were transformed to daily data by assigning each day its corresponding month's average value (i.e., flow was a constant value for each day in a given month).

- Diversions, exports, and river flow rates used as model input are not actual WY64 and WY88 historical flows, but those specified in CALSIM II runs provided by Dan Steiner.

Results

Results showing the fate of San Joaquin River water entering the Delta between February 1 and April 15 are shown in Table 2. Additionally, the results are shown in graphical format in Figures 1-4.

7 Telephone conversation with Andy Chu, Senior Water Resources Engineer, California Department of Water Resources, 1/18/05.

Table 2: Fate of San Joaquin River water entering the Delta between February 1 and April 15

	Exported: Central Valley Project	Diverted: Contra Costa Canal	Exported: State Water Project	Delta Outflow
Case1-64	64.2%	0.5%	28.4%	0.2%
Case9-64	64.7%	0.5%	27.9%	0.2%
Case1SDIP-64	63.3%	0.7%	33.9%	0.2%
Case9SDIP-64	63.5%	0.7%	34.1%	0.2%
Case1-88	57.1%	0.7%	27.6%	0.2%
Case9-88	57.5%	0.7%	27.4%	0.2%
Case1SDIP-88	56.9%	0.9%	25.6%	0.3%
Case9SDIP-88	57.4%	0.9%	25.3%	0.2%

Figure 1: Percent of San Joaquin River water exported for the Central Valley Project

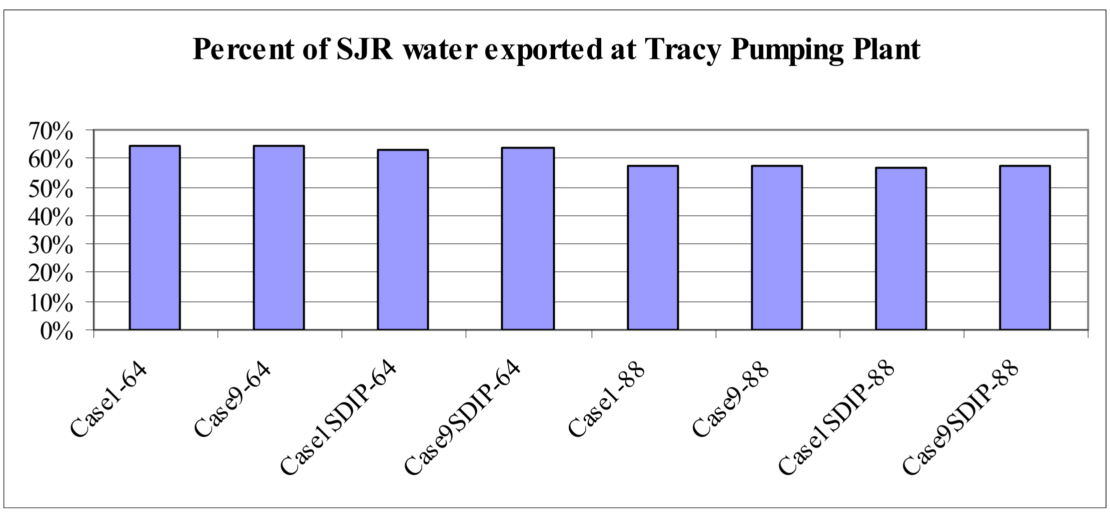


Figure 2: Percent of San Joaquin River water diverted at the Contra Costa Canal

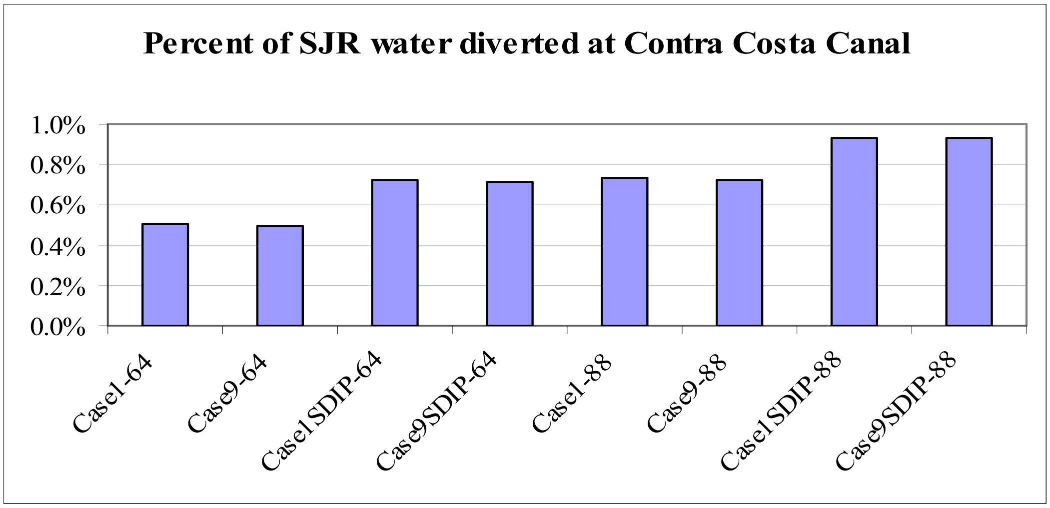


Figure 3: Percent of San Joaquin River water exported for the State Water Project

