ENVIRONMENTAL IMPACT STATEMENT
APPENDIX N: Record of Interagency Coordination

SAVANNAH HARBOR EXPANSION PROJECT

Chatham County, Georgia and Jasper County, South Carolina

January 2012

US Army Corps of Engineers
Savannah District
South Atlantic Division

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Record of Interagency Coordination

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8. MFR Draft dated 19 May 04, Final dated 15 June 04. Federal Agencies Responses to Questions and Uncertainties Raised in Georgia Port Authority's Letter of 11 May 2004.
9. E-MAIL from EPA, Heinz Mueller, dated 2 April 2007, SHEP, Decision on Model-To-Marsh proposal.
10. E-MAIL from Thomas A. Garrett, SAS dated 2 April 07, SHEP, Decision on M2M
11. E-MAIL from Joseph T. Hoke, SAW@SAS dated 2 April 07, SHEP, Decision on M2M
12. E-MAIL from Ed Eudaly@fws.gov, dated 27 March 2007, SHEP, Decision on Model-To-Marsh Revisions.
13. E-MAIL from Kay Davy, NOAA, dated 22 March 2007, SHEP. Decision of Model-To-Marsh Revisions.

CESAS-PM-CN 23 May 2000

MEMORANDUM FOR RECORD

SUBJECT: Multi-Agency Meeting, Savannah River Hydrodynamic Model, Savannah Harbor Expansion (SHE) Project, Georgia and South Carolina

1. At the request of the EPA, a multi-agency meeting of the Federal Agencies associated with the SHE project was held on Tuesday, 22 May 2000 at the Offices of the U.S. Fish & Wildlife Service to discuss concerns that have surfaced in regard to the subject model. In attendance were the following:

Douglas H. Plachy	U.S. Army Corps of Engineers (CESAS-PM-CN)
William G. Bailey	U.S. Army Corps of Engineers (CESAS-PD-E)
Susan E. Durden	U.S. Army Corps of Engineers (CESAS-PD-PF)
Ed EuDaly	U.S. Fish & Wildlife Service
Wiley Kitchens	University of Florida (U.S. Fish & Wildlife Service)
Paul Conrads	U.S. Geological Survey
Jim Greenfield	U.S. Environmental Protection Agency

[*It should be noted that the attendees typically referred to "GPA" during the meeting in lieu of specific firms when referencing discussions with one of GPA's contractors since it is GPA that is funding and controlling the various contractors and since it is GPA that is ultimately accountable for the contractor's actions.*]

2. It was understood that the initial goal of the subject model was to provide a method for predicting numerical values for physical parameters that may change as a result of alterations to the Savannah River. However, there is now great concern regarding the technical adequacy of the model and whether it will have the ability to accurately predict changes in the ecosystem, i.e., water levels, dissolved oxygen (DO), salinity, etc. Several examples were given such as:

a. The water levels have been off (and still are) by as much as 1 meter. It was stated that the tolerance should be no greater than +/- 3 inches. This is in light of the fact that changes of water level of only ½ inch can cause major impacts to the species of vegetation growing in the marsh.

b. The model does fine at and/or near the boundary condition, but gets worse the farther you go upriver away from the boundary. A potential problem may be that the model is build upon an estuary model rather than a riverine model.

c. A sensitivity analysis has not been done. This is a key aspect to model development.

d. The convergence test specifically requested by the Corps has not been done to validate the grid resolution. It was noted that ATM had in the past discussed reducing the grid resolution without knowing the convergence.

e. The model has been inconsistent, i.e., sometimes it under predicts and sometimes it over predicts. Therefore, as it currently exists, it is unreliable as a tool to assess impacts of "what if" conditions.

f. To be an adequate tool for assessing impacts, the peaks and ravines are just as important as the mean. Currently, the model has only marginally met the mean and has substantially missed the peaks and ravines. Are the problems due to limitations of the model itself (i.e., WQMAP), application of the model set up and calibration, or skill of the modelers?

3. There was extensive discussion in regard to GPA's unwillingness to provide the Federal Agencies direct access to the model. Although there had been a meeting in Atlanta prior to the last MTRG meeting to discuss the access issue, it is clear that the parties left that meeting with different understandings of the decisions and commitments made. The agencies need access to the model ASAP in order to assess & determine what may be causing the model not to perform as expected. The undersigned relayed the conversations he had with GPA shortly after the last MTRG meeting wherein it was stated by ATM that the model would be provided to EPA, etc., post calibration, i.e., not anytime soon. GPA's understanding is that EPA wants access to the model for DO and TMDL work unrelated to the SHE project. It was not understood that it was not possible for the agencies to accept the model (as it currently exists).

4. It was clear from the discussions that the Federal Agencies are not attempting to impede the development of the model, but wish to help to ensure that the model is as accurate and complete as possible. It was understood that without a good model, it would be very hard to grasp the potential impacts of any changes to the navigation channel. In this regard there was frustration on the part of the Federal Agencies over the following issues:

a. Requests for the 1999 data set, i.e., the electronic version of the processed data have gone unanswered. It was noted at the meeting by the undersigned that GPA might not have been aware that the agencies have requested the data set.

b. ATM has been selective in regard to what they choose to show the Federal Agencies at the MTRG meetings.

c. Dialogue and Feedback to the MTRG has changed (in a negative way) since the departure of the original ATM modelers.

d. There is the perception of "obstructionist behavior" on the part of GPA's contractors.

5. Several courses of action were discussed ranging from starting all over with the development of a new model to completely giving up on attempting to model the Savannah River. However, it was eventually decided that the Federal Agencies would put together some very precise and explicit criteria a.k.a. goalposts, which clearly defines what specifically the model must provide in order to be used to assess potential impacts. (It was noted that this information should have been provided/requested very early on in the development process.) This set of requirements would be staffed by the Federal Agencies and then provided to the MTRG for discussion at the next scheduled meeting.

6. In addition to the above, it was also agreed that the Federal Agencies would renew their requests to obtain from GPA:

a. An electronic data set of the processed 1999 data collection. Since State funds were used to obtain this data set, it is felt that there should not be a problem with it being placed in the public domain.

b. Direct access to the model in order to attempt to determine why the model has not performed as expected. This will be necessary before any of the agencies would consider signing off on the calibration. It was stated by the undersigned at the meeting that GPA requested in April that ATM determine how to go about providing direct access of the model to the Federal Agencies.

7. The information stated above is that of the undersigned's comprehension, and may not be the consensus of all of the Federal Agencies.

/dHPlachy/ 26 May 01

DOUGLAS H. PLACHY
Senior Project Manager
Navigation & Coastal Projects Team
Civil Works Branch, PPMD

CESAS-PD-E 18 January 2002

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; SMART meeting

DATE: 12 December 2001

LOCATION: EPA, Atlanta

PARTCIPANTS:

Jim Greenfield	EPA
Paul Conrads	USGS
William Bailey	USACE
Danny Mendelsohn	ASA
Bo Ellis	ATM
Eduardo Yassuda	ASATM
Matt Goodrich	ATM

BACKGROUND: This was the second meeting of the Savannah Multi-Agency Review Team (SMART) to review and discuss ATM's progress on the hydrodynamic modeling that they are conducting for GPA on the Expansion Project. The SMART is composed of technical modeling experts from EPA (Jim Greenfield), USGS (Paul Conrads) representing the USFWS, and USACOE (Sung-Chan Kim), and myself. The NMFS is kept informed of the SMART meetings and any conclusions that are reached, but the NMFS has declined to participate directly, relying instead on the views of the USFWS. The SMART was formed to assist ATM/GPA in the final stages of their model development. The intention is for the SMART to meet on a regular basis to discuss direction, ideas, developments and generally to coordinate the calibration development activities.

MEETING HIGHLIGHTS:

1. Danny Mendelsohn (ASA/ATM) gave an update of his efforts on the Hydro model calibration. He reported primarily on his efforts on the temperature portion of the model.
   - (A) He had tried the 25% shading of the upper river (Clyo to the harbor) that the SMART had recommended at its previous meeting. He said that the model's calculated values were still substantially higher than the data.
   - (B) The group suggested he try higher shading values, up to a 50% level. They thought that value would be acceptable since the river is relatively narrow with trees lining both banks.

(C) No new input data had been obtained on the heat release for the SEPCO power plant in the harbor. ATM will check further to try to obtain or develop input values for this feature.

2. Danny then briefly discussed the salinity portion of the model.

(A) The group agreed that the model output should be in 1-hour time steps. More detailed information would not be particularly useful in evaluating impacts.

(B) The group agreed that Danny should adjust the model to correct for any error in phase before statistics are run on the calibration. In addition to reporting the statistic, the phase correction applied will be reported.

3. At this point, the following looks reasonable as a schedule for progress on the Hydro model: Preliminary calibration in February and final calibration in March.

4. Eduardo Yassuda (ASATM) then gave an update of his efforts on the Dissolved Oxygen model.

(A) He has begun reviewing the D.O. data.

(B) EPA/GADNR will provide upstream input data from their model of the Savannah River by the February meeting. ATM needs to include this in their model.

(C) Eduardo will also present statistics on the model performance in terms of D.O. deficit.

(D) The Corps will write (email) ATM requesting that model be capable of using 2 CBOD degradation rate constants. Including this capability now would save valuable time later if the initial calibration is inadequate using only a single rate. The modeler's time would be saved during the critical period later in the calibration process.

5. The group agreed to meet again in February. The SMART would meet on the afternoon of the 12^{th}, and the MTRG would meet on the morning of the 13^{th}.

William Bailey
PD-E

CESAS-PD-E 7 March 2002

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; SMART meeting

DATE: 28 February 2002

LOCATION: EPA, Atlanta

PARTCIPANTS:

Jim Greenfield	EPA
Paul Conrads	USGS
William Bailey	USACE-SAS
Dr. Sung-Chan Kim	USACE-ERDC
Danny Mendelsohn	ASA
Bo Ellis	ATM
Matt Goodrich	ATM
Chris Ahern	ATM

MEETING HIGHLIGHTS:

1. Danny Mendelsohn (ASA/ATM) gave an update of his efforts on calibration of the Hydro model.
   - (A) He said he still had a problem with water surface elevation at Clyo because the model would not allow him to raise the bottom elevation the 12-13 foot distance the river actually has climbed by that point. This boundary problem elevation offset is completely resolved by GPA-17 (i.e. GPA-17 surface elevation is correct and no effect from GPA-17 south). Therefore, this should not affect the model's usefulness in making predictions below I-95.
   - (B) He is continuing to make minor adjustments to the model to increase its performance.
   - (C) For the calibration period (1999), he will use the time periods when data exists for the offshore boundary.
   - (D) He will display the model's performance statistics by river mile.
   - (E) He will show time series comparisons for the entire duration of the model run.
   - (F) The Approval Package should contain information on the convergence testing, as well as the sensitivity items listed at the end of the Expectations Document.
   - (G) The comparisons to the Expectations Document will be based on results from the model or – if needed – from any transfer function.
   - (H) For the Approval Package, the Federal agencies will email to the Corps what they want to see in the package. The agencies will want a hard copy of the Approval Package and an updated version of the model. The packages will be sent directly to the agencies to speed their review.

2. Matt Goodrich (ATM) then discussed the transfer function that he was developing.

(A) He is using a state-spaces model, which is different from a neural network.
(B) ATM will develop and apply a transfer function whenever a model does not reasonably meet the Expectations Document.
(C) ATM will need to identify how it will develop data between the stations. They may use linear interpolation.
(D) The Approval Package should include the performance both without the transfer function and with the function, to demonstrate the improvements that the additional work (through this technique) provide.

3. Chris Ahern (ATM) then gave an update of their efforts on the Dissolved Oxygen model.

(A) D.O. in Savannah Harbor is influenced by:
  Temperature
  Freshwater flows (as measured at Clyo)
  Tidal amplitude (Spring / Neap)
  Marsh loading & Point source loading
  Primary productivity
(B) Neaps are periods of greatest D.O. sag because of the reduced mixing.
(C) GPA-6 shows the largest difference in D.O. saturation between the surface and the bottom.
(D) During the data collection, Chris noticed that the Secci Depth was greater by about 1/3 meter if they used the shaded side of the boat. He theorized that on the sunny side of the boat, the suspended clays refracted the light more, reducing its penetration. ATM did use the standard procedure (sunny side) when they collected the data for this project.

4. ATM will pursue the following schedule:

Submit Approval Package	end of March
First look at D.O. model	end of April
Transfer of initial D.O. model to EPA	end of April
MTRG meeting	April 30^{th} 10 AM
SMART meeting	May 1 9 AM
Letters from Federal agencies	end of May (60 day review)
Completion of D.O. model (Submission of Approval Package)	end of June (3 months)

William Bailey
PD-E

CESAS-PD-E 1 May 2002

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; 30 April SMART meeting

1. A SMART meeting was held on 30 April 2002, after completion of the MTRG. The following people attended:

Jim Greenfield	EPA
Paul Conrads	USGS
Dr. Sung-Chan Kim	USACE-ERDC
William Bailey	USACE-SAS
Larry Keegan	Lockwood-Greene
Bo Ellis	ATM
Matt Goodrich	ATM
Dan Mendelsohn	ASA
Eduardo Yassuda	ASATM

2. The group discussed comparing the Transfer Functions for salinity to conditions that existed prior to the 1993-1994 deepening project. The group decided, instead, that ATM will first look at the effects of further deepening of the channel to ascertain the extent to which such deepening alters the present trends and patterns of tidal flows and forcing. If such deepening would not appear to substantially alter the present trends and patterns, then the group would have more confidence that the physics represented by the salinity Transfer Functions would still be applicable with the proposed changes in river geometry.

3. ATM agreed to provide the Federal agencies with the following additional information to aid their review of the Hydrodynamic and Salinity Model. This information will be provided by 14 May:

A. Comparisons of the model to data at the USGS stations. This had been inadvertently left out of the Approval Package.

B. ATM will develop Transfer Functions for all or most of the 1999 data stations. An explanation will be provided where Transfer Functions are not developed.

C. ATM will perform a sensitivity analysis to evaluate the model's sensitivity to river depth where water levels do not match well. They will run the model twice; first with a ½ meter increase in depth, and then with a ½ meter decrease in depth. They will report only the statistics of the model's performance.

4. The group discussed Convergence Testing. No additional work was done on this issue after the March 2001 Calibration Report. Information in that report should be used to assess the model's performance on this issue. Danny will review Figure 5-4c from that

report and provide additional explanation on why ATM believes the convergence is acceptable.

5. The group discussed the link between the Hydro Model and the D.O. Model. ASATM will check salinity movement in the D.O. Model early in their development of that model to ensure both models are moving salinity the same.

6. The next meeting will be the afternoon of June 6th, after the MTRG meeting. The group will provide initial responses to morning's presentation of the D.O. Model, and discuss Critical Conditions for application of the models.

William Bailey
Physical Scientist

CESAS-PD-E 18 June 02

MEMORANDUM FOR RECORD

SUBJECT: Summary of 6 June SMART meeting; SH Expansion Project

1, Attendees:
EPA: Jim Greenfield
USGS: Paul Conrads
COE: Bill Bailey
GPA: Larry Keegan; Bo Ellis; Danny Mendelsohn; Eduardo Yasuda

2. We started by reviewing the position of EPA on the model. Jim stated that the model was sufficiently calibrated to proceed to D.O. modeling. He also stated that EPA would defer to the USFWS on utility of the model (salinity and water levels) to address impacts to the marshes.

3. We discussed **Convergence Testing.**
I stated that CEWES was satisfied with the information ASA/ATM had provided.
Paul stated that USGS needed the following additional information: results of convergence both longitudinal and width testing for Water Levels, Currents, and Salinity on grids for the Front River and Back River. An idealized grid would be acceptable. He went on to state that the downstream flow rate used in previous convergence tests appeared low (1/2 the normal flow at Augusta). He stated that the new testing needed to either be performed with 2 flow rates or a variation in flows that include normal downstream flows. ASA did not need to run 2 flow rates on the grid for Back River.
I commented that the previous convergence testing results appear to indicate that model results stabilize after a certain modeling duration. The group agreed that to increase confidence in the model results, application runs of the Hydro & Salinity Model would use a 25-day ramp-up period before output data is recorded. ASA/ATM could accomplish this by adding a synthetic set of data at the beginning to allow the model to stabilize prior to recording outputs.

4. We discussed **Water Surface Elevations.**
EPA and the USGS agreed that ASA/ATM needed to provide additional information to describe how remaining errors in the model results will be accounted for (process or methodology) as they are used in follow-on modeling and/or during application runs. Paul stated he would check with USFWS to ensure this position was acceptable to them.
I stated that it was likely that the Corps would not state that the model is acceptable for assessment of wetland impacts until we saw the results of the accounting for the remaining errors and the extent of the correction.

5. We discussed the USFWS concerns about the accuracy of both salinity and water surface elevations.
Paul stated that he thought that the USFWS just wanted to make sure that any improvements made in the Hydro Model's ability to predict water surface elevations would not

be made at the expense of accuracy on salinity predictions. ATM will provide additional information regarding the effect that any process used to account for remaining errors in water surface elevations is likely to have on salinity predictions.

6. We discussed **Current Predictions**.

Danny stated that GPA 14 was a station where the currents were altered by the orientation of the structure and adjacent structures. Therefore, the data on currents obtained from that station is not reliable and was not used.

ATM agreed to provide statistics and graphs on currents for both the 1997 and 1999 data collection periods. This would include model to data comparisons.

Paul will check with Ed Eudaly to ensure that additional data is all he needs, or if the USFWS is particularly concerned with the model's present level of accuracy.

The Expectations Document included goals of +/- 25% for currents. Danny stated he believes the model results are within that range.

7. We discussed **Volume Flux**.

No time series plots are available. ATM will provide new information in the new package on this issue. This data will include model to data comparisons and plots of the data. ASA believes the new information demonstrates that the model's performance has improved on this issue.

8. Agreements.

A) ATM will provide a revised acceptance package that acknowledges additional processing is needed to provide usable input for evaluation of wetland impacts. It will include all revisions, updates, errata sheets and new information provided since the original April 2, 2002 document.

B) ATM will work to develop post processing techniques for water level output from the Hydrodynamic and Salinity Model.

C) USGS and the USFWS will arrange a meeting to discuss water level accuracy requirements and possible ways to reach them. Expected attendees will be Danny Mendelsohn, Paul Conrads, Bo Ellis, John Bossart, Wiley Kitchens, Ed Eudaly and Bill Bailey.

William Bailey
Environmental Resources Branch

CESAS-PD-E 16 May 03

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 7 May SMART Meeting

1. Attendees:

EPA:	Jim Greenfield
	Steve Whitlock
USGS	Paul Conrads
ATM/GPA:	Steve Peene & Bo Ellis
	Danny Mendelsohn, Henry Rines & Tom Gallagher
LGE/GPA:	Larry Keegan
COE:	Doug Plachy
	Sung-Chan Kim
	Bill Bailey

2. A copy of the agenda is attached.

3. I opened the meeting by stating that ATM wanted us to review what they were doing leading to calibration of the D.O. Model, provide them with guidance, and inform the group if anything they are doing may be unacceptable to our agencies.

4. We began by discussing the schedule. The Characterization Report would be used to develop the Base Case. ATM is not waiting for anyone to proceed in their calibration work. We will meet again on June 18 to discuss the interim calibration. The Draft D.O. Calibration Report will be delivered on 1 August. We will meet on 7 August to discuss the report.

5. We briefly discussed the goals of the calibration. That is to meet the meet the +/- 0.2 mg/l dissolved oxygen and D.O. deficit stated in the Expectation Document produced by the SMART in 2001.

6. Henry Rines presented the findings in their **Draft D.O. Characterization Report**. Concerning **Primary Productivity**, it appears that algal production is not a major factor within the estuary. The D.O. data do not demonstrate a marked diurnal cycle. Algae enter the estuary from upriver and the ocean, but the low light penetration appears to limit productivity within the harbor area. ATM will use Chlorophyll as a boundary condition, with inputs at levels observed levels and not model chlorophyll production within the estuary. ATM will expand the Characterization Report to include a historical analysis of chlorophyll data. ATM will perform a sensitivity analysis of the chlorophyll boundary values. They will examine D.O., BOD distribution, and Nitrogen distribution.

Concerning **BOD**, the data values are close to the detection limits and within the variability of the test at those levels. Therefore, there do not appear to be any marked differences between the values for BOD5, CBOD5, and LTBOD5. The decay rates do not demonstrate a pattern by location (Table 4-1). ATM will look at decay rates from the marshes by Freshwater, Brackish, and Saltwater zones.

Concerning the **marshes**, the marshes appear to consume D.O. and nitrate, and (possibly) export Ammonia, Organic Nitrogen, and BOD. Paul Conrads will send Chapter 5 of the Characterization Report to Ed Eudaly of the USFWS.

Concerning **Longitudinal Profiles**, the data showed what the reviewers expected.

Concerning **SOD**, the highest values were reported in the Kings Island Turning Basin. A 1985 study showed increases in ammonia in the sediment chamber. ATM will include this information in their calibration work. The "Redfield Ratio" of N-P-K in phytoplankton was offered as an initial measure of the carbon ratio for wetland vegetation.

Concerning **Instream D.O.**, both the upstream river and the ocean appeared to be well oxygenated. Lower D.O. values were observed in the middle of the harbor. Tidal variations in D.O. were observed. Stratification varies with the range of tide. The D.O. data shows recurring sharp (short term) drops in D.O. at slack tides. The group agreed that the data appear to be a sampling artifact or probe fouling problem, rather than a natural occurrence. EPA and USGS agreed that these spikes are most likely not real and should be deleted from the dataset.

7. ATM then discussed the **Base Case**. International Paper is by far the largest point source of CBOD. Flows from upstream and the marshes appear to provide the largest net CBOD loads to the estuary. The loadings given to ATM from MACTEC include short-term rainfall events during the period of the summer 1999 calibration. SOD is assumed to be equal across the width of the cross-section. We discussed the proposed ANN SOW. ATM and USGS agreed to review the SOW to separate out (and resubmit their proposal to GPA) any portions that appear to be more important – possibly that dealing with the offshore boundary. ATM in conjunction with USGS and EPA will submit a justification write up for the ANN data analysis.

8. ATM then discussed the availability of the model. Steve Peene stated that the model could be used by EPA, USGS and COE for any simulation within the Savannah River estuary. EPA stated they need full public access to the model if it is part of their Administrative Record for their TMDL. Steve will meet with ASA soon and discuss what EPA needs. ATM also discussed the limitations on the number of machines that USGS, EPA, and COE can presently use the model on. Steve will also address this issue with ASA.

9. ATM then provided an example of the costs for running the H&S and D.O. Models. A $4,000 per run cost was given as an average value. This was based upon a mid-level complexity run and the costs would be variable depending on the number of runs needed. It was discussed that there will be a considerable economy of scale to be had in reducing costs if the number of runs becomes large.

10. At the beginning of the next day we discussed two items: (1) the schedule for completion of the D.O. Model, and (2) communication. The schedule that was developed is included as Enclosure 2. As part of this discussion, it was agreed that the D.O. Model Calibration Report (draft and final) and the Hydro Model Calibration Report would be distributed to the agencies in both hard copy and CD. A CD would be included with each hard copy report. It was also agreed that the models themselves would be included with the Final Calibration Reports that are delivered to agencies for final agency approvals. The group agreed to enhance communications by including more team members when the discussions were more than technical modeling issues or interagency deliberations.

Enclosures

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

SMART MEETING

MAY 7, 2003

AGENDA

MORNING

D.O. Characterization Report	**ATM (2 hours)**

AFTERNOON

"Base Case" Conditions for Calibration • Boundary Conditions • Loading • Constants & Coefficients	**ATM lead**
Acceptability Criteria/Goals	**Bill Bailey**
Schedule for completion of D.O. Model • Interim Checkpoints	**ATM**
Application of the models • Time & costs per run (including analysis) • SH Expansion and other projects	**ATM**
Open Discussion	All (1 hour)

SCHEDULE FOR COMPLETION

OF

DISSOLVED OXYGEN MODEL

ID	Task Name	Duration	Start Date	End Date
87	Dissolved Oxygen Distribution Evaluation	1855 d	6-Apr-1999	3-May-2004
88	Develop Dissolved Oxygen Model	1720 d	6-Apr-1999	20-Dec-2003
89	Dissolved oxygen & sedimentation field data collection	210 d	6-Apr-1999	1-Nov-1999
90	Vertical & lateral dissolved oxygen profiling	120 d	5-Jun-1999	2-Oct-1999
91	Dissolved Oxygen model calibration	243 d	3-Feb-2003	3-Oct-2003
92	Evaluation of EPA-GAEPD RIV1	60 d	3-Feb-2003	3-Apr-2003
93	WQ model boundary conditions and loading evaluation – draft	94 d	3-Feb-2003	7-May-2003
94	WQ model boundary conditions and loading evaluation - final	42 d	8-May-2003	18-Jun-2003
95	Evaluate marsh boundary influence - draft	136 d	3-Feb-2003	18-Jun-2003
96	Evaluate marsh boundary influence - final	44 d	19-Jun-2003	1-Aug-2003
97	Evaluate rate constants and coefficients - draft	94 d	3-Feb-2003	7-May-2003
98	Evaluate rate constants and coefficients - final	42 d	8-May-2003	18-Jun-2003
99	DO characterization study	89 d	3-Feb-2003	2-May-2003
100	Investigate DO ANN	94 d	3-Feb-2003	7-May-2003
101	BMD output post processor	136 d	3-Feb-2003	18-Jun-2003
102	Implement upstream time series boundary	94 d	3-Feb-2003	7-May-2003
103	Develop segmentation and time averaging tool	136 d	3-Feb-2003	18-Jun-2003
104	Deliver DO model calibration letter report	1 d	11-Jun-2003	11-Jun-2003
105	Preliminary DO model calibration meeting	1 d	18-Jun-2003	18-Jun-2003
106	Scoping level analysis of bio-impacts model	16 d	21-Aug-2003	5-Sep-2003
107	Draft DO Model calibration report	180 d	3-Feb-2003	1-Aug-2003
108	Prepare draft H & S calibration report	35 d	2-Aug-2003	5-Sep-2003
109	DO model draft report meeting	1 d	20-Aug-2003	20-Aug-2003
110	Sensitivity study	79 d	15-May-2003	1-Aug-2003
111	Final DO Model calibration report	44 d	21-Aug-2003	3-Oct-2003
112	Federal agency (SMART) formal calibration evaluation	60 d	3-Oct-2003	2-Dec-2003
113	Dissolved Oxygen model calibration accepted by SMART	1 d	3-Dec-2003	3-Dec-2003
114	Federal agency (SMART) review of H & S calibration	30 d	6-Sep-2003	5-Oct-2003
115	Prepare final report of H&S model calibration	30 d	5-Oct-2003	4-Nov-2003
116	Agency review of DO and H & S model calibration report	45 d	4-Nov-2003	19-Dec-2003
117	Agency DO and H & S model performance acceptance and documentation	1 d	19-Dec-2003	20-Dec-2003

CESAS-PD-E

8 March 04
Revised 18 March 04

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 3 March SMART Meeting

1. Attendees:

EPA:	Jim Greenfield
	Steve Whitlock
	Earl Hayter
USGS	Paul Conrads
COE:	Doug Plachy
	Sung-Chan Kim
	Bill Bailey

2. This summary is an overview of the critical issues discussed and decided at the meeting. It does not represent all the discussions that were held during the course of the meeting.

3. Dr. Kim had gotten the Hydro Model working, although it took several communications with Danny to learn items that were not included on the CDs or in the report.

Dr. Kim had examined the hindcast that ATM had used to support the validity of the vertical mixing approach with other channel depths. ATM had examined how well their vertical mixing approach would have matched those from a multivariate approach. Dr. Kim explained that the Final Report did not compare sites with a large difference in calculated values between the two approaches, but instead chose a location where they did not differ by much. Even so, the values for mixing differed by a factor of 1.6 to 2. So Dr. Kim's assessment was that the hindcast did not demonstrate that the approach used in the Final Calibration Report reasonably matched conditions that occurred prior to the last harbor deepening. Therefore, the hindcast did not prove the present vertical mixing approach worked with different channel depths.

4. Paul Conrads discussed his findings about how vertical mixing was calculated in the model. Based on information provided by Danny (not in the Final Calibration Report), the final value of vertical diffusivity (Dv) is based on two computations within Equation 5 using two sets of coefficients. Calculations are performed on both equations and then the highest value is selected for use in the model. Each equation uses a smoothed tidal range computed for each time step and calculates vertical mixing based on the tidal height. Although only small differences in tide height may exist between certain periods (especially for maximum tidal ranges), the exponential nature of the equations

sometimes results in significant differences in the calculated values for mixing between those days. The group felt that tidal energy, rather than tide height, may have been a more realistic parameter to calculate vertical mixing.

The group discussed the offsets that ATM added to both of the vertical mixing equations. (A different offset was used for 1997 than for 1999.) The group felt that since the offset was dependent upon the tidal conditions present at that specific time, that the offset to be used when the model is being applied in a predictive mode could not be known. This significantly reduces the utility of the model for predictive purposes. Paul also explained that a second offset was applied to the equation for the 1999 conditions. This second offset made the reviewers question the technical validity of the approach, as the approach appeared to be an exercise in curve-fitting. (After the meeting, the group realized that the additional constant was applied to both the 1999 and 1997 time series. A correction to the discussion was sent out to the attendees of the meeting.)

Paul described that Danny had smoothed the tide heights (three iterations) to obtain a better curve for the vertical mixing. He explained how he had investigated the effects of this smoothing. Smoothing reduces the tidal range for that period. Paul showed how the peak in vertical mixing would be about 1/3 higher if the smoothing had been performed after the calculations had been made, rather than before. The result of that investigation is that the vertical mixing values are very sensitive to how they are derived.

5. The group concluded that the turbulence equation used in the Hydro Model is different from the one cited and previously applied. (This issue is included in Appendix BB of the Hydro Model Calibration Report.) Since it is a different equation, the proponent for use of the new equation must justify its technical validity. EPA, USGS, and ERDC each stated that explanation in the Final Report did not sufficiently demonstrate the technical validity of that equation. The description in Appendix Q of the application of the vertical mixing scheme to Savannah Harbor was inadequate.

6. The group discussed what uses they could support for the Hydrodynamic & Salinity Model. They concluded the model could be used for examination of (1)conditions that occurred during the periods over which observations were recorded (summers of 1997 and 1999), (2) velocities and water levels with flows up to about 15,000 CFS, and (3) parameters based on the existing (1997/1999) channel bathymetry.

7. The group concluded that the vertical mixing approach was not physics-based. Therefore, it couldn't be used to analyze changes in channel depth. It could only be used to examine conditions arising from the existing (1997/1999) channel bathymetry.

William Bailey
Environmental Resources Branch

CESAS–PM-CM

Draft: 19 May 2004

Final: 15 June 2004

MEMORANDUM FOR RECORD

SUBJECT: Federal Agencies Responses to Questions and Uncertainties Raised in Georgia Port Authority's Letter of 11 May 2004.

At the request of the US Environmental Protection Agency, National Marine Fisheries Service and US Fish and Wildlife Service points of contact, the Savannah Harbor Expansion Project Manager has prepared the following summary of responses to the comments/issues raised in the subject letter to the four Federal agencies.

Georgia Port Authority (GPA) Item 1. The review of the Plan A calibration has focused primarily on vertical mixing. Some recommendations have been identified to improve the Plan A model, but only preliminarily discussed with the reviewers. The review comments and agency letters did not specifically reference or discuss the latest documentation and testing provided for Plan A. Other concerns have also been identified, and the review remains unfinished. Consequently, it is impossible to understand the extent of work that would have to be done to revise Plan A, which renders an estimation of time and cost inaccurate.

***Federal Agencies' Response**: The review of the Plan A calibration was focused on the vertical mixing scheme according to the established evaluation procedure. It was agreed by all parties that the evaluation would be done in phases. The first phase was to determine the technical defensibility of the vertical mixing scheme. No further review of the model would occur if the model did not satisfy this criterion. The Plan A vertical mixing scheme did not meet this criterion, therefore, according to the established evaluation procedure no further review of the remaining portions of the model occurred. As a result of several informal discussions, meetings, and detailed review comments on the January 2004 Final Calibration Report for Plan A, the agencies believe that GPA/ATM has sufficient information to determine what is needed to upgrade and further develop Plan A. It is apparent to the Federal agencies that GPA/ATM have been reluctant to accept the agencies' finding on the Plan A vertical mixing scheme and have focused their efforts on defending the current unique empirical approach to the Boundary Fitted Hydrodynamic/Water Quality Management and Analysis Package (BFHYDRO/WQMAP-GPA) model. Only recently has GPA/ATM agreed to look at using a more standard physics-based approach to the vertical mixing.*

While it may be possible to upgrade and further develop the Plan A models, the Federal agencies recommends that GPA take the following considerations into account before expending additional resources on such an effort;

1. The Federal and state agencies have made several recommendations to ATM for improving their model over the years and ATM has demonstrated a reluctance to accept these recommendations. It was only very recently that ATM agreed to consider the Federal and state *agencies recommendations, primarily as a result of the agencies' repeated concerns about the technical indefensibility of the Plan A model vertical mixing scheme. Given this lack of technical defensibility, and the fact that the physics-based vertical mixing scheme in Plan B appears to be defensible, the agencies lack confidence in ATM's ability to upgrade and further develop their current Plan A model in a timely and cost-effective manner.*

2. Given the difficulties with the development of the BFHYDRO vertical mixing scheme is it worth pursuing another vertical mixing scheme for this model? According to ATM, it chose the empirical approach to the vertical mixing because it could not get a physics-based approach to work. The Plan B Environmental Fluid Dynamics Computer Code (EFDC) utilizes a physics-based approach and the vertical mixing scheme has been found to be technically defensible.

3. The developer of BFHYDRO/WQMAP, Applied Science Associates, will not support and defend these models due to the unique changes made by ATM. Would ASA support and defend the model after further upgrades by ATM?

GPA Item 2. GA EPD and SC DHEC have not provided detailed comments resulting from their review of the Plan A DO model. Their letters contain their conclusions but provide little to no insight into the basis for their conclusions. Their feedback is essential to estimating the revision work to be done. In the meeting on March 31st, the GA EPD representative stated that he was not prepared to comment on the DO model since he understood the focus was solely on vertical mixing.

***Federal Agencies' Response**: During the September 2003 and the April 2004 technical meetings, the specific problems with BFHYDRO/WQMAP-GPA Savannah Harbor application were listed by the Federal, state, and local agencies. Though the states did not provide a lot of detailed comments, they did indicate that there were problems with the Plan A model. Additionally, the states have made it clear that they were relying on the hydrodynamic modeling expertise of the Federal agencies. ATM and GPA should be able to put together the requirements for completing the Plan A Dissolved Oxygen model, by going back through the meeting notes from the Technical Advisory Group (TAG), Modeling Technical Review Group (MTRG) and Savannah Multi-agency Review Team (SMART) meetings. ATM contacted members of the review team after the April 7, 2004 Executive Management Group (EMG) meeting to solicit specific concerns with technical aspects of the model that would need to be addressed to fix BFHYDRO/WQMAP-GPA. These were extensive conversations and ATM should have sufficient information to develop a draft scope of work for review.*

GPA Item 3. It appears, based on conversation between our consultants and some of the model reviewers, that there may be areas of misunderstanding or misinterpretation about what was done to calibrate Plan A. There has been little to no real time interaction subsequent to the distribution of the calibration report between the reviewers and the modelers who calibrated Plan A to identify, discuss and resolve them. The representative from GA EPD in the Water Quality Coordination Group meeting on March 31st made the point in his remarks that there had been very limited interaction for over the past two years regarding the DO model. It is essential that misunderstandings or poor reporting not be allowed to obscure the factual objections to the calibration of the Plan A models.

***Federal Agencies' Response**: As agreed upon by the Federal agencies and ATM, the final calibration report was to be the final basis for a decision – this was spelled out very clearly in the September 2003 meeting. A special meeting was arranged on March 31, 2004 to provide*

ATM with another opportunity to clear up any misunderstandings, to ask any questions, and to clear up misstatements in the final report. At this meeting, ATM did not take the opportunity to review the individual comments of the reviewers. Rather than trying to create a better understanding of the Plan A model, new data was introduced which only served to raise further questions. At the March 31, 2004 meeting, EPA made it clear that it could not continue to expend resources on Plan A any longer and was moving forward with Plan B. The other Federal agencies agreed that Plan B should be given serious consideration as an alternative to Plan A.

GPA Item 4. Agencies rejected the Plan A model on the basis of an empirical approach to the vertical mixing component and stated that in using an empirical component, the model is valid for running tests only for those periods of time where conditions to be tested are the same as the field conditions that existed when field data were taken. Since the critical conditions to be tested are quite similar (or maybe nearly exactly the same) to those at the time the field data were gathered, will the model run results for the critical conditions be valid? If so, how would the decision process be enhanced by other tests for conditions that are not critical to the issues at hand?

***Federal Agencies' Response**: The model reviewers have raised questions about the vertical mixing approach for the last three years. When the true empirical and curve-fitting nature of the BFHYDRO/WQMAP-GPA vertical mixing approach was finally documented in the January 2004 Final Calibration Report, which also showed that the previous documentation and technical "peer" reviewed papers contained an incomplete description of the vertical mixing scheme, the Federal agencies had no option but to determine that the hydrodynamic model was not technically defensible. The critical technical defensibility issue was the predictive nature of the vertical mixing routine to simulate a potential 6-foot deepening. The hindcasting tests showed different model performance for the 1999 calibration period and the 1999 hindcast test. One simulation over predicts the salinity at the Fish and Wildlife Service dock and one under predicts the salinity. The hindcast test does not support the calibration simulations. This disparity gives rise to the question of which is right? If the hindcast is correct, then the calibration and report are wrong. If the calibration is correct, then the hindcast is wrong. This makes it difficult to determine how the model be would applied to various project scenarios.*

GPA Item 5. EPA stated in its letter dated April 6, 2004: "With financial assistance from other Savannah Harbor stakeholders, EPA intends to expand the capabilities of these EPA models to evaluate the water quality and hydrologic impacts associated with the various harbor deepening alternatives. EPA will continue to cooperate with GPA, the Savannah District Army Corps of Engineers, and other stakeholders to support the EIS process." Should this be interpreted as meaning that EPA has already made its decision to employ the Plan B model relative to the Savannah Harbor Expansion Project and further discussion will not change it?

***Federal Agencies' Response**: Given the lack of meaningful progress on the Plan A model and the reluctance of ATM to fully disclose the details of the Plan A model, EPA had no choice but to look at an alternative modeling approach to meet its court-mandated deadline. Since the fall of 2003, EPA has spent considerable time and resources developing the EFDC/Water Quality Analysis Simulation Program (WASP) model for establishing TMDL and water quality standards. EPA offered the use of this model as a contingency to Plan A for the SHE project. Given the same concerns about the lack of progress on Plan A for the SHE project, and the ongoing delays to the project schedule, the other Federal agencies agreed and this became the Plan B modeling approach. GPA/ATM have not been able to provide a technically defensible* *model that would meet the needs of the SHE project and the Plan B model meets the technically defensible criteria. Additionally, the Federal agencies have spent considerable time providing input to ATM during the development of the Plan A model. For the most part this input has not been appropriately considered. Also, the information provided by ATM has been incomplete or confusing, and there has been a reluctance by GPA/ATM to accept the agencies' position that the Plan A model is flawed. Given this historical pattern, the agencies are reluctant to proceed further with the development of the Plan A model. The Plan B model has passed the initial technical defensibility test and EPA's contractor appears to be willing to listen and adjust the Plan B model as needed. Therefore, the other Federal agencies see several advantages to the Plan B modeling approach and it is not just a matter of EPA driving this model selection for the SHE project.*

GPA Item 6. Once there is a full understanding of the areas of the Plan A models that have to be revised, a proposed revision for each has to be developed. It is important to know if those proposed revisions, if carried out correctly, would be acceptable to the agencies before a decision to proceed with any of them can be made.

***Federal Agencies' Response**: The first step would be to revise the vertical mixing scheme so that it is defensible. The Federal agencies believe that ATM has sufficient information to know what is required to accomplish this. Once this criterion has been satisfied then other portions of the model can be reviewed in more detail to determine what revisions are needed. The critical issue is that the modification to the vertical mixing approach would have to be done correctly and be subject another round of review. As the minutes of the various MTRG, TAG, and SMART meetings demonstrate, the agencies have patiently reviewed key aspects of model development with ATM, such as basic calibration of a water quality model (MTRG meeting with review of calibration approach with Eduardo Yasuda). However, ATM chose not to follow this advice and guidance. At the March 31, 2004 meeting when ATM offered to modify the vertical mixing scheme to satisfy the Federal agencies, ATM was asked why the agencies should assume they would get it right this time. ATM had no response to this question and this is a crucial area of concern for the agencies. Successful upgrading and further development of the Plan A model would require a significant change in the way ATM has responded, in the past, to input from the Federal and state reviewing agencies.*

GPA Item 7. Two of the areas of concern expressed by the Federal agencies involved the modification of the BFHYDRO code in the calibration process and use of an empirical relationship. Consultants we have questioned indicate that it is common for modelers to modify code in the calibration process. It is important to understand how much modification of code is accepted modeling practice and when it exceeds those bounds resulting in a unique model. We have been informed that the empirical relationship in question has been used in the model and was discussed with model reviewers from the beginning of the MTRG process. It was recently determined to be unacceptable to each of the agencies. It is important to know how to make this aspect of the model acceptable to all of the agencies for the SHEP applications.

***Federal Agencies' Response**: The issue is not that empirical approaches are unacceptable. The Federal agencies understand that there are valid empirical-based models. Acceptable empirical models for predictive purposes are those applied to a limited range of conditions or those that have been derived from extensive databases covering a very broad range of observed conditions. The ATM empirically-derived vertical mixing scheme meets neither of these conditions. The data used to derive the empirical vertical mixing scheme was limited to the summer and fall of 1997* *and 1999. These are typically low flow periods for the Savannah River and the particular sampling years had abnormally low flows. The application of the model would be limited to moderate and low flow periods. However, the SHE project needs to look at the full range of flow conditions of the river. Therefore, the Federal agencies do not believe that the unique BFHYDRO/WQMAP-GPA model will meet many of the project's needs.*

Model modifications are how models are updated and new releases are created. The developer of BFHYDRO/WQMAP, ASA, does not stand behind modifications made to BFHYDRO/WQMAP-GPA for the Savannah application. They have not incorporated the ATM modifications into their release of their model. ASA views it as a unique application of BFHYDRO/WQMAP to Savannah and not one in the long history of peer-reviewed applications of their model. Also, ATM stated they tried other vertical mixing schemes and they did not work, although the Federal agencies were provided with no documentation supporting this statement. If ATM were correct that other physics-based vertical mixing methods do not work for the harbor, because of it's uniqueness, then the Federal agencies would be willing to use the best method available. Initially, the Federal agencies accepted ATM's statement about their attempts to work with other models. When EPA initiated Plan B (using EFDC because of its robustness in other areas), EPA discovered that the complex mixing scheme of the Savannah Harbor could be predicted by a physics-based vertical mixing scheme and that it was not necessary to use an empirical method. ATM was informed of this but refused to acknowledge this and continued to pursue their empirical method.

For the SHE project, an acceptable model would have to be shown to be technically defensible, tested against known test cases, and applied to other projects. This testing would have to include the vertical mixing, upper stream representation (including stream slope), and ability to handle marsh storage.

GPA Item 8. If a decision is made to modify the Plan A models, and the revisions that are made utilize acceptable methodologies that are properly implemented, the resulting model performance will have to be reevaluated against the Federal Expectations document goals in order to judge its acceptability. Until then, there is no conclusive information on which to judge performance.

***Federal Agencies' Response**: Based on the established expectations and evaluation procedures, which GPA/ATM agreed to, performance goals do not come into play until the BFHYDRO/WQMAP-GPA model is technically defensible. According to the procedures, the BFHYDRO/WQMAP-GPA vertical mixing scheme had to first pass the technical defensibility test before looking at other portions of the model. A model with good performance, but lacking in technical defensibility does not serve the interests of EPA or the SHE Project.*

GPA Item 9. Until the technical objections to the Plan A and Plan B calibration are resolved, it is impossible to determine which model's performance comes closest to meeting the goals of the Federal Expectations document. Performance of each can only be judged if common criteria and goals are used.

***Federal Agencies' Response**: The performance issue has been addressed in our response to GPA Item 8. The technical objections to the Plan A and Plan B model are not of the same order of magnitude. The objections to the Plan A model are related to fundamental problems with the modifications to the BFHYDRO code that render it technically indefensible. Based on the agreed upon phased evaluation, there was no point in evaluating Plan A's performance, when it could not pass the initial test of technical defensibility. The objections to the Plan B (EFDC and*

WASP) model are not related to technical defensibility, rather the need for finer grid resolution, boundary conditions, and how tide-marsh interactions are handled. EFDC and WASP have a proven record of being technically defensible and have gone through review in numerous other projects and other applications. A review of the calibration report for Plan B found that it can and does represent the physics of the Savannah Harbor stratification and de-stratification. Therefore, it has passed the initial test and additional development is warranted for comparison against the Federal Expectations Document.

GPA Item 10. Plan B is still an unknown entity. The results of agency review of the Hydrodynamic model are not available yet. The Water Quality model calibration has not been published yet.

***Federal Agencies' Response**: While the calibration of the water quality model is not yet finished, the agencies' review of the EFDC model is complete. The agencies have found that it meets the technically defensibility criterion and is therefore suitable for developing the water quality model. However, BFHYDRO has not passed the initial test and therefore is not suitable for developing the water quality model. Therefore, the unknowns are greater with the Plan A models than the Plan B models.*

GPA Item 11. The changes needed to Plan B to adapt them to meet the needs of the Savannah Harbor Expansion Project are unknown. Consequently, the time and cost to do so cannot be estimated. Until they are known, these factors cannot be considered in making a choice of the path forward.

***Federal Agencies' Response**: The Federal agencies believe the work needed to adapt the Plan B models to the SHE project are sufficiently known to compare and decide between modeling approaches. Although GPA/ATM, has not provided any estimates for revising Plan A, the Federal agencies have an understanding of what is required to revise Plan A and have obtained estimates from Tetra Tech for the additional work required for Plan B. This comparison indicates that the development costs and schedules would be about the same, given comparable assumptions.*

GPA Item 12. In part, the potential choices are being driven by a desire to use only one model for both the EPA's TMDL purposes and the Savannah Harbor Expansion Project's purposes. We should reexamine that goal to evaluate whether it is practical and its degree of necessity. Both projects (TMDL setting and SHEP) face the likely prospects of being challenged in court by powerful groups. The modeling, if it is a common element between the two projects, is a likely point of any challenge to come. Would it be better to not use common models for each project so that both are not stalled while legal challenges are resolved?

***Federal Agencies' Response**: The Federal and state agencies have expressed the preference to use one model for all harbor evaluations. EPA has been developing the Plan B models to meet its particular needs. However, adjustments were made to the Plan B model to determine if it could meet SHE project needs. The Plan B model has passed the initial test of technical defensibility and could be further modified to meet the remaining needs of SHE project. A multiple model approach runs the risk of having conflicting results that are not easily resolved and this can result in prolonged challenges. The concern with BFHYDRO/WQMAP-GPA is that it would not stand up to legal challenges. If a two-model approach were taken, the second model would have to be technically defensible (such as a proven model like Estuarine and Coastal Ocean Model- ECOM).*

GPA Item 13. The grid resolution employed for Plan A emerged after months of work with the Modeling Technical Review Group. Significant effort was expended, examining various degrees of resolution and testing the sensitivity of the model performance to them. The Plan B hydrodynamic model employs a much coarser grid resolution. How can this be reconciled with the MTRG identified needs for SHEP? How will that reconciliation be accomplished? What are the ramifications if a higher resolution grid has to be employed?

Federal Agencies' Response: *The MTRG, SMART or TAG was not involved in the grid resolution. The agencies requested that ATM perform convergence testing to support their choice of a computational grid. Similar testing will be required of any model that is proposed for use on the SHE project. The results of that testing would be included in the final calibration report for the hydrodynamic model. The reviewers have found that the Plan B model is technically defensible with the coarser grid. Finer grid resolution is not going to change the defensibility of the Plan B model, and will likely increase its performance. Since EFDC is a public domain model, grid resolution or other adjustments can be made to suit individual users needs.*

GPA Item 14. The calibration of Plan A received years of intense scrutiny by both the MTRG and the SMART. Iterative testing of modifications, discussion and explanation of the calibration choices and their results, sensitivity testing, and statistical analysis all contributed to the understanding of the calibration. Similar scrutiny of the calibration of Plan B should be afforded the federal and state agencies, the MTRG members and the SEG members. How will that be accomplished?

Federal Agencies' Response: *The intense scrutiny of the Plan A model was in large part the result of problems that arose with the Plan A model and the apparent lack of responsiveness by ATM to the concerns and advice of the reviewers. As problems continued to arise, with no apparent resolution, more and more of the reviewers' attention was required to address these and recommend corrective measures. The review of the January 2004 Final Calibration Report made it apparent to the reviewers that ATM had not taken advantage of the considerable effort and expertise of the reviewers to produce a technically defensible model.*

Plan B was developed to meet the needs that stakeholders brought up during the model discussions and this development is being conducted by people with substantial water quality modeling experience. For example, the WASP model has been adapted to include various reaeration options and multiple component BOD analysis. EPA is and will continue to hold technical meetings with the other agencies and the Harbor Committee that are involved in or potentially impacted by the TMDL development to assure that the hydro and water quality models are technically defensible and address the relevant issues.

GPA Item 15. The Plan A DO model calibration was done employing, in part, a "weight of evidence" approach suggested by EPA. Will a similar approach be followed in the case of the Plan B Water Quality model? Will the documentation be comparable to that available for Plan A? What is the cost to produce such documentation?

Federal Agencies' Response: *Water quality experts will be conducting the Plan B modeling and they will be using normal modeling procedures, one of which is the weight of evidence approach. The model calibration will be documented accordingly. For any model that is proposed for use on the SHE project, the intent is to provide the same information to the reviewers on the development and performance of the model.*

GPA Item 16. Are there other alternatives that are viable that have yet to be identified?

Federal Agencies' Response: *There are several other alternative models that are available. However, use of another model would require additional development time and cost and there is no guarantee that it would be technically defensible. Considerable time and effort has already been expended on Plan B and the Federal and state agency reviewers have found that it is technically defensible.*

GPA Item 17. Plan A benefited from extensive effort and feedback from SEG members over a period of years. That cannot be ignored in our decision process. The adaptation of the Plan B models must consider all of that information.

Federal Agencies' Response: *There has been little effort or feedback on the model by the SEG members, other than through the MTRG, which was composed mainly of Federal and state agencies and chaired by ATM. Since the SMART was formed, the MTRG has been inactive. For the past few years, when the model was mentioned at the SEG meetings, there was a brief progress report by the ATM representative. This was followed by few, if any, follow-up questions. Also, no substantive discussion of model issues occurred after these brief reports. There has been no SEG consensus on the Plan A or the Plan B model.*

The developers (EPA/Tetra Tech) of the Plan B EFDC model have utilized information that the Federal agencies accumulated as a result of their participation in the Plan A model development. They will continue to consider all relevant and useful information as they proceed with further development of the Plan B model. EPA/Tetra Tech has already demonstrated their willingness to work with users/potential users of the Plan B model by working with the States of Georgia and South Carolina.

GPA Item 18. The choice of the modeling to be employed in the Savannah Harbor Expansion Project must be the appropriate and correct choice for the project's requirements. The appropriateness and correctness must be documented and demonstrated. While an attempt has been made to use the same model for both the SHEP and EPA efforts, there is no reason for the SHEP model selection to be driven by the court-mandated TMDL time line.

Federal Agencies' Response: *The Federal agencies agree that an appropriate model must be selected to meet the needs of the SHE Project and that its development and application must be appropriately documented. The lessons learned during the Plan A model development indicate that it was a lack of input on the model selection and appropriate and timely documentation that created the current difficulties. GPA/ATM did not involve the other stakeholders in the BFHYDRO/WQMAP model selection and BFHYDRO/WQMAP-GPA had to be modified extensively even to work, empirically, on the Savannah Harbor system. BFHYDRO was not then or is it now the only hydrodynamic model that could have been used. Also, the information provided to the stakeholders was often incomplete and untimely. It was not until the agencies received the January 2004 Final Calibration Report that they had sufficient information to understand the details of the Plan A model. Even as they reviewed this report, they found that it was not complete and additional information had to be obtained from GPA/ATM in order for the agencies to complete their review.*

Development of the BFHYDRO/WQMAP-GPA model was scheduled to have been completed years ago. The ongoing schedule slippage necessitated EPA developing a defensible model (EFDC/WASP) to meet the agency's more stringent time schedule. The EPA, Georgia Department of Natural Resources Environmental Protection Division, and South Carolina

Department of Health and Environmental Control have used the EFDC and WASP models on other projects. EFDC has proven that it has the appropriate physics-based mixing scheme, the models are public domain, and they are technically defensible. These models have demonstrated their versatility on a number of different projects and under a variety of conditions. Further refinement of the EFDC/WASP model to meet the needs of the SHE Project will build on EPA's Plan B modeling efforts and will not be constrained by the court-ordered TMDL mandate.

GPA-SEG: We met with members of the SHEP Stakeholders Evaluation Group (SEG) on May 3, 2004 to solicit their feedback. From that meeting, the following feedback emerged:

The risk and uncertainty inherent in the prediction of changes to the Savannah River estuary has not been addressed. Data that results from model simulation should be considered as a range of possible values, rather than point values. This range of values should be established as a part of the process for determining natural resource impacts and the sensitivity of predicted values to variation in input conditions should also be established.

Utilization of a single model for evaluation of impacts does not contribute to the reduction of uncertainty in the predictions. Consideration should be given to the use of a matrix of several models to determine the changes invoked in the with-project condition. If all predictions converge or cluster, the uncertainty in the accuracy of prediction is reduced. Utilization of just one model makes it more difficult to develop an understanding of the uncertainties and, consequently, the risks involved.

The SEG members clearly communicated their interest and desire to be afforded the opportunity to provide feedback for consideration in the decision process regarding the path forward for modeling. They have asked that they be kept apprised of the progress to a decision.

Federal Agencies' Response: *Agency reviewers attended this meeting and are aware of the discussion that took place on the multi-model approach. There was not a recommendation from the SEG, rather there was discussion and query regarding various modeling approaches. Individual SEG members requested or recommended certain actions, but as a SEG body they made no recommendations. The attending SEG members were informed that this multi-model approach has cost and schedule implications. The agencies see more difficulties with the multi-model approach than benefits, aside from the cost and schedule implications. However, the uncertainty and multi-parameter sensitivity analyses discussed at the SEG meeting will be considered and may be useful.*

The SEG was also informed that a decision would be forthcoming at the May 2004 EMG meeting and requested that a follow-up SEG meeting be held as early as June in order to discuss the outcome of this EMG meeting. The Federal agencies are prepared to attend this meeting and answer questions about the final decision. Copies of the decision document and support documents will be in the public domain and will be available to the SEG.

GPA General: None of the Cooperating Agencies will be prepared to proceed to decisions until understanding of the options and the contributing factors is sufficient to make informed choices. We respectfully request a full discussion of this subject at the Executive Management Group meeting on May 21, 2004, and development of an action plan for resolution of the concerns before proceeding to a decision.

Federal Agencies' Response: *The Federal agencies have carefully reviewed both the Plan A and Plan B calibration reports, the defensibility of these models, what is needed for upgrading and* *further development, the applicability of these models to the needs of the SHE project, and the historical problems with the Plan A development. They also have the requisite capability, knowledge, and expertise to understand the contributing factors and options. Therefore, the undersigned believe that the Federal agencies have sufficient information to make an informed decision on the Plan A and Plan B modeling approaches.*

W. Kenneth Derickson, Ph.D.
Senior Project Manager

Agency POC Concurrence on Responses

U.S. Environmental Protection Agency

James Greenfield, SMART Representative

U.S. Fish and Wildlife Service

Edwin Eudaly, SMART Representative

National Marine Fisheries Service

Prescott Brownell, SMART Representative

Willett, Brenda W SAW

From: Mueller.Heinz@epamail.epa.gov
Sent: Monday, April 02, 2007 11:19 AM
To: Bailey, William G SAM@SAS
Cc: Welborn.Tom@epamail.epa.gov
Subject: RE: Savannah Harbor Expansion Project - Decision on Model-To-Marsh proposal

Bill, per our earlier e-mail, R4 concurs with your proposed approach.
Heinz

"Bailey, William G SAM@SAS" <William.G.Bailey@sas02.usace.army.mil>

04/02/2007 11:12 AM

To: Heinz Mueller/R4/USEPA/US@EPA

cc

Subject: RE: Savannah Harbor Expansion Project - Decision on Model-To-Marsh proposal

Did you hear anything from Water Mgt Division?

BB
-----Original Message-----
From: Mueller.Heinz@epamail.epa.gov
[mailto:Mueller.Heinz@epamail.epa.gov]
Sent: Thursday, March 29, 2007 11:47 AM
To: Bailey, William G SAM@SAS
Cc: Hamilton.John@epamail.epa.gov
Subject: Re: Savannah Harbor Expansion Project - Decision on Model-To-Marsh proposal

Yes Bill, the way Ted left it that unless I hear from the W ater Div to the contrary by COB today, we will send you a concurrence e-mail tomorrow morning. HM

"Bailey, William G SAM@SAS" <William.G.Bailey@sas02.usace.army.mil>

03/29/2007 10:42 AM

To: Heinz Mueller/R4/USEPA/US@EPA

cc

Subject: Savannah Harbor Expansion Project - Decision on Model-To-Marsh proposal

Ted Bistereld said he would be out of the office this week and next. Is someone continuing actions to obtain an EPA position on my recommendation concerning the USGS proposal to modify the Model-To-Marsh linkage?

BB

Sent from my BlackBerry Wireless Device

Willett, Brenda W SAW

From: Garrett, Thomas A SAS
Sent: Monday, April 02, 2007 10:41 AM
To: Bailey, William G SAM@SAS
Subject: FW: SH Expansion - decision on M2M

Based on the meetings held on this subject and the opinions of the technical modellers, I concur that modification of the M2M is not necessary.

T. Alan Garrett
Project Manager

-----Original Message-----
From: Hoke, Joseph T SAW@SAS
Sent: Monday, April 02, 2007 7:44 AM
To: Bailey, William G SAM@SAS; Garrett, Thomas A SAS
Cc: Bradley, Kenneth P SAM
Subject: RE: SH Expansion - decision on M2M

I concur that we do not need to modify the M2M. The alternatives that it was designed to address appear to be of little interest to the agencies now, given their impacts on tide range.

Joseph T. Hoke, Jr., P.E.
Hydraulic Engineer
U.S. Army Corps of Engineers
Wilmington District (SAW-TS-EC)
100 West Oglethorpe Ave.
Savannah, GA 31401
912-652-5516

-----Original Message-----
From: Bailey, William G SAM@SAS
Sent: Tuesday, March 27, 2007 5:11 PM
To: Garrett, Thomas A SAS
Cc: Hoke, Joseph T SAW@SAS; Bradley, Kenneth P SAM
Subject: SH Expansion - decision on M2M

I've received concurrence in my recommendation from 2 of the 3 agencies. The one I have not heard from is now out of the office for 2 weeks.

I have not heard from either of the 2 Corps folks included on the concurrence/non-concurrence list.

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BB

Sent from my BlackBerry Wireless Device

Willett, Brenda W SAW

From: Ed_Eudaly@fws.gov

Sent: Tuesday, March 27, 2007 8:56 AM

To: Bailey, William G SAM@SAS

Cc: bisterfeld.ted@epa.gov; Hoke, Joseph T SAW@SAS; kay.davy@noaa.gov; Bradley, Kenneth P SAM; mueller.heinz@epamail.epa.gov; Pace Wilber; Garrett, Thomas A SAS; John_Robinette@fws.gov; Jane_Griess@fws.gov; Russell_Webb@fws.gov

Subject: Re: Savannah Harbor Expansion Project: Decision on Model-To-Marsh Revisions

Bill:

I concur with your recommendation to not pursue modification of the model-to marsh link. I have coordinated with Savannah NWR and they also concur. Please consider this e-mail as Service concurrence with your recommendation.

Ed EuDaly
U.S. Fish and Wildlife Service
176 Croghan Spur Road, Suite 200
Charleston, SC 29407
843-727-4707 ext. 227
FAX 843-727-4218

"Bailey, William G SAM@SAS" <William.G.Bailey@sas02.usace.army.mil>

03/22/2007 12:19 PM

To <bisterfeld.ted@epa.gov>, <ed_eudaly@fws.gov>, <kay.davy@noaa.gov>, "Garrett, Thomas A SAS" <Thomas.A.Garrett@sas02.usace.army.mil>, "Hoke, Joseph T SAW@SAS" <Joseph.T.Hoke@sas02.usace.army.mil>

cc <mueller.heinz@epamail.epa.gov>, "Pace Wilber" <Pace.Wilber@noaa.gov>, "Bradley, Kenneth P SAM" <Kenneth.P.Bradley@sam.usace.army.mil>

Subject Savannah Harbor Expansion Project: Decision on Model-To-Marsh Revisions

I have attached a decision document with my recommendation to (1) continue using movement of the 0.5 ppt point from the EFDC model, and (2) not pursue modifying the Model-To-Marsh link that we discussed on 8 March. Not revising the M2M will mean that we will use the Marsh Succession Models to identify wetland impacts from a harbor deepening (checking the predictions of the EFDC Model), but not with the various mitigation scenarios.

<<EXPAN LCA M2M revision decision – Mar 07 V2.doc>>
I have spoken to each of you separately and each expressed preliminary support for this approach.

Please let me know if you concur in the recommended course of action. If you want to sign the attached document, you may. But if you prefer, you can just send me an email letting me know whether you Concur or Non-Concur with the recommendation.

William Bailey [attachment "EXPAN LCA M2M revision decision -- Mar 07 V2.doc" deleted by Ed Eudaly/R4/FWS/DOI]

Willett, Brenda W SAW

From: Kay Davy [Kay.Davy@noaa.gov]
Sent: Thursday, March 22, 2007 12:56 PM
To: Bailey, William G SAM@SAS
Subject: Re: Savannah Harbor Expansion Project: Decision on Model-To-Marsh Revisions

Attachments: EXPAN LCA M2M revision decision -- Mar 07 V2. KayD.doc; Kay.Davy.vcf

EXPAN LCA M2M revision decisio... Kay.Davy.vcf (370 B)

Hi Bill,
I've attached our concurrence.
Thanks,
Kay

Bailey, William G SAM@SAS wrote:
>
> I have attached a decision document with my recommendation to (1)
> continue using movement of the 0.5 ppt point from the EFDC model, and
> (2) not pursue modifying the Model-To-Marsh link that we discussed on
> 8 March. Not revising the M2M will mean that we will use the Marsh
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> mitigation scenarios.
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> each of you separately and each expressed preliminary support for this
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> Please let me know if you concur in the recommended course of action.
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> prefer, you can just send me an email letting me know whether you
> Concur or Non-Concur with the recommendation.
>
>
> William Bailey
>

II. ENVIRONMENTAL RESOURCES

II. Environmental Resources

A. Marsh Succession

1. MFR dated 17 October 2005, Marsh Succession Modeling Teleconference Notes
2. MFR dated 22 March 2007, Proposed Revision to the Model to Marsh Linkage

B. Wetlands

1. MFR dated 7 July 2003, SHEP, Summary of 1 July Interagency Meeting on Wetlands.
2. MFR dated 5 June 2006, SHEP, Summary of 31 May Meeting of the Wetlands Interagency Coordination Team.
3. MFR dated 5 June 2006, Revised 30 June 2006, SHEP, Summary of 31 May Meeting of the Wetlands Interagency Coordination Team.
4. MFR dated 28 December 2006, Revised 9 January 2007, SHEP, Summary of 15 December Meeting of the Wetlands Interagency Coordination Team.
5. MFR dated 26 June 2007, revised 29 June 07 and 3 August 07, SHEP, Interagency Coordination Meeting Record 01'20-21 June Meeting.
6. E-MAIL from William G. Bailey, SAS, dated 5 April 07, SHEP, Wetlands Interagency Coordination Team – Decision on Model-To-Marsh Revision
7. E-MAIL from William G. Bailey, SAS, dated 21 July 09, SHEP, Wetlands Interagency Coordination Team Area 1S
8. E-MAIL from William G. Bailey, SAS, dated 03 June 2011, SHEP, Wetlands Interagency Coordination Team meeting Presentation
9. MFR dated 7 June 2011, SHEP, Wetlands Interagency Coordination Team Meeting Summary

October 17, 2005 Marsh Succession Modeling Teleconference Notes

Attendees;

Paul Conrads – USGS
Hope Moorer - GPA
Ed Roehl - ADMLi
Ruby Daamen - ADMLi
Bo Ellis - ATM
Joe Hoke – USACE, Savannah District
Elizabeth Godsey – USACE, Mobile District
Bill Bailey – USACE, Savannah District
Larry Keegan (host) – Lockwood Greene
Steven Davie – Tetra Tech
Fran Way – ATM

Agenda:

(1) Schedule validation of tasks, durations and dates for task family MSM - Marsh Succession Model

(2) Clarification and agreement on:

- USGS remaining work in Retraining M2M module and completion dates.
- Review plans and schedule for M2M module
- Plan and schedule for finalization of M2M report
- Needs of USGS from Tetra Tech to complete M2M retraining and testing, particularly regarding the output format from EFDC for input to M2M. Preference is for the output format to be directly importable into M2M without manipulation or modification as it comes from EFDC.
- Needs of USGS from ATM to complete M2M retraining and testing, particularly regarding the output format from M2M (Output data file must be directly importable into MSM without manipulation or modification as it comes from the M2M)
- Needs of ATM from USGS to complete MSM and report
- Delivery date for MSM and report for review
- Review plans and schedule for MSM
- Determination of training dates for USACE personnel in use of MSM

Summary of Results

Schedule validation for task family MSM - Marsh Succession Model

This was not discussed pending research of the scope and duration of potential modification to M2M module to match ATM grid requirements.

USGS remaining work in retraining M2M module, completion dates and needs of USGS from Tetra Tech

The retraining work is done. USGS is awaiting an input file from Tetra Tech which is an output from the EFDC model subjected to post processor manipulation. The post processing will put the data into comma delineated format and ensure date formats are correct as needed by M2M module . The work has been done and the simulation was run over the weekend. USGS should get the output file later today or tomorrow. After receipt of the output file from Tetra Tech, USGS needs 10 to 14 days to test and stress the M2M module.

Review plans and schedule for M2M module and finalization of M2M report

Assuming no impact by the work to modify the output grid, the expected delivery date of the M2M module is 10/28/05. A draft report will have to go through internal USGS review before it will be ready for project review. The draft report is slated for delivery for review by 12/2/2005 after internal review in USGS.

October 17, 2005 Marsh Succession Modeling Teleconference Notes

Once the module is finished and delivered, there is a need to have a training session for users of the M2M module. This should be a one day session, probably in Savannah, for users to ask questions, familiarize themselves with the module and run through several example runs.

Needs of USGS from ATM to complete M2M retraining and testing

No needs were identified by USGS from ATM

Needs of ATM from USGS to complete MSM and report

The output from the M2M module cannot be used directly for input into the MSM. The MSM developed by ATM uses grid cells centered at 100' intervals. The M2M module output is in grid cells of 10 X 10 m or 100 X 100 m on a side. There was considerable surprise and discussion of this requirement. Neither ADMLi nor USGS were aware of the difference in grid cell layout. Their proposal to retrain the M2M module specifically included identification of an option to revise the grid size based on their understanding of ATM's needs. Discussion identified three options to resolve this:

- Revise the output of the M2M module to meet the grid cell size and spacing as used in the MSM.
- Develop a "post processor" for the M2M to interpolate the output into the grid layout used by ATM's MSM model
- Revise ATM's MSM model to either conduct an interpolation of the input data from M2M or revise the grid layout used in the MSM to match the output of the M2M module.

Discussion of the options led to agreement that the preferred approach would be to avoid using a post processing approach if possible. ADM will evaluate what is needed to revise the output from the M2M module to match the ATM MSM grid layout. To avoid further confusion, ATM will transmit exactly what they need for input grid as soon as possible, either by resending what they provided earlier or in a new document when John Bossart gets back from into the US later this week.

In addition, ATM expressed that they also needed salinity layers output from the M2M module using historical values. These layers need to be time averaged values of periods that end on a date that they were out monitoring vegetation. They need to be periods of two years, one year, six months and three months duration ending up on particular dates. The periods and dates are known to USGS and have been provided in the past. No confusion existed over the format or requirements for this information.

Review plans and schedule for MSM and finalization of MSM report

Completion of M2M module and delivery is needed to complete the MSM. That means that the g rid question must be resolved. After ATM receives the salinity layers they need, it will take approximately one month to finish validation of the MSM and to be ready to conduct training on the MSM usage. It will take an additional two weeks to finish the draft report which will be ready to go into the project review process (ITR).

Determination of training dates for USACE personnel in use of MSM

Not discussed pending results of resolution of MSM input grid layout question.

Summary of schedule finish dates

- Deliver M2M module – 10/28/05
- Deliver M2M module report for USACE review – 12/2/05
- Deliver salinity layers to ATM for validation – 10/28/05
- Complete validation of MSM – 11/30/05
- Complete draft report for MSM – 12/14/05
- M2M user training – to be determined
- MSM user training – to be determined

October 17, 2005 Marsh Succession Modeling Teleconference Notes

Summary of Action Items

- ATM to document needs of MSM for input grid resolution and layout as soon as possible
- ADMLi to review ATM requirements and evaluate effort to revise the output grid of the M2M module. They will advise of effects on cost, effort and schedule.
- ATM to investigate options for revising MSM model to manipulate M2M module output from 10 X 10 m grid for use by MSM model as an initial step in MSM modeling. They will advise of the impact of this on cost, schedule and performance. This option will require a detailed description of how the manipulation will be done for technical review.
- USGS to begin coordination of internal review cycle for M2M module report
- USACE to finalize plans for M2M and MSM project review

CESAM-PD-E 22 March 07

DECISION DOCUMENT

SUBJECT: Savannah Harbor Expansion Project;
Proposed revision to Model-To-Marsh linkage

1. A problem has developed with use of the Marsh Succession Models (MSMs) on some of the mitigation scenarios. The scenarios affected are those that substantially modify flows between the Front, Middle, and Back Rivers. The problem results in an overstatement of salinity in the Middle and Back Rivers, rendering the MSMs unreliable to evaluate wetland impacts on those scenarios. We've identified the Model-To-Marsh linkage (M2M) as the source of the problem.

2. The following two courses of action are available.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the "impact" and "mitigation" runs. We would use the MSM to provide more detail on the vegetation changes on the "impact" runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for "mitigation" runs. This Option describes our present condition and plan for proceeding with the wetland evaluations.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the "impact" and "mitigation" runs. We would revise the M2M as described in the enclosed proposal and apply the MSM to both "impact" and "mitigation" runs.

3. The Lead and Cooperating Agencies discussed this issue on 8 March 2007. The MFR, which summarizes the discussions of the meeting, are attached.

4. The USGS would lead the work to revise the M2M. They estimate it would take $110,750 and 12 months to produce a final product (including internal review). The work would include participation of an interagency team to identify flow paths from the rivers to specific locations in the marsh.

5. The following summarizes the pros and cons of proceeding with the proposed revisions (Option 2):

PROS

- The revisions would allow the Marsh Succession Models to be applied to all mitigation scenarios presently being considered. At this time, the MSMs do not give reliable results when applied to mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers).
- The revisions would include the use of an interagency team, increasing the likelihood of those agencies approving the final product.

CONS

- The EFDC model in conjunction with spatial data can acceptably be used to identify movement of the 0.5 ppt contour, allowing predictions of change between freshwater and brackish marsh. Use of the MSM on the impact runs will provide a comparison of the EFDC and MSM impact predictions (without mitigation).
- Revision of the M2M would cost roughly $110,000 and possibly delay decisions on the project by a year. The 1998 Feasibility Report estimated project net benefits (benefits – costs) to be about $35,000,000 per year.
- The effectiveness of the proposed revisions and the reliability of the MSM results will not be known until after the work is performed. The proposal acknowledges substantial uncertainty regarding accuracy of salinity predictions even with the proposed revisions.
- The revised M2M may have to be further modified if additional mitigation scenarios are developed. The further modifications would require additional costs and possibly further delay decisions on the project.

6. Conclusions.

The project has one accepted method of identifying potential impacts to wetlands (using EFDC to identify movement of the 0.5 ppt contour).

The accuracy of that model can be judged by use of the Marsh Succession Models for impacts from deepening scenarios without mitigation.

Therefore, the revised M2M – and the Marsh Succession Models – are not required to identify wetland impacts from the various harbor deepening alternatives (with mitigation).

Implementation of the proposed M2M revisions would cost roughly $110,000 and possibly delay decisions on the project by a year.

The additional information that may be obtained by revising the M2M does not appear to be sufficient to justify the cost of the modifications or delay to the project.

7. Recommendation.

Based on the information provided in this document and its enclosures, I believe that implementation of the proposed Model-To-Marsh revision is not warranted and recommend that the modifications not be pursued.

William B. Bailey

William Bailey
Physical Scientist
Mobile/Savannah Regional Planning Center

8. Concurrence:

	CONCUR	NON-CONCUR	INITIALS
Joseph Hoke Hydraulic Engineer USACE Wilmington/Savannah Engineering	________	____________	________
T. Alan Garrett Project Manager USACE Savannah District	________	____________	________
Ed EuDaly Senior Biologist USFWS Charleston	________	____________	________
Ted Bisterfeld Ecologist EPA Region 4	________	____________	________
Kay Davy Fishery Biologist NOAA Fisheries Charleston	________	____________	________

CESAM-PD-E 20 Mar 07

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Lead & Cooperating Agency meeting, 08 March 07

1. The meeting was called to learn more about a proposal (attached) to revise the Model-To-Marsh (M2M) component of the Marsh Succession Models. Alan Garrett, Corps Project Manager, chaired the meeting. A list of attendees is attached.

2. Bill Bailey provided an overview of the problem.

The Corps has successfully run the Marsh Succession Models to identify changes in wetlands from the various channel deepening scenarios. These are the "impact" runs. As we applied the models to the mitigation scenarios, we observed unexpected results. For some mitigation scenarios, the EFDC runs predict a decrease in salinity but the MSMs show shifts to more saline wetland species. Upon further inspection, we observed that on those runs the M2M component was providing higher root zone salinity values than were occurring in nearby rivers. The M2M extrapolates riverine salinity values from seven sites to root zone salinity values across the entire marsh surface. Apparently the limited number of points from which the M2M is starting its extrapolation leads to inaccuracies in mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers). The M2M takes higher salinity levels on the Front River and uses them as a basis for incorrectly predicting higher salinity levels in portions of Middle and/or Back Rivers.

3. We described two avenues through which the project could more forward.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the "impact" and "mitigation" runs. We would use the MSM to provide more detail on the vegetation changes on the "impact" runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for "mitigation" runs.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the "impact" and "mitigation" runs. We would revise the M2M as proposed and apply the MSM on both "impact" and "mitigation" runs.

4. Paul Conrads and Ed Roehl provided an overview of the proposed SOW to revise the M2M. This write-up is only a small part of the description Paul and Ed provided.

The present M2M starts with river flows and tidal conditions. It adds to that foundation riverine salinity values from the EFDC model. The present M2M could be considered more a far-field approach since it uses a limited number of riverine salinity values and extrapolates them across the entire marsh surface. It determines a relationship between river salinity and the well gages through time-delayed input signals and moving window averages between river salinity and pore-water salinity. The M2M was designed to primarily identify changes in root zone salinity that occur longitudinally in the estuary (along the length of the river).

The proposed revisions would allow the M2M to better identify lateral changes in root zone salinity that occur across the estuary (between different rivers or away from a single river). These revisions would start with a more detailed network of river salinity stations. It would then extrapolate those values to nearby areas of marsh. This could be considered more of a near-field approach. Additional marsh well data would be obtained to establish strong relationships between river and marsh root zone salinities. The Q-zone approach would be used as a starting point for the river to marsh flow paths. An interagency panel would be used to identify those pathways and guide the model revisions.

Uncertainty in the results of this M2M revision include three components: (1) Quality of the original data, (2) Quality of the data used to forecast or hindcast to fill in missing data, and (3) Quality of the data from EFDC. These are the same sources of uncertainty with use of the present M2M. This revision will require development of additional synthetic data to fill in records for the extra river sites that will be used.

5. The group then asked questions of Paul and Ed Roehl about the proposed work.

What will be the reliability of the results when using more synthetic data? Would the public accept the use of more synthetic data? RESPONSE: The reliability will not be known until the model is produced. However, data for the existing M2M show it is highly reliable for use with the present configuration of the estuarine rivers. As with any model, the ultimate accuracy of the revised model's predictions would not be known until after post-construction monitoring is performed.

What will be the reliability of the results when using data from the GPA stations? Those data were determined to be unacceptable in development of the existing M2M. RESPONSE: Data from the GPA stations were not used in the existing M2M primarily because of their short period of record. A much longer – and therefore more reliable – record exists for the USGS gages. The GPA stations would be used in the model revisions to provide a finer grid of river locations from which to extrapolate salinity levels across the marsh surface. The finer grid should increase the accuracy and reliability of the model predictions within specific marsh areas. The additional stations

would also allow a more detailed quantification of the sensitivity of marsh areas to local riverine conditions. The GPA stations also provide data obtained during 1997 – the flow conditions that are being modeled during the mitigation analyses. The reliability of the revised models would not be known until they are developed.

What are the differences between the GPA stations, marsh gages, and USGS gages? RESPONSE: The differences include both duration and density. The marsh gages provide salinity information in the marsh root zone at 7 sites from 1999 to 2005 and 10 GPA sites from 1999 to 2002. The GPA stations hare 14 riverine stations with data from portions of 1997 and 1999. The USGS gages provide salinity information at 4 riverine sites for many years.

What will be the reliability of the final predictions if the development of the revised model includes extensive synthetic data? RESPONSE: Models are regularly developed and applied when only limited actual data exists. Synthetic data is an accepted technique in the modeling community when insufficient historical data exists.

If new algorithms need to be developed for each mitigation plan, it could appear that we have developed a model just to show the results we want on the plan we want. If the same model is not used to evaluate all plans, how can we ensure we are evaluating all plans to the same degree of accuracy? RESPONSE: The same procedures would be followed to evaluate all plans, even if the models differ.

The existing M2M and its algorithms appear to work well with the present river configuration. If new algorithms only are effective for the mitigation plans that substantially modify river flows, how can we ensure their accuracy? RESPONSE: The change from a "far-field" approach to a "near-field" approach increases the likelihood that the revisions would be accurate when flows are substantially modified. The reliability of the results will not be known until the models are developed.

The MSM provides more detailed information on expected wetland changes than does the EFDC model. Do we really need those more detailed predictions for each mitigation scenario? RESPONSE: If reviewers want the detailed information, the revised M2M is the only way to obtain it.

Although a provisional version may be available in 5 months, the project will need a fully accepted version before it could release a report containing results using this approach. The final report is scheduled to be available in 12 months. If complications occur that delay the work, the date would extend further. A 12-month delay in the project would be a major impact to GPA. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

The proposed revisions would likely extend the duration of the project. That extension may decrease the reliability of other analyses, requiring they be updated. That would require additional time and money. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

Some of the mitigation scenarios appear to decrease the tidal range. The USFWS may not be able to support those plans as a substantial decrease in the depth of flooding over the marsh may adversely affect nekton use of those areas. The plans which have the most effect on tidal range are the ones that substantially alter flows between the three rivers. RESPONSE: The proposed M2M revisions would not be beneficial if the final mitigation plans do not include measures that substantially alter flows between the three rivers.

Have the status and trends of wetlands since the last harbor deepening been taken into account? RESPONSE: Both the M2M and the MSM are based on data obtained since the last deepening.

Would the proposed revisions be necessary for the post-construction monitoring and adaptive management? RESPONSE: The EFDC will be used to ensure that changes in riverine salinity that are predicted are not exceeded. The existing M2M and MSM could be used to provide a perspective on what should have been expected in the wetlands with the observed flows if no further deepening occurs.

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

LEAD & COOPERATING AGENCY MEETING
08 MAR 2007

ATTENDEES

Ed EuDaly	USFWS – Charleston	(by phone)
Ted Bisterfeld	EPA Region 4	(by phone)
Kay Davy	NOAA Fisheries - Charleston	(by phone)
Alan Garrett	USACE - Savannah	
Joe Hoke	USACE – Wilmington/Savannah	
Hugh Heine	USACE – Wilmington	(by phone)
Elizabeth Godsey	USACE – Mobile	(by phone)
William Bailey	USACE – Mobile/Savannah	
Hope Moorer	GPA	(by phone)
Larry Keegan	Lockwood-Greene Engineers / GPA	(by phone)
Morgan Rees	Rees Engineering / GPA	(by phone)
Paul Conrads	USGS – Columbia	(by phone)
Ed Roehl	Advanced Data Mining	(by phone)

Estimation of Pore-water Marsh Salinities for Harbor Reconfiguration Scenarios

By
Paul Conrads, U.S. Geological Survey – Water Resources Division
Edwin Roehl, Advanced Data Mining, LLC
Wiley Kitchens, U.S. Geological Survey – Biological Resources Division
Zachariah Welch, Florida Coop Unit, University of Florida,

INTRODUCTION

Under sponsorship from the U.S. Army Corps of Engineers (USCOE) and the Georgia Ports Authority (GPA), the Lower Savannah River Estuary and the surrounding freshwater tidal marshes of the Savannah National Wildlife Refuge (SNWR) have been studied for years by a variety of governmental agencies, water users, universities, and consultants. Their interests are in maintaining water quality and predicting the potential impacts of a proposed harbor deepening on the estuary and tidal wetlands. Two major initiatives were the development of a three-dimensional hydrodynamic model (3DM) by a team of hydrologists, and the development of a marsh succession model (MSM) by a team of plant ecologists. The 3DM predicts changes in riverine water levels and salinity in the system in response to potential harbor changes. The MSM predicts plant distribution in the tidal marshes in response to changes in the water-level and salinity conditions in the marsh. A mechanism for linking riverine and marsh behaviors was needed.

To support 3DM and MSM development, many disparate databases were created that described the natural system's complexity and behaviors, but these databases had not been compiled into a usable form. Variables having particular relevance include those describing bathymetry, meteorology, streamflow (Q), water level (WL), specific conductance (SC), water temperature (WT), and dissolved oxygen concentration (DO). Most of the databases were composed of time series that varied by variable type, periods of record, measurement frequency, location, and reliability. Scientists recognized that data-mining techniques, which include artificial neural networks (ANN), could be used to link riverine and marsh behaviors.

To link the riverine predictions of the 3DM to the MSM, a "model to marsh" (M2M) model was developed by the U.S. Geological Survey and Advanced Data Mining (ADM) using data mining techniques that included ANN models. The ANNs simulated riverine and marsh water levels and salinity in the vicinity of the SNWR for the full range of 11½ years of data from riverine and marsh gaging networks. With M2M, the 3DM and MSM comprise an integrated decision support system for use by various regulatory and scientific stakeholders. The development and application of the M2M is described in Conrads and others (2006).

The M2M has been successfully applied to evaluate the effects of deepening the harbor by generating the inputs to the MSM from the outputs of the 3DM. The M2M also has been used to evaluate potential mitigation scenarios for minimizing the impacts from

harbor deepening. These mitigation scenarios included minor and major changes in channel configuration and flow distribution in the system.

PROBLEM STATEMENT

Eight mitigation scenarios that involve major structural changes in the vicinity of the SNWR, such as the installation of flow diversion structures and the cutting and filling of channels, have been proposed for evaluation. The M2M was not designed to accommodate mitigation scenarios that involve major structural changes. Currently (2007) there is not a mechanism for reliably estimating pore-water salinities in the marsh from riverine inputs for these major mitigation scenarios.

The responses of the SNWR to major changes are very likely to be different from any behaviors ever manifest in the historical record. While the 3DM can be configured to estimate riverine WL and SC with the major changes, it is limited to riverine estimates and cannot be credibly configured to estimate pore-water salinities in the marsh. Using data mining techniques, Conrads and others (2006) found that pore-water salinities integrate riverine WL and salinity variability over several months and often there are long time delays between riverine salinity conditions and marsh pore-water salinity response. A new tool similar to the M2M, hereafter referred to as M2M.2, needs to be developed to estimate pore-water salinity concentrations to evaluate mitigation scenarios involving major structural changes. To provide the necessary technical input and agency review, it is proposed that a multi-agency and multi-disciplinary technical working group be formed of the USGS-S.C. Water Science Center (USGS-SCWSC), the USGS-Florida Coop Unit (USGS-FCU), U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACOE), and Advanced Data Mining (ADMi).

OBJECTIVES

There are three objectives for this project.

1. *Develop new marsh salinity estimation models* - for estimating pore-water salinities at marsh gaging sites for various mitigation model scenarios, using either measured or predicted river water level and specific conductance data at gage locations. It is possible that algorithms would have to be developed for each mitigation scenario.

2. *Develop new salinity spatial interpolation scheme(s)* – that estimate salinities throughout the SNWR from the USGS marsh gaging sites. The current scheme is embedded in the M2M's two-dimensional visualization and gridding application (2DVG). The new schemes must reflect greater lateral variation in the pore-water salinity than the current scheme. It is possible that new schemes would be created for each mitigation scenario.

3. *Develop M2M.2 2DVG and Simulator Applications* – to deploy the work products from Objectives 1 and 2. This includes adapting the 2DVG and the M2M Simulator, which estimates salinities at the USGS marsh gages.

SCOPE

The scope of this study is to address the relation between the riverine salinity and the pore-water marsh salinity for harbor deepening mitigation scenarios. The study's major tasks are described below.

Task 1 *Develop Pore-water Estimation Matrix* – that defines the usable permutations of input USGS or GPA river gages to estimate salinities at each marsh gaging station for each mitigation scenario. Consideration will be given to the proximities of gages and flow diversion structures, and the overall quality of input gage measured, forecasted, and hindcasted data used for developing or generated by the M2M.

