Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

26th Annual Progress Report
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Chapter 2:
Using Dye-Injection Study to Revise DSM2-SJR Geometry

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2 Using Dye-Injection Study to Revise DSM2-SJR Geometry

2.1 Introduction

Channel descriptions in the San Joaquin River extension of the Delta Simulation Model Version 2 (DSM2-SJR), spanning from Vernalis upstream to Bear Creek, were refined after closer examination of bathymetry data. To include field-measured depths in determining a representative cross section, distance was reduced upstream and downstream of a cross section. Irregular cross sections in DSM2 were generally reduced in width and cross-sectional area. This change reduced the modeled travel time in this reach of the San Joaquin River, bringing it closer to an actual dye-tracer study. Original estimates for Manning's *n* values were also modified to further improve the accuracy of modeled travel time and better reproduce water levels.

2.2 Background

The Stockton Deep Water Ship Channel Total Maximum Daily Load Dissolved Oxygen Modeling Team is using DSM2-SJR to model dissolved oxygen at Vernalis. In evaluating the model for this purpose, Brown and Huber (2004) used a 1994 dye-tracer study (Kratzer and Biagtan, 1997) to check travel times down the San Joaquin River. Plugs of high-concentration electrical conductivity (EC) were input to the model near the dye-injection input locations in the field study. The modeled travel time was found to be approximately 50% longer than that observed in the field. By examining the irregular cross sections in DSM2, staff at Jones and Stokes noticed that DSM2-SJR channels near Patterson were too wide. Although past modeling of EC to estimate salinity at the lower boundary of the DSM2-SJR grid had been adequate for model calibration (Pate, 2001), the error in travel time noted by Jones and Stokes was thought to be a problem when modeling non-conservative constituents such as dissolved oxygen, particularly during lower flows. As a consequence, the Department of Water Resources' Delta Modeling Section investigated modifying the grid in the San Joaquin River upstream of Vernalis.

2.3 DSM2 Simulation of Dye-Tracer Studies

DSM2-SJR was first used to repeat Jones and Stokes' simulation of historical conditions during two dye-injection studies in 1994. Historical flow and EC had already been modeled for the period of 1990 through water year 1999 (Wilde, 2004). Given the data presented in the Kratzer and Biagtan (1997) study, the dye-injection studies of February 9 and June 20, 1994, were found to be appropriate to be simulated. The actual dye-tracer injection locations were in streams flowing into the San Joaquin River. The February location was in the Merced River at River Road, and the June location was in Salt Slough at Highway 165. DSM2-SJR does not model the tributaries of the San Joaquin River. For simulation purposes slugs of high EC concentrations were injected at the respective stream confluences with the San Joaquin River (Figure 2.1) at the estimated time when the dye-tracer plugs reached the confluences (Kratzer and Biagtan, 1997).

Simulated EC concentrations were output at locations monitored in the dye-tracer studies. The estimated travel times to Vernalis are shown for comparison (Figures 2.2 and 2.3). For the original DSM2-SJR grid, the estimated travel times were significantly longer than the field study, agreeing with the findings by Jones and Stokes. In the February study during an average flow of 2,800 cubic feet per second (cfs), the DSM2-SJR estimated travel time from the Merced River to Vernalis was 50 hours, but the estimated travel time in the field was approximately 38 hours. For the June study during an average flow of 1,000 cfs, the DSM2-SJR estimated travel time from Salt Slough to Vernalis was 106 hours, but the estimated travel time in the field was approximately 74 hours. The modeled travel times in February and June of 1994 were, respectively, 32% and 43% longer than those indicated by field measurements. These differences were considered mandates for refining the DSM2-SJR grid.