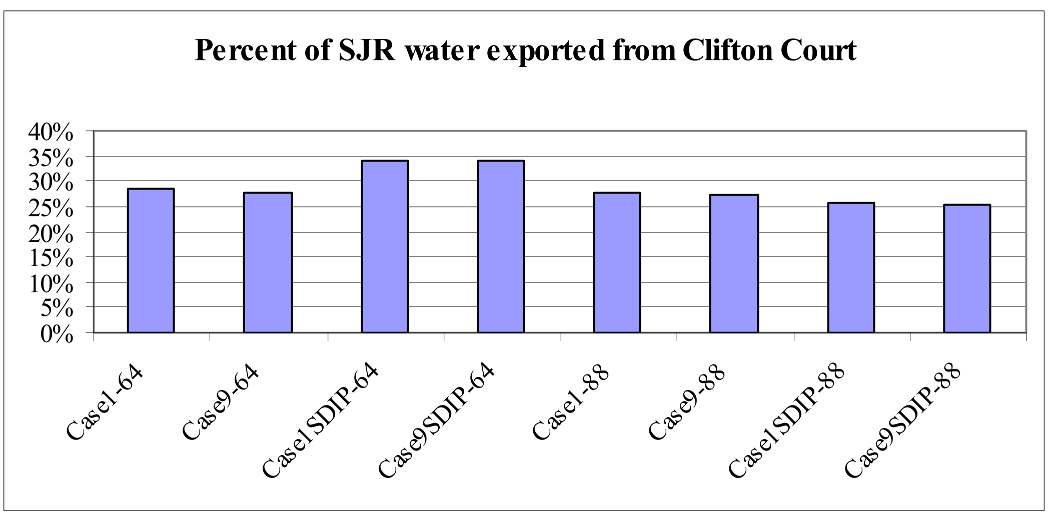
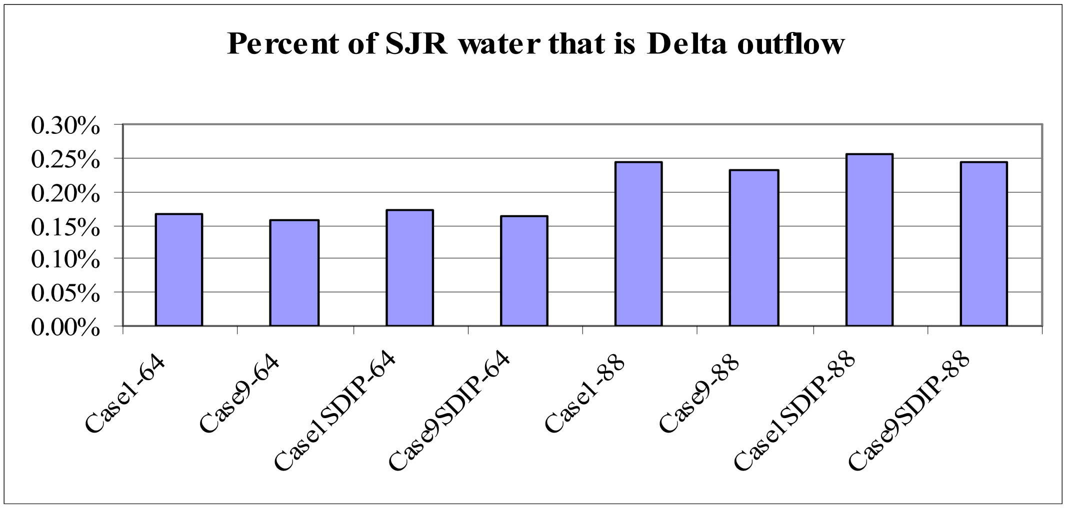


Figure 4: Percent of San Joaquin River water that flows out of the Delta at Martinez



The sum of the exports, diversions and Delta outflow is ~93-98% for all 1964 scenarios, and ~83-86% for all 1988 scenarios. This indicates that ~2-17% of the San Joaquin River water that entered the Delta between February 1 and April 15 remained in the Delta September 30, the end of the modeling period, was pumped out for agricultural use, or was diluted by other flows to concentrations below the level that can be resolved by the model.