Suisun Marsh
Habitat Management, Preservation, and Restoration Plan

Final
Environmental Impact Statement/ Environmental Impact Report

Volume II: Appendices

U.S. Department of the Interior
Bureau of Reclamation

U.S. Fish and Wildlife Service

California Department of Fish and Game

November 2011

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The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The Mission of the Department of Fish and Game is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

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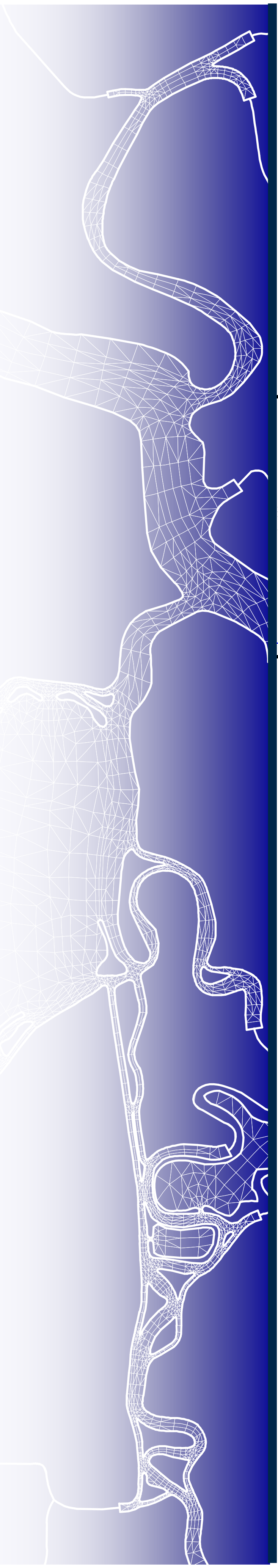
Appendix A

Numerical Modeling in Support of Suisun Marsh PEIR/EIS— Technical Appendix, September 2009



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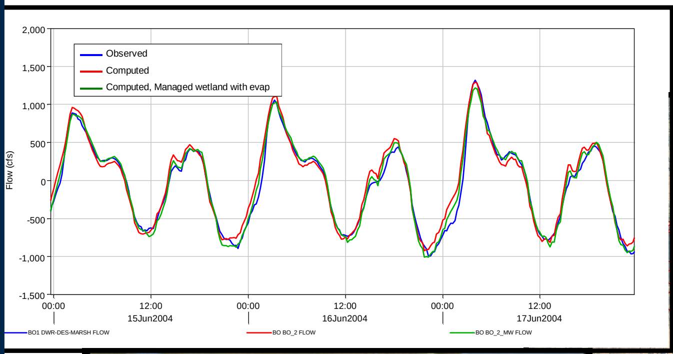

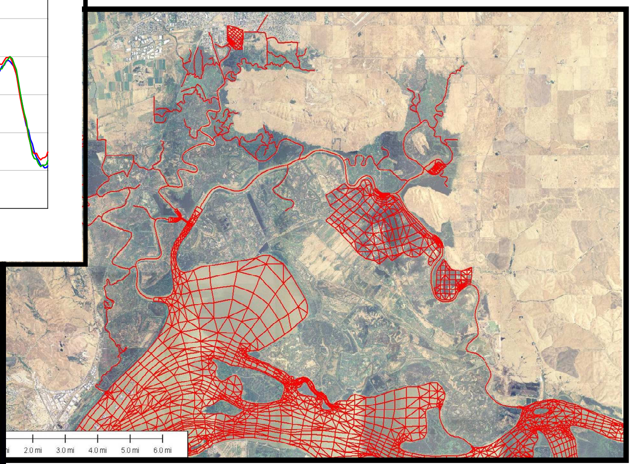

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1. Executive Summary

1.1. Background

Resource Management Associates, Inc. (RMA) has developed a numerical model of the Suisun Marsh area to simulate the current hydrodynamics and salinity of the marsh as well as the changes to this regime under a set of four marsh restoration scenarios. RMA refined the representation of the Suisun Marsh area in their current numerical model of the San Francisco Bay and Sacramento-San Joaquin Delta system (Bay-Delta model). The computer programs used in the Bay-Delta model, RMA2 (King 1990) and RMA11 (King 1998), utilize a finite element formulation to simulate the one- and two-dimensional flow and water quality transport[1], respectively, in streams and estuaries. The Bay-Delta model, which uses electrical conductivity[2] (EC) as a surrogate for salinity, has been successively updated, refined and recalibrated in numerous studies over the past 11 years, for example, to evaluate the water quality responses of treated wastewater discharges, and the potential effects of various Suisun Marsh levee breach scenarios.

1.2. Report Summary

This Technical Summary of the Suisun Marsh Modeling Project describes:

- the refined Bay-Delta model;
- the calibration of this representation;
- the further development of the model to represent four representative marsh restoration scenarios; and
- analysis of the modeling results of these scenarios to evaluate their effects on tidal range, scour velocities, and tidal prism in Suisun Marsh, and on salinity in Suisun Marsh and the Delta in comparison with simulated Base case conditions.

1.3. Summary of the Calibration

RMA's Bay-Delta model was refined in the Suisun Marsh area, with increased detail to represent off-channel storage in overbank/fringe marsh regions, a better representation of precipitation and evaporation, estimation of local creek flows, inflows and withdrawals within the Suisun Marsh, plus an overall refinement of the mesh. These additions generally improved the representation of tidal dynamics and EC in Suisun Marsh. A recent Delta calibration effort (RMA, 2005) was used as the starting point for the current effort. There was no recalibration in the Delta, as the focus was on improving the representation of Suisun Marsh.

Hydrodynamic calibration of the refined model took place in the period April – July, 2004 to take advantage of new LiDAR elevation data and data from new flow and stage measurement stations in the Suisun Marsh area (DWR 2007). Stage calibration was generally good in Suisun Marsh. The results of the flow calibration were mixed. Flows in

[1] RMA11 can also be used to simulate three-dimensional transport in conjunction with other RMA model formulations, for both conservative and non-conservative constituents.

[2] EC measurements give an estimate of the amount of total dissolved solids in the water; units are typically given in µmhos cm^{-1} or, equivalently, µS cm^{-1}

the smaller sloughs were greatly improved by the increased detail and refinement of the grid, the addition of off-channel storage, withdrawals for managed wetlands, and representation of evaporation in the tidal marsh areas. Flow through Montezuma Slough was low in comparison with measured data, and low flows through Hunter Cut were compensated by higher flows through Suisun Slough. These results have the potential of biasing modeled EC in the marsh restoration scenarios.

EC calibration results were also mixed, with some areas showing good correspondence with measured data, while other areas suffered from approximations intrinsic to the model or from the lack of sufficient data. In particular, density stratification is not explicitly represented in the 2-dimensional depth-averaged formulation used in the Bay-Delta model, leading to variations in the representation of EC. In the current model, diffusion coefficients are used to approximate effects due to density stratification. Using this method to improve the representation of EC during high flow periods tends to bias modeled EC when outflow is low. As a consequence, modeled EC at Martinez is low winter through spring and high summer through fall. This bias in modeled EC at Martinez propagates through western Suisun Marsh. In general, EC was low everywhere in the marsh in winter 2003. EC was low year-round in the eastern end of Montezuma Slough.

1.4. Summary of the Modeling Results

Four scenarios (Figure 1-1) for representative tidal marsh restoration in Suisun Marsh were modeled and compared to a Base case. The scenarios present a range of locations and acreages for restoration projects. Locations where levees were breached are indicated on Figure 1-1. As expected, each of the scenarios increased the tidal prism, i.e., the volume of water exchanged in the Suisun Marsh area, but muted the tidal range and shifted stage timing throughout the marsh in comparison with the Base case. Average tidal flow generally increased in the larger sloughs and decreased in smaller sloughs in the interior regions of Suisun Marsh. The peak velocity increased in sloughs near the breaches of the flooded areas, with the largest velocity changes localized at and near the mouths of the breached levees.

Electrical conductivity (µmhos cm^{-1} or µSiemens cm^{-1}), or EC, was modeled as a surrogate for salinity. One part per thousand EC is equivalent to about 1.5 µmhos cm^{-1} of EC. EC in the Delta was similar to the Base case in each scenario January – June, but changed July – December in several of the scenarios. Delta EC decreased during the latter period for the Zone 4 and Set 1 scenarios where the breached areas were located in channels further from Suisun, Grizzly and Honker Bays. The Set 2 scenario resulted in EC increase in the Delta due to tidal trapping[3] in the breached area adjacent to Suisun Bay. Tidal trapping in Zone 1 caused only minor increases in Delta EC.

Tidal restoration scenarios that decreased Delta EC tended to increase EC in Suisun Marsh, although changes in the details of the EC profile for each scenario depended on

[3] Tidal trapping refers to the dispersive mechanism by which differences in tidal phase between a main channel and side channel or embayment create a net horizontal dispersion, in this case, of EC.

the particular location examined, the operation of the Suisun Marsh Salinity Control Gate (SMSCG), and the season. The Zone 1 scenario was most similar to the Base case, with little or no EC change in the eastern marsh but some increase in the west. The Zone 4 scenario decreased EC in most of the marsh whenever the SMSCG was operating, except in eastern Montezuma Slough where it increased EC. The Set 1 scenario generally resulted in the highest EC conditions in the Marsh, except upstream of the Zone 4 breaches on Montezuma Slough. The Set 2 scenario tended to increase EC in much of the marsh when the SMSCG was operating, with variable increase or decrease otherwise.

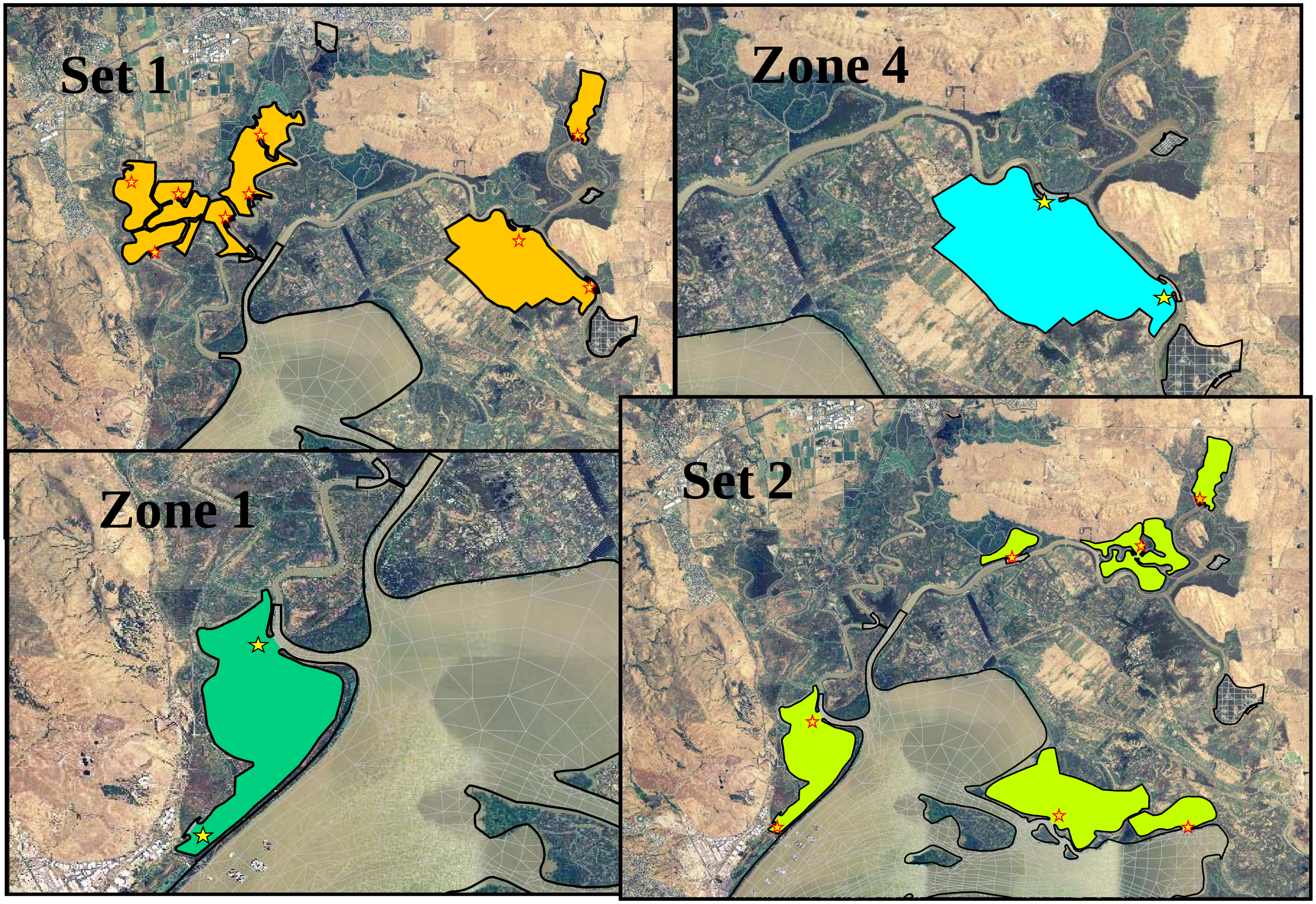


Figure 1-1 Regions flooded as tidal marsh in each of the scenarios, with the location of breaches in levees indicated by stars.

2. RMA Suisun Marsh Modeling

2.1. Introduction

The goal of the Suisun Marsh project numerical modeling effort is to evaluate the effects of each of the four marsh restoration scenarios (Figure 1-1) on tidal range, scour, and tidal prism in Suisun Marsh, and on salinity in Suisun Marsh and the Delta. To accomplish these objectives, Resource Management Associates, Inc. (RMA) was tasked with developing a numerical model of the Suisun Marsh area to accurately simulate the current hydrodynamics and salinity regimes in the marsh, as well as the changes to these regimes in the marsh and to the salinity regime in the Delta under the four scenarios. EC is used as a surrogate for salinity in the Bay-Delta model for this project – this is discussed in more detail in Section 2.3.

During the Suisun Marsh Levee Breach modeling project (RMA, 2000), considerable detail was added to the representation of Suisun Bay and the western Delta, and to a lesser extent to representations of the Central Bay and Carquinez Strait. Wetting and drying of the tidal mudflats was represented in sufficient detail to provide a good definition of change in the tidal prism with change in tidal stage. The current model development and calibration efforts focused on further refinement of the finite element mesh and model capabilities in and around Suisun Marsh.

When the RMA Bay-Delta model was first developed, there was very limited observed data available to verify its performance in Suisun Marsh Region. Comparison of RMA model results to recent DWR monitoring data collected in 2004 and 2005 identified some deficiencies in the previous model representation of the Suisun Marsh Region. The discrepancies in flow results were primarily due to inaccurate representation of tidal prism at high tide. Before the model was used for alternative analysis simulations, the model was updated to better represent observed flows. The update primarily included assessment of inundated area and review/refinement of model geometry.

2.2. Background

RMA has developed and refined a numerical model of the San Francisco Bay and Sacramento-San Joaquin Delta system (Bay-Delta model) utilizing the RMA finite element models for surface waters. RMA2 (King, 1990) is a generalized free surface hydrodynamic model that is used to compute two-dimensional depth-averaged velocity and water surface elevation. RMA11 (King, 1998) is a generalized two-dimensional depth-averaged water quality model that computes a temporal and spatial description of conservative and non-conservative water quality parameters. RMA11 uses the results from RMA2 for its description of the flow field. As shown in Figure 2-1, the full model extends from the Golden Gate to the confluence of the American and Sacramento Rivers and to Vernalis on the San Joaquin River.

The current version of RMA's Bay-Delta model has been developed and continually refined during numerous studies over the past 11 years. One of the most important additions has been the capability to accurately represent wetting and drying in shallow estuaries. The most comprehensive calibration efforts in recent years were performed during studies for the City of Novato (RMA, 1997), the City of Palo Alto Regional Water Quality Control Plant (RMA, 1998), Central Contra Costa Sanitary District (RMA, 2000), CALFED (RMA, 2000), and Flooded Islands Feasibility Study (RMA, 2005).

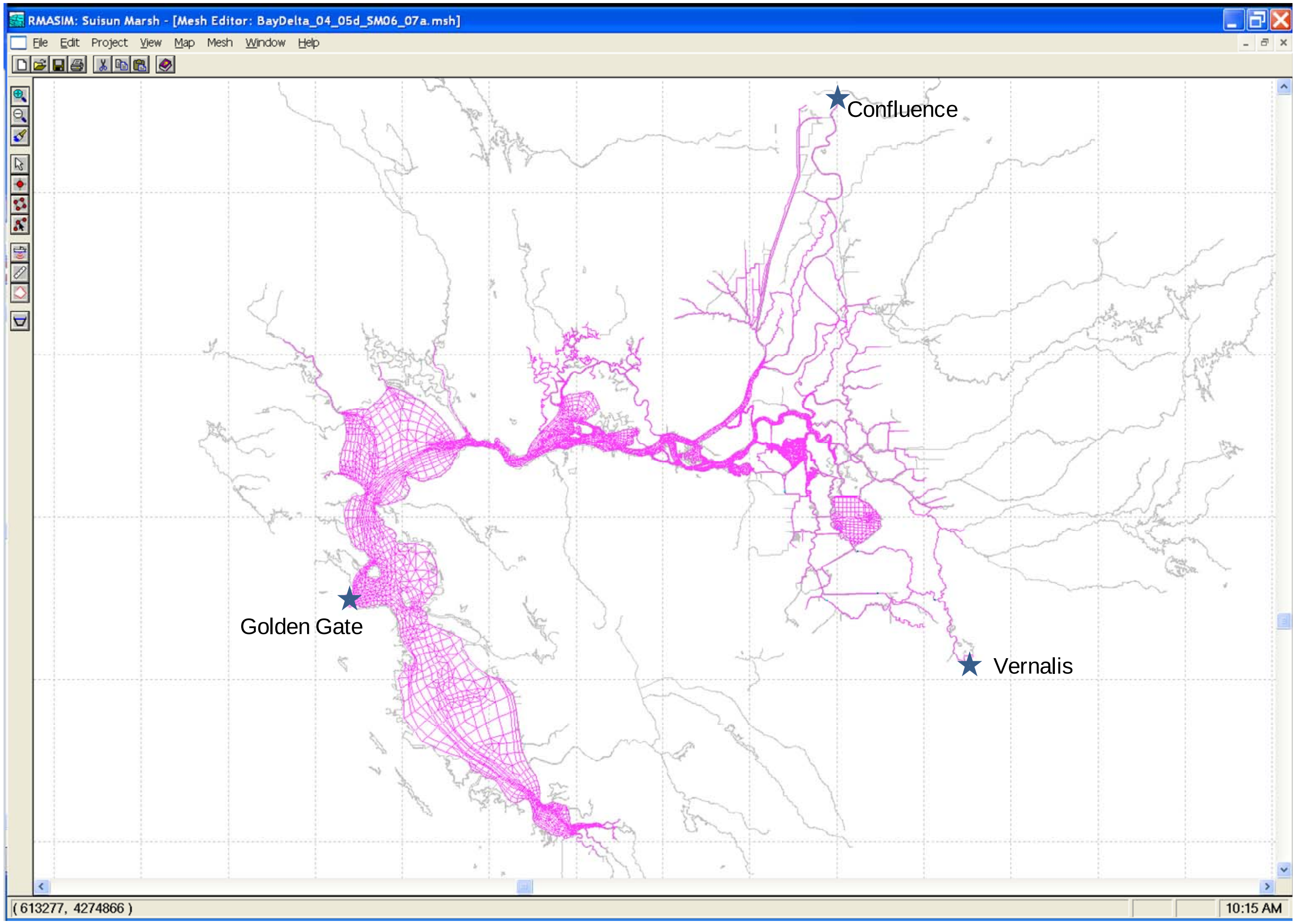


Figure 2-1 RMA Bay-Delta model finite element mesh.

2.3. General Description of Model Capabilities

Hydrodynamic and water quality model output from RMA's Bay-Delta models, RMA2 and RMA11, provided temporal and spatial descriptions of velocities and water depths, and EC (μmhos cm^{-1}), respectively, throughout the model domain. The results of the flow simulation are saved and used by the water quality model to compute EC[4]. The computational time step used for modeling the depth-averaged flow and EC transport in the Delta is 7.5 minutes, and output from each model is saved every 15 minutes.

The version of the Bay-Delta model used in this study sets the tidal boundary condition at the Golden Gate. Although the RMA11 formulation assumes transport of a conservative constituent, EC is used as a practical surrogate for modeled salinity in the Bay-Delta model for several reasons, despite concerns about its non-conservative behavior. The number and reliability of measurement locations in the Bay-Delta region is much greater for EC than for other measures of salinity. In addition, transformation relationships between EC and constituents generally considered conservative, such as chloride and Total Dissolved Solids (TDS), can introduce additional error. EC underestimates true salinity at high concentrations (DWR, 2002). Because the Bay-Delta transport model is calibrated using EC, dispersion coefficients may be too high to utilize the model for truly conservative constituents.

Significant vertical salinity gradients are often present in the western Delta and Suisun Bay which can lead to three dimensional circulation patterns not fully represented by a two-dimensional depth-averaged model, but are instead approximated by two-dimensional mixing parameters.

Due to the variable grid capability of the finite element method, fine detail can be added to emphasize specific areas in the vicinity of the current project without increasing detail elsewhere in the model grid.

3. Model Set-up

The standard Bay-Delta Model hydrodynamic model operation (RMA2) requires specification of the tidal stage at the Golden Gate and inflow and withdrawal rates at other boundaries. Inflows include Sacramento River, Yolo Bypass, San Joaquin River and other rim flows, channel depletions and exports (SWP, CVP, Contra Costa Canal, and North Bay Aqueduct). The water quality model (RMA11) requires specification of EC boundary conditions at all inflow boundaries. The refined model developed for the current project added new boundary conditions for flow and EC within Suisun Marsh that are covered in Section 3.3.

[4] RMA11 can also compute the transport of other water quality constituents with more complex interactions

3.1. Model Geometry

Figure 2-1 shows the entire mesh of the Bay-Delta model used in the calibration effort (the calibration effort is covered in Section 4 of this report). In the previous version of the model, a two-dimensional, depth-averaged representation was used for the San Francisco Bay and Suisun Bay regions, the Sacramento-San Joaquin confluence area, Sherman Lake, the Sacramento River up to Rio Vista, Big Break, the San Joaquin River up to its confluence with Middle River, False River, Frank's Tract and the surrounding channels, and the Delta Cross Channel. Suisun Marsh and Delta channels, and tributary streams were represented using a one-dimensional cross-sectionally averaged approximation.

The Bay-Delta finite element network was developed using an in-house GIS based graphical user interface program. This program allows for specification of the finite element mesh over layers of bathymetry points and contours, USGS digital line graph (DLG) and digital orthoquad (DOQ) images, and aerial photo surveys processed by USGS and Stanford University. Bottom elevations and the extent of mudflats were based on bathymetry data collected by NOAA, DWR, USACE and USGS. These data sets have been compiled by DWR and can be downloaded from DWR's Cross Section Development Program (CSDP) website at http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/csdp/index.html.

Additional data were collected around Franks Tract by DWR and the USGS in 2004. USGS 10 m resolution Delta Bathymetry grids were obtained from the Access USGS website at http://sfbay.wr.usgs.gov/access/Bathy/Delta/.

3.2. Network Refinement

The existing finite element mesh was refined in the Suisun Marsh area. The length of the 1-D elements was reduced and additional channels were added. Overbank/fringe marsh was added as off-channel storage based on flow data, LIDAR elevation data and aerial photos. An example illustrating the level of detail in the old and new meshes is shown in Figure 3-1. The entire updated Suisun Marsh network is shown in Figure 3-2.

Five new models grids, each with a project-specific finite element mesh, were developed for the four marsh restoration scenarios as well as for a Base case. The Base case added three new tidal areas to the calibration grid, at Hill Slough, Meins Landing and Blacklock. Hill Slough and Meins Landing represent projects that are under development. The model details for each scenario and the Base case are discussed in Section 5 of this report.

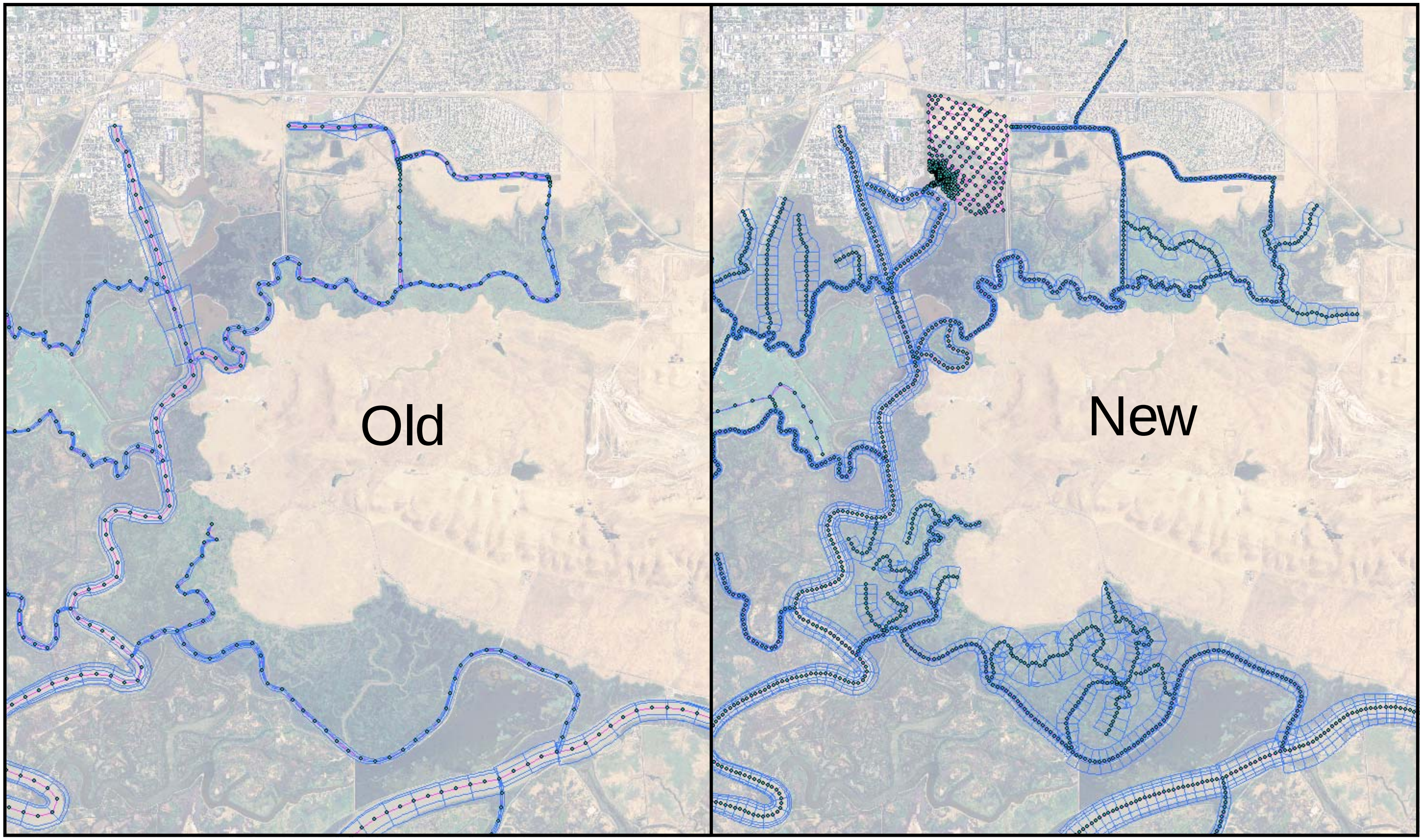


Figure 3-1 Comparison between old and new grid details in the Suisun Marsh Area.

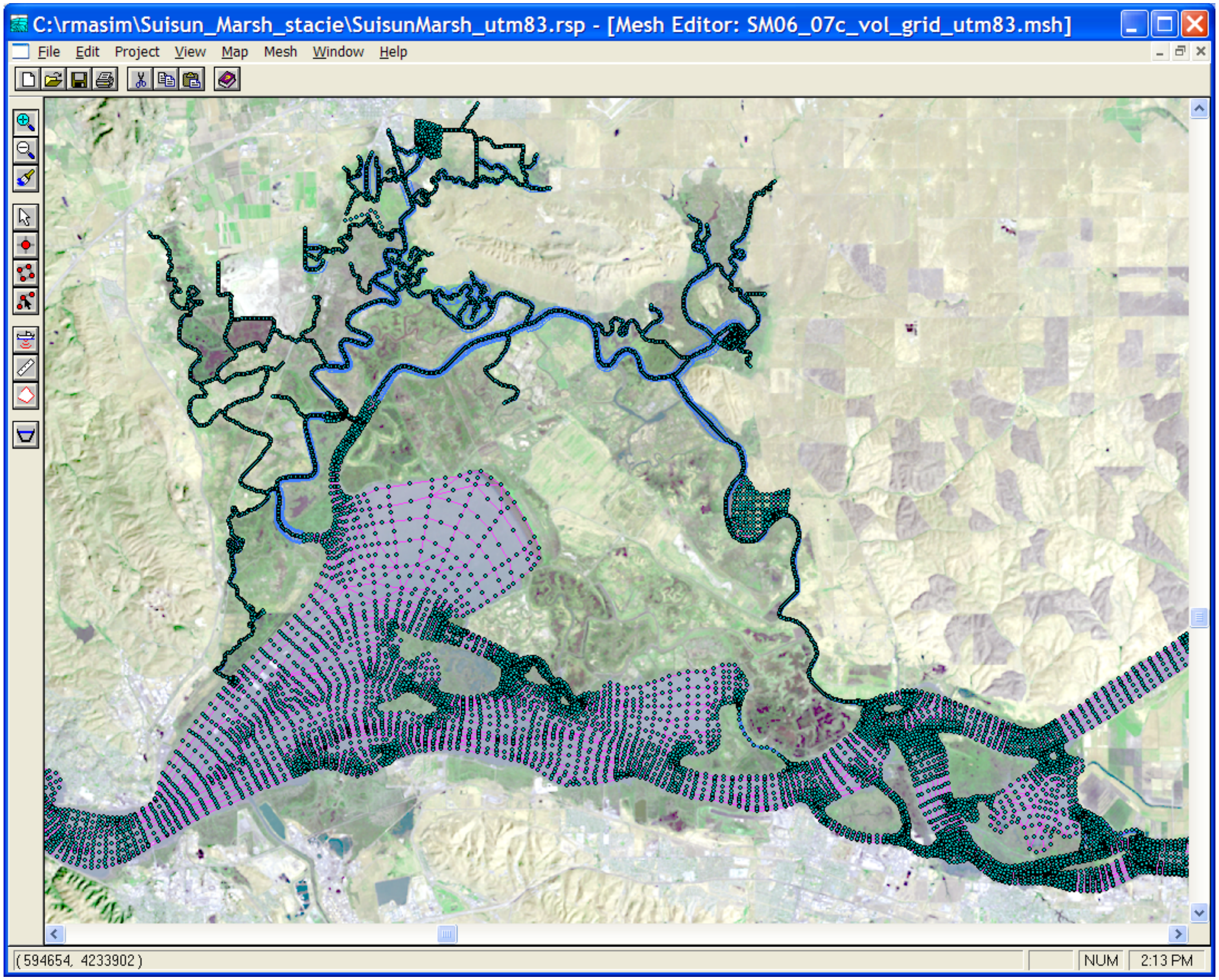


Figure 3-2 Base case Suisun Marsh finite element network.

3.3. Boundary Conditions

Boundary conditions are specified for all inflow and outflow locations and for flow control structures. The locations of the model boundaries for the calibration grid are shown in Figure 3-4.

3.3.1. **Simulation periods**

The hydrodynamic calibration was April – July, 2004, a period where a DWR data collection effort (DWR 2007) provided a crucial dataset. The EC calibration period was April 2002 through December 2003, the same as for the Base case and marsh restoration scenarios simulations. Delta outflow during this period, shown in Figure 3-5, ranged from below average to slightly above average. With a few exceptions noted in Section 5.1, the scenario and Base case boundary conditions are the same as those used in the EC calibration.

3.3.2. **Tidal boundary**

The tidal boundary is set at the Golden Gate, the western boundary of the model, using observed data for the NOAA station at San Francisco. These data were smoothed using a 5 point moving average of the 6-minutes data, and shifted to NGVD + 0.1 m. The 0.1 m shift accounts for density effects between the tidal boundary and Suisun Marsh. The result at Martinez varies with Delta outflow, tidal and atmospheric conditions. An example plot of computed and observed stage at Martinez is shown in Figure 3-3.

3.3.3. **Flows, exports, precipitation, evaporation, DICU**

Inflow locations in the model are shown in Figure 3-4, with the exception of Delta Island Consumptive Use (DICU), which is discussed below. DICU flows incorporate channel depletions, infiltration, evaporation, and precipitation, as well as Delta island agricultural use. (DWR 1995)

Time series of daily average inflow boundary conditions are plotted in Figure 3-5 to Figure 3-7 for the 2002-2003 EC calibration/scenario simulation period and in Figure 3-9 and Figure 3-10 for the 2004 hydrodynamic calibration period. These flows are applied for the Sacramento River, Yolo Bypass, Napa River, San Joaquin River, Cosumnes River, Mokelumne River, and miscellaneous eastside flows which include Calaveras River and other minor flows. The model interpolates between the daily average flows at noon each day. Data from Dayflow (http://www.iep.ca.gov/dayflow/index.html) and the IEP database (http://iep.water.ca.gov/dss/) are used to set these boundary conditions.

Estimated Fairfield Wastewater Treatment Plant (WWTP) flows were are plotted in Figure 3-6 (lower) for the 2002-2003 period. The reported average dry weather flow (ADWF) for the Fairfield WWTP is 13.2 – 14.8 mgd, with a peak wet weather capacity of 34.8 mgd. During dry periods, the WWTP flow in the model was set to 14 mgd. Daily precipitation data from the CIMIS station at Suisun Valley were used to estimate wet weather flows. Total wet weather flows were 14 mgd plus an additional flow of 3.8 mgd for each inch of the previous day's precipitation. These flows were not included in the hydrodynamic calibration because, although they have a large effect on EC, their effect on hydrodynamics is insignificant.

Flow data for Suisun Creek at Putah South Canal and Green Valley Creek at Green Valley Country Club are plotted in Figure 3-7 for the 2002-2003 period. Data were provided by Solano County Water Agency. Gaps in the Suisun Creek data were filled using flows estimated from Napa River flows scaled based on drainage area. This Suisun Creek data set was in turn scaled by drainage area for application to Ledgewood and Laurel Creeks. These flows were not included in the hydrodynamic calibration, as their effect on hydrodynamics is only significant during storm flow periods.

DICU values are applied on a monthly average basis and were derived from monthly DSM2 input values (DWR, 1995). Table 3-1 summarizes the total monthly diversions (incorporates agricultural use, evaporation and precipitation), drains (agricultural returns), seeps (channel depletions) and total flows used for DICU flows. Negative flows indicate net withdrawal from the system. These flows are distributed to multiple elements throughout the Delta using an in-house utility program.

Delta exports applied in the model include SWP, CVP, Contra Costa exports at Rock Slough and Old River intakes, and North Bay Aqueduct intake at Barker Slough. Exports are plotted for the 2002-2003 period in Figure 3-8 and the 2004 period in Figure 3-10. Dayflow and IEP database data are used to set daily average export flows for the CVP, North Bay Aqueduct and Contra Costa’s exports.

Hourly SWP export flows for 2003 and 2004 are computed using the Clifton Court gate ratings and inside and outside water levels. The flows are adjusted on a monthly basis so the total computed flow matches the monthly SWP export. For 2002, when water levels inside and outside the gates were not available, SWP exports were defined using DSM2 node 72 flow, modified to remove erroneously large flows. Further details on Clifton Court Forebay gate operations can be found in (RMA, 2000), RMA’s Flooded Islands Feasibility Study (RMA, 2005), and in (DWR 2004).

Duck club ponds are filled and drained seasonally to provide appropriate habitat and opportunity to attract migrating ducks. Flows had to be estimated to approximate diversion (filling) and return (draining) flows in the vicinity of the marsh. For modeling purposes, it was assumed that they filled at a constant rate (no tidal variation) from a depth of -1.0 ft to +1.0 ft over a 14 day period beginning October 1. The ponds were subsequently drained at a constant rate between March 1 and June 1. Flow rates were computed as the area to be filled multiplied by the depth of water (2.0 ft) divided by the time to fill or drain. No exchange between the modeled marsh flows and the duck club ponds occurred during the summer, from June 1 through October 1.

Evaporation and precipitation data were used to compute flows required to maintain ponds at a constant level from October 15 (following filling) through February. Flow volumes were based on areas for the following locations: Montezuma Slough (East, Middle and West), Suisun Slough, Nurse Slough, Morrow Island (fill only) and Roaring

River. Locations of inflow/withdrawal in the Marsh are shown for the Base case mesh in Figure 3-13 – these locations are the same for the four scenarios.

Daily Suisun Valley CIMIS station precipitation data was used to compute additional inflows from tidal marsh areas during rainfall events. Areas of tidal marsh were estimated and multiplied by the daily precipitation data. Inflows from tidal marsh were input at Beldon's Landing, Boynton Slough, Cutoff Slough, First Mallard Slough, Hill Slough and Peytonia Slough. Locations are shown in Figure 3-12.

3.3.4. Electrical Conductivity (EC)

The western EC boundary of the model, at the Golden Gate is set at 50,000 µmhos cm^{-1}, the EC of seawater. EC boundary conditions are set at all inflow boundaries. Table 3-2 gives the source of the EC boundary conditions. Figure 3-13 shows the EC time series boundary conditions at the major boundaries.

3.3.5. Suisun Marsh Slough Salinity Control Gate operation

The model representation of the Suisun Marsh Salinity Control Gates (SMSCG) consists of a series of three tide gates to represent the radial gates, and a standard gate to represent the flashboard (Figure 3-14). All four gates can be operated individually. Figure 3-15 and Figure 3-16 illustrate the timing of the radial gate operation and the flashboard structure placement during the 2002-2003 simulation period, and the 2004 hydrodynamic calibration period, respectively. The SMSCG control season is from early October through the end of May.

3.3.6. Precipitation and evaporation by element type

The ability to apply daily time series of precipitation and evaporation was added to the model for the Suisun Marsh simulations. In previous versions of the model, the monthly DICU inflows/outflows were the only evaporation and precipitation inputs, and these were applied to individual model elements only in the Delta. In Suisun Marsh, the impacts of evaporation and short time scale variations in precipitation were incorporated in selected areas of the grid by element type ID, and applied on a per-unit-area basis using daily time series of precipitation and evaporation data from the Suisun Valley CIMIS Station.

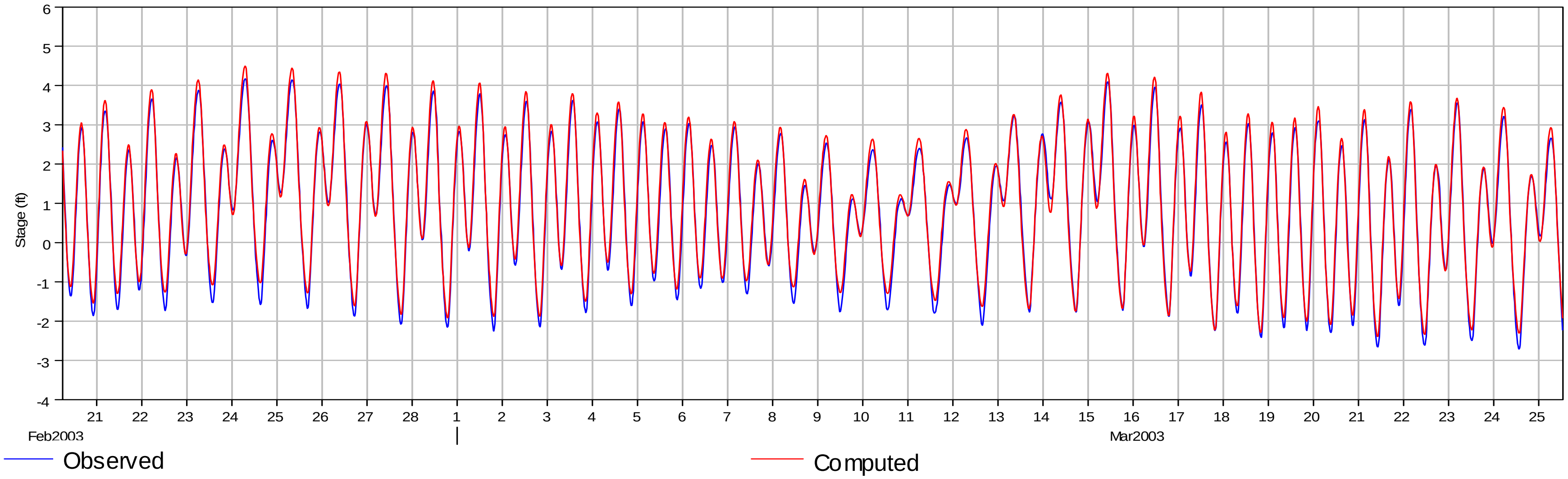


Figure 3-3 Example of computed and observed stage at Martinez.

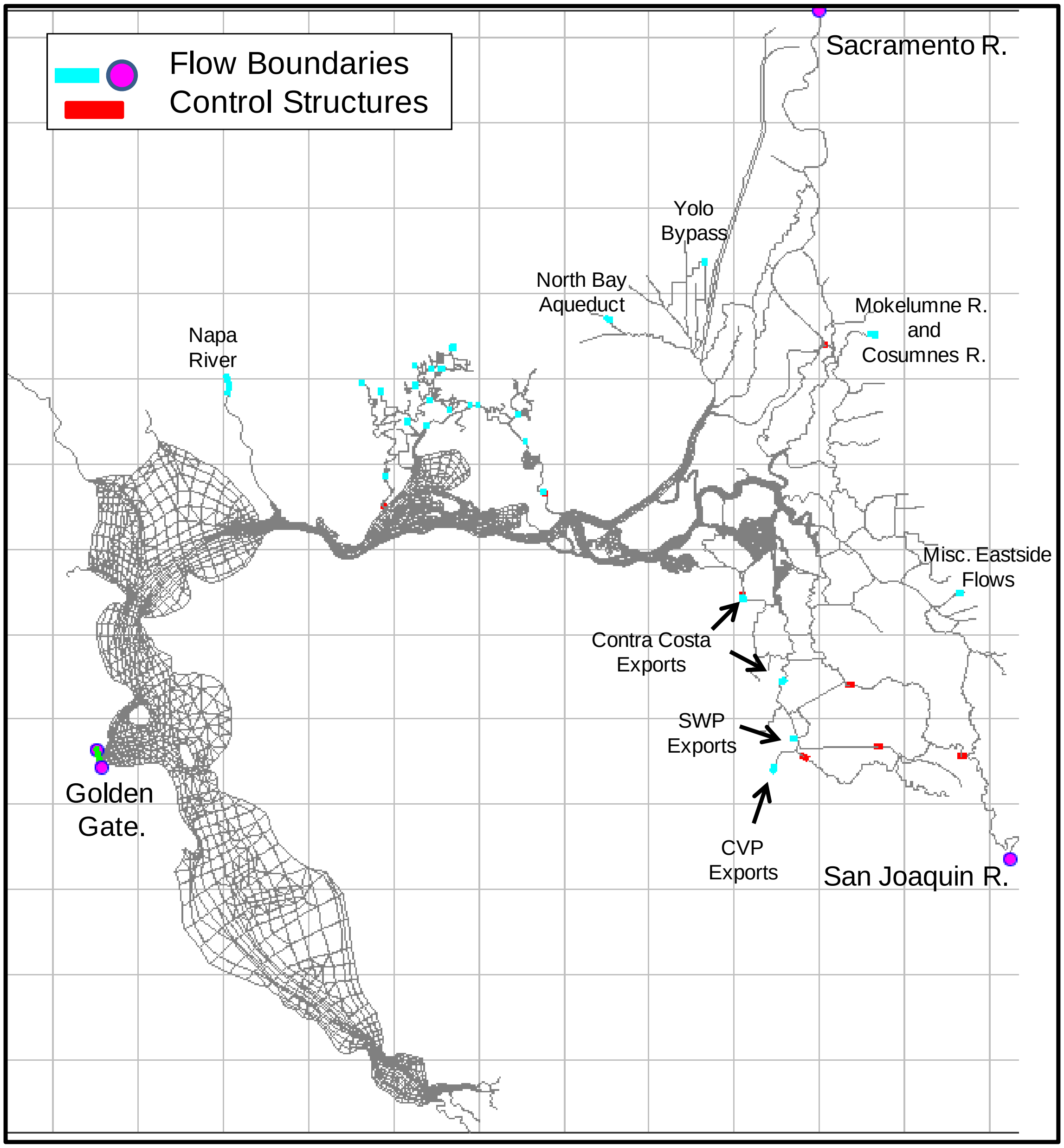


Figure 3-4 Model grid showing inflow and export locations, and flow control structures.

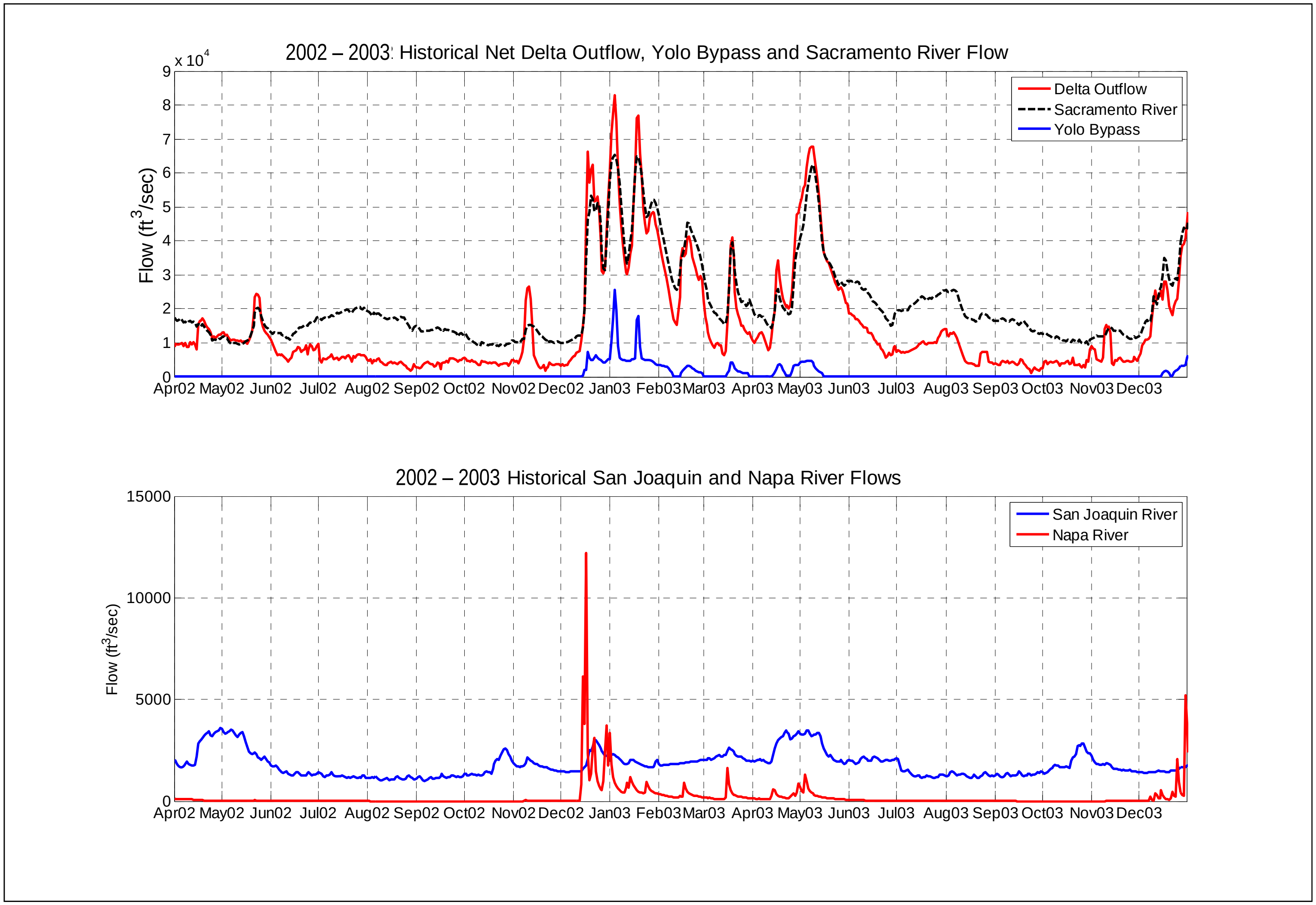


Figure 3-5 Net Delta outflow and major boundary flows for the 2002-2003 EC calibration/scenario simulation period.

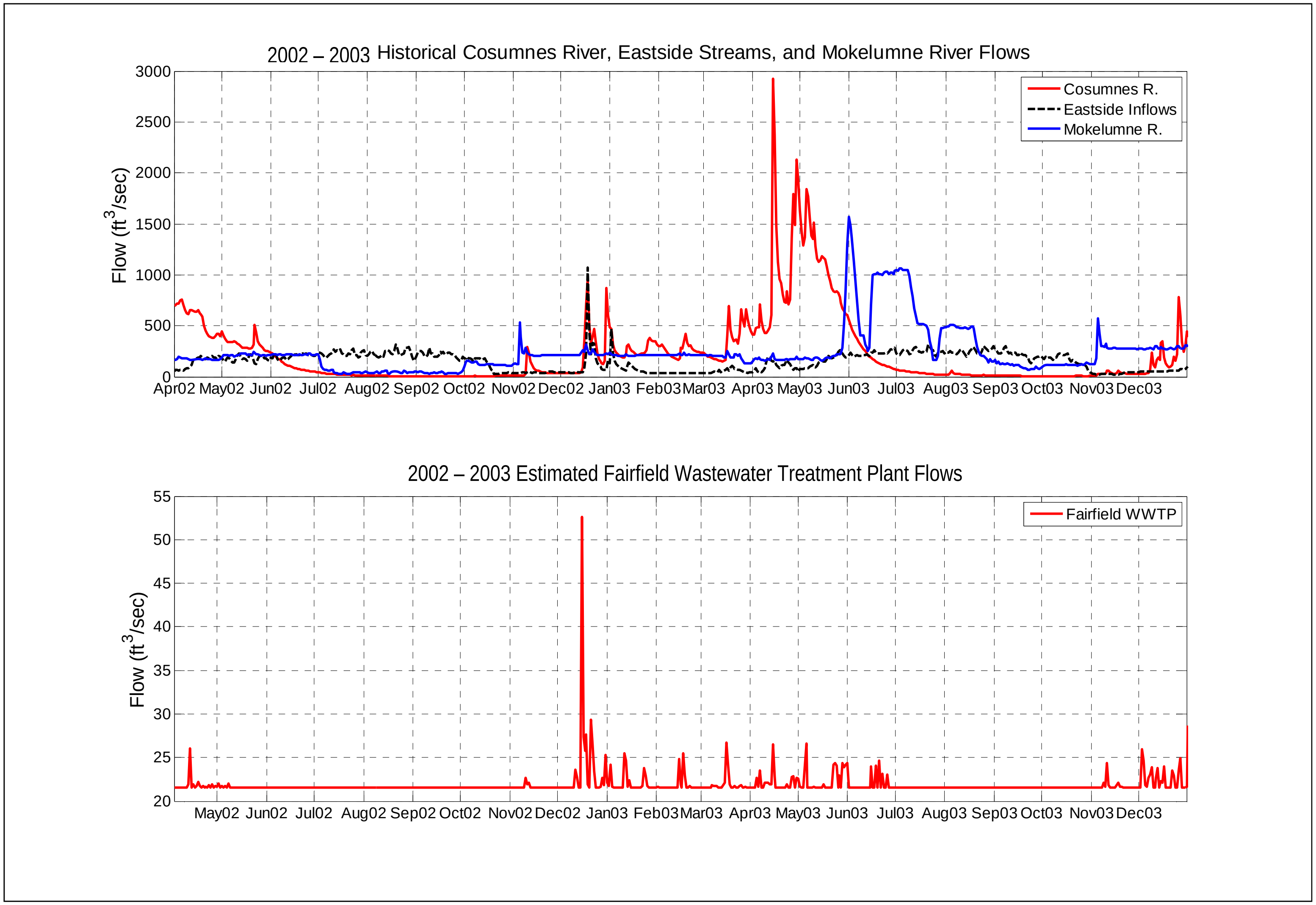


Figure 3-6 Minor boundary flows for the 2002-2003 EC calibration/scenario simulation period.

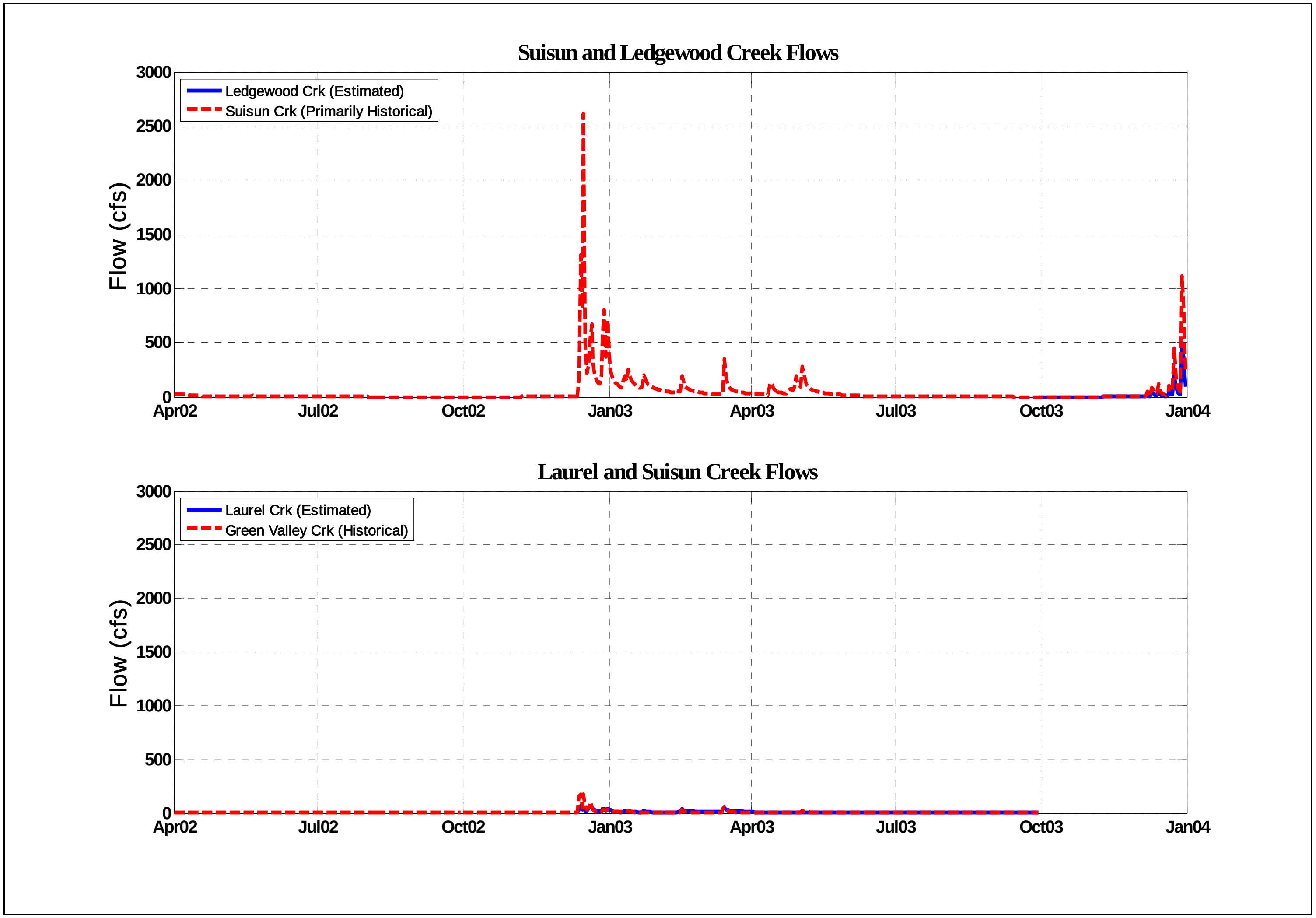


Figure 3-7 Suisun Marsh local creek flows for the 2002-2003 EC calibration/scenario simulation period.

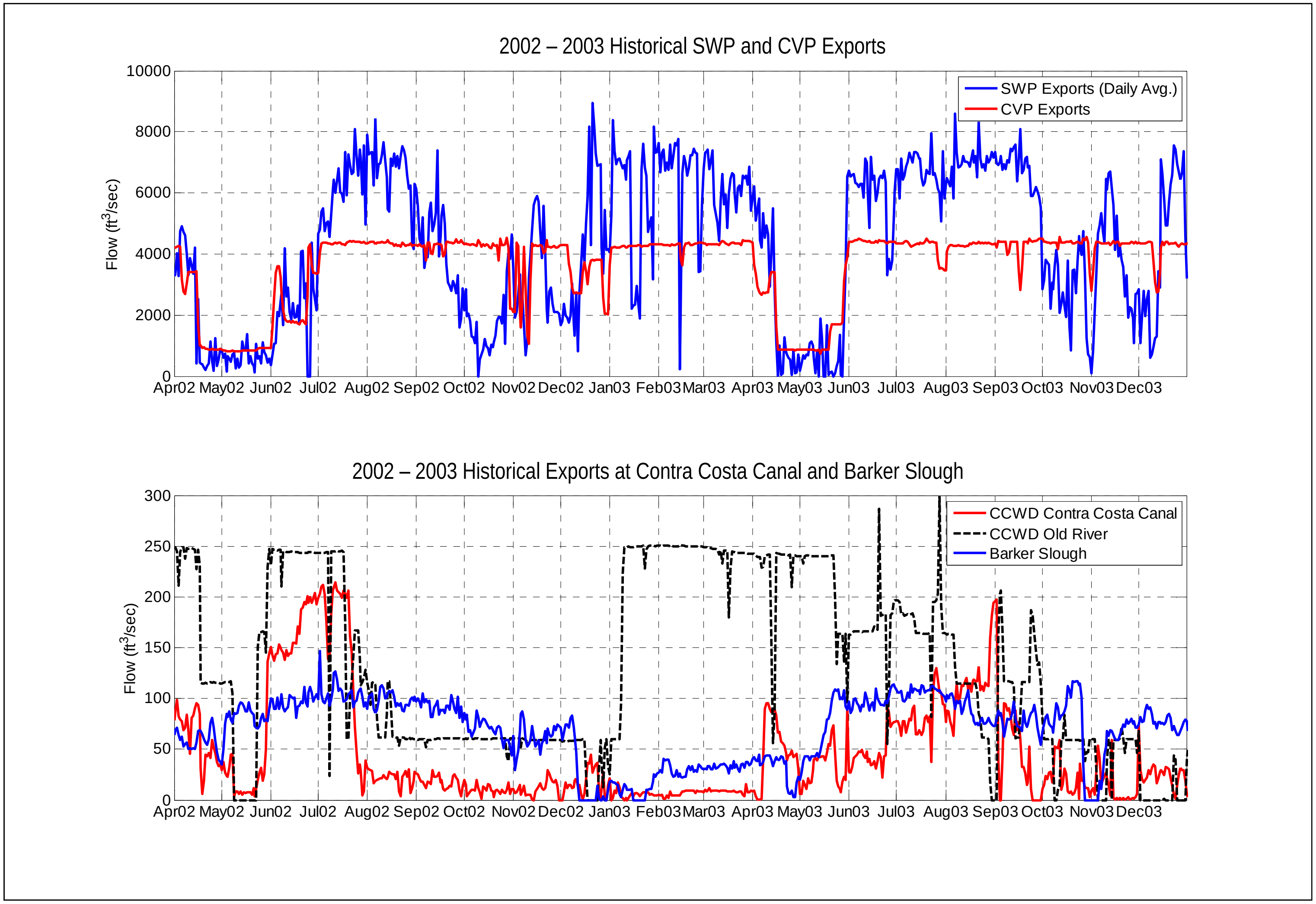


Figure 3-8 Historical exports and diversions used in the model for the 2002-2003 EC calibration/scenario simulation period. Note that daily averaged SWP exports are plotted, however the model uses 15-minute inputs.

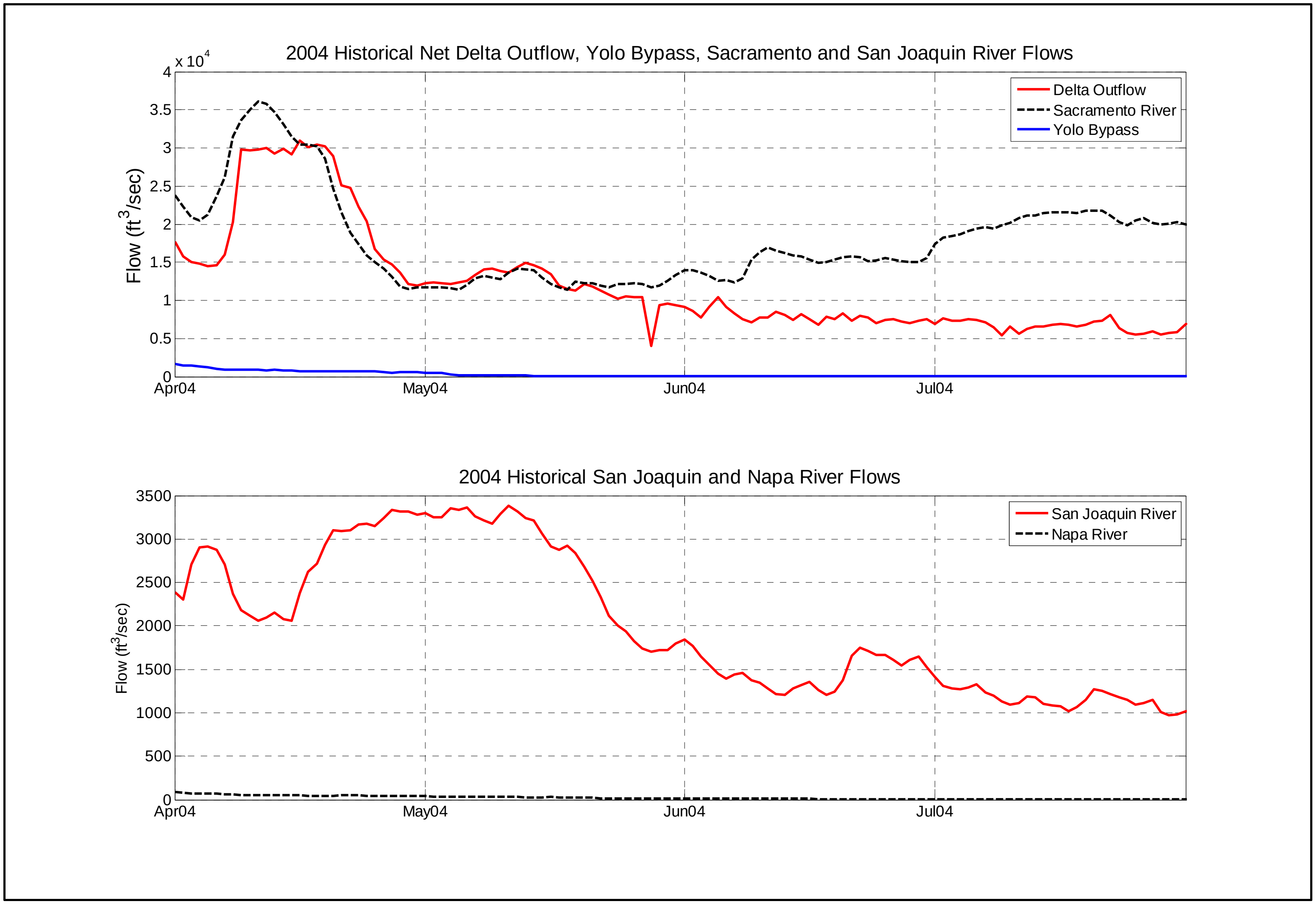


Figure 3-9 Major boundary flows for the 2004 hydrodynamic calibration period.

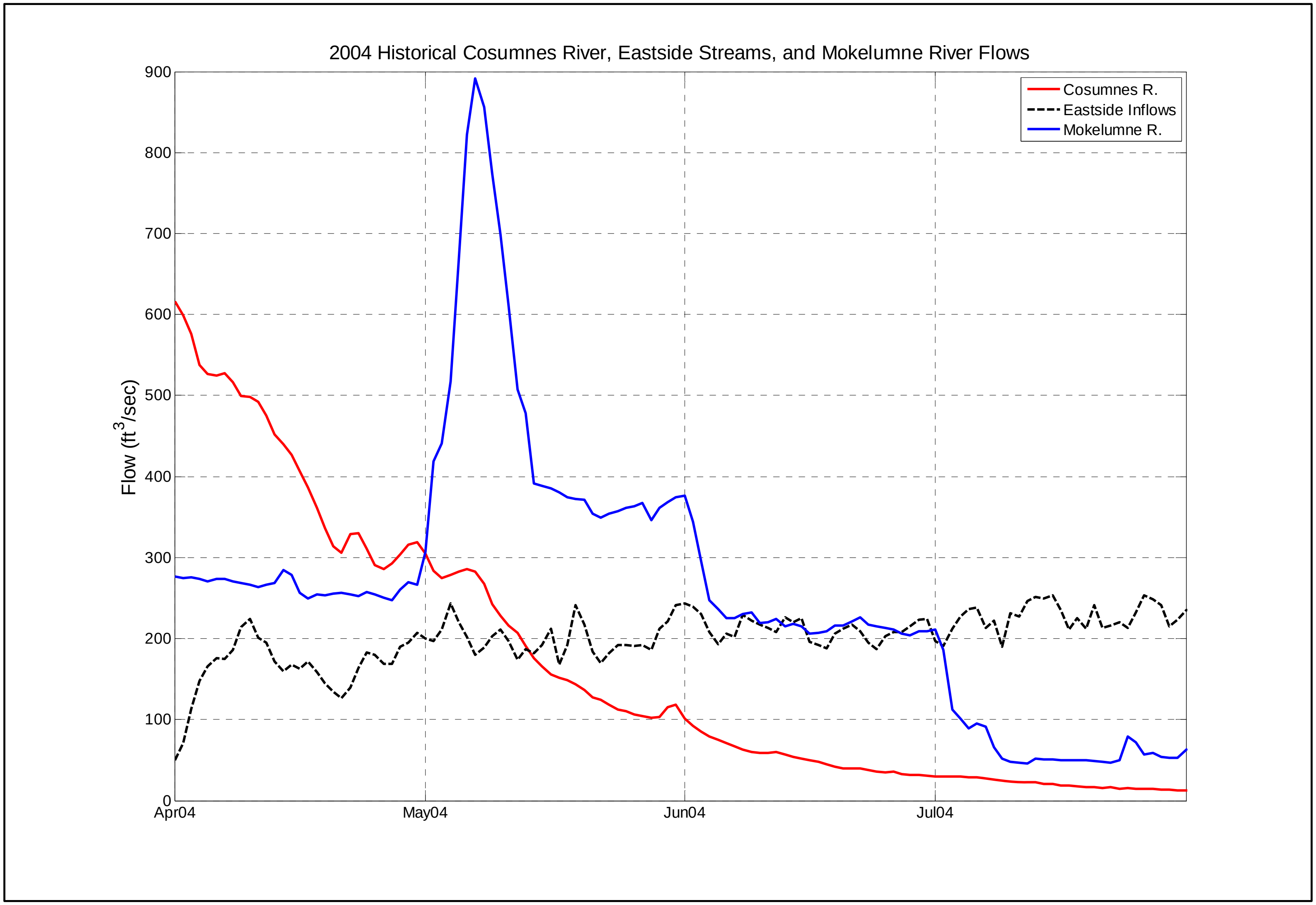


Figure 3-10 Minor boundary flows for the 2004 hydrodynamic calibration period.

Table 3-1 Summary of monthly DICU flows ($ft^3 sec^{-1}$) for the calibration and scenario simulation periods. Negative values indicate Delta withdrawal.

Month	Diversions (-)	Drains (+)	Seeps (-)	Total
EC calibration period				
April 2002	2109.9	1121.8	1006.4	-1994.5
May 2002	3978.0	1710.4	973.4	-3241.0
June 2002	4850.2	1995.6	1006.4	-3860.9
July 2002	4943.0	2011.0	973.4	-3905.4
August 2002	2659.8	1265.9	973.4	-2367.3
September 2002	1231.2	848.4	1006.2	-1389.1
October 2002	875.2	681.1	973.2	-1167.4
November 2002	268.9	576.2	1018.0	-710.8
December 2002	429.2	2318.5	633.9	1255.4
January 2003	2.0	133.4	575.7	755.7
February 2003	62.6	873.8	714.1	97.1
March 2003	314.5	741.1	725.6	-299.0
April 2003	405.9	825.8	701.1	-281.2
May 2003	1438.8	894.3	980.5	-1525.0
June 2003	2929.1	1346.7	1006.2	-2588.6
July 2003	5254.4	2108.3	973.1	-4119.2
August 2003	2569.5	1237.3	985.8	-2318.0
September 2003	1351.0	884.2	1006.2	-1472.9
October 2003	981.1	709.1	973.1	-1245.2
November 2003	272.5	528.7	1027.2	-771.0
December 2003	429.2	1011.2	791.9	-209.9
Hydrodynamic calibration period				
April 2004	1559.5	951.8	1003.9	-1611.6
May 2004	3014.1	1364.0	975.0	-2625.1
June 2004	4018.5	1705.6	1006.3	-3319.2
July 2004	5006.5	2030.6	973.4	-3949.4

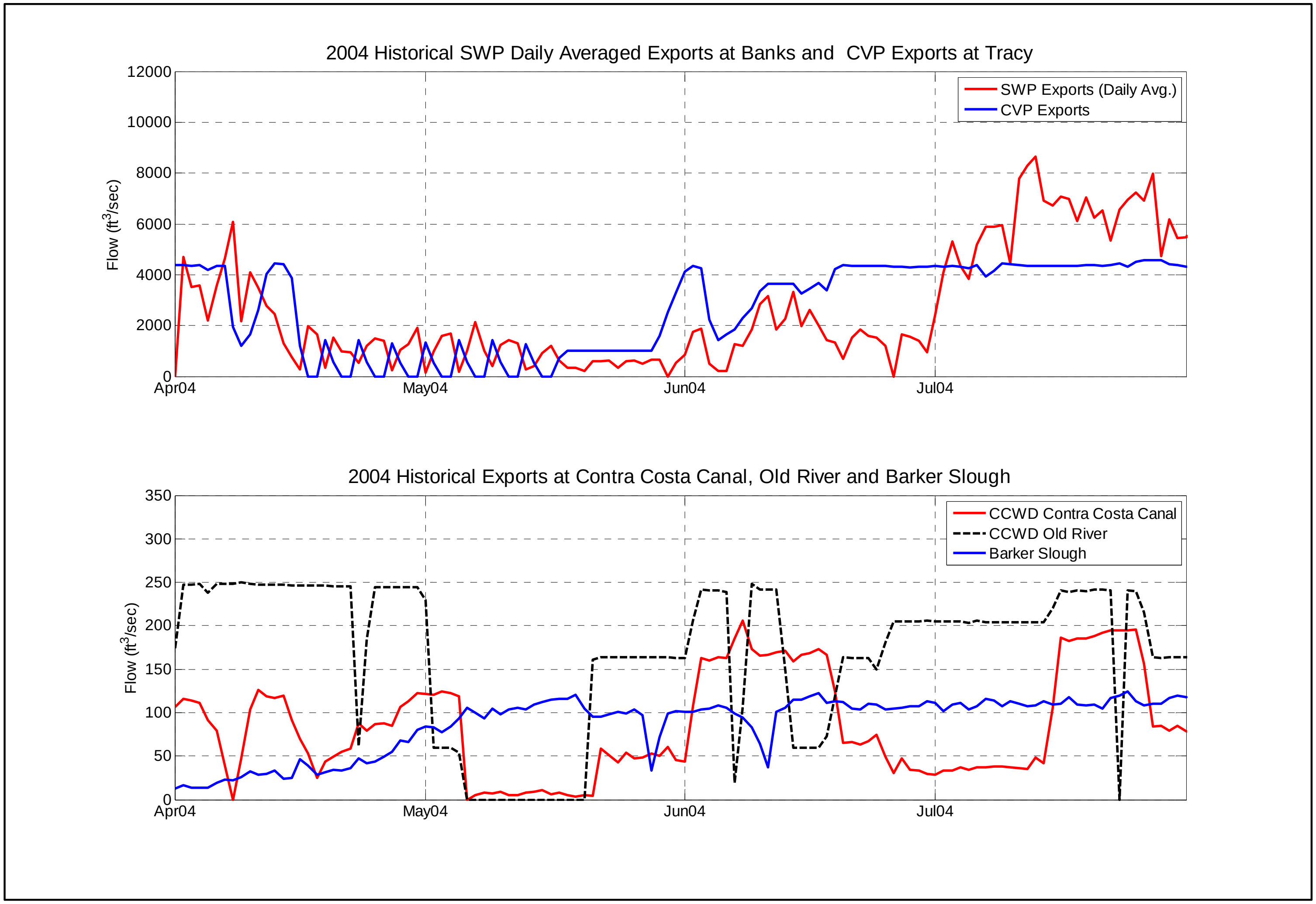


Figure 3-11 Historical exports and diversions used in the model for the 2004 hydrodynamic calibration period. Note that daily averaged SWP exports are plotted, however the model uses 15-minute inputs.

