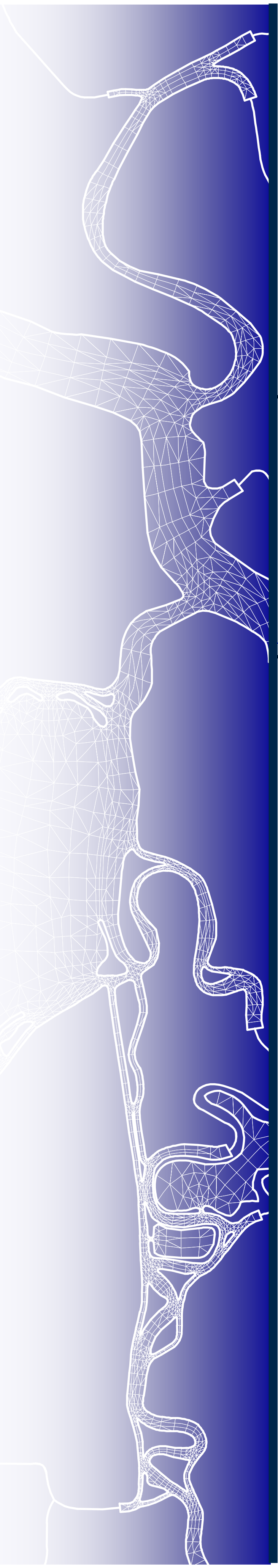
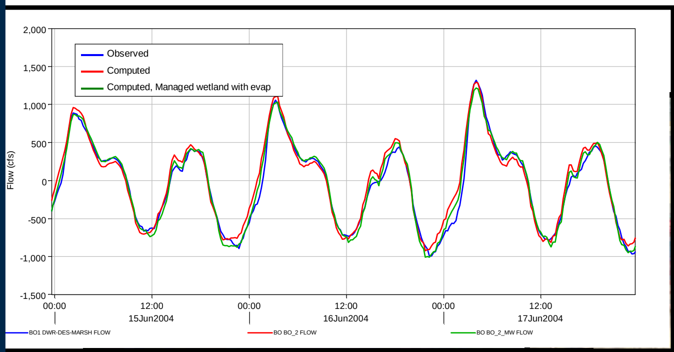
Appendix A

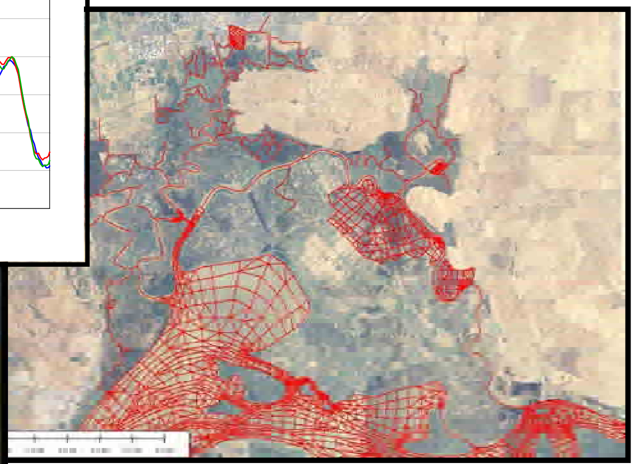
Numerical Modeling in Support of Suisun Marsh PEIR/EIS—Technical Appendix, September 2009



NUMERICAL MODELING IN SUPPORT OF SUISUN MARSH PEIR/EIS

TECHNICAL APPENDIX, SEPTEMBER 2009





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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.

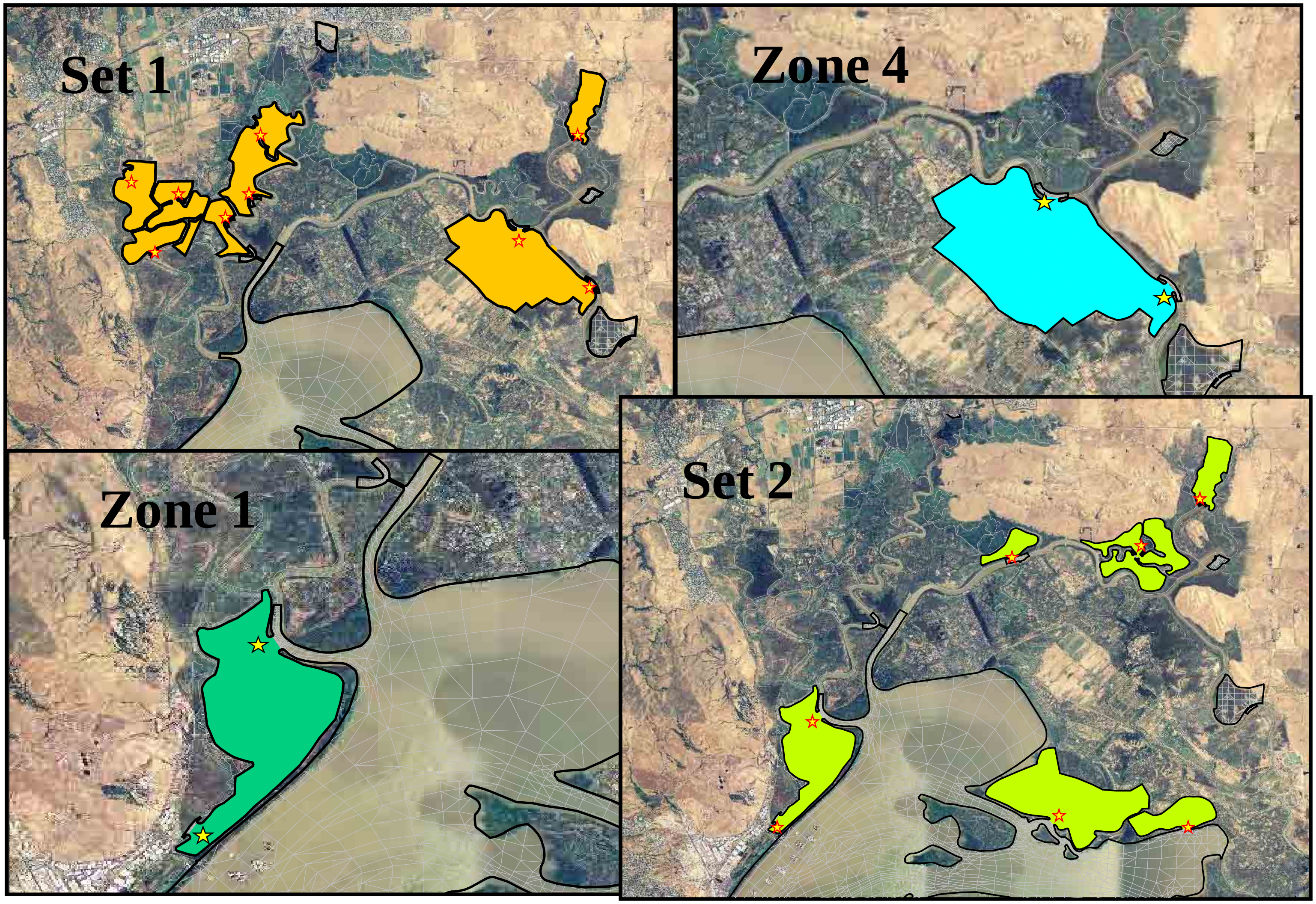

Figure 1-1 Regions flooded as tidal marsh in each of the scenarios, with the location of breaches in levees indicated by stars.