Task 2 *Develop predictive models* - for each permutation defined in Task 1. This involves determining optimal time delays and moving window averages between river salinity and pore-water responses through correlation analysis. ANNs provide the best possible correlations in terms of the process information they provide and their prediction accuracy. The number of models to be developed depends on the permutations defined in Task 1.

Task 3 *Define area of influence and spatial gradient of the USGS marsh gages* - for the new salinity spatial interpolation scheme.

Task 4 *Develop M2M.2 2DVG application* - to reflect findings from Task 3. It is likely that multiple visualizations and grids will need to be developed to accommodate all of the mitigation scenarios.

Task 5 *Develop M2M.2 Simulator* – like M2M, it will integrate the 3DM with the MSM using the models from Task 2 and the M2M.2 2DVG application from Task 4, but tailored for the mitigation scenarios involving major structural changes.

Task 6 *Document the approach and results.*

RELEVANCE AND BENEFITS

An important part of the USGS mission is to provide scientific information for the effective water-resources management of the Nation. To assess the quantity and quality of the Nation's surface-water, the USGS collects hydrologic and water-quality data from rivers, lakes, and estuaries using standardized methods, and maintains the data from these stations in a national database. Often these databases are under utilized and under interpreted for addressing contemporary hydrologic issues. The techniques used to develop the M2M and models of the Cooper River (Conrads and Roehl, 1999), the Beaufort River (Conrads and others, 2003), and the Pee Dee River (Conrads and Roehl, 2006) demonstrate how valuable information can be extracted from existing databases to assist local, state and Federal agencies.

The project benefits the Georgia Ports Authority and the Army Corps of Engineers by providing data analysis needed by water-resource managers to make decisions concerning mitigation of the Savannah River Estuary to accommodate potential deepening of Savannah Harbor. The project builds on previous studies relating river salinity to marsh pore-water response. This is consistent with primary USGS activities that include providing knowledge and expertise to assist various levels of government in understanding and solving critical water-resources problems.

TECHNICAL APPROACH

The historical data do not contain information explicitly about the impacts of the proposed mitigation scenarios involving major structural changes. For these circumstances, the best available data, tools, and human expert knowledge and experience must be brought to the problem. The development and use of the M2M.2, and related findings will provide the best possible resources for evaluating the major mitigation scenarios.

Available Data and Utilities from M2M Study

The M2M is based on river and marsh WL and SC ANN models for the USGS and GPA gaging stations in the river and marshes. These are empirical models and for a system as complex as the Savannah River estuary, it was critical that measured, not estimated, data were used that cover the greatest range of hydrologic and tidal responses. For making predictions of pore-water salinity, the most valuable data for M2M development were from the long-term USGS river and marsh gaging stations, which covered over 11 years and 5 years respectively, and comprise a range of flow conditions from drought to floods. Of lesser value were the GPA river and marsh data, which were limited to short measurement periods and a small range of hydrologic conditions. The USGS river data are the major inputs for the final pore-water salinity models and a few of the GPA stations are used to reduce the error in the pore-water models.

The M2M Simulator and 2DVG applications will be valuable for estimating pore-water salinity for the major mitigation scenarios. The Simulator integrates a collection of individual models of the GPA and USGS river gages with the various field databases, such that all of the WL and SC data from the river gages were individually modeled. By hindcasting and forecasting the short-term data collection periods at the GPA sites, a complete database was generated for the 11½ year period from 1994 to 2005. This feature was incorporated to allow scientists and managers to simulate any period from the last deepening and analyze system responses at any gage location. The 2DVG provides spatial interpolation-extrapolation and visualization of the marsh responses across the marsh wells. It is easily modified to accommodate new pore-water estimates at the USGS marsh sites and new interpolation-extrapolation schemes across the marsh.

Pore-water Estimates for Mitigation Scenarios

The MSM models use the growing-season average pore-water salinity as input. The measured, forecasted, and hindcasted SC records at the GPA river sites can be used in conjunction with the USGS sites to determine the best estimates of the average pore-water salinity during the growing season. Estimates will be based on the assumption that a marsh gage responds to nearby river gage(s) and that the candidate river gage(s) may vary by mitigation scenario. Often good correlations between two time series, such as river and marsh SC, can be obtained by adjusting the time delay and moving window average of the explanatory variable (river SC) to achieve the highest correlation with the response variable (marsh SC). For highly dynamic SNWR, trend information proved invaluable for estimating inertia-driven behaviors. Representing trends requires at least two input variables whose values represent two different times or two different locations at the same time, or both.

To estimate pore-water responses to mitigation scenarios, river sites will be selected as candidate explanatory variables for each mitigation plan. For example, the schematic for Mitigation Plan 5 is shown in figure 1. In this scenario, it is believed that salinity intrusion occurs further up the Front River and that freshwater flows increase down the Little Back River. The riverine gages closest to the Middle River 1 (M1) for estimating its pore-water salinity are GPA12 and GPA12r. For Back River 2 (B2), gages 8979, 89784, and GPA15 appear to be good candidates. Final river site selection will be based on the quality of the measured, hindcasted, and forecasted GPA data.

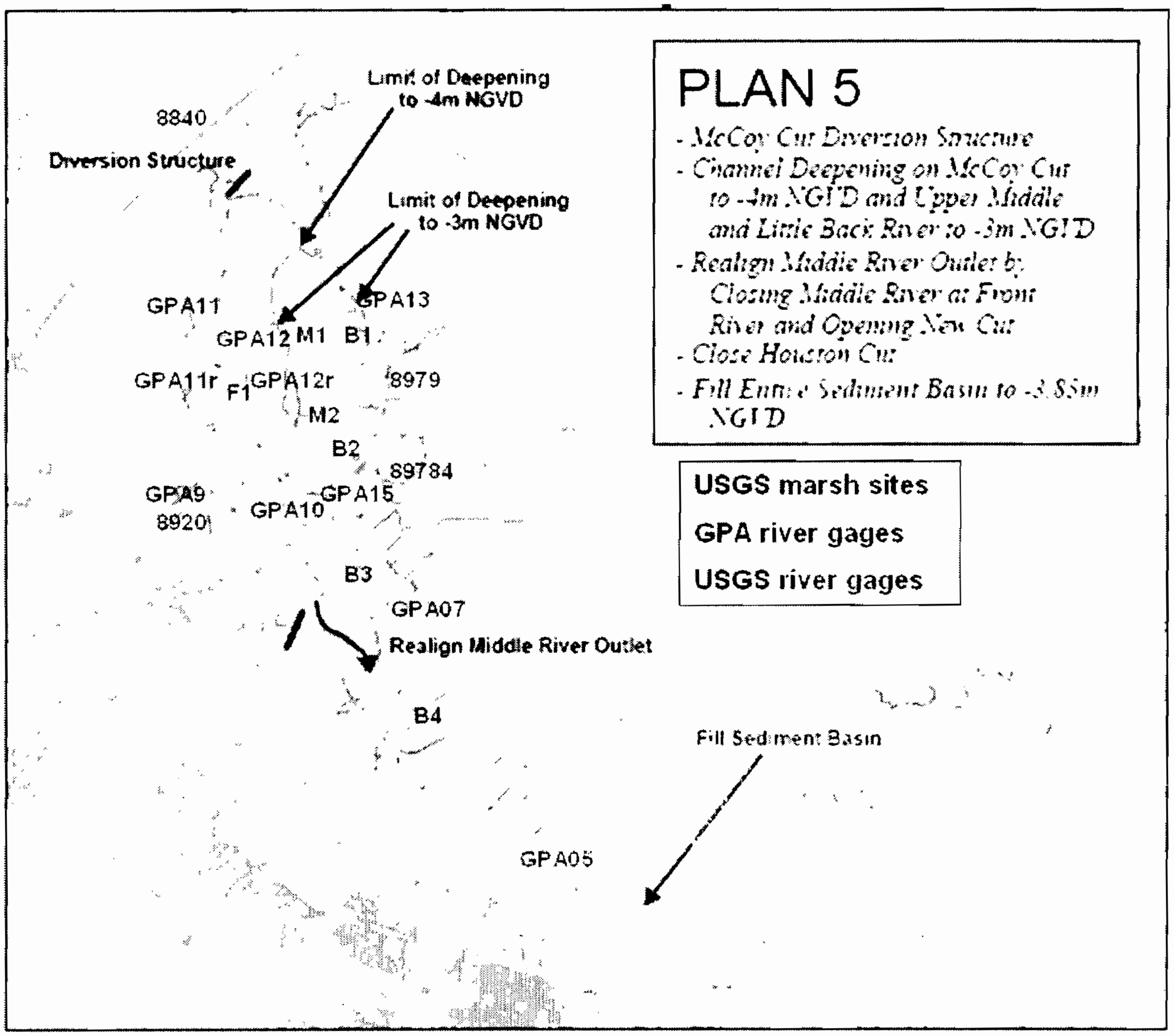


Figure 1. Locations of river and marsh gages and schematic of Plan 5 mitigation scenario

The Pore-water Estimation Matrix will be developed of mitigation plans, marsh gages, and candidate river sites. It is anticipated that some of the plans will share configurations of river gages to marsh gages. Pore-water estimates will be determined for each plan and the estimates will be compared with the predictions made with the original ANN models of the M2M.

Pore-Water Salinity Projections Across the Marsh

The time-series data of the individual marsh gages depict the longitudinal gradient of the system to various hydrologic and tidal conditions. The time-series data do not support the lateral gradients in the system. The M2M's 2DVG is based on estimates of the longitudinal variations from model predictions at the marsh sites. A simple interpolation scheme is used to estimate the lateral gradients.

For the mitigation scenarios, marsh wells will be assigned to the vegetative zones (Q-zones) depicted in Figure 2 and added to the Pore-water Estimation Matrix. Lateral variation across the marsh will be based on field experience and limited data taken during transect studies by the Florida Coop Unit (FCU) at the University of Florida.

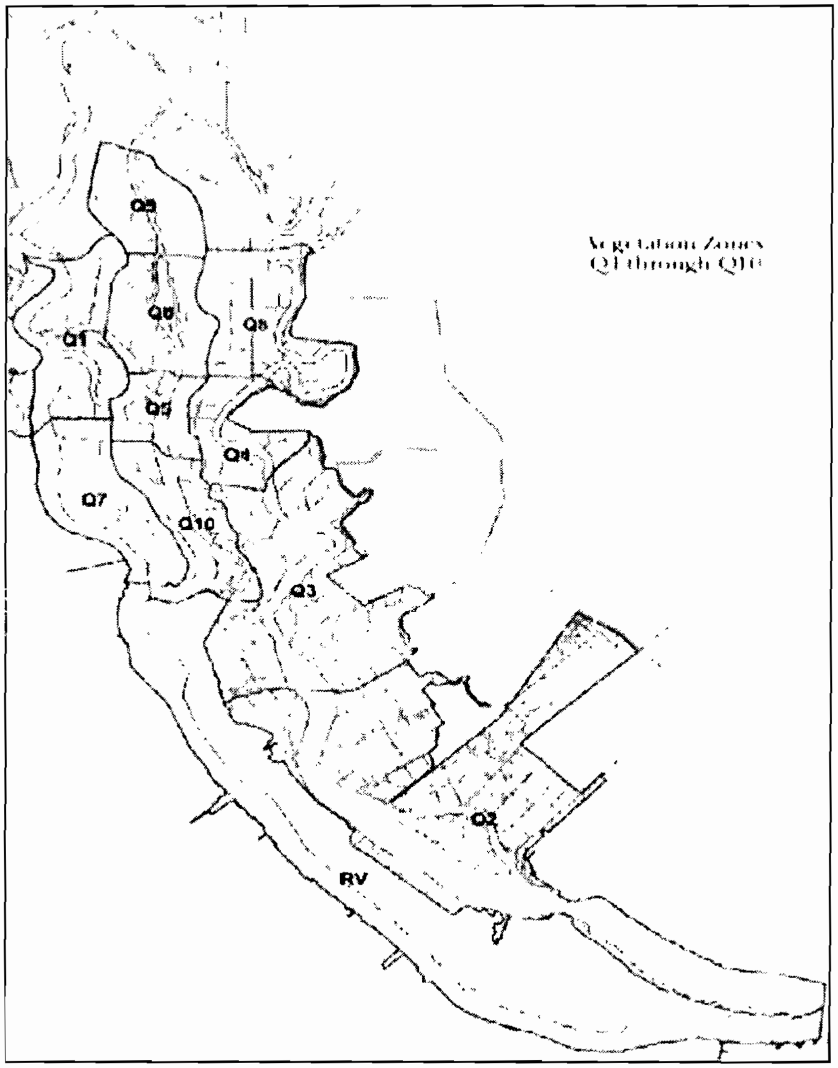


Figure 2. Locations of Q-zones in the tidal marsh in the vicinity of the Savannah National Wildlife Refuge

Integration of Hydrodynamic Model and Marsh Succession Models – M2M.2

Like M2M, M2M.2 will integrate output from the 3DM and generate the marsh salinity grid for input to the MSM. Linking the 3DM is accomplished by reading in a file of simulated differences in SC values for the river for the mitigation plan scenarios. The use of differences, or deltas, from the 3DM increases the prediction accuracy of the model. Mechanistic model, such as the 3DM, typically are better suited from predicting relative differences between two conditions rather than making absolute predictions for one

scenario. The differences (deltas) from the 3DM are added to the historical time series for the scenario and then used in the M2M.2. The application estimates pore-water salinity at the marsh gages and the salinity grid is generated for input to the MSM applications.

Figure 3 describes the data and workflow from the 3DM, through the M2M.2 Simulator and 2DVG applications, and to the MSM. Here, the eight mitigation scenarios are handled separately, providing each with completely customized solution bearing the best ideas of the multi-disciplinary team. At left the 3DM is run for each scenario and separate output files are generated. Next at top center, in the M2M.2 Simulator the user selects the scenario to be run, the appropriate 3DM output file is loaded, the appropriate prediction models are engaged, a simulation is run, and an output file of marsh specific conductivities is generated. Next at right, in the M2M.2 2DVG the user selects the scenario to be run, the M2M.2 Simulator output file is loaded, and an output file of spatially interpolated marsh salinities is generated, which can be loaded into the MSM.

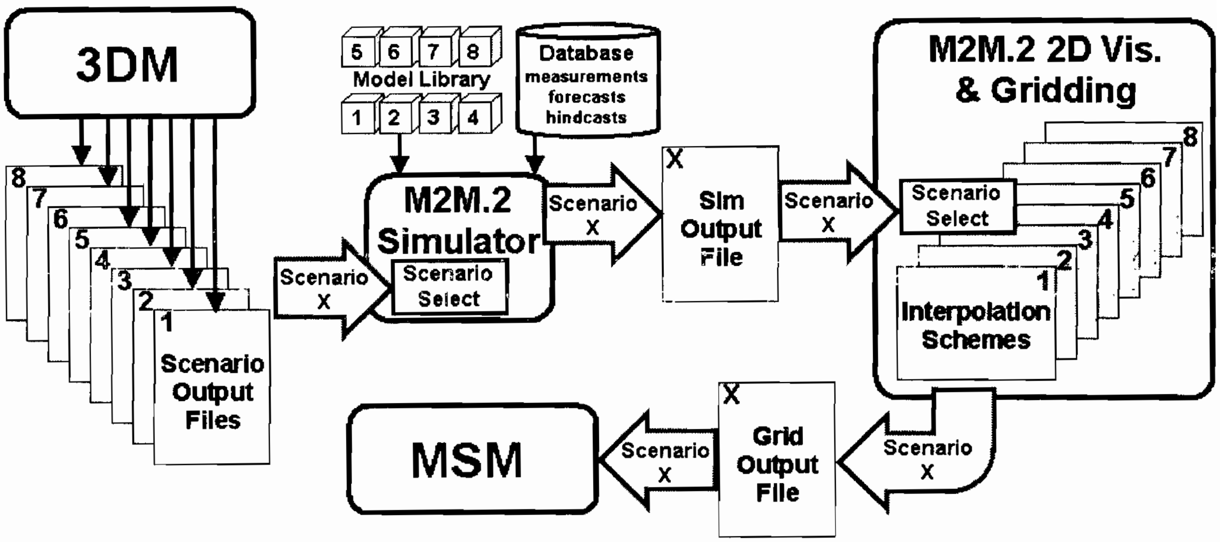


Figure 3. Schematic of data and workflow through the M2M.2.

UNCERTAINTY OF OUTCOME

In this technical approach, each scenario will have a custom solution developed by a multi-disciplinary technical team composed of the USGS-SCWSC, the USGS-FCU, the USFWS, USACOE, and ADMi personnel that are most knowledgeable in the issues, history, and science of the harbor deepening. As with the M2M, the behaviors and predictive performance of the new "local" models of the M2M.2 will be fully described to the technical team. The performance of the models is expected to be comparable to those of the M2M, with the major sources of uncertainty to be associated with the quality of the data collected from the GPA sites, the quality of the SC hindcasts and forecasts at the GPA sites, and the accuracy of the 3DM predictions.

Generally, the 3DM prediction accuracy of flow and salinity throughout the model domain are better on the Front River and lower portion of the system. The prediction

accuracy is not as good in the vicinity of the SNWF and farther inland in the system. This can be seen in the summary statistic of the model performance for the 50 percentile and the coefficient of determination for the 1999 calibration data and the 1997 validation data set (Tetra Tech, 2006). The accuracy of estimates made by the 3DM for scenarios involving major structural changes is unknowable *a priori*, but very likely to be less accurate that the calibration and validation prediction. The used of differences from the 3DM will reduce absolute prediction error by the model. The 3DM's performance will be the primary source of uncertainty, but significant reliance on its estimates inside the SNWR is unavoidable.

The technical team will leverage the tools in hand to formulate a process of mitigating deepening-related problems. The process may employ a succession of structural changes of varying impact severity. It is likely that each change will have surprising results that can only be determined *post priori* by continued field monitoring and data analysis. This suggests a conservative, iterative mitigation approach composed of these steps - hypothesize, change, test, review, and most importantly, learn will be required.

PROJECT COORDINATION

In making estimates of system responses to the structural changes in the SNWR, it is essential that the appropriate technical resources from the agencies be involved. It is proposed that periodic meetings of the technical working group (USCOE, USF&W, USGS-SCWSC, USGS-FCU, and ADMI) be scheduled to review interim products such as the pore-water estimation matrix, pore-water estimation models, and prototypes of the M2M.2 2DVG and M2M.2. Many of these meeting could be accomplished by teleconferencing.

REPORTING

The project will be documented in a USGS Open-File Report, tentatively titled "Estimation of Tidal Marsh Pore-water Salinity in the Vicinity of Savannah National Wildlife Refuge for Savannah Harbor Deepening Mitigation, Coastal South Carolina and Georgia." A provisional copy of the report will be available for colleague/cooperator review 3 months after the completion of the project. The review process will require an additional 5 months. A limited number of paper copies of the report will be provided to the cooperating agencies; however, the primary outlet for the publication will be the Internet. A link to the report will be posted on the USGS South Carolina Water Science Center web sites.

BUDGET AND SCHEDULE

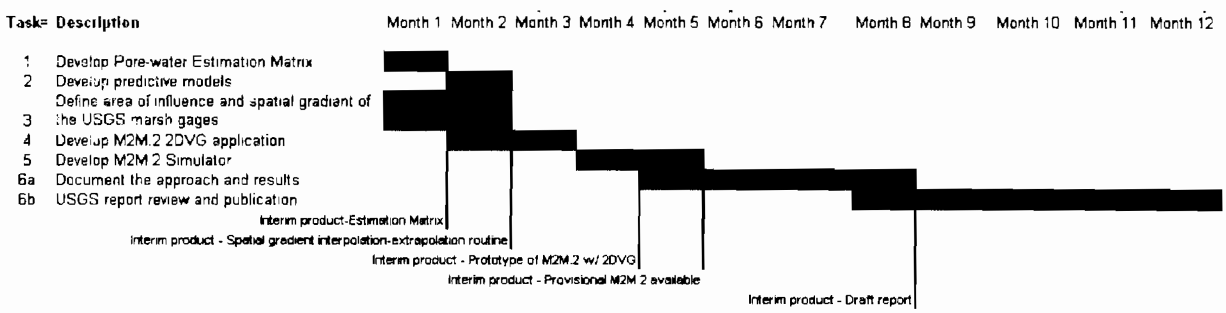
The Project will be collaboration between the USGS-SCWSC, the USGS-FCU, and ADMi. The project will take approximately 4-5 months to complete the technical analysis and develop the provisional M2M.2 from the start date. The final documentation of the project will be complete approximately 10-12 months from the start date. The total cost of the project will be $110,750. An itemized description of the tasks and required hours

are listed in Table 1 and a timeline for completion of the project from initiation is presented in Table 2.

Table 1. Tasks, description, notes, hours, and costs.

Task #	Description	Notes	USGS-SCWSC Hours	USGS-SCWSC Cost	USGS-FCU Hours	USGS-FCU Hours	ADMI Hours	ADMI Cost
1	Develop Pore-water Estimation Matrix	tooling up, evaluate data quality, matrix development, meeting with Agencies to finalize matrix	40	$4,400			40	$5,000
2	Develop predictive models	upper limit = 8 scenarios x 7 models per = 56 models, x 8hrs/model, use 50% - USGS-SCWSC to review	25	$2,750			224	$28,000
3	Define area of influence and spatial gradient of the USGS marsh gages	mostly USGS-FCU with assitence from USGS-SCWSC, ADMI to assimilate, meeting for concurance with Agencies prior to finalization	40	$4,400	64	$6,400	12	$1,500
4	Develop M2M.2 2DVG application	assume 8 interp schemes to program/integrate at 2days per - USGS-SCWSC to revew	25	$2,750			128	$16,000
5	Develop M2M.2 Simulator	assume 4 weeks for mostly new but derivative app programming and testing - USGS-SCWSC to rev	25	$2,750			160	$20,000
6	Document the approach and results	mostly USGS-SCWSC and USGS-Publications Unit, ADMI and USGS-FCU to assist	120	$13,200	16	1600	16	$2,000
		Totals	275	$30,250	80	$8,000	580	$72,500

Table 2. Timeline for completion of project.



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CESAS-PD-E 7 July 2003

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 1 July Interagency Meeting on Evaluation of Wetlands

1. Attendees:

USFWS:	Ed Eudaly
	John Robinette
SCDNR:	Priscilla Wendt
SCDHEC-OCRM	Rob Mikell
GADNR-CRD:	Kelie Moore
	Debra Barreiro
GADNR-EPD	Keith Parsons
COE:	Doug Plachy
	Bill Bailey
	Steve Calver
GPA	Larry Keegan
ATM/GPA:	John Bossart
	Bo Ellis

By phone:

EPA	Bob Lord

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the meeting.

4. The majority of the meeting was a presentation by John Bossart (ATM). He divided his talk into 2 sections: **Data Collection** and **Modeling**. He said the ultimate goal of these 2 efforts was to be able to predict plant changes expected to result from changes in salinity in the rivers.

John summarized the GPA-funded data collection studies that ATM had conducted in wetlands on the Savannah National Wildlife Refuge from 1997 through 2002. Their monitoring could be broken into 2 general types. The first consisted of monitoring salinity and water surface levels in the tidal creeks and on the wetlands. The second consisted of periodic monitoring of vegetation that occurred along established marsh transects. These monitoring efforts are described in detail in reports that were distributed at the meeting.

We also mentioned that the USFWS had conducted other studies on the Refuge wetlands from 2001 through 2002. Those GPA-funded studies were aimed at identifying the resource value of the tidal wetlands that could be impacted by the Expansion Project. The studies were titled "Tidal Wetland Resource Utilization Studies". John Robinette distributed a copy of the report that documents those activities.

Concerning modeling, John said that Wiley Kitchens (USGS/DOI) had used a community-based approach. Although Wiley had identified 126 vegetative species in the field, he used a cluster analysis to group the species based on importance value. The result of this analysis was identification of 10 functional groups that characterize the observed vegetation and span the range of salinity in the upper estuary. The Structural Equation Methodology (SEM) developed by Wiley forms the core of the GIS model that ATM is developing. John stated that the GIS model was capable of displaying additional information, if required by the agencies. This would include such information as species richness, the locations where an individual species would occur throughout the estuary, and the probability of an individual species occurring at a specific site.

5. In response to questions, John said he believed the model would function best at salinities from 0 to 10 ppt, and that was a function of the SEM decision tree. John stated he thought the drought had an order of magnitude of change greater than is expected from a deepening project. The vegetation monitoring revealed that smaller vegetation changes were observed as one moved closer to the ocean. The group also questioned the possible effect of a time lag between the observed salinity and a change in the vegetation at the site. I stated that I had asked Wiley to evaluate that possibility as he refined his SEM Model.

6. Ed Eudaly (USFWS) stated he believes that vegetative communities in fresher water are more valuable to the Savannah River estuarine ecosystem. He defined that as areas having salinities of 0 to 1.0 ppt. He stated that such areas provide the greatest diversity in plant species. The Service will evaluate potential impacts to the Refuge and Refuge operations from proposed project alternatives. The Service favors a community-based approach to assessing impacts to these tidal wetlands.

7. Keith Parsons (GADNR-EPD) raised the issue of the possible need for a sensitivity analysis of alternate river flows on the estuarine vegetation. This would provide information that would be useful if the Corps proposes changes in river flows in the Savannah River Basin Comprehensive Study.

8. I concluded by requesting the agencies review the reports (ATM and USFWS) that were provided at the meeting. One of the first questions to decide is whether an agency believes that any specific additional field investigation is needed. I will contact the agency representatives again early in August. Other decisions are (A) What conditions to use in the impact analysis modeling runs (time of year, river flows, etc.); (B) What type of data the agencies desire in the output of the models; and (C) How much change reflects an impact.

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY COORDINATION ON WETLANDS

JULY 1, 2003

AGENDA

COMPLETED WETLAND MONITORING ACTIVITIES ------------------ ATM

IMPACT IDENTIFICATION METHODOLOGY ---------------------------- ATM

DISCUSSION --- ALL

- Adequacy of existing datasets
- Adequacy of impact identification procedure

BRIEF DISCUSSION OF WETLAND ISSUES AHEAD -------------------- COE

- Without Project Condition
  - Average or "Critical" Conditions
  - River Flows
  - Effect of Drought
- Pre-Construction Monitoring (Establish Baseline)
- Post-Construction Monitoring

WRAP-UP -- COE

CESAM-PD-E 5 June 2006

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 31 May meeting of the Wetlands Interagency Coordination Team

1. Attendees:

USFWS:	Ed Eudaly
	John Robinette
	Jane Griess
EPA:	Gerald Miller
	Ntale Kajumba
NMFS:	Prescott Brownell
SC DNR:	Priscilla Wendt – by phone
SC DHEC:	Amy Cappellino
GA DNR-EPD:	Keith Parsons
COE:	Bill Bailey
	Hugh Heine
	Joe Hoke
	Gary Mauldin
Observers:	
GPA:	Hope Moorer
	Larry Keegan (CH2MHill)

2. The meeting was held at the USFWS Refuge Office outside of Savannah from roughly 1000 to 1600. The meeting was an information meeting only, not a decision meeting. The Corps was not requesting concurrence from the agencies on the level of impacts predicted for the project alternatives.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the meeting.

4. The Corps started by reviewing the process the Team had followed to arrive at this point:

- Harbor deepening is expected to result in changes to salinity levels in the rivers. This salinity will move up the tidal creeks, across the surface of the marshes, to the root zone of the wetland vegetation. The changes in root zone salinity may result in changes in wetland vegetation.
- A hydrodynamic Model would be developed and used to identify changes to salinity in the rivers,
- A Model-To-Marsh model would be used to translate those salinity levels across the entire marsh surface to the root zone of the plants.

- A Wetland Succession Model would be developed and used to identify changes in vegetation (or plant community) expected from the predicted salinity changes.
- We would have three methods of identifying potential changes in wetland vegetation:
    - Movement of the 0.5 ppt salinity contour, as predicted by the hydrodynamic model. This is a widely-accepted method that has historically been used when hydrodynamic models are used to predict project impacts.
    - A Marsh Succession Model developed by ATM based on sampling they had conducted in the Savannah estuary.
    - A Marsh Succession Model developed by the USFWS/USGS (Wiley Kitchens) based on sampling they conducted in the Savannah estuary.
- After development of these three tools, we may see that one of these methods is more technically defensible or more accurately predicts the observed field data than another.
- The agencies recently approved use of the hydraulic model for impact evaluation purposes on the Savannah Harbor Expansion Project.

5. The Corps stated that the initial impact analyses using the hydraulic model to predict movement of the 0.5 ppt salinity contour had been completed. Thee ATM Marsh Succession Model has been developed, but no results are available at this time. The USFWS/USGS Marsh Succession Model (MSM) is still under development. The decision trees have been completed, but the model has not been put together and its performance validated.

6. The group then reviewed the impact analysis parameters which it had previously developed. The basic analysis would be conducted using average river flows based on long term historical records. The Corps explained that the 1997 water year was close to the historical average and was a year in which we had field data. A sensitivity analysis would be conducted using drought conditions. The group had agreed to use 2001 river flows since they were a fairly severe drought that had occurred recently and had been observed during the field sampling for this project. Two sensitivity analyses would be performed for various amounts of sea level rise – 9 and 25 cm over the 50-year project life. Members of the team stated that since we had developed these guidelines, many researchers now expect sea level to generally be higher. The 1995 EPA report which the group had previously reviewed contained an equation that produced a mid-level prediction of a 25 cm rise for this area, based on a range of predictions made by different researchers. The USFWS provided the Corps with a document from NOAA's Center for Sponsored Coastal Ocean Research that states that the projected rise in sea level by 2095 for the mid-Atlantic region now ranges between 4 and 103 cm. After some discussion, the group decided it would like to see evaluations conducted using two levels of sea level rise – – 25 and 50 cm over the 50-year project life.

The Interagency Team had previously said the Corps should evaluate impacts over a 1 March to 30 October growing season. A member of the Team questioned whether the winter period should also be considered in this southern portion of the country. The Team said that the Spring vegetation sampling, which both versions of the model incorporate, reflects the winter growth period. In addition, the Model-To-Marsh program is based on a 3-month look-back feature, so the salinities occurring in the past 3 months are considered. The group reiterated its belief that the summer growing season was appropriate for analysis of potential impacts.

The Corps explained that the ATM and USFWS/USGS versions of the MSM had considered slightly different durations for the growing period. The ATM version had used 1 March to 30 October, while the USFWS/USGS version used a 1 March to 1 October period. The Corps explained that the ATM version of the MSM was not particularly sensitive to the delay period between river salinity and vegetation. (The model's performance was not adversely affected by varying between a 3-, 6-, 9-, or 12-month period between river salinity and observed vegetation.) The group agreed that it would be acceptable to run both the ATM and USFWS/USGS Marsh Succession Model over a 1 March to 1 October period of analysis.

Members of the Team requested the Corps provide outputs for a scenario combining sea level rise and drought. This would be more of a worst-case analysis. The group did not thoroughly discuss which alternatives this scenario should be evaluated (all alternatives or just the recommended plan), but the limited consensus appeared to be that this scenario need only be run on the recommended plan.

7. The Corps then distributed the results of its initial impact analyses using the hydraulic model and the movement of 0.5 ppt contour. The Corps had previously distributed figures showing areas within the estuary that are predicted to change from <0.5 ppt to >0.5 ppt. Some of the figures distributed at this meeting had been revised from what had previously been distributed, some had not. The group then reviewed and discussed the results.

The hydrodynamic model includes grid cells (boxes) that represent areas of marsh within the estuary. These boxes reflect the marsh areas served by the major tidal creeks. The Corps used the model to identify areas of marsh (cells/boxes) that would change from having an average of <0.6 ppt to >0.5 ppt of salinity. The analysis showed an increasing acreage affected from the 2-foot alternative to the 4-, and 5-foot alternatives. The 6-foot deepening alternative showed no additional increase. This method of evaluation does not show the extent to which the marsh areas exceed the 0.5 ppt threshold, only that they do cross the threshold with the alternative being considered.

Impact areas with the 10% exceedence salinity values were further up in the estuary than either the average (50% exceedence) or 90% exceedence (which were located lowest in the estuary). These are as expected, since they reflect probabilities of exceedence.

As expected, the impact areas are generally further up in the estuary with the drought scenarios (lower river flows).

As expected, the impact areas were generally further up in the estuary with the sea level rise scenarios, although large shifts were not predicted.

The title block on the figures should be revised to clarify which flow year was used. The legend (scales and colors) should also be revised to be the same on all figures.

8. The Team requested the Corps provide the output of the Model-To-Marsh Model. Figures showing the actual salinity predicted within the root zone across the marsh with each alternative were requested. Figures showing the changes in root zone salinity across the marsh were also requested (delta plots).

9. The Corps then presented the preliminary results of the mitigation modeling. The Corps had used salinity as the critical parameter since it affects wetlands, dissolved oxygen levels, and fishery habitats. The Corps used surface salinity because it directly relates to impacts to wetlands. The runs are the first steps at developing mitigation plans. The initial runs evaluated the effects of single changes within the estuarine network of tidal creeks and rivers. Two examples are the closure of Rifle Cut or the removal of the Tidegate.

One Team member asked the group is there is a portion of the estuary that is more important than another from an ecological perspective. They sought this information to help the Corps and the entire Interagency Team focus its attention during development of the mitigation plans. The USFWS said that it continues to maintain that the freshwater tidal wetlands in the Middle and Back River areas are extremely diverse areas that are the most ecologically valuable within the entire lower estuary (river mouth to I-95). Areas along the existing navigation channel that are highly developed have substantially less ecologically value. The USFWS reiterated that it believes it can accept no further loss of tidal freshwater wetlands.

Run #5 looks promising (deepening from McCoys Cut to junction of Middle and Back Rivers) because it brings more freshwater into the Middle and Back River systems. The Corps should evaluate runs #7 & 8 because the results are not what are expected. The benefits from run #9 are in an area of lower ecological value. Runs #14, 15 & 17 show promise. Removal of the Tidegate does not show beneficial effects as far upstream as expected. Filling the Sediment Basin appears to show promise, as it benefits much of the lower half of Back River.

10. The Corps asked about the Team's view of the value of acquiring and preserving the Harrison property, which is located upstream and adjacent to US17. A few years ago, Mr. Harrison had indicated that he may be interested in selling the property if it were used by the Government for mitigation purposes. Potential restoration actions that could occur at site were discussed. The USFWS would have to prepare an EA and get approval from Washington to include the property into documents showing areas it has an interest in acquiring. The Team concluded that the site had potential value as wetland mitigation for the Project and should be evaluated by the Corps.

11. A member of the Team requested that all baseline and mitigation runs display surface, middle, and bottom salinity. They believe this information is necessary for a complete understanding of each modification and further uses the capabilities of the hydrodynamic model for decision-making.

12. A member of the Team requested that the outputs display the geographical areas that would receive a change in salinity with an alternative. Information on the amount of change (acreage) for various vegetative classifications should be provided. Information on the % change for various vegetative classifications should also be provided. (An example is that freshwater wetlands would be reduced by xx percent with Alternative Y.)

13. The Corps agreed to provide revised Impact Reports to the agencies when those revisions and corrections are complete. The updated report will be provided on CD only. Agency Team members are free to send the Corps any comments they may have after further review of the present Impact Report and impact displays or review of the revised information.

14. The Corps will continue its work on evaluating potential mitigation measures. When it has developed combinations of mitigation measures that it believes would be effective, the Corps will hold another meeting of the Interagency Coordination Team to share those results. That meeting would be prior to the Corps' completion of a Draft EIS or a request for agency concurrence on the acceptability of the mitigation plans or the project alternatives.

// DRAFT //

William Bailey
Environment and Resources Branch

CESAM-PD-E

5 June 2006
Revised 30 June 2006

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 31 May meeting of the Wetlands Interagency Coordination Team

1. Attendees:

USFWS:	Ed Eudaly
	John Robinette
	Jane Griess
EPA:	Gerald Miller
	Ntale Kajumba
NMFS:	Prescott Brownell
SC DNR:	Priscilla Wendt – by phone
SC DHEC:	Amy Cappellino
GA DNR-EPD:	Keith Parsons
COE:	Bill Bailey
	Hugh Heine
	Joe Hoke
	Gary Mauldin
Observers:	
GPA:	Hope Moorer
	Larry Keegan (CH2MHill)

2. The meeting was held at the USFWS Refuge Office near Savannah from roughly 1000 to 1600. The meeting was an information meeting only, not a decision meeting. The Corps was not requesting concurrence from the agencies on the level of impacts predicted for the project alternatives.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the meeting.

4. The Corps started by reviewing the process the Team had followed to arrive at this point:

- Harbor deepening is expected to result in changes to salinity levels in the rivers. This salinity will move up the tidal creeks, across the surface of the marshes, to the root zone of the wetland vegetation. The changes in root zone salinity may result in changes in wetland vegetation.
- A hydrodynamic model would be developed and used to identify changes to salinity in the rivers,
- A Model-To-Marsh model would be used to translate those salinity levels across the entire marsh surface to the root zone of the plants.

- A Wetland Succession Model would be developed and used to identify changes in vegetation (or plant community) expected from the predicted salinity changes.
- We would have three methods of identifying potential changes in wetland vegetation:
    - Movement of the 0.5 ppt salinity contour, as predicted by the hydrodynamic model. This is a widely-accepted method that has historically been used when hydrodynamic models are used to predict project impacts.
    - A Marsh Succession Model developed by ATM based on sampling they had conducted in the Savannah estuary.
    - A Marsh Succession Model developed by the USFWS/USGS (Wiley Kitchens) based on sampling they conducted in the Savannah estuary.
- After development of these three tools, we may see that one of these methods is more technically defensible or more accurately predicts the observed field data than another.
- The agencies recently approved use of the hydrodynamic model for impact evaluation purposes on the Savannah Harbor Expansion Project.

5. The Corps stated that the initial impact analyses using the hydrodynamic model to predict movement of the 0.5 ppt salinity contour had been completed. The ATM Marsh Succession Model has been developed, but no results are available at this time. The USFWS/USGS Marsh Succession Model (MSM) is still under development. The decision trees have been completed, but the model has not been put together, and its performance has not been validated.

6. The group then reviewed the impact analysis parameters which it had previously developed. The basic analysis would be conducted using average river flows based on long term historical records. The Corps explained that the 1997 water year was close to the historical average and was a year in which we had field data. A sensitivity analysis would be conducted using drought conditions. The group had agreed to use 2001 river flows since they were a fairly severe drought that had occurred recently and had been observed during the field sampling for this project. Two sensitivity analyses would be performed for various amounts of sea level rise – 9 and 25 cm over the 50-year project life. Members of the team stated that since we had developed these guidelines, many researchers now expect sea level to generally be higher. The 1995 EPA report which the group had previously reviewed contained an equation that produced a mid-level prediction of a 25 cm rise for this area, based on a range of predictions made by different researchers. The USFWS provided the Corps with a document from NOAA's Center for Sponsored Coastal Ocean Research that states that the projected rise in sea level by 2095 for the mid-Atlantic region now ranges between 4 and 103 cm. After some discussion, the group decided it would like to see evaluations conducted using two levels of sea level rise – – 25 and 50 cm over the 50-year project life (and no longer desired the 9 cm sea level rise scenario.)

The Interagency Team had previously said the Corps should evaluate impacts over a 1 March to 30 October growing season. A member of the Team questioned whether the winter period should also be considered in this southern portion of the country. The Team said that the Spring vegetation sampling, which both versions of the model incorporate, reflects the winter growth period. In addition, the Model-To-Marsh program is based on a 3-month look-back feature, so the salinities occurring in the past 3 months are considered. The group reiterated its belief that the summer growing season was appropriate for analysis of potential impacts.

The Corps explained that the ATM and USFWS/USGS versions of the MSM had considered slightly different durations for the growing period. The ATM version had used 1 March to 30 October, while the USFWS/USGS version used a 1 March to 1 October period. The Corps explained that the ATM version of the MSM was not particularly sensitive to the delay period between river salinity and vegetation. (The model's performance was not adversely affected by varying between a 3-, 6-, 9-, or 12-month period between river salinity and observed vegetation.) The group agreed that it would be acceptable to run both the ATM and USFWS/USGS Marsh Succession Model over a 1 March to 1 October period of analysis.

Members of the Team requested the Corps provide outputs for a scenario combining sea level rise and drought. This would be more of a worst-case analysis. The group did not thoroughly discuss which alternatives this scenario should be evaluated (all alternatives or just the recommended plan), but the limited consensus appeared to be that this scenario need only be run on the recommended plan.

7. The Corps then distributed the results of its initial impact analyses using the hydrodynamic model and the movement of 0.5 ppt contour. The Corps had previously distributed figures showing areas within the estuary that are predicted to change from <0.5 ppt to >0.5 ppt. Some of the figures distributed at this meeting had been revised from what had previously been distributed, some had not. The group then reviewed and discussed the results.

The hydrodynamic model includes grid cells (boxes) that represent areas of marsh within the estuary. These boxes reflect the marsh areas served by the major tidal creeks. The Corps used the model to identify areas of marsh (cells/boxes) that would change from having an average of <0.5 ppt to >0.5 ppt of salinity. The analysis showed an increasing acreage affected from the 2-foot alternative to the 4-, and 5-foot alternatives. The 6-foot deepening alternative showed no additional increase. This method of evaluation does not show the extent to which the marsh areas exceed the 0.5 ppt threshold, only that they do cross the threshold with the alternative being considered.

Impact areas with the 10% exceedence salinity values were further up in the estuary than either the average (50% exceedence) or 90% exceedence (which were located lowest in the estuary). These are as expected, since they reflect probabilities of exceedence.

As expected, the impact areas are generally further up in the estuary with the drought scenarios (lower river flows).

As expected, the impact areas were generally further up in the estuary with the sea level rise scenarios, although large shifts were not predicted.

The title block on the figures should be revised to clarify which flow year was used. The legend (scales and colors) should also be revised to be the same on all figures.

8. The Team requested the Corps provide the output of the Model-To-Marsh Model. Figures showing the actual salinity predicted within the root zone across the marsh with each alternative were requested. Figures showing the changes in root zone salinity across the marsh were also requested (delta plots).

9. The Corps then presented the preliminary results of the mitigation modeling. The Corps had used salinity as the critical parameter since it affects wetlands, dissolved oxygen levels, and fishery habitats. The Corps used surface salinity because it directly relates to impacts to wetlands. The runs are the first steps at developing mitigation plans. The initial runs evaluated the effects of single changes within the estuarine network of tidal creeks and rivers. Two examples are the closure of Rifle Cut or the removal of the Tidegate.

One Team member asked the group if there is a portion of the estuary that is more important than another from an ecological perspective. They sought this information to help the Corps and the entire Interagency Team focus its attention during development of the mitigation plans. The USFWS said that it continues to maintain that the freshwater tidal wetlands in the Middle and Back River areas are extremely diverse areas that are the most ecologically valuable within the entire lower estuary (river mouth to I-95). Areas along the existing navigation channel that are highly developed have substantially less ecological value. The USFWS reiterated that it believes it can accept no further loss of tidal freshwater wetlands.

Run #5 looks promising (deepening from McCoys Cut to junction of Middle and Back Rivers) because it brings more freshwater into the Middle and Back River systems. The Corps should evaluate runs #7 & 8 because the results are not what are expected. The benefits from run #9 are in an area of lower ecological value. Runs #14, 15 & 17 show promise. Removal of the Tidegate does not show beneficial effects as far upstream as expected. Filling the Sediment Basin appears to show promise, as it benefits much of the lower half of Back River.

10. The Corps asked about the Team's view of the value of acquiring and preserving the Harrison property, which is located upstream and adjacent to US17. A few years ago, Mr. Harrison had indicated that he may be interested in selling the property if it were used by the Government for mitigation purposes. Potential restoration actions that could occur at site were discussed. The USFWS would have to prepare an EA and get approval

from Washington to include the property into documents showing areas it has an interest in acquiring. The Team concluded that the site had potential value as wetland mitigation for the Project and should be evaluated by the Corps.

11. A member of the Team requested that all baseline and mitigation runs display surface, middle, and bottom salinity. They believe this information is necessary for a complete understanding of each modification and further uses the capabilities of the hydrodynamic model for decision-making. We had focused on surface salinity for wetland impacts because it is the high tide waters that most flood onto the marshes.

12. A member of the Team requested that the outputs display the geographical areas that would receive a change in salinity with an alternative. Information on the amount of change (acreage) for various vegetative classifications should be provided. Information on the % change for various vegetative classifications should also be provided. (An example is that freshwater wetlands would be reduced by xx percent with Alternative Y.)

13. The Corps agreed to provide revised Impact Reports to the agencies when those revisions and corrections are complete. The updated report will be provided on CD only. Agency Team members are free to send the Corps any comments they may have after further review of the present Impact Report and impact displays or review of the revised information.

14. The Corps will continue its work on evaluating potential mitigation measures. When it has developed combinations of mitigation measures that it believes would be effective, the Corps will hold another meeting of the Interagency Coordination Team to share those results. That meeting would be prior to the Corps' completion of a Draft EIS or a request for agency concurrence on the acceptability of the mitigation plans or the project alternatives.

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William Bailey
Environment and Resources Branch

CESAM-PD-E | 28 Dec 2006
Revised 09 Jan 2007

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 15 December meeting of the Wetlands Interagency Coordination Team

1. Attendees:

USFWS:	John Robinette	
	Ed EuDaly	(by phone)
NMFS:	Kay Davy	
SC DNR:	Priscilla Wendt	
SC DHEC:	Wade Cantrell	
GA DNR-EPD:	Keith Parsons	
GA DNR-CRD:	Kelie Moore	(by phone)
GA DNR-WRD:	Matt Thomas	
COE:	Bill Bailey	
	Hugh Heine	
Observers:		
GPA:	Hope Moorer	

2. The meeting was held at the USFWS Refuge Office near Savannah from roughly 0930 to 1130. The meeting was an information meeting only, not a decision meeting. The purpose was to review the results of the EFDC modeling conducted using the movement of the 0.5 ppt salinity contour. The modeling had been conducted for both impacts (channel deepening w/o mitigation) and the first five mitigation plans (channel deepening plus mitigation).

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the meeting.

4. We then had a brief discussion about how to include information about the extent of the salinity increase, rather than just the change to the 0.5 ppt contour. The report does contain information on the actual salinity values for each alternative evaluated. The Marsh Succession Model will also provide information on the extent of salinity increases.

5. The Corps mentioned that the USFWS had requested we consider two other mitigation measures: (1) no dredging in Middle and Little Back Rivers, and (2) blocking the original mouth of McCoys Cut. The first measure is intended to reduce project construction impacts and make the mitigation more self-sustaining. The second measure is in response to observations of flows entering McCoys Cut on an ebb tide and exiting through the original upper mouth of the river, rather than pass down through Middle and Little Back Rivers. The hope is that closing that channel would increase freshwater flows

down those two rivers. The Corps agreed to conduct EFDC screening-level runs of those measures.

6. The Corps also mentioned that it had requested the team review the two Marsh Succession Models and provide comments on their acceptability for use on this project and whether they thought one model may be more effective than the other. The comment period had ended 9 December. The Corps had received a comment from the USFWS stating that it believes the USGS version of the model is suitable and recommended its use over the ATM version. We distributed a copy of the USFWS letter (attached) to the entire team. SC DHEC asked if it could have more time to respond. Since the external reviews are still underway, the Corps agreed to accept agency comments for another 30 days. Wade confirmed later that SC DHEC would not be providing any separate comments.

7. The team had previously asked who the Corps was using for the external review of the Marsh Succession Models. The Corps reported that the following individuals have agreed to conduct those reviews: Richard Dame, Curtis Richardson, Denise Reed, and Courtney Hackney.

8. We reviewed the model run conditions the team had previously agreed upon to identify wetland impacts. These were summarized in a paper produced by the Corps on 17 August 2005 titled "Wetland Impact Evaluation Process".

9. After reviewing the setup of the summary tables, we then considered the effects of each mitigation plan.

IMPACTS ALONE. Increasing channel depth did not appear to produce an increase in wetland impacts for the basic evaluation. Some increase was observed for the 46- and 48-foot depths with drought flows. Impacts from salinities at the 10% exceedence level were generally less than those at the 50% exceedence level. This was contrary to our expectations. We briefly looked at the salinity plots and observed that the 10% exceedence levels occur further up the estuary, as we had expected. The non-linearity of the estuary (ground elevations not rising uniformly and marshes generally being fed by only a few tidal creeks) result in the responses sometimes being different than are expected.

PLAN 1. The McCoys Cut mitigation measures would reduce the extent of marshes that are adversely affected and enhance some marshes. These measures do appear to be effective.

PLAN 2. No marked changes were observed by adding the Sediment Basin to the McCoys Cut measures (Plan 1). Few changes in movement of the fresh/saltwater contour were observed. Changes may become apparent when this plan is considered using the MSM, which will show gradations of salinity change. A suggestion was made that we consider adding wetland species diversity as a benefit, rather than just changing from brackish to freshwater marsh.

PLAN 3. There appeared to be substantial effects from adding closure of Rifle Cut to the previous mitigation plan. Net positive effects are observed during normal flow conditions, while a greater amount of acres would be enhanced during both normal and drought flows.

PLAN 4. During normal flow conditions, adding the Middle River measures to the McCoys Cut measures (Plan 1) appears to increase salinity levels and worsen wetland impacts. However, during drought flows, adding these measures would improve the salinity regime and reduce overall wetland impacts.

The team mentioned that if Middle River and Houston Cut are closed, that fishing access to many of the tidal rivers in the Savannah NWR would be greatly reduced because access from the boat ramp at the Houlihan Bridge would have been effectively eliminated. The team said suggested that construction of a replacement ramp somewhere on Back River could compensate for those adverse impacts to fishermen.

PLAN 5. Adding the Sediment Basin to the previous plan (Plan 4) appears to be highly beneficial. It had the greatest number of acres enhanced of all the mitigation plans evaluated. The net effect was better with Plan 5 than with Plan 3.

Ed EuDaly and the USFWS suggested another mitigation measure to evaluate. The suggestion is to replace rerouting Middle River through New Cut. It consists of blocking Middle River just above Houston Cut and routing the Middle River flow through Rifle Cut. This would allow sturgeon to continue to use the lower end of Middle River while also protecting wetlands in the upper portions of Middle River. A sketch of the proposal is attached. The NMFS expressed concerned with two aspects of this proposal. The first is that the upper Middle River would be cut off from the lower portion of the river. The second is that this option could drastically change (increase) salinity in the lower Middle River and thus affect the suitability of that reach as habitat for sturgeon. The group recognized that Rifle Cut may need to be expanded for this proposal to work effectively. After some discussion, the USFWS stated it would allow Rifle Cut to be expanded if that is necessary for this proposal to work effectively. The Corps agreed to conduct an EFDC screening-level run on this proposal.

11. The Corps will continue its work on evaluating the potential mitigation plans developed in July and August 2006. This will include analysis of potential impacts to fisheries and water quality from the mitigation plans, as well as use of at least one Marsh Succession Model as another method of identifying potential impacts to wetlands. We will also conduct screening level runs on the three additional measures suggested by the USFWS. The Corps will provide the results of those wetland analyses to the Interagency Coordination Team when they become available.

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William Bailey
Environment and Resources Branch

U.S. Fish and Wildlife Service

Memo

To: Bill Bailey, COE, Savannah, GA

From: Ed EuDaly, FWS, Charleston, SC

Date: December 7, 2006

Re: Savannah Harbor Expansion, marsh succession model

Your e-mail of November 2, 2006 requested that we review the two marsh succession models (USGS and ATM) and provide comments on suitability to determine wetland impact from the expansion project. You also requested views and rationale on whether one of the approaches should be used over the other.

I believe that the USGS model is suitable to determine wetland impacts and evaluate mitigation plans. The model predicts the plant community that will be found at a site based on relationships between the plant community and salinity, soil and distance to canal. Based on the demonstration runs dated October 2006, the model is sensitive to deepening impacts and appears to predict a reasonable level of impact on the wetland community. There was good agreement between the marsh communities predicted by the model and observed dominant species (Table 4.1, Figures 4.32-4.45 in USGS/USFWS Marsh Succession Model Report, October 2006).

I recommend that the USGS model be used rather than the ATM model for the following reasons.

- During field data collection, the USGS used a quantitative approach by sampling stem density and above ground biomass to provide information on habitat structure and ecological value. The ATM field data collection determined species importance value from transects. The ATM approach is less quantitative and provides less information on habitat structure and ecological value.
- Based on the quantitative field data, the USGS used sophisticated statistical procedures to identify community groupings that are ecologically valid. These community groupings are then predicted by the model based on the environmental gradient. The ATM model used a similar environmental gradient approach but predicted only the two most dominant species rather than a discrete community. Therefore, I believe there is uncertainty regarding whether the ATM model is predicting valid community groupings.

Thank you for the opportunity to review these documents and provide recommendations. If you have questions or need additional information please contact me.

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CESAS-PD-E

26 June 2007
Revised 29 June 2007
Revised 03 Aug 2007

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Interagency Coordination Meeting
Record of 20-21 June meeting

PARTICIPANTS:

NAME	**REPRESENTING**
Ed Eudaly	USFWS-Charleston
John Robinette	USFWS-Savannah NWR
Kay Davy	NOAA-Fisheries
Brad Gane	GA DNR-CRD
Kelie Moore	GA DNR-CRD
Matt Thomas	GA DNR-WRD
Tim Barrett	GA DNR-WRD
Paul Lamarre	GA DNR-EPD
Chris Beckham	SC DHEC-Columbia
Wade Cantrell	SC DHEC-Columbia
William Bailey	USACOE-Mobile
Paul Bradley	USACOE -Mobile
Joe Hoke	USACOE-Wilmington
Beth Williams	USACOE-Wilmington

OBSERVERS:

Hope Moorer	GPA
Larry Keegan	GPA/CH2M Hill

1. The meeting was held at the Armstrong Center in Savannah on June 20-21. The agenda is attached at the end of this document. This summary does not include all the items that were discussed during the meting, but summarize important points and decisions that were reached.

2. The meeting was called to (A) review information in the previously distributed impact and mitigation reports, (B) determine what information is most representative, and (C) identify appropriate mitigation.

3. We began by discussing impacts to **<u>wetlands</u>**. We first discussed the percent exceedence information on salinity. The Corps passed out handouts that USGS (Paul Conrads) had prepared that show the agreement between surface salinity values from the Model-To-Marsh (M2M) Model with those calculated by the hydrodynamic model (EFDC) and (when available) data measured in the marsh root zone. We reviewed data for stations in Front, Middle, and Back Rivers, and both average (1997) and low river flows (2001). The 50%-tile exceedence value was identified as being the best single measurement across the range of stations of flows. It was more accurate than the 10%-tile exceedence values (90% on distribution frequency) and therefore the best single exceedence value. Therefore, the group agreed for the Corps to use that parameter (50-%tile exceedence value) when assessing surface salinity levels for wetland effects.

4. We then reviewed **river flows**. Average river flows generally represent 50% of the flow distribution, while low flows and high flows each represent other 25% portions of the flow. Since average conditions represent more of the entire range of flows, the group reaffirmed our previous decision to use that condition in our basic impact evaluation.

5. We discussed **sea level rise**. As requested by the agencies, the reports contain information on conditions with both a 25 and 50-cm rise in sea level. The 25-cm rise is roughly the average of the range of sea level rise predictions for this area over the next 50 years. The 50-cm rise is at the high end of predictions for that time period. Both of those conditions would occur at the end of the 50-year planning time horizon. The group agreed that we should conduct our basic impact evaluation using conditions that would occur near the time of construction. Therefore, we decided to use the existing sea level for the basic impact evaluation.

6. We then discussed **mitigation for wetland impacts**. The evaluation procedure we have available uses the position of the 0.5 ppt surface salinity as the distinction between the locations of fresh and brackish marsh. The 0.5 ppt salinity value is a commonly accepted threshold between those two types of marsh vegetation. With the flows into tidal creeks that serve a large area of marsh, the procedure is essentially an ON/OFF switch for impacts. Because of this, the procedure shows irregular wetland impacts (rather than a smooth consistent increase) with increasing salinity levels. To address this we distributed information we had just prepared showing the effects of ranges of salinity (-0.5, 0.5-1, 1-2, 2-4, >4 ppt). This new format provides information on the effects on low salinity brackish marsh. This format requires someone to extend salinity contours from the rivers out into the marsh. Although drawing this contour is somewhat subjective, the group felt that it was acceptable if all the extrapolation is performed using the same criteria. Use of a single analyst (using the same criteria) would further normalize the results. One member suggested we graph the incremental wetland

acreage by river mile for each of the 3 rivers (Front, Middle, and Back). This could remove some of the subjectivity of drawing contours. The group requested we provide the salinity range information for all the depth alternatives and that we include columns showing the net acreage effect on each of these 5 wetland categories.

Plans that substantially reroute flows within the estuary were found to reduce the tide range upstream of the Houlihan Bridge. Some plans reduce the range 0.2-0.3 meters, while others reduce it 0.3-0.5 meters. USGS (Wiley Kitchens) measurements showed 1-1.5 feet of flooding of the freshwater marsh sites. One suggestion was to recalculate the marsh impacts with marsh elevations included. The USFWS expressed its opposition to conversion of freshwater wetlands to uplands. The USFWS also expressed concern that the loss of flooding over extensive marsh areas would eliminate use of those areas by small fish. Because of these concerns, we agreed to drop consideration of Plans 4, 5, and 8 and concentrate on Plans 1-3. The Corps would proceed with its modeling of Plans 6 and 7 using Plan 3 as a base.

The Corps provided the following information on the diversion of water from the Savannah River into the Middle and Back River system:

River Flow	48-foot Channel No diversion	48-foot Channel + Plan 1 (With Diversion Structure)
McCoys Cut	583 cfs	1130 cfs
Little Back River	429 cfs	646 cfs
Middle River	333 cfs	663 cfs

These numbers are based on average flows down the Savannah River.

We then discussed **restoration or compensation for wetland impacts**. The USFWS reiterated its position that because of previous losses over time, we cannot afford to lose additional tidal freshwater wetlands. They stated that due to the large historic loss of tidal freshwater wetlands within the estuary, they would not consider any out-of-kind replacement as acceptable mitigation for project impacts to the remaining tidal freshwater wetlands. Acquisition and conversion of the Poindexter property was discussed. The property is located on the eastern side of the Refuge and is managed by private landowners for waterfowl hunting. Diked portions of the site are seasonally flooded from the freshwater diversion canal. In the past, crops were grown in the diked areas during the summer before they were flooded in the fall. We understand that the owners use soil management practices similar to those used by the Fish and Wildlife Service to operate their impoundments. Based on that information, Federal acquisition and management would not provide substantially different environmental values. This would substantially reduce the number of wetland mitigation credits could be claimed. In 2006, the owners were approached with an offer to sell the property for development, so there is a threat that the property may be developed in the near future. An imminent threat of development is a factor which increases the amount of mitigation credits which can be claimed for protecting a site. The USFWS is interested in ownership of the property, but the site is not presently within their approved acquisition boundary. If the property is acquired and the dikes retained, the Federal ownership would protect the site from development and result in the diked areas being considered managed wetlands. The dikes would control water access to the site, so that acreage could not be considered tidal freshwater wetlands. The controlled access would mean that those acres would not provide the fishery habitats provided by natural wetlands. Those fishery functions would have to be made up separately. If the property is acquired and the dikes removed, brackish marsh would move in and occupy the previously diked areas. Since nearby brackish marsh provides high ecological values for fisheries, removal of the dikes could receive substantial credit for fishery habitats. NOAA-Fisheries prefers removal of the dikes if the property is acquired. (Note: This wording reflects subsequent discussion between the USFWS, NOAA-Fisheries, SCDHEC, and the COE on 18 July.)

The USFWS is interested in acquisition of upriver areas that are already within their approved acquisition plan. They stated that such acquisition would not be acceptable for loss of tidal freshwater wetlands.

The vast majority of the present tidal freshwater marshes are located within the Savannah National Wildlife Refuge. The group agreed that all tidal freshwater marshes within the Refuge possess the same ecological value.

The USFWS requested we include closing the lower (western) arm at McCoys Cut in future modeling of mitigation plans. They observed ebbing flows passing from McCoys Cut back out to the Savannah River. The hope is that closing that reach would increase flows down into the LBR/MR area. The Corps stated that if we pursue excavation of berms (previously deposited fill) along the banks of Little Back and/or Middle Rivers, placing those sediments in the lower arm would save substantial construction costs. Filling the arm would also result in creation of tidal freshwater wetlands. The USFWS said that the area needed to be surveyed for freshwater mussels. Subsequent to the meeting it was determined that a consulting firm with trained mussel divers would be required for this survey. The USFWS expressed concern about filling the lower arm and would rather see it plugged on the Little Back River side. That action would create a slough and provide fishery habitats for many years.

We discussed work at the Sediment Basin. The agencies have expressed concern about water quality (turbidity) impacts if sediments are directly deposited in the basin. The Corps said that initial modeling showed a narrow sill at the lower end of the basin would not stop salinity moving upstream with the tide. Momentum appears to carry the tidal flow over the top of a narrow sill and continue some distance upstream. The mitigation modeling is based on the Sediment Basin being filled to the same depth as upriver of the Tidegate (depth of -3.85 meters). Constructing only a sill would reduce the beneficial aspects on salinity of removing the Basin from operation. Sediments that would be excavated during a harbor deepening are primarily sands. The sediment composition does vary by station and depth. Placing silty or clay-dominated sediments in the Basin with a hydraulic dredge could produce extensive turbidity. Placement of clay-dominated sediments with a clamshell would produce substantially less turbidity.

Operations that produce more turbidity could be conducted during winter months which are less stressful to biota. We agreed to continue this discussion later.

7. We discussed impacts to **fisheries**. We started with Shortnose sturgeon. The modeling shows a deepening could reduce sturgeon habitat substantially. The adverse effects are most pronounced in the adult life stage during August. The wetland mitigation plans do not reduce those impacts. The impacts appear to be salinity related and not caused by reductions in dissolved oxygen. One method of mitigating for those impacts is to construct the fish bypass channel that had previously been proposed at the New Savannah Bluff Lock & Dam (NSBL&D). The group felt that this structure would help sturgeon, as it would open up new areas upstream for spawning. They believe it would also help American shad and other anadromous fish species. From an ecological perspective, removal of the NSBL&D would be more effective than implementing bypassing fish around the structure. The Corps explained that although Congress has not funded rehabilitation of the lock and dam (with its bypass), local governments continue to position themselves for the continued existence of that dam. The Corps would not consider proposing removal of that structure as part of this project unless someone first discusses the concept with a local government representative and obtains an indication that they would not oppose such a proposal. The group could not identify a method other than action at NSBL&D to mitigate for adverse impacts to this species. The Corps will coordinate further on this issue with the St. Petersburg office of NOAA-Fisheries.

We reviewed impacts to **American shad**. Those range from <1% loss of habitat in January and May to a loss of 7% in August with Plan 3. The out-migration of juveniles to the ocean would commence late summer and continue through fall and winter. Since the criteria for acceptable habitat for this species consists of only a dissolved oxygen level, the oxygen injection system should remove these impacts and likely result in net improvements in habitat volume.

We reviewed impacts to **Striped bass**, which result in roughly a 25% loss in acreage of acceptable habitat across the three life stages we examined – spawning, eggs, and larvae (50% flow, 6-foot deepening, Plans 1-3). GA DNR-WRD believes that average river flows (50%-tile) are appropriate for identifying project impacts.

Although the habitat criteria include several parameters, velocity and salinity seem to be the most important ones. The Corps examined ways to increase velocity in the LBR and MR areas. This included use of pilings, rocks, and additional flow volume. Increasing flow in the Savannah River during April by 500 and 1000 cfs did not result in noticeable improvements. Further increases in flow are also not likely to be effective, as even flows at the 80% cumulative frequency level do not reduce the adverse effects of a deepening. The Corps will check the actual velocity numbers to identify the level of effect, as well as examining whether the velocity is above or below the defined threshold.

GA DNR-WRD requested we examine inclusion of a flow partitioning structure at the junction of LBR and MR as a potential adaptive management tool. This could allow us to modify the distribution of flows in that system to improve areas that provide more and/or better habitats for striped bass.

The Savannah River striped bass population is currently not used as the sole source of broodfish for GA's statewide striped bass stocking program. Both SC and GA recently opened the recreational fishery for this species. The stocking program appears to have been successful, as a good number of large adult fish occur in the estuary. Records indicate that some natural spawning has resumed in the last 2 year classes checked (2003 and 2004). Sixty percent of the 2004 year-class was naturally spawned. Dr. Bill Daven's 1999 report of egg transport identified 3 locations in the spawning area with a silty bottom substrate. GA DNR did not believe that further field study of that issue was needed. Questions were raised about the potential value of cleaning the sediments in those areas to make that area more productive. Unknowns about the flow velocities keep anyone from knowing whether the sites would silt back in again.

GA DNR-WRD and USFWS suggested we further examine closing the lower arm of McCoys Cut during future modeling. Ebbing flows have been observed passing from the lower arm of McCoys Cut (original channel) back out to the Savannah River. The hope is that closing that reach would increase flows down into the LBR/MR area. They also requested we examine not deepening through McCoys Cut. This may be a way of increasing velocities through that upper LBR/MR area.

The group could not identify any other physical action that could be examined to increase Striped bass habitats in the project area. If the 25% loss in habitat remains in the final plans, funding a striped bass culture/stocking program may be the only way to compensate for the unavoidable impacts to this species.

We reviewed impacts to **Southern flounder**. Habitat losses for this species are substantial (up to 47% with 6-foot deepening and Plan 5). However, since the criteria for acceptable habitat for this species consists of only a bottom slope and dissolved oxygen components, the oxygen injection system should remove these impacts and likely result in net improvements in habitat volume.

8. We discussed impacts to **water quality**. GA DNR identified two statements on page 7 in the Impact Report that were questionable. The Corps concurred that the wording should be revised and said that we would revise the wording when it is published in the GRR or EIS.

EPA is considering revising the water quality model in LBR and MR (6 layers to 1). SC DHEC reiterated that the water quality model was not optimized for that area and that the D.O. results for that area are better used on a comparison basis. The Corps said that if the model is revised, it would need a new calibration report that was independently reviewed before it could vary from the present model which has gone through that process. No participant knew if EPA had obtained new SOD samples, as recommended by SC and previously proposed by EPA.

GPA is conducting a demonstration project of a dissolved oxygen injection system starting at the end of July and running for 6 weeks. They will produce a report with the results of their monitoring program. Agencies suggested that the Corps incorporate information obtained during the monitoring into the final predictions for performance of the proposed D.O. systems.

The Corps stated that the Water Quality Team had previously recommended that the upper two locations identified in the Task II Report on the D.O. system not be constructed. Those sites were identified as being best from a modeling perspective, with no consideration for land availability. One of the sites (McCoys Cut) is located within the Savannah National Wildlife Refuge with no land access or power. The other (Mill Stone Landing) is located at an upriver site. The Corps intends to combine the oxygen proposed from those sites into others located more in the harbor area. The site at Houlihan Bridge would likely be expanded to compensate for eliminating those upriver sites. Another site could be required around the Sediment Basin. The final modeling will identify the most cost effective tradeoff of number of stations vs. total volume of oxygen to be added.

The Corps will try to find information on the success of the demonstration project of oxygen injection in a California harbor.

One comment on the siting of the oxygen injection facility near the Houlihan Bridge is that if the facility is located between the Front and Middle Rivers, the same facility could be used to improve oxygen in both rivers with lines going to each river. The only high ground with road access between Front and Middle Rivers is CDF 1N, which is located within the Savannah National Wildlife Refuge. The USFWS would have to find that use of the site compatible with the overall goals of the Refuge.

9. We discussed **monitoring and adaptive management**. The Corps distributed a framework for a monitoring and adaptive management plan for the project. The group decided that agencies should be involved in decisions about implementing adaptive management features. The public should be informed of the results of the monitoring, but could not assist in making Federal and State decisions.

There was a recommendation that we monitor forested wetlands. This would be helpful in ensuring that the project does not unexpectedly impact this resource. Another recommendation is that we include a flow partitioning structure at the junction of LBR and MR. This could allow us to modify the distribution of flows in that system to improve areas that provide more habitats for Striped bass.

10. We discussed other **mitigation** measures. Filling the Sediment Basin (or allowing it to fill) would help low salinity marshes that provide extensive fishery benefits and display large species diversity. Removal of the Tidegate could affect the tide cycle and velocities upstream of that site.

The Corps should remove "Increase flows down the Savannah River" from its list of possible mitigation features. It should also remove "Modify Tidegate into fishing pier" from its list of possible mitigation features, as such a pier would have substantial liability concerns. It should also remove "Tybee NWR" from its list of possible mitigation features, as there is nothing this project could do to improve that Refuge. The Corps should move up in its priority list the measure to "Block western connection at McCoys Cut". We should add "Restore wetlands at CDF 1S" to the list. Depositing sediments in the nearshore area off Tybee would help Wassaw Island. Add as a possible Other Measure the cleaning of silty sediments in LBR and MR to restore the sandy bottom substrate so that it would be more suitable for Striped bass.

11. Kay recommended that the Corps initiate formal consultation with NOAA on Essential Fish Habitat and compliance with the Endangered Species Act, now that information on project impacts is available.

12. The meeting was beneficial. We were able to narrow the focus of our consideration of the data that has been produced. The Corps will perform some more modeling of project impacts. We agreed to evaluate the Tidegate (Plan 6) and Steamboat Cut features (Plan 7) based on Plan 3, rather than Plan 5. The Corps will evaluate the feasibility of grading down a high ground site to produce tidal freshwater wetlands. The Corps will provide the results of that work to the agencies when it becomes available.

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William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY MEETING

JUNE 20 & 21, 2007

AGENDA

<u>WEDNESDAY</u>

OPENING & INTRODUCTIONS	**9:30 – 9:45**

- Purpose of Meeting
  - Review information in Impact and Mitigation reports
  - Determine what information is most representative
  - Identify appropriate mitigation

WETLANDS	**9:45 – 12:00**
LUNCH	**12:00 – 1:00**
WETLANDS (Cont)	**1:00 – 3:30**
FISHERIES	**3:30 – 5:00**

<u>THURSDAY</u>

FISHERIES (Cont)	**8:30 – 10:00**
WATER QUALITY	**10:00 – 12:00**
LUNCH	**12:00 – 1:00**
OTHER MITIGATION MEASURES	**1:00 – 2:00**
MONITORING & ADAPTIVE MANAGEMENT	**2:00 – 3:00**
WRAP-UP	**3:00 – 3:30**

Meeting Minutes
Savannah Harbor Expansion (SHE) Project Model Development
January 11, 2005 at Tetra Tech, Inc., Atlanta, GA

Attendees:

Joe Hoke, USACE Savannah District
Bill Bailey, USACE Savannah District
Margaret Tanner, MACTEC
Larry Neal, MACTEC
Paul Lamarre, GAEPD
Jim Greenfield, EPA Region 4
Bob Scanlon, City of Savannah and Harbor Committee
Steven Davie, Tetra Tech
Yuri Plis, Tetra Tech
Will Anderson, Tetra Tech
via conference call:
  Larry Keegan, Lockwood-Green
  Hope Moorer, GPA
  Chuck Watson, Kinetic Analysis Corporation
  Sri Rangarajan, HydroQual
  Paul Conrads, USGS
  Card Smith, USACE
  John Hamrick, Tetra Tech

Meeting Agenda:

1. Overview of Tetra Tech's contract with USACE/GPA.
2. Schedule of work tasks.
3. Specific work tasks for discussion:
   a. Update on model enhancements
   b. Preliminary production runs & output
   c. Uncertainty analysis (Kinetic Analysis Corporation)

Discussion Items:

- Steven Davie presented an overview of the modeling contract with the USACE, an overview of the schedule, and a status report on Tetra Tech's work. Tetra Tech is under contract to the USACE Savannah District to provide the following tasks: EFDC modifications and re-calibration, re-evaluate WASP calibration, uncertainty analysis, EFDC/WASP training, EFDC/WASP reports, and model application files.

- Modeling Schedule:
  - Initiated Work – Oct 6, 2004
  - EFDC Training – completed on Oct 26-28, 2004
  - WASP Training – To be determined
  - Draft Uncertainty Analysis – completed on Jan 7, 2005
  - Final Uncertainty Analysis – Jan 31, 2005
  - Draft EFDC and WASP Report – Feb 2, 2005
  - Final EFDC and WASP Report – March 9, 2005 (or based on agency comments)

- Model Enhancements:
    - Re-fined grid resolution
    - Updated bathymetry
    - Marsh interactions

? New Grid Resolutions:

- ~ 950 horizontal cells, probably end up with 900 to 950 cells.
- 657 in TMDL grid and 1,368 in finer grid.
- Running with 6 vertical layers.
- Upstream boundary at Clyo ~ 61 miles from Fort Pulaski
- Downstream boundary ~18 miles offshore from Fort Pulaski
- Man-made connections included (McCoys Cut, Rifle Cut, Drakies Cut, New Cut closed, Tide Gate)
- Shipping channel defined - matches channel configuration (GIS from Corps)
- Revised enhanced grid incorporating agency comments such as smoothed channel mouth, merged two channel cells into one, merged multiple cells next to channel into one on each side for most areas, except Kings Island Turning Basin and Elba Island Bight/Sediment Basin area.
- Handout distributed on Tetra Tech's December 10, 2004 Technical Memorandum No 1 on the grid resolution.
- Handout distributed summarizing the grid comments was given based on December 10, 2004 Tetra Tech memo.
- The grid convergence test has not been completed and will be discussed in the final report.

- Bathymetry Data Sources:

- USACE Annual Surveys (1999, 2002) for the navigation channel.
- USGS SNWR (2004) for Front, Middle, Back, and Little Back Rivers.
- USACE Upstream of I-95 (1999) for upper Savannah River.
- NOAA Surveys (1980's) - offshore non-channel and South Channel.

- Marsh Interactions

- Using Q-Zones developed by ATM marsh report and implemented in the TMDL grid.
- TMDL grid approach did fairly well except on strong spring tides.
- Enhanced approach will use external cells inundated only during strong spring tides with wetting and drying as an option.

- Production Run Scenarios:

- Tetra Tech has been using the TMDL grid as a "screening level" model to work out details associated with deepening production runs, such as how to represent the deepened channel and how to produce output. The USACE stated that developing a program to process and organize all output was not part of the scope but will help in future production run scenarios. (The Tetra Tech scope calls for setting up the bathymetric files for the production runs, but does not require delivery of output files.)
- Baseline conditions were August 1999, which is consistent with EPA's draft DO TMDL, and the project conditions were the 46-foot channel. The 46-foot channel was represented in the TMDL grid by increasing the depths in the navigation channel by 4 feet (1.2 meters).
- Habitat suitability requirements were shown through contoured plots of the grid for the following: Striped Bass (April) spawning, egg development, larval development; Southern Flounder (August); American Shad (January, May, August); and Shortnose Sturgeon (January, August).

- Other EFDC/WASP output was discussed such as plan view of salinity and D.O. distributions, 2-D (longitudinal and vertical) distributions, salinity statistics horizontal distributions, water volumes with D.O. increments, ship channel, entire Middle and Back Rivers, statistics of salinity responses to alternatives, Ship Channel, Entire Middle and Back Rivers, USGS gages

- Uncertainty Analysis:
- Chuck Watson from Kinetic Analysis Corporation (KAC) presented preliminary results of the uncertainty analysis (UA) on the TMDL model grid.
- KAC evaluated the quality and quantity of data available for the development of the hydrodynamic and salinity and water quality models.
- KAC evaluated the uncertainty of the TMDL configuration of the EFDC model (aka the TMDL model)
- KAC has made preliminary recommendations for the development of the enhanced grid model.
- KAC concentrated on salinity – good data, checks mass transfer – with seven sets of simulations: 1) Baseline, 2) +1m Bathymetry, 3) -1m Bathymetry, 4) Friction bias to 0.0, 5) Friction bias to 0.1, 6) Bathymetry set to 1992, 7) Randomly perturbed bathymetry (10 at 10%).
- KAC used "R" package for automated analysis and plot generation, spot checked manually using JMP (from SAS Institute)
- KAC's preliminary recommendations include: 1) enhanced grid model calibration should take care to avoid over calibration to 1997/1999 conditions, 2) long term data should be partitioned to include both calibration and blind test (verification) runs, 3) use of bottom roughness for calibration should be carefully examined to ensure additional uncertainty is not being introduced in the calibration process, and 4) bathymetry should be for average conditions – not just immediately after maintenance or dredging. This could be a data problem having only data before and after maintenance rather than for average conditions.

Next Meeting

Scheduled for February 16, 2005 at EPA Region 4 to review the draft modeling reports and go over comments. Agency comments will be due to Joe Hoke by February 25, 2005. Please be prepared to review the reports during this time period.

From:	Bailey, William G SAM@SAS
To:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Keith_Parsons@mail.dnr.state.ga.us"; "Matt Thomas (E-mail)"; "Wade Cantrell"; "beckhajc@dhec.sc.gov"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Priscilla Wendt"; "Kay Davy (kay.davy@noaa.gov)"; "Ed_Eudaly@fws.gov"; "john_robinette@fws.gov"; "Lord.Bob@epamail.epa.gov"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"
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Subject:	Savannah Harbor Expansion Project: Wetlands Interagency Coordination Team -- Decision on Model-To-Marsh Revision
Date:	Thursday, April 05, 2007 10:16:44 AM
Attachments:	EXPAN LCA M2M revision decision -- Mar 07 V2.doc

I believe I informed you that we were experiencing problems with applying the Marsh Succession Models to the mitigation plans. We traced the problem to the Model-To-Marsh component -- the link between the EFDC hydrodynamic model and the Marsh Succession Models.

The USGS had developed the Model-To-Marsh (M2M) linkage, so we requested a proposal from them to revise it so we could use it on the mitigation plans. They provided a proposal, which the Federal agencies reviewed and discussed. The SOW was for $110K and would take about a year. We felt that we could not be reasonably certain that the predictions made by the revised M2M would be reliable. Therefore, the Federal agencies (EPA, USFWS, NMFS and Corps) concluded that the proposed modification is not warranted. I have attached the decision document that led us to that point. The document includes the proposed SOW.

This action means that evaluation of the mitigation plans for wetlands will be performed through use of the EFDC hydrodynamic model. With that model, we will look at movement of the 0.5 ppt salinity contour and the wetlands that change from <0.5 to > 0.5 ppt salinity.

We will use the Marsh Succession Models to review the impacts predicted by the EFDC model from a deepening of the harbor without any mitigation. The comparison between the results from those three different methods will provide information on the reliability of the EFDC results.

If you have concerns about this decision, including wanting the Wetlands Interagency Coordination Team to meet to discuss the issue, please let me know by 20 April.

William Bailey
912-652-5781

CESAM-PD-E 22 March 07

DECISION DOCUMENT

SUBJECT: Savannah Harbor Expansion Project;
Proposed revision to Model-To-Marsh linkage

1. A problem has developed with use of the Marsh Succession Models (MSMs) on some of the mitigation scenarios. The scenarios affected are those that substantially modify flows between the Front, Middle, and Back Rivers. The problem results in an overstatement of salinity in the Middle and Back Rivers, rendering the MSMs unreliable to evaluate wetland impacts on those scenarios. We've identified the Model-To-Marsh linkage (M2M) as the source of the problem.

2. The following two courses of action are available.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the "impact" and "mitigation" runs. We would use the MSM to provide more detail on the vegetation changes on the "impact" runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for "mitigation" runs. This Option describes our present condition and plan for proceeding with the wetland evaluations.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the "impact" and "mitigation" runs. We would revise the M2M as described in the enclosed proposal and apply the MSM to both "impact" and "mitigation" runs.

3. The Lead and Cooperating Agencies discussed this issue on 8 March 2007. The MFR, which summarizes the discussions of the meeting, are attached.

4. The USGS would lead the work to revise the M2M. They estimate it would take $110,750 and 12 months to produce a final product (including internal review). The work would include participation of an interagency team to identify flow paths from the rivers to specific locations in the marsh.

5. The following summarizes the pros and cons of proceeding with the proposed revisions (Option 2):

<u>PROS</u>

- The revisions would allow the Marsh Succession Models to be applied to all mitigation scenarios presently being considered. At this time, the MSMs do not give reliable results when applied to mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers).
- The revisions would include the use of an interagency team, increasing the likelihood of those agencies approving the final product.

<u>CONS</u>

- The EFDC model in conjunction with spatial data can acceptably be used to identify movement of the 0.5 ppt contour, allowing predictions of change between freshwater and brackish marsh. Use of the MSM on the impact runs will provide a comparison of the EFDC and MSM impact predictions (without mitigation).
- Revision of the M2M would cost roughly $110,000 and possibly delay decisions on the project by a year. The 1998 Feasibility Report estimated project net benefits (benefits – costs) to be about $35,000,000 per year.
- The effectiveness of the proposed revisions and the reliability of the MSM results will not be known until after the work is performed. The proposal acknowledges substantial uncertainty regarding accuracy of salinity predictions even with the proposed revisions.
- The revised M2M may have to be further modified if additional mitigation scenarios are developed. The further modifications would require additional costs and possibly further delay decisions on the project.

6. Conclusions.

The project has one accepted method of identifying potential impacts to wetlands (using EFDC to identify movement of the 0.5 ppt contour).

The accuracy of that model can be judged by use of the Marsh Succession Models for impacts from deepening scenarios without mitigation.

Therefore, the revised M2M – and the Marsh Succession Models – are not required to identify wetland impacts from the various harbor deepening alternatives (with mitigation).

Implementation of the proposed M2M revisions would cost roughly $110,000 and possibly delay decisions on the project by a year.

The additional information that may be obtained by revising the M2M does not appear to be sufficient to justify the cost of the modifications or delay to the project.

7. Recommendation.

Based on the information provided in this document and its enclosures, I believe that implementation of the proposed Model-To-Marsh revision is not warranted and recommend that the modifications not be pursued.

William G. Bailey

William Bailey
Physical Scientist
Mobile/Savannah Regional Planning Center

8. Concurrence:

	CONCUR	NON-CONCUR	INITIALS
Joseph Hoke Hydraulic Engineer USACE Wilmington/Savannah Engineering	________	____________	________
T. Alan Garrett Project Manager USACE Savannah District	________	____________	________
Ed EuDaly Senior Biologist USFWS Charleston	________	____________	________
Ted Bisterfeld Ecologist EPA Region 4	________	____________	________
Kay Davy Fishery Biologist NOAA Fisheries Charleston	________	____________	________

CESAM-PD-E 20 Mar 07

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Lead & Cooperating Agency meeting, 08 March 07

1. The meeting was called to learn more about a proposal (attached) to revise the Model-To-Marsh (M2M) component of the Marsh Succession Models. Alan Garrett, Corps Project Manager, chaired the meeting. A list of attendees is attached.

2. Bill Bailey provided an overview of the problem.

The Corps has successfully run the Marsh Succession Models to identify changes in wetlands from the various channel deepening scenarios. These are the “impact” runs. As we applied the models to the mitigation scenarios, we observed unexpected results. For some mitigation scenarios, the EFDC runs predict a decrease in salinity but the MSMs show shifts to more saline wetland species. Upon further inspection, we observed that on those runs the M2M component was providing higher root zone salinity values than were occurring in nearby rivers. The M2M extrapolates riverine salinity values from seven sites to root zone salinity values across the entire marsh surface. Apparently the limited number of points from which the M2M is starting its extrapolation leads to inaccuracies in mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers). The M2M takes higher salinity levels on the Front River and uses them as a basis for incorrectly predicting higher salinity levels in portions of Middle and/or Back Rivers.

3. We described two avenues through which the project could more forward.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the “impact” and “mitigation” runs. We would use the MSM to provide more detail on the vegetation changes on the “impact” runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for “mitigation” runs.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the “impact” and “mitigation” runs. We would revise the M2M as proposed and apply the MSM on both “impact” and “mitigation” runs.

4. Paul Conrads and Ed Roehl provided an overview of the proposed SOW to revise the M2M. This write-up is only a small part of the description Paul and Ed provided.

The present M2M starts with river flows and tidal conditions. It adds to that foundation riverine salinity values from the EFDC model. The present M2M could be considered more a far-field approach since it uses a limited number of riverine salinity values and extrapolates them across the entire marsh surface. It determines a relationship between river salinity and the well gages through time-delayed input signals and moving window averages between river salinity and pore-water salinity. The M2M was designed to primarily identify changes in root zone salinity that occur longitudinally in the estuary (along the length of the river).

The proposed revisions would allow the M2M to better identify lateral changes in root zone salinity that occur across the estuary (between different rivers or away from a single river). These revisions would start with a more detailed network of river salinity stations. It would then extrapolate those values to nearby areas of marsh. This could be considered more of a near-field approach. Additional marsh well data would be obtained to establish strong relationships between river and marsh root zone salinities. The Q-zone approach would be used as a starting point for the river to marsh flow paths. An interagency panel would be used to identify those pathways and guide the model revisions.

Uncertainty in the results of this M2M revision include three components: (1) Quality of the original data, (2) Quality of the data used to forecast or hindcast to fill in missing data, and (3) Quality of the data from EFDC. These are the same sources of uncertainty with use of the present M2M. This revision will require development of additional synthetic data to fill in records for the extra river sites that will be used.

5. The group then asked questions of Paul and Ed Roehl about the proposed work.

What will be the reliability of the results when using more synthetic data? Would the public accept the use of more synthetic data? RESPONSE: The reliability will not be known until the model is produced. However, data for the existing M2M show it is highly reliable for use with the present configuration of the estuarine rivers. As with any model, the ultimate accuracy of the revised model's predictions would not be known until after post-construction monitoring is performed.

What will be the reliability of the results when using data from the GPA stations? Those data were determined to be unacceptable in development of the existing M2M. RESPONSE: Data from the GPA stations were not used in the existing M2M primarily because of their short period of record. A much longer – and therefore more reliable – record exists for the USGS gages. The GPA stations would be used in the model revisions to provide a finer grid of river locations from which to extrapolate salinity levels across the marsh surface. The finer grid should increase the accuracy and reliability of the model predictions within specific marsh areas. The additional stations

would also allow a more detailed quantification of the sensitivity of marsh areas to local riverine conditions. The GPA stations also provide data obtained during 1997 – the flow conditions that are being modeled during the mitigation analyses. The reliability of the revised models would not be known until they are developed.

