APPENDIX F KOHLER REPORT ON TIME DEVELOPMENT

This Appendix contains an unpublished memo written by Mike Kohler that contains relevant documentation on development of TIME v1.0. Since described by Wang et al. (2007), the TIME model was used to simulate hydrologic conditions under varying restoration plans as part of the Florida Bay Florida Keys Feasibility Study (FBFKFS), cosponsored by the U.S. Army Corps of Engineers and the South Florida Water Management District. In the FBFKFS, TIME output was used as boundary input in a Florida Bay version of the Environmental Fluid Dynamics Code (EFDC) (Hamrick, 2006) to improve salinity approximations produced by the EFDC. The development of TIME v1.0 as a result of the work on this project was completed before the project described in the main section of this report had commenced. The reproduction of the Kohler memo in this Appendix is intended to fill in the documentation gap on development of TIME during that period. The date on the original document file obtained by NPS staff from Mike Kohler is May 17, 2007.

LITERATURE CITED

Hamrick, J. (2006). *The Environmental Fluid Dynamics Code Theory and Computation; Volume 3; Water Quality Module*. Prepared for the U.S. Environmental Protection Agency, Office of Research and Development, by Tetra Tech, Inc., Fairfax, VA.

Wang, J., Swain, E., Wolfert, M., Langevin, C., James, D. and Telis, P. (2007). Application of Flow and Transport in a Linked Overland/Aquifer Density Dependent System (FTLOADDS) to simulate flow, salinity, and surface-water stage in the Southern Everglades, Florida, 114 p. Scientific Investigations Report 2007-5010, U.S. Geological Survey.

TIME Model Development for Representation of CERP Restoration Scenarios

Development of the TIME model for application to CERP restoration scenarios proceeded from the initial model construction described in Wang et al (2007). The TIME model is an expansion of the SICS application (Swain et al, 2004) using the combination of the SWIFT2D two-dimensional hydrodynamic model (Swain, 2005) and the SEAWAT three-dimensional ground-water model (Guo and Langevin, 2002) referred to as FTLOADDS (Langevin et al, 2005). This initial TIME model construction was based on a simulation period from 1996-2002 with boundaries defined by field data. Discharges at the coast to Florida Bay were output in terms of equivalent fresh-water flows as described in Wang et al (2007). This was designed for the interface with the Florida Bay EFDC model (Hamrick and Moustafa, 2003).

In order to represent the different restoration scenarios, the TIME model's inland boundaries are defined with values produced by the SFWMM (South Florida Water Management District, 2005), similar to the development described in Wolfert et al (2004). Inland discharge inputs are divided into two categories; "overland" flows from SFWMM model cells and "structure" flows that are from the canal control structures represented in the SFWMM. These inland discharge inputs are defined from SFWMM output and reflect the structural and operational changes between the scenarios ALT7R5, 2050B0, and CERP0.

Another change to the TIME model is the representation of the reservoirs west of the L31N canal. These areas are removed from the surface-water computational grid and any inflows or outflows accounted for as boundaries. Ground-water level boundaries are also obtained from the SFWMM for each of the three scenarios and distributed to the appropriate boundary cells in the TIME ground-water model. Water released in the Frogpond area through a reservoir floway is input directly to the ground-water model.

During the 12/06 PDT meeting, one main issue of concern was the large disagreement between the alternatives and observed salinities for both the TIME and EFDC models. It was assumed that the Alt7R5 alternative would be the closest to the observed conditions and therefore the models should be close to predicting observed salinities in both seasonal patterns and peak events. The similarity of salinities during the 1996-1999 period from all the alternatives to the observed conditions would pass most any qualitative or quantitative analysis. The period from 1990-1995 was the period of concern and the alternatives produced salinities that were 10, 15 or 25 ppt away from observed conditions. This was the main point brought up by the Model Reader and Time Series Analyst presentations of performance measures at the PDT meeting.

There were many possible reasons for the discrepancy that ranged from assumptions of fresh water flux to initial conditions, missing input data and model inadequacies or limitations. These all had to be examined for their effect on salinity. Some of the tests that were done compared the TIME transect flows to 2x2 transect flows, 2x2 alternative generated inputs and how they compare to observed inflow and observed stages. Some of the tasks done were to create initial salinity grids for models based on observed conditions and run assimilations, analyze the rainfall inputs compared to the 2x2 inputs for the same areas, update wind field and rainfall datasets for the 1990-1995 period, turn off inflows and rainfalls to evaluate effects, and much more.

This document describes the detail of the modeling efforts for the FBFKFS since the 12/06 PDT meeting. It contains the performance measure graphics that were shown at the PTD meeting that brought up the issue. Results of the testing and preliminary conclusions are presented to resolve the issue. Finally, an attempt was made to document the myriad changes that have gone into the alternative scenarios since the Fall of 2006 and any issues that were identified requiring specific assumptions.

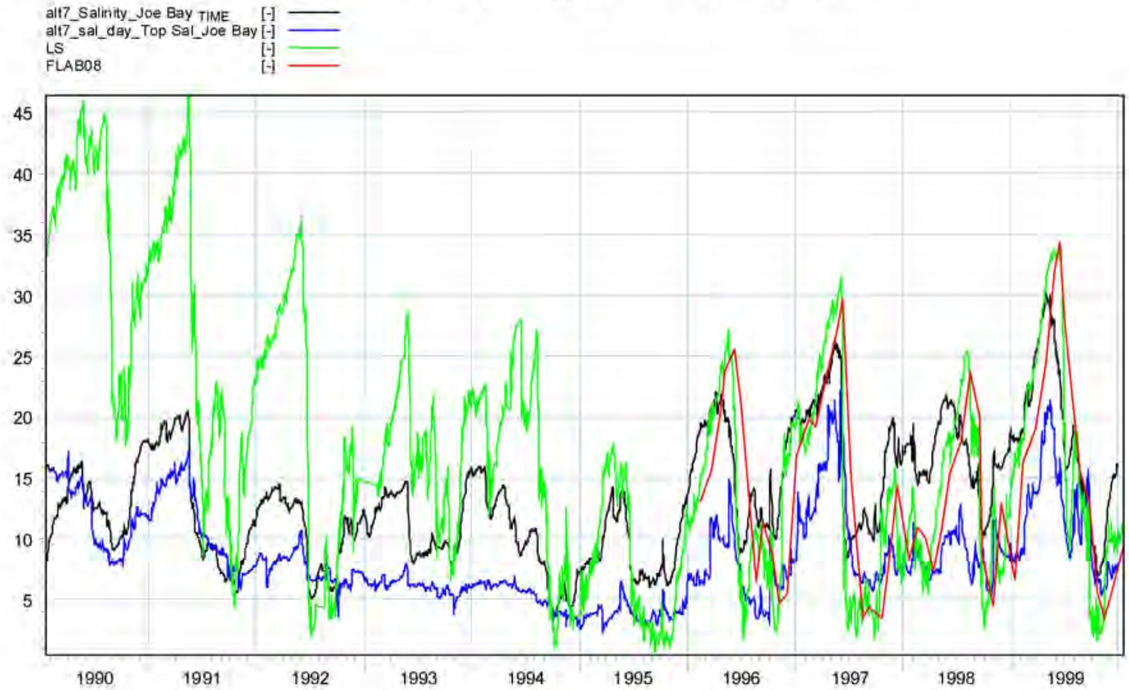
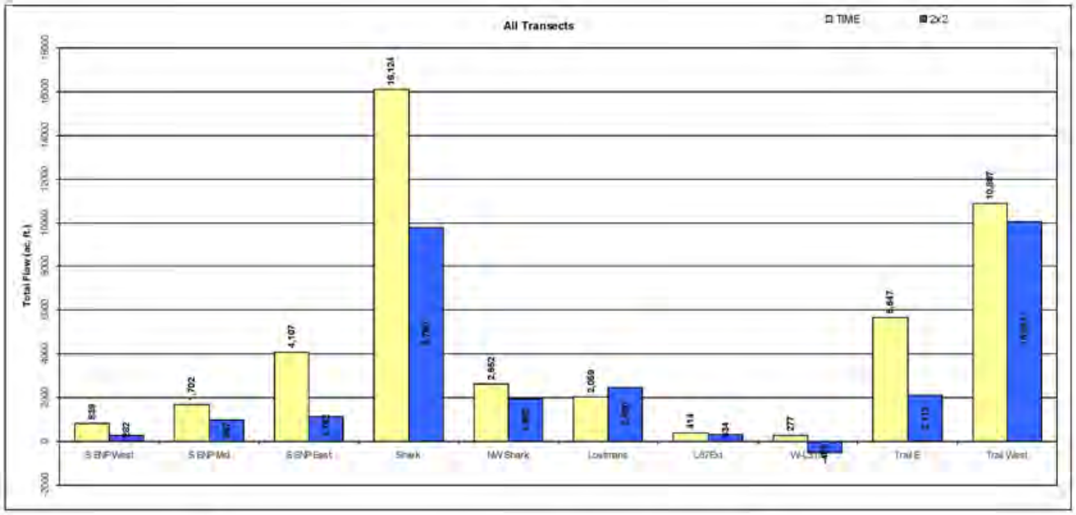


Figure 1: Plot from December 2006 PDT meeting showing modeled vs. observed salinity in the Joe Bay area.

Figure 1 shows a plot from the 12/2006 PDT meeting where the observed salinity is shown with the modeled salinity. The black line is the TIME modeled salinity, the blue line is the EFDC salinity, and the red and green lines are observed salinity at nearby FIU and ENP monitoring stations. From this graph, it is easily seen that during the 1996 to 1999 period, the modeled salinity matches observed salinity. The TIME model would seem to be a better fit, especially to the peak events. During the 1990 to 1995 period, the models have a very hard time predicting the peak events while the seasonal patterns are visible mainly in the TIME output. It was this graph that prompted the effort to perform a pseudo-calibration of the Alt7R5 alternative. During this effort, many tests were carried out to improve the prediction and quantify some of the limiting factors.

One of the first tests done was to examine how the surface water flows from the TIME model compared to the 2x2 model. To do this, the 2x2 model data was requested from the IMC and TIME data was extracted using the TIME Quick post processing program. For each year in the simulation and for each transect, the total flow across each transect was accumulated. Then a plot was created that showed the differences. These plots are shown in figure 2 and 3.