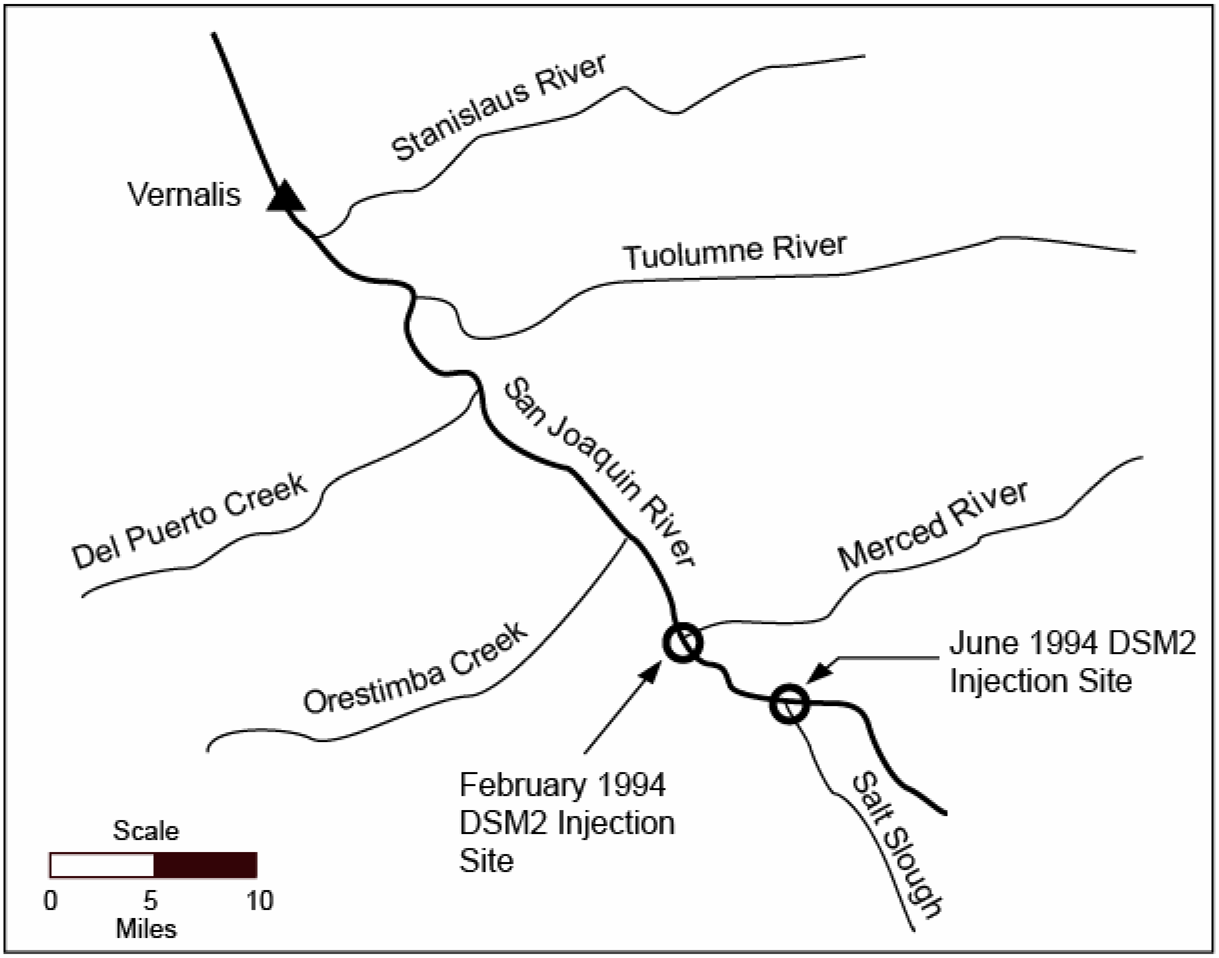

Figure 2.1: Locations of DSM2 Injection Sites to Simulate February and June 1994 Dye-Injection Studies.

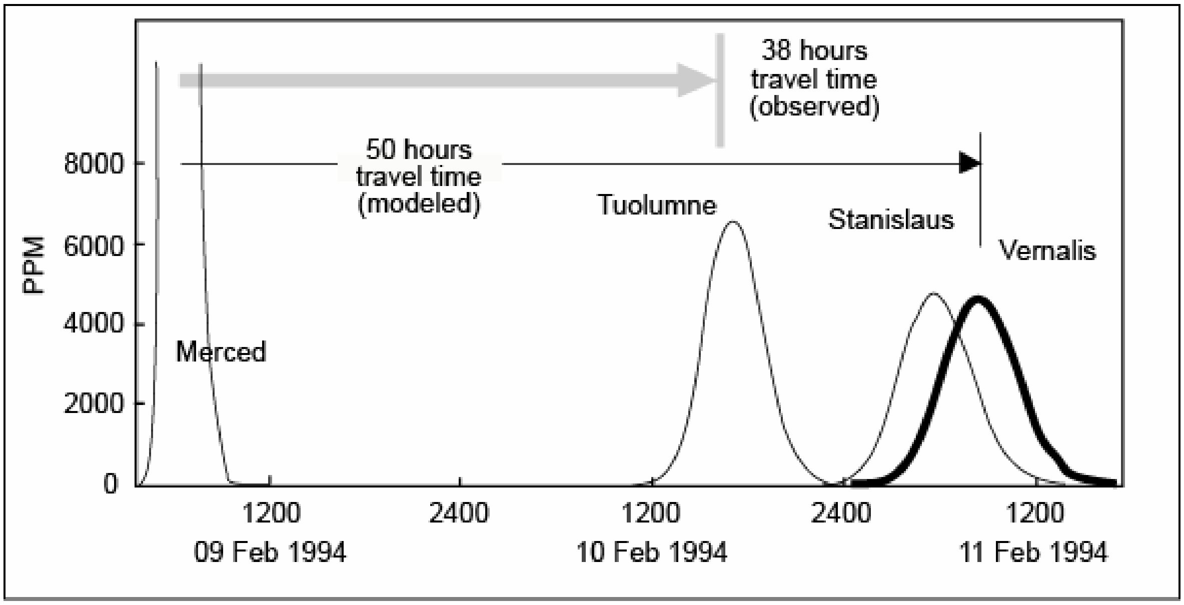

Figure 2.2: Original DSM2-SJR Modeled EC along the San Joaquin River during Simulation of Dye-Injection Study in February of 1994 (Model Travel Time is 50 Hours Compared to Observed 38 Hours).

