Savannah Harbor Data Analysis and Modeling Expectations of Federal Agencies

The purpose of this memorandum is to establish criteria (guidelines) by which to evaluate the performance of the hydrodynamic and water-quality models and post-processing routines used to predict impacts associated with the proposed Savannah Harbor Deepening Project. This memo provides a brief background of the modeling effort to date, a description of the resource areas of concern, a description of the modeling approach, and a guide for the evaluation of the model performance.

Background:

The purpose of the 1997 Savannah Harbor data collection and subsequent modeling activities was to provide a hydrodynamic and water-quality model to analyze impacts of deepening on circulation, salinity, and dissolved oxygen. The aquatic resources in the system are sensitive to small changes in water level, salinity, and dissolved-oxygen concentration. Additional understanding of the system and its behavior, beyond the 1997 data set and model calibration was recommended in order to make the necessary absolute predictions of water-level, salinity, and dissolved oxygen necessary to evaluate the mitigation issues associated with the potential deepening of the harbor.

The purpose of the 1999 Savannah Harbor data collection and modeling effort was to better understand and quantify the processes affecting circulation and water quality in the system, and to develop a defensible hydrodynamic and dissolved-oxygen model. These models are then to be used in conjunction with the extensive monitoring data and other tools to make the necessary absolute predictions for the evaluation of impact and mitigation issues. The 1999 data set provides the detailed data to develop this defensible hydrodynamic and water quality model.

Areas of Concern:

There are four resources of concern for federal agencies. These are:

1. Shortnose sturgeon
2. Striped bass
3. Tidal Wetlands
4. Dissolved oxygen

The federal agencies believe that accurate prediction of the following parameters and time scales at specific locations are necessary for evaluating project related impacts for each of the resources of concern:

Sturgeon:

- Critical parameters and statistic
  - Bottom DO --10th and 50th percentile
  - Bottom salinity – 50th and 90th percentile
- Critical time scale – hours for durations of DO concentrations below 3 mg/L
- Important stations- GPA8 and GPA22

Striped Bass:

- Critical parameter and statistics
  - High-tide surface salinities -- 90th percentile
  - Ebb and Flood velocity of top 2 meters
- Critical time scale – hours (maximum duration of salinity excursion)
- Important stations – GPA 5, 6, 7, 8, 9,10, 11R, 12R, 15, 22 and USGS Stations 02198840 (I-95), 02198920 (Houlihan Bridge), 02198979 (Limehouse), and 021989791 (USFW Dock).

Tidal Wetlands:

- Critical parameter—high tide water levels and salinities over 60 days
- Critical time scale – daily, weekly to monthly
- Important stations -- GPA 5, 6, 7, 8, 9,10, 11R, 12R, 15, and USGS Stations 02198840 (I-95), 02198920 (Houlihan Bridge), 02198979 (Little Back River nr Limehouse), and 021989791 (USFW Dock).

Dissolved-Oxygen:

- Critical parameter--10th and 50th percentiles
- Critical time scale – hourly to daily
- Important stations -- GPA 2, 4, 6, 8, 9,10, 11R, 14, 21, and 22.

Based on the resources of concern, the model calibration should focus on the following stations:

- Elevation and Salinity: GPA 5, 6, 7, 8, 9,10, 11R, 12R, 15, 22 and USGS Stations 02198840 (I-95), 02198920 (Houlihan Bridge), 02198979 (Limehouse), and 021989791 (USFW Dock).
- Temperature: GPA 2, 4, 6, 8, 9,10, 11R, 14, 21, and 22.
- Dissolved oxygen: GPA 2, 4, 6, 8, 9,10, 11R, 14, 21, and 22.

Description of Modeling Approach:

A key issue for the Resource Agencies, researchers and managers is the need for the model calibration to be capable of accurately predicting extreme conditions that are expected to occur less than 5 to10 percent of the time. The reason for this request is the desire to have the full range of values (peak or minimum), "absolute numbers", regardless of the duration, for various conditions that might, in later analysis, be found to be important in the evaluation of impacts. The agencies conclude that the numbers for the long-term effects alone of post-project conditions being predicted by the hydrodynamic/salinity model (e.g., change in 50th percentile values only) would be necessary, but may not be sufficient to fulfill their needs for identifying all likely project effects.