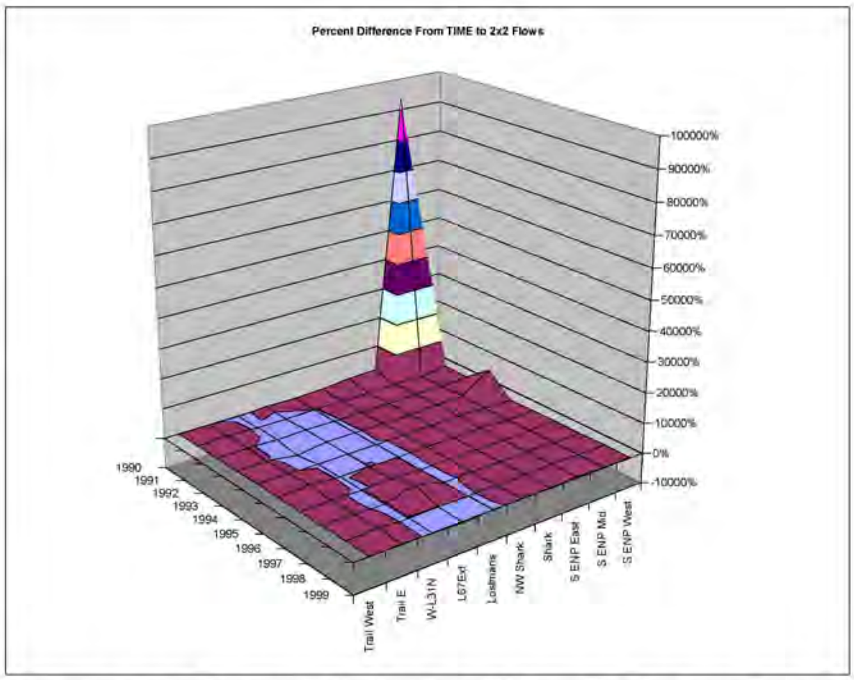
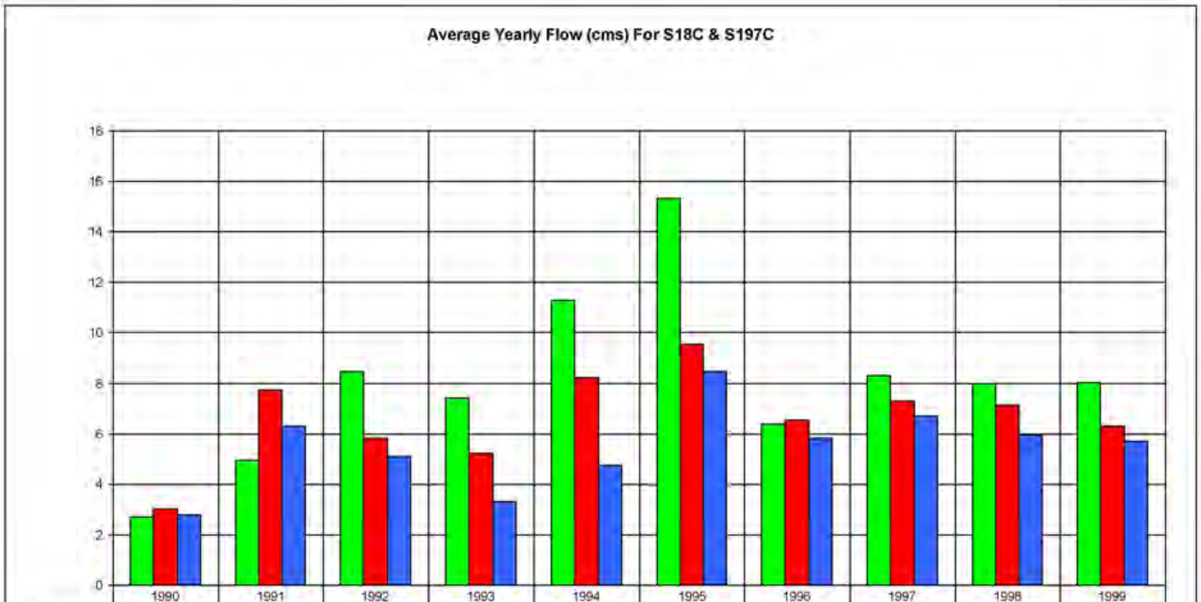


Figure 2, above, shows the total flow over the transect for the entire POR. Figure 3 shows the % difference from 2x2 flows to the TIME flows by year and transect.

From these 2 plots, it is easy to see that overall, the 2 models are in the same ranges and magnitudes. But there are some differences with the TIME model being higher than the 2x2. Figure 3 shows the percent difference for each year and transect between the 2x2 and TIME models. The obvious point in this figure is the spike in the Southern ENP transects at the start of the model simulation. The conclusion for this test is that the TIME and 2x2 models produced similar flows except for the Southern ENP. The reason for the discrepancy might be attributed to the inability of the models to properly simulate the flow of water from the C-111 area to Florida Bay. Other possibilities for this issue, and ones that will be examined next, are problems with either the inflows from the 2x2 model into TIME from the C-111 area or the initial conditions of stage for the TIME model.

For the 2x2 inflows, 2 tests were carried out. The first was to compare the 2x2 generated TIME structure inputs to the observed structure flows. The second test was to run the TIME model and replace the 2x2 inputs with the observed structure flows. This was a comparison of 2x2 generated inputs for the structures to the actual observed structure flow data and would determine if there was too much water coming in from the area around C-111.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Observed	2.71	4.96	8.47	7.41	11.30	15.33	6.39	8.30	7.98	8.03
Alt7R5	3.03	7.74	5.81	5.21	8.24	9.53	6.55	7.31	7.16	6.31
2050B0	2.79	6.33	5.10	3.29	4.74	8.46	5.82	6.71	5.94	5.70

Figure 4: Average yearly combined flows from the S18C and S197 structures for observed, Alt7R5 and 2050B0.

Figure 4 shows the average yearly flow from the S18C and S197 structures for the observed conditions as well as the Alt7R5 and 2050B0 inputs. For the period of interest where the predicted salinities are in disagreement, 1990-1995, the observed flows are generally higher than either of the alternatives. During the first 2 years where the hyper salinity event is at its worst, the Alt7R5 alternative is providing more water than under the actual observed conditions. From this, you can see that if the Alt7R5 flows were replaced with observed conditions, there would be more water flowing into the bay over the 90'-95' time frame. For the first 2 years where the salinity is at the highest, the Alt7R5 run is putting the same or more water in the bay than under the observed conditions. During 1990, the flows from all 3 are basically the same. While in 1991, the observed flows are less than the 2x2 generated for input to the TIME model. The 2x2 generated inputs are all that is available for the alternatives and even though the data may be questionable, the relative measures of difference between alternatives will still be significant. The best way to see what would happen in the TIME model if the 2x2 flows were closer to the observed flows was to run the TIME model with the structure flows replaced by observed conditions.

The plot in figure 5 shows the results of TIME run with the observed structure flows. From this figure it is evident that the structure inputs are of minimal importance as far as salinity is concerned.

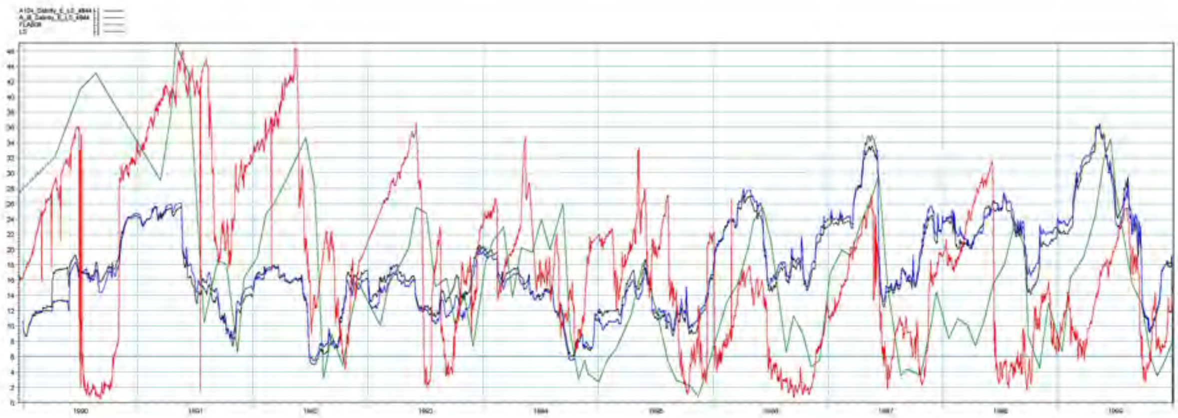


Figure 5: Salinity plot of Long Sound IR with FIU and ENP observed salinity data for the replaced structure input flow test of TIME Alt7R5.

The blue and black lines are the original 2x2 structure flow salinity and observed structure flow salinity. The red and green lines are the ENP and FIU Long Sound observed station data. The data taken from the model for this test was a single TIME cell and was compared to a single observation station at the same location. The observed structure inputs had very little impact with the average for both being 17.7 psu. The peak events in the start of the model run are off by around 20psu. While this value is much smaller in the well behaving 1996+ time frame. One of the things that is easily seen is the difference for the starting salinity of observed and modeled being 10 to 15 psu off. This prompted the test with the initial conditions changed.

Changing the initial conditions should show little to no significant difference when the model has equilibrated and reached a steady state. Given that the issue is at the start of the modeling period, there may be a large warm-up period, causing a larger discrepancy, if the starting salinity is too low. This test changed the initial salinity and compared the results to previous runs. Figure 6 illustrates the difference in salinity caused by changing the initial salinity.

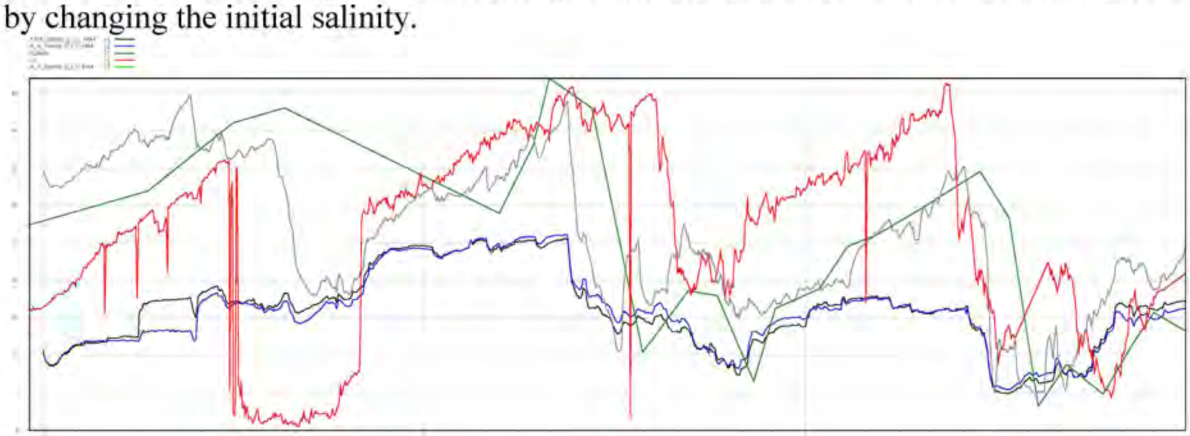


Figure 6: Plot showing the results from changing the initial conditions of salinity and stage of water level.

Besides the change of initial conditions of salinity, this plot also shows the results of dropping the initial stage of water level. The gray line represents the salinity from the changed initial conditions. It is quite obvious that the changes resulted in a dramatic improvement of salinity prediction from the TIME model. The change to initial salinity for the TIME and EFDC models came from observed data. The observed salinity for 1/1/1990 was extracted for all ENP stations. The FIU dataset was used to get salinity for the closest sampling date to the 1/1/1990 start date. A total of 12 stations were used in an interpolation process to create a salinity surface. The surface was then used in conjunction with the model grids to produce a single salinity value for each model cell from observed conditions.

The reason for the change in initial salinity was seen in figures 1 and 5. The reason for the change in initial stages was less evident in the salinity plots and more visible in figure 3. To see this aspect, transect flows are best. Figure 7 shows the flows across the Southern ENP middle transect that represents the Taylor Slough.