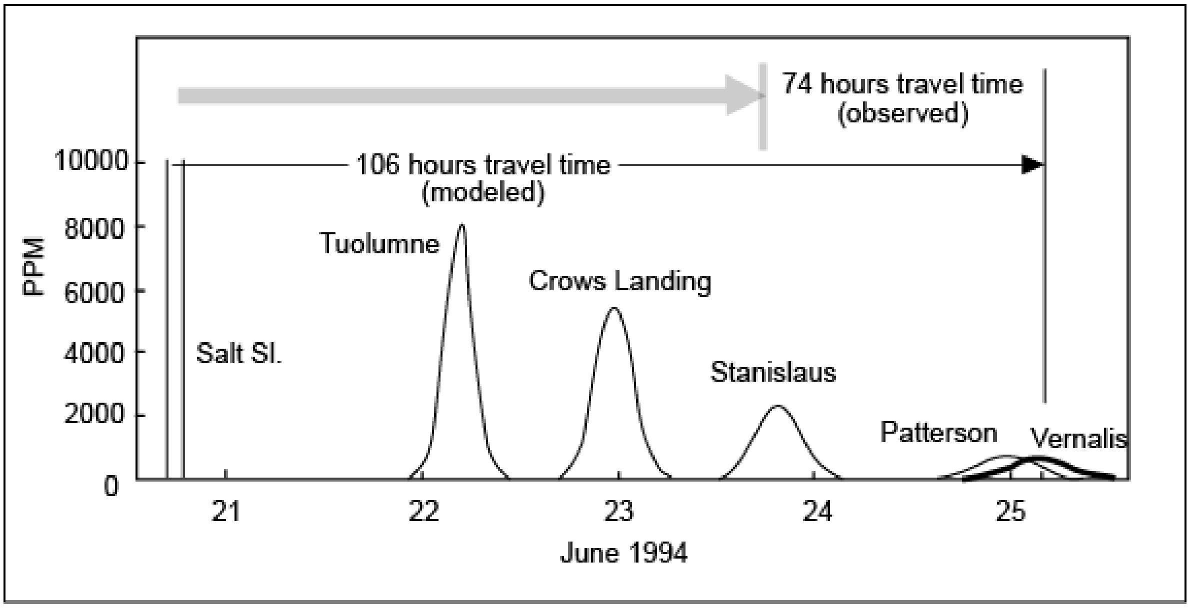

Figure 2.3: Original DSM2-SJR Modeled EC along the San Joaquin River during Simulation of Dye-Injection Study in June of 1994 (Model Travel Time is 74 Hours Compared to Observed 106 Hours).

2.4 Irregular Cross Section Investigation and Adjustments

In order to better replicate hydraulic conditions, the river geometry in DSM2-SJR was re-examined. The Cross Section Development Program (CSDP) had been used to develop the original irregular cross sections in the San Joaquin River upstream of Vernalis, using the bathymetry gathered from the US Army Corps of Engineers (Tom, 1998, Pate, 2001). For any given cross section, CSDP requires a distance upstream and downstream of the cross section to query and return bathymetry data. The user then fits a single cross section to the data. The upstream and downstream distances generated in CSDP and used in the DSM2-SJR reach were judged to be too large and to introduce bias in channel width. CSDP used meandering, hand-drawn centerlines as the reference datum to project the elevation data in a cross-sectional view. If the centerline does not follow the true center of the channel, a wide sampling of the elevation data may yield a misrepresentation of the bathymetry because elevation data points may be too scattered. This results in the channel width being too large. Figure 2.4 shows a cross-section display at location 625_1, just upstream of Patterson, with elevation data displayed 1,000 feet upstream and downstream of the cross section. The resulting cross-sectional width approaches 700 feet. A smaller cross-sectional width results by reducing the display thickness from the default value of 1,000 feet. Figure 2.5 shows an example of a thickness set at 300 feet at the same location. The cross section now displays a more representative channel width that is less than 200 feet. Where adjustment to an irregular cross section was warranted, sampling of bathymetry data were taken based upon varying distances from the cross section to derive an average representation at the location of the adjustment.

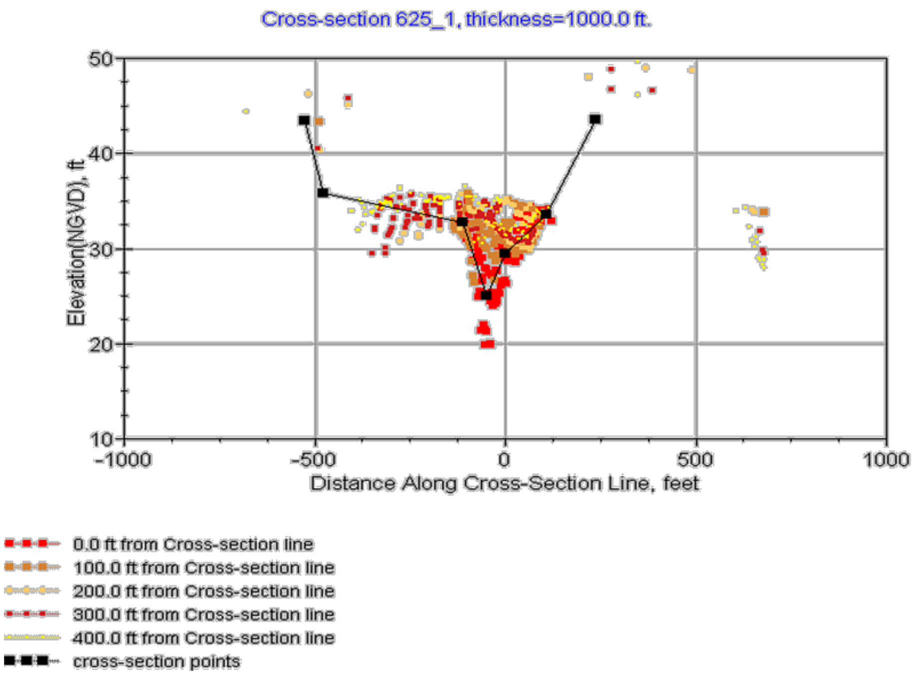

Figure 2.4: Irregular Cross Section with a Thickness of 1,000 Feet and a Misrepresented Width of Approximately 700 feet at Channel Location 625_1.