1	Morrow Island managed wetland
2	Green Valley Creek
3	Suisun Creek
4	Suisun Slough
5	Montezuma Slough west managed wetland
6	Boynton Slough tidal marsh
7	Fairfield WWTP
8	Ledgewood Creek
9	Peytonia Slough tidal marsh
10	Hill Slough tidal marsh
11	Laurel Creek
12	First Mallard Slough tidal marsh
13	Cutoff Slough tidal marsh
14	Beldons Landing tidal marsh
15	Montezuma Slough middle managed wetland
16	Nurse Slough managed wetland
17	Montezuma Slough east managed wetland
18	Roaring River managed wetland

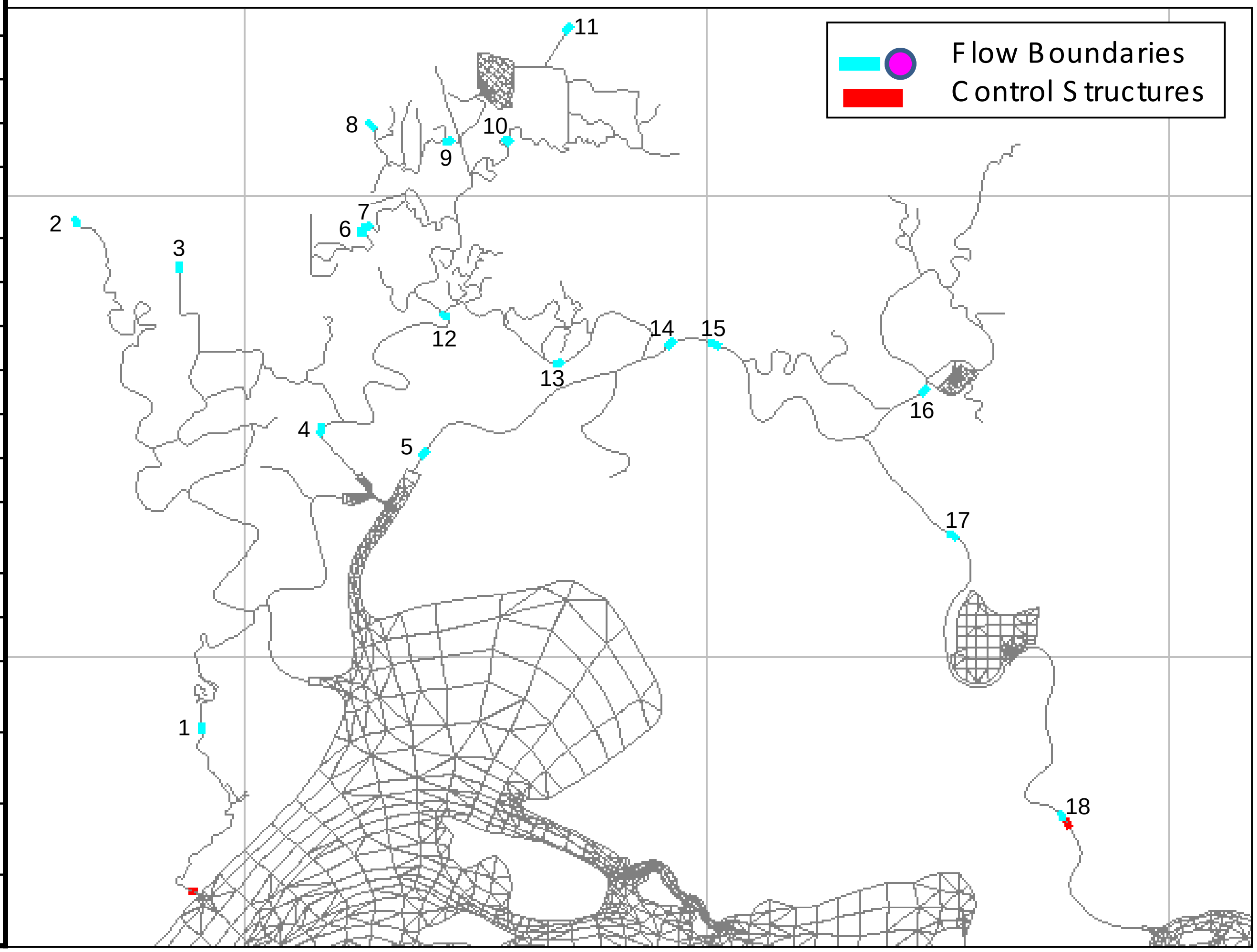


Figure 3-12 Inflow/export locations in Suisun Marsh.

Table 3-2 EC boundary conditions for the EC calibration, Base case and scenarios simulations.

Boundary Location	Value (µmhos cm^{-1})	Data Source
Golden Gate	50,000	Seawater EC
Sacramento River	Time Series	DWR DSM2
Yolo Bypass	Sac. River Time Series	DWR DSM2
San Joaquin River	Time Series	DWR DSM2
DICU	Monthly Time Series	DWR's DICU model
Cosumnes River	150	Estimated
Mokelumne River	150	Estimated
Misc. Eastside Rivers	750	Estimated
Fairfield WWTP	120	Estimated
Napa River, Green Valley Creek, Suisun Creek, Ledgewood Creek, Laurel Creek	120	Estimated; Napa R. based on measured data
Duck Club Drains: Nurse Slough drain Suisun Slough drain Roaring River drain Montezuma Slough West Montezuma Slough Middle Montezuma Slough East	Estimated Using Source Time Series Data:	 Beldon's Landing Observed EC Boynton Sl. Observed EC, shifted in time Roaring River Observed EC Hunter Cut Observed EC Beldon's Landing Observed EC National Steel Observed EC
Tidal Marsh – Boynton Slough Peytonia Slough Hill Slough First Mallard Slough Cutoff Slough	Estimated Using Source Time Series Data:	 Boynton Sl. Observed EC, shifted in time Hill Slough Observed EC Hill Slough Observed EC Beldon's Landing Observed EC Beldon's Landing Observed EC

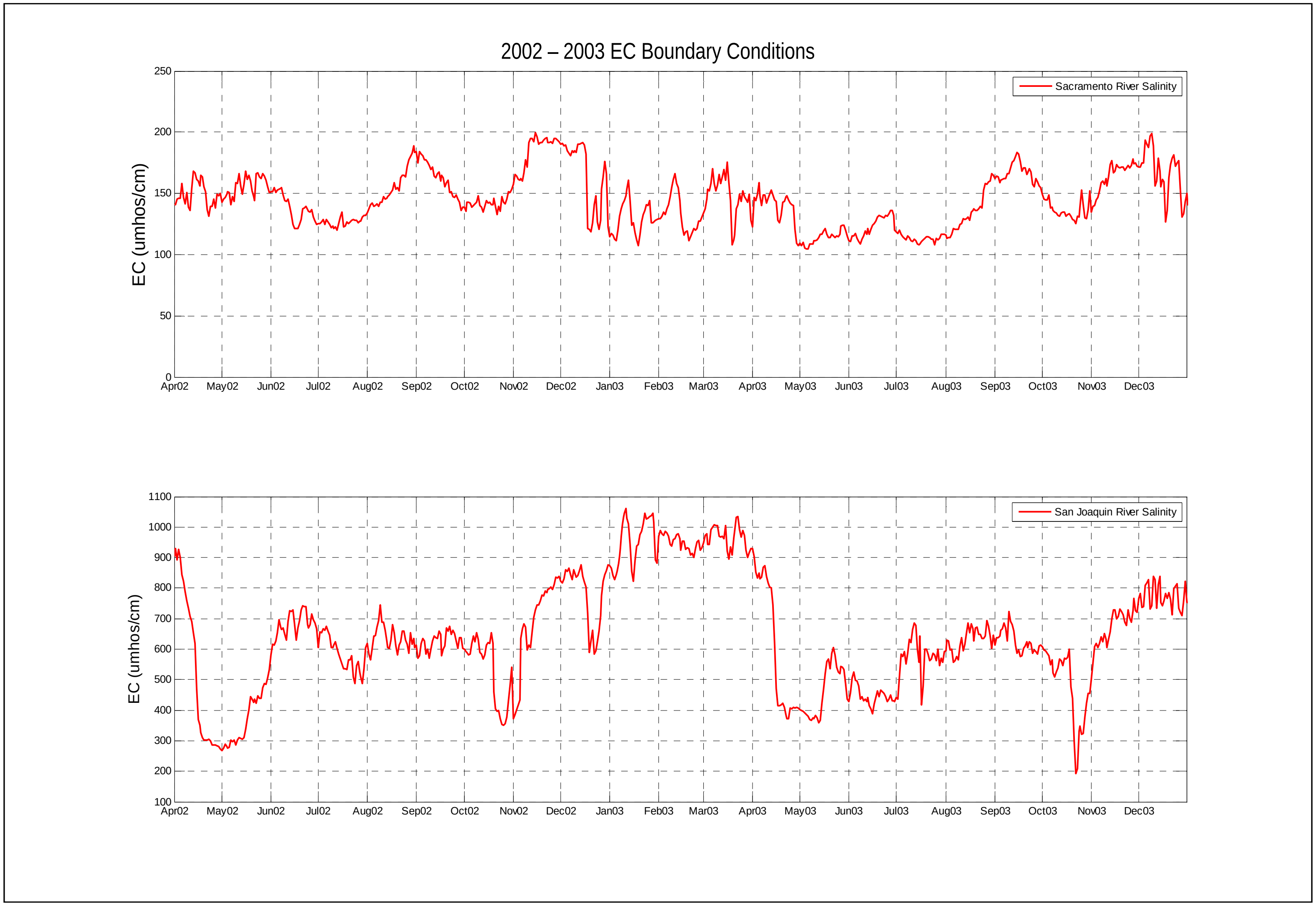


Figure 3-13 Daily EC time series used as boundary conditions for the Sacramento River and Yolo Bypass (upper) and for the San Joaquin River (lower) for the 2002-2003 EC calibration/scenario simulation period.

Figure 3-14 Aerial view of the Suisun Marsh Salinity Control Gates.

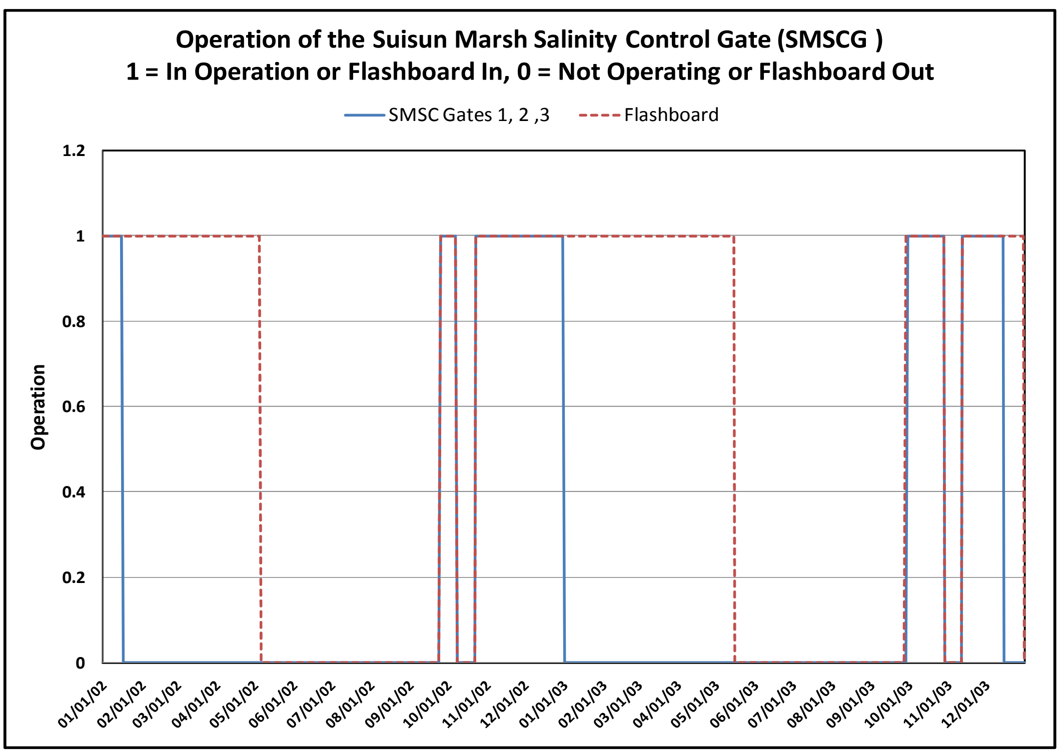


Figure 3-15 Operational schedule for the SMSCG during the 2002-2003 EC calibration/scenario simulation period.

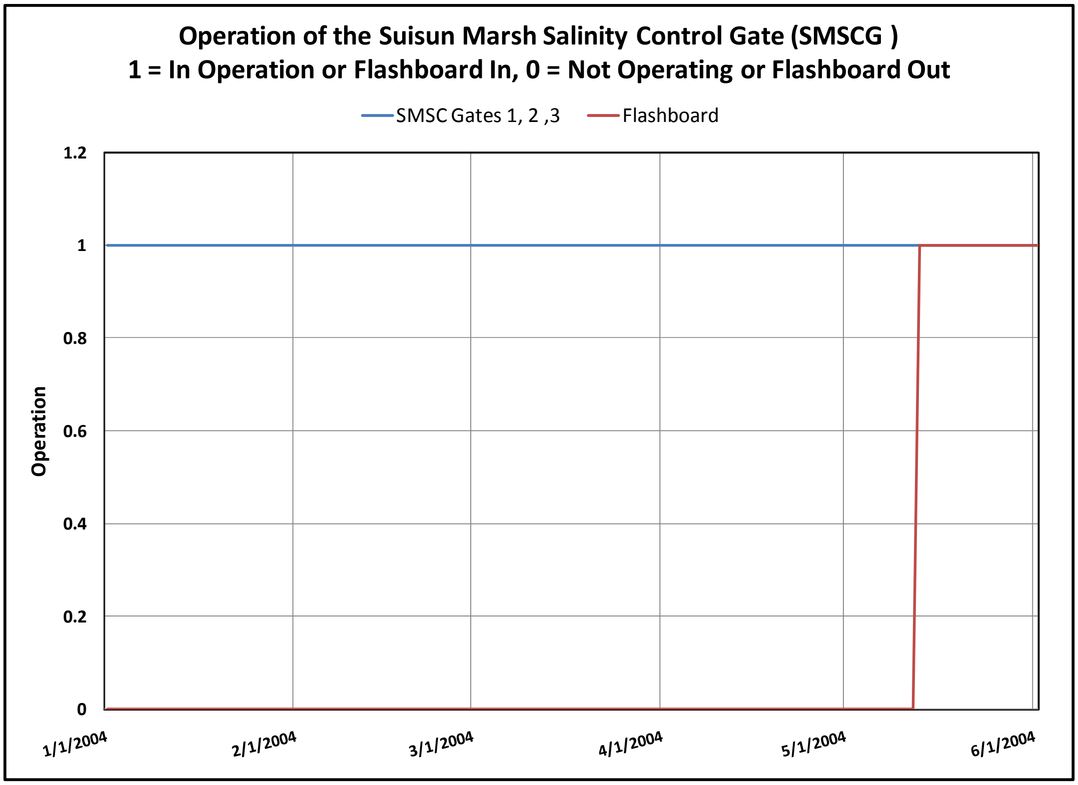


Figure 3-16 Operational schedule for the SMSCG during the 2004 hydrodynamic calibration period.

4. Model Calibration

The objective of the calibration effort was to prepare the model for detailed evaluation of flow and EC effects associated with the four marsh restoration scenarios proposed in the Suisun Marsh study. Understanding and accurately representing the changes in short time scale flow and mixing processes in the model is important in predicting the effects of these scenarios.

A recent calibration of RMA's Bay-Delta model for the Flooded Islands Feasibility Study (RMA, 2005) was used as the starting point for the current effort to improve the representation in Suisun Marsh. There was no recalibration of flow or EC in the Delta.

4.1. Hydrodynamics Calibration

The RMA2 hydrodynamic model calibration covered the period April – July, 2004. The Jones Tract levee break occurred during this period, which is included in the model representation (RMA, 2005). Both the breach event and the subsequent levee repair were explicitly modeled.

In 2004, the DWR field program collected continuous flow data in major channels and dead-end sloughs in Suisun Marsh from April through early August – these data were used for calibrating the hydrodynamic model (DWR 2004a). Figure 4-1 gives the locations of stations in Suisun Marsh providing data for the hydrodynamic calibration. A new LiDAR dataset provided detailed elevation data, shown in Figure 4-2, which was instrumental in improving the model representation and the subsequent calibration in Suisun Marsh along with aerial photographs.

The flow and stage calibration greatly improved the representation of hydrodynamics in the Suisun Marsh region. DWR's continuous monitoring data from Suisun Marsh (Figure 4-1, white boxed labels) for flow and stage was used to guide the calibration, and LiDAR data (DWR, 2007) and aerial photographs were used to help define the extent and elevation of tidal marsh areas. The revised mesh geometry incorporated new marsh channels and off-channel storage to represent marsh overbank. RMA2 was updated to include the ability to represent daily time series of precipitation and evaporation.

4.1.1. **Refining Suisun Marsh sloughs**

The 2004 DWR field survey included the monitoring of flow and stage at the mouths of a number of dead-end sloughs. These sloughs were Nurse Slough (NS1), Hill Slough (HS1), First Mallard Slough (FM1), Cutoff Slough (C01 and C02), Boynton Slough (B01) and Shelldrake Slough (SH1). The first step of the calibration procedure was to model an individual dead-end slough and refine the network representation until the model flow closely matched the observed flow as recorded at the mouth of the slough. The model slough tidal boundary was driven by the observed stage at the mouth of the slough or from a nearby Suisun Marsh monitoring/compliance station (Figure 4-1). The refined and calibrated dead-end sloughs were then inserted back into the RMA Bay-Delta model for the subsequent calibration of the major Suisun Marsh sloughs and channels, specifically Montezuma (M01, M02, M03 and M04) and Suisun Sloughs (SS1) and Hunter Cut (HC1).

Details of the observed flow and stage records were used to iteratively refine the model representation. LiDAR images and aerial photographs were used to understand the geography, and to estimate the location, extent and elevation of tidal marsh. For example, aerial photographs sometimes helped define areas covered with specific vegetation such as tules, which gives an indication of inundation around Mean Higher High Water (MHHW).

Figure 4-3 illustrates how differences between the observed and computed values for flow as the tidal marsh filled and drained were used to refine the initial estimates of marsh area associated with Boynton Slough. As the water level rises above 3.0 feet (June 16 @ 22:00), the initial slough model (red line) shows an early fall off in flood flow relative the observed flow. Similarly, the initial slough model is low on the following peak ebb flow as the stage begins to fall. The slough model was modified to increase the amount of overbank marsh and the simulation rerun. The green line in Figure 4-3 shows the better fit to observed flow with the revised slough representation.

4.1.2. **Incorporating managed wetlands**

Figure 4-4 presents the tidally averaged observed and computed flow for Boynton (B01) and Hill (HS1) Sloughs and the observed stage at Hill Slough (S-4). The observed tidally averaged flows show a distinct net flow landward during most spring tide periods. This was typical of all observed flow records for the dead-end sloughs for the April – July, 2004 monitoring period. The tidally averaged computed flows show only small fluctuations in the net flows as the average water level rises with the spring tide and falls with the neap tide. The observed flow records show a significantly greater net landward flow during the spring tide periods. The Boynton Slough observed flow also exhibits notable net outward flow around July 5 and July 31.

The differences between the observed and initial computed net flows are most likely related to exchange with the managed wetlands and the wetting and evaporation of the tidal marsh on the spring tide. A trial model simulation was performed for Boynton Slough in which an adjacent managed wetland was added and connected to the slough by open culverts. Evaporation was simulated with a withdrawal from the managed wetlands of 7 cfs in the May 1-27 period and 21 cfs in the May 27 – June 30 period.

The addition of the managed wetland with evaporation significantly improves the fit of the model to the observed net flows. Figure 4-5 compares the new simulation result to the observed record and to a simulation with no evaporation or managed wetland. Figure 4-6 shows the improved fit to the intertidal flow with the managed wetland addition, in particular where the computed flood flow was initially too low. Evaporation from adjacent tidal marsh and the channel water surface is another source of water loss from Boynton Slough and other marsh channels. The 21 cfs rate of water loss modeled for late May and June is equivalent to 1260 ac-ft/month. The open tidal marsh and water surface upstream of the Boynton Slough flow meter is about 230 acres. Thus evaporation from the tidal marsh alone is not sufficient to account for the 1260 ac-ft/month flow loss.

The trial model demonstrated that the addition of managed wetland with evaporation significantly improved intertidal flow. However, simulation of tidal flow through the managed wetlands was not incorporated into the final model simulations.

The observed flow records may also indicate the diversion of flow from Montezuma Slough. Figure 4-7 shows the tidally averaged observed flow for the Montezuma Slough stations M03, south of Nurse Slough, and M04, south of the Suisun Marsh Salinity Control Gates. The curves show more flow into Montezuma Slough at M04 than exiting at M03 for portions of April and May 2004. The net flows at the two stations are roughly equal in June and July. Peak difference is about 500 cfs around May 5, 2004. The stage records inside the managed wetlands at the Roaring River intake location and for Montezuma Slough suggests large diversions occurring at the intake in early May (Figure 4-7).

Except for the trial simulations for the model of only Boynton Slough, diversions to the managed wetlands were not generally part of the 2004 hydrodynamic calibration. There was not sufficient detailed knowledge to attempt to reproduce all the characteristics of the managed wetlands culvert structures and operation within the tidal cycle. The observed flow data suggests the diversions and returns by the managed wetland, and evaporative losses for the tidal marsh. The differences in observed and computed net flows were used to help guide estimates of the wetlands diversions and returns. Further estimation of wetlands diversions/returns and evaporative losses for the channels and marsh were refined in the EC calibration phase.

4.1.3. **Results of the hydrodynamic calibration**

As described above, the dead-end sloughs were first calibrated in the isolated fashion, and then the revised slough networks were reinserted into the full RMA Bay-Delta model. The model flows and stages presented in this section are for the full Bay-Delta model. The diversions to the managed wetlands were not included in this hydrodynamic calibration and would likely influence both the net and intertidal flows. The estimation of the managed wetlands diversions/returns on a gross basis was performed as part of the EC calibration. The detailed hydraulic properties of the many culvert structures throughout the Suisun Marsh and the operation of these structures on a tidal and daily time scale create a large set of unknown variables. As such, the managed wetlands diversions/returns were not generally included during the hydrodynamic calibration except on an experimental basis.

Flow in dead-end sloughs and stage representations were generally good through-out the marsh. Figure 4-8 through Figure 4-11 give representative results for stage calibration (NGVD29) at three monitoring locations. Timing was slightly retarded in comparison with observed stage. Modeled stage tended to be somewhat low in Montezuma Slough, particularly during neap tides.

Tidal flow results were more variable. Figure 4-12 illustrates the tidal flow calibration at station NS-1 in Nurse Slough , showing that calculated flood tide flow was generally too low at this location. The tidally averaged observed flows for Nurse Slough showed large negative values on average of -400 cfs. There was no attempt to simulate culvert flows to managed wetlands for Nurse Slough, which may have improved the computed vs. observed fit. The computed flow vs. observed for Hill Slough (HS1) is very good, with the computed tidal flow amplitude slightly overestimated (Figure 4-9).

Tidal flow in Cutoff Slough (Figure 4-13) and First Mallard Slough (Figure 4-14) is slightly too large during ebb tide, but otherwise good in phase and magnitude. Tidal flow in Montezuma Slough was generally too low (Figure 4-15 through Figure 4-17), and the differences were significant here although phasing was quite good. Trial simulations were performed which examined incorporating culvert flows into the Roaring River distribution system (just north of the Suisun Marsh Salinity Control Gates). These results suggested that computed tidal flow and net flow for M04 may be somewhat improved by explicit modeling of the culverts to the Roaring River distribution system and to other managed wetlands diversions.

The differences between observed and calculated tidal flow in Suisun Slough and Hunter’s Cut are likely related, as Suisun Slough above Hunter Cut is filled by both channels. Figure 4-18 and Figure 4-19 show modeled and observed tidal flows at the mouth of Suisun Slough and in Hunter Cut, respectively. The low values for tidal flow in Hunter Cut may be compensated by larger-than-observed tidal flow through the mouth of Suisun Slough.

Generally, these calibration results showed good agreement between the simulated and measured tidal elevations (stage) and between the simulated and measured tidal flows at many different locations in the marsh during 2004. The model results can be used with confidence to estimate the effect of additional tidal restoration.

Figure 4-1 Locations of stations in Suisun Marsh used for flow and EC calibration. The white boxed labels indicate special continuous monitoring stations implemented during spring 2004.

Figure 4-2 Suisun Marsh LiDAR data used in the model calibration – elevations shown in the color scale are in feet (NGVD29).

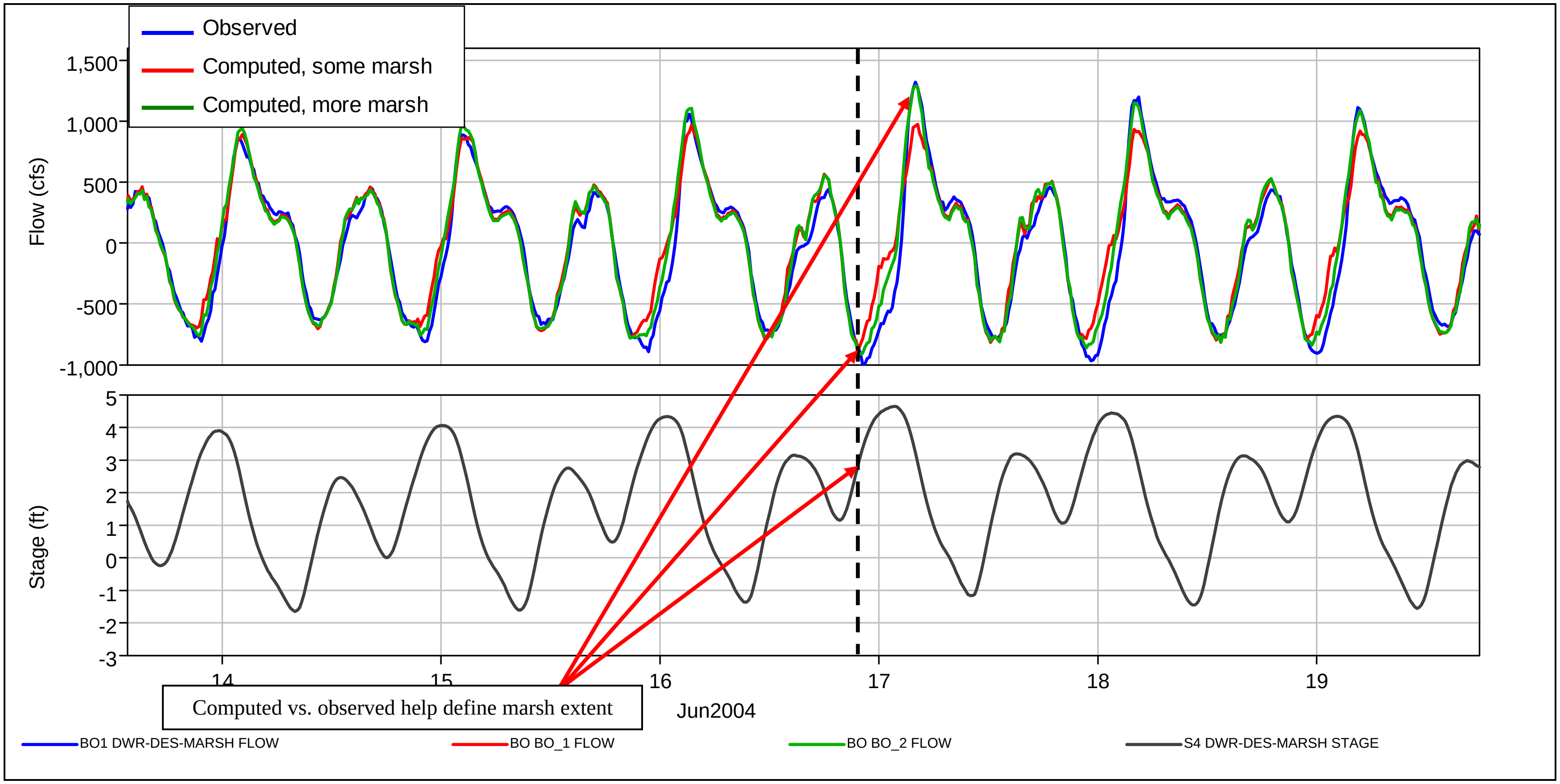


Figure 4-3 Observed and computed flow and stage data in Boynton Slough with two iterations of flow results showing how addition of tidal marsh affects computed flows.

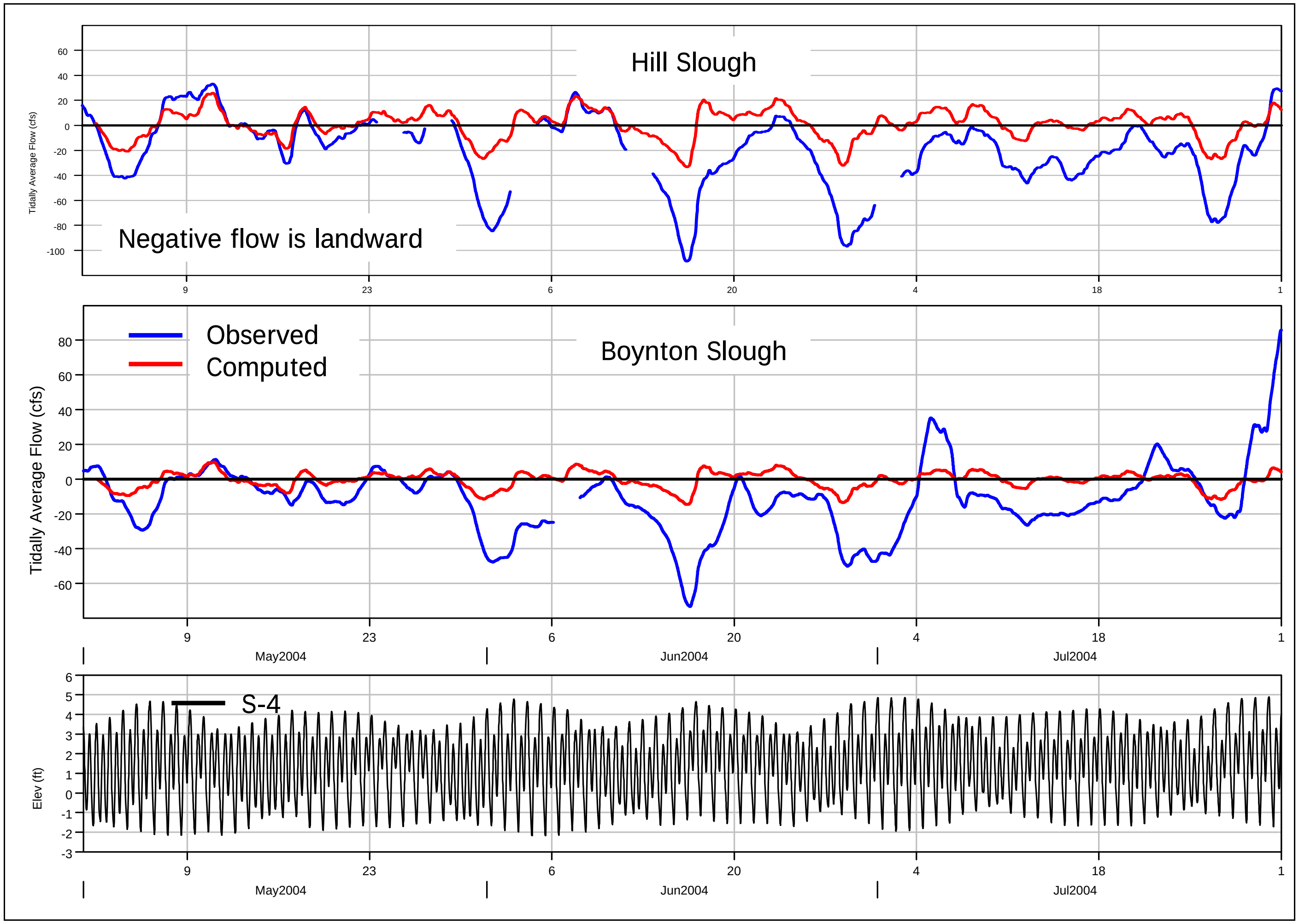


Figure 4-4 Observed and computed tidally averaged flow in Boynton Slough (B01) and Hill Slough (HS1), and observed stage at Hill Slough (S-4).

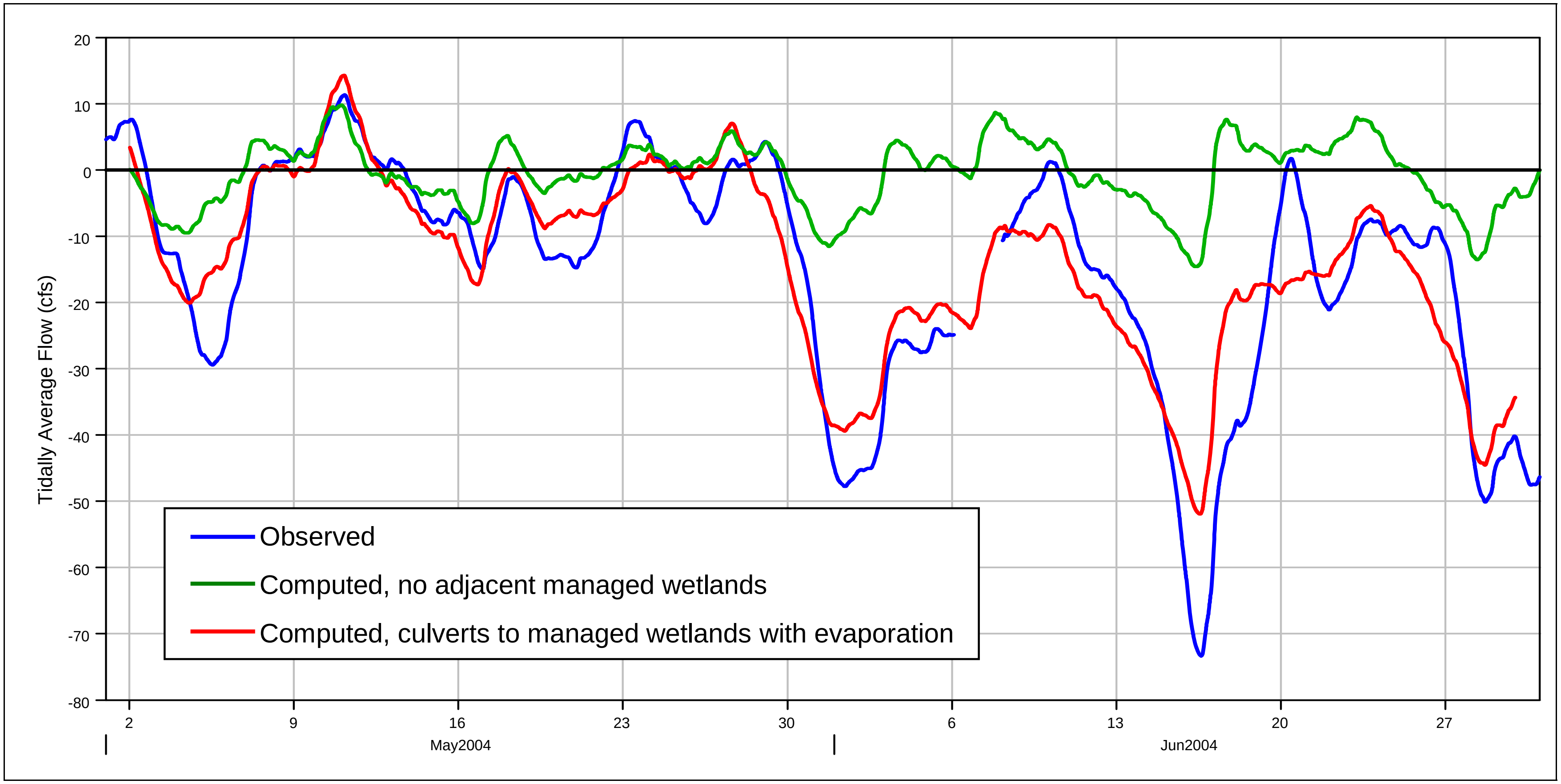


Figure 4-5 Observed and computed tidally averaged flow for Boynton Slough. The red line is the flow for a modeled system with an adjacent managed wetland connected by open culverts to Boynton Slough.

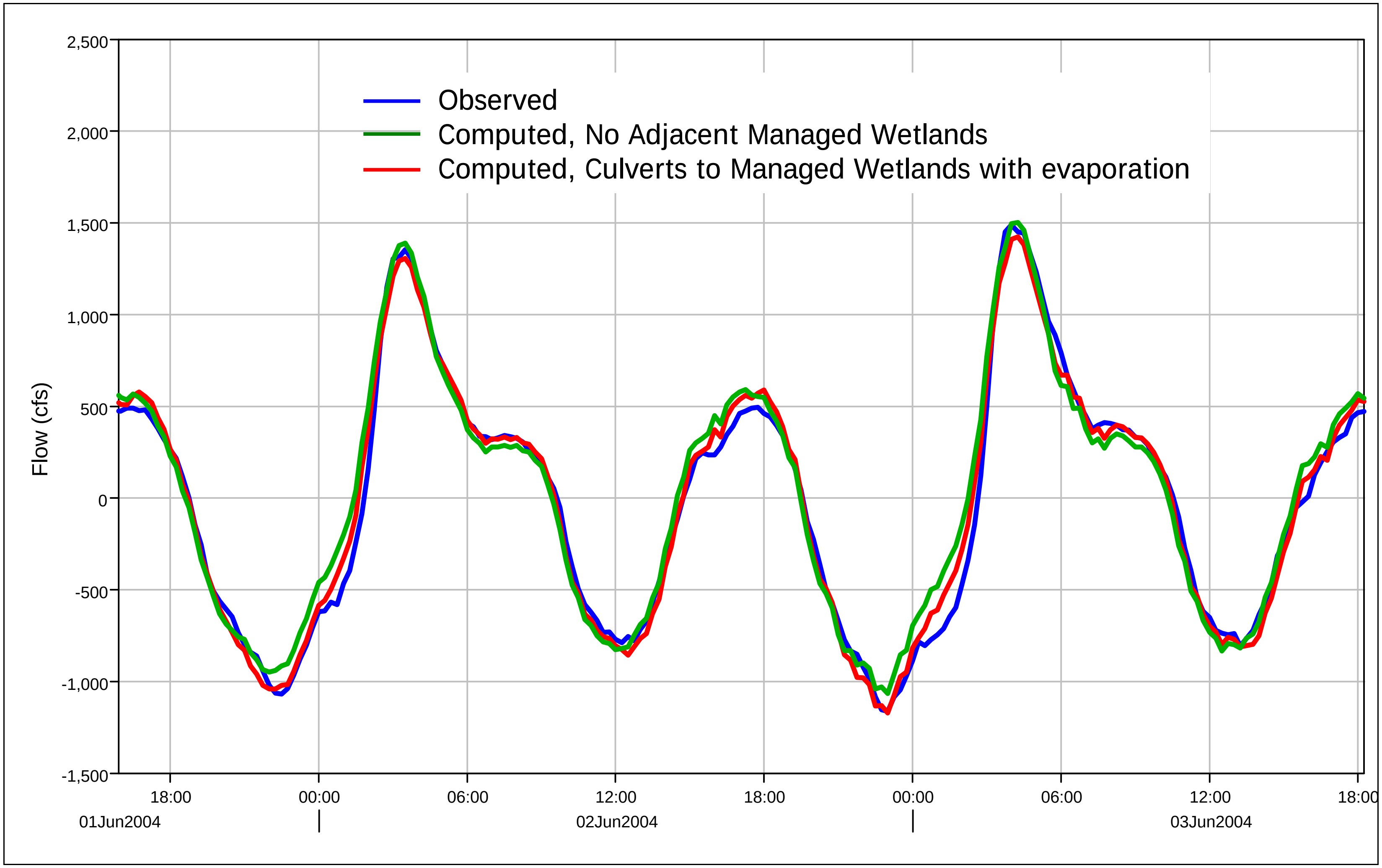


Figure 4-6 Observed and computed flow for Boynton Slough. The red line is the flow for a modeled system with an adjacent managed wetland connected by open culverts to Boynton Slough.

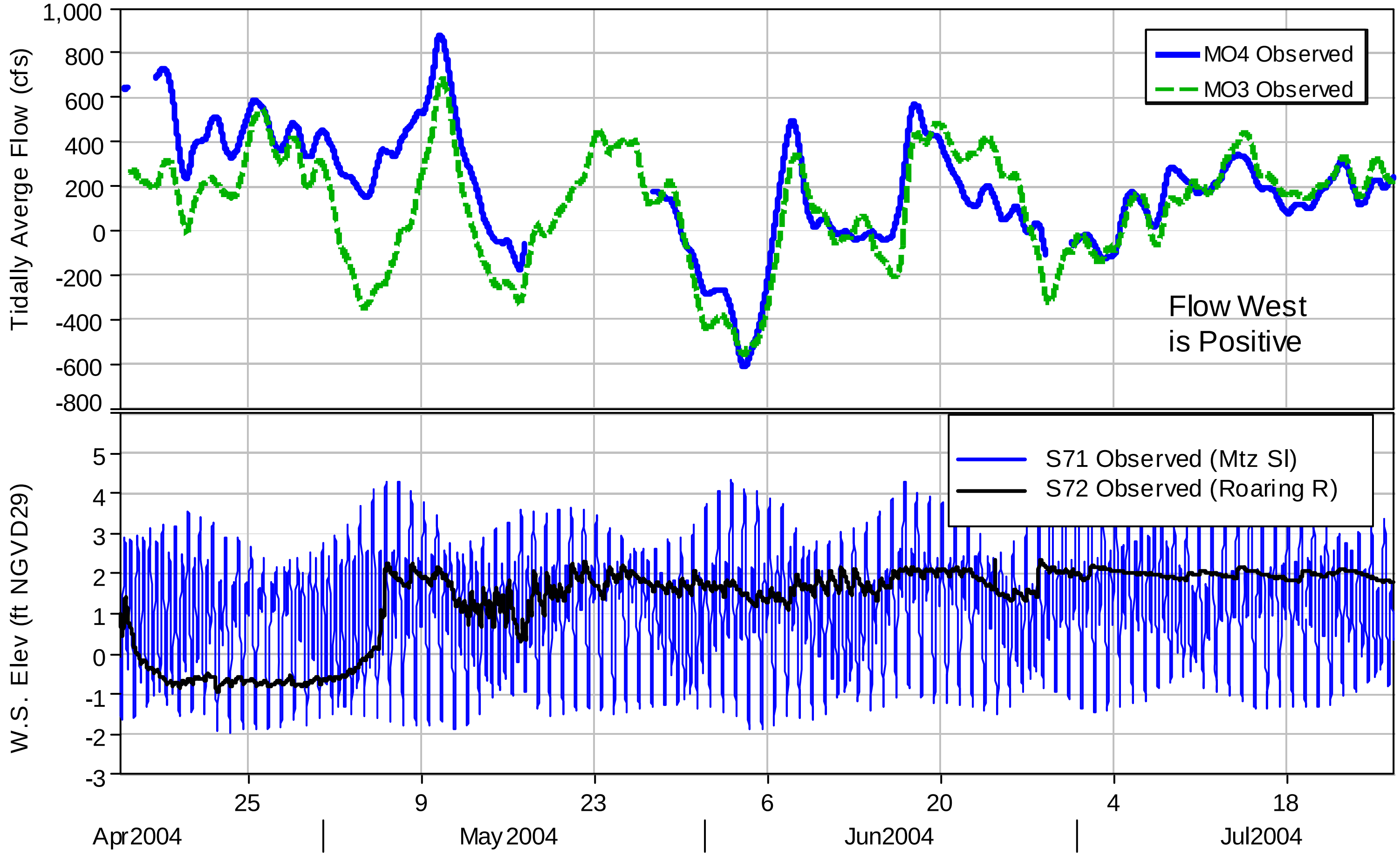


Figure 4-7 Observed tidally averaged flow for the east side Montezuma Slough stations M04 and M03, and the Observed Stage at S71 and S72.

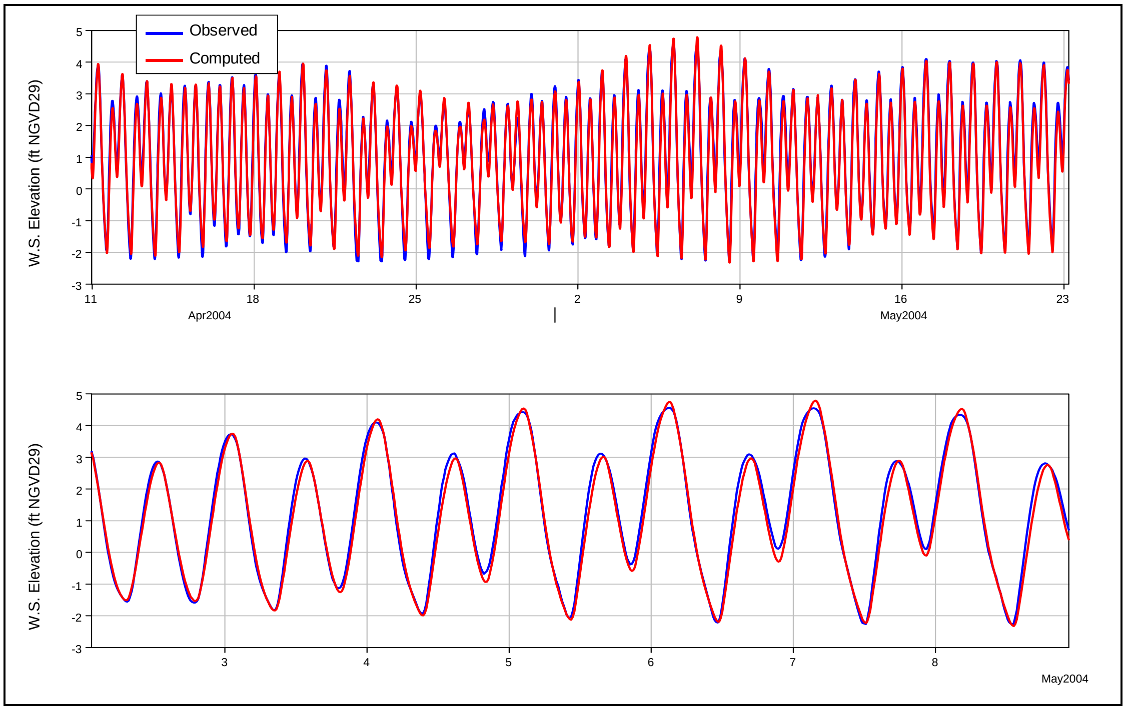


Figure 4-8 Observed and computed stage at monitoring station S-4 in Hill Slough during April – May 2004 (shorter time period shown in lower plot).

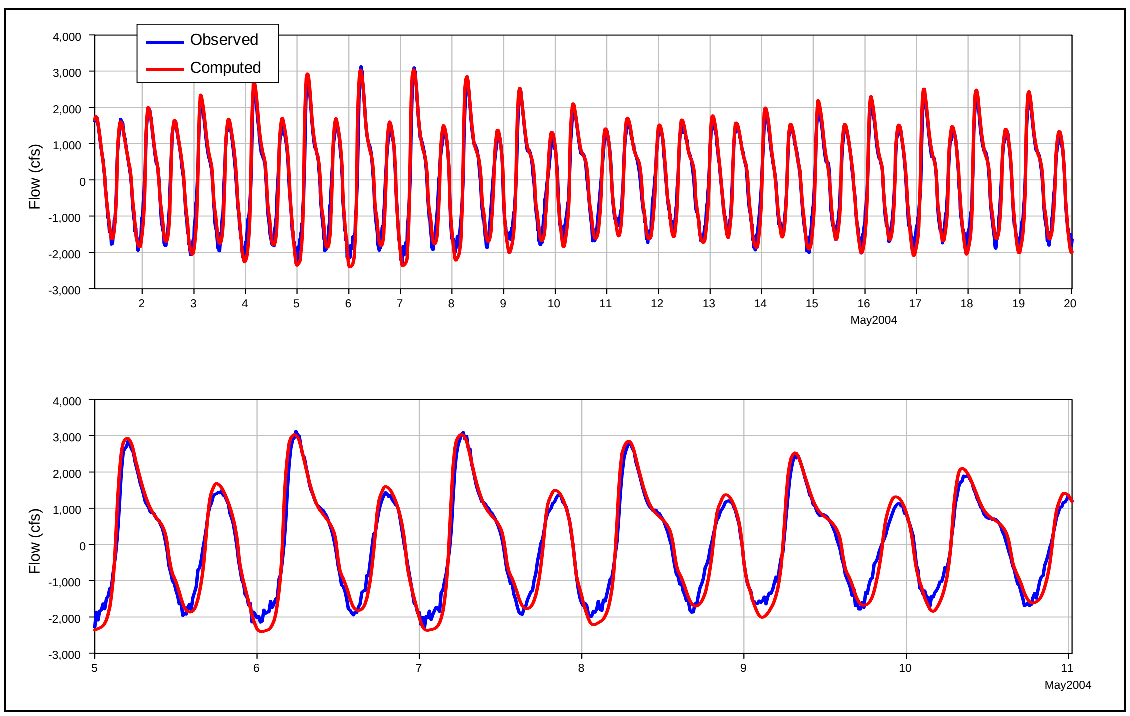


Figure 4-9 Observed and computed flow at Hill Slough, station HS1 during May 2004 (shorter time period shown in lower plot).

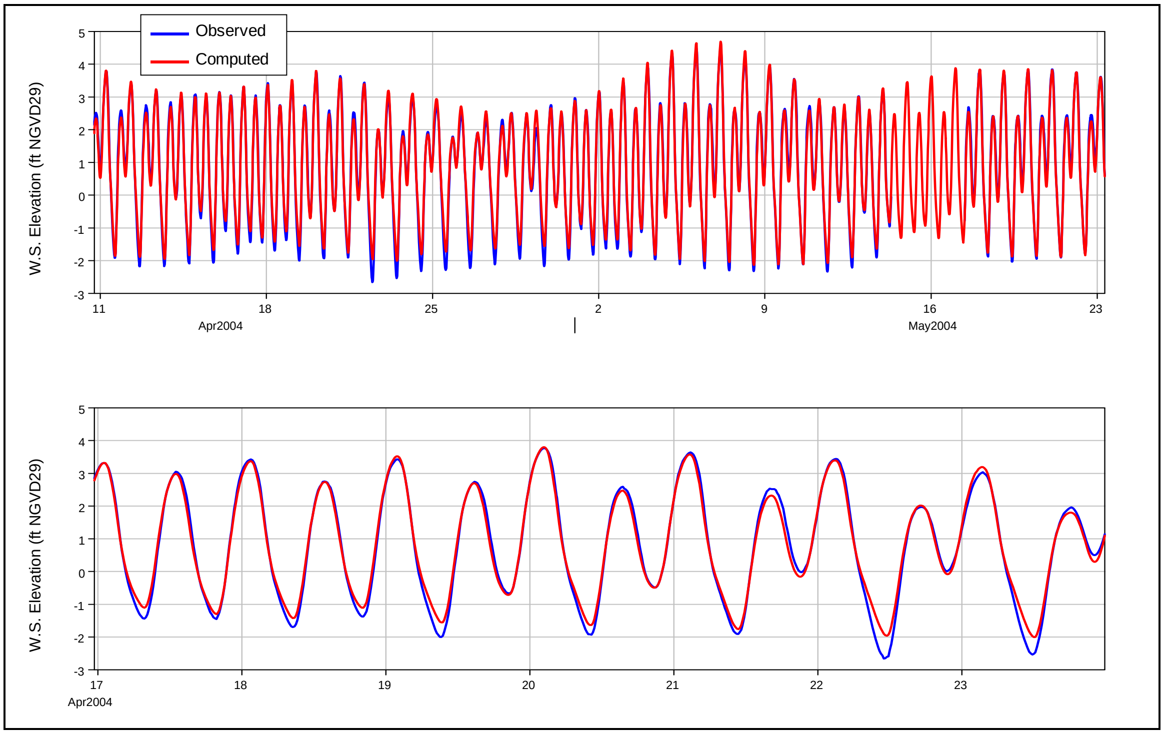


Figure 4-10 Observed and computed stage at monitoring station S-49 at Beldon's Landing on Montezuma Slough during April – May 2004 (shorter time period shown in lower plot).

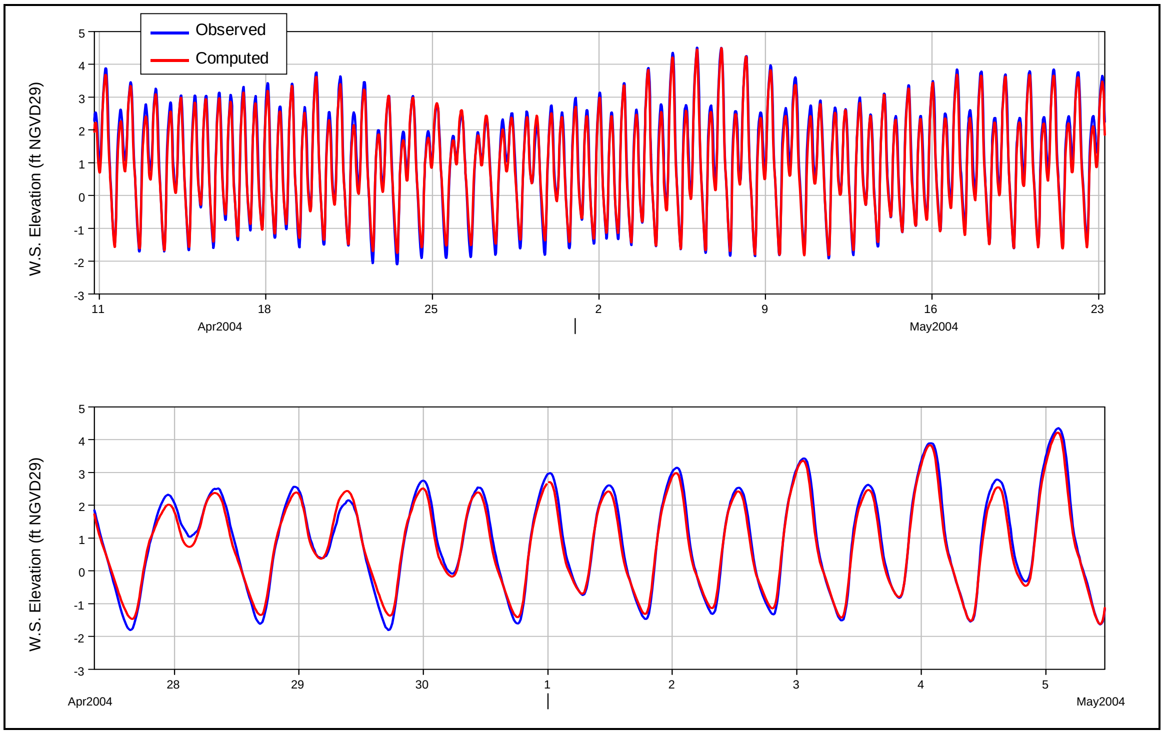


Figure 4-11 Observed and computed stage at monitoring station S-64 at National Steel on Montezuma Slough April – May 2004 (shorter time period shown in lower plot).

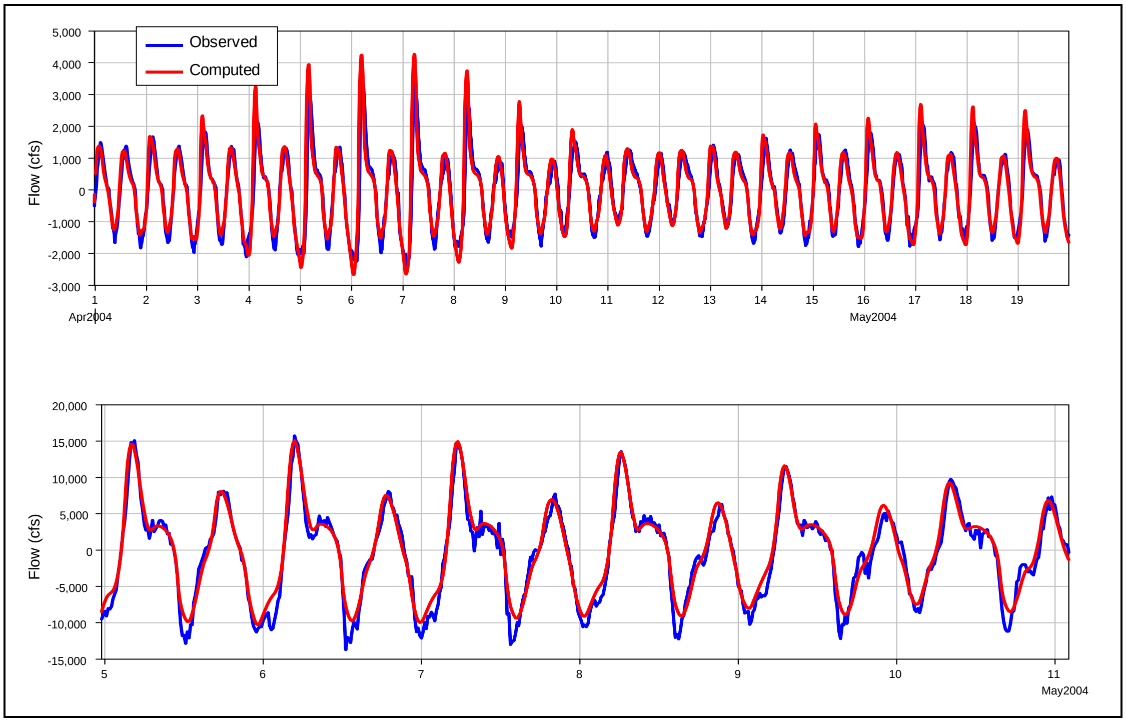


Figure 4-12 Observed and computed flow at the Nurse Slough monitoring station, NS1 May 2004 (shorter time period shown in lower plot).

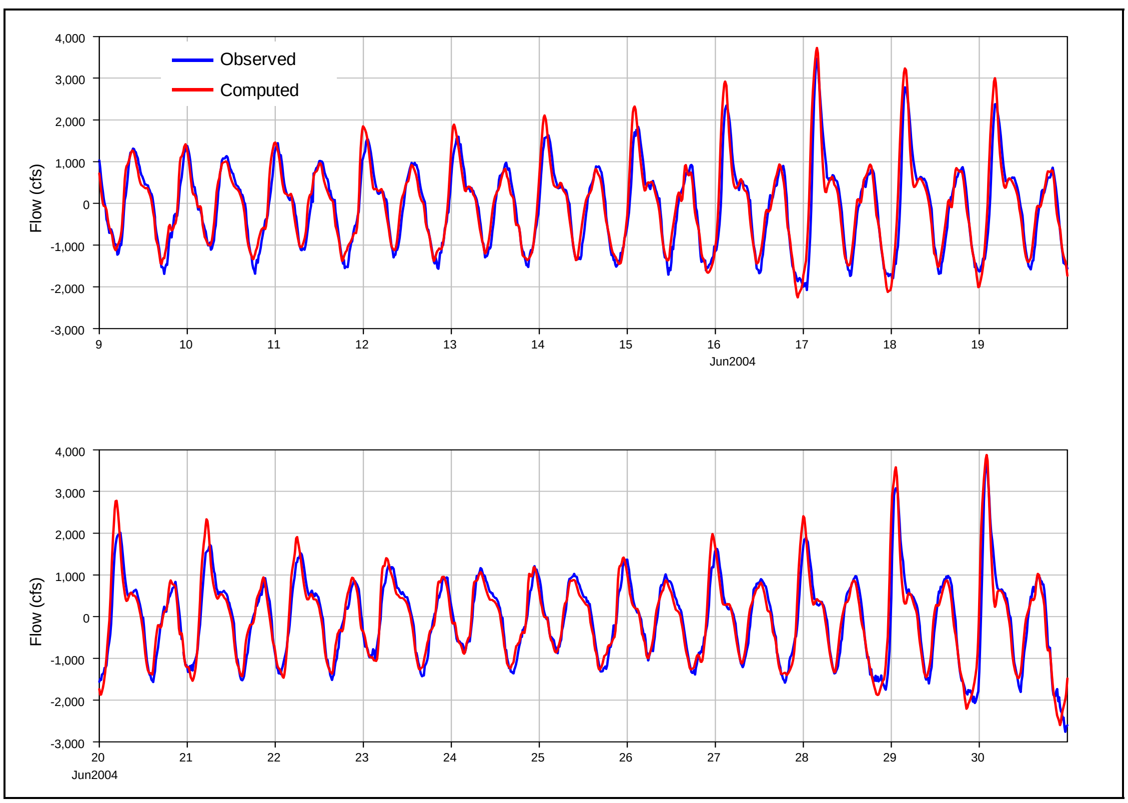


Figure 4-13 Observed and computed flow at the Cutoff Slough monitoring station, CO2 during June 2004.

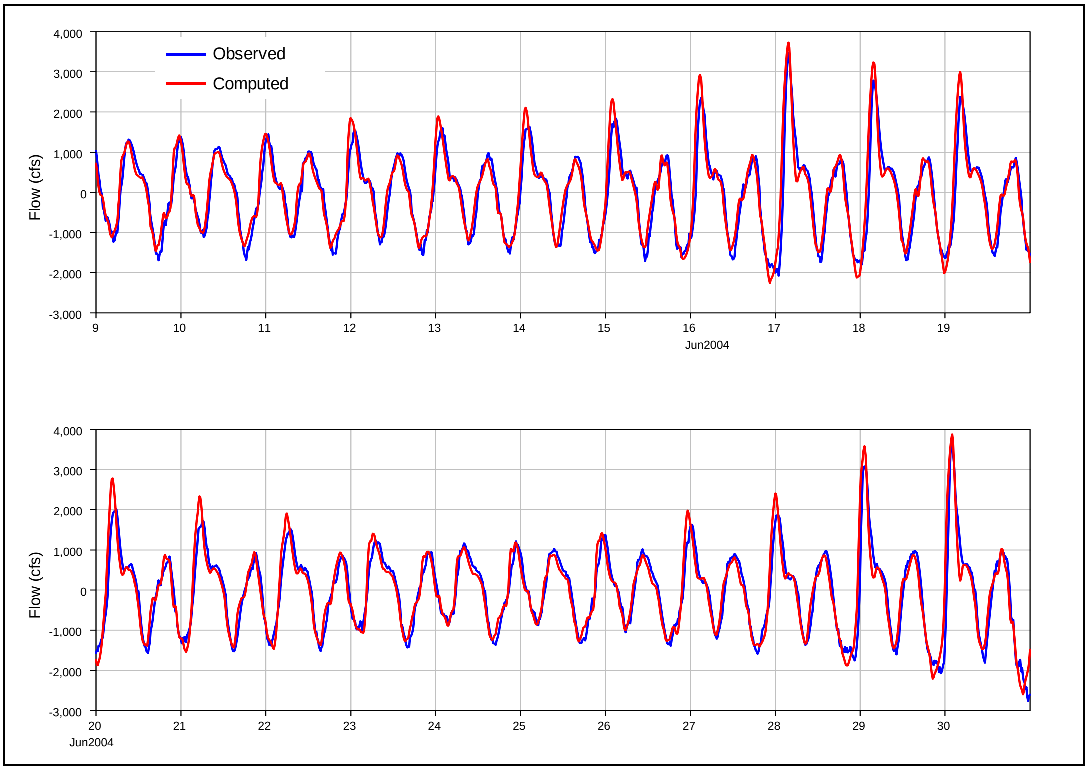


Figure 4-14 Observed and computed flow in First Mallard Slough at station FM1 during June 2004.

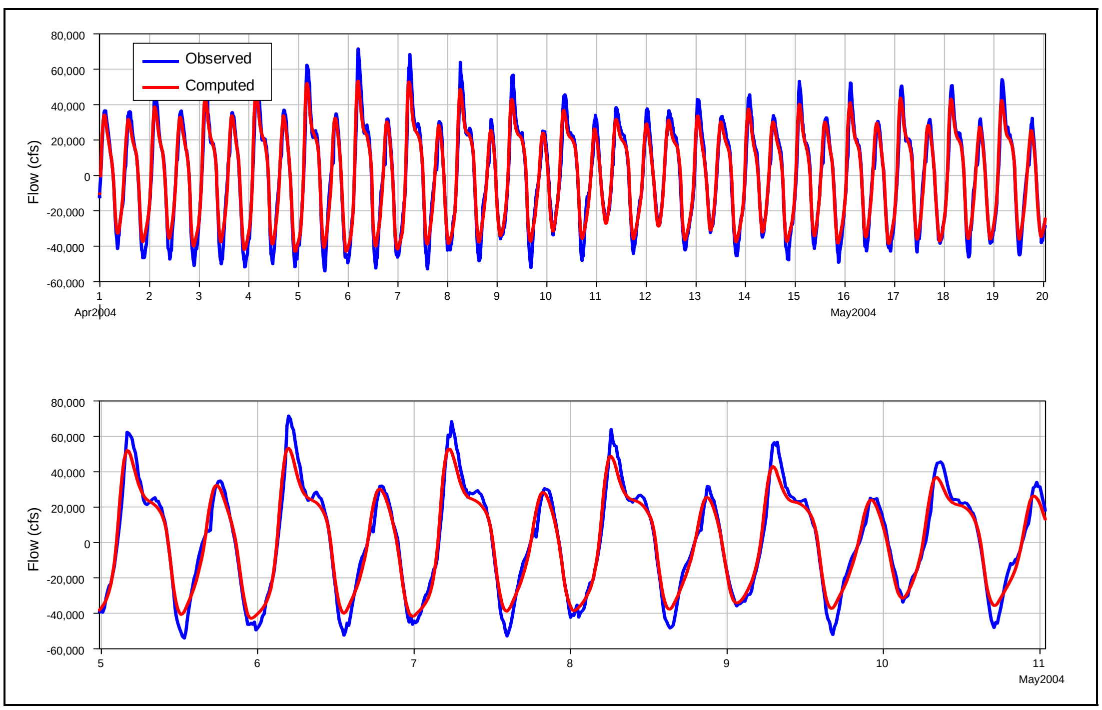


Figure 4-15 Observed and computed flow in Montezuma Slough at station MO1 during May 2004 (shorter time period in lower plot) – positive values indicate flow is eastward.

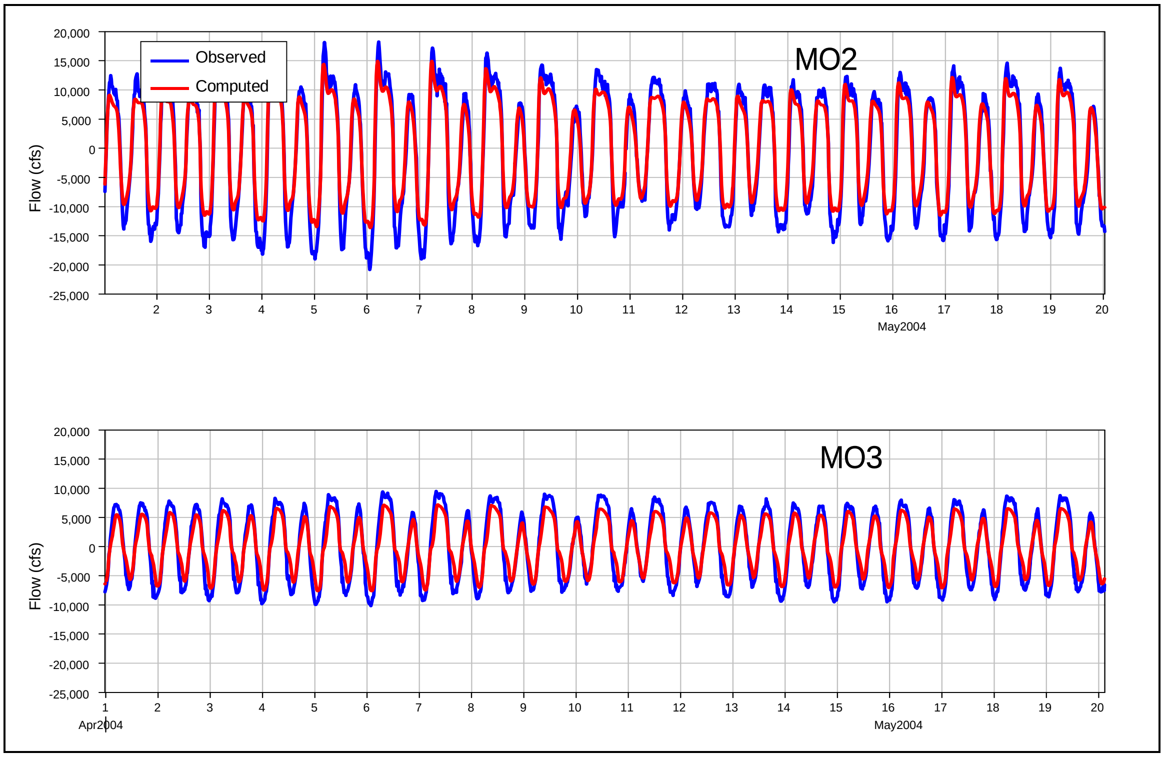


Figure 4-16 Observed and computed flow in Montezuma Slough at monitoring locations MO2 and MO3 – positive values indicate flow is eastward.

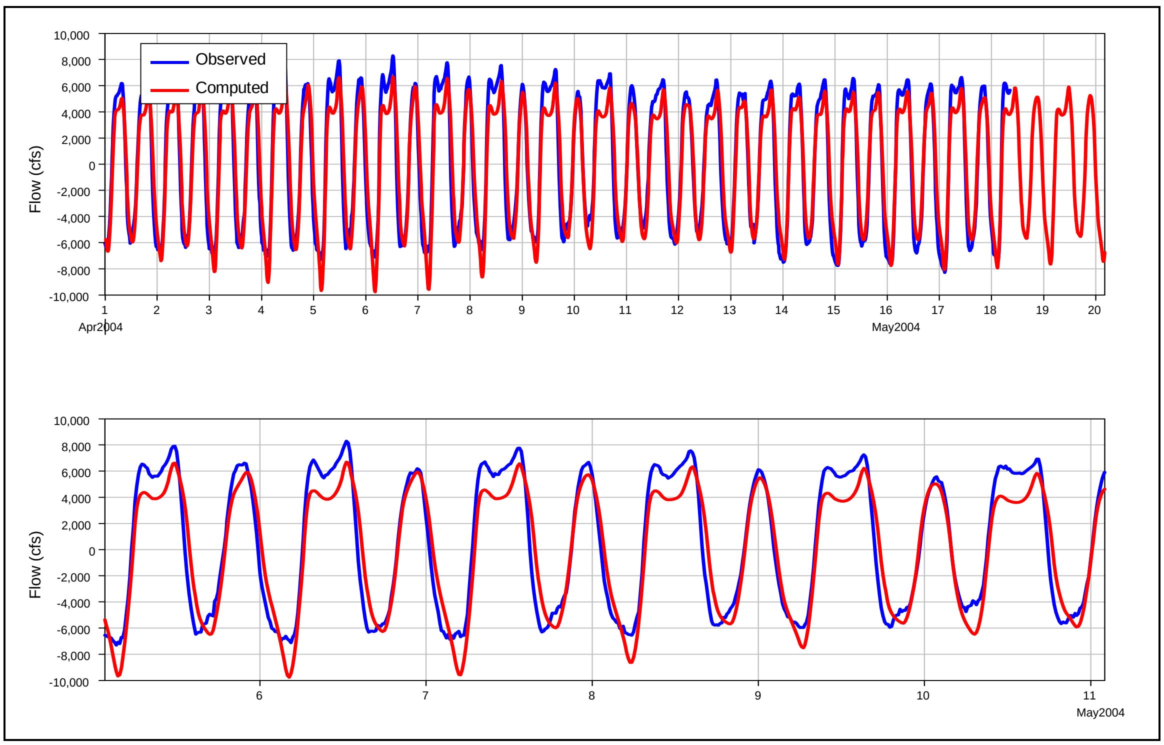


Figure 4-17 Observed and computed flow in Montezuma Slough at monitoring location MO4 (shorter time period shown in lower plot) – positive values indicate flow is eastward.

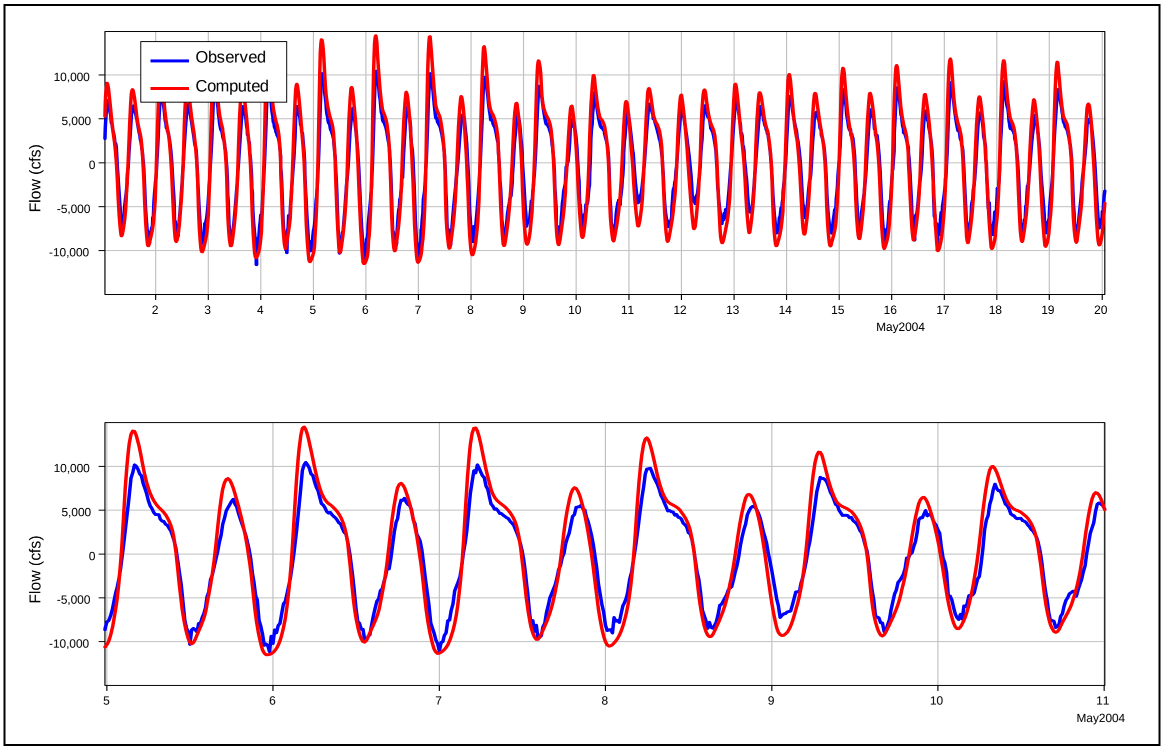


Figure 4-18 Observed and computed flow at the mouth of Suisun Slough, station SS1 (shorter time period shown in lower plot).

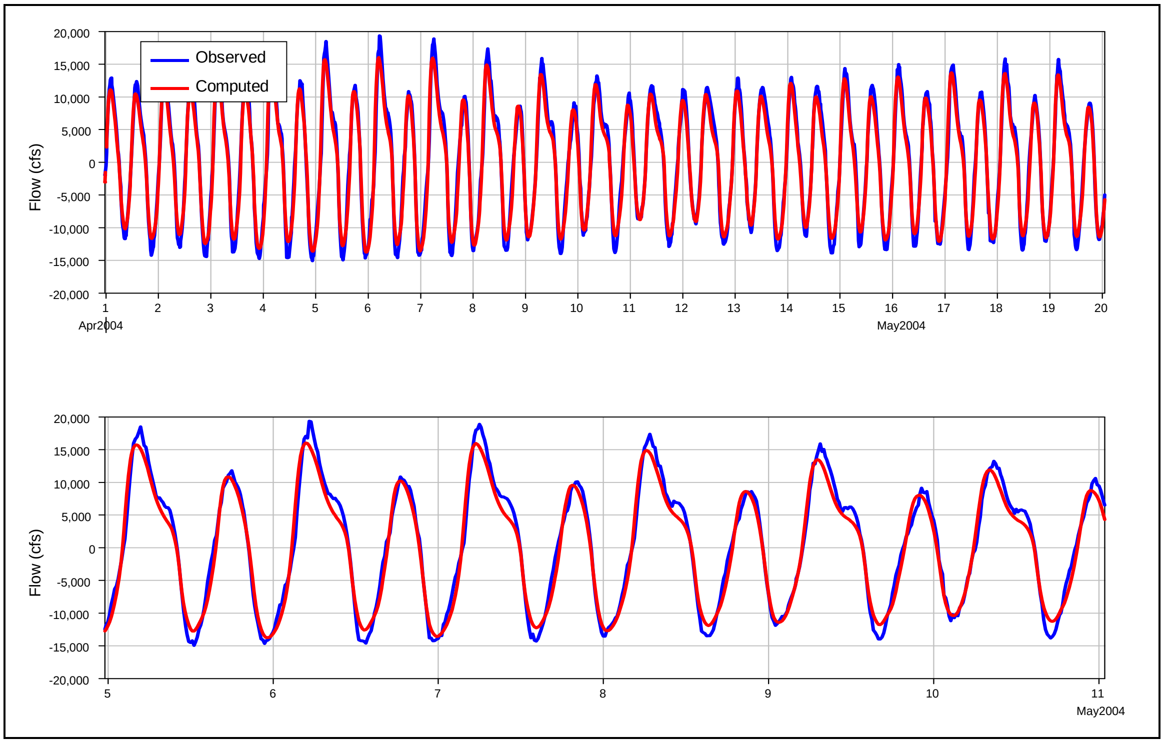


Figure 4-19 Observed and computed flow through Hunter Cut at monitoring station HC1 (shorter time period shown in lower plot).