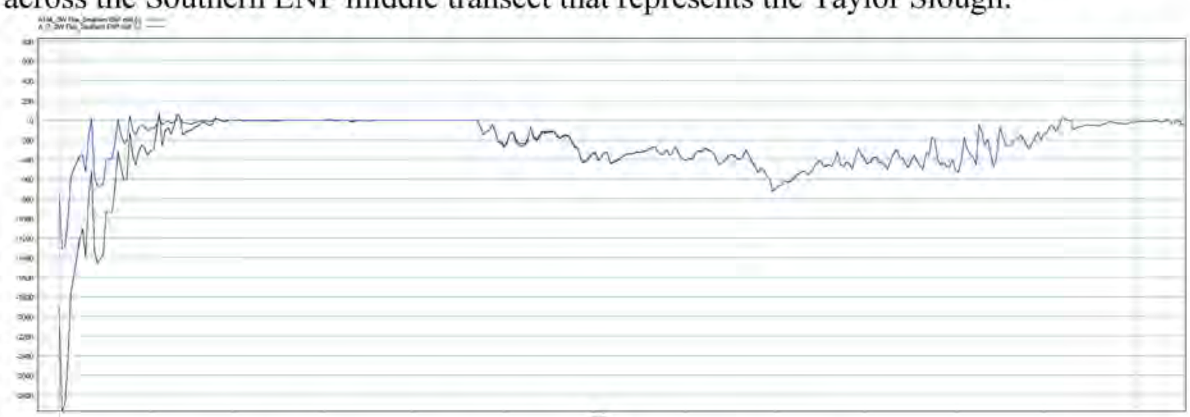


Figure 7: Graph of flow over S ENP Mid transect for 1990.

The black and blue lines represent the flow for the original and modified initial conditions run. From figure 7, it can be seen that when the model starts, there is an extremely large flow event to the bay through Taylor Slough. The 1990 year was dry and there should not have been flows this large during this time period. With the models severely under predicting salinity in this time frame, it seems evident that there is too much fresh water moving to the bay causing the lower salinity. The TIME model started with the water level at a level pool. This was done to avoid dry cells at the start of the model. This issue had been fixed in the model code and the initial water level could be dropped without any impacts.

This describes the changes that were made to the TIME model to improve the predicted salinity at the start of the simulation. The EFDC went through a few tests to evaluate the early salinity issues. One of the most important features of the model integration is the dependence of the EFDC on the TIME outflows and the dependence of TIME on EFDC salinity for boundary conditions in the bay. If the TIME model doesn't give the EFDC the right flows, then how can the EFDC produce the right salinity? Additionally, if the TIME model can't do a decent job of predicting the salinity, then how can the EFDC predict salinity when the inflows provided by TIME are wrong?

The first test done to the EFDC was to run the model without inflows. The EFDC receives water by the TIME model providing outflow through river cells and through rainfall. To see if the EFDC was even capable of producing salinities in the hypersaline range, the model was run with the rainfall and inflows turned off. The salinities were then compared to the observed data. Figure 8 illustrates this test.

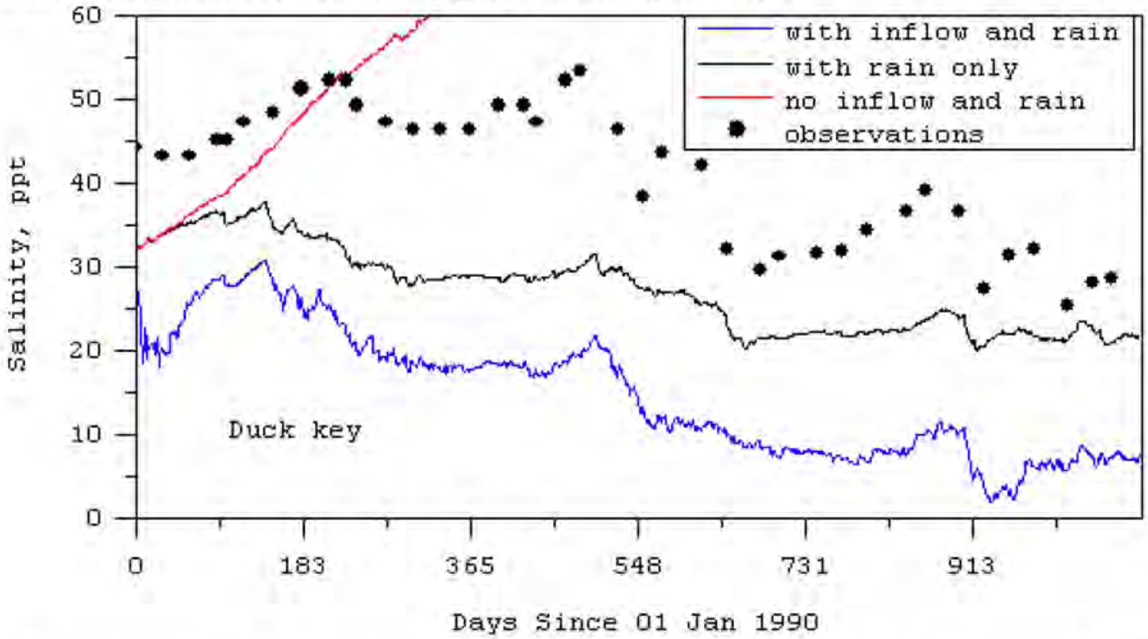


Figure 8: EFDC model test of Alt7R5 with the inflow and rainfall turned off.

From the graph, one can see that with the rainfall and inflow turned off, the salinity quickly rises off the scale. Of important note in this plot is the black line that shows what the salinity is like when there is only rainfall. The difference in the black and blue lines is caused by the TIME inflows. The rainfall only test being short of observed conditions would tend to indicate that there is too much rainfall in the system. With only rainfall, one would expect the salinity to be higher than observed. Figure 9 illustrates the same plot at Whipray Basin and there are a few key differences.

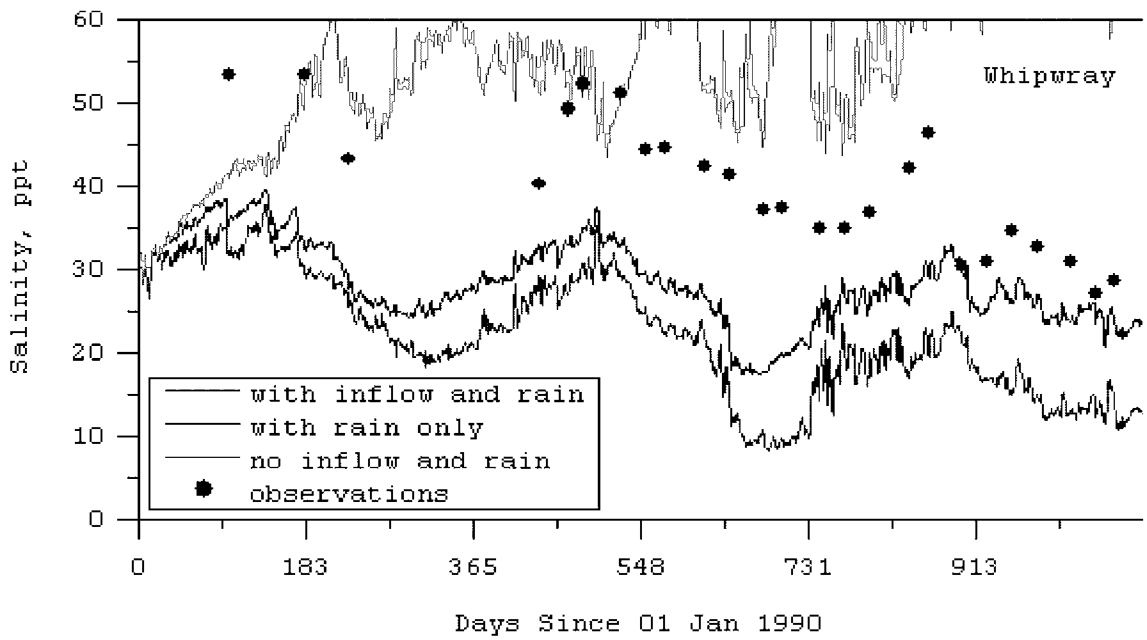


Figure 9: EFDC model test of Alt7R5 with the inflow and rainfall turned off at the Whipray Basin FIU monitoring location.

Figure 9 shows the same key features as seen in Duck Key. The difference is the magnitude of the separation between the black and blue lines being smaller. Another related difference is the slope of the red line being shallower. Whipray Basin is more isolated from the effects of coastal influxes from ENP. This makes Whipray more sensitive to open boundary conditions along the south and west than to input from the ENP areas. The time that it takes salinity to reach higher levels is almost 3 years while the Duck Key salinity took under 1 year. The open boundaries are providing some recirculation allowing the salinity to climb slower. The black and blue lines show the differences caused by inflow to the EFDC from TIME. Given the location of the basin, it is expected that the differences would be less obvious offshore than closer to the source of inflows.

During the TIME testing, EFDC was also running tests like those above. The interaction between models is one of the most exciting features of the FBFKFS. Finding the best way for the two models to exchange information is of utmost importance. This is evident in the tests that have been done. Figure 10 gives a plot of an EFDC run with increased initial salinities as was done with TIME. This figure clearly shows an improvement in the start of the model that quickly dissipates. This test had all inflows and rainfall turned on. The quick reverting to the same values as shown in figure 9 tend to point to the TIME inflows as providing too much fresh water as well as there being too much rainfall. During the testing process, the 3 year TIME run with increased initial salinity and decreased initial stage passed data to the EFDC whereby the EFDC was run again. This produced the data shown in figure 11. This clearly shows a marked improvement in the salinity compared to observed conditions and only reinforces the idea that EFDC is very dependant on TIME. Figures 12 and 13 show the same plots at Duck Key.

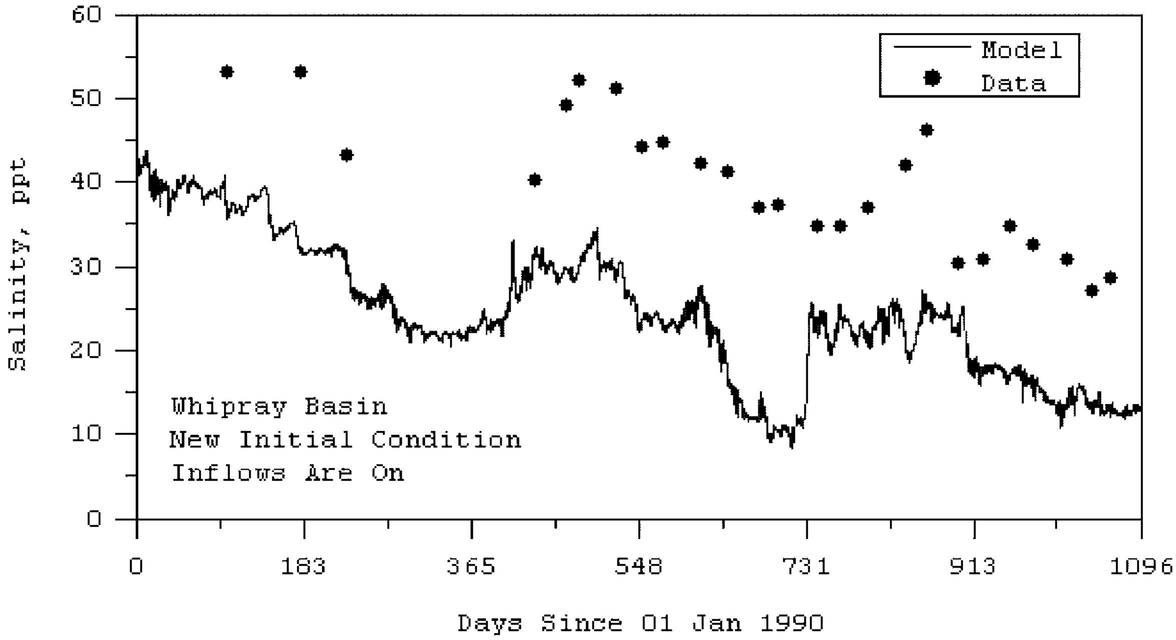


Figure 10: EFDC model test with increased initial salinity from observed data.