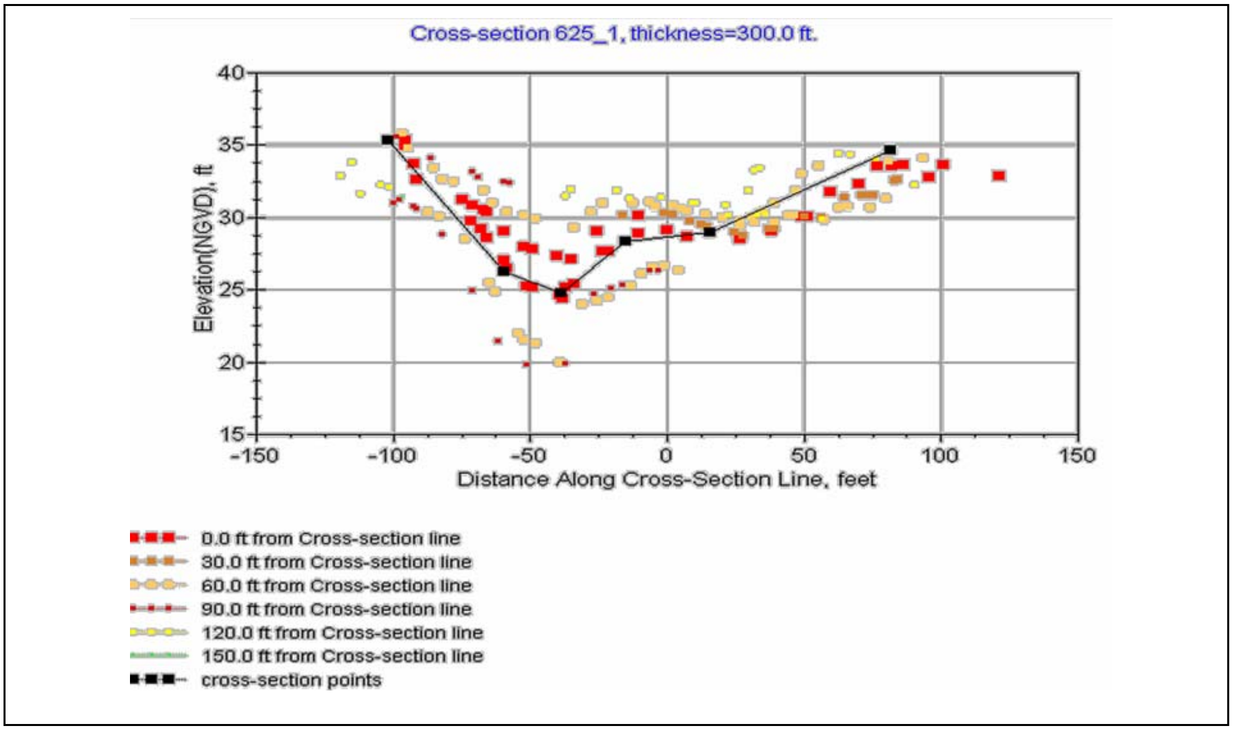

Figure 2.5: Irregular Cross Section with a Thickness of 300 Feet and a More Representative Width of Approximately 180 Feet at Channel Location 625_1.

The cross sections in the San Joaquin River between the Tuolumne and Stanislaus rivers were also adjusted to smooth the channel bottom by averaging unrepresentative and unusually low or high invert elevations that may form unrealistically large pools and riffles. Because the simulated travel time after the adjustment for widths was much longer than the field data indicated, the channel bottoms between the Tuolumne and the Stanislaus rivers were adjusted to induce lower velocities. As shown in Figure 2.6 the original DSM2 bottom geometry in the San Joaquin River upstream of Vernalis widely fluctuated, so adjustments were made within reason of the given elevation data (Figure 2.7).

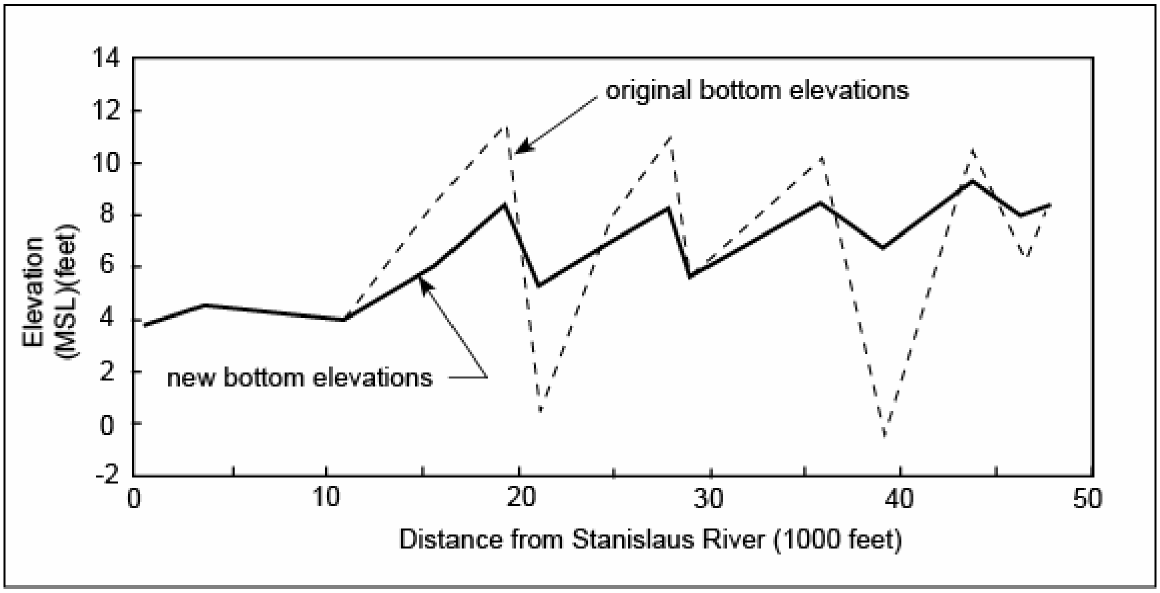

Figure 2.6: Thalwegs Constructed from the Irregular Cross Sections between the Stanislaus River Confluence and the Tuolumne River Confluence.