4.2. Electrical Conductivity (EC) Calibration

4.2.1. Background

The RMA11 EC calibration was performed for the period of April 2002 – December 2003. To calibrate the EC model, computed EC was compared with observed data at the sampling locations shown in Figure 4-2.

Calibration results were hampered by the lack of sufficient model input data, for example the lack of managed wetlands withdrawals and returns and local creek flows, and by approximations to some mechanisms that are intrinsic to the model. Specifically, density stratification cannot be explicitly represented in the depth-averaged model formulation.

Density stratification is particularly important following high flow periods during neap tide, although periods of stratification also occur intermittently during neap tide periods when net Delta outflow is sufficiently low. Periods of higher (> 30,000 cfs) and lower (~ 4,000 cfs) outflow, are illustrated in Figure 4-21 and Figure 4-22, respectively, which show observed top and bottom EC, stage at Martinez, and Delta outflow. In Figure 4-22, during a neap tide in a lower outflow period around August 19, 2003, top and bottom EC data indicate that significant stratification developed at Martinez, which lasted for about five days.

The result of neglecting density stratification in the 2-D model is slow recovery of model EC following high flow periods. In the calibration results, attempts to compensate for the stratification using diffusion coefficients have pushed computed EC too high during the late fall. These problems become evident in the model at the Martinez station and are propagated through Suisun Marsh. Modeled, tidally-averaged EC at Martinez (Figure 4-23) illustrates the effect of the 2-D model approximation in comparison with data. The winter period of low EC accentuates the inability of the model to capture stratification, and the high fall EC shows the effect of the compensating diffusion coefficients.

4.2.2. Results

EC calibration results were geographically and seasonally variable along Montezuma Slough. The inclusion of managed wetlands and evaporation resulted in significant improvements in modeled EC at Beldon's Landing, S-49 (Figure 4-24), during some periods. The tidally averaged computed EC (Figure 4-25) is a fairly good match with tidally averaged observed data throughout most of the calibration period, except during winter 2003 and late fall 2002 and 2003. This location seems to be near the balancing point between the overestimated EC at Martinez in the fall, and the incorrect net flow balance in Montezuma Slough during the periods when SMSCG is not operating (although flow data are not available specifically for this time and location to confirm this). Intertidal results at this location show slightly less tidal variation in computed EC compared with observed data.

In eastern Montezuma Slough, modeled EC is lower than observed EC year-round. This can be seen at stations S-64 at National Steel, in Figure 4-26, and S-71 at Roaring River, in Figure 4-27. This is due to insufficient propagation of higher EC up Montezuma

Slough from the west, possibly because of incorrect net flows and/or due to insufficient representation of local effects, for example, exchange with Roaring River. Also, the hydrodynamic calibration did not include wetland diversions, while EC calibration did.

Calibration results at Collinsville (Figure 4-29) are relatively good on a tidally averaged basis. Throughout much of the year the tidal signal in the computed EC is dampened compared with the observed data, and at other times, the agreement between computed and observed 15-minute data is quite good. Although it is not always true, the results tend to be best when the SMSCG is operating (Figure 4-30).

The addition of Green Valley Creek, Suisun Creek, Ledgewood Creek and Laurel Creek and WWTP flows in the model representation greatly improved the storm period results in the eastern and northeastern marsh. Figure 4-32 to Figure 4-36 illustrate these effects at S-4 in Hill Slough, S-42 at Volanti in Suisun Slough, and at S-97 in Cordelia Slough at Ibis, respectively. EC results at S-4 and S-42, although very much improved with the addition of creek flows, seem to indicate either missing inflows, or possibly that the shape of the hydrograph is not quite right. Ledgewood and Laurel Creek flows, which contributed to this area of the marsh, were estimated because no data were available, so an excellent match with observed data is not expected.

Results in western Montezuma Slough at S-54, Hunter Cut (Figure 4-28), follow the pattern of EC under- and over-estimation observed at Martinez in Figure 4-23. The results are similar in the south-western areas of the marsh (Figure 4-37 to Figure 4-40), although EC increases are somewhat muted at S-37 in Suisun Slough (Figure 4-38).

4.2.3. **Summary**

Although the model development and calibration effort improved modeled EC in Suisun Marsh, the improvements were geographically and seasonally variable. The inclusion of managed wetlands and evaporation alone resulted in significant improvements in modeled EC in some areas, such as Beldon’s Landing (Figure 4-24). The addition of creek flows greatly improved the representation of EC in the northern and north-eastern portions of the marsh.

Modeled EC tended to be too low January – June, 2003 in most of Suisun Marsh. Computed EC was generally good in the western and middle portions of Montezuma Slough and in the south-western regions of the marsh. EC was low in the eastern portion of Montezuma Slough, and high in the northern portions of Suisun Slough.

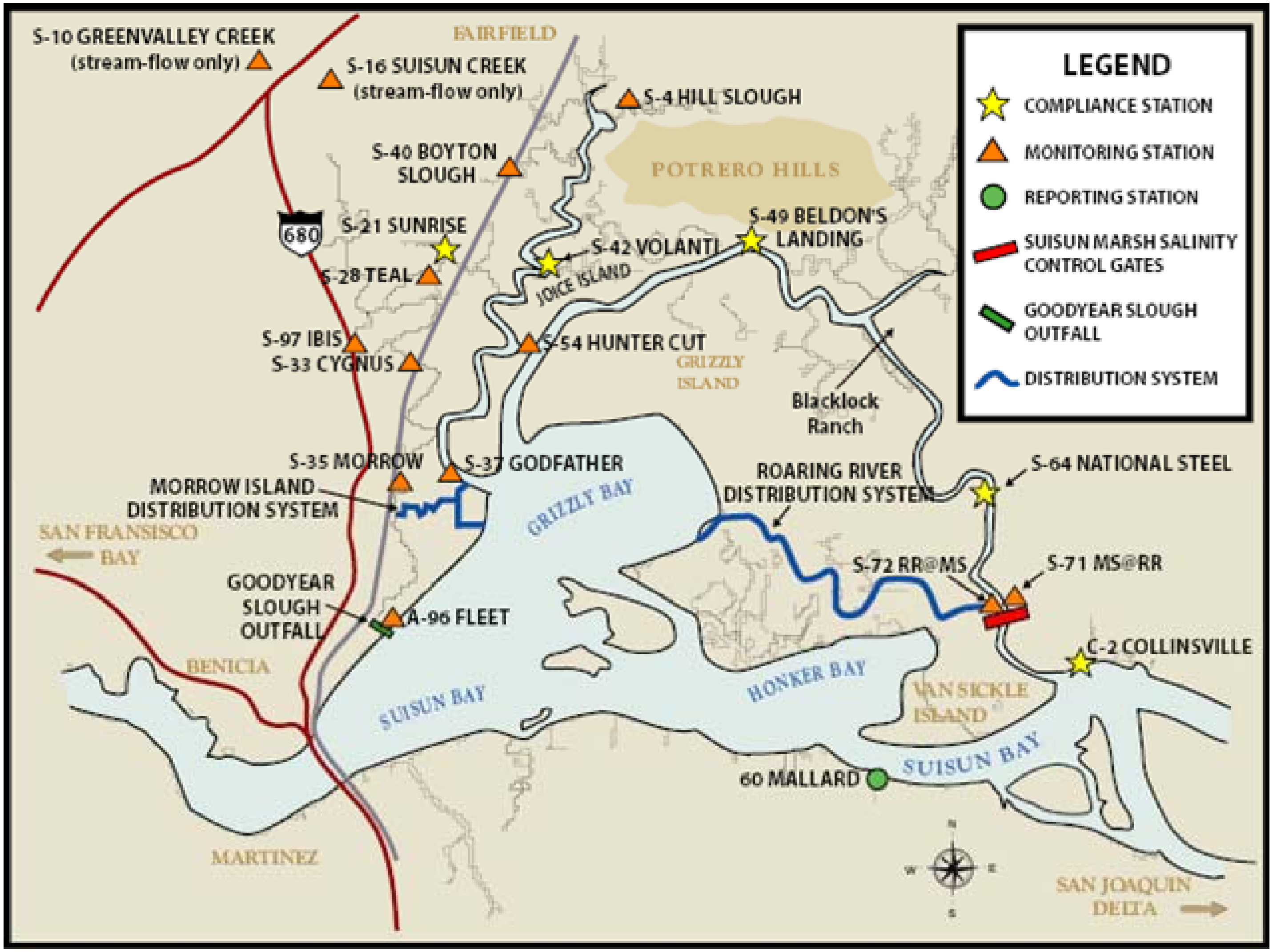


Figure 4-20 Locations of monitoring stations used in EC model calibration.

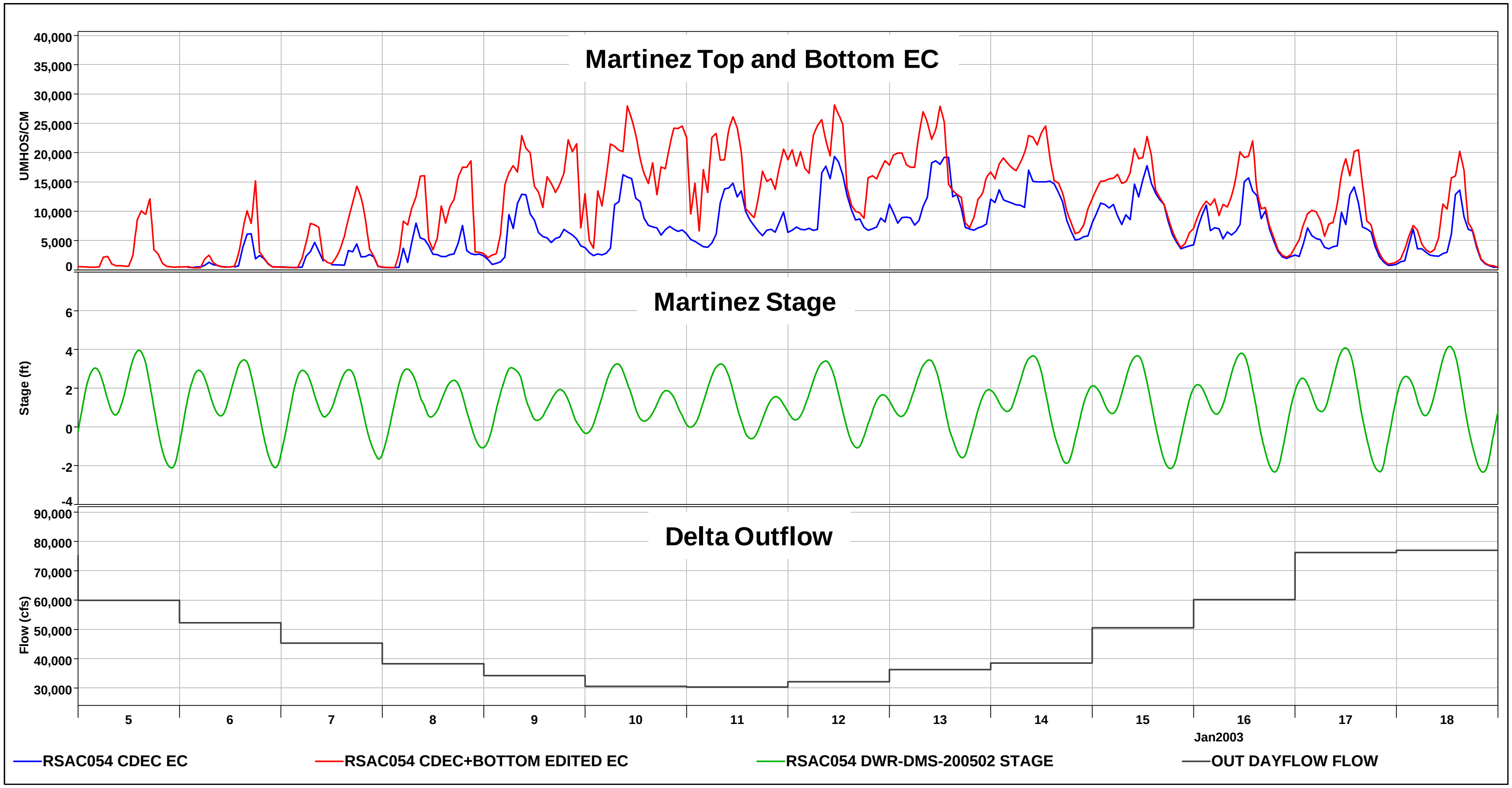


Figure 4-21 Top/bottom EC and stage at Martinez (RSAC054), and Sacramento River flow during a high outflow, neap tide period.

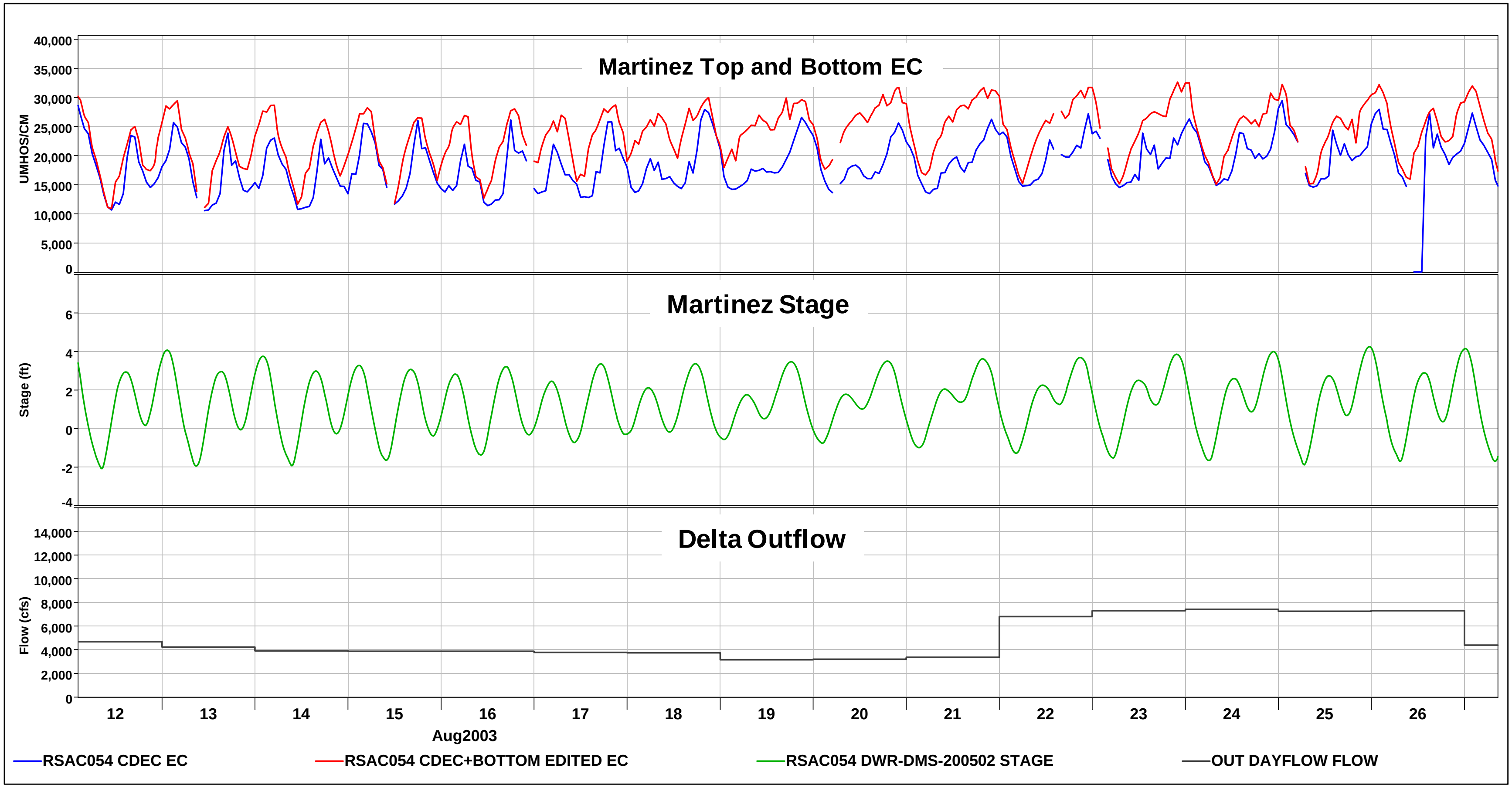


Figure 4-22 Top/bottom EC and stage at Martinez (RSAC054), and Sacramento River flow during a lower outflow period, neap tide period.

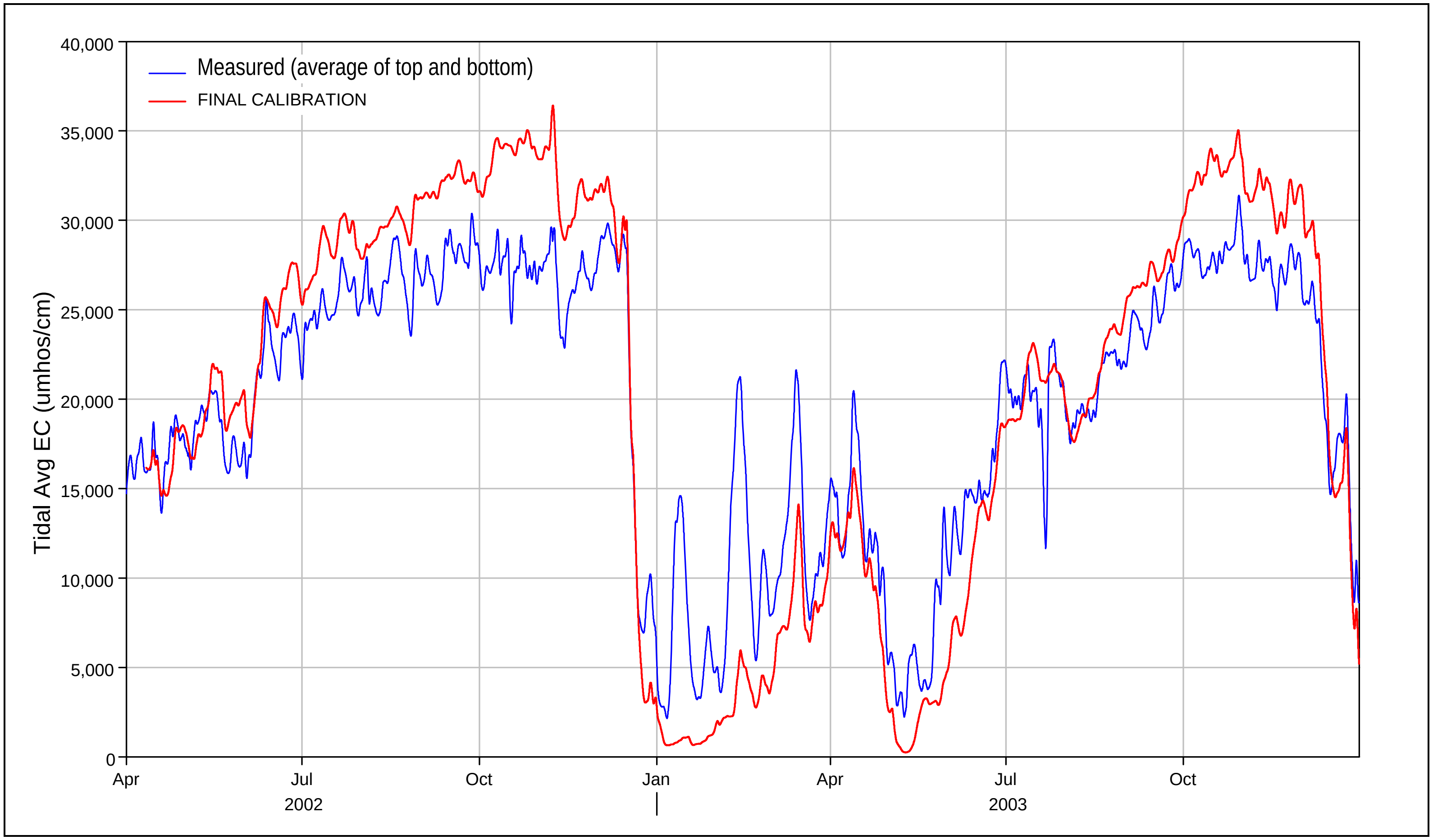


Figure 4-23 Tidally averaged measured (average of top and bottom) and computed EC at Martinez station (RSAC054).

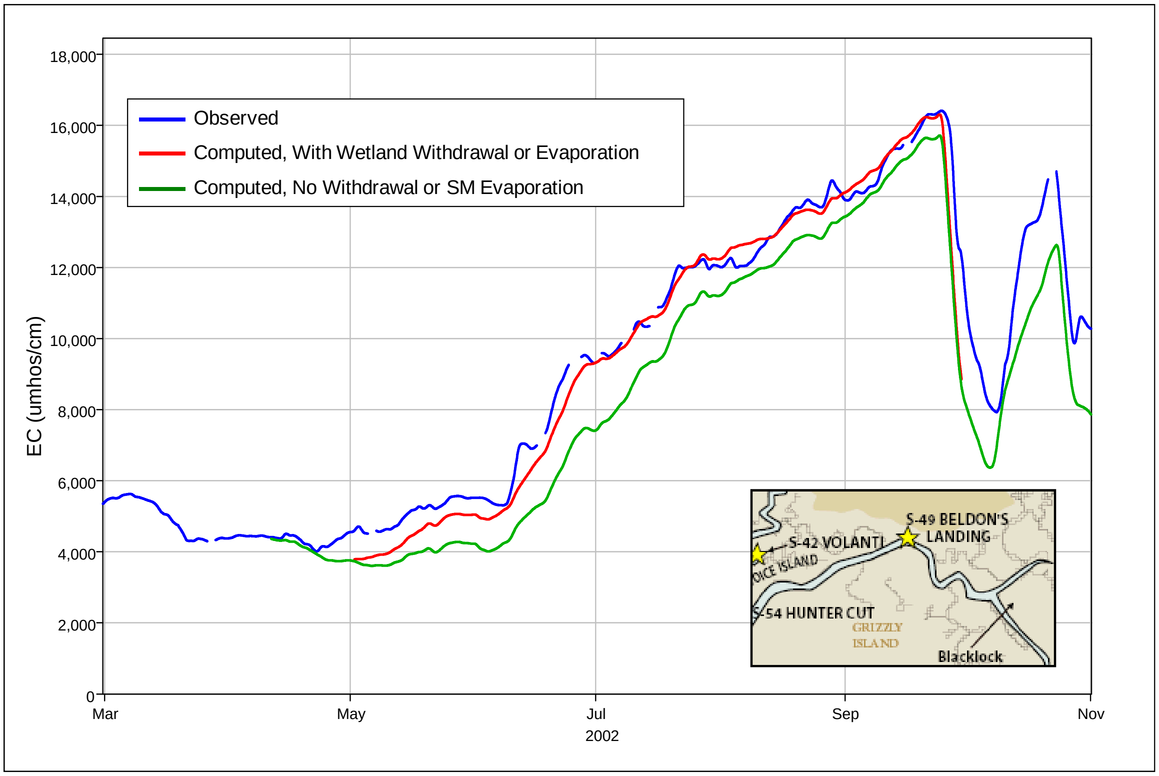


Figure 4-24 Tidally averaged observed and computed EC at S-49, Montezuma Slough at Beldon's Landing. Computed shown with and without duck club withdrawals and evaporation.

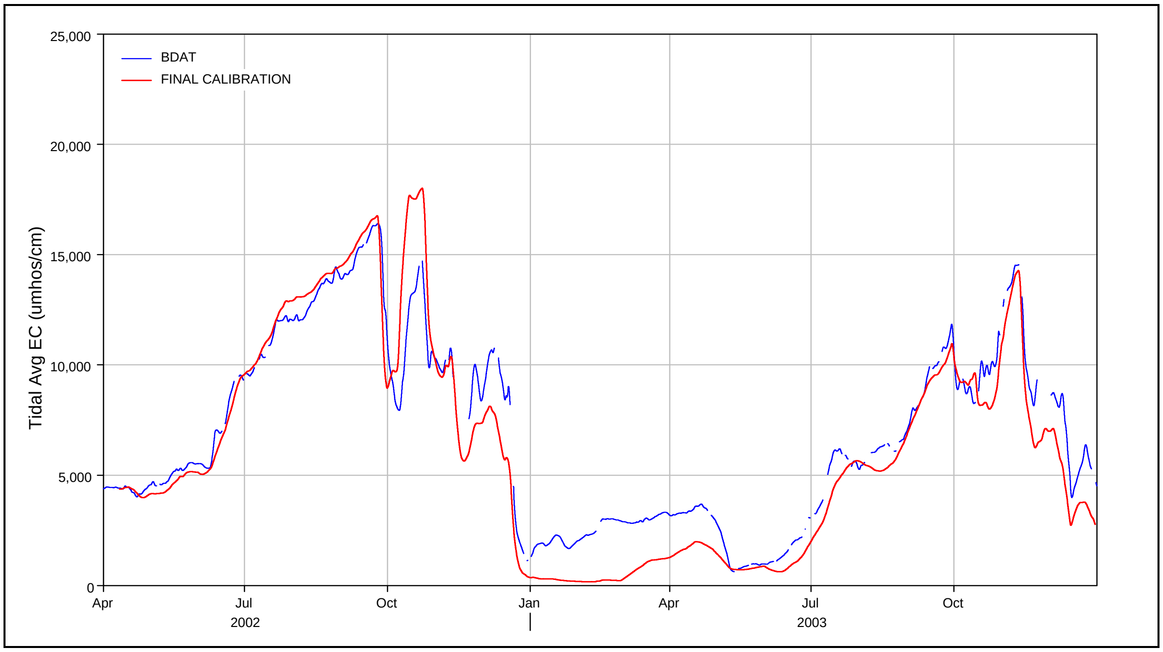


Figure 4-25 Tidally averaged observed and computed EC at station S-49, Beldon's Landing.

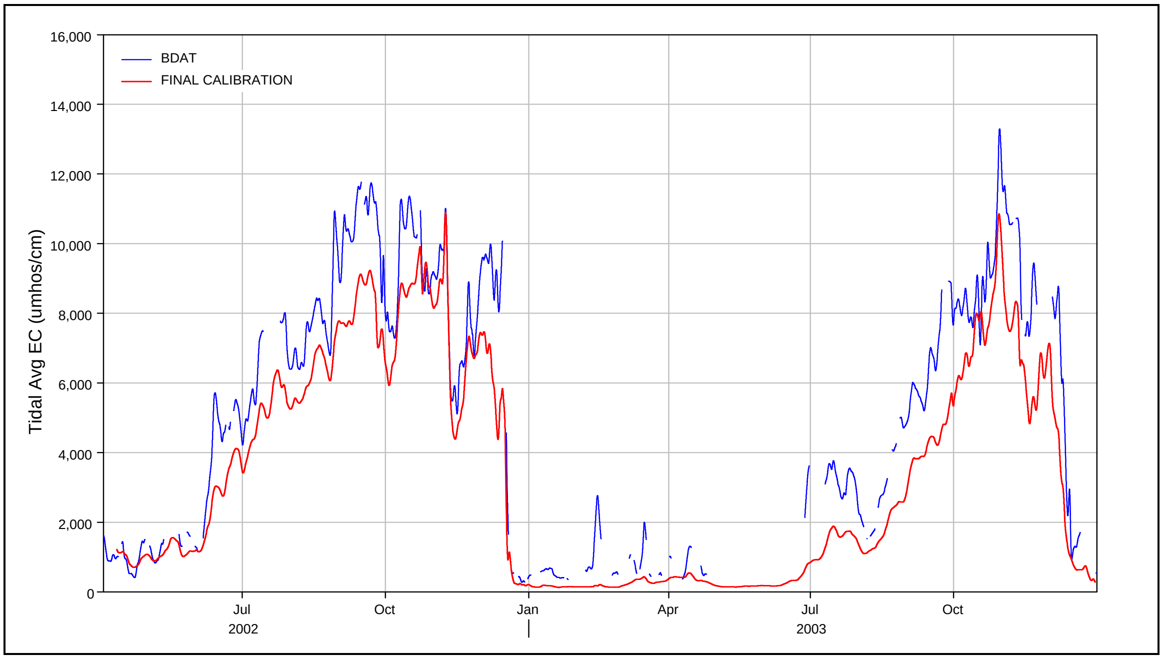


Figure 4-26 Tidally averaged observed and computed EC at station S-64, National Steel in eastern Montezuma Slough.

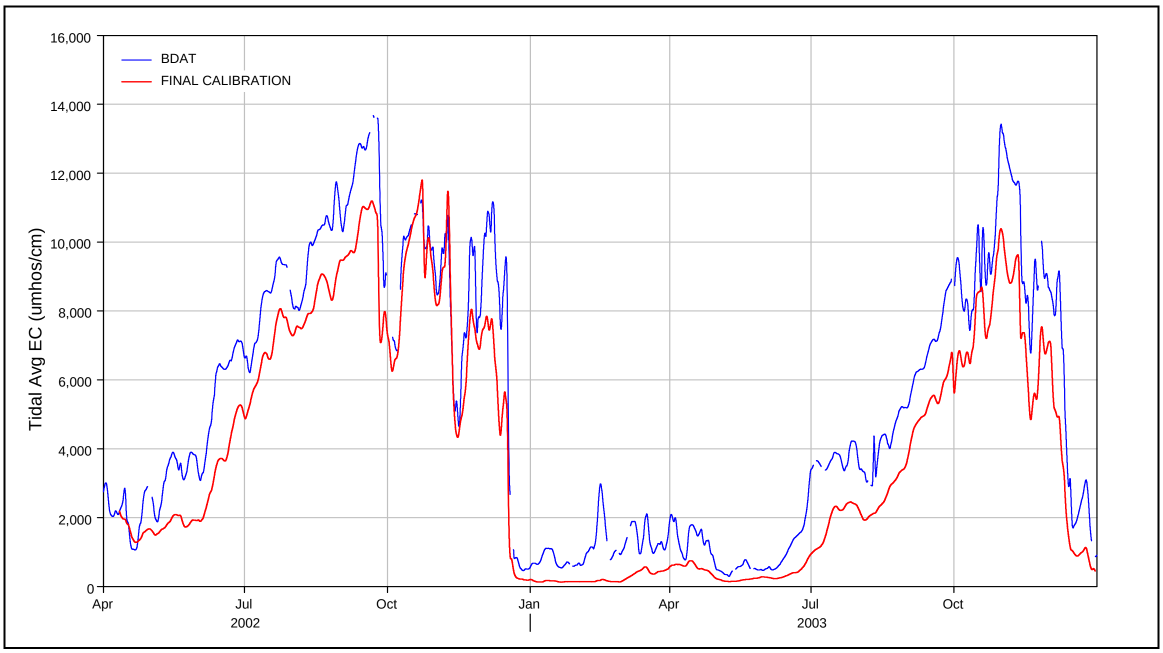


Figure 4-27 Tidally averaged observed and computed EC at station S-71 Roaring River in eastern Montezuma Slough.

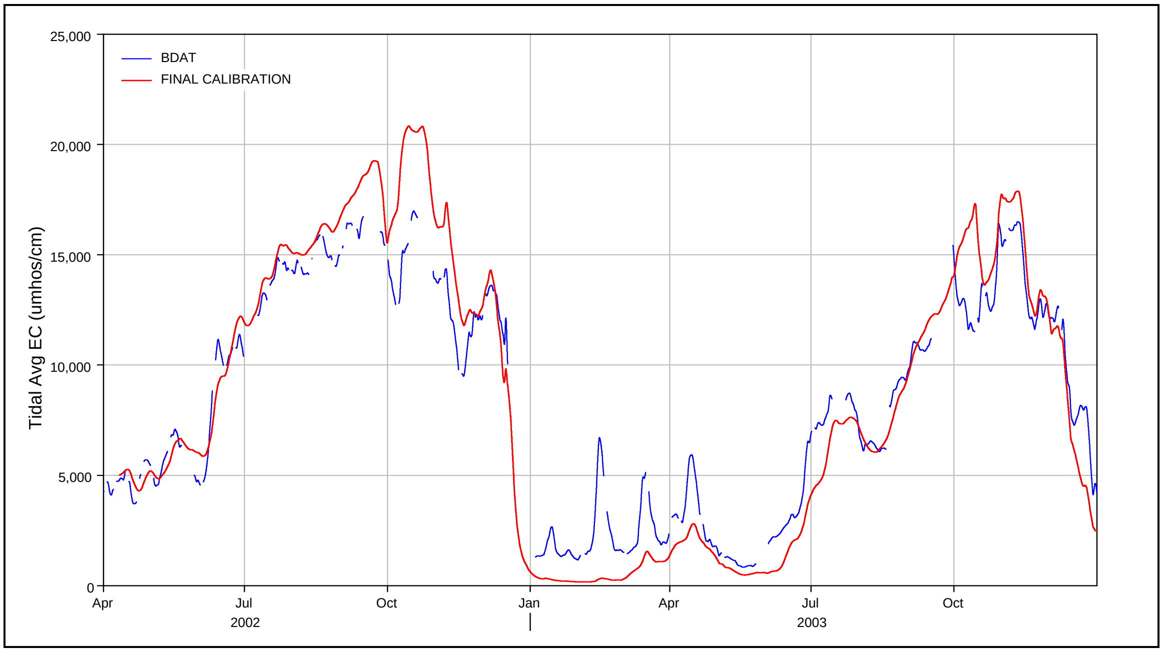


Figure 4-28 Tidally averaged observed and computed EC at station S-54, Hunter Cut.

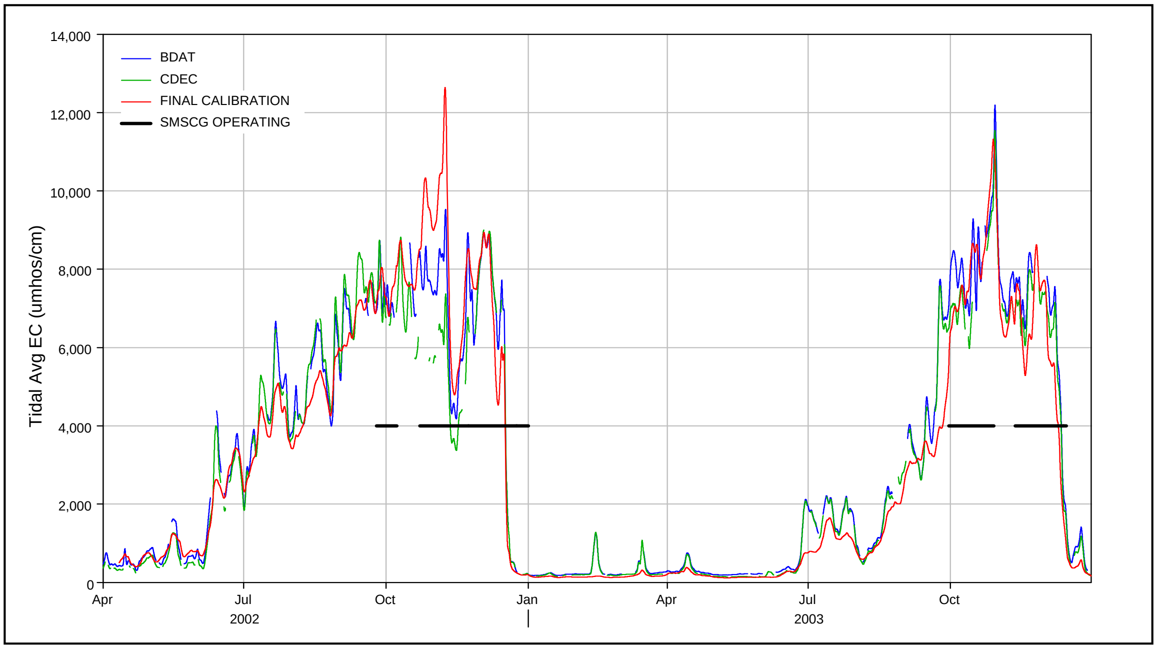


Figure 4-29 Tidally averaged observed and computed EC at Collinsville (RSAC081).

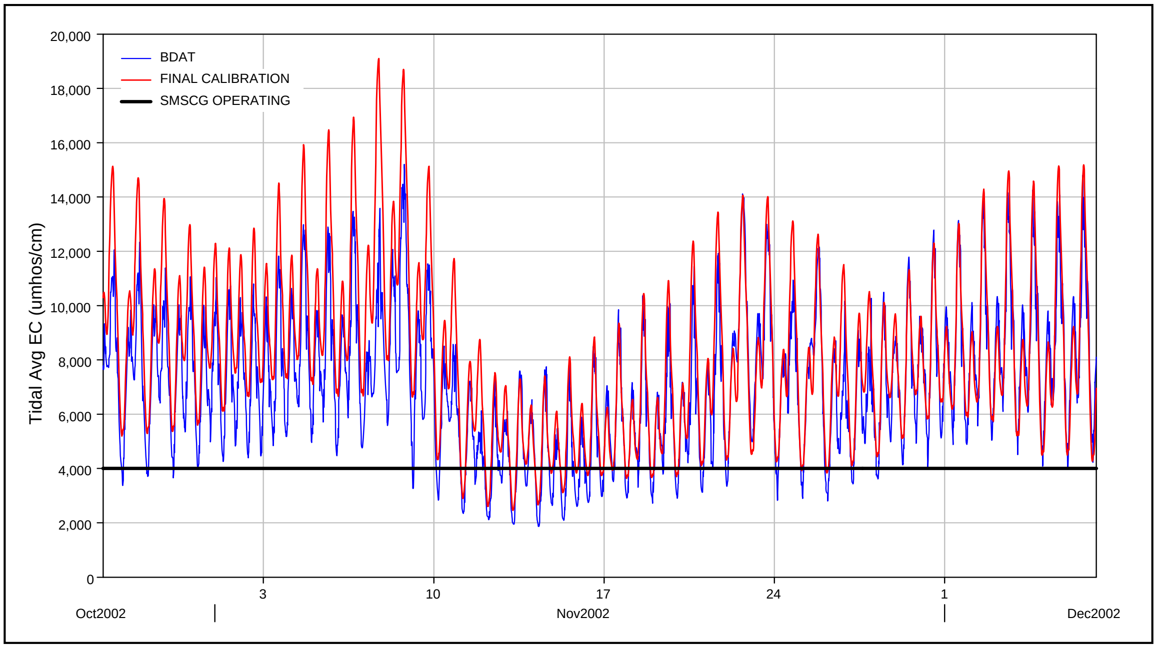


Figure 4-30 Observed and computed EC at Collinsville (RSAC081) during a period of SMSCG operation.

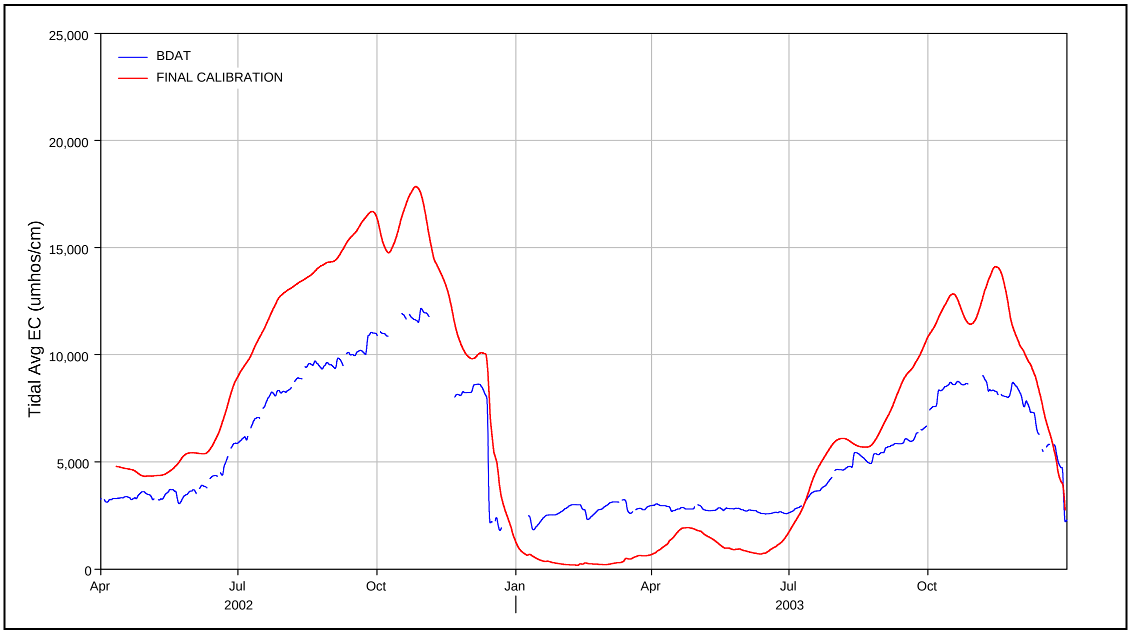


Figure 4-31 Tidally averaged observed and computed EC at station S-4, Hill Slough.

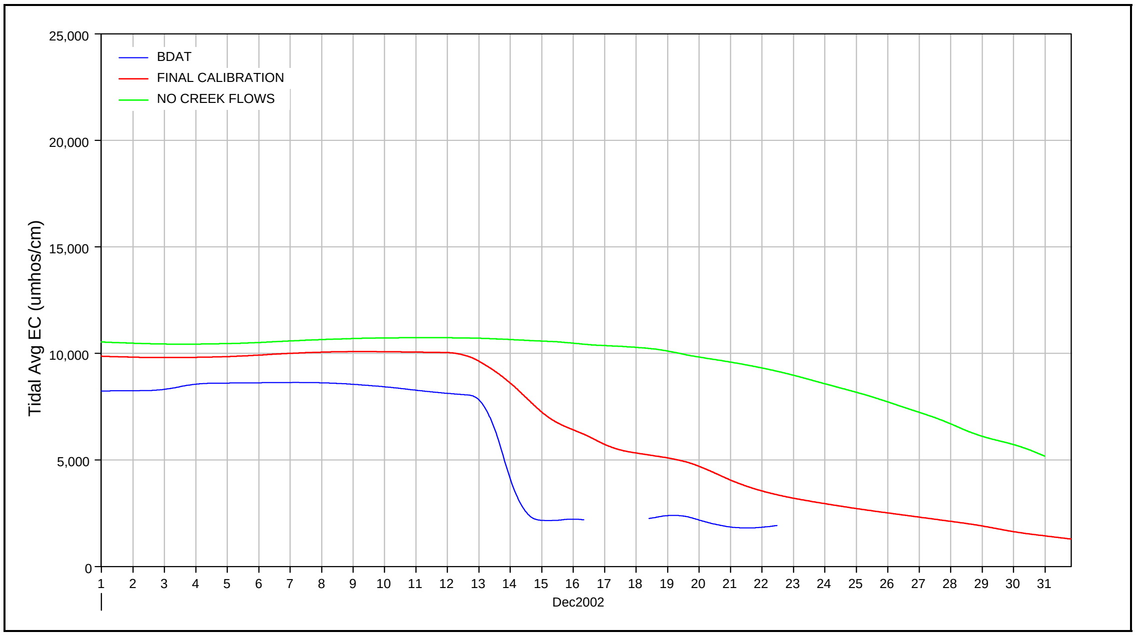


Figure 4-32 Tidally averaged observed and computed EC at station S-4, Hill Slough in December, 2002. Computed results shown with and without local creek flow addition.

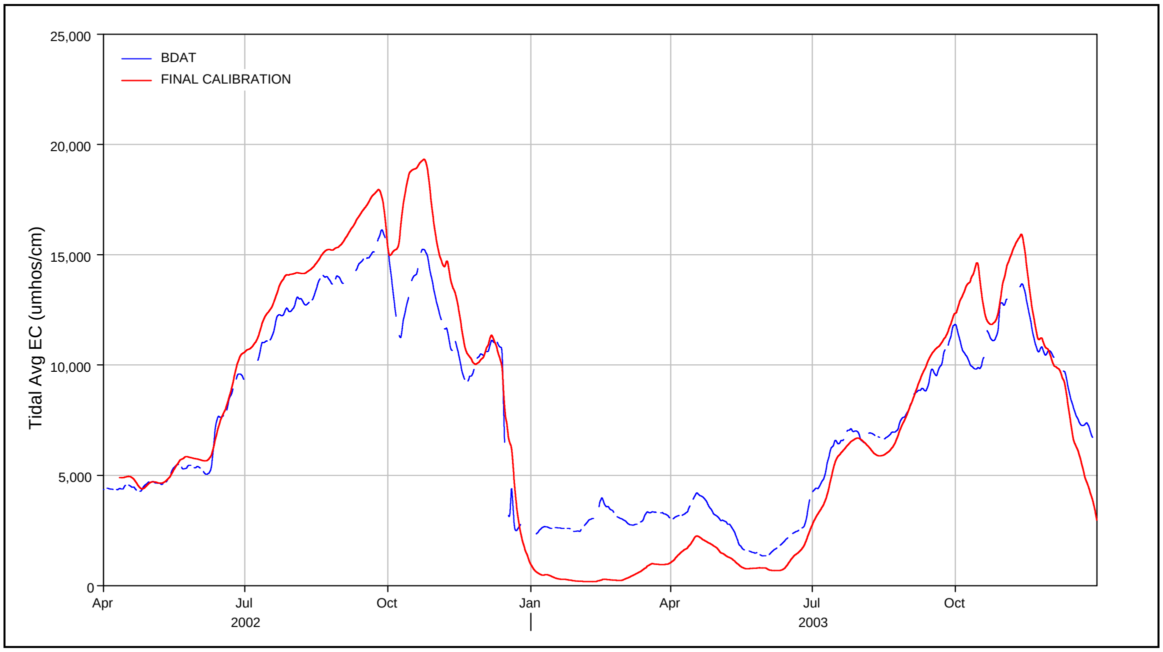


Figure 4-33 Tidally averaged observed and computed EC at station S-42, Volanti.

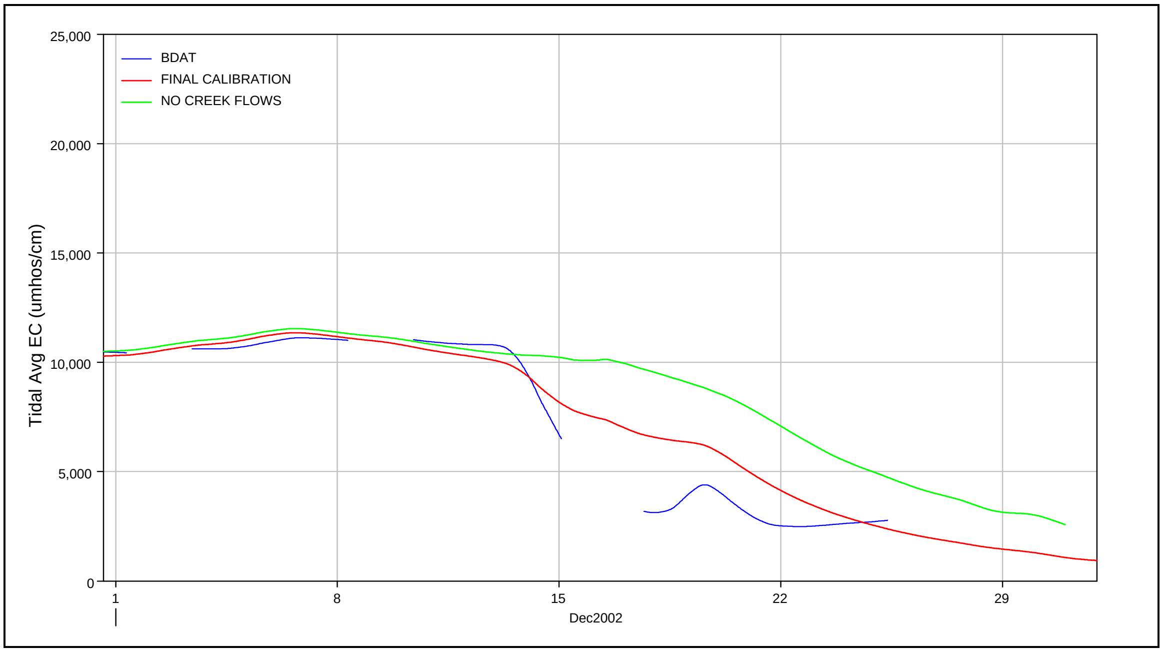


Figure 4-34 Tidally averaged observed and computed EC at station S-42, Volanti in December, 2002. Computed results shown with and without local creek flow addition.

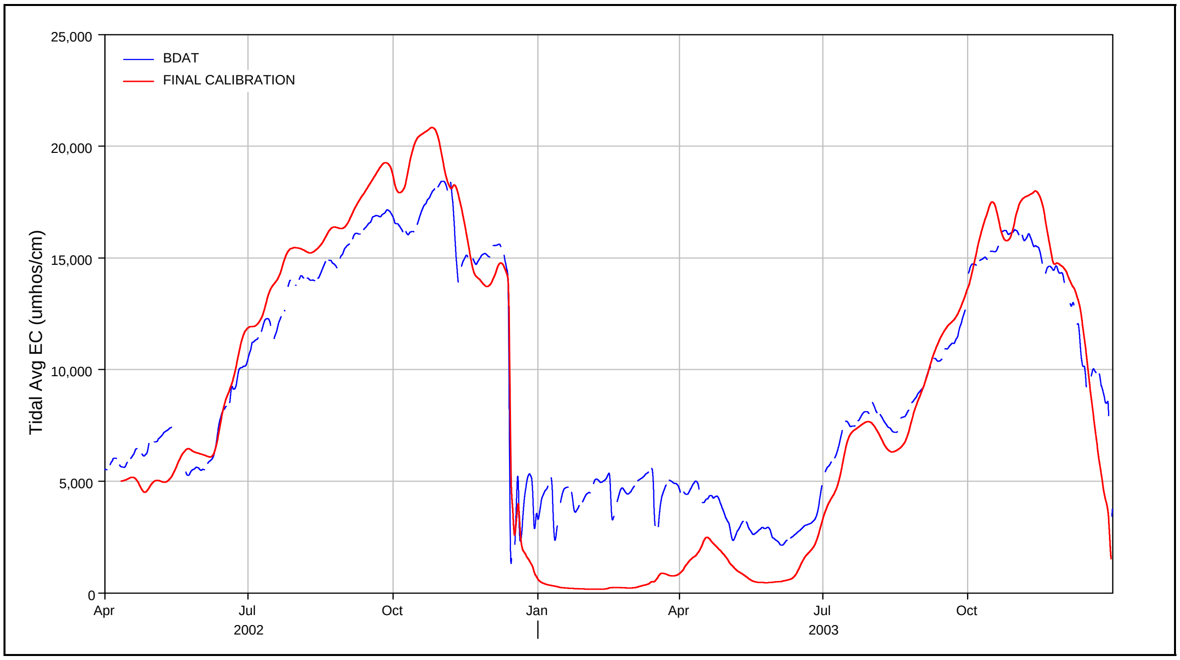


Figure 4-35 Tidally averaged observed and computed EC at station S-97, in Cordelia Slough at Ibis.

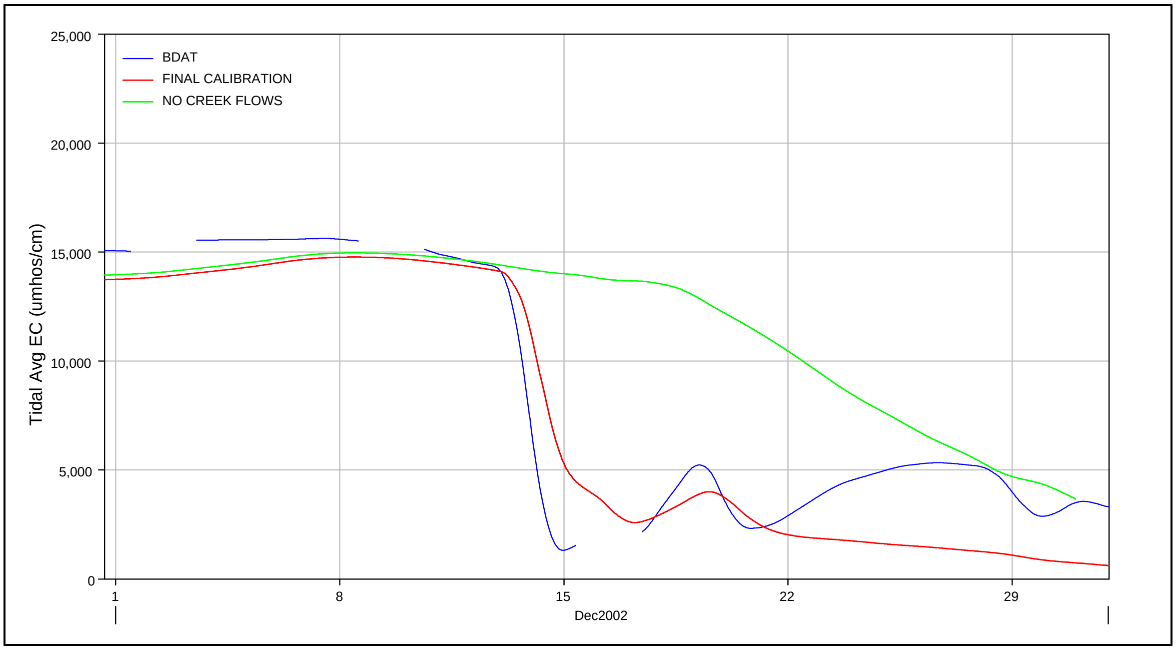


Figure 4-36 Tidally averaged observed and computed EC at station S-97, in Cordelia Slough at Ibis December, 2002. Computed results shown with and without local creek flow addition.

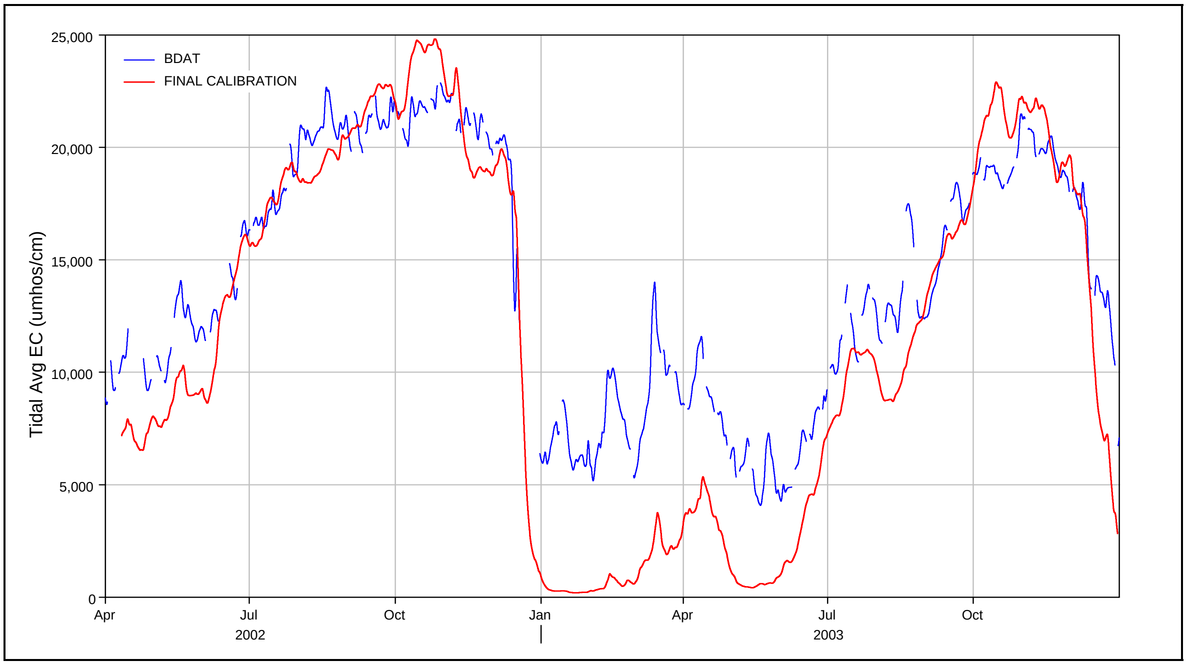


Figure 4-37 Tidally averaged observed and computed EC at station A-96 on Goodyear Slough at Fleet.

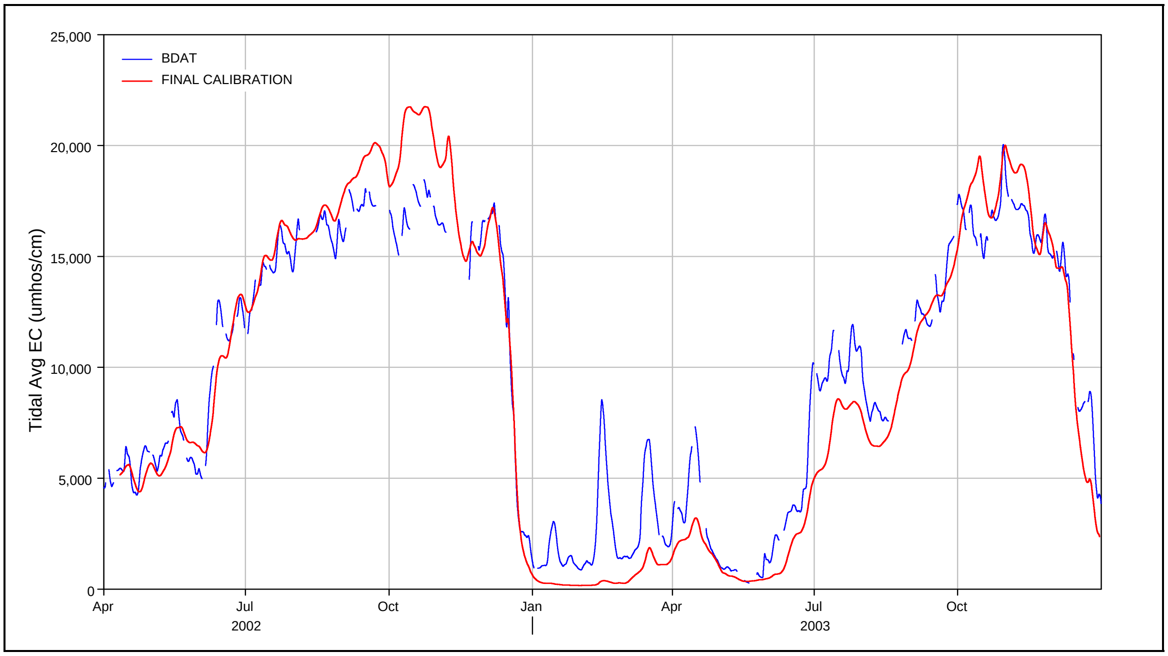


Figure 4-38 Tidally averaged observed and computed EC at station S-37 in Suisun Slough at Godfather.

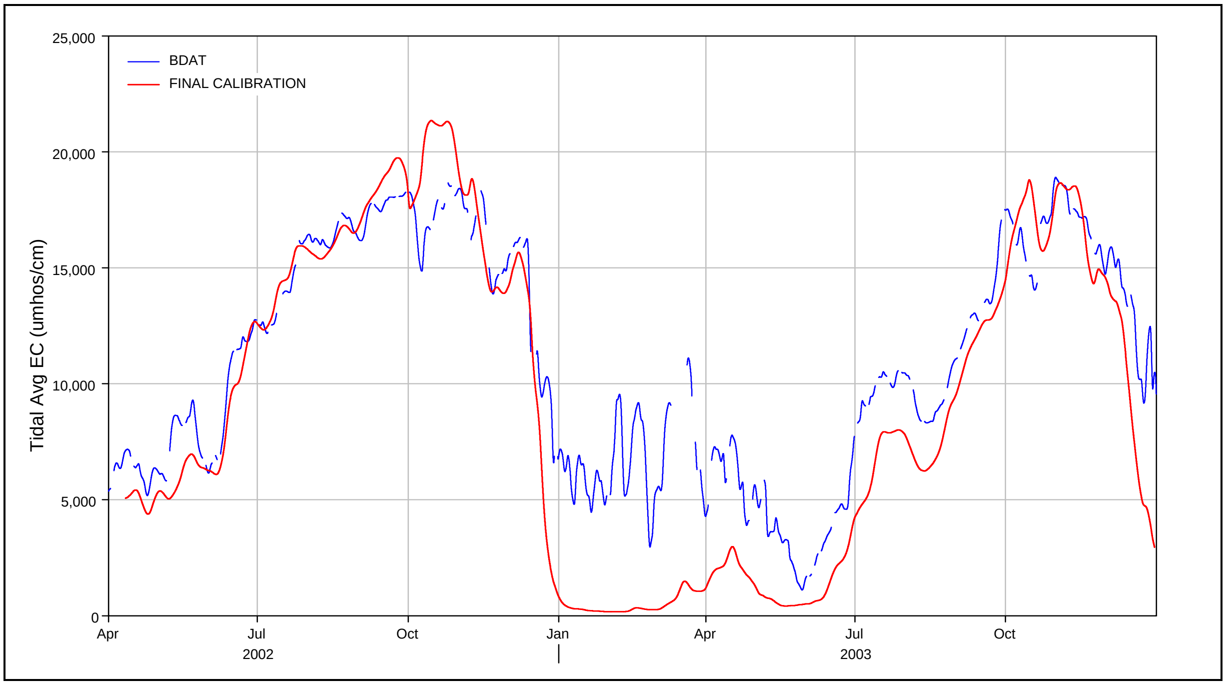


Figure 4-39 Tidally averaged observed and computed EC at station S-35 at Morrow Island.

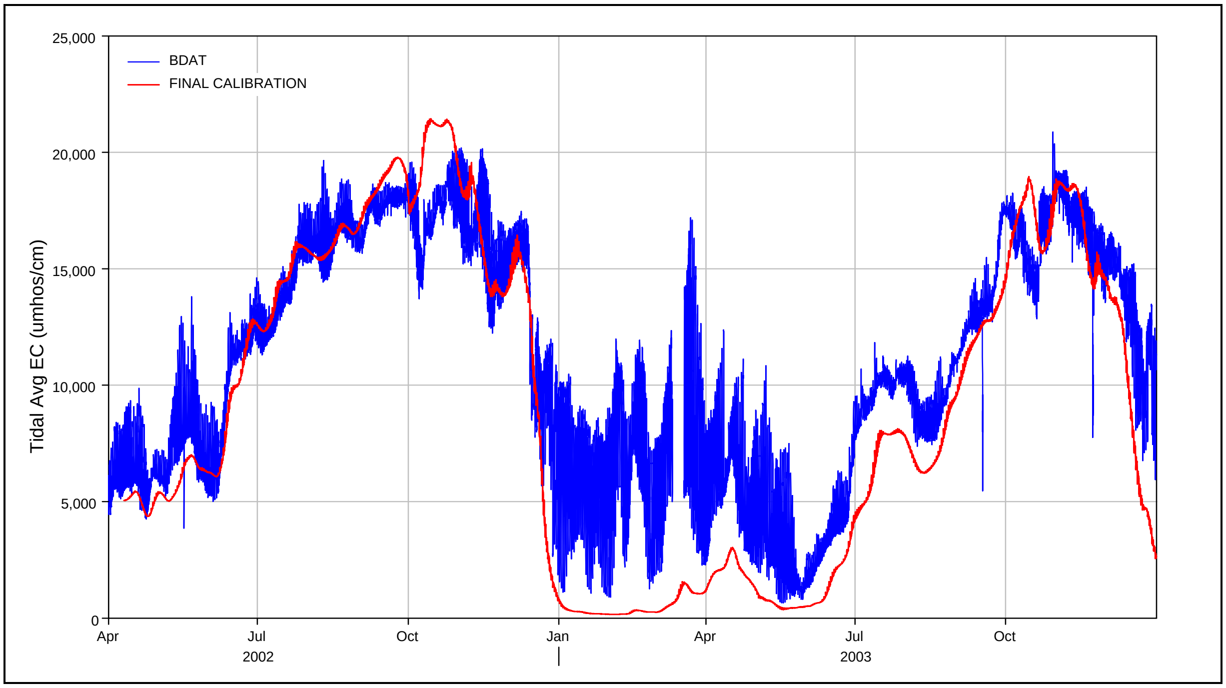


Figure 4-40 Intertidal observed and computed EC at station S-35 at Morrow Island.

4.3. Summary of Unresolved Calibration Issues

Although the model additions and improvements, and the hydrodynamic and EC calibration efforts greatly improved the representation of flows and EC in Suisun Marsh, there are several issues that may influence the representation of scenario results. One modification to the model that could potentially improve calibration results would be to include a formulation for gravitational circulation to improve the representation of salinity stratification effects.

There was insufficient data in some critical areas of the model, such as insufficient data to represent local inflows and withdrawals in Suisun Marsh. Although modeled stage representation was generally good, some of the flows in major sloughs had substantial error, such as in Montezuma and Suisun Sloughs, which may bias EC model results in the scenarios. In the periphery areas of Suisun Marsh, much of the difference between modeled and measured EC and flow may be due to estimation of local creek flows and managed wetland diversions and returns.

5. Tidal Restoration Scenario Simulations

Each of the Suisun Marsh restoration scenarios (Figure 1-1) was modeled to evaluate its effect on tidal range, scour, tidal prism and EC in Suisun Marsh and EC in the Delta. A Base case scenario was also modeled. In cases where 1-D sections of the Base case mesh were extended to 2-D for the scenarios, the comparison between the cross-sectionally averaged 1-D Base case mesh results and depth-averaged 2-D scenario mesh results is not necessarily direct. However, comparison plots are still used to get a general idea of the potential magnitude of the differences.

Zone 1 has one breached levee near the mouth of Suisun Slough and another on Goodyear Slough. This restored area is incorporated in Set 2, which also has two restored areas with breaches on or near Honker Bay, an area off of Montezuma Slough, and two areas on smaller sloughs in the interior of the northeastern area of Suisun Marsh. Zone 4 has two breach locations on Montezuma Slough. Set 1 includes the Zone 4 area, as well as areas in the interior of the marsh, with breaches on smaller sloughs in the northeastern and northwestern corners of the marsh.

5.1. Boundary Conditions

Boundary conditions for the four scenarios were in large part the same as those for the Base case, with the primary difference in filling and draining of the duck club ponds to accommodate changes in geometry. The fill and drain flow rates of the duck ponds were reduced by eliminating the flooded area from the volume calculation.

5.2. Simulation Period

The simulation period for the Base case and four scenarios extends from April 10, 2002 through December 31, 2003.

5.3. Mesh

LiDAR data (DWR, 2007) and aerial photographs were used to guide the elevation and extent of the breached and flooded areas incorporated in each of the scenarios.

5.3.1. **Base**

The Base case model differs slightly from the calibration model. It was assumed that the Meins Landing and Hill Slough marsh restoration projects, although not currently complete, would be in place by the time any of the scenarios would be implemented. Therefore, these areas were included in the Base case and in each of the scenarios. Figure 5-1 and Figure 5-2 illustrate the grid and bottom elevation, respectively, in the Suisun Marsh region for the Base case.

5.3.2. **Set 2 and Zone 1**

The total restoration area for Set 2 is approximately 7529 acres (not including Meins Landing, Hill Slough or Blacklock). Figure 5-3 and Figure 5-4 illustrate the grid and bottom elevation, respectively, in the Suisun Marsh region for Set 2.

Set 2 scenario geometry incorporates the Zone 1 (see Figure 1-1) marsh restoration which occurs at Morrow Island with breaches off of Suisun Slough and Goodyear Slough. The flooded area is approximately 2003 acres. The remainder of the restoration area for Set 2 consists of breaches flooding approximately 2107 acres north of Suisun Slough at Cutoff Slough, north and south of Cross Slough, and between Nurse Slough and Luco Slough. Two additional breaches off of Suisun Bay flood approximately 3419 acres of Simmons, Dutton and Wheeler Islands.

5.3.3. **Set 1 and Zone 4**

Total restoration area for Set 1 is approximately 7821 acres (not including Meins Landing, Hill Slough or Blacklock). Figure 5-5 and Figure 5-6 illustrate the grid and bottom elevation, respectively, in the Suisun Marsh region for Set 1.

Set 1 scenario geometry incorporates Zone 4 (see Figure 1-1), as well as the breached area between Nurse Slough and Luco Slough (approximately 582 acres), and several breached areas in western Suisun Marsh totaling approximately 3895 acres. Zone 4 scenario geometry includes proposed tidal marsh restoration area south of Suisun Slough at Frost Slough, with two breaches off of Suisun Slough. The flooded area is approximately 3344 acres.

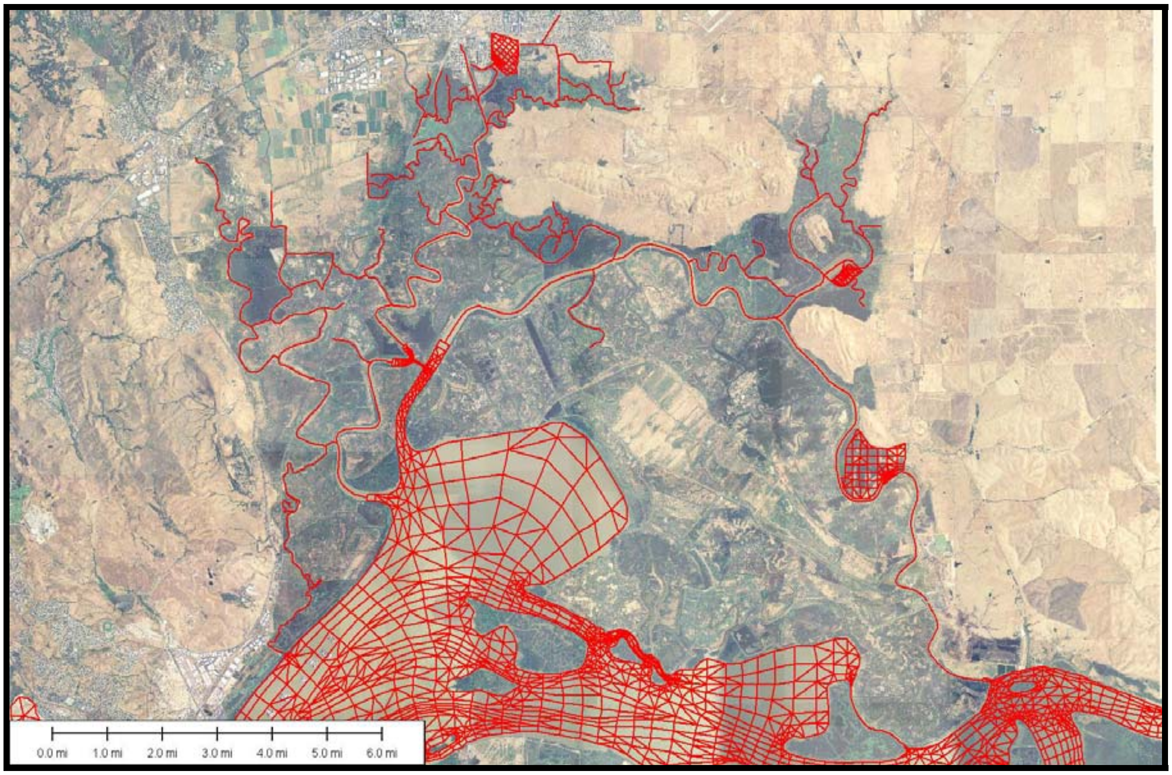


Figure 5-1 Base case grid in Suisun Marsh.

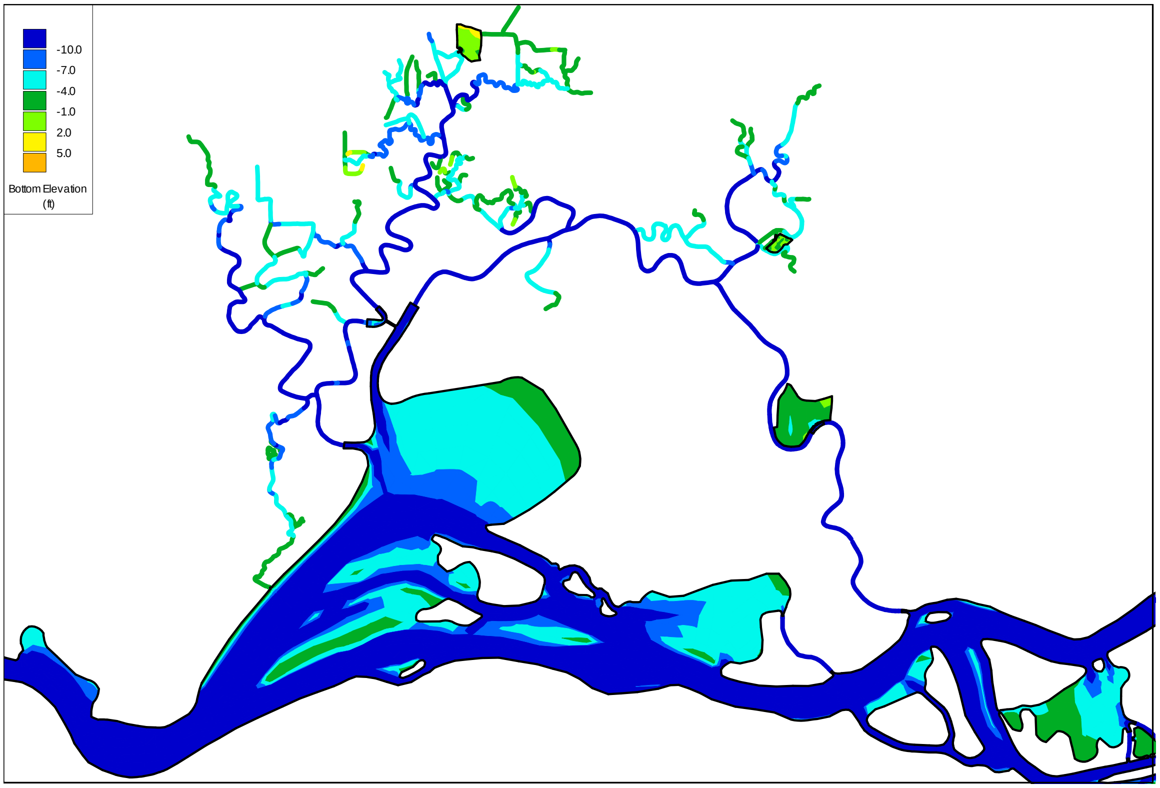


Figure 5-2 Bottom elevation for the Base case grid.