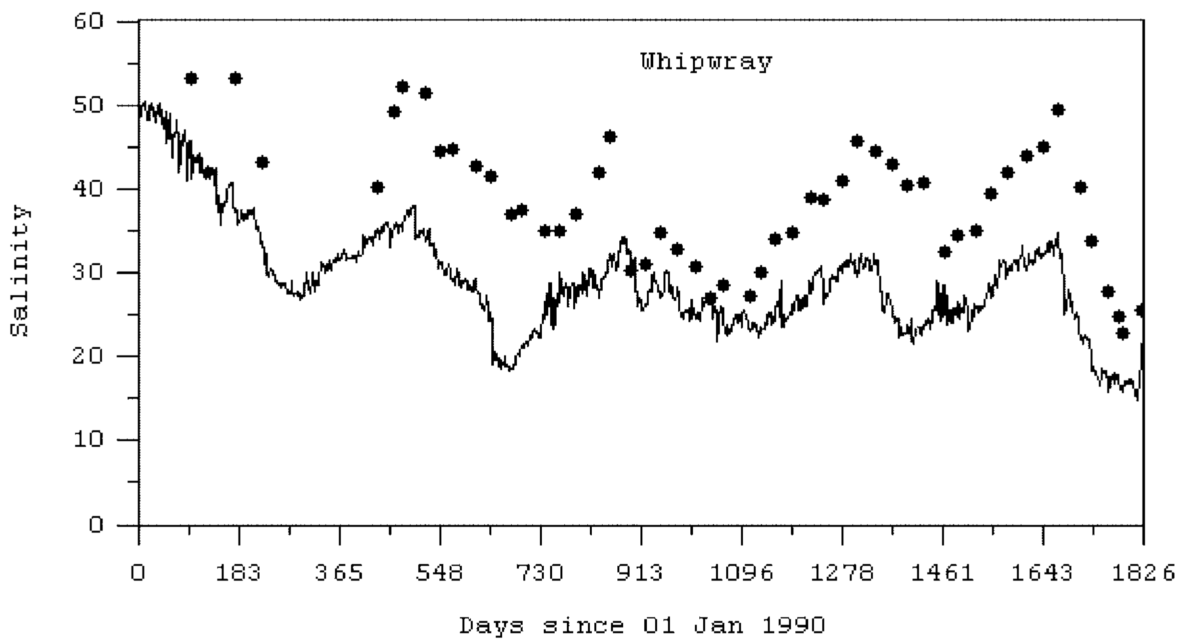


Figure 11: EFDC model test with increased initial salinity and updated TIME inputs from the latest testing.

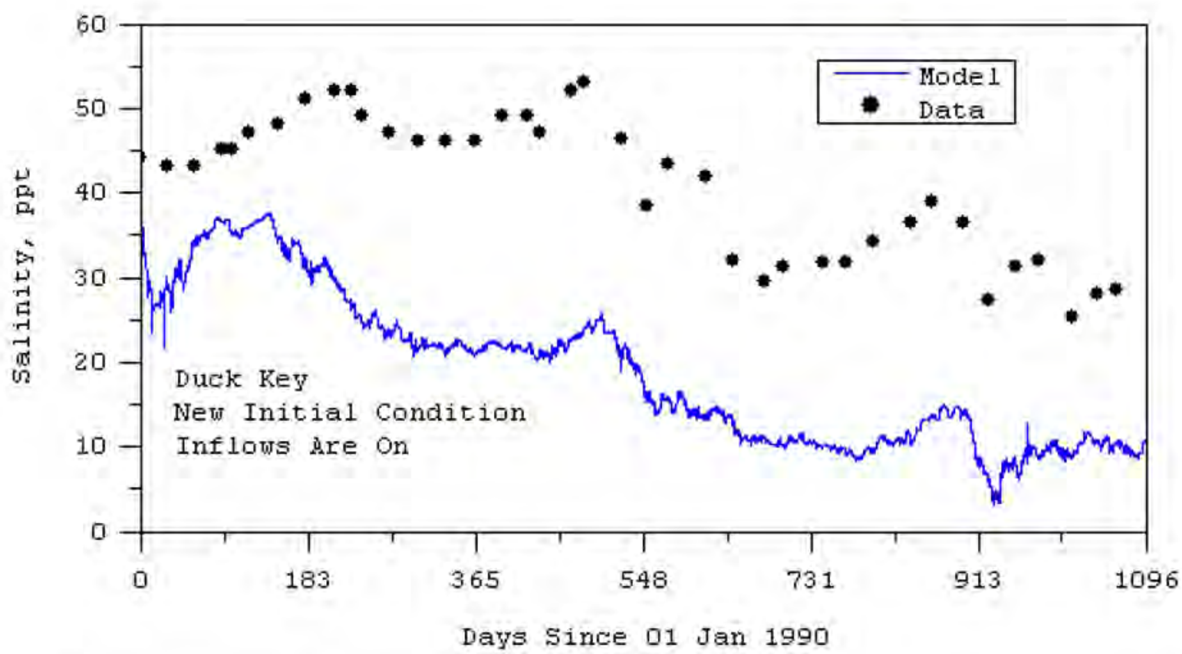


Figure 12: EFDC model test with increased initial salinity.

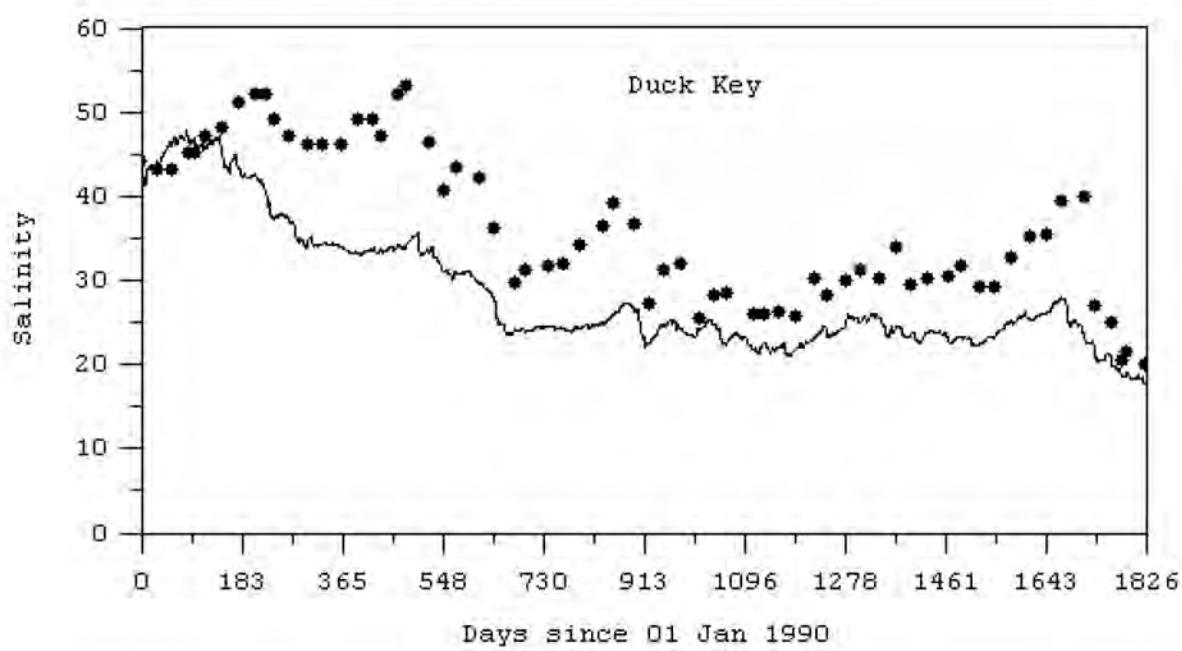


Figure 13: EFDC model test with increased initial salinity and updated TIME inputs from the latest testing.

The Long Sound area continues to be one of the areas where salinity is underpredicted. In the original SICS application, three culverts that connect Long Sound on the eastern side under U.S. Highway 1 with Manatee Bay were represented (Swain et al, 2004) however this was not originally in the TIME model due to the low net flows through these culverts. In order to better represent salinity in Long Sound, the effects of these culverts were incorporated. No continuous flow measurements exist at the culverts, but point measurements indicate tidal reversals with low daily net flow. The culverts are represented at a point salinity source with zero advection. Salinity values are from the SFWMD Manatee Bay monitoring station. Results with this new representation are shown in figure 14.

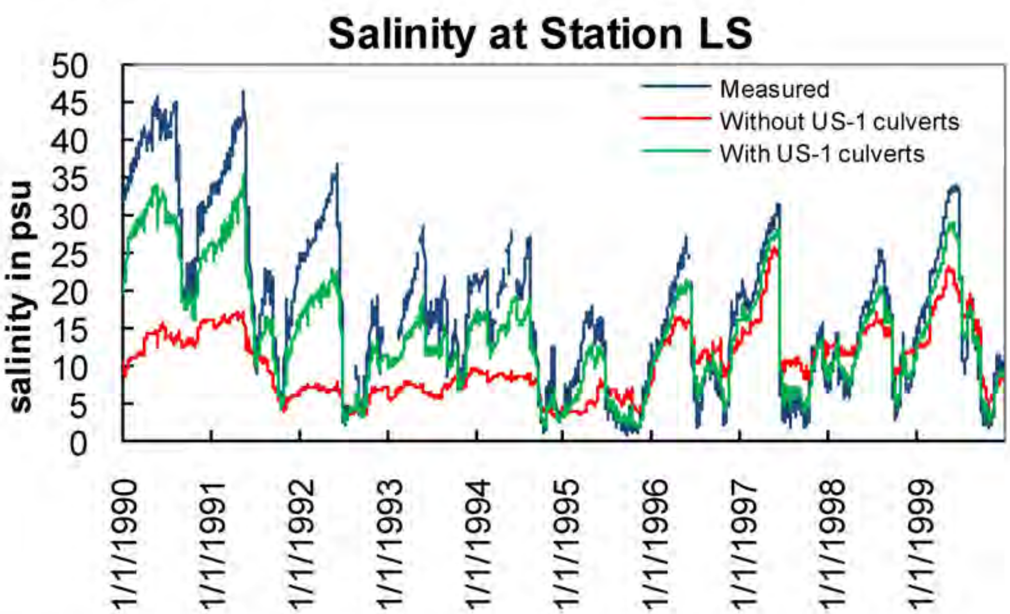


Figure 14. Salinity in Long Sound with addition of culverts under U.S. Highway 1.

The issue of how the salinity of the coastal discharge from the TIME model to the EFDC model is expressed also affected the interaction of the models. The original technique to compute equivalent freshwater flows from inland to offshore was based on the concept of calculating a quantity of freshwater that will have the same effect on the offshore waters as the actual outflow. Note that the effective freshwater flux is not designed to have the same effect on the inland waters as the actual outflow, only the effect on the offshore waters. Figure 15 shows the concept of flux computed from the TIME model to the EFDC model.