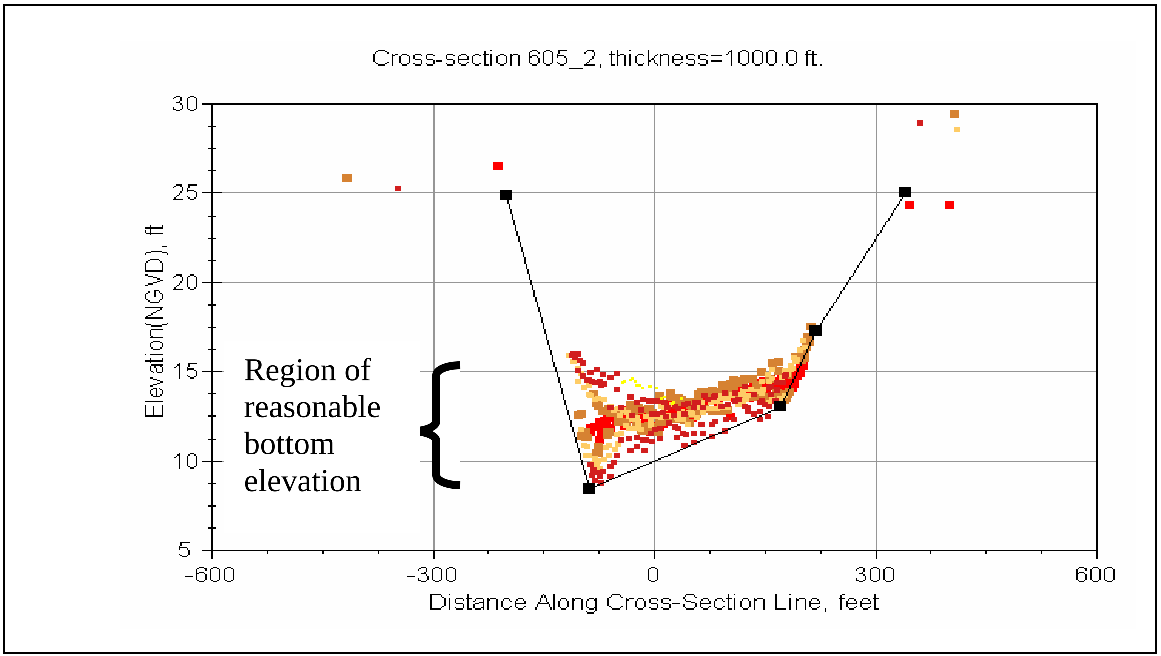

Figure 2.7: Irregular Cross Section along the San Joaquin River at a Distance of 19,330 Feet upstream of the Stanislaus River Confluence (Here the Bottom Elevation Was Lowered from 11.5 Feet to 8.5 Feet MSL).

After local widths and bottom elevations for cross sections were adjusted, a simulation of flow down the San Joaquin River produced noticeable improvements to travel times (Figures 2.8 and 2.9). The modeled February injection produced a travel time of 41 hours from the Merced River confluence to Vernalis. The modeled June injection produced a travel time of 88 hours from the Salt Slough confluence to Vernalis. These times are respectively 11% and 19% greater than the field data. Further refinements of the irregular cross sections to improve the travel times, such as smoothing the channel bottom in other regions, were attempted but were not effective and, therefore, not used.

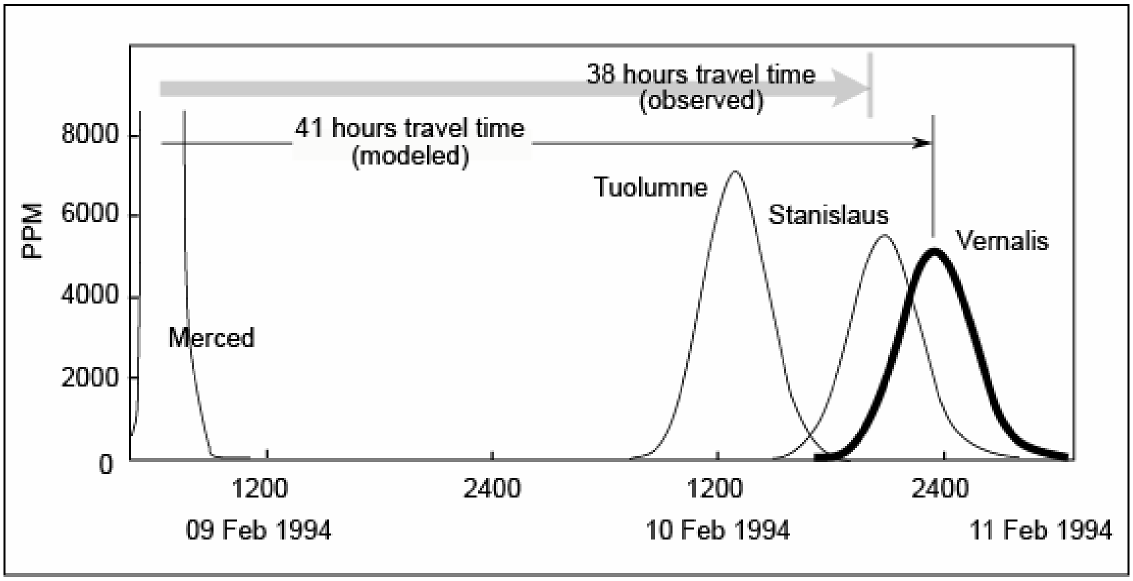

Figure 2.8: Travel Time in February with Final Adjustments to the Irregular Cross Sections.