What are the differences between the GPA stations, marsh gages, and USGS gages? RESPONSE: The differences include both duration and density. The marsh gages provide salinity information in the marsh root zone at 7 sites from 1999 to 2005 and 10 GPA sites from 1999 to 2002. The GPA stations hare 14 riverine stations with data from portions of 1997 and 1999. The USGS gages provide salinity information at 4 riverine sites for many years.

What will be the reliability of the final predictions if the development of the revised model includes extensive synthetic data? RESPONSE: Models are regularly developed and applied when only limited actual data exists. Synthetic data is an accepted technique in the modeling community when insufficient historical data exists.

If new algorithms need to be developed for each mitigation plan, it could appear that we have developed a model just to show the results we want on the plan we want. If the same model is not used to evaluate all plans, how can we ensure we are evaluating all plans to the same degree of accuracy? RESPONSE: The same procedures would be followed to evaluate all plans, even if the models differ.

The existing M2M and its algorithms appear to work well with the present river configuration. If new algorithms only are effective for the mitigation plans that substantially modify river flows, how can we ensure their accuracy? RESPONSE: The change from a “far-field” approach to a “near-field” approach increases the likelihood that the revisions would be accurate when flows are substantially modified. The reliability of the results will not be known until the models are developed.

The MSM provides more detailed information on expected wetland changes than does the EFDC model. Do we really need those more detailed predictions for each mitigation scenario? RESPONSE: If reviewers want the detailed information, the revised M2M is the only way to obtain it.

Although a provisional version may be available in 5 months, the project will need a fully accepted version before it could release a report containing results using this approach. The final report is scheduled to be available in 12 months. If complications occur that delay the work, the date would extend further. A 12-month delay in the project would be a major impact to GPA. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

The proposed revisions would likely extend the duration of the project. That extension may decrease the reliability of other analyses, requiring they be updated. That would require additional time and money. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

Some of the mitigation scenarios appear to decrease the tidal range. The USFWS may not be able to support those plans as a substantial decrease in the depth of flooding over the marsh may adversely affect nekton use of those areas. The plans which have the most effect on tidal range are the ones that substantially alter flows between the three rivers. RESPONSE: The proposed M2M revisions would not be beneficial if the final mitigation plans do not include measures that substantially alter flows between the three rivers.

Have the status and trends of wetlands since the last harbor deepening been taken into account? RESPONSE: Both the M2M and the MSM are based on data obtained since the last deepening.

Would the proposed revisions be necessary for the post-construction monitoring and adaptive management? RESPONSE: The EFDC will be used to ensure that changes in riverine salinity that are predicted are not exceeded. The existing M2M and MSM could be used to provide a perspective on what should have been expected in the wetlands with the observed flows if no further deepening occurs.

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

LEAD & COOPERATING AGENCY MEETING
08 MAR 2007

ATTENDEES

Ed EuDaly	USFWS – Charleston	(by phone)
Ted Bisterfeld	EPA Region 4	(by phone)
Kay Davy	NOAA Fisheries - Charleston	(by phone)
Alan Garrett	USACE - Savannah	
Joe Hoke	USACE – Wilmington/Savannah	
Hugh Heine	USACE – Wilmington	(by phone)
Elizabeth Godsey	USACE – Mobile	(by phone)
William Bailey	USACE – Mobile/Savannah	
Hope Moorer	GPA	(by phone)
Larry Keegan	Lockwood-Greene Engineers / GPA	(by phone)
Morgan Rees	Rees Engineering / GPA	(by phone)
Paul Conrads	USGS – Columbia	(by phone)
Ed Roehl	Advanced Data Mining	(by phone)

Estimation of Pore-water Marsh Salinities for Harbor Reconfiguration Scenarios

By
Paul Conrads, U.S. Geological Survey – Water Resources Division
Edwin Roehl, Advanced Data Mining, LLC
Wiley Kitchens, U.S. Geological Survey – Biological Resources Division
Zachariah Welch, Florida Coop Unit, University of Florida,

INTRODUCTION

Under sponsorship from the U.S. Army Corps of Engineers (USCOE) and the Georgia Ports Authority (GPA), the Lower Savannah River Estuary and the surrounding freshwater tidal marshes of the Savannah National Wildlife Refuge (SNWR) have been studied for years by a variety of governmental agencies, water users, universities, and consultants. Their interests are in maintaining water quality and predicting the potential impacts of a proposed harbor deepening on the estuary and tidal wetlands. Two major initiatives were the development of a three-dimensional hydrodynamic model (3DM) by a team of hydrologists, and the development of a marsh succession model (MSM) by a team of plant ecologists. The 3DM predicts changes in riverine water levels and salinity in the system in response to potential harbor changes. The MSM predicts plant distribution in the tidal marshes in response to changes in the water-level and salinity conditions in the marsh. A mechanism for linking riverine and marsh behaviors was needed.

To support 3DM and MSM development, many disparate databases were created that described the natural system's complexity and behaviors, but these databases had not been compiled into a usable form. Variables having particular relevance include those describing bathymetry, meteorology, streamflow (Q), water level (WL), specific conductance (SC), water temperature (WT), and dissolved oxygen concentration (DO). Most of the databases were composed of time series that varied by variable type, periods of record, measurement frequency, location, and reliability. Scientists recognized that data-mining techniques, which include artificial neural networks (ANN), could be used to link riverine and marsh behaviors.

To link the riverine predictions of the 3DM to the MSM, a "model to marsh" (M2M) model was developed by the U.S. Geological Survey and Advanced Data Mining (ADM) using data mining techniques that included ANN models. The ANNs simulated riverine and marsh water levels and salinity in the vicinity of the SNWR for the full range of 11½ years of data from riverine and marsh gaging networks. With M2M, the 3DM and MSM comprise an integrated decision support system for use by various regulatory and scientific stakeholders. The development and application of the M2M is described in Conrads and others (2006).

The M2M has been successfully applied to evaluate the effects of deepening the harbor by generating the inputs to the MSM from the outputs of the 3DM. The M2M also has been used to evaluate potential mitigation scenarios for minimizing the impacts from

harbor deepening. These mitigation scenarios included minor and major changes in channel configuration and flow distribution in the system.

PROBLEM STATEMENT

Eight mitigation scenarios that involve major structural changes in the vicinity of the SNWR, such as the installation of flow diversion structures and the cutting and filling of channels, have been proposed for evaluation. The M2M was not designed to accommodate mitigation scenarios that involve major structural changes. Currently (2007) there is not a mechanism for reliably estimating pore-water salinities in the marsh from riverine inputs for these major mitigation scenarios.

The responses of the SNWR to major changes are very likely to be different from any behaviors ever manifest in the historical record. While the 3DM can be configured to estimate riverine WL and SC with the major changes, it is limited to riverine estimates and cannot be credibly configured to estimate pore-water salinities in the marsh. Using data mining techniques, Conrads and others (2006) found that pore-water salinities integrate riverine WL and salinity variability over several months and often there are long time delays between riverine salinity conditions and marsh pore-water salinity response. A new tool similar to the M2M, hereafter referred to as M2M.2, needs to be developed to estimate pore-water salinity concentrations to evaluate mitigation scenarios involving major structural changes. To provide the necessary technical input and agency review, it is proposed that a multi-agency and multi-disciplinary technical working group be formed of the USGS-S.C. Water Science Center (USGS-SCWSC), the USGS-Florida Coop Unit (USGS-FCU), U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACOE), and Advanced Data Mining (ADMi).

OBJECTIVES

There are three objectives for this project.

1. *Develop new marsh salinity estimation models* - for estimating pore-water salinities at marsh gaging sites for various mitigation model scenarios, using either measured or predicted river water level and specific conductance data at gage locations. It is possible that algorithms would have to be developed for each mitigation scenario.

2. *Develop new salinity spatial interpolation scheme(s)* – that estimate salinities throughout the SNWR from the USGS marsh gaging sites. The current scheme is embedded in the M2M’s two-dimensional visualization and gridding application (2DVG). The new schemes must reflect greater lateral variation in the pore-water salinity than the current scheme. It is possible that new schemes would be created for each mitigation scenario.

3. *Develop M2M.2 2DVG and Simulator Applications* – to deploy the work products from Objectives 1 and 2. This includes adapting the 2DVG and the M2M Simulator, which estimates salinities at the USGS marsh gages.

SCOPE

The scope of this study is to address the relation between the riverine salinity and the pore-water marsh salinity for harbor deepening mitigation scenarios. The study's major tasks are described below.

Task 1 *Develop Pore-water Estimation Matrix* – that defines the usable permutations of input USGS or GPA river gages to estimate salinities at each marsh gaging station for each mitigation scenario. Consideration will be given to the proximities of gages and flow diversion structures, and the overall quality of input gage measured, forecasted, and hindcasted data used for developing or generated by the M2M.

Task 2 *Develop predictive models* - for each permutation defined in Task 1. This involves determining optimal time delays and moving window averages between river salinity and pore-water responses through correlation analysis. ANNs provide the best possible correlations in terms of the process information they provide and their prediction accuracy. The number of models to be developed depends on the permutations defined in Task 1.

Task 3 *Define area of influence and spatial gradient of the USGS marsh gages* - for the new salinity spatial interpolation scheme.

Task 4 *Develop M2M.2 2DVG application* - to reflect findings from Task 3. It is likely that multiple visualizations and grids will need to be developed to accommodate all of the mitigation scenarios.

Task 5 *Develop M2M.2 Simulator* – like M2M, it will integrate the 3DM with the MSM using the models from Task 2 and the M2M.2 2DVG application from Task 4, but tailored for the mitigation scenarios involving major structural changes.

Task 6 *Document the approach and results.*

RELEVANCE AND BENEFITS

An important part of the USGS mission is to provide scientific information for the effective water-resources management of the Nation. To assess the quantity and quality of the Nation's surface-water, the USGS collects hydrologic and water-quality data from rivers, lakes, and estuaries using standardized methods, and maintains the data from these stations in a national database. Often these databases are under utilized and under interpreted for addressing contemporary hydrologic issues. The techniques used to develop the M2M and models of the Cooper River (Conrads and Roehl, 1999), the Beaufort River (Conrads and others, 2003), and the Pee Dee River (Conrads and Roehl, 2006) demonstrate how valuable information can be extracted from existing databases to assist local, state and Federal agencies.

The project benefits the Georgia Ports Authority and the Army Corps of Engineers by providing data analysis needed by water-resource managers to make decisions concerning mitigation of the Savannah River Estuary to accommodate potential deepening of Savannah Harbor. The project builds on previous studies relating river salinity to marsh pore-water response. This is consistent with primary USGS activities that include providing knowledge and expertise to assist various levels of government in understanding and solving critical water-resources problems.

TECHNICAL APPROACH

The historical data do not contain information explicitly about the impacts of the proposed mitigation scenarios involving major structural changes. For these circumstances, the best available data, tools, and human expert knowledge and experience must be brought to the problem. The development and use of the M2M.2, and related findings will provide the best possible resources for evaluating the major mitigation scenarios.

Available Data and Utilities from M2M Study

The M2M is based on river and marsh WL and SC ANN models for the USGS and GPA gaging stations in the river and marshes. These are empirical models and for a system as complex as the Savannah River estuary, it was critical that measured, not estimated, data were used that cover the greatest range of hydrologic and tidal responses. For making predictions of pore-water salinity, the most valuable data for M2M development were from the long-term USGS river and marsh gaging stations, which covered over 11 years and 5 years respectively, and comprise a range of flow conditions from drought to floods. Of lesser value were the GPA river and marsh data, which were limited to short measurement periods and a small range of hydrologic conditions. The USGS river data are the major inputs for the final pore-water salinity models and a few of the GPA stations are used to reduce the error in the pore-water models.

The M2M Simulator and 2DVG applications will be valuable for estimating pore-water salinity for the major mitigation scenarios. The Simulator integrates a collection of individual models of the GPA and USGS river gages with the various field databases, such that all of the WL and SC data from the river gages were individually modeled. By hindcasting and forecasting the short-term data collection periods at the GPA sites, a complete database was generated for the 11½ year period from 1994 to 2005. This feature was incorporated to allow scientists and managers to simulate any period from the last deepening and analyze system responses at any gage location. The 2DVG provides spatial interpolation-extrapolation and visualization of the marsh responses across the marsh wells. It is easily modified to accommodate new pore-water estimates at the USGS marsh sites and new interpolation-extrapolation schemes across the marsh.

Pore-water Estimates for Mitigation Scenarios

The MSM models use the growing-season average pore-water salinity as input. The measured, forecasted, and hindcasted SC records at the GPA river sites can be used in conjunction with the USGS sites to determine the best estimates of the average pore-water salinity during the growing season. Estimates will be based on the assumption that a marsh gage responds to nearby river gage(s) and that the candidate river gage(s) may vary by mitigation scenario. Often good correlations between two time series, such as river and marsh SC, can be obtained by adjusting the time delay and moving window average of the explanatory variable (river SC) to achieve the highest correlation with the response variable (marsh SC). For highly dynamic SNWR, trend information proved invaluable for estimating inertia-driven behaviors. Representing trends requires at least two input variables whose values represent two different times or two different locations at the same time, or both.

To estimate pore-water responses to mitigation scenarios, river sites will be selected as candidate explanatory variables for each mitigation plan. For example, the schematic for Mitigation Plan 5 is shown in figure 1. In this scenario, it is believed that salinity intrusion occurs further up the Front River and that freshwater flows increase down the Little Back River. The riverine gages closest to the Middle River 1 (M1) for estimating its pore-water salinity are GPA12 and GPA12r. For Back River 2 (B2), gages 8979, 89784, and GPA15 appear to be good candidates. Final river site selection will be based on the quality of the measured, hindcasted, and forecasted GPA data.

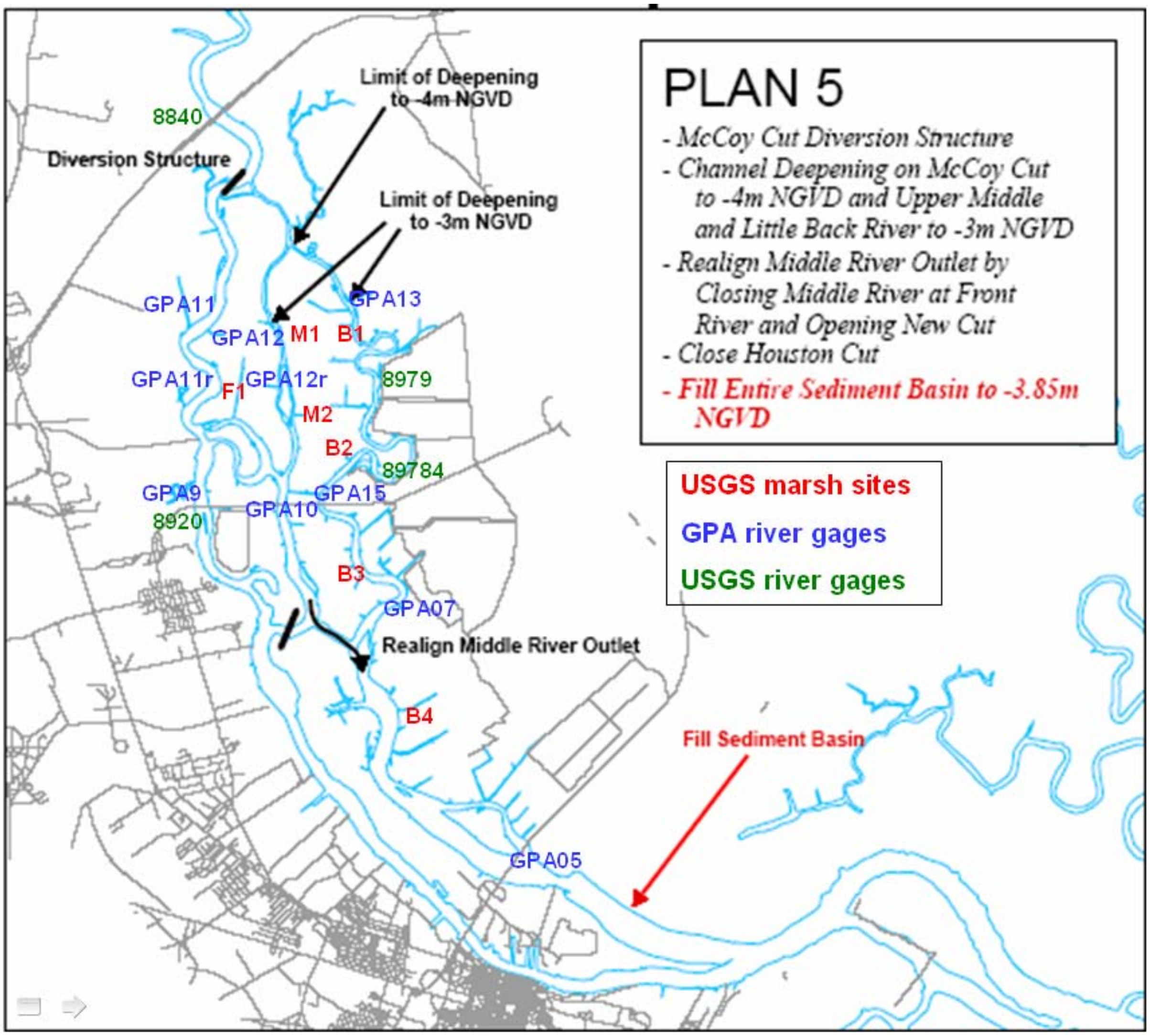

Figure 1. Locations of river and marsh gages and schematic of Plan 5 mitigation scenario

The Pore-water Estimation Matrix will be developed of mitigation plans, marsh gages, and candidate river sites. It is anticipated that some of the plans will share configurations of river gages to marsh gages. Pore-water estimates will be determined for each plan and the estimates will be compared with the predictions made with the original ANN models of the M2M.

Pore-Water Salinity Projections Across the Marsh

The time-series data of the individual marsh gages depict the longitudinal gradient of the system to various hydrologic and tidal conditions. The time-series data do not support the lateral gradients in the system. The M2M's 2DVG is based on estimates of the longitudinal variations from model predictions at the marsh sites. A simple interpolation scheme is used to estimate the lateral gradients.

For the mitigation scenarios, marsh wells will be assigned to the vegetative zones (Q-zones) depicted in Figure 2 and added to the Pore-water Estimation Matrix. Lateral variation across the marsh will be based on field experience and limited data taken during transect studies by the Florida Coop Unit (FCU) at the University of Florida.

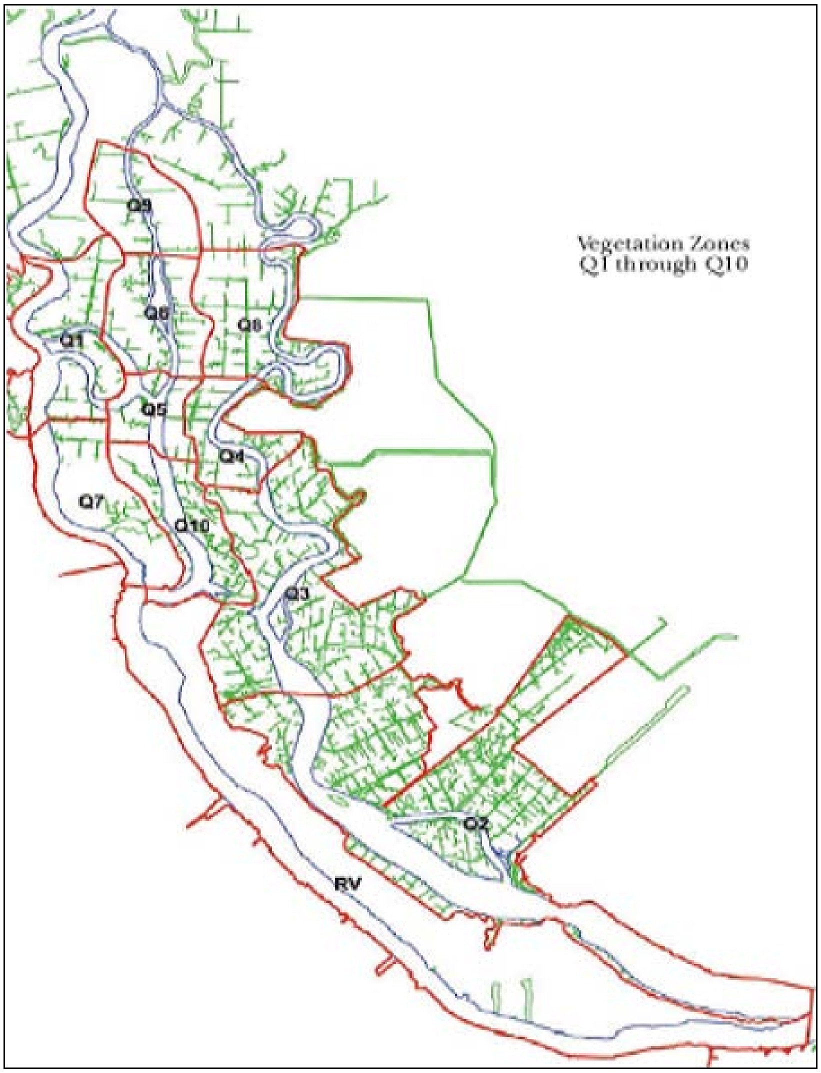

Figure 2. Locations of Q-zones in the tidal marsh in the vicinity of the Savannah National Wildlife Refuge

Integration of Hydrodynamic Model and Marsh Succession Models – M2M.2

Like M2M, M2M.2 will integrate output from the 3DM and generate the marsh salinity grid for input to the MSM. Linking the 3DM is accomplished by reading in a file of simulated differences in SC values for the river for the mitigation plan scenarios. The use of differences, or deltas, from the 3DM increases the prediction accuracy of the model. Mechanistic model, such as the 3DM, typically are better suited from predicting relative differences between two conditions rather than making absolute predictions for one

scenario. The differences (deltas) from the 3DM are added to the historical time series for the scenario and then used in the M2M.2. The application estimates pore-water salinity at the marsh gages and the salinity grid is generated for input to the MSM applications.

Figure 3 describes the data and workflow from the 3DM, through the M2M.2 Simulator and 2DVG applications, and to the MSM. Here, the eight mitigation scenarios are handled separately, providing each with completely customized solution bearing the best ideas of the multi-disciplinary team. At left the 3DM is run for each scenario and separate output files are generated. Next at top center, in the M2M.2 Simulator the user selects the scenario to be run, the appropriate 3DM output file is loaded, the appropriate prediction models are engaged, a simulation is run, and an output file of marsh specific conductivities is generated. Next at right, in the M2M.2 2DVG the user selects the scenario to be run, the M2M.2 Simulator output file is loaded, and an output file of spatially interpolated marsh salinities is generated, which can be loaded into the MSM.

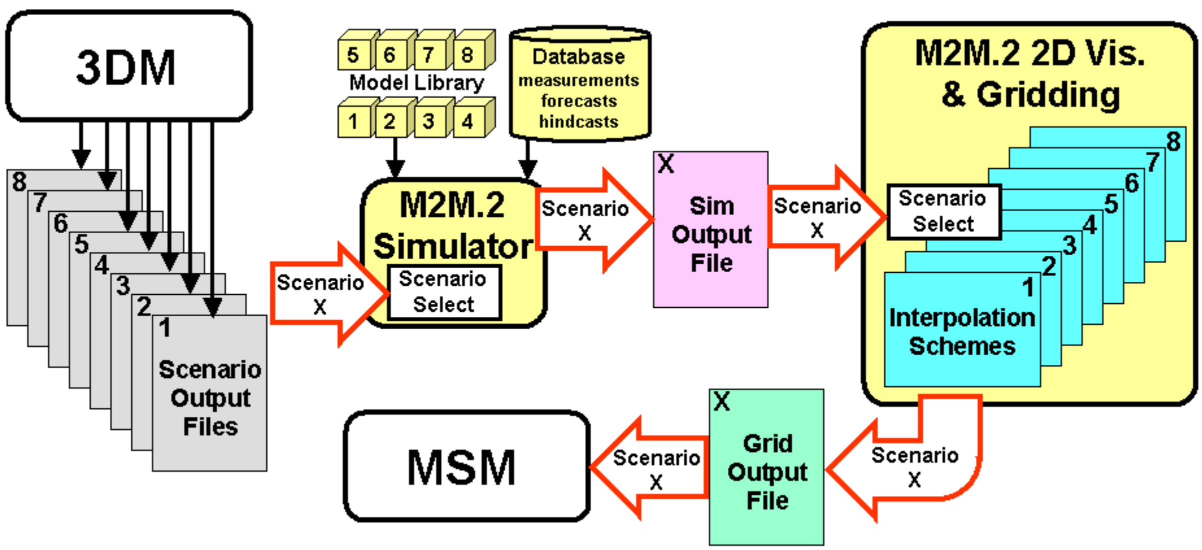

Figure 3. Schematic of data and workflow through the M2M.2.

UNCERTAINTY OF OUTCOME

In this technical approach, each scenario will have a custom solution developed by a multi-disciplinary technical team composed of the USGS-SCWSC, the USGS-FCU, the USFWS, USACOE, and ADMi personnel that are most knowledgeable in the issues, history, and science of the harbor deepening. As with the M2M, the behaviors and predictive performance of the new “local” models of the M2M.2 will be fully described to the technical team. The performance of the models is expected to be comparable to those of the M2M, with the major sources of uncertainty to be associated with the quality of the data collected from the GPA sites, the quality of the SC hindcasts and forecasts at the GPA sites, and the accuracy of the 3DM predictions.

Generally, the 3DM prediction accuracy of flow and salinity throughout the model domain are better on the Front River and lower portion of the system. The prediction

accuracy is not as good in the vicinity of the SNWF and farther inland in the system. This can be seen in the summary statistic of the model performance for the 50 percentile and the coefficient of determination for the 1999 calibration data and the 1997 validation data set (Tetra Tech, 2006). The accuracy of estimates made by the 3DM for scenarios involving major structural changes is unknowable *a priori*, but very likely to be less accurate that the calibration and validation prediction. The used of differences from the 3DM will reduce absolute prediction error by the model. The 3DM's performance will be the primary source of uncertainty, but significant reliance on its estimates inside the SNWR is unavoidable.

The technical team will leverage the tools in hand to formulate a process of mitigating deepening-related problems. The process may employ a succession of structural changes of varying impact severity. It is likely that each change will have surprising results that can only be determined *post priori* by continued field monitoring and data analysis. This suggests a conservative, iterative mitigation approach composed of these steps - hypothesize, change, test, review, and most importantly, learn will be required.

PROJECT COORDINATION

In making estimates of system responses to the structural changes in the SNWR, it is essential that the appropriate technical resources from the agencies be involved. It is proposed that periodic meetings of the technical working group (USCOE, USF&W, USGS-SCWSC, USGS-FCU, and ADMI) be scheduled to review interim products such as the pore-water estimation matrix, pore-water estimation models, and prototypes of the M2M.2 2DVG and M2M.2. Many of these meeting could be accomplished by teleconferencing.

REPORTING

The project will be documented in a USGS Open-File Report, tentatively titled "Estimation of Tidal Marsh Pore-water Salinity in the Vicinity of Savannah National Wildlife Refuge for Savannah Harbor Deepening Mitigation, Coastal South Carolina and Georgia." A provisional copy of the report will be available for colleague/cooperator review 3 months after the completion of the project. The review process will require an additional 5 months. A limited number of paper copies of the report will be provided to the cooperating agencies; however, the primary outlet for the publication will be the Internet. A link to the report will be posted on the USGS South Carolina Water Science Center web sites.

BUDGET AND SCHEDULE

The Project will be collaboration between the USGS-SCWSC, the USGS-FCU, and ADMi. The project will take approximately 4-5 months to complete the technical analysis and develop the provisional M2M.2 from the start date. The final documentation of the project will be complete approximately 10-12 months from the start date. The total cost of the project will be $110,750. An itemized description of the tasks and required hours

are listed in Table 1 and a timeline for completion of the project from initiation is presented in Table 2.

Table 1. Tasks, description, notes, hours, and costs.

Task #	Description	Notes	USGS-SCWSC Hours	USGS-SCWSC Cost	USGS-FCU Hours	USGS-FCU Hours	ADMI Hours	ADMI Cost
1	Develop Pore-water Estimation Matrix	tooling up, evaluate data quality, matrix development, meeting with Agencies to finalize matrix	40	$4,400			40	$5,000
2	Develop predictive models	upper limit = 8 scenarios x 7 models per = 56 models, x 8hrs/model, use 50% - USGS-SCWSC to review	25	$2,750			224	$28,000
3	Define area of influence and spatial gradient of the USGS marsh gages	mostly USGS-FCU with assitence from USGS-SCWSC, ADMI to assimilate, meeting for concurance with Agencies prior to finalization	40	$4,400	64	$6,400	12	$1,500
4	Develop M2M.2 2DVG application	assume 8 interp schemes to program/integrate at 2days per - USGS-SCWSC to revew	25	$2,750			128	$16,000
5	Develop M2M.2 Simulator	assume 4 weeks for mostly new but derivative app programming and testing - USGS-SCWSC to rev	25	$2,750			160	$20,000
6	Document the approach and results.	mostly USGS-SCWSC and USGS-Publications Unit, ADMI and USGS-FCU to assist	120	$13,200	16	1600	16	$2,000
		Totals	275	$30,250	80	$8,000	580	$72,500

Table 2. Timeline for completion of project.

Task#	Description	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
1	Develop Pore-water Estimation Matrix												
2	Develop predictive models												
3	Define area of influence and spatial gradient of the USGS marsh gages												
4	Develop M2M.2 2DVG application												
5	Develop M2M.2 Simulator												
6a	Document the approach and results.												
6b	USGS report review and publication												
	Interim product-Estimation Matrix												
	Interim product - Spatial gradient interpolation-extrapolation routine												
	Interim product - Prototype of M2M.2 w/ 2DVG												
	Interim product - Provisional M2M.2 available												
	Interim product - Draft report												

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Conrads, P.A. and E.A. Roehl, 1999, Comparing physics-based and neural network models for predicting salinity, water temperature, and dissolved oxygen concentration in a complex tidally affected river basin, South Carolina Environmental Conference, Myrtle Beach, March 1999.

Conrads, P.A., Roehl, E.A., and W.P. Martello, 2003, Development of an empirical model of a complex, tidally affected river using artificial neural networks, Water Environment Federation TMDL Specialty Conference, Chicago, Illinois, November 2003.

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Tetra Tech, 2006, Development of the hydrodynamic and water quality models for the Savannah Harbor Expansion Project. Prepared for the U.S. Army Corps of Engineers – Savannah District, Tetra Tech, Inc. Atlanta, Georgia.

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To:	"Wade Cantrell"; "beckhajc@dhec.sc.gov"; "wendtp@dnr.sc.gov"; "Bob Perry"; "Kelie Moore"; "Brad_Gane@dnr.state.ga.us"; "Keith_Parsons@mail.dnr.state.ga.us"; "Dale Caldwell"; "bisterfeld.ted@epa.gov"; "Bob Lord (Lord.Bob@epa.gov)"; "kay.davy@noaa.gov"; "peconsulting@comcast.net"; "Bill Wikoff"
Cc:	"Ed Duncan"; "hmoorer@gaports.com"; "Chuck_Hayes@fws.gov"; "jane_griess@fws.gov"; "Jeff_Larson@dnr.state.ga.us"; "Tim Barrett"; "joynercm@dhec.sc.gov"; Okane, Jason D SAS; Bradley, Kenneth P SAM; Heine, Hugh SAW; Small, Daniel L SAD; "Pace Wilber"; "David Bernhart"; "Mueller, Heinz J."
Subject:	Savannah Harbor Expansion Project: Wetlands Interagency Coordination Team
Date:	Tuesday, July 21, 2009 8:15:21 AM
Attachments:	savannah_ACOE_Onslow_Area1S_mitigation_additional_acres.pdf

Last January I let you know that we had identified a previous sediment disposal site in Savannah Harbor (Area 1S) to grade down to provide in-kind mitigation for project impacts to saltmarsh. If you remember, the site is located along the Savannah River, where it is joined by Middle River. During subsequent discussions, folks suggested a site visit to jointly inspect the site.

The CESAS Regulatory Division will be having a Quarterly Interagency Meeting in Savannah on 11 August. Some of you will be coming to attend. Would those who are interested, be available to visit Area 1S the afternoon before -- 10 August? The Corps would provide a boat to get to the site.

The USFWS visited the site and provided the attached figure of the portions of the site to restore.

If you want to see the site, please let me know by COB next Monday if you could come the afternoon of 10 August to visit it. If you want to see it, but are not available that day, please let me know.

When we meet, we'll also review the overall approaches we have taken on this project to identify and quantify wetland impacts and subsequent mitigation.

Bill Bailey


Additional acreage identified
for mitigation for Chatham County.
Area would benefit from restoration
to marsh level.
Open to marsh (Middle River)
Open to marsh
(Middle River)
Buffer from Front River
Open to Middle River
115

From:	Bailey, William G SAS
To:	"beckhajc@dhec.sc.gov"; "Blair N. Williams"; "Kelie Moore"; "Dale Caldwell"; "Keith_Parsons@mail.dnr.state.ga.us"; "Bob Lord (Lord.Bob@epa.gov)"; "Mueller, Heinz J."; "Bill Wikoff"; "wendtp@dnr.sc.gov"; "Bob Perry"; "kay.davy@noaa.gov"
Cc:	"Wade Cantrell"; "Chuck_Hayes@fws.gov"; "hmoorer@gaports.com"; "Jeff_Larson@dnr.state.ga.us"; "Brad_Gane@dnr.state.ga.us"; "Tim Barrett"; Okane, Jason D SAS; Bradley, Kenneth P SAM; McIntosh, Margarett (Mackie) SAS; King, Jeffrey K. SAS; Small, Daniel L SAD; Lampley, Vechere V SAD; "Pace Wilber"; "David Bernhart"; "Jack_Arnold@fws.gov"; "Mark_Musaus@fws.gov"; "Sandy_Tucker@fws.gov"; "Jane_Griess@fws.gov"; "Gagliano.Paul@epamail.epa.gov"; "Godfrey.Annie@epamail.epa.gov"; "Derby.Jennifer@epamail.epa.gov"; "Melville.William@epamail.epa.gov"; "Mancusi-Ungaro.Philip@epamail.epa.gov"; "Gregory_Hogue@ios.doi.gov"; "joyce_stanley@ios.doi.gov"; "Rheta Geddings DiNovo"; "Barbara Neale"; "Heather Preston"
Subject:	Savannah Harbor Expansion Project: Wetlands Interagency Coordination Team meeting (UNCLASSIFIED)
Date:	Friday, June 03, 2011 3:06:38 PM
Attachments:	2011-06-01 SHEP Wetland Presentation.pdf

Classification: UNCLASSIFIED
Caveats: NONE

I've attached the presentation we gave at this Wednesday's meeting and the sign-in sheet.

Thank you all for attending.

We are adding some of the figures that had in the presentation to our write-up for the FEIS. We expect to complete that and send it out to you by the end of next week.

Bill Bailey
Chief, Planning Division

Classification: UNCLASSIFIED
Caveats: NONE

Savannah Harbor Expansion Project (SHEP) – Information Meeting Wetland Impacts and Mitigation

Bill Bailey and Jeffrey King

US Army Corps of Engineers,
Savannah District

Atlanta, Georgia

June 1, 2011

US Army Corps of Engineers
BUILDING STRONG.

Outline

- Provide agencies with history of Wetland Interagency Coordination Team (ICT) discussions and recommendations concerning wetland impact evaluation and mitigation
- Review direct impacts to wetlands
- Review mitigation for direct impacts to wetlands
- Review indirect impacts to wetlands
- Review mitigation for indirect impacts to wetlands

History of Wetland Interagency Coordination Team

- EPA, USFWS, NMFS, GA DNR-EPD, GA DNR-CRD, SC DNR, and SC DHEC
- Previous meetings
  - ►01 July 2003
  - ►31 May 2006
  - ►15 Dec 2006
  - ►20/21 June 2007
- Site visit to Disposal Area 1S on 10 August 2009

BUILDING STRONG®

Guidance Provided By
Wetland Interagency Coordination Team

- 01 July 2003 Meeting
  - ►Freshwater vegetative communities are more valuable in the Savannah River estuarine ecosystem
  - ►USFWS favors a community-based approach to assessing impacts to tidal wetlands
  - ►Possibly need a sensitivity analysis of alternate river flows

Guidance Provided By Wetland Interagency Coordination Team

- 31 May 2006 Meeting
  - Would use hydrodynamic model to identify changes in salinity
  - Would use Marsh Succession Model to identify changes in vegetation/community resulting from salinity changes
  - Would develop multiple methods of identifying changes in vegetation
    - Movement of 0.5 ppt contour
    - Would use ATM Marsh Succession Model
    - Would use USFWS/USGS Marsh Succession Model

Guidance Provided By
Wetland Interagency Coordination Team

- 31 May 2006 Meeting (continued)
  - Conduct basic analysis using average river flows (1997)
  - Conduct drought sensitivity analysis using 2001 flows
  - Conduct sensitivity analysis on sea level rise
    - 25 and 50 cm over 50 years
  - Evaluate impacts over a 1 Mar – 30 Oct growing season
  - Evaluate sea level rise and drought (combined) on recommended plan

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Guidance Provided By Wetland Interagency Coordination Team

- 31 May 2006 Meeting (continued)
  - Corps should provide salinity values predicted in root zone from Model-To-Marsh
  - Corps should provide changes in root zone salinity from Model-To-Marsh
  - USFWS maintains that freshwater tidal wetlands in Middle and Back Rivers are most ecologically valuable areas within the lower estuary
  - Areas along navigation channel have considerably less ecological value
  - USFWS reiterated that it can accept no further loss of tidal freshwater marsh

Guidance Provided By
Wetland Interagency Coordination Team

- 31 May 2006 Meeting (continued)
  - Corps should evaluate acquiring Harrison property adjacent to SNWR as mitigation
  - Present surface, middle and bottom salinities
  - Use surface salinity for wetland evaluation because that is what floods the marshes
  - Display locations where the surface salinity would change
  - Provide acreage and % change for each vegetative type

Guidance Provided By
Wetland Interagency Coordination Team

- 15 Dec 2006 Meeting
  - ► Evaluate not dredging the upper portions of Middle and Back Rivers
  - ► Evaluate blocking original mouth of McCoys Cut
  - ► Evaluate rerouting Middle River through Rifle Cut

Guidance Provided By
Wetland Interagency Coordination Team

- 20/21 June 2007 Meeting
  - Use 50%-tile exceedence surface salinity values for wetland evaluations
  - Reaffirmed basic analysis should use average river flows
  - Manually extending salinity contours across the marsh is an acceptable procedure
  - Provide information on acreage of 5 salinity categories (<0.5; 0.5-1.0; 1-2; 2-4; >4 ppt)

Guidance Provided By Wetland Interagency Coordination Team

- 20/21 June 2007 Meeting (continued)
  - ► Drop consideration of flow rerouting plans 4,5 and 8 because they decrease flooding of marshes
  - ► Evaluate flow rerouting plans 6 and 7, using 3 as a base
  - ► USFWS would not consider any out-of-kind replacement for loss of tidal freshwater wetlands

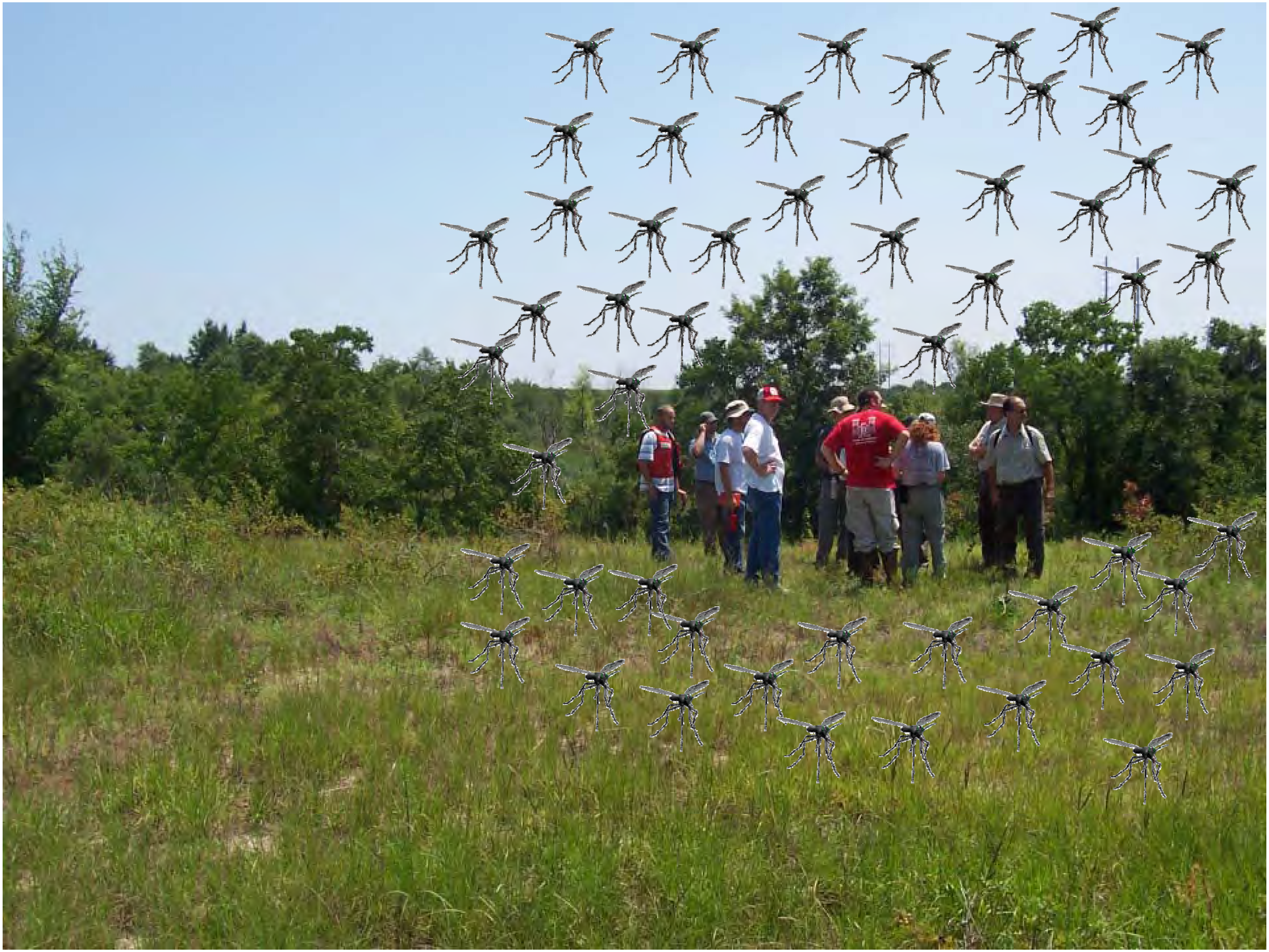
Guidance Provided By
Wetland Interagency Coordination Team

- 20/21 June 2007 Meeting (continued)
  - All tidal freshwater marshes within the Refuge possess the same ecological value
  - USFWS preferred leaving slough at lower arm of McCoys Cut for fishing rather than filling to create tidal freshwater wetlands
  - Constructing an earthen sill at the lower end of the Sediment Basin could create water quality impacts, depending on material used and construction technique
  - Add “Restore wetlands at Disposal Area 1S” to list of potential mitigation features
  - Corps will consider grading down high ground to produce tidal freshwater wetlands

Interagency Site Visit

Disposal Area 1S

10 August 09



Wetland Impacts

Wetland Impacts Associated with SHEP

- DEIS Evaluated several alternative depths
- For simplicity, discussions on wetland impacts will use 48-foot depth alternative
  - Direct Impacts: 15.68 acres salt marsh
  - Indirect Impacts:
    - 337 acres of tidal freshwater conversion
    +1067 acres of brackish marsh conversion
    - 730 acres of salt marsh conversion

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Final Compensatory Mitigation Rule and Wetland Impacts

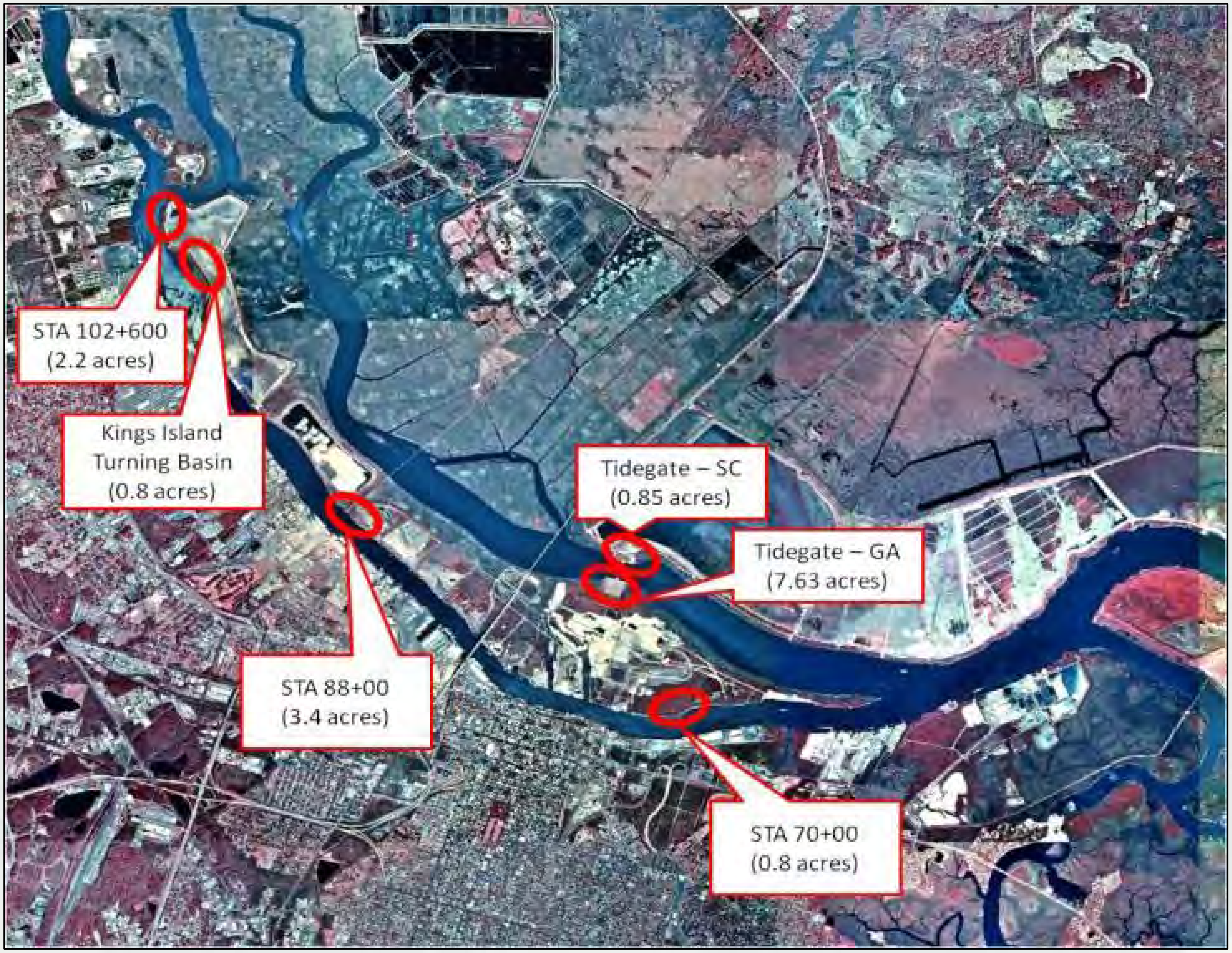
- Functional assessment of impact sites and mitigation areas
- Watershed approach (considerations, information, site selection)
- Type and location of mitigation
- Responsible parties
- Timing
- Ecological Performance Standards
- Monitoring
- Adaptive Management
- Long term Management
- Financial Assurances and Protection

Direct Impacts to Wetlands

Direct Impacts to Wetlands

Location (Channel Station)	Wetland Acres Affected by Excavation
Refuge Lands	
102+600 - GA	2.2
Kings Island Turning Basin- GA	0.8
Non-Refuge Lands	
88+000 – GA	3.4
70+000 – GA	0.8
Tidegate – GA	7.63
Tidegate - SC	0.85
Total	15.68

Location of Direct Impacts to Wetlands



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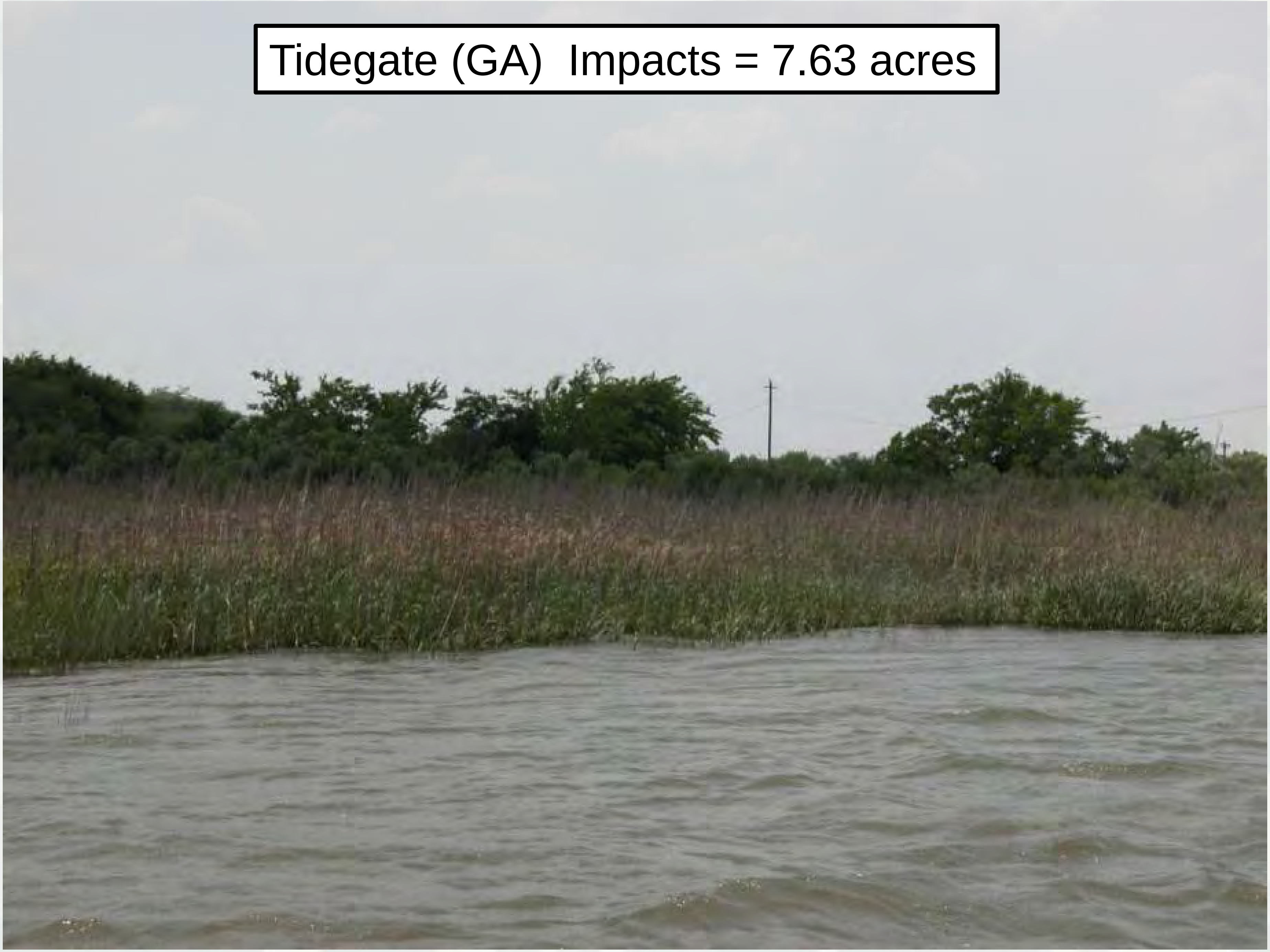
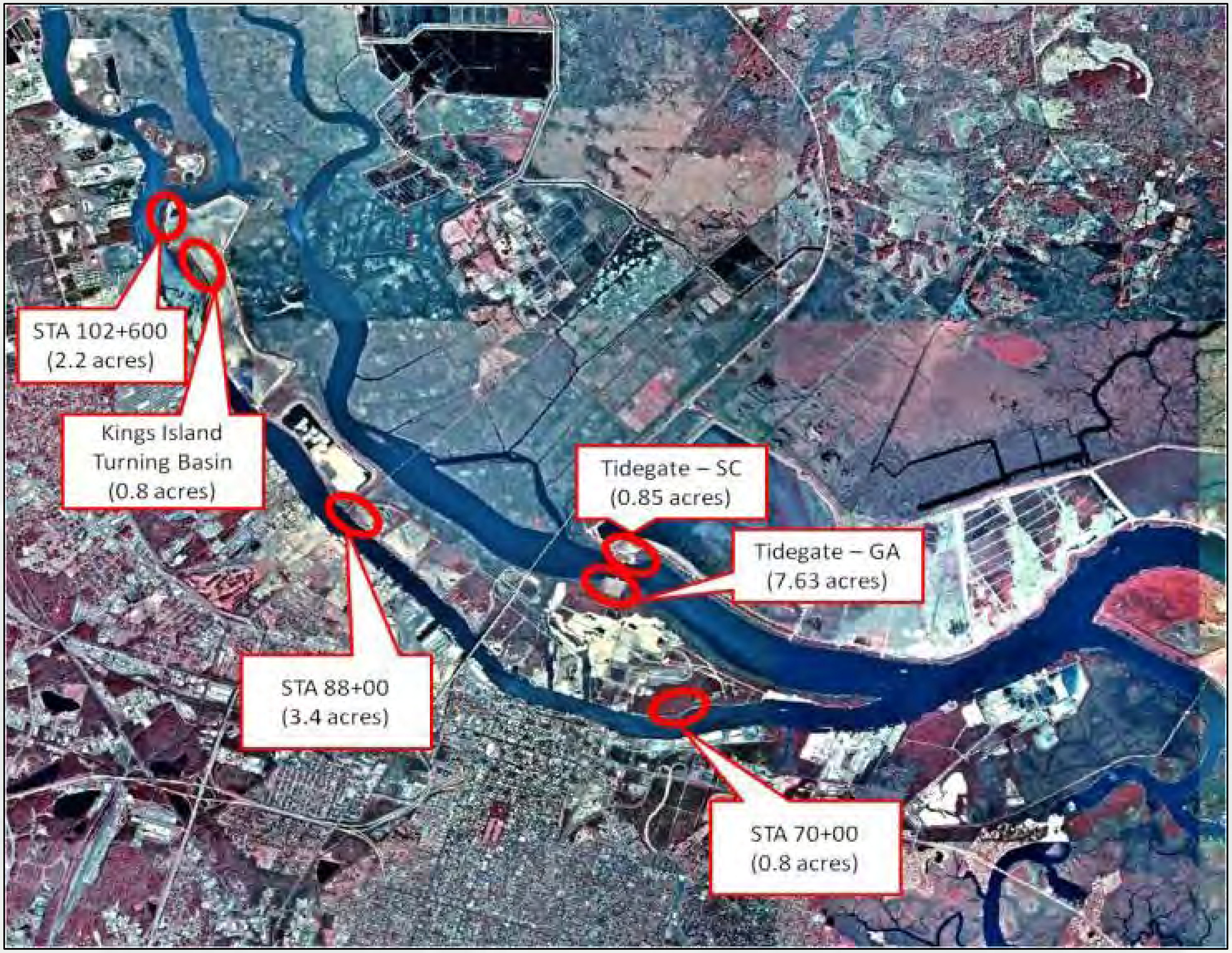
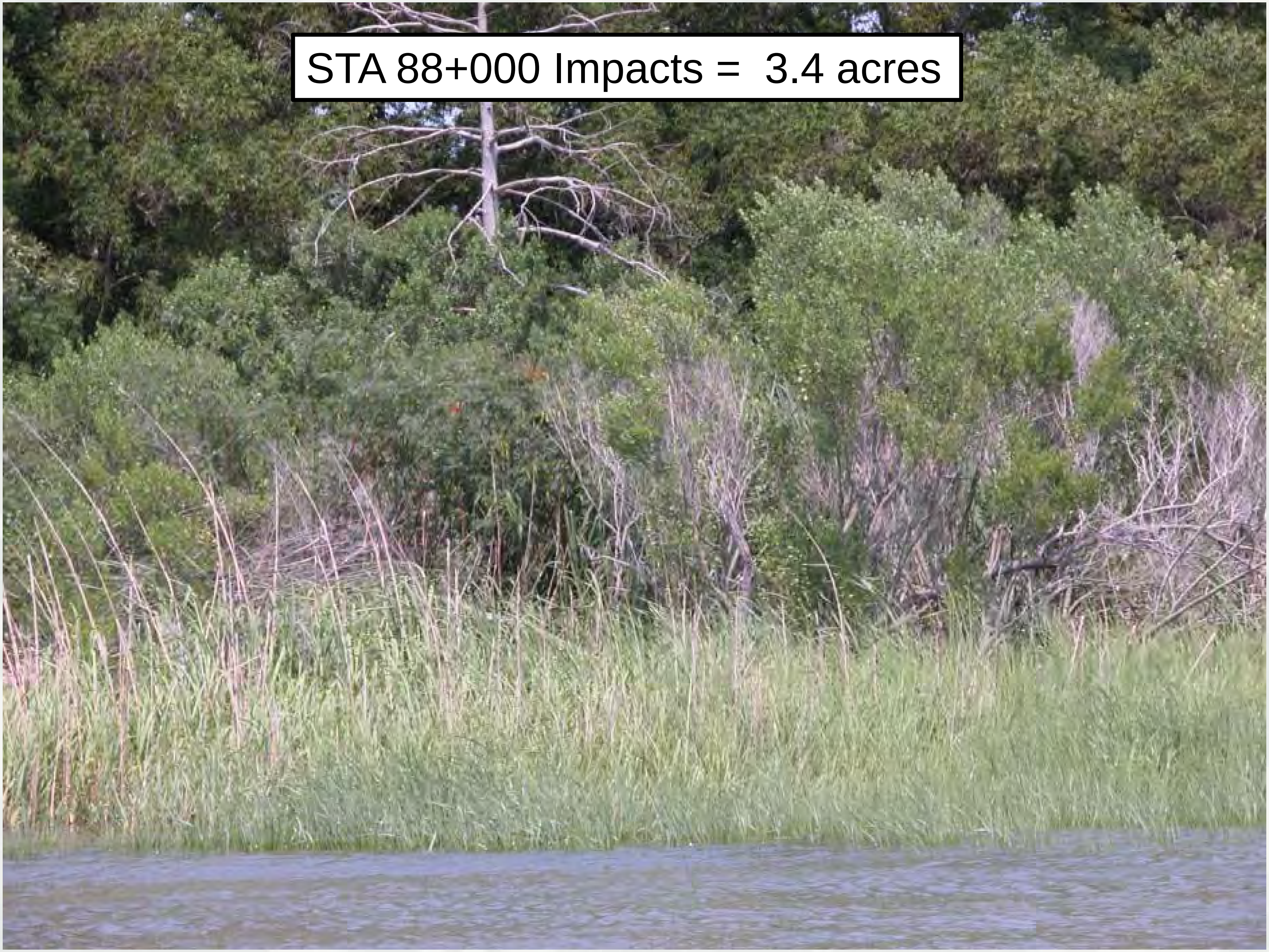
Tidegate (GA) Impacts = 7.63 acres




STA 70+000 Impacts = 0.8 acres

Location of Direct Impacts to Wetlands




STA 88+000 Impacts = 3.4 acres


STA 88+000 Impacts = 3.4 acres


KITB Impacts = 0.8 acres


STA 102+000 Impacts = 2.2 acres

Changes in Wetland Function as a Result of Brackish Marsh Excavation

Elements of Wetland Function	Effect of Excavation on Wetland Function (15.68 acres)
Water Purification	Major Adverse (lost)
Flood Protection	Major Adverse (lost)
Shoreline Stabilization	Major Adverse (lost)
Groundwater Recharge	Major Adverse (lost)
Streamflow Maintenance	Major Adverse (lost)
Retention of Particles	Major Adverse (lost)
Surface Water Storage	Major Adverse (lost)
Subsurface Storage	Major Adverse (lost)
Nutrient Cycling	Major Adverse (lost)
Values to Society	Major Adverse (lost)
Fish and Wildlife Habitat	Major Adverse (lost)

Mitigation for Direct Impacts

- Conducted watershed assessment
- Evaluated use of mitigation banks

Bank Name	Watershed	Acreage of Bank*	Status	USACE District
Salt Creek	Ogeechee-Coastal	98.9	Pending	Savannah
Tronox	Lower Savannah	88	Pending	Savannah
Vallambrosa	Ogeechee-Coastal	1,513	Pending	Savannah
Clydesdale Club	Lower Savannah	693	Pending	Charleston

* Acreage reflects total size of bank and may include additional habitat other than saltmarsh.

- Reviewed possible in-lieu fee option

Mitigation for Direct Impacts

- **"In Kind / In Basin" Restoration Opportunity**

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Marsh Adjacent to DA 1S

Amount of Compensatory Mitigation

- ICT participation and use of Savannah District SOP
- Restoration of 28.75 acres for the 15.68 acres of impact (1.8 to 1 mitigation ratio)
- Mitigation ratio consistent with RD requirements
- Restoration would encompass 1.7 acre marsh site previously restored by GPA
- Remaining 11.55 acres would be used for future harbor improvements and/or adaptive management

Example Regulatory Division Authorized Projects

Project Name	USACE File Number	Brackish Marsh Impacts (Acres)	Brackish Marsh Creation (Acres)	Mitigation Ratio (mitigation: Impact)
Slip One- Hutchinson Island	200501453	0.28	0.56	2:1
Hardin Canal Drainage	200600393	0.27	0.54	2:1
Skidaway Narrows Emergency Access	200600909	0.56	0.56	1:1
Skidaway Road Drainage Improvements	200601249	0.52	0.75	1.4 :1
SLNG-Slip Construction	200200640	3.24	7.5	2.3 :1

Site Selection for “In Kind / In Basin” Restoration

- USFWS required “In Basin” mitigation for impacts
- Site located in close proximity to impacts
- Previously existed as brackish marsh with continuity to adjacent marsh
- One large contiguous marsh vs. multiple sites
- Site in area of Lower Savannah River Watershed that supports a brackish marsh ecosystem
- Site is upriver of major Port of Savannah activities
- Located within designated boundaries of SNWR (compatible with adjacent land use)

Responsible Parties and Timing

- **Savannah District will be responsible for implementation, performance, and long-term management of the brackish marsh site.**
- **The Wetland ICT (USEPA, USFWS, NOAA, GADNR-CRD, SCDNR, SCDHEC-OCRM) will receive annual reports on the status of the mitigation project. Also, Savannah District will work with ICT to implement any Adaptive Management plans.**
- **Savannah District has committed to construction of the restored marsh concurrently with dredging in the Inner Harbor.**

Ecological Performance Standards

- Developed so that mitigation project can be objectively evaluated to determine if it is developing into the desired resource type.
- Grade down Disposal Area 1S; allow *in situ* Spartina seed stock to vegetate site.
- Successful restoration will be determined based on following table.

Revegetation Rate for Restored Marsh	
Time Period	Percent Vegetative Cover
Construction	0
Year 1	15
Year 2	25
Year 3	40
Year 4	60
Year 5	80

Monitoring Restored Marsh Site

- Restored Marsh will be monitored for a period of five years.
- Ten, 30-foot transects established on site and one in adjacent reference marsh; Vegetative counts and density measurements.
- Success based on meeting or exceeding the percent vegetative cover on previous slide.
- ICT will be provided with annual reports documenting the success of the restored marsh site.

Site Protection

- Corps and GDOT will relinquish sediment disposal easement on Disposal Area 1S.
- Restored brackish marsh ecosystem will be permanently protected through the State of Georgia's Coastal Marshlands Protection Act.
- Restored marsh is within boundaries of SNWR. Thus, permanently integrated into SNWR's conservation and management plan.

Adaptive Management

- Site inspected twice annually. If it does not naturally revegetate as indicated in performance standards, then site will be planted with *Spartina.*

- If invasive species are identified, then they will be removed from the site.

- If percent colonization not achieved, site would be sprigged or then purchase salt marsh mitigation credits from approved bank.

- Wetland ICT will be provided annual monitoring reports and consulted annually to provide input and recommendations.

Long Term Management

- Plan includes description of long-term needs, annual cost estimates and management responsibility.

- After revegetation, brackish marsh would be self-sustaining.

- Restoration area already within boundaries of SNWR and contiguous with existing marsh. As such, restored site would be managed by USFWS and integrated into the same long-term management plan that currently protects the SNWR as defined in the National Wildlife Refuge System Improvement Act of 1997.

Indirect Impacts to Wetlands

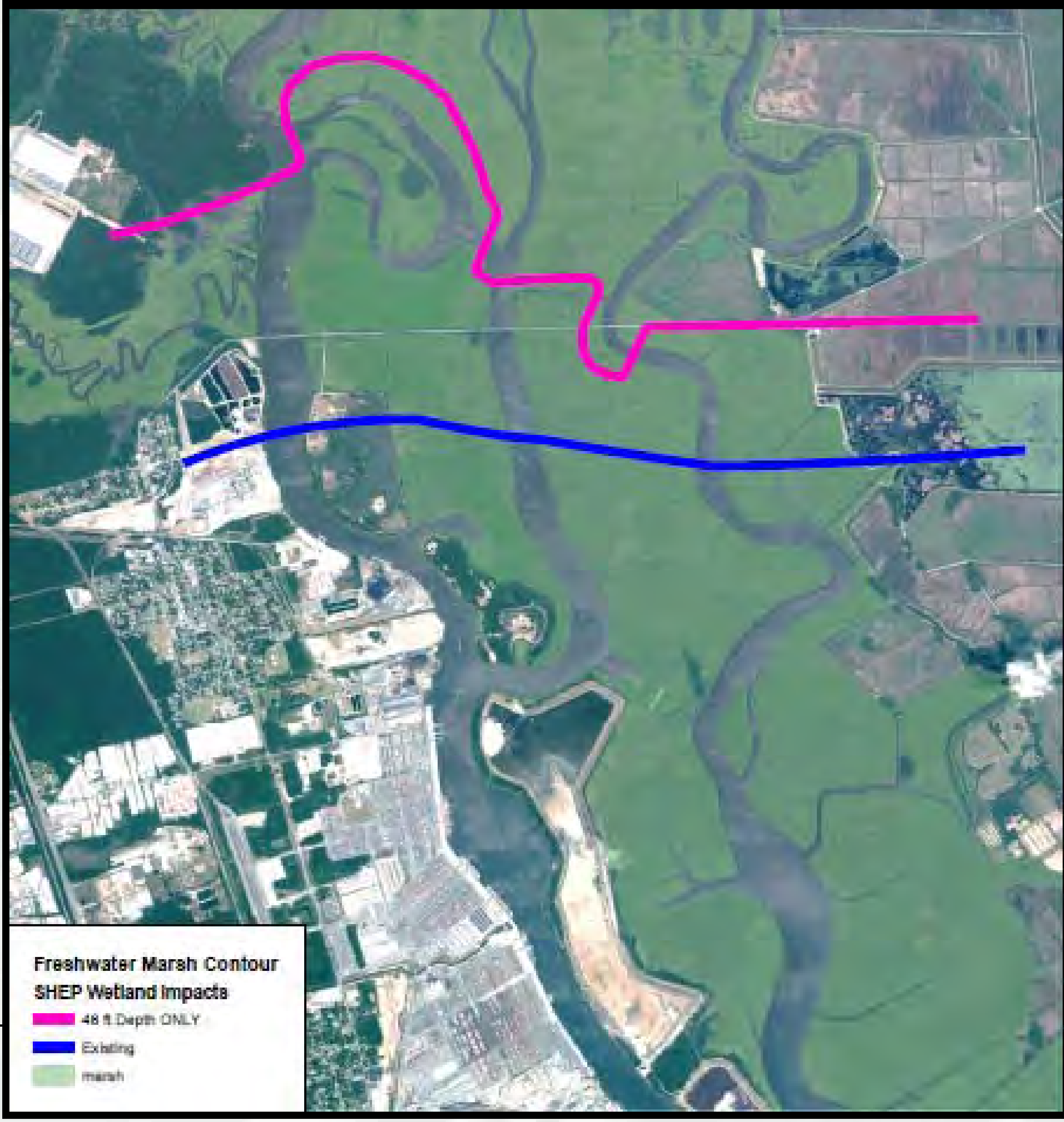
Model Used to Evaluate Vegetative Shifts Associated Changes in Salinity

- **EFDC Model used to determine changes in salinity and associated influence over marsh areas**
  - **0.0 – 0.5 ppt Tidal Freshwater Wetland**
  - **> 0.5 – 4 ppt Brackish Marsh**
  - **> 4 ppt Salt Marsh**
- **Model Used to Analyze all Depth Alternatives**
- **Use 48' Depth Alternative as Example**

Indirect Impacts Without Flow Diversion

Wetland Type	48-Foot Depth (Wetland Conversion)
Freshwater Wetlands (< 0.5 ppt salinity)	1,212 acres
Salt Marsh (> 4 ppt salinity)	0 acres

Salinity: Existing Conditions and Post- Deepening



Lines indicate limits of 0.5 ppt salinity

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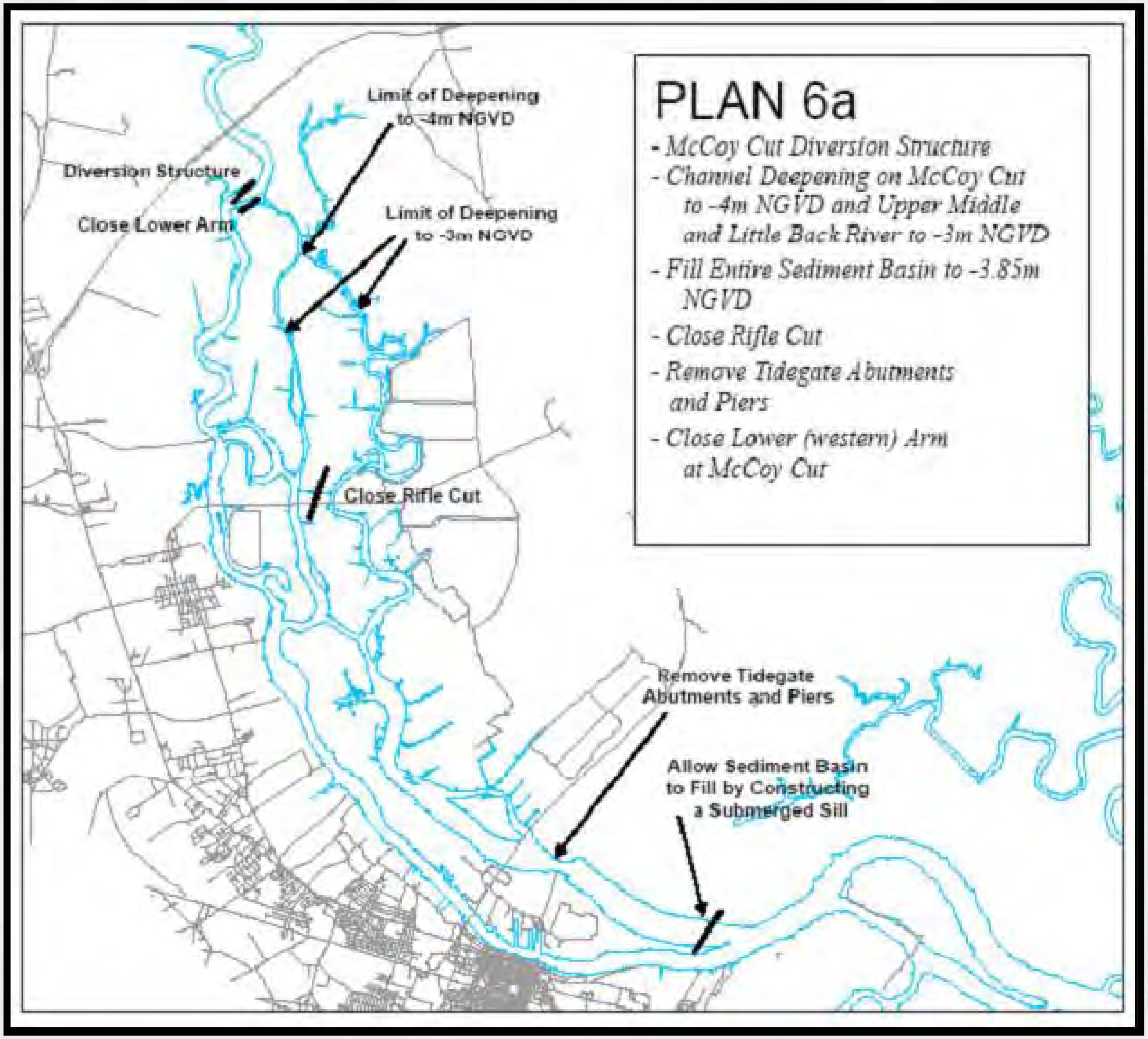
Flow Diversion Plan 6A



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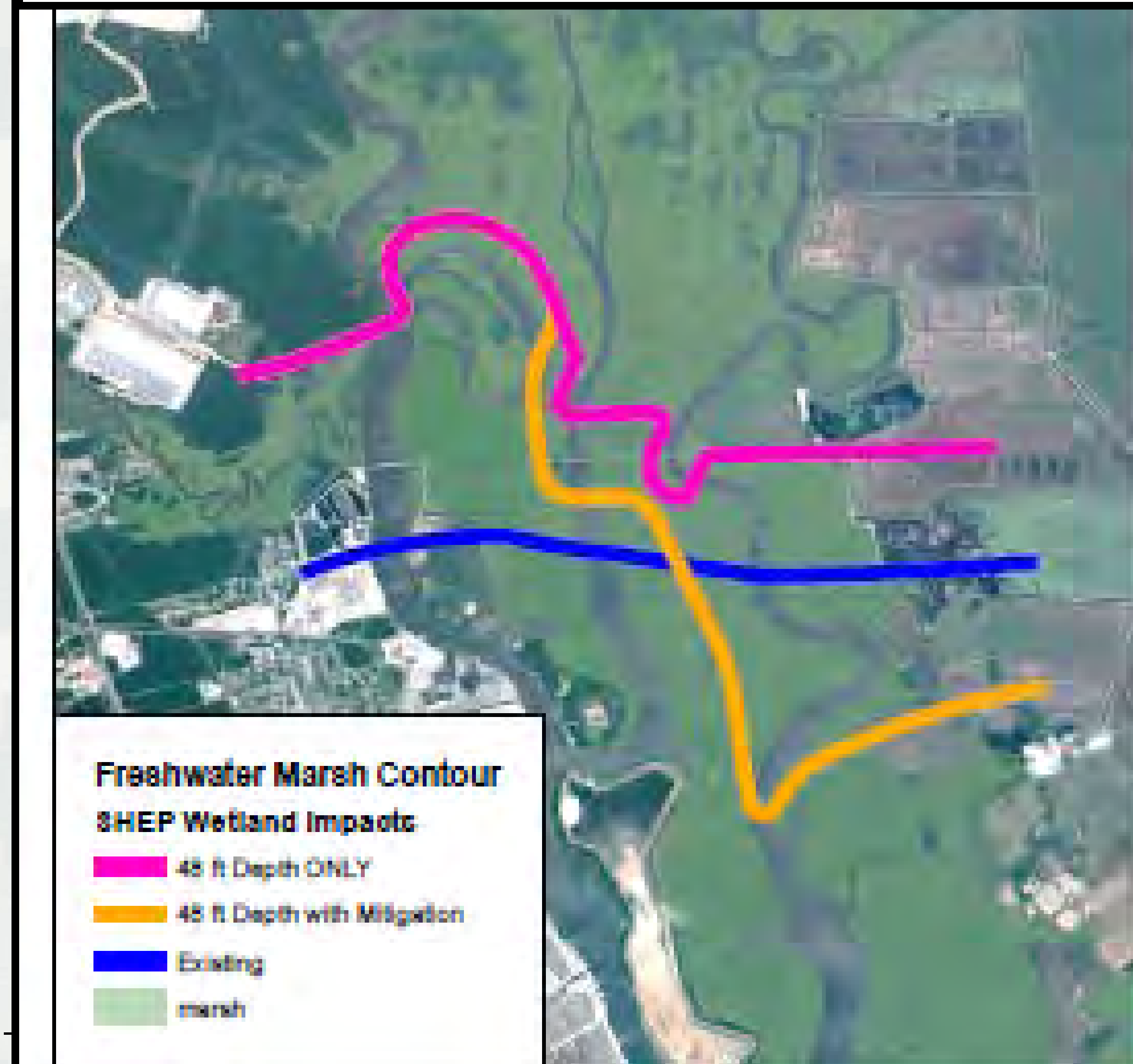
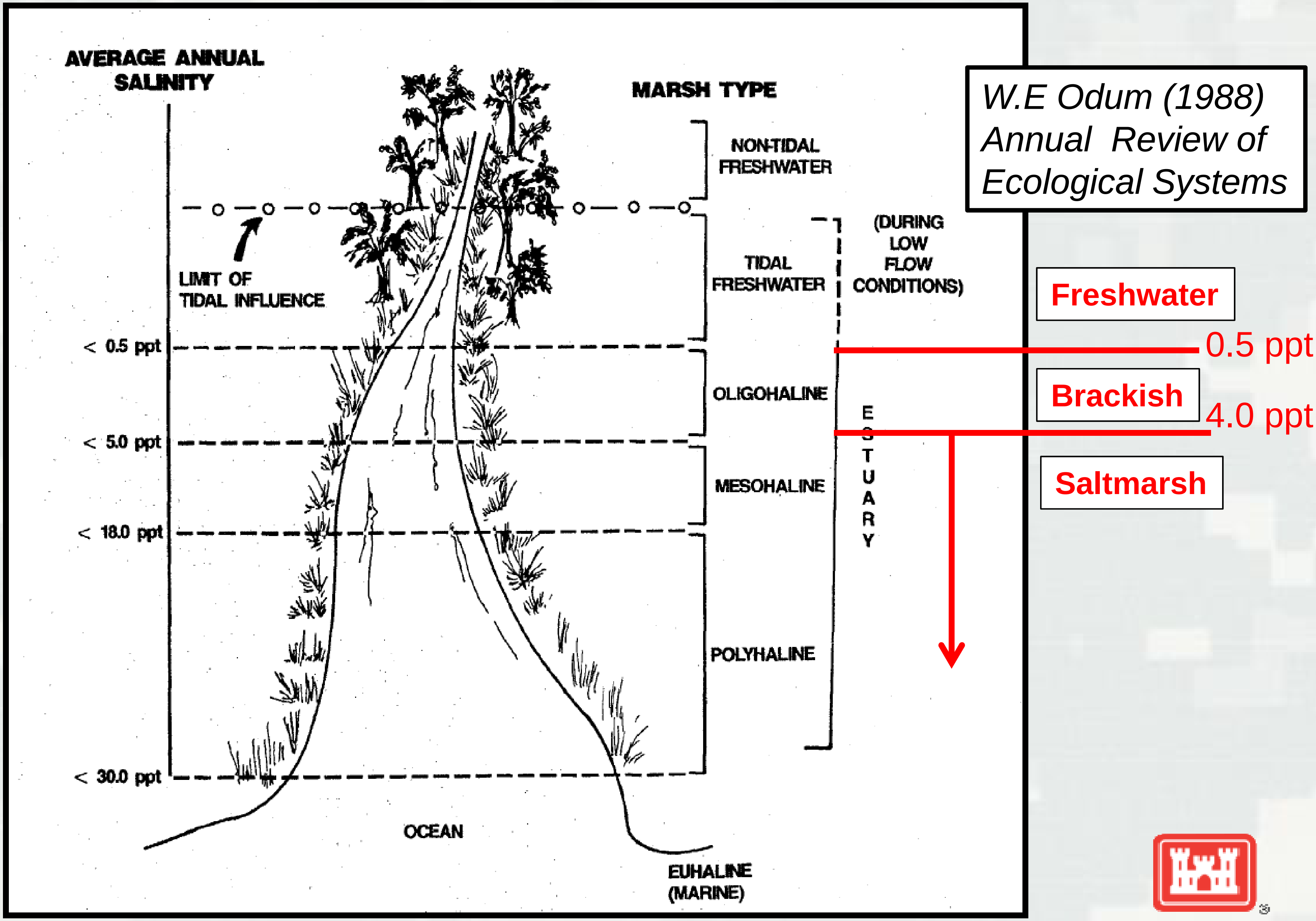
Indirect Impacts With Flow Diversion 6A

Wetland Type	48-Foot Depth (Wetland Conversion)
Freshwater Wetlands (< 0.5 ppt salinity)	337 acres
Salt Marsh (> 4 ppt salinity)	730 acres

Salinity: Existing Conditions and Post- Deepening with Flow Diversion Plan 6A



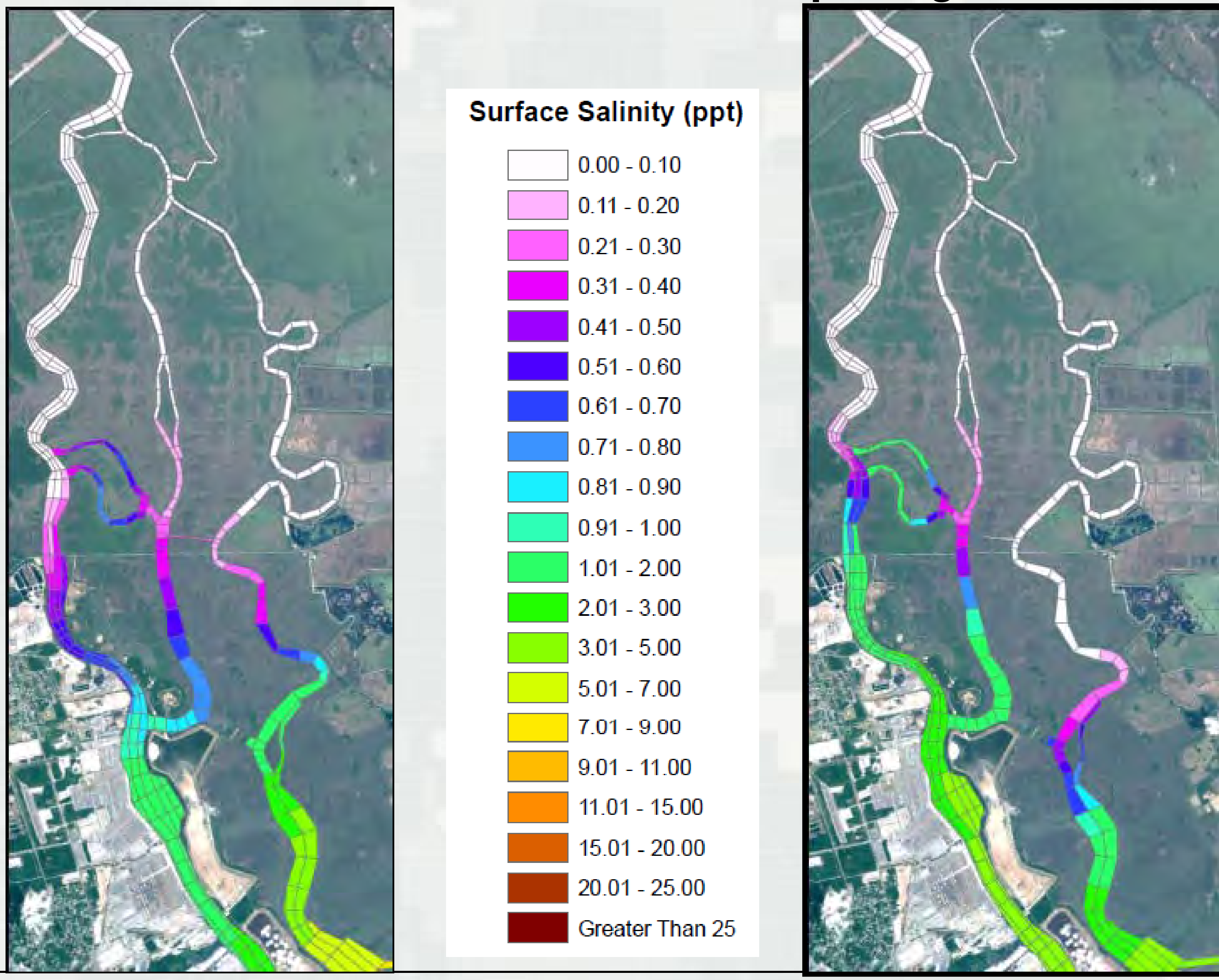
Lines indicate limits of 0.5 ppt salinity



W.E Odum (1988) Annual Review of Ecological Systems

Existing 42 ft Depth
No Deepening, No Mitigation

48 ft Depth
6 ft Deepening, Flow Diversion 6A



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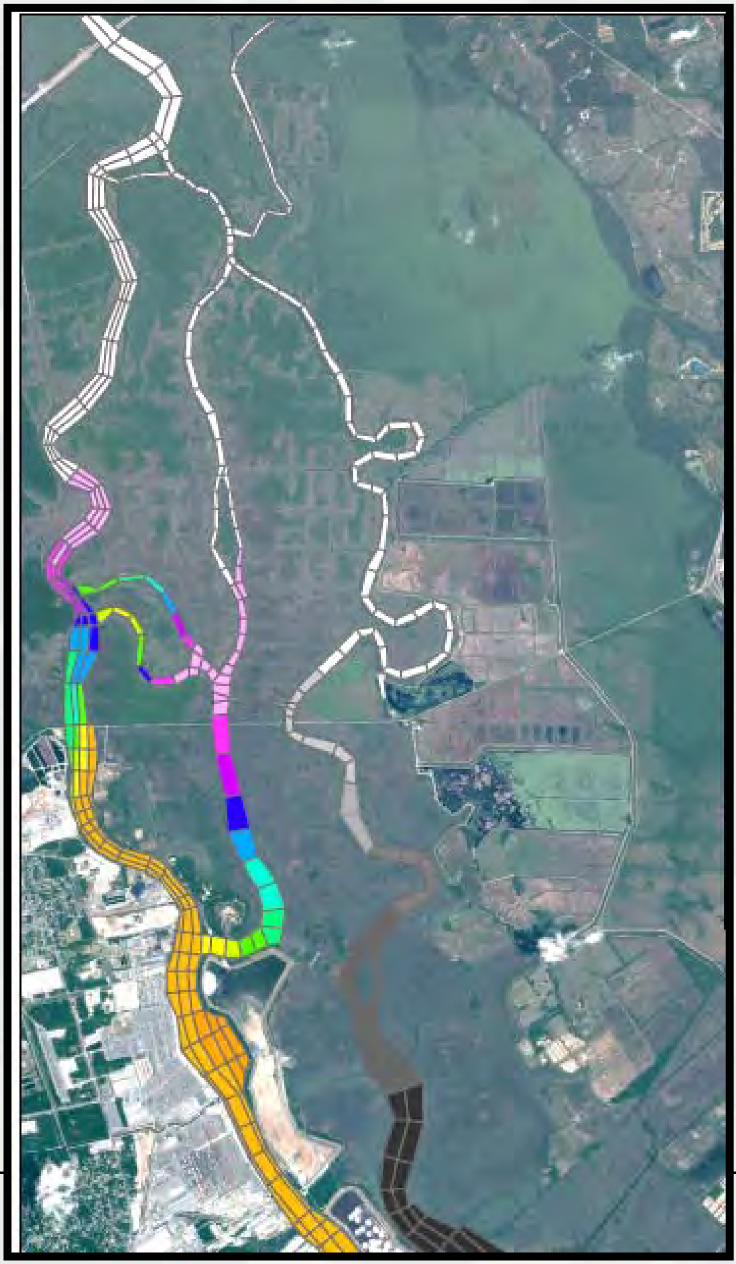
Change in Salinity Following Harbor Deepening



48 ft Channel Depth
6 ft Deepening, Mitigation 6A

Surface Salinity Difference (ppt)

	-3.25 - -2.00
	-1.99 - -1.00
	-0.99 - -0.50
	-0.49 - -0.30
	-0.29 - -0.10
	-0.09 - 0.00
	0.01 - 0.10
	0.11 - 0.20
	0.21 - 0.30
	0.31 - 0.40
	0.41 - 0.50
	0.51 - 0.60
	0.61 - 0.70
	0.71 - 0.80
	0.81 - 0.90
	0.91 - 1.00
	1.01 - 2.00
	2.01 - 2.16

Negative values indicate a reduction in river salinity.