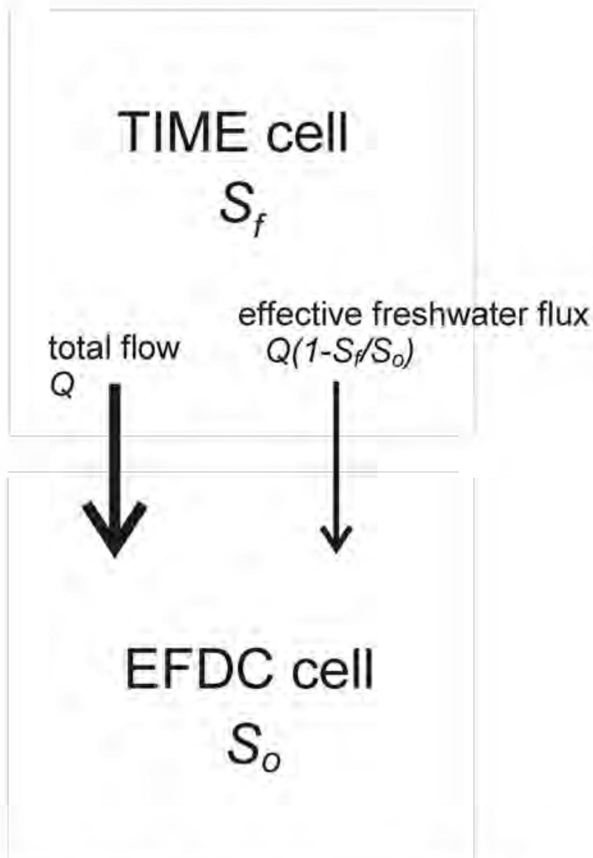


Figure 15. – Actual and freshwater flux.

Thus the equivalent freshwater flow does not correspond to an actual volume; it is a function of the salinity of the receiving water. For example, if the offshore water was totally fresh, any flow of water from the inland could not reduce the salinity and would result in zero freshwater flux.
The initial technique was to calculate the fraction of seawater salinity that the outflow has by:

$$1-\frac{S_f}{S_o}$$

Where S_f is the salinity of the outflow and S_o is the salinity of the seawater. Originally, the value of S_o was set uniformly to 36 psu to represent the "typical" seawater. This fraction is then multiplied by the total flow to get the equivalent freshwater flow:

$$Q_f = Q\left(1-\frac{S_f}{S_o}\right)$$

Although the initial simulations of the TIME model has user defined salinity boundaries, the later simulations use salinities generated by the EFDC model at the boundary locations. The logical value to use for S_o is these same values from the EFDC model; so the resulting freshwater flux is assumed to reach the same EFDC cells, and have the same effect, as the actual flow.
Complications to the scheme arise when:
1) the flowrate Q is towards inland (negative) and;

2) S_f is larger than S_o; this is more likely to occur when EFDC salinity is used for S_o.
In the original computational scheme, when condition 1 occurred, the freshwater flux computed was stored up, and then applied the next time flow was positive (towards the sea). This scheme was somewhat arbitrary and did not produce the desired effect. When water is removed from the sea, the seawater salinity is not changed, so an applied freshwater flux is not appropriate. The algorithm was changed so that freshwater flux was only calculated when flow Q is towards the sea.
Condition 2 should be rare or S_f/S_o should only be slightly more than one. Conditions where the inland salinity is higher than offshore are observed in the simulation initialization; when initial values at the TIME model boundary are high, but this is considered a model warmup condition. The freshwater flux equation tends to become increasingly negative when this happens, trying to remove freshwater from the sea. This is an inappropriate application of the equation, in that S_f/S_o asymptotically approaches infinity as S_o goes to zero. Given the anomalous nature of condition 2, zero freshwater flux is added to the sea when the inland water's salinity is equal to are higher than the offshore. In summary:

If Q is positive (seaward) and S_o greater than S_f, $Q_f = Q\left(1 - \frac{S_f}{S_o}\right)$

If Q is negative (inward) and/or S_o less than S_f $Q_f = 0$

If S_o equals zero, $Q_f = 0$

The method of computing an equivalent freshwater flow was initially considered important due to the need to conserve storage space and minimize the amount of data that needed to be transferred from the TIME model to the EFDC. However, using binary storage protocols, file size turned out to not be such a problem. So a method which simply outputs from TIME the total discharge values and salinity was implemented and compared with the equivalent freshwater flow method. Overall, using the total discharge and salinity produced a better match at comparison locations than the equivalent freshwater flow method, as shown in figures 16 A-D below. This may indicate that the neglecting of volumetric changes in the equivalent freshwater flow method is significant.

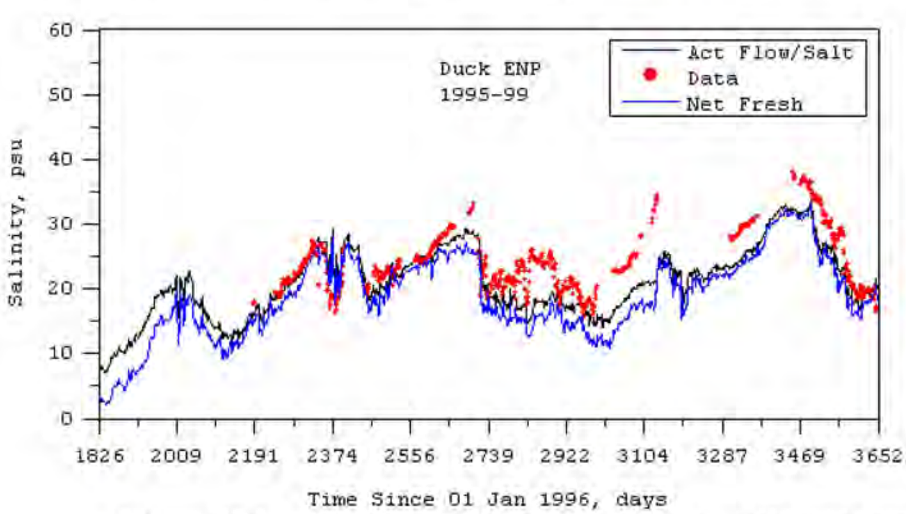


Figure 16A – Duck Key salinities using two methods to transfer salinity.

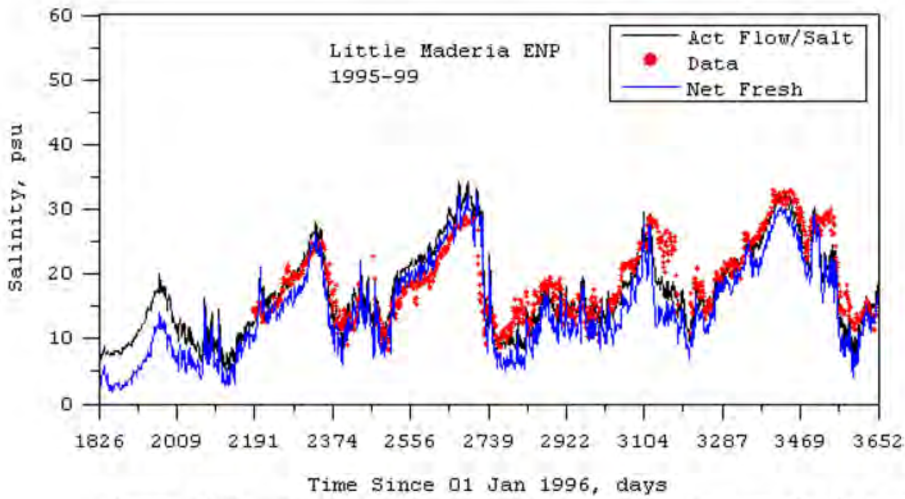


Figure 16B – Little Maderia salinities using two methods to transfer salinity.

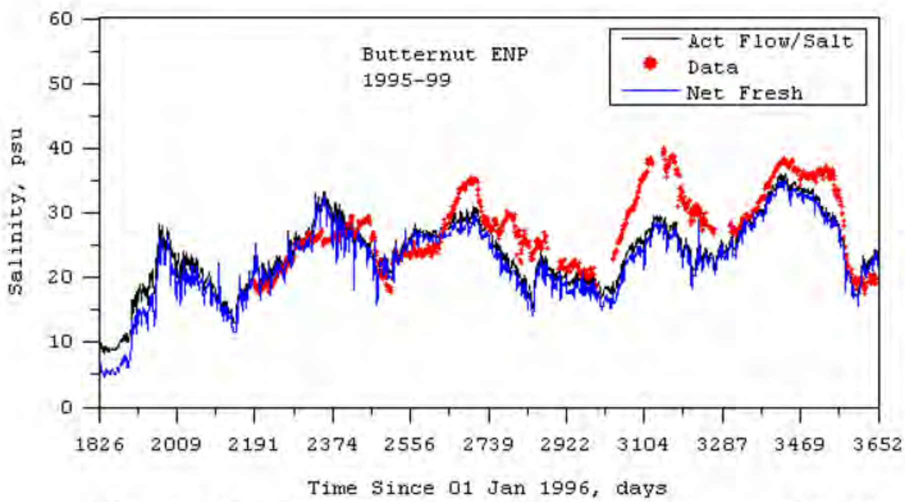


Figure 16C – Butternut Key salinities using two methods to transfer salinity.

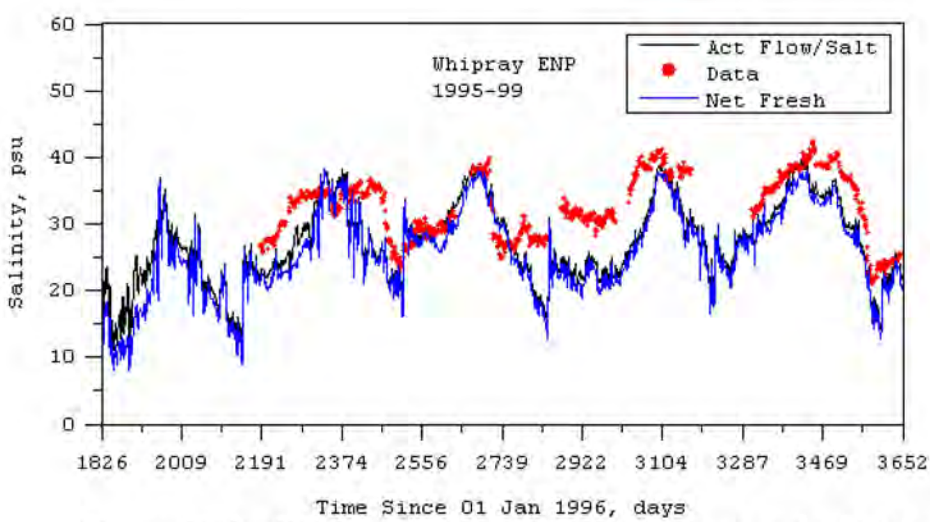


Figure 16D – Whipray Basin salinities using two methods to transfer salinity.

As with most inputs for the EFDC, the rainfall for the bay model was not as good for the 90 to 95 period as for the 96 to 99 time frame. As a way to improve the estimation of rainfall inputs, the TIME rainfall data for Zone-6 was used in a new EFDC run. The data shown in the following plots have no TIME inflows. However, the output is still meaningful as shown in figure 17.

