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

22nd Annual Progress Report
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Chapter 2:
DSM2 Calibration and Validation

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2 DSM2 Calibration and Validation

2.1 Introduction

DSM2-HYDRO (HYDRO) and DSM2-QUAL (QUAL) were originally calibrated and validated in 1997 (see the Eighteenth Annual Progress Report, June 1997). Since then, a great amount of new bathymetry, flow, and water quality data have become available. A project work team (PWT) was formed with representatives from various agencies under IEP (Interagency Ecological Program). Members included representatives from the following agencies:

- DWR
- USGS
- USBR
- Contra Costa Water District (CCWD)
- Metropolitan Water District (MWD)
- Stanford University

Chris Enright (DWR, Environmental Services Office) was the chair of this PWT. The team was given the task of calibrating and validating HYDRO and QUAL. It was decided that the calibration/validation of DSM2 be an open process. All the results were posted on a public web-site during each iteration of the calibration. Conference calls made it easier for the PWT to frequently discuss these public results and agree upon what changes to make for the next iteration of the calibration.

Comparison of model-predicted values and field data was done both in an instantaneous and tidally averaged sense. The comparison of instantaneous data shows the model's capability to predict the tidal amplitude and phase. The comparison of the tidally averaged data demonstrates the long-term effects. It is also useful for evaluating flow splits at key locations in the Delta.

All the activities with regards to the calibration can be found at the IEP web-site at:

http://www.iep.water.ca.gov/dsm2pwt/dsm2pwt.html

2.2 Choice of Model Grid

Staff from DWR ESO (Environmental Services Office) had made several changes to the DSM1 grid. Most of the changes were in the Suisun Marsh area. IEP-PWT decided to adapt ESO's version of its grid map for the DSM2 calibration/validation effort. For a more in-depth explanation of the differences between the two grids, refer to the Twenty-First Annual Progress Report (pg. 10-2)

2.3 DSM2-HYDRO Calibration

HYDRO was calibrated using data from four different time-periods:

1- May 1988
2- April 1997
3- April 1998
4- Sept.-Oct. 1998

For HYDRO, the Manning's n parameter was chosen as the calibration parameter. The Manning's n set corresponding to the 1997 calibrated version was used as the initial set. With each subsequent run, these values were modified with the hope of achieving a better match. Phase and tidal amplitude error indexes were introduced to quantify the goodness of fit for stage. The magnitude of the error indexes was calculated for each period separately, and values were written directly on the figures. The presence of these indexes directly on the plot made it a lot easier to improve the fit. See Figure 2-1a and 2-1b for an explanation of these error indexes.