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Comparison of Physical Characteristics in Tidal Freshwater Marsh and Salt Marsh

Table 1 Comparison of physical characteristics between tidal freshwater marshes and salt marshes

	Tidal freshwater marsh	Salt marsh
Location	Head of the estuary (above the oligohaline zone)	Mid and lower estuary
Geographical distribution	Worldwide, usually associated with rivers	Worldwide, not always associated with rivers
Salinity	Annual average below 0.5 ppt	Annual average between 18.0 and 35.0 ppt
Tidal range	Ocean-derived lunar tide, often greater amplitude than nearby salt marshes	Ocean-derived lunar tide
Sediments	Silt-clay, high organic content, low-moderate root and peat content	More sand, lower organic content, higher peat and root content
Sediment erodability	High erodability (particularly in the low marsh)	Generally lower erodability
Streambank morphology	Low gradient, little undercutting	Steeper gradient, more undercutting
Stream channel morphology	Low sinuosity	Moderate to high sinuosity
Dissolved sulfur	Trace (approximately 1 ppm)	Very high (approximately 2500 ppm)
Sediment redox potential	Moderate to strongly reducing (multiple redox pairs)	Strongly reducing (sulfur redox pairs most important)
Reduced iron-sulfur compounds	Rare or absent	Plentiful
Dissolved and particulate organic carbon	High concentrations	Moderate to low concentrations

W.E Odum (1988) Annual Review of Ecological Systems

Percent of Vegetation Correctly Classified by Environmental Variables

Latham et. al. Wetlands 1994

Table 2. Discriminant analysis results of vegetation classes from freshwater, oligohaline, strongly oligohaline, and mesohaline sites on the lower Savannah River. Wilk's-Lambda = 0.18; F = 1743.28; DF = 3/1144; P = 0.0001.

A. Classification matrix.

	Class	Percent Cases Correctly Classified by Site: Fresh	Oligo-haline	Strongly Oligohaline	Meso-haline
0.54 ppt +/- 0.63	Fresh	87	13	0	0
2.10 ppt +/- 1.04	Oligohaline	37	47	17	0
4.67 ppt +/- 1.49	Strongly oligohaline	9	13	68	9
9.27 ppt +/- 1.97	Mesohaline	0	2	19	79

Proportion of correct classifications between sites = 70%

"Overlap between adjacent classes was high, non-neighboring classes did not seem to overlap; Percent of vegetation correctly classified by environmental variables was 87%, 47%, 68%, and 79% for freshwater, oligohaline, strongly oligohaline and mesohaline, respectively."

Percent Organics at Different Marsh Sites

Table 3-3. Mean percent organics of marsh sediments in relation to distance from primary canals, using repeated measures analysis of variance. H_0: Mean percent organics are equal for each site between dates. (Designations "A" = 20 m, "B" = 70m, "C"= 120m.).

	Site	N	Mean Percent Organic A	B	C	p	*Significance*
0.5 ppt +/- 0.2	B1M	90	0.47	0.59	0.62	0.0390	Reject, lower at "A" points
1.3 ppt +/- 1.1	B2M	87	0.44	0.50	0.52	0.1181	ns
2.0 ppt +/- 1.2	B3M	90	0.29	0.42	0.45	0.0044	Reject, lower at "A" points
7.5 ppt +/- 1.7	B4M	90	0.31	0.34	0.33	0.8042	ns
	F1M	72	0.57	0.65	0.67	0.0091	ns
	M1M	72	0.33	0.59	0.67	< 0.0001	Reject, lower at "A" points
	M2M	72	0.47	0.68	0.57	0.1176	ns

Dusek and Kitchens
Technical Report (2002)

Spatial Patterns in Fish Distribution

Jennings and Weyers (2003)

Polyhaline (>15 ppt)				Mesohaline (5-15 ppt)				Oligohaline (1-5 ppt)				Tidal Freshwater (<1 ppt)			
F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su	F	W	Sp	Su
141	324	724	3731	1297	1165	9582	14147	2953	4616	5448	6264	1627	3401	7967	4071
TOTAL: 4,920				TOTAL: 26,191				TOTAL: 19,281				TOTAL: 17,066			

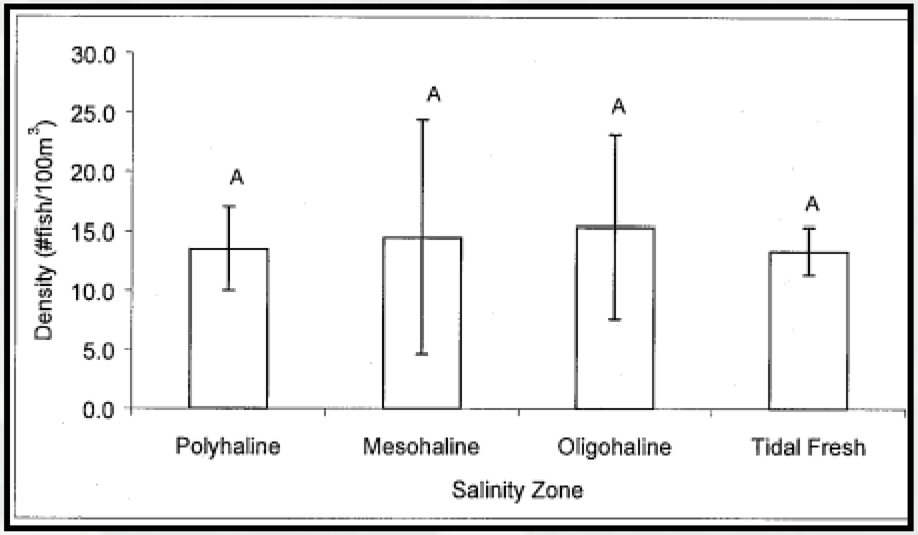
Temporal and Spatial Distribution of Estuarine-Dependent Species in the Savannah River Estuary July 2000-December 2002.

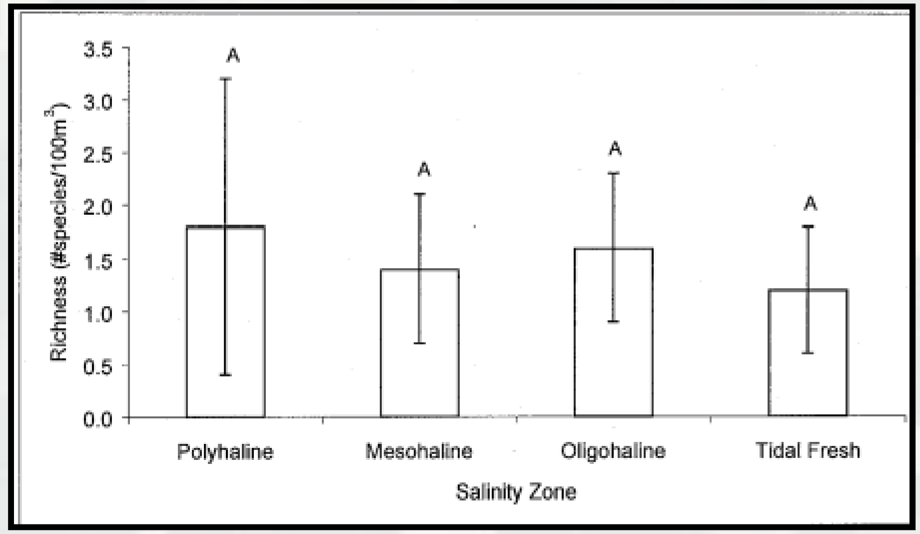
90% of catch were estuarine generalist fish species: Bay Anchovy, Atlantic menhaden, Atlantic croaker, spot, other drum species, gobies, blueback herring, Southern flounder, and striped mullet.

91 fish species identified throughout most habitat types

Fish Density and Species Richness in Tidal Creeks

Jennings and Weyers (Feb 2002) Annual Report
Temporal and Spatial Distribution of Estuarine-Dependant Species



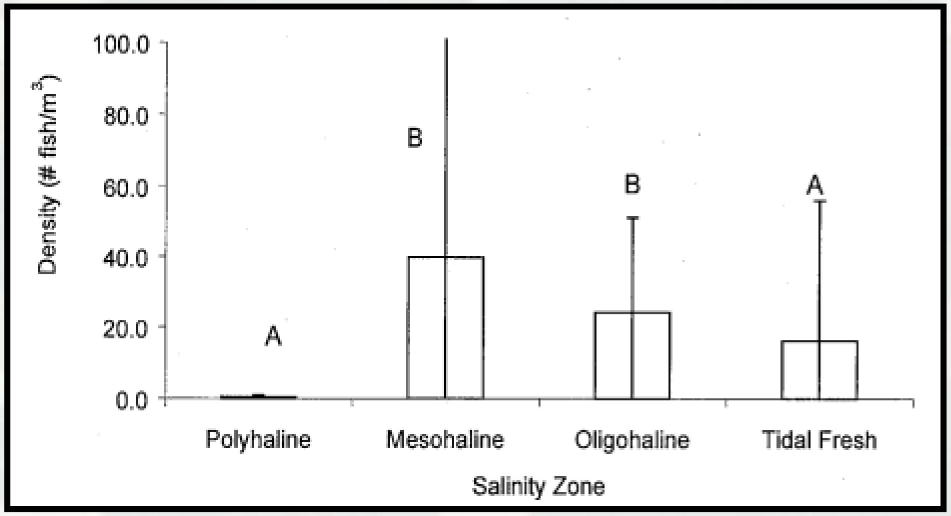


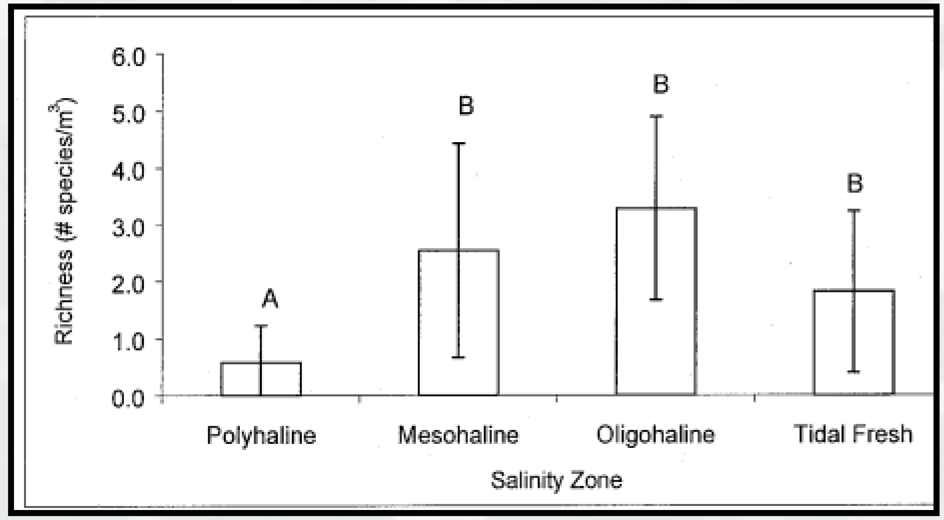
Tidal Freshwater (0-1 ppt); Oligohaline (1-5 ppt); Mesohaline (5-15 ppt); Polyhaline (> 15 ppt)

Figure 5. Mean fish density (± st. dev.) and species richness(± st. dev.) for ichthyoplankton surveys conducted in the four salinity zones from September 2000 to August 2001. Different letters denote means that were significantly different.

Fish Density and Species Richness Along Marsh Edge

Jennings and Weyers (Feb 2002) Annual Report
Temporal and Spatial Distribution of Estuarine-Dependant Species





Tidal Freshwater (0-1 ppt); Oligohaline (1-5 ppt); Mesohaline (5-15 ppt); Polyhaline (> 15 ppt)

Figure 9. Mean fish density (± st. dev.) and species richness (± st. dev.) for marsh-edge drop surveys conducted in the four salinity zones from October 2000 to September 2001. Different letters denote means that were significantly different.

Changes in Wetland Function as A Result of Marsh Conversion

(Wetland ICT Procedures: Greater Vegetative Diversity is Beneficial)

Elements of Wetland Function	Freshwater to Brackish Marsh (337 acres)	Saltmarsh to Brackish Marsh (730 acres)
Water Purification	Negligible	Negligible
Flood Protection	Negligible	Negligible
Shoreline Stabilization	Negligible	Negligible
Groundwater Recharge	Negligible	Negligible
Streamflow Maintenance	Negligible	Negligible
Retention of Particles	Negligible	Negligible
Surface Water Storage	Negligible	Negligible
Subsurface Storage	Negligible	Negligible
Nutrient Cycling	Negligible	Negligible
Values to Society	Negligible	Negligible
Fish and Wildlife Habitat	Minor Adverse	Minor Beneficial

Changes in Wetland Function as A Result of Marsh Conversion

(Recent Corps Analysis: Salinity Shifts + Data and Literature Review)

Elements of Wetland Function	Freshwater to Brackish Marsh (337 acres)	Saltmarsh to Brackish Marsh (730 acres)
Water Purification	Negligible	Negligible
Flood Protection	Negligible	Negligible
Shoreline Stabilization	Negligible	Negligible
Groundwater Recharge	Negligible	Negligible
Streamflow Maintenance	Negligible	Negligible
Retention of Particles	Negligible	Negligible
Surface Water Storage	Negligible	Negligible
Subsurface Storage	Negligible	Negligible
Nutrient Cycling	Negligible	Negligible
Values to Society	Negligible	Negligible
Fish and Wildlife Habitat	Minor Adverse	Negligible

Indirect Impacts: Watershed Assessment to Identify Appropriate Mitigation Options

- Evaluated use of Mitigation Banks:
  - No mitigation banks with credits derived from tidal freshwater wetlands.

- Evaluated use of In Lieu Fee Program

- A perceived high risk of failure for created tidal freshwater wetland systems. USFWS determined not sustainable, and therefore, not viable alternative.

Watershed Approach to Identify Appropriate Mitigation: *Existing Watershed Plan*

- GA DNR-EPD's (2001) Savannah River Basin Management Plan

- Long-term priorities for Lower Savannah River Basin
  - *Preserving habitat suitable for the support of healthy aquatic and riparian ecosystems*

Watershed Approach: *Considerations*

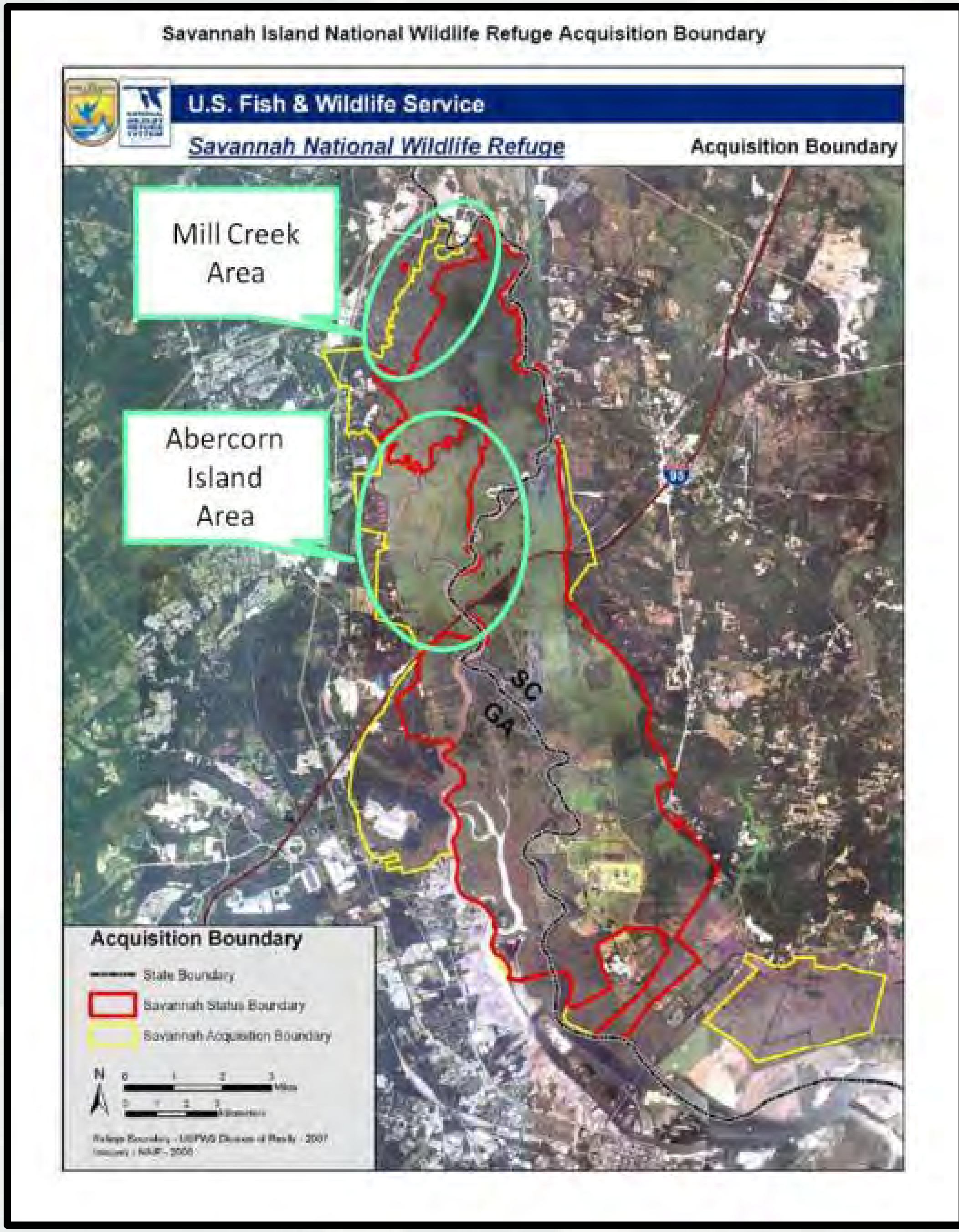
- Identified 20+ considerations in revised EIS
  - Functional Assessment
  - Landscape position, resource type, location, inventory of resources
  - Growth/Land Use Conversion in Lower Savannah River Watershed
  - In SRE, Savannah National Wildlife Refuge (SNWR) is conservation area of national importance
  - Development adjacent to SNWR boundaries could directly/indirectly impact fish/wildlife habitat, wetlands, and water quality

Watershed Approach: *Information Needs*

- Evaluated Watershed Condition and Needs
  - Wetland ICT Coordination and identification of properties in F&W Coordination Act Report
  - Functional Assessment
  - Trends in habitat loss, cumulative impacts, development trends
    - ✓ Development within 5 miles of SNWR
    - ✓ Impaired Waters in Lower Savannah River Watershed and SNWR
  - Presence and needs of sensitive species

Watershed Approach: *Site Selection*

- Site must be suitable for providing the desired aquatic resource function
  - Comparative wetland analysis: wetland threats, fish and wildlife function, opportunities for mitigation, and long-term sustainability
  - Watershed scale features (aquatic habitat diversity and connectivity)
  - Size and location of compensatory mitigation relative to hydrologic resources.
  - Reasonably foreseeable effects the project will have on aquatic and terrestrial resources



SNWR

Existing Boundary
and
Acquisition Boundary
and
Proposed
Mitigation Areas

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Preservation Sites

(Mitigation for Indirect Impacts)
2,683 acres for Preservation

Mill Creek Area
Tracts 36 a-d
(1,122 total acres)

Existing SNWR
Boundary
(Red Line)

Abercorn Island Area
Tract 40
(1,989 total acres)

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Abercorn Island Area

1,989 Acres of Wetland
0 acres of Upland

National Wetland Inventory GIS Layer -

Wetland Classifications For Abercorn Island Area:

PFO1A
PFO6F
PFO1C

Functional assessment of wetland preservation areas and detailed characterization of wetland types/habitats is located in Appendix C

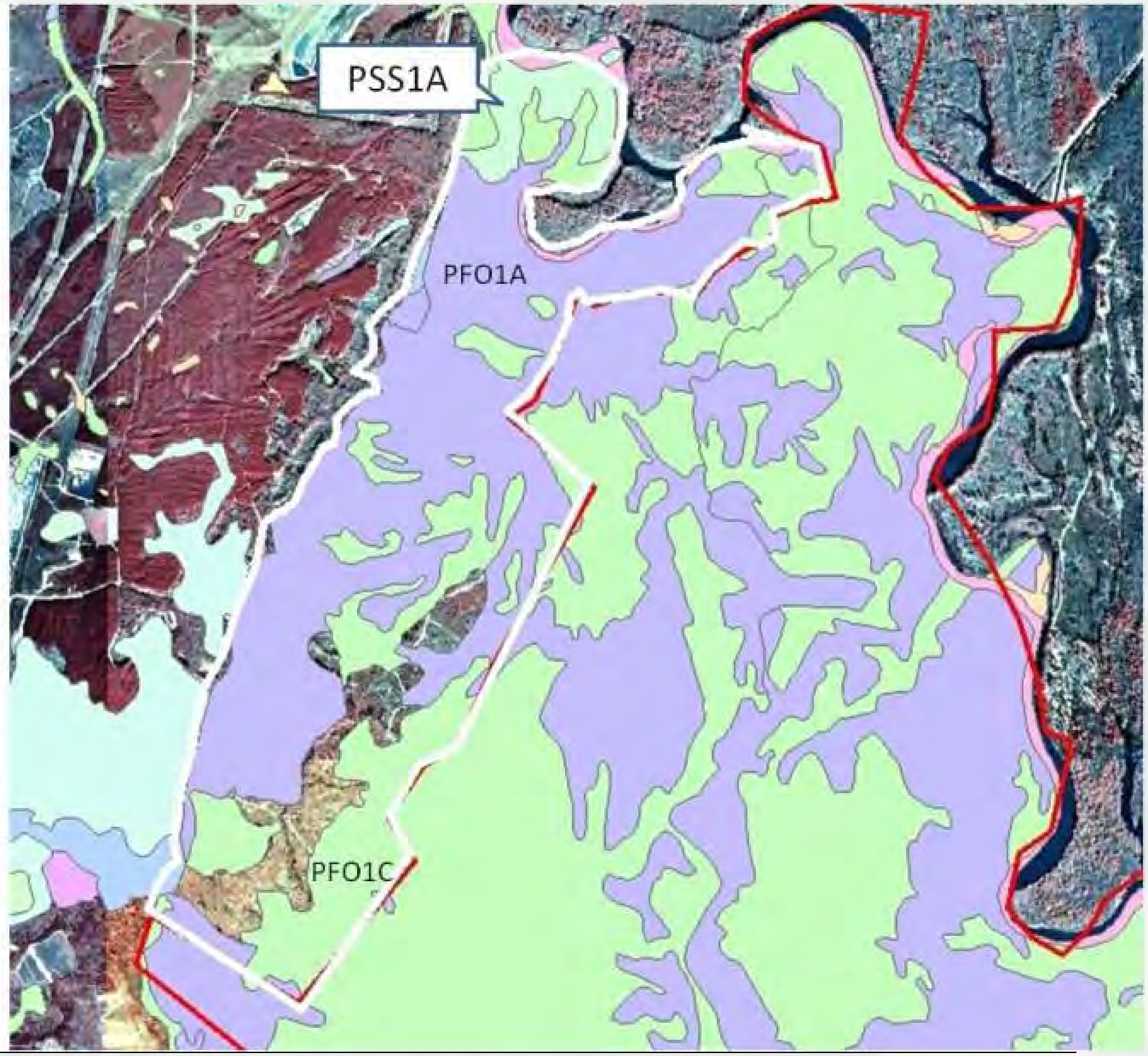
Mill Creek Area

877 acres of Wetland
135 acres of Upland

National Wetland Inventory GIS Layer –

Wetland Classifications For Mill Creek Area:
- PFO1A
- PSS1A
- PFO1

Functional assessment of wetland preservation areas and detailed assessment of wetland types/habitats is located in Appendix C.



Watershed Approach: Mitigation Type and Amount

- Corps recent watershed evaluation and functional assessment confirmed that out-of-kind compensatory mitigation will serve aquatic resource needs of the watershed
- Wetland ICT agreed to use Savannah District SOP as a tool (i.e., suitable metric) to determine how much compensatory mitigation would be required
- Preservation of 2,683 acres is sufficient to replace the impacts to aquatic function that were previously discussed

SOP Worksheets

ADVERSE IMPACT WORKSHEET					
		FRESHWATER MARSH	BRACKISH MARSH	SALT MARSH	
		------------- SALINITY ZONE	---------------------------		
	RANGE	0 to 0.5	0.6 to 4.0	> 4.0	
Dominant Effect	2.0 to 0.5	0.5		0	
Duration of Effects	2.0 to 0.1	2		2	
Existing Condition	2.0 to 0.1	2		1.8	
Lost Kind	2.0 to 0.1	2		2	
Preventability	2.0 to 0	0.5		0.5	
Rarity	2.0 to 0.1	2		0.1	
Sum		9		6.4	
Impacted Acreage		337		730	
Impact Total		3033		4672	
TOTAL					7705

RESTORATION WORKSHEET					
		FRESHWATER MARSH	BRACKISH MARSH	SALTMARSH	
		----------- SALINITY ZONE ----------------------------			
	RANGE	**0 to 0.5**	**0.6 to 4.0**	**> 4.0**	
Net Improvement - Vegetation	0.1 to 1.4		1.4		
Net Improvement - Hydrology	0.1 to 1.4		0.9		
Credit Schedule	0 to 0.4		0.4		
Kind	0.2 to 0.6		0.6		
Maintenance	0 to 0.3		0.2		
Monitoring	0 to 0.4		0.2		
Control	0.1 to 0.5		0.5		
Sum			4.2		
Restored Acreage			1068		
Salinity Zone			0.6 to 4.0		
Restoration Total			4485.6		
TOTAL					4485.6

PRESERVATION WORKSHEET			
	RANGE		
Threat	0 to 0.5	0.3	
Kind	0.2 to 0.6	0.4	
Control	0.1 to 0.5	0.5	
Sum		1.2	
Preservation Acreage		2683	Calculated to fulfill total credit need
Preservation Total		3219.4	From Restoration worksheet

SUMMARY WORKSHEET				
Project Depth	48			
		Credits	Percent	Acres
Required Mitigation		7705		
Amount Provided by Restoration		4485.6	58	1068
Amount Provided by Preservation		3219.4	42	2683
Total		7705		3751

Responsible Parties and Timing

- The Corps would acquire 2,683 acres of land identified in the SNWR's Comprehensive Conservation Plan
- Provide the land to USFWS to manage as additions to the SNWR
- Properties would be acquired prior to or concurrent with the activity that results in conversion of wetland

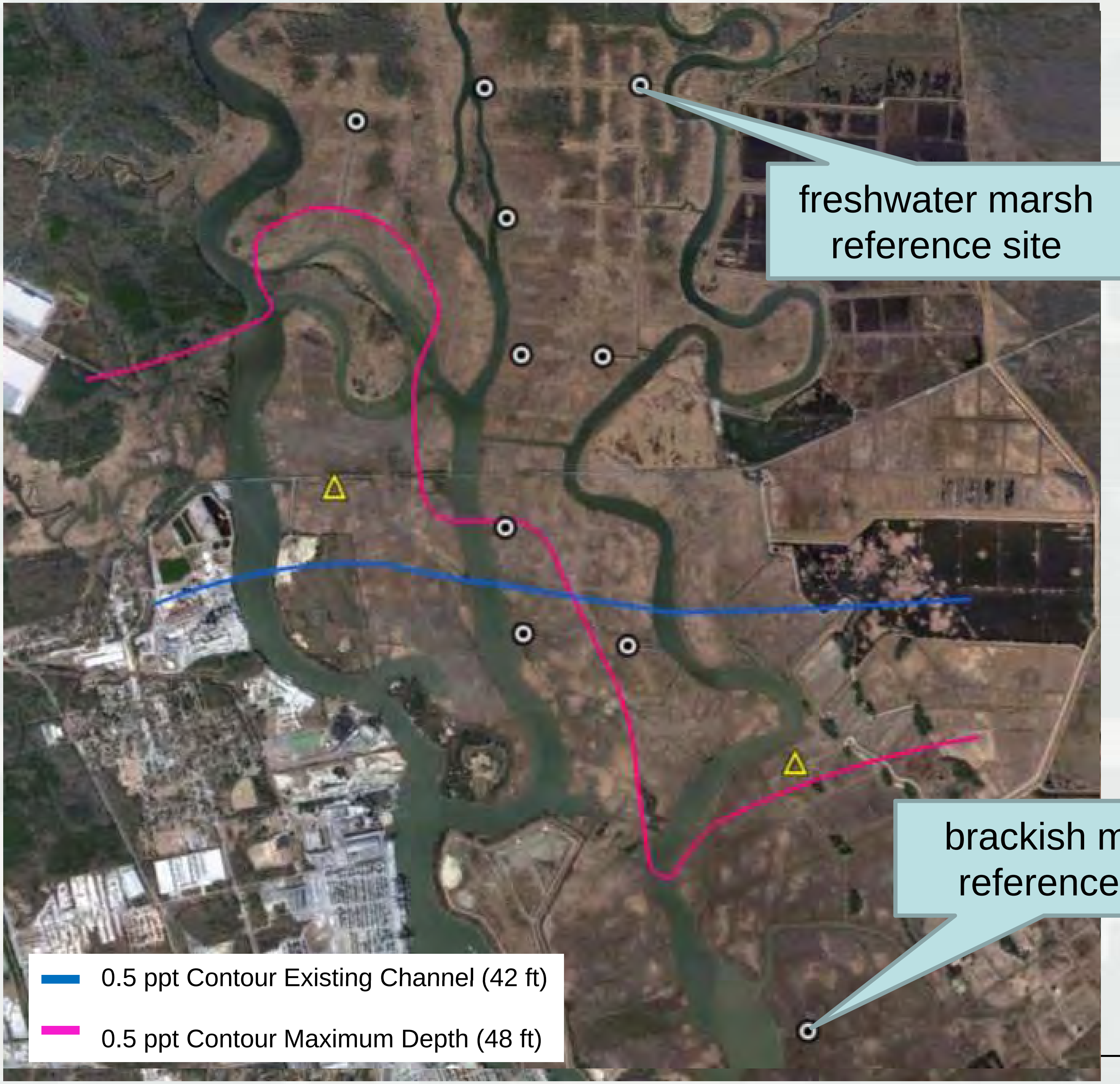
Protection and Long Term Management of Preservation Sites

- The 2,683 acres of Abercorn Island and Mill Creek become part of SNWR
- Managed by USFWS
- Lands would be subject to same protections and use requirements as defined in the National Wildlife Refuge System Improvement Act of 1977 and the SNWR's Comprehensive Conservation Plan

Monitoring Marsh Conversion Areas

- Establish 10 monitoring sites in areas subject to vegetative conversion.
- An upriver freshwater site and downriver brackish marsh site will be selected as reference sites
- Sample stations: record water surface elevation, specific conductance of surface waters and interstitial waters, and depth every 30 minutes (downloaded monthly).
- Twice annual vegetation counts - six transects per site (species and stem density)
- Monitor: 1 year pre-construction, 3-4 years during construction, and an additional 5 years post construction
- Wetland ICT provided with annual reports that document findings

Location of Monitoring Sites



Adaptive Management

- Monitoring of marsh sites:
  - Wetland ICT will be provided annual monitoring reports and consulted frequently for input and recommendations
  - If vegetative conversion extends beyond limits of monitoring, then will establish more sampling sites to determine margins of conversion
  - Additional wetland preservation will be acquired if model results are under predicted.

Summary for Direct Impacts

- Direct impacts to 15.68 acres of brackish marsh result in major adverse impact to all wetland functions
- Restoration of 28.75 acres of brackish marsh at DA 1S is appropriate mitigation and ratio is similar to regulatory projects requiring brackish/salt marsh mitigation
- Monitoring and adaptive management plans are sufficient to ensure “no net loss of aquatic resources”
- Wetland ICT will be active participants in all phases of site development, monitoring, adaptive management, etc.

Summary for Indirect Impacts

- Small changes in salinity relative to dynamics of freshwater, oligohaline and mesohaline systems in SRE
- A majority of the areas that experience vegetative shifts will still retain a percentage of pre-project vegetation
- Functional assessment for conversion of freshwater to brackish marsh resulted in negligible impacts to wetland functions with a minor adverse impact to fish and wildlife habitat.
- Functional assessment for conversion of salt marsh to brackish marsh resulted in negligible impacts to all wetland functions
- Mitigation options were considered using a watershed approach with consideration of impacts to wetland function

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Summary for Indirect Impacts (Continued)

- Preservation of 2,683 acres of bottomland hardwood and emergent wetland adjacent to SNWR is adequate mitigation for impacts to fish and wildlife habitat
- Proposed monitoring of marsh areas susceptible to vegetative conversion is a long term commitment by Corps to ascertain effects associated with changes in salinity.
- Adaptive management plan Includes the purchase of additional properties to further benefit fish and wildlife habitat adjacent to SNWR.
- Wetland ICT will be active participants in all phases of plan review, monitoring, adaptive management, etc.

Final Compensatory Mitigation Rule and Wetland Impacts

- ✓ Functional assessment of impact sites and mitigation areas
- ✓ Watershed approach (considerations, information, site selection)
- ✓ Type and location of mitigation
- ✓ Responsible parties
- ✓ Timing
- ✓ Ecological Performance Standards
- ✓ Monitoring
- ✓ Adaptive Management
- ✓ Long term Management
- ✓ Financial Assurances and Protection

Next Steps

- Corps will respond to agency comments in Final EIS
- New information will be included in Final EIS
- Final EIS will receive agency and public review at end of 2011

CESAS-PD **7 June 2011**

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project (SHEP) Wetlands Interagency Coordination Team (ICT) Meeting Summary

1. In response to a request from the Environmental Protection Agency (EPA) in their comments on the SHEP Draft Environmental Impact Statement (EIS), the US Army Corps of Engineers, Savannah District (USACE) called a meeting of the SHEP Wetlands Interagency Coordination Team. The meeting was held on 1 June 2011 in Atlanta, Georgia at the EPA Region 4 office and attended by representatives from the following agencies: USACE; EPA; US Fish and Wildlife Service (USFWS); US Department of the Interior; Georgia Department of Natural Resources, Environmental Protection Division (GA DNR-EPD); Georgia Department of Natural Resources, Coastal Resources Division (GA DNR-CRD); South Carolina Department of Health and Environmental Control (SC DHEC); and SC DHEC Office of Coastal Resource Management (SC DHEC-OCRM).

2. The meeting began with Mr. William Bailey (USACE) and Mr. Heinz Mueller (EPA) welcoming the group, introductions of meeting attendees, and a brief overview of the meeting objectives. Mr. Bailey then presented an overview of the project history and summaries of past meetings of the Wetlands ICT. The review included the 2003 determination that tidal freshwater vegetative communities are the most critical wetland community in the Savannah River estuarine ecosystem. He reviewed the development of the salinity criteria that the Corps used to predict and evaluate impacts from harbor deepening and summarized attempts to develop and use Marsh Succession Models to predict marsh impacts, rather than using in-river salinity predictions. Mr. Bailey concluded his presentation with a summary of the most recent Wetlands ICT meeting in August 2009, a site visit to a proposed restoration site at Disposal Area 1S.

3. Dr. Jeff King continued the presentation with technical information on the project's wetland analyses and both the direct and indirect impacts to wetlands that are expected to occur as a result of harbor deepening. Dr. King indicated that the Final EIS would include a more rigorous discussion of the functional assessment analysis the Corps conducted to address EPA's concerns regarding consistency with the 2008 EPA/US Army Corps of Engineers Mitigation Rule. He began his presentation with a discussion of the direct impacts, where wetlands would be lost through excavation during harbor deepening. He showed pictures of vegetation at the various impact sites. He also presented the mitigation plan proposed for those impacts – grading down most of Disposal Area 1S to allow the site to restore to brackish marsh.

4. Dr. King then presented technical information on the project's indirect impacts to wetlands. This included information from wetland studies within the harbor and scientific journal articles that discussed the relationship between observed salinities and vegetative species occurrence, diversity, and function. He compared the nomenclature used in scientific literature to distinguish between the vegetative communities with that previously recommended by the Wetlands ICT and used by the Corps for the SHEP analyses. Based on the expected project change in marsh

salinities of +/– 2 parts per thousand, Dr. King summarized that the vegetative conversion would not be a major one and would have a negligible or minor adverse effect on overall wetland function. He identified fish and wildlife habitat as the single wetland function that could change as a result of the expected changes in salinity.

5. After summarizing the expected indirect impacts to wetlands, Dr. King then presented the mitigation plan presented in the Draft EIS to compensate for the expected impacts. He included the District's watershed assessment to identify appropriate mitigation options and all its associated considerations. He showed maps identifying the potential sites for habitat preservation (the chosen mitigation alternative) and the Standard Operating Procedure (SOP) Worksheets that were used as a tool to help assess the preservation acreage requirements for the proposed action. He concluded the presentation with a brief overview of the proposed monitoring network, the adaptive management process that could be implemented should the vegetative conversion exceed that which is expected, and a summary of all the information presented.

6. The group discussion focused on the application of the SOP worksheets to the harbor deepening and the values of certain parameters used in the calculations. The group did not agree that the values applied were consistent, namely the Dominant Effect, Control, and Threat. The group discussed the impacts of the expected vegetative conversion and if there were better tools that could be used to quantify the level of acceptable mitigation for that expected wetland conversion. No other tools or methods were suggested. Mr. Bailey stated that members of the Wetlands ICT had previously recommended using the Savannah SOP as a quantification tool. The worksheets were included in the Draft EIS and the Draft Fish and Wildlife Coordination Act Report (FWCAR). Mr. Bailey also noted that the resource agencies had not expressed concern with the SOP values in their official comments on the Draft EIS or the FWCAR. A portion of the discussion focused on the historical landscape and its value in determining the appropriate mitigation strategy. SC DHEC stated that saltmarsh is ecologically valuable and losses of that community need to be mitigated. The USFWS indicated that while saltmarsh is a valuable vegetative community, the Savannah National Wildlife Refuge (SWNR) was historically tidal freshwater marsh, a unique habitat that had been adversely impacted by higher salinity levels and replaced over time, and is therefore a priority in this estuary because of the historic adverse cumulative impacts. USFWS also indicated that the parcels proposed by the Corps for habitat preservation are not necessarily their present top priority for parcels to add to the SNWR. Ms. Jane Griess (USFWS) indicated that the SNWR prioritizes acquisition of the "Exley" and "Del-a-Rae" parcels over the proposed "Mill Creek" parcel. The Corps said it was open to substituting parcels that provided similar of better habitats then those identified in the Draft EIS.

7. The group discussed the desire of some agencies to re-designate their official member of the Wetlands ICT, as a number of the original members have retired or are no longer involved with the project. The group agreed that the Wetlands ICT should be actively involved with the monitoring (particularly the post-construction monitoring), to identify the need for adaptive

management, and enact any agreed measures in a timely fashion. The group also discussed the proposed length of the post-construction monitoring period. Mr. Bailey acknowledged that the natural resource agencies had requested a longer monitoring period and that USACE was internally discussing extending the period beyond the five years stated in the Draft EIS.

8. At the conclusion of the meeting, Mr. Mueller thanked the USACE personnel for presenting the information. Mr. Bailey and Mr. Mueller thanked everyone for attending, and the meeting was adjourned.

Encl

MARGARETT G. McINTOSH
Planning Division

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C. Fisheries

1. MFR dated 10 November 1999, SHEP, SEG Fisheries Committee: Minutes of October 29, 1999 meeting.
2. MFR dated 24 January 2000, SHEP, SEG Fisheries Committee: Minutes of January 21, 2000 meeting.
3. MFR dated 19 June 2000, SHEP. SEG Fisheries Committee: Minutes of June 19, 2000 meeting.
4. SEG Striped Bass & Fisheries and Aquatic Resources Committee Meeting Summary dated June 21. 2002.
5. MFR dated 23 September 2002. SHEP, Summary of 10 September Interagency Meeting on Evaluation of Fisheries.
6. MFR dated 13 November 2002. SHEP, Summary of 13 November Interagency Meeting on Evaluation of Fisheries.
7. MFR dated 20 December 2002, SHEP, Summary of 19 December Interagency Meeting on Evaluation of Fisheries.
8. MFR dated 20 December 2002, Revised, SHEP, Summary or 19 December Interagency Meeting on Evaluation of Fisheries.
9. MFR dated 6 February 2003. SHEP, Summary of 28 January Interagency Meeting on Evaluation of Fisheries.
10. MFR dated 23 May 2003. SHEP, Summary of 21 April Interagency Meeting on Evaluation of Fisheries.
11. MFR dated 5 June 2006. SHEP, Summary of 1 June Meeting of Fisheries Interagency Coordination Team.
12. E-MAIL from William G. Bailey, dated 7 October 04, SHEP, EFDC and D.O. Model Inputs and Outputs for Fisheries; Habitat Suitability Criteria
13. E-MAIL from William G. Bailey, dated 9 August 07, SHEP, Striped Bass Habitat (velocities)
14. E-MAIL from William G. Bailey, dated 17 March 08, SHEP, Fishery Impact Table
15. E-MAIL from William G. Bailey, dated 29 August 09, SHEP, Fisheries Interagency Coordination Team – Revised Juvenile SNS Habitat Suitability Criteria

CESAS-PD-E 10 November 1999

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
SEG Fisheries Committee;
Minutes of October 29, 1999 meeting

PARTICIPANTS:

NAME	**REPRESENTING**
In Person:	
William Bailey	US Army Corps of Engineers
Frank Mathews	Coastal Georgia Center for Sustainable Development
Tom Meronek	GADNR-WRD
Charles Griffen	GPA
Bo Ellis	ATM
Ed Eudaly	USFWS
Judy Jennings	Sierra Club
By Telephone:	
Tripp Boltin	SCDNR
John Pafford	GADNR-CRD
Carl Hall	GADNR-WRD
Ted Will	UGA Fish & Wildlife Coop Unit
Tom Reinert	UGA Fish & Wildlife Coop Unit
Mark Collins	SCDNR-MRD

1. The meeting was held at the Corps of Engineers office in Savannah from 9:00 to 11:45 on Friday, October 29, 1999. Individuals who could not attend in person were able to participate through a teleconference capability.

2. The meeting was structured by first attempting to identify potential impacts to individual fishery resources from the proposed harbor deepening project, then identifying any information needs that would limit or prohibit an evaluation or analysis of the expected project impacts to that resource.

3. We began by discussing the various fisheries for which the South Atlantic Fishery Management Council has developed a management plan. A handout taken from "EFH Guidance for Federal Agencies" listed these plans. The first is the **Shrimp Fishery**. Participants identified that this was an important resource in the area. Potential project effects were from turbidity during construction and alterations of flow velocities. All agreed that the project was unlikely to have a large effect on this resource. Jim Music from GADNR-CRD was identified as a likely source of more information. The **Red Drum/Snapper Fishery** was then discussed. It was also identified as important in this

area. Little is known about the location of juveniles and larvae (early life history) in the immediate project area. Further discussion on this lack of information was held over until later in the meeting. The next several fisheries were taken as a group since they all dealt with fish that primarily spent their lives offshore. This included **the Coastal Migratory Pelagics Fishery**, the **Golden Crab Fishery**, the **Coral and Coral Reef Fishery**, the **Callico Scallop Fishery**, and the **Sargassum Habitat Fishery**. All felt that the project was unlikely to have much impact on these resources. Weakfish were discussed. A management plan had recently been approved for them. This is primarily a recreational fishery. Flounder were also identified as a fishery of importance in the project area.

4. The committee next went through a second handout of fish species for which the NMFS has management plans. This handout was also taken from materials titled "EFH Guidance for Federal Agencies". This list included Billfish, Swordfish, Tuna, and Sharks. For the first three, the committee felt that the project would have no impact since these species were predominantly found offshore. For sharks, the committee felt that the potential project impact would not be substantial, since the project could only impact a small portion of the large expanse of habitat available to the species.

5. The committee then discussed a third handout from materials titled "EFH Guidance for Federal Agencies" that listed the habitats defined as being Essential Fish Habitat by the South Atlantic Fishery Management Council. The first grouping of habitats is titled "<u>Estuarine Areas</u>". The group first discussed **Estuarine Emergent Wetlands**. This habitat was identified as being very valuable to numerous fish species. Information is presently lacking on the use of this habitat by various species, particularly how species use changes with gradients in vegetation corresponding to salinity gradients. Juvenile and larval life stages in particular use this resource. The committee recommended a direct assessment of the habitat's value to fisheries in the harbor. In theory, a habitat model could be used to predict project impacts to fisheries using this habitat, but these models typically require information that is presently unavailable for Savannah Harbor. The direct assessment would determine the species use of various emergent wetland habitats in the harbor. A range of wetland habitats would be assessed, corresponding to the range of salinities in the harbor; saline, brackish, to fresh. Sampling would need to be performed both spatially and temporally (all four seasons). Three sampling gears would be needed to evaluate fishery use of three different categories of habitats: a drop sampler for emergent marsh areas, a bloom (fyke) net for small tidal creeks on ebb tide, and trawls for open water. The field sampling would need to be correlated to site information (such as water depth and substrate type), as well as water chemistry information; salinity, D.O., flow rate, etc. Four to five sampling zones would be needed across the salinity range. Since there has been so much development in the harbor over time, a reference site would also be needed to better reflect conditions at an undeveloped (more natural) area. The Altamaha River was identified as a likely candidate for that purpose since it contains a large freshwater flow, in the same way that

the Savannah River does. Ted Will and Tom Reinert agreed to prepare an initial Scope Of Work to better define this work. They will have something to present at the next committee meeting.

6. **Estuarine Scrub/Shrub Mangroves** was the next habitat on the list. It is not present in the harbor. **Seagrass** was the next habitat. It also is not present in the harbor. **Oyster Reefs & Shell Banks** was the next habitat listed. They would be affected by salinity changes, bank erosion, turbidity during construction, ship wakes, and increases in the number of ships using the harbor. They are present in the lower harbor; along the banks of the main river below Fields Cut and between the jetties, primarily in the intertidal zone. SCDNR may have some data on their occurrence in the harbor. Creation of this habitat was identified as a potential mitigation action. **Intertidal Flats** was the next habitat listed. This habitat is present in the harbor. Shrimp sometimes use these sites as overwintering areas. Fiddler crab use of these sites is important to fisheries and ecological processes in the estuary. Evaluation of the fishery use of these habitats would be included by proper selection of sampling sites in the wetland fishery assessment discussed previously.

7. The next habitat discussed was **Palustrine Emergent Wetlands** (tidal freshwater marsh). The group agreed that this habitat was important, could be impacted by the project, and would be evaluated as part of the wetland fishery assessment discussed previously. The next habitat discussed was **Palustrine Forested Wetlands**. The group agreed that this habitat was important, could be impacted by project-induced changes to salinity or water levels. The group agreed that this habitat should be evaluated by adding another sampling zone to the wetland fishery assessment discussed previously.

8. **Aquatic Beds** was the next habitat discussed. Although there are some beds in the upper portion of Back River, the group felt that the beds were not of sufficient size or frequency to warrant special study.

9. The **Estuarine Water Column** was the final habitat listed and discussed in the Estuarine Areas group. The committee recognized that the project may result in the lower portion of the navigation channel being less suitable for fishery resources. Dissolved Oxygen was the particular parameter of concern. Juvenile life stages were of concern because of their inability to avoid areas of low D.O.. The discussion centered around whether there is sufficient information to determine whether certain species use only portions of the water column. The species of concern were identified as American shad, Hickory shad, and Blueback herring. Of particular interest was the time when the juveniles moved downriver through the harbor to the ocean. These species are known to use sandbars, but the water depth they use when they move through the harbor in later summer and fall was unknown to committee members. The committee agreed to **recommend the following action to the SEG**: **GPA contact regional experts and conduct a literature review to attempt to determine the expected depth of passage that juvenile American shad, Hickory shad, and Blueback herring use as they migrate downstream through the harbor.** NOTE: The SEG approved this

recommendation at the November 9 meeting with the following addition: **The Committee chair – in consultation with the Committee – will provide GPA with the names of the regional experts to be consulted."** If sufficient information cannot be obtained, field studies may be needed this fall. SCDNR performed fish sampling during June/July/August/September 1999. They are scheduled to issue a final report in December 1999. Information from their sampling should be of benefit to quantify variations in the harbor in fishery use in the water column. The UGA Coop Unit also has trawl data over the past years that may be useful for this purpose. Other than the issue concerning outmigrating shad, the existing data should provide sufficient information so that no additional sampling is needed for analysis of fishery impacts to this habitat.

10. The second group of EFH habitats listed in the handout from materials titled "EFH Guidance for Federal Agencies" is titled "Marine Areas". This group included the following habitats: **Live/Hard Bottoms, Coral & Coral Reefs, Artificial/Manmade Reefs, Sargassum**, and **Water Column**. These habitats are generally offshore areas and the committee felt that these would not be greatly affected by the proposed project. In the area of the bar channel extension, a sidescan survey had already been performed. It did not indicate any hardbottoms.

11. The committee then discussed sturgeon. It was stated that Atlantic sturgeon are present in the Savannah River estuary about 10 months out of the year. Shortnose sturgeon are caught in nets by shad fishermen. Frank Mathews stated that from his experience as a manager of commercial fishermen that it appears that the population of adults has doubled over the past 5 years. Other quantitative data seem to indicate that the number of adults are roughly the same as in 1992, and that a substantial percentage is made up of stocked fish. Mark Collins gave a brief overview of the investigation he was conducting. The group could not reach agreement on whether additional field studies would add additional information for use on this project. Until a concise study objective can be determined, the committee will not recommend any additional field studies for this species. Bill Bailey stated he would contact EPA's Gulf Breeze Laboratory and make a report on the status of their recent work on this species on dissolved oxygen.

12. It was mentioned that the project could have an impact on the Blue Crab fishery. John Pafford stated he would check with other GADNR-CRD staff for information on this fishery.

13. It was mentioned that the South Atlantic Fishery Management Council has a study on red bass that may be helpful.

14. This concluded the group's discussions. The committee agreed to meet again in about a month.

William Bailey
Chairman

CESAS-PD-E 24 January 2000

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
SEG Fisheries Committee;
Minutes of January 21, 2000 meeting

PARTICIPANTS:

NAME	**REPRESENTING**
In Person:	
William Bailey	US Army Corps of Engineers
Bo Ellis	ATM
By Telephone:	
Prescott Brownell	NMFS
Ed Eudaly	USFWS
John Pafford	GADNR-CRD
Tom Meronek	GADNR-WRD
Carl Hall	GADNR-WRD
Bert Deener	GADNR-WRD
Spud Wafford	GADNR-WRD
Ted Will	UGA Fish & Wildlife Coop Unit
Tom Reinert	UGA Fish & Wildlife Coop Unit
Cecil Jennings	UGA Fish & Wildlife Coop Unit

1. The meeting was held at the Corps of Engineers office in Savannah from 1:30 to 3:30 on Friday, January 21, 2000. Individuals who could not attend in person were able to participate through a teleconference capability.

2. The meeting was called primary to discuss two study proposals that had been submitted to the Committee for consideration. The first proposal was prepared by the UGA Fish & Wildlife Coop Unit at the request of the Committee. This need for this type of work was discussed at the previous Committee meeting. The second proposal was submitted by Dr. Mark Collins as a result of additional thoughts he had since the previous Committee meeting concerning fishery information needs in the Savannah estuary.

3. We began by discussing the proposal prepared by the UGA Fish & Wildlife Coop Unit titled "**Temporal and Spatial Distribution of Estuarine-Dependent Species in the Savannah River Estuary**". This is the evaluation discussed by the Committee to document the fishery habitat value of **Estuarine Emergent Wetlands**. The Committee had previously agreed that a reference site should be included in the work, but this was

not included in the SOW. The Committee's discussions are summarized as follows: (1)Inclusion of a reference site would probably not be useful for impact analysis purposes. (2)Inclusion of a reference could be useful for identification of cumulative impacts. (3)An evaluation of cumulative impacts would be complicated by the numerous physical and chemical differences between rivers. The group concluded that a reference site would not be needed to accomplish the study's goals of documenting the fishery habitat value of **Estuarine Emergent Wetlands**.

4. The committee then reviewed why the work described in the UGA SOW was needed. The NMFS stated that the work would provide information to address project impacts on Essential Fish Habitat. It would document the relative distribution (seasonally and spatially) of fish species and document the linkage between fish species and habitat types and features. The study would also provide information that would be helpful when evaluating mitigation options. The USFWS stated that the work would describe the relative values of different wetland habitats to estuarine fisheries. The group mentioned that the study would be useful in evaluating the fishery effects of project-induced changes in salinity and river flows. Ted Will (UGA Coop Unit) agreed to include these study outputs in the SOW.

5. The committee then discussed whether the proposed 1-year investigation could answer the study questions or whether a multi-year effort would be needed. A 1-year study would provide a picture of the intra-year variation of fish assemblages. It would identify key habitat areas for specific groups of fish species. However, it would miss the effects of alternate river flow conditions that are expected to alter the physical conditions that are important to determining the physical location in the estuary that a species chooses to reside in at a point in time. Fish communities reside at different locations in the estuary in response to changes in river flows. The largest differences are likely to occur in brackish waters, which is the region most likely to be changed by a channel deepening project. A multi-year study – which includes an alternate river flow regime – would document fishery responses to varying flows that are typical of this estuary. **The group concluded that a 2-year study would be needed to adequately document the use of the estuary by the various fishery communities.** It would help it the impact assessment identify spatial shifts in the fishery communities that are expected as a result of various river flows. Some modification to the SOW would be likely in the second year to optimize the value of the data to be collected. The group also concluded that additional years of this study may be needed as post-construction monitoring to ensure that fishery responses to the modified conditions do not exceed what is predicted.

6. The Committee discussed the proposal prepared by Dr. Mark Collins (SCDNR-MRD) titled "**Spawning Aggregations of Recreationally Important Sciaenid Species in Savannah Harbor**". John Pafford stated that Scianeids spawn offshore, inshore and in inlets. These species use deep-water habitats to spawn and are known to use the channel at Kings Bay. Salinity around 20 ppt are needed to buoy the eggs, which are spawned in mid-water, possibly on incoming tides. Larvae and young subsequently move to lower salinity waters. Spawning locations vary by river discharge and temperature.

Fishermen have reported that these species spawn in the Savannah River inlet. The group noted that the study would confirm the presence of spawning aggregations in this estuary. Potential project impacts to the spawning include alterations of salinity or velocities at a site. The Committee decided the SOW needed to include the following features to be performed at the spawning aggregation sites, once sites are identified: (1)water quality sampling, (2)velocity measurements (top to bottom), (3)sediment grabs (with grain size analyses), and (4)egg tows to confirm that spawning is occurring. The chairman would relay the need for these additional features to Dr. Collins for inclusion in the SOW.

7. I then gave a report on the status of EPA's research concerning the dissolved oxygen requirements of juvenile shortnose sturgeon. EPA conducted this research at their Gulf Breeze laboratory last summer. I had spoken with Larry Goodman who oversaw this research. He stated that they had conducted research to confirm what SCDNR had previously identified, that the sensitivity of this species to low D.O. levels decrease with increasing age. The SCDNR was performed using 100-day old fish. EPA was only able to secure 150-day old fish. In phase 1, EPA ran its tests at the same temperature as SCDNR had, and found similar results. In phase 2, EPA increased the temperature to 26 degrees and found that the fish's sensitivity was the same as SCDNR had found. EPA plans to continue its research next summer (phase 3). It hopes to use younger fish and study them at higher water temperatures. Gulf Breeze uses water of 4 ppt salinity. They expect to produce a report on their entire project in March 2001.

8. This concluded the group's discussions. The chairman will redistribute the revised SOWs when he receives them from the authors. Once the Committee approves the scopes, the chairman will present them to the SEG with a recommendation for approval. Hopefully the presentation can be made at the February 1 SEG meeting.

William Bailey
Chairman

CESAS-PD-E 19 June 2000

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
SEG Fisheries Committee;
Minutes of June 19, 2000 meeting

PARTICIPANTS:

NAME	**REPRESENTING**
In Person:	
William Bailey	US Army Corps of Engineers
By Telephone:	
Prescott Brownell	NMFS
Ed Eudaly	USFWS
Bo Ellis	ATM
Carl Hall	GADNR-WRD
Bert Deener	GADNR-WRD
Ted Will	UGA Fish & Wildlife Coop Unit
Tom Reinert	UGA Fish & Wildlife Coop Unit

1. The meeting was held at the Corps of Engineers office in Savannah from 9:30 to 10:15 on Monday, June 19, 2000. Individuals who could not attend in person were able to participate by telephone.

2. The meeting was called primary to discuss the results of the documents ATM had prepared titled (1)Literature Review: Migration of Juvenile American shad, Hickory shad, and Blueback herring in the Savannah River, and (2)References. We discussed the "Literature Review", as it summarized the information contained in "References" document.

3. The first item of discussion originated from the 3rd paragraph of the Existing Data section. A statement is included that a major assumption is that the adult American shad all die after spawning. Bert Deener said that his field work revealed < 1 percent of this species are repeat spawners. He said that their analyses of scales over a 10-year period found no evidence of repeat spawning. The Committee agreed that this assumption was a good one to make for the purposes of impact assessment and population dynamics.

4. The second item of discussion originated from the end of the 4th paragraph of the Existing Data section, where it states that "Future study is needed …". Bo Ellis clarified that these documents were not making any recommendations for additional studies as part of the Expansion Project. The Committee agreed that no additional study was needed on the issue of mortality after spawning.

5. The Committee then discussed the presence of juveniles in the estuary during the summer. The 6th paragraph in the Existing Data section states that juvenile American shad were found in Charleston Harbor from April through the summer and winter until the next February. Bert Deener said that in the Altamaha River, shad show up in the estuary about September. Carl Hall said that he expected fish behavior in the Savannah River to roughly approximate that observed in the Altamaha River, since they are both large rivers. Bert said that juvenile shad are about 70 mm in length by the time they reach the estuary. Tom Reinert said that the UGA Coop Unit had found shad eggs in the trawls they perform in the spring when they are looking for Striped bass eggs. This indicates that shad may be present in the estuary throughout the summer. When juvenile shad are present in the estuary, they are generally found in waters with between 0 – 5 ppt salinity. The area in Savannah Harbor with the sag in dissolved oxygen (D.O.) generally has a higher salinity than that. ATM's hydrodynamic model will identify the size, location and timing of the occurrence of low D.O. areas in the harbor. ATM will be able to use that to see if there are any overlaps of low D.O. and areas frequented by juvenile shad. Carl Hall suggested ATM use criteria in the USFWS Habitat Suitability Index to help define areas within the harbor that provide suitable habitat for these three species. The study being funded by GPA on spatial distribution of estuarine-dependent fish in the Savannah River estuary may also provide information on the presence and habitats frequented by these three species.

6. Ed Eudaly requested a literature review of avoidance mechanisms of these species to low D.O.. Bo Ellis said that ATM would normally do this as part of their development of evaluation criteria. Therefore, no separate recommendation is needed from this committee. Ed Eudaly agreed to send ATM some literature on this issue.

7. The Committee concluded that no further field work was needed to address the issue of timing and depth of passage of out migrating juvenile American shad, Hickory shad and Blueback herring.

William Bailey
Chairman

SEG Striped Bass & Fisheries and Aquatic Resources Committee Meeting Summary
Date: June 21, 2002
Time: 10:00 A.M.
Place: U.S. Fish and Wildlife Service Savannah Coastal Refuge Administrative Office

Members Present:

Bill Post	South Carolina Department of Natural Resources
Ted Will	Georgia Department of Natural Resources WRD
Matt Thomas	Georgia Department of Natural Resources WRD
Terry Stratton	U.S. Army Corps of Engineers
Bill Bailey	U.S. Army Corps of Engineers
Ed Eudaly	U.S. Fish and Wildlife Service
John Robinette	U.S. Fish and Wildlife Service
Tom Reinert	University of Georgia
Cecil Jennings	USGS / Georgia Cooperative Fish and Wildlife Research Unit
Richard Weyers	Georgia Cooperative Fish and Wildlife Research Unit
Larry Keegan	Lockwood Greene
Ron Michaels	Georgia Department of Natural Resources CRD
John Paffert	Georgia Department of Natural Resources CRD
Patrick Geer	Georgia Department of Natural Resources CRD
Bo Ellis	Applied Technology and Management

AGENDA

Striped Bass Committee -

(1) Ed's striped bass modeling document
(II) The COEs report "Current Status of Information on Striped Bass in the Savannah River Estuary"
(III) Spring 2002 striped bass sampling update and the direction for future studies and monitoring

Fisheries and Aquatic Resources Committee -

(2) Status of current studies
(3) Assessment of impacts on target species groups through ATM's model (e.g., white & brown shrimp, spotted seatrout & red drum, shortnose and Atlantic sturgeon, and shad)
(4) Fisheries workshop meeting

Striped Bass Committee

(I) Ed's striped bass modeling document

Listed below are main items that were discussed. Ed and Ted will revisit these items and submit a final draft for review.

Although the document contains four main categories (spawning, egg development, larval development, and egg and larval transport), the general consensus was "there is some overlap" between categories and that model runs could be formatted to meet the committee's needs.

A. Spawning:

1) Discussion began asking for input on the value of velocity as an environmental cue for striped bass spawning. The value was suggested as important, but given the variability of velocity in the Savannah River Estuary (i.e., different discharges and tidal influences) it would be difficult to suggest one key velocity and then expect meaningful data from the model results. A literature search will be conducted to see if an actual spawning velocities would be meaningful. Also, John Robinette will talk to Tennessee biologist who are conducting research on spawning striped bass in circular tanks.

2) Without velocity, evaluation criteria would be based on reaches of the Savannah River Estuary containing 90th percentile salinities $\leq$ 1 ppt. Bo Ellis then brought up the point the 90th percentile salinities may be to conservative given the pass or fail mode of the model. After discussions, Tom and Ed suggested the value of adding another output (e.g., 75th percentile salinity $\leq$ 0.5 ppt). This additional output will be considered fo the next draft report.

3) Mean and low river discharge are currently proposed for the model runs. Ted suggested that we may want to include a high flow. After discussions, it was concluded to look at gauge data at Clyo from mid-March through the 1st of May (1953 to present) and use a 20th, 50th, and 80th percentile flows for model runs.

B. Egg Development:

1) The committee discussed the evaluation criteria of the mean 50th percentile salinity $\leq$ 9 ppt. Is this value to liberal or should we consider a

more conservative measure (i.e., mean of 90th percentile salinity)?

2) Again, It was suggested to use 20th, 50th, and 80th percentiles mid-March through the 1st of May flows for model runs.

C. Larval Development:

1) The committee discussed the criteria of the mean 50th percentile salinity ranging from 3-9 ppt. Is mean 50th percentile salinity ≤ 9 ppt suitable for the model. Again, do we want to take the mean of the 50th percentile salinity or the 90th percentile salinity?

2) Ted indicated that some past research has shown 1-2 day old striped bass larvae as being the most susceptible to increased salinities. Given this fact, should the model flow data reflect the peak spawning period (Mid-march through the 1st of May). Ed pointed out that there may be dissolved oxygen (D.O.) problems during end of May and June and wanted to include May-June flows and D.O.'s in the model. It was then suggested that we use two different flow regimes.

3) Bo pointed out that we need to be aware of temperature outputs when we are obtaining D.O. readings for the proposed time periods that we want the model runs to encompass. Ed and Tom suggested weekly or daily water temperature outputs need to be considered in the model to correct D.O. readings.

4) Again, for whatever time periods we consider to run the model, use 20th, 50th, 80th percentiles for discharge.

D. Egg and Larval Transport

Questions were raised concerning how the model would predict egg transport. Discussion was brought up about how the egg would drift within the model (i.e., would a drift rate of 64% of the average current velocity be used or not), and can the model could approximate the actual drift (throughout the water column) of striped bass eggs. A decisions on the validity and usefulness of this data will be considered.

(II) USCOE's report "Current Status of Information on Striped Bass in the Savannah River Estuary"

The report was well prepared and received. Further peer review is needed. Individuals with knowledge of striped bass biology in coastal rivers comments will on potential data gaps that may have missed or overlooked.

Matt Thomas has agreed to comment and Terry Stratton will call other state fishery biologist.

(III) Spring 2002 striped bass sampling update and the direction for future studies and monitoring

1) Ted gave a sampling update from the Savannah River. Fewer large (> 9 kg) striped bass were collected this year. Two main factors likely contributed to this decrease in catch: 1) low flows and increased water temperatures likely cued large fish to migrate further north beyond the standardized sampling area, and 2) increased salinities prohibited eletrofishing in the lower reaches of the estuary during late-February and early March.

2) One day of electrofishing trip was conducted above Hwy. 301 (about RM 130-150). In 2.85 pedal hours, four large (>9 kg) female striped bass were collected. Two of the fish were spent and two fish were gravid.

3) The significance of spawning in the upper Savannah River is unknown and if spawning is related to river discharge (with low discharges correlated with increased salinities and higher water temperatures).

4) No data has been collected on striped bass recruitment in the upper reaches of the Savannah River. GADNR will conduct night shocking survey to assess recruitment of juvenile striped bass during July-September.

5) GADNR will be monitoring thermal refuge above and below the New Savannah Bluff Lock and Dam.

6) Ted mentioned that spatial striped bass egg and larvae collections at the historic sampling areas combined with sampling in the upper reaches (RM 60-180) would be beneficial information. Perhaps under normal flow years there would be the appropriate environmental cues favoring the upper Back River for striped bass spawning habitat. Further, under low, normal, or high flows what is the contribution of striped bass spawning in the upper reaches (RM 60-180).

7) Richard Weyers mentioned that Georgia Cooperative Fish and Wildlife Research Unit (GACOOP) collected about 40 striped bass larvae in mid-March of 2002. The larvae were collected on the Front River at RM 26. Collecting this many striped bass larvae was surprising for three reasons. First, studies in 1999 and 2000 resulted in no larval striped bass collected. Secondly, the amount of sampling effort in past studies (7 days a week from

mid-March through May) was much more extensive than the present study (4 sample periods in one month). Finally, collecting larvae in mid-March is early into the spawning season (spawning peak is generally in mid-April).

Fisheries and Aquatic Resource Committee

(I) Status of Current Studies

Bill Post gave an sampling update for SCDNR. Everything is going well, an annual report should be posted on the web site soon and the final report should be completed by December 2002. Richard Weyers gave an update for GACOOP. Mentioned that their annual report is posted on the web site, gave brief description of sampling efforts and number of species collected, and the final report should be available by December 2002.

(II) Assessment of impacts on target species groups through ATM's model (e.g., white & brown shrimp, spotted seatrout & red drum, shortnose and Atlantic sturgeon, and shad)

Ted began discussions by reading Prescott Brownells (NMFS) email regarding this assessment. Prescott suggested in the email that "we consider using a small (3-5) selection of estuarine and freshwater species models as an 'extension' of ATM's hydrodynamic model. Using a team approach we can easily adjust the species models to more accurately reflect Savannah River conditions.

A listing of models (and species profiles)is available from the USGS National Wetlands Research Center at the following link:

http://www.nwrc.usgs.gov/diglib.htm

We should be able to use selected models plus outputs from the ATM hydrodynamic model with GIS to identify and display changes in suitable habitat area and location from historic conditions, present conditions, and forecast changes with project alternatives and mitigation alternatives."

After much discussion it was decided that the first step was to identify species of concern. John Pafford and Patrick Geer would review GACOOP's annual report and then provide feedback on any saltwater/estuarine species that they may need further consideration. It was decided that a process of soliciting volunteers to look at literature (Habitat Suitability Indices and Specie Profiles) for the identified species of concern should begin. One committee member would pick one fish species and then provide feedback to committee on potential impacts.

Mark Collins was volunteered for shortnose and Atlantic sturgeon and Patrick Geer volunteered for white and brown shrimp.

(III) Fisheries workshop meeting

The committee agreed that the final reports from SCDNR and GACOOP need to completed and reviewed before holding the workshop. If reports are completed by December 2002, the suggested time to hold the fisheries workshop was February 2003.

CESAS-PD-E 23 September 02

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 10 September Interagency Meeting on Evaluation of Fisheries

1. Attendees:

USFWS:	Ed Eudaly
NMFS:	Prescott Brownell
SCDNR:	Priscilla Wendt and Mark Collins
GADNR-WRD:	Matt Thomas and Ted Will
GADNR-CRD:	Pat Geer
COE:	Bill Bailey
ATM/GPA:	Bo Ellis and Bridget Callahan
GA Coop:	Cecil Jennings and Tom Reinert

2. The Agenda is attached.

3. After introductions I explained the purpose of the interagency meeting.

4. I then reviewed the **Completed and Ongoing Fisheries Studies**. A list is included in the agenda.

5. We then discussed the **Potential Need for Additional Fishery Field Studies**. I explained one flow rerouting that had been proposed and that the project would be evaluating – closing Houston Cut and rerouting flow through Steamboat Bend; accompanied by closing Middle River and rerouting the downstream exit to Back River near New Cut. Members of the group were concerned about possible reductions in fish passage between Front River and Middle River. The group also identified the lower end of Middle River as the location for juvenile shortnose sturgeon during the winter in the study conducted as part of this project. We agreed that this proposal would be a major modification to the estuary and would need to be examined thoroughly.

The group mentioned that the completed and ongoing studies will all have been conducted during a drought. The distribution of fish would differ somewhat during normal flow conditions. Members of the group expressed a desire for the following studies to be conducted under normal flow conditions:

- Striped bass egg and larval study
  - Where is spawning occurring under normal flows?
  - How much spawning occurs in the estuary under normal flows?

- Shortnose Sturgeon
  Where do the juveniles stay during normal flows?
  Is the lower end of Middle River critical to this population?

- Striped bass spawning/flow conditions
  Velocity measurements at spawning locations and egg development areas under normal flows. Are the average velocities sufficient to meet the habitat requirement (velocity) to keep the eggs suspended?

6. We then discussed **Impact Evaluation Techniques.**

I explained the procedure I hoped to follow – combine a Habitat Suitability Index Model with the Hydrodynamic Model to identify and quantify locations of suitable habitat. Ed Eudaly and Ted Will had worked on this approach through the SEG Striped Bass Committee as a way to identify acceptable habitat and project impacts to Striped Bass. Cecil mentioned that Tom Reinert was developing a Decision Support Model for Striped Bass. It will include probabilities of impact and should be available next year. No one identified an alternate impact evaluation approach for this project. I stated that should someone come across an alternate approach in the future that they think may work better, they should let the group and the Corps know.

7. We then discussed what species should be evaluated in the EIS. The agenda includes a list that Pres Brownell had suggested may be appropriate for inclusion in the EFH Evaluation. Pres suggested that if the right species could be identified, it may be sufficient to fully evaluate 1 or 2 species plus an anadromous or diadromous species. The group concluded that there was insufficient information on Atlantic sturgeon to define acceptable criteria in the estuary. Since an HSI model is not available, the group decided to drop Atlantic silversides from the list. The group agreed that Shortnose sturgeon should be one of the species evaluated in detail; Striped bass would be another. The group thought that Blue Crabs should be considered because of their commercial importance. Although shrimp may not be particularly sensitive to salinity changes, it may be beneficial to evaluate them because of their commercial importance. Red drum should be evaluated because of their recreational importance. Southern flounder and Spotted seatrout should also be considered because of their recreational importance.

We briefly mentioned water quality factors that would be important to specific species:

- Shad: D.O. and temperature for the young; mean river discharge
- Shrimp: Temperature and salinity; D.O. not an effect

8. The next step is examination of the HSI Models to identify whether they could be used to obtain water quality parameters that could define acceptable habitat. The group agreed to divide the review of the HSI models as follows:

• Striped Bass	USFWS (Ed Eudaly)
• Shortnose sturgeon	SCDNR (Mark Collins) and NMFS (Pres Brownell)
• American shad	NMFS (Pres Brownell)
• Red Drum	SCDNR (Priscilla Wendt – coordinator)
• Spotted Seatrout	SCDNR(Priscilla Wendt – coordinator)
• Shrimp	GADNR (Pat Geer)
• Blue Crab	GADNR (Pat Geer)
• Southern Flounder	ATM (Bridget Callahan)

For their specific species, the individuals would do the following:

- Review the HSI Model and available information
- Recommend whether it is doable to identify criteria of acceptable habitat for which the Hydrodynamic Model could be used to identify locations and quantity of areas meeting the criteria
- Identify which characteristics would define acceptable habitat
- Recommend specific parameters (if possible) that would define acceptable habitat

Each reviewer would present their findings to the group for their consideration. If additional reports needed to be obtained, ATM would most likely be identified as organization to obtain them.

I distributed the Striped Bass Application developed by Ed and Ted as an example for the reviewers and stated that a goal would be to develop a similar document for each species.

9. We agreed that it would take at least a month to review these HSI Models. I will schedule another interagency meeting in 1-2 months.

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

FISHERIES WORKGROUP

SEPTEMBER 10, 2002

AGENDA

INTRODUCTIONS

PURPOSE OF THE WORKGROUP

ONGOING / COMPLETED FIELD INVESTIGATIONS

- Striped Bass Egg & Larval Distribution
- Literature Review: Migration of Shad and Blueback Herring in Savannah Harbor
- Contacts with Regional Experts on Fish Migration
- Distribution of Shortnose Sturgeon
- Spawning Aggregations of Sciaenid Species
- Temporal & Spatial Distribution of Estuarine Dependent Species

NEED FOR ADDITIONAL FIELD STUDIES

- Proposal to close Houston Cut
- Others ??

SPECIES TO CONCENTRATE ON FOR IMPACT ASSESSMENT

- Species identified by NMFS under EFH
    - Atlantic and shortnose sturgeon
    - Striped bass
    - White and brown shrimp
    - American shad
    - Juvenile spot
    - Red drum
    - Atlantic silversides
- Others ??

IMPACT EVALUATION TECHNIQUES

- Combine HSI models with Hydrodynamic Model to identify areas of acceptable habitat
- Others ??

EVALUATION OF IMPACTS TO FISHERIES

TECHNIQUE: Combine HSI models with Hydrodynamic Model to identify areas of acceptable habitat

STRIPED BASS
Plan developed through the SEG Striped Bass Committee (Ed Eudaly)

- Spawning
- Egg Development
- Larval Development

STURGEON
Review of HSI by SCDNR (Mark Collins)

SHRIMP
Review of water quality requirements by GADNR-CRD (Patrick Geer)
Review of HSI

JUVENILE SPOT
Review of HSI by GADNR-CRD (Patrick Geer)

RED DRUM
Review of HSI by SCDNR

AMERICAN SHAD
Review of HSI by GADNR-CRD (Patrick Geer)

ATLANTIC SILVERSIDES
No HSI model on website

CESAS-PD-E 13 November 2002

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 13 November Interagency Meeting on Evaluation of Fisheries

1. Attendees:

USFWS:	Ed Eudaly
NMFS:	Prescott Brownell
SCDNR:	Mark Collins
GADNR-WRD:	Matt Thomas and Ted Will
GADNR-CRD:	Pat Geer
COE:	Bill Bailey
ATM/GPA:	Bridget Callahan
GA Coop:	Cecil Jennings and Richard Weyers

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. I explained the purpose of this interagency meeting: To discuss how information from the HSI models could combined with the Hydrodynamic Model to identify areas of acceptable habitat.

5. We started with **Striped Bass**. We discussed the broad changes we had made as the Application was refined – how we eliminated transport due to uncertainties in the Hydro Model; how the percentages were based primarily on literature, and that we had a several site-specific studies to use. <u>We concluded that the Version 6.0 dated September 18, 2002 of the Striped Bass Application is acceptable to identify project impacts.</u>

We also discussed having the Hydro model identify minimum D.O. values at 0.1 mile intervals. This information would not be part of the habitat suitability criteria, but may provide useful information to understand aquatic habitats in the estuary.

6. We then discussed **Shortnose sturgeon** and Atlantic sturgeon. Mark informed us of what he had gathered from he and Pres' review of the HIS and other knowledge they had of the species. The existing models do not help much with this estuarine site. The summer habitat appears to be deep areas (15 to 20 feet deep) with 0 to 1 ppt salinity. Sturgeon larvae have been collected in the Savannah estuary by UGA. Juveniles use areas with salinity 3 to 9 in the winter and 0.1 to 0.2 in the summer. It appears that there not sufficient information available to develop suitability criteria for Atlantic sturgeon.

The habitat evaluation should be performed on both winter and summer conditions. We believe that substrate and velocity can be eliminated from consideration. Velocity is primarily an issue during spawning. The habitat of concern is along the bottom -- either the bottom layer of the model or the bottom 6 feet of the water column. Mark and Pres would continue to work together to document and define the habitat definitions for use with the Hydrodynamic Model.

7. We then discussed **Red drum**. Mark said this species is probably not a good one for application of the Hydro model. He thought the ecological problems that this species has do not relate to water quality. He stated that tidal creeks are a nursery habitat, so providing access to more creeks could be potential mitigation option. He stated that there are concerns about potential impacts to spawning aggregations during construction of the Expansion Project. He said that a dredging window near the mouth of the river may be necessary. We agreed that no further work will be done with this species to link the habitats to the Hydrodynamic Model.

8. We discussed **Spotted seatrout**. Mark said this species has similar issues as Red drum and will likely not be a good candidate for application of the Hydro model. As with Red drum, nursery habitat is a limiting factor. He envisioned no concerns about a dredging window with this species. We agreed that no further work will be done with this species to link the habitats to the Hydrodynamic Model.

9. We discussed **Blue crab**. Pat said that spawning occurs near the mouth of the river and eggs and larvae are transported offshore. Salinity is important, with acceptable levels generally being <12 ppt. Early juveniles use areas with salinity <5 ppt. Declines in populations have occurred recently, with the drought-induced salinity intrusion being a significant factor. Blue crab move further upriver as the salinity moves up the estuary. This species is likely to not be too sensitive to the expected incremental project-induced changes. We agreed that no further work will be done with this species to link the habitats to the Hydrodynamic Model.

10. We discussed **Shrimp**. Pat said that White shrimp move offshore in April and May to spawn. The amount of tidally-flooded vegetation is important. This species is likely to not be too sensitive to the expected incremental project-induced changes. We agreed that no further work will be done with this species to link the habitats to the Hydrodynamic Model.

11. We discussed **Southern flounder**. Bridget said that flounder appeared to be most sensitive to D.O., appearing to need > 4.5 ppm. Larvae need salinity of 0 to 5 ppt and occur during the months of January and February. The critical time for adults would be the summer months, June/July/August. We agreed that substrate was not critical in the analysis of flounder habitat at this site since the constant shoaling would cover any

naturally hard river bottom material. The group agreed to continue work on developing a model application for this species. The application should have two components: larvae and adults. Bridget will continue to refine the habitat requirement write-up for this species.

We will consider adding a second separate step to this analysis to include the value of tidally marsh along the river. This would allow us to capture the value of the tidal marshes to several estuarine-dependent species.

12. We discussed **American shad**. Pres said that from studies conducted in northern areas, eggs and larvae need D.O. > 5 ppm. D.O. levels of 5 ppm were found to be lethal to outmigating juveniles. Shad are found near the bottom during the day and near the top at night. Juveniles would be of most interest in this estuarine project area. Larvae are probably found further upstream, out of the immediate project area. More information is needed about two items: (1) the residence time of this species in the Savannah River estuary, and (2) how lower natural D.O. levels in southern estuaries affects their presence in the harbor area. Pres would summarize what he had found. Bridget will pursue additional information on the two issues.

13. One side comment made was that oysters and Spartina form much of the base of a properly-functioning estuarine ecosystem. If/when one becomes available, the resource agencies would like a GIS file containing a recent aerial photograph or satellite image showing the harbor and estuary. I concluded by stating that I would call another meeting in about a month (before December 20th).

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY FISHERIES COORDINATION

NOVEMBER 13, 2002

AGENDA

INTRODUCTIONS

OVERVIEW OF PREVIOUS MEETING
- Completed & Ongoing Studies
- Species of Concern
- Impact Evaluation Techniques

REVIEW PURPOSE OF THE MEETING
- Discuss information from HSI models for identification of areas of acceptable habitat

SPECIES TO CONCENTRATE ON FOR IMPACT ASSESSMENT

• Striped Bass	USFWS (Ed Eudaly)
• Shortnose sturgeon	SCDNR (Mark Collins) & NMFS (Pres Brownell)
• Red Drum	SCDNR (Priscilla Wendt – coordinator)
• Spotted Seatrout	SCDNR(Priscilla Wendt – coordinator)
• Shrimp	GADNR (Pat Geer)
• Blue Crab	GADNR (Pat Geer)
• Southern Flounder	ATM (Bridget Callahan)
• American shad	NMFS (Pres Brownell)

WRAP-UP
- Next Meeting

CESAS-PD-E 20 December 2002

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 19 December Interagency Meeting on Evaluation of Fisheries

1. Attendees:

ATM/GPA:	Bo Ellis
	Bridget Callahan
By phone:	
USFWS:	Ed Eudaly
NMFS	Prescott Brownell
SCDNR:	Mark Collins
COE:	Bill Bailey

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. I reviewed our previous meeting and the major conclusions we reached. We completed our work on the Striped Bass application. We decided that no further work was needed to attempt to use the Hydrodynamic Model to the Habitat Suitability Indexes for the following species: Atlantic sturgeon; Red drum; Spotted seatrout; Blue crab; and Shrimp. We will continue work on Shortnose sturgeon; Southern flounder; and American shad.

5. We started with a **clarification of the use of the Hydro Model to determine minimum levels of dissolved oxygen (D.O.)**. We had discussed this at our previous meeting, but I was uncertain of exactly what information we should ask the model to produce. We decided that the 5 percent occurrence values should be identified as a measure of the minimum D.O. levels in the estuary. This data should be reported every 0.2 mile along each river in the estuary. The information would not be part of the habitat suitability criteria, but would be additional information to assess the general fishery habitat conditions in the estuary under those flow conditions. At this point, we will request this information for every species that we use the Hydro Model to assist in the evaluation of project impacts.

6. We then discussed **Southern Flounder**. Bridget had been somewhat unsure of what actions she needed to take. Because of the seasonal differences in their occurrence in the harbor, we agreed that the analysis should evaluate habitat for both adults and juveniles. By this decision, we substituted juveniles for larvae from the position we

reached at our last meeting. This substitution is due to (1) the occurrence of juveniles in the estuary over a longer duration that larvae, and (2) the temporal overlap of adult's occurrence with that of larvae. Juveniles are present in the estuary over the spring, summer and fall months. We will evaluate the summer months, since the habitat will be most limited during that period due to the requirement for relatively higher D.O. levels. Bridget will review the HSI criteria for D.O. to determine the 0.7 suitability threshold. We expect it is around 4.0 mg/L. Unless she uncovers something to indicate that is not a good number to use, we will use 4.0 mg/L as our criteria. The location in the water column where that would be determined is at the bottom. Bridget will revise the application for this species prior to our next meeting.

7. We then discussed **American shad**. Bridget reviewed that the studies for the HSI had been conducted primarily in northern areas. As opposed to behavior in the north, it is believed that for American shad in the south, (1) adults are not repeat spawners, and (2)juveniles overwinter in the estuary. This species uses two types of habitat in the Savannah River: (1) Riverine -- spawning adults, freshwater, January to May, and (2)Estuary -- juveniles and migrating adults, emergent or submerged vegetation is important, November to March. Relatively high D.O. is needed by this species. Juveniles need >3.0 mg/L for equilibrium. In the Temporal and Spatial Distribution Study conducted in this estuary, shad were found at locations with D.O. >= 4.1 mg/l. We decided to use 4.0 mg/l as our criterion for acceptable habitat. There is no need to look further at adult habitat because they move through this harbor when the water is cooler, and therefore when the D.O. is higher. We will look at juveniles and use the following criteria: summer months; D.O. >= 4.0 mg/l; bottom layer. Bridget will revise her write-up to include our conclusions and any other information she may find from additional research.