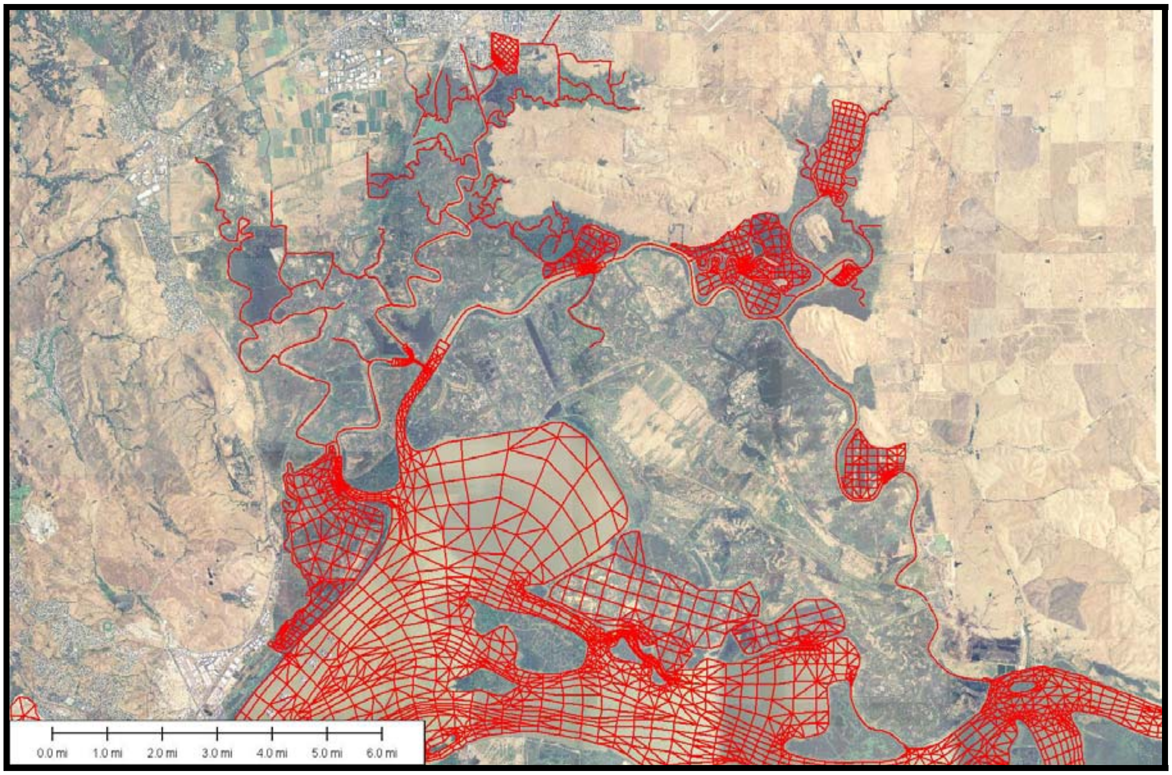


Figure 5-3 Set 2 grid in Suisun Marsh.

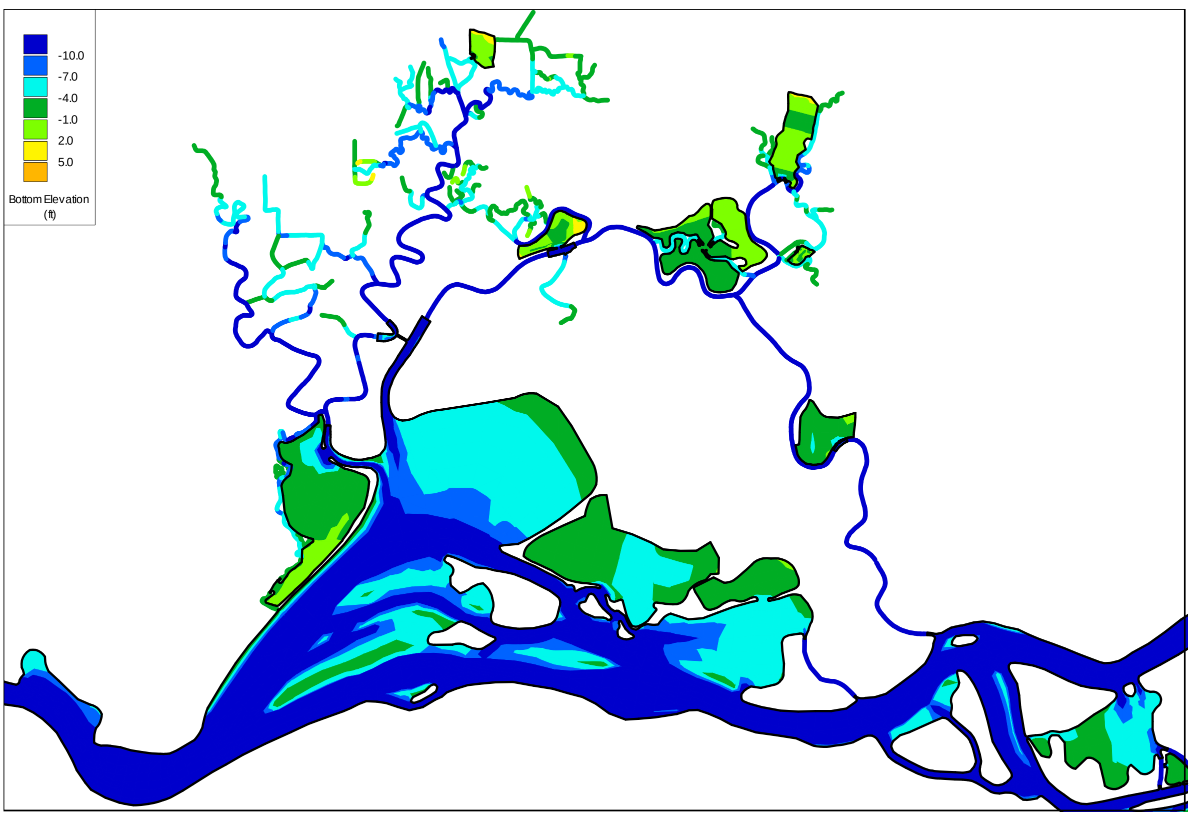


Figure 5-4 Bottom elevation for the Set 2 grid.

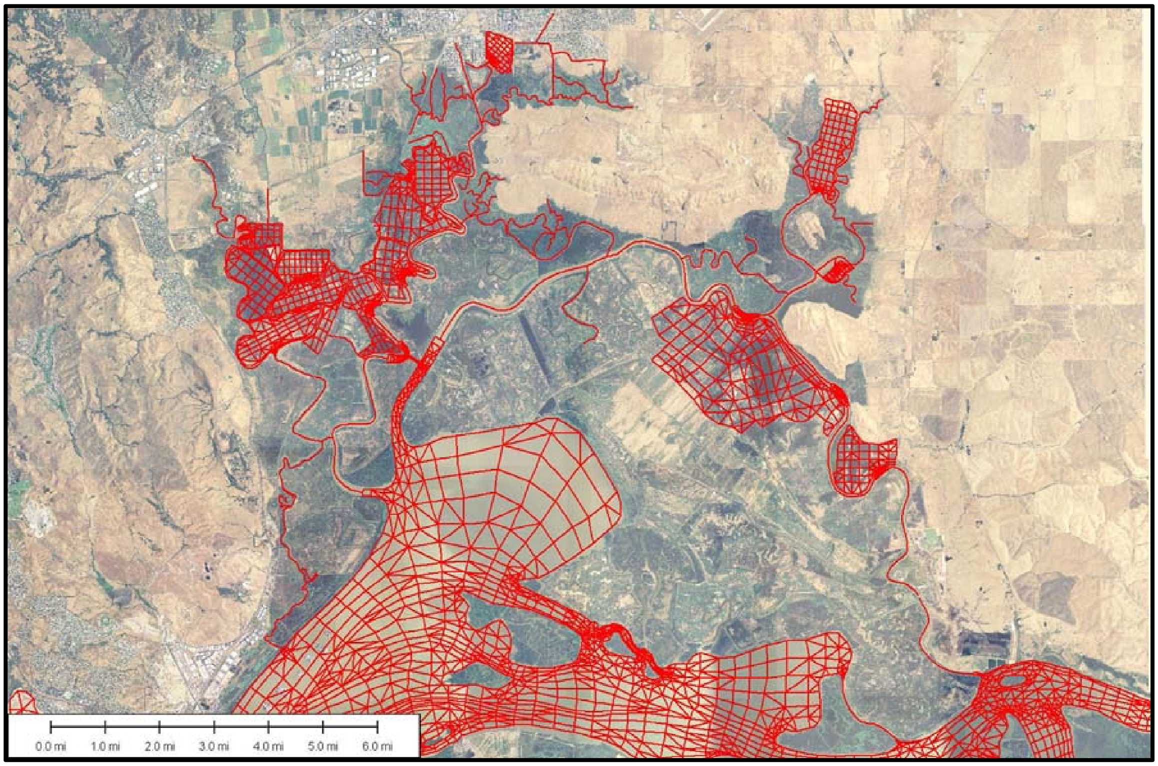


Figure 5-5 Set 1 grid in Suisun Marsh

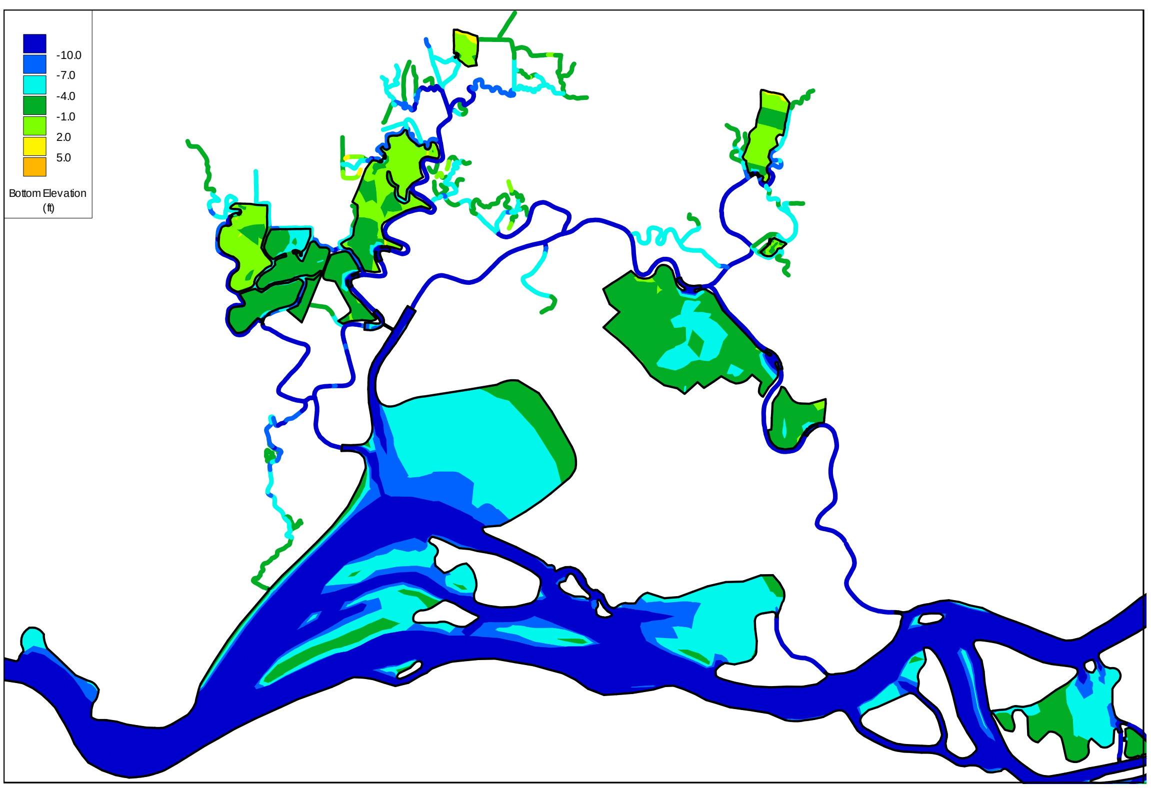


Figure 5-6 Bottom elevation for the Set 1 grid.

5.4. Stage Results

5.4.1. **Background**

Tidal damping can occur if channels are not large enough to convey the full tidal prism of the restored areas. This effect will persist until channel scour (or levee breaches) increase the capacity of the channels feeding the upstream marshes. Velocity results indicate that some channels (Montezuma Slough, Hunter Cut) will be subject to scouring and tidal damping until sufficient conveyance is established.

5.4.2. **Results**

Each scenario resulted in reduced tidal amplitude throughout Suisun Marsh, and a shift in timing. These changes were generally the most pronounced in Set 1 and Set 2 scenarios, and varied depending on location in the marsh (Figure 5-7). Time series plot of stage at Beldon’s Landing, S-49, during October 2003 (Figure 5-8, duck clubs filling) shows that the Set 1 and Zone 4 scenarios have the most prominent effect at this location, while the Zone 1 scenario has very little effect.

The significant dampening effect for the Set 1 scenario can be seen in plots of MHHW and MLLW for April and October 2003, shown in Figure 5-9 and Figure 5-10, respectively. During these months, MHHW was reduced by as much as 0.8 ft and MLLW increased by as much as 1.2 ft. Greater differences are seen in the immediate vicinity of the breaches in the western marsh.

Although the restriction of Set 1 restoration area to Zone 4 (not shown) had less effect in the western marsh, with no breaches there, in the eastern portion, MHHW was reduced by as much as 0.6 ft and MLLW increased by as much as 1.1 ft.

Set 2 restoration areas resulted in MHHW reduced by up to 0.3 ft and an increase in MLLW of up to 0.2 ft (Figure 5-11). Restriction of Set 2 restoration area to Zone 1 (not shown) demonstrated this area had minimal effect on stage throughout Suisun Marsh. The tidal dampening effect was generally less than 0.1 ft overall.

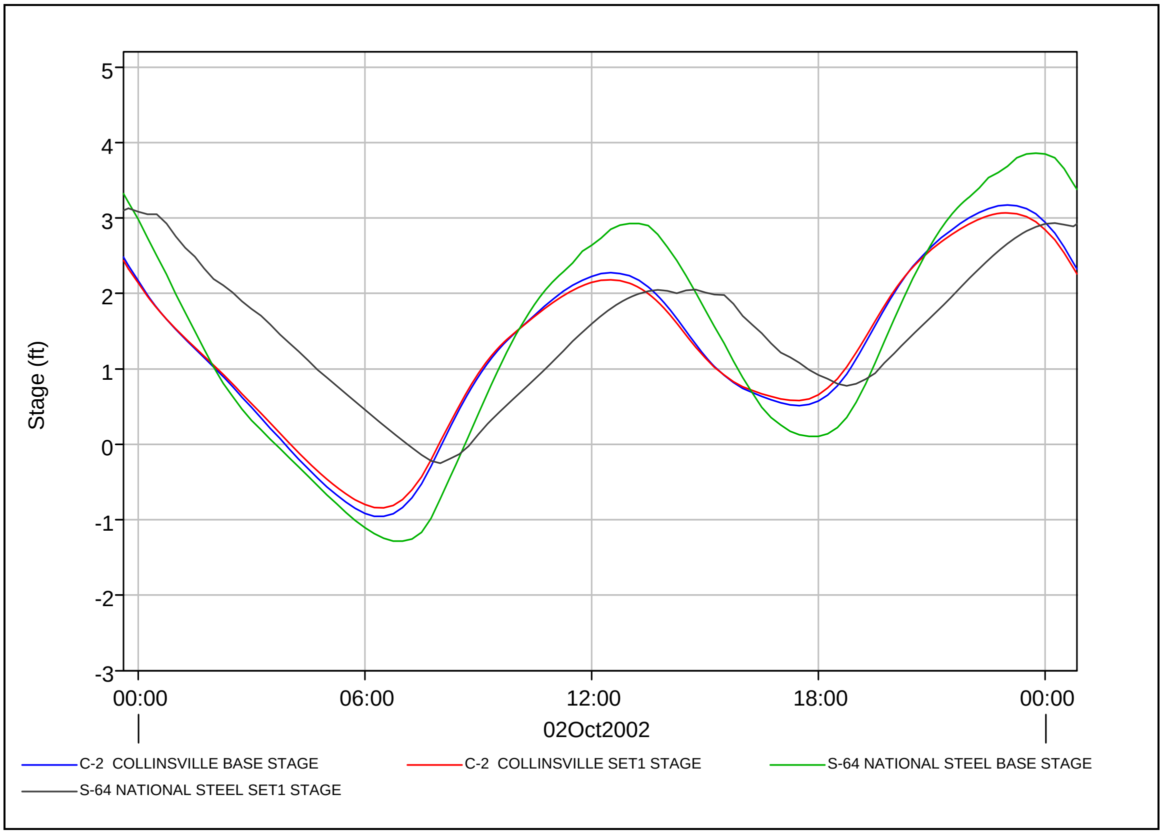


Figure 5-7 Stage time series showing stage shifts at Collinsville monitoring station C-2 and National Steel monitoring location S-64 for Base and Set 1 Scenarios.

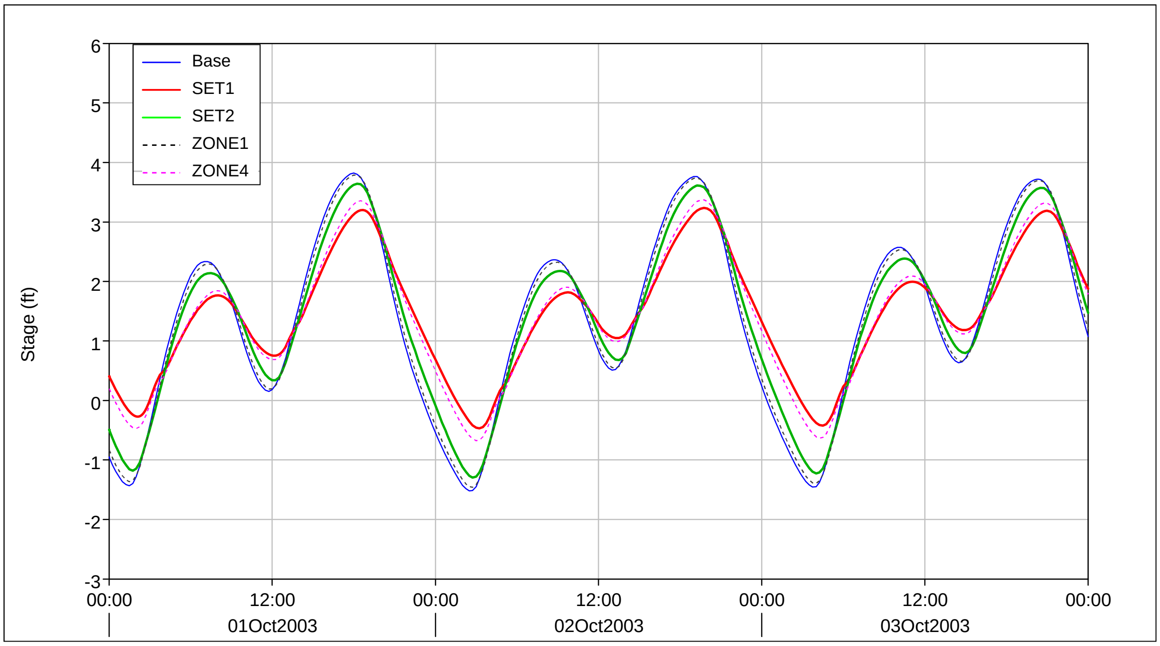


Figure 5-8 Stage time series at monitoring station S-49 at Beldon's Landing when Duck Clubs in the Suisun Marsh region are filling in the fall.

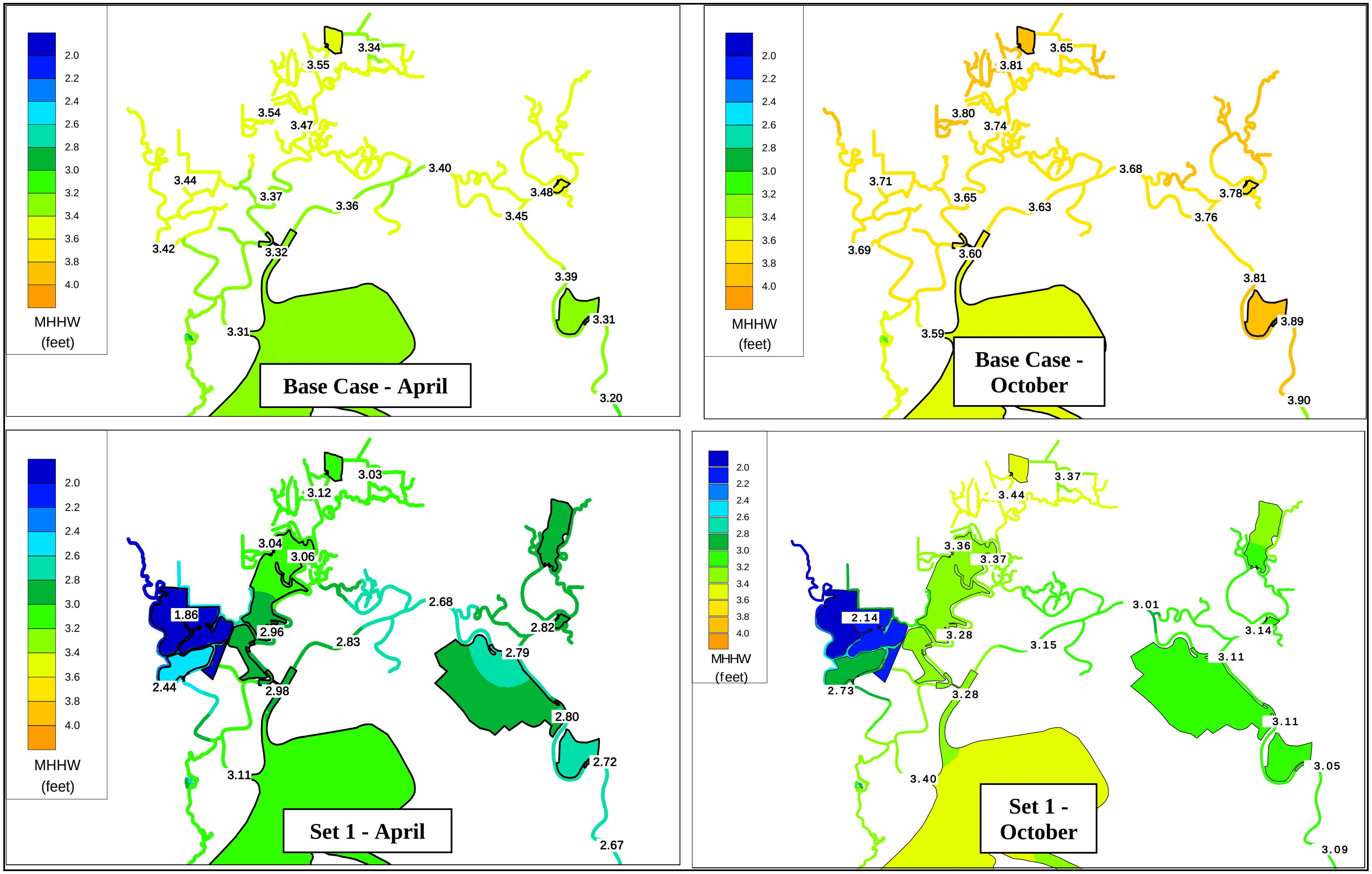


Figure 5-9 Color contour plots of Base case (upper) and Set 1 (lower) MHHW elevations for April (left) and October (right) 2003.

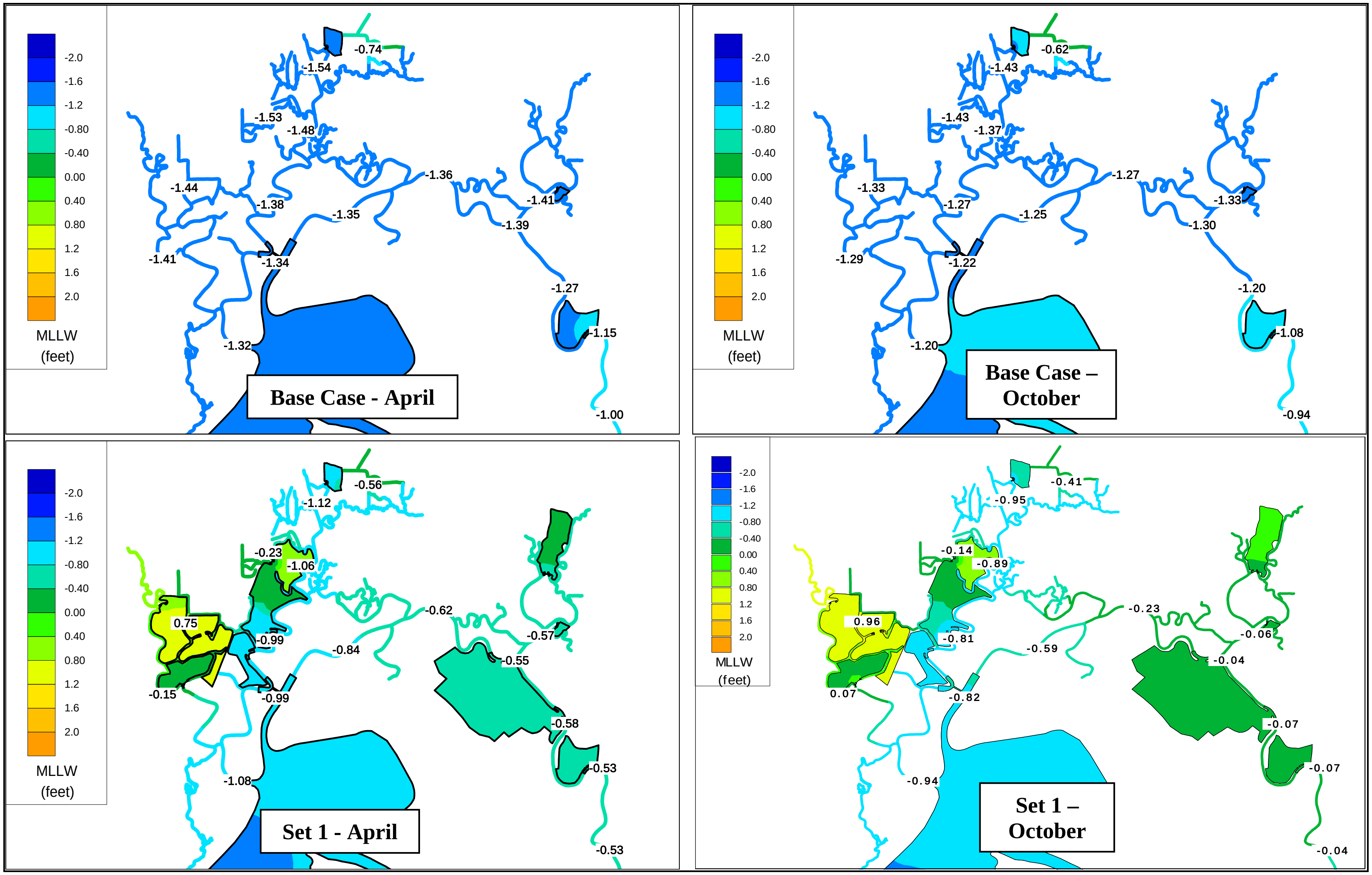


Figure 5-10 Color contour plots of Base case (upper) and Set 1 (lower) MLLW elevations for April (left) and October (right) 2003.

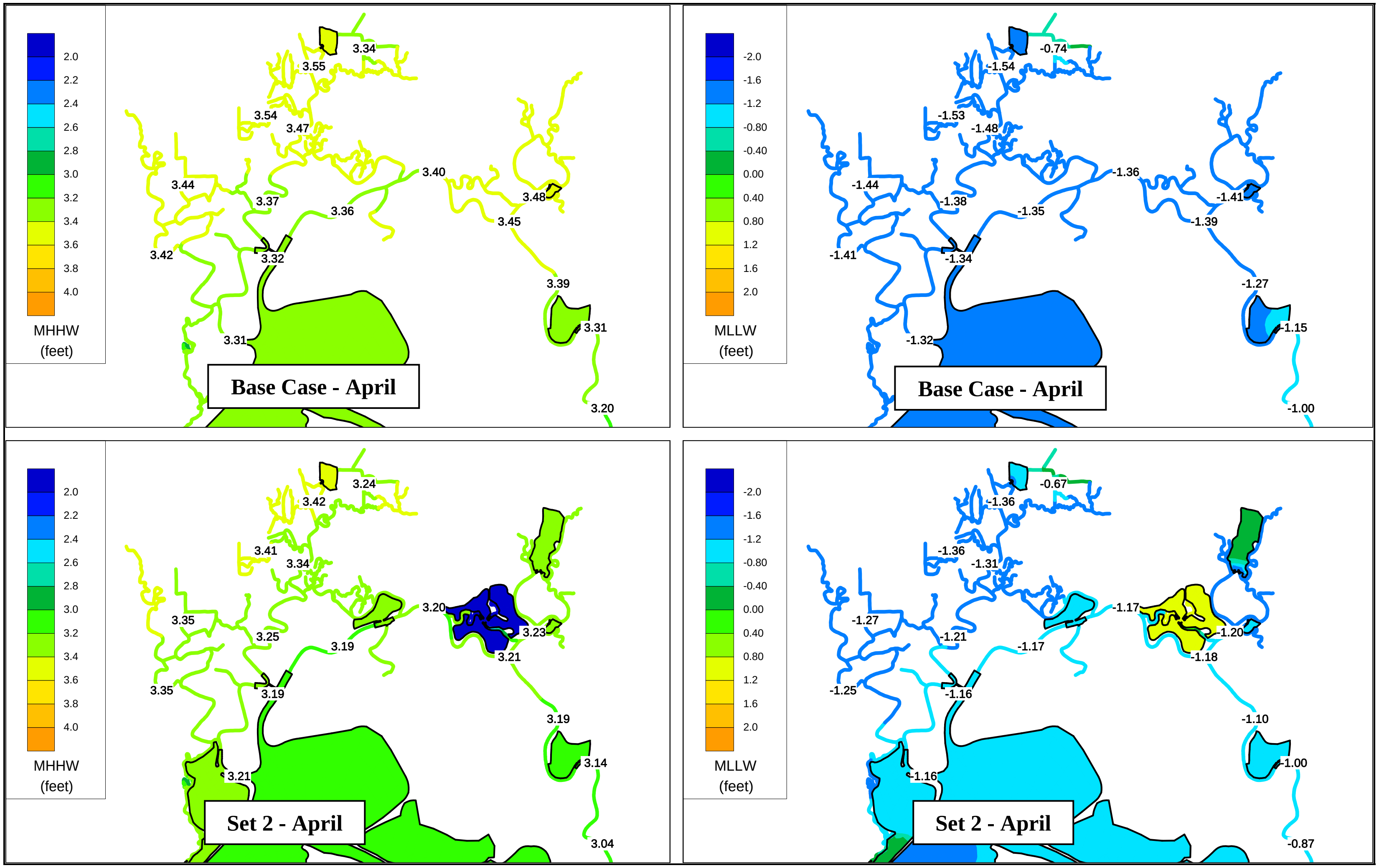


Figure 5-11 Color contour plots of Base case (upper) and Set 2 (lower) MHHW (left) and MLLW (right) elevations for April 2003 (note scale differences for MHHW and MLLW).

5.5. Tidal Prism Results

5.5.1. **General observations**

As expected, each of the scenarios increased the tidal prism, i.e., the volume of water exchanged in the Suisun Marsh area, in comparison with the Base case. Figure 5-12 shows locations where net tidal flow results are presented for July 2003. Values for tidal flow were calculated by accumulating ebb and flood (tidal) flow in ac-ft/day and averaging over the month. The results are grouped by general location in Suisun Marsh and by range of tidal flow.

The Set 1 scenario increased tidal flow everywhere except the boundary sloughs of the Marsh (e.g. Hill Slough) as flow increased through both ends of Montezuma Slough, and through Suisun Slough and Hunter Cut. Tidal flows in boundary sloughs decrease when tidal marsh restoration occurs at downstream locations because not as much of the tidal prism makes it past these new areas. For the Set 2 scenario, the increased flow in Suisun Slough and western Montezuma Slough increased tidal flow in the larger sloughs and adjacent sloughs, but decreased flow to the boundary areas of the Marsh and through the eastern end of Montezuma Slough. Zone 4 resulted in increased flow through Montezuma Slough and through the northern-central portion in the Marsh interior through Suisun Slough, but decreased tidal flow in the north eastern and western regions of the Marsh. Zone 1 decreased tidal flow everywhere, except in areas in the immediate vicinity (e.g., Hunter Cut) of the breached area.

5.5.2. **Central Marsh**

The increase in tidal flow through the largest sloughs in the central portion of the Marsh depended on the location of the breached area. Set 1 and Zone 4 increased average tidal flow through both ends of Montezuma Slough to fill the Zone 4 breached area. At the western end of Montezuma Slough, tidal flow increased ~ 24% for the Zone 4 scenario and ~ 48% for the Set 1 scenario in comparison with the base, and at the eastern end ~ 60% for both Zone 4 and Set 1. Zone 4 filled through the breaches at both ends, with the timing of the filling and draining of the eastern breach delayed for a short while in comparison with the western end.

Set 2 and Zone 1 also increased tidal flow through the western end of Montezuma Slough, but decreased tidal flow through the eastern end.

Changes in the Set 2 and Zone 1 scenarios were very similar, as tidal flow through the mouth of Suisun Slough to fill the Zone 1 breached area increased substantially, while the tidal flow increases were more moderate through Hunter Cut. Zone 1 flows were higher than Set 2 flows by ~ 7% in Hunter Cut, and by ~ 2 % at the mouth of Suisun Slough. Set 1 also increased flows in these two locations, except that the flow increase through Hunter Cut was larger than in Suisun Slough to fill the breached areas northeast of the Cut.

5.5.3. North Interior Marsh

The tidal flow in the northern region of the Marsh decreased as distance from Montezuma Slough increased, and all scenarios were less than the Base case at the four northernmost interior locations (Figure 5-14 and Figure 5-15) because of the downstream restoration areas.

5.5.4. Western Interior Marsh

Filling and draining of the Zone 1 breached area decreased the tidal flow in interior locations of the western Marsh, west and north of the breached area. Zone 1 and Set 2 tidal flows increased through Hunter Cut and the mouth of Suisun Slough (Figure 5-13), and decreased at the interior Suisun Slough locations(Figure 5-15). Flow through Goodyear Slough only increased at the southern end (Figure 5-16), and then only for the Zone 1 and Set 2 scenarios.

The Set 1 scenario increased flow through Hunter Cut and through portions of Suisun Slough south of the Cut to fill the breached areas in the western Marsh, partly through Cordelia Slough. For Zone 4, there were minor increases in tidal flows through Suisun Slough downstream of Hunter Cut, but decreases in Hunter Cut and in Suisun Slough upstream of Hunter Cut.

5.5.5. Comparison of flood flow for the scenarios

Figure 5-17 and Figure 5-18 illustrate the magnitude of flows ($ft^3 sec^{-1}$) near peak flood tide for the Set 1 and Set 2 scenarios on July 11, 2003 22:00. These results are also shown in Table 5-1 Flow magnitude (cfs) at four locations near peak flood tide (July 11, 2003 22:00)., below. The plots give the magnitude vectors at key locations in Suisun Marsh for the Base case and the two restoration configurations. The flow arrows are scaled by flow magnitude, which is indicated on each plot for the downstream openings at Suisun Slough, Montezuma Slough and Hunter Cut. The color scale gives water surface elevation (ft).

The plots show that when the area on Morrow Island is restored (Set 2, Figure 5-17), Hunter Cut provides almost all of the flow for Suisun Slough above the junction with Cordelia Slough. When filling the Zone 4 breached area in Set 1, most of the flow comes through the mouth of Montezuma Slough (Set 1, Figure 5-18). The red arrows in these figures give the direction and magnitude of the indicated flows.

Table 5-1 Flow magnitude (cfs) at four locations near peak flood tide (July 11, 2003 22:00).

	Base	Set1	Set2
Suisun Sl. @ Mouth	10,900 cfs	17,400 cfs	20,050 cfs
Montezuma Sl. - west	39,200 cfs	62.300 cfs	44,800 cfs
Hunter Cut	10,600 cfs	19,600 cfs	15,600 cfs
Montezuma Sl. - east	3,440 cfs	1,500 cfs	5,820 cfs

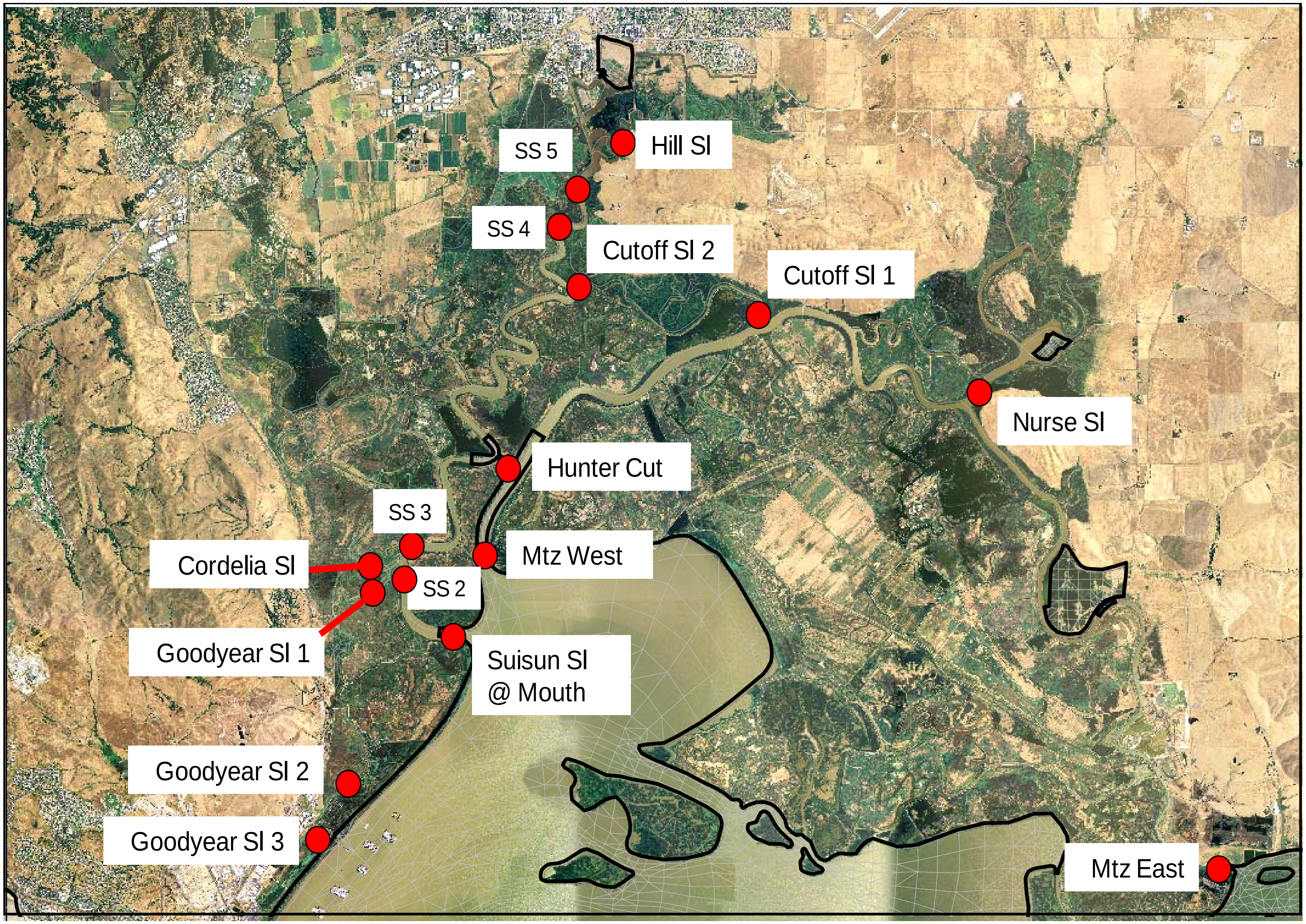


Figure 5-12 Locations where tidal flow was calculated (Base case grid).

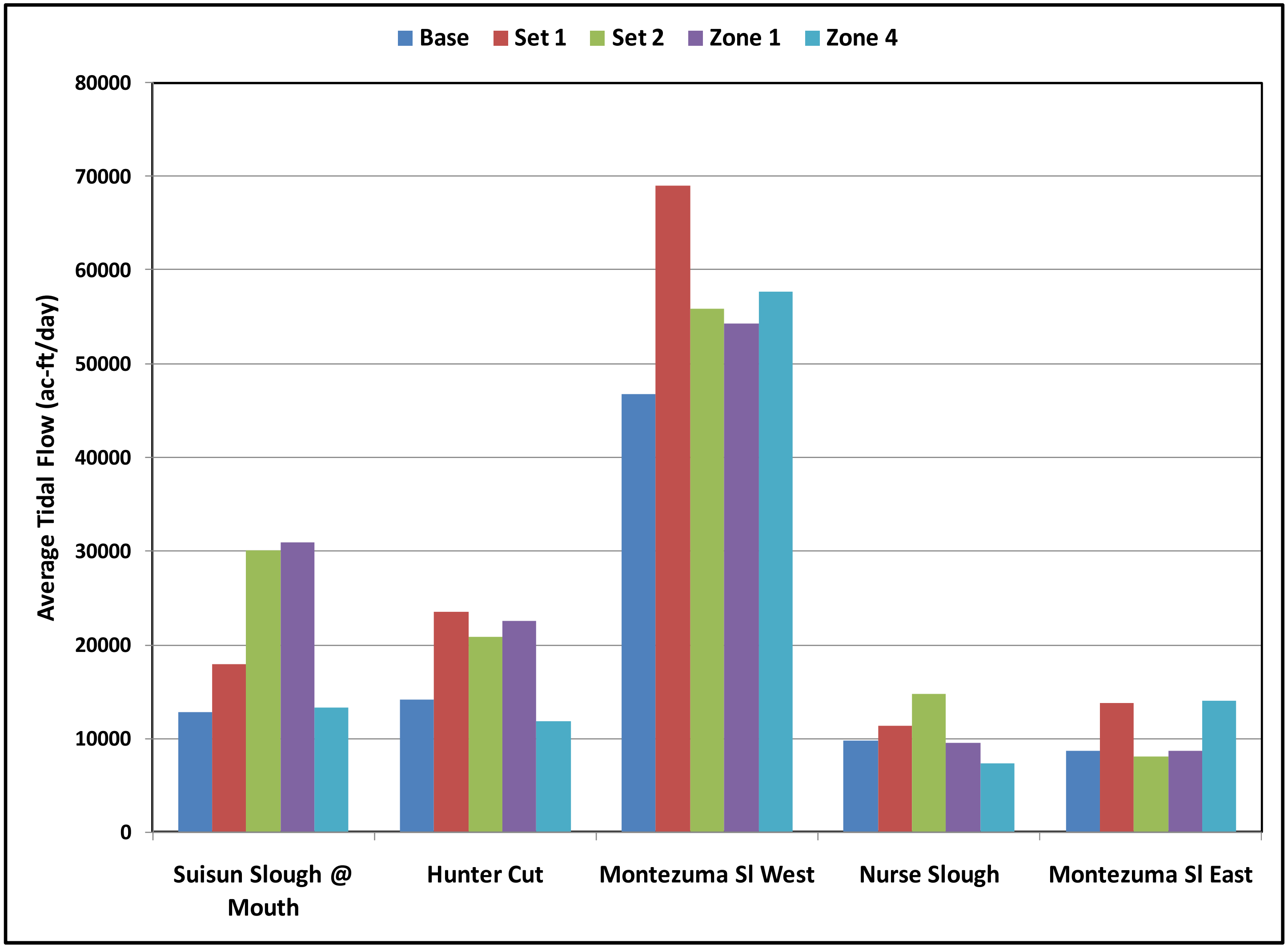


Figure 5-13 Average modeled tidal flow in the larger sloughs in central Suisun Marsh.

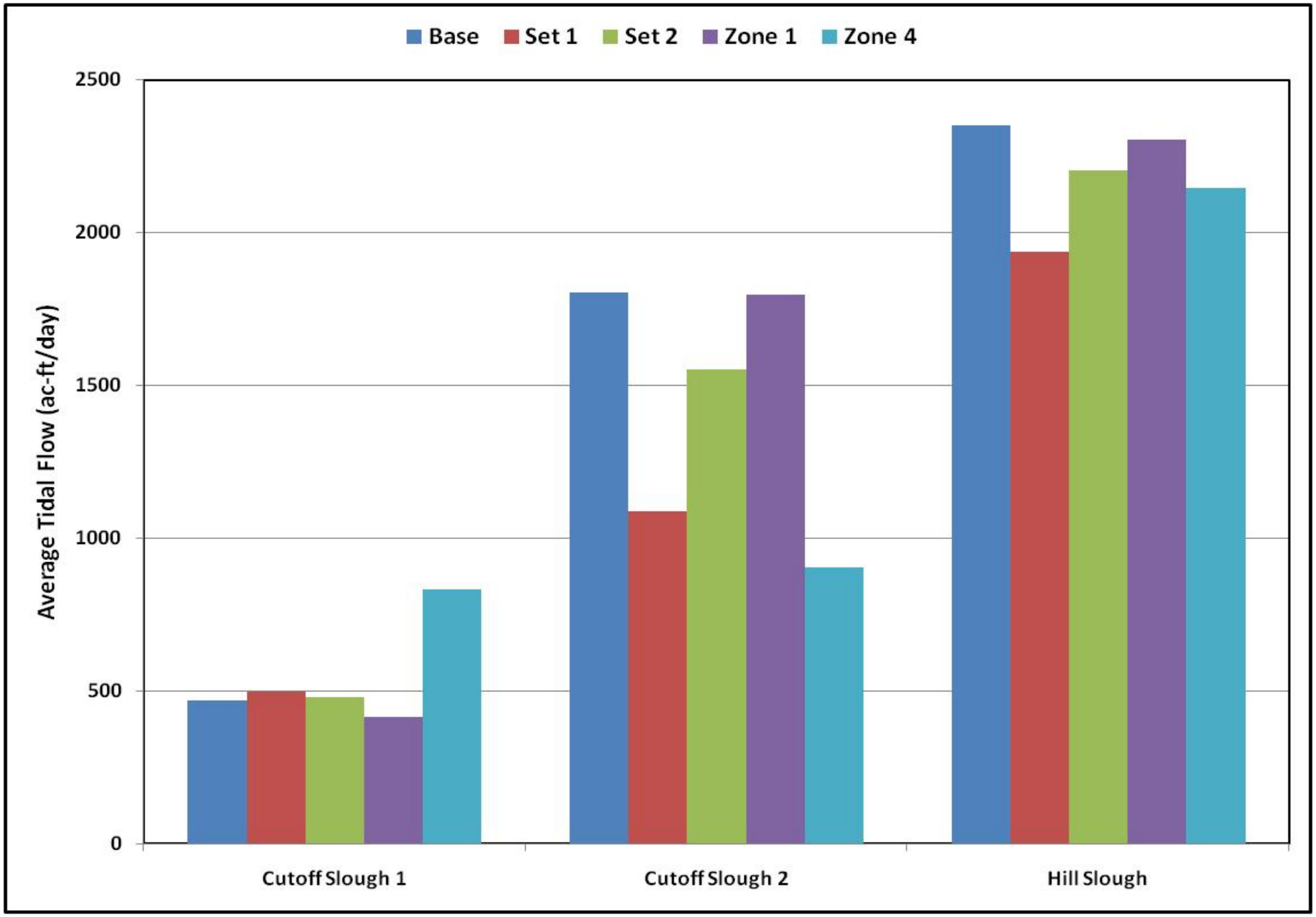


Figure 5-14 Average modeled tidal flow in the smaller sloughs in the northern interior region of Suisun Marsh.

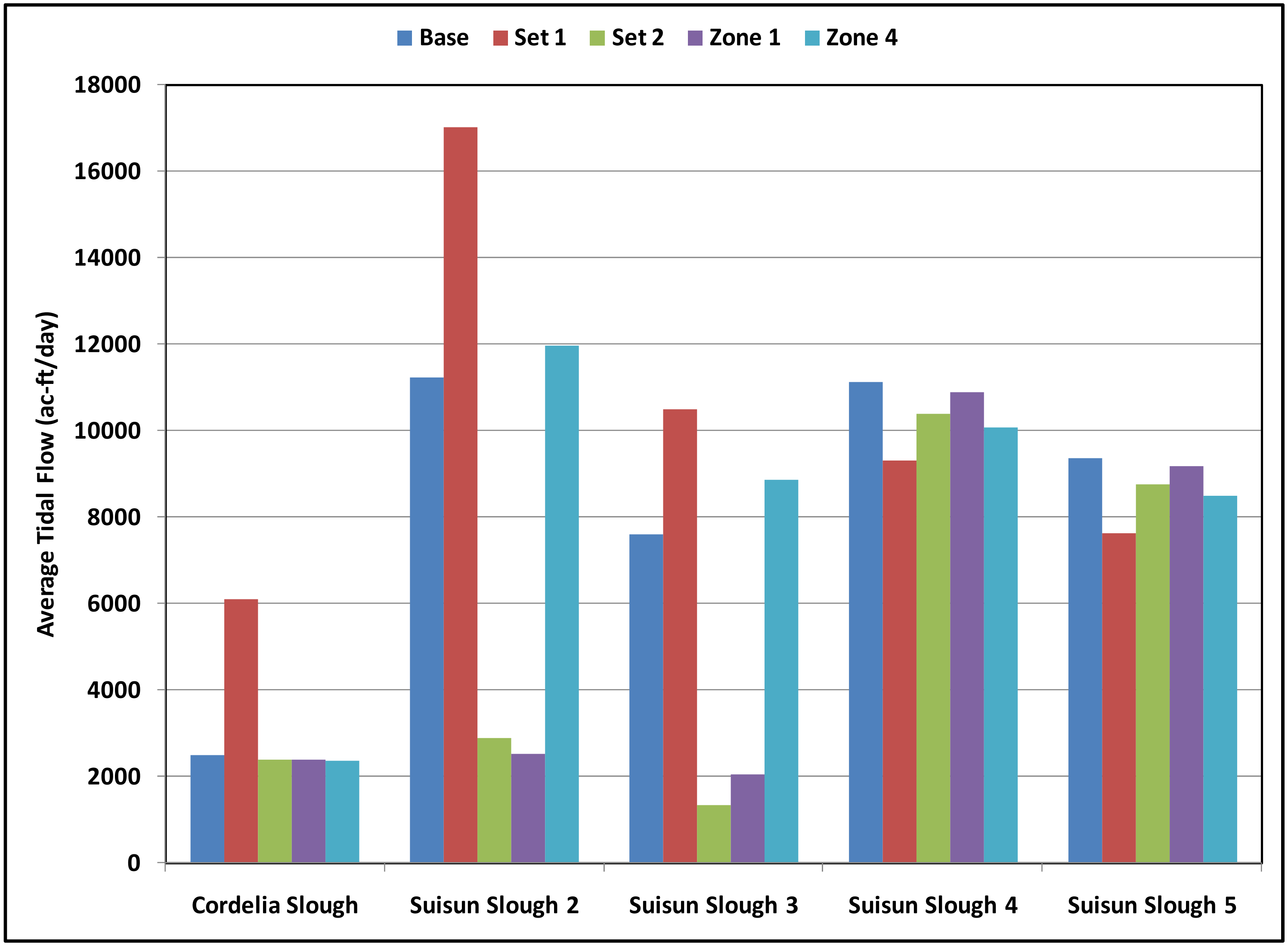


Figure 5-15 Average modeled tidal flow in the sloughs west and north of the Zone 1 area.

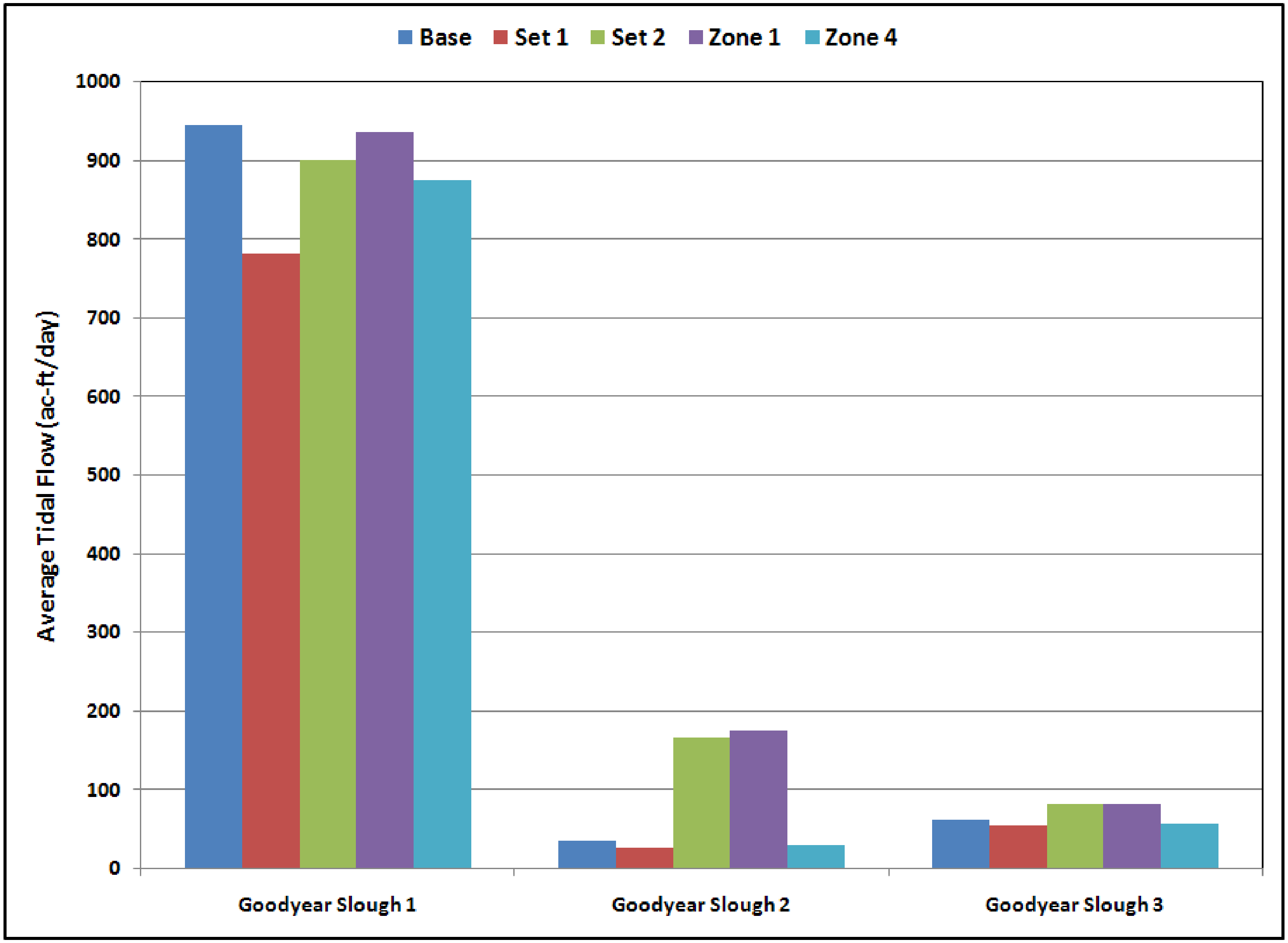
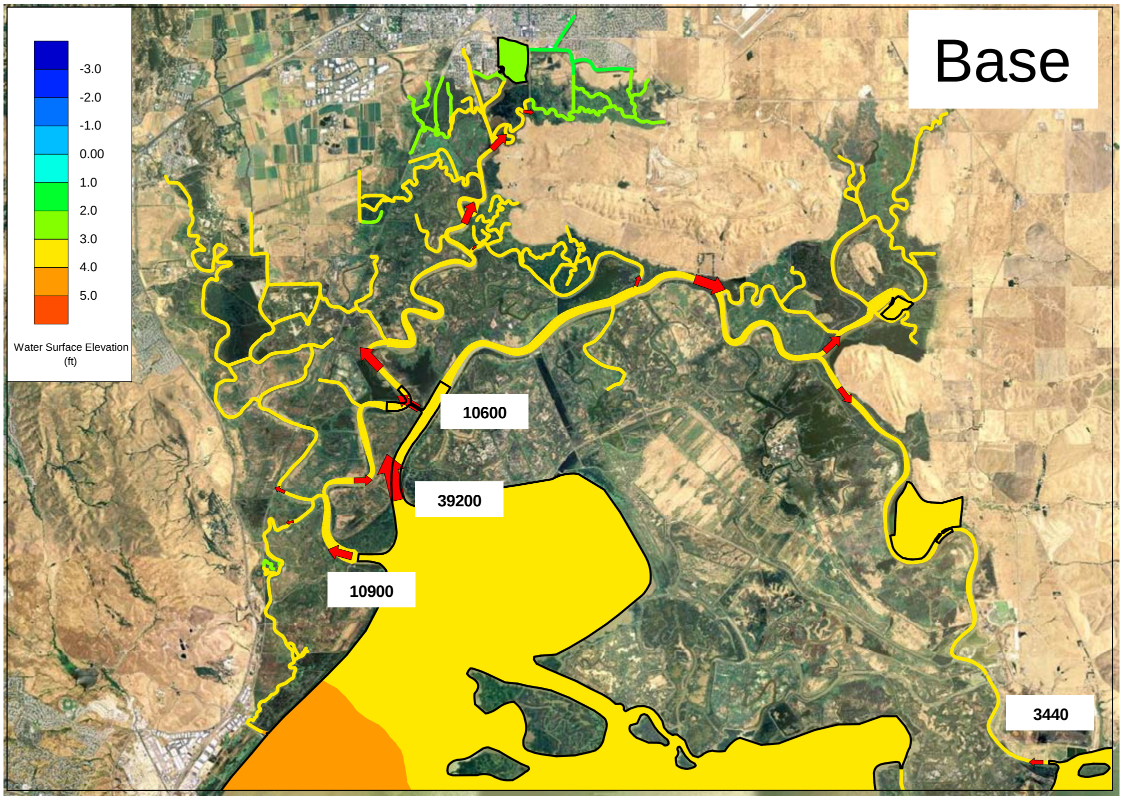


Figure 5-16 Average modeled tidal flow in Goodyear Slough.



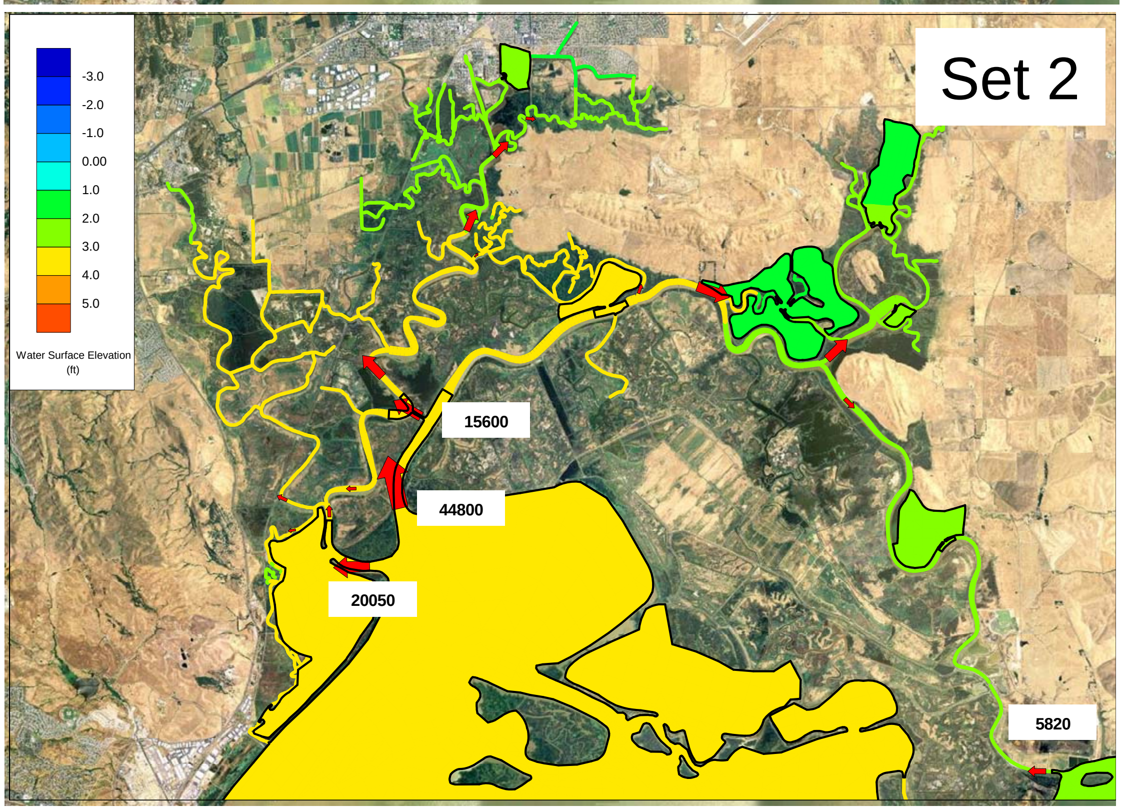
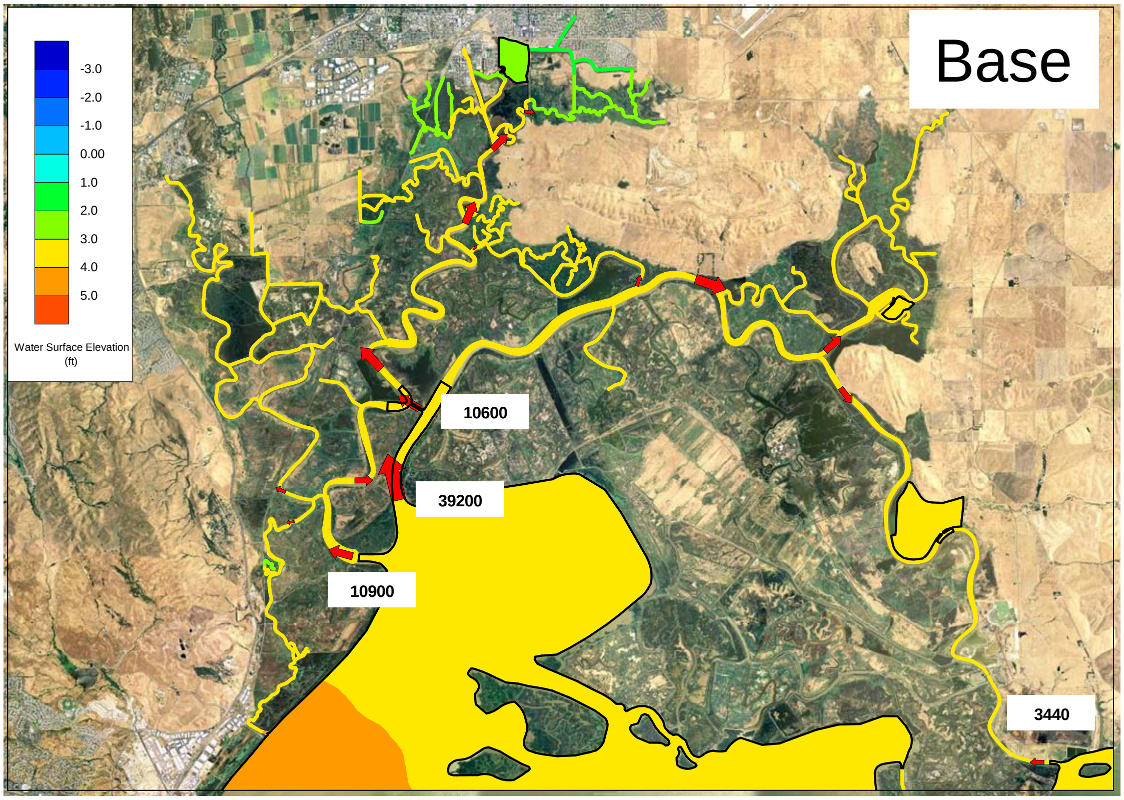


Figure 5-17 Red arrows illustrate flow magnitude (cfs) near peak flood tide (July 11, 2003 22:00) for Base case in comparison with Set 2. Color Scale is water surface elevation.



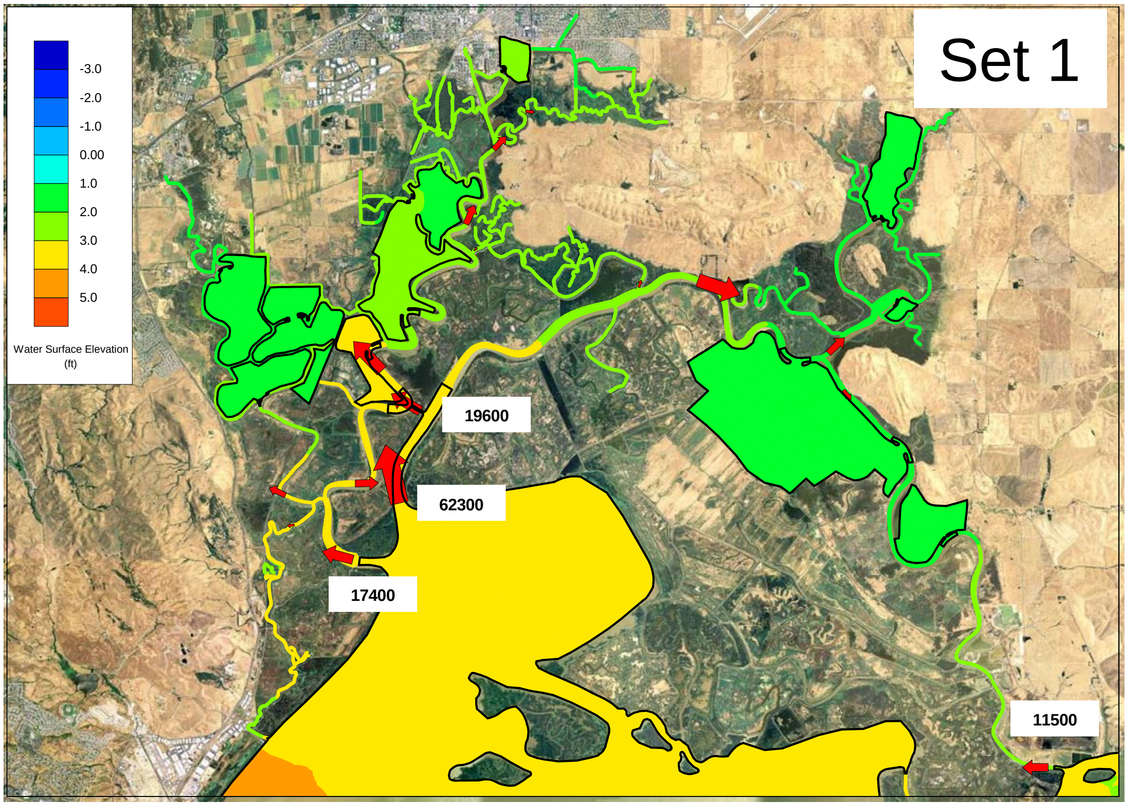


Figure 5-18 Red arrows illustrate flow magnitude (cfs) near peak flood tide (July 11, 2003 22:00) for Base case in comparison with Set 1. Color Scale is water surface elevation.

5.6. EC Results

To present a clear picture of the effects of the scenarios on EC in Suisun Marsh and in the Delta, several types of plots are provided. These include time series plots of the scenario EC at selected locations in Suisun Marsh and the Delta; color contour plots of percent change from base; comparison plots of Base case and scenario EC in Suisun Marsh; and comparison plots of Base case and scenario EC in the Delta. For all of the scenarios, large percent changes calculated in the winter are due to very low values, i.e. relatively small increases in modeled EC can translate to large percent increases. Therefore, contour plots of % change during the winter are not provided.

5.6.1. **Martinez to Collinsville**

Tidally averaged EC at Martinez (Figure 5-19) is relatively uniform between scenarios. However, upstream at Chipps and Collinsville, Figure 5-20 and Figure 5-21 respectively, the effect of the Set 2 tidal restoration with breaches between Honker and Grizzly Bays is seen as a pronounced increase in EC throughout the year.

5.6.2. **Suisun Marsh**

Changes in the details of the EC profile for each scenario depended on the particular location examined, the operation of the SMSCG, and the season. Each of the scenarios resulted in EC increases in Montezuma Slough at Beldon's Landing. Tidally averaged EC for the Base case and the four restoration scenarios are plotted in Figure 5-22 through Figure 5-34 for locations throughout Suisun Marsh.

The Set 1 scenario produced the greatest increases in EC throughout much of Suisun Marsh, as most of the tidal marsh restoration occurs in the interior portions of the marsh and off of Montezuma Slough. See for example, stations S-49 at Beldon's Landing, S-40 at Boynton Slough, and S-97 at Ibis in Figure 5-22 through Figure 5-24. At Beldon's Landing, the Zone 4 breaches pull high salinity water in from western Montezuma Slough increasing EC there year-round. The Set 1 breaches in north-western Suisun Marsh increase EC near those locations, again through the increased volume of higher salinity moving up western Montezuma Slough.

Effects from Set 1 restoration in the western portions of the marsh primarily result from the breaches in that area, as can be seen when comparing results with the Zone 4 scenario results at station S-97, Figure 5-24. Zone 4 had very little effect on EC in the western and northern marsh when the SMSCG was open and decreased EC when SMSCG was operating, as illustrated in Figure 5-24 through Figure 5-31.

Zone 4 increased EC at Beldon's landing regardless of the SMSCG status. In eastern Montezuma Slough at National Steel (Figure 5-33) and Roaring River (Figure 5-34), EC decreased when SMSCG was open and increased when the gates were operating.

In eastern Montezuma Slough, Set 1 reduced EC when the SMSCG was open (see station S-64 at National Steel, Figure 5-33 and station S-71 at Roaring River, Figure 5-34). The

Zone 4 breaches on Montezuma Slough pull high EC water into the marsh from the west during flood tide. Ebb flows on the upstream side of the breaches pull additional lower EC Sacramento River water into the eastern end of Montezuma Slough. This is illustrated in Figure 5-40, which shows color contours of EC for the Base case and Zone 4 scenario at the same timing on a flood tide and on an ebb tide.

The Zone 1 restoration increased EC throughout much of the marsh. As shown in the color contour plot of percent change in EC in Figure 5-47, % EC in Grizzly Bay at the mouth of Montezuma Slough is about 4.5% higher than the Base case with similar increases at the mouth of Suisun Slough. The flows that progress up Suisun Slough past the Zone 1 breach are smaller than in the Base case due to the breach, and the marsh is being filled with higher EC water from the mouth of Montezuma Slough in the west.

The Zone 1 scenario EC results were the most similar to the Base case, showing little difference from the Base case in the eastern Marsh (station S-64 at National Steel and station S-71 at Roaring River) and at Morrow Island (station S-35, Figure 5-26), but resulted in at least some EC increase in the western Marsh (for example, S-42 in Volanti Slough, Figure 5-27 and S-21 on Sunrise Slough, Figure 5-25) and in Montezuma Slough near Beldon's Landing.

The Set 2 scenario, which incorporates Zone 1, increased EC when the SMSCG was operating. In the western and central marsh (for example S-21 and S-49), EC was increased throughout the simulation, but at Morrow Island, Set 2 resulted in little change when the SMSCG was not operating. When the SMSCG was not operating, EC decreased appreciably only in eastern Montezuma Slough at S-64 and S-71.

Operation of the SMSCG acts to decrease EC in comparison to the Base case. Specific locations on Montezuma Slough illustrate the effect of SMSCG operation and changes in tidal flow due to the breaches.

- S-49 – Beldon's Landing (Figure 5-22): For the Set 2 scenario, the breaches north of Montezuma Slough only affect EC at Beldon's Landing when the SMSCG is operating. This can be seen because Set 2 and Zone 1 EC are nearly the same at this location when the gates are open.
- S-64 – National Steel (Figure 5-33): In general, all of the scenarios decrease EC at S-64 when the SMSCG is open because they decrease the flood tide flow of higher EC water to this location. When the gate is operating, EC increases for Set 2 because EC at the eastern end of Montezuma Slough near Collinsville is higher due to the breaches in Suisun Bay. On ebb tide, this higher EC water flows past S-64. For the Zone 1 scenario, the same thing occurs only the effect is much smaller. For the Set 1 and Zone 4 scenarios, the increase in EC is the result of a change in phasing. The breaches off of Montezuma Slough changed the tidal phasing and amplitude so that flow from Collinsville into Montezuma Slough occurs at high tide, when EC at Collinsville is highest.

5.6.3. **Delta**

Scenarios that tended to increase EC in Suisun Marsh tended to decreased Delta EC. Delta EC was similar to the Base case in all of the scenarios during early winter through spring, but changed in relation to the Base case during summer through fall. This can be seen in plots of tidally averaged EC for the Base case and four marsh restoration scenarios at several Delta stations in Figure 5-35 through Figure 5-39, and in contour plots of % change from base in Figure 5-41 to Figure 5-53.

The two scenarios incorporating Zone 4 (Zone 4 and Set 1) resulted in a decrease in Delta EC, while the two scenarios incorporating Zone 1 (Zone 1 and Set 2) resulted in an increase in summer through fall Delta EC. This is seen at locations from Jersey Point, Figure 5-35, to various locations in the central and south Delta - at Old River near Rock Slough (5-36), in Victoria Canal (5-37) and at the CVP (Figure 5-38) and SWP (Figure 5-39) export locations.

The Set 2 scenario causes the greatest increase in Delta EC, as shown in Figure 5-41 through Figure 5-46 for the months with the highest EC changes. An example is seen in the color contour plot of percent change from Base case EC for the Set 2 scenario on September 1, 2002 in Figure 5-42. At this time, EC at the SWP is 12% greater than Base and at the CVP, it is 10% greater than Base. These changes are due to tidal mixing in the breaches off of Suisun Bay, which causes increased EC there, and later in the year increased EC up the San Joaquin River into Franks Tract and the western Delta. A similar plot for the Zone 1 scenario, in Figure 5-47, shows that it has minimal change to Delta EC, as the largest increases at the export locations are approximately 2% during the at this time.

The Set 1 and Zone 4 scenarios generally reduce EC at the export locations and in the western Delta summer through fall, as shown in Figure 5-48 through Figure 5-53. The Set 1 scenario produces the largest reductions – approximately 10% near the export locations on September 1, 2002, as shown in the color contour plot in Figure 5-49, while the Zone 4 restoration area alone reduces EC by 5 – 6% near the exports (not shown).

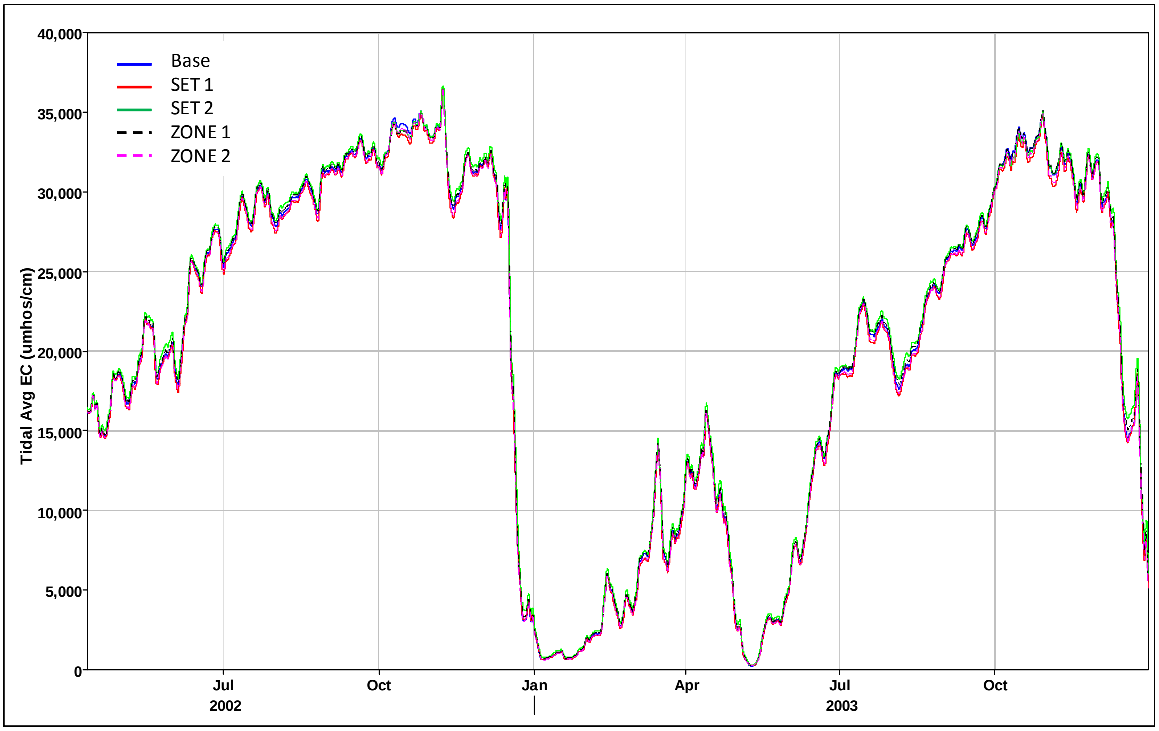


Figure 5-19 Tidally averaged computed EC at Martinez.