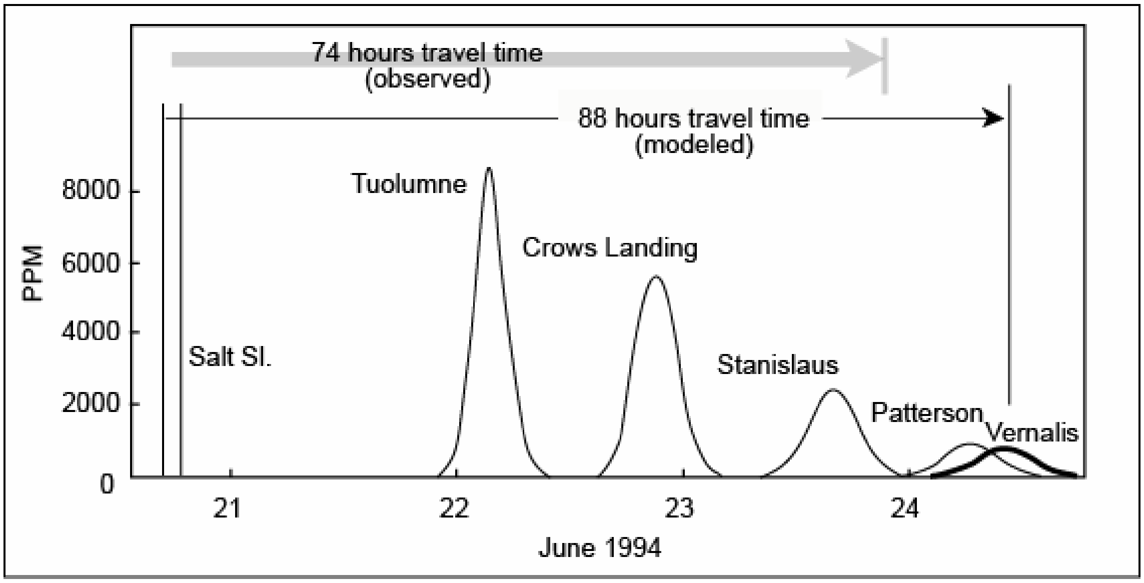

Figure 2.9: Travel Time in June with Final Adjustments to the Irregular Cross Sections.

2.5 Manning's *n* Adjustment

The DSM2-SJR channel description was further modified by adjusting the Manning's *n* values used in DSM2 to represent channel roughness and friction. The modification was made to better reproduce observed travel times during the dye-injection studies. The calibrated version of

DSM2-SJR assumed only two values for Manning's *n*: a value of 0.035 from the upper boundary of the grid near Stevinson down to the San Joaquin River near Patterson, and a value of 0.030 from Patterson to Vernalis.

Manning's *n* values were refined via experimentation to better match the estimated dye-tracer travel time to and from various locations down the San Joaquin River. Locations included Hills Ferry, Crows Landing, Patterson, the Tuolumne River confluence, the Stanislaus River confluence, and Vernalis. The Manning's *n* values that were considered most effective ranged from 0.024 to 0.037 and were applied as shown in Figure 2.10. The values are constant between the individual locations of the San Joaquin River: Stevinson to Salt Slough, Salt Slough to the Merced River, the Merced River to Crows Landing, Crows Landing to just above Patterson, just above Patterson to just below Patterson, just below Patterson to the Tuolumne River, the Tuolumne River to the Stanislaus River, and the Stanislaus River to Vernalis. The Manning's *n* value of 0.035 around Patterson was required for better stage agreement with data at the Patterson station.

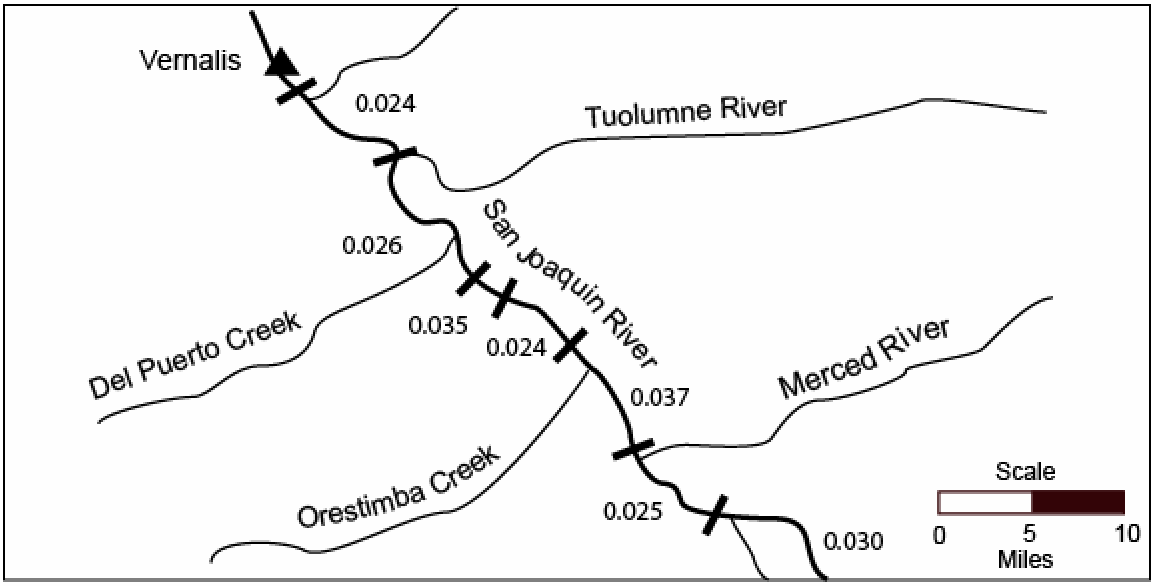

Figure 2.10: New Manning's *n* Values Used in DSM2-SJR.

The travel time of the DSM2 injections considerably improved using the adjusted irregular cross sections and the new Manning's *n* values. As shown in Figure 2.11, the observed February travel time from the Merced River to Vernalis was approximately 38 hours compared to the model's initial travel time of 37 hours. The June injection produced an observed 74-hour travel time from the Salt Slough confluence to Vernalis, compared to the model's initial travel time of 75 hours (Figure 2.12). These new simulated travel times more closely reproduce the respective field estimates of 38 hours and 74 hours.