8. We discussed **Shortnose sturgeon**. Salinity and D.O. are critical water quality parameters. In the summer, sturgeon move upriver out of the harbor. Pres indicated we may want to consider designating an "Area of Concern" where no impacts are desired. This area is just above the mouth of the Middle River, where SCDNR found sturgeon during the winter in their most recent monitoring. This designation would be separate from any habitat areas identified by the Hydro Model. We agreed that we should look at both winter and summer conditions, since it is believed that these are the two seasons in which the fish are under the greatest environmental stress. Pres will document his and Mark's findings and our discussions, and prepare a paper describing the habitat criteria we could use to identify suitable habitat in the Savannah River estuary.

9. Next meeting: Preliminary date: Tuesday, January 28 starting at 9:30 AM.

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY FISHERIES COORDINATION

DECEMBER 19, 2002

AGENDA

REVIEW OF PREVIOUS MEETING

- Completed procedure to ID habitat for Striped Bass
- Question on Dissolved Oxygen
    - How to measure minimum levels
    - All species or just Striped Bass runs
- Deleted further work to link to Hydro Model on:
    - Atlantic Sturgeon
    - Red Drum
    - Spotted Seatrout
    - Blue Crab
    - Shrimp

CONTINUE WORK ON THESE SPECIES FOR IMPACT ASSESSMENT USING HYDRO MODEL

• Southern Flounder	Bridget Callahan	
• American shad	Pres Brownell	summarize existing info
	Bridget Callahan	info on Residence time Effects of low DO
• Shortnose sturgeon	Pres Brownell & Mark Collins	

WRAP-UP

- Next Meeting

CESAS-PD-E

20 December 2002
Revised

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 19 December Interagency Meeting on Evaluation of Fisheries

1. Attendees:

ATM/GPA:	Bo Ellis
	Bridget Callahan
COE:	Bill Bailey
By phone:	
USFWS:	Ed Eudaly
NMFS	Prescott Brownell
SCDNR:	Mark Collins

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. I reviewed our previous meeting and the major conclusions we reached. We completed our work on the Striped Bass application. We decided that no further work was needed to attempt to use the Hydrodynamic Model to the Habitat Suitability Indexes for the following species: Atlantic sturgeon; Red drum; Spotted seatrout; Blue crab; and Shrimp. We will continue work on Shortnose sturgeon; Southern flounder; and American shad.

Review of the Habitat Suitability Index models for red drum, seatrout, crab, and shrimp revealed that these models were generally not designed for use in evaluating changes in salinity or dissolved oxygen. That does not mean that those species are not affected by changes in salinity and D.O., but the models were designed to assess changes in other habitat variables. Rather than spend time developing modified models responsive to D.O. and salinity, it was realized that other species and key life stages could be employed as surrogates for the estuarine fish community. Accordingly, a focus on Shortnose sturgeon, Southern flounder, Striped bass and American shad is appropriate for initial habitat analysis employing the Hydrodynamic Model.

5. We started with a **clarification of the use of the Hydro Model to determine minimum levels of dissolved oxygen (D.O.)**. We had discussed this at our previous meeting, but I was uncertain of exactly what information we should ask the model to produce. We decided that the 5 percent occurrence values should be identified as a measure of the minimum D.O. levels in the estuary. This data should be reported every

0.2 mile along each river in the estuary. The information would not be part of the habitat suitability criteria, but would be additional information to assess the general fishery habitat conditions in the estuary under those flow conditions. At this point, we will request this information for every species that we use the Hydro Model to assist in the evaluation of project impacts.

The Hydro Model can display zones (spatial distribution) of dissolved oxygen under test scenarios. We will then be able to identify changes in area of available suitable habitat under the various test scenarios. The reporting of minimum levels of D.O., as discussed in the previous paragraph) will also allow us to identify any areas with D.O. problems that may develop under the test scenarios.

6. We then discussed **Southern Flounder**. Bridget had been somewhat unsure of what actions she needed to take. Because of the seasonal differences in their occurrence in the harbor, we agreed that the analysis should evaluate habitat for both adults and juveniles. By this decision, we substituted juveniles for larvae from the position we reached at our last meeting. This substitution is due to (1) the occurrence of juveniles in the estuary over a longer duration that larvae, and (2) the temporal overlap of adult's occurrence with that of larvae. Juveniles are present in the estuary over the spring, summer and fall months. We will evaluate the summer months, since the habitat will be most limited during that period due to the requirement for relatively higher D.O. levels. Bridget will review the HSI criteria for D.O. to determine the 0.7 suitability threshold. We expect it is around 4.0 mg/L. Unless she uncovers something to indicate that is not a good number to use, we will use 4.0 mg/L as our criteria. The location in the water column where that would be determined is at the bottom. Bridget will revise the application for this species prior to our next meeting.

7. We then discussed **American shad**. Bridget reviewed that the studies for the HSI had been conducted primarily in northern areas. As opposed to behavior in the north, it is believed that for American shad in the south, (1) adults are not repeat spawners, and (2)juveniles overwinter in the estuary. This species uses two types of habitat in the Savannah River: (1) <u>Riverine</u> -- spawning adults, freshwater, January to May, and (2)<u>Estuary</u> -- juveniles and migrating adults, emergent or submerged vegetation is important, November to March. We will consider that shad juveniles may be in the estuary at any month of the year, particularly summer months, not limited to November to March. Relatively high D.O. is needed by this species. Juveniles need >3.0 mg/L for equilibrium. In the Temporal and Spatial Distribution Study conducted in this estuary, shad were found at locations with D.O. >= 4.1 mg/l. We decided to use 4.0 mg/l as our criterion for acceptable habitat. There is no need to look further at adult habitat because they move through this harbor when the water is cooler, and therefore when the D.O. is higher. We will look at juveniles and use the following criteria: summer months; D.O. >= 4.0 mg/l; bottom layer. Bridget will revise her write-up to include our conclusions and any other information she may find from additional research.

8. We discussed **Shortnose sturgeon**. Salinity and D.O. are critical water quality parameters. In the summer, sturgeon move upriver out of the harbor. Pres indicated we may want to consider designating an "Area of Concern" where no impacts are desired. This area is just above the mouth of the Middle River, where SCDNR found sturgeon during the winter in their most recent monitoring. This designation would be separate from any habitat areas identified by the Hydro Model. He and Mark will try to identify those areas, based on the telemetry study experiences, prior to the next meeting. We agreed that we should look at both winter and summer conditions, since it is believed that these are the two seasons in which the fish are under the greatest environmental stress. Pres will document his and Mark's findings and our discussions, and prepare a paper describing the habitat criteria we could use to identify suitable habitat in the Savannah River estuary.

9. Next meeting: Preliminary date: Tuesday, January 28 starting at 9:30 AM.

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY FISHERIES COORDINATION

DECEMBER 19, 2002

AGENDA

REVIEW OF PREVIOUS MEETING

- Completed procedure to ID habitat for Striped Bass
- Question on Dissolved Oxygen
  - How to measure minimum levels
  - All species or just Striped Bass runs
- Deleted further work to link to Hydro Model on:
  - Atlantic Sturgeon
  - Red Drum
  - Spotted Seatrout
  - Blue Crab
  - Shrimp

CONTINUE WORK ON THESE SPECIES FOR IMPACT ASSESSMENT USING HYDRO MODEL

• Southern Flounder	Bridget Callahan	
• American shad	Pres Brownell	summarize existing info
	Bridget Callahan	info on Residence time Effects of low DO
• Shortnose sturgeon	Pres Brownell & Mark Collins	

WRAP-UP

- Next Meeting

CESAS-PD-E 6 February 2003

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 28 January Interagency Meeting on Evaluation of Fisheries

1. Attendees:

USFWS:	Ed Eudaly
GADNR-WRD:	Matt Thomas
	Ted Will
ATM/GPA:	Bo Ellis
	Bridget Callahan
COE:	Bill Bailey

By phone:

NMFS	Prescott Brownell
SCDNR:	Mark Collins
	Priscilla Wendt
GADNR-CRD:	Pat Geer

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. We reviewed our previous meeting and the major conclusions we reached.

We started with a **clarification of the use of the Hydro Model to determine minimum levels of dissolved oxygen (D.O.)**. We decided the information should be provided for top, mid-depth, and bottom of each grid cell in a cross-section, every 0.2 miles up the length of the river. The data should be presented both in tables and color figures. This information would be produced as an additional output of each Hydro Model application run for evaluation of impacts to fisheries.

We discussed **comments that Pres Brownell provided after the December meeting summary was finalized**. Pres suggested in his comments that we should use a range of suitability thresholds. We had much discussion on this issue of identifying the intensity of an impact on fisheries. The approach the group had agreed to follow was one that distinguishes between locations that provide suitable vs. unsuitable habitat for a particular species (or representative species). This is basically a pass/fail approach. The group concluded that if we were able to obtain more information (shades of gray rather than just black or white), it would likely not identify more areas of impact or more useful information when compared to the pass/fail approach we presently plan to use. The group (including Pres) agreed that the pass/fail approach was acceptable for now. Pres said that his comments on including a range of suitability thresholds could be deleted from the December summary. I have attached a revised summary of the December meeting, deleting the comments that Pres said could be removed.

5. We then discussed **Southern Flounder**. Bridget reviewed the findings of the research she had found and our conclusions from the previous meeting. We discussed suitability criteria for D.O. from the HSI model. The HSI shows 4.5 mg/L as having a suitability criteria of 1.0. We recognize that the estuary supports a long-standing population of Southern flounder, while also experiencing D.O. values below 4.5 mg/L. AT the conclusion of our discussion, we reconfirmed the use of the 0.7 suitability criteria for D.O., which is a value of 4.0 mg/L. We agreed that the model runs should use the following:

- Dates: August
- Temperature: Average August
- Flow: Average August
- D.O.: >= 4.0 mg/L as the threshold of suitable habitat

Bridget will include these items in her write-up on this species.

6. We then discussed **Shortnose sturgeon**. We confirmed that we should look at both winter and summer conditions and that salinity and D.O. are critical water quality parameters. We again discussed a D.O. threshold, and reiterated that 4.0 mg/L appeared to be a good threshold acceptability criteria. Pres reiterated that he may consider designating an "Area of Concern" where sturgeon were found in the most recent field investigation. Bridget will take over responsibility for the write-up describing the rationale for habitat criteria we would use to identify suitable habitat in the Savannah River estuary. She will coordinate with both Pres and Mark as she prepares the document.

7. We discussed **American shad**. Bridget reviewed information that she had found. Although Billy McCord (SCDNR) had reported that juvenile American shad are present in the estuary throughout the year, he defined "estuary" as being up to River Mile 100. (For perspective, the upper end of the navigation channel is about R.M. 22, Interstate-95 is about R.M. 28, and Clyo (upper end of tidal influence) is about R.M. 61.) The SCDNR and UGA efforts in the Estuarine Dependent Resources Study didn't find many juveniles in the summer. Ted will check with Cecil Jennings on his opinion of whether juvenile American shad are an important fishery in the estuary. Matt will review GADNR records for locations of juveniles in other river basins. Both will transmit their findings to Bridget. She will revise her write-up to include this information.

8. We concluded by agreeing to have documents to review prior to meeting again. Bridget is preparing the documents for the three remaining species. When she provides drafts of those documents, I will distribute them and schedule another meeting.

William Bailey

Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY FISHERIES COORDINATION

JANUARY 28, 2003

AGENDA

REVIEW OF PREVIOUS MEETING

- Identify Dissolved Oxygen levels throughout the estuary
  - Report 5 % occurrence level every 0.2 miles
  - Runs performed for every species
- Discussion on habitat suitability for four species:
  - Southern Flounder
    - Adults & juveniles; summer months; bottom layer
    - Consider 0.7 suitability threshold for D.O.
  - American shad
    - Juveniles; summer months; bottom layer; D.O >=4.0 mg/l
  - Shortnose sturgeon
    - Winter & summer months
    - Separate "Area of Concern"
- Recent comments by Prescott Brownell on summary of December meeting

CONTINUE WORK ON THESE SPECIES FOR IMPACT ASSESSMENT USING HYDRO MODEL

• Southern Flounder	Bridget Callahan
• American shad	Bridget Callahan
• Shortnose sturgeon	Pres Brownell (& Mark Collins)

WRAP-UP

- Next Meeting

CESAS-PD-E

20 December 2002
Revised

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 19 December Interagency Meeting on Evaluation of Fisheries

1. Attendees:

ATM/GPA:	Bo Ellis
	Bridget Callahan
COE:	Bill Bailey

By phone:

USFWS:	Ed Eudaly
NMFS	Prescott Brownell
SCDNR:	Mark Collins

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. I reviewed our previous meeting and the major conclusions we reached. We completed our work on the Striped Bass application. We decided that no further work was needed to attempt to use the Hydrodynamic Model to the Habitat Suitability Indexes for the following species: Atlantic sturgeon; Red drum; Spotted seatrout; Blue crab; and Shrimp. We will continue work on Shortnose sturgeon; Southern flounder; and American shad.

Review of the Habitat Suitability Index models for red drum, seatrout, crab, and shrimp revealed that these models were generally not designed for use in evaluating changes in salinity or dissolved oxygen. That does not mean that those species are not affected by changes in salinity and D.O., but the models were designed to assess changes in other habitat variables. Rather than spend time developing modified models responsive to D.O. and salinity, it was realized that other species and key life stages could be employed as surrogates for the estuarine fish community. Accordingly, a focus on Shortnose sturgeon, Southern flounder, Striped bass and American shad is appropriate for initial habitat analysis employing the Hydrodynamic Model.

5. We started with a **clarification of the use of the Hydro Model to determine minimum levels of dissolved oxygen (D.O.)**. We had discussed this at our previous meeting, but I was uncertain of exactly what information we should ask the model to produce. We decided that the 5 percent occurrence values should be identified as a measure of the minimum D.O. levels in the estuary. This data should be reported every

0.2 mile along each river in the estuary. The information would not be part of the habitat suitability criteria, but would be additional information to assess the general fishery habitat conditions in the estuary under those flow conditions. At this point, we will request this information for every species that we use the Hydro Model to assist in the evaluation of project impacts.

The Hydro Model can display zones (spatial distribution) of dissolved oxygen under test scenarios. We will then be able to identify changes in area of available suitable habitat under the various test scenarios. The reporting of minimum levels of D.O., as discussed in the previous paragraph) will also allow us to identify any areas with D.O. problems that may develop under the test scenarios.

6. We then discussed **Southern Flounder**. Bridget had been somewhat unsure of what actions she needed to take. Because of the seasonal differences in their occurrence in the harbor, we agreed that the analysis should evaluate habitat for both adults and juveniles. By this decision, we substituted juveniles for larvae from the position we reached at our last meeting. This substitution is due to (1) the occurrence of juveniles in the estuary over a longer duration that larvae, and (2) the temporal overlap of adult's occurrence with that of larvae. Juveniles are present in the estuary over the spring, summer and fall months. We will evaluate the summer months, since the habitat will be most limited during that period due to the requirement for relatively higher D.O. levels. Bridget will review the HSI criteria for D.O. to determine the 0.7 suitability threshold. We expect it is around 4.0 mg/L. Unless she uncovers something to indicate that is not a good number to use, we will use 4.0 mg/L as our criteria. The location in the water column where that would be determined is at the bottom. Bridget will revise the application for this species prior to our next meeting.

7. We then discussed **American shad**. Bridget reviewed that the studies for the HSI had been conducted primarily in northern areas. As opposed to behavior in the north, it is believed that for American shad in the south, (1) adults are not repeat spawners, and (2)juveniles overwinter in the estuary. This species uses two types of habitat in the Savannah River: (1) Riverine -- spawning adults, freshwater, January to May, and (2)Estuary -- juveniles and migrating adults, emergent or submerged vegetation is important, November to March. We will consider that shad juveniles may be in the estuary at any month of the year, particularly summer months, not limited to November to March. Relatively high D.O. is needed by this species. Juveniles need >3.0 mg/L for equilibrium. In the Temporal and Spatial Distribution Study conducted in this estuary, shad were found at locations with D.O. >= 4.1 mg/l. We decided to use 4.0 mg/l as our criterion for acceptable habitat. There is no need to look further at adult habitat because they move through this harbor when the water is cooler, and therefore when the D.O. is higher. We will look at juveniles and use the following criteria: summer months; D.O. >= 4.0 mg/l; bottom layer. Bridget will revise her write-up to include our conclusions and any other information she may find from additional research.

8. We discussed **Shortnose sturgeon**. Salinity and D.O. are critical water quality parameters. In the summer, sturgeon move upriver out of the harbor. Pres indicated we may want to consider designating an "Area of Concern" where no impacts are desired. This area is just above the mouth of the Middle River, where SCDNR found sturgeon during the winter in their most recent monitoring. This designation would be separate from any habitat areas identified by the Hydro Model. He and Mark will try to identify those areas, based on the telemetry study experiences, prior to the next meeting. We agreed that we should look at both winter and summer conditions, since it is believed that these are the two seasons in which the fish are under the greatest environmental stress. Pres will document his and Mark's findings and our discussions, and prepare a paper describing the habitat criteria we could use to identify suitable habitat in the Savannah River estuary.

9. Next meeting: Preliminary date: Tuesday, January 28 starting at 9:30 AM.

William Bailey
Environmental Resources Branch

CESAS-PD-E 23 May 2003

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 21 April Interagency Meeting on Evaluation of Fisheries

1. Attendees:

USFWS:	Ed Eudaly
NMFS	Stephania Bolden
SCDNR	Mark Collins
GADNR-CRD:	Pat Geer
COE:	Bill Bailey

<u>By phone:</u>

UGA-Coop	Cecil Jennings

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. We scanned the conclusions of our previous meeting and used them as a basis for discussions at this meeting.

5. We started with a discussion of the habitat suitability criteria for **Shortnose sturgeon**. I agreed to add a map to show the river miles; possibly one map for the overall river and another for the estuary. We discussed the areas of concern for this species: Juveniles in winter in mouth of Middle River; Adults in winter in Savannah River; Juveniles in summer further upstream in Savannah River. We then discussed several changes to the wording of the document. I recorded the specific recommended changes on a hard copy of the document. We agreed we wanted the DO data from only a portion of the channel cross-section. Where the Hydrodynamic Model grid is 3 cells wide, we want the deepest cell. Where the grid model has >3 cells wide, we want the deepest 2 cells.

6. We then discussed the habitat suitability criteria for **Southern flounder**. We developed several changes to document we reviewed. I recorded the specific recommended changes on a hard copy of the document.

7. We then discussed the habitat suitability criteria for **American shad**. We developed several changes to document we reviewed. I recorded the specific recommended changes on a hard copy of the document.

8. I agreed to send out revised copies of the three habitat suitability criteria we discussed to ensure I had captured all the changes. After we agree on the changes, I would send out the documents again for agency approval.

9. NOTE: I sent out the revised versions on 23 April and on 14 May I sent the final versions out for agency approval. I requested the agencies provide their positions by 6 June.

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY FISHERIES COORDINATION

APRIL 21, 2003

AGENDA

REVIEW OF PREVIOUS MEETING

- Use Hydro Model to also identify Dissolved Oxygen levels when performing analyses of habitat suitability
    - Use to obtain picture of overall health of aquatic environment
    - Report 5 % occurrence level every 0.2 miles
    - Runs performed for every species
- Discussion on habitat suitability for three species:
    - Southern Flounder
        - Adults & juveniles; summer months; bottom layer
        - Consider 0.7 suitability threshold for D.O.
    - American shad
        - Juveniles; summer months; bottom layer; D.O >=4.0 mg/l
    - Shortnose sturgeon
        - Winter & summer months
        - Separate "Area of Concern"
- Discussion of use of degrees of suitability
    - Joint decision to proceed with separating into GOOD or NOT GOOD, and not use intermediate degrees of suitability.

DISCUSSION OF THE WRITE-UPS FOR HABITAT SUITABILITY CRITERIA

- Shortnose sturgeon
- Southern flounder
- American shad

WRAP-UP

- Next Steps

CESAM-PD-E 5 June 2006

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 1 June Meeting of Fisheries Interagency Coordination Team

1. Attendees:

USFWS:	Ed Eudaly
	John Robinette
	Jane Griess
NMFS:	Prescott Brownell
SC DNR:	Priscilla Wendt – by phone
GA DNR-EPD:	Keith Parsons
GA DNR-WRD:	Matt Thomas
EPA:	Gerald Miller
	Ntale Kajumba
COE:	William Bailey
	Hugh Heine
	Joe Hoke
	Gary Mauldin
Observers:	
GPA:	Hope Moorer
	Larry Keegan (CH2MHill)

2. The meeting was held at the USFWS Refuge Office outside of Savannah from roughly 0900 to 1200. The meeting was an information meeting only, not a decision meeting. The Corps was not requesting concurrence from the agencies on the level of impacts predicted for the project alternatives.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. The Corps started by reviewing the process the Team had followed to arrive at this point:

- The Interagency Team had reviewed the fisheries found in the estuary and agreed that impacts should be identified for Striped bass, Southern flounder, American shad, and Shortnose sturgeon.
- The Team had developed measures to define acceptable habitat for those species.
- The intent is to use the hydraulic and water quality models to identify the amount and location of suitable and unsuitable habitat so that potential impacts of the harbor expansion project could be identified and evaluated.
- The Corps combined the habitat requirements and provided them to the hydraulic modelers for running the hydraulic and water quality models.

- The agencies recently approved use of the hydraulic and water quality models for impact evaluation purposes on the Savannah Harbor Expansion Project.
- The modelers had completed their impact runs and prepared a report documenting their findings. The report had been sent to the Interagency Team for review. Errors in the report had been identified and revisions are needed.

5. The Corps distributed a summary it had prepared of the predicted changes in suitable fishery habitats. The summary was based on information in the report that had been updated to reflect recent corrections. The summary was not complete, as the modelers are still in the process of re-doing some runs to correct errors that had been identified since the report was distributed. The group reviewed the summary in a general way and identified the following range potential changes to habitat depending on channel depth:

Striped bass spawning	7 to 19 percent – also depending on river flow condition (high, average or drought)
Striped bass eggs	8 to 25 percent – average flow only
Striped bass larvae	13 to 21 percent – average flow only
Striped bass spawning	8 to 25 percent – average flow only
American shad (Jan)	0 percent – average flow only
American shad (May)	0 percent – average flow only
American shad (Aug)	0.4 to 2 percent – average flow only
Sturgeon adults (Jan)	4 to 7 percent – average flow only
Sturgeon adults (Aug)	6 to 10 percent – average flow only
Sturgeon juveniles	4 to 9 percent – average flow only
Southern flounder	18 to 28 percent – average flow only

6. The group then discussed the summary and impact report. A question arose on how the model was calculating habitat for Striped bass. The grid is one cell wide in the Middle River and upper Back River areas, so lateral averaging is not necessary. Except for one station, those areas are well mixed, as recently confirmed by Paul Conrads (USGS) after reviewing the field data and EFDC model results. Since rivers in the area are well mixed, the group believes that vertical averages of salinity and dissolved oxygen is acceptable for use in predicting Striped bass habitats.

There was surprise expressed that the analysis identified that areas were unsuitable as Shortnose sturgeon habitat only because of failures to meet the salinity criteria. The group had expected some areas to be unsuitable because of low dissolved oxygen conditions. The Corps said it would recheck how the model determined a cell was unsuitable for sturgeon.

A member of the Team requested that information be provided for all habitat analyses – similar to what had been done for Shortnose sturgeon – to show why cells were identified as unacceptable habitat (which criteria they failed to meet).

A member of the Team requested that an additional plot be provided for all habitat analyses to show the location of the areas predicted to be impacted by the alternative (delta plot).

A question arose on what flows were used for the analysis for Figure B.3.2. Were they August 1999 (varied flows) or Historical average flows (constant flow)? The Corps will review and confirm that constant flows were used, matching the other fishery impact runs.

A question arose on the report's prediction of identical impacts for some species in both high and low flow conditions (20 and 80 percentile flows). The Corps reiterated that those results were caused by errors in file management while the models were being run and stated that is was re-running those runs and would send the group the updated information when it becomes available.

A member of the Team requested that the information reported by the Corps contain a clearer description of the percent and percentile used in that particular analysis. The Corps acknowledged the difficulty in keeping this information straight and understandable for those who need to use the information being produced. We will attempt to clarify and better distinguish between the percentile for a parameter (such as percentile river flow from a historical cumulative frequency distribution), and percent exceedence (amount that level is exceeded at a specific location).

A member of the Team requested that information be provided on the cumulative effects of historical changes in the estuary on the habitat volumes of the four selected species. The Corps explained the cumulative impact analysis that it was conducting – using the model to differences in salinity and dissolved oxygen levels between present bathymetry and that recorded in the1850's. The Corps said it would investigate running those results through the post-processor to determine the locations and volumes of acceptable fish habitats.

7. A member of the Team requested that the Corps develop an index of fishery information (reports, MFRs, etc.) that is important to the analyses being conducted in the SH Expansion Project. With such a list, each agency reviewer could ensure that they have a complete record of the critical documents and that thy have the latest version of those documents. The Corps agreed to develop and provide such an index.

8. Except for one individual, most of the members of the team had been present the day before when the Corps presented the preliminary results of the mitigation modeling. Since most of the group had heard that information, the Corps presented the results to that individual after the main meeting was over.

9. The Corps agreed to provide revised Impact Reports to the agencies when those revisions and corrections are complete. The updated report will be provided on CD only. Agency Team members are free to send the Corps any comments they may have after further review of the present Impact Report or review of the revised report.

10. The Corps will continue its work on evaluating potential mitigation measures. When it has developed combinations of mitigation measures that it believes would be effective, the Corps will hold another meeting of the Interagency Coordination Team to share those results. That meeting would be prior to the Corps' completion of a Draft EIS or a request for agency concurrence on the acceptability of the mitigation plans or the project alternatives.

11. After the meeting Ed EuDaly (USFWS) provided an email containing the following points that he wanted to reiterate and clarify:

- I strongly suspect that the wrong salinity criteria was used for the adult sturgeon winter habitat (unless the bottom salinity impact is much higher than anticipated).

- I also suspect that the D.O. criteria used for the sturgeon may have been incorrect. This suspicion is due to the D.O. figures provided that show higher than expected minimum D.O. levels. However, it could be that inapplicable DO information was displayed and the correct information was used in the model run.

- For the baseline and mitigation runs, all maps need to use a uniform salinity scale legend. With the current maps and a sliding scale, interpretation is difficult.

- After further consideration, I believe that all baseline and mitigation runs must display surface, middle and bottom salinity. This display is necessary for a complete understanding of each modification. A great deal of effort has gone into completing the model and it should be fully utilized for decision making. Output can be provided in electronic format to reduce color reproduction cost.

// DRAFT //

William Bailey
Environment and Resources Branch

From:	Bailey, William G SAS
To:	"Steven Davie"
Cc:	Ed Eudaly (E-mail); smtp-Brownell, Prescott; Gerald Miller (E-mail); Jim Greenfield; Paul Conrads; Hoke, Joseph T SAS; Plachy, Douglas H SAS; Larry Keegan (E-mail); Yuri Plis
Subject:	SH Expansion: EFDC and D.O. Model Inputs and Outputs for Fisheries
Date:	Thursday, October 07, 2004 8:02:56 AM
Attachments:	EXPAN H and S Modeling Plan.xls EXPAN Habitat Suitability Criteria - Flounder.doc EXPAN Habitat Suitability Criteria - Shad.doc EXPAN Habitat Suitability Criteria - SNS final.doc EXPAN Habitat Suitability Criteria - Striped Bass.doc

Here are the agreed upon inputs and outputs for identifying impacts to fisheries.

This is a summary table I constructed to combine the input/output information.

Here are the "source documents". They are the documents that we and the agencies used to develop and define the needed/desired input and outputs. Each document describes habitat for a different species. The model inputs and outputs are specified at the end of each document.

BB

Southern Flounder

Habitat Suitability Model Review

Prepared by: Bridget Callahan, Applied Technology and Management, Inc.;
February 20, 2003
Modified by: William Bailey, US Army Corps of Engineers
September 5, 2003

1.0 Summary

This report reviews the habitat suitability index model for the southern flounder (*Paralichthys lethostigma*) (Enge and Mulholland 1985) to determine its applicability to the Savannah River system. First, it proposes a general approach to evaluate impacts of Savannah Harbor modification on southern flounder and describes how the hydrodynamic model can be used for flounder impact assessment. Then, it describes how available information on South Atlantic Bight flounder and Savannah River populations can be applied to fine-tune the model developed for the Gulf of Mexico. Following the caveats described for model application, it identifies water quality and substrate characteristics that mark acceptable habitat for this species, and the general parameters for those characteristics that appear to be optimal and acceptable for flounder based on Enge and Mulholland (1985). Finally, it suggests model outputs and graphical products to help managers and regulators to evaluate project impacts to southern flounder from the proposed deepening.

Uncertainty in the modeling efforts is unavoidable, regardless of the work and care involved in determining suitable habitat parameters. Therefore, intense efforts to replicate the natural system may not result in better decision making because the outputs are only models. The modelers can explain where uncertainty is greatest in the outputs; however, biologists should be clear about where uncertainty lies in their understanding of southern flounder population dynamics.

This report is based on the best available information at the time. The document is developed for impact assessment purposes on projects in the Savannah River estuary and is not to be taken as the definitive work on the biology of this species.

2.0 Introduction

In order to better understand the implications of deepening the harbor on fisheries and the ecosystem, the fisheries working group would like to apply HSI models for species of concern to project alternatives. These species include striped bass, shortnose sturgeon, American shad, and southern flounder. Other species of concern include red drum, spotted seatrout, penaeid shrimp, and blue crab.

The 3-D hydrodynamic model developed by ATM will be used to predict pre- and post-project salinity, temperature, and dissolved oxygen conditions to support impact evaluation. This approach is meant to guide decision-making and evaluation of impacts by resource managers and regulators, not to substitute for the ongoing processes led by the USACE.

Habitat Suitability Model

An existing southern flounder (*Paralichthys lethostigma*) HSI (Enge and Mulholland 1985) was reviewed and found to be suitable for the Savannah River population. However, Gulf of Mexico (GOM) studies in Texas and Louisiana formed the basis for much of the model. Further, because the commercial flounder fishery in the South Atlantic Bight (SAB) is primarily from shrimp bycatch, and not a directed fishery, little information is available on populations in this region. Differences between the GOM and the SAB should be considered in any results of this HSI model/exercise and following discussions. The species are the same and there have not been subspecies identified between the marine provinces, however, the populations are geographically isolated and significant habitat condition differences exist between the regions that may relate to life history differences and requirements.

The Enge and Mulholland (1985) model addresses water quality (temperature, salinity, dissolved oxygen, pH), depth, substrate, vegetation, and food. For the Savannah River project, impact concerns revolve around water quality, particularly salinity elevation and dissolved oxygen depression, particularly during summer months.

3.0 Life History

The factors in the HSI model can be understood better with a brief introduction to the life history requirements of southern flounder. This discussion contains substantial data from the temporal and spatial distribution studies conducted in the Savannah River estuary (Jennings and Weyers 2001, Collins et al. 2001). Those studies were performed during a moderate to severe drought. So, that data are only used as examples.

Seasonal Distribution and Habitat Use

Flounder inhabit the Savannah River in larval through adult life stages, in all seasons. However, this evaluation will focus only on the juvenile and adult life stages. They begin life during the winter in the coastal spawning areas. The larvae and juveniles make their way into the estuary in January through March using tidal currents, the Gulf Stream, and weak swimming abilities. The juveniles settle in tidal creeks and in the shallows near the brackish and salt marsh edges. The flounder leave the tidal creek habitats when they reach adult size (20 to 25 cm) and move into other benthic habitats in the estuary where they spend their first year. The following year, adult flounder move out into the ocean after a sharp drop in the fall water temperature (around September). After spawning in the ocean, they will re-enter an estuary in the spring when the water temperature rises.

SCDNR's gill net and trawl studies found the flounder in the main channel (Front River), Back River, and the South Channel at the northern end of Elba Island in March through

April (Collins et al 2002). While UGA's study found larval and juvenile fish in all seasons, most were caught in the spring and summer (unpublished data). Disparities in the total fish caught between years may hint at high variability in larval and juvenile survival, ingress, transport, etc.

Cover: Substrate Requirements

Flounder are benthic fish that spend most of their lives on or near bottom areas comprised of relatively fine sediment. Preferred habitats include soft bottom areas, vegetated or not, for adults, and shallow marsh fringe and tidal creeks for juveniles. Substrate that allows the flounder to partially bury itself is necessary for them to successfully ambush prey, however, they can change their color to match the background and better conceal themselves. The substrate should be relatively flat (<= 5 % slope) and be partially unconsolidated and fine-grained, such as sand or silt. In laboratory studies, it appears that flounder will endure sub optimal water quality conditions to remain on a preferred substrate. In a tagging and habitat use study of juvenile summer flounder in Chesapeake Bay, Kraus (1998) observed highest catch rates at sites that possessed the following qualities: moderately sloped bottom (1 to 2 degrees), salinities between 4 and 20 ppt, and located within 2 km of submerged aquatic vegetation. The influence of bottom slope was identified as a possible behavioral response, since the slopes form areas of convergence that concentrate phytoplankton, which in turn attract small fish which serve as prey for the flounder.

Prey and Predators

Prey items include grass shrimp, penaeid shrimp, mummichogs, spot, mullet, anchovies, and other fish, depending on the size of the flounder and the availability of the prey throughout the seasons. Predator information was not identified during the review; however, they are considered to be top predators (Hill 2001). Flounder are a significant predator on spot, which are plentiful in the Savannah River.

Water Quality Requirements: Salinity, Dissolved Oxygen, and Temperature

Southern flounder have a wide salinity tolerance and prefer high temperatures. Higher temperatures also spur higher oxygen consumption, however, which is important to consider during critical summer months. For fish caught in the UGA study, dissolved oxygen conditions ranged from 2.9 to 10.7 mg/L. Dissolved oxygen levels above 4.5 mg/L are considered optimal. In laboratory studies, flounder have avoided areas when the DO dropped below 3.7 mg/L.

In estuarine studies reviewed in Enge and Mulholland (1985), flounder were captured in temperatures between 5 and 35°C. In the Savannah River, flounder were caught in temperatures between 6 and 30°C (UGA unpublished data.) Laboratory studies seeking to determine optimal growth temperature found southern flounder juveniles preferred temperatures between 25 and 29°C (van Maaren et al 1999).

While juveniles and adults can tolerate salinities of 0 to 36 ppt, larvae younger than 50 days tolerate salinities as low as 5 ppt. In laboratory conditions, larvae tolerate salinity levels from 0 to 36 ppt (van Maaren et al 1999), field studies have found flounder at salinities of 0.4 ppt or greater. UGA's study found juvenile flounder in marsh edge habitats with salinities as low as 0.4 ppt. UGA found that "larvae were most abundant in oligohaline and tidal fresh water marshes in the winter, but that adults and juveniles were found along the marsh edge and tidal creeks in other salinity zones in all seasons." (Jennings and Weyers 2001). The SCDNR study caught 10 flounder ranging from 80 to 380 mm, in salinity ranging from 0.4 to 13.1 ppt, and in dissolved oxygen ranging from 2.97 to 8.64 mg/L. From a preliminary review of at the UGA data, flounder ranging in length from 17 to 284 mm were found in salinity ranging from 0.1 to 19.7 ppt.

4.0 Impact Analysis Considerations

The impact analysis will rely on a modification of the habitat suitability model which was developed for flounder larvae and juveniles. The model will be adapted by using only the critical life stages and variables that will be impacted by the proposed project and by using site-specific data from various studies. The habitat quality for adult and juvenile life stages will be evaluated as follows.

Water Quality Considerations

The model includes a water quality component for salinity, bottom water temperature, and average minimum dissolved oxygen. For all three parameters, the water column 10 to 15 cm above bottom is the area of concern. For temperature and dissolved oxygen, the critical period season (May to August) is considered. These boundaries focus the model outputs. Adults tolerate up to full sea strength and spawn offshore. Optimal salinity for adults is given as 0 to 20 ppt. Many of the flounder captured in the study described above are small juveniles, and they were often found at salinities below 5 ppt. This may require an adjustment for juvenile life stages. Flounder are generally not found far above the estuary. Water temperature for juveniles is given as over 30° C, and it decreases as the fish grow older. From May to August, Enge and Mulholland (1985) give a 20 to 35° C range as optimal. For dissolved oxygen, 3.0 mg/L is given as the lower limit, with 4.5 mg/L and over considered optimal.

Cover and Substrate Considerations

Areas with muddy substrates are considered to have the best habitat. Enge and Mulholland (1985) do not include vegetative cover because flounder are found in vegetated and unvegetated substrates, however, tidal marsh edge and vegetated flat habitats are important for juveniles because they offer greater cover as well as prey concentrations. In order for flounder to bury partially and conceal themselves, the substrate should be partially unconsolidated. The river bottom currently has areas that are soft, especially if operations and maintenance materials settle there, as well as areas that are scoured and relatively compacted. Areas where the Miocene level is exposed may be rather compacted, for example. Channel banks or side slopes that exceed a 5 % grade are generally unsuitable for flounder.

The bottom substrate of the river may change following the proposed deepening project due both to direct impacts of dredging and to indirect impacts from a change in salinity pattern that affects sedimentation processes. The harbor generally experiences a high shoaling rate, in some areas up to one foot per month. Channel maintenance sediments from the inner harbor are generally fine-grained silts. Even though clay areas may become exposed during a harbor deepening, the high shoaling rate would quickly cover up those areas with silty material again. After that covering has occurred, the bottom substrate exposed to flounder would be the same as it had before the deepening took place. Changes in salinity patterns may result in an upstream shift of sedimentation locations. However, we believe that this potential impact on substrate composition will not significantly affect flounder habitat in the project area.

5.0 Suitability Criteria

To display pre and post project suitable habitat for this species, the hydrodynamic model can be used to compare areas where the criteria shown below occur before and after the project under various flow scenarios at the bottom layer of the water column.

Juveniles are present in the lower estuary during the spring, summer, and fall months. For this effort, only the bottom of the water column will be considered. Their suitable dissolved oxygen would be 4.0 mg/L or greater, because 4.0 mg/L is considered the threshold for suitable habitat using a 0.7 index level rather than a 1. Adults are present during the winter when dissolved oxygen levels usually remain higher than 4.0 mg/L. It appears that salinity tolerance is so wide that it can be disregarded for this species. The I-95 Bridge is selected as the upstream boundary for this evaluation based on field experiments that found salinity exceeded 0.4 ppt downstream of that location. The entire river cross-section should be analyzed. Areas where the bottom slope exceeds 5 % do not provide suitable habitat and should be deleted from the analysis. This should be determined by using the maximum and minimum depth and width in each cell along the river bottom. No slope calculations are necessary for the bottom of the navigation channel, which is assumed to be flat.

The southern flounder habitat suitability criteria for impact evaluation purposes in the Savannah River estuary can be summarized as follows:

Life Stage	Adults	Juveniles
Time of Year	Summer	Same
Dissolved Oxygen	4.0 mg/L	Same
D.O. Exceedance	10 %	Same
Temperature	Normal August	Same
River Flow	Normal August	Same
Location – depth	Bottom layer	Same
Location – slope	<= 5 %	Same
Location – upstream limit	I-95 Bridge	Same

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American Shad

Habitat Suitability Model Review

Prepared by: Bridget Callahan, Applied Technology and Management, Inc.:
February 25, 2003
Modified by: William Bailey, US Army Corps of Engineers
April 23, 2003

1.0 Introduction

In order to better understand the implications of deepening the harbor on fisheries and the ecosystem, interagency coordination with natural resource agencies led to a decision to apply habitat suitability index (HSI) models for species of concern to evaluate potential impacts from project alternatives. ATM's hydrodynamic model will be used to portray suitable habitat before the proposed project and under various project alternatives. Criteria for striped bass, shortnose sturgeon, and southern flounder have been developed.

Through interagency coordination, it was decided that the HSI model for the American shad (*Alosa sapidissima*) (Stier and Crance 1985) would require modification for use in the Savannah River. This report reviews the HSI model and available unpublished and anecdotal information on shad in the Savannah River system to adjust the model for this estuary. Based on guidance from National Marine Fisheries Service, it includes special attention to dissolved oxygen and salinity tolerance, seasonal occurrence, and habitat preferences including depth, diel migration, and key bottom types. Suggestions to consider the combined effects of temperature, salinity, and dissolved oxygen could not be fulfilled due to a lack of information.

This report is based on the best available information at the time. The document is developed for impact assessment purposes on projects in the Savannah River estuary and is not to be taken as the definitive work on the biology of this species.

2.0 American Shad Life History

The American shad is a widespread anadromous species, inhabiting the Atlantic Ocean from the St. Lawrence River to the St. Johns River, and the Pacific Ocean, (where it is not native), from Cook Inlet, Alaska to Baja California. It is most abundant in colder waters and not a common species south of North Carolina; therefore, most of the research and available literature comes from the northern part of their range. Main differences between northern and southern stocks appear to include the protracted out-migration and over-wintering of juveniles, and minimal repeat spawning in southern stocks.

Shad are fast-swimming, schooling planktivorous fish. They spend most of their lives in large schools in the ocean. At 4 to 6 years of age, they return to their natal rivers to spawn. The adults typically die after spawning in the southeast; in the northern extent of their range, they may return to spawn several times. In the southeast, shad spawn far upstream in freshwater during the winter and early spring, from January to April. The semi-buoyant eggs are released in the water column, and like striped bass eggs, require enough velocity to remain suspended until hatching. Time to hatching is likely 4 to 6 days.

Larval and juvenile shad spend their first spring and summer in the river, utilizing freshwater habitats before emigrating to the ocean in the late summer and fall. In the north, outmigration is cued by water temperature. In southern rivers, however, outmigration may be dictated by individual size and availability of food in the estuary. This has lead to a theory about shad out-migration called "grow and go." Studies from the Altamaha River found that juveniles leave the estuary once they have reached 90 to 100 cm (Goodwin and Adams 1969). In order to increase their fat reserves in the estuary before leaving for the ocean, juvenile shad may spend time in the lower Savannah River during the summer when water quality is most poor. For example, the Temporal and Spatial Distribution Study (TSD Study) found many juvenile shad in the lower river during the summer.

Savannah River Shad

Little information exists on the Savannah River shad; to date, no study has focused on this species in this river. Knowledge of southern stocks derive from studies in the Ogeechee, Altamaha, and Santee-Cooper River systems (Smith 1968, Goodwin and Adams 1969, Probst 1988, Cooke and Chappelear 1994, Boltin 1999), and communications with commercial fishermen, researchers, and resource managers summarized in a literature review included as an appendix to this report (Applied Technology and Management, Inc. 2000).

The Savannah River shad population size is unknown. Trawl and gillnet catches from the TSD Study included approximately 37 larvae and juveniles and 60 adults during two years of sampling (Jennings and Weyers 2001, Collins et al. 2002). While few shad were caught in the surveys, as fast swimmers, shad may avoid the gear types used to characterize the fish community (pers. comm. Billy McCord, SCDNR). Shad are present in sufficient numbers to support a commercial fishery on the Savannah River, the season for which runs from January 1 to March 31. The low catch rate of the TSD Study does not necessarily mean a low population of shad in the river. In fact, some resource managers believe that the shad population in the river has been robust and stable for the last 20 years. However, using catch rates to estimate population levels could be misleading because the level of effort is not known (McCord, pers. comm.).

3.0 Habitat Suitability Criteria

Seasonal Distribution

Adult shad enter the river from January to May to spawn. For most, this is a one-way journey. Based on Charleston SC studies, the juveniles likely migrate out of the river from November to March, but some fish may stay through the summer to feed (McCord, pers. comm.). This may be related to food availability in nursery habitat. While not well documented, juveniles may spend the summer in the upper estuary, above RM 40, and may not be affected by any changes in salinity from the Expansion Project or recent drought. It seems unlikely that juvenile shad are in the lower estuary during the sensitive summer period, however they would require suitable habitat (temperature and dissolved oxygen) during out-migration.

Habitat Use and Preference

Shad use all areas of the water column and juveniles may concentrate at drop-offs or in deep main stem channels adjacent to sandy banks or sand bars, and do not like backwater areas, sloughs, or other low flow habitats (Godwin and Adams 1969). The adults are often captured in deep parts of the channel during shrimp trawls in Charleston, and it appears that they are negatively phototropic (McCord, pers. comm.). However, they are known rise to the surface to feed at night.

For spawning, shad can use any part of the water column but appear to prefer broad shallow flats with sufficient velocity to eliminate silt accumulation. Optimal water velocities for spawning appear to range between 30 to 91 cm/second. However, they have been observed spawning in depths to 12 m. Turbidity greater than 100 ppm appears to be a problem for larvae (Auld and Schubel 1978 in Stier and Crance 1985).

Prey and Predators

Shad are planktivorous, straining small prey through their gill rakers. Juvenile and larval shad eat small insects at the surface of the water and small crustaceans caught in the water column. The adults eat plankton such as shrimp and other small crustaceans, and small fishes, but do not eat while migrating upriver to spawn. Stier and Crance (1985) focus on vegetation as an important habitat factor because it would be a proxy indicator of high zooplankton and other food abundance. They assign 50% cover of vegetation as the optimal level for habitat suitability.

Temperature Preference

Shad in the Savannah River are at the southern extent of their range, and most do not reside in the project area during the summer months when the temperatures are highest. Optimal water temperatures for spawning appear to lie between 14 to 20° C. For juvenile shad, optimal near bottom water temperatures range between 10 to 25° C. Temperatures below 3° and above 35° are considered unsuitable.

Dissolved Oxygen Tolerance

Shad eggs and larvae may require levels of 5.0 mg/L or more for growth, and the lethal dose necessary to kill 50% of a test population of eggs and larvae was between 2.5 and 2.9 mg/L (Bradford et al. 1966 in Stier and Crance 1985). For juveniles, some data show that they require greater than 3.0 mg/L to maintain equilibrium, while others show mortality at level of 5.0 mg/L and that such a level of dissolved oxygen would create a lethal barrier for migration (Ellis et al. 1947 in Stier and Crance 1985). In the Savannah River, all life stages (except eggs) of shad were captured during the TSD Study in dissolved oxygen levels ranging from 4 to over 9 mg/L. However, in Collins et al 2000, only four juveniles were found in waters with 4 to 5 mg/L of dissolved oxygen, and only one was found in waters containing 5 to 6 mg/L. No information was available on synergistic effects of dissolved oxygen depression and high temperatures; however, such data would be relevant for Savannah River concerns.

Salinity Preference

Shad are tolerant of a wide range in salinity. However, they require a period of adaptation when entering freshwater from the ocean that takes approximately 2 to 3 days (Dodson et al. 1972 Leggett 1976 in Stier and Crance 1985). Although they begin life in freshwater, the eggs and larvae are also very tolerant of salinity up to 15 ppt (Leim 1924 in Stier and Crance 1985).

4.0 Impact Analysis Considerations

The project concerns revolve around water quality, particularly salinity elevation and dissolved oxygen depression, particularly during summer months. Review of the existing American shad HSI (Stier and Crance 1985) found it suitable for the Savannah River population. Differences between the northern populations and the southern extreme ranging populations should be considered in any results of this HSI model/exercise and following discussions.

In regards to potential effects on dissolved oxygen and salinity from the proposed project shad appear to be most sensitive to dissolved oxygen. However, their wide salinity tolerance may allow them to access areas of the river with higher dissolved oxygen that fish such as sturgeon, which have a narrower tolerance for salinity, would not find suitable. Synergistic effects of dissolved oxygen and temperature may also be more important in the Savannah River due to increased stress and metabolic requirements from high temperatures and low dissolved oxygen. If unfavorable conditions prevailed during the critical summer months, shad may outmigrate to the ocean. Conversely, if the young of the year can put on the required weight and are not of sufficient size to survive ocean life then they may remain in the food-rich estuary until they are physiologically prepared for this transition.

Suitability Criteria

The most important habitat for this species in the estuary that could be affected by the Expansion Project is that used by outmigrating juveniles. This outmigration could occur at any time of year. For impact evaluation purposes for this estuary, the habitat would be considered suitable when the following conditions are met:

Life Stage	Juveniles	Juveniles	Juveniles
Time of Year	Spring	Summer	Winter
Dissolved Oxygen	4.0 mg/L	Same	Same
D.O. Exceedance	10 %	Same	Same
Temperature	Normal May	Normal August	Normal January
River Flow	Normal May	Normal August	Normal January
Location – depth	Top half of water column	Same	Same

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Shortnose Sturgeon

Habitat Suitability Model Review

Summarized by: **Bridget Callahan, Applied Technology and Management, Inc.**

March 14, 2003

Modified by: **William Bailey, US Army Corps of Engineers**

October 31, 2003

1.0 Introduction

The shortnose sturgeon (*Acipenser brevirostrum*) was federally listed as an endangered species in 1967. This smallest of sturgeons is long lived, and reaches sexual maturity at 3 (for males) and 6 years of age (for females) in southern populations. Its populations have dwindled due to habitat loss, pollution, and fishing mortality from by-catch (especially in shad gill nets) and poaching for its valuable roe. Unlike other anadromous species, such as American shad, shortnose sturgeon do not spend much time in the ocean. They spend most of their lives near the bottom of fresh and brackish rivers and estuaries, a habitat that is vulnerable to water quality degradation and other impacts. Damming rivers has been particularly devastating, because, like some salmon species, it spawns in the upper reaches of its natal rivers.

Identifying potential impacts to the shortnose sturgeon due to the Savannah Harbor Expansion Project is more complicated in a regulatory sense than for the other species (striped bass, southern flounder, American shad). Endangered status requires compliance with the ESA and specific consultation procedures. The Expansion Project raised concerns about this fish because it is endangered and because it spends much of its life in the interface between fresh and saltwater, where potential project impacts to salinity and dissolved oxygen may occur. As a result of interagency coordination on fisheries for this project, the habitat suitability index (HSI) developed for this species (Crance 1986) was considered less than useful for the Savannah River. The HSI focuses on temperature, velocity, and substrate and the effects these variables have on summer habitat and spawning and incubation. Because these variables are not expected to be affected by the Expansion Project, or the activity occurs outside the project effect area (spawning), the scientists agreed to develop site-specific criteria for suitable estuarine habitat.

Based on guidance from the National Marine Fisheries Service, this report describes general population status, range, habitat requirements, existing habitat models, and environmental variables applicable to the Savannah River estuary, including temperature, dissolved oxygen, and salinity. This information will help identify suitable habitat areas before and after the Expansion Project.

The information and ideas presented in this report are the result of a literature review and consultation with personnel at the South Carolina Department of Natural Resources and the National Marine Fisheries Service. This report does not synthesize the available literature on this population, and review of Habitat Use and Movements of Juvenile Shortnose Sturgeon in the Savannah River, Georgia-South Carolina (Collins et al. 2002) is strongly suggested for more background.

This report is based on the best available information at the time. The document is developed for impact assessment purposes on projects in the Savannah River estuary and is not to be taken as the definitive work on the biology of this species.

2.0 Population Status

Shortnose sturgeon live in the main stems of coastal rivers from the Saint John River in New Brunswick, Canada to the St. Johns River in Florida. Because they do not generally migrate between river systems, each one is considered a "population segment." However, they do sometimes exhibit coastal movement. Fish from the most northerly populations use saline estuarine waters more than fish from southern populations, while fish from mid-Atlantic populations use saline waters the least (Kynard 1997). This behavior suggests a variable degree of reproductive isolation of riverine populations by region. A recent genetic study (Wirgin et al, in press) concludes that the present Savannah River population can be considered genetically distinct from those found in the nearby Ogeechee River. Another recent genetic investigation (Quattro et al., 2002) determined that the Savannah River fish were most closely related to the Edisto River fish, and confirmed that fish from the Savannah and Ogeechee Rivers were genetically distinct. Figure 1 from Quattro shows that relationship. However, it should be noted that there is a dominant SE haplotype that is found in many of the fish from the SE that complicates the analysis. Hatchery-reared offspring were used to restock the Savannah River from 1987 to 1992. Recent evidence indicates that a moderate percentage of hatchery-reared offspring have moved into other nearby rivers in the southeastern U.S., including the Ogeechee River, GA (Smith et al. 2002), perhaps compromising the genetic integrity of recipient populations. Southeastern populations face threats such as habitat loss and water quality degradation, and all *natural* populations are below the critical level of 1000 individuals (Kynard 1987).

Shortnose sturgeon populations in Georgia include the Savannah, Altamaha, Satilla and Ogeechee Rivers. The Altamaha River population appears to be the largest and healthiest of those south of Cape Hatteras (NMFS 1998). Exact population sizes are unknown for Savannah, but stocking efforts put approximately 97,000 hatchery-reared juveniles in the river between 1984-1992 (Smith and Jenkins 1991), allowing the population to reach an estimated size of over 1600 (Ted Smith, personal communication, in Kynard 1997). However, high adult to juvenile ratios indicate low recruitment and an artificially elevated adult population from stocking (Collins and Smith 1993, Collins et al. 2002). Studies in the nearby Ogeechee River also indicate low juvenile abundance compared with adults (Weber 1996).

GENETIC SIMILARITY OF

GA & SC SHORTNOSE STURGEON

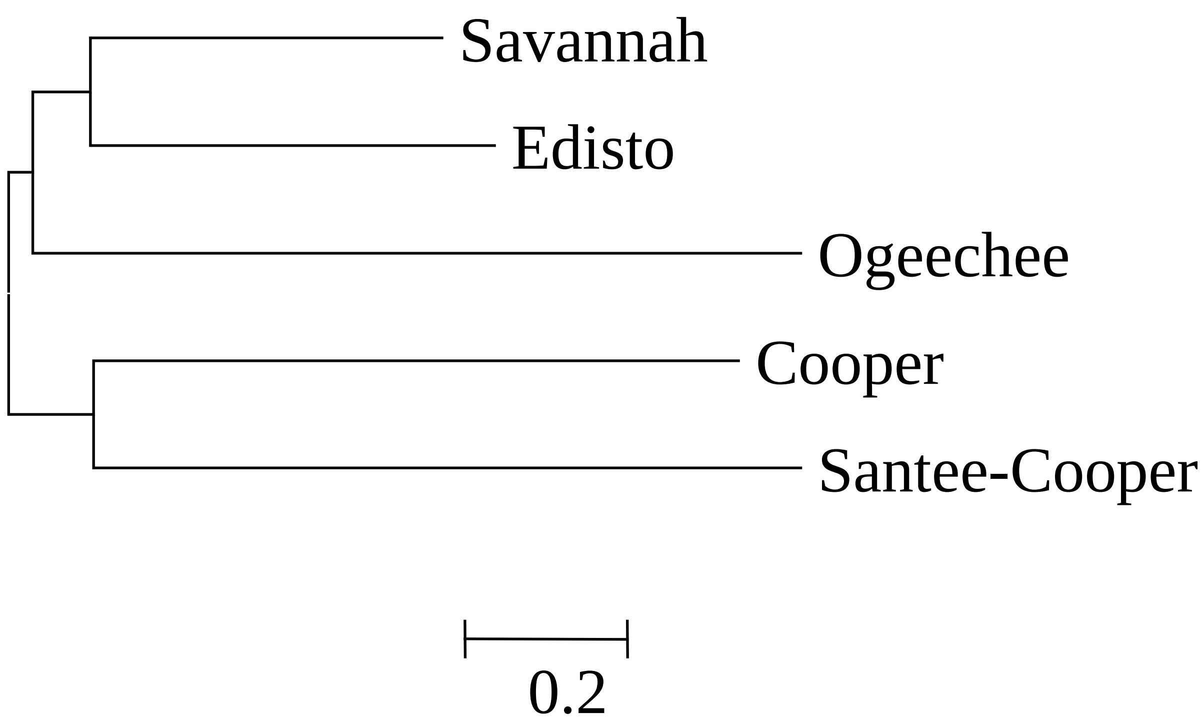

Figure 1

3.0 Seasonal Distribution and Habitat Requirements by Life Stage

Researchers from the South Carolina Department of Natural Resources (SCDNR) have been conducting research on Savannah River shortnose sturgeon since 1985. Experiments with hatchery raised sturgeon and field studies conducted by Mark Collins, Wayne Hall, Wally Jenkins, Bill Post, Ted Smith, and others provided most of the following information. Please see the Literature Cited and Selected References for helpful reports and publications.

Spawning Life Stage

As with most fish, southern populations of shortnose sturgeon mature earlier than northern ones: females reach sexual maturity at approximately 6 years, and males reach it at 3 years. In early February to late March, shortnose sturgeon spawn far upstream in freshwater. In most population segments, sturgeon spawn at the uppermost river reaches that are accessible. Damming rivers has blocked passage to many spawning grounds as a result; fortunately, the Savannah River is not dammed until just below the fall line. Hall et al. (1991) identified potential spawning sites at river kilometer (RKM) 179 to 190 and 275 to 278 (see Figure 2). Spawning habitat is well upstream of the project influence, in channels and curves in gravel sand, and log substrate in the Savannah River (Hall et al. 1991). Other suitable substrates include riffles near limestone bluffs with gravel to boulder-sized substrate (Rogers and Weber 1995). Spawning lasts for about 3 weeks, beginning when water temperatures are at about 8 to 9° C, and ending when it reaches approximately 12 to 15° C. The spent fish migrate downriver from March to May, and spend the summer from June to December in the lower river (Hall et al. 1991). Females likely do not spawn every year, while males may do so.

Adult Life Stage

Adult shortnose sturgeon migrate extensively through the river system. Observations indicate that they seek relatively deep, cool holes upriver for sanctuary from warm temperatures (and possibly to escape low dissolved oxygen coupled with salinity stress), and in the winter, they migrate downstream to the estuary, perhaps to feed or escape extreme cold.

In 1999 and 2000, Collins et al. (2001) tracked adult and juvenile sturgeon in the Savannah River and identified distinct summer and winter habitats in terms of location and water quality (Table 1). Therefore, through the interagency coordination on fisheries, it was agreed decided to divide habitat requirements into winter and summer needs. When temperatures are less than 22° C, it appears that both adult and juvenile sturgeon stay in the lower river, particularly around RKM 31, where the Middle and Front Rivers meet (Figure 2). During warmer periods when temperatures exceed 22° C, their telemetry observations and gill net surveys indicated that sturgeon use the upper estuary, especially the area around RKM 47. When the fish were observed in this upper area, the salinity was very low: 0.1 parts per thousand (ppt).

Table 1. Mean water temperature, salinity, and dissolved oxygen (D.O.) by season at locations where adult shortnose sturgeon were found. Reproduced from Collins et al. 2001.

Season	°C	Salinity (ppt)	D.O. (mg/L)
Spring	19.9	1.4	7.84
Summer	27.3	2.0	6.36
Fall	21.1	3.3	7.06
Winter	12.3	5.4	8.36

The adult sturgeon tagged by Collins et al. (2001) were also tracked as far downstream as the river's mouth. They can be very mobile, provided the temperatures are not stressfully high. While they are known to occur in 4 to 33° C, sturgeon show signs of stress at temperatures above 28°, and this stress may be exacerbated by low dissolved oxygen conditions during summer critical months. We believe that sturgeon seek thermal refuges during these periods, deep cool waters where salinity conditions are appropriate and food is available with minimal foraging movements. For example, Flournoy et al. (1992) found that sturgeon may use spring-fed areas for summer habitat in the Altamaha River system. The synergistic effects of high temperatures and low dissolved oxygen should be considered in any impact analysis. Based on work done in the Chesapeake Bay, sturgeon may suffer an "oxygen squeeze" in the summer when they seek deep cool areas that also have low dissolved oxygen (Secor and Niklitschek, 2001).

Juvenile Life Stage

Juvenile shortnose sturgeon mature at approximately 3 to 6 years of age, and they live in the salt/fresh interface in most rivers. After spending their first year in the upper freshwater reaches, they adopt the adult migratory lifestyle and go upriver in the summer and down in the winter. Like adults, they need sand or mud substrate for foraging (Hall et al. 1991). They are less tolerant of low dissolved oxygen and high salinity than the adults and appear to migrate accordingly within the river system. For example, when temperatures exceeded 22° C in the Savannah River, they spend the summer in deep (5 to 7 m) holes with 0 to 1 ppt salinity levels (Collins et al. 2001 see Table 2). During the winter, they use the warmer estuarine-influenced lower river. For example, they move into more saline areas (0 to 16 ppt) when temperatures dropped below 16° C in the Ogeechee River. Warm summer temperatures over 26° limit movement of juveniles who may not be able to forage extensively during summers.

Table 2. Mean water temperature, salinity, and dissolved oxygen by season at locations where juvenile shortnose sturgeon were found. Reproduced from Collins et al. 2001.

Season	**°C**	**Salinity**	**D.O.**
Spring	20.4	2.4	7.58
Summer	28.5	0.3	6.8
Fall	21.7	4.7	6.45
Winter	12.5	8.6	8.63

Tolerance to both dissolved oxygen and salinity is thought to increase with age; very young sturgeon are known to be extremely sensitive to both (Jenkins et al., 1993). For example, Jenkins et al (1993) reported that in a 6-hour test, fish 64 days old exhibited

86% mortality when exposed to dissolved oxygen concentrations of 2.5 mg/L. However, sturgeon >100 days old were able to tolerate concentrations of 2.5 mg/L with<20% mortality. Jenkins also reported that dissolved oxygen at less than 3 mg/L causes changes in sturgeon behavior: fish hold still and pump water over their gills, an apparent adaptation to survive low dissolved oxygen conditions. If fish spawn in the spring, it is believed that late age 0 individuals encounter these low dissolved oxygen conditions in the lower estuary. EPA (Chesapeake Bay Program Office) recently revised its D.O. criteria for living resources in Chesapeake Bay tributaries from 2.0 mg/L to 3.5 mg/L to be protective of sturgeons. This was based on work done by Secor and Gunderson 1998 and Niklitschek and Secor 2000 for the Chesapeake Bay, a colder environment. It is possible that 3.5 mg/L may be acceptable, but 4.0 mg/L would be safer for the higher temperatures in this southern river. As with adults, temperatures above 28° reduce tolerance to low dissolved oxygen (Flournoy et al. 1992).

Egg and Larval Life Stages

The demersal, adhesive eggs hatch in freshwater, and develop into larvae within 9 to 12 days. Larvae start swimming and initiate their slow downstream migrations at about 20 mm in length. It is generally agreed that shortnose sturgeon larvae are not in the project impact area. No shortnose sturgeon larvae (including ichthyoplankton and ichthyofauna) were found in a recent 2-year study in the Savannah River estuary ("Temporal and Spatial Distribution of Estuarine-Dependent Species in the Savannah River Estuary" conducted by UGA, in press). However, an Atlantic sturgeon (*A. oxyrinchus*) larva was found at approximately RKM 41 during a recent ichthyoplankton study (Reinert et al. 1998). The maintained harbor extends up to RKM 34.3.

4.0 Prey and Predators

Soft sediments with abundant prey items such as macroinvertebrates are thought to be preferred by shortnose sturgeon for foraging, so established benthic communities are likely important. They are thought to forage for small epifaunal and infaunal organisms over gravel and mud by sucking up food. A few prey studies have been conducted and prey include small crustaceans, polychaetes, insects, and mollusks. Sturgeon forage by slowly swimming along the bottom, lightly dragging their barbels until they feel something that may resemble food at which time they suck it up in their protrusible mouths. The non-food items are expelled through their gills. Juveniles may be even more indiscriminate, and just vacuum their way across the bottom.

The HSI for shortnose sturgeon addresses food availability as a major habitat criterion. The hydrodynamic model does not contain any data on this matter, nor does a substrate map exist in readily adaptable format, so through the interagency coordination, it was decided to omit this parameter from evaluation.

5.0 Suitability Criteria

Previous efforts for striped bass, American shad, and southern flounder established a threshold level for salinity and/or dissolved oxygen so that suitable habitat could be displayed before and after the proposed project. For shortnose sturgeon, this effort is complicated by the interactions between salinity, dissolved oxygen, and temperature for the juvenile and adult life stages, as well as their migration patterns.

Based on the known effects of dissolved oxygen, temperature, and salinity during the critical summer months, a safe threshold for suitable habitat appears to be approximately 4.0 mg/L in the bottom meter of the water column when temperatures exceed 26°, and 3.5 mg/L when they do not exceed that temperature threshold. While Chesapeake Bay established 3.5 mg/L as acceptable in a similar effort, the synergistic effects of high temperatures and low dissolved oxygen found in the Savannah estuary should be incorporated in some manner. While sturgeon can survive in lower oxygen levels, that level may not meet the definition of good habitat and the fish is likely being stressed. In addition, prolonged exposure to these lower oxygen levels may not produce acute impacts to fish health, but would result in extended periods of stress that would likely result in chronic or delayed complications to fish health that could influence condition, reproduction or survival.

Salinity criteria are more complicated due to the migration patterns of sturgeon and various tolerance levels by life stage. For juveniles at age 1, salinity levels between 0 and 4 ppt could be considered suitable habitat. For adults, salinity from 0 to 17 ppt could be considered appropriate. However, for both juveniles and adults, salinity tolerances are likely related to temperature.

During the winters of 1999-2000, juvenile shortnose sturgeon consistently utilized a deep hole in Middle River near the confluence with the Front River. These juveniles enter and exit the Middle River area through its connection with the Front River. Therefore, predicted impacts in that area and also to the migratory pathway in the Front River should be carefully considered when interpreting the results of the habitat suitability analysis.

The shortnose sturgeon habitat suitability criteria for impact evaluation purposes in the Savannah River estuary are summarized in Table 3 on the following page.

Table 3. Summary of shortnose sturgeon habitat suitability criteria in the Savannah River Estuary

Life Stage	Adults	Adults	Juveniles
Time of Year	Winter	Summer	Winter
Salinity	<= 25 ppt	<= 10 ppt	<= 4 ppt
D.O. Exceedance	10 %	Same	Same
Dissolved Oxygen	3.5 mg/L	4.0 mg/L	3.5 mg/L
D.O. Exceedance	5 %	Same	Same
Dissolved Oxygen	3.0 mg/L	3.0 mg/L	3.0 mg/L
D.O. Exceedance	1 %	Same	Same
Dissolved Oxygen	2.0 mg/L	2.0 mg/L	2.0 mg/L
Temperature	Normal January	Normal August	Normal January
River Flow	Normal January	Normal August	Normal January
Location – depth	Bottom layer	Same	Same
Location – width	Where Hydrodynamic Model is 3 cells wide, use deepest cell; where >3 cells wide, use deepest 2 cells	Same	Same

Model outputs would also include the following:

1. Identification of why cells at a given location were determined to have unsuitable habitat; whether they failed the salinity or the Dissolved Oxygen criteria.

2. Displaying the 1%, 5% and 10 % D.O. contours on a map.

3. On the maps that show the suitable habitat for sturgeon in the Existing or Without Project Condition, display the locations of where sturgeon were found (by age and season) in the Collins et al 2002 study.

6.0 Other Recommendations

The Shortnose Sturgeon Recovery Team (NMFS 1998) notes that sturgeon essential habitat can be easily portrayed in GIS format. Putting the data into a GIS database to share with the natural resource agencies and other interest groups may be helpful for visualizing the sturgeon's migrations and habitat needs. For example, SCDNR has suggested showing the conditions at the Middle River nursery area during the times the sturgeon are there and displaying what the conditions would be like after the Expansion Project to assess changes to potential nursery habitat.

Graphically documenting important habitat areas would make a practical addition to the decision-making support system. National Marine Fisheries Service has recommended designating "Areas of Concern" that may serve as important habitat, for example, the confluence of the Middle and Front Rivers where juveniles occupied a deep hole during the winters of 1999-2000. Efforts towards establishing such areas should consider that persistence of these sites under a range of flow conditions is unknown and use by sturgeon may change from year to year. For example, Hall et al. (1991) noted that juvenile Atlantic and shortnose sturgeon used the Kings Island Turning Basin in 1985-1987; however, none were captured there during 1999-2000 (Collins et al. 2002).

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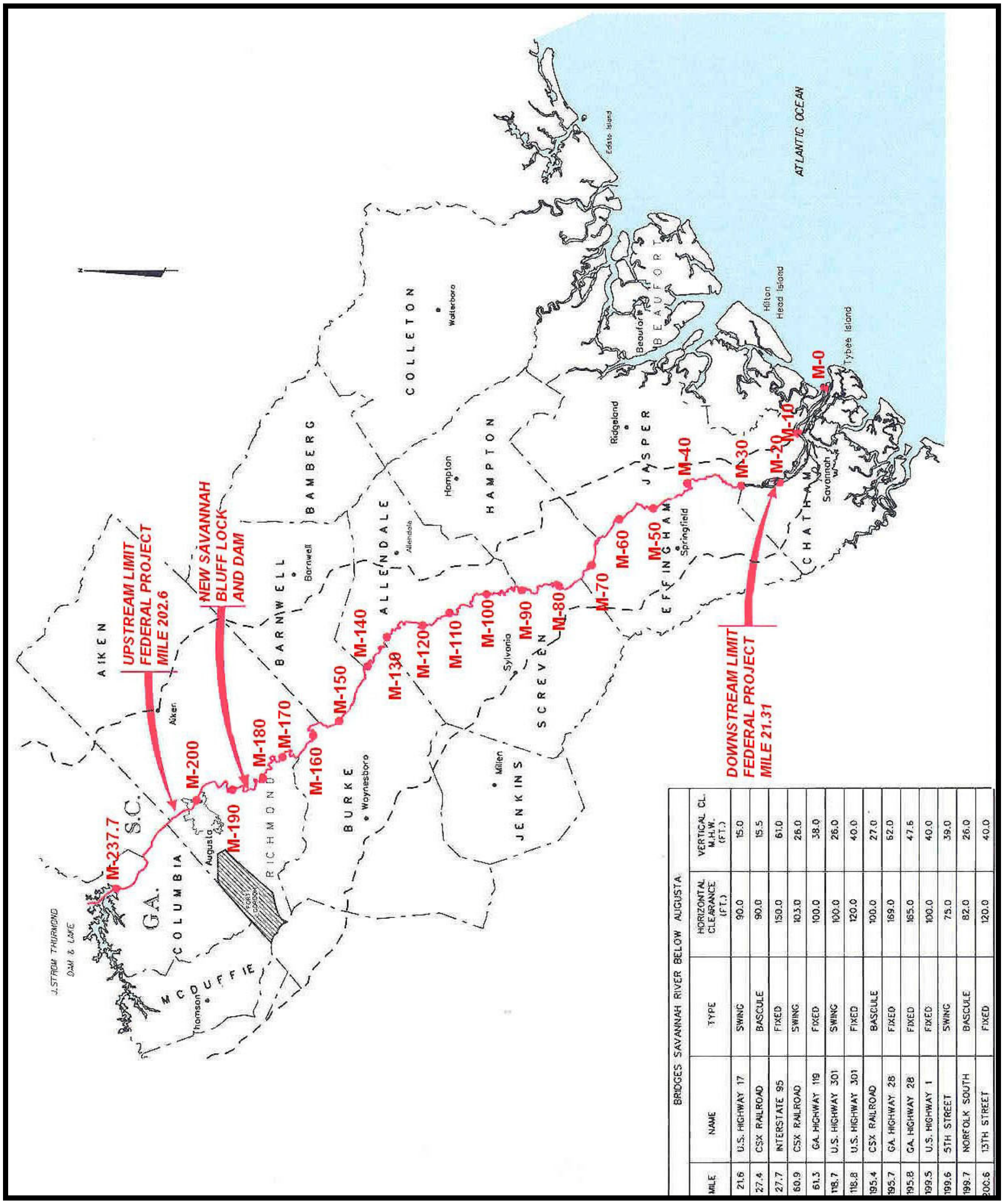

BRIDGES SAVANNAH RIVER BELOW AUGUSTA

MILE	NAME	TYPE	HORIZONTAL CLEARANCE (FT.)	VERTICAL CL. M.H.W. (FT.)
21.6	U.S. HIGHWAY 17	SWING	90.0	15.0
27.4	CSX RAILROAD	BASCULE	90.0	15.5
27.7	INTERSTATE 95	FIXED	150.0	61.0
60.9	CSX RAILROAD	SWING	103.0	26.0
61.3	GA. HIGHWAY 119	FIXED	100.0	38.0
118.7	U.S. HIGHWAY 301	SWING	100.0	26.0
118.8	U.S. HIGHWAY 301	FIXED	120.0	40.0
195.4	CSX RAILROAD	BASCULE	100.0	27.0
195.7	GA. HIGHWAY 28	FIXED	169.0	62.0
195.8	GA. HIGHWAY 28	FIXED	165.0	47.6
199.5	U.S. HIGHWAY 1	FIXED	100.0	40.0
199.6	5TH STREET	SWING	75.0	39.0
199.7	NORFOLK SOUTH	BASCULE	82.0	26.0
200.6	13TH STREET	FIXED	120.0	40.0

Figure 2

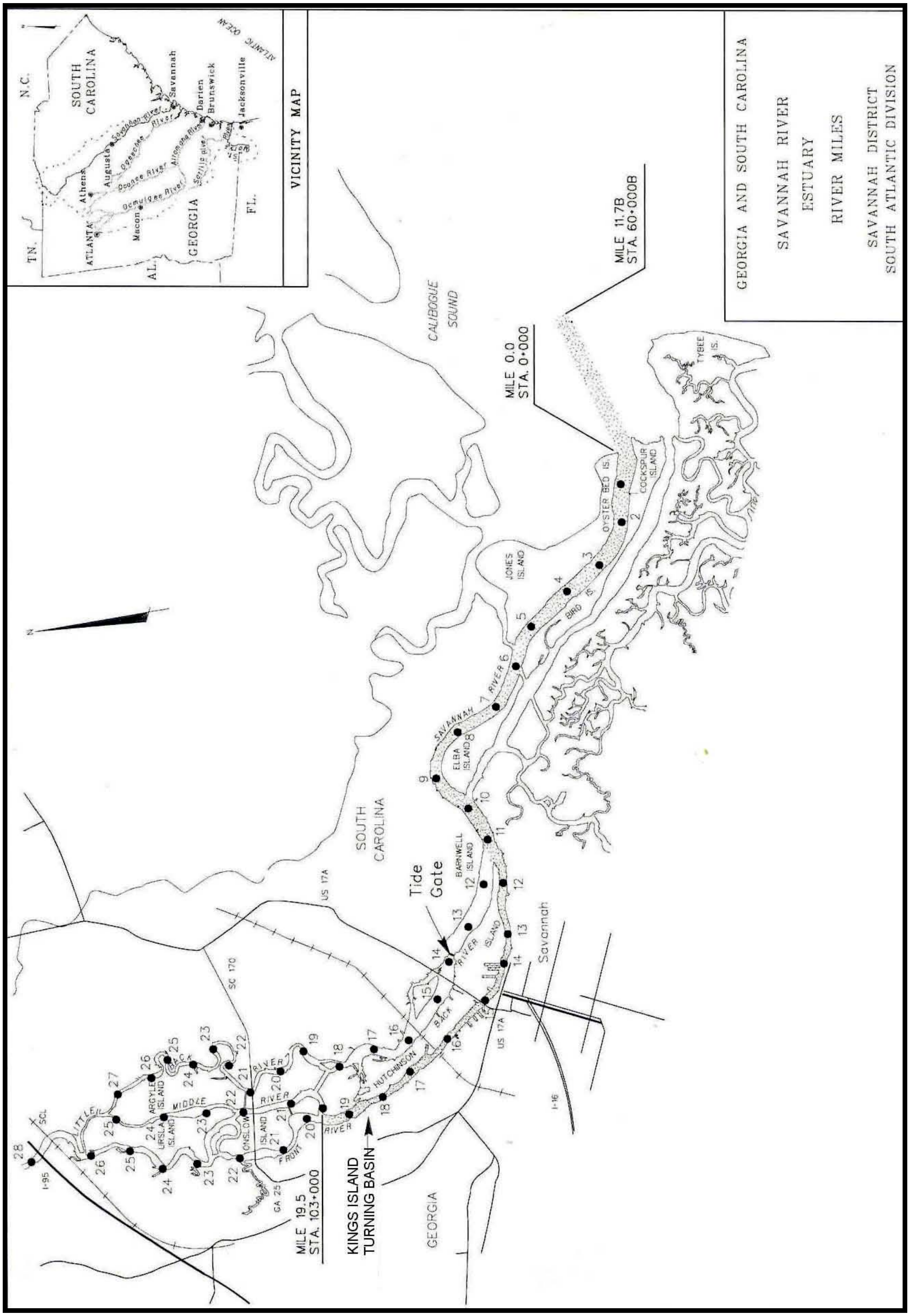
GEORGIA AND SOUTH CAROLINA
SAVANNAH RIVER
ESTUARY
RIVER MILES
SAVANNAH DISTRICT
SOUTH ATLANTIC DIVISION
VICINITY MAP
MILE 11.7B
STA. 60+000B
MILE 0.0
STA. 0+000
CALIBOGUE SOUND
TYBEE IS.
COCKSPUR ISLAND
OYSTER BED IS.
JONES ISLAND
BIRD IS.
SAVANNAH RIVER
ELBA ISLAND
SOUTH CAROLINA
BARNWELL ISLAND
Tide Gate
Savannah
HUTCHINSON ISLAND
BACK RIVER
MIDDLE RIVER
FRONT RIVER
ARGYLE ISLAND
ONSLOW ISLAND
MILE 19.5
STA. 103+000
KINGS ISLAND
TURNING BASIN
GEORGIA

Figure 3

Striped Bass Application
Version 6
Prepared by: Ed EuDaly, US Fish and Wildlife Service
Reviewed by: Ted Will, GA Department of Natural Resources
Date: September 18, 2002

Purpose: This document proposes a method to evaluate striped bass impacts of Savannah Harbor modification and describes how the hydrodynamic model can be used for striped bass impact assessment. For the purposes of this analysis, I assumed that the hydrodynamic model and water quality model will be improved and verified to produce accurate chemical and physical predictions.

Impact Analysis

The impact analysis will rely on a modification of the habitat suitability model for coastal stocks of striped bass (Bain and Bain 1982). The model will be modified by using only the critical life stages and variables that will be impacted by the proposed project and by using site specific data from various studies. The habitat quality for various life stages will be evaluated as follows.

(I) SPAWNING:

The habitat suitability model for striped bass indicates that a maximum salinity of 1.5 ppt or less is optimal for spawning (Bain and Bain 1982). Studies on the Savannah River indicate that striped bass almost exclusively spawn in areas where maximum salinity near the surface is less than one ppt (Van Den Avyle et al 1990, Reinert and Jennings 1998, Will et al 2000). In addition, the habitat suitability model for striped bass indicates that a mean current velocity of 30 cm/s or more is needed to keep eggs suspended in the water column and allow normal development (Bain and Bain 1982). Therefore, we assume that this mean velocity is needed for suitable spawning habitat. In the Savannah River the spawning and egg development period occurs from about March 16 - May 7. By using April flow data for the evaluation, the bulk of the spawning season will be covered and the extremes at either end of the season will be eliminated. The result should be representative of average spawning season conditions.

Suitable reaches will contain the following variables:

a) 90^{th} percentile salinity ≤ 1 ppt.
b) Mean velocity ≥ 30 cm/s.

Areas not meeting these criteria will be considered unsuitable (value 0).

Run Conditions

Geometry: Current baseline conditions and two-foot deepening increments up to 48 ft nominal channel depth, and mitigation features.

Discharge/Tides: We need to evaluate a range of representative flows to cover drought, average and high flow conditions. Therefore, we recommend using the 20% percentile, 50% percentile and 80% percentile levels for April based on the USGS Clyo gauge data from 1955 (Thurmond Reservoir was completed in July 1954) to 2002.

Daily tidal conditions and daily temperature input should be should be based on April data.

Output

Salinity - Recordings should be taken of the entire tidal cycle for the April period. During the model run, salinity should be recorded every ten minutes for each cell. The 90th percentile for the 1st layer (surface) for all ten minute intervals should be recorded and laterally averaged across the channel.

Velocity - Recordings should be taken every ten minutes over both ebb and flood tides. Velocity should be recorded for the surface layer and laterally averaged across the channel.

Tables and Figures

1) Tables for all Back River, all Middle River and Front River from river mile 10 to 31 showing the salinity and velocity output at 0.1 river mile intervals at each discharge.
2) Salinity output vs river mile at each discharge.
3) Velocity output vs river mile at each discharge.

Figures showing suitable and unsuitable habitat will be produced after analysis of the tables and figures.

(II) EGG DEVELOPMENT

The habitat suitability model for striped bass indicates that a mean current velocity of 30 cm/s or more is needed to keep eggs suspended in the water column and allow normal development (Bain and Bain 1982). The habitat suitability model also indicates that a minimum dissolved oxygen level of five (5.0) mg/l or more is optimal for larval development and that habitat suitability decreases rapidly and becomes unsuitable at about three (3.0) mg/l (Bain and Bain 1982). Winger and Lasier (1989) concluded that exposure to salinity greater than 15 ppt was toxic to Savannah River striped bass eggs. However, the eggs will develop into larvae within about two days of spawning. Winger and Lasier (1989) concluded, using laboratory studies at a constant salinity, that Savannah River striped bass larvae survived well at three (3.0) to nine (9.0) ppt salinity but survival decreased at higher salinity. Five day old larvae were able to tolerate higher salinity than two day old larvae. Therefore, we believe that suitable egg habitat will have a mean salinity of nine (9.0) ppt or less. In the Savannah River the spawning and egg development period occurs from about March 16 - May 7. By using April flow data for the evaluation, the bulk of the spawning season will be covered and the extremes at either end of the season will be eliminated. The result should be representative of average spawning season conditions.

Suitable reaches will contain the following variables:

a) Mean 50^{th} percentile salinity ≤ 9 ppt
b) Mean velocity ≥ 30 cm/s.
c) 10^{th} percentile D.O. ≥ 4.5 mg/l

Areas not meeting these criteria will be considered unsuitable.

Run Conditions

Geometry: Current baseline conditions and two-foot deepening increments up to 48 ft nominal channel depth, and mitigation features.

Discharge/Tides: We need to evaluate a range of representative flows to cover drought, average and high flow conditions. Therefore, we recommend using the 20% percentile, 50% percentile and 80% percentile levels for April based on the USGS Clyo gauge data from 1955 to 2002.

Daily tidal conditions and daily temperature input should be should be based on April data.

Output

Salinity - Recordings should be taken every ten minutes of the entire tidal cycle for the April period. The mean of the 50^{th} percentile for the 1^{st} layer (surface), 6^{th} layer (mid-depth), and 11^{th} layer (bottom), laterally averaged across the channel, should be reported.

Velocity- Recordings should be taken every ten minutes of the entire tidal cycle for the April period. The mean velocity for the 1^{st} layer (surface), 6^{th} layer (mid-depth), and 11^{th} layer (bottom), laterally averaged across the channel, should be reported.

Dissolved Oxygen - Recording should be taken every ten minutes over both ebb and flood tides. Mean 10^{th} percentile dissolved oxygen (D.O.) of the 1^{st}, 6^{th} and 11^{th} layer, laterally averaged across the channel, should be reported.

Tables and Figures

1) Tables for all Back River, all Middle River and Front River from river mile 10 to 31 showing the salinity and velocity and dissolved oxygen output at 0.1 mile intervals for each discharge.
2) Salinity output vs river mile at each discharge.
3) Velocity output vs river mile at each discharge.
4) Dissolved oxygen output vs river mile at each discharge.

Figures showing suitable and unsuitable habitat will be produced after analysis of the tables and figures.

(II) LARVAL DEVELOPMENT:

The habitat suitability model for striped bass indicates that an average salinity of three (3.0) to seven (7.0) ppt is optimal but that larvae can survive in up to 15 ppt salinity (Bain and Bain 1982). Winger and Lasier (1989) concluded, using laboratory studies at a constant salinity, that Savannah River striped bass larvae survived well at three (3.0) to nine ppt (9.0) salinity but survival decreased at higher salinity. Five day old larvae were able to tolerate higher salinity than two day old larvae. The habitat suitability model for striped bass also indicates that a minimum dissolved oxygen level of five (5.0) mg/l or more is optimal for larval development and that habitat suitability decreases rapidly with lower dissolved oxygen levels (Bain and Bain 1982). Larvae are assumed to be motile for most of the period of analysis and could avoid unfavorable conditions such as higher salinity and lower dissolved oxygen levels near the river bottom. The larval development period in the Savannah River can occur from late March through early June. However, the egg development evaluation will cover the April time period and output the same data as the larval analysis with the exception of current velocity. Therefore, we propose to use May flow data for this evaluation. By using the April flow data for the egg evaluation and the May flow data for the larval evaluation, we can obtain more information on how the habitat varies over the season. If the evaluations were to combine the April and May flows, temporal changes will be masked by averaging data over a time of year when factors like dissolved oxygen and salinity in the estuary are changing significantly.

Suitable reaches will contain the following variables:

a) Mean 50^{th} percentile salinity 3 - 9 ppt
b) Mean 10^{th} percentile D.O. ≥ 4.5 mg/l

Areas not meeting these criteria will be considered unsuitable.

Run Conditions

Geometry: Current baseline conditions and two-foot deepening increments up to 48 ft nominal channel depth, and mitigation features.

Discharge/Tides: We need to evaluate a range of representative flows to cover drought, average and high flow conditions. Therefore, we recommend using the 20% percentile, 50% percentile and 80% percentile levels for May based on the USGS Clyo gauge data from 1955 to 2002.

Daily tidal conditions and daily temperature input should be should be based on May data.

Output

Salinity - Recordings should be taken every ten minutes of the entire tidal cycle for the larval period. The mean of the 50th percentile for the 1st layer, 6th layer and 11th layer, laterally averaged across the channel, should be reported.

Dissolved Oxygen - Recording should be taken every ten minutes over the entire tidal cycle for the larval period. The mean of the 1st layer, 6th layer and 11th layer, laterally averaged across the channel, should be reported.