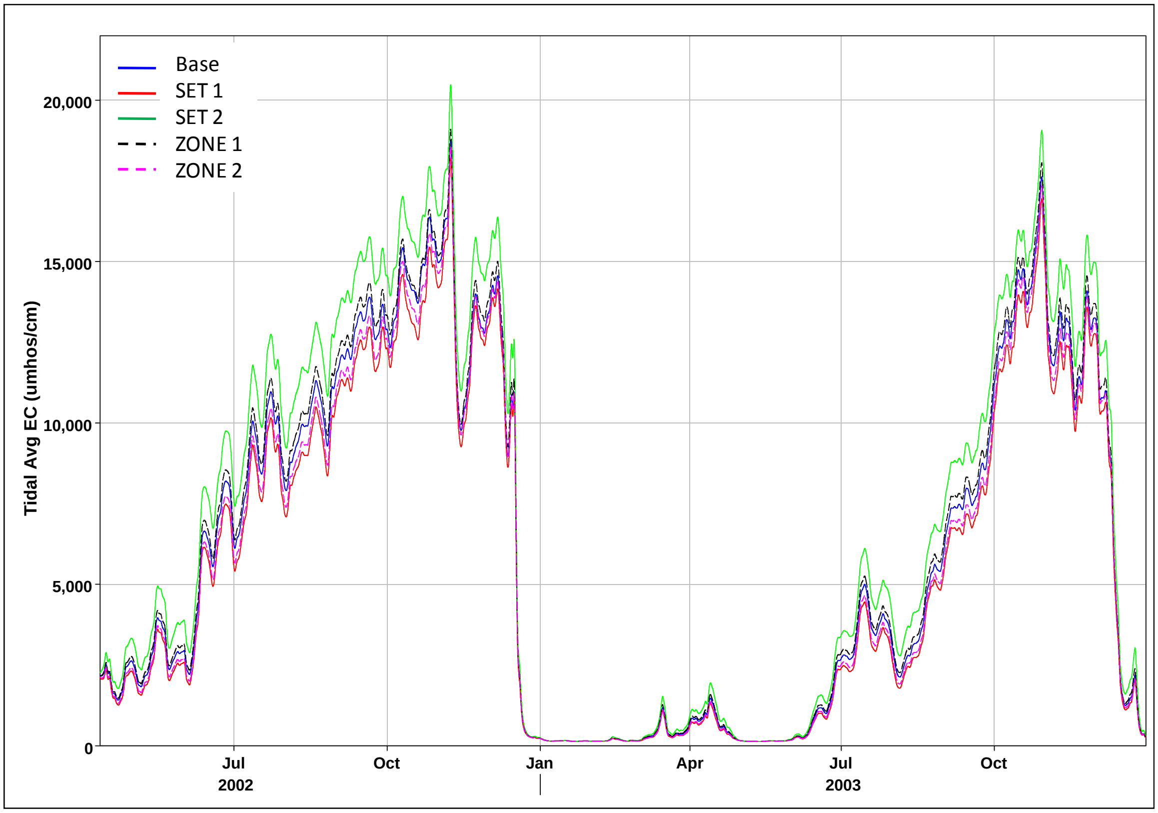


Figure 5-20 Tidally averaged computed EC at Chipps.

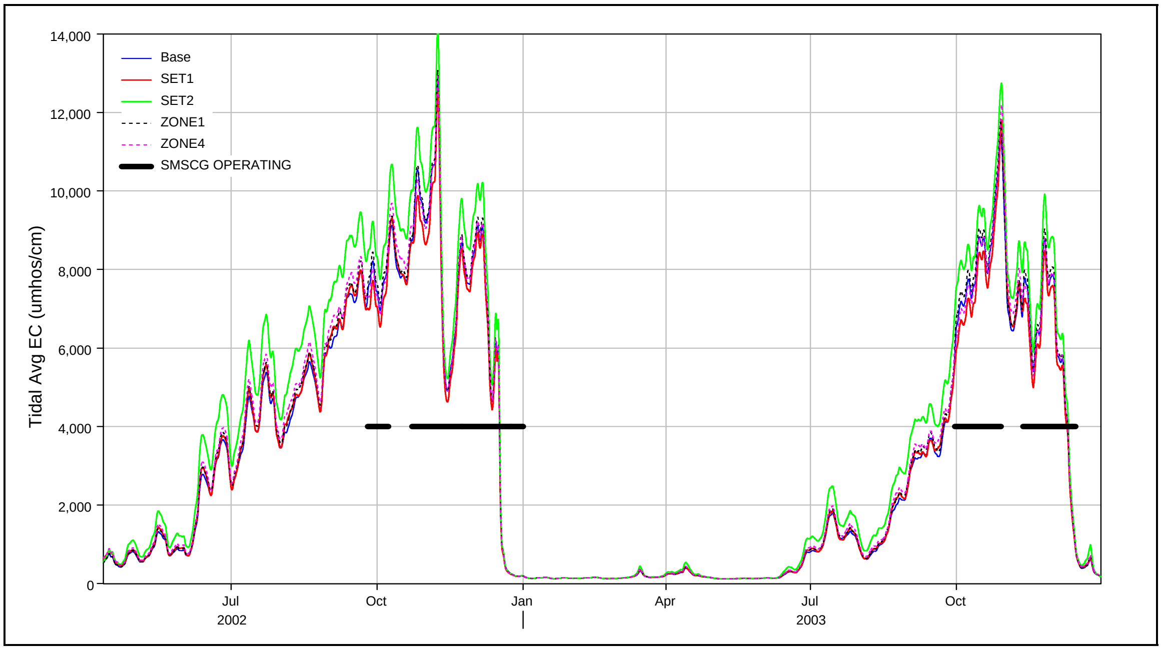


Figure 5-21 Tidally averaged observed and computed EC at Collinsville.

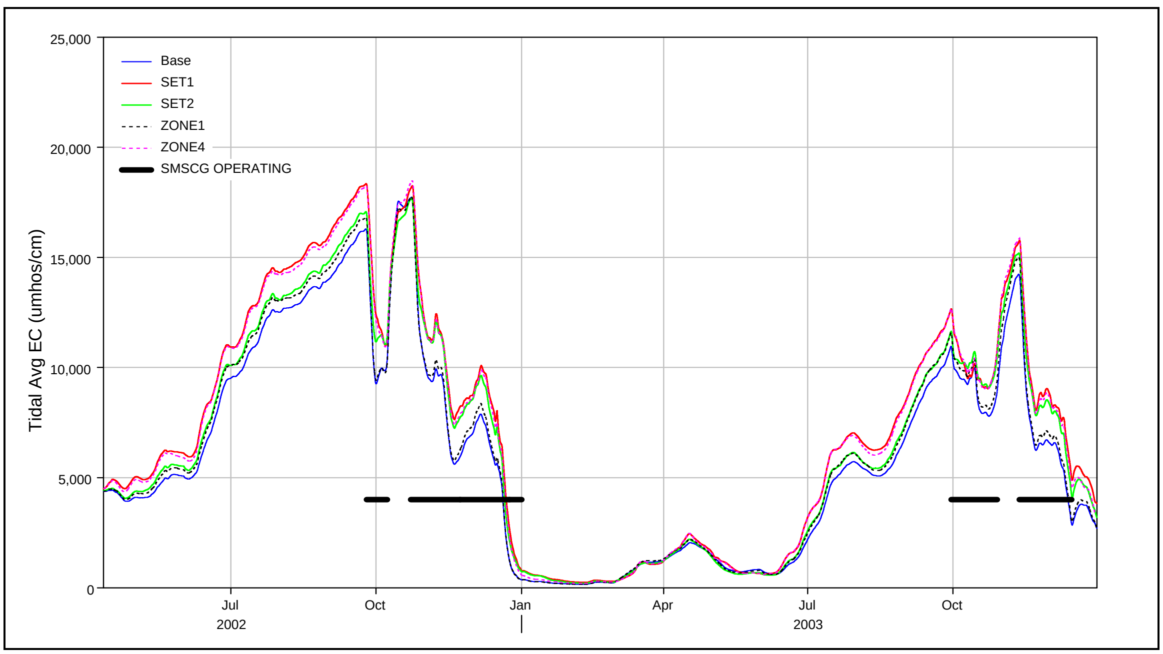


Figure 5-22 Tidally averaged computed EC at Beldon's Landing at monitoring station S-49 in Montezuma Slough.

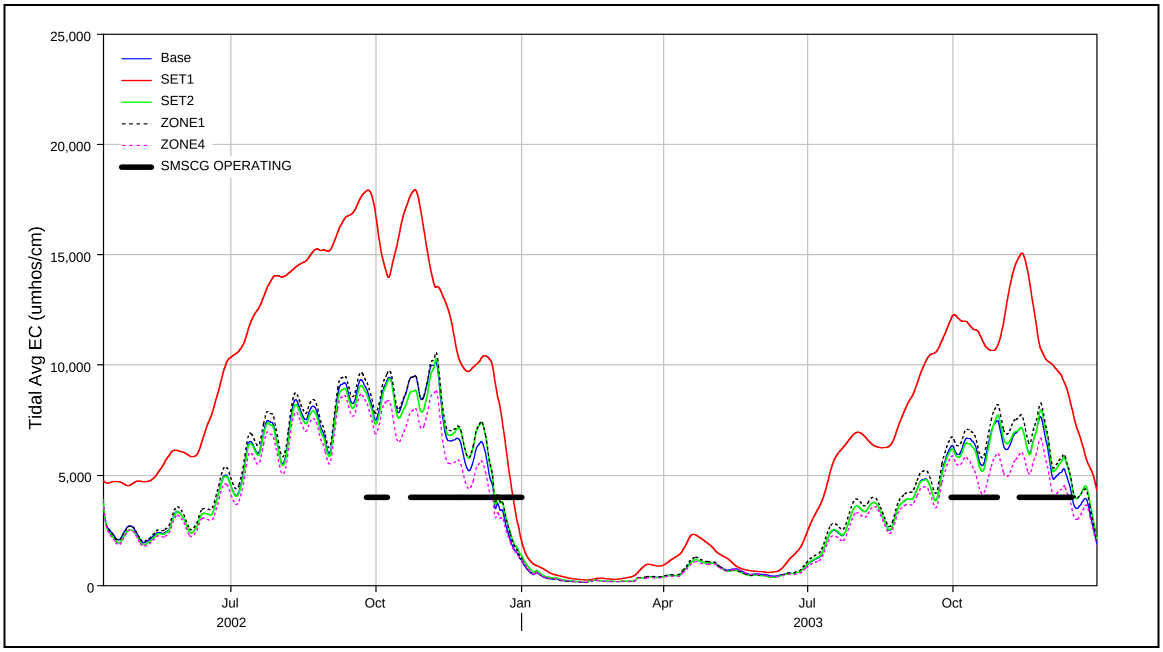


Figure 5-23 Tidally averaged computed EC at station S-40 on Boynton Slough.

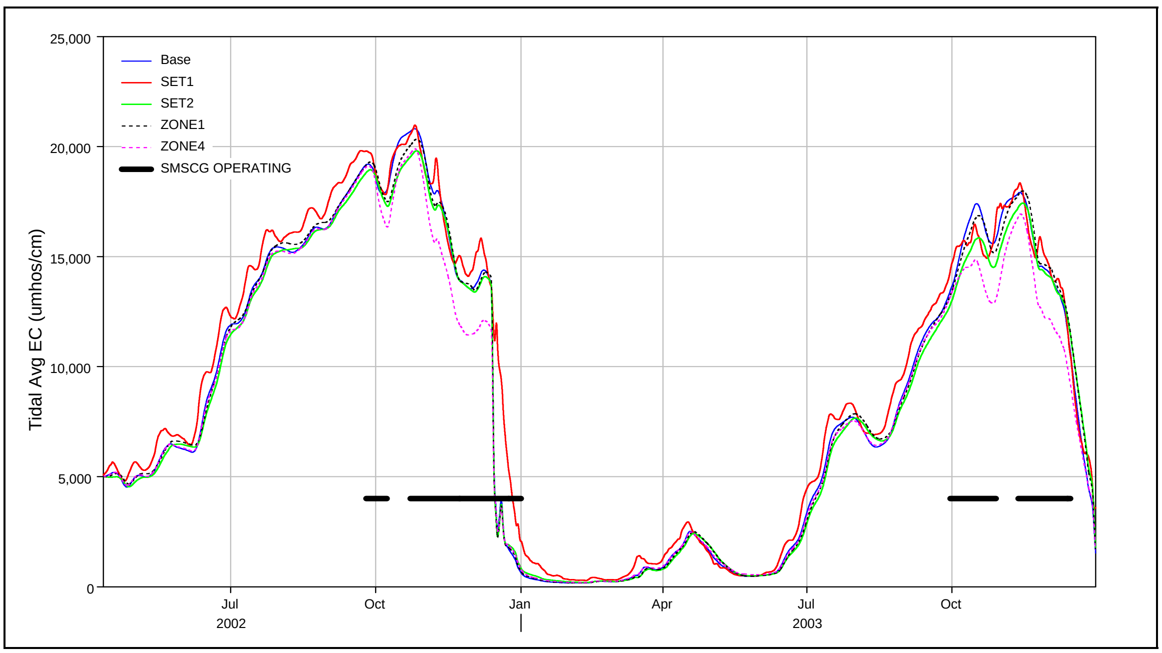


Figure 5-24 Tidally averaged computed EC at station S-97 on Ibis Slough.

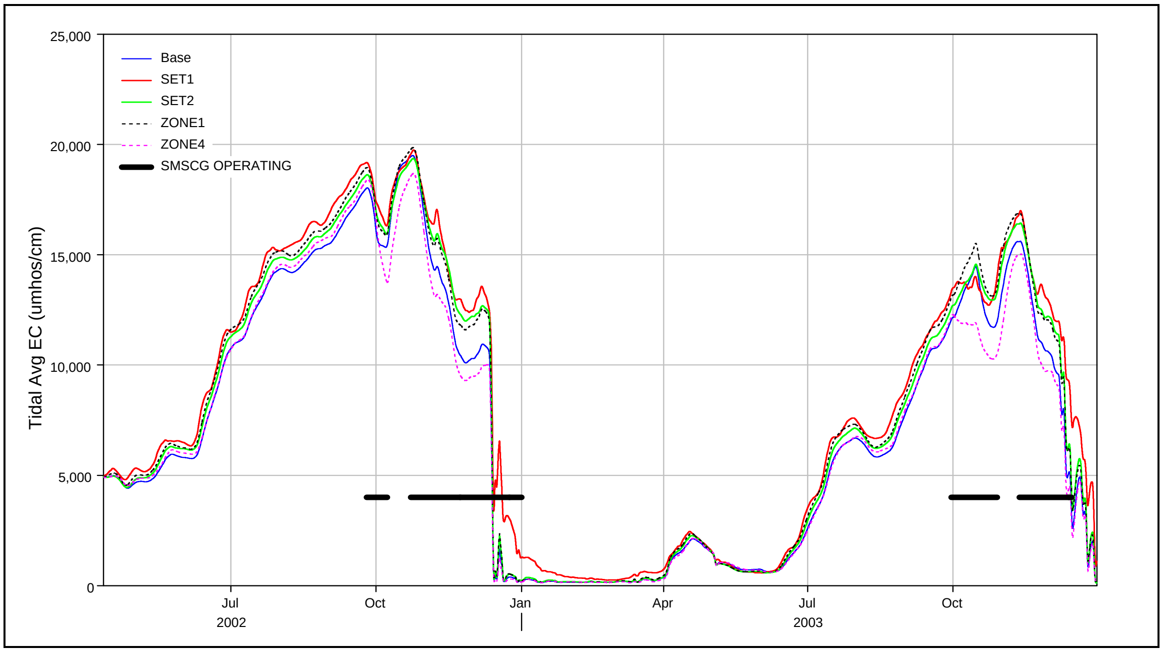


Figure 5-25 Tidally averaged computed EC at station S-21 in Sunrise Slough.

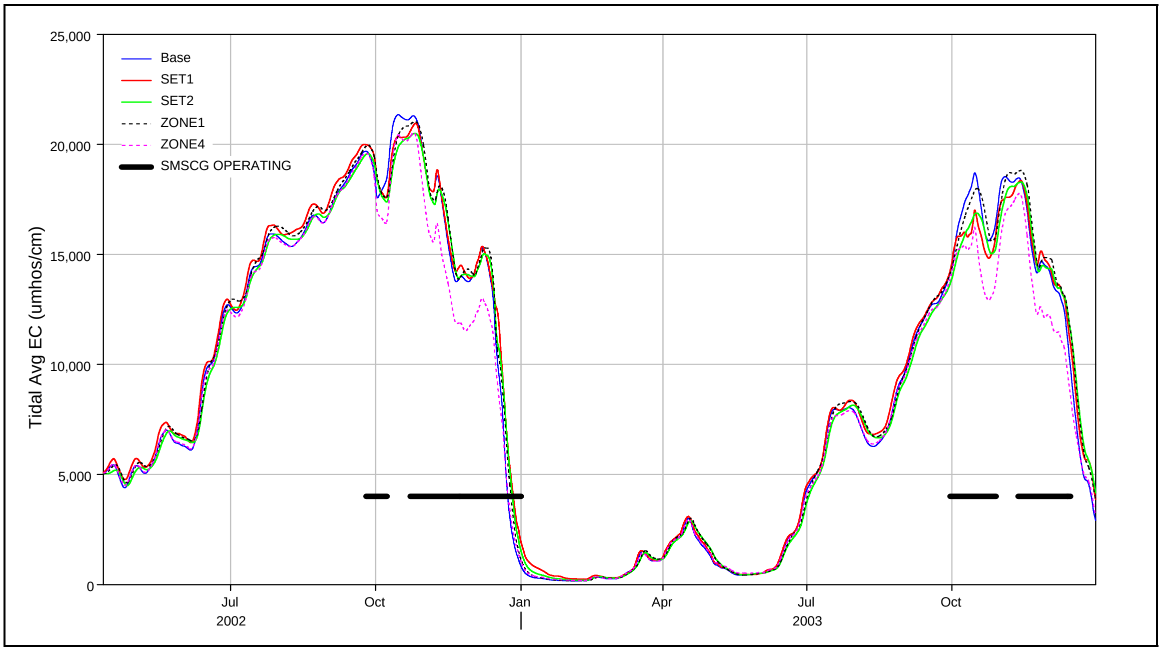


Figure 5-26 Tidally averaged computed EC at station S-35 at Morrow Island.

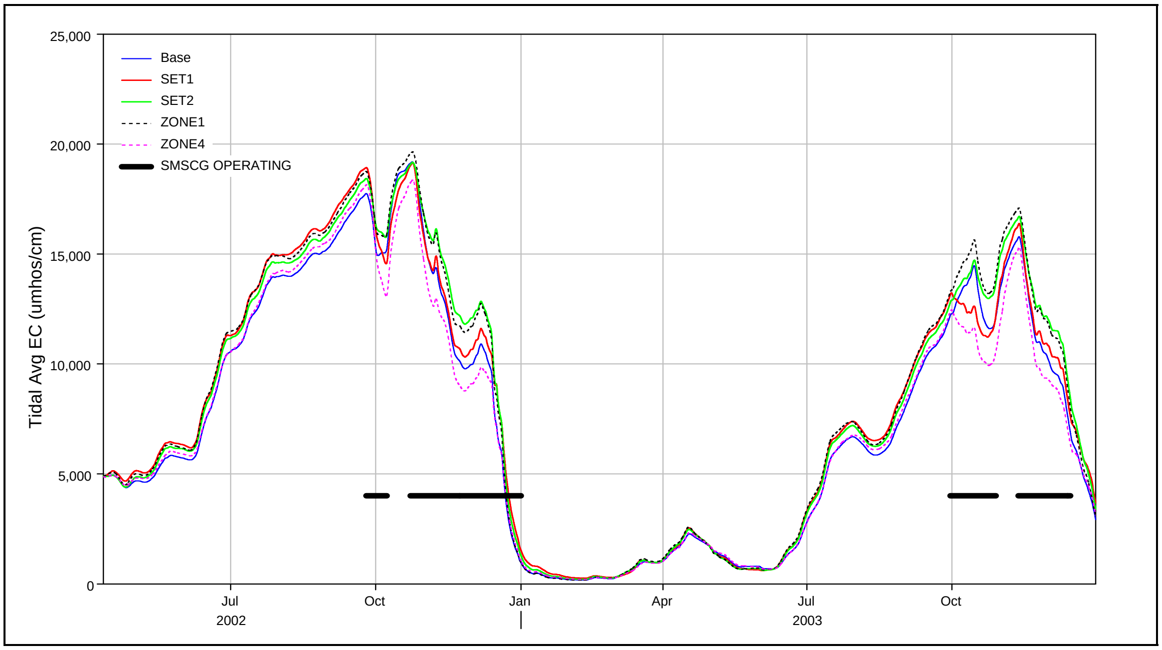


Figure 5-27 Tidally averaged computed EC at station S-42 on Volanti Slough.

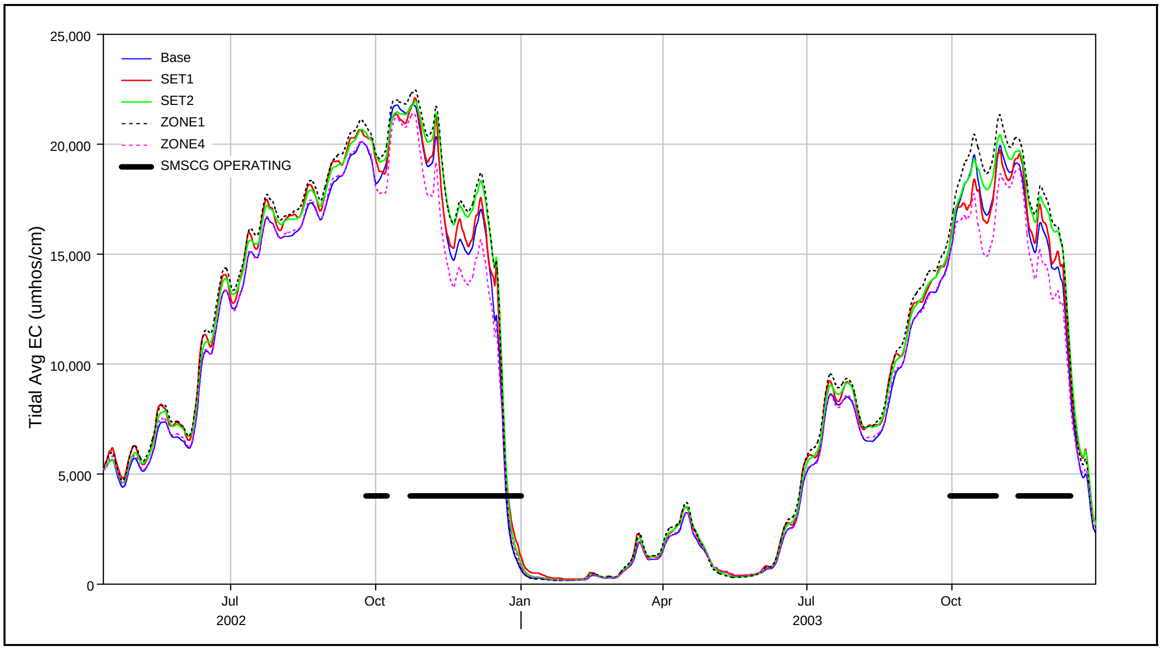


Figure 5-28 Tidally averaged observed and computed EC at station S-37 on Godfather Slough.

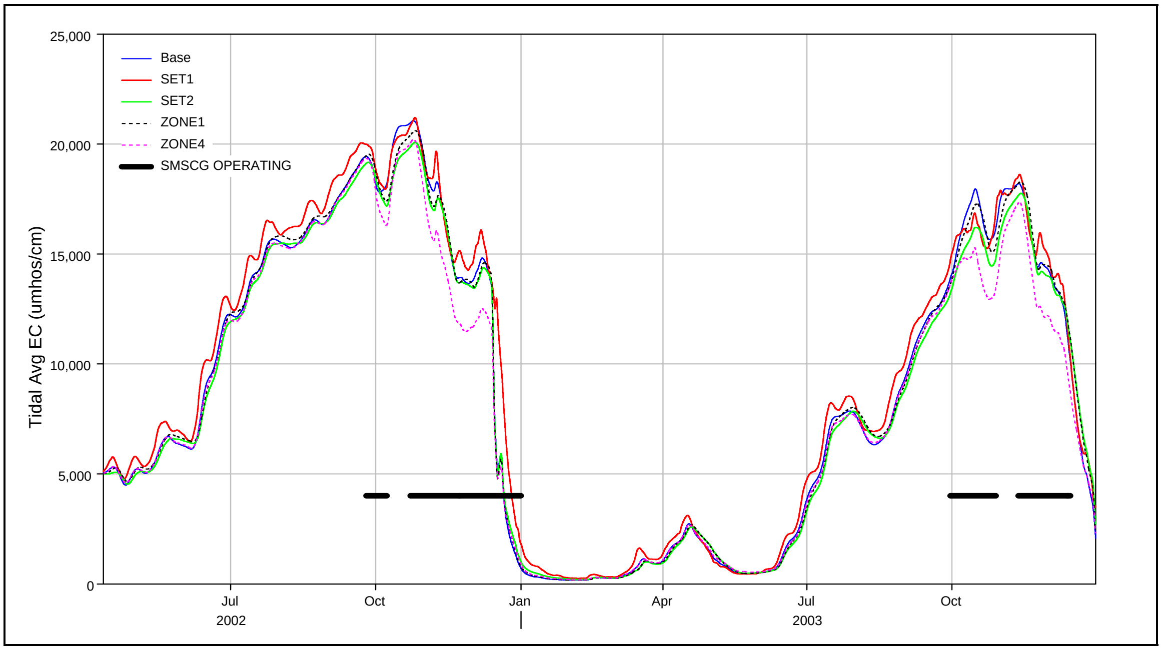


Figure 5-29 Tidally averaged observed and computed EC at station S-33 on Cygnus Slough.

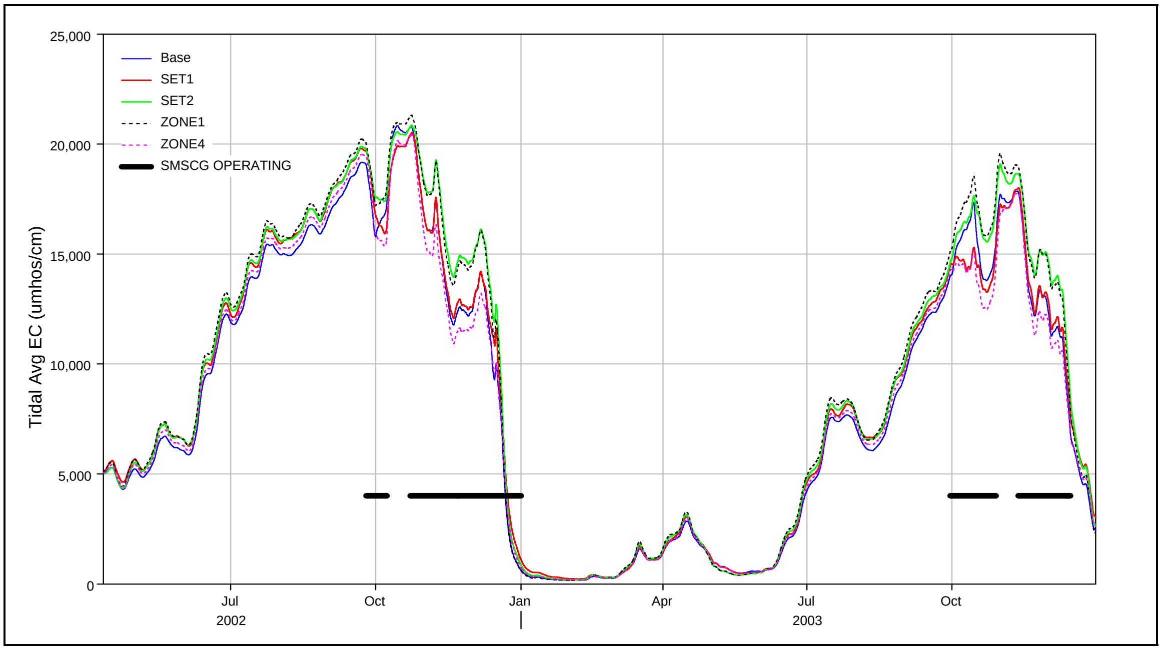


Figure 5-30 Tidally averaged observed and computed EC at station S-54 on Hunter Cut.

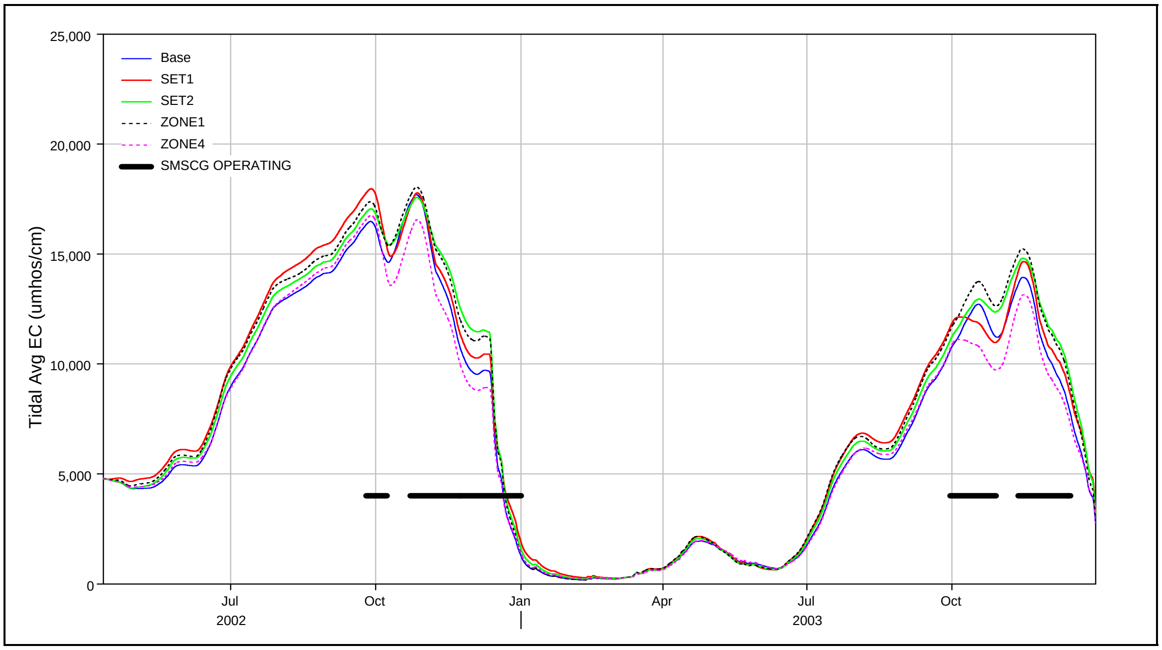


Figure 5-31 Tidally averaged observed and computed EC at station S-4 on Hill Slough.

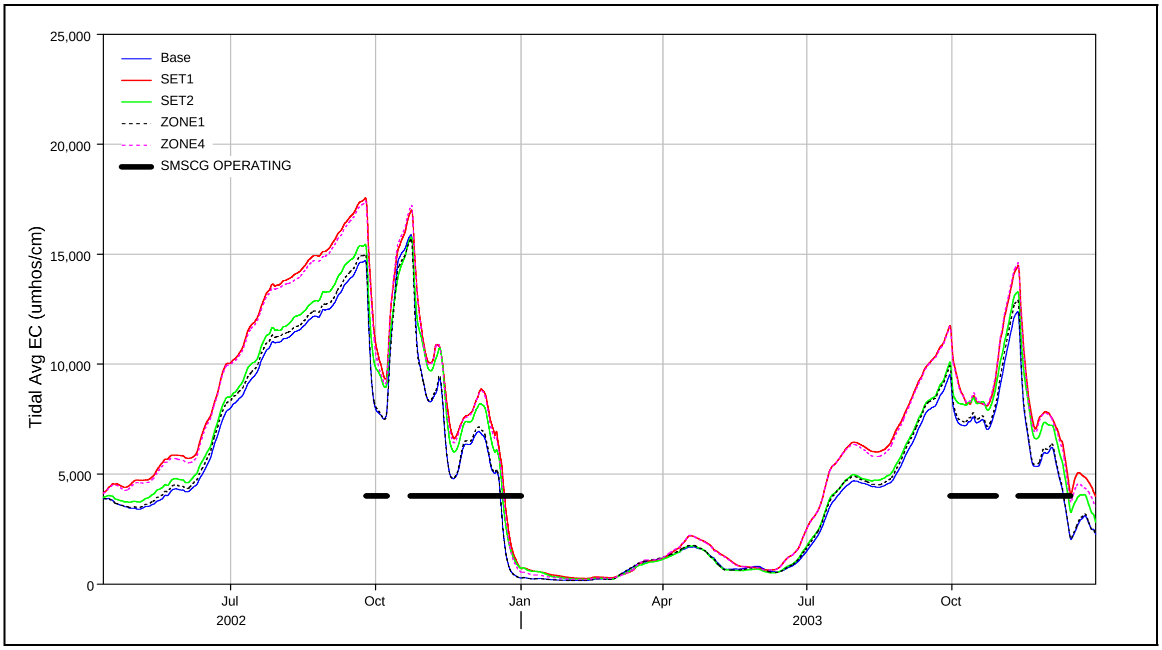


Figure 5-32 Tidally averaged observed and computed EC at station NS-1 on Nurse Slough.

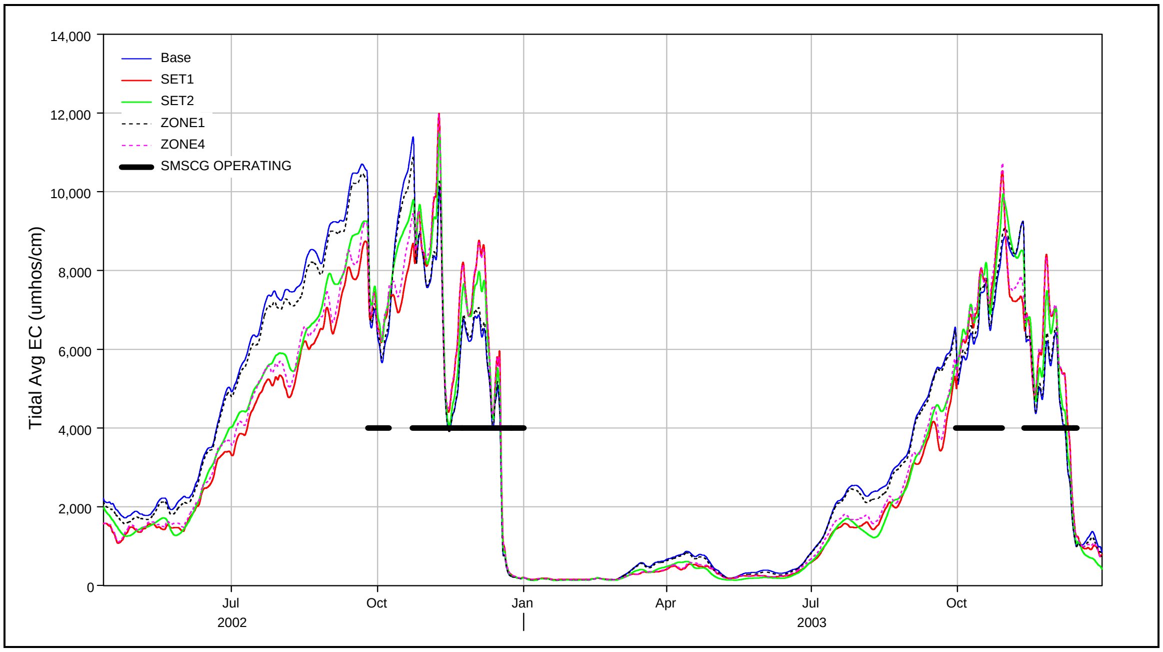


Figure 5-33 Tidally averaged computed EC at the S-64 monitoring location near National Steel on Montezuma Slough.

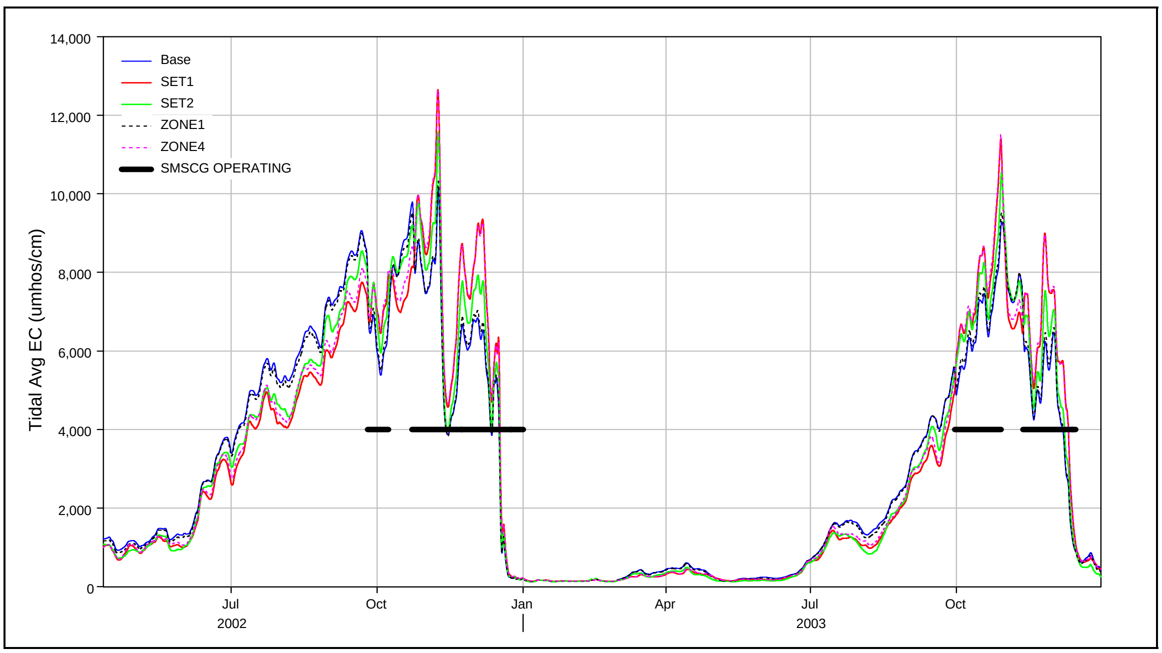


Figure 5-34 Tidally averaged computed EC at the S-71 monitoring location at Roaring River on Montezuma Slough.

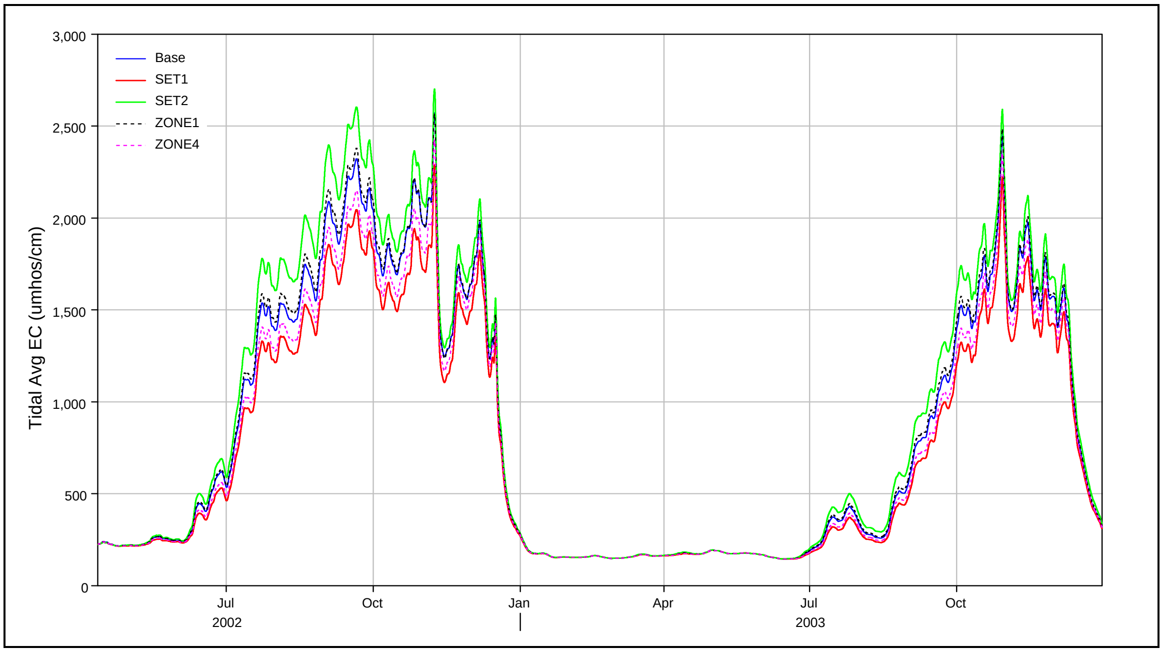
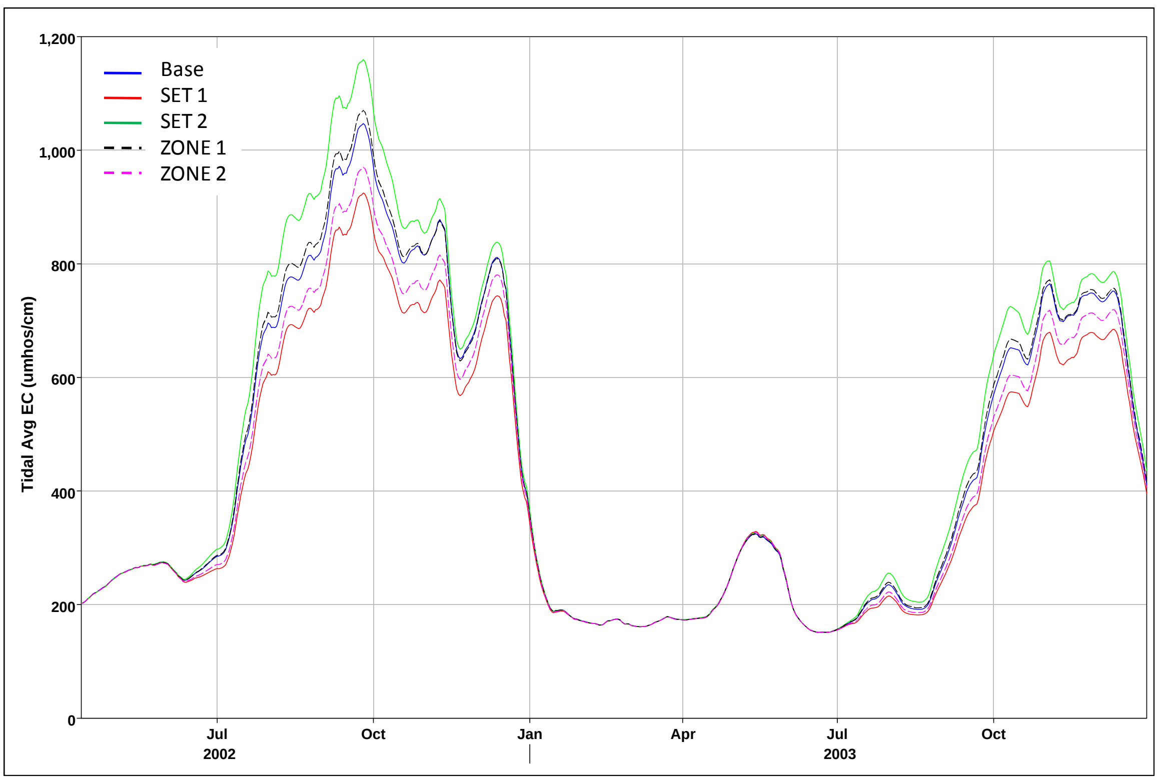
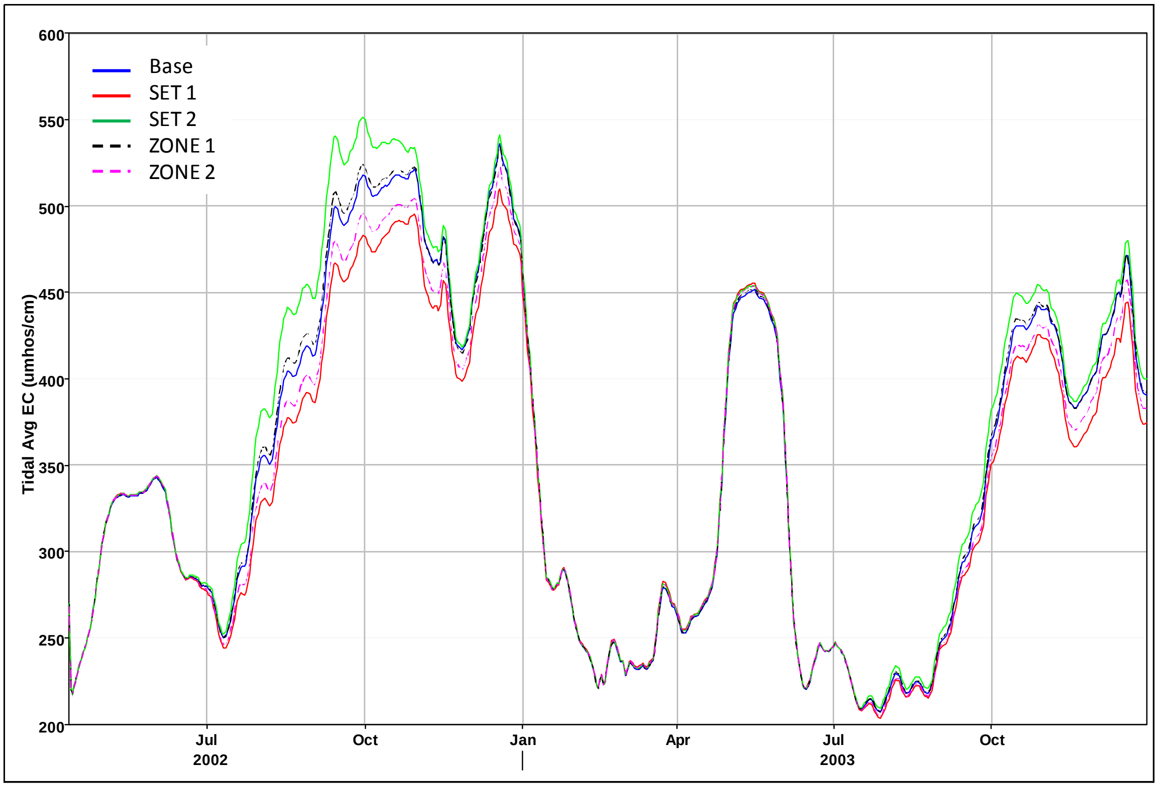


Figure 5-35 Tidally averaged computed EC time series at Jersey Point.



5-36 Tidally averaged computed EC time series at Old River at Rock Slough.



5-37 Tidally averaged computed EC time series at the CCWD Victoria Canal export location for Los Vaqueros.

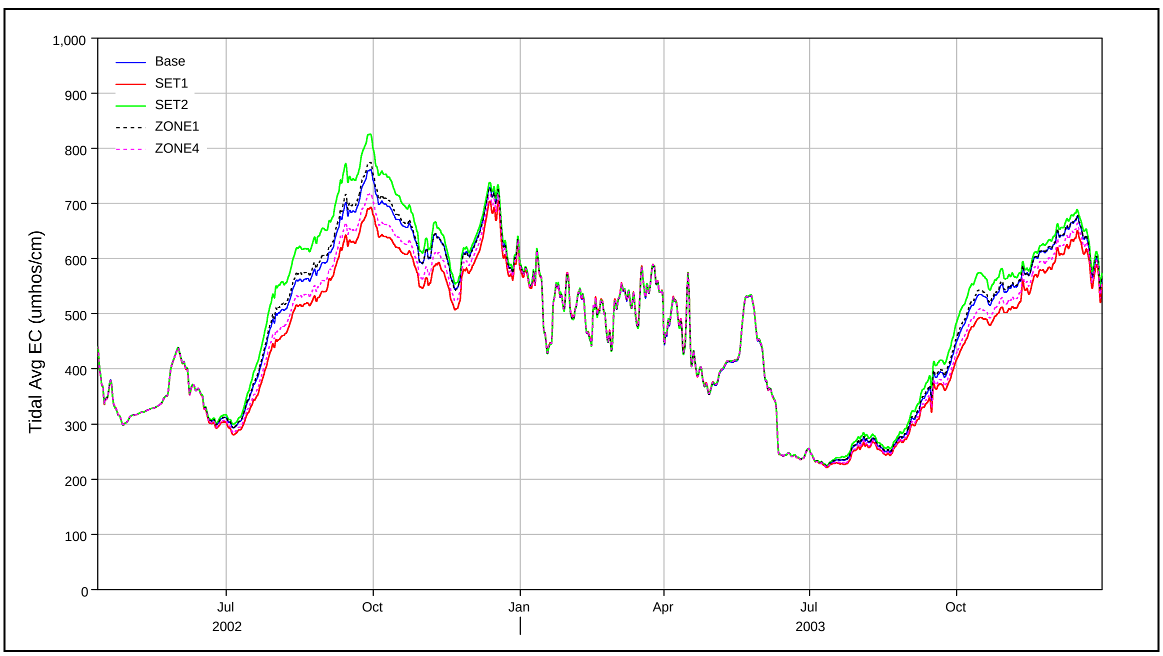


Figure 5-38 Tidally averaged computed EC time series at the CVP export location.

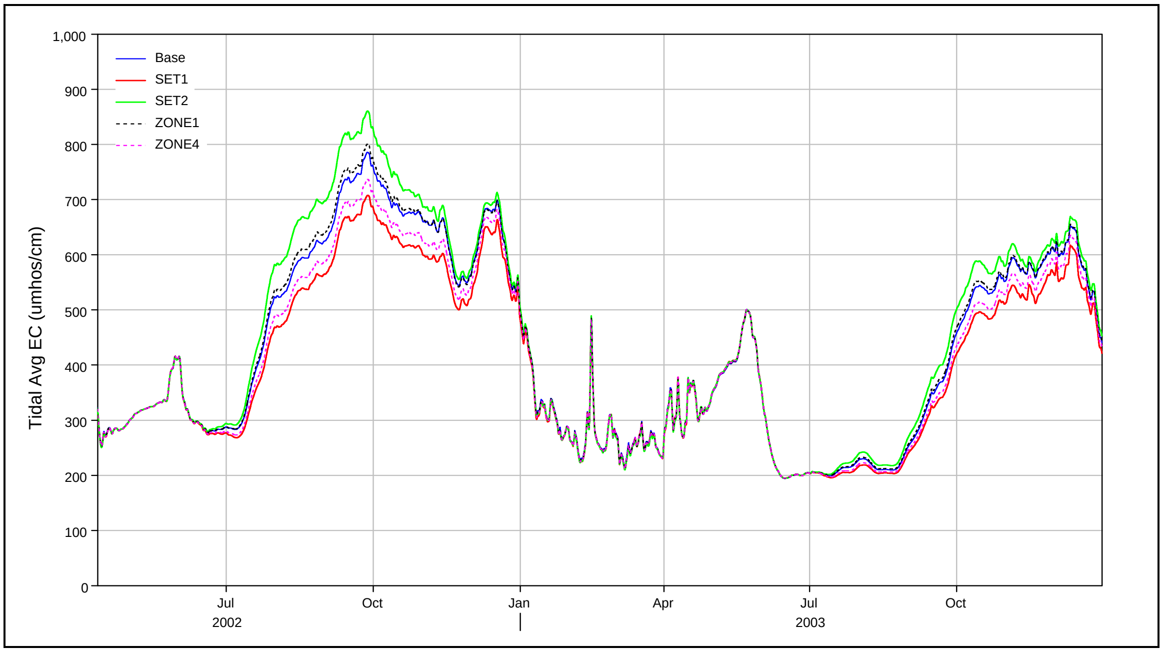


Figure 5-39 Tidally averaged computed EC time series at the SWP export location.

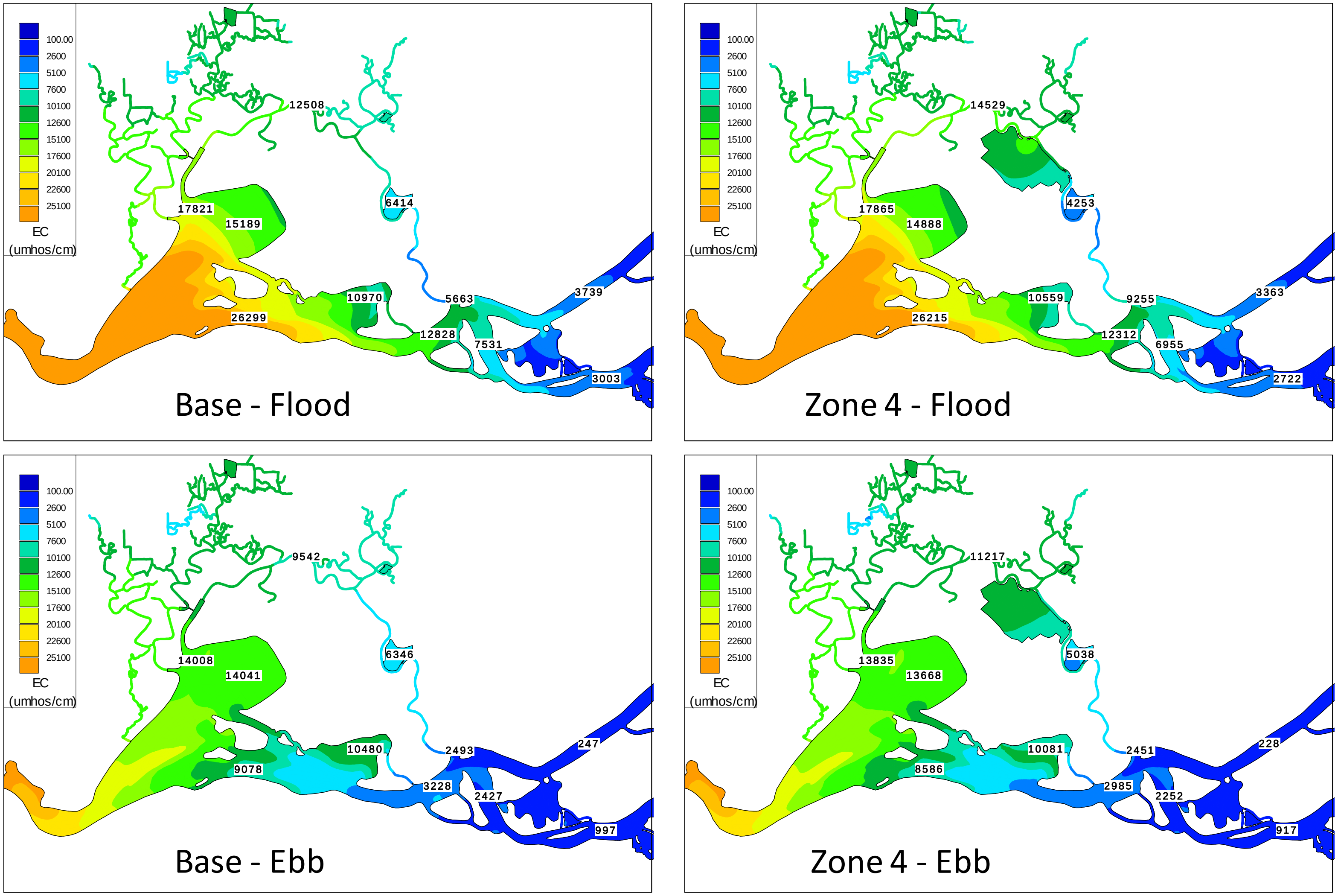


Figure 5-40 Color contour plots of EC for the Base case (left) and Zone 4 scenario (right) at the same timing on a flood tide (upper) and ebb tide (lower).

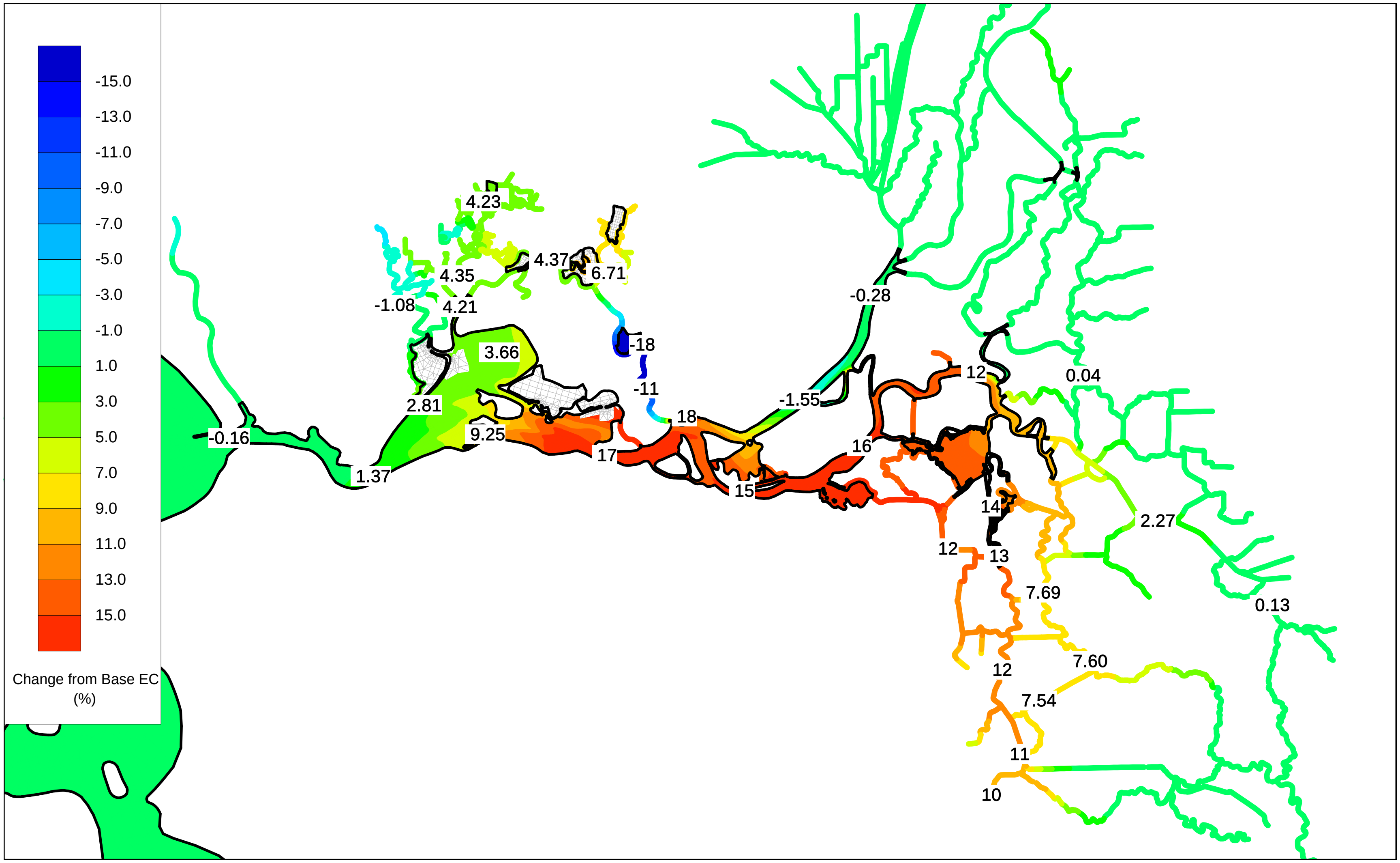


Figure 5-41 Set 2 EC % change from Base case – August 1, 2002.

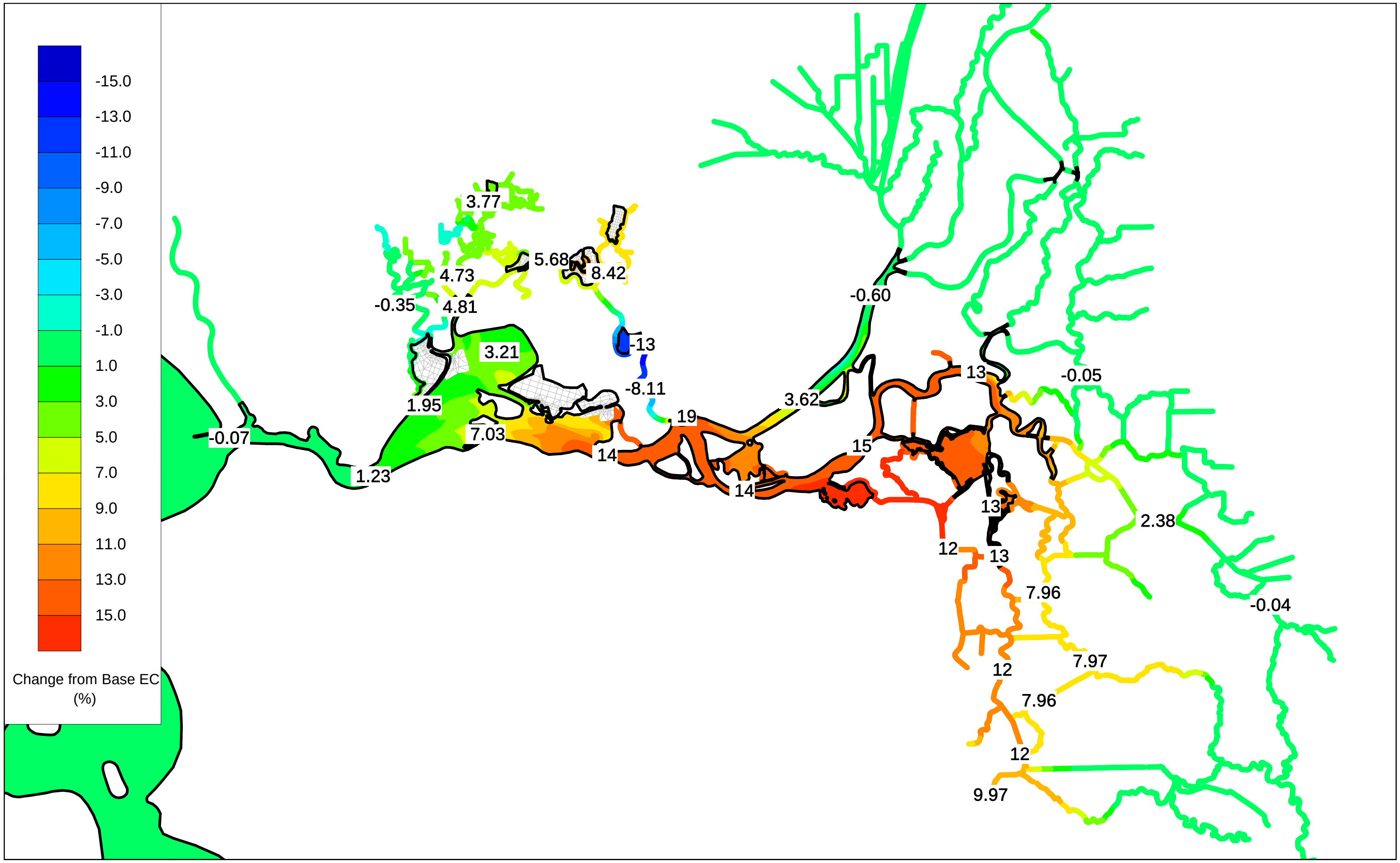


Figure 5-42 Set 2 EC % change from Base case – September 1, 2002.

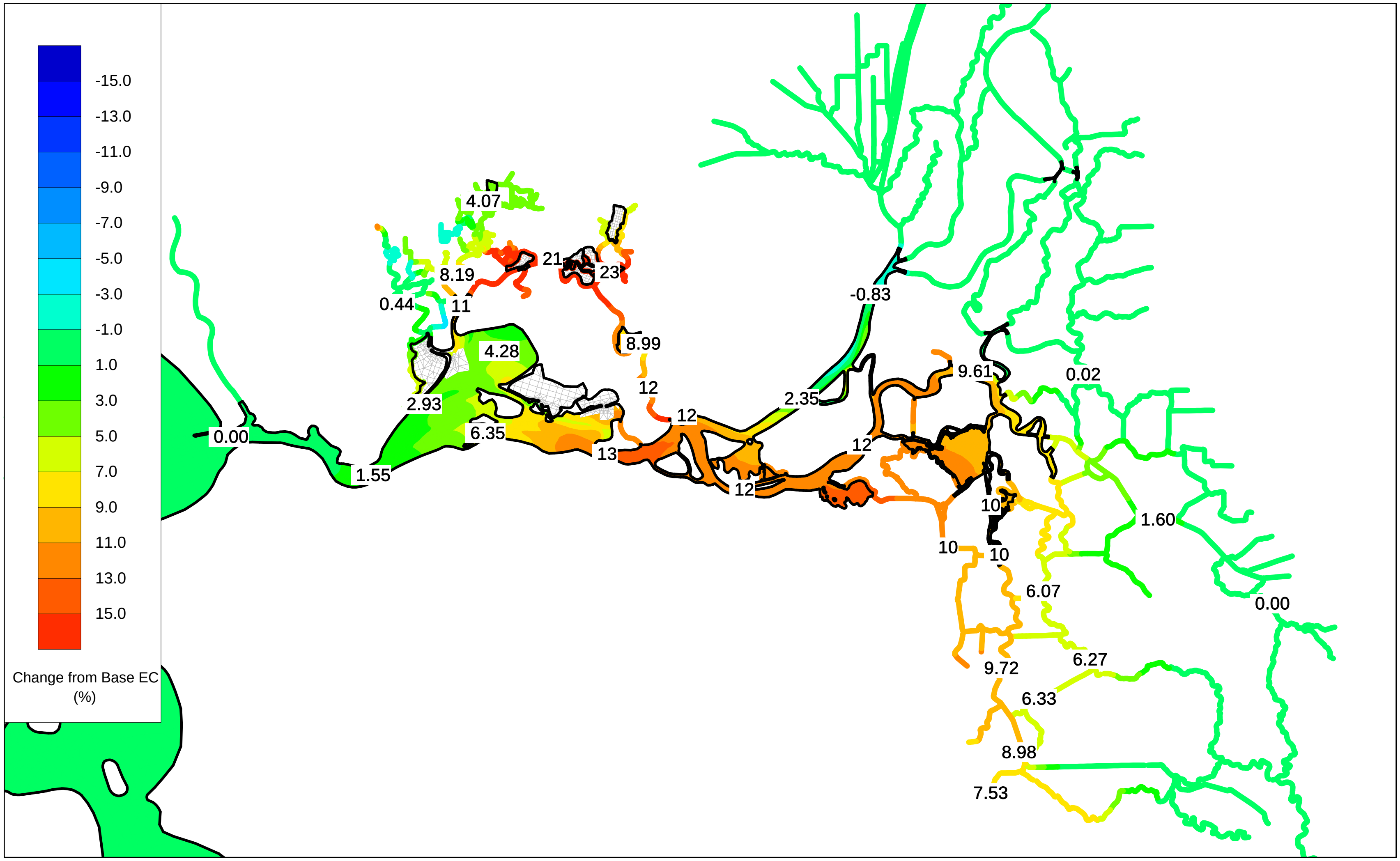


Figure 5-43 Set 2 EC % change from Base case – October 1, 2002.

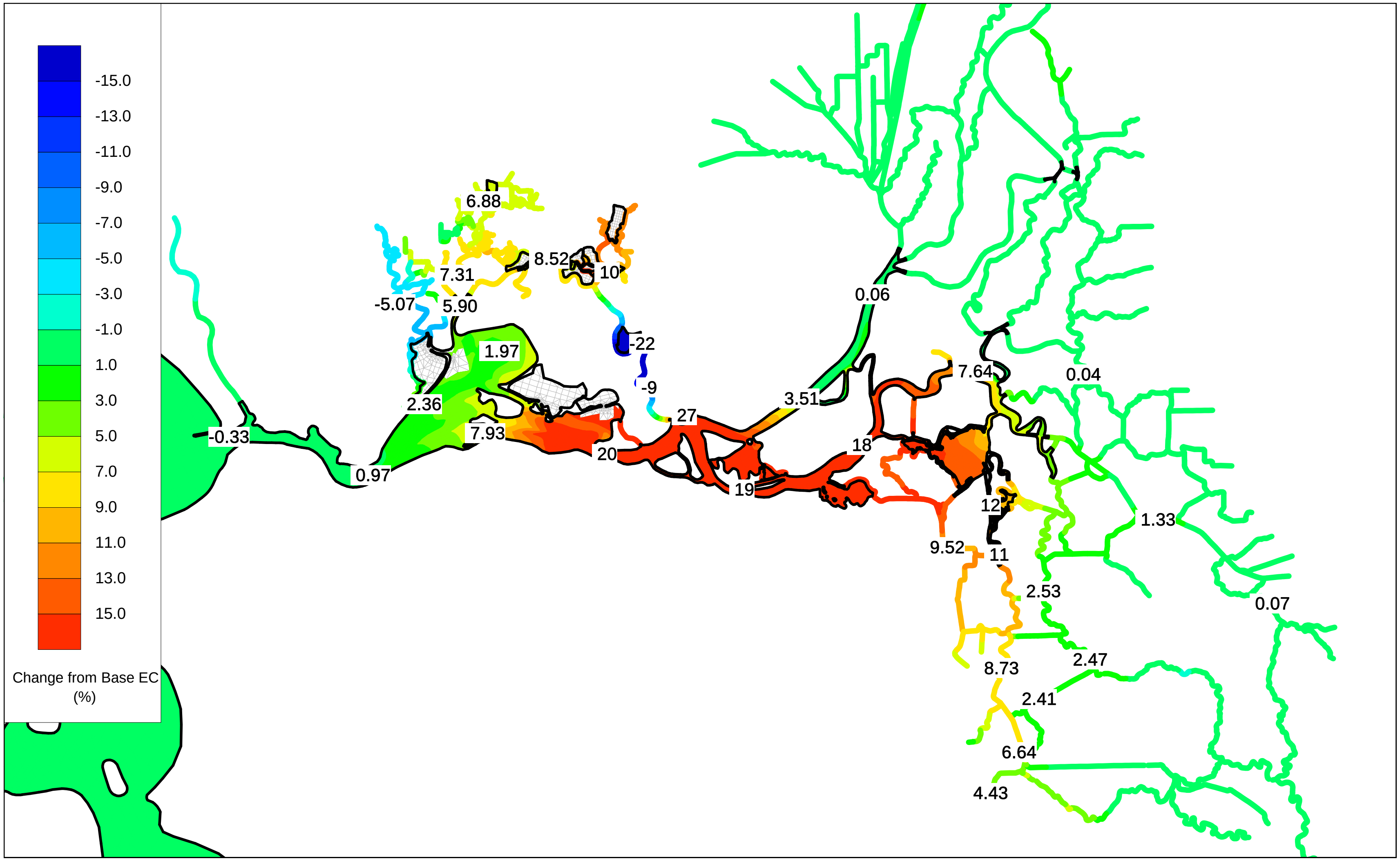


Figure 5-44 Set 2 EC % change from Base case – September 1, 2003.

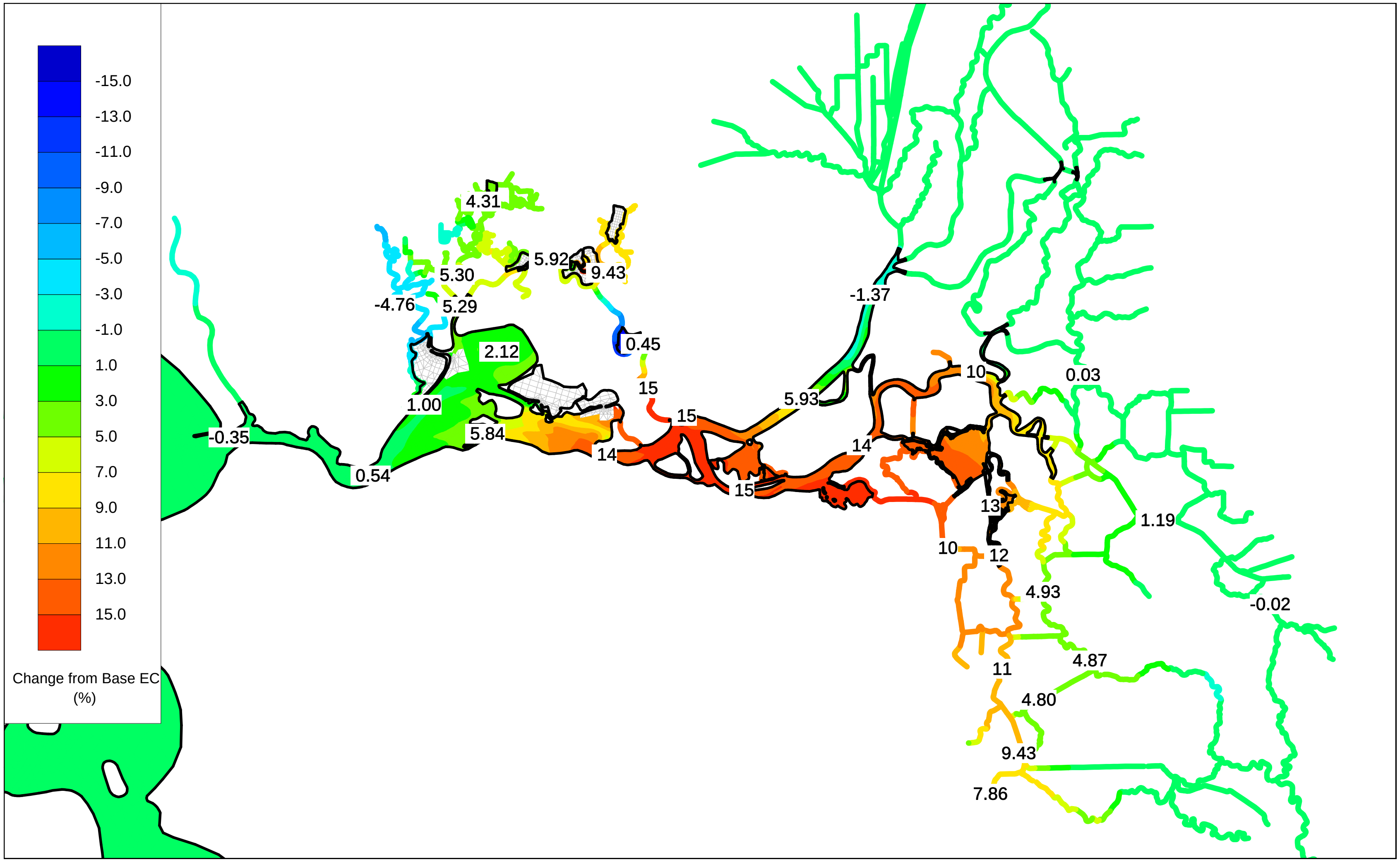


Figure 5-45 Set 2 EC % change from Base case – October 1, 2003.