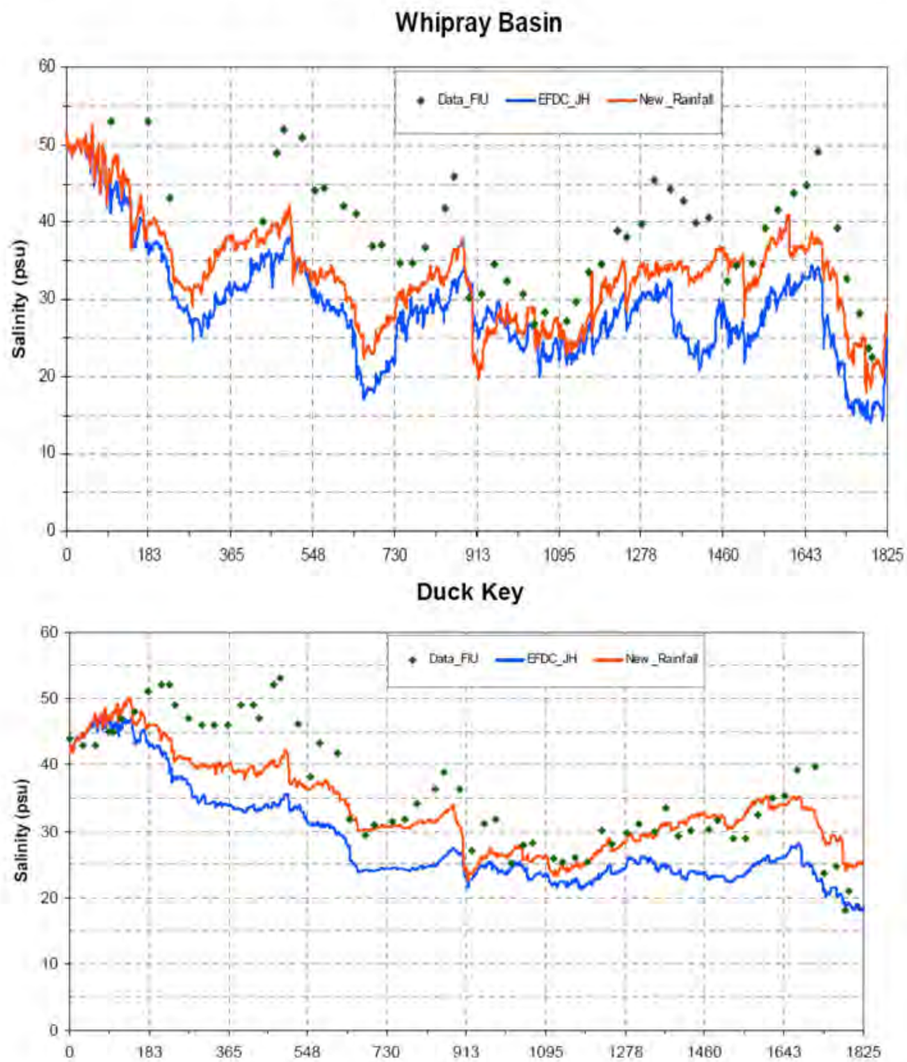


Figure 17: EFDC model test with improved rainfall, increased initial salinity, and updated TIME inputs from the latest testing.

Figure 17 shows the same bay model plots as seen earlier. The blue line represents the salinity with the original rainfall data and flows turned on. The red line indicates the salinity with the improved rainfall dataset and no inflows. At the Duck Key station, the improved rainfall increases salinity by 5 to 10 psu, while in Whipray Basin, the salinity rises by a few psu.

The next step in the model testing was to do a full 10 year run and perform a complete set of iterations between EFDC and TIME to establish the connections between boundary salinity for time and outflows for EFDC.

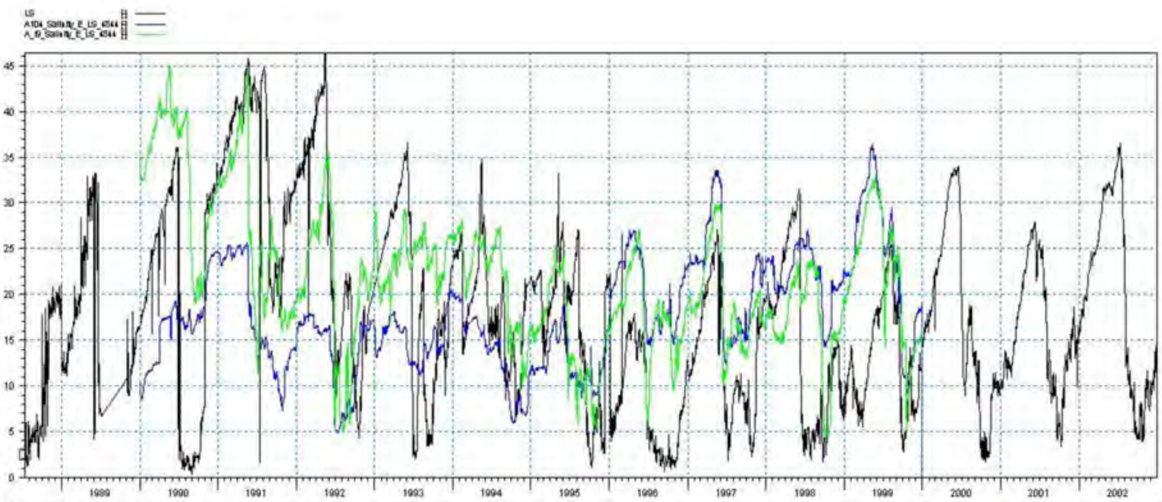


Figure 18: TIME model results at Long Sound showing the differences between the PDT runs and the modified initial conditions runs.

The black line in figure 18is the observed salinity from the ENP Long Sound station. The blue line is the salinity as reported at the PDT meeting from the December runs. The green line is the salinity from the modified initial salinity and stage runs. The same colors apply in figure 19.

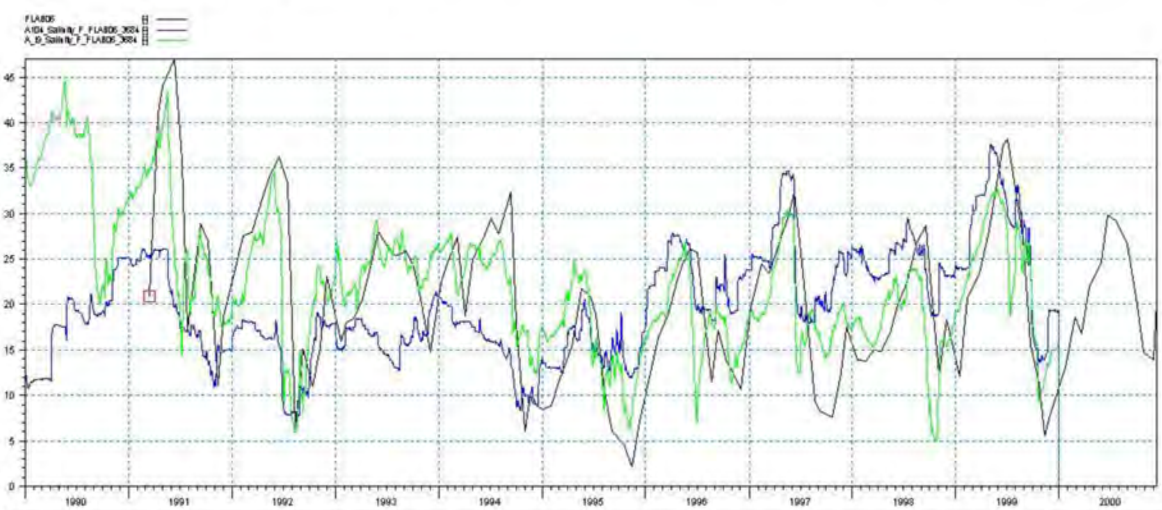


Figure 19: TIME model results at FLAB06 showing the differences between the PDT runs and the modified initial conditions runs.

Both of these plots show a dramatic improvement in the ability of TIME to predict salinity at these two locations as a result of the modified initial conditions and a full set of iterations.

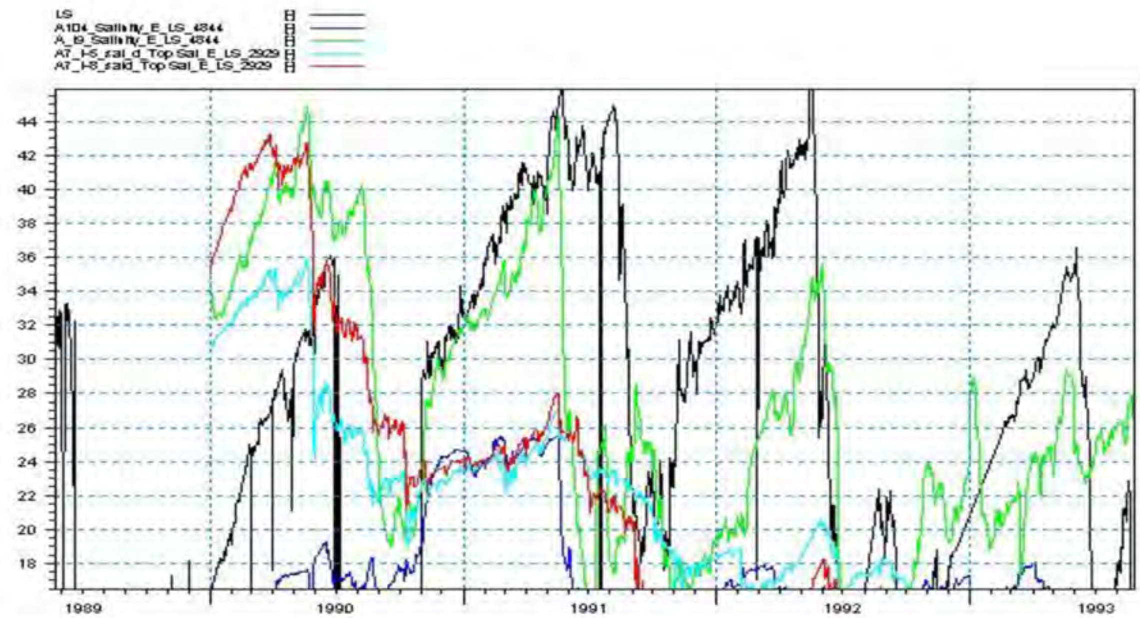


Figure 20: TIME & EFDC model results at Long Sound showing the differences between the PDT runs and the modified initial conditions runs.

Figure 20 illustrates a comparison of the TIME and EFDC salinity at the ENP Long Sound Station. The black line is the observed salinity; the dark blue line is the TIME salinity from the December run; the green line is the modified initial conditions run; the light blue line is the EFDC salinity from the PDT meeting; and the red line is the salinity from the latest EFDC model configuration after 2 iterations. Most striking about figure 20 is how the EFDC salinity shows a gradual decrease or washing out of the initial salinity conditions while the TIME model shows better agreement and mimics the stronger seasonal salinity pattern. The EFDC shows this quick decline of initial salinity over the entire model domain. Figure 21 shows another plot to illustrate the point.

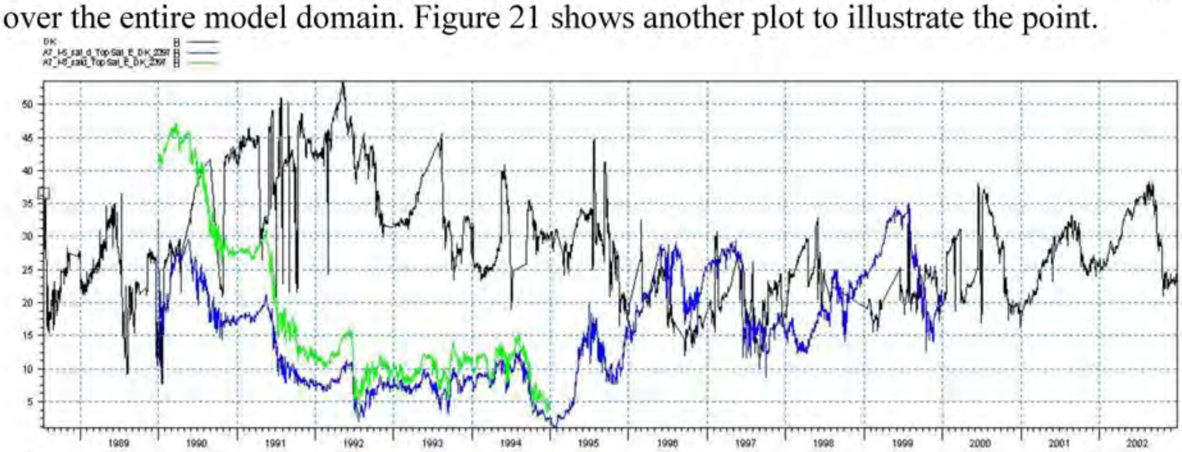


Figure 21: EFDC model results at Duck Key showing the differences between the PDT runs and the last iteration of the modified runs.