Tables and Figures

1) Tables for all Back River, all Middle River and Front River from river mile 10 to 31 showing the salinity and dissolved oxygen output at 0.1 mile intervals and each discharge.
5) Salinity output vs river mile at each discharge.
6) Dissolved oxygen output vs river mile at each discharge.

Figures showing suitable and unsuitable habitat will be produced after analysis of the tables and figures.

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Subject:	Savannah Harbor Expansion: Striped Bass Habitat (velocities)
Date:	Thursday, August 09, 2007 1:48:13 PM
Attachments:	Plan3_6ft_EGGS_velocities.pdf Plan3_6ft_SPAWN_velocities.pdf

Here is some velocity information concerning impacts to Striped Bass. Please let me know within a few days whether you think this information is helpful and if we should develop it for other mitigation plans we are evaluating. If this does not provide the information you were looking for, please let me know.

I asked Beth to include velocity info at some locations where the velocity does not cross the 30 cm/s threshold just to see what the velocity is in that portion of the river.

Bill Bailey

-----Original Message-----
From: Williams, Laura E (Beth) SAW@SAS
Sent: Thursday, August 09, 2007 12:08 PM
To: Bailey, William G SAM@SAS
Cc: Hoke, Joseph T SAW@SAS
Subject: Striped Bass Habitat (velocities)

Bill,

Attached are two figures showing impacts to striped bass habitat for the 48 ft depth with Mitigation Plan 3. The maps are broken down into two main categories: habitat gained and habitat lost. However, the habitat lost is broken down even further to tell why the habitat isn't suitable (velocity, salinity, DO, or a combination). There are mean velocities shown on the map for some of the cells as well.

Just as a reminder, the habitat criteria is as follows:

Striped Bass Spawning:
    90th percentile salinity <= 1ppt.
    mean velocity >=30 cm/s

Striped Bass Eggs:
    50th percentile salinity <= 9 ppt
    mean velocity >= 30 cm/s
    10th percentile DO>= 4.5 mg/L

Let me know if the agencies think this is useful information.

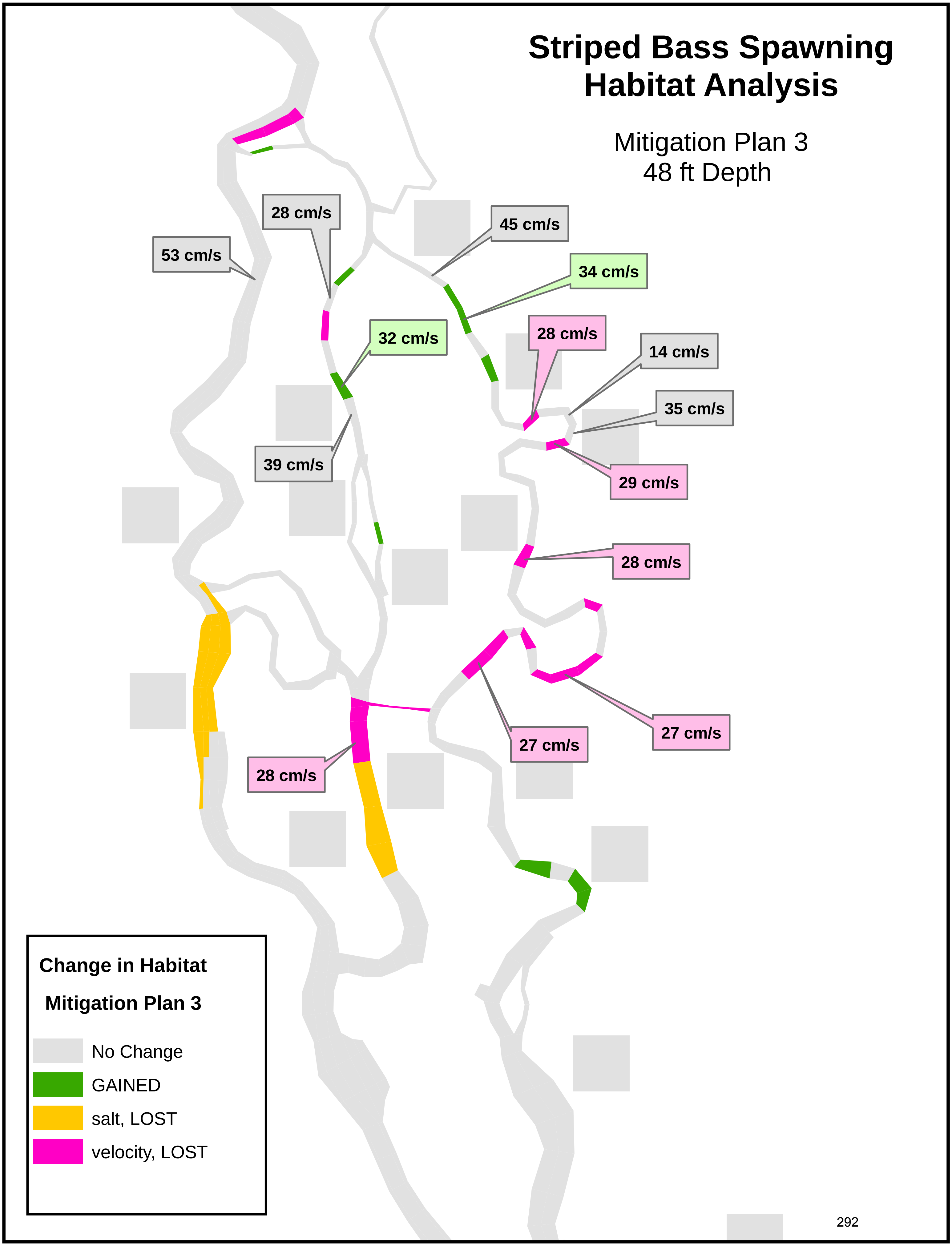
Thanks,
Beth

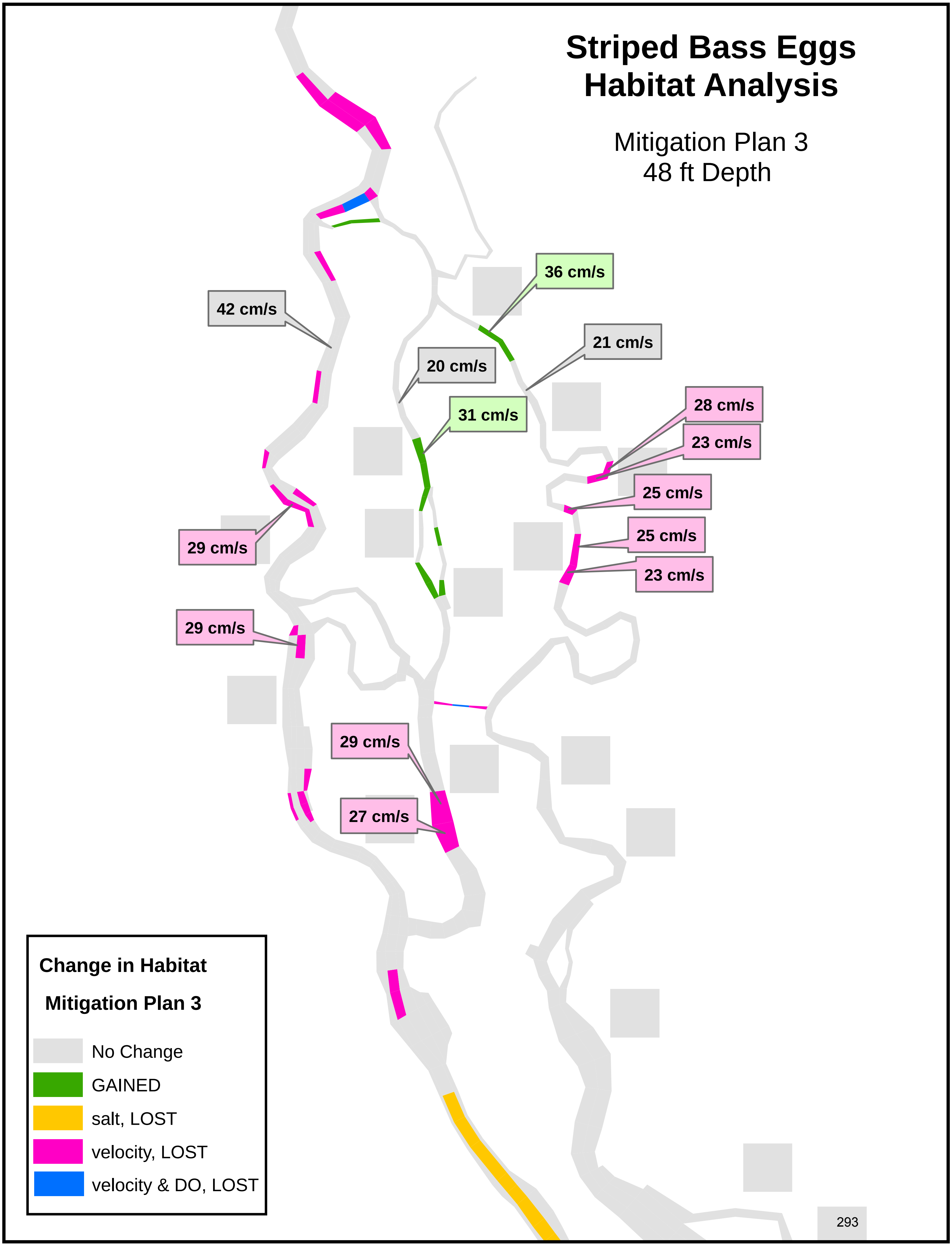
Beth Williams, PE

Hydraulic Engineer
US Army Corps of Engineers
(912) 652-5268
laura.e.williams@sas02.usace.army.mil

Striped Bass Spawning Habitat Analysis

Mitigation Plan 3
48 ft Depth





Striped Bass Eggs
Habitat Analysis
Mitigation Plan 3
48 ft Depth
36 cm/s
42 cm/s
21 cm/s
20 cm/s
28 cm/s
31 cm/s
23 cm/s
25 cm/s
29 cm/s
25 cm/s
23 cm/s
29 cm/s
29 cm/s
27 cm/s
Change in Habitat
Mitigation Plan 3
No Change
GAINED
salt, LOST
velocity, LOST
velocity & DO, LOST
293

From:	Bailey, William G SAM@SAS
To:	"Kay Davy (kay.davy@noaa.gov)"; "Stephania Bolden"; "Ed_Eudaly@fws.gov"; "john_robinette@fws.gov"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"; "Bob Perry"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "beckhajc@dhec.sc.gov"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Kelie_Moore@coastal.dnr.state.ga.us"; "Ron Michaels (E-mail)"; "Keith_Parsons@mail.dnr.state.ga.us"; "Matt Thomas (E-mail)"; "Tim_Barrett@dnr.state.ga.us"
Cc:	Garrett, Thomas A SAS; "Keegan, Larry (E-mail)"; "Hope Moorer (E-mail)"; "Mark R. Collins, PhD (collinsm@dnr.sc.gov)"; "Ed Duncan"; "kajumba.ntale@epamail.epa.gov"; "Brad_Gane@dnr.state.ga.us"; "jane_griess@fws.gov"; Bradley, Kenneth P SAM; "Pace Wilber"; "JENNINGS@smokey.forestry.uga.edu"; "Jeff Isely"; "kitchensw@wec.ufl.edu"; Heine, Hugh SAW; Hoke, Joseph T SAW@SAS; Williams, Laura E (Beth) SAW@SAS; "kirklagl@dhec.sc.gov"; "PRESTOHS@dhec.sc.gov"; "_Jeff_Larson@dnr.state.ga.us"; Bradley, Kenneth P SAM; Eubanks, Michael J SAM; Heine, Hugh SAW; Small, Daniel L SAD; Barnett, Dennis W SAD; Kopecky, Steven A HQ02; Matusiak, Mark HQ02
Subject:	Savannah Harbor Expansion Project: Fishery Impact Table
Date:	Monday, March 17, 2008 11:43:23 AM
Attachments:	Fishery Impacts with Proposed Plans.xls

I've attached a table which summarizes the fishery impact information with the D.O. systems.

We are finalizing the impact report which contains figures showing locations of Acceptable vs. Unacceptable Habitat. We expect to send out a link to that report later this week. The report is too big to send my email, so you will have to download it from an ftp site. If you want us to send it on CD, please let me know.

Bill Bailey
912-652-5781

FISHERY IMPACTS

AMERICAN SHAD

	Suitable Habitat (km^2)					
	May20%flows	May50%flows	May80%flows	January50%flows	August Avg flows*	August Low flows*
Existing Conditions 42 ft Depth	**19.96**	**19.96**	**19.96**	**19.96**	**19.53**	**13.56**
44 ft depth Plan 6b	**19.60**	**19.60**	**19.60**	**19.61**	**19.58**	**-**
% difference	*-1.8%*	*-1.8%*	*-1.8%*	*-1.7%*	*0.3%*	*-*
*% diff (Deepening Only)***	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-1.4%*	*-*
45 ft depth Plan 6a	**19.61**	**19.61**	**19.61**	**19.61**	**19.59**	**-**
% difference	*-1.8%*	*-1.8%*	*-1.8%*	*-1.7%*	*0.3%*	*-*
*% diff (Deepening Only)***	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-0.4%*	*-*
46 ft depth Plan 6a	**19.61**	**19.61**	**19.61**	**19.61**	**19.61**	**-**
% difference	*-1.8%*	*-1.8%*	*-1.8%*	*-1.7%*	*0.4%*	*-*
*% diff (Deepening Only)***	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-0.4%*	*-*
48 ft depth Plan 6a	**19.61**	**19.61**	**19.61**	**19.61**	**19.61**	**19.58**
% difference	*-1.8%*	*-1.8%*	*-1.8%*	*-1.7%*	*0.4%*	*44.4%*
*% diff (Deepening Only)***	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-1.9%*	*-*

STRIPED BASS

	---------------------- EGGS ----------------------			---------------------- LARVAE ----------------------			---------------------- SPAWNING ----------------------		
	Suitable Habitat (km^2)			Suitable Habitat (km^2)			Suitable Habitat (km^2)		
	April20%flows	April50%flows	April80%flows	May20%flows	May50%flows	May80%flows	April20%flows	April50%flows	April80%flows
Existing Conditions 42 ft Depth	**3.89**	**6.78**	**9.13**	**0.81**	**2.28**	**4.02**	**2.59**	**4.21**	**7.45**
44 ft depth Plan 6b	**3.02**	**6.15**	**9.82**	**2.22**	**2.16**	**3.47**	**2.19**	**4.08**	**7.23**
% difference	*-22.3%*	*-9.4%*	*7.6%*	*174.6%*	*-5.6%*	*-13.7%*	*-15.2%*	*-2.9%*	*-2.9%*
*% diff (Deepening Only)***	*-10.4%*	*-9.7%*	*-2.2%*	*38.0%*	*-13.5%*	*-1.1%*	*-7.6%*	*-8.0%*	*-6.2%*
45 ft depth Plan 6a	**3.21**	**7.13**	**9.86**	**2.32**	**2.32**	**4.32**	**2.23**	**3.82**	**6.82**
% difference	*-17.6%*	*5.2%*	*8.0%*	*187.4%*	*1.7%*	*7.6%*	*-13.9%*	*-9.2%*	*-8.5%*
*% diff (Deepening Only)***	*-12.3%*	*-11.2%*	*-4.9%*	*56.4%*	*-18.6%*	*-7.1%*	*-10.9%*	*-12.2%*	*-6.6%*
46 ft depth Plan 6a	**3.59**	**6.78**	**9.76**	**2.35**	**2.41**	**4.43**	**2.10**	**3.79**	**6.64**
% difference	*-7.8%*	*0.0%*	*6.9%*	*191.4%*	*5.6%*	*10.1%*	*-18.7%*	*-10.0%*	*-10.8%*
*% diff (Deepening Only)***	*-14.0%*	*-15.9%*	*-4.8%*	*99.5%*	*-21.0%*	*-4.8%*	*-12.7%*	*-13.0%*	*-12.8%*
48 ft depth Plan 6a	**3.71**	**6.05**	**9.44**	**2.06**	**2.20**	**5.22**	**1.97**	**3.53**	**6.47**
% difference	*-4.6%*	*-10.8%*	*3.4%*	*154.6%*	*-3.5%*	*30.0%*	*-23.9%*	*-16.1%*	*-13.2%*
*% diff (Deepening Only)***	*-19.4%*	*-24.5%*	*-7.2%*	*104.6%*	*-13.8%*	*6.0%*	*-16.9%*	*-19.7%*	*-17.3%*

SHORTNOSE STURGEON

	JUVENILES	---------------------- ADULTS ----------------------		
	Suitable Habitat (km^2)			
	January50%flows	January50%flows	August Avg flows*	August Low flows*
Existing Conditions 42 ft Depth	**6.98**	**16.10**	**5.73**	**0.81**
44 ft depth Plan 6b	**7.05**	**15.08**	**6.34**	**-**
% difference	*1.1%*	*-6.4%*	*10.6%*	*-*
*% diff (Deepening Only)***	*-5.0%*	*-0.5%*	-26.20	*-*
45 ft depth Plan 6a	**7.15**	**14.97**	**5.55**	**-**
% difference	*2.4%*	*-7.0%*	*-3.1%*	*-*
*% diff (Deepening Only)***	*-10.4%*	*-0.5%*	-33.80	*-*
46 ft depth Plan 6a	**6.98**	**14.72**	**5.51**	**-**
% difference	*0.1%*	*-8.6%*	*-3.9%*	*-*
*% diff (Deepening Only)***	*-15.9%*	*-0.8%*	-39.10	*-*
48 ft depth Plan 6a	**6.86**	**14.33**	**5.17**	**6.21**
% difference	-1.6%	-11.0%	-9.7%	665.5%
*% diff (Deepening Only)***	-21.6%	-1.1%	-41.90	-

From:	Bailey, William G SAM@SAS
To:	Kay Davy (kay.davy@noaa.gov); "Ed_Eudaly@fws.gov"; "john_robinette@fws.gov"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"; "kajumba.ntale@epamail.epa.gov"; "Mark R. Collins, PhD (collinsm@dnr.sc.gov)"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "beckhajc@dhec.sc.gov"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Kelie_Moore@coastal.dnr.state.ga.us"; "Keith_Parsons@mail.dnr.state.ga.us"; "Matt Thomas (E-mail)"; "Joel Fleming"; "Patrick Geer (E-mail)"; "John Pafford (E-mail)"; "Ron Michaels (E-mail)"; "Stephania Bolden"
Cc:	Calver, James S SAM@SAS; Garrett, Thomas A SAS; "Keegan, Larry (E-mail)"; "Hope Moorer (E-mail)"; "Ed Duncan"; "Brad_Gane@dnr.state.ga.us"; "jane_griess@fws.gov"; Bradley, Kenneth P SAM; "kirklagl@dhec.sc.gov"; "PRESTOHS@dhec.sc.gov"; "david.bernhart@noaa.gov"; "Pace Wilber"; "JENNINGS@smokey.forestry.uga.edu"; "Jeff Isely"; "Wade Cantrell"; Heine, Hugh SAW; Hoke, Joseph T SAW@SAS; "steven.davie@tetratech-ffx.com"
Subject:	Savannah Harbor Expansion: Fisheries Interagency Coordination Team -- summary of fisheries results for impact and mitigation runs
Date:	Friday, April 06, 2007 11:13:24 AM
Attachments:	Summary of Fisheries habitat for Savannah River Expansion Project Update 27 February 2007 BB.xls Mitigation Run Summaries of Fisheries Habitat for Savannah River Expansion Project 28 February 2007 BB.xls

Here are summaries we prepared of the fishery results for the impact and mitigation runs.

I hope these help with your review of the reports we sent out last week.

Bill Bailey

DRAFT
MITIGATION PLAN 1
COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS
SAVANNAH HARBOR EXPANSION PROJECT

STRIPED BASS - SPAWNING

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	2.958258	2.145611	-0.812647	-201.03	-27.5%
	50	4.289636	3.860990	-0.428646	-106.00	-10.0%
	80	7.472033	7.067389	-0.404644	-99.70	-5.4%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	2.958258	2.045795	-0.912463	-225.15	-30.8%
	50	4.289636	3.716500	-0.573136	-142.04	-13.4%
	80	7.472033	6.784634	-0.687399	-169.87	-9.2%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	2.958258	1.921294	-1.036964	-256.58	-35.1%
	50	4.289636	3.680251	-0.609385	-150.52	-14.2%
	80	7.472033	6.547445	-0.924588	-228.95	-12.4%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	2.958258	1.799652	-1.158606	-286.55	-39.2%
	50	4.289636	3.395432	-0.894204	-220.48	-20.8%
	80	7.472033	6.246614	-1.225419	-302.81	-16.4%

DRAFT
MITIGATION PLAN 1
COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS
SAVANNAH HARBOR EXPANSION PROJECT

STRIPED BASS - EGGS

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	4.903563	3.385002	-1.518561	-375.63	-31.0%
	50	7.284086	5.946143	-1.337943	-331.19	-18.4%
	80	9.148369	9.017840	-0.130529	-31.65	-1.4%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	4.903563	3.301659	-1.601904	-396.22	-32.7%
	50	7.284086	5.764220	-1.519866	-376.19	-20.9%
	80	9.148369	8.838564	-0.309805	-76.86	-3.4%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	4.903563	3.229359	-1.674204	-413.19	-34.1%
	50	7.284086	5.307388	-1.976698	-487.78	-27.1%
	80	9.148369	8.709830	-0.438539	-108.51	-4.8%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	4.903563	2.913681	-1.989882	-491.95	-40.6%
	50	7.284086	4.841949	-2.442137	-602.98	-33.5%
	80	9.148369	8.374261	-0.774108	-192.15	-8.5%

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MITIGATION PLAN 1

COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS

SAVANNAH HARBOR EXPANSION PROJECT

STRIPED BASS - LARVAE

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	0.818275	1.233199	0.414924	102.52	50.7%
	50	2.423079	2.061628	-0.361451	-89.21	-14.9%
	80	4.048194	6.191287	2.143093	529.17	52.9%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	0.818275	1.338056	0.519781	128.40	63.5%
	50	2.423079	1.993000	-0.430079	-105.98	-17.7%
	80	4.048194	5.771564	1.723370	426.14	42.6%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	0.818275	1.607562	0.789287	195.12	96.5%
	50	2.423079	1.992009	-0.431070	-106.58	-17.8%
	80	4.048194	6.136214	2.088020	516.17	51.6%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	0.818275	1.693488	0.875213	216.35	107.0%
	50	2.423079	1.979390	-0.443689	-109.57	-18.3%
	80	4.048194	6.042082	1.993888	493.16	49.3%

DRAFT

MITIGATION PLAN 1

COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS

SAVANNAH HARBOR EXPANSION PROJECT

AMERICAN SHAD **MAY**

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	19.962807	19.927399	-0.035408	-9.9	-0.2%
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%
	80	19.962807	19.927399	-0.035408	-9.9	-0.2%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	19.962807	19.927399	-0.035408	-9.9	-0.2%
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%
	80	19.962807	19.927399	-0.035408	-9.9	-0.2%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	19.962807	19.927399	-0.035408	-9.9	-0.2%
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%
	80	19.962807	19.927399	-0.035408	-9.9	-0.2%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	20	19.962807	19.927399	-0.035408	-9.9	-0.2%
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%
	80	19.962807	19.927399	-0.035408	-9.9	-0.2%

DRAFT

MITIGATION PLAN 1

COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS

SAVANNAH HARBOR EXPANSION PROJECT

AMERICAN SHAD **JANUARY**

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	19.962807	19.927399	-0.035408	-9.9	-0.2%

DRAFT
MITIGATION PLAN 1
COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS
SAVANNAH HARBOR EXPANSION PROJECT

AMERICAN SHAD **AUGUST**

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	15.191188	16.248356	1.057168	262.77	7.0%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	15.191188	16.168022	0.976834	240.24	6.4%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	15.191188	16.168022	0.976834	240.24	6.4%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	15.191188	16.168022	0.976834	240.24	6.4%

DRAFT

MITIGATION PLAN 1

COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS

SAVANNAH HARBOR EXPANSION PROJECT

STURGEON ADULTS JANUARY

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	5.012443	4.525763	-0.486680	-120.14	-9.7%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	5.012443	4.308158	-0.704285	-174.64	-14.1%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	5.012443	4.141656	-0.870787	-215.52	-17.4%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	5.012443	3.842213	-1.170230	-288.59	-23.3%

DRAFT
MITIGATION PLAN 1
COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS
SAVANNAH HARBOR EXPANSION PROJECT

STURGEON ADULT: AUGUST

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.292598	0.193631	-0.098967	-24.44	-33.8%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.292598	0.178336	-0.114262	-28.27	-39.1%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.292598	0.170142	-0.122456	-30.29	-41.9%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.292598	0.162281	-0.130317	-32.17	-44.5%

DRAFT
MITIGATION PLAN 1
COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS
SAVANNAH HARBOR EXPANSION PROJECT

STURGEON JUVENILES

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	2.815892	2.765188	-0.050704	-12.52	-1.8%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	2.815892	2.756995	-0.058897	-14.61	-2.1%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	2.815892	2.756995	-0.058897	-14.61	-2.1%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	2.815892	2.749133	-0.066759	-16.70	-2.4%

DRAFT
MITIGATION PLAN 1
COMPARISONS OF HABITAT AREAS FOR BASELINE AND PROJECT SCENARIOS
SAVANNAH HARBOR EXPANSION PROJECT

SOUTHERN FLOUNDER

2-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.402031	0.356592	-0.045439	-11.23	-11.3%

3-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.402031	0.345221	-0.056810	-14.01	-14.1%

4-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.402031	0.335332	-0.066699	-16.49	-16.6%

6-FOOT DEPTH	% - TILE	BASELINE (km2)	PROJECT (km2)	DIFFERENCE (km2)	DIFFERENCE (acre)	% CHANGE
	50	0.402031	0.274398	-0.127633	-31.49	-31.7%

From:	Bailey, William G SAM@SAS
To:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Tim_Barrett@dnr.state.ga.us"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "Bob Perry"; "beckhajc@dhec.sc.gov"; "Kay Davy (kay.davy@noaa.gov)"; "Stephania Bolden"; "Ed Eudaly"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"
Cc:	"Brad_Gane@dnr.state.ga.us"; " Jeff_Larson@dnr.state.ga.us"; "Mark R. Collins, PhD (collinsm@dnr.sc.gov)"; "Curtis Joyner"; Flakes, Curtis M SAM; Bradley, Kenneth P SAM; Okane, Jason D SAS; "Miles M. Croom (E-mail)"; "David Bernhart"; "Pace Wilber"; "bob.hoffman@noaa.gov"; "Mueller.Heinz@epamail.epa.gov"; "Bill_Wikoff@fws.gov"; "jane_griess@fws.gov"; "Chuck Hayes"; "Russ Webb"
Subject:	Savannah Harbor Expansion: Fisheries Interagency Coordination Team -- Revised Juvenile SNS Habitat Suitability Criteria
Date:	Saturday, August 29, 2009 9:42:33 AM
Attachments:	SNS_Jan_habitat_50%maxsalt14.9Plan6a6ftPLUS.pdf SNS_Jan_habitat_50%maxsalt14.9EXISTING.pdf SNS_Jan_habitat_50%maxsalt14.9.pdf bottom_salinity_existingJAN99.gif SNS_JAN_50saltEX.pdf SNS_JAN_75ofmaxsaltEX.pdf SNS_JAN_maxsaltEX.pdf SNS_I_J.pdf SNS_JAN_50ofmaxsaltEX.pdf

NOAA Fisheries has expressed concern that the present habitat suitability criteria do not sufficiently reflect known areas of suitable habitat. The main area of concern is on the Front River between the Houlihan Bridge and the confluence of the Front and Middle Rivers. Recent studies have found juvenile Shortnose sturgeon there in the winter months, but the models didn't show that area as providing acceptable habitat. The Corps described how the Fisheries Coordination Team developed the criteria (if erring, then the error would be on the conservative side) and how the hydrodynamic and D.O. models aggregate salinity and D.O. values that they calculate for each grid cell for every 15 minutes over the duration of a modeling run.

NOAA reviewed the water quality data associated with the SNS collections in Savannah Harbor. Collins et al 1999-2000 data showed that when juvenile SNS were captured in or adjacent to the fish hole in Middle River (when temperatures were <22 degrees), the maximum salinity was 14.9 ppt. NOAA also kept in mind research conducted at other locations that included salinity information -- juvenile SNS found in salinities up to 17.6 ppt. We jointly tried a couple different salinity criteria, trying to make the models' identification of acceptable habitat match where the fish have been found. The wide tidal range here in Savannah doesn't make things easy, as the salinity in the upper end of the navigation channel is constantly changing. That variation makes is important whether the criteria use average values (over a model run), maximum values, of some percentile of the maximum. We always examined salinity levels in the bottom layer of the model, since SNS are bottom-oriented fish.

I have attached several figures that we used in our analysis of the situation and development of our proposed revision of the juvenile SNS salinity criteria. Although dissolved oxygen is also a component of the SNS habitat suitability criteria, the concern is for the model's performance for juvenile SNS habitat in the winter. During the winter months, D.O. is not a problem and is not a factor in determining which model grid cells show up as providing suitable habitat.

One figure shows the maximum salinity values in that portion of Front River, which range from 11 to 20 ppt (existing conditions). However, another figure shows the average bottom salinity in that same area -- which range from <1 to 3 ppt (existing conditions). I've attached a plot showing how the bottom salinity varies with the tide and over a lunar cycle. It varies quite a bit, which also means that the salinity at a given location is constantly changing. The peak salinity values occur during neap tide, when the mixing is less and salinity moves further into the estuary.

In light of the large tidal influence and the marked effect it has on bottom salinities in this area, one can conclude that maximum salinity values do not fully characterize the habitat quality in a given location. The salinity levels change hourly, often by 0.5 ppt per hour. So the maximum salinity values overstate the salinity that the fish must deal with on a regular (constant) basis.

As a result of all that, we propose revising the salinity criteria for juvenile SNS in the winter as shown below:

EXISTING	PROPOSED
bottom layer	bottom layer
max salinity	50%-tile of max salinity
<= 4 ppt	<= 14.9 ppt

The Corps believes that the 50%-tile of maximum bottom salinity is a better representation of the typical (average) conditions under which SNS must survive. That parameter is well above the average bottom salinity value as it includes also the higher values which SNS must deal with for a few hours at a time. NOAA Fisheries agree that the 50%-tile of maximum bottom salinity parameter with the 14.9 ppt upper threshold best reflects SNS juvenile habitat as known by field studies. They support our proposing the revised criteria to the Fisheries Team for approval.

NOTE: The Habitat Suitability Criteria that the Interagency Team developed in 2003 did not specify the details of the salinity number (average, maximum, etc.). When the Corps began to apply the criteria, we interpreted the <= 4 ppt as being a maximum threshold. If we had interpreted it as being an average value for a grid cell, the area in the harbor identified as being suitable would have been much larger than the original analysis, extending even further downstream than what shows as being suitable using the proposed <= 14.9 ppt and 50%-tile of maximum salinity threshold.

Please let me know by COB 8 September if you concur in our proposal to use the 50%-tile of the maximum bottom salinity and 14.9 ppt as the upper threshold for acceptable SNS juvenile habitat in the winter.

Thank you for your time on this project.

Bill Bailey

>
>
>
>

D. Water Quality

1. MFR dated 24 September 2002, SHEP, Summary of 18 Sep Interagency Meeting on Evaluation of Impacts to Water Quality.
2. MFR dated 13 May 2003, SHEP, Summary of 8 May Interagency Meeting on Evaluation of Impacts to Water Quality.
3. MFR dated 24 June 2003. SHEP, Summary of 18 June Interagency Meeting on Evaluation of Impacts to Water Quality.
4. MFR dated 3 September 2003, SHEP, Summary of 20 August Joint Meeting on Review of Draft D.O. Model Calibration Report.
5. MFR dated 7 March 04, Revised 15 March 04, SHEP, Summary of 4 March Meeting of the Interagency Water Quality Team.
6. MFR dated 31 March 04, Revised 10 May 04, SHEP, Summary of 31 March Meeting of Interagency Water Quality Team.
7. MFR dated 22 April 04. SHEP, Summary of 20 April Meeting of the Interagency Water Quality Team.
8. Memo. Notes, SHEP Model Review Meeting 16-17 June 2005 and SHEP Interagency Water Quality Team Meeting held 17 June 2005. Tetra Tech. Inc . Atlanta. Georgia
9. MFR dated 5 June 06. Revised 30 June 06, SHEP, Summary of25 Meeting of the Water Quality Interagency Coordination Team.
10. MFR dated 23 Jan 07. Revised 29 Jan 2007, SHEP, Summary of 19 Jan Meeting of the Interagency Water Quality Coordination Team.
11. MFR dated 7 June 08. SHEP, Summary of 27 May Meeting of the Interagency Water Quality Coordination Team.
12. E-MAIL from Joseph T. Hoke, dated 12 October 2004, SHEP, EFDC Training, EFDC model contract review meeting
13. E-MAIL from Joseph T. Hoke, dated 13 December 2004, SHEP, EFDC Model Grid Resolution Technical Memo
14. MINUTES, 11 January 2005 Meeting , SHEP, Project Model Development
15. LETTER from EPA, dated 25 August 2005, SHEP, Final Report – Hydrodynamic and Water Quality Model for the Savannah Harbor.
16. E-MAIL from Joseph T. Hoke, dated 17 November 2005, SHEP, Hydrodynamic and WQ Model Calibration Report Review
17. LETTER from South Carolina DHEC, dated 10 March 2006, SHEP, Review of Report, "Development of the Hydrodynamic and Water Quality Models for SHEP."
18. E-MAIL from Wilber Pace, dated 14 May 2006, SHEP, Hydrodynamic Water Quality Models
19. E-MAIL from William G. Bailey, dated 18 May 2007, SHEP, Interagency Water Quality Team – EFDC/WASP input & output files
20. E-MAIL from William G. Bailey, dater 14 May 2008, SHEP, Review of D.O. Demonstration Project Report
21. MFR dated 7 June 2008, Summary of 27 May meeting of the Interagency Water Quality Coordination Team
22. E-MAIL from William G. Bailey, dated 30 June 2008, SHEP, Interagency Water Quality Coordination Team – Review of D.O. Demonstration Project Report.

23. MFR dated 30 April 2009, SHEP, Summary of 29 April meeting of the Interagency Water Quality Team
24. EMAIL from William G. Bailey, dated 27 Oct 2010, SHEP, Interagency Water Quality Coordination Team: DO Injection Design Report

CESAS-PD-E 24 September 02

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 18 September Interagency Meeting on Evaluation of Impacts to Water Quality

1. Attendees:

GA DNR-EPD:	Roy Burke III
SC DHEC:	Wade Cantrell
COE:	Bill Bailey
EPA:	Steve Whitlock
USGS	Paul Conrads
ATM/GPA:	Bo Ellis & Matt Goodrich
ASA/GPA:	Danny Mendelsohn & Eduardo Yasuda
City of Sav:	Bob Scanlon
Law Env:	Larry Neal & David Sample

2. I started by explaining the purpose of this interagency coordination. It is for agencies with regulatory authority over the Expansion Project to discuss their views about water quality impacts with Savannah District. The Corps wants to discuss how the water quality modeling tools will be applied once they are fully developed. We want to identify what the agencies will want (tools and techniques) to properly identify and evaluate project impacts. The ultimate goal is for the Corps to ensure the EIS addresses all the items in acceptable manners, so that the agencies will be able to approve the project when they review the draft EIS. The Corps will also separately coordinate with the agencies to discuss potential project impacts to wetlands, fisheries, groundwater, and on sediment placement. This particular coordination offort is intended to discuss issues that will arise in the evaluation of water quality impacts and Section 401 certification.

3. We then discussed the parameters that the agencies believe will need to be evaluated in the EIS. The items include the following:

- Dissolved Oxygen
- Temperature
- Mixing zone of point sources
- Assimilative capacity of Dissolved Oxygen in the harbor
- Chlorides at Abercorn Creek

4. We then started to discuss the critical conditions under which the models should be run to evaluate each of these parameters. The state representatives quickly informed me that the issue of critical conditions was a substantial one and one that would ultimately be determined by the managers in their agencies. They also said they were

somewhat uncomfortable having this type of discussion when members of the regulated community are present. They traditionally do not involve the point source dischargers or their consultants in pre-decisional discussions on these issues. We agreed that I would review the project files and find the letter that EPA and the States had prepared a year or so ago about the critical conditions. I would then attach that letter to this meeting summary and provide it to the States so they could start discussions with the managers within their agencies. We concluded this discussion with a recommendation from the States that I send a letter to their agencies explaining what I desired from them through this coordination. I will use the next paragraphs in lieu of such a letter.

> The Georgia Ports Authority will soon complete development of several computer models that can identify physical impacts to the environment that would occur from proposed changes to Savannah Harbor. The Savannah District, U.S. Army Corps of Engineers intends to use these models in its identification and evaluation of potential impacts from the Savannah Harbor Expansion Project. To maximize the efficiency of Federal, State and private manpower resources, the District would like to know what the agencies will need in their Section 401 review of this project. We would like to identify the specific model runs the regulatory agencies would like see performed for them to consider a water quality impact evaluation to be sufficient and complete. If we know what analyses the regulatory agencies will want to see when they review the Draft EIS, we will be able to ensure those analyses are performed and included in that document. This should simplify review of the proposed actions.
>
> Savannah District would like to know the views of each regulatory agency on the input conditions (critical conditions) it should use to adequately identify water quality impacts from proposed actions in the estuary. For evaluation of Dissolved Oxygen, these input conditions would likely include the river discharge, the period of year, extent of loading from point source discharges (existing loads or some percentage of their permitted loads), and possibly the tidal period. Evaluation of possible impacts to (1) temperature, (2) the mixing zones of point sources, and (3) the harbor's assimilative capacity for Dissolved Oxygen, may use the same list of input conditions but with slightly different numbers/dates. To evaluate potential impacts to chlorides at Abercorn Creek, it would seem that the important input parameters would be the river discharge and the tidal period.
>
> We would also like to know how the regulatory agencies would like to see the model output. This question is of most importance in identifying impacts to Dissolved Oxygen. Do the agencies want to see the daily average results at a given location, hourly results, or the minimum values? Should the results be in terms of a cross-sectional average, depth averaged, or at any point in the water column? If an agency has a specific

output format that they desire, please let us know. Otherwise, we intend to present the information through both numerically (charts) and visually (maps).

5. The timing of subsequent coordination meetings will depend upon the agencies' response to this meeting summary and their decisions on how to best meet the Corps' desire for ongoing coordination for this project.

William Bailey
Environmental Resources Branch

PROMOTE PROTECT PROSPER
South Carolina Department of Health and Environmental Control

Environmental Protection Division, Water Protection Branch
4220 International Parkway, Suite 101, Atlanta, Georgia 30354
Alan W. Hallum, Branch Chief
404/675-6232

May 4, 2000

Ms. Beverly Banister, Acting Director
Water Management Division
US EPA - Region 4
61 Forsyth Street SE
Atlanta, Georgia 30303

Dear Ms. Banister:

South Carolina and Georgia are keenly interested in the Savannah Harbor and Savannah River modeling projects and how they should be used to assess water quality standards and develop wasteload allocations and Total Maximum Daily Loads (TMDLs) in the watershed. It is important, for proper stewardship and effective management of this vital resource, that both states adopt and employ consistent critical conditions and modeling practices for these regulatory functions.

Over the last six months, staff members from the South Carolina Bureau of Water (SCDHEC) and the Georgia Environmental Protection Division (GAEPD) Water Protection Branch met several times to assess respective state regulations and procedures. From this, they compiled a set of critical conditions for the Savannah River watershed, including Savannah Harbor, which are consistent between the states, which conform to state laws and regulations, and which should be used for water quality issues involving interstate waters. The list below contains the initial set now confirmed and adopted by each state.

- The critical minimum low flow from Thurmond Dam is 3600 cfs (as a daily average).
- Critical minimum flows in the River downstream of Thurmond Dam will be determined by adding 7Q10 low flows from incremental drainage areas to the minimum from Thurmond Dam. (Critical low flow values for various points in the River will be provided by the combined staff of the Bureau of Water and Water Protection Branch.)
- Critical low flows in the River, thus determined, will in turn become the critical freshwater flows input to the upstream boundary of the Harbor model.
- For the Harbor model critical meteorological and tidal conditions will be those measured during the recent Summer-Fall 1999 field survey.

- o All intakes and discharges should be represented in the critical conditions model at their permit limits expressed as a monthly average.

- o The current 1999 Harbor channel 'bathymetric' configuration should be used to determine natural or baseline conditions for the Harbor if that becomes necessary.

Additional state specifications of critical conditions, that do not appear in this list, are likely. These will be provided by the combined staffs of the South Carolina Bureau of Water Pollution Control and the GAEPD Water Protection Branch, when needed.

Sincerely,

Alton C. Boozer

Alton Boozer, Chief
Bureau of Water Pollution Control
SCDHEC

Sincerely,

Alan W. Hallum

Alan W. Hallum, Chief
Water Protection Branch
GA EPD

AB/AH/rbf

CESAS-PD-E 13 May 03

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 8 May Interagency Meeting on Evaluation of Impacts to Water Quality

1. Attendees:

EPA:	Jim Greenfield
	Steve Whitlock
USGS	Paul Conrads
GA DNR-EPD:	Roy Burke III
	Paul Lamarre
City of Sav:	Bob Scanlon
MACTEC (Law Env):	Larry Neal
ATM/GPA:	Steve Peene & Bo Ellis
	Danny Mendelsohn, Henry Rines & Tom Gallagher
LGE/GPA:	Larry Keegan
COE:	Doug Plachy
	Bill Bailey

2. A copy of the agenda is attached.

3. I opened the meeting by stating that ATM wanted us to review what they were doing leading to calibration of the D.O. Model, provide them with guidance, and inform the group if anything they are doing may be unacceptable to our agencies.

4. Henry Rimes began by discussing the findings in their **Draft D.O. Characterization Report**. Concerning **Primary Productivity**, it appears that algal production is not a major activity within the estuary. Algae enter the estuary from upriver and the ocean, but the low light penetration appears to limit productivity within the harbor area. ATM agreed to conduct an initial test to determine whether the model indicates that algal production is important in the harbor area. If the initial runs show no real production (loss rates > growth rates), ATM will then "turn off" the algal production components of the model and proceed with the major calibration effort without the algal production factors working. The Calibration Report will describe this testing and the conclusions reached.

Concerning **BOD**, it was mentioned that the inhibitor in the BOD test may have suppressed the CBOD5 values. The BOD values were noticeably different during Week 2 of the sampling. The group did not know of a reason for this. ATM will flag the Week

2 BOD values to identify their influence on the averages over the sampling period. ATM will use the BOD5 instream data to apply the F ratios.

Concerning the **marshes**, ATM and USFWS ecologists have delineated drainage basins and obtained elevations for the intertidal marshes between the Houlihan Bridge and I-95. The loadings from these marshes appear to be a major contributor to the BOD loading in the estuary. To ensure the best information is included in the H&S and D.O. Models, ATM will compare (1) the intertidal volumes passing through the tidal creeks based on the drainage basins and marsh elevations developed by the ecologists, and (2) the volumes for those creeks that as they are now configured in the H&S Model.

Concerning **Longitudinal Profiles**, the data showed what the reviewers expected.

Concerning **SOD**, we have data for four locations. Because of the similarities in sediment characteristics (high fines content) and the high shoaling rates in both locations, the group agreed to apply the SOD values measured in the Kings Island Turning Basin to the Sediment Basin.

Concerning **Instream D.O.**, to follow the Expectations Document, ATM will calibrate to both D.O. and D.O. deficit. We discussed the low D.O. spikes that were observed at slack tides. The D.O. data shows recurring sharp (short term) drops in D.O. at slack tides. This occurs more frequently at stations closer to the ocean. The group agreed that the data appear to be a sampling artifact or probe fouling problem, rather than a natural occurrence. The group agreed that these spikes are most likely not real and should be deleted from the dataset.

5. ATM then discussed the **Loadings**. Flows from upstream and the marshes appear to provide the largest net CBOD and TKN loads to the estuary. On the marshes, ATM has initially split the marshes (vertically) along the length of Back River, grouping Transects 2 & 5 together. With this split, the marshes are separated according to which side of Middle River they fall on. The group recommended ATM reexamine this split to determine whether it should instead be based on marsh types (which correspond to salinity levels). They should do this by examining the data obtained during the Tidal Wetland Studies and consulting with the ecologists that obtained that data. Dividing the marsh based on salinity would generally separate the marsh (horizontally) into types as one moved up the river, with the same type generally occurring on both sides of the river. ATM will also check with the ecologists from the Tidal Wetland Studies for values on the productivity of the marshes. This would be used as a check on the appropriateness of the production values used in the marsh loadings. The Redfield Ratio (N-P-K in phytoplankton) was suggested as a starting point for carbon ratios for marsh vegetation. It was observed that the Redfield Ratio was based on aquatic plants, and that upland plants possess a higher carbon ratio.

6. ATM then discussed the **Boundary Conditions**. The group provided no decisions or guidance.

7. ATM then discussed the **Coefficients**. ATM will restart the calibration using median literature values.

8. We then briefly discussed the availability of the model after it is calibrated. ATM agreed to have an answer by 23 May for both the Corps (availability of a version with the calibration locked) and EPA (availability of a version where all calibration parameters can be changed).

9. One footnote to the meeting summary is that the Corps did receive the joint letter from SC and GA dated 1 May 2003 concerning model application runs. I have attached a copy of that letter to this summary.

10. Another footnote (as a reminder) is this paragraph from the summary from our September 02 meeting:

> We then discussed the parameters that the agencies believe will need to be evaluated in the EIS. The items include the following:
> - Dissolved Oxygen
> - Temperature
> - Mixing zone of point sources
> - Assimilative capacity of Dissolved Oxygen in the harbor
> - Chlorides at Abercorn Creek

Attachment

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY COORDINATION
ON
WATER QUALITY

MAY 8, 2003

AGENDA

MORNING

D.O. Characterization Report	**ATM (2 hours)**

AFTERNOON

"Base Case" Conditions for Calibration — **ATM lead**
- Boundary Conditions
- Loading
- Constants & Coefficients

Acceptability Criteria/Goals — **COE lead**

Schedule for completion of D.O. Model — **ATM**

Application of the models — **ATM**
- Time & costs per run (including analysis)
- SH Expansion, Ecosystem Restoration, TMDL, and other projects

D H E C

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

Georgia Department of Natural Resources
Environmental Protection Division, Water Protection Branch
4220 International Parkway, Suite 101, Atlanta, Georgia 30354
Alan W. Hallum, Branch Chief
404/675-6232
FAX: 404/675-6247

May 1, 2003

Mr. David V. Schmidt
Chief, Planning Division
Savannah District, Corps of Engineers
Department of the Army
P. O. Box 889
Savannah, Georgia 31402-0889

Dear Mr. Schmidt:

In a letter dated 15 October 2002 you requested that the States identify conditions to be represented by the Savannah Harbor Model when used to evaluate water quality impacts of the proposed harbor deepening project. These included: model critical conditions, specific model simulations needed, and guidelines for the presentation of model results.

Staff members from the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Environmental Protection Division (GAEPD) met to consider this request and formulate our response which will be delivered in two phases. The Phase I response, included in this letter, represents those we can state now without further information. The Phase II response, to be delivered at a later date, requires: (1) an understanding of the dissolved oxygen standard which has not yet been proposed; (2) a finalized Harbor model which has not yet been fully calibrated: and, (3) an opportunity for our staff to examine the new standard with respect to model capabilities and the specific issues to be addressed.

This Phase I response focuses on model critical conditions reflected in State regulations and implemented through standard modeling practices to examine the protection of water quality standards and develop TMDLs and NPDES permit limits. In a letter to USEPA Region 4, dated 4 May 2000, SCDHEC and GAEPD outlined an initial set of critical conditions to be used for the analysis of water quality issues for both Savannah River and Harbor. We confirm those conditions and, as an update, add the following:

- The upstream boundary conditions for the Harbor Model will be determined by the States' Savannah River Model.

- Kinetic rate parameters, sediment oxygen demand, and non point source conditions determined during Harbor Model calibration shall be used in the critical conditions model.

- The Corps has recently proposed a modification to the drought operation plan for Thurmond Dam. The States reserve the right to redefine critical minimum flows, earlier described in our 4 May 2000 letter, in response to any changes in minimum flows from Thurmond Dam.

- All of our responses to your request relate exclusively to the use of the River and Harbor models and those issues that can be directly addressed with these models.

SCDHEC and GAEPD will continue to work and communicate together on issues of joint concern for Savannah River and Harbor. Additional specifications, especially those involving the Phase II response, will be provided by our combined staffs when appropriate.

Sincerely,

Alton Boozer

Alton Boozer, Chief
Bureau of Water
SCDHEC

Sincerely,

Alan W. Hallum

Alan W. Hallum, Chief
Water Protection Branch
GAEPD

CESAS-PD-E 24 June 03

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 18 June Interagency Meeting on Evaluation of Impacts to Water Quality

1. Attendees:

USGS	Paul Conrads
GA DNR-EPD:	Roy Burke III
	Paul Lamarre
SC DHEC	Wade Cantrell
ATM/GPA:	Danny Mendelsohn, Steve Peene & Bo Ellis
LGE/GPA:	Larry Keegan
COE:	Doug Plachy
	Bill Bailey
EPA	William Melville

2. The meeting was held to allow ATM to provide a status report on their calibration efforts on the D.O. Model.

3. I opened the meeting by stating that we would handle issues recently raised by Jim Greenfield (EPA) about vertical mixing and Richardson Number after the presentation by ATM. I felt we needed to first allow ATM to tell us what they wanted; secondly, to provide an opportunity for the agencies to give ATM any guidance on items that may come up; and lastly address Jim's concerns, if possible, that day. We agreed that Steve Peene would contact Jim Greenfield directly to work out acceptable wording for a letter on access to the calibrated models, then provide that letter to the Corps.

4. Danny began by discussing a **comparison of salinity movement in the BFHYDRO and BFWASP models**. The peaks show BFWASP to be about 1 ppt higher in the Front River. The peaks and troughs were <1 ppt lower in BFWASP in the Back River. USGS requested ATM display this information for the full length (70 days) of model runs.

5. Danny then discussed the **Upstream Boundary**. He used the EPA-RIV1 output as input to the Hydro Model. Results for Ammonia, Phosphate, D.O. and Organic Phosphate looked OK. (There was no field data to compare computed values of Organic Phosphate.) For Nitrate, the data showed values of about 0.2 mg/L, while the model predicted values of about 0.4 mg/L. ATM is concerned that the EPA model is too high for this parameter. For CBOD, the predictions appear to match the data, but ATM thinks the EPA model is too high.

Roy Burke expressed that the RIV1 Model was developed in a data-poor environment. It was based on 1990/1991 data and a calibration performed at that time. He believes that model captures the trends well, but may not match absolute values well. For Nitrate and CBOD, he felt it would be OK to use either the RIV1 model results or the observed data. ATM should explain the rationale for their choice. USGS recommended giving priority to the collected data rather than relying on the RIV1 predictions.

6. Danny then discussed **loadings**. The marshes are the largest factor in Nitrate and BOD. Point sources and the downstream boundary are small factors.

7. Danny then reviewed the **point source loads**. No particular issues were raised.

8. Danny then discussed **vertical mixing**. Danny and Steve stated that information on this issue had been discussed before and they thought we had reached resolution. Danny stated that vertical mixing was calculated within the Hydro Model. It uses the amount of tidal energy. Only the non-linear momentum term is turned off in the model. ATM had evaluated that issue previously and concluded this parameter did not affect the model results other than the time step. Danny stated this had been described in a paper that had received peer review. After the meeting he provided the paper to USGS, who distributed it to the rest of the Federal agencies. We requested ATM provide their explanation of what the model did for both vertical mixing and the Richardson number to Jim Greenfield prior to completing the Hydro Model Calibration Report, and then include that information in the Calibration Report. The explanation should state why ATM believes the model will function accurately when changes in bathymetry are considered.

9. Concerning model results, ATM is rethinking the marsh boundary condition. They proposed a population limiting approach. An alternate is the Area Flux Method. The group did not recommend one approach over the other. They just requested ATM describe what they selected and provide a rationale for their choice.

10. We concluded by briefly discussing the multiple CBOD decay rates. I stated that based on the recent letters from GADNR-EPD and SCDHEC, ATM was to proceed with the original plan – which was to attempt to calibrate using a single CBOD decay rate. If they were unsuccessful in obtaining good calibration, ATM would then use two decay rates. ATM has already built into the model the capability to use a second CBOD decay rate.

11. The next meeting will be on August 20th to review the Draft D.O. Calibration Report. That report is to be provided to the agencies on August 1st.

William Bailey
Environmental Resources Branch

CESAS-PD-E 3 September 2003

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 20 August Joint Meeting on Review of Draft D.O. Model Calibration Report

1. Attendees:

ATM:	Daniel Mendelsohn, Steve Peene & Bo Ellis
Hydroqual:	Tom Gallagher
LGE:	Larry Keegan
GPA:	Hope Moorer
City of Sav'h:	Bob Scanlon & Larry Neal
GA DNR-EPD:	Roy Burke & Paul Lamarre
SC DHEC	Wade Cantrell & Larry Turner
EPA:	Jim Greenfield
USGS:	Paul Conrads
CE-ERDC:	Sung-Chan Kim
CESAS:	Doug Plachy & Bill Bailey

2. The Agenda is attached.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. The City provided its comments first. Larry Neal spoke for the City. He led off by stating that the City's main goal is for the model to be an accurate and defensible representation of the point source dischargers' effects on the D.O. Deficit in the harbor. He then provided the following specific comments:

- Model appears to be sensitive to CBOD decay rates.
- Would like to see sensitivity of CBOD loading at Clyo and the ocean boundary.
- ATM should look at the salinity levels in the samples collected at Fort Pulaski.
- It appears that the model has too much BOD at the upper end (boundary) and too little at the lower end (boundary).
    - GADNR-EPD stated that there are possible additional sources of BOD loads from the saltmarshes in the lower portion of the estuary. In SC, from marshes around Wright River and New River. In GA, from marshes around Wilmington River and South Channel. This is possible justification for adding more BOD in the lower end of the model.

- Concerned about ATM using a single CBOD decay rate for each point source discharge, marshes, etc.
  - GADNR-EPD stated that the following actions could be pursued to obtain an acceptable calibration: (1) adjust the long term decay rates from the few values that were measured, and (2) use spatially variable rates.
- Would like to see a test of the sensitivity of the f-ratio of point sources and marshes.
  - Hydroqual suggested using a unit-response approach to identify the effect of changes in f-ratios.

5. GADNR-EPD provided its comments next. Roy started by questioning the purpose of this review. I stated that this review of the Draft Report was an opportunity to suggest revisions, while the review of the Final Report will be for determining whether the model is Acceptable or Not Acceptable for its proposed use. We would have a Comment/Response round on the Final Report before seeking the agency's position on the model.

Roy said that the time series for D.O. indicate that the model currently doesn't capture the range of highs and lows in the data. He stated that the diurnal highs and lows indicate to him that the D.O. processes are tidally-driven rather than being driven by photosynthesis. It appears that there are equal errors of D.O. on the surface and bottom, indicting to him that there is not a vertical mixing problem. The differences in D.O. between the surface and the bottom appear to be more of a longitudinal effect. He called this area of D.O. sag in the harbor another example of a "coastal big dipper", an effect that can be observed in other larger coastal rivers.

EPA requested that ATM show a comparison of model and data with the 24-hour and 36-hour synoptic sampling that was performed of both salinity and D.O..

6. SCDHEC had no comments at this time.

7. I followed with the comments from CESAS.

- Talked through the written comments that we already provided to ATM.
- Requested that the smaller data reports (such as EPA's SOD Report) referenced in the Calibration Report be included on the CD containing the Calibration Report.
- ATM will at a minimum conduct a sensitivity analysis of the effects of using a dynamic offshore boundary. They will review the results of USGS's ANN work on the offshore boundary if it becomes available in time. ATM will review the USGS ANN work and determine how it could be included in the D.O. Model calibration. They will inform the Corps of their position. The possible extent to which ATM could include that ANN information will be greatly influenced by when the USGS completes that work.

8. The USGS was next. Paul gave the following specific comments in addition to the written ones already provided to ATM:

- The report needed to better describe how and why the modelers made decisions during the model development process.
- ATM should explain their modeling philosophy (trying to match at GPA17 and Fort Pulaski; adjusted values at the boundaries to match data at those locations, etc.).
- Should show the sensitivity of reaeration rates.

9. The CE-ERDC was next. Dr. Kim gave the following specific comments in addition to the written ones already provided to ATM:

- The report should describe the range of flows covered by the calibration and verification data.
    - Hydroqual recommended that the report show the range of all important environmental conditions (tidal range, etc.)
- The vertical mixing issue is critical to resolve before ERDC could recommend use of the model for evaluation of harbor deepening scenarios.

10. EPA was last. In addition to the written comments already provided to ATM, Jim expressed a few general comments. One was that the report needed to include more to make the model defensible. Any changes to the model code should be described, explained and justified. Was the advection term turned off or not? If so, why is that not important to the model? EPA would like faster run times for these models. He questioned whether the coarser grid – with 4-8X faster run time – could be used to conduct some screening of alternatives.

11. We then discussed vertical mixing. The agencies stated that a better explanation was needed of (1) what was done, (2) why those choices were made, and (3) why the procedure is acceptable for application on a proposed harbor deepening project.

12. We discussed the upcoming schedule for production of the Final Calibration Report and agency review. We agreed that the Final Calibration Report for the Hydrodynamic & Salinity Model would be completed at the same time as the one for the D.O. Model. For a schedule, the group agreed to 30 days for the review, 30 days for the comment/response resolution, and then 15-30 days to get a written agency position. EPA indicated that if the reports become available later than scheduled, they would not be as available to review the reports, resulting in a longer review time for them. At the time, the D.O. Model was scheduled for completion on 3 October. ATM agreed to review the comments and inform GPA when they would complete the reports. Their initial reaction was that the comments did not constitute a change in scope from the work they had been contracted to perform. ATM has since notified GPA and the Corps that the reports will be sent out on 24 October. That will likely extend the review time beyond 30 days.

William Bailey
Environmental Resources Branch

SAVANNAH HARBOR EXPANSION PROJECT
AND
SAVANNAH HARBOR
ECOSYSTEM RESTORATION PROJECT

JOINT REVIEW OF
DRAFT D.O. MODEL CALIBRATION REPORT

AUGUST 20, 2003

AGENDA

OPENING & INTRODUCTIONS	**CESAS**
REVIEW OF PRELIMINARY COMMENTS	**Reviewers**
• City of Savannah	
• GA DNR-EPD	
• SC DHEC	
• CESAS	
• USGS	
• CE-ERDC	
• EPA	
VERTICAL MIXING IN HYDRO MODEL	**CESAS**
REVIEW OF SCHEDULE AND REQUIREMENTS	**CESAS**
NEXT STEPS	
• Incorporation of comments	**LGE**

NOTE: There will be no presentation by ATM on the D.O. Model

CESAS-PD-E

7 March 04
Revised 15 March 04

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 4 March Meeting of the Interagency Water Quality Team

1. Attendees:

USGS	Paul Conrads
GA DNR-EPD:	Roy Burke III & Paul Lamarre
SC DHEC	Wade Cantrell & Larry Turner
COE:	Doug Plachy; Bill Bailey & Ken Derickson Sung-Chan Kim
EPA	Jim Greenfield & Steve Whitlock
Harbor Committee	Larry Neal & Margaret Tanner

2. The meeting was held to determine whether those reviewing the ATM/GPA Final Calibration Reports for the Hydrodynamic & Salinity and Dissolved Oxygen Models need additional information or clarifications before they are able to reach their decisions on the models.

3. I opened the meeting by reviewing the purpose for the meeting and providing an agenda. I reiterated that these two documents are intended to be ATM's final reports on development of their models and that the Project is not envisioning another round of Comment / Response with the reviewers. I asked that each agency reviewer summarize their findings and explain any concerns they may have so far.

4. Dr. Kim (USACE-ERDC) led off the discussion. He explained that transport of mass is very important in the models. For the vertical mixing used in BFHYDRO, the report states that the diffusivity is based on the tidal range. He stated that the formulas used to calculate the diffusivity are empirical – and are not physics based. The equations use two sets of coefficients, one developed from 1997 data and the other from 1999. which was not documented in the report. Because of the inconsistent method used to calculate the diffusivity, Dr. Kim believes the application of the models should be limited to only those time periods over which the data was collected.

Dr. Kim also stated that the Hindcast evaluation was not conducted properly. It did not prove that the vertical mixing approach works for different channel depths.

Because of these two items, Dr. Kim believes that the mixing scheme is not defensible for extrapolation beyond conditions observed during the data collection periods (both in time and in bathymetry).

5. Paul Conrads (USGS) that described the findings of his review of the vertical mixing described in Appendix Q. He explained that the mixing was driven by the tidal range, and was calculated using Equation 5. He described how the equation was implemented – that there were two sets of coefficients for the different years over which ATM collected data. The manner in which the equation was implemented was not described in the ATM report, but instead in a spreadsheet that ATM subsequently provided to Paul. He explained that offsets were added to the values calculated for mixing. Offsets were added twice, once within the formula and another time to the highest of the values calculated from the two equations.

Paul explained some sensitivity work he had conducted on the tidal smoothing that ATM had used. He showed how the order in which the smoothing is performed resulted in a 14 percent difference in the model results at the peaks. The conclusion was that this model results are very sensitive to the vertical mixing approach.

Paul mentioned that he had consulted other modelers within USGS in the review of the vertical mixing approach. After their independent review of the model, they also expressed strong reservations about the defensibility of the vertical mixing when used for making predictions of harbor deepening.

6. Jim Greenfield (EPA Region 4) then explained his findings. He started by saying that he had brought in a modeler from EPA's research lab in Athens to review the model. That reviewer had expressed concerns about the vertical mixing approach used in the model. Jim explained that the Hydro Model used a backwater calculation for the riverine portion of the model domain. He said that WQMAP using this river formulation had not been applied previously in riverine conditions and not previously defended. He stated that the procedures used were not sufficiently well defined in these Final Reports for him to be able to sufficiently defend results produced by the model.

Jim stated that in the D.O. Model, the SOD rates were quite high and that the reports did not sufficiently justify the BOD decay rates that were used.

He stated that the reports did not fully describe how or why ATM decided to use only 2/3 of the data that they had previously provided in the WRDB database. That database had about 31,000 records, but ATM used on 18,000 in their present reports.

7. Roy Burke (GADNR-CRD) then stated his findings. He reminded the group that he thought one goal was to develop a "legacy model" that the states could use to evaluate other proposed actions. He believes that the ATM models are too complicated and take too long to run. Roy praised the Federal agencies for their detailed review of the vertical mixing. He stated that any other model must perform equally as well, or better.

Concerning BOD, he said that (1) the model did not describe the marsh loading well, (2) that the instream decay rates had been changed from 0.06 to 0.09, with insufficient explanation given, and (3) that the marsh loads are very important in this system.

He said that the calibration appeared to be OK, except for the main river section where D.O. problems occur (Front River from Fort Jackson to the Houlihan Bridge). He said the balance between SOD and reaeration were not described well.

Roy stated that the State of Georgia had been left out of meetings that the Federal agencies had concerning this model. He believes the State should have been informed of those meetings and provided an opportunity to participate in those technical discussions on the models. He requested the States be informed in the future about scheduled meetings, their purposes, and then their outcomes. I apologized for leaving him out and said that although the Federal Cooperating Agencies felt a high level of responsibility for the conduct of the technical work performed as part of the project, we would include him in the future. To provide an example of work that had occurred during what the State perceived as a long period of inactivity (silence), Roy mentioned the Expectations Document that the Federal agencies had prepared in 2001. For ready reference, he requested a copy of that document, which we distributed during the meeting.

Roy concluded by stating that ATM's Final Reports did not address many of the issues that were discussed at the August 2003 meeting with ATM and GPA.

8. For the purposes of this record, I will continue with the review comments, although the group heard a presentation on another topic at this point in the meeting.

9. Larry Turner (SC DHEC) then provided some of their thoughts on the models. Larry concurred in the importance of the ability of the States to use the model in the future. He supported Roy Burke's desire to be kept in the loop on review of the models, but also expressed staff limitations and did not want to be overwhelmed with just this project. He explained that salinity in the National Wildlife Refuge is important to SC, as is any area where a change in use would occur as a result of the project. He reiterated that salinity was a very important parameter in this system.

Wade Cantrell (SC DHEC) then continued by stating that the reports did not sufficiently describe why the CBOD decay rates of 0.09 were used, when previous meetings a value of 0.06 had been discussed.

Wade said that the reports did not sufficiently support why 10 percent of additional flow had been added to those recorded at Clyo. He said it appeared that in 1999 that the flow volumes used in the model may have been reduced by 10 percent. The reduction is about 10 percent at the beginning of the 1999 simulation, but then it declines steadily to 0 percent at the end of the simulation, when the model inflow equals measured flow at Clyo.

10. Larry Neal (MACTEC for the Harbor Committee) then discussed his review comments. He said he had reviewed the D.O. Calibration Report only and had trusted the Federal and State agencies to assess the adequacy of the Hydro & Salinity Model.

Larry suggested using the CBOD measured decay rates. The measured range was 0.03 to 0.08. He believes the 0.09 decay rate used in the model substantially overstates the impact of the point source dischargers which have much lower measured decay rates.

Larry said that sensitivity tests are needed for CBOD levels used for the offshore boundary.

Larry stated that the reaeration rates are probably too high. He stated that the empirical reaeration equations are based on tidally averaged velocity and mean depth. He suspected that the model may incorrectly use instantaneous velocities and depths, rather than averaged ones. The reaeration rates in the report range from 0.35 to 1.6, while those in EPA literature range from 0.08 to 0.65 for tidal rivers and estuaries, with the rates calculated in this model about 3 to 4X those used in other tidal river and estuarine projects (including Savannah).

He believes the D.O. calibration started from the wrong point, levels of D.O. in the system that are too high and not realistic. He believes the modelers then adjusted SOD, the offshore boundary values, and the BOD decay rates to improperly balance the D.O. in the system. He stated that he found no sensitivity testing on ocean boundary BOD or percent DO saturation assumption of 75 percent.

During application, Larry recommended not using a combination of all critical conditions, since the probability of those events occurring simultaneously would be very small.

11. I then asked each reviewer if they needed any more information from ATM/GPA before they could reach their conclusions about these models. They uniformly said "No".

I agreed to send the agencies an email restating the question(s) that I wanted each agency to answer concerning the ATM/GPA models.

12. I asked each reviewer to state their overall assessment about the models at this time. This is a summary of their responses:

EPA

- The vertical mixing approach makes the Hydro Model unacceptable.

USACE-ERDC

- The vertical mixing approach in the Hydro Model is unacceptable.
- The approach used limits the application to the 1997 and 1999 data collection periods.
- Hydro Model could be used to evaluate water surface elevation and velocities, generally within the range of flows observed during the data collection periods.
- The approach used renders the application unusable to evaluate the effects of changes in channel depth.

USGS

- The vertical mixing approach in the Hydro Model is unacceptable.
- Hydro Model could be used to evaluate water surface elevation within the general range of flows observed during the data collection periods.

Harbor Committee

- The D.O. calibration is unacceptable.
- They will rely on the Federal and State agencies for the Hydro Model.

SC DHEC

- Based on the questions raised concerning the defensibility of the vertical mixing scheme and the conclusions of the Federal review agencies, the AEM Models cannot be used for the expansion project.

GADNR-EPD

- The BOD mass balance is insufficiently documented.
- The D.O. Model is unacceptable in its defensibility.

13. The group heard a presentation by EPA's contractor (Steve Davie from TetraTech) on the Plan B Hydro Model. They distributed a Calibration Report for that model. TetraTech had worked with both a coarse and a fine grid. The coarse grid performed reasonably well, so the statistics in the Calibration Report are based on use of that coarse grid. The coarse grid is 6 layers deep and 3 wide in the navigation channel. The document describes their efforts and overall findings with the fine grid. They extended the ocean boundary out to 18 miles from the entrance.

Steve described the work they had done to include the marsh volumes in the model. They adjusted the shape of the marsh cells to ensure they did not go dry, but maintained the total flow volume into those cells.

For vertical mixing, they adjusted one parameter from the standard settings. That parameter is the one that the technical paper describing the mixing approach said could be adjusted without compromising the underlying assumptions. Their adjustment is within the bounds described in the original technical paper.

For salinity at the offshore boundary, they evaluated many different levels and approaches. They settled on a constant 33.5 at the boundary, which matched the observed data at Fort Pulaski well.

For Calibration, they used a single run covering from 1996 through 1999. The statistics are reported for the entire 4-year period, as well as for the 2-week periods described in the Expectations Document. They did not add to the river flows measured at Clyo. For their Validation, they used the same set of input data, but compared the model results to a different set of observations – those recorded at the continuously recording USGS stations. TetraTech's Hydro Model with a coarse grid takes about 3 hours to do a 12-month run, 11 hours for a 4-year run. The fine grid takes about 6 hours for a 12-month run.

14. EPA provided the group with a brief update on the status of the RIV1 model. EPA is continuing to add recent point source discharge data into the model. ATM used the RIV1 model for their 1999 calibration runs. EPA intends on using the RIV1 model for the 1997-2000 period during calibration of their D.O. Model.

15. I agreed to review the previous agency letters and let the reviewers know where the need that I had quoted in my Feb 20 email for Evaluation of Impacts to Mixing Zones for Point Source originated.

16. Concerning the scheduling of future work and coordination, EPA expects to have their D.O. Model complete by the end of May. EPA would like to meet fairly regularly between now and then to keep the group of the status of that model development process. The group agreed to meet back at EPA at 10:00 on April 15th. Subsequently, that date was revised to April 20th

I requested the reviewers send me an email with their preliminary findings on TetraTech's Hydro Model Calibration Report **by the end of March**.

Savannah District would like an agency letter expressing their position on the ATM/GPA models **by 5 April**. The Project's Executive Management Group (heads of EPA, USFWS, NMFS, Savannah District, and GPA) will be meeting on 7 April to discuss these models and one other issue.

William Bailey
Environmental Resources Branch

CESAS-PD-E

31 March 04
Rev 10 May 04

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 31 March Meeting of the Interagency Water Quality Team

1. Attendees:

USGS	Paul Conrads
GA DNR-EPD:	Roy Burke III & Paul Lamarre
SC DHEC	Larry Turner
COE-Savannah	Dan Parrott; Bill Bailey & Ken Derickson
COE-ERDC	Sung-Chan Kim
EPA	Jim Greenfield & Steve Whitlock
Harbor Committee	Larry Neal
GPA	David Schaller & Hope Moorer
LGE	Larry Keegan
ATM	Tom Schanze, Steve Peene, Bo Ellis, & Danny Mendelsohn

2 The meeting was held to provide ATM an opportunity to explain the vertical mixing approach used in their Hydrodynamic & Salinity Model. Agency reviewers had provided comments on the vertical mixing approach and ATM had provided written responses to those comments. This face-to-face meeting was to insure the agencies are making their review decisions based on correct information and a correct understanding of the written documents.

3 I opened the meeting by stating that we had all invested a lot of time and effort into these models, that the Final Reports had taken much hard work, and that hard decisions now had to be made on the acceptability of the models. I stated that all attendees were present because we are professionals concerned about a quality product. The meeting was to review only the vertical mixing comments on the models.

4 Steve Peene gave an **overview**. He stated that ATM had developed the vertical mixing equations for the 1997 model. ATM did not alter those equations when they began their Tier II calibration efforts. They applied the 1997-based equations to the 1999 data and found that they reasonably reproduced the 1999 dataset. After reaching that conclusion, they did not adjust the equations to calibrate to the 1999 data. ATM used the same basic set of equations in both the calibration and validation efforts. They applied the 0.0001 offset in January 2004 to marginally increase the performance of the H&S Model. That same offset was used in both the calibration and validation efforts. Steve stated that numerous other projects had used an empirical formulation for vertical mixing.

5 Steve then opened the floor up to any **general questions**. Dr. Kim stated that based on the charts ATM provided, ATM would likely have developed a different set of constants for the vertical mixing equation if they had started with the 1999 data. The need for a 2-component equation such as ATM developed would not have been obvious based only on the 1999 data. He expressed concern that the model validation still contained a mixture of 1999 and 1997-derived data/constants. ATM responded by saying that because of the drought, 1999 was an odd-ball year and that 1997 was more of a normal year in terms of flows. They had been fortuitous in having data from 1997 to produce a more comprehensive foundation from which to develop the equation constants. They stated that they should not be penalized for having a better foundation upon which to develop the constants. ATM stated that in their response-to-comments they evaluated the model's performance over other time periods: 1992, and the entire years of 1997 and 1999. They feel that this work demonstrates that the equation applies well to a broader set of conditions than just those observed during the data collection periods.

I asked whether the other models that ATM had listed as successfully using an empirical approach had been applied to address changing bathymetry (harbor deepening) or were they TMDL-type projects evaluating changes in water quality inputs. ATM did not know if any had been used to address the issues facing this project.

Dr. Kim did not believe ATM had used a true zero order model to calculate vertical eddy viscosity. Such a model is used for each of several vertical layers, while ATM's approach applied a single number throughout the entire water column. ATM concurred.

Dr. Kim questioned the relationships for the Richardson Number developed from the data shown in Figure 9 (page Q-25) and Figure 18 (page Q-31). He did not think that one could easily conclude that the data from the two years, as expressed in the two figures, were from the same population. The relationship developed to represent each year did not match each other well. He said that with the variability in the data, the relationship that was developed was not reliable – it would have a wide confidence interval. He questioned whether using that equation was truly representative of that entire population. ATM stated that the model did not use the relationship developed from those figures as an input.

ATM believes that the model is good for flows between 5,000 and 20,000 CFS. No impact analyses have been requested outside that range.

6 Dr. Kim stated that after having read ATM's responses to his comments, he still could not defend the approach to determine eddy diffusivity. ATM stated that the approach they used is based upon and represents well the observed data and patterns in the data.

7. ATM said they feel that performance is an important part of defensibility when using an empirical approach. The group stated that the defensibility of the empirical approach is critical and needed to be addressed before considering how well a model may represent observed data. The Federal agencies had decided that it would be best to conduct a phased review (defensibility before performance) prior to release of the Jan 04 Calibration Reports.

8. The group concluded that **further efforts to refine the empirical approach** will not likely result in the model becoming acceptable. ATM said they could replace the empirical approach for vertical mixing with a physics-based approach. The group believes that such a replacement would provide the basis for an acceptable model.

9. GPA asked **whether the reviewers felt the D.O. Model was or could become acceptable**. I went around the table asking for the reviewers' opinions on this question.

GADNR stated that they expressed their concerns about the D.O. Model at the last meeting. These concerns included the reaeration rates, SOD, and BOD mass loading. The model and calibration as described in the Jan 04 Calibration Report would not be acceptable. They believe there is still a significant amount of work ahead to make the D.O. Model and its calibration satisfactory.

SCDHEC stated that they have not been able to perform sufficient review to make a determination.

The Harbor Committee stated that they believe the reaeration rates are 3-4 times too high and that ATM was then forced to make several counter-balancing adjustments to correct that situation. They believe the BOD balance is not good. They have numerous questions about the model formulation and calibration. They are resistant to adopt the model as presented in the Jan 04 Calibration Report, but they believe they can help in identifying realistic and defensible values to use in the calibration.

USGS stated that their review had centered around the technical defensibility of the vertical mixing routine in the model, and that the approach was presently unacceptable. In addition, there was concern with how the riverine dynamics were handled in the model.

EPA stated that their review had centered on the technical defensibility of the model, and that the approach used by ATM was presently unacceptable. EPA also had questions on the data portion of the report and how marsh issues were handled. They concurred that there were D.O. issues, but believed that those could be fixed if the Hydro Model was calibrated correctly and was technically defensible. With sufficient time and manpower the D.O. Model most likely could be made acceptable, but until the Hydro Model fixed it would not be fruitful to start on recalibration of the D.O. Model.

10. EPA stated that they are **pursuing development of the Plan B model for their Dissolved Oxygen TMDL**. They expect to have the D.O. Model developed by June and have a draft TMDL out for review in August. Jim stated that the Plan B Model would be acceptable for use in the Expansion Project, even though developed for the TMDL. He said that the Plan B Model would be designed to meet the Expectations Document, as had the ATM (Plan A) Model.

11. As a summary, the group reached three major **conclusions**:
   (A) The empirical vertical mixing approach is not acceptable for use on the Expansion Project. Further refinement of this approach is not likely to make it acceptable for such use.
   (B) ATM could replace the empirical approach with a physics-based approach. Assuming this is successful, the agencies would then evaluate in detail the performance of the H&S and D.O. Models.
   (C) There are several concerns about the formulation and calibration of the D.O. Model.

12. I identified the following **next actions**:

<u>Plan A</u>	
Agency letter on acceptability of the H&S and DO Models	5 April
<u>Plan B</u>	
Email from technical reviewers on preliminary assessment of Hydro Model	31 March
Agency letter on acceptability of H&S Model	30 April
Meeting of Executive Management Group	7 April

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William Bailey
Environmental Resources Branch

CESAS-PD-E 22 April 04

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 20 April Meeting of the Interagency Water Quality Team

1. Attendees:

GA DNR-EPD	Roy Burke III & Paul Lamarre
SC DHEC	Wade Cantrell
COE	Bill Bailey
COE-ERDC	Joe Letter
EPA	Jim Greenfield & Steve Whitlock
Harbor Committee	Larry Neal & Margaret Tanner
USGS	Paul Conrads (by phone)
TetraTech	Steve Davie

2. The meeting was held to review the status of EPA's efforts to develop the Plan B D.O. Model. The group also discussed the review goals for the Plan B Hydro Model. Savannah District would like a letter from each agency expressing their position on the EFDC (Plan B) Hydro Model **by the end of April**. The Expansion Project's Executive Management Group will be meeting in mid-May to decide whether to pursue the Plan A or Plan B models to evaluate impacts on the Expansion Project.

3. Jim Greenfield opened the meeting by distributing and discussing a revised agenda. We discussed EPA's goals for their TMDL analysis and setting of a D.O. WQ standard for the State of Georgia. We also discussed the Corps need to develop or select and then apply models to identify expected impacts from a harbor deepening project. We agreed that EPA would take the lead for issues concerning TMDL development and technical development of the EFDC Models. The Corps would take the lead on issues concerning the application of the models to evaluate harbor deepening.

4. We discussed whether the group should adopt any **new processes** for their coordination on these efforts this summer. USGS suggested keeping a running list of "Unresolved Issues". EPA said they intend to prepare a series of "Technical Notes" to document how the group reaches decisions on specific issues as they move along.

5. We discussed the **coarse and fine grids for the EFDC model**. EPA said the coarse grid was acceptable to them for use on the TMDL and on the water quality issues in the Expansion Project. Joe Letter thought that a finer grid would be necessary to catch subtle changes that could be produced by proposed changes in the harbor bathymetry. He agreed that a coarse grid could be used as a screening tool. He suggested using a fine grid to tune the predictions of a coarse grid if model run times become an important factor.

6. EPA stated that they were working on both WASP 6.1 and WASP 7.0. If they could get WASP 7.0 working in time, they would use that in their final calibration. If it wasn't working acceptably when the model development time is complete, EPA will use the WASP 6.1 version for their work.

7. We discussed **Boundary Conditions**. Concerning CBODu, MACTEC stated that they had completed the analyses of the latest samples collected near the harbor entrance. They would electronically distribute the results. In response to a question from the Corps, the group confirmed that model application runs should use the permit limits from the upstream dischargers, as well as those from those in the harbor.

8. We discussed **Loadings**. Concerning temperature, EPA will first use a sensitivity analysis to determine the sensitivity of the transport to this parameter. MACTEC said that one could back into a temperature loading for a power plant from the energy production and the heat rejection of the equipment. GA stated that we may need to consider heat loads under full permit limits in a critical conditions analysis.

Concerning the marshes, GA asked TetraTech to further analyze ATM's data to try to determine SOD levels from the marshes. This could assist in a further review of the BOD loads from the marshes.

EPA asked the group to review their files and provide LTBOD information related to the decision to use a K = 0.06. The group thought that issue was discussed after May 2000.

The City requested an additional look at multiple BOD decay rates. They said effluent from the paper plants has a K = 0.02 and produces a large total load, while the model assumes a K = 0.06 for the entire river.

The City stated that the Stone Container plant went back on line in 2002 with one production line. Its effluent is blended with that from Savannah Sugar and Port Wentworth municipal wastewater.

9. EPA said it would be using the mid to end of August 1999 period for the sensitivity analyses since the data are more complete over that period of time.

10. SCDHEC will pick a station in SC water that it wants EPA to run the model to compare the results to SC WQ standards.

11. Concerning **GA's review of the EFDC Hydro Model**, they stated that they were using the same review goals as they had used for the Plan A ATM Models. They reviewed their previous concerns about Plan B's performance on water surface elevation, flow, currents, and salinity. TetraTech will respond to GADNR's concerns in writing before the end of April.

GADNR stated that the "Expectations" were correctly "goals" and not criteria. ERDC concurred that the "Expectations" set quite a high bar for performance. All agreed with those characterizations and stated that they expected that when the goals were not met, the modelers would explain why they did not / could not reach those goals.

GADNR noted that the Hydro Model results possessed a phase shift that exceeded > 30 minutes half of the time. TetraTech explained that they wrote Appendix A to address comments that Dr. Billy Johnson had previously made about the Plan A Hydro Model concerning the tidal surge being a progressive vs. a standing wave. GADNR requested TetraTech compare the model results directly with the data.

12. The following day a smaller group reconvened to get more hands-on explanations of the working of the EFDC Hydro Model. Before that discussion got underway, I asked about the **input conditions for model application runs**. Roy Burke explained that GA and SC laws require use of 7Q10 flows before a permit decision can be made. EPA regulations require that dischargers and water withdrawals be examined at permit limits. Roy explained that modelers may conduct a "Natural Conditions" analysis as well as a "Critical Conditions" analysis. In a Natural Conditions analysis, all discharges would be removed, so that the model would indicate the conditions that could occur in a more natural state. I explained that the Corps normally uses a "most likely to occur" approach. Roy agreed that evaluating potential impacts from a harbor deepening using just a "Critical Conditions" approach may not present a complete picture for decision-makers. For application runs on the Expansion Project, I believe the group should identify the model input conditions for both a "most likely to occur" approach and a "Critical Conditions" approach. Roy explained that typically the input conditions for the application runs are determined after a model has been developed and calibrated. I stated that the Corps has been trying to define the input conditions now solely because of a desire to speed the project along – to be able to begin application runs as soon as the agencies agree that a model is acceptably calibrated.

To allow a more informed discussion of this topic EPA / TetraTech should obtain the following information for each discharger and water withdrawal: (A) permit limits, and (B) levels observed during the 1999 calibration period.

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William Bailey
Environmental Resources Branch

Savannah Harbor Expansion Model Review Meeting
June 16-17, 2005
Savannah Harbor Expansion Interagency Water Quality Team Meeting
June 17, 2005
Tetra Tech, Inc. – Atlanta, GA

Attendees:
Roy Burke, GAEPD
Paul Lamarre, GAEPD
Wade Cantrell, SCDHEC
Bill Bailey, USACE Savannah District
Joe Hoke, USACE Savannah District
Jim Greenfield, USEPA Region 4
Paul Conrads, USGS (via phone)
Larry Neal, MACTEC
Margaret Tanner, MACTEC
Steven Davie, Tetra Tech, Inc.
Will Anderson, Tetra Tech, Inc.
Yuri Plis, Tetra Tech, Inc.

Agenda:
1. WASP model – consistency with enhanced grid and status of TMDL process
2. Status of calibration report from Tetra Tech
    - Issues/concerns from Federal and State agencies
    - Dr. Kim's (ITR USACE) comments
    - July 1, 2005 deadline for agency position
3. Application of the models for impact simulations (inputs and outputs)
    - Comments from states and other users

I. Status of TMDL (Jim Greenfield):
- EPA will now use one model for the harbor – enhanced grid
- WQ standard for dissolved oxygen still being developed, EPA headquarters is going to talk to GAEPD about proposing the standard
- SCDHEC will still have to develop a site specific criteria for SC waters
- Recruitment (fish) model will be used to develop the criteria values; being used in the Escatawpa River Estuary for the dissolved oxygen criterion (3.0 g/L); using daily dissolved oxygen values and comparing to acute and chronic limits
- 2004 loads being used to update the TMDL – using July, August, and September average DMR data – Jim send to MACTEC for review
- Riverside Power Plant decommissioned
- Kerr McGee immediate oxygen demand load is now removed
- Need to check heat loads with GA Power (MACTEC to verify this with GA Power)

II. Issues and Concerns on Final Report on Hydrodynamic and Water Quality Models:

1. Discussed Dr. Kim's comments and went around the table discussing issues and concerns from each agency/group represented.
2. Larry Neal summarized his organization's concerns in a handout.
3. The group then had a wide-ranging discussion of that included a number of issues. These are summarized in the next two sub-sections. The first paragraph is the group's attempt to develop categories for the comments that describe the amount of effort expected to address a concern. The second paragraph states the concern and the category of future effort (in bold) expected to address it. These issues should be considered further before using the models to identify impacts of the recommended plan.

Ways to address concerns with the models and the reports

The group categorized the concerns according to the level of action that is appropriate to fully address each concern. The following four categories were developed, roughly in order of the effort expected:

A Explain better in the report, no modeling action needed.
B Keep in mind when interpreting the model results.
C Additional sensitivity model runs are needed.
D Recalibrate / revise model.
(note: a "**C**" action could turn into a "**D**" action depending on the results)

Summary of issues and concerns and actions to address each concern [option from above]:

1. **[B]** Marsh water quality loads:
    a. **[A]** Inclusion in the enhanced grid
    b. **[A]** Equal comparison between the TMDL and enhanced grids
    c. **[C]** Is the CBODu too high?
    d. **[C]** Mass exchange – flows and concentration
    e. **[C]** Surface to bottom – CBODu vertical differences are a function of how marsh areas were loaded into the enhanced model
2. **[C]** Offshore boundary:
    a. Salinity 34 to 36 ppt versus 32.5 to 35 ppt
        i. Mass flux surface to bottom – may need to re-distribute at FR-26
    b. Dissolved oxygen saturation 95 to 105% versus 90%
    c. Temperature
    d. Larry Neal gave info "World Ocean Atlas 2001" with data
    e. CBOD decay rate – confirmed 0.5 multiplier on ocean cells
3. **[C]** Surface salinity:
    a. Model appears to under predict surface salinity on the Front River. How does this impact the marsh succession modeling? The EFDC will output salinity for the neural net application, which feeds the marsh succession model. Right now, the neural net is using the USGS gages located between the Talmadge Bridge and I-95, located on Front and Back Rivers. These gages are considered to be mid-depth. The EFDC model is

predicting salinity well at the bottom and at mid-depth but under predicting salinity at the surface.