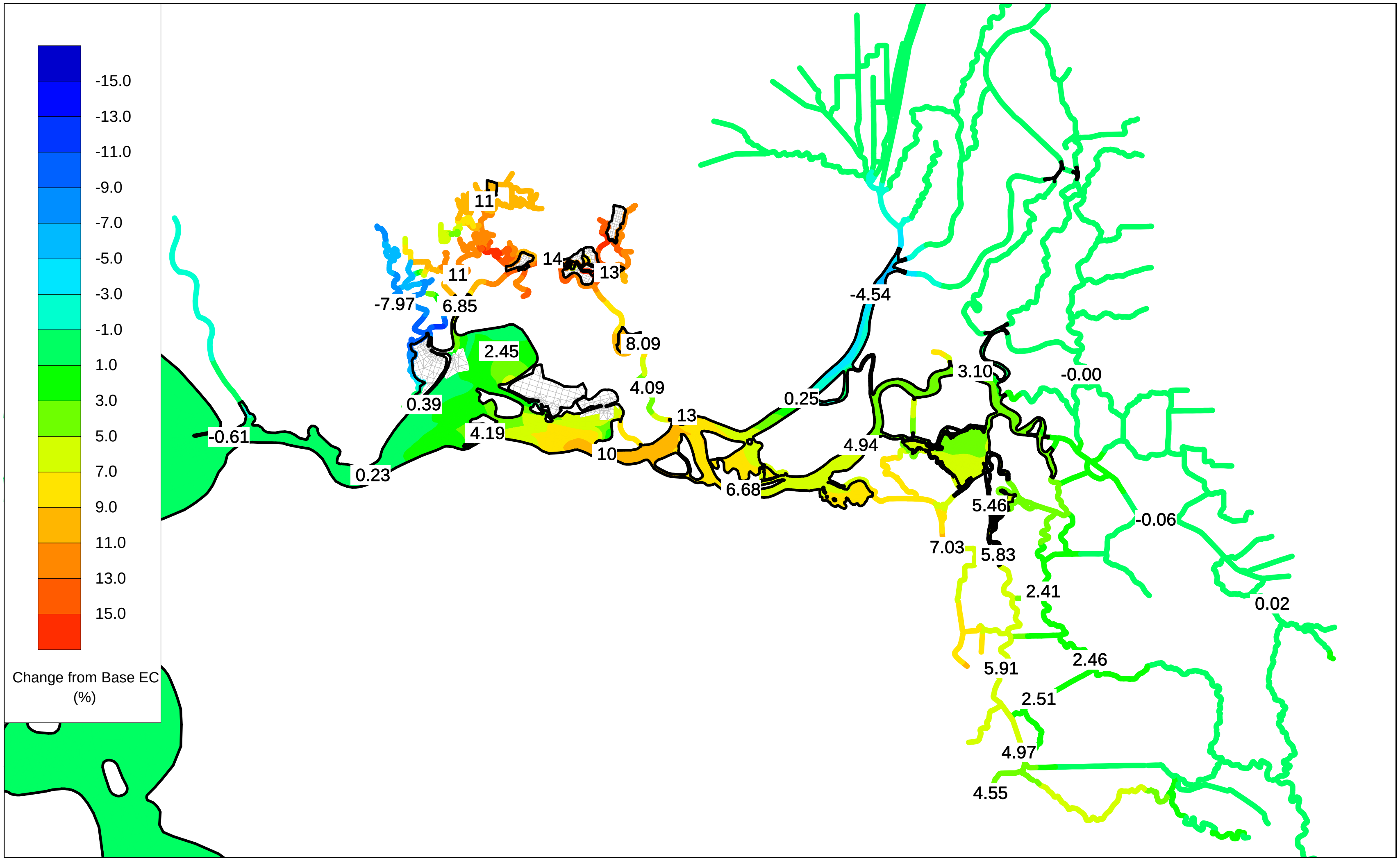


Figure 5-46 Set 2 EC % change from Base case – November 1, 2003.

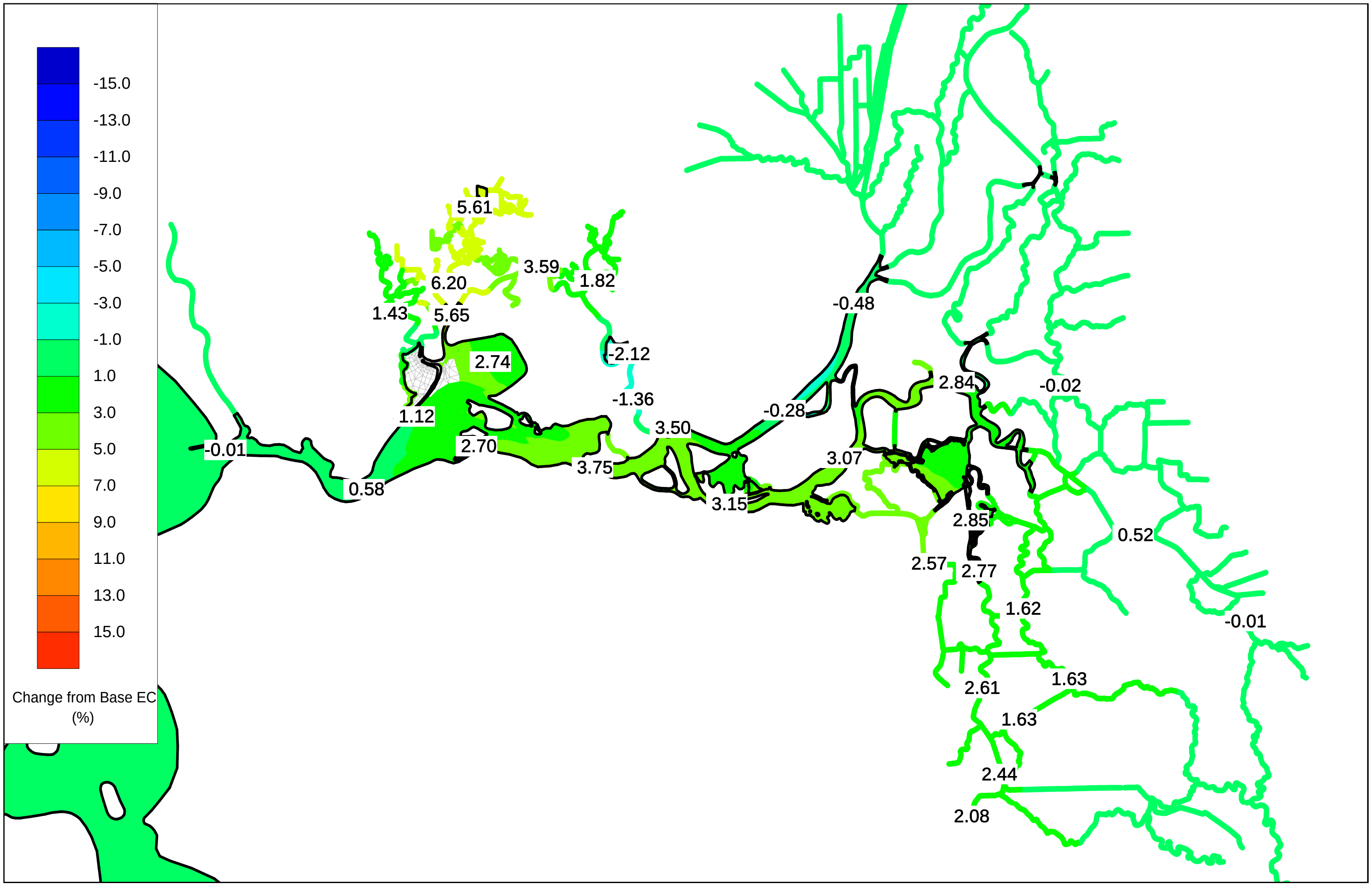


Figure 5-47 Zone 1 EC % change from Base case – September 1, 2002.

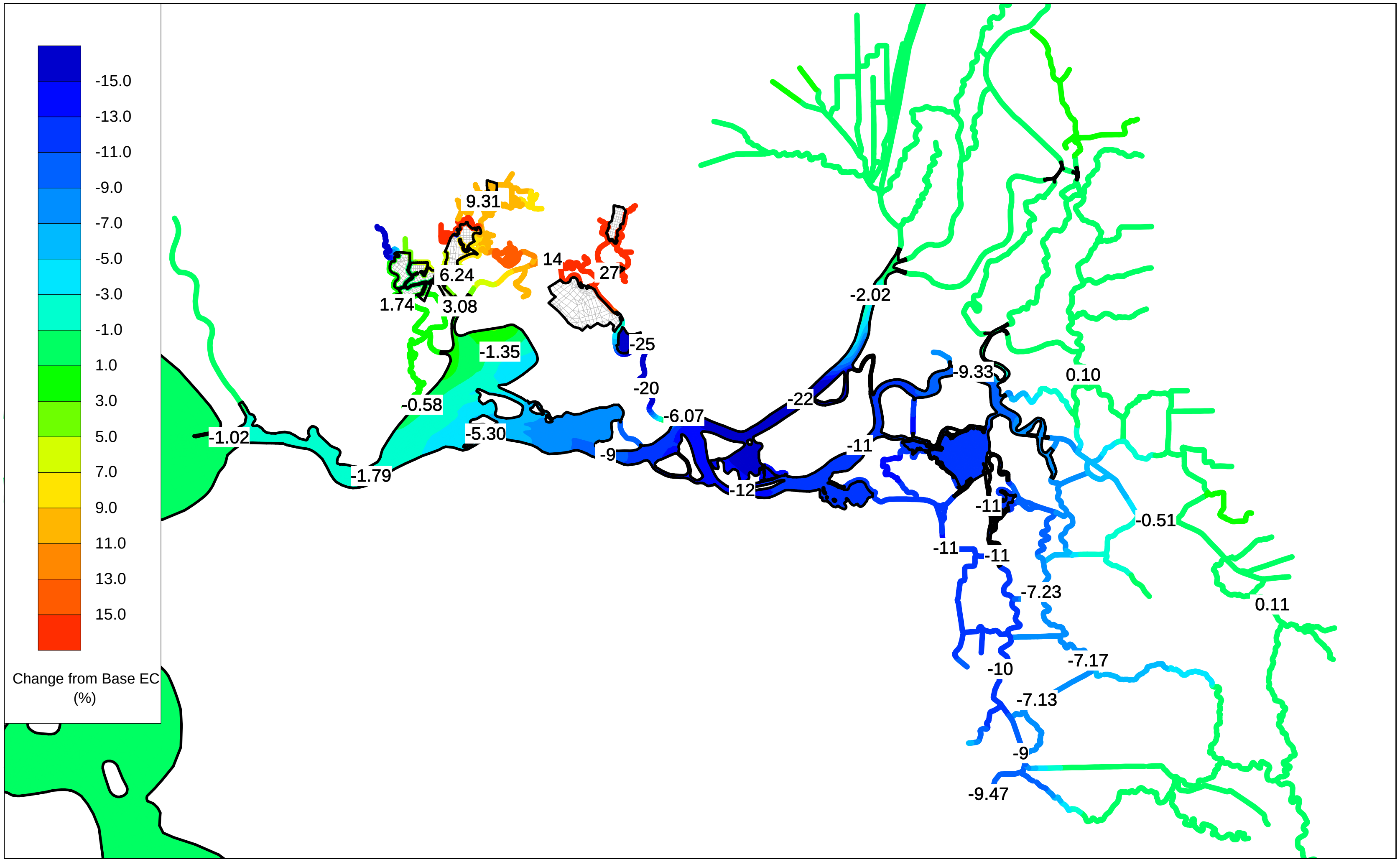


Figure 5-48 Set 1 EC % change from Base case – August 1, 2002.

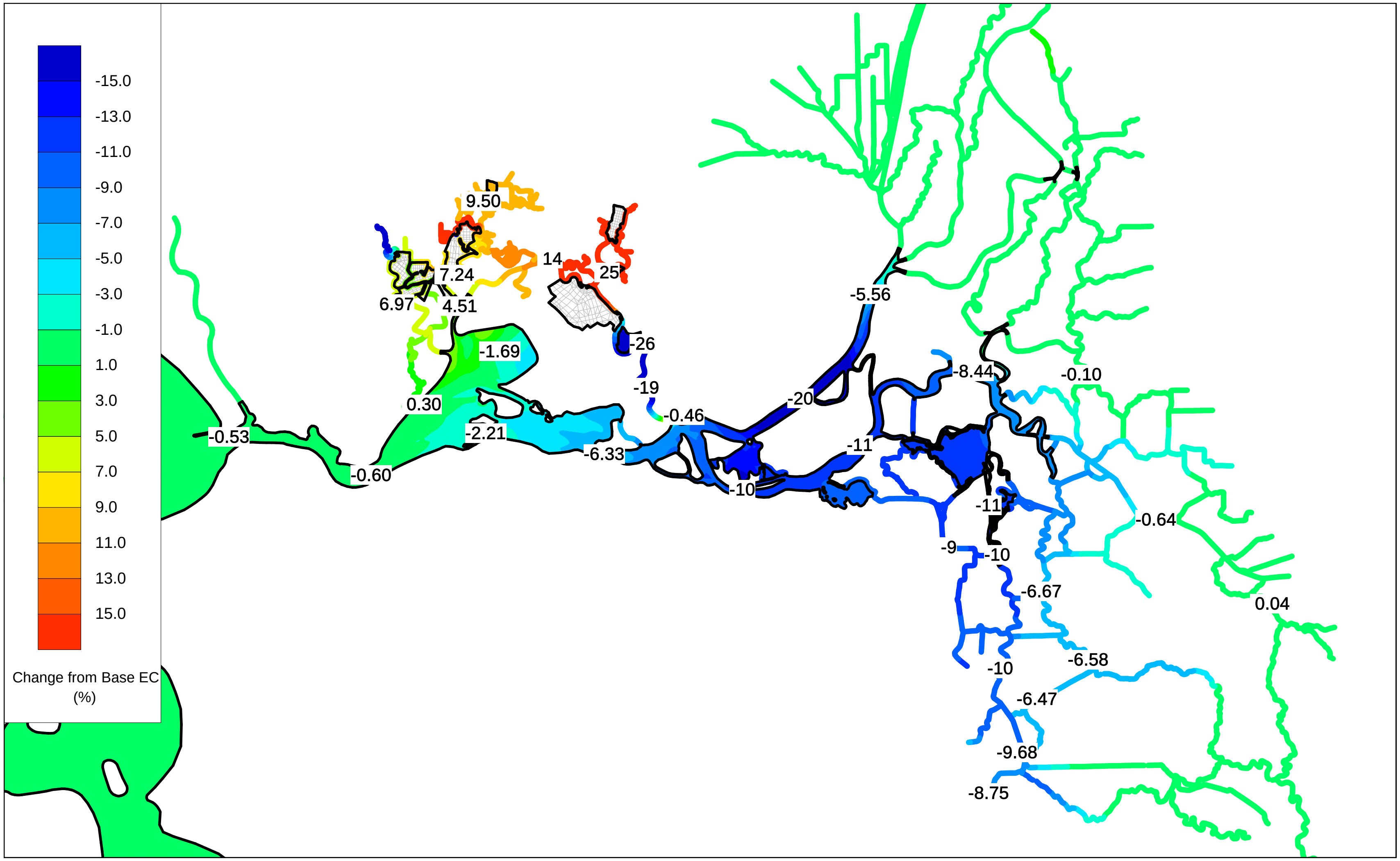


Figure 5-49 Set 1 EC % change from Base case – September 1, 2002.

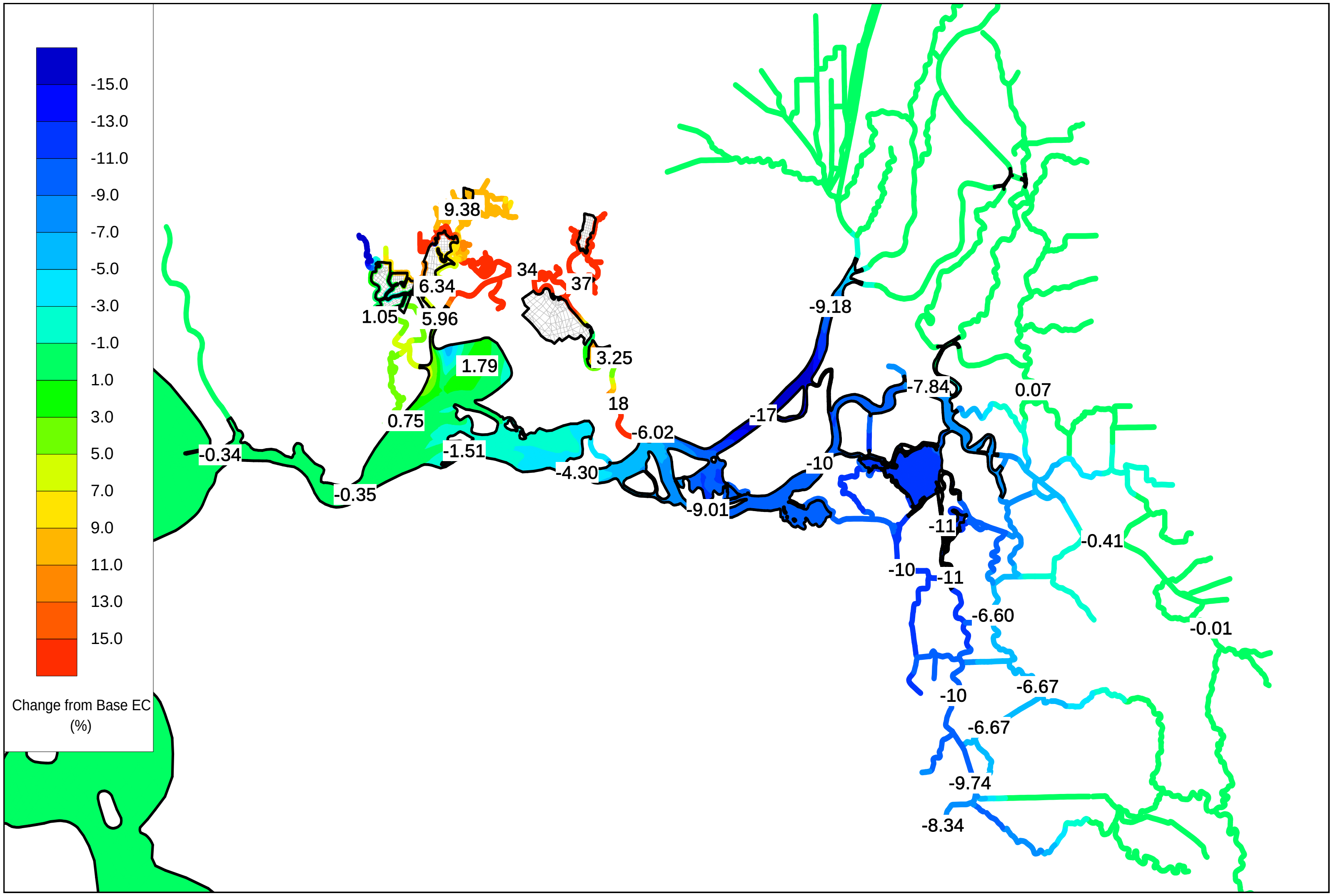


Figure 5-50 Set 1 EC % change from Base case – October 1, 2002.

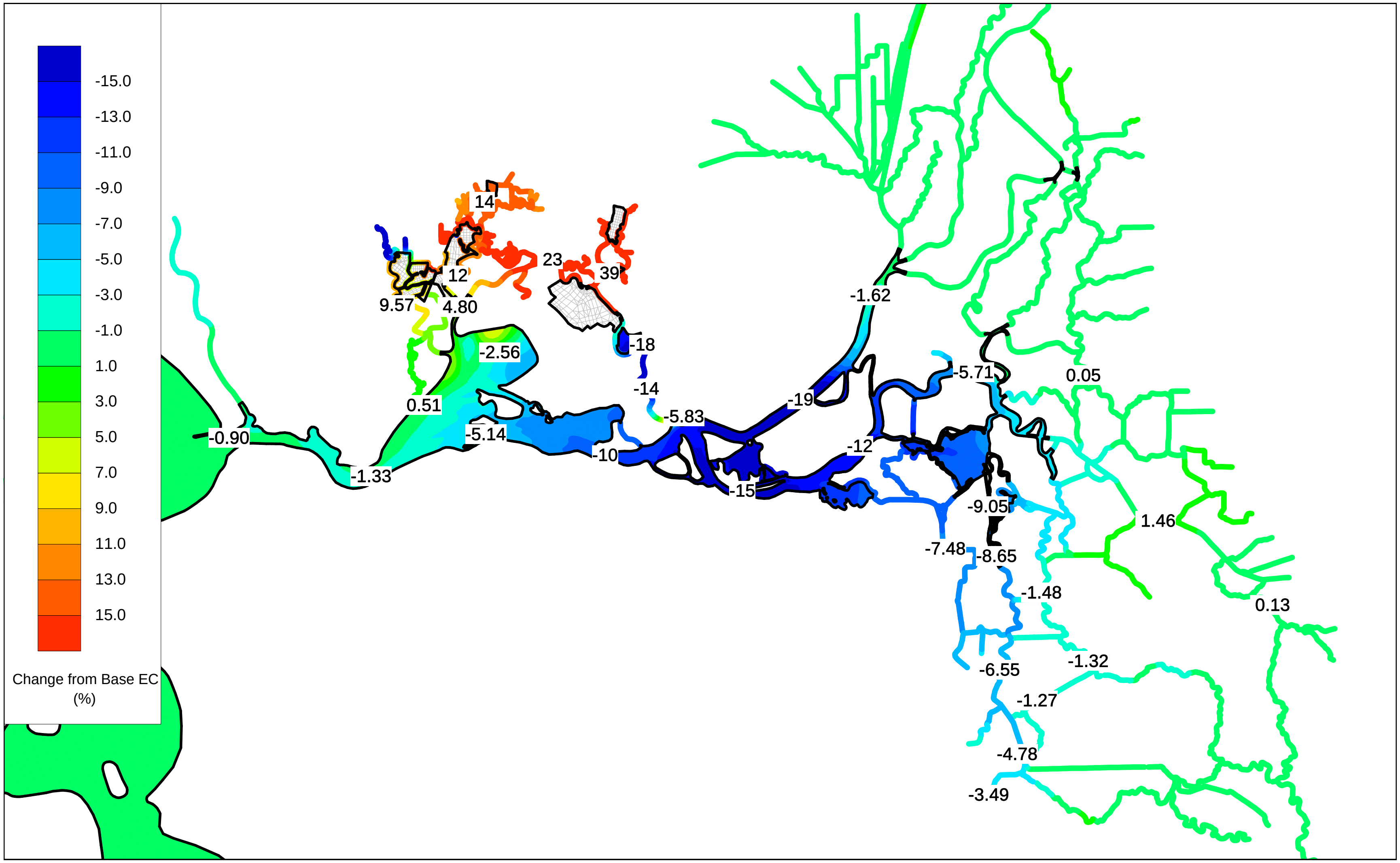


Figure 5-51 Set 1 EC % change from Base case – September 1, 2003.

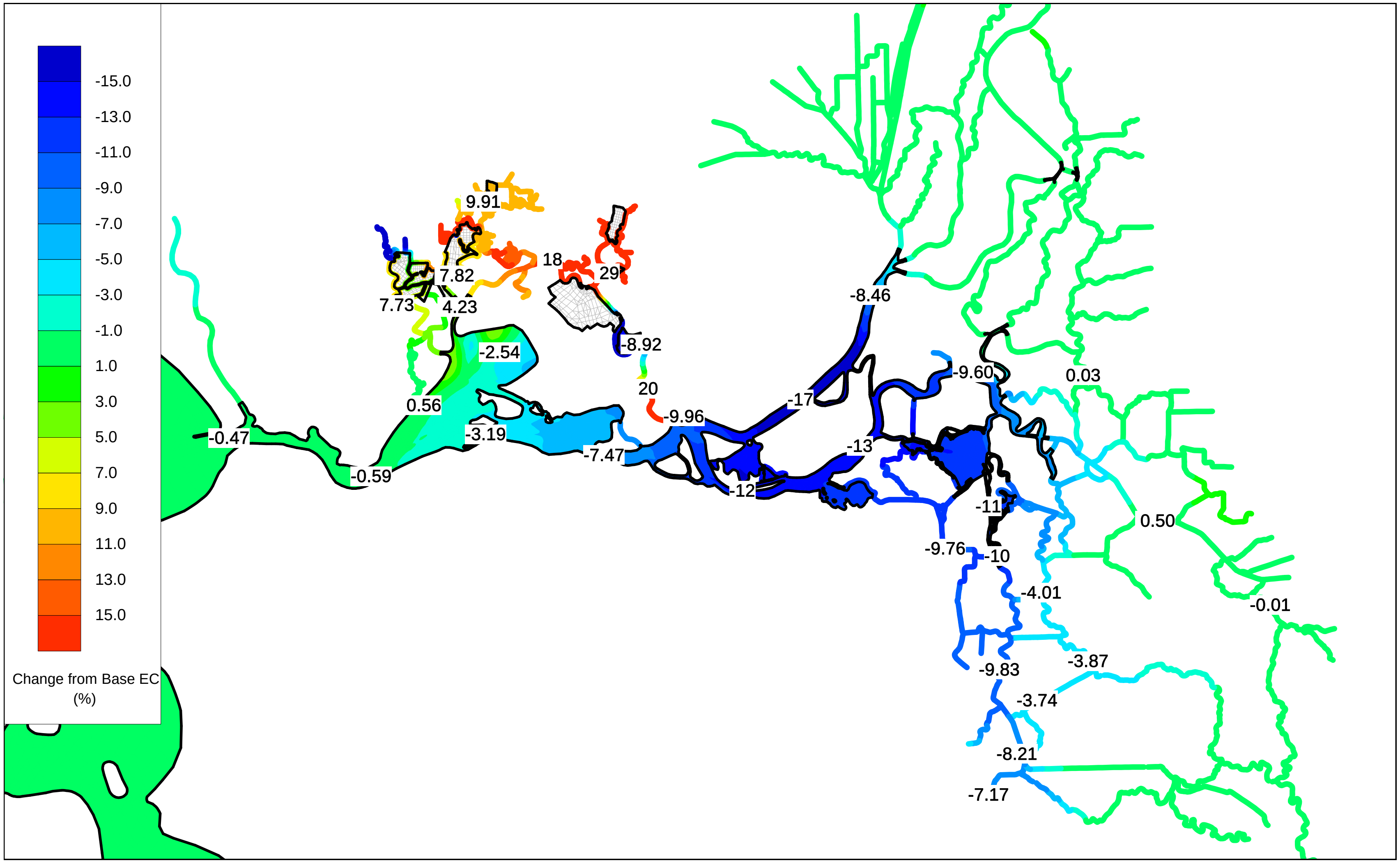


Figure 5-52 Set 1 EC % change from Base case – October 1, 2003.

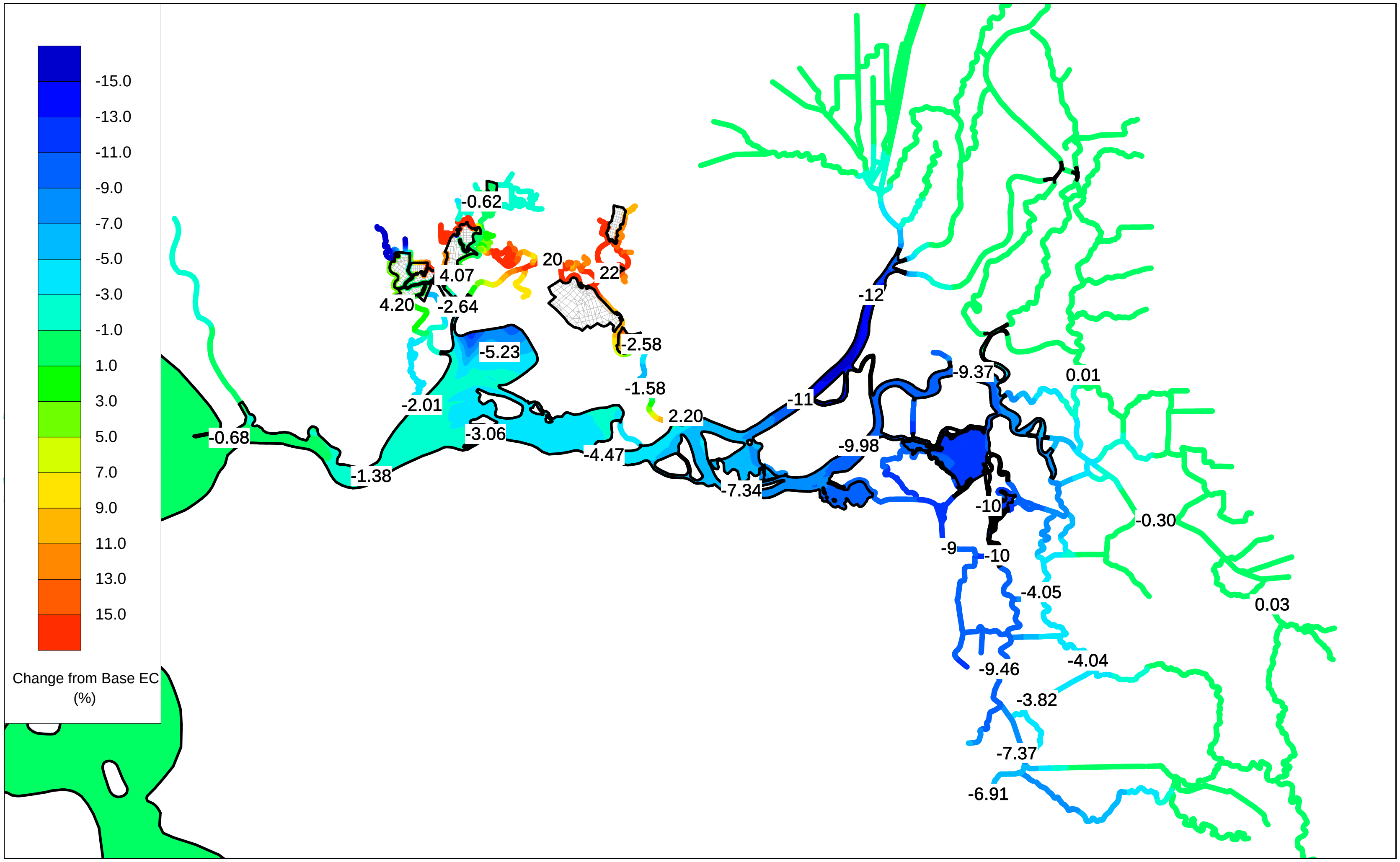


Figure 5-53 Set 1 EC % change from Base case – November 1, 2003.

5.7. Velocity Results – Scour Potential

5.7.1. **Background**

The creation of tidal marsh in restoration areas increased the volume of water flowing through downstream channels in Suisun Marsh each tidal cycle without a change in channel capacity. The result was an increase in velocity in some channels and sloughs and the potential for scour in channels and on banks and subsequent risk of levee failure.

The potential for channel scour and levee failure was evaluated using modeled velocity. Problem locations were identified as places where modeled velocity in the scenarios increased substantially with respect to the Base case during the July 2002 model period, in particular where velocity magnitude exceeded 2.0 ft/sec in the scenario but not in the Base case. Figure 5-54 gives location names for the six areas where potential scour problems were identified. Velocity changes in comparison with the Base case were generally small elsewhere.

Potential effects were assessed using exceedance plots of velocity distribution and magnitude. The velocity distribution plots show velocity versus the percent of time during July 2002 that each velocity was exceeded. Time series plots are also shown at some locations. Specific locations where results were assessed are indicated on velocity contour plots.

Although comparison locations for one and two-dimensional grids were selected at comparable geographical co-ordinates, comparisons between depth-averaged velocity at 2-dimensional *vs.* cross-sectionally averaged velocity at 1-dimensional grid locations should be interpreted with caution.

5.7.2. **Scouring potential for the scenarios**

Six locations were identified where the potential for scouring increased due to the incorporation of restoration area for the scenarios. Four of the six locations where large changes in velocity were identified occurred in channels adjacent to newly flooded areas. The maximum velocity at a given location did not occur at the same time or in the same tidal cycle in each scenario, partly due to shifts in stage timing. Velocity profiles at some problem locations exhibited a large asymmetry in velocity, e.g., the magnitude of the velocity on the incoming tide (negative velocity) increased substantially in comparison to increases on the outgoing tide.

The Set 1 and Set 2 scenarios each had the most extensive flooded areas, but the Zone 4 scenario resulted in the largest increases in channel velocity; it also reduced velocities at some locations in comparison with the Base case.

Figure 5-55 illustrates the magnitude and frequency of velocity changes at Beldon's Landing in Montezuma Slough for the scenarios. The velocity distributions for the scenarios vary in timing, as the percent of time with negative velocities (incoming tide) ranged from 47 to 49% in July, 2002. The Zone 4 restoration area has the greatest potential to influence sediment movement in Montezuma Slough, as both the Set 1 and

Zone 4 scenario velocities are nearly double the Base case values on both incoming (negative values) and outgoing (positive values) tides. Set 1 and Zone 4 velocity magnitudes were greater than 2.0 ft/sec ~ 25% of the time on both the incoming tide and outgoing tides, and were nearly symmetric with respect to tidal direction. These scenarios also produced the greatest tidal flow in Montezuma Slough (Figure 5-13).

Two points were examined at Hunter Cut: Point 1 at the bank (edge of the grid) and Point 2 in a mid-channel location (Figure 5-56). The Set 1 scenario (Figure 5-58) has the largest velocity effect mid-channel in Hunter Cut, which occurs on the outgoing tide. The large amount of restored area in the western marsh for Set 1 means that Suisun Slough and Hunter Cut contribute heavily to the channel conveyance for filling and draining the large volume of water in that restored area. Zone 1 contributes the greatest potential for scour on the levee bank in Set 2 with a large velocity magnitude on the incoming tide. The Zone 4 restoration area reduced tidal flow through Hunter Cut (Figure 5-13), as well as velocity in comparison with the Base case (Figure 5-58).

The other locations where velocity increases might result in scouring were all at the entrance to breaches at restoration areas within the marsh. Near the breach at Morrow Island (Figure 5-59), velocities are much higher for Set 2 and Zone 1 than the other scenarios (Figure 5-61). Velocities peak on the incoming tide, with the Zone 1 area contributing the majority of the velocity increase. Near the breach location at Meins Landing (Figure 5-62), the Zone 4 and Set 1 scenarios have similar velocity profiles (Figure 5-65), as both incorporate the Zone 4 region off of Montezuma Slough. Velocities on the bank (Point 1) and in mid-channel (Point 2) are very similar, while Point 3 near the entrance to the northern breach for the zone has an asymmetry profile which peaks on the incoming tide (negative velocity).

In the region near the Cross Slough (Figure 5-66), only the Set 2 scenario exhibits scour potential in comparison with the Base case. There are large velocity asymmetries in all three Set 2 points, with the mid-channel point showing the greatest potential for scour (lower right plot, Figure 5-66). Near the breach for the Duck Clubs restoration, the Set 1 scenario (Figure 5-68) has complex velocity profiles (Figure 5-69, lower plot). The modeled velocity profiles at the five points in Set 1 (Figure 5-70 and Figure 5-71) indicate that there is a high potential for scour in the channels and possibly to the levee banks, in some cases on the incoming tide (Points B and C, negative) and in others on the outgoing tide (Point B, positive).

5.7.3. **Summary**

Of the six locations identified as problematic for scouring, only two (Beldon's Landing and Hunter Cut) were located away from breach locations. The other four locations were located directly upstream of the breach. The grid development for channels near breach locations conforms to the existing channel configuration, and breaches were opened at the width of the channel at the location of the breach. Depending on the location in this channel, the increase in velocity magnitude could indicate potential problems with scour leading to failure on a levee bank (i.e., at the edge of the 2-dimensional grid) or scouring of the channel.

Changes to the channels such as deepening or widening could be modeled to assess the ability reduce scour potential both on levees and on levee banks.

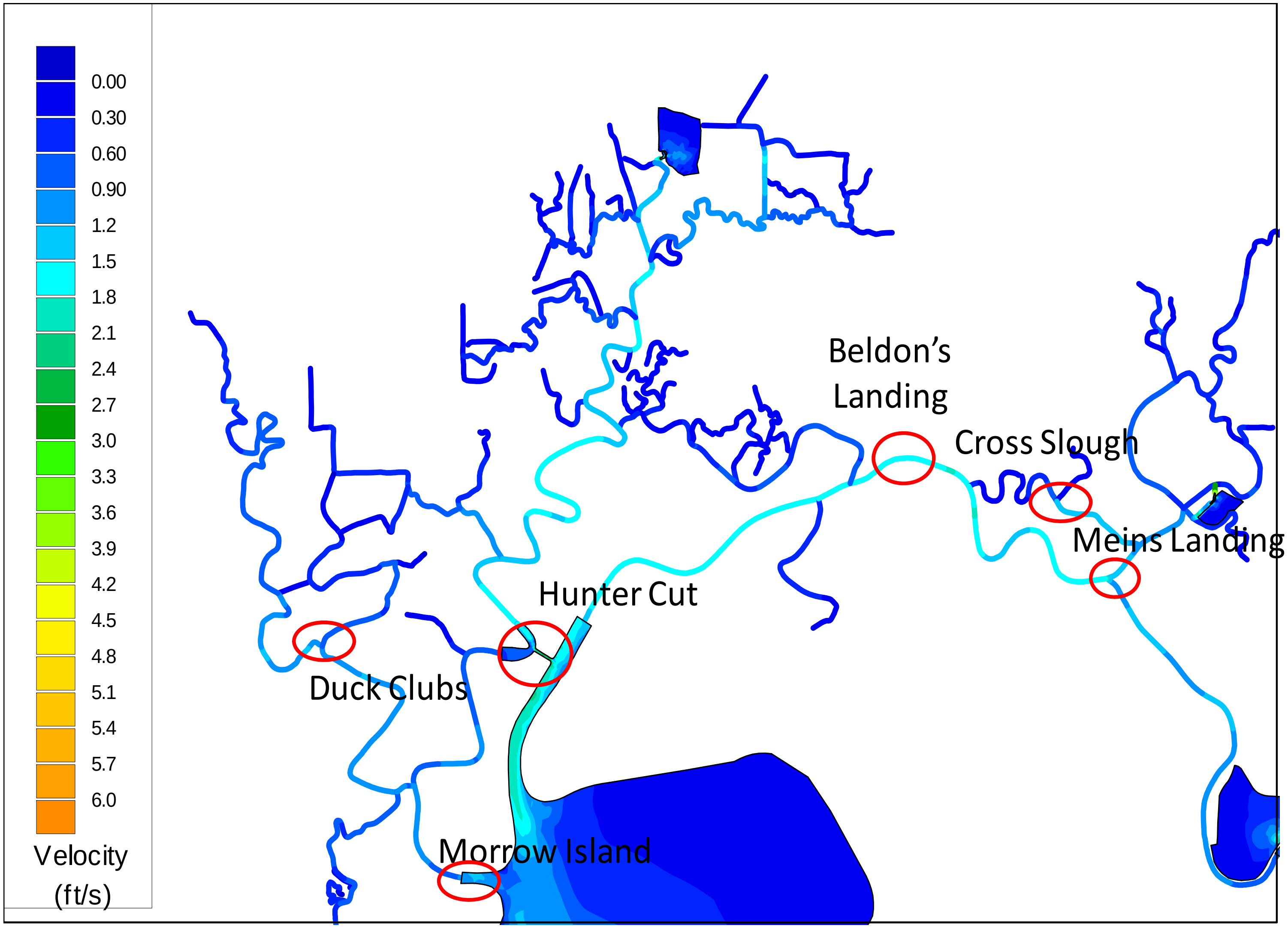


Figure 5-54 Location names for the areas examined for scouring potential.

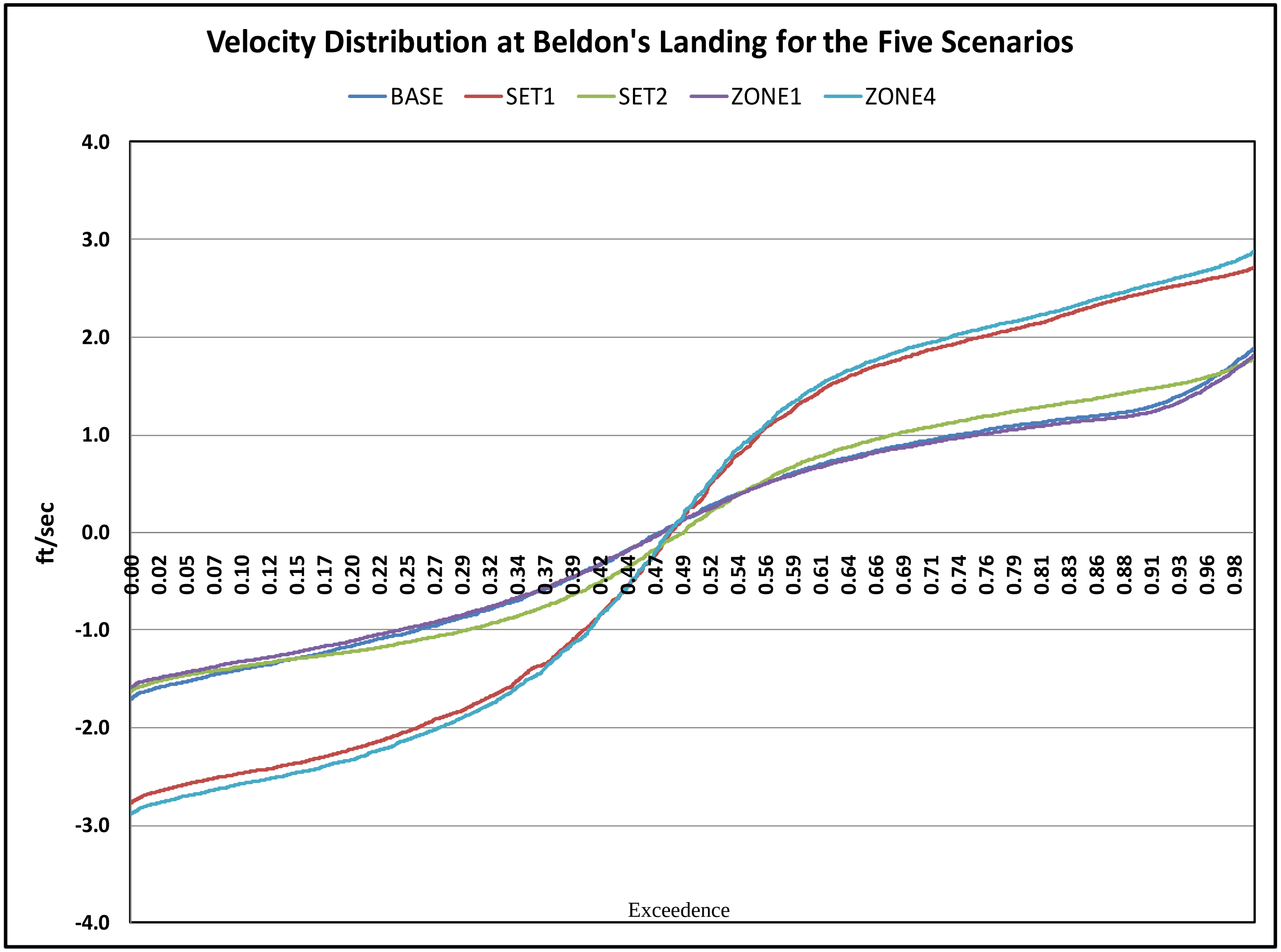


Figure 5-55 Velocity distributions for the five scenarios at Beldon's Landing, July 2002.

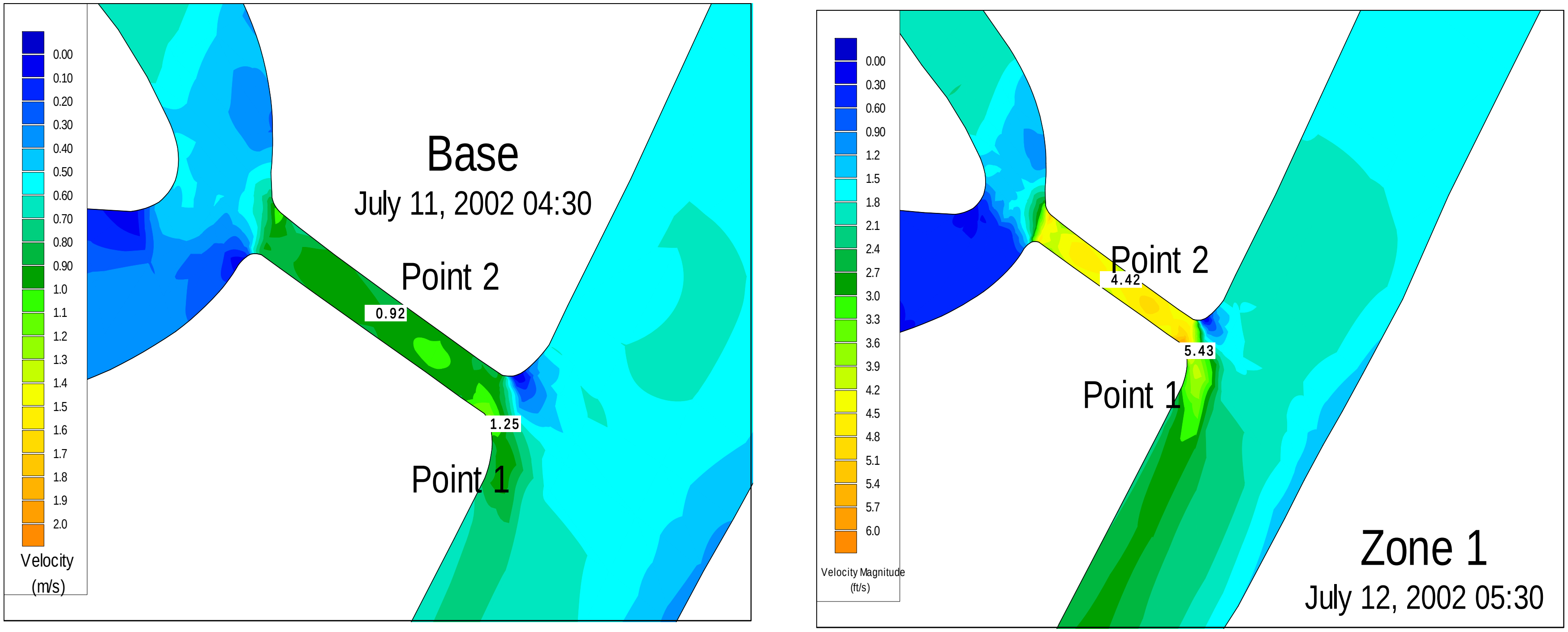


Figure 5-56 Color contour plots of velocity for Base case and Zone 1 at Hunter Cut in July 2002. Points analyzed: Point 1 on bank Point 2 mid-channel.

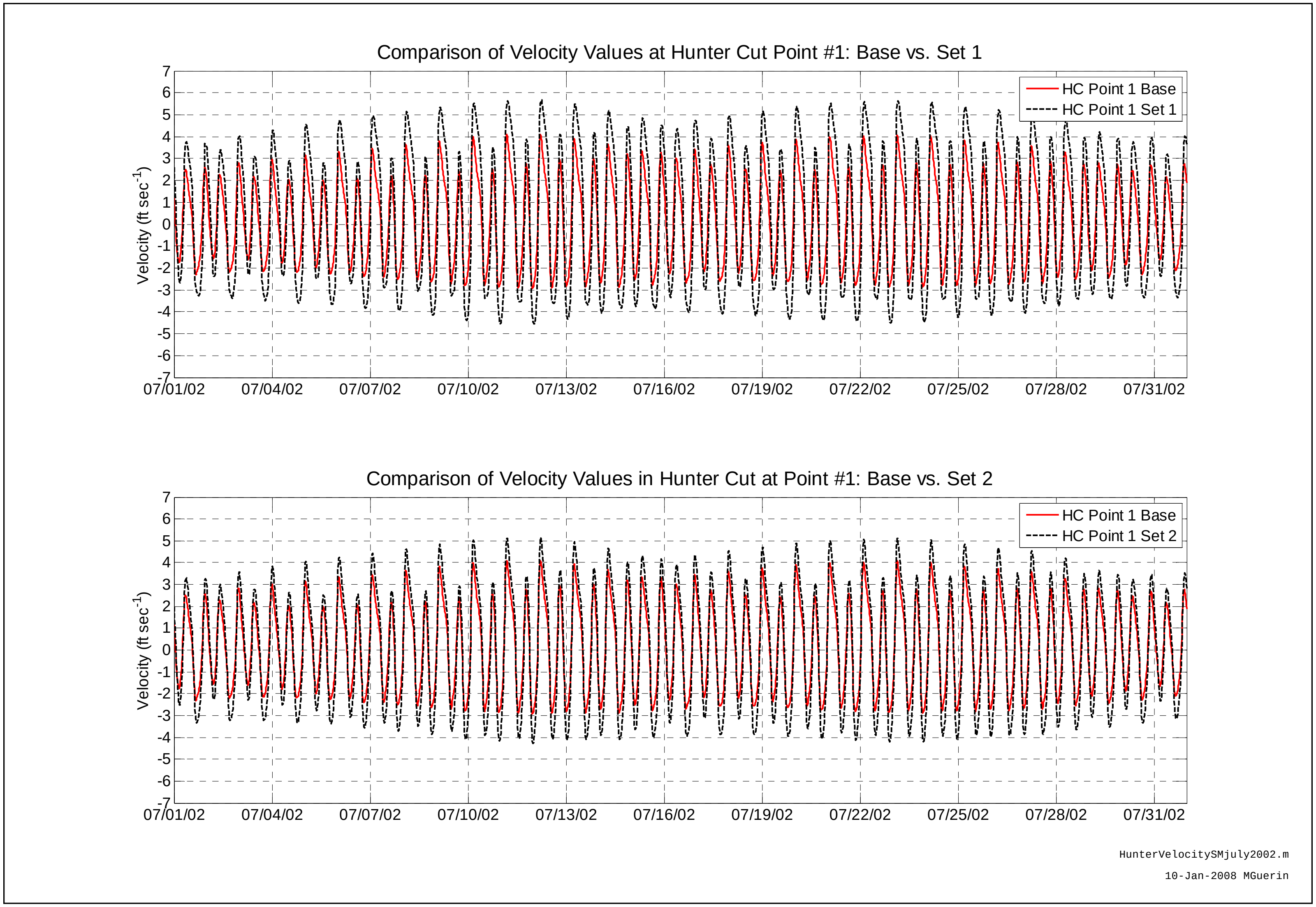
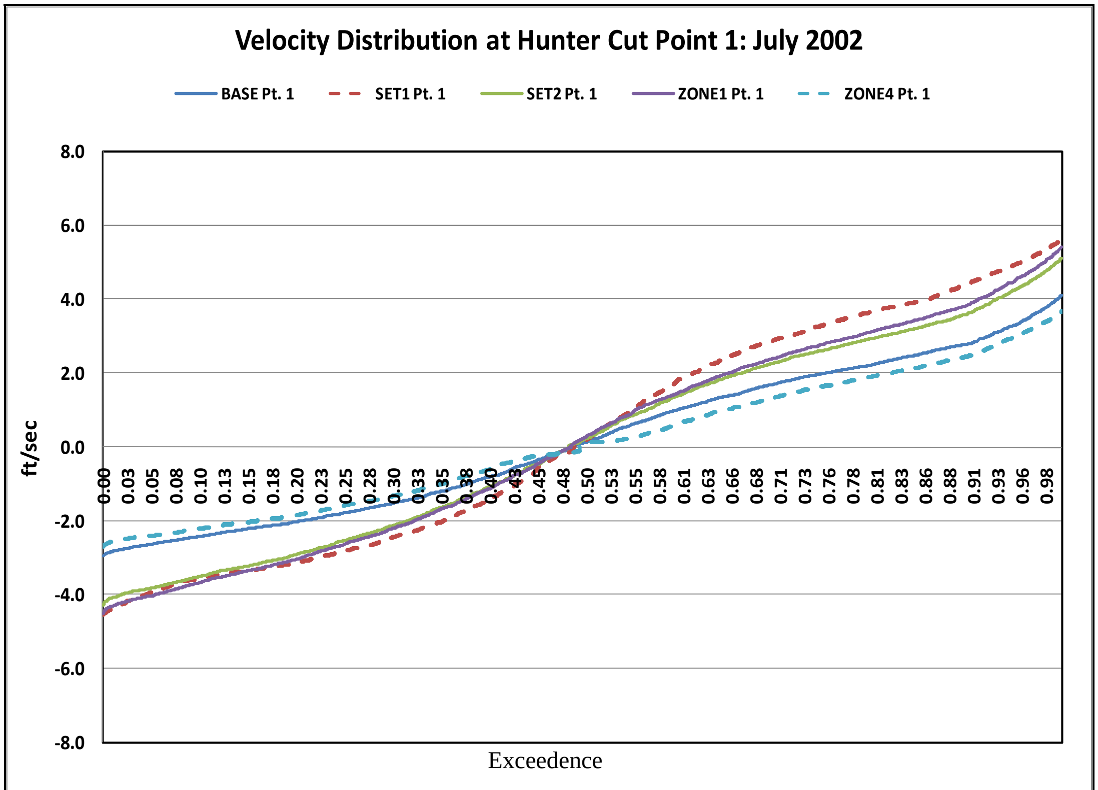


Figure 5-57 Hunter Cut velocity at Point 1 for Sets 1 and 2 in comparison with the Base case.



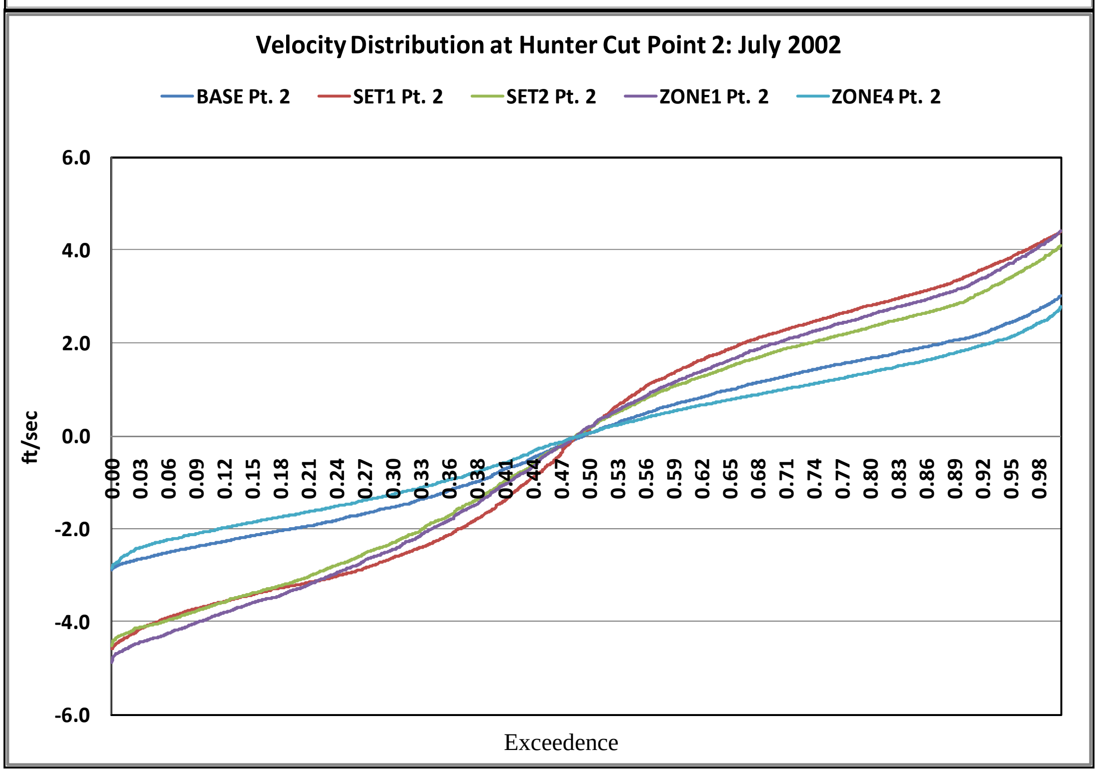


Figure 5-58 Velocity distributions for points 1 (bank) and 2 (mid-channel) at Hunter Cut.

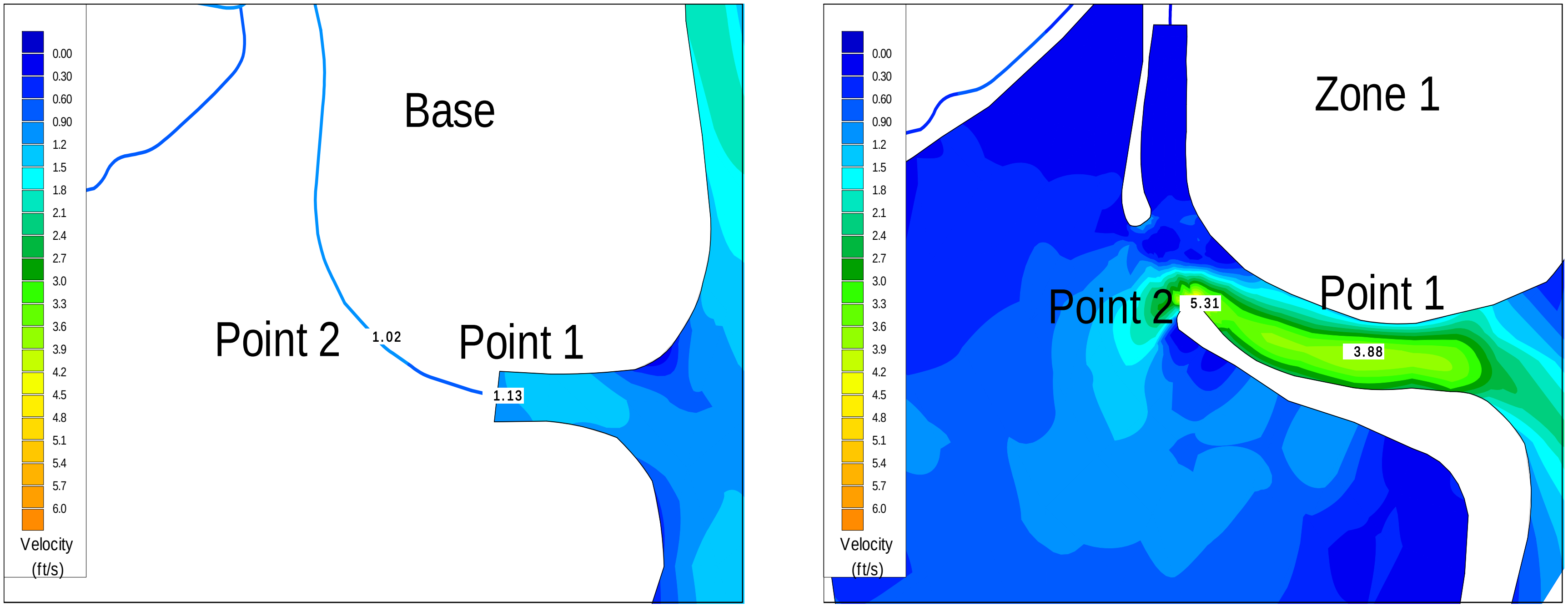


Figure 5-59 Color contour plots of velocity for Base case and Zone 1 near Morrow Island on July 12, 2002 14:00. Points analyzed: channel (Point 1) and bank (Point 2).

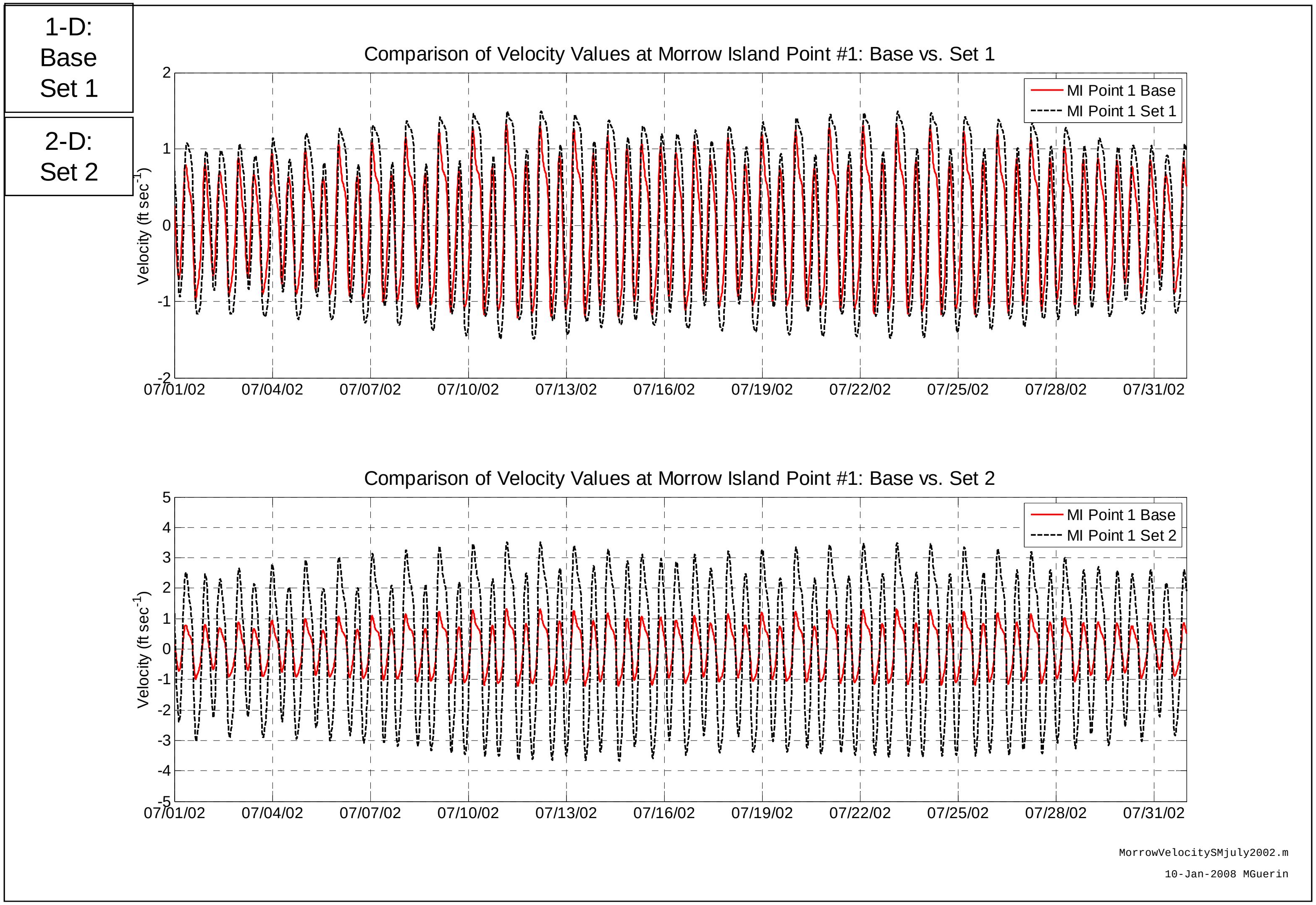


Figure 5-60 Morrow Island velocity at Point 1 for Sets 1 and 2 in comparison with the Base case.

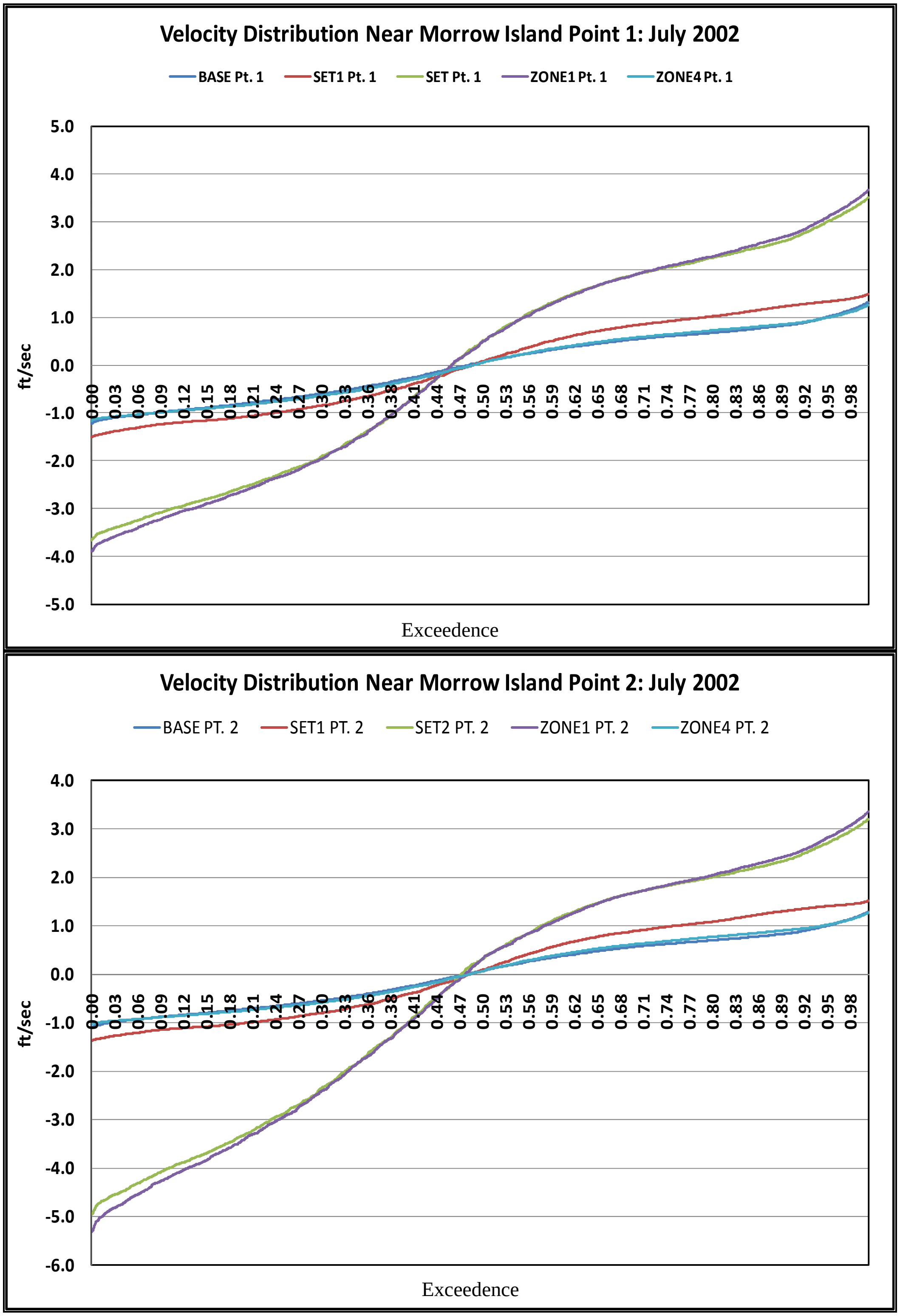


Figure 5-61 Velocity distributions for points analyzed near Morrow Island: point 1 (channel) and point 2 (bank).

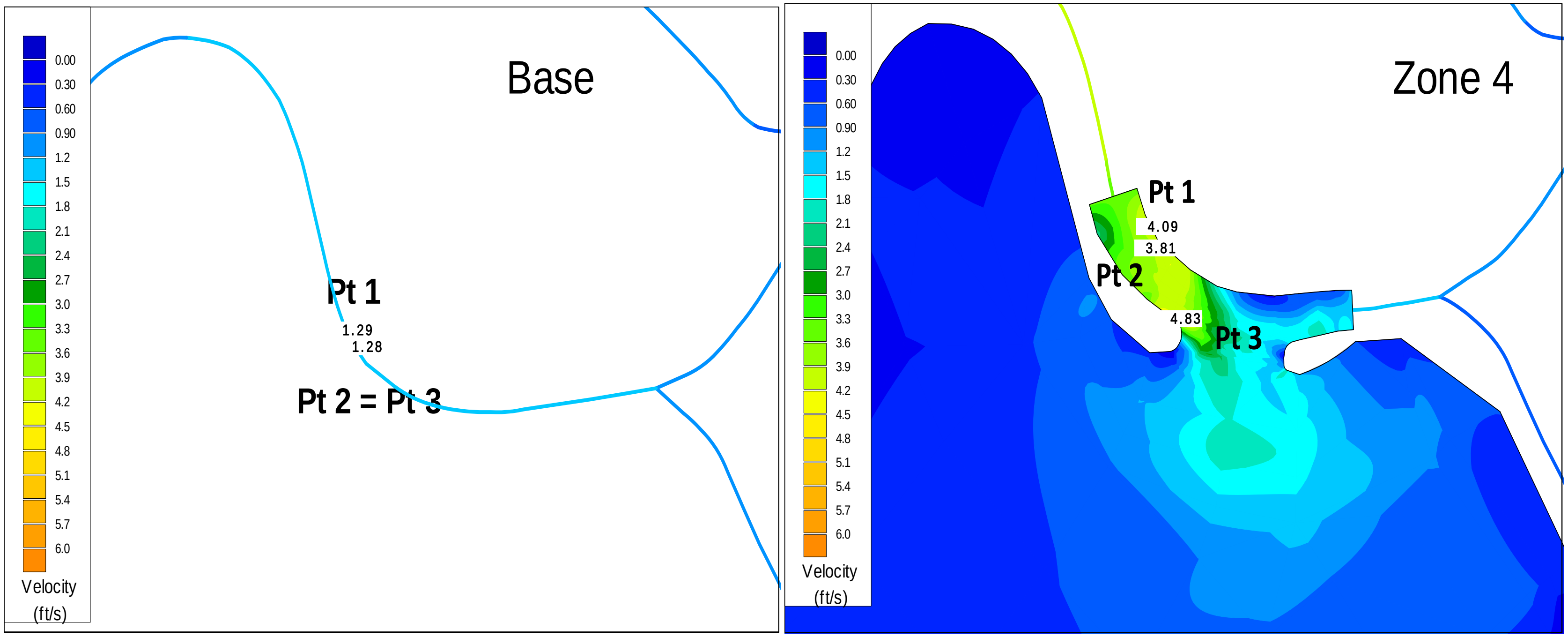


Figure 5-62 Color contour plots of velocity for Base case and Zone 4 near Meins Landing on July 17, 2002 1915. Points analyzed: points 1 and 3 (bank) and point 2 (mid-channel).

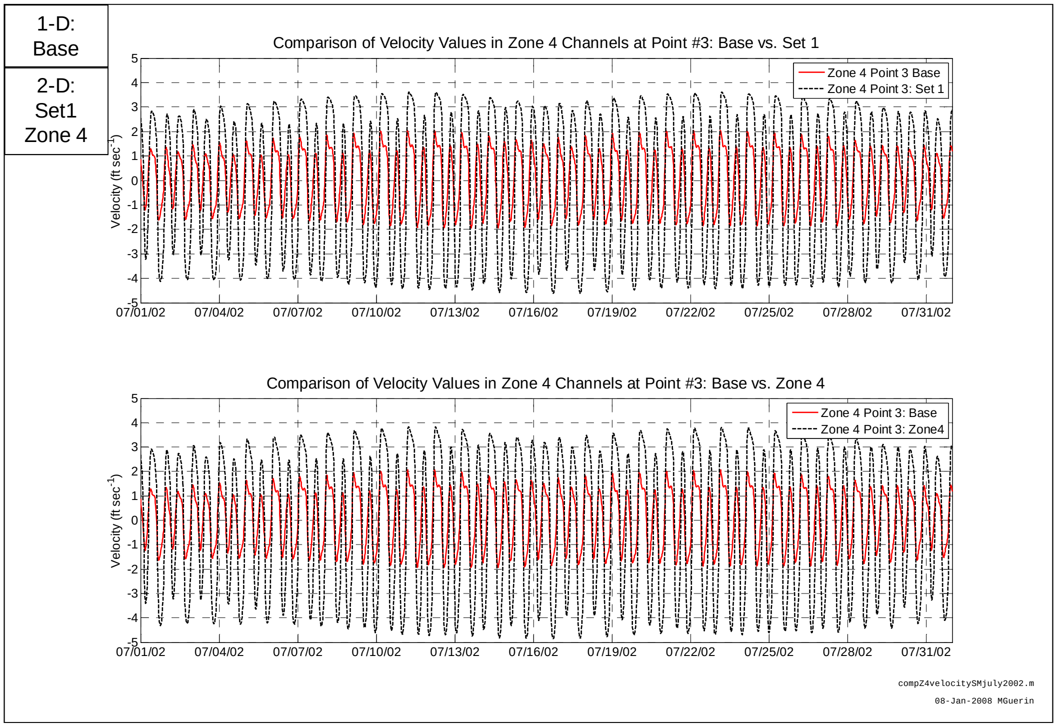


Figure 5-63 Meins Landing velocity at Point 2 for Set 1 and Zone 4 in comparison with the Base case.

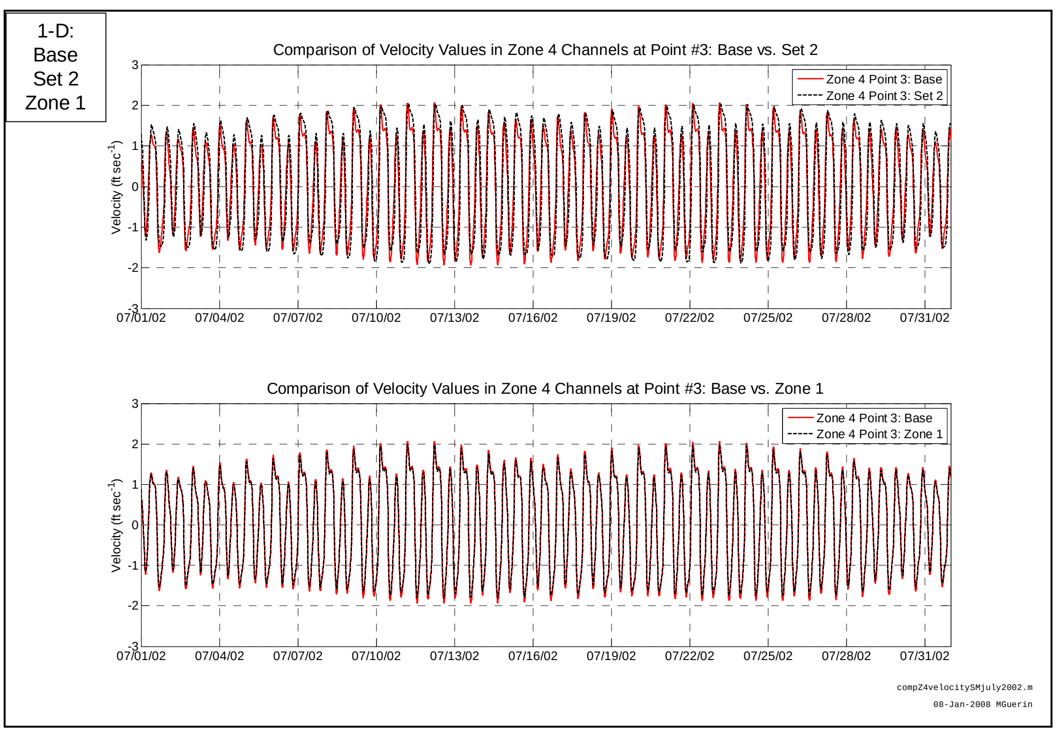


Figure 5-64 Meins Landing velocity at Point 2 for Set 2 and Zone 1 in comparison with the Base case.