Black is observed data; Blue is original 12/06 salinity; and green is latest data.

From this attempt at a series of iterations, it is evident that the TIME model responded better to the changes than did the EFDC model. Possible reasons for this may range from problems with the bathymetry of the banks as derived from the LANDSAT data, rainfall inputs, solar radiation inputs, wind field inputs, salinity boundary conditions, and TIME interactions.

The EFDC model had few meteorological stations for the 1990 – 1995 periods. The TIME model data supplied a better estimation of rainfall in the area of the bay. The results of using the rainfall with no other inflows were shown in figure 17. The same issue also occurred with the wind field data and solar radiation computation for evaporation. There were only 2 stations, one at the very bottom of the model in Key West and the other out of the model domain in Miami. Data was found for wind that extended back to 1993 and was added to the EFDC inputs.

Figure 22 shows some bay model runs with modified inputs. The 2-CMan means that wind input used only two-station wind data where records are available for the whole simulation period. 5-CMan means the wind input used five-station wind data, in which, for year 1993~1994, when data are available at all 5 stations, the input were setup using wind records at each station, for year 1990~1992, since at some stations, there is no wind record, the wind records at closest station were used

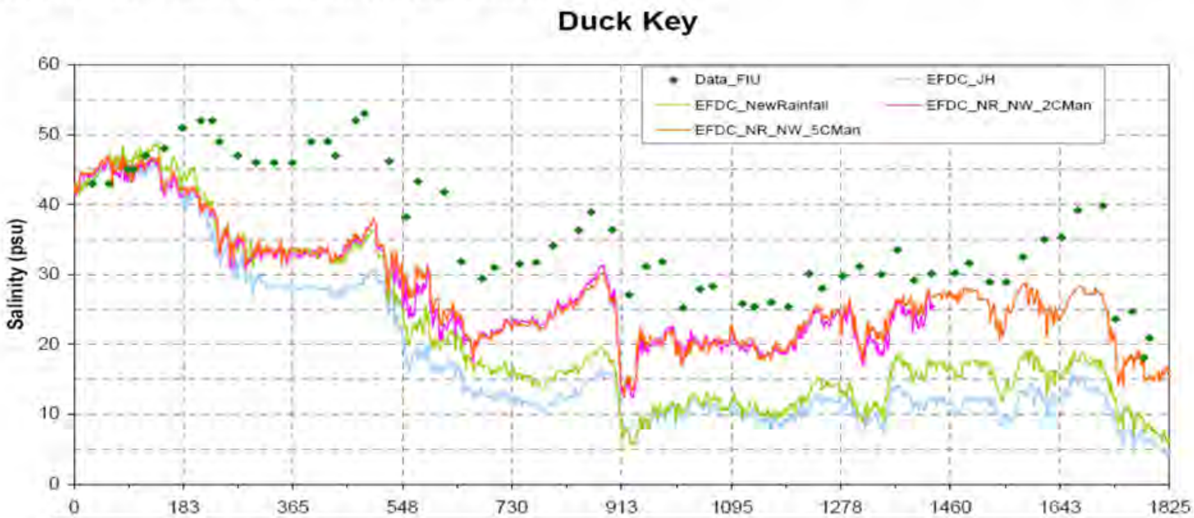


Figure 22: EFDC model results at Duck Key showing the differences between modified input runs.

The green points in figure 22 show the observed FIU data at Duck Key; the blue line is the original EFDC salinity from the latest ALT7 iteration; the green line is the salinity with modified rainfall inputs; the pink and orange lines show the results using modified wind data. The addition of the rainfall data makes an initial impact at the start of the model and carries on producing higher salinities. The modified wind field data shows an improvement before the end of the first year and again improves salinity, this time by an even larger amount than rainfall. The graph in figure 22 shows how the EFDC responded to changes in wind and rain data. The same information is shown in figure 23.

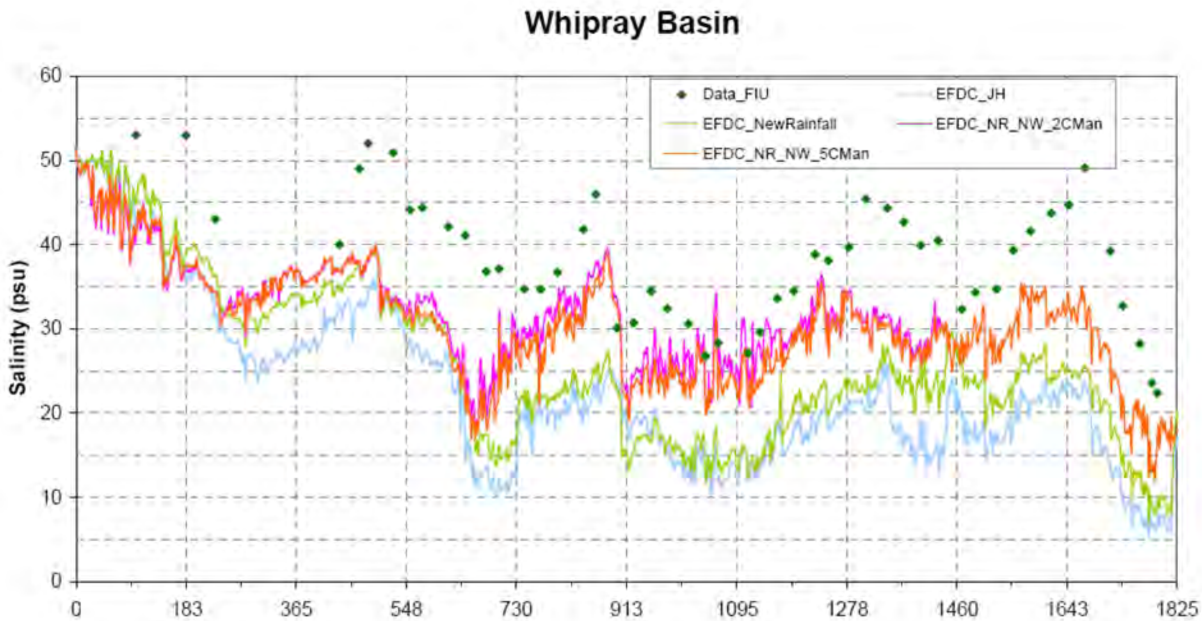


Figure 23: EFDC model results at Whipray Basin showing the differences between modified input runs.

As a way to show the differences caused by boundary and initial conditions, a plot for the second half of the POR at Little Maderia is shown in figure 24. This shows remarkable agreement between observed and modeled data and the improvement caused by the type of input taken from TIME.

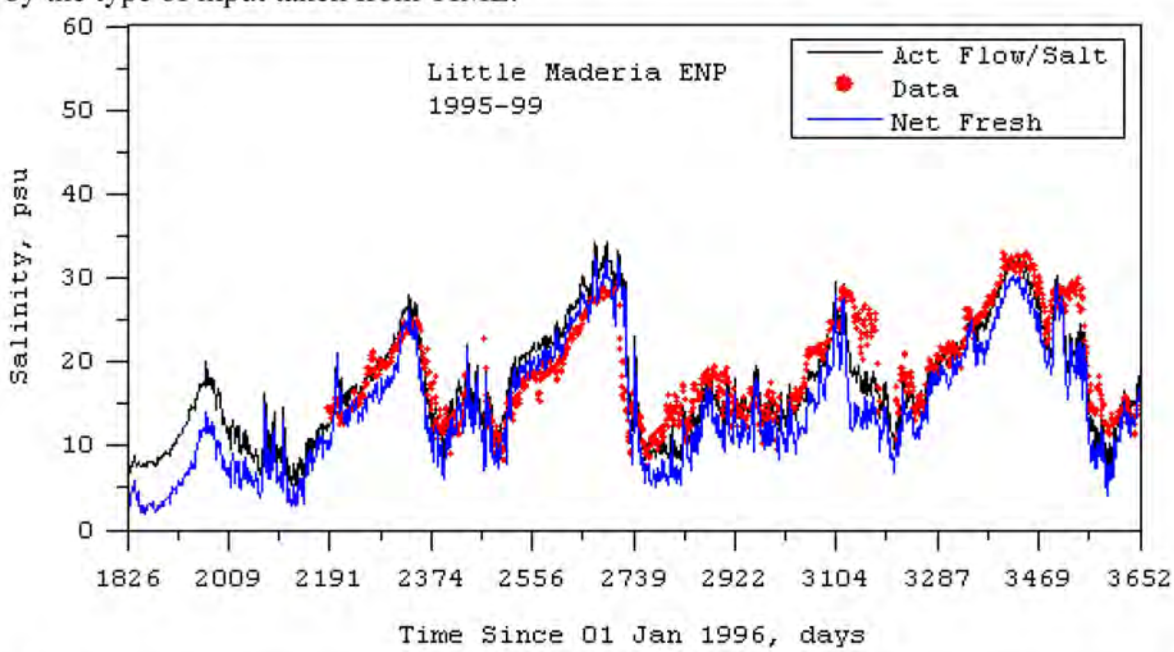


Figure 24: EFDC model results at Little Maderia showing the differences between runs caused by the type of TIME inputs.

Following this, the TIME Model ran with increased salinity boundary conditions to start a new series of iterations. The increased boundary salinity conditions had the obvious effect of increasing predicted salinity. Figure 25 shows the difference at Duck Key. The black line is observed data; Blue is predicted salinity from i9; and green is salinity from increased salinity boundary conditions run.

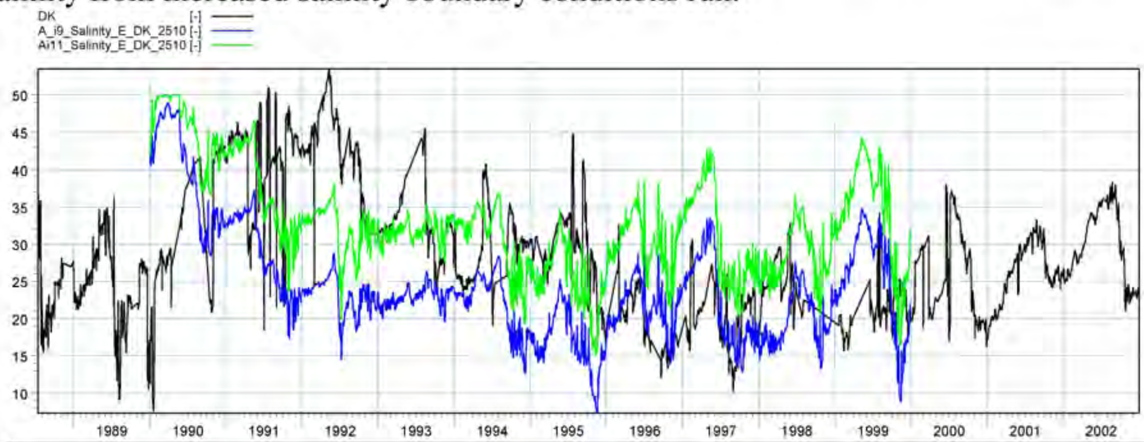


Figure 25: TIME model results at Duck Key showing the differences between runs caused by the increased salinity boundary conditions.

The same increased salinity is evident to different degrees spatially.