4. **[A & B]** Ebb flows and currents:
    a. Under prediction of the ebb flows and currents on the Little Back and Back Rivers
5. **[A]** Water level at SR-17 on the Upper Savannah River
    a. Potential of adding marsh storage areas upstream of I-95 Bridge
    b. Show comparisons at the USGS Hardeeville gage (show plot)
6. **[C & A]** Global versus source-specific BOD decay rates
    a. Sensitivity of calibration
    b. Sensitivity on allocation scenarios (more for TMDL)
7. **[A]** Check all point sources and heat loads, especially Plant MacIntosh (MACTEC to verify)
8. [none] BOD loads from Corps' confined dredged sediment placement sites in SC and potential impacts on dissolved oxygen (future TMDL issue)
9. **[A]** Grid convergence test:
    a. Show results of the TMDL grid with the same depth;
    b. Show results on TMDL grid, enhanced grid, and convergence grid on the same plots;
    c. Show comparisons on the Middle and Little Back Rivers;
    d. Perform moving average of results to reduce tidal noise; and
    e. Quantification of grid convergence test results.
10. **[B & C]** Delay in EFDC model salinity results at US FWS Dock comparisons of model versus data
11. **[A]** Clearer description of 1999 versus 2002 bathymetry and why the 2002 bathymetry data is representative of 1997 through 2003 conditions in the harbor
12. UA/SA Analysis: The group concluded that the inability to run the models over a 7-year duration was the result of synthetic data that was developed to fill in a data gap around December 2000. The group concluded that the inability of the model to run over the entire 7-year period of data does not reflect on the structure of the model or its performance, and should not be a consideration of the model's usefulness for its intended purposes of predicting impacts of the Savannah Harbor Expansion Project, developing a dissolved oxygen TMDL, or permitting point source discharges.

III. Model Application for Identifying Impacts to Water Quality.

The Interagency Water Quality Team then discussed application of the models for identifying impacts to water quality from the Savannah Harbor Expansion Project.

1. The impact evaluation runs should use a varying flow, rather than the uniform flow that was previously proposed by Savannah District.

2. Dissolved oxygen should be reported at increments of 0.1 mg/L, rather than the 0.5 mg/L that was proposed by Savannah District.

3. Model results in hourly outputs will be sufficient.

4. BOD loads should use the loads reported in 2004, rather than what was reported in 1999. The loads should be averaged over the entire summer. The loads should be run through both the RIV1 model and WASP.

5. Potential impacts to the assimilative capacity of the harbor would need to be identified. This should be performed with the following model inputs:

- August 1999 tides, flows, temperature, and salinity
- Loads from upstream sources should include CBOD and ammonia

NOTE: A. flows would be varying, rather than uniform as previously proposed
B. flows measured at Clyo are considered representative of the critical conditions and the 7Q10 flow did occur during 1999

6. Natural condition runs would need to be performed. This should be performed with the following model inputs:

- Without point sources – no heat and BOD loads in harbor and upstream
- Without nonpoint sources – no stormwater loads, but marshes should be included
- Existing bathymetry (as expressed in calibrated model)

7. Further identification of potential impacts to temperature would be developed as part of the impact runs for Fisheries, which will include runs over January,

8. For water quality impact evaluation runs, the following scenarios would need to be evaluated:

A. Natural condition without deepening
B. Natural condition with deepening
C. 2004 point source loads with deepening
D. 2004 point source loads without deepening

9. The Corps expects to perform the following runs to evaluate potential effects of deepening the navigation channel:

1. existing = 42 feet
2. 44 feet
3. 45 feet
4. 46 feet
5. 47 feet
6. 48 feet

10. The team recognized that the various scenarios and model outputs that had been requested will require a great deal of effort and would produce a very large quantity of information. The team also recognized that some of that information may, ultimately, not be useful. To minimize the time spent developing, presenting, and interpreting model outputs, the team recommended they meet again as soon as the initial water quality model runs had been completed. The hope is that the initial outputs would show what type of information is truly needed to identify impacts from the proposed actions and

differentiate between the plans. This would allow other information to no longer be developed, presented or interpreted. The team recommended that the initial runs consist of (A) 2004 point source loadings, (B) natural conditions, and (C) maximum permitted loadings. Each of these three scenarios should be run for both the existing channel depth and the maximum deepening being considered.

Prepared by:
Steven Davie
Tetra Tech, Inc.

CESAM-PD-E 5 June 2006
Revised 30 June 2006

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 25 May meeting of the Water Quality Interagency Coordination Team

1. Attendees:

GA DNR-EPD	Paul Lamarre
SC DHEC	Wade Cantrell
COE	Bill Bailey
	Joe Hoke
	Hugh Heine
EPA	Steve Whitlock
	Tim Wool
USGS	Paul Conrads (by phone)
Tetra Tech	Steve Davie

2. The meeting was held at EPA in Atlanta from roughly 1000 to 1500. The meeting was an information meeting only, not a decision meeting. The Corps was not requesting concurrence from the agencies on the level of impacts predicted for the project alternatives.

3. The following is a summary of the discussion and does not include all the information that was presented or all comments made during the discussion.

4. The Corps started by reviewing the process the Team had followed to arrive at this point:

- EPA (through Tetra Tech) developed the initial version of the hydraulic and water quality models of the Savannah River estuary for TMDL purposes. Then the Corps (through Tetra Tech), under the review of the full Interagency Coordination Team, enhanced the models. The Corps will use these models for impact evaluation purposes on the Savannah Harbor Expansion Project
- The agencies recently approved use of those two models for impact evaluation purposes on the SH Expansion Project.
- The modelers had completed their impact runs using the input and output criteria specified by numerous resource agency reviewers. The modelers prepared a report documenting their findings and containing all the outputs that had been requested by the agency reviewers. The Corps sent that report to the Interagency Team for review.
- The meeting was called to review the report and identify (A) what information is helpful to the water quality reviewers, (B) any information that was requested by

does not appear to be helpful, and (C) any information which is now believed to be needed to adequately assess potential project impacts to water quality but that is not in the present version of the report.

5. Steve Davie (Tetra Tech) gave a PowerPoint presentation with an overview of the impact analyses.

6. The group looked through the report and made several general observations:

- The increase in salinity at the surface at the Kings Island Turning Basin for a 6-foot deepening (90%) is predicted to 2-3 ppt.
- The increase in salinity at the bottom at the Kings Island Turning Basin for a 6-foot deepening (10%) is predicted to 5-6 ppt.
- The increase in salinity at the bottom at Drakies Cut for a 6-foot deepening (90%) is predicted to 6-7 ppt.
- The increase in salinity at the surface at the Sediment Basin for a 6-foot deepening (10%) is predicted to 2-3 ppt.
- Tables 3 & 4 show the water temperature to be cooler with a 6-foot deepening alternative.
- Figures 11 & 12, 13 & 14, and 15 & 16 show the areas of low dissolved oxygen extending further up in the water column with the deepening alternative. The location of the area of low dissolved oxygen also appears to moves upstream somewhat. adoesn't change substantially. It was difficult to get more than just general information from these plots.
- Figures 19 & 20 show areas of lower dissolved oxygen in the shallows just upstream of the Tidegate.

7. The group looked through the report and made the following observations and recommendations:

- The SC D.O. standard includes an allowable impact component, which applies when numeric criteria are not attained under natural conditions. Modeling indicates this is the case over much of the system. The allowable impact ("delta D.O.") is specified as a daily average, which we take to mean the reduction in D.O. on any given calendar day. To compare to the SC D.O. standard, we will need to see the daily average delta D.O. for each transect plotted longitudinally from the inlet up Back River to the Tidegate and on up Back-Little Back Rivers. At each transect, surface, bottom, and water column average delta D.O. should be shown. Each plot should show the maximum, mean, and minimum daily average delta D.O. during the simulation period (in this case August 1999). We will start with the 6-foot deepening and coordinate the results with SC DHEC to evaluate this presentation format. Examination of these results could lead to more refined presentations to address compliance with this SC standard if (1) timing shifts confound the daily average comparison (in which case percentiles may be a better way), (2) showing the maximum delta D.O. for the entire simulation period overstates the extent of the impact on any single day, (3) it is determined it is appropriate to group transects into segments to evaluate impacts, (4) etc. At this time, we will not develop this presentation format for the Front and Middle Rivers.

- The percentiles should be calculated first, then the differences between alternatives.
- Items #1 & 2 (Tables A.1.1 and A,1.2) are not useful to the States. They could be of use to EPA.
- Items #3 & 4 (temperature) are OK.
- Items #5 & 6 and 7 & 8. The volumes are OK. Use a cumulative frequency distribution function rather than the existing tables.
- Items #11 & 12, and 13 & 14, and 15 & 16 (D.O. Dynamics). The Without Project is OK. Show the change (delta) rather than the actual values for the deepening alternatives.
- Items #17 & 18 (Maximum velocity along perimeter). Value to the Corps only.
- Items #19 & 20, and 21 & 22 (Minimum D.O.). The Without Project is OK. Show the change (delta) rather than the actual values for the deepening alternatives. Why are there lower D.O. values along the bottom in Back River? Is this an influence of the Sediment Basin or discharges from the CDFs?
- Items #23 through 26. Value to EPA.
- Items #27 through 40 and 41 through 54 (dissolved oxygen). The Without Project is OK. Show the change (delta) rather than the actual values for the deepening alternatives. Possibly plot D.O. vs. cumulative frequency of exceedence (volume weighted).
- Items #55 through 68, and 69 through 82 (salinity). The Without Project is OK. Show the change (delta) rather than the actual values for the deepening alternatives.
- The report should describe how the input flow conditions are used for the various resources – varying flow for water quality, and constant flow for fisheries and wetlands.
- One member questioned whether the Middle and Back Rivers are stratified. This could affect how the model is applied for evaluating impacts to some resources. NOTE: After the meeting Paul Conrads (USGS) confirmed that after reviewing the field data and EFDC model results, except for one station (LBR-15), those areas are well mixed.
- One member wanted the group to remember that the model's performance (reliability in matching field data) is lower in the Middle and Back River areas. This should be considered when the model is used to evaluate the effects of "replumbing" to modify flows in that portion of the estuary.

8. The Corps stated that it is continuing to evaluate use of oxygen injection to mitigate for project-induced impacts to dissolved oxygen. Designing oxygen injection systems to mitigate for project impacts is the next step in that process. The SC DHEC position on this technique had been stated in a letter dated 12 August 2005. Separate from the SH Expansion Project, the Corps is resuming the Savannah Harbor Ecosystem Restoration Study, which is evaluating methods of restoring dissolved oxygen levels within the harbor. The Corps will carefully consider the siting of the oxygen injection

during the design process. Co-locating an oxygen injection system with an existing point source discharge is one measure that will be examined.

9. One member reported that report and CD did not contain the results of the 1850's bathymetry, and the maximum permitted loads. These had been requested by the Team. The Corps will look into this and make sure these runs are included when a CD with the revised reports are distributed.

10. One member requested the raw EFDC and WASP BMD files for the existing and 6-foot deepening scenarios for August 1999. The Corps will ensure they are made available to the Team.

11. After the meeting, one member requested that the final impact analyses include BOD loadings from the SC CDFs. These loadings should include (A) any increases in flow expected from the CDFs during construction of the harbor deepening, and (B) the potential contribution of ammonia to the total oxygen demand. If an increase would occur only during construction, then it would be appropriate to consider only potential increases from regular maintenance of the deeper channel.

12. After the meeting, one member questioned why the model predicts dissolved oxygen levels in Little Back River decreasing at the surface by 0.3-0.4 mg/l, while increasing at along the bottom by 0.3-0.45 mg/l. They also questioned why point source loadings appear to affect dissolved oxygen levels differently from surface to bottom.

13. The Corps will provide revised Impact Reports to the agencies when those revisions and corrections are complete. The updated report will be provided on CD only. Agency Team members are free to send the Corps any comments they may have after further review of the present Impact Report or review of the revised report.

14. The Corps will continue its work on evaluating potential mitigation measures. When it has developed combinations of mitigation measures that it believes would be effective, the Corps will hold another meeting of the Interagency Coordination Team to share those results. That meeting would be prior to the Corps' completion of a Draft EIS or a request for agency concurrence on the acceptability of the mitigation plans or the project alternatives.

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William Bailey
Environment and Resources Branch

CESAM-PD-E 23 Jan 2007
Revised 29 Jan 2007

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 19 Jan meeting of the Interagency Water Quality Coordination Team

1. Attendees:

GA DNR-EPD	Paul Lamarre	
SC DHEC	Wade Cantrell	
	Amy Bennett	
COE	Bill Bailey	
EPA	Jim Greenfield	
	Ted Bisterfeld	
	Annie Godfrey	
USGS	Paul Conrads	
Tetra Tech	Steve Davie	
	Yuri Plis	
NOAA-Fisheries	Kay Davy	
USFWS	Ed EuDaly	(by phone)
Georgia Ports Authority	Hope Moorer	

2. The meeting was held at EPA in Atlanta from roughly 0900 to 1430. The meeting was primarily an information meeting, but recommendations were made on some items. The team reviewed and discussed three recent reports produced for the Corps by Tetra Tech (described below). The Corps did not request concurrence from the agencies on the acceptability of the dissolved oxygen mitigation designs developed for the SH Expansion Project.

3. The following is a summary of the discussions and does not include all the information that was presented or all comments made during the discussion.

4. The team started by reviewing the December 2006 report titled "Determination of Dissolved Oxygen Impacts for the Savannah Harbor Ecosystem Project". This report was developed for the SH Ecosystem Restoration Study, but provides useful information for the team's discussions on the SH Expansion Project. The following items were discussed:

- The report was to identify the causes of the D.O. problem and evaluate the model's predictions of the manner in which injected D.O. would mix in the harbor.
- All runs include the upriver point source discharges.
- The report shows D.O. values that are both vertically and laterally averaged.

- Tetra Tech summarized the findings by stating that the harbor discharges appear to have a 0.3-0.4 ppm impact on D.O., while the existing harbor appears to have a 1-2 ppm impact.
- Tetra Tech observed that salinity did not progress further upriver than Fort Jackson in the pre-harbor (1854) runs.
- When the analysis was conducted of the pre-harbor condition, only the bathymetry was changed. The SOD and decay rates were not altered.
- EPA stated they believed that an analysis of "natural conditions" should include a single SOD rate throughout the harbor, pre-dam river flows, and no upstream or downstream point source discharges.

5. The team then reviewed the November 2006 report titled "Design of Dissolved Oxygen Improvement Systems in Savannah Harbor; **Task II** Report". The following items were discussed:

- One team member stated that the report purpose is not clear. Although the report contains information about compliance with state standards, the purpose for this work was to design D.O. injection systems that would mitigate for incremental effects to D.O. from further deepening of the harbor. Section 1 could be clarified.
- SC DHEC expressed concern about the 2nd paragraph in Section 1. They believe the statement about the models being acceptable to identify dissolved oxygen impacts "throughout Savannah Harbor" overstates their approval. Their letter had expressed concerns about the performance of the models in the Middle, Back, and Little Back Rivers. They concurred in the models' use for comparative purposes, but had concerns about its use for prediction of absolute values of D.O..
- We discussed the design approach and had the following comments:
  - The critical cell is the cell with the lowest calculated D.O. in that segment.
  - The segment approach is more detailed than the TMDL analysis.
  - The siting of the D.O. injection systems was based primarily on modeling and did not include great consideration of the landside conditions (wetlands, access, power availability, etc).
  - The only difference in the models between the Calibration Report and now is the use of the latest EPA-approved versions of EFDC and WASP. These revisions slightly changed dispersion in the riverine reaches.
  - Injection of D.O. is modeled to occur at the channel toe, at the same depth as its withdrawal.
  - Water is modeled to be withdrawn roughly 20 feet from the injection. A large horizontal separation is not needed.
  - Concerns were raised by GA DNR and SC DHEC about potential toxicity of the oxygenated water. The team stated that this concern could be addressed by a dye test or near-field monitoring if a demonstration project occurs.
  - NOAA-Fisheries stated that the systems should be designed with an intake velocity of <= 0.5 feet-per-second across the screens to minimize potential impacts to fish.
  - The systems are not expected to have any effect on water temperature.

- The modeling shows that to address the D.O. impacts of a further harbor deepening, higher river flows require more oxygen to be added than do low flows.
- NOAA-Fisheries requested the system operation include the ability and a procedure to cease operation if a fish entrainment event occurs.

- We then discussed siting the D.O. injection systems and had the following comments:
  - The USFWS stated that the McCoys Cut site is not feasible. It has very little high ground and no road access or power.
  - We could possible combine the D.O. to be added at Mill Stone Landing and McCoys Cut into a single location. Locating the system along I-95 was identified as one possibility.
  - USFWS stated that the salinity mitigation plans are likely to modify D.O. impacts. Major salinity mitigation features that may affect D.O. levels and D.O. mitigation features include: reduction in depth of the Sediment Basin, McCoys Cut diversion structure, and closing or opening various channels.
- The team recommended we run the models at high river flows (75 %-tile flows) to ensure the design is sized to handle the entire spectrum of river flows.
- We discussed extent of change or improvement. The team decided that we did not need to improve D.O. at levels < 1 % (for zones/segments with D.O. standards violations) or < 0.01 ppm (for mitigation purposes).

6. The team then reviewed the November 2006 report titled "Design of Dissolved Oxygen Improvement Systems in Savannah Harbor; **Task I** Report". This report was developed for the SH Ecosystem Study. The Corps is separately seeking resource agency views on completing that study, so it was seeking the views of the technical staff on the most recent study product. The group looked through the report and made the following observations and recommendations:

- Again, the report purpose in Section 1 could be clarified.
- Again, the wording of the 2nd paragraph in Section 1 should be revised to reflect SC DHEC's concerns about the models' performance in the Middle, Back, and Little Back Rivers.
- The report evaluated both the SC and GA standards in those rivers that include the state border. The design used the most restrictive of the two standards – required the most oxygen to be added – when that occurred.
- The SC standard was generally found to be more restrictive. The analysis used the standard of a minimum of 4.0 ppm.
- The proposed D.O. standard (Draft TMDL) was applied in a separate analysis throughout the entire model grid.
- The team discussed a "natural conditions" analysis, which is a typical component of a permit review. The team concluded that the analysis should include the following components for this system:
  - No point sources – upriver or harbor
  - Historic river depths (1854 is available for the harbor)
  - Pre-dam river flows (drought flows were lower before the dams)

- Single SOD rate throughout the estuary
- Without the type of "natural conditions" run described above, the designs are likely to be a worst–case analysis for D.O. needs in the harbor. A "natural conditions" analysis is likely to show that adding oxygen to some areas would result in those locations being above "natural conditions" and thus exceed what would be considered restoration.
- We discussed specific sites.
  - The most upriver site (Savannah River) experiences D.O. at the 1 %-tile of 2.34 ppm during a drought and 4.56 during average flows. A D.O. improvement system would not need to operate during all flow conditions. This site is one where the proposed improvements may exceed the natural conditions.
  - Again, the McCoys Cut site is not feasible.
  - The South Channel site was then discussed. Tetra Tech stated that location receives a D.O. impact of 0 to 0.15 ppm from harbor point source loads but no effect from a further deepening. This is another site where the proposed improvements may exceed the natural conditions.
- With the present designs, Table A-1 shows that the SC standard is not met in Middle River 2 % of the time (reduced from 6 to 2 %). We distributed revised tables that show the results for all the areas where the SC standard applies (Attachment 1). The revisions show different model performance in Back and Little Back Rivers. The new results show the present design does not meet SC standards up to 55 % of the time (BR2, Table B-1). Although an improvement from the present condition, the designs need to be revised to better meet the standard in the BR/LBR/MR areas. We distributed the results of analyses Tetra Tech conducted after completing the report which show the D.O. regime with more oxygen being added at the Tidegate (Attachment 2). Those designs greatly reduce the number of time the SC standard is not met in those areas.
- The team agreed that this report provides valuable information for the states and EPA as they develop new D.O. standards for the harbor.
- It was mentioned that additional work could be conducted under the SH Ecosystem Restoration Study – such as natural conditions runs – which would further benefit, the resource agencies in the development of a D.O. standard.

7. The Corps asked how we should model one of the mitigation options we are evaluating -- filling the Sediment Basin (or letting it fill naturally). The question is whether the major alteration of the site's present depth (from 42 to 12 feet) and cessation of its fine sediment accumulation would modify its high SOD rate. The team concurred that a lower SOD rate should be applied to the Sediment Basin area when modeling that mitigation option. The group felt that we should use the same SOD rate as the model now has in the Middle River, Back River (upstream of Tidegate) and Little Back River areas.

8. The team requested the Corps distribute the preliminary water quality report so they could see if all the previously-requested outputs are as useful as they had envisioned. I sent the report out on 23 January.

// ss //

William Bailey
Environment and Resources Branch

ATTACHMENT 1

Revisions to Tables A-1, B-1, etc to include entire SC border (and conformance with SC D.O. standard)

Table A-1 (Appendix A.1)

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1997 AUGUST 1 -AUGUST 31

Scenario: 97-IN7_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FR2	0	0	0	0	0	0	0	0	0	0	0	0	7	1	-6
FR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR5	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR6	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MR1	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR5	0	0	0	0	0	0	0	0	0	3	0	-3	6	2	-4
MR6	0	0	0	0	0	0	0	0	0	1	0	-1	5	1	-4
LBR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LBR2	0	0	0	0	0	0	0	0	0	0	0	0	9	0	-9
LBR3	0	0	0	0	0	0	0	0	0	0	0	0	22	1	-21
BR1	0	0	0	0	0	0	0	0	0	1	0	-1	47	10	-37
BR2	0	0	0	0	0	0	1	0	-1	1	0	-1	66	9	-57
BR3	0	0	0	0	0	0	1	0	-1	1	0	-1	61	17	-44
SCh1	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B-1 (Appendix B.1)

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1997 AUGUST 1 -AUGUST 31

Scenario: 97-I-3_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FR2	0	0	0	0	0	0	0	0	0	0	0	0	7	6	-1
FR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR5	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR6	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MR1	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR5	0	0	0	0	0	0	0	0	0	3	0	-3	6	3	-3
MR6	0	0	0	0	0	0	0	0	0	1	0	-1	5	3	-2
LBR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LBR2	0	0	0	0	0	0	0	0	0	0	0	0	9	0	-9
LBR3	0	0	0	0	0	0	0	0	0	0	0	0	22	3	-19
BR1	0	0	0	0	0	0	0	0	0	1	0	-1	47	36	-11
BR2	0	0	0	0	0	0	1	0	-1	1	1	0	66	55	-11
BR3	0	0	0	0	0	0	1	0	-1	1	0	-1	61	44	-17
SCh1	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C-1 (Appendix C.1)

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1999 AUGUST 1 -AUGUST 31

Scenario: 99-M10_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	19	0	-19
FR2	0	0	0	0	0	0	0	0	0	1	0	-1	65	1	-64
FR3	0	0	0	5	0	-5	2	0	-2	9	0	-9	N/A	N/A	N/A
FR4	0	0	0	13	0	-13	2	0	-2	15	0	-15	N/A	N/A	N/A
FR5	0	0	0	10	0	-10	1	0	-1	13	0	-13	N/A	N/A	N/A
FR6	0	0	0	4	0	-4	1	0	-1	7	0	-7	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	1	0	-1	0	0	0	3	0	-3	10	0	-10
MR1	0	0	0	0	0	0	1	0	-1	1	0	-1	N/A	N/A	N/A
MR2	0	0	0	1	0	-1	1	0	-1	3	0	-3	N/A	N/A	N/A
MR3	0	0	0	8	0	-8	1	0	-1	8	0	-8	N/A	N/A	N/A
MR4	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
MR5	0	0	0	2	0	-2	1	0	-1	8	0	-8	14	1	-13
MR6	0	0	0	0	0	0	0	0	0	5	0	-5	12	0	-12
LBR1	0	0	0	3	0	-3	0	0	0	3	0	-3	30	0	-30
LBR2	2	0	-2	13	0	-13	1	0	-1	16	0	-16	45	0	-45
LBR3	9	0	-9	25	0	-25	1	0	-1	29	0	-29	58	5	-53
BR1	0	0	0	26	0	-26	3	0	-3	33	0	-33	94	8	-86
BR2	4	0	-4	48	0	-48	3	0	-3	54	0	-54	95	3	-92
BR3	7	0	-7	45	0	-45	3	0	-3	57	0	-57	86	21	-65
SCh1	3	0	-3	6	0	-6	1	0	-1	9	0	-9	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	3	0	-3	0	0	0	4	0	-4	11	0	-11

Table D-1 (Appendix D.1)

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1999 AUGUST 1 -AUGUST 31

Scenario: 99-120_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	19	9	-10
FR2	0	0	0	0	0	0	0	0	0	1	0	-1	65	39	-26
FR3	0	0	0	5	0	-5	2	0	-2	9	0	-9	N/A	N/A	N/A
FR4	0	0	0	13	0	-13	2	0	-2	15	0	-15	N/A	N/A	N/A
FR5	0	0	0	10	0	-10	1	0	-1	13	0	-13	N/A	N/A	N/A
FR6	0	0	0	4	0	-4	1	0	-1	7	0	-7	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	1	0	-1	0	0	0	3	0	-3	10	7	-3
MR1	0	0	0	0	0	0	1	0	-1	1	0	-1	N/A	N/A	N/A
MR2	0	0	0	1	0	-1	1	0	-1	3	0	-3	N/A	N/A	N/A
MR3	0	0	0	8	0	-8	1	0	-1	8	0	-8	N/A	N/A	N/A
MR4	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
MR5	0	0	0	2	0	-2	1	0	-1	8	0	-8	14	2	-12
MR6	0	0	0	0	0	0	0	0	0	5	0	-5	12	2	-10
LBR1	0	0	0	3	0	-3	0	0	0	3	0	-3	30	0	-30
LBR2	2	0	-2	13	0	-13	1	0	-1	16	0	-16	45	0	-45
LBR3	9	0	-9	25	0	-25	1	0	-1	29	0	-29	58	7	-51
BR1	0	0	0	26	0	-26	3	0	-3	33	1	-32	94	45	-49
BR2	4	0	-4	48	0	-48	3	0	-3	54	0	-54	95	37	-58
BR3	7	0	-7	45	0	-45	3	0	-3	57	0	-57	86	47	-39
SCh1	3	0	-3	6	0	-6	1	0	-1	9	0	-9	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	3	0	-3	0	0	0	4	0	-4	11	7	-4

ATTACHMENT 2

Information showing compliance with D.O. standards with additional volumes of oxygen being injected at the Tidegate

Appendix A-1
Table A-1

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1997 AUGUST 1 -AUGUST 31

Scenario: 97-mm1_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FR2	0	0	0	0	0	0	0	0	0	0	0	0	7	0	-7
FR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR5	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR6	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MR1	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR5	0	0	0	0	0	0	0	0	0	3	0	-3	6	2	-4
MR6	0	0	0	0	0	0	0	0	0	1	0	-1	5	1	-4
LBR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LBR2	0	0	0	0	0	0	0	0	0	0	0	0	9	0	-9
LBR3	0	0	0	0	0	0	0	0	0	0	0	0	22	0	-22
BR1	0	0	0	0	0	0	0	0	0	1	0	-1	47	4	-43
BR2	0	0	0	0	0	0	1	0	-1	1	0	-1	66	0	-66
BR3	0	0	0	0	0	0	1	0	-1	1	0	-1	61	3	-58
SCh1	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source (I=31, J=63 – Tide Gate) = 8,000 kg/day

Appendix A-1
Table A-1

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1997 AUGUST 1 -AUGUST 31

Scenario: 97-mm2_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FR2	0	0	0	0	0	0	0	0	0	0	0	0	7	0	-7
FR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR5	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR6	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MR1	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR3	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
MR5	0	0	0	0	0	0	0	0	0	3	0	-3	6	2	-4
MR6	0	0	0	0	0	0	0	0	0	1	0	-1	5	1	-4
LBR1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LBR2	0	0	0	0	0	0	0	0	0	0	0	0	9	0	-9
LBR3	0	0	0	0	0	0	0	0	0	0	0	0	22	0	-22
BR1	0	0	0	0	0	0	0	0	0	1	0	-1	47	2	-45
BR2	0	0	0	0	0	0	1	0	-1	1	0	-1	66	0	-66
BR3	0	0	0	0	0	0	1	0	-1	1	0	-1	61	0	-61
SCh1	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source (I=31, J=63 – Tide Gate) = 12,000 kg/day

Appendix C-1
Table C-1

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1999 AUGUST 1 - AUGUST 31

Scenario: 99-mm1_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	19	0	-19
FR2	0	0	0	0	0	0	0	0	0	1	0	-1	65	0	-65
FR3	0	0	0	5	0	-5	2	0	-2	9	0	-9	N/A	N/A	N/A
FR4	0	0	0	13	0	-13	2	0	-2	15	0	-15	N/A	N/A	N/A
FR5	0	0	0	10	0	-10	1	0	-1	13	0	-13	N/A	N/A	N/A
FR6	0	0	0	4	0	-4	1	0	-1	7	0	-7	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	1	0	-1	0	0	0	3	0	-3	10	0	-10
MR1	0	0	0	0	0	0	1	0	-1	1	0	-1	N/A	N/A	N/A
MR2	0	0	0	1	0	-1	1	0	-1	3	0	-3	N/A	N/A	N/A
MR3	0	0	0	8	0	-8	1	0	-1	8	0	-8	N/A	N/A	N/A
MR4	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
MR5	0	0	0	2	0	-2	1	0	-1	8	0	-8	14	1	-13
MR6	0	0	0	0	0	0	0	0	0	5	0	-5	12	0	-12
LBR1	0	0	0	3	0	-3	0	0	0	3	0	-3	30	0	-30
LBR2	2	0	-2	13	0	-13	1	0	-1	16	0	-16	45	0	-45
LBR3	9	0	-9	25	0	-25	1	0	-1	29	0	-29	58	3	-55
BR1	0	0	0	26	0	-26	3	0	-3	33	0	-33	94	1	-93
BR2	4	0	-4	48	0	-48	3	0	-3	54	0	-54	95	0	-95
BR3	7	0	-7	45	0	-45	3	0	-3	57	0	-57	86	6	-80
SCh1	3	0	-3	6	0	-6	1	0	-1	9	0	-9	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	3	0	-3	0	0	0	4	0	-4	11	0	-11

Source (I=31, J=63 – Tide Gate) = 20,000 kg/day

Appendix C-1
Table C-1

PERCENTAGE OF WATER VOLUME WITH VIOLATION OF STANDARDS FOR DISSOLVED OXYGEN IN WATER COLUMN OF SPECIFIED ZONES

Simulation Period: Year 1999 AUGUST 1 - AUGUST 31

Scenario: 99-mm2_

Zones	D.O. STANDARDS														
	1-Day Average			7-Day Average			30-Day Average			GA MINIMUM D.O.			SC MINIMUM D.O.		
	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B	Baseline(B)	Project(P)	Delta=P-B
FR1	0	0	0	0	0	0	0	0	0	0	0	0	19	0	-19
FR2	0	0	0	0	0	0	0	0	0	1	0	-1	65	0	-65
FR3	0	0	0	5	0	-5	2	0	-2	9	0	-9	N/A	N/A	N/A
FR4	0	0	0	13	0	-13	2	0	-2	15	0	-15	N/A	N/A	N/A
FR5	0	0	0	10	0	-10	1	0	-1	13	0	-13	N/A	N/A	N/A
FR6	0	0	0	4	0	-4	1	0	-1	7	0	-7	N/A	N/A	N/A
FR7	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR8	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR9	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR10	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
FR11	0	0	0	1	0	-1	0	0	0	3	0	-3	10	0	-10
MR1	0	0	0	0	0	0	1	0	-1	1	0	-1	N/A	N/A	N/A
MR2	0	0	0	1	0	-1	1	0	-1	3	0	-3	N/A	N/A	N/A
MR3	0	0	0	8	0	-8	1	0	-1	8	0	-8	N/A	N/A	N/A
MR4	0	0	0	2	0	-2	0	0	0	4	0	-4	N/A	N/A	N/A
MR5	0	0	0	2	0	-2	1	0	-1	8	0	-8	14	1	-13
MR6	0	0	0	0	0	0	0	0	0	5	0	-5	12	0	-12
LBR1	0	0	0	3	0	-3	0	0	0	3	0	-3	30	0	-30
LBR2	2	0	-2	13	0	-13	1	0	-1	16	0	-16	45	0	-45
LBR3	9	0	-9	25	0	-25	1	0	-1	29	0	-29	58	2	-56
BR1	0	0	0	26	0	-26	3	0	-3	33	0	-33	94	0	-94
BR2	4	0	-4	48	0	-48	3	0	-3	54	0	-54	95	0	-95
BR3	7	0	-7	45	0	-45	3	0	-3	57	0	-57	86	3	-83
SCh1	3	0	-3	6	0	-6	1	0	-1	9	0	-9	N/A	N/A	N/A
SCh2	0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A
SR	0	0	0	3	0	-3	0	0	0	4	0	-4	11	0	-11

Source (I=31, J=63 – Tide Gate) = 25,000 kg/day

CESAM-PD-E 7 Jun 2008

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 27 May meeting of the Interagency Water Quality Coordination Team

1. Attendees:

GA DNR-EPD	Liz Booth
SC DHEC	Wade Cantrell
	Larry Turner
	Chris Beckham
SC DNR	Priscilla Wendt (by phone)
COE	Bill Bailey
EPA	Jim Greenfield (by phone)
	Ted Bisterfeld
	Heinz Mueller
USFWS	Ed EuDaly (by phone)
USGS	Paul Conrads
Georgia Ports Authority	Hope Moorer
MACTEC	Margaret Tanner
	Larry Neal
Tetra Tech	Steve Davie

2. The meeting was held at the Corps' South Atlantic Division offices in Atlanta from roughly 1000 to 1400. The meeting was primarily an information meeting, but some recommendations were made. The primary issue was a review of the January 2008 report produced for GPA by MACTEC titled "Savannah Harbor ReOxygenation Demonstration Project Report". Paul Conrads had reviewed the report for the USFWS and had expressed concerns about its technical adequacy.

3. The following is a summary of the discussions and does not include all the information that was presented or all comments made during the discussion.

4. MACTEC reviewed the technical details of the demonstration project that GPA performed last summer of oxygen injection in Savannah Harbor. MACTEC had conducted the project and prepared the monitoring report. MACTEC also described the observations it made during the project about the technology and the effects it observed in the river. They went on to explain the findings that they had included in the report and their overall assessment of the demonstration project.

MACTEC agreed that their analysis of the monitoring data could have been more detailed. They agreed to examine the data further, with particular emphasis on the issues that Paul Conrads had raised. They would issue a supplemental report with their additional findings.

GPA also agreed to include use of the approved EFDC and WASP hydrodynamic and water quality models in this more detailed analysis to attempt to identify (1) how far the effects of the oxygen addition should have been observable, (2) what the D.O. levels would have been in the harbor had the oxygen not been added, and (3) whether the amount of oxygen that was added produced the level of improvement that the model would predict. The last of those three questions would address uncertainty in whether the oxygen addition produces the beneficial effects that the modeling predicts.

5. The Corps attempted to clarify the major issues associated with this report. It identified two major questions:

(1) Did the Demonstration Project alter the dissolved oxygen in the river? If the Demonstration Project found that the dissolved oxygen in the harbor was not altered and improved by the addition of oxygen, then the Corps would need to identify another technique to mitigate for expected adverse impacts to D.O. from a further harbor deepening.

(2) Did the Demonstration Project indicate that the oxygen transfer efficiency of the Speece cones should be revised in the final design to ensure the oxygen addition produces the beneficial effects that the modeling predicts? If the oxygen transfer efficiency observed during the Demonstration Project was substantially less than what was assumed by the designers, then additional oxygen would need to be added to produce the desired amount of beneficial effects.

No agency represented would disagree that the Demonstration Project beneficially altered the dissolved oxygen in the river. There was considerable uncertainty among the meeting attendees on the extent of that improvement. The agencies continue to believe that oxygen addition may be an effective method of mitigating for adverse impacts on D.O. from further deepening of the harbor. In light of that continued support for the mitigation technique, the Corps will continue to the addition of oxygen as mitigation as it writes the Draft EIS for the project.

The Corps will review the supplemental report issued by MACTEC and GPA to determine whether it should revise the oxygen transfer efficiency used in the final designs of the D.O. improvement systems.

// DRAFT //

William Bailey
Physical Scientist

From:	Hoke, Joseph T SAS
To:	"Ed Eudaly"; "Jim Greenfield"; "Paul Conrads"; smtp-Brownell, Prescott; "cantrewm@dhec.sc.gov"; "Paul_Lamarre@dnr.state.ga.us"; "Roy_Burke@mail.dnr.state.ga.us"; "TURNERLE@dhec.sc.gov"; "METANNER@mactec.com"; "lneal@mactec.com"
Cc:	Plachy, Douglas H SAS; Bailey, William G SAS; "lkeegan@lg.com"
Subject:	Savannah Harbor - EFDC training, EFDC model contract review meeting
Date:	Tuesday, October 12, 2004 1:57:48 PM

The U.S. Army Corps of Engineers, Savannah District, will be hosting a workshop on the Savannah Harbor Expansion EFDC model, presented by intructors from Tetra Tech, Inc. The workshop will take place on October 26, 27, and 28 in the Savannah District office. On the 26th, beginning at 1 pm, there will be a lecture/chalkboard session on the background and basics of the model in the 3rd floor Planning Division conference room. On Wednesday, 27 October, it will be an all-day hands-on computer workshop session in the 2nd floor Information Management Training Room. Finally, on the 28th, we will move back to the Planning Conference Room for a wrap-up session that should end by 10 am.

Following the workshop will be a meeting of the SHEP EFDC model review team at 10:30 am, which will feature a briefing by Tetra Tech on the status of the EFDC modeling effort, preliminary results, and discussion.

Note that although the EFDC model being used for SHEP is similar to the TMDL model, the focus of this training will be on the model application to the Savannah Harbor Expansion, thus no TMDL issues will be addressed as part of this workshop.

Margaret, feel free to pass this invitation along to other representatives of local agencies.

The review team is welcome to attend just the meeting, or any or all of the training session. Please let me know if you are planning to attend, and which parts.

Joe Hoke
Hydraulic Engineer Team Leader
U.S. Army Corps of Engineers, Savannah District
912-652-5516

From:	Hoke, Joseph T SAS
To:	Douglas H SAS Plachy (E-mail); Ed Eudaly (E-mail) (E-mail); Jim Greenfield (E-mail) (E-mail); Larry Keegan (E-mail) (E-mail); "Larry Turner" (E-mail); Paul Conrads (E-mail) (E-mail); "Paul Lamarre" (E-mail); Prescott Brownell (E-mail) (E-mail); "Roy Burke" (E-mail); "Wade Cantrell" (E-mail); William G SAS Bailey (E-mail)
Cc:	Steven Davie (E-mail); "Chuck Watson"
Subject:	Savannah Harbor EFDC Model Grid Resolution Technical Memo
Date:	Monday, December 13, 2004 6:01:54 PM
Attachments:	Tt Memo on Model Grid (12-10-04).doc

To: Savannah Harbor Model Review Team Members

Please review the attached technical memo from Steven Davie on the enhanced grid for the EFDC model, and provide comments back to me by Monday, 20 December. If you have no comments, please respond with that message so I know you have seen the memo. Please let me know if you think I have overlooked anyone on the distribution list.

Also, we are due in early January to review the EFDC and WASP calibration. I thought about piggybacking on the TMDL meeting, but I know that Paul Conrads is not available that week. Please e-mail me the dates that you are NOT available and I will try to put together a matrix of potential meeting dates. Also let me know what meeting site(s) you prefer; or another option under consideration is a virtual meeting with slides presented via internet connection and discussion via conference call. Opinions welcome.

Joe Hoke
Hydraulic Engineer Team Leader
U.S. Army Corps of Engineers, Savannah District
912-652-5516

-----Original Message-----
From: Steven Davie [mailto:steven.davie@tetratech-ffx.com]
Sent: Friday, December 10, 2004 5:55 PM
To: Joe Hoke
Cc: Yuri Plis; Will Anderson; Chuck (Charles) Watson; William (Bill) Bailey; Doug Plachy
Subject: Savannah Model Grid Resolution Technical Memo

Joe,

Please find attached the technical memo that describes the enhanced model grid. We placed several graphics in the file so that specific areas can be reviewed. We are currently working on getting the appropriate bathymetry into the grid and should be running the model sometime next week. We will keep you posted on the model run times, the vertical resolution, and the marsh approach. If you would like some other graphics on the grid, we would be glad to provide them or give you the ArcView shape file of the grid.

Thanks and have a good weekend,
Steven

Steven R. Davie
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Atlanta, Georgia 30339
Phone: (770) 850-0949
Fax: (770) 850-0950

TECHNICAL MEMORANDUM NO. 1

Date: December 10, 2004

To: Joe Hoke, USACE Savannah District

From: Steven Davie

Cc: Doug Plachy and Bill Bailey, USACE Savannah District

Subject: Savannah Harbor EFDC and WASP Model Grid
Tt Project No. J391-02

Tetra Tech, Inc. (Tetra Tech) has completed the initial enhancements to the model grid for the Savannah Harbor application. The enhanced model grid will be used by the hydrodynamic model (EFDC) and the water quality model (WASP). Both models will use the same grid segmentation. The enhanced model grid will be used to simulate environmental impacts from the Savannah Harbor Expansion Project (SHEP).

The overall grid is shown in Figure 1. The enhanced grid contains 1,131 horizontal cells. The offshore extent is approximately 17.5 miles from Fort Pulaski and Oyster Bed Island measured by following the navigation channel out to sea. This is the same boundary as the TMDL grid and covers the extent of the navigation channel, however, the southwest offshore grid has been extended and fitted to the shoreline to Wassaw Island as shown in Figure 2. The offshore cells total 305 compared to 372 cells in the TMDL grid.

The enhanced grid in the navigation channel is two cells wide from toe to toe, except for turning basins where there are more grid cells. At the Elba Island Bight in Figure 3, the navigation channel is three cells wide. The enhanced grid was mapped to the navigation channel using NOAA charts and GIS data provided by the USACE Savannah District as seen in all of these figures. Near the River Street and downtown areas, the river is four cells wide total, including the two in the channel. The Kings Island turning basin is seven cells wide to account for the side areas where sedimentation occurs as shown in Figure 4, 6, and 7. The Middle and Little Back Rivers were represented as one grid cell wide and these areas are shown in Figures 5, 8, and 9.

The Tide Gate was considered as one cell with a width of 645 feet based on the as-built drawings. The Tide Gate area is shown in Figures 6 and 7. The Back River downstream of the Tide Gate is three cells wide, where the center cell is the sediment basin according to the USACE channel (Figure 6). Pennyworth and Hog Islands are included in the enhanced grid. For the navigation channel, four cells wide are maintained up to Drakies Cut, three cells to McCoys Cut, then two cells to Abercorn Creek, and one cell up to Clyo. From the top of the dredged channel to McCoys Cut is considered an area where model bathymetry is very critical for salinity intrusion results, especially because the cross-sections are extremely variable in this area.

New Cut is included in the enhanced grid, but five of the cells will have a flow barrier because New Cut is currently closed (Figure 9). This will allow future scenarios of opening New Cut to be easily configured in model production runs. Steamboat River is represented in the enhanced grid at its current width of navigability for small craft (i.e., the USGS survey). Drakies Cut will be important in future expansion scenarios so three grid cells are used to represent the width of the river shown in Figure 9. The length of Rifle Cut is comprised of three very narrow cells. McCoys Cut was configured slightly finer than in the TMDL model and shown in Figure 8. Union Creek is not included but will be handled as a freshwater inflow into the Little Back River.

Please review and provide any comments by December 20, 2004 as we are proceeding with the model calibration.

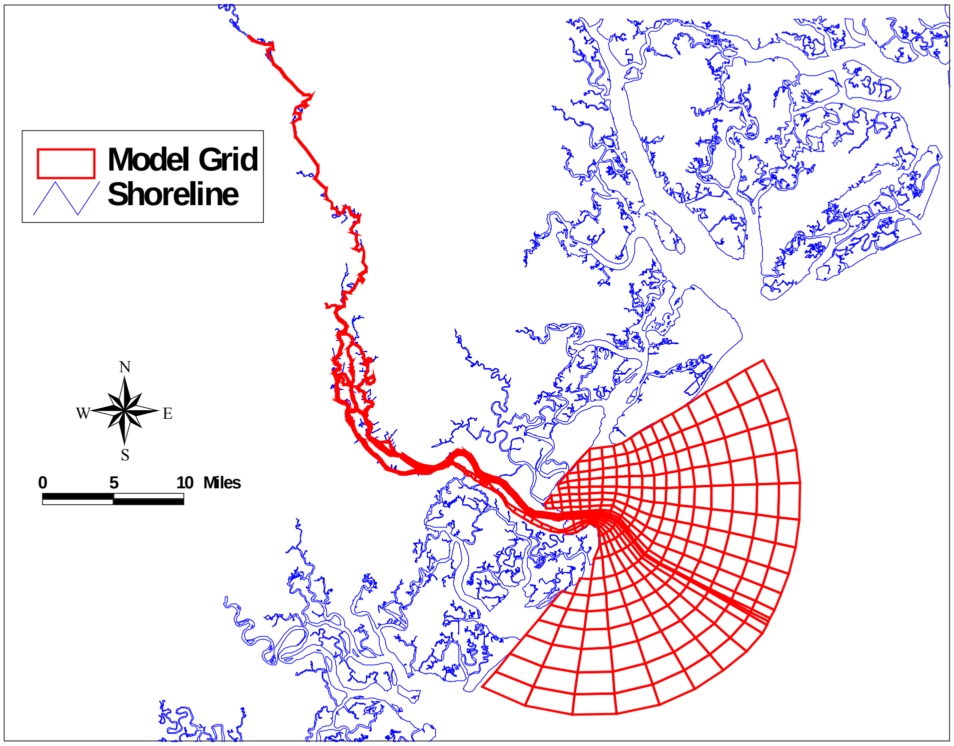

Figure 1 – Overall Location of Grid with Shoreline

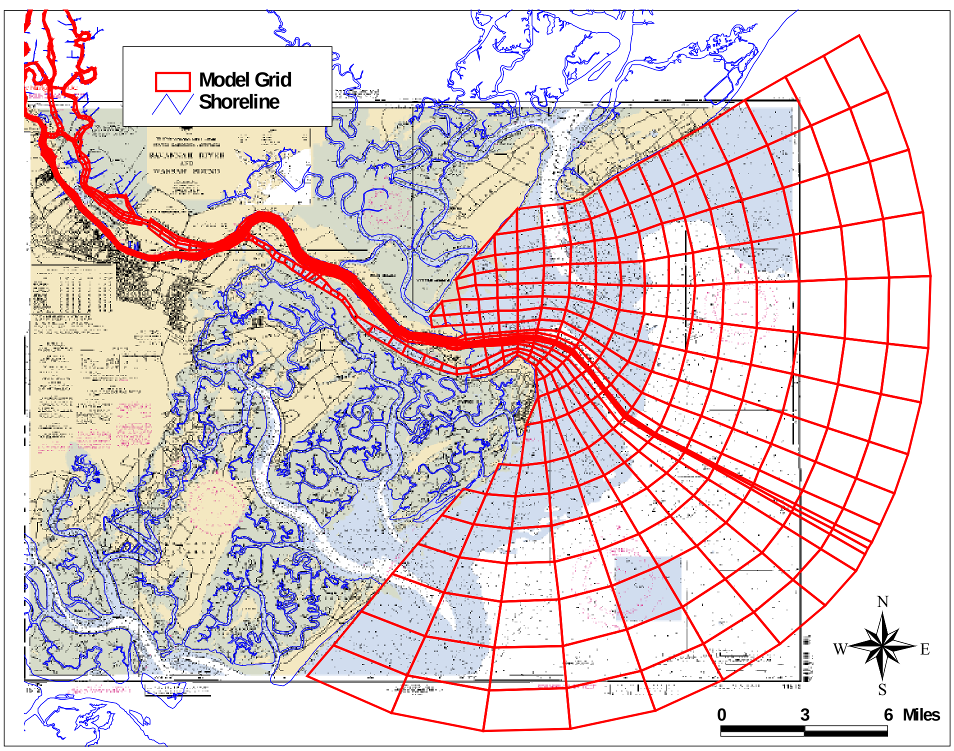

Figure 2 – Offshore Section Overlay with NOAA Chart

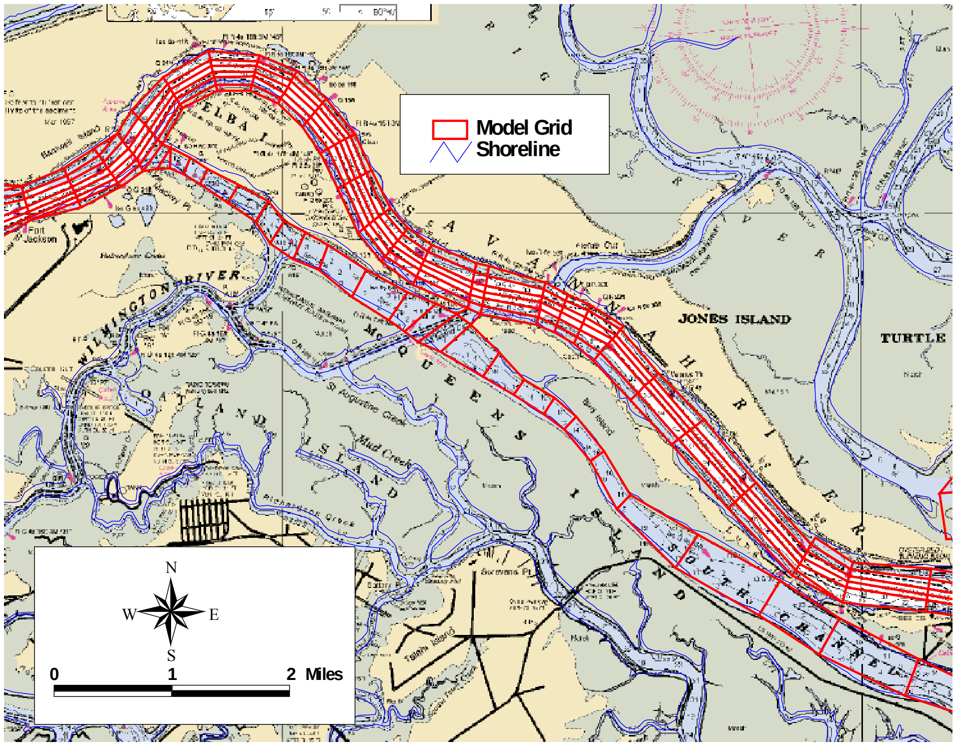

Figure 3 – Entrance Channel Section Overlay with NOAA Chart

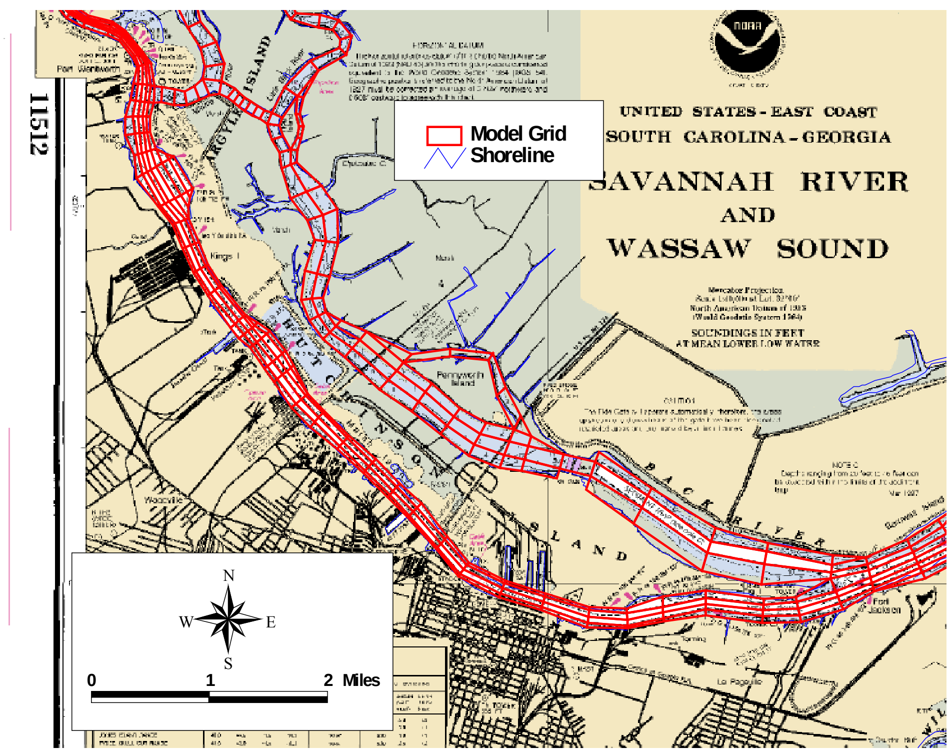

Figure 4 – Downtown Savannah Grid Section Overlay with NOAA Chart

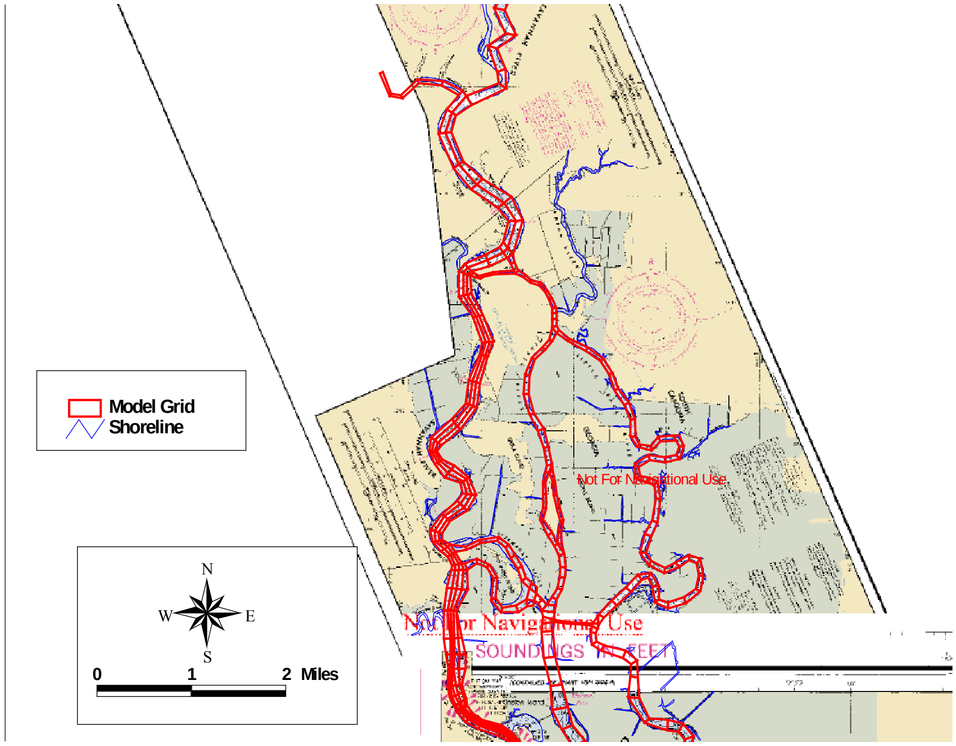

Figure 5 – Upper Savannah Harbor Section Overlay with NOAA Chart

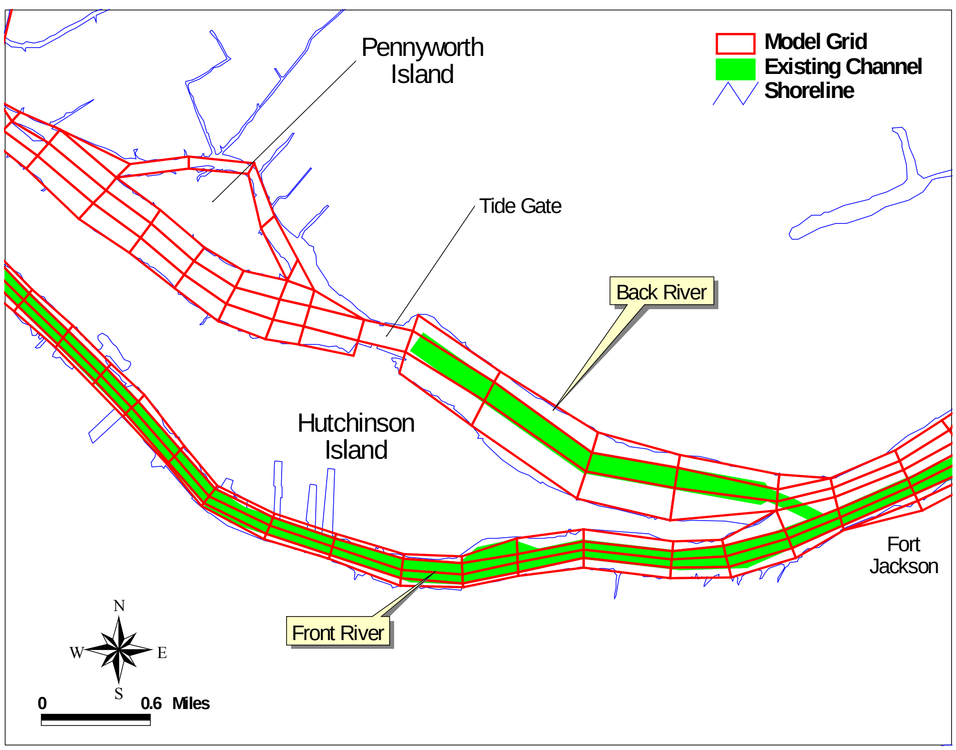

Figure 6 – Tide Gate Area

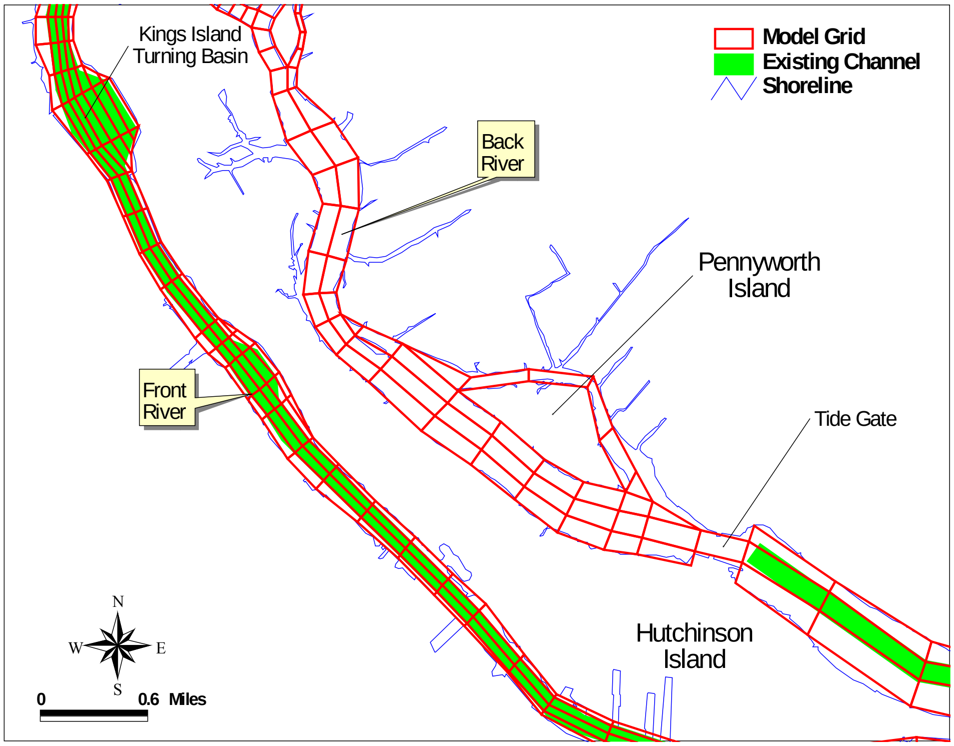

Figure 7 – Front River and Navigation Channel Including the Kings Island Turning Basin

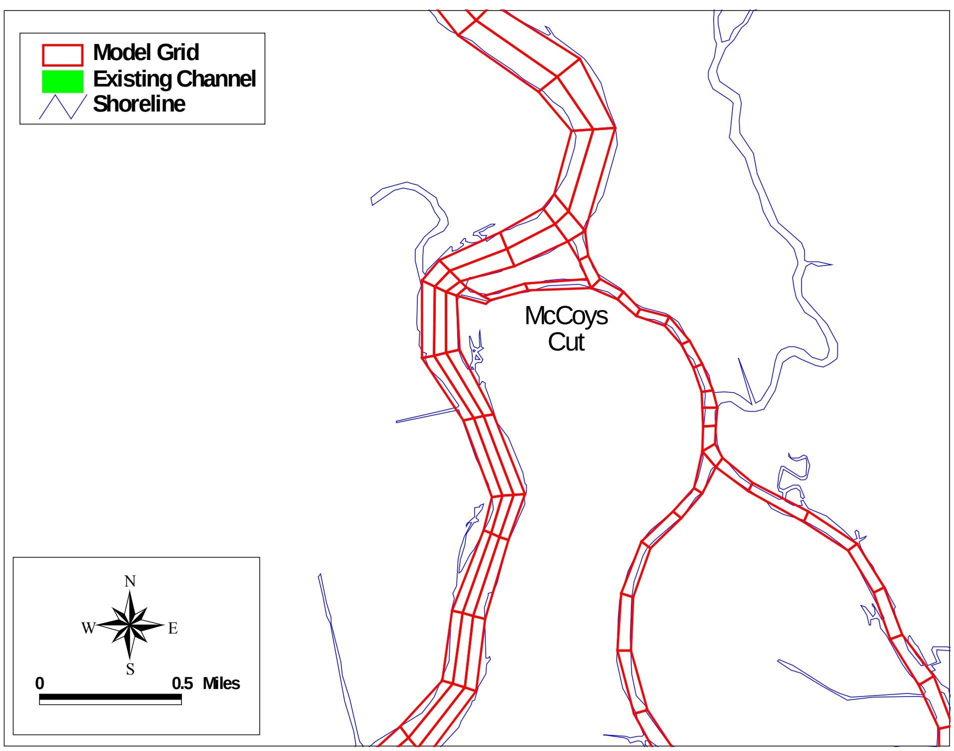

Figure 8 – McCoys Cut between Front, Middle, and Little Back Rivers

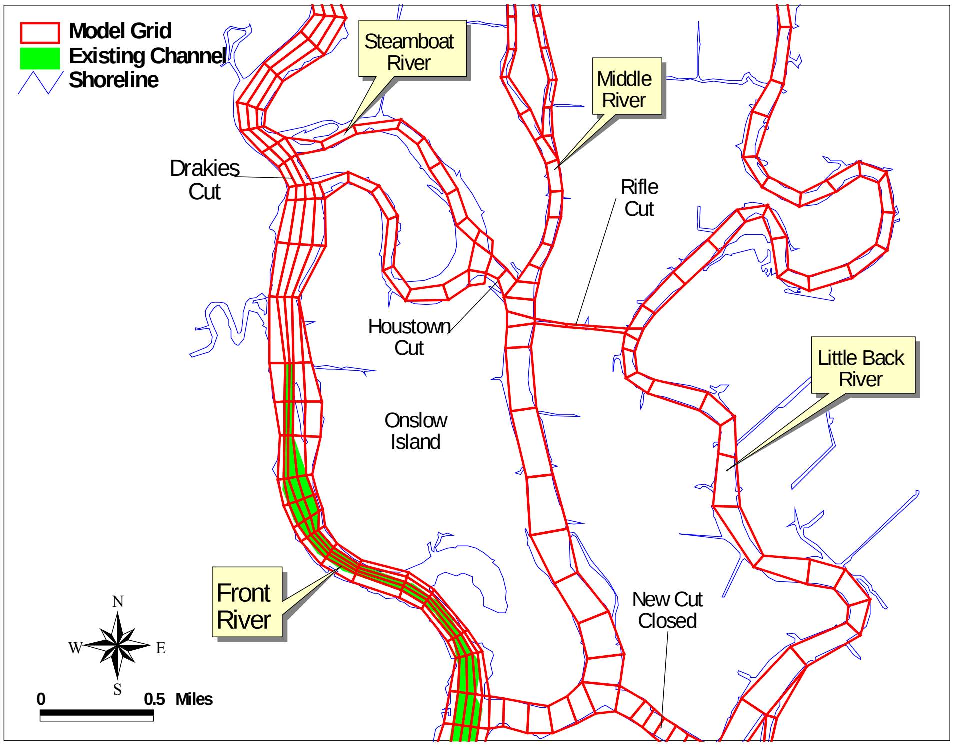

Figure 9 – Cuts in the Front, Middle, and Little Back Rivers

Meeting Minutes
Savannah Harbor Expansion (SHE) Project Model Development
January 11, 2005 at Tetra Tech, Inc., Atlanta, GA

Attendees:
Joe Hoke, USACE Savannah District
Bill Bailey, USACE Savannah District
Margaret Tanner, MACTEC
Larry Neal, MACTEC
Paul Lamarre, GAEPD
Jim Greenfield, EPA Region 4
Wade Cantrell, SCDHEC
Bob Scanlon, City of Savannah and Harbor Committee
Steven Davie, Tetra Tech
Yuri Plis, Tetra Tech
Will Anderson, Tetra Tech
via conference call:
  Larry Keegan, Lockwood-Green
  Hope Moorer, GPA
  Chuck Watson, Kinetic Analysis Corporation
  Sri Rangarajan, HydroQual
  Paul Conrads, USGS
  Card Smith, USACE
  John Hamrick, Tetra Tech

Meeting Agenda:
1. Overview of Tetra Tech's contract with USACE/GPA.
2. Schedule of work tasks.
3. Specific work tasks for discussion:
   a. Update on model enhancements
   b. Preliminary production runs & output
   c. Uncertainty analysis (Kinetic Analysis Corporation)

Discussion Items:
- Steven Davie presented an overview of the modeling contract with the USACE, an overview of the schedule, and a status report on Tetra Tech's work. Tetra Tech is under contract to the USACE Savannah District to provide the following tasks: EFDC modifications and re-calibration, re-evaluate WASP calibration, uncertainty analysis, EFDC/WASP training, EFDC/WASP reports, and model application files.

- Modeling Schedule:
  - Initiated Work – Oct 6, 2004
  - EFDC Training – completed on Oct 26-28, 2004
  - WASP Training – To be determined
  - Draft Uncertainty Analysis – completed on Jan 7, 2005
  - Final Uncertainty Analysis – Jan 31, 2005
  - Draft EFDC and WASP Report – Feb 2, 2005
  - Final EFDC and WASP Report – March 9, 2005 (or based on agency comments)

- Model Enhancements:

- Re-fined grid resolution
- Updated bathymetry
- Marsh interactions

- New Grid Resolutions:
  - ~ 950 horizontal cells, probably end up with 900 to 950 cells.
  - 657 in TMDL grid and 1,368 in finer grid.
  - Running with 6 vertical layers.
  - Upstream boundary at Clyo ~ 61 miles from Fort Pulaski
  - Downstream boundary ~18 miles offshore from Fort Pulaski
  - Man-made connections included (McCoys Cut, Rifle Cut, Drakies Cut, New Cut closed, Tide Gate)
  - Shipping channel defined - matches channel configuration (GIS from Corps)
  - Revised enhanced grid incorporating agency comments such as smoothed channel mouth, merged two channel cells into one, merged multiple cells next to channel into one on each side for most areas, except Kings Island Turning Basin and Elba Island Bight/Sediment Basin area.
  - Handout distributed on Tetra Tech's December 10, 2004 Technical Memorandum No 1 on the grid resolution.
  - Handout distributed summarizing the grid comments was given based on December 10, 2004 Tetra Tech memo.
  - The grid convergence test has not been completed and will be discussed in the final report.

- Bathymetry Data Sources:
  - USACE Annual Surveys (1999, 2002) for the navigation channel.
  - USGS SNWR (2004) for Front, Middle, Back, and Little Back Rivers.
  - USACE Upstream of I-95 (1999) for upper Savannah River.
  - NOAA Surveys (1980's) - offshore non-channel and South Channel.

- Marsh Interactions
  - Using Q-Zones developed by ATM marsh report and implemented in the TMDL grid.
  - TMDL grid approach did fairly well except on strong spring tides.
  - Enhanced approach will use external cells inundated only during strong spring tides with wetting and drying as an option.

- Production Run Scenarios:
  - Tetra Tech has been using the TMDL grid as a "screening level" model to work out details associated with deepening production runs, such as how to represent the deepened channel and how to produce output. The USACE stated that developing a program to process and organize all output was not part of the scope but will help in future production run scenarios. (The Tetra Tech scope calls for setting up the bathymetric files for the production runs, but does not require delivery of output files.)
  - Baseline conditions were August 1999, which is consistent with EPA's draft DO TMDL, and the project conditions were the 46-foot channel. The 46-foot channel was represented in the TMDL grid by increasing the depths in the navigation channel by 4 feet (1.2 meters).
  - Habitat suitability requirements were shown through contoured plots of the grid for the following: Striped Bass (April) spawning, egg development, larval development; Southern Flounder (August); American Shad (January, May, August); and Shortnose Sturgeon (January, August).
  - Other EFDC/WASP output was discussed such as plan view of salinity and D.O. distributions, 2-D (longitudinal and vertical) distributions, salinity statistics horizontal distributions, water

volumes with D.O. increments, ship channel, entire Middle and Back Rivers, statistics of salinity responses to alternatives, Ship Channel, Entire Middle and Back Rivers, USGS gages

- Uncertainty Analysis:
  - Chuck Watson from Kinetic Analysis Corporation (KAC) presented preliminary results of the uncertainty analysis (UA) on the TMDL model grid.
  - KAC evaluated the quality and quantity of data available for the development of the hydrodynamic and salinity and water quality models.
  - KAC evaluated the uncertainty of the TMDL configuration of the EFDC model (aka the TMDL model)
  - KAC has made preliminary recommendations for the development of the enhanced grid model.
  - KAC concentrated on salinity – good data, checks mass transfer – with seven sets of simulations: 1) Baseline, 2) +1m Bathymetry, 3) -1m Bathymetry, 4) Friction bias to 0.0, 5) Friction bias to 0.1, 6) Bathymetry set to 1992, 7) Randomly perturbed bathymetry (10 at 10%).
  - KAC used "R" package for automated analysis and plot generation, spot checked manually using JMP (from SAS Institute)
  - KAC's preliminary recommendations include: 1) enhanced grid model calibration should take care to avoid over calibration to 1997/1999 conditions, 2) long term data should be partitioned to include both calibration and blind test (verification) runs, 3) use of bottom roughness for calibration should be carefully examined to ensure additional uncertainty is not being introduced in the calibration process, and 4) bathymetry should be for average conditions – not just immediately after maintenance or dredging. This could be a data problem having only data before and after maintenance rather than for average conditions.

Next Meeting

Scheduled for February 16, 2005 at EPA Region 4 to review the draft modeling reports and go over comments. Agency comments will be due to Joe Hoke by February 25, 2005. Please be prepared to review the reports during this time period.

DRAFT Production Run Outputs
Discussed with USACE Savannah District
Tetra Tech, Inc.

1. EFDC and WASP TMDL production runs

- Production runs will be made with the Draft TMDL models until the value of the potential enhancements to those models are complete. If the enhancements are effective, they will be used for the final impact analysis runs.

- Description of outputs to be available to evaluate potential project impacts.
  1. D.O. concentrations will be at 0.1 mg/L increments.
  2. Tables and graphics of water volumes with D.O. increments of 0.5 mg/L
     - Navigational channel - mouth to Houlihan Bridge
     - Back River to Hwy 17 Bridge
  3. Plan view of the D.O. minimal values distribution.
  4. 2-D (longitudinal and vertical) distributions of grid cells / longitudinal sections that do not meet the SC and GA standards. The criteria will be 1-, 7-, and 30-day DO values and also the 10% deficit based on the 4.0 mg/L natural TMDL run.
  5. Tables/Statistics of salinity responses to alternatives.
     - Navigational channel - mouth to I-95
     - Entire Middle and Back Rivers
     - Show data at USGS gages
  6. Animation of production scenario results.
  7. Creating software for extracting information from the BMD files and processing with layouts' fill in.
  8. BMD file subtraction in MOVEM (will allow direct comparison of alternative with baseline).

2. Baseline Run for Water Quality

- Time-period = 30-days

- Critical period = August 1999
  Use temperature and flows that occurred during that period.

- Use TMDL run with 362,000 lbs/day of total load and 132,000 lbs/day of point source load. (Assumes TMDL has been implemented by base year of 2010.) We will work with EPA on the spatial distribution of the point source load. (The beginning position is that ½ of the point-source reduction will be made in up-river sources and ½ from harbor sources.)

- Start EFDC model on June 1, 1999 and then start the WASP model on July 1, 1999 for baseline and production runs.

- Assumes water quality standard proposed by EPA in August 2004 has been adopted by GADNR-EPD.

- Assumes point source discharges are operating at their full permit levels.

Comments on the
Savannah Harbor EFDC and WASP Model Grid
Technical Memorandum No. 1 to Joe Hoke, USACE Savannah District
Tetra Tech, Inc

1. Commenter: Larry Keegan, Lockwood Greene
    - Can we get some understanding of their reasoning and the underlying sensitivity data that supports their choice?

2. Commenter: Paul Lamarre and Roy Burke, GAEPD
    - We have no additions or technical comments and recommend that Tetra Tech proceed with model calibrations.

3. Commenter: Sung-Chan Kim, ERDC, CEERD-EP-W, Vicksburg, Mississippi
    - Offshore boundary: The offshore extent is approximately 17.5 miles from the entrance of the Savannah River. I believe this will be sufficient to relieve the boundary condition control for the hydrodynamics of the river. However, it will be nice to show the inside dynamics is not much affected by a range of boundary conditions (maybe by doing a couple of sensitivity runs). The extension of the southwest offshore grid makes sense because the boundary is aligned with coastline where one can pose no normal flux across the shoreline.
    - Grid resolution: Two-cell wide navigation channel may be good enough for water quality modeling purpose. However, this also has to be justified by showing measured data which shows small gradient across the channel (the model should be able to resolve the gradient). If there is no data, then we may hypothesize very small variability across the navigation channel. A convergence test showing that two-cell wide channel gives similar results to many-cell wide channel may validate the hypothesis. When a sudden depth change occurs between the navigation channel and the shoal, a pressure gradient error term may become significant. This may be minimized by increasing resolution over the channel slope. However, there is no need to worry about this error term if the flux along the river is dominant compared to the flux across the river. I believe this is the case for the Savannah River. It will be good if this is supported by existing data. The Middle and Little Back Rivers were represented as one grid cell wide and I believe this is adequate. Other enhancements around the Tide Gate also seem to be adequate. Putting flow barrier in the New Cut is a good idea. All the comments given above may be backed by series of convergence test. This was required for previous modeling work by ATM. I think it may be fair to go through the similar paths.
    - Summary: I have two concerns-one major and one minor. The major concern is that the convergence has not been tested. One may still argue a good calibration statistics supersedes this and I think it is a judgment call. The minor concern I have is the resolution of the navigation channel and the slope. I think it can be justified by showing little gradient across the river (from existing data). I believe the enhanced grid accommodates detailed local geometry.

4. Commenter: Paul Conrads (USGS representing USF&W Service and National Marine Fisheries)
    - From the memo it was a little difficult to visually compare the enhanced grid with either the coarse or fine grid shown in the March 2004 report (figures 4-1 and 4-2). The coarse grid has approximately 50 percent less horizontal cells than the fine grid. The enhanced grid is a 17 percent reduction from the fine grid. From the memo and the report, it is difficult to see here the "savings" in cells between the enhanced and fine grids occurred.

- Resolving grids with smaller cells is a cost-benefit analysis. There is a optimum cell size and time-step where the model is numerically convergent for the state variable of interest. Refining grids past this point may be necessary to get output at desired locations or to analyze some time response. For the three grids set up for the Savannah.
- The coarse grid was created because of the need for reasonable run times in developing the TMDL. There is a balancing act between run times, output time intervals, and file sizes and the grid plays a central role in this act. Does the enhanced grid satisfy the needs of the SHEP and the TMDL?
- The tech memo does not describe the schematization of the marshes. There has been discussion of refinements of the marsh but the cell representation is not included in the enhanced grid. Will this be added latter?

5. Commenter: Jim Greenfield, USEPA Region 4
    - Bottom line is the coarse grid does a good job for water quality and evaluating any changes (pollutant loadings or depths) on DO in the critical front river channel area, any enhancements would be to make the salinity predictions better in the upper portion of the model and in the middle and back rivers. Also to allow the model to better look at any possible rechanneling options.
    - That said, the enhanced grid better defines the channel (4 to 6 grid cells wide) and better represents the middle and back rivers (finer grids and new up to date bathymetry). But does it do a better job??? and is it worth the cost (computer run time)?? As Paul stated a cost benefit ratio needs to be completed.
    - Initial reaction, the enhanced grid is over kill - do we need the main harbor dredged channel defined by 2 grid cells wide? Is this option needed to evaluate channel deepening? Does it improve the hydrodynamics - I doubt this provides any improvement so if deepening options will not require 2 cells wide would suggest this be returned to one cell wide - again a CB ratio needed.
    - Middle and back rivers - way to much detail and to many small segments that will increase run time in my humble opinion - I doubt this provides any improvement -suggest this be modified - again a CB ratio needed.
    - I like the changes to the ocean portion - eliminates the "wave bouncing off the shore issue" while encompassing the whole near field ocean area. this will allow for more detailed analyses of the marsh loads from the ocean marshes (forget the name of the rivers coming in north of the harbor)
    - Overall the girding is a good enhancement although to detailed - to many cells and to small of cells that will make unacceptable run times to evaluate multiple years. But it should be able to be easily modified and CB ratios developed to see what we gained or lost.
    - On another note - the additional work we are conducting in examining an alternative DO standard suggest more and more we need long term runs and look at multiple years and reasons, so the run times are very critical for the DO evaluation.
    - For the next meeting - I would like USFW and NMFS along with State DNR be invited so we can have a discussion on the fisheries portion and the fishery needs - we have some new tools and mechanisms to link DO, temp and Salinity Timeseries to fishery life stage needs and want to discuss this with the other agencies - also need aquatic life stage information and input specific to Savannah Harbor from these agencies.

6. Commenter: Bill Bailey, USACE Savannah District
    - With the Tidegate being modeled as a single cell, would we be able to model the effects of removing the Tidegate and opening up that cross-section to its original width (basically same as adjacent 3-cell wide river)? We may need to examine the effects of such a proposal. The

proposal could include leaving the concrete sill of the Tidegate in place, so we couldn't model the increased cross-section by deepening that cell.

- I'm pretty sure that convergence testing was part of the SOW. It was section III.A.1 of one draft of the SOW. It would seem that the results of that analysis would greatly influence decisions on the acceptability of the grid shown in this Memo. I recommend that you not state that this grid is acceptable based solely on the contents of this Memo; we should wait until we see the results of the convergence testing. Presumably those results will be in the draft report Tetra Tech will soon produce, and this Memo is just a heads-up of their findings.

Meeting Minutes
Savannah Harbor Expansion (SHE) Project Model Development
February 16, 2005 at EPA Region 4, Atlanta, GA

Attendees:
Jim Greenfield, EPA Region 4
Steve Whitlock, EPA Region 4
Joe Hoke, USACE CESAS
Bill Bailey, USACE CESAS
Paul Conrads, USGS
Paul Lamarre, GAEPD
Wade Cantrell, SCDHEC
Margaret Tanner, MACTEC (consultant for the City of Savannah)
Yuri Plis, Tetra Tech
Will Anderson, Tetra Tech
via conference call:
  Larry Keegan, Lockwood-Greene
  Steven Davie, Tetra Tech
  Dr. Sung-Chan Kim, ERDC-EL-MS

Meeting Agenda:
1. Draft Hydrodynamic (EFDC) and Water Quality (WASP) Report sent out on February 7, 2005.
2. Status of Tetra Tech's calibration to date.
3. New Appendices of Model Calibration.
4. Initial Agency comments.

Known work items to be completed by Tetra Tech:
1. Grid convergence test
2. Marsh enhancements
3. Revised appendices based on latest model runs
4. Better salinity and D.O. calibration
5. How to deal with flows in upper basin
6. Need to clean up bad salinity and D.O. data; convert currents data
7. Chuck Watson analysis of enhanced grid model

Discussion Items:
- Dr. Kim: Statistics (MAE, RMS, etc.) are not included in appendices. Will they be included in final report? It is hard to see results on current plots. S. Davie responds: 2-week periods should be on a scale to see, will include additional statistics in final report.
- Dr Kim: Fig. 5.1 not clear – red and blue dots obscure graph. For WSE, we show 90th percentile of amplitude, but not time of maxima? In salinity, we discuss stratification and destratification--how can we assess this on a time axis? Can plot difference between surface and bottom – show vertical gradient? Can we demonstrate quantitatively that the model performs adequately? Prove the stratification/destratification events are occurring. S. Davie responds: we will revise Figures 5-1 through 5-6 so that the model shows up on top of the data. Also, time of maxima comparisons will be included in the stats tables. Also, 2-week plots will help the reviewers see the model versus data. Paul Conrads suggests: use moving window to compare surface/bottom data and results, not instantaneous.
- Tetra Tech will use the TMDL Model as the starting point for the Grid Convergence Test. They will use a smoothed channel bottom and then vary the grid size/spacing to determine when further

refinements in grid size result in no substantial changes in the model predictions. (They will compare run predictions against each other, not against measured data.)

- Paul Conrads: The distribution of flows in the Middle, Back, and Little Back Rivers are very important. The model is "freshening" (salinity going to 0) when the data does not show this. This is very important for scenarios. Tetra Tech is adjusting the marsh flows and salinity and hopes to improve the salinity calibration in the Little Back River and Middle River.
- Bill Bailey: Since Chuck Watson's draft report indicated that an uneven bottom would improve the EFDC model's performance, why do we show in channel thalweg figure that it is smoothed? Maybe use smaller averaging period or use closer to real data. Tetra Tech will consider using the actual channel stationing without any averaging and then compare. Instead of 5,000-foot smoothing, no smoothing or a lower interval smoothing may be more appropriate. Check the calculations on average depth from –60 to –25 (Figure 4-3).
- Paul Lamarre: Can we overlay thalweg picture somehow with shapefile? S. Davie: We can do an uncertainty run with the channel bottom varying more. We can also show the grid cells on top of the channel stationing figure (Figure 4-3).
- Tt will include point source locations and flow transect figures in final report.
- Union Creek flow transects add to Appendix C. Using constant inflow to Union Creek u/s boundary. Include reference map.
- Paul Conrads: Union Creek maybe more tide dominated in drought period, -in flood period, more flow dominated. Jim G.—can we do some kind of rainfall/flow analysis for Union Creek? S. Davie: we can use the Black Creek nr. Mill Creek USGS gage for a time series of flows to Union Creek.
- Wade Cantrell: Observed that integrated flows from QSER file are very high, up to 600 cms and 4 M m^3. Tetra Tech needs to check and reconsider marsh flows. They are in the middle of adjusting the marsh flows.
- Wade-why not include SABSOON analysis in the report, it was in previous coarse grid report. It is helpful to show why constant boundary is appropriate, since major concern is predicting salinity, would it be helpful to do sensitivity runs for constant boundary. Tetra Tech will include the SABSOON data back in the report and show that the model represents the same signature at the boundary (i.e., constant salinity moving in and a lower salinity moving out).
- Is the model better at magnitude of change or absolute value predictions of salinity? Relative impacts of point source impacts or absolute value of dissolved oxygen? Jim Greenfield: Absolute value of salinity important, there are data issues for DO.
- Wade: about alignment of currents—what does it mean that the model axis not the same as data axis? We are still having a problem with the currents data in WRDB provided by ATM. S. Davie will send a memo to Joe Hoke requesting the raw currents files from ATM. Joe will send the memo to Larry Keegan.
- How do we request correct raw files for currents and DO? Tetra Tech will check to see if they have the raw data files used by ATM to create the WRDB. If not, Tetra Tech will send a request to Joe Hoke that can be forwarded to Larry Keegan.
- How do we ensure the proper quality control has been used on the raw data files? Paul Conrads: Currently doing analysis of FR-22-surface DO results to assess what resources it takes. This will be complete on 22 February and will then provide the procedure and results for that station to Tetra Tech.
- Paul Lamarre: Reiterated concern about absolute value predictions for salinity.
- Jim Greenfield: for appendix plots, can we put surface and bottom plots on the same page?
- Paul Lamarre: we do not see amplitude matching in salinity plots.
- Jim Greenfield: Concerns about run time. Fine grid may be necessary for "plumbing" scenarios. Can we upgrade coarse grid with new bathymetry for TMDL model predictions?