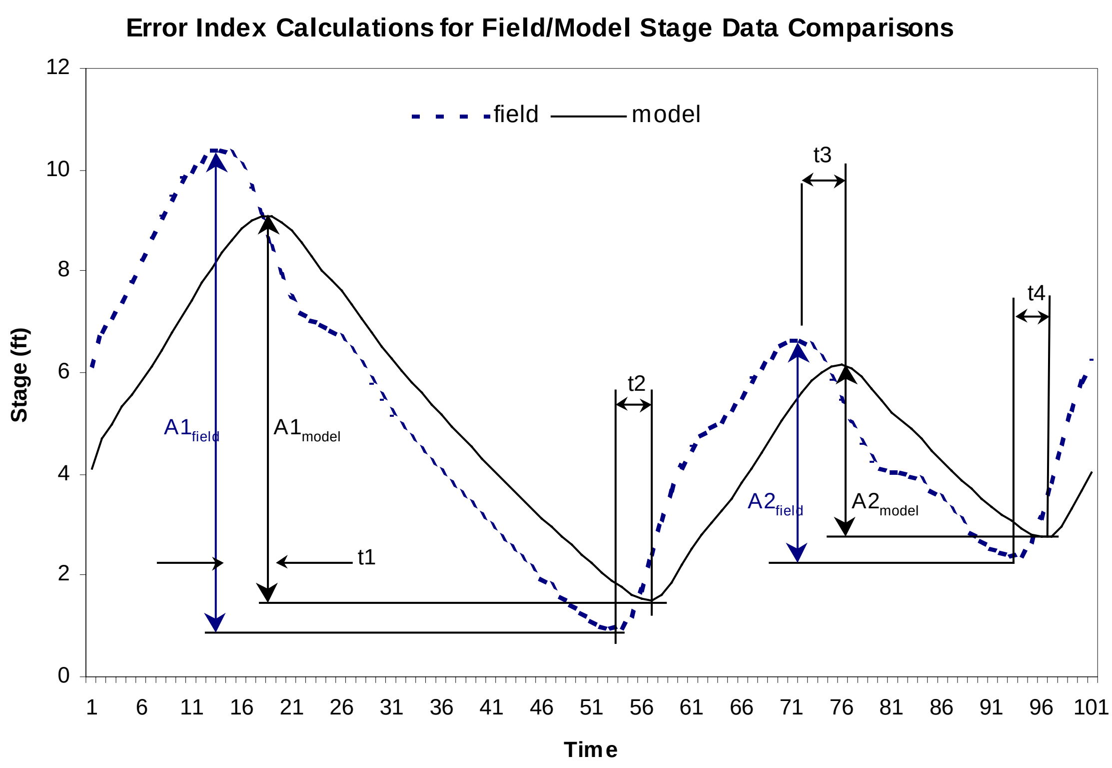

Figure 2-1a: Error Index Calculations for Field / Model Stage Data Comparisons.

Error Index Equations:

rms error = $\dfrac{[\text{sum(model-field)**2}]\text{**}.5}{\text{n**}.5}$

amp error = $\dfrac{\text{dif1+dif2}}{2}$ where: dif1 = A1model - A1field
(feet) dif2 = A2model - A2field

ph error = $\dfrac{(\text{t1+t2+t3+t4})}{4}$ where: t1 = time of model peak1 - time of field peak2
(minutes) t2 = time of model peak2 - time of field peak2
t3 = time of model peak3 - time of field peak3
t4 = time of model peak4 - time of field peak4

Figure 2-1b: Error Index Equations for Field / Model Stage Data Comparisons.

A total of 56 iterations were completed. In the final version, the Delta was divided into 59 regions, each containing one or more channels. Each group was assigned a single Manning's n value. Overall, model predictions for the final iteration of the calibration are noticeably closer to the field data than the 1997 version. This is especially true for the flow data. This is clearly important, since one expects that an improvement in flow predictions would naturally follow with improvements in water quality predictions. For a direct comparison of the results corresponding to the final iteration of the calibration with the 1997 version, the reader is referred to:

http://iep.water.ca.gov/dsm2pwt/calibrate/Run56vsRun1/index.html

2.4 DSM2-QUAL Calibration

Unlike HYDRO, QUAL was calibrated in one continuous interval. In general, QUAL needs about two to six months to 'warm-up'. In other words, the model results are affected by the initial conditions (initial water quality in all the channels) during that time span. HYDRO's predictions, on the other hand, are only affected by the initial conditions for about two days. This renders QUAL calibration for short periods impractical.

QUAL was calibrated using electric conductivity (EC) data. This was primarily due to the fact that EC data is in plentiful supply. The assumption was that EC behaves like a conservative substance. Ideally, one would prefer to calibrate using chloride data, which is believed to be truly conservative. However, chloride data are only available on a limited basis. Regression equations have been developed to convert EC to chloride, but these equations have their own errors. A recent investigation (literature search and data analysis) conducted by the Delta Modeling Section concluded that EC values of up to about 3,000 umhos/cm can be considered as conservative. EC values of 15,000 umhos/cm or higher are clearly in the non-conservative range. The Delta Modeling Section plans to revisit the QUAL calibration using 'Practical Salinity'. More explanation will be provided in the next annual report.

Meanwhile, the recent calibrated model is suitable for use with EC, but not for predicting other minerals, simply because the calibrated parameters are selected based on EC predictions. Use of the model for predicting organic constituents is also appropriate, since the ocean is not a major source of organics. See Chapter 3 for information about the validation of DSM2-Qual for DOC and UVA.