The approach for meeting these expectations incorporates a hydrodynamic model that is being calibrated for predicting long-term trends (the mean) for all of the selected parameters. However, because of the need to model absolute values for hypothesis testing purposes, the calibrated model will be supplemented with adjunct data based interfaces (such as transfer functions based on neural networking methods, system identification methods, relative change techniques, or other acceptable approaches). These adjunct models utilize the extensive field data to develop the relationship between the model simulation output and the measured absolute values. If the hydrodynamic model is well calibrated to the mean, then its performance will be consistent and a translation of model predictions to provide absolute value predictions is possible.

Modeling Expectations:

The following provides the federal agencies' viewpoint on the necessary statistical analyses and the performance goals of the modeling results for selective parameters.

Statistical Analyses:

Statistical analysis should include calculation of the mean error, root mean square error, absolute mean error and relative error. Additionally, comparison of selected percentiles should be used to evaluate model performance.

Statistical analysis should be performed on the 1997 and 1999 data sets. For the 1997 validation data set, analysis should be performed on each of the 6spring/neap tidal cycles between July 9, 1997 and Oct 5, 1997. The Julian dates for the six periods are: 191-204,205-219,220-234,235-249,250-263,264-279. For the 1999 calibration data set, analysis should be performed on each of the five spring/neap tidal cycles between July 31 and October 13, 1999. The Julian dates for the five periods are: 213-226, 227-241, 242-255, 256-270, and 271-285

Evaluation Criteria:

This memorandum puts forward a number of criteria for salinity, dissolved oxygen, water levels, circulation, and temperature based on resources of concern, namely, shortnose sturgeon, striped bass, tidal wetlands and dissolved oxygen. No actual physical or biological evidence is discussed herein, whether in terms of literature citation or data, to support that the tolerance in the criteria listed is appropriate for the evaluation of impacts on resources in the study domain. These criteria are therefore viewed as performance goals to which model predictions will be compared and evaluated for strengths and weaknesses and by which an understanding of their uncertainties may be developed. The stated criteria will not be used individually (by station and parameter) for "pass/fail" evaluation of the model calibration and/or post-processing routine.

The Federal agencies recently received the water quality database from ATM and need to evaluate the data in order to finalize the proposed model criteria. The preliminary criteria for the model performance are tabulated below:

Parameter		Percentiles					Timing of Maxima (Min)
		5 %	10 %	50 %	90 %	95 %	
Elevation (cm)		+/- 2	-	+/- 2	-	+/- 2	+/- 30
Salinity (ppt)	50% > 5 ppt	-	+/- 10%	-	+/- 10%	-	+/- 30
	50% < 5 ppt	-	-	+/- 0.5	+/- 0.5	-	+/- 30
DO (mg/L)		-	+/- 0.2	+/- 0.2	-	-	+/- 30
DO Deficit (mg/L)		-	+/- 0.2	+/- 0.2	-	-	+/- 30
Temperature (^{o}C) *		-	-	+/- 1	-	-	-
Surface Currents (m/s) **		+/- 25%	-	-	-	+/- 25%	+/- 30
Volume Flows (m/s) **		+/- 25%	-	-	-	+/- 25%	-

* 50% represent Absolute Mean Error for temperature
** 5% and 95% represent the max. ebb and flood conditions for current and flow

Model Defensibility:

The federal agencies believe that the following analyses should be completed to ensure that the model is defensible:

Convergence testing:

- Convergence testing of the model must be performed on the application to the Savannah Harbor.

Sensitivity Analysis: Sensitivity analysis needs to be performed on the following model parameters and boundary inputs:

- Turbulence scheme coefficients
- Offshore salinity concentration
- Freshwater inflow rate and timing
- Bottom friction
- Horizontal eddy viscosity
- Selected water-quality rate kinetics

Data Description and Analysis:

- For the 1999 data set, some time periods are missing due to equipment failure and an approaching hurricane. Data analysis and descriptions are needed that describe boundary stations and critical internal stations. Descriptions should include a general statistical summary and a narrative outlining over data quality and, for boundary stations, techniques used to fill period of missing record.