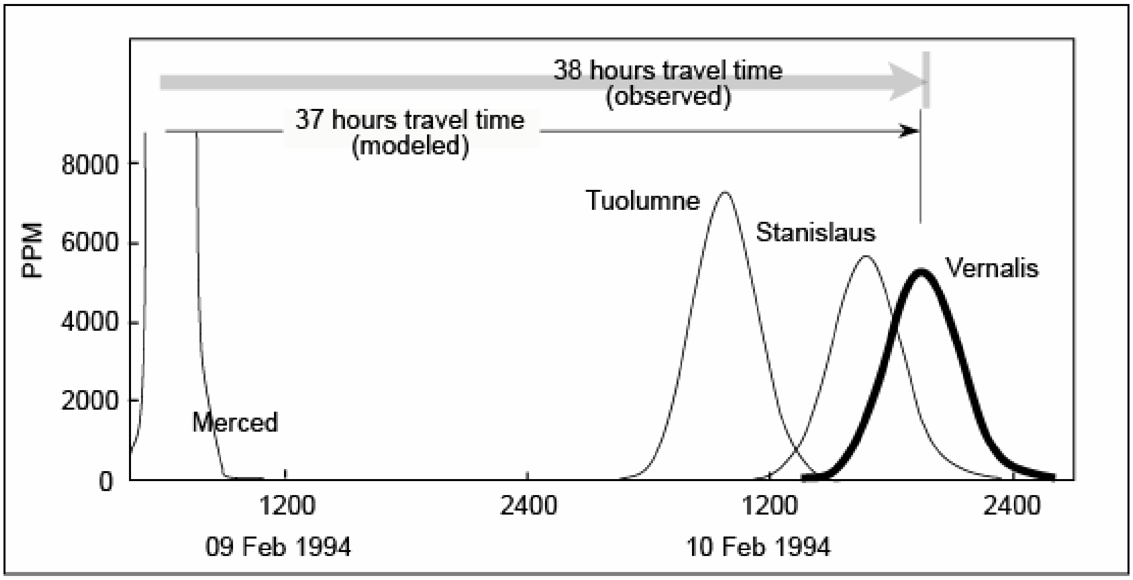

Figure 2.11: Travel Time in February with Final Adjustments to the Grid and Manning's *n* Values.

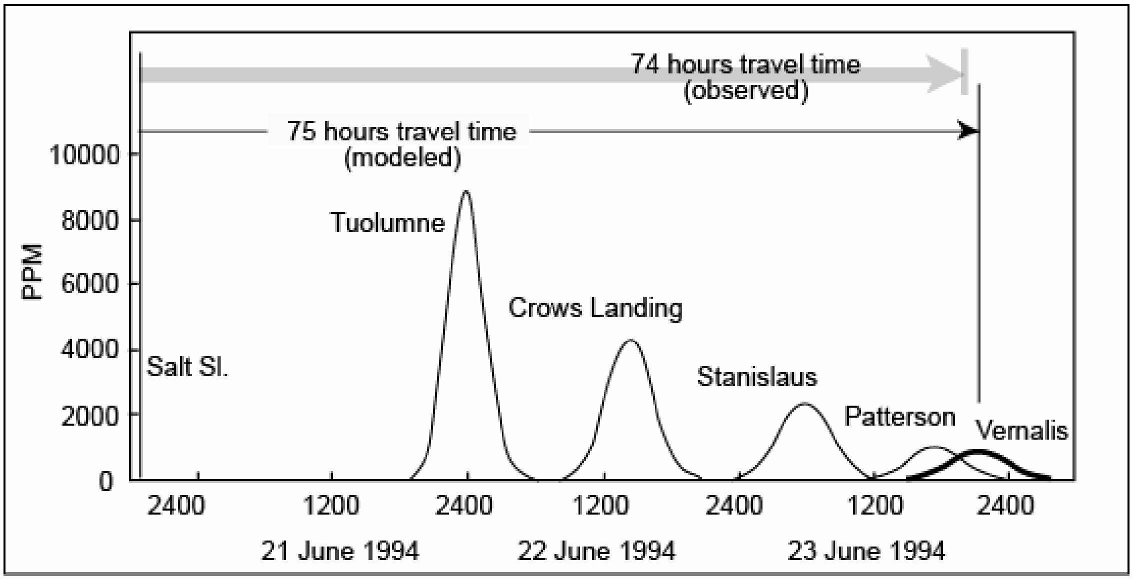

Figure 2.12: Travel Time in June with Final Adjustments to the Grid and Manning's *n* Values.

2.6 General Effect on EC and Flow

The modifications generally changed the timing of EC and flow values at Vernalis but did not greatly affect the magnitudes or overall trends. The most noticeable change in EC was a shift of a day earlier to changes in output concentration (Figure 2.13). The simulated travel time of changes in EC was decreased by about a day from Mud and Salt Sloughs, where a large portion of the San Joaquin River salt load is derived, to Vernalis. The flow at Vernalis also was shifted, but by a lesser degree than EC. As shown in Figure 2.14, the shift was up to half a day earlier depending on the relative volume of water entering at the Stanislaus River confluence. The effect to stage at Vernalis was minimal due to the changes in Manning's *n*.