The choice of time period for QUAL calibration is also an important one. Periods with high flows with little salinity intrusion are not really suitable. Most suitable periods are dry periods, during which highly saline water from the ocean enters the Delta and blends in with the water that is from 100 to 300 times less saline. During dry periods, a small change in flow regime can potentially lead to noticeable changes in water quality. If the model predictions are close to field data for various dry periods, that would increase the level of confidence in the model. The IEP-PWT selected the 3-year period from October 1991 to September 1994. This period contains four sub-periods when high-salinity intrusions were recorded.

Dispersion factors were considered to be the calibration parameter. The Delta was divided into 22 regions, each containing many channels. Adjustments of the dispersion factors started from Martinez (the downstream boundary). The dispersion factors for regions further upstream were modified with each iteration. After 16 iterations, the IEP-PWT decided that the objective was met and calibration considered complete. The reader is referred to:

http://wwwdelmod.water.ca.gov/studies/calibration/base-hydro-56/run16cv15a/index.html

for a clickable map showing a comparison of the model results versus the field data. Overall, there is a good agreement. Salt intrusion into the Delta is captured fairly well. However, in the San Joaquin River between Antioch and Jersey Point and continuing up the Old River to Bacon Island, the model seems to over-predict the high peak of salt intrusion. This is especially evident in the summer of 1992. For an example, see Figure 2-2. For additional comments on the QUAL calibration, please refer to Sec. 2.6.