- Bill Bailey: What about the code changes we mention for marshes—needs to be documented. Address what portions of the code/model were modified and what portions were not modified and affected.
- Consider adding longitudinal plots of variables, possibly with percentiles or quartiles

BREAK FOR LUNCH

- Jim Greenfield: WASP latest version is broken.
- Dr Kim: Addressing DO results: would expect DO to decrease plots H1 and H2 during Aug 19 stratification. Jim Greenfield: WASP is broken, DO results invalid.
- Paul Conrads: Figures 8-12 and 8-13 are not referenced in the text.
- Wade Cantrell: Report indicates that nutrients are turned off in model? S.Davie: still runs kinetics but not photosynthesis. Jim Greenfield: light/dark bottle tests show photosynthesis not important. The report should explain and document this.
- Paul Lamarre: Model temperature shows higher than observed—isn't this important? Little Back 5-7 deg higher. Jim Greenfield—this should be fixed.
- Bill Bailey: report indicates p58 shallower areas should have higher CBOD decay rate, but in Table 8-8 we have 0.05 for back river?
- Paul Lamarre: Appendix G: we are over predicting ammonia. Yuri Plis: perhaps we need to lower boundary.
- Jim Greenfield: what about ammonia in the marshes? Jim Greenfield: Tt started with EPA rates—SOD-temp correction now 1.065, maybe 1.05 may be better late Sept-Oct? Can we do sensitivity runs for SOD-temp correction?
- Paul Conrads: Run time, what about long-term runs? Jim Greenfield: maybe TMDL model with adjusted bathymetry better for long-term runs, friction adjusted. Maybe TMDL model still viable for DO results?
- S. Davie: What else should we show in report—other nutrient parameters, vertical profiles? Longitudinal DO or nutrient percentiles? Frequency distributions of DO or salinity or both? Suggestion: Paul Conrads: maybe chemistry quartiles.
- Joe Hoke: back to EFDC, for Table D-1 make sure to put correct expectation numbers, +/- 1 deg C rather than percentile. S. Davie: we will and highlight which ones meet criteria and which ones do not meet for explanation in the text of the report.

Next Actions:

- Tetra Tech will prepare notes for the meeting and provide them to Joe Hoke.
- Reviewers will provide any additional comments they may have by COB Friday, 18 February.
- Tetra Tech will inform Joe Hoke when it will be ready to distribute the Final Report. That report will include all of Tetra Tech's revisions to the models and the report. The agencies will then review that Final Report and provide their assessment of the usefulness of the models to assess impacts on the Savannah Harbor Expansion Project.
- Check with hydrographic surveyors to see if there is any data on Rifle Cut.

Next Meeting:

Next meeting will be determined after Tetra Tech completes the final report.

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TECHNICAL MEMORANDUM NO. 2

Date: March 16, 2005

To: Joe Hoke, USACE Savannah District

From: Steven Davie

Cc: Alan Garrett and Bill Bailey, USACE Savannah District

Subject: Status Report of Savannah Harbor EFDC and WASP Models
Tt Project No. J391-02

Tetra Tech, Inc. (Tetra Tech) has been working on the final 1999 calibration and 1997 validation of the EFDC and WASP models. Based on comments and questions at the February 16, 2005 meeting at EPA Region 4, we have been addressing the calibration issues in both the EFDC hydrodynamic and WASP water quality models.

The status of the model and major improvements can be summarized in the following categories:

1. Water surface elevation in upper Savannah River,
2. Revised marsh approach,
3. Salinity stratification in the Front River,
4. Salinity in the Back and Little Back Rivers,
5. Flow calibration, and
6. WRDB data assessments.

<u>(1) Water surface elevation in the upper Savannah River</u>
In the February 7 draft modeling report, the EFDC model was under predicting the ebb water levels at the I-95 Bridge (FR-14). We worked on the bathymetry and longitudinal bottom elevation between Houlihan Bridge and I-95 Bridge to better simulate the water levels in the upper Front River. Figure 1 shows the Upper Savannah River and Harbor with the bottom elevations for each of the grid cells. Improvements in model predictions of water surface elevation are largely due to adjustments to the Front River bathymetry between Houlihan Bridge (FR-09) to I-95 Bridge (FR-14). The results of the calibration are shown in Figures 1-4. Figures 2 and 3 show the Houlihan Bridge location and Figures 4 and 5 show the I-95 Bridge location. According to the measured bathymetry soundings along the Front River (USGS 2004), the channel thalweg alternates from bank to bank and the channel is deepest on the outside of channel bends. In order to properly represent this for optimal model results, the thalweg was considered to be the center cell in the model grid. This is shown in Figure 6 with I = 14 being the center cell (thalweg) and I = 13 and 15 the side cells.

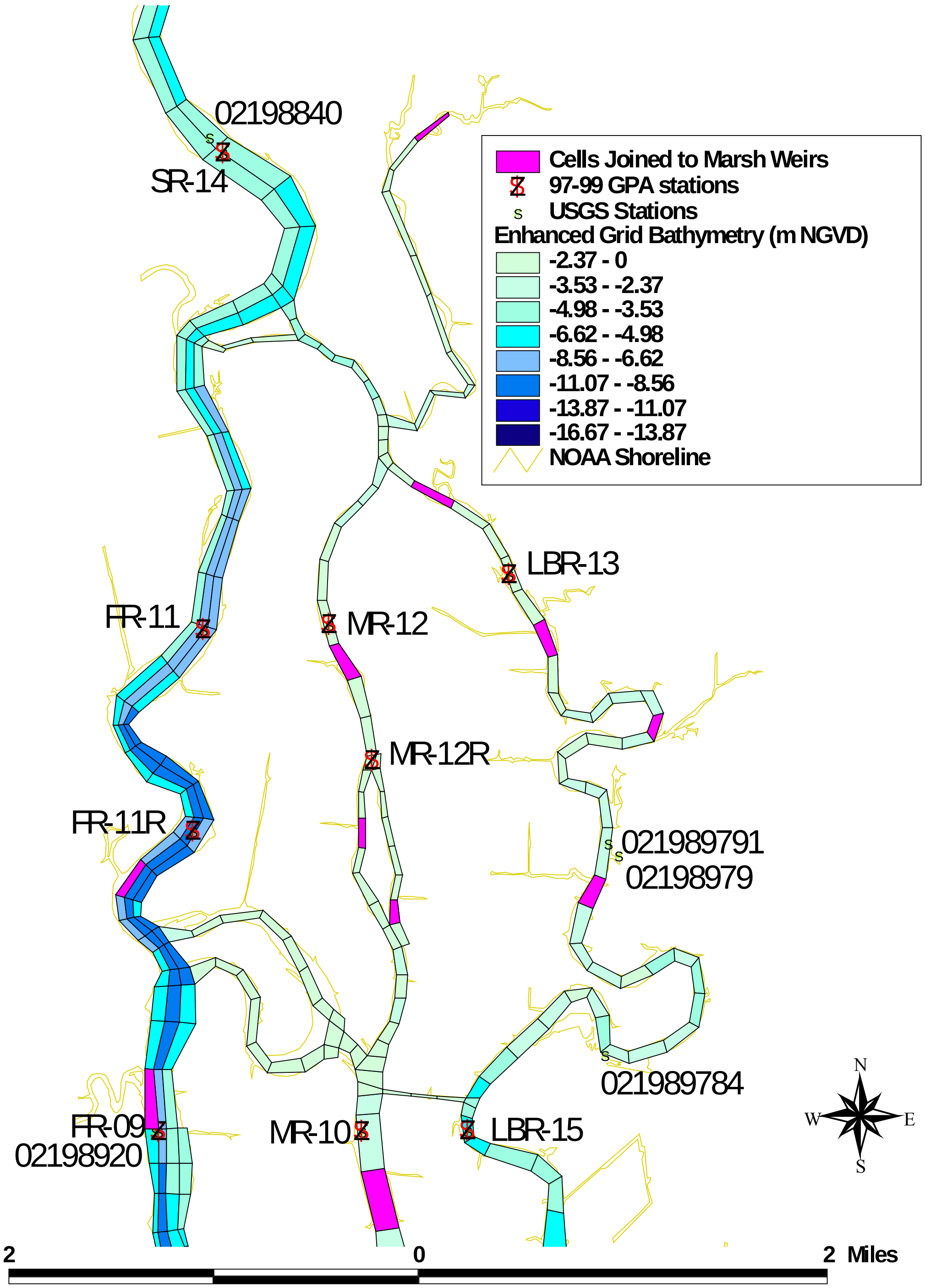

Figure 1 – Map of Upper Savannah River including Front, Middle, and Little Back Rivers

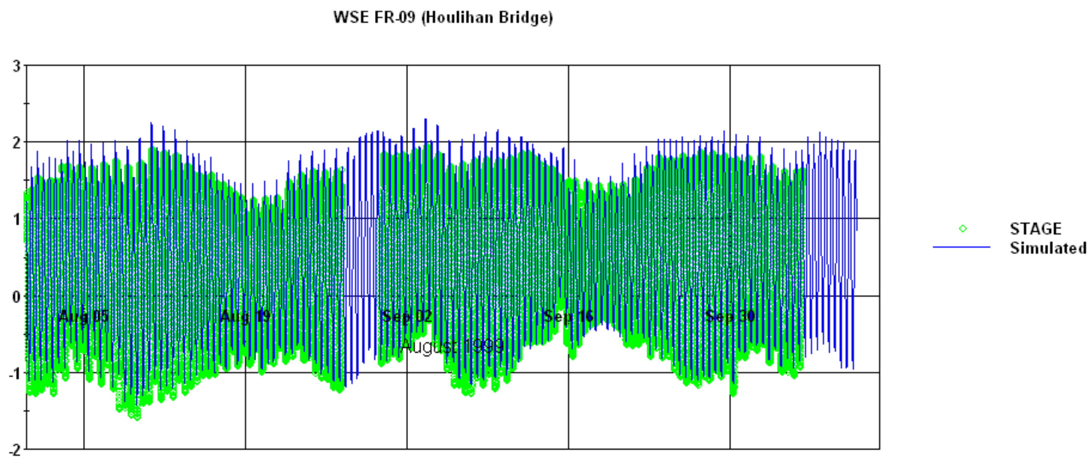

Figure 2 – 1999 Water Surface Elevation at Houlihan Bridge (FR-09)

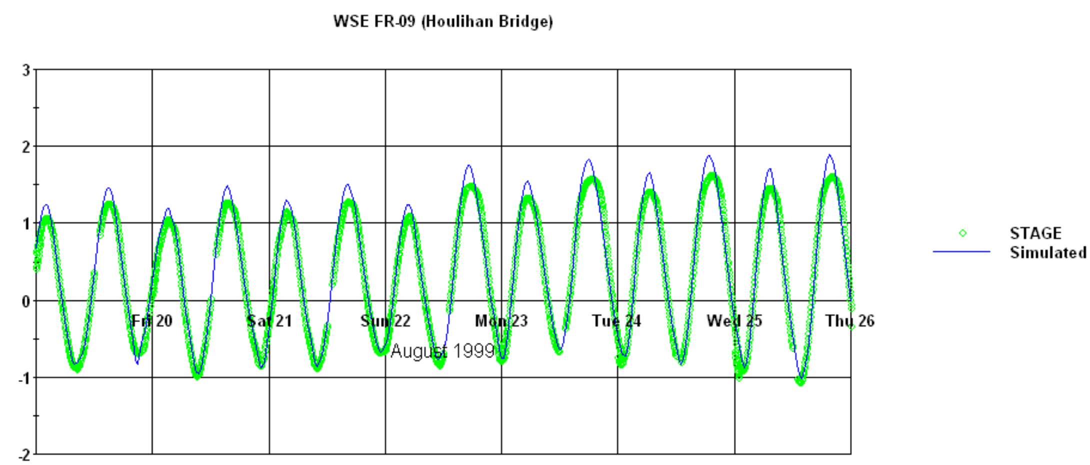

Figure 3 – August 1999 Water Surface Elevation at Houlihan Bridge (FR-09)

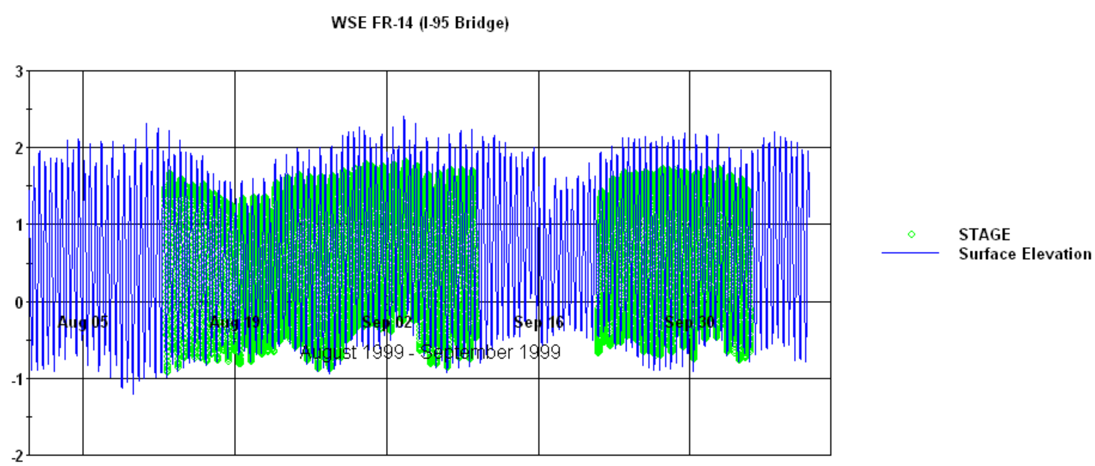

Figure 4 – 1999 Water Surface Elevation at I-95 Bridge (FR-14)

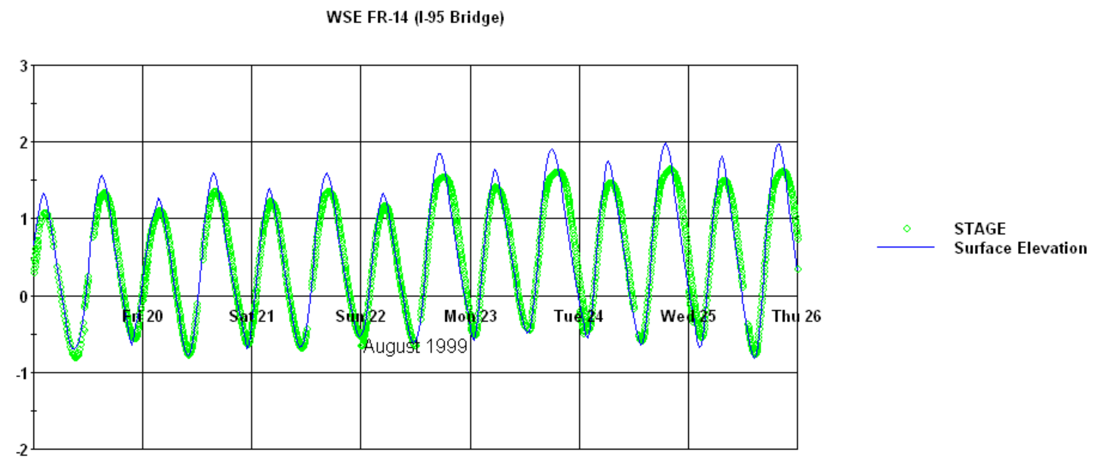

Figure 5 - August 1999 Water Surface Elevation at I-95 Bridge (FR-14)

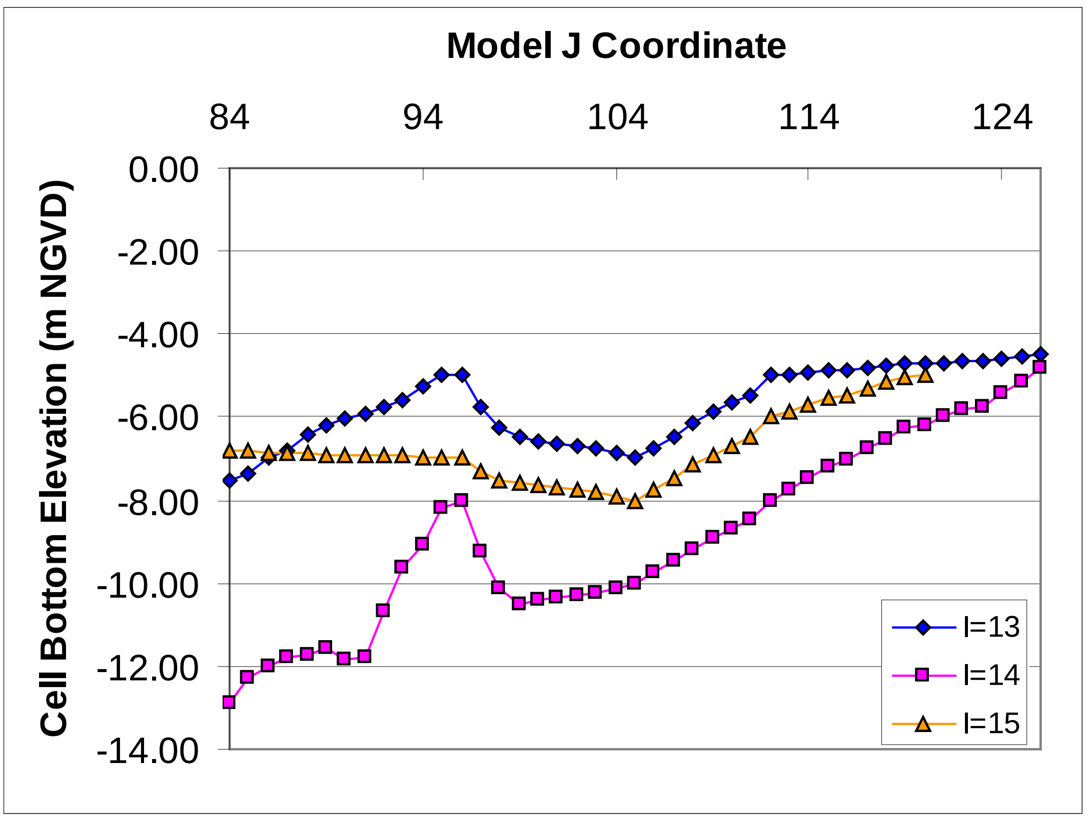

Figure 6 – Longitudinal Bottom Elevations from Houlihan Bridge to I-95 Bridge (I = 14 is the center cell and I = 13 and 15 are the side cells)

(2) Revised marsh approach

The inclusion of the marsh areas is critical to the success of the model's performance. As discussed during the February 7 meeting, the EFDC model was having difficulties simulating flows on the Little Back and Middle Rivers and we confirmed that it was due to the marsh approach. The original marsh approach was to calculate a tidal prism based on the simulated water surface elevation in the river compared to the bottom elevation of the marsh. The draft report detailed the equations used for flow, salinity, and temperature. It was discussed at the Feb 7 meeting that we were going to implement these equations in the EFDC code after we proved that they were working. The draft report flows on the Little Back and Middle Rivers appeared to reflect with one another and produces a flow that was out of phase with the data. We also tested different size marsh areas and making them very large but did not see improved results. Therefore, we decided to abandon the original marsh approach and use a function that was already in the EFDC code. The revised marsh approach entails having a marsh cell connected to the model grid through a hydraulic structure. There were 17 marsh areas added to the enhanced grid and they are listed in Table 1 and shown in Figure 7. The structure requires an invert elevation and a flow table. The marsh cell is similar to any other model cell and requires a bottom roughness and elevation. The hydraulic structure simply allows the water to move back and forth between the river and the marsh based on the water surface elevation difference. The hydraulic structures were calibrated by modifying the marsh areas and invert elevations of the structure. Table 1 below shows the marsh cell connections, dimensions, bottom elevations, and structure inverts. The Q-zones reported by ATM's "Tidal Marsh Studies Data Report" Volumes 1 and 3 (2003) were still used to determine the marsh areas. Since the marsh areas do not flood on every tidal cycle, the areas were adjusted down to 600 meters by 600 meters as shown in Table 1. There were additional marsh cells used to represent Union Creek, Upper Little Back River, and Augustine Creek that are in addition to the reported Q-zones. Union Creek was put in as a storage cell without a structure. Q zone 10 has not been added to the model at this time. We will make a map of the Q-zones for the final report.

Table 1 – Marsh Grid Cell Parameters used in the EFDC Model

River Cell		Marsh Cell		Marsh Dimensions		Bottom Elevations		Q-zone
I	J	I	J	Calculated Size (m x m)	Adjusted Size (m x m)	Marsh (m, NGVD)	Structure Invert (m, NGVD)	
23	133	23	134	1000	600	-0.7	no structure	Union Creek
28	123	28	125	1000	600	-0.6	-0.5	Upper LBR
33	123	33	125	1000	600	-0.6	-0.5	Upper LBR
39	122	41	122	1000	600	-0.6	-0.5	Q8
39	113	41	113	1300	600	-0.6	-0.5	Q8
30	92	32	92	1183	600	-0.6	-0.5	Q4
30	87	32	87	1354	600	-0.6	-0.5	Q3
36	68	38	68	1354	600	-0.6	-0.5	Q3
31	76	33	76	1354	600	-0.6	-0.5	Q3
26	95	28	95	922	600	-0.6	-0.5	Q5
22	108	24	108	1110	600	0.2	0.3	Q6
26	110	28	110	1110	600	0.2	0.3	Q6
26	116	28	116	1110	600	0.2	0.3	Q9
36	66	38	66	very large	600	-0.6	-0.5	Q2
13	104	11	104	1378	600	-0.6	-0.5	Q1
15	86	17	86	1000	600	-0.6	-0.5	Q7
13	96	11	96	2000	600	-0.6	-0.5	Augustine

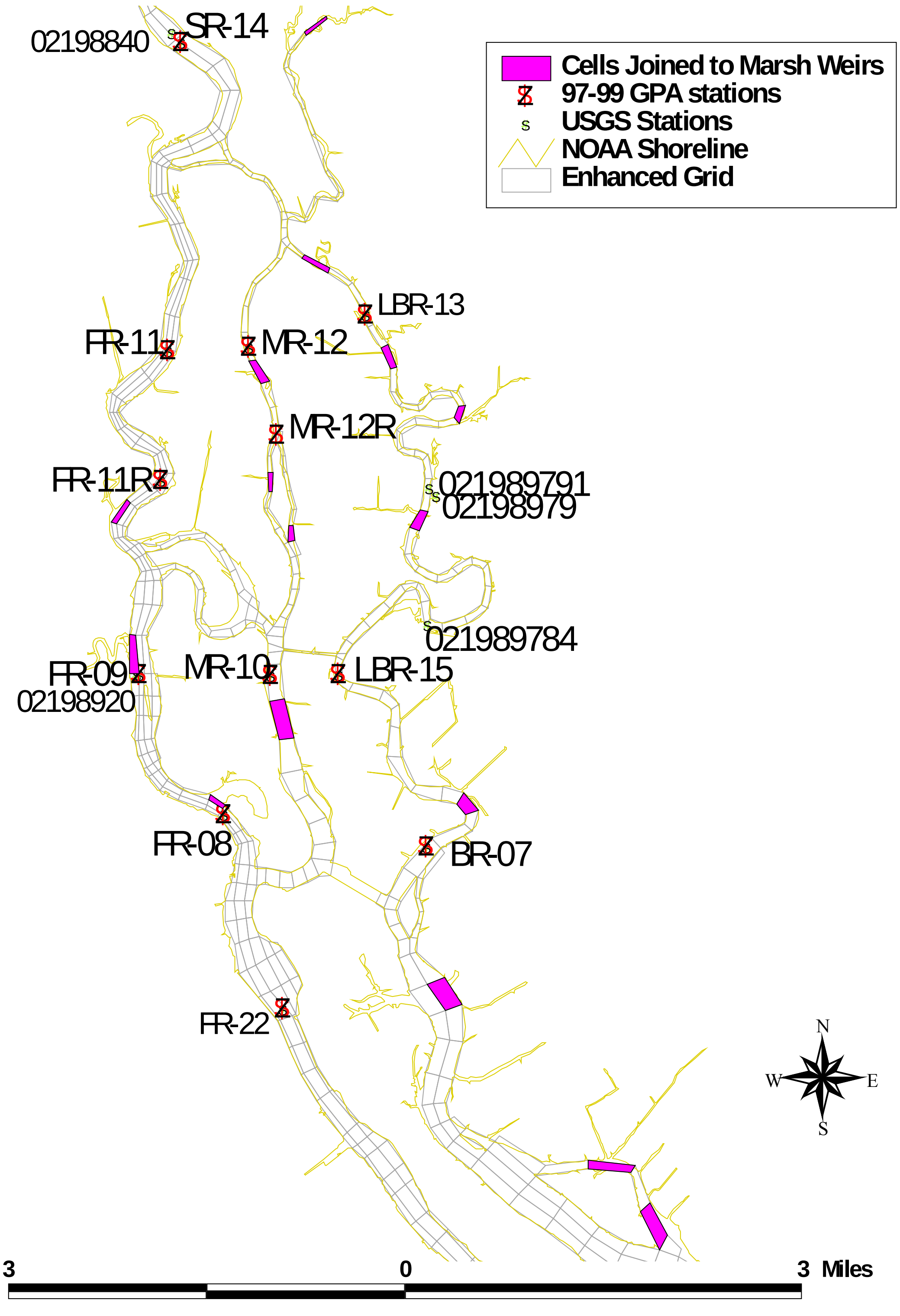

Figure 7 – 17 Marsh Locations in the Enhanced Model Grid

There were several advantages to the revised marsh approach. First, our flow calibration was much improved and the simulated flows were smoother similar to the rising and falling tides. Second, there were no changes to the EFDC code necessary since the hydraulic structures have always been in the EFDC code. Third, the salinity calibration was much improved in the Little Back and Middle Rivers as we now see the elevated levels of salinity at those stations. Fourth, we did not have to use the wetting and drying options in EFDC that would significantly lower our model time step and increase the model run times.

<u>(3) Salinity stratification in the Front River</u>

The EFDC calibration for 1999 has improved since the draft modeling report. Once again, we went back through the bathymetry data to confirm the deepest point of the cross-section to verify the model depths in the channel. Also, the revised marsh approach increased the tidal prism, or amount of water moving into and out of the harbor on a tidal cycle, which has improved the mixing in the channel. The more tidal prism (spring tides), the more mixing. We tried to characterize the amount of stratification and de-stratification by producing Table 2 and Figure 8 below based on Dr. Kim's comment at the Feb 16 meeting. The analysis below was performed at FR-06 for a stratified and de-stratified (mixed) period in August 1999.

Table 2 – Characterization of Stratified and Mixed Salinity Conditions

Stratified Conditions: 8/20/99 0:00 - 8/23/99 0:00		
	Mean Observed	**Mean Predicted**
Bottom:	23.9	21.1
Surface:	6.5	5.2
Delta:	**17.4**	**15.8**
Mixed Conditions: 8/28/99 0:00 - 8/31/99 0:00		
	Mean Observed	**Mean Predicted**
Bottom:	12.0	11.8
Surface:	5.5	3.5
Delta:	**6.5**	**8.3**

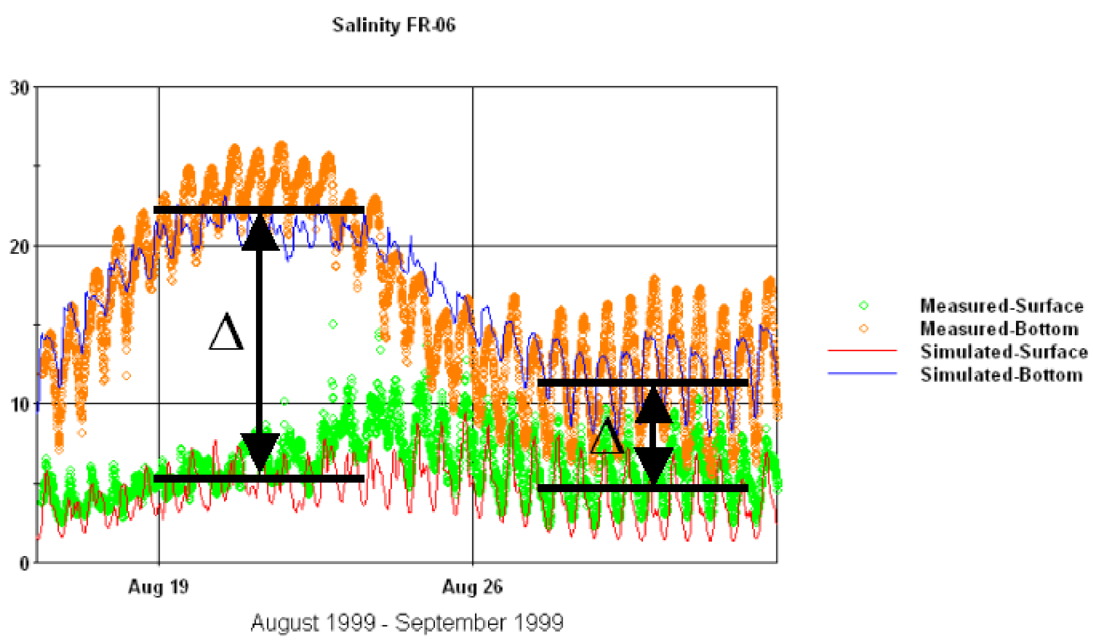

Figure 8 – Salinity Stratification at FR-06 on the Front River

Figures 9 through 12 show the model's performance on stratifying and de-stratifying at stations FR-04, -06, -08, and –09, respectively. The EFDC model is capturing the dynamics of the salinity stratification for the navigation channel. The model still under predicts the range in salinity but this is much improved from the draft report.

Figures 13 and 14 show the salinity at station FR-11R, which is 2 miles upstream of the Houlihan Bridge on the Front River. This station captures the edge of the salinity wedge as it moves out of the navigation channel downstream of the Houlihan Bridge and pushes up the river. This is a critical station to compare to the model and will be important for demonstrating the model's capabilities for future deepening scenarios. Figure 13 shows the entire 1999 calibration period and Figure 14 shows a 7-day neap event in August. The salinity pumping is evident in Figure 14 by the steepness of the salinity signal and the intrusion events go from 0 to 10 back to 0 ppt in a very short period of time.

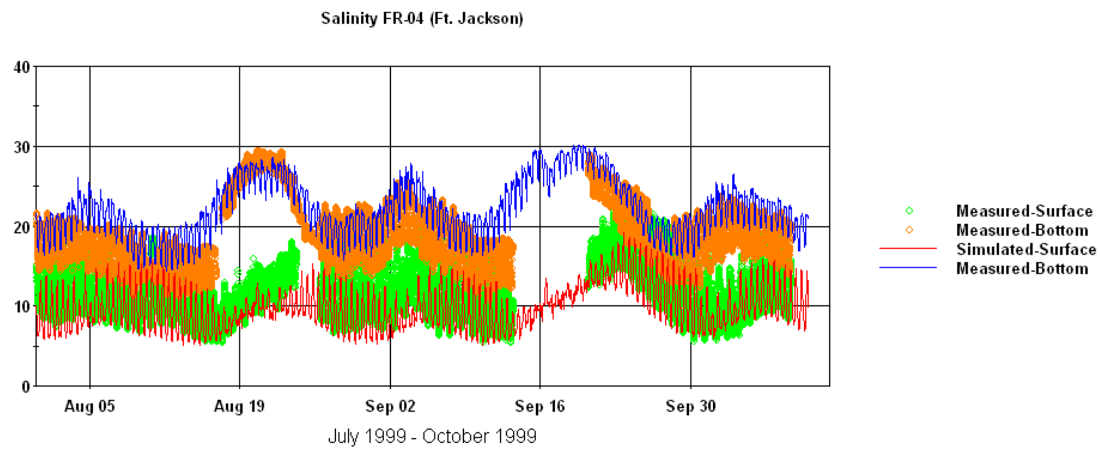

Figure 9 – 1999 Salinity on the Front River at Fort Jackson (FR-04)

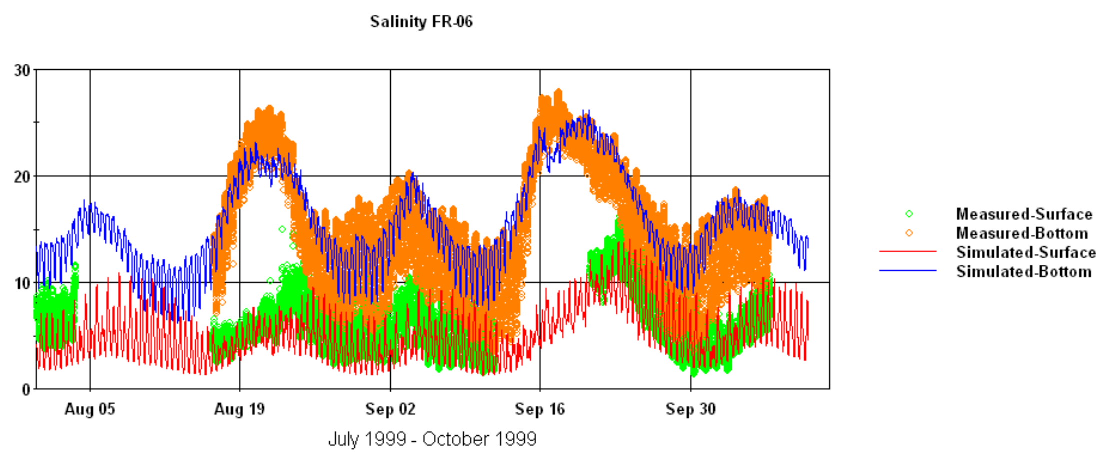

Figure 10 – 1999 Salinity on the Front River Upstream of Talmadge Bridge (FR-06)

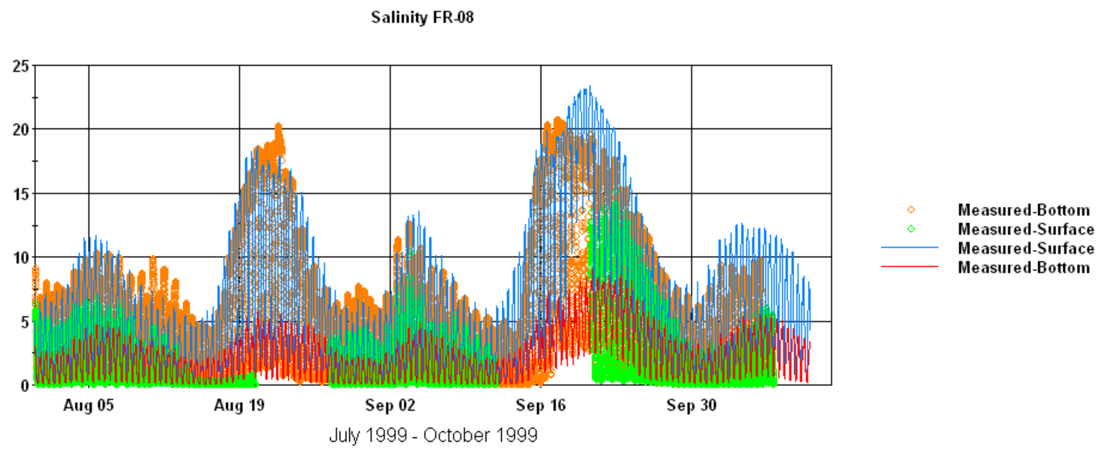

Figure 11 – 1999 Salinity on the Front River near Middle River Confluence (FR-08)

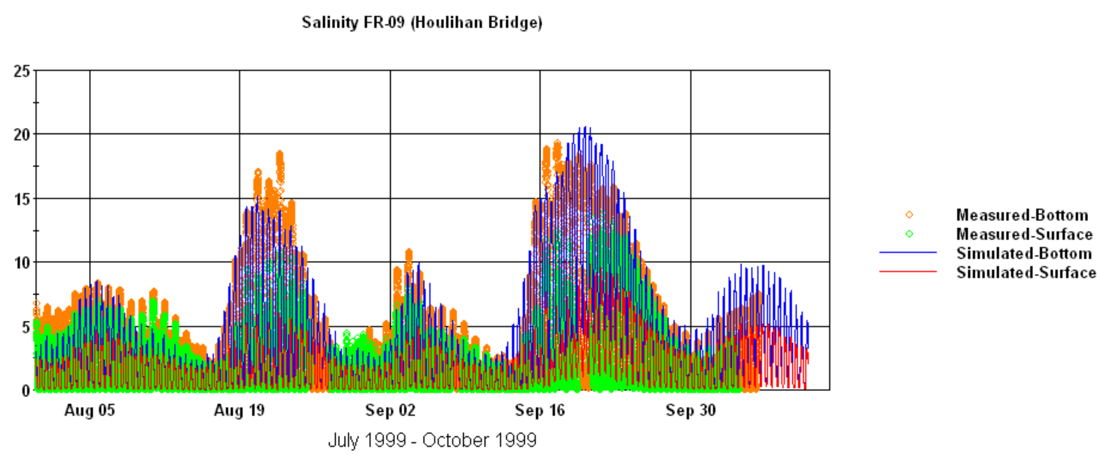

Figure 12 – 1999 Salinity on the Front River at Houlihan Bridge (FR-09)

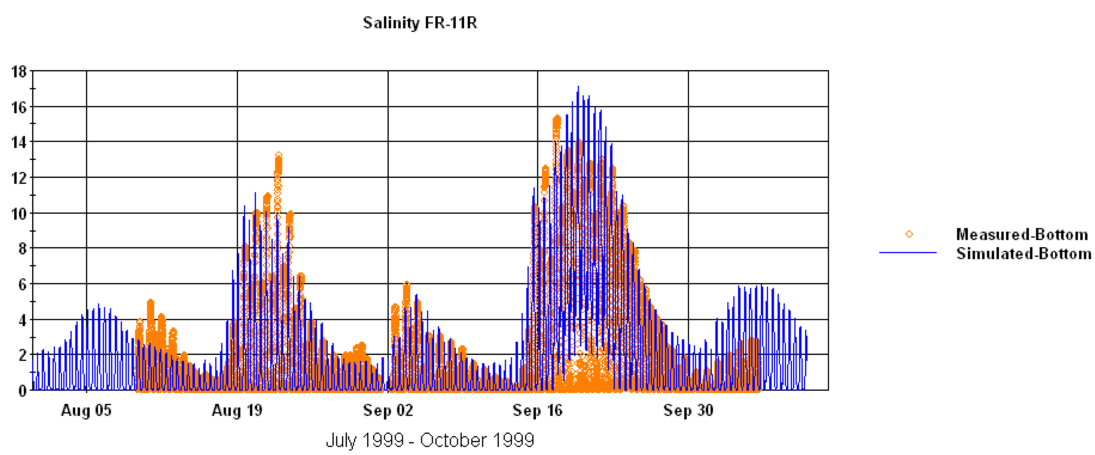

Figure 13 – 1999 Salinity on the Front River Upstream of Houlihan Bridge (FR-11R)

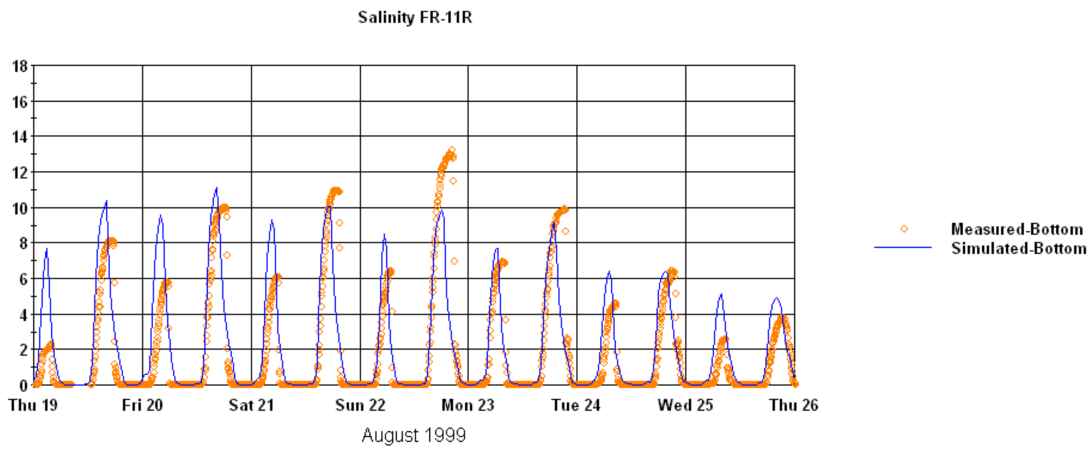

Figure 14 – August 1999 Salinity on the Front River Upstream of Houlihan Bridge (FR-11R)

(4) Salinity in the Back and Little Back Rivers
Improvements to salinity results in the Little Back River were achieved by the application of the revised marshes. The marshes serve a number of functions: including modulation of tide wave propagation, smoothing of flows in that area, and retention of water and salinity in that the Little Back River rather than completely flushing. Figures 15, 16 and 17 show the LBR-15, the UF&W Dock, and Lucknow Canal as examples of the model's performance.

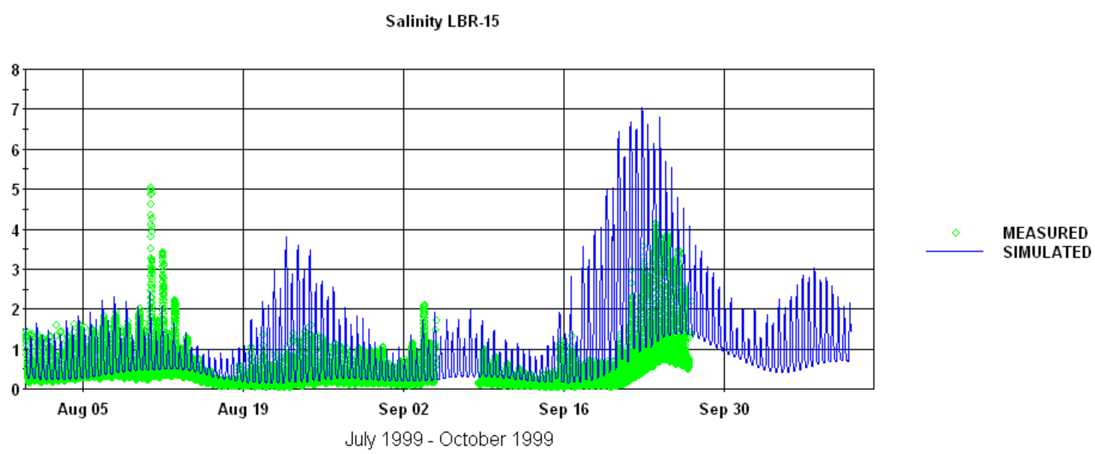

Figure 15 – 1999 Salinity on the Little Back River at Houlihan Bridge (LBR-15)

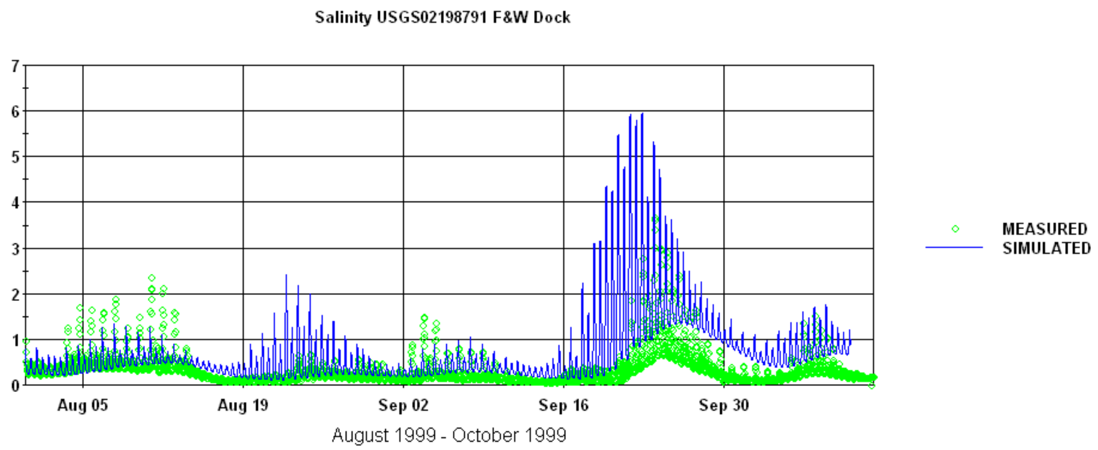

Figure 16 – 1999 Salinity on the Little Back River at F&W Dock (USGS 02198791)

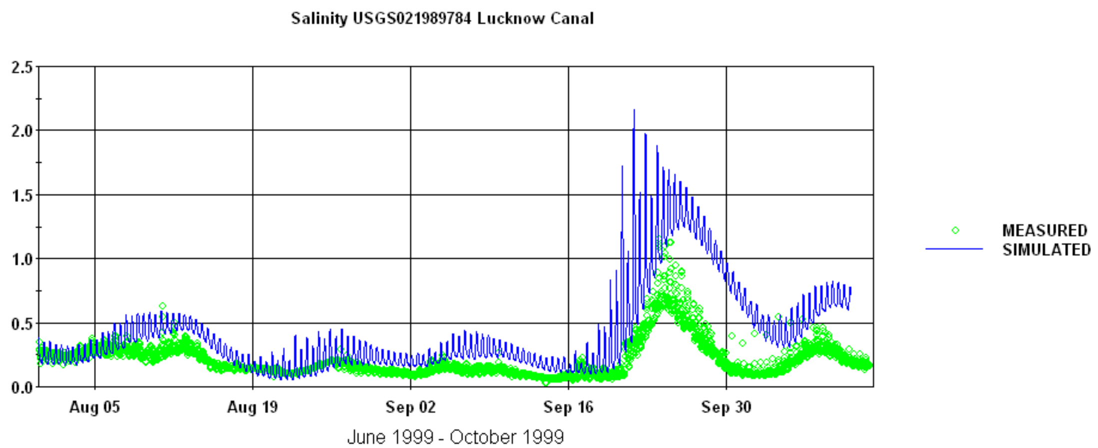

Figure 17 – 1999 Salinity on the Little Back River at Lucknow Canal (USGS 021989784)

<u>(5) Flow calibration</u>

The 1999 flow calibration has been completed and the 1997 validation is currently being performed. The phasing and magnitudes of the simulated flows have improved. The ebb flows are under predicting the measured flows but the flood flows are matching in magnitude and phase. Figures 18 through 21 show an example of the upper Savannah River area near McCoys Cut, I-95 Bridge, and the Middle/Little Back River connection for a spring tide event on October 6, 1999.

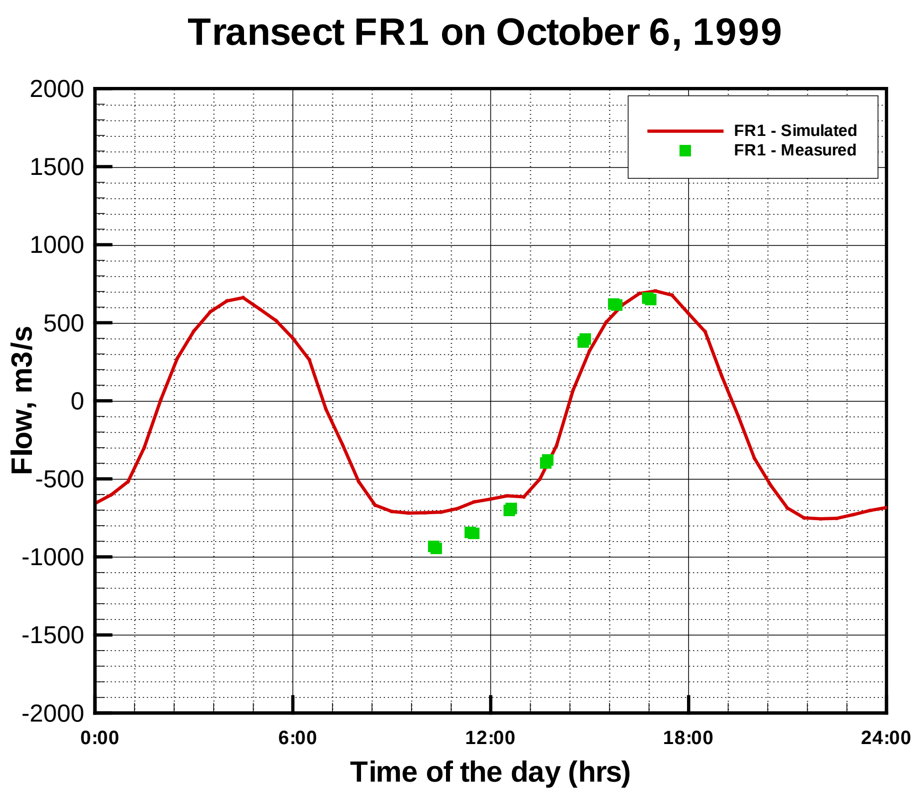

Figure 18 – Front River (FR1) Transect on October 6, 1999

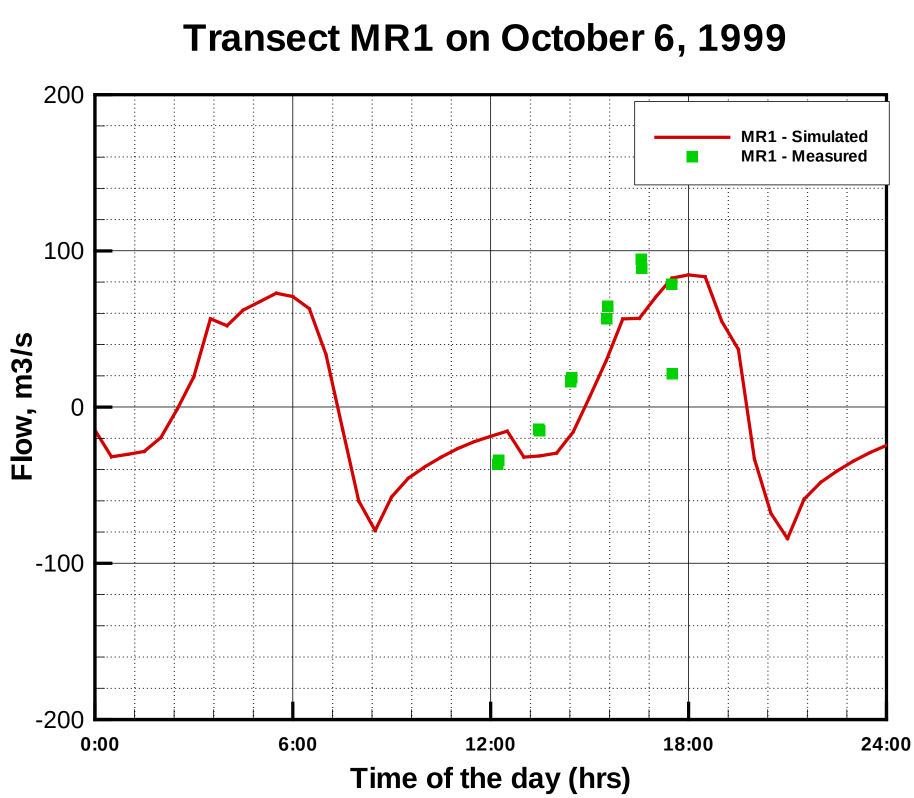

Figure 19 – Middle River (MR1) Transect on October 6, 1999

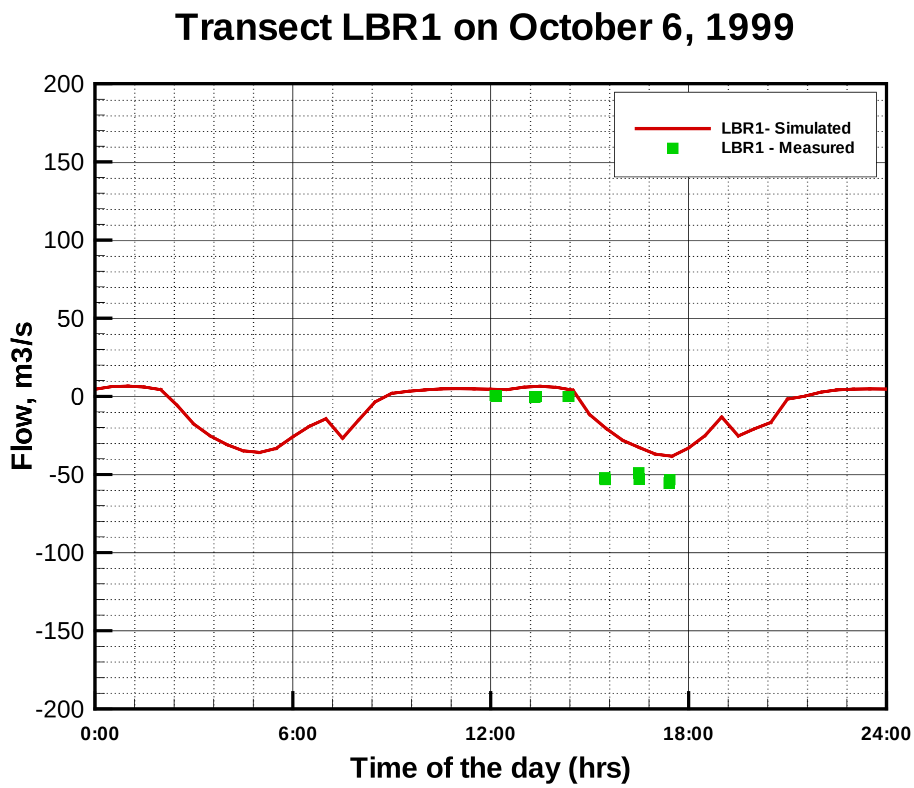

Figure 20 – Little Back River (LBR1) Transect on October 6, 1999

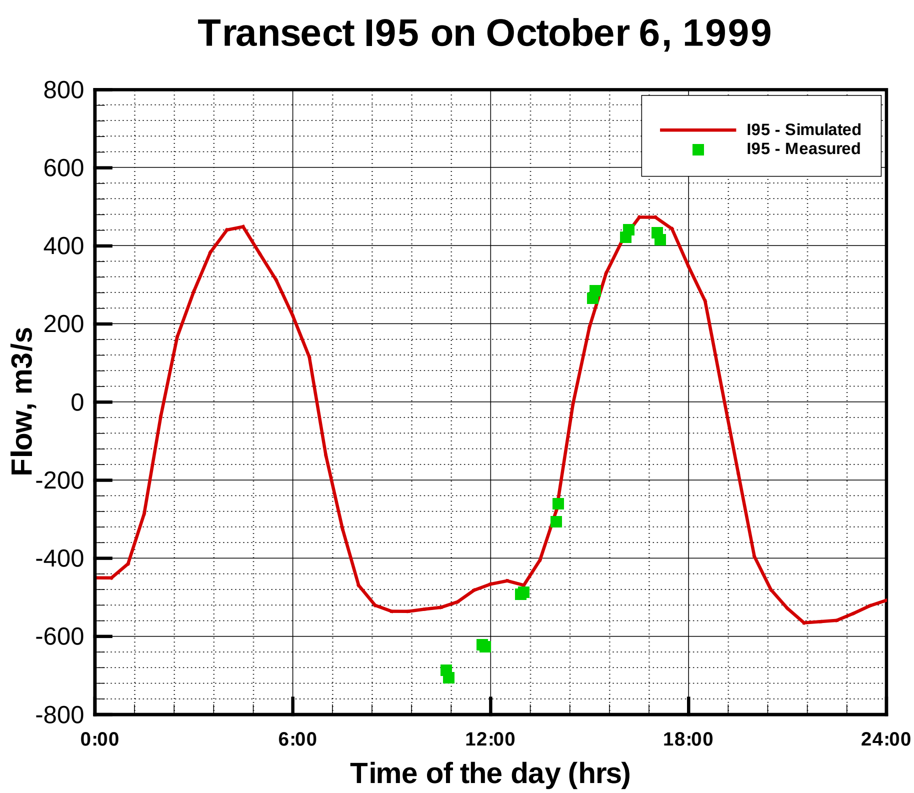

Figure 21 – I-95 Bridge Transect on October 6, 1999

(6) WRDB Data Assessment
Tetra Tech received the DVD from ATM on March 14, 2005 containing all of the raw and processed data. The original DVD did not operate so they followed up with another copy. These files are currently being updated in the WRDB for the project. Based on the data ATM delivered with their final modeling report in January 2004, there are significant differences between the final QA/QC data and what we have in WRDB. Even though this was not part of our scope with the USACE Savannah District, we are updating the WRDB with the final QA/QC datasets. For the DO data, Paul Conrads has been working on a process to document the QA/QC of the DO data. He started with the raw DO files from the instruments and ran it through USGS's protocols for adjusting or removing data from the final time series. He has completed FR-22 surface and is working on FR-22 bottom. As shown below in Figures 22 and 23, the surface station is relatively good but the bottom data has some obvious bad data points. The green points are the ATM QA/QC and the magenta are the WRDB data. We have agreed to send Paul more datasets for the critical sites for him to run through the USGS protocol.

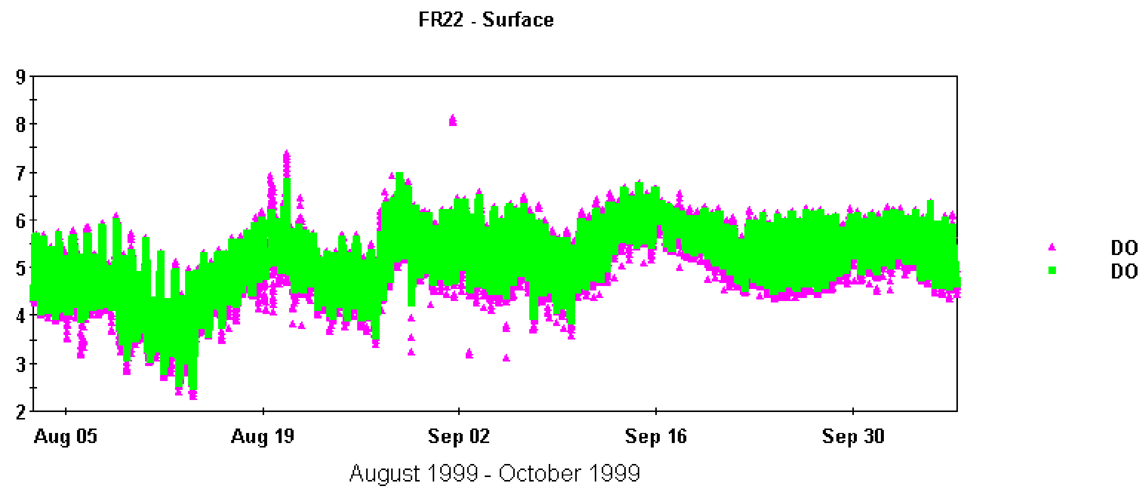

Figure 22 – 1999 Dissolved Oxygen on Front River in Kings Island TB (FR-22) Surface

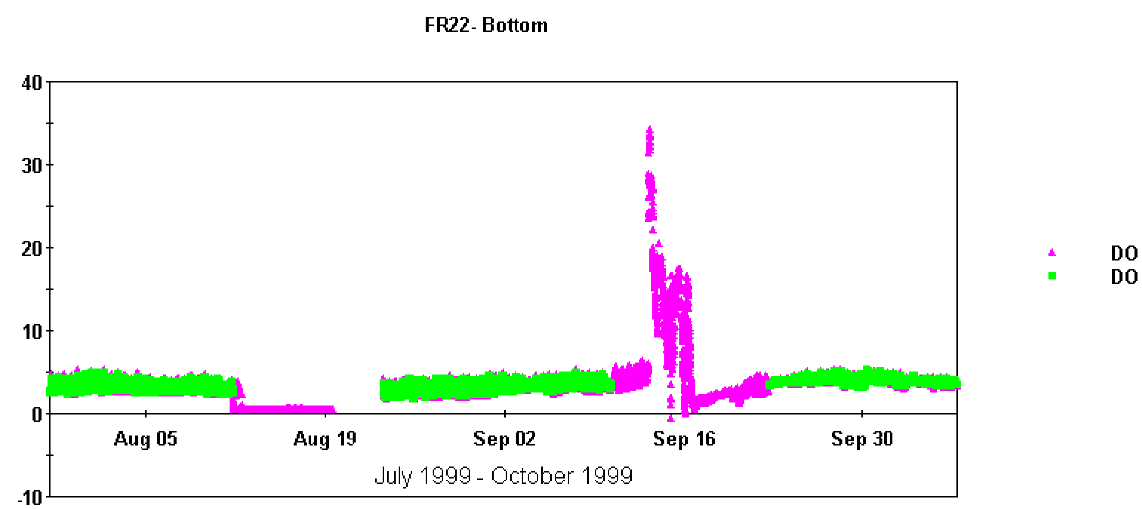

Figure 23 – 1999 Dissolved Oxygen on Front River in Kings Island TB (FR-22) Bottom

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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DE
PM-C

AUG 25 2005

Colonel Mark S. Held
District Engineer
Savannah District
P. O. Box 889
Savannah, GA 31402-0889

S: DE
DC
DP
DX

Subject: **Final Report** - ***Hydrodynamic and Water Quality Model for the Savannah Harbor*** **[May 20, 2005]**

Dear Colonel Held:

The U.S. Environmental Protection Agency, Region 4 (EPA) has completed its review of the subject report prepared by Tetra Tech (TT) for the U.S. Army Corps of Engineers – Savannah District (District). The report and its appendices describe the hydrodynamic, salinity transport, and dissolved oxygen models being used to characterize ambient conditions in the Lower Savannah River and Harbor environs. These documents also discuss the specifics as to how these models will be applied to predict water quality impacts based upon changes in pollution loading and proposed Harbor dredging. The documentation also includes information related to model calibration, validation, and confirmation.

Because this river system is complex hydro-dynamically, it was necessary to develop these water quality assessment tools in an evolutionary manner. TT originally formulated the Environmental Fluid Dynamic Code (EFDC) model for EPA to use in determining the Total Maximum Daily Loading (TMDL) for dissolved oxygen conditions in the Savannah Harbor. TT has subsequently updated/modified this model with a higher resolution model to better evaluate the water quality impacts of the various harbor dredging scenarios to enhance the navigation channel.

While the above report addresses most of the comments/concerns cited by EPA in its previous review of the TMDL model report, we understand that a more detailed analysis is currently underway to further document the model's application/performance. Jim Greenfield of my staff has been involved in the on-going water quality modeling efforts and is confident that any remaining issues can be addressed after additional model sensitivity runs are performed and evaluated.

The model development and review for upgrading Savannah Harbor has been a long and demanding process for all stakeholders. However, it is encouraging that we are in the final stages of producing an acceptable model for use in making the critical water quality decisions regarding this Harbor project and the TMDL. We will continue to provide support for the successful completion of this water quality modeling effort which is a priority for both of our Agencies.

Sincerely,

James D. Giattina, Director
Water Management Division

From:	Hoke, Joseph T SAWatSAS
To:	Ed Eudaly (E-mail) (E-mail); Jim Greenfield (E-mail) (E-mail); Paul Conrads (E-mail) (E-mail); Paul Lamarre (E-mail); smtp-Brownell, Prescott; "Roy Burke" (E-mail); "Wade Cantrell" (E-mail); Kim, Sung-Chan ERDC-EL-MS; "Larry Turner" (E-mail)
Cc:	Larry Keegan (E-mail) (E-mail); Steven Davie (E-mail); Bailey, William G SAMatSAS; Garrett, Thomas A SAS; Rees, Susan I SAM
Subject:	Sav Harbor Hydrodynamic and WQ Model Calibration Report Review
Date:	Thursday, November 17, 2005 3:02:21 PM
Attachments:	Oct26 Model Review Meeting b.doc TechMemo3(rev).pdf PeerReviewInterna1105.doc kac recs1.pdf mfr kac resp.doc Hydrologic Monitoring Plan draft.doc
Importance:	High

Hydrodynamic and WQ Model Review Group:

This is to document the results of the 26 October meeting, provide an updated Tech Memo #3, of which you received a draft copy at or just before the meeting, and describe the next steps that we plan to take in this modeling effort. There are six attachments. The first, Oct26_Model Review Meeting_b.doc, contains a summary of the discussions that took place at the meeting. The second attachment, TechMemo3(rev).pdf, contains the revised Tetra Tech responses to review comments on the calibration report. It has been updated and expanded to incorporate feedback received at the 26 Oct meeting. The third attachment, PeerReviewInternal1105.doc is the updated Tetra Tech responses to the ITR comments. These have been expanded from what you saw at the meeting, by additional plots in Comment I, more of Dr. Hamrick's e-mail in Comment II, and a few typo corrections in Comment IV.

The fourth attachment, kac_recs_1.pdf contains the KAC recommendations for additional study.. As you recall, during our discussion of KAC's recommendations, there were some items that needed clarification, which I was requested to obtain via e-mail. The fifth attachment contains the Corps of Engineers proposed response to Mr. Watson's recommendation letter, mfr_kac_resp.doc, as well as the clarification questions to and responses from Chuck Watson of KAC. The sixth attachment is the preliminary draft monitoring plan referenced in the mfr. Please let me know if you concur with this proposed response; or, if you disagree with the proposed response, please state what action(s) you think should be taken.

Each agency had previously stated that we could move forward with our analysis of project impacts, subject to having their comments satisfactorily addressed prior to the final impact analysis. Please confirm that (1) you continue to support this position and (2) these responses satisfactorily address your technical concerns. The final calibration report, and final agency determination on the model's acceptability, will be delayed pending completion of the USGS QA/QC checks of the ATM data so that the final model performance comparisons can use the data sets that have received the accepted quality control procedures. Our aim is for official agency acceptance of the models after review of the final report.

We request that you review this information and let me know via e-mail if you have any outstanding issues with the model calibration, and if you concur with the direction we are taking. Please respond by 29 Nov 2005. Thank you very much for your assistance.

Joseph T. Hoke, Jr., P.E.
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REVISED TECHNICAL MEMORANDUM NO. 3

Date: October 25, 2005, Revised on November 14, 2005

To: Agency Technical Review Group

From: Steven Davie

Cc: Joe Hoke, Alan Garrett, and Bill Bailey - USACE Savannah District

Subject: Response to Agency Comments on the Savannah Harbor Models
Tt Project No. 16807-01

Tetra Tech, Inc. (Tetra Tech) has been developing the EFDC and WASP models for the Savannah Harbor Estuary. During this effort, Tetra Tech has developed two prior memorandums to communicate with the Agency Technical Review Group. Technical Memorandum No. 1 was distributed on December 10, 2004 dealing with the model grid enhancements. Technical Memorandum No. 2 was distributed on March 16, 2005 that entailed an update on the EFDC and WASP calibrations. This memo (No. 3) is a response to the agency comments outlined in the meeting on June 16, 2005 in Atlanta, Georgia.

During the June 16, 2005 meeting, the federal and state agencies made comments on the Final Modeling report dated May 20, 2005. The purpose of this meeting and discussion was to have an additional round of comments to address any concerns dealing with the model calibration. Agency letters were submitted to the USACE Savannah District that approved moving forward with the model while addressing the group's comments satisfactorily. The group had a wide-ranging discussion at the June meeting and the comments were categorized into 12 topics. The paragraph on the next page was the group's attempt to develop categories for the comments that describe the amount of effort expected to address a concern. The following discussion presents each of the 12 comments and Tetra Tech's response. These comments and responses were discussed at the October 26, 2005 meeting in Atlanta, Georgia. These issues will be considered further before using the models to identify impacts of the recommended plan.

Ways to address concerns with the models and the reports

The group categorized the concerns according to the level of action that is appropriate to fully address each concern. The following four categories were developed, roughly in order of the effort expected:

- **A** Explain better in the report, no modeling action needed.
- **B** Keep in mind when interpreting the model results.
- **C** Additional sensitivity model runs are needed.
- **D** Recalibrate / revise model.

(note: a "**C**" action could turn into a "**D**" action depending on the results)

Summary of concerns and actions to address each concern [option from above]:

COMMENT 1: [B] Marsh water quality loads:

a. **[A]** Inclusion in the enhanced grid
b. **[A]** Equal comparison between the TMDL and enhanced grids
c. **[C]** Is the CBODu too high?
d. **[C]** Mass exchange – flows and concentration
e. **[C]** Surface to bottom – CBODu vertical differences are a function of how marsh areas were loaded into the enhanced model

RESPONSE 1:

a. The enhanced grid contains 16 marsh cells: 3 along Front River, 4 along Middle River, and 9 along Back River. TMDL model grid had 9 marsh cells along Middle and Back River. Areas of TMDL model marshes were set in accordance with ATM Q-zones assessments. Marsh areas of enhanced grid model were based on the same Q-zone areas and adjusted during calibration process for capturing flows and salinity trends in upper part of estuary.
b. Total marsh CBODu loads for enhanced grid water quality model were set up equal to total marsh CBODu loads of the USEPA TMDL model (Greenfield, 2004). The last ones were quantified based on field measurements. The 9 TMDL model marsh loads were redistributed between 16 enhanced model marsh loads in accordance with their locations and areas.
c. The surface layer values of CBODu were too high in the calibration report. At that time, we were adding the loads from the marsh areas to the surface layer only. After our modification described in (e) below, the surface layer values are much lower and closer to the data.
d. Similar to the response (e), we feel that after the adjustment to the marsh loads, the mass exchange is more appropriate in the top three layers and the model results are closer correlated to the data.
e. Initial approach presented in Tetra Tech Report (May, 2005) was to input marsh CBODu loads in the surface layer (Figure 1). During the June meeting, there was a concern about high CBODu model results compared to the data and the stratification of CBODu in these areas. To address the concern Tetra Tech found it was appropriate to redistribute the loads between top three layers. The results of revised approach are shown in Figure 2 as an example on the Middle River (MR-12R). The load redistribution does not show any noticeable effect on CBODu and dissolved oxygen dynamics on the Front River.

RESPONSE 1 SUMMARY: Tetra Tech revised the WASP model by spreading the marsh loads into the top three layers instead of the surface layer only.

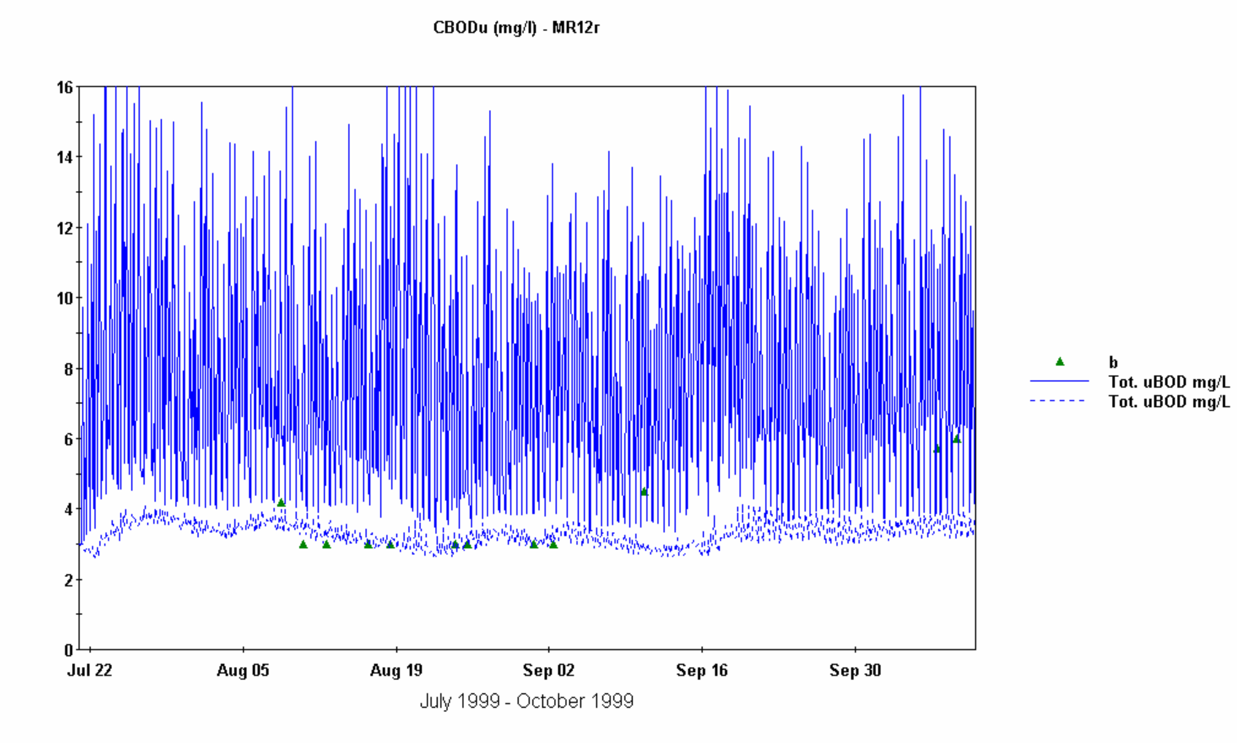

Figure 1 - Loads in the Surface Layer as Presented in the May 20, 2005 Report

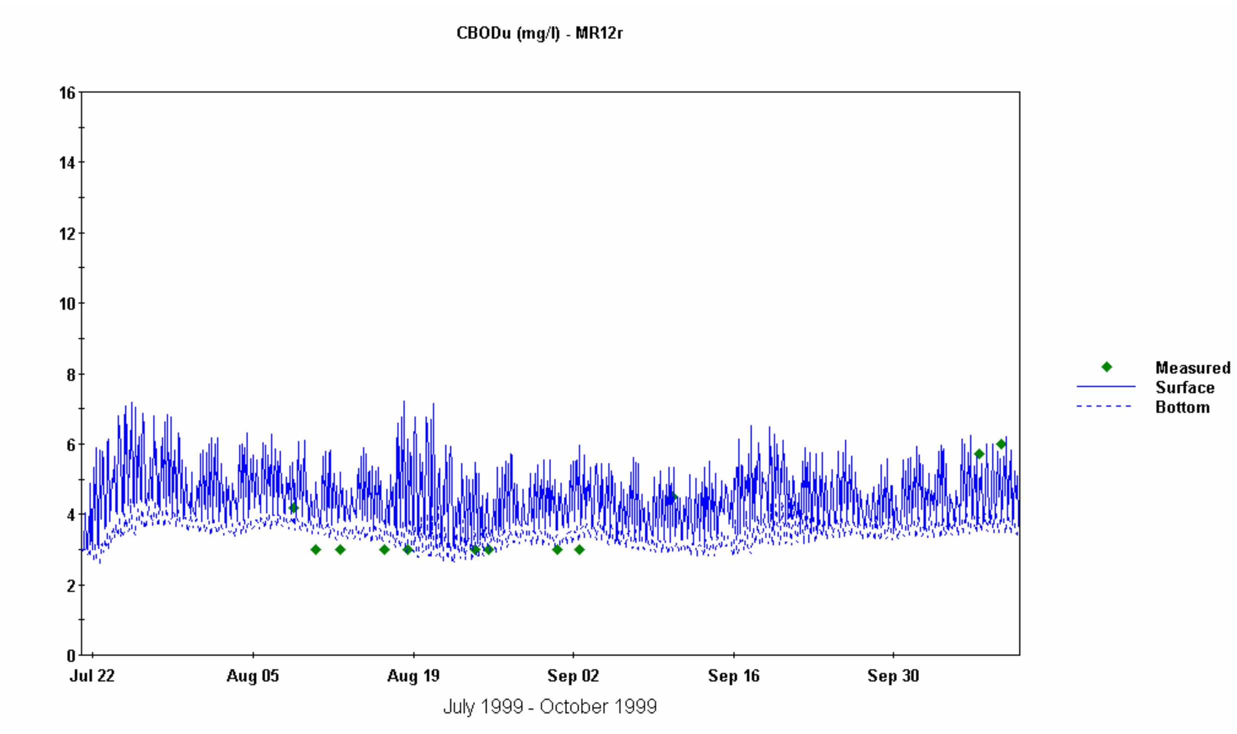

Figure 2 – Revised Approach with the Loads in the Top Three Surface Layers

COMMENT 2: [C] Offshore boundary:
a. Salinity 34 to 36 ppt versus 32.5 to 35 ppt, Mass flux surface to bottom – may need to re-distribute at FR-26.

RESPONSE 2a: The calibration boundary was determined to be a best-fit linear function from 32.5 ppt (surface) to 35 ppt (bottom). The issue was raised that based on "World Ocean Atlas" annual means, that regional annual mean value of surface salinity may be in the range 34-36 ppt. For comparison, data from Sabsoon site R2 that is located approx. 50 miles offshore from the mouth of the Savannah River indicate mean surface salinity of 36.0 ppt (range 31.5-36.5 in the period 1999-2002), however, this site is much farther from the effects of littoral freshwater inflows than the model boundary 17 miles offshore from Oysterbed Island. To assess model sensitivity and the possibility of improving the calibration, the EFDC model was run for 35 ppt (surface to bottom) and 36 ppt constant boundary conditions. Results were increased salinity in the lower Front River both at the surface and the bottom. As expected, predicted salinity was increased more at Ft. Pulaski (FR-26) than upstream at sites such as FR-08, for example. Results are shown in Figures 3 through 6 for FR-26 and FR-08. We conclude that increasing the offshore boundary condition for salinity does not improve the calibration.

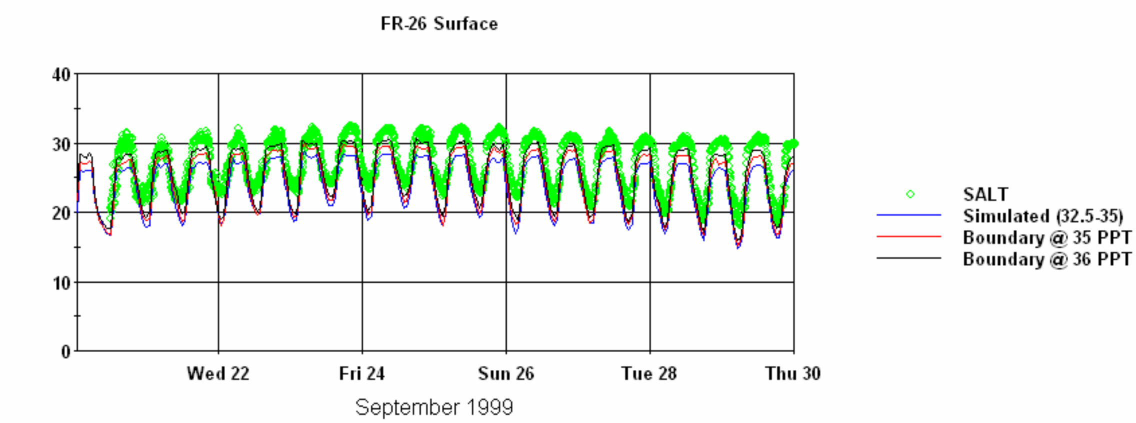

Figure 3 – Salinity Comparisons at FR-26 at the Surface

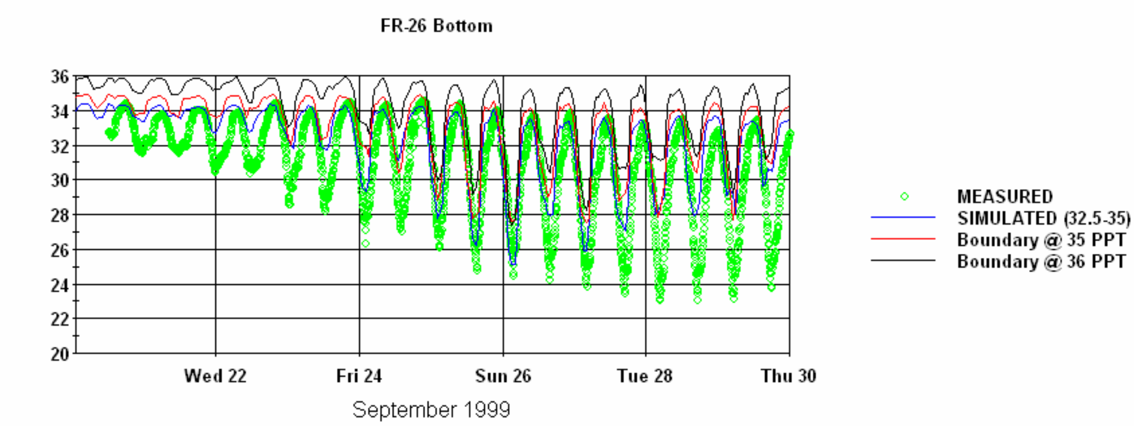

Figure 4 – Salinity Comparisons at FR-26 at the Bottom

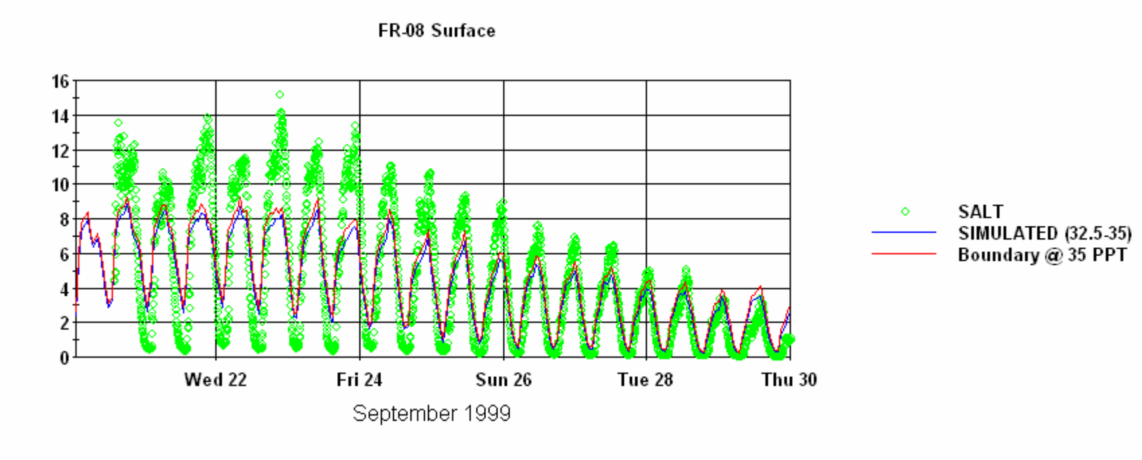

Figure 5 – Salinity Comparisons at FR-08 at the Surface

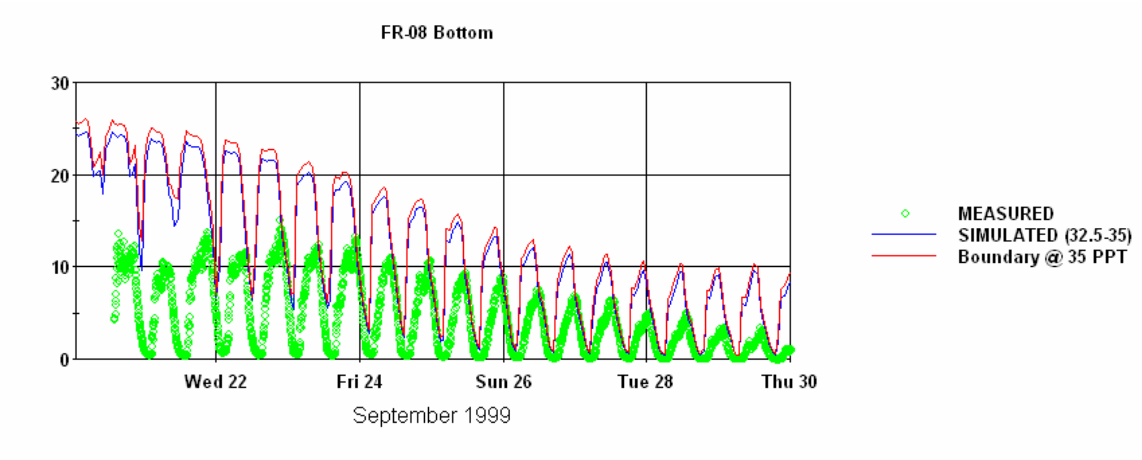

Figure 6 – Salinity Comparisons at FR-08 at the Bottom

b. Dissolved oxygen saturation 95 to 105% versus 90%

RESPONSE 2b: The water quality model calibration used an offshore dissolved oxygen boundary condition was approximately 6 mg/L for August 1999 (USEPA TMDL water quality model, Greenfield, 2004). Sensitivity tests were run for August 1999 calibration input. The dissolved oxygen boundary variations were set up as +/- 15%. The estimates of 10th and 50th percentiles were used for evaluation of the sensitivity. Tetra Tech agrees with 95-105% that was proposed for consideration by the Interagency WQ Team. 105% will be close to the used in sensitivity tests value (7 mg/L). The sensitivity analysis shows that the influence of the offshore D.O. boundary positive variation is most significant for bottom layers of downstream stations FR-02 (+ 13%), FR-04 (+ 8-9%), FR-06 (+6-8%), FR-21 (+ 5-8%), and FR-22 (+3-6%). The boundary effect becomes insignificant after FR-22. Surface layers of the model demonstrate low sensitivity to offshore D.O. boundary concentration variations. For these reasons, Tetra Tech is comfortable adjusting the downstream boundary condition from 90% to 95% of saturation.

c. Temperature

RESPONSE 2c: Summer (July-Sept.) mean surface temperature values were discussed at the offshore boundary in the range 28.0-28.5 degrees C from the “World Ocean Atlas.” For comparison, mean surface temperature at Sabsoon R2 was calculated to be 27.6 degrees for 1999-2002. For the EFDC model, the temperature data from Station R2 were applied as the ocean boundary condition. These data were not available for the calibration period, only later time periods, so a harmonic sine curve with a least squares fit was used to develop a seasonal temperature boundary. For the 1999 model year, summer (July-Sept.) surface temperatures averaged 27.0 degrees. We do not believe that altering the temperature boundary condition would improve the calibration.

d. Larry Neal gave info “World Ocean Atlas 2001” with data
RESPONSE 2d: Tetra Tech used the “World Ocean Atlas” data in the discussions in 2a, 2b, and 2c.

e. CBOD decay rate – confirmed 0.5 multiplier on ocean cells
RESPONSE 2e: Tetra Tech confirmed that a 0.5 multiplier was used in the ocean cells (j = 8 to 15) and then adjusted back to 1 coming in the mouth of the river.

COMMENT 3: [C] Surface salinity:
a. Model appears to under predict surface salinity on the Front River. How does this impact the marsh succession modeling? The EFDC will output salinity for the neural net application, which feeds the marsh succession model. Right now, the neural net is using the USGS gages located between the Talmadge Bridge and I-95, located on Front and Back Rivers. These gages are considered to be mid-depth. The EFDC model is predicting salinity well at the bottom and at mid-depth but under predicting salinity at the surface.
RESPONSE 3: The model does under predict surface salinity in the Front River. Our response is discussed in 2a dealing with the offshore boundary. We do not believe it is related to the boundary, but rather related to the amount of mixing along the navigation channel. For the upper stations near the wildlife refuge, the model predictions match the data better for salinity peaks. For