Tasks, Limitations, & Assumptions

There are many things that can be done and still need to be done to get the alternatives to a point where they may be accepted. Not only would these things need to be done, but model issues that involve critical assumptions or inherit limitations need to be identified. The remainder of this document describes the tasks that were done, tasks that are still outstanding and the assumptions or limitations of the models.

EFDC

1. Connections:
    a. Connections between Long Sound and Manatee Bay: Connections between Florida Bay through Jewfish Creek and connections between Little Blackwater Sound and Florida Bay were investigated. These caused the model to crash initially. Changes were made to modify the connections, and certain connections removed allowing the model to finish.
2. Barnes Sound & Manatee Bay:
    a. The EFDC model extends into the Barnes Sound and Manatee Bay areas. The connections between Long Sound and Manatee Bay exchange salinity that could improve model predictions in the Long Sound and far north east Florida Bay. The EFDC however, does not receive any inputs of freshwater from east of US1. TIME ends at US1 and can not give this information. As a way to gauge the impact of waters east of US1 and possibly provide inputs for one or more of the scenarios, the RSM simulation of the C-111 Spreader Canal model is being investigated for application to the EFDC runs where TIME does not.
3. Inputs
    a. Salinity
        i. The initial salinities for the model were modified from end of simulation salinity grids to salinity grids obtained from analysis of observed data.
        ii. The model was run with the higher initial salinity. The results given in this document show the salinity is quickly dissipated.
        iii. Salinity boundaries are harder to develop from the scattered information available for the 90' – 95' problem
    b. Rainfall:
        i. Analyze the rainfall inputs for EFDC. The EFDC appears to have too much rainfall as seen during the no inflow experiment where rainfall was the only input. The EFDC has the TIME rainfall data and should try to incorporate the information to produce a better spatial variation and patterns.
        ii. The EFDC was run by Momo with a modified rainfall dataset and the results shown in figures 22 and 23. This improved salinity by a small amount and rainfall could be modified further
    c. Wind:
        i. The wind field input data for the period of trouble is highly suspect due to there only being 2 stations. Searched for and acquired

additional wind data and incorporated into model inputs. The bay model was run by Momo with a modified wind field dataset and results are shown in figures 22 and 23.

d. Solar:
    i. There is a lack of boundary conditions for the 1990 – 1995 periods.
e. Tidal:
    i. There is a lack of boundary conditions for the 1990 – 1995 periods for the water surface elevations related to tide and sea level. These are easier to replicate with standard tidal relationships
f. TIME:
    i. Accumulation of Negative Flow Events: TIME accumulated negative flows (flows from the bay to ENP) and on the next outward flow event, added the accumulated flows back to the bay, causing larger flows and decreased salinity.
    ii. Invalid Values: In earlier runs, the TIME output had values of ****** when there were large flows. These values were replaced by 0's. The current runs have fixed this problem with the proper formatting of output.
    iii. Net Freshwater Flux: The concept of net fresh water flux from ENP to the bay was to take the salinity out of the water and transfer, from TIME to EFDC, the equivalent volume of fresh water.
    iv. Total flows: As another method of examining the flow from ENP to the bay, the total flow was also supplied and utilized in different methodologies to investigate TIME-EFDC communication.
    v. Total Flow and Salinity: An addition to the total flow output from TIME, the salinity of the water is also given to EFDC. The bay model then uses both the volume and salinity as flow inputs.

4. Model Performance
    a. Bank Elevations
        i. Does the EFDC model represent the banks in the bay by circulation patterns being altered and directed by banks? Created a video that shows daily vectors.
        ii. Video is done and located in the CERP Zone. Banks can be seen to influence flow to some extent. The magnitude of the influence that the banks have is hard to determine from the information. Need to get the model representation of the banks and then examine the daily vector flow videos again at various scales.
    b. Hypersaline Events:
        i. Run the model with no rainfall or TIME inputs to produce extreme hypersalinity conditions.
    c. Rainfall vs TIME contributions:
        i. Run the model with only rainfall and compare the hypersaline run with the rainfall only and normal runs.
        ii. The output from this comparison is shown in figures 8 and 9.
    d. Keys Transport Volumes:

i. How to check

e. Residence Times:

i. How to check

f. Model Warm-up Period:

i. Create a model warmup period back past the hyper salinity events in 1990. Run the bay model from 1989.

TIME

1. Structures
   a. For the CERP0 run, the flows from the S-12 structures were turned off as they should. However, the overland flow for these cells was not turned on. These flows had to be identified and requested from the 2x2 team.
   b. Need to change the S-12's under CERP, they need to be changed to overland flow instead of structure flow. There are currently 4 locations where S-12 flow enters TIME as structure flow instead of the TIME cells that should be taking overland flow.
   c. For Alt7 and 2050B0, flows from the S356 are routed from the L31N to the L29 canal. This setup does not require any changes to the TIME model. The current configuration is accurate. For CERP0, the S356 is replaced by the S356A and S356B structures. These split the flow given by S356 to the park further down L31N approximately 2 and 4 miles into the park. These flows had to be identified and obtained from the 2x2 team.
   d. During the data procurement process, there were errors in the formatting of the delivered data in both format and units. Sometimes the csv format was corrupted by larger than expected flow values. On another occasion, the values were not converted from 2x2 output units to TIME input units.
2. Overland Flow
   a. For cells along Tamiami Trail that have overland flow in the X direction. At first the TIME model had only the Y component of the overland flow entering the model. Along the trail and C-111, there are 2x2 cells that would supply an X component to flow into the TIME model domain. These cells were identified and the 2x2 flows requested and input to the model.
   b. Related to the X flow components from the 2x2 model: The flow convention for the 2x2 model gives the flow over the southern and eastern faces. The data taken from 2x2 earlier assumed the southern and western faces. The 2x2 cells had to be identified and data requested for input to the TIME model.
   c.
3. ENP Seepage Management:
   a. The Everglades Seepage Management Project along L31N was not being modeled under the CERP alternative. This project is designed to minimize the seepage that moves from the park to the developed areas. During the wet season, no flow is passing the canal by seepage in surface or ground water. This water is pumped back into the domain. During the dry season,

water is allowed to flow to the east in the ground water, but all canal seepage is retained in the domain. This was implemented in the TIME model by modifying the conductance of the GHB. Setting the conductance to 0 during the wet season, stops the flow of groundwater. The use of wells in the TIME model simulates the replacement of water back into the domain.

4. Reservoirs:
   a. The reservoir outflow under the CERP scenario wasn't being input to the model. The 2x2 data was acquired and then input to the model.
   b. The reservoir conceptualization was confirmed as in CERP0 and 2050B0, there is one reservoir using groundwater wells for input. Under Alt7, there are S332b and S332bn reservoir.
5. Initial/Boundary Conditions:
   a. Salinity:
      i. The initial salinity conditions for TIME were adjusted from values of 0 everywhere to a value set from the ending salinity of a previous run.
      ii. The starting salinity of previous runs still forced a longer warm-up period.
      iii. The current initial salinity field is taken from observed data and translated to the TIME grid.
      iv. Model was run as an initial iteration with higher salinity boundary conditions along the Florida Bay boundary. The standard 36 psu value was increased by 5 on the eastern side and 15 on the western side with linear interpolation between. This change to the model is an attempt to correct the early salinity prediction problems by artificially raising the boundary to the observed levels. With one iteration returned from EFDC, this boundary condition is replaced by one from the bay model.
   b. Stage:
      i. The initial pool level for the TIME model was set at too high a value. This caused extremely large flow events at the start of the POR adding to the problems of salinity prediction from 1990 to 1995. This initial pool water level was dropped and the model run again.
      ii. There is still a large flow event at the start of the POR through the Southern ENP transects. Consider dropping the pool level even more or trying some other way to affect the initial flows in this area.
6. Inputs:
   a. Rainfall: Rainfall for the model was checked against the 2x2 rainfall and there was a discrepancy between the 2x2 rainfall and TIME – Zone 6. The resolution to this issue was that the 2x2 data compared to TIME zone 5 offset the difference in Zone 6. It was also seen that there was a difference on the west coast where the 2x2 stops and doesn't have the best rainfall

data. The main change was the addition of a few rainfall stations in the Zone 6 area. This increased the rainfall.

7. Connections:
    a. The connection between Long Sound and Manatee Bay through a culvert plays a key role in the salinity regime of the area. Observed data for salinity at the Manatee Bay station were used as a time series of salinity at the culvert opening for the first iteration. This allows salinity to move back and forth through the culvert as happens in reality.
8. Model Performance
    a. The TIME model was run with the leakage turned off to estimate what the impact to overland flow and therefore flow to the bay was from leakage.
    b. The TIME model was run with the observed structure flows replacing the 2x2 generated flows for Alt7R5 along C-111 to see what impact structure flows had on the bay. This was also done to see if the structure inputs were modified, how much was the salinity modified. This helped to qualify the role played by structure flow in flows to the bay and ultimately salinity in the bay.
    c. The transport code for the surface water model was changed by John Wang. There was a counter or summation variable that wasn't being reset. When implemented, this change caused the TIME model to crash in 1998.
9. Task List: This section describes tasks that are being done or could be done.
    a. Get calibration runs that are mentioned in the calibration report to analyze the park road, leakage, mannings, etc…
    b. Extend the warmup period back past the hyper salinity events in 1990. Need to get data from 2x2 for ground water and structures for 1989 if not already in possession.
    c. The park road is not being modeled. Was modeled under the calibration run with and without the road and no significant difference was seen. Run a TIME scenario with the park road modeled to ensure that the differences are minimal and that the park road can be left out of alternatives. The calibration run might not have shown a difference, but with more water being added under CERP, there might be a more significant impact.

Bibliography

Hamrick, J.M. Moustafa, M. Z., 2003, Florida Bay Hydrodynamic and Salinity Model Analysis (abstract), Joint Conference on the Science and Restoration of the Greater Everglades and Florida Bay Ecosystem "From Kissimmee to the Keys", April 13-18, 2003, Palm Harbor, Florida

Langevin, C.D., Swain, E.D., and Wolfert, M.A., 2005, Simulation of integrated surface-water/ground-water flow and salinity for a coastal wetland and adjacent estuary: *Journal of Hydrology* 314, 212-234.

South Florida Water Management District, 2005, Documentation of the South Florida

Water Management Model Version 5.5: SFWMD technical document, November 2005.

Swain, E.D., 2005, A model for simulation of Surface-Water Integrated Flow and Transport in Two dimensions: SWIFT2D user's guide for application to coastal wetlands: *U.S. Geological Survey Open-File Report* 2005-1033, 88 p.

Swain, E.D., Wolfert, M.A., Bales, J.D., and Goodwin, C.R., 2004, Two-dimensional hydrodynamic simulation of surface-water flow and transport to Florida Bay through the Southern Inland and Coastal Systems (SICS): *USGS Water-Resources Investigations Report 03-4287*, 56 p. plus 6 plates.

Wang, J, D., Swain, E.D., Wolfert, M. A., Langevin, C.D., James, D. E., and Telis, P. A., 2007 - Applications of Flow and Transport in a Linked Overland/Aquifer Density Dependent System (FTLOADDS) to Simulate Flow, Salinity, and Surface-Water Stage in the Southern Everglades, Florida: *U.S. Geological Survey Scientific Investigations Report* 2007-5010.

Wolfert, M.A., Langevin, C.D., and Swain, E.D. 2004. Assigning boundary conditions to the Southern Inland and Coastal Systems (SICS) model using results from the South Florida Water Management Model (SFWMM): *U.S. Geological Survey Open-File Report* 2004-1195, 30 p.