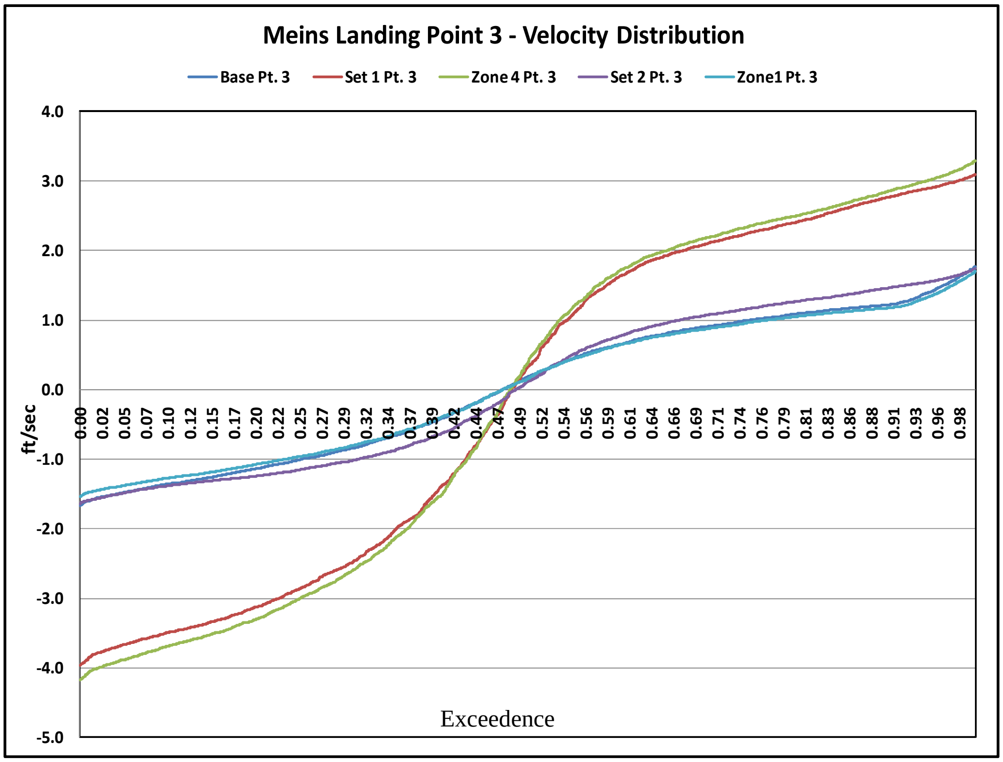


Figure 5-65 Velocity distributions for Point 3 (bank) analyzed near Meins Landing.

Exceedence

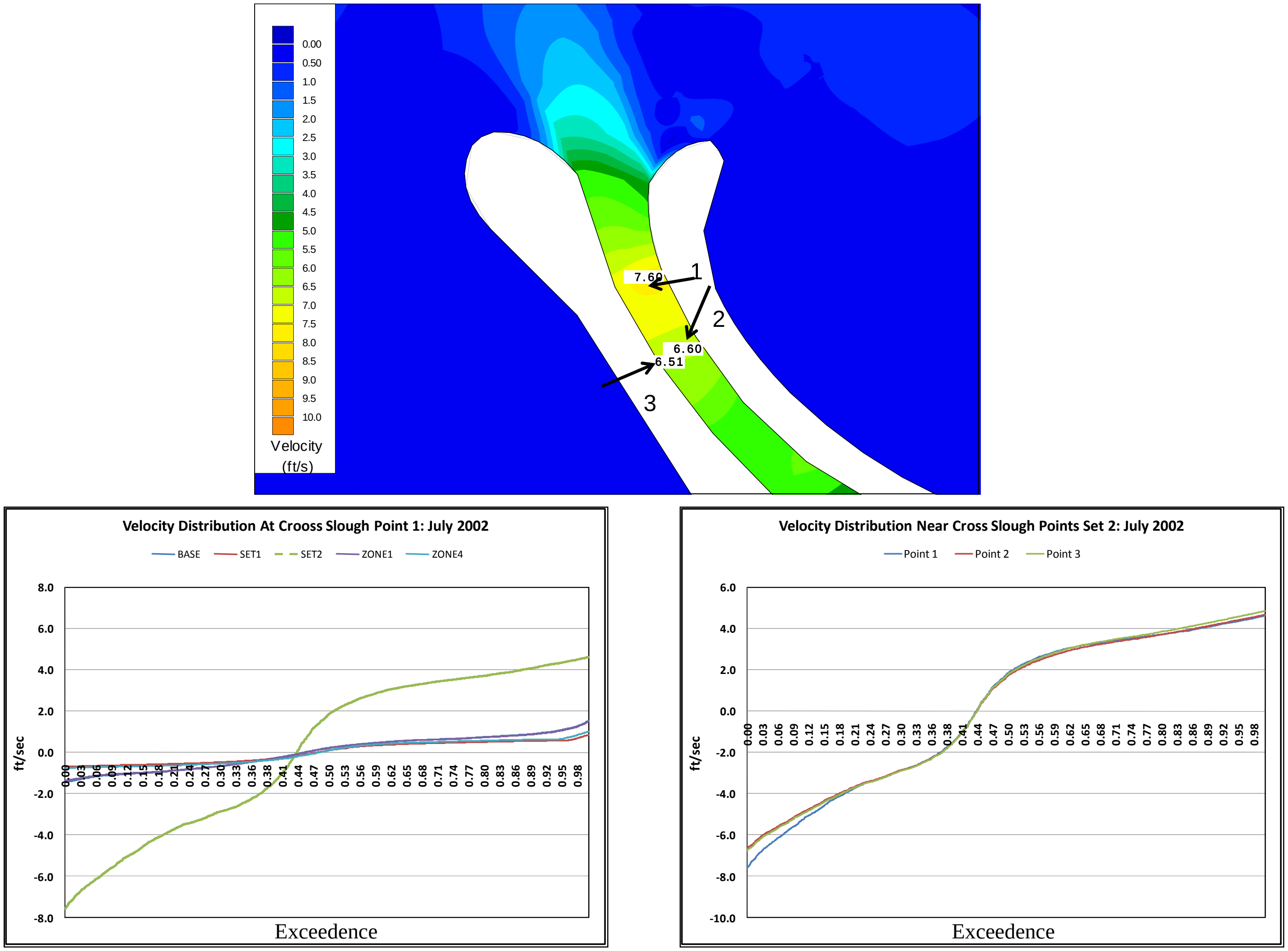


Figure 5-66 (Above) Color contour plot of Set 2 velocity near Cross Slough on July 19, 2002 23:15. (Below) Velocity distributions in Cross Slough. Points analyzed: points 1 and 2 mid-channel.

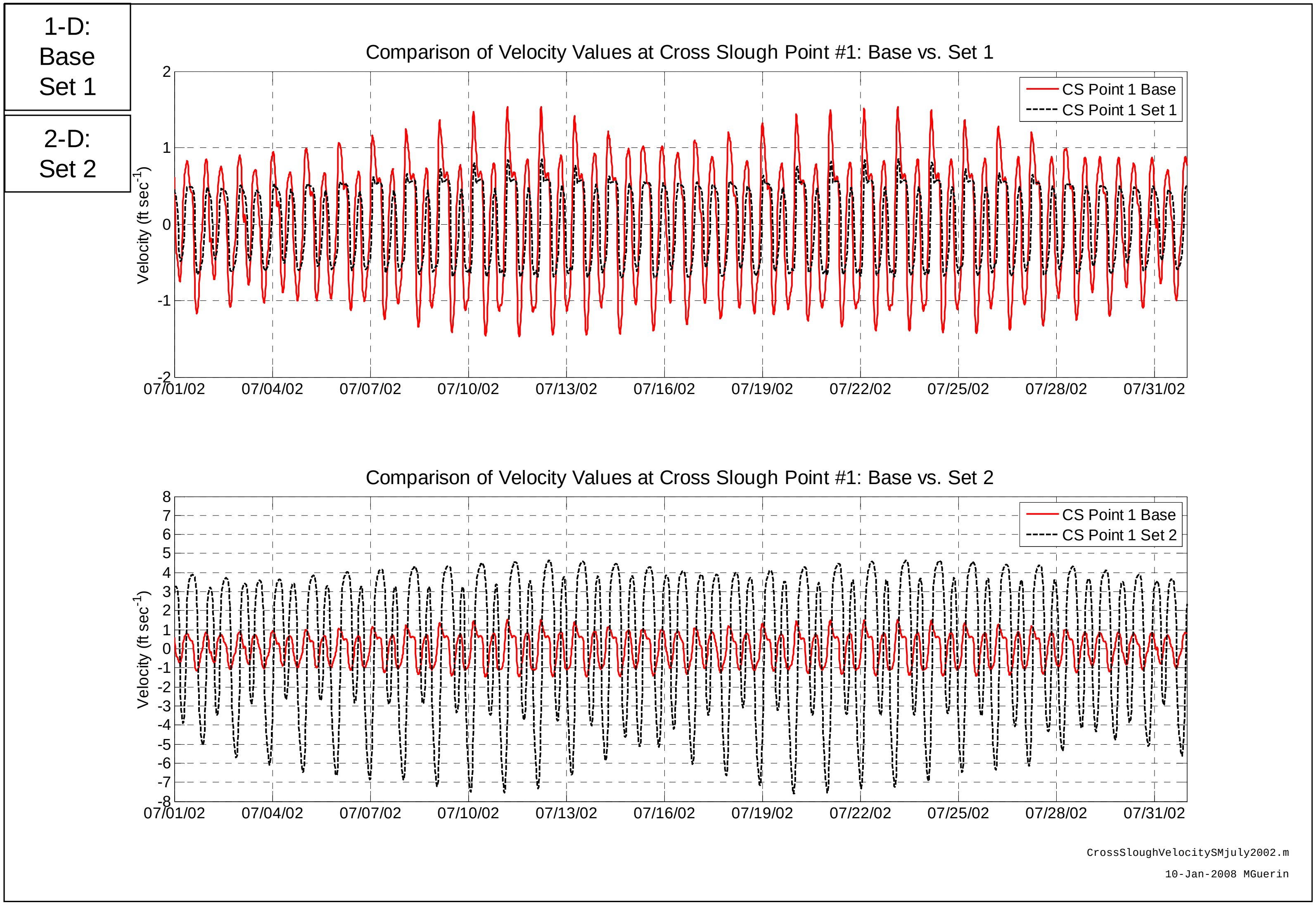


Figure 5-67 Cross Slough velocity at Point 1 for Set 1 and Set 2 in comparison with the Base case.

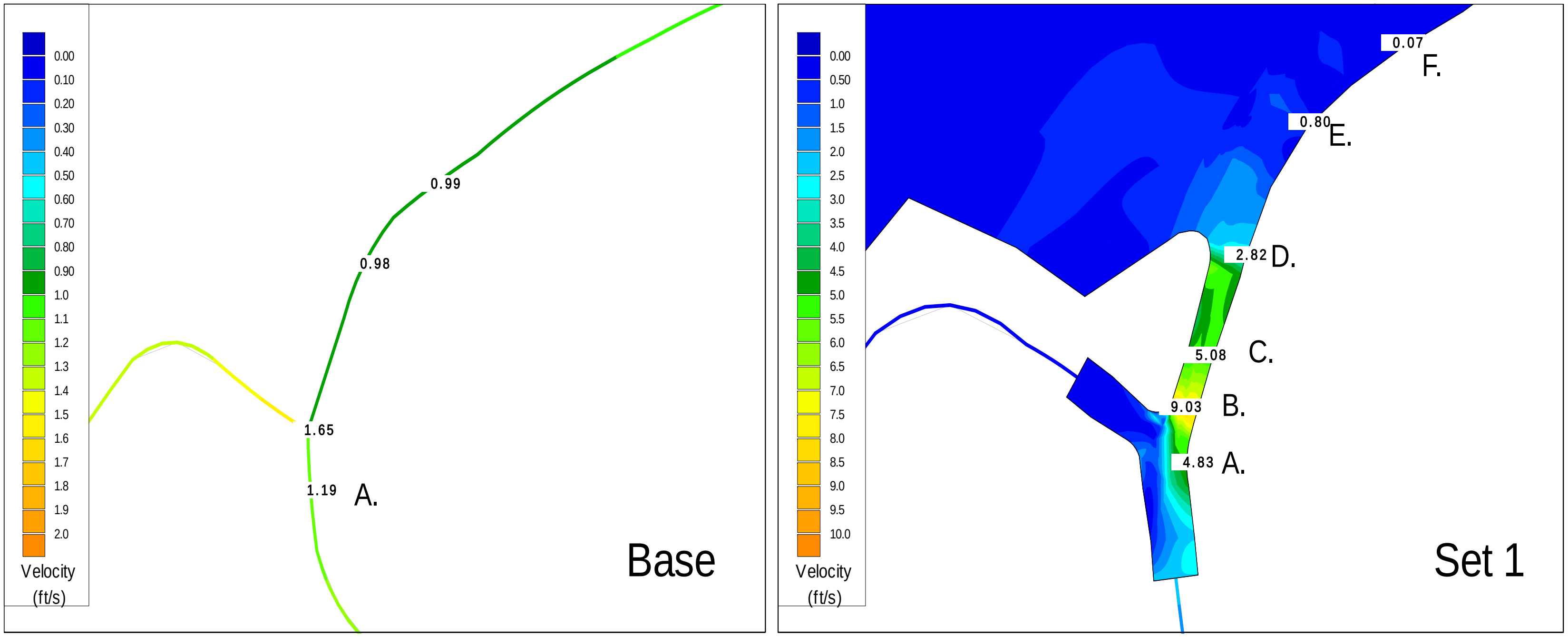
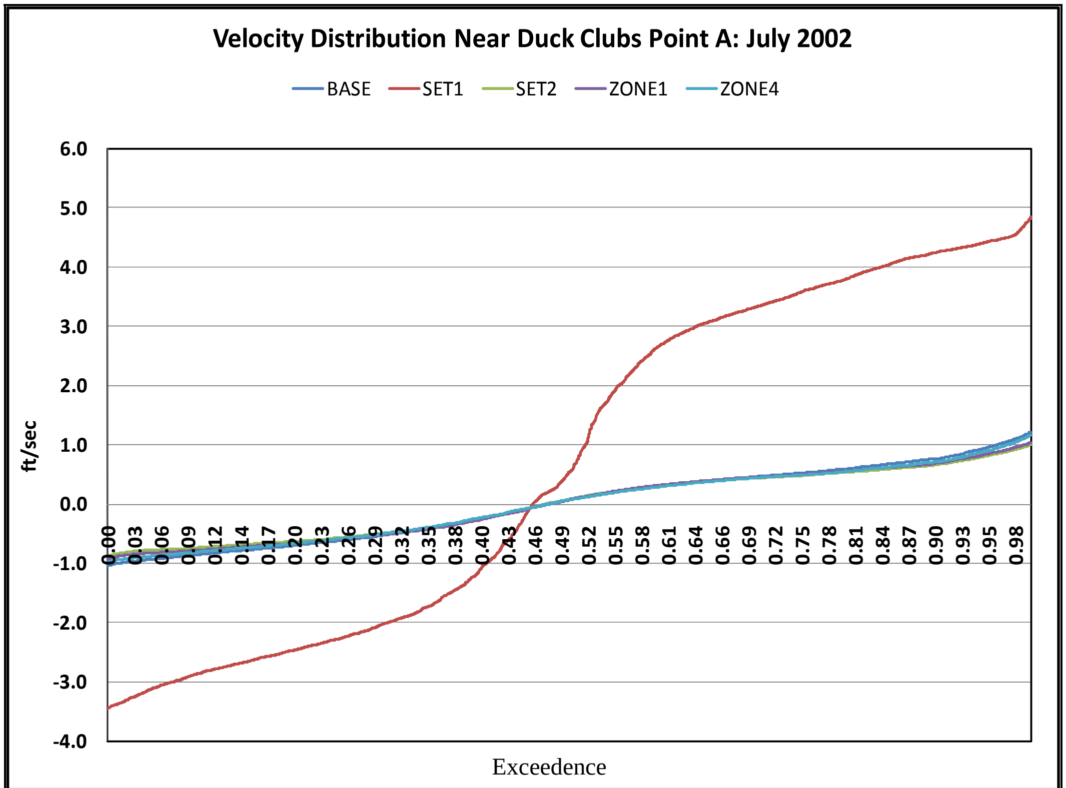


Figure 5-68 Color contour plots of velocity for the Base case and set 1 scenario on July 11, 2002 04:45 (note scale differences on contour plots). Points analyzed near the Duck Club location are indicated.



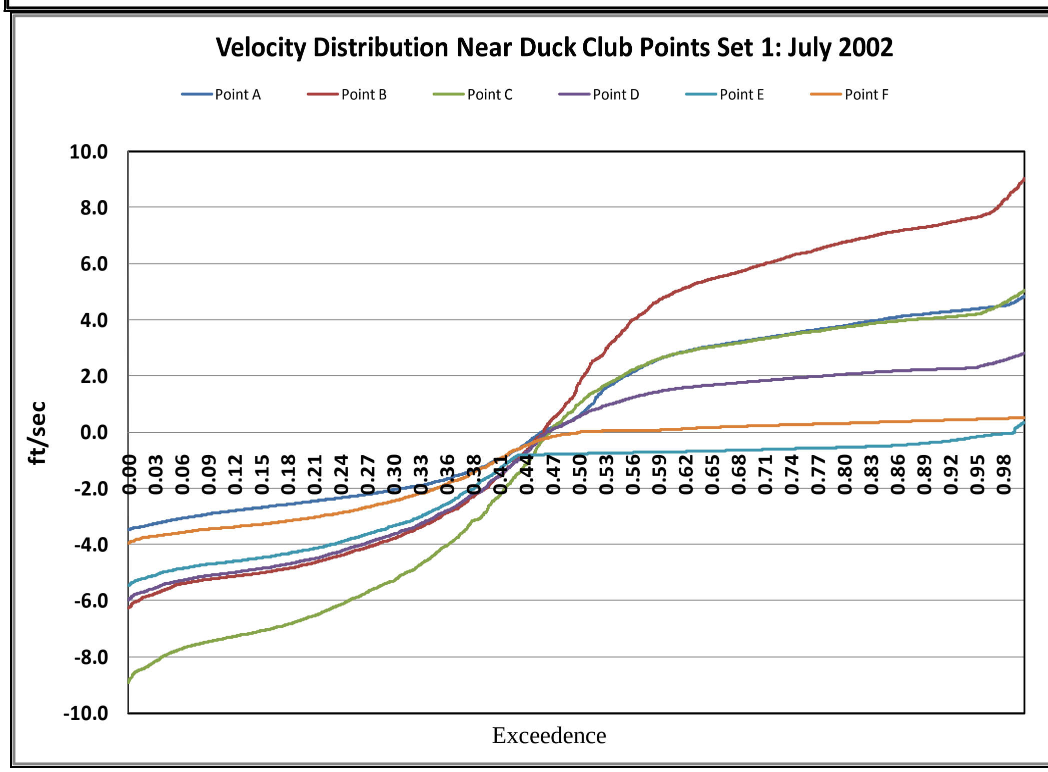


Figure 5-69 Velocity distributions for points analyzed near the Duck Club location. Lower plot shows velocity distributions for Set 1 at six points.

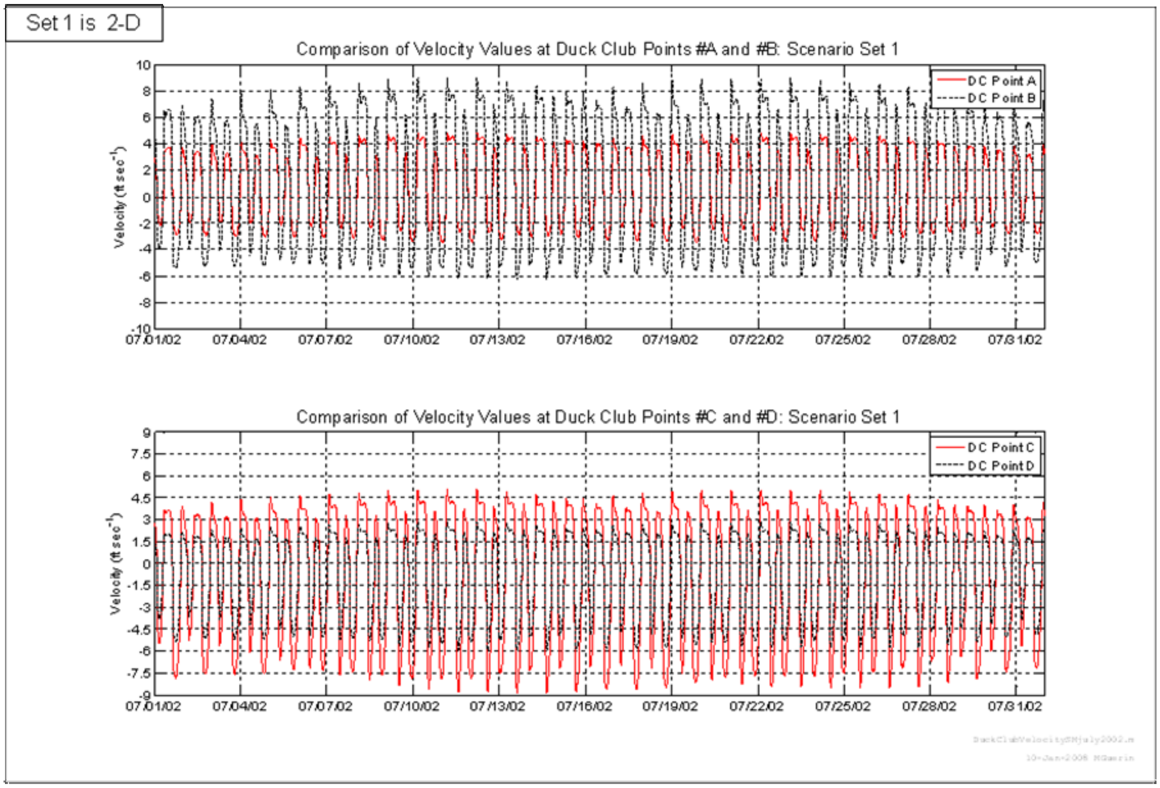


Figure 5-70 Velocity time series for points A - D analyzed near the Duck Club location.

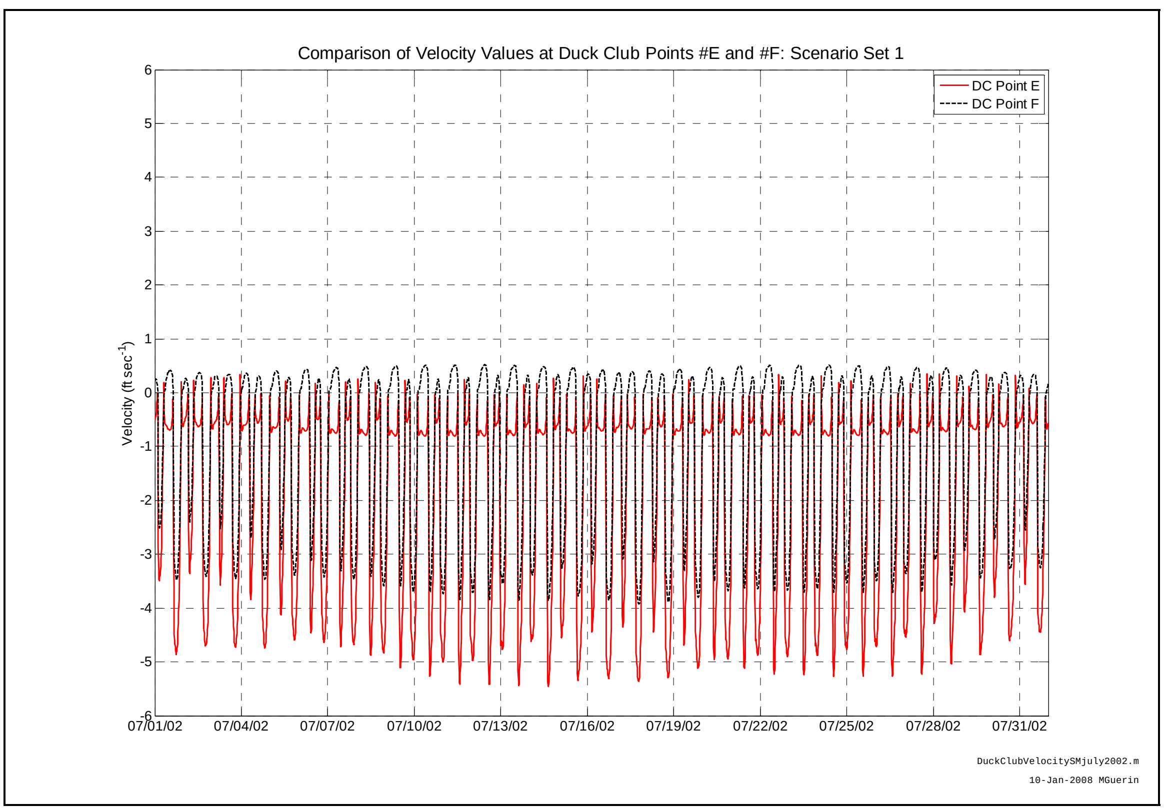


Figure 5-71 Velocity time series for points E and F analyzed near the Duck Club location.

6. Discussion/Summary/Conclusions

The representation of the Suisun Marsh area in RMA's current numerical model of the San Francisco Bay and Sacramento-San Joaquin Delta system was refined to simulate the current hydrodynamics and EC of the Suisun Marsh as well as the changes to this regime under a set of four marsh restoration scenarios.

Refinement in the Suisun Marsh area involved addition of increased detail to represent off-channel storage in overbank/fringe marsh regions, a better representation of precipitation and evaporation, estimation of local creek flows, inflows and withdrawals within the Suisun Marsh, and an overall refinement of the mesh. These additions generally improved the representation of tidal dynamics and EC in Suisun Marsh.

Stage calibration was generally good in Suisun Marsh. Flows in the smaller sloughs were greatly improved by the increased detail and refinement of the grid, the addition of off-channel storage, withdrawals for managed wetlands, and representation of evaporation in the tidal marsh areas. Flow through Montezuma Slough was low in comparison with measured data, and low flows through Hunter Cut were compensated by higher flows through Suisun Slough. These results have the potential of biasing modeled EC in the marsh restoration scenarios.

EC calibration results were variable, with some areas showing good correspondence with measured data, while other areas suffered from the lack of sufficient data or from approximations intrinsic to the model. In general, EC was low everywhere in the marsh in winter 2003. EC was low year-round in the eastern end of Montezuma Slough. Problems with flow calibration in Montezuma Slough or with insufficient representation of local effects are potential causes.

Density stratification is not explicitly represented in the 2-dimensional depth-averaged formulation used in the Bay-Delta model, leading to variations in the representation of EC. In the current model, diffusion coefficients are used to approximate effects due to density stratification. The use of diffusion coefficients to improve the representation of EC during high flow periods tends to bias modeled EC when outflow is low. As a consequence, modeled EC at Martinez is low winter through spring and high summer through fall. This bias in modeled EC at Martinez propagates through western Suisun Marsh.

Using the calibrated model, four marsh restoration scenarios - Zone 1, Zone 4, Set 1 and Set 2 - were simulated and compared to a Base case. Analysis of the results indicated that each of the scenarios increased the tidal prism, but muted the tidal range and shifted stage timing throughout the marsh in comparison with the Base case. Average tidal flow generally increased in the larger sloughs and decreased in smaller sloughs in the interior regions of Suisun Marsh. Tidal flow downstream of the restoration areas will likely increase, but reduced tidal range will reduce tidal flow at the sloughs upstream of the restored areas. The peak velocity increased in sloughs near the breaches of the flooded areas, with the largest changes localized at and near the mouths of the breached levees.

This increases the potential for failure on the banks of some of the affected levees or for scouring in some of the channels.

Water quality model results for the marsh restoration scenarios indicated that Delta EC decreased during July through December for the Zone 4 and Set 1 scenarios where the breached areas were located in channels further from Suisun Bay. The Set 2 scenario resulted in EC increase in the Delta due to tidal trapping in the breached area adjacent to Suisun Bay. Tidal trapping with the Zone 1 scenario caused only minor increases in Delta EC.

Scenarios that decreased Delta EC tended to increase EC in Suisun Marsh, although changes in the details of the EC profile for each scenario depended on the particular location examined, the operation of the Suisun Marsh Salinity Control Gate (SMSCG), and the season. The Zone 1 scenario was again most similar to the Base case, with little or no EC change in the eastern marsh but some increase in the west. The Zone 4 scenario decreased EC in most of the marsh whenever the SMSCG was operating, except in eastern Montezuma Slough where it increased EC. The Set 1 scenario generally resulted in the highest EC conditions in the Marsh, except upstream of the Zone 4 breaches on Montezuma Slough.

In comparison with the Base case:

- Each of the Alternatives resulted in increased EC in Montezuma Slough at Beldon's landing either because of pulling more water from the west, as in the cases of Zone 4 and Set 1, or because of increases in EC at the west end of Montezuma Slough, as in the cases or Zone 1 and Set 2.
- Zone 1 showed little difference in EC compared with the Base case in the eastern Marsh and at Morrow Island, but resulted in at least some EC increase in the western marsh and a small increase in Montezuma Slough at Beldon's Landing. The salinity increases are due in part to large volumes of higher salinity water being pulled into the marsh through Suisun Slough and Hunter Cut.
- When the SMSCG is open, Set 1 tends to have the most pronounced EC increase of all the scenarios in all areas of the Marsh except eastern Montezuma Slough, where Set 1 has greatest EC decrease. This is because of the locations and extent of the Set 1 restoration areas result in large volumes of (higher velocity) water being pumped through the main channels and sloughs in the marsh on both incoming and outgoing tides.
- When the SMSCG is operating, Zone 4 resulted in the greatest EC reduction throughout the western and northern Marsh, and increased EC at Beldon's Landing and eastward in the Marsh. The increases occur because the fresher water from Collinsville is entering the Zone 4 area rather than moving westward and northward in the marsh. With the gates open, EC was decreased in eastern Montezuma Slough and increased in Nurse Slough and at Beldon's Landing. Locations east of the breach benefit from the additional inflow of fresher water from the east, whereas less of the fresher water makes it past the breach to the west and north. Effects elsewhere were minor.

- At most locations, Set 2 increased EC when the gates were operating and otherwise resulted in increased EC or little change, in general. In the western marsh at Ibis, Cygnus and Morrow, very small decreases occurred when the SMSCG were operating. EC decreased only in eastern Montezuma Slough when the gates were open, due to increased flow of lower EC water from the east.

7. References

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Appendix B
Emission Calculations Spreadsheets

Appendix B. Tug Emissions Calculations

Based on Puget Sound methodology
Emissions (g/year)=kW*Activity (hours/year)*load factor*Emission Factor (g/kW-hr)*fuel correction factor

Avg Tug HP	86
kW=HP/1.341	64.13124534
Activity (90 days, 10 hours day)	900
load factor for tugs	0.31
fuel correction factor	1
grams to pounds	0.002204623

Emission Factor			grams/year	grams/day	pounds/day
ROG	0.27		4831.006711	53.68	0.12
NOx	11		196818.7919	2186.88	4.82
CO	2		35785.2349	397.61	0.88
PM	0.9		16103.3557	178.93	0.39
CO2	690		12345906.04	137176.73	302.42

Source: Starcrest Consulting Group, 2007. Puget Sound Maritime Air Emissions Inventory. Prepared April 2007.

Finding PM 10 and PM2.5

Offroad Equipment	PM2.5 fraction of total PM	0.92	0.36
	PM10 fraction of total PM	1	0.39

Source: SCAQMD Final Methodology to Calculate Particulate Matter (PM)2.5 and PM2.5 Significance Thresholds. October 2006.

Appendix C
USFWS Special-Status Species List

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825

August 25, 2010

Document Number: 100825030324

Harry Oakes
ICF International
630 K Street, Suite 400
Sacramento, CA 95814

Subject: Species List for Suisun Marsh Habitat Management, Preservation, and Restoration Plan

Dear: Interested party

We are sending this official species list in response to your August 25, 2010 request for information about endangered and threatened species. The list covers the California counties and/or U.S. Geological Survey 7½ minute quad or quads you requested.

Our database was developed primarily to assist Federal agencies that are consulting with us. Therefore, our lists include all of the sensitive species that have been found in a certain area *and also ones that may be affected by projects in the area*. For example, a fish may be on the list for a quad if it lives somewhere downstream from that quad. Birds are included even if they only migrate through an area. In other words, we include all of the species we want people to consider when they do something that affects the environment.

Please read Important Information About Your Species List (below). It explains how we made the list and describes your responsibilities under the Endangered Species Act.

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be November 23, 2010.

Please contact us if your project may affect endangered or threatened species or if you have any questions about the attached list or your responsibilities under the Endangered Species Act. A list of Endangered Species Program contacts can be found at www.fws.gov/sacramento/es/branches.htm.

Endangered Species Division

TAKE PRIDE IN AMERICA

U.S. Fish & Wildlife Service
Sacramento Fish & Wildlife Office
Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 100825030324

Database Last Updated: April 29, 2010

Quad Lists

BIRDS LANDING (481A)
Listed Species

Invertebrates

Branchinecta conservatio

Conservancy fairy shrimp (E)

Branchinecta lynchi

vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus

valley elderberry longhorn beetle (T)

Elaphrus viridis

Critical habitat, delta green ground beetle (X)
delta green ground beetle (T)

Lepidurus packardi

vernal pool tadpole shrimp (E)

Fish

Hypomesus transpacificus

Critical habitat, delta smelt (X)
delta smelt (T)

Oncorhynchus mykiss

Central Valley steelhead (T) (NMFS)

Oncorhynchus tshawytscha

Central Valley spring-run chinook salmon (T) (NMFS)
winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense

California tiger salamander, central population (T)
Critical habitat, CA tiger salamander, central population (X)

Rana draytonii

California red-legged frog (T)

Reptiles

Thamnophis gigas

giant garter snake (T)

Birds

Rallus longirostris obsoletus

California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni

California least tern (E)

Mammals

Reithrodontomys raviventris

salt marsh harvest mouse (E)

Plants

Sidalcea keckii

Keck's checker-mallow (=checkerbloom) (E)

DENVERTON (481B)

Listed Species

Invertebrates

Branchinecta conservatio

Conservancy fairy shrimp (E)

Critical habitat, Conservancy fairy shrimp (X)

Branchinecta lynchi

Critical habitat, vernal pool fairy shrimp (X)

vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus

valley elderberry longhorn beetle (T)

Elaphrus viridis

Critical habitat, delta green ground beetle (X)

delta green ground beetle (T)

Lepidurus packardi

Critical habitat, vernal pool tadpole shrimp (X)

vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris

green sturgeon (T) (NMFS)

Hypomesus transpacificus

Critical habitat, delta smelt (X)

delta smelt (T)

Oncorhynchus mykiss

Central Valley steelhead (T) (NMFS)

Oncorhynchus tshawytscha

Central Valley spring-run chinook salmon (T) (NMFS)

winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense

California tiger salamander, central population (T)

Rana draytonii

California red-legged frog (T)

Reptiles

Thamnophis gigas

giant garter snake (T)

Birds

Rallus longirostris obsoletus

California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni

California least tern (E)

Mammals

Reithrodontomys raviventris

salt marsh harvest mouse (E)

Plants

Cirsium hydrophilum var. hydrophilum

Suisun thistle (E)

Cordylanthus mollis ssp. mollis

soft bird's-beak (E)

Lasthenia conjugens

Contra Costa goldfields (E)

Critical habitat, Contra Costa goldfields (X)

Proposed Species

Plants

Cirsium hydrophilum var. hydrophilum

Critical habitat, Suisun thistle (PX)

Cordylanthus mollis ssp. mollis

Critical habitat, soft bird's-beak (PX)

HONKER BAY (481C)

Listed Species

Invertebrates

Branchinecta lynchi

vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus

valley elderberry longhorn beetle (T)

Elaphrus viridis

delta green ground beetle (T)

Fish

Acipenser medirostris

green sturgeon (T) (NMFS)

Hypomesus transpacificus

Critical habitat, delta smelt (X)

delta smelt (T)

Oncorhynchus mykiss

Central Valley steelhead (T) (NMFS)

Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha

Central Valley spring-run chinook salmon (T) (NMFS)

Critical habitat, winter-run chinook salmon (X) (NMFS)
winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)

Rana draytonii
California red-legged frog (T)

Reptiles

Masticophis lateralis euryxanthus
Alameda whipsnake [=striped racer] (T)

Thamnophis gigas
giant garter snake (T)

Birds

Rallus longirostris obsoletus
California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni
California least tern (E)

Mammals

Reithrodontomys raviventris
salt marsh harvest mouse (E)

Plants

Cordylanthus mollis ssp. mollis
soft bird's-beak (E)

Oenothera deltoides ssp. howellii
Antioch Dunes evening-primrose (E)

Proposed Species

Amphibians

Rana draytonii
Critical habitat, California red-legged frog (PX)

ANTIOCH NORTH (481D)

Listed Species

Invertebrates

Apodemia mormo langei
Lange's metalmark butterfly (E)

Branchinecta lynchi
vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
valley elderberry longhorn beetle (T)

Elaphrus viridis
delta green ground beetle (T)

Lepidurus packardi
vernal pool tadpole shrimp (E)

Fish

Acipenser medirostris

green sturgeon (T) (NMFS)

Hypomesus transpacificus

Critical habitat, delta smelt (X)

delta smelt (T)

Oncorhynchus mykiss

Central Valley steelhead (T) (NMFS)

Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha

Central Valley spring-run chinook salmon (T) (NMFS)

Critical Habitat, Central Valley spring-run chinook (X) (NMFS)

Critical habitat, winter-run chinook salmon (X) (NMFS)

winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense

California tiger salamander, central population (T)

Rana draytonii

California red-legged frog (T)

Reptiles

Thamnophis gigas

giant garter snake (T)

Birds

Rallus longirostris obsoletus

California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni

California least tern (E)

Mammals

Reithrodontomys raviventris

salt marsh harvest mouse (E)

Vulpes macrotis mutica

San Joaquin kit fox (E)

Plants

Cordylanthus mollis ssp. mollis

soft bird's-beak (E)

Erysimum capitatum ssp. angustatum

Contra Costa wallflower (E)

Critical Habitat, Contra Costa wallflower (X)

Lasthenia conjugens

Contra Costa goldfields (E)

Neostapfia colusana

Colusa grass (T)

Oenothera deltoides ssp. howellii

Antioch Dunes evening-primrose (E)

Critical habitat, Antioch Dunes evening-primrose (X)

Sidalcea keckii

Keck's checker-mallow (=checkerbloom) (E)

FAIRFIELD SOUTH (482A)
Listed Species

Invertebrates

Branchinecta conservatio
Conservancy fairy shrimp (E)

Branchinecta lynchi
Critical habitat, vernal pool fairy shrimp (X)
vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
valley elderberry longhorn beetle (T)

Elaphrus viridis
delta green ground beetle (T)

Lepidurus packardi
Critical habitat, vernal pool tadpole shrimp (X)

Speyeria callippe callippe
callippe silverspot butterfly (E)

Syncaris pacifica
California freshwater shrimp (E)

Fish

Acipenser medirostris
green sturgeon (T) (NMFS)

Hypomesus transpacificus
Critical habitat, delta smelt (X)
delta smelt (T)

Oncorhynchus mykiss
Central Valley steelhead (T) (NMFS)

Oncorhynchus tshawytscha
Central Valley spring-run chinook salmon (T) (NMFS)
Critical habitat, winter-run chinook salmon (X) (NMFS)
winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)

Rana draytonii
California red-legged frog (T)
Critical habitat, California red-legged frog (X)

Reptiles

Thamnophis gigas
giant garter snake (T)

Birds

Pelecanus occidentalis californicus
California brown pelican (E)

Rallus longirostris obsoletus

California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni

California least tern (E)

Mammals

Reithrodontomys raviventris

salt marsh harvest mouse (E)

Plants

Cirsium hydrophilum var. hydrophilum

Suisun thistle (E)

Cordylanthus mollis ssp. mollis

soft bird's-beak (E)

Lasthenia conjugens

Contra Costa goldfields (E)

Critical habitat, Contra Costa goldfields (X)

Proposed Species

Amphibians

Rana draytonii

Critical habitat, California red-legged frog (PX)

Plants

Cirsium hydrophilum var. hydrophilum

Critical habitat, Suisun thistle (PX)

Cordylanthus mollis ssp. mollis

Critical habitat, soft bird's-beak (PX)

VINE HILL (482D)

Listed Species

Invertebrates

Branchinecta lynchi

vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus

valley elderberry longhorn beetle (T)

Elaphrus viridis

delta green ground beetle (T)

Speyeria callippe callippe

callippe silverspot butterfly (E)

Syncaris pacifica

California freshwater shrimp (E)

Fish

Acipenser medirostris

green sturgeon (T) (NMFS)

Hypomesus transpacificus

Critical habitat, delta smelt (X)

delta smelt (T)

Oncorhynchus mykiss

Central Valley steelhead (T) (NMFS)
Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha

Central Valley spring-run chinook salmon (T) (NMFS)
Critical habitat, winter-run chinook salmon (X) (NMFS)
winter-run chinook salmon, Sacramento River (E) (NMFS)

Amphibians

Ambystoma californiense

California tiger salamander, central population (T)

Rana draytonii

California red-legged frog (T)
Critical habitat, California red-legged frog (X)

Reptiles

Masticophis lateralis euryxanthus

Alameda whipsnake [=striped racer] (T)

Thamnophis gigas

giant garter snake (T)

Birds

Rallus longirostris obsoletus

California clapper rail (E)

Sternula antillarum (=Sterna, =albifrons) browni

California least tern (E)

Mammals

Reithrodontomys raviventris

salt marsh harvest mouse (E)

Plants

Cordylanthus mollis ssp. mollis

soft bird's-beak (E)

Proposed Species

Amphibians

Rana draytonii

Critical habitat, California red-legged frog (PX)

County Lists

No county species lists requested.

Key:

(E) *Endangered* - Listed as being in danger of extinction.

(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.

(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.

(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.

Critical Habitat - Area essential to the conservation of a species.

(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.

(C) *Candidate* - Candidate to become a proposed species.

(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.

(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

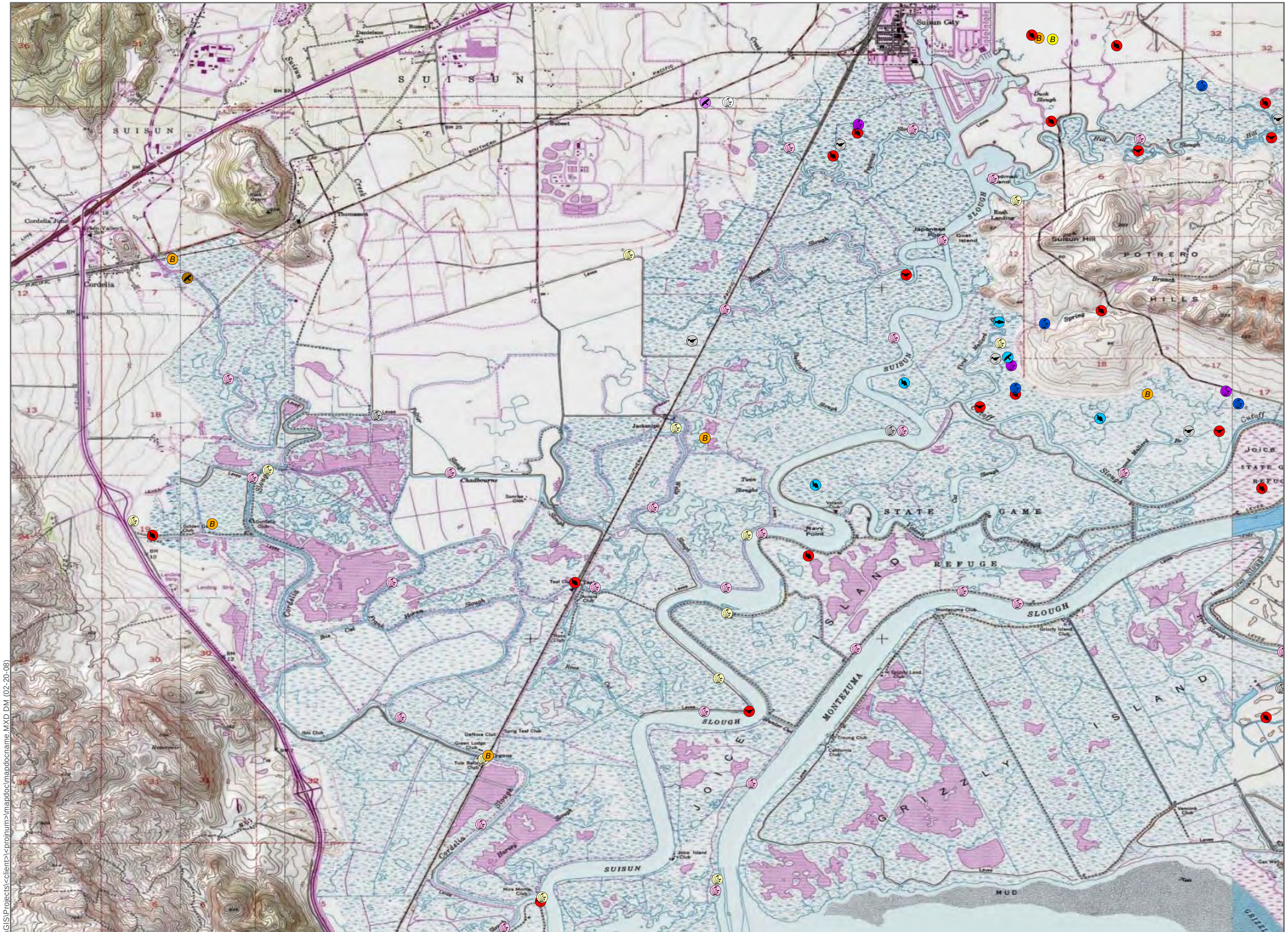
If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6580.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be November 23, 2010.

Appendix D

California Natural Diversity Database Occurrences of Special-Status Plant and Wildlife Species in Suisun Marsh



Appendix G
CNDDB Occurrences of Special-Status Plant and Wildlife Species in Suisun Marsh Region1

Legend

- alkali milk-vetch
- burrowing owl
- California black rail
- California clapper rail
- California least tern
- Delta mudwort
- Delta tule pea
- Mason's lilaeopsis
- northern harrier
- Sacramento splittail
- salt-marsh harvest mouse
- saltmarsh common yellowthroat
- short-eared owl
- soft bird's-beak
- Suisun Marsh aster
- Suisun shrew
- Suisun song sparrow
- Suisun thistle
- Swainson's hawk
- tricolored blackbird
- western pond turtle

N

0 0.5 1 Miles

ICF Jones & Stokes
an ICF International Company

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Appendix G
CNDDB Occurrences of Special-Status Plant and Wildlife Species in Suisun Marsh
Region 2

Legend

- alkali milk-vetch
- burrowing owl
- California black rail
- California clapper rail
- California least tern
- Delta mudwort
- Delta tule pea
- Mason's lilaeopsis
- northern harrier
- Sacramento splittail
- salt-marsh harvest mouse
- saltmarsh common yellowthroat
- short-eared owl
- soft bird's-beak
- Suisun Marsh aster
- Suisun shrew
- Suisun song sparrow
- Suisun thistle
- Swainson's hawk
- tricolored blackbird
- western pond turtle

N

0 0.5 1 Miles

ICF Jones & Stokes
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Appendix G
CNDDB Occurrences of Special-Status Plant and Wildlife Species in Suisun Marsh Region 3

Legend

- alkali milk-vetch
- burrowing owl
- California black rail
- California clapper rail
- California least tern
- Delta mudwort
- Delta tule pea
- Mason's lilaeopsis
- northern harrier
- Sacramento splittail
- salt-marsh harvest mouse
- saltmarsh common yellowthroat
- short-eared owl
- soft bird's-beak
- Suisun Marsh aster
- Suisun shrew
- Suisun song sparrow
- Suisun thistle
- Swainson's hawk
- tricolored blackbird
- western pond turtle

N

0 0.5 1 Miles

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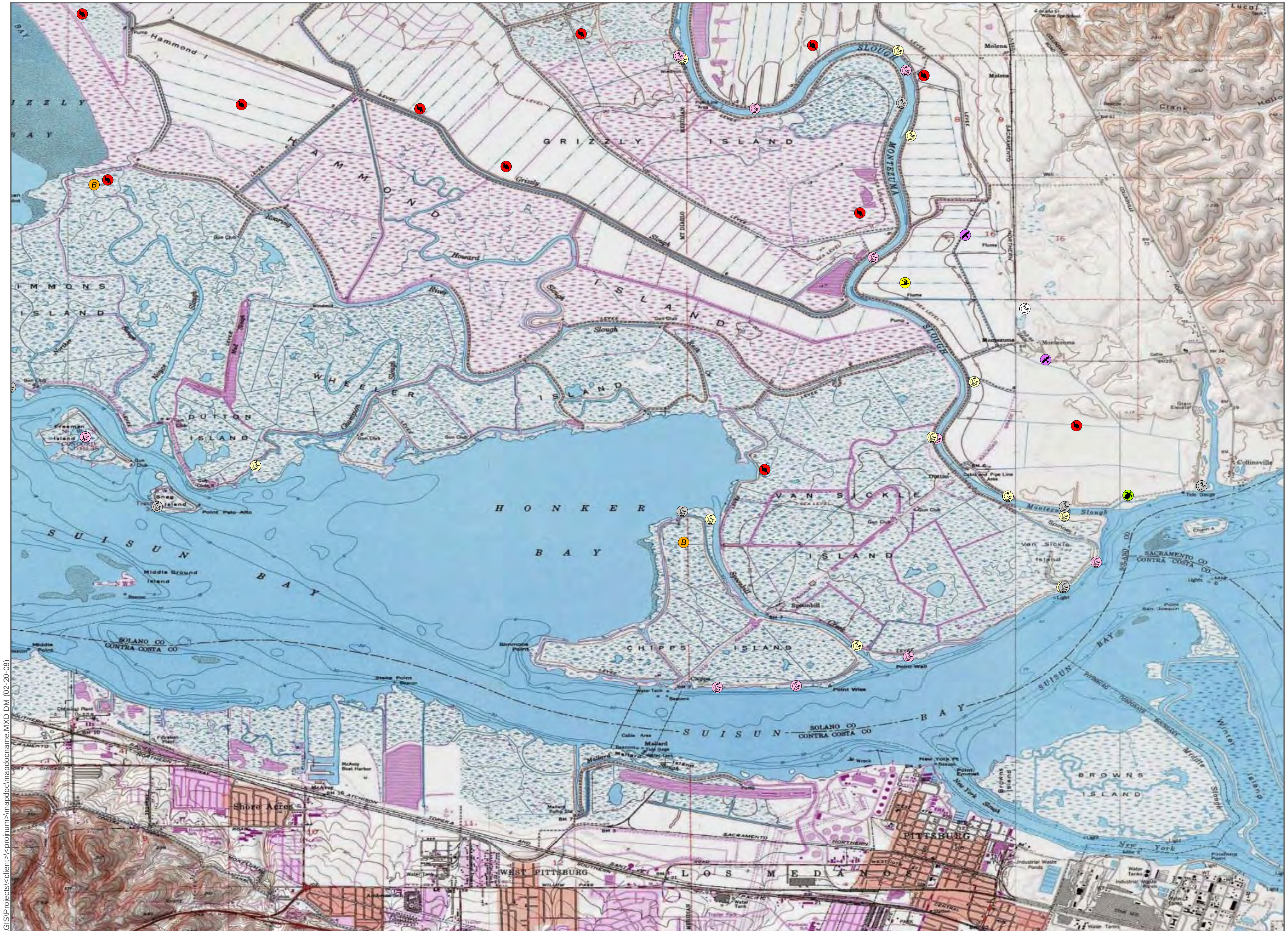

Appendix G
CNDDB Occurrences of Special-Status Plant and Wildlife Species in Suisun Marsh
Region 4

Legend

- alkali milk-vetch
- burrowing owl
- California black rail
- California clapper rail
- California least tern
- Delta mudwort
- Delta tule pea
- Mason's lilaeopsis
- northern harrier
- Sacramento splittail
- salt-marsh harvest mouse
- saltmarsh common yellowthroat
- short-eared owl
- soft bird's-beak
- Suisun Marsh aster
- Suisun shrew
- Suisun song sparrow
- Suisun thistle
- Swainson's hawk
- tricolored blackbird
- western pond turtle

N

0 0.5 1 Miles

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Appendix E

Adaptive Management Plan

APPENDIX E

Suisun Marsh Monitoring and Adaptive Management Plan

CONTENTS

I. Introduction
- A. Background
- B. Suisun Marsh Plan Objectives
- C. Role of Adaptive Management
- D. Suisun Marsh Plan Conceptual Models and Uncertainties

II. Monitoring
- A. Ongoing Monitoring
- B. SMP EIS/EIR Monitoring
- C. Potential Tidal Restoration Project Monitoring

III. Adaptive Management Implementation
- A. Roles and Responsibilities
- B. Project Success Criteria
- C. Assessment of Monitoring Results
- D. Decision Making and Feedback Loop

References

Attachment—Suisun Marsh Plan Conceptual Model Uncertainties

Figure—Adaptive Management Decision Making Matrix

Suisun Marsh
Monitoring and Adaptive Management Plan

I. Introduction

A. Background

Suisun Marsh (Marsh) is the largest contiguous brackish water marsh remaining on the west coast of North America and is a critical part of the San Francisco Bay/Sacramento-San Joaquin River Delta (Delta) estuary ecosystem. It encompasses more than 10% of California's remaining natural wetlands and serves as the resting and feeding ground for thousands of birds migrating on the Pacific Flyway. In addition, the Marsh consists of several habitat types that provide essential habitat for more than 221 bird species, 45 animal species, 16 reptilian and amphibian species, and the salmon fishery by providing important tidal rearing areas for juvenile fish.

Managed wetlands are the most common land cover type in the Marsh, accounting for approximately 51,416 acres, or 66.5% of the Marsh. Managed wetlands in the study area provide valuable nesting, foraging, and wintering habitat for waterfowl and shorebirds. Managed wetlands also provide nesting and foraging area for several special status species, such as salt marsh harvest mouse, Suisun shrew, California black rail, California clapper rail, western pond turtle, Suisun song sparrow, and salt marsh common yellowthroat. Managed wetlands also provide habitat for raptors, songbirds, and numerous wildlife species.

Bays and sloughs comprise approximately 25% of the Marsh. Bays and sloughs provide foraging habitat for several species of diving ducks, cormorants, grebes, and other waterfowl that are permanent residents or that winter in the Marsh. The upper reaches of the sloughs provide foraging habitat for waterfowl species, kingfishers, piscivorous birds and wading birds. Shallow freshwater aquatic areas provide rearing, escape cover, and foraging habitat for reptiles and amphibians and may be used as foraging habitat by river otters and raccoon. This habitat also provides the largest area of habitat for fish species in the Marsh. Section 6.1 of the SMP EIS/EIR contains further information on fish habitat in the Marsh.

Tidal wetlands make up approximately 7.5% of the Marsh and are divided into three zones – low marsh, middle marsh, and high marsh. The low tidal zone receives tidal inundation twice a day and provides habitat for shorebirds, California clapper rail, California black rail, other wading birds, and many fish species. Dominant plant species in the low tidal zone include hardstem bulrush and common bulrush. The middle tidal wetlands marsh provides foraging habitat for salt marsh harvest mouse and Suisun shrew, as well as common and special-status bird species, and shorebirds; this marsh zone also provides nesting and foraging habitat for Suisun song sparrow and salt marsh yellowthroat, and when inundated, for fish species. Dominant plant species in the middle tidal zone include pickleweed, saltgrass, and American bulrush. The high tidal wetland zone provides escape cover for salt marsh harvest mouse, Suisun shrew, California clapper rail during periods when the middle and low zones are inundated. The high marsh zone provides foraging and nesting habitat for special status species, such as salt marsh harvest mouse, and Suisun shrew; and provides foraging and nesting habitat for shorebirds, California clapper rail, California black rail, and other birds. Dominant plant species in the high tidal zone include saltgrass, pickleweed, annual grasses, baltic rush, and is critical habitat for special-status plant species such as, Suisun Thistle, Soft Bird's-beak, Suisun Aster, Delta Tule Pea, and Mason's Lilaeopsis. Sections 6.2 and 6.5 of the SMP EIS/EIR contain further information on tidal marsh vegetation and wildlife in the Marsh.

B. Suisun Marsh Plan Objectives

The Suisun Marsh Habitat Management, Preservation and Restoration Plan (SMP) is the result of a collaborative effort among federal, state, and local agencies working with scientists and the public to develop a plan to protect and enhance the Pacific Flyway and existing managed wetland values, natural wetland functions, tidal habitats, endangered species, water quality, and levee integrity. The SMP is a 30-year comprehensive plan that addresses habitats and ecological processes, public and private land use, levee system integrity, and water quality through tidal restoration and managed wetland activities. The SMP will guide near-term and future actions related to the various uses of the Marsh's resources with the focus on achieving an acceptable multi-stakeholder approach to the restoration of tidal wetlands and the management of managed wetlands and their functions. As such, the SMP is a flexible, science-based, management plan for the Marsh, consistent with the revised Suisun Marsh Preservation Agreement (SMPA) and California Bay-Delta Authority (CALFED) Ecosystem Restoration Program Plan (ERPP) targets for the Suisun Marsh Ecological Management Zone, which will contribute to the US Fish and Wildlife Service's (USFWS) *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Recovery Plan). The SMP will set the regulatory foundation for future actions, and relies on the incorporation of existing science and information developed through adaptive management.

The SMP's purpose is to create an acceptable balance between protection and enhancement of managed wetlands, and the restoration and protection of tidal wetlands. As such, this adaptive management plan (AMP) targets multi-species benefits, rather than focusing on individual species. As described in Chapter 1 of the SMP EIS/EIR, the SMP objectives include:

- Habitats and Ecological Processes – Implement the CALFED ERPP targets for the Suisun Marsh Ecological Management Zone by restoring 5,000 to 7,000 acres of tidal marsh and protection and enhancement of 40,000 to 50,000 acres of managed wetlands. Create an acceptable balance between protection and enhancement of managed wetland habitats for waterfowl and other resident and migratory wildlife species, and restoration and protection of tidal wetland habitat and other aquatic and terrestrial habitats in the Marsh to contribute to the recovery of threatened and endangered species, improve ecological processes, and reduce stressors such as invasive species and other contaminants.

- Public and Private Land Use - Maintain the heritage of waterfowl hunting and other recreational opportunities and increase the surrounding communities' awareness of the ecological values of the Marsh. Managed wetlands and publicly owned lands in the Marsh provide important wetlands for migratory waterfowl and other wetland-dependent species and opportunities for heritage hunting, bird watching, and other recreational activities.

- Levee System Integrity – Maintain and improve Marsh levee system integrity to protect property, infrastructure, and wildlife habitats from catastrophic flooding; support tidal restoration; and maintain water quality standards in the Marsh and Delta; and

- Water Quality – Protect and, where possible, improve, water quality for beneficial uses in the Marsh. Multiple factors contribute to the degradation of water quality in the Marsh, including some flooding and drainage practices in managed wetlands, minimal tidal exchange in dead-end sloughs, urban runoff, and naturally occurring contaminants such as mercury. Improvement of water quality and water management practices will benefit the ecological process for all habitats, including managed and tidal wetlands.

C. Role of Adaptive Management

Adaptive management is the process of learning by doing and then using the results to improve management actions (Walters and Holling, 1990). It also involves ongoing, real-time learning and knowledge creation. In an adaptive management approach, resource management and restoration policies are viewed as scientific experiments. This concept is important because the environmental outcomes of management policies are often uncertain. To be effective, decision-making processes must be flexible and designed to be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood.

Adaptive management is essential to keeping the SMP on track toward its objectives, while avoiding and minimizing potential impacts associated with the implementation of SMP actions. The information produced through adaptive management will permit changes to be made that will assist in the design of future steps. Adaptive management will assist project proponents in understanding the restored system and will aid in their ability to explain management actions to Marsh neighbors and the general public.

Restoration practitioners have found that, because knowledge of natural and social systems is incomplete, systems will respond in unexpected ways. Surprises are also inherent in restoration because nature is variable and unpredictable, especially at large spatial scales and over long time frames. Adaptive management allows managers to prepare for and respond to events, ranging from unexpected changes in habitat to vandalism. When and where such events occur may not be predictable, but part of the adaptive approach is to anticipate the range of events and system responses that might occur and develop a process for dealing with them when it happens. Monitoring and adaptive management can help to prevent unintended consequences of implementing actions under the SMP or, when they occur, can avoid unnecessary reoccurrence, help to minimize any negative impacts and address issues before they become substantial.

The SMP will occur over a 30-year implementation horizon. The SMP's adaptive management approach will allow managers to learn from their actions and will:

- Generate science-based information for managers;
- Convert information into effective management decisions;
- Involve stakeholders to help provide management direction; and
- Store and organize information for use by current and future decision-makers and stakeholders.

This AMP has been prepared in accordance with the Department of Interior Adaptive Management Technical Guide (Williams et al. 2009) and uses the concepts of passive and active adaptive management. Through passive adaptive management, the Suisun Marsh Charter Principals Group will learn how to ensure better attainment of the SMP's objectives based on the measured success of previous actions (as indicated by effectiveness monitoring results). The SMP will also take an active adaptive management approach by encouraging project proponents to identify uncertainties applicable to their specific project and carry out targeted studies to resolve uncertainties related to the best approaches for achieving project specific objectives. Project proponents could design and implement experimental pilot projects to test the relative efficacy of several approaches for attaining an objective and evaluate different monitoring techniques.

Project implementation will be guided by the best available information, but will be monitored and implemented with the goal of increasing our understanding about the science of restoration. The opportunities for restoration and research are unknown due to the inability to predict where restoration projects will occur. As described in

Chapter 1 of the SMP EIS/EIR, the SMP is consistent with the Recovery Plan in splitting restorable acreage into specific regions in order to provide a range of environmental gradients necessary to contribute to the recovery of multiple listed species. Implementation of the SMP Mitigation Monitoring and Reporting Program (Appendix F) will inform adaptive management decision making and tidal restoration planning efforts.

This AMP is designed to assist in achieving the SMP objectives by providing a guided approach to learning from restoration, research, monitoring and management actions, and actions which have uncertainties. Results of effectiveness monitoring may indicate that some restoration or management measures are less effective than anticipated. To address these uncertainties, the monitoring and adaptive management program will:

- Ensure impacts to benthic communities from dredging activities described and analyzed in the SMP EIS/EIR are not exceeded

- Gauge the effectiveness of restoration projects and techniques to implement SMP objectives

- Track project–specific targets to ensure restoration benefits listed species

- Propose alternative or modified measures as the need arises consistent with available funding and

- Be used to improve future restoration designs to achieve desired physical and ecological results;

As such, potential monitoring done under this AMP falls into two categories. The first category is monitoring required to ensure impacts analyzed in the EIS/EIR are not exceeded. Benthic community recovery monitoring during implementation of the dredging program as described in Chapter 2 of the SMP EIS/EIR is the only monitoring in this category. This benthic monitoring will be implemented by the Suisun Resource Conservation District (SRCD) and Department of Fish and Game (DFG) in accordance with the requirements of the USFWS and National Marine Fisheries Service (NMFS) Biological Opinions (Opinions) on the effects of the SMP.

The other potential category of monitoring that would occur under the SMP would be based on key uncertainties and would be considered for implementation as applicable for each tidal restoration project to assess project outcomes. Currently, monitoring in the Suisun Marsh is being carried out by a number of agencies and organizations (see Section II Monitoring). This monitoring will also provide additional information towards the key uncertainties.

D. SMP Conceptual Models and Uncertainties

During preparation of the SMP, conceptual models were developed for several resource categories, including managed wetlands, tidal marsh and aquatic habitat, levees, scalar transport and geometry, and water quality. These conceptual models have been developed to assist projects with information regarding the current scientific understanding of the Marsh, and identify uncertainties and potential actions. The models can be used to assist with selecting, designing, and predicting outcomes of project-specific design and objectives. These conceptual models include: Organic Matter, Mercury, Levee, Tidal and Aquatic, and Managed Wetlands, and are accessible at http://www.fws.gov/sacramento/ea/news_releases/2010_News_Releases/SuisunMP_EIS-EIR_DraftRelease.htm

Despite the extensive scientific information available, the SMP conceptual models identified a number of scientific uncertainties and knowledge data gaps that still exist. However, all the uncertainties cannot be resolved before restoration starts. In fact, many data gaps can only be addressed by implementing restoration actions and learning from the results. Therefore, these uncertainties form the basis for potential monitoring that could apply to specific restoration projects. Each restoration project will be unique and have distinct questions appropriate for monitoring or additional scientific studies. All new information gathered will be combined with existing monitoring data for the Marsh and collected to formalize knowledge, develop expectations of future conditions and outcomes that can be tested by further monitoring, and assess the likelihood of outcomes. Conceptual models are templates for organizing information and will require revision and updating based on monitoring results and new scientific knowledge. A list of uncertainties identified in the conceptual models that could be monitored as appropriate for specific tidal restoration projects can be found in the Attachment of this AMP.

In addition to the resource-specific uncertainties identified in the conceptual models, climate change and changes to Delta outflow are two overarching long term uncertainties that have been identified and may aeffect the Marsh. The effects of rising sea levels on tidal marshes are dependent upon the relative rate of sea level rise versus rates of sedimentation and accretion of the marsh surface. Sea level rise will cause salinity levels to increase up the estuary as tides push higher up bays, rivers, and sloughs. The Suisun Bay and the Delta may become saltier. Closer study is needed of the potential amount and extent of salinity and habitat change, and the species-level effects of these changes. The maintenance of tidal marsh habitat area during sea level rise requires (1) space for tidal marshes to expand upward into adjacent habitats as sea and tide levels increase; (2) available sediment adequate to support marsh accretion rates equal to or greater than the rate of sea level rise; (3) stable erosion rates, or at least rates that do not defeat marsh accretion. The first of these requirements - room for marshes to “move up” in elevation – is especially problematic in many areas of the San Francisco Bay

Estuary where tidal marsh abuts a dike, levee, seawall, or other human barrier at its landward edge. The requirement for moderate erosion rates is also of concern, given that climate change and sea level rise in California are expected to be accompanied by increased storm severity and maximum wave heights; trends that are already suggested by available data (Wilkinson 2002, Bromirski *et al.* 2004). Sediment supply for marsh accretion is not yet well understood.

The State Water Project and Central Valley Project operations affect Suisun Marsh salinities by regulating Delta outflow through upstream reservoir storage and releases and Delta exports. As described in Chapter 1 of the SMP EIS/EIR, there are several other plans and policies currently being developed that have the potential to affect the Marsh. These plans are in varying stages of development, and details on how they would affect the Marsh are limited at this time. As information is made available for these uncertainties, it will be incorporated into tidal restoration planning efforts as appropriate in the future.

II. Monitoring

A. Ongoing monitoring

Monitoring is ongoing within the Marsh to varying degrees on public and private lands, and public waters. For example, the Interagency Ecological Program is comprised of state and federal agencies, as well as university and private scientists, who conduct long-term monitoring and applied research in the San Francisco Estuary directed towards effective management. Several ongoing monitoring programs currently exist in the Marsh:

- Salt Marsh Harvest Mouse Surveys: These surveys are conducted annually by DFG and DWR to monitor salt marsh harvest mouse populations.

- California Clapper Rail and Black Rail Surveys: These surveys are conducted annually by DFG to monitor clapper rail and black rail breeding pairs.

- Suisun Marsh Vegetation Surveys: These surveys are conducted every three years by DFG to monitor vegetation changes throughout the Marsh. An aerial survey is flown every three years and using GIS, produces a precise vegetation map with detailed descriptions of vegetation types. This survey is used to support monitoring of salt marsh harvest mouse and California clapper rail habitats, and can be used by private landowners to evaluate managed wetlands habitat response to management activities. Recently, this monitoring has included breach and channel network evolution for the Blacklock Tidal Restoration Project.

- Water Quality Monitoring: DWR maintains water quality and tide stage monitoring stations throughout the Marsh as part of the California Data

Exchange Center (CDEC) monitoring network. These stations measure a variety of parameters depending on the station which may include precipitation, water temperature, wind speed and direction, and atmospheric pressure on an hourly basis. Data is telemetered to CDEC so tide stage can be monitored remotely.

- Interagency Ecological Program Database: This database contains data collected by UC Davis, DFG, and the USFWS, including: fishery, benthos, nutrient, pesticide, bioassay, water-weather condition, and survey fish tag data. (http://www.water.ca.gov/iep)

- Blacklock Restoration Project: This tidal restoration project has a monitoring plan which includes levee breach geometry, inundation regime monitoring, marsh surface elevation changes/sedimentation accretion, slough network evolution, native marsh vegetation, wildlife, water quality, methyl mercury, and erosion of adjacent sloughs.

- SRCD: DFG and Private Lands Reporting: Annually, SRCD compiles a summary report of actual annual managed wetlands maintenance work completed under the US Army Corps of Engineers Regional General Permit #3. In compliance with this permit, DFG and SRCD also conduct compliance inspections for diversion restrictions and submit report to the regulatory agencies.

- DFG Grizzly Island Wildlife Area: DFG conducts annual surveys for wintering waterfowl, and breeding surveys for tule elk, pheasant, and waterfowl.

- Audubon Society Christmas Bird Count: This data is collected annually to study long-term health and status of bird populations across North America. Surveys are conducted in the Marsh every year as the Benicia (CABE) count circle. http://birds.audubon.org/christmas-bird-count

- Tricolored Blackbird Surveys: These surveys are carried out every three years during April. DFG participates in this statewide survey coordinated by Audubon California. http://tricolor.ice.ucdavis.edu/

- Solano County Mosquito Breeding Habitat Monitoring - Adult mosquitoes are routinely monitored (7 night cycles) throughout the Solano County Mosquito Abatement District. Each week (from April through October) the samples are identified after which the findings are sent to the California Department of Health Services Vector Borne Disease Section (http://www.solanomosquito.com/aboutus.html).

In addition, several other monitoring programs are currently being implemented that could provide useful information in the adaptive management decision making process:

- South Bay Salt Ponds Project: USFWS is monitoring of similar restoration targets and objectives.
- Dutch Slough Restoration Project: DWR is monitoring fish hypotheses, water quality hypotheses, and miscellaneous bio-geomorphic hypotheses.
- Napa River Salt Marsh Restoration Project: DFG is monitoring wildlife use of evolving tidal habitats.
- Bay Delta and Tributaries (BDAT): BDAT contains environmental data concerning the San Francisco Bay-Delta and provides public access to that data. Over fifty organizations contribute data voluntarily to this project. The database includes biological, water quality, and meteorological data. These can be used to gauge the health of the estuary and to manage water.
- UC Davis Fish and Invertebrate Study: This monthly study uses multiple methods to sample fish in shallow, brackish-water habitat and has been designed since inception to monitor the status of fishes in the Marsh.
- Time-Series Databases: Hydrodynamics and water quality data of the California Bay-Delta Tributary collected by various agencies at over 120 stations (mostly fixed-position stations), using the data storage system which is suitable for time-series data and was developed by the Hydrologic Engineering Center of the US Army Corps of Engineers.
- California Waterfowl Association: Waterfowl nesting surveys are conducted on the Grizzly Island Wildlife Area to help monitor and assess waterfowl populations.

Information from these monitoring efforts is currently reported to the Suisun Environmental Compliance Advisory Team for use in agency planning efforts.

B. SMP EIS/EIR Monitoring

As previously mentioned, because there is scientific uncertainty regarding recovery times for benthic communities, SRCD and DFG will initiate a benthic community monitoring program concurrent with the implementation of the new dredging program in accordance with the USFWS and NMFS Opinions. The objectives of this monitoring are to determine benthic community richness and abundance prior to and following dredging at selected sites, with an extended post dredging component to determine species reestablishment of disturbed areas over an appropriate period of time. The purpose of this effort is to confirm the potential impacts of dredging on benthic invertebrate communities in the vicinity of dredging activities and to make necessary adjustments to the dredging program to ensure that the anticipated effects as analyzed in the SMP EIS/EIR and biological opinions are not exceeded.

C. Potential Tidal Restoration Project Monitoring

Under the SMP each tidal restoration project will have its own specific objectives in support of the overall SMP tidal restoration objective of implementing 5,000 to 7,000 acres of tidal marsh restoration in the Marsh and contributing to recovery of listed species consistent with the Recovery Plan. Therefore, as applicable to project specific objectives, project specific monitoring will be recommended based on the previously described uncertainties during project planning and design. Project proponents will be responsible for implementing monitoring as incorporated into project planning documents. The approach for each restoration action will be determined by the specific lead agencies and will be based on the SMP EIS/EIR, project-specific design components, consideration of any new information (including that obtained through the implementation of the AMP), or other factors. Each project will create a monitoring plan that clearly identifies each monitoring activity, expected results, and responsible party for each monitoring activity.

During project monitoring planning, project proponents will:

- Assemble all available data
- Determine priorities
- Identify focal species or suites of species, if appropriate
- Identify performance indicators
- Develop monitoring protocols if none exist

To make monitoring useful, choices of ecological attributes to monitor and how to monitor them (frequency, extent, intensity, etc.), must be linked closely to the management situation that motivates the monitoring in the first place. There are always limits on staff and funding for monitoring, and it is important to choose design protocols that will provide the most useful information within those limits. Protocol design should be based on the purposes of monitoring and the way in which monitoring data will be analyzed.

Whenever possible, monitoring methods will be designed to collect data from multiple parameters. For example, aerial photographs or satellite images can show the extent of tidal marsh, connectivity of habitats, form and location of channels, and changes in invasive plant populations. After choosing parameters and methods, monitoring protocols must be used and, if not in existence, must be developed. These protocols must be designed to collect enough data at a scale and frequency that allows managers to discern spatial differences and trends through time. Monitoring will be targeted at specific mechanisms thought to underlie measures and or actions and be used to assess results. Monitoring actions will be prioritized, and considerations should include feasibility of implementation, availability of funding, and uncertainty of outcome. Capturing baseline condition information, if it is not already available, will be a component of any project-specific monitoring plan.

There are several types of monitoring that would be implemented as part of tidal restoration projects under the SMP:

- Compliance monitoring would be built into project-specific permit requirements

- Performance monitoring would identify whether project-specific actions are achieving their expected outcomes or targets

- Mechanistic monitoring would demonstrate whether the mechanisms thought to link actions to desired outcomes are working as predicted.