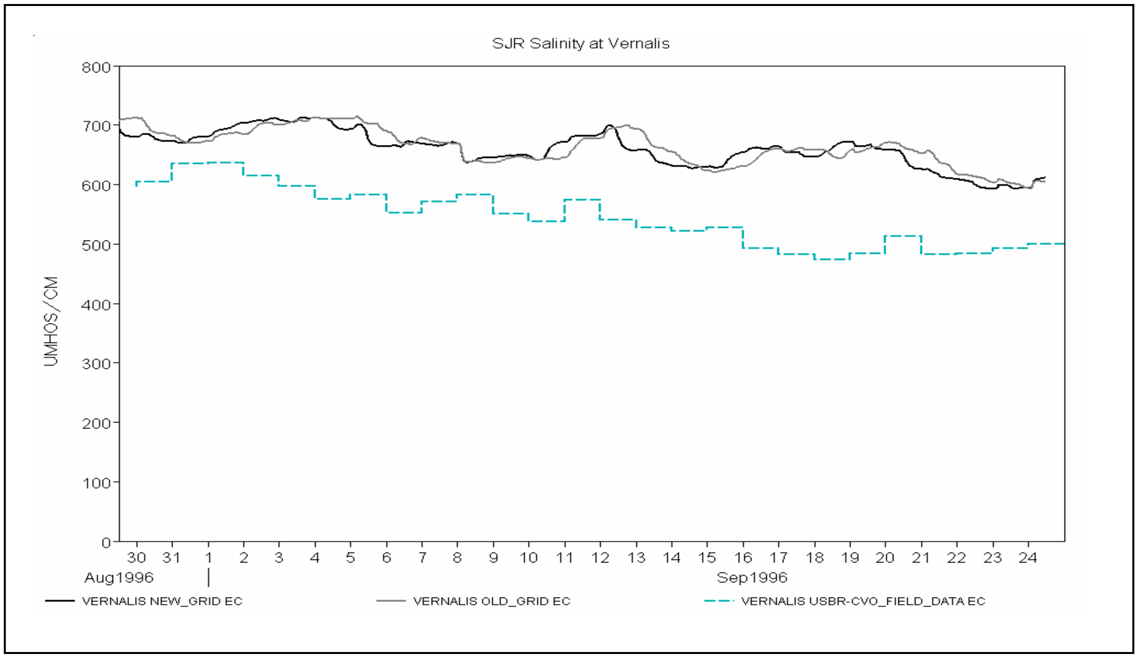

Figure 2.13: Example of Modeled EC at Vernalis before the Modifications (OLD_GRID) Versus after the Modifications (NEW_GRID).

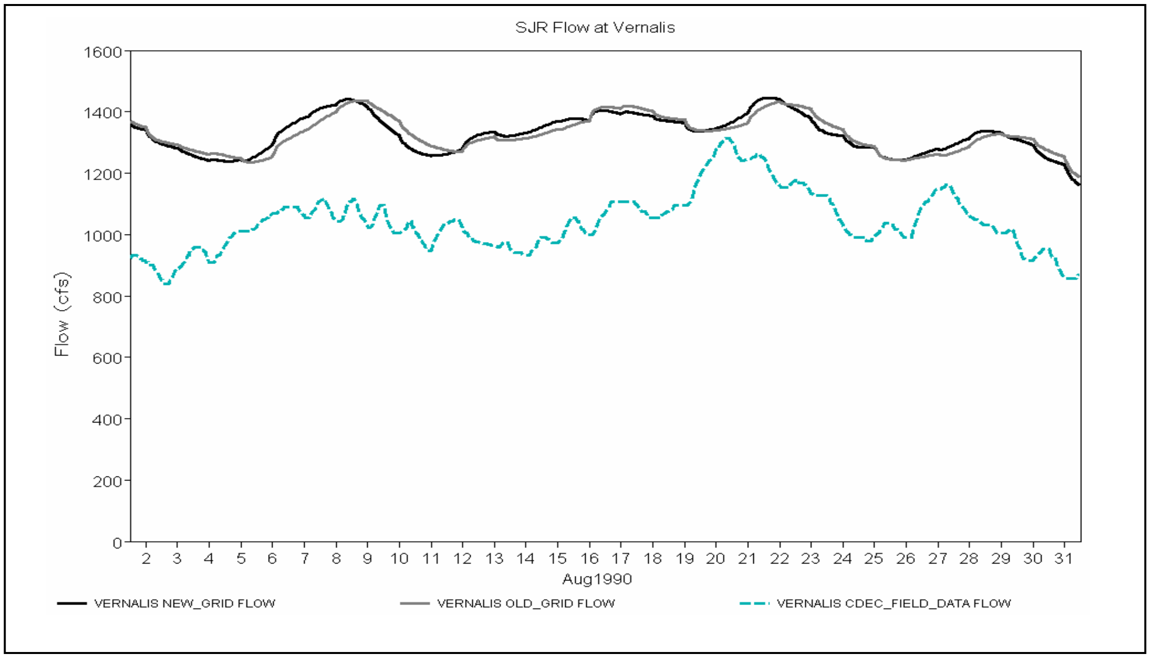

Figure 2.14: Example of Modeled Flow at Vernalis before the Modifications (OLD_GRID) Versus after the Modifications (NEW_GRID).

2.7 Summary

Kratzer and Biagtan (1997) estimated travel times for two dye-tracer studies performed in February and June 1994. Their work was the basis for a mini-recalibration of DSM2-SJR. Using the model as originally calibrated by the 1997 to 1999 period, travel times simulated in an attempt to replicate the 1994 dye-tracer studies were 132% and 143% of the field results. To enhance DSM2-SJR's appropriateness for non-conservative constituent estimations, the grid and applied Manning's *n* values were refined to better calculate hydrodynamics down the San Joaquin River from the Salt Slough confluence to near Vernalis. Modification to the irregular cross sections, bottom elevations between the Stanislaus and Tuolumne River confluences, and Manning's *n* values were applied to better simulate the travel times indicated by the 1994 dye-injection studies. As a result, DSM2-SJR simulations of flow in the San Joaquin River upstream of Vernalis improved.

2.8 References

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