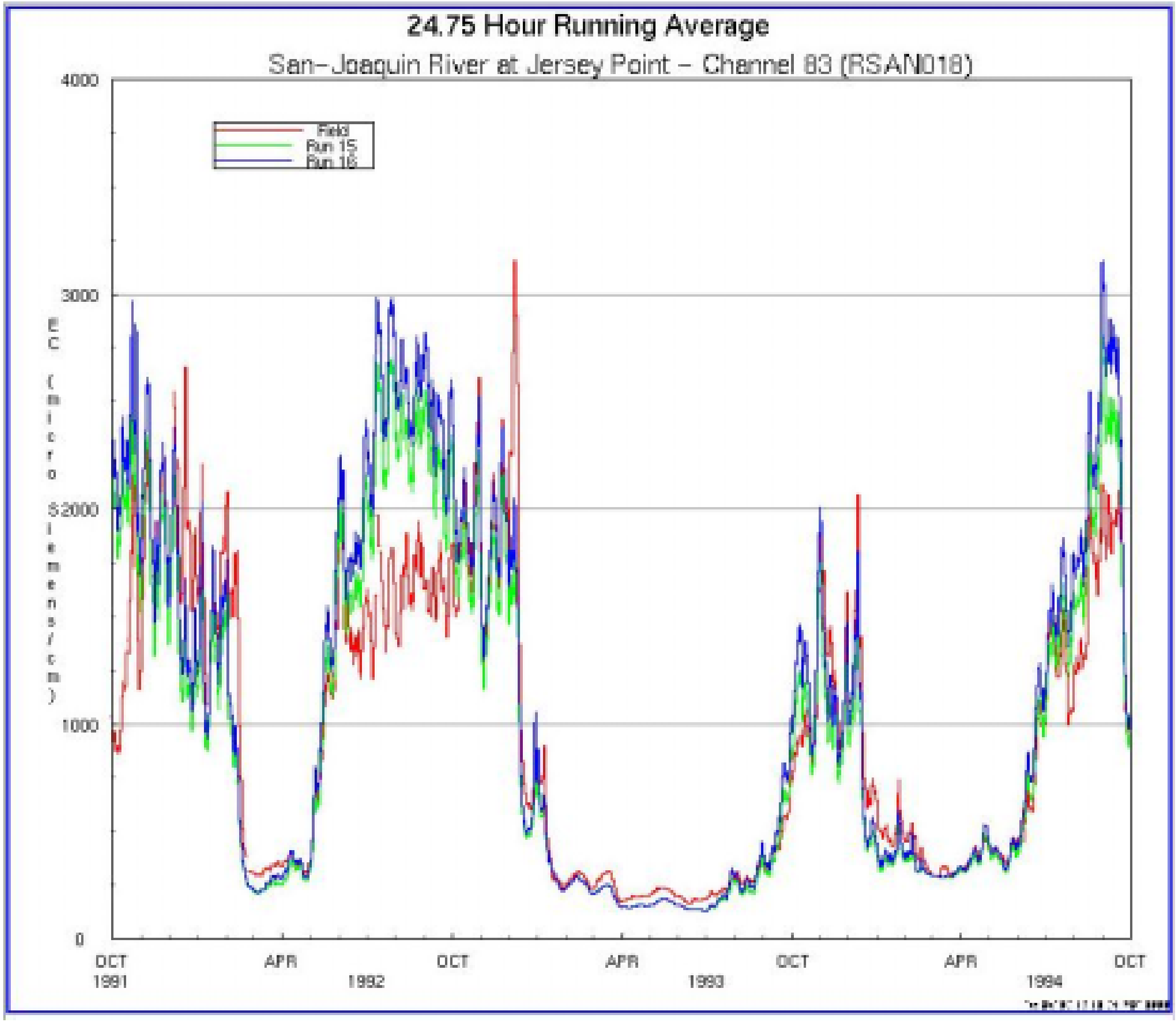

Figure 2-2: San Joaquin River EC at Jersey Point.

2.5 DSM2 Validation

Once the calibration parameters were selected, these parameters were kept constant. The validation period selected was from early 1990 to September 1999. The reader is referred to:

http://wwwdelmod.water.ca.gov/studies/validation/

for a clickable map pointing to all validation plots. There, the reader will find a three-way comparison of model predictions (flow, stage, and EC) for the new calibrated version (referred to as the new grid), the 1997 calibrated version (referred to as the old grid), and the observed data. These comparisons are available as 14-day moving averages, tidal day averages, and instantaneous plots. Overall, the results for the new calibrated model are in much better agreement with observed data.

2.6 General Comments on DSM2 Calibration/Validation

With HYDRO, flow predictions improved the most. This is especially true for Cross-Delta Flow (sum of flow going through Delta Cross Channel and Georgiana Slough), flow at Old River at Bacon Island, and Middle River at Bacon Island. During the course of calibration, it was discovered that the datum position for measuring the stage for many locations was questionable. This made it difficult to compare stage in an absolute sense. So the IEP-PWT decided to check stage amplitude and phase, and not rely on stage data in an absolute sense. Stage predictions also improved somewhat. The biggest improvement came in South Delta (Grant Line Canal and Old River near DMC), and North Delta (Sacramento River above Delta Cross Channel and below Georgiana Slough).

With QUAL, the validation period actually contained the calibration period. So to check the validation, one should look for the comparison of model output, either prior to October 1991, or beyond September 1994. Comparison of model results clearly shows a much better match for almost all locations with the new validated model. Surprisingly, in the reach from Antioch to Old River at Holland's Tract, model results show a better match during the validation period than during the calibration period.

The IEP-PWT looked for reasons for the EC over-predictions in the San Joaquin River during the calibration period. The IEP-PWT believes that inaccuracies in the channel depletion estimates are one possible cause of the over-predictions. Channel depletions are estimated by the Delta Island Consumptive Use (DICU) model. DICU computes channel depletions based on water needs of the plants, and assumes diversion water is in plentiful supply. As an example, according to DICU, Delta channel depletions for July 1992 were around 4200 cfs. When one computes the Net Delta Outflow (NDO) using this estimate, NDO values that approach 1000 cfs are observed (see Figure 2-3). Under such hydrologic conditions, a great amount of salinity intrusion is expected. This is clearly reflected in the model results. Yet, there is no trace of huge salinity intrusion in the field data. In fact, the field data show the peak salinity intrusion in 1992 to have occurred from October through December, with EC values about double those for the summer (as an example, see EC data for Jersey Point). This is an inconsistency since the computed NDO was, in fact, higher in October through December 1992 than in summer. The IEP-PWT performed a sensitivity test (run 17 versus run 16) with channel depletion values adjusted for 1992. This was done by decreasing the irrigation water demands for June through September by around 500 cfs. That, in turn, increased the water demands in October through November due to a lower stored soil moisture. The result is a predicted salinity that is noticeably closer to the field data. Channel depletion estimates can easily be off by 500 cfs or more. The IEP-PWT decided to concentrate on improving QUAL's performance during the next phase of calibration. Overall, the IEP-PWT does not feel that the mismatch from 1992 through 1994 in the San Joaquin River can be resolved without adjusting the flow field (i.e. NDO).