Project monitoring needs to be designed to help reduce uncertainty, be measurable with observable responses to project implementation, noting that subtle differences in responses before and after project implementation are seldom detected. Tidal restoration project proponents will receive input from the Suisun Marsh Adaptive Management Advisory Team (AMAT) (further described in Section III) and Suisun Principals regarding project planning, design, and monitoring. In addition, it is recommended that each individual tidal restoration project seek the input of other science based work groups to develop goals, objectives, and performance measures for each restoration project, as applicable.

The following sections summarize categories for which key uncertainties have been identified (as listed in the previous section), and potential monitoring that could be recommended, as applicable, for specific tidal restoration projects. Further information on these uncertainties can be found in the appendix and in the conceptual models, as previously mentioned.

1. Managed Wetland Enhancement

There is scientific uncertainty regarding the potential effects of tidal restoration on species currently utilizing managed wetlands. As the SMP's purpose is to create an acceptable balance between protection and enhancement of managed wetlands and the species that utilize them, and the restoration and protection of tidal wetlands, monitoring in this category will be crucial to balanced implementation of the SMP. Monitoring in this category will be closely integrated with existing monitoring efforts in the Marsh.

Objectives of this monitoring would include gaining information related to one or more of the following key uncertainties:

- Managed wetland enhancement effects on resident and migratory wildlife species and plant populations

- Regional waterfowl habitat availability and quality and the effects of managed wetland enhancement actions on indicators of waterfowl use

2. Tidal Restoration

The expected outcome of tidal restoration is the creation of marsh habitat for endangered soft bird's-beak (*Cordylanthus mollis ssp. mollis*), endangered Suisun thistle (*Cirsium hydrophilum var. hydrophilum*), endangered California clapper rail (*Rallus longirostris obsoletus*) (clapper rail), and endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) (harvest mouse) which will contribute to the recovery goals in the US Fish and Wildlife Service's Suisun Bay Area Recovery Unit. There is uncertainty associated with the ways tidal restoration may change natural processes in unexpected ways during SMP implementation. Tidal marsh development will vary depending on its location within the Marsh.

Evaluating primary productivity at a tidal restoration site attempts to determine if a restoration project supports native fish species, including chinook salmon, delta and longfin smelt and other pelagic organisms by increasing the production of nutritionally valuable phytoplankton and zooplankton. An understanding of the magnitude of fish food production and release from restored tidal marshes in the Marsh is critical to determining the ability of restored intertidal marshes to aid in the recovery of pelagic species.

Objectives of this monitoring would include gaining information related to one or more of the following key uncertainties:

- Use of newly restored tidal habitats by special status plant and wildlife species

- Tidal restoration effects on resident and migratory wildlife species and plant populations

- Regional waterfowl habitat availability and quality and the effects of tidal restoration actions on indicators of waterfowl use

- Producer population growth in newly restored tidal habitats

- Nutrient cycling

- Zooplankton growth and availability in newly restored tidal habitats
- Native and non native fish habitat utilization and residence time in newly restored tidal habitats

3. Water Quality

Multiple factors contribute to the degradation of water quality in the Marsh, including increased salinities from tidal restoration projects, some flooding and drainage practices in managed wetlands, minimal tidal exchange in dead-end sloughs, urban runoff, and naturally occurring contaminants such as mercury. Improvement of water quality and water quality management practices will benefit ecological process for all habitats, including managed and tidal wetlands.

In cooperation with regional monitoring and research efforts, sediment and water quality monitoring could be conducted at several tidal restoration project sites. Ongoing information can be used adaptively to correct long-term construction and management plans and activities associated with restoration. Water quality parameters that could be monitored include salinity, temperature, dissolved oxygen, and methyl mercury.

Objectives of this monitoring would include gaining information related to one or more of the following key uncertainties:

- Carbon production with tidal restoration and potential for transport to Delta pumps and contribution to trihalomethane production
- Burial or exposure of existing mercury deposits in the Marsh
- Marsh biota exposure to mercury and reducing potential for methyl mercury exposure and transport in tidal restoration site design
- Effects of short term pulses of methyl mercury versus long term annual concentrations

4. Hydrodynamic Modeling

Hydrodynamic modeling is employed as a planning and predictive tool to investigate alternative breach options for tidal restoration projects. Hydrodynamic modeling at a planned and/or naturally occurring breach could be used as an indicator of outcome and a possible diagnostic tool to evaluate changes in tide stage, inundation regimes or increased salinities that where not anticipated. Cross sectional profiles of any additional natural breaches (of significant size) should be conducted where appropriate.

The previous sections describe a few examples of monitoring that could be implemented for tidal restoration projects under the SMP, based on key uncertainties identified in the conceptual models. However, this is not intended to be an all-inclusive list, and it is recognized that specific tidal restoration projects will have individual objectives and there may be monitoring for projects that is not captured here. Additional monitoring elements could include those developed for the Recovery Plan, the Bay Delta Conservation Plan Independent Science Advisors, or the Delta Stewardship Council. In addition, uncertainties not identified here could be realized during specific tidal restoration project design, and through information learned from completed tidal restoration project monitoring. Such information would be used to update the conceptual models and this AMP.

III. Adaptive Management Implementation

A. Roles and Responsibilities

To implement adaptive management, an effective decision-making structure must be developed to complete the loop between information from monitoring and the use of that information in decision-making. To be effective, decision-making processes must be flexible and designed to be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. The following structure has been collaboratively working on Marsh issues for over ten years and will continue through the implementation of the SMP. The structure for decision-making (Figure 1) is designed to achieve these functions:

- Convert information into effective management decisions;
- Provide a forum for project development and collaboration;
- Involve the public/landowners to help provide management direction;
- Store and organize information for use by decision-makers and the public.

1. Suisun Marsh Charter Group Principals

The Suisun Marsh Charter Group Principal Agencies (Principals) have collaboratively prepared the SMP. The Principals include agency managers from DFG, DWR, Reclamation, USFWS, and SRCD that have experience with Marsh issues, policies, and permits. The Principal agencies are ultimately responsible for decisions that are implemented regarding the SMP. Projects will be reviewed for consistency with the SMP goals and objectives. Principal agency actions related to the SMP are as follows, and are further described in the SMP.

Principal Agencies' Actions Related to the Suisun Marsh Plan

Agency	Suisun Marsh Habitat Management, Preservation, and Restoration Plan Action
Reclamation	Implementation of Managed Wetland Activities Implementation of PAI Fund[1]
USFWS	Implementation of Restoration Issuance of Biological Opinion
DFG	Implementation of Restoration Implementation of Managed Wetland Activities Issuance of Incidental Take Permit for non–Fully Protected Species Implementation of PAI Fund
NMFS	Issuance of Biological Opinion; Issuance of Essential Fish Habitat Conservation Recommendations
DWR	Implementation of Restoration Implementation of Managed Wetland Activities Implementation of PAI Fund
SRCD	Implementation of Managed Wetland Activities Implementation of PAI Fund
CALFED	Provide Guidance for Restoration through the Science Program

Reclamation = U.S. Department of the Interior, Bureau of Reclamation.
PAI = Preservation Agreement Implementation.
USFWS = U.S. Fish and Wildlife Service.
DFG = California Department of Fish and Game.
NMFS = National Marine Fisheries Service.
DWR = California Department of Water Resources.
SRCD = Suisun Resource Conservation District.
CALFED = CALFED Bay-Delta Program.

[1] The PAI Fund is included in the Revised SMPA and is proposed to fund certain maintenance activities to support mitigation obligations for the CVP and SWP operations, and is described in Chapter 2.

2. Adaptive Management Advisory Team (AMAT)

While project planning and design relies ultimately on the project managers for each restoration project, a network of staff from state and federal agencies will provide an interface for effective science, management, and outreach partnerships. The AMAT will be comprised of technical staff from DFG, DWR, SRCD, Reclamation, and USFWS, with invitations to other entities to participate as appropriate. Project proponents are encouraged to use the AMAT and their knowledge of the Marsh for project development and support and as a forum to coordinate and cooperate for the benefit of the overall restoration goals. An MOU among the AMAT agencies will be pursued defining the roles and responsibilities of the members with respect to achieving the SMP objectives and implementing adaptive management. While retaining their existing individual land management authorities, project proponents will coordinate with the AMAT to develop project planning and design documentation, quantify specific restoration objectives and targets, and develop monitoring plans and schedules. Coordination with the AMAT does not preclude project proponents from their regulatory due diligence. No regulatory authority has been delegated to the AMAT. Each AMAT participating agency retains their own regulatory authority. The AMAT will coordinate with the Suisun Principals as appropriate.

The AMAT will:

- Provide access to detailed and updated conceptual models that synthesize existing knowledge of the Marsh
- Provide access to ongoing monitoring
- Review proponents' projects, restoration targets, and monitoring plans
- Evaluate whether each project is contributing towards the overall SMP objectives
- Make recommendations for project additions or changes
- Conduct periodic reviews of project results
- Incorporate a feedback loop that links implementation and monitoring to a decision-making process
- Improve restoration designs to achieve desired SMP results
- Make recommendations to the Principal Agencies regarding implementation of the SMP
- Submit, every other year, an implementation status report to DFG, NMFS, USFWS and other regulatory agencies as required.

3. Information Management

As funding and staff become available for site specific projects, and in accordance with permit requirements (ie, biological opinions); data storage and access, including monitoring and/or GIS data, will be collected and made available to act as a link for planning future projects. The AMAT will be responsible for data storage and access, including monitoring and/or GIS data, and act as a link for all data collected. Data collected by this group will also include other relevant projects from around the Bay such as the San Francisco Bay and Napa Salt Ponds Restoration Projects. The AMAT will ensure that monitoring data and reports are made widely available, including to the Principal Agencies

4. Stakeholder Participation

Local stakeholder involvement is essential to meet the SMP objectives. Stakeholders will provide input to the AMAT to help guide restoration and adaptive management actions. The Stakeholder Group could include local public agencies, including SRCD; landowners; and other interested parties to provide on-going, local landowner-derived input to the Principals on adaptively managing implementation of the SMP.

B. Project Success Criteria

The U.S. Department of the Interior (USDOI) Adaptive Management Technical guide defines adaptive management as successful if progress is made toward achieving management goals through a learning-based (adaptive) decision process (Williams et. al. 2009). It also indicates that successful adaptive management: shows recognizable progress toward achieving objectives in a reasonable time frame, implements learning-based management with stakeholder involvement, and is consistent with all applicable laws and regulations. The SMP project success criteria is based on meeting the targets of restoring 5,000 to 7,000 acres of tidal wetlands habitat and protecting and enhancing 40,000 to 50,000 acres of seasonal wetland habitat.

Restoration of tidal wetlands is consistent with the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California.* The goal of the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* is the comprehensive restoration and management of tidal marsh ecosystems in five recovery units; Suisun Bay, San Pablo Bay, the Central/South San Francisco Bay, Central Coast, and Morro Bay Recovery Units. Restoring 5,000 to 7,000 acres of tidal wetlands will aid in the recovery of the California clapper rail, salt marsh harvest mouse, Suisun thistle, and soft bird's-beak with the Suisun Bay Recovery Unit.

Due to the long time frame for tidal marsh evolution and the difference in wildlife values of various types of tidal habitats, it is difficult to determine the end-point for project success. Projects related to, or tiered, from the SMP should incorporate post-construction monitoring and adaptive management to assess whether natural processes can sustain the long-term evolution of tidal marsh.

As elements and processes of managed wetland are constantly changing, adaptive management should be incorporated annually to track and determine the success of enhancement projects.

For each individual project tiered from the SMP a clear time line of monitoring would be developed in a manner to document results that would require a modification of the project, or identify possible new actions needed for the project to perform as intended.

C. Assessment of Monitoring Results

As it becomes available, the AMAT will review monitoring data for specific projects to assess how successful the individual tidal restoration projects are being at meeting their specific objectives. Also, the AMAT will annually review available monitoring data to assess progress towards achieving the overall SMP objectives. The AMAT will provide recommendations on additional monitoring needs and changes to restoration design based on review of past projects.

D. Feedback Loop and Decision Making

Technical learning will occur over a relatively short term, during which objectives, alternatives, and other elements remain unchanged. On the other hand, learning about the decision process itself will occur through periodic revisiting of the AMP elements over the longer term. The AMAT will primarily act as a feedback loop for new knowledge assimilated from ongoing actions and individual enhancement and restoration projects. An important role of the AMAT will be ensuring clear communication of the current understanding of existing baseline condition data to project proponents during the planning process. Also, the AMAT will provide a forum to advise project proponents of adverse conditions potentially impacting tidal restoration projects early in the planning process. As appropriate, the AMAT will advise the Prinicpal Agencies of the need for changes to the SMP objectives and/or implementation strategy based on new information from project specific monitoring.

As described in the Implementation Strategy Section of Chapter 2 of the SMP EIS/EIR and as consistent with regulatory permits, the SMPA agencies (Reclamation, SRCD, DWR, and DFG) will submit implementation status reports no less frequently than every other year to DFG, NMFS, and USFWS, and other regulatory agencies that would describe the implemented restoration activities, monitoring, application of adaptive management, results of adaptive management, and any activities that are being planned.

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SMP Conceptual Model Uncertainties

Water Quality

Methylmercury/Contaminants

Are existing mercury deposits in Suisun being buried or eroded?

Is the methyl mercury that is produced in the Marsh a source to the estuary or is the estuary a source to the Marsh?

Within the Marsh, where will the exposure of methyl mercury to biota be the highest? Managed
wetlands, marshes, channels? Which species are most at risk?

If tidal wetlands are created how can the methyl mercury exposure to biota be minimized? How can export to surrounding marshes and/or sloughs be minimized?

Do the discharges from the managed wetlands that have low dissolved oxygen readings also have high methyl mercury concentrations and can the discharges be regulated to minimize the methyl mercury concentrations?

Are there habitats in Suisun which are better mercury methylators? Can we learn something from these that will be useful in tidal marsh restoration?

Do biota respond to periodic pulses of available methyl mercury or is it the longterm annual concentration that is critical?

Document the distribution and forms of mercury within the Suisun Marsh.

What are the mercury transport mechanisms in the Marsh?

Determine the mass balance of mercury and methyl mercury in the Marsh.

The relative contribution of methyl mercury production in managed wetlands and tidal wetlands has not been determined.

What are the methyl mercury concentrations in fish in the Marsh?

What factors influence methyl mercury production in the Suisun Marsh?

Is the oxic-anoxic sediment interface in a given wetland the primary factor in methyl mercury production?

Are existing total mercury concentrations known for the given location? Is mercury speciation known?

Will implementation of the alternative result in a change in the amount of oxicanoxic interface in the sediments?

What is the toxicity of Ammonia/um to pelagic organism decline (POD) (CALFED Science Workshop 2009)?

Is implementation of the alternative likely to affect the level of activity of methylating bacteria (see Methyl Mercury Conceptual Model Table 1)?

What are the effects of pollutants on food production for wildlife?

What are the effects of managed wetland drainage water on ambient water quality?

What role do managed wetlands play in dissolved organic carbon and methelated mercury production?

What is the relationship between low dissolved oxygen events and management of wetlands?

Fish and Wildlife

What is the current use and density of species inhabiting managed wetlands?

Will enhancing current managed wetland functions aid multiple species?

Would it benefit listed species to allow wetland managers to manage specific sections of their property for them?

Would unrestricted access to water during fresh periods and saltier water later in the year benefit listed species?

What are the effects of tidal aquatic restoration on food web productivity at levels that could support fish and wildlife?

What is the waterfowl food availability and densities on managed wetlands?

What are waterfowl food preferences in Suisun?

What habitats do ducklings use and the effects of salinity on ducklings?

What are the effects of tidal restoration on waterfowl populations?

What are the Regional habitat availability effects on indicators of waterfowl use in Suisun?

Is it possible to increase the carrying capacity of managed wetlands for waterfowl under current regulatory restrictions?

Will increasing carrying capacity for wintering waterfowl on managed wetlands enhance other wildlife values?

What are the impacts of wetland management on birds nesting in wetland areas?

Evaluate the California clapper rail for effects of contaminants, connectivity, salinity, and use of dredge material to accelerate the restoration process.

Do fish screens affect foraging of waterbirds on managed wetlands?

Evaluate the Salt marsh common yellowthroat for connectivity, effects of non-native invasive plant species, inundation regime, and brown headed cowbirds.

Evaluate the Salt marsh harvest mouse for effects of other rodent species, non-native invasive plant species, connectivity, effects of contaminants, and geomorphology.

What are the effects of tidal restoration on salt marsh harvest mouse (SMHM)?

How do bat species use the Suisun Marsh?

What is the distribution of Suisun shrew on both managed and tidal wetlands of Suisun?

What impacts does wetland management have on the Suisun shrew ?

What are the impacts to wetlands by wild pigs?

What are the effects of mosquito control and management on bat populations?

What are the impacts to fish species by drain water conditions (i.e. organic matter, low DO)?

What are the impacts to fish species by unscreened diversions with current regulations on diversions?

Would additional fish-screens address potential impacts to anadromous and special status fish in the Suisun Marsh?

Is fish entrainment in managed ponds temporary (fish return to sloughs) or permanent?

What is the abundance, distribution, and detailed species composition of submerged aquatic vegetation (SAV) in Suisun Marsh?

How do waterfowl and fish use SAV in Suisun Marsh?

Explore the effects of decreased habitat connectivity in the marsh due to the SMSCG and other water control structures on aquatic species such as delta smelt, longfin smelt, splittail, and resident native species.

Investigate effects of marsh geomorphology on delta smelt and longfin smelt use of Suisun Marsh.

Determine the importance of turbidity in comparison to other water quality parameters, to longfin smelt use of Suisun Marsh.

Evaluate the importance of invertebrate community composition to delta and longfin smelt use of Suisun Marsh.

Evaluate the Central Valley fall/late-fall, Sacramento River winter-run and Central Valley spring-run Chinook salmon for habitat utilization and residence time in the marsh.

Evaluate the Central California Coast and Central Valley steelhead for habitat utilization and residence time in the marsh.

Evaluate the Green sturgeon for habitat utilization, water quality preferences and residence time in the marsh.

Research is needed on determining effects of dredging on fisheries rearing, spawning, and migration habitat in tidal sloughs.

Salinity

What is the relationship between applied water salinity and plant community composition and growth (poor water salinity)?

What is the leaching efficiency of applied water?

Is salinity the primary driver of ecological functions in the Suisun Marsh?

What is the distribution of phytoplankton with regard to salinity?

Identify which levees are most important to the protection of local and regional salinity, and what are their critical design features.

Subsidence

What is the mechanism for subsidence?

Where is subsidence occurring in the Suisun Marsh?

Specifically, where in a managed pond does subsidence take place?

How much subsidence is there and at what rate does it occur in Suisun?

What is the importance of drying ponds in August to September?

What is the re-suspension of sediment by wind and wave action?

Does the placement of mineral sediment onto peat soil cause subsidence?

How do management strategies affect soil chemistry?

What is the relationship between internal recirculation of water and sedimentation?

What is the source of sediment in internal ditches?

What are the subsidence rates in the Suisun Marsh?

Would reduced discing frequency and reflooding fallow fields to maintain a high water table slow subsidence in the Suisun Marsh?

What are the long-term trends in sediment supply into Suisun Marsh and Bay from the Delta with projected sea level rise?

Research is needed on management practices that can reduce, eliminate, or mitigate for ongoing subsidence.

Research is needed to determine the cause as well as the individual and cumulative effect of subsidence and sea level rise on levee stability.

Current and continuing studies of sea level rise should consider the associated effects on levees in Suisun Marsh. Research is needed to determine if natural geomorphic processes, such as local or regional sediment accumulation or erosion, can benefit levee program elements to an extent that will counter local or regional sea level rise.

Levees

Would the construction of new interior levees within large wetland ponds improve flooding and draining capabilities?

Would the construction of new interior levees within large wetland ponds create new habitat for multiple species?

Would dividing some ponds into smaller cells (i.e. 50 to 100 acres) reduce the need for aerial mosquito abatement?

What is the effect of future sea level rise on managed wetland levee's and management activities?

Research is needed to determine the beneficiaries for maintenance, improvements, and environmental costs of optimum designs and layouts for successful implementation. An evaluation of an incentive program that will encourage conservation practices and/or appropriate levee design and placement that can reduce overall programmatic cost, habitat impacts, and future risk is needed.

Additional research is needed as follow-up to the linkages identified by the CALFED Levee Program between the Suisun Marsh levee system configuration and water quality in the Delta. (CALFED Suisun Marsh Levees Investigation Report, March 2001)

Research on the design of levees with additional habitat features such as extended levee berms to provide opportunities to improve the level of flood protection and create needed habitat is needed. Research on the ability of dense vegetation growth on replacing the need for rip-rap is needed.

Evaluation of the potential use of newly established upland-like habitat levee areas by terrestrial vertebrate predators and what are impacts to species of concern is needed.

Additional research is needed to evaluate if larger initial environmental impacts may be offset in the long-term through reduced maintenance requirements associated with reinforced levee slopes. At the same time, research is needed to evaluate if the larger volume of material needed can be effectively supported by the existing underlying Marsh peat soils.

Research is needed in developing a strategy for utilizing dredge material collected within Suisun Marsh and from adjacent waterways as well as alternative sources.

Invasives

What are the threats posed by *Phragmites australis* in tidal marsh and adjacent shallow aquatic habitats?

What is the status of native versus non-native stands of common reed in invaded areas?

What is the potential for establishment of *Corbula* in restoration sites?

Processes

What are the causes of decline in phytoplankton biomass in Suisun?

What is the relative importance of different mechanisms relating river flow to chlorophyll concentration?

What is the ecological difference between shallow subtidal habitat from deep subtidal habitat?

How do changes in the abiotic or biotic structure of the marsh change the processes and functions of the marsh?

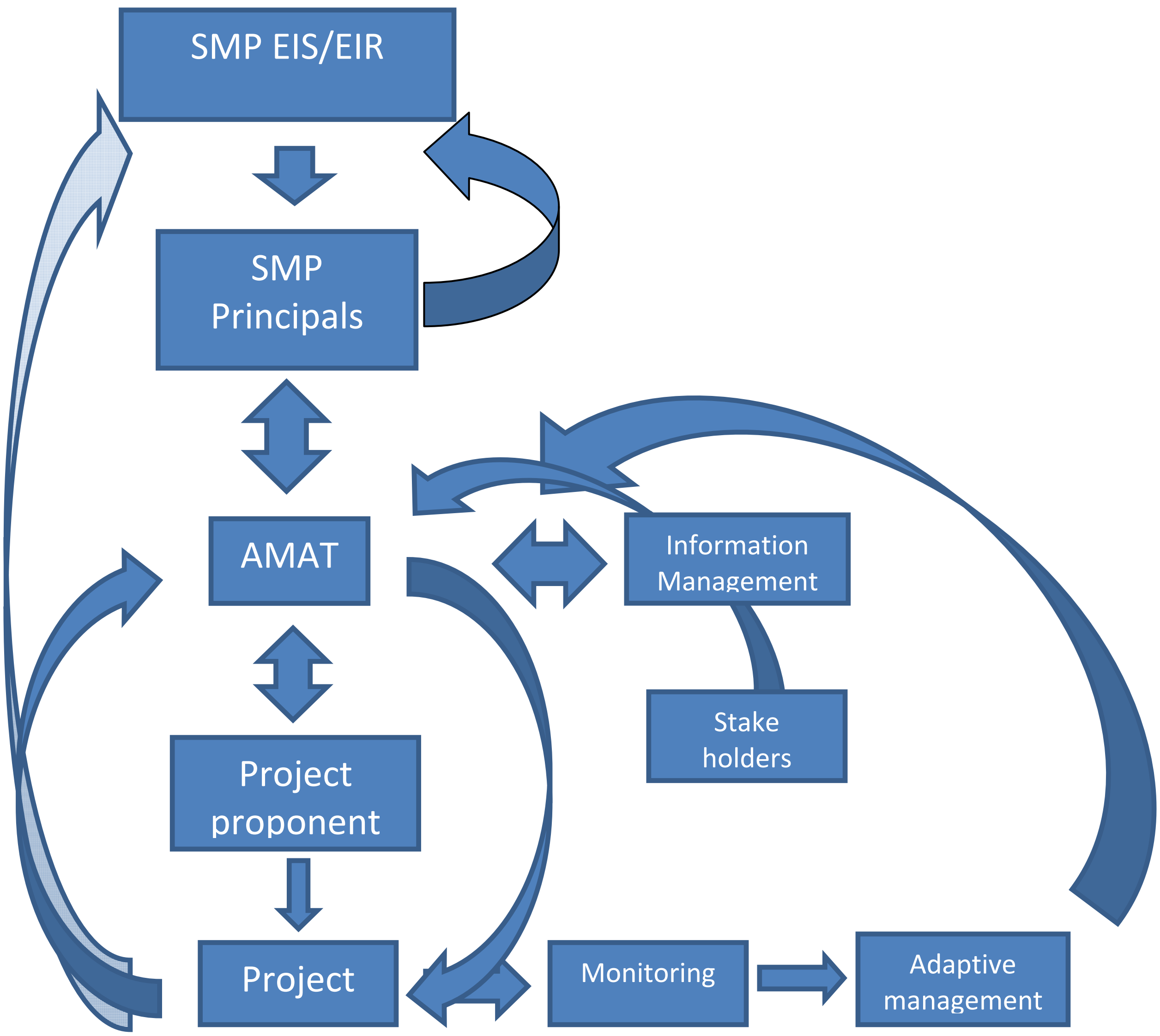
Do the shallow water habitats of diked wetlands provide an inundated floodplain value (e.g.Yolo bypass)?

Determine the characteristic population growth rate of producers in donor (title restoration) habitats.

Measure nutrient cycling in both high and low productivity habitats for evidence of nutrient limitation in productive habitats and possible export of reconstituted nutrients from respiration dominant habitats.

Investigate mechanical and metabolic constraints on zooplankton growth as a function of food availability.

Figure 1: Adaptive Management Decision Matrix



Appendix F
Mitigation Monitoring and Reporting Plan

Appendix F
Mitigation Monitoring and Reporting Program

Mitigation Monitoring and Reporting Program for the Suisun Marsh Habitat Management, Preservation, and Restoration Plan

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
General			
Implement standard design features and construction practices for restoration activities: • Construct structures in accordance with California Building Code and County General Plan Standards to resist seismic effects and to meet the implementation standards outlined in the Solano County General Plan; • Ensure that changes within the Suisun Marsh channels will not significantly affect navigation and emergency access by having Rio Vista and Vallejo Coast Guard Stations review plans to assess safety issues associated with changes when there is potential for in-channel work to affect access; • Implement Best Management Practices to minimize any disease-carrying mosquitoes and threats to public health if it is found that project components pose a threat to public health; • Control construction equipment access and placement of fill to maintain acceptable loading based on the shear strength of the foundation material; • Minimize degradation of wetland habitats where feasible, i.e., work will be conducted from levee crown; • Implementing BMPs and measures to minimize water quality impacts such as temporary turbidity increases. (see Erosion and Sediment Control Plan); • Inspect all equipment for oil and fuel leaks every day prior to use. Equipment with oil or fuel leaks will not be used within 100 feet of wetlands; • Require the construction contractor to remove all trash and construction debris after construction and to implement a revegetation plan for temporarily disturbed vegetation in the construction zones; and • Maintain waste facilities. Waste facilities include concrete wash-out facilities,, chemical toilets, and hydraulic fluid containers. Waste will be removed to a proper disposal site.	Environmental commitment	Prior to and during construction	Contractor
Establish access point/staging areas	Environmental commitment	Prior to and during construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Continue existing Best Management Practices	Environmental commitment	Prior to, during and following construction	SRCD, DWR, Reclamation, and landowners (including DFG)
Water Supply, Hydrology, and Delta Water Management			
None			
Water Quality			
Prepare and implement an Erosion and Sediment Control Plan	Environmental commitment	Prior to and during construction	Contractor
Prepare and implement a Stormwater Pollution Prevention Plan, which will include but is not limited to: • a description of potential pollutants to stormwater from erosion; • management of dredged sediments and hazardous materials present on site during construction (including vehicle and equipment fuels; • details of how the sediment and erosion control practices comply with state and federal water quality regulations; and • a description of potential pollutants to stormwater resulting from operation of the project.	Environmental commitment	Prior to and during construction	Contractor
Prepare and implement a Hazardous Materials Management Plan	Environmental commitment	Prior to and during construction	Contractor
Geology and Groundwater			
Prepare and implement an Erosion and Sediment Control Plan	Environmental commitment	Prior to and during construction	Contractor
Prepare and implement a Stormwater Pollution Prevention Plan, which will include but is not limited to: • a description of potential pollutants to stormwater from erosion; • management of dredged sediments and hazardous materials present on site during construction (including vehicle and equipment fuels; • details of how the sediment and erosion control practices comply with state and federal water quality regulations; and	Environmental commitment	Prior to and during construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
• a description of potential pollutants to stormwater resulting from operation of the project.			
Flood Control and Levee Stability			
Prepare and implement an Erosion and Sediment Control Plan	Environmental commitment	Prior to and during construction	Contractor
Sediment Transport			
Prepare and implement an Erosion and Sediment Control Plan	Environmental commitment	Prior to and during construction	Contractor
Transportation and Navigation			
Ensure that changes within the Suisun Marsh channels will not significantly affect navigation and emergency access by having Rio Vista and Vallejo Coast Guard Stations review plans to assess safety issues associated with changes when there is potential for in-channel work to affect access. Prepare and implement a Traffic and Navigation Control Plan and Emergency Access Plan, which will include but not be limited to the following actions, depending on site-specific conditions: • coordinating with the affected jurisdictions on construction hours of operation; • following guidelines of the local jurisdiction for road closures caused by construction activities; • installing traffic control devices as specified in the California Department of Transportation's (Caltrans's) Manual of Traffic Controls for Construction and Maintenance Works Zones; • notifying the public of road closures in the immediate vicinity of the open trenches in the construction zone and of temporary closures of recreation trails; • posting signs that conform to the California Uniform State Waterway Marking System upstream and downstream of the dredge areas to warn boaters of work; • providing access to driveways and private roads outside the immediate construction zone; • coordinating with Solano County to monitor and repair road damage to levee roads and any other roads damaged during construction to the extent allowed by law, depending on the specific project proponent. An MOU may be implemented for specific restoration projects and could include the following as suggested by Solano County: o The restoration project will be responsible for the cost of maintaining, repairing, paving and/or reconstructing roads affected during construction, operation, and maintenance of the restoration project. o Repairs will be implemented to comply with the current County Road Improvement Standards, except that repairs to damaged paved sections may be made within 5 inches of	Environmental commitment	Prior to and during construction	Project proponent

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
asphalt concrete at the discretion of the County, while repairs to damaged gravel sections of road will replace the preexisting depth of aggregate base but not less than 12 inches in depth; • coordinating with the Union Pacific Railroad prior to beginning any work within the right-of-way of a rail line to ensure that the integrity of the rail line is maintained and to minimize disruptions to service; and • coordinating with emergency service providers before construction to develop an emergency access plan for emergency vehicles into and adjacent to the construction zone; the emergency access plan would require effective traffic direction, substantially reducing the potential for disruptions to response routes.			
Establish Access Point/Staging Areas	Environmental commitment	Prior to and during construction	Contractor
Air Quality			
Implement air quality Best Management Practices: <u>Basic Control Measures</u> • treat all graded surfaces to prevent nuisances from dust or spillage on roads or adjacent properties. <u>Enhanced Control Measures</u> The following measures will be implemented at construction sites greater than 4 acres in area: • hydroseed with native or non-invasive species appropriate to that specific location or apply (nontoxic) soil stabilizers to inactive construction areas (i.e., previously graded areas inactive for 10 days or more); • limit traffic speeds on unpaved roads to 15 mph; • install sandbags or other erosion control measures to prevent silt runoff to public roadways; and • replant vegetation with native or non-invasive species appropriate to that specific location in disturbed areas as quickly as possible. <u>Additional Air Quality BMPs:</u> The following measures will be required in order to further reduce construction emissions: • maintain properly tuned engines; • minimize the idling time of diesel-powered construction equipment to 2 minutes; • use alternative-powered (e.g., hybrid, compressed natural gas, biodiesel, electric) construction equipment;	Environmental commitment	Prior to, during and following construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
• use add-on control devices such as diesel oxidation catalysts or particulate filters; and • require all contractors to use equipment that meets California Air Resources Board’s (CARB’s) most recent certification standard for off-road heavy-duty diesel engines.			
AQ-MM-1: Limit construction activity during restoration	CEQA-triggered mitigation measure	During construction	Contractor
AQ-MM-2: Reduce construction NO_X emissions	CEQA-triggered mitigation measure	During construction	Contractor
AQ-MM-3: Implement all appropriate BAAQMD mitigation measures	CEQA-triggered mitigation measure	Prior to and during construction	Contractor
AQ-MM-4: Limit restoration and management activity	CEQA-triggered mitigation measure	During construction	Contractor
Noise			
Comply with local noise regulations by limiting construction to the hours specified by Solano County when construction activities occur near residences.	Environmental commitment	During construction	Contractor
When it is determined through site-specific analysis that construction has the potential to occur near residences, the following noise-reduction practices will be implemented: • use electrically powered equipment instead of internal combustion equipment where feasible; • locate staging and stockpile areas and supply and construction vehicle routes as far away from sensitive receptors as possible; • establish and enforce construction site and haul road speed limits; • restrict the use of bells, whistles, alarms, and horns to safety warning purposes; • design equipment to conform to local noise standards; • locate equipment as far from sensitive receptors as possible; • equip all construction vehicles and equipment with appropriate mufflers and air inlet silencers; • restrict hours of construction to periods permitted by local ordinances; and • locate redirected roadways away from sensitive receptors.	Environmental commitment	Prior to and during construction	Contractor
Climate Change			
None			

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Fish			
Prepare and implement a Stormwater Pollution Prevention Plan, which will include but is not limited to: • a description of potential pollutants to stormwater from erosion; • management of dredged sediments and hazardous materials present on site during construction (including vehicle and equipment fuels; • details of how the sediment and erosion control practices comply with state and federal water quality regulations; and • a description of potential pollutants to stormwater resulting from operation of the project.	Environmental commitment	Prior to and during construction	Contractor
Prepare and implement a Hazardous Materials Management Plan	Environmental commitment	Prior to and during construction	Contractor
Prepare and implement and Erosion Control Plan	Environmental commitment	Prior to and during construction	Contractor
Implement and adhere to construction period restrictions. Landside work will occur between July and September. In-water activities will be conducted from August 1 to November 30. Working outside this window will require additional approvals from the resource agencies.	Environmental commitment	During construction	Contractor
Vegetation and Wetlands			
Minimize degradation of wetland habitats where feasible, i.e., work will be conducted from levee crown.	Environmental commitment	During construction	Contractor
Inspect all equipment for oil and fuel leaks every day prior to use. Equipment with oil or fuel leaks will not be used within 100 feet of wetlands.	Environmental commitment	Prior to and during construction	Contractor
Implement special-status plant species protection measures: • Perform a complete botanical survey of restoration areas using the USFWS's Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed and Candidate Plants (September 23, 1996) and DFG's Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities (November 24, 2009); • Special-status plant surveys required for project-specific permit compliance will be conducted within 1 year prior to initiating construction. The purpose of these surveys will be to verify that	Environmental commitment	Prior to and during construction	Project proponent

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
the locations of special-status plants identified in previous surveys are extant, identify any new special-status plant occurrences, and cover any portions of the project area not previously identified. The extent of mitigation of direct loss of or indirect impacts on special-status plants will be based on these survey results; • Locations of special-status plants in proposed construction areas will be recorded using a global positioning system (GPS) unit and flagged; • If initial screening by a qualified biologist identifies the potential for special-status plant species to be directly or indirectly affected by a specific project, the biologist will establish an adequate buffer area to exclude activities that would directly remove or alter the habitat of an identified special-status plant population or result in indirect adverse effects on the species; • Access may be restricted around restoration sites where necessary to protect special-status plant populations though appropriate management plans and the design of the tidal marsh restoration. This may include signage, buffers, seasonal restrictions and design or no access depending on the sensitive species in question; • The project proponents will oversee installation of a temporary, plastic mesh–type construction fence (Tensor Polygrid or equivalent) at least 1.2 meters (4 feet) tall around any established buffer areas to prevent encroachment by construction vehicles and personnel. A qualified biologist will determine the exact location of the fencing. The fencing will be strung tightly on posts set at maximum intervals of 3 meters (10 feet) and will be checked and maintained weekly until all construction is complete. The buffer zone established by the fencing will be marked by a sign stating: *This is habitat of [the special-status species being protected], a [identify the species' status] plant species, and must not be disturbed. This species is protected by [the Endangered Species Act of 1973, as amended/California Endangered Species Act/California Native Plant Protection Act]. Violators are subject to prosecution, fines, and imprisonment.* • No construction activity, including grading, will be allowed until this condition is satisfied; • No grading, clearing, storage of equipment or machinery, or other disturbance or activity will occur until all temporary construction fencing has been inspected and approved by the qualified biologist; and • Where feasible, for stump-sprouting vegetation, construction will limit removal of woody vegetation by trimming vegetation to approximately 1 foot above ground level.			
Implement non-native plant control measures as follows: • Use certified, weed-free, imported erosion control materials (or rice straw in upland areas);	Environmental commitment	Prior to and during construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
• Coordinate with the county agricultural commissioner and land management agencies to ensure that the appropriate BMPs are implemented; • Educate construction supervisors and managers on weed identification and the importance of controlling and preventing the spread of noxious weeds; • Clean equipment at designated wash stations after leaving noxious weed infestation areas; • Treat isolated infestations of noxious weeds identified in the project area with approved eradication methods at an appropriate time to prevent further formation of seed, and destroy viable plant parts and seed; • Minimize surface disturbance to the greatest extent possible; • Use certified weed-free native mixes for any restoration planting or seeding as may be necessary, as provided in the revegetation plan developed in cooperation with DFG. Mulch with certified weed-free mulch. Rice straw may be used to mulch upland areas; and • Use native, noninvasive species or nonpersistent hybrids in erosion control plantings to stabilize site conditions and prevent invasive species from colonizing.			
Wildlife			
Implement general biological BMPs: • No firearms (except for federal, state, or local law enforcement officers and security personnel) will be permitted at the project site to avoid harassment, killing, or injuring of wildlife; • No pets will be permitted at the project site to avoid harassment, killing, or injuring of wildlife; • Native vegetation trimmed or removed on the project site will be stockpiled during work. After construction activities, removal of temporary mats and construction-related materials, and application of native seed mix have been completed, stockpiled native vegetation will be reapplied over temporarily disturbed wetlands to provide temporary soil protection and as a seed source; • Where vegetation removal is required, work will be conducted using hand-held tools to enable wildlife to escape. If any areas with pickleweed or vegetation within 50 feet of the edge of pickleweed need to be cleared for project activities, vegetation shall be removed only with non-mechanized hand tools (i.e., trowel, hoe, rake, and shovel). No motorized equipment, including weed whackers and lawn mowers, shall be used to remove this vegetation. Vegetation shall be removed under the supervision of a qualified biologist approved by DFG and USFWS. If a mouse of any species is observed within the areas being removed of vegetation, DFG and USFWS shall be notified. Vegetation removal may begin when no mice are observed and shall	Environmental commitment	Prior to, and during construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
start at the edge farthest from the salt marsh or the poorest habitat and work its way toward the salt marsh or the better salt marsh habitat; • Removal of vegetation in wetland habitat will be conducted with a qualified biological monitor present. This monitor will watch for special-status wildlife species and temporarily stop work if special-status species are encountered. Wildlife will be allowed to escape before work is resumed. Monitors with the appropriate qualifications to handle special-status species will be allowed to move special-status species to safe locations as permitted by their authorizations; and • Temporarily affected wetlands will be restored by removing construction-related debris, and trash. Affected areas will be seeded with a seed mix of local native wetland species.			
Prepare and implement an environmental resources worker training program. Project proponents will provide training to field management and construction personnel on the importance of protecting environmental resources. Communication efforts and training will be done during preconstruction meetings. Construction personnel will be educated on the types of sensitive resources located in the project area and the measures required to avoid impacts on these resources. Materials covered in the training program will include environmental rules and regulations for the specific project and requirements for limiting activities to the construction right-of-way and avoiding demarcated sensitive resources areas. Training seminars will educate construction supervisors and managers on: • the need for resource avoidance and protection; • construction drawing format and interpretation; • staking methods to protect resources; • the construction process; • roles and responsibilities; • project management structure and contacts; • environmental commitments, and • emergency procedures. If new construction personnel are added to the project, the contractor will ensure that the personnel receive the mandatory training before starting work. A representative will be appointed during the employee education program to be the contact for any employee or contractor who might inadvertently kill or injure a listed species or who finds a dead, injured, or entrapped individual. The representative's name and telephone number will be provided to the USFWS before the initiation of ground disturbance.	Environmental commitment	Prior to and during construction	Project proponent

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Perform preconstruction surveys if individuals of listed wildlife species may be present and subject to potential injury or mortality from construction activities. A qualified biologist will conduct a preconstruction survey; minimum qualifications for the qualified biologist will be a 4-year college degree in biology or related field and 2 years of professional experience in the application of standard survey, capture, and handling methods for the species of concern. However, in the case of fully protected species, no capture or handling will be done. Any special-status mammal, bird or other species observed during surveys will be reported to DFG so the observations can be added to the California Natural Diversity Database.	Environmental commitment	Prior to construction	Project proponent
Implement protection measures for salt marsh harvest mouse and Suisun shrew: • A USFWS-approved biologist, with previous salt marsh harvest mouse monitoring and surveying experience, will identify suitable salt marsh habitat for the mouse prior to project initiation; • Disturbance to wetland vegetation will be avoided to the extent feasible in order to reduce potential impacts on salt marsh harvest mouse habitat. If wetland vegetation cannot be avoided, it will be removed by hand. The USFWS-approved biologist will be on site to monitor all wetland vegetation removal activities; • The upper 6 inches of soil excavated within salt marsh harvest mouse habitat will be stockpiled separately and replaced on top of the backfilled material; • Vegetation will be removed by hand using hand tools; • In construction and staging areas where habitat is to be disturbed, vegetation must be cleared to bare ground or stubble no higher than 1 inch; • Work will be scheduled to avoid extreme high tides (6.5 feet or above, as measured at the Golden Gate Bridge) when there is potential for salt marsh harvest mouse to move to higher, drier grounds. All equipment will be staged on existing roadways away from the project site when not in use; • To prevent salt marsh harvest mouse from moving through the project site during construction, temporary exclusion fencing will be placed around a defined work area before construction activities start and immediately after vegetation removal. The fence should be made of a material that does not allow salt marsh harvest mouse to pass through or over, and the bottom should be buried to a depth of 2 inches so that mice cannot crawl under the fence. Any supports for the salt marsh harvest mouse exclusion fencing must be placed on the inside of the project area; • Prior to the start of daily construction activities during initial ground disturbance, the USFWS-	Environmental commitment	Prior to and during construction	Project proponent/ contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
approved biological monitor will inspect the salt marsh harvest mouse–proof boundary fence to ensure that it has no holes or rips and the base is still buried. The fenced area also will be inspected to ensure that no mice are trapped in it. Any mice found along and outside the fence will be closely monitored until they move away from the construction area; • If a salt marsh harvest mouse is discovered, construction activities will cease in the immediate vicinity of the individual until DFG and USFWS are contacted and the individual has been allowed to leave the construction area; and • A DFG- and USFWS-approved biologist with previous salt marsh harvest mouse experience will be on site during construction activities occurring in wetlands. The biologist will document compliance with the project permit conditions and avoidance and conservation measures. The biologist has the authority to stop project activities if any of the requirements associated with these measures is not being fulfilled. If the biologist has requested work stoppage because of take of any of the listed species, the USFWS and DFG will be notified within 1 day by email or telephone.			
Implement general protection measures for bird species: • The project proponents will remove all woody and herbaceous vegetation from construction areas (earthwork areas) during the nonbreeding season (September 1–February 1) to minimize effects on nesting birds; • During the breeding season, all vegetation subject to impact will be maintained to a height of approximately 6 inches to minimize the potential for nesting; • If construction occurs during the breeding season and not all affected vegetation has been removed, a qualified biologist will survey the construction area for active nests and young migratory birds immediately before construction; • If active nests or migratory birds are found within the boundaries of the construction area, the project proponents will develop appropriate measures and coordinate with DFG to determine an acceptable buffer width; • Inactive migratory bird nests (excluding raptors) located outside of the construction areas will be preserved. If an inactive migratory bird nest is located in the area of effect, it will be removed before the start of the breeding season (approximately February 1); and • Impacts on great blue heron rookeries will be avoided; mature trees will not be removed and nearby work will occur outside the nesting season.	Environmental commitment	Prior to and during construction	Contractor
Perform preconstruction surveys for raptors, adhering to the following: • Surveys will be performed before and during the raptor nesting season (bimonthly, i.e., two	Environmental commitment	Prior to construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
times per month) to identify existing nests that may be used during the nesting season; • Raptors may nest from later winter through mid-summer; therefore, multiple nesting season surveys will performed; • DFG will be notified of all raptor nests located during the preconstruction surveys. If a raptor nest is located within the recommended buffer, the project proponents will coordinate with DFG to determine an acceptable buffer width; and • If an active raptor nest is found outside the construction areas, a buffer zone will be created around the nest tree. For special-status species a larger buffer will be required (e.g., 0.5-mile Swainson's hawk buffer). The project proponents will coordinate with DFG prior to project implementation to determine the species-specific buffer widths.			
Perform preconstruction surveys for California clapper rail and California black rail if construction activities are necessary during the breeding season as follows: • Surveys will be conducted at and adjacent to areas of potential tidal and managed wetlands habitats for California clapper rail and black rail; • Surveys will focus on potential habitat that may be disturbed by construction activities during the breeding season to ensure that these species are not nesting in these locations. Survey methods will follow the protocols used by DFG during previous rail surveys in Suisun Marsh (California Department of Fish and Game 2007). The specific project proponent will implement the following survey protocols: o Surveys should be initiated sometime between January 15 and February 1. A minimum of four surveys should be conducted. The survey dates should be spaced at least 2 to 3 weeks apart and should cover the time period from the date of the first survey through the end of March or mid-April. This will allow the surveys to encompass the time period when the highest frequency of calls is likely to occur; o Listening stations will be established at 150-meter intervals along road, trails, and levees that will be affected by plan implementation; o California clapper rail and California black rail vocalization recordings will be played at each station; o For California clapper rails, each listening station will be occupied for a period of 10 minutes, followed by 1 minute of playing California clapper rail vocalization recordings, then followed by an additional minute of listening; o For black rails, each listening station will be occupied for 1 minute of passive listening, 1 minute of "grr" calls followed by 30 seconds of "ki-ki-krrr" calls, then followed by another	Environmental commitment	Prior to construction	Project proponent/ contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
3.5 minutes or passive listening; o Sunrise surveys will begin 60 minutes before sunrise and conclude75 minutes after sunrise (or until presence is detected); o Sunset surveys will begin 75 minutes before sunset and conclude 60 minutes after sunset (or until presence is detected); o Surveys will not be conducted when tides are greater than 4.5 National Geodetic Vertical Datum (NGVD) or when sloughs and marshes are more than bankfull; and o California clapper rail and California black rail vocalizations will be recorded. A GPS receiver will be used to identify call location and distance. The call type, location, distance, and time will be recorded on a data sheet. If California clapper rail or black rail is present in the immediate construction area, the following measures will apply during construction activities: • To avoid the loss of individual California clapper rails or black rails, activities within or adjacent to California clapper rail or black rail habitat will not occur within 2 hours before or after extreme high tides (6.5 feet or above, as measured at the Golden Gate Bridge), when the marsh plain is inundated, because protective cover for California clapper rails is limited and activities could prevent them from reaching available cover; • To avoid the loss of individual California clapper rails or black rails, activities within or adjacent to tidal marsh areas will be avoided during the California clapper rail breeding season from February 1 through August 31 each year unless surveys are conducted to determine California clapper rail locations and California clapper rail and black rail territories can be avoided. Figure 2–5 shows the areas of known clapper rail breeding habitat; • If breeding California clapper rails or black rails are determined to be present, activities will not occur within 700 feet of an identified calling center. If the intervening distance across a major slough channel or across a substantial barrier between the California clapper rail calling center and any activity area is greater than 200 feet, it may proceed at that location within the breeding season. • *Exception*: Only inspection, maintenance, research, or monitoring activities may be performed during the California clapper rail or black rail breeding season in areas within or adjacent to California clapper rail breeding habitat with approval of the USFWS and DFG under the supervision of a qualified biologist.			

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Implement protection measures for California least tern as follows: • No activities will be performed within 300 feet of an active least tern nest during the least tern breeding season, April 15 to August 15 (or as determined through surveys). • *Exception*: Only inspection, maintenance, research, or monitoring activities may be performed during the least tern breeding season in areas within or adjacent to least tern breeding habitat with approval of the USFWS and DFG under the supervision of a qualified biologist.	Environmental commitment	During construction	Contractor
Implement biological monitoring as follows: • The project proponents will provide a biologist/environmental monitor who will be responsible for monitoring implementation of the conditions in the state and federal permits (federal Clean Water Act [CWA] Section 401, 402, and 404; ESA Section 7; Fish and Game Code Section 1602 and/or 2050; project plans [SWPPP]; and EIS/EIR mitigation measures); • The biologist/environmental monitor will determine the location of environmentally sensitive areas adjacent to each construction site based on mapping of existing land cover types and special-status plant species. If such maps are not available, the biologist/environmental monitor will map and quantify the land cover types and special-status plant populations in the proposed project footprint prior to construction; • To avoid construction-phase disturbance to sensitive habitats immediately adjacent to the project area, the monitor will identify the boundaries of sensitive habitats and add at least a 100-foot buffer, where feasible, using orange construction barrier fencing. The fencing will be mapped on the project designs. Erosion-control fencing also will be placed at the edges of construction where the construction activities are upslope of wetlands and channels to prevent washing sediment off site. The sensitive habitat and erosion-control fencing will be installed before any construction activities begin and will be maintained throughout the construction period; • The biologist/environmental monitor will ensure the avoidance of all sensitive habitat areas outside direct project footprints, including patches of tidal wetland along channel banks, during dredging operations, to the extent practical; and • Plants for revegetation will be accompanied by a California Nursery Stock Certificate.	Environmental commitment	Prior to and during construction	Project proponent/ contractor
Implement and adhere to construction period restrictions.	Environmental commitment	During construction	Project proponent/ contractor
Land and Water Use			
None			

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Social and Economic Conditions			
None			
Utilities and Public Services			
Stop work immediately if a conflict with a utility facility occurs and contact the affected utility to (1) notify it of the conflict, (2) aid in coordinating repairs to the utility, and (3) coordinate to avoid additional conflicts in the field.	Environmental commitment	During construction	Contractor
UTL-MM-1: Relocate or protect overhead powerlines or other utilities that could be affected by construction.	CEQA-triggered mitigation measure	Prior to construction	Contractor
UTL-MM-2: Avoid ground-disturbing activities within pipeline right-of-way.	CEQA-triggered mitigation measure	During construction	Contractor
UTL-MM-3: Relocate or upgrade utility facilities that could be damaged by inundation.	CEQA-triggered mitigation measure	Prior to inundation	Contractor
UTL-MM-4: Test and repair or replace pipelines that have the potential for failure.	CEQA-triggered mitigation measure	Prior to inundation	Contractor
Recreation Resources			
Avoid nesting habitats and other sensitive areas, such as important roosting and foraging sites during critical nesting periods.	Environmental commitment	During construction	Contractor
Construction will not occur during major summer holiday periods.	Environmental commitment	Major holiday periods	SRCD
Maintain boat access to prime areas.	Environmental commitment	During construction	Contractor
Provide public information regarding alternate access.	Environmental commitment	Prior to and during construction	Contractor
Post warning signs and buoys in channels, upstream of, and downstream of, all construction equipment, sites and activities during construction.	Environmental commitment	Prior to and during construction	Contractor
Post signs describing alternate boating routes in convenient locations when boating access is restricted.	Environmental commitment	During construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Minimize water-level fluctuation during construction.	Environmental commitment	During construction	Contractor
Power Production and Energy			
None			
Visual/Aesthetic Resources			
For projects that have the potential to affect views or create a new source of light or glare, identify sensitive view receptors for site-specific analysis and ensure that contractors minimize fugitive light from portable sources used for nighttime operations. In addition, a visual barrier will be installed to prevent light spill from truck headlights in areas with sensitive view receptors.	Environmental commitment	Prior to and during construction	Project proponent/ contractor
Cultural Resources			
Immediately cease work within 100 feet inadvertent discoveries of cultural resources, including human remains. All construction personnel will leave the area. Vehicles and equipment will be left in place until a qualified archaeologist identifies a safe path out of the area. The on-site supervisor will flag or otherwise mark the location of the find and keep all traffic away from the resource. The on-site supervisor immediately will notify the lead state or federal agency of the find.	Environmental commitment	During construction	Contractor
Comply with Native American Grave Protection and Repatriation Act (43 CFR 10) if inadvertent discovery of Native American remains occurs on federal lands.	Environmental commitment	During construction	Project proponent
Comply with state laws relating to the disposition of Native American burials (Public Resources Code [PRC] 5097 and California Health and Safety Code 7050.5[b]) for human remains discoveries on non-federal lands.	Environmental commitment	During construction	Project proponent
If human remains of Native American origin are discovered during ground-disturbing activities on non-federal land, the lead state or federal agency must comply with state laws relating to the disposition of Native American burials, which fall within the jurisdiction of the Native American Heritage Commission (NAHC) (PRC 5097). If human remains are discovered or recognized in any location other than a dedicated cemetery, the lead state or federal agency will not allow further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until: • the Solano County coroner has been informed and has determined that no investigation of the cause of death is required; and • if the remains are of Native American origin,	Environmental commitment	During construction	Project proponent/ contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
o the descendants of the deceased Native Americans have made a recommendation to the landowner or the person responsible for the excavation work for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in PRC 5097.98; or o the NAHC was unable to identify a descendant or the descendant failed to make a recommendation within 48 hours after being notified by the NAHC.			
CUL-MM-1: Document and evaluate the Montezuma Slough rural historic landscape, assess impacts, and implement mitigation measures to lessen impacts.	CEQA-triggered mitigation measure	Prior to construction	Project proponent
CUL-MM-2: Evaluate previously recorded cultural resources and fence NRHP- and CRHR-eligible resources prior to ground-disturbing activities.	CEQA-triggered mitigation measure	Prior to construction	Project proponent
CUL-MM-4: Resolve adverse effects [to known cultural resources] prior to construction.	CEQA-triggered mitigation measure	Prior to construction	Project proponent
CUL-MM-5: Conduct cultural resource inventories and evaluations and resolve any adverse effects.	CEQA-triggered mitigation measure	Prior to construction	Project proponent
Public Health and Environmental Hazards			
Prepare and implement a Hazardous Materials Management Plan	Environmental commitment	Prior to and during construction	Contractor
Prepare and implement a Stormwater Pollution Prevention Plan, which will include but is not limited to: • a description of potential pollutants to stormwater from erosion; • management of dredged sediments and hazardous materials present on site during construction (including vehicle and equipment fuels; • details of how the sediment and erosion control practices comply with state and federal water quality regulations; and • a description of potential pollutants to stormwater resulting from operation of the project.	Environmental commitment	Prior to and during construction	Contractor
Ensure that changes within the Suisun Marsh channels will not significantly affect navigation and emergency access by having Rio Vista and Vallejo Coast Guard Stations review plans to assess safety issues associated with changes when there is potential for in-channel work to affect access.	Environmental commitment	Prior to and during construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
RESTORATION ACTIVITIES			
Develop site-specific plans to address mosquito production for each restoration activity based on the following recommendations, which would be implemented prior to removal or breaching of any levee or water control structure: 1. Develop a management program consistent with Marsh-wide management actions for the control of mosquitoes; and 2. If necessary, obtain an engineering survey to locate depressions that would retain tidal water and design site restoration to promote water drainage.	Environmental commitment	Prior to, during and following construction	Project proponent
UTL-MM-2: Avoid ground-disturbing activities within pipeline right-of-way.	CEQA-triggered mitigation measure	During construction	Contractor
UTL-MM-3: Relocate or upgrade utility facilities that could be damaged by inundation.	CEQA-triggered mitigation measure	Prior to inundation	Contractor
UTL-MM-4: Test and repair or replace pipelines that have the potential for failure.	CEQA-triggered mitigation measure	Prior to inundation	Contractor
Environmental Justice			
None			
Indian Trust Assets			
None			

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
General			
Continue existing Best Management Practices.	Environmental commitment	Prior to, during and following construction	SRCD, Landowners, DFG, Reclamation, DWR
Implement the construction period restrictions as follows: • Limit in-water work to the period between August 1 and November 30; • Most managed wetland activities are expected to be implemented from June to September when the wetlands are dry enough to conduct these activities; • Activities may be conducted during other times of the year, depending on the potentially affected species for each site-specific case; and • Activities occurring during the hunting season will not occur on Saturday, Sunday, or Wednesday when such activities have a reasonable possibility of disrupting access to hunting or represent a safety concern.	Environmental commitment	During construction	SRCD, Landowners, DFG, Reclamation, DWR
Implement standard design features and construction practices for wetland management activities: • When possible, drain pipes should be relocated to drain into larger receiving sloughs with good tidal circulation to avoid and minimize the degradation of water quality in receiving waters; • All new and/or replacementdrain pipes will be located on the largest possible sloughs, or sloughs with the highest levels of tidal circulation possible, to minimize or lessen the possibility of degraded water quality conditions; • Management options, including vegetation management and diversion timing and location, will be pursued to avoid and minimize occurrence of low dissolved oxygen (DO) water conditions in managed wetlands; • New exterior drain structures will be installed where the discharge channel already exists. The new drain will not be placed on emergent vegetation. The pipe will be installed at low tide. No in-water work is authorized; • Landowners importing any material besides rock material from outside the Suisun Marsh must contact the RWQCB before importation. Landowners must obtain the RWQCB's concurrence that the imported material is acceptable before use; • Material excavated from existing spreader ditches and creation of new spreader ditches may be sidecast adjacent to the ditch. No excavated material will be more than 12 inches high; • Exterior pipes will be placed below the depth of emergent vegetation;	Environmental commitment	Prior to and during construction	SRCD, Landowners, DFG, Reclamation, DWR

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
• Pipe replacement as well as repair, replacement, or installation of exterior water control structures will not change the existing use or diversion capacity; • All pipes will be pre-assembled before installation to minimize work time; • All material shall remain on the crown or interior side of the levee during the repair of exterior existing levees, the coring of existing exterior levees, and the installation of drain pumps and platforms; • All bulkheads will be in place prior to backfilling the bulkhead during installation, repair, or re-installation of water control structures; • Installation of drain pumps and platforms will be done entirely within the managed wetland; although discharge pipes will comply with permit terms and conditions for exterior discharge pipe installation; • All work to be performed on the exterior side of levees shall commence and be completed within a 6-hour period, from 3 hours prior to low tide to 3 hours after low tide; • Construction equipment used for projects will be checked each day prior to work and, if necessary, action will be taken to prevent fluid leaks. If leaks occur during work, the Corps, its permittee, or the contractor will contain the spill and remove the affected soils; • All contractors must have a supply of erosion and pollution control materials on site to facilitate a quick response to unanticipated storm events or emergencies; • No in-water work will occur during the repair of existing exterior levees; the coring of existing levees; pipe replacement at the exterior flood or dual-purpose gate; pipe replacement at the existing exterior drain gate; installation, repair, or re-installation of water control bulkheads; installation of drain pumps and platforms; or installation of new exterior drain structures; • Emergent vegetation will not be disturbed during the following activities: repair of existing exterior levees, replacement of existing riprap on exterior levee, or installation of the new exterior drain structure; and • No fresh concrete, cement, silts, clay, soil, or other materials will be discharged to Marsh waters.			
Prepare and submit monthly work reports to the Corps, NMFS, State Lands Commission, and the RWQCB.	Environmental commitment	During construction	SRCD, DWR, Reclamation
Prepare and submit an annual activities summary report to the Corps, U.S. Environmental Protection Agency, NMFS, USFWS, State Lands Commission, and the RWQCB.	Environmental commitment	Post-construction	SRCD, DWR, Reclamation

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Prepare and submit a written annual report to NMFS by December 31 of each year. The report shall contain, at a minimum, the following information: • Project-related activities—The report shall include the type, size, and location of specific actions (exterior pipe replacement and installation and rip rap placement) undertaken under RGP 3; dates when specific actions began and were completed; a description of BMPs implemented to minimize project effects; photographs taken before, during, and after the activity from photo reference points; and a discussion of specific project performance or efficacy; • Unanticipated project effects—The report shall include a discussion of any unanticipated project effects or unanticipated levels of project effects on salmonids, green sturgeon, and/or critical habitat and a description of any and all measures taken to minimize those unanticipated effects as well as a statement regarding whether the unanticipated effects had any effect on ESA-listed fish or critical habitat; • Gate closures and diversion curtailment—The report shall summarize compliance monitoring for gate closures and diversion curtailments; and • Observations of salmonids and green sturgeon—The report shall document observations of any salmonids or green sturgeon occurring within the action area during project actions.	Environmental commitment	Post-construction	SRCD, DWR, Reclamation
Adhere to riprap placement requirements: • Riprap will not be placed directly on emergent vegetation (e.g., tules, *Scirpus* spp.); • Emergent vegetation will not be uprooted during the placement of riprap, nor will it be displaced by riprap; and • Riprap placed on the exterior side of the levee will commence and be complete within a six-hour period, from three hours prior to low tide to three hours following low tide.	Environmental commitment	During construction	Contractor
Adhere to dredging practice requirements: • All construction facilities and working platforms required for dredging operations will maintain an operating environment free of fuel spills; • Runoff generated on the job site will be controlled; • Dredging activities will occur only between August 1 and November 30; • Removal of emergent vegetation will be avoided where feasible, although areas of vegetation may need to be disturbed during construction to provide site access, adequate volume of material for construction, and proper water flow at the site; • Dredging will be avoided within 200 feet of storm drain outfall and urban discharge locations, unless suitable preconstruction contaminant testing is conducted (coordination and consulting	Environmental commitment	During construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
with the DMMO relative to evaluation and placement of the materials); • A berm will be constructed on the channel-side of the levee crown to prevent runoff into adjacent aquatic habitats; • Releases of discharge water from managed wetlands will be limited following dredged material placement; • The extent of dredging disturbance will be limited based upon slough channel habitat classification and plan region in Table 2-6; • Alternate boating routes will be identified if dredging impedes navigation.			
Water Supply, Hydrology, and Delta Water Management			
None			
Water Quality			
Restrict levee repairs and pipe replacements to the dry season and dry days.	Environmental commitment	During construction	Landowners
Develop and implement a hazardous spill plan.	Environmental commitment	Prior to and during construction	SRCD, DFG, DWR, Reclamation, Contractor
Geology and Groundwater			
None			
Flood Control and Levee Stability			
None			
Sediment Transport			
None			
Transportation and Navigation			
None			

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Air Quality			
AQ-MM-2: Reduce construction NO_X emissions	CEQA-triggered mitigation measure	During construction	Contractor
AQ-MM-3: Implement all appropriate BAAQMD mitigation measures	CEQA-triggered mitigation measure	Prior to and during construction	Contractor
AQ-MM-4: Limit construction activity during restoration and management activities	CEQA-triggered mitigation measure	During construction	Contractor
Noise			
Comply with local noise regulations by limiting construction to the hours specified by Solano County when construction activities occur near residences.	Environmental commitment	During construction	Contractor
When it is determined through site-specific analysis that construction has the potential to occur near residences the following noise-reduction practices will be implemented: • use electrically powered equipment instead of internal combustion equipment where feasible; • locate staging and stockpile areas and supply and construction vehicle routes as far away from sensitive receptors as possible; • establish and enforce construction site and haul road speed limits; • restrict the use of bells, whistles, alarms, and horns to safety warning purposes; • design equipment to conform to local noise standards; • locate equipment as far from sensitive receptors as possible; • equip all construction vehicles and equipment with appropriate mufflers and air inlet silencers; • restrict hours of construction to periods permitted by local ordinances; and • locate redirected roadways away from sensitive receptors.	Environmental commitment	Prior to and during construction	Contractor
NZ-MM-1: Limit Noise from Pump Operations	CEQA-triggered mitigation measure	During construction	SRCD and DFG
Climate Change			
None			

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Fish			
Report any suspected take of listed fish species to DFG and the Suisun Resource Conservation District. Any carcasses of listed fish will be frozen in a whirl-pak bag and retained until instructions are received from the applicable agency.	Environmental commitment	During construction	Landowners
Consolidate and/or equip water control structures with state-of-the-art fish screens when practicable and as funding allows.	Environmental commitment	During construction of new water control structures	Landowners
Screen any new or enlarged exterior water control structures in accordance with DFG's criteria unless DFG and the Corps determine that the structure would not adversely affect any listed species and the Corps obtains concurrence for any federally listed species with that determination from NMFS or USFWS as applicable.	Environmental commitment	During construction of new or enlarged water control structures	Landowners
Install or replace water control structures only during low tides (within a six-hour period, from three hours prior to low tide to three hours following low tide) when there is the least chance of affecting fish.	Environmental commitment	During construction	Contractor
Identify and prioritize placement of water control structures that require fish screens in consultation with the Corps, NMFS, and the USFWS.	Environmental commitment	Prior to construction	SRCD and DFG
Operate water control structures to minimize impacts on listed fish, taking into consideration seasonal timing and water quality.	Environmental commitment	During operations of water control structures	Landowners
Perform all in-water work by hand and during low tide (within a six-hour period, from three hours prior to low tide to three hours following low tide) as part of the following activities: • repair, replacement, or installation of exterior water control structures; • pipe replacement at the exterior flood or dual-purpose gate; • pipe replacement at the existing exterior drain gate; and • installation of the new exterior drain structure	Environmental commitment	During construction	Landowners
Restrict levee repairs and pipe replacements to the dry season and dry days.	Environmental commitment	During construction	Landowners

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Complete repairs of existing exterior levees (to stop the flow of tidal waters entering into the managed wetlands) within 7 days of the breach for coverage under the RGP.	Environmental commitment	Within 7 days of breach	Landowners
Install fish screens on any new or enlarged water control structures.	Environmental commitment	During construction of new or enlarged water control structure	Landowners
Do not fill more than 1,000 square feet of wetlands throughout the Marsh per year during installation of fish screens.	Environmental commitment	During construction of fish screens	SRCD, DFG, DWR, Reclamation
An evaluation by a biologist or on-site monitor shall be done at each site during project implementation of exterior pipe replacement or riprap placement to document project actions for the purpose of identifying any condition that could adversely affect salmonids, green sturgeon, or their habitat. A NMFS biologist will be immediately notified whenever conditions are identified that could adversely affect salmonids, green sturgeon, or their habitat in a manner not described in the opinion.	Environmental commitment	During construction of waterside activities	Landowners
Rectify any identified project-related conditions that could adversely affect salmonids, green sturgeon, or their habitat.	Environmental commitment	Prior to or during construction	Landowners
SRCD shall notify DFG, NMFS, and the Corps of the starting and closing dates of duck hunting season annually at least 1 month prior to the start of the season. Landowners diverting water from sloughs designated by NMFS (i.e., Montezuma Slough and its tributaries lower Nurse Slough [from the confluence with Denverton Slough to Montezuma], Denverton Slough; Cuttoff Slough [including Spring Branch Slough, first and second Mallard Branch Slough]; Suisun Slough, [from downstream of the confluence with Boynton Slough to Grizzly Bay; and Chipps Island]) shall use no more than 25% of the water control structure's diversion capacity from November 1 to the last day of duck hunting season. These landowners are prohibited from diverting water from designated sloughs from February 21 to March 31.	Environmental commitment	Prior to and during hunting season	SRCD and landowners
Landowners diverting water from sloughs designated by NMFS [i.e., Montezuma Slough and its tributaries lower Nurse Slough (from the confluence with Denverton Slough to Montezuma), Denverton Slough; Cuttoff Slough (including Spring Branch Slough, first and second Mallard Branch Slough); Suisun Slough, (from downstream of the confluence with Boynton Slough to Grizzly Bay; and Chipps Island] shall use only 35% of the water control structure's intake capacity between April 1 and May 31. If, during this time, two out of the three DFG 20-millimeter trawl	Environmental commitment	Post hunting season	Landowners

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
surveys sites (sites 606, 609, and 610) predict delta smelt densities greater than 20 delta smelt individuals per 10,000 cubic meters over a 2-week sampling period, all diversions from these sloughs shall use only 20% of the water control structure's intake capacity. Survey trawls shall take place at least once every 14 days between April 1 and May 31.			
SRCD and DFG shall monitor gate closures while diversion restrictions are in place. If an open gate is observed, the landowner shall be contacted and the gates shall be brought into compliance	Environmental commitment	During periods of diversion	SRCD, DFG and landowners
If the managed wetlands are subject to uncontrolled tidal flow, dewatering of the managed wetland area will be conducted through the use of existing gravity tidal drainage gates as much as possible. DFG will be consulted to determine if fish salvage efforts are needed prior to completely dewatering of the site.	Environmental commitment	During and after breach or uncontrolled tidal flow into managed wetlands	SRCD and landowners
Limit in-water work to the period between August 1 and November 30.	Environmental commitment	During construction	SRCD, DFG, Reclamation, and DWR
Develop and implement a hazardous spill plan.	Environmental commitment	Prior to and during construction	SRCD, DFG, DWR, Reclamation, Contractor
Continue existing Best Management Practices and Biological Opinion terms and conditions.	Environmental commitment	Prior to, during and following construction	Contractor
Vegetation and Wetlands			
Report any suspected take of listed wildlife species to DFG and the Suisun Resource Conservation District.	Environmental commitment	During construction	Landowners
Conduct on-site field inspection for special-status plants for managed wetlands activities on the water side of exterior levees. Special-status plants include: • soft bird's beak (*Cordylanthus mollis* ssp. *mollis*); • salt marsh bird's beak (*C. maritimus* ssp. *maritimus*); • hispid bird's beak (*C. mollis* ssp. *hispidus*); • Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*); • Mason's lilaeopisis (*Lilaeopsis masonii*);	Environmental commitment	Prior to construction	Landowners

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
• Suisun thistle (*Cirsium hydrophilum* var. *hyrdophilum*); • Suisun Marsh aster (*Aster lentus*); • alkali milk-vetch (*Astragalus tener*); • heartscale (*Atriplex cordulata*); • brittlescale (*Atriplex depressa*); • valley spearscale (*Atriplex joaquiniana*) If a special-status plant is found during a survey, it should be avoided, and a map showing the location of the plant should be provided to DFG, the Corps, and USFWS no later than 7 calendar days after the survey is completed. If a special-status plant cannot be avoided during the proposed work and it is not listed as threatened or endangered, the plant will be carefully transplanted to the nearest suitable habitat provided this action and the proposed transplantation site are determined by DFG to be adequate to offset any impact. If approved by DFG, a qualified representative of Suisun Resource Conservation District (SRCD) or DFG may conduct the transplantation. If DFG does not determine that transplantation will offset the impact, a restoration plan will be prepared and implemented, after DFG approval, that will be able to ensure that impacts on the plant population are offset. This determination by DFG will include an assessment of species distribution, the abundance in the Marsh, and the level of proposed impact. If a federally listed threatened or endangered plant is found that cannot be avoided during the proposed work, the qualified representative of SRCD or DFG will notify the Corps immediately so it can consult with the USFWS. If determined necessary by USFWS and if a federally listed plant cannot be avoided during the proposed work, the plant will be carefully transplanted to the nearest suitable habitat provided this action and the proposed transplantation site is determined by USFWS to be adequate to offset any impact. If approved by USFWS, a qualified representative of SRCD or DFG may conduct the transplantation. If USFWS does not determine that transplantation will offset the impact, a restoration plan will be prepared and implemented, after USFWS approval, that will be able to ensure that impacts on the plant population are offset. This determination by USFWS will include an assessment of species distribution, abundance in the Marsh, and the level of proposed impact.			
Continue existing Best Management Practices and Biological Opinion terms and conditions.	Environmental commitment	Prior to, during and following construction	SRCD, DFG, DWR, and Reclamation

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Wildlife			
Limit work in California clapper rail habitat to between February 1 and August 31 unless surveys indicate that the species is not present.	Environmental commitment	During construction	Contractor
Report any suspected take of listed wildlife species to DFG and the Suisun Resource Conservation District.	Environmental commitment	Prior to, during, or following construction	Landowners
Avoid and minimize impacts on great blue heron and egret rookeries by removing mature trees only outside the nesting season and maintaining a 500-foot buffer between roost sites and managed wetland activities during nesting season.	Environmental commitment	During construction	Landowners
Do not implement managed wetland activities in the vicinity of active raptor nests during breeding season.	Environmental commitment	During active raptor breeding season	Landowners
Continue existing Best Management Practices and Biological Opinion terms and conditions.	Environmental commitment	Prior to, during and following construction	SRCD, DFG, DWR, and Reclamation
Land and Water Use			
None			
Social and Economic Conditions			
None			
Utilities and Public Services			
UTL-MM-2: Avoid ground-disturbing activities within pipeline right-of-way	CEQA-triggered mitigation measure	During construction	Contractor
Recreation Resources			
Construction will not occur during major summer holiday periods.	Environmental commitment	Major holiday periods	SRCD
In sloughs and exterior waters, place warning signs and buoys upstream of, and downstream of all construction equipment, sites, and activities.	Environmental commitment	Prior to and during construction	Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Provide adequate warning regarding activities and equipment to recreationists in construction sites by postings and/or notices.	Environmental commitment	Prior to and during construction	Contractor
Post signs describing alternate boating routes in convenient locations when boating access is restricted.	Environmental commitment	During construction	Contractor
Power Production and Energy			
None			
Visual/Aesthetic Resources			
For projects that have the potential to affect views or create a new source of light or glare, identify sensitive view receptors for site-specific analysis and ensure that contractors minimize fugitive light from portable sources used for nighttime operations. In addition, a visual barrier will be installed to prevent light spill from truck headlights in areas with sensitive view receptors.	Environmental commitment	Prior to and during construction	SRCD, DFG, DWR, and Reclamation/ contractor
Cultural Resources			
If any previously unknown historic or archeological artifacts are discovered while accomplishing the authorized work, the landowner must stop work immediately and notify the Corps. The activity is not authorized until the requirements of Section 106 of the NHPA have been satisfied.	Environmental commitment	During construction	Landowners
Work is not authorized within 100 feet of archeological site CAL-SOL-13.	Environmental commitment	During construction	Contractor
CUL-MM-6: Stop ground-disturbing activities, evaluate the significance of the discovery, and implement mitigation measures as appropriate.	CEQA-triggered mitigation measure	During construction	Contractor and landowner
CUL-MM-7: Complete NHPA Section 106 consultation and prepare and implement context study; evaluate previously recorded cultural resources and fence NRHP- and CRHR-eligible cultural resources prior to ground-disturbing activities.	CEQA-triggered mitigation measure	Prior to and during construction	Reclamation
CUL-MM-8: Complete NHPA Section 106 consultation and prepare and implement context study; conduct cultural resources inventories and evaluations and resolve any adverse effects.	CEQA-triggered mitigation measure	Prior to and during construction	Reclamation
Public Health and Environmental Hazards			
Develop and implement a hazardous spill plan.	Environmental commitment	Prior to and during construction	SRCD, DFG, DWR, Reclamation, Contractor

Mitigation Measures and Environmental Commitments	Type of Action	Implementation Schedule	Party Responsible
MANAGED WETLAND ACTIVITIES			
Environmental Justice			
None			
Indian Trust Assets			
None			