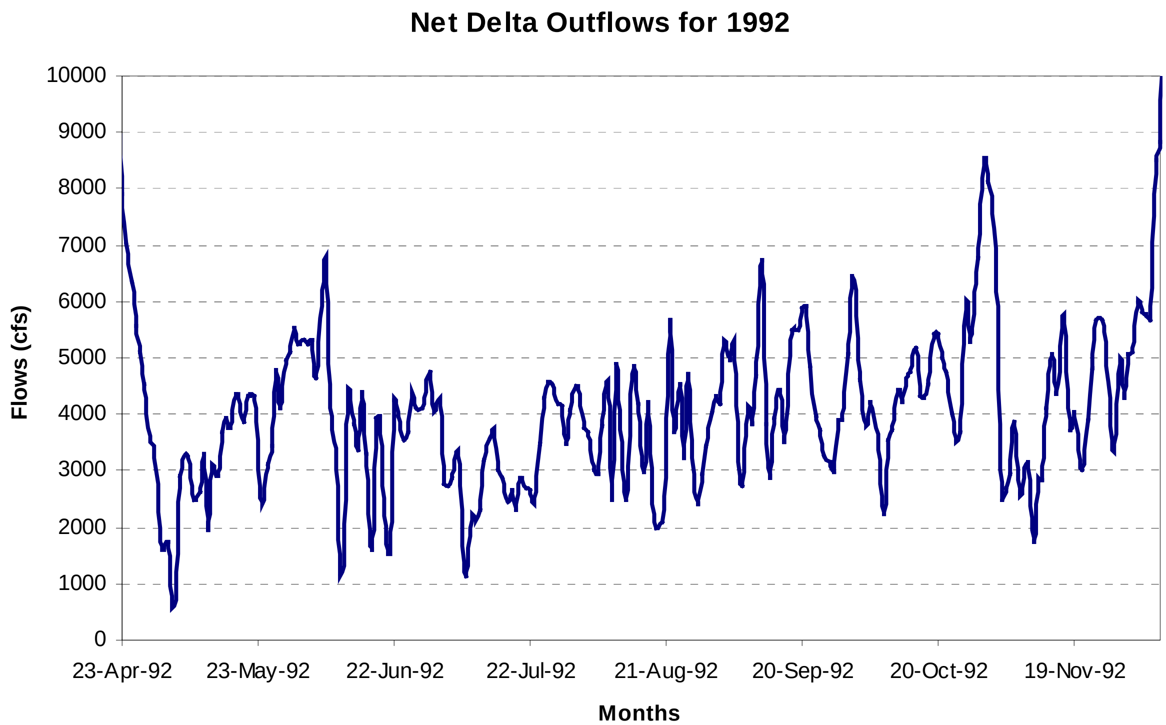

Figure 2-3: Net Delta Outflow for 1992.

2.7 Conclusion

Overall, model predictions using the most recent calibration seem to capture field conditions much better than the 1997 version. Since January 1, 2001, the Delta Modeling Section has officially started using the new calibrated version. It is, however, expected that there will be future calibration efforts when significant new bathymetry, flow, stage, and water quality data become available. The IEP-PWT also plans to look for ways to clarify some of the unresolved issues (such as DICU estimates).

Refer to Chapter 3 for work done in simulation of other water quality constituents such as DOC and UVA. For additional work done in dissolved oxygen and water temperature calibration, refer to Chapter 6.

2.8 References

California Department of Water Resources. (1997). *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 18th Annual Progress Report to the State Water Resources Control Board.* Sacramento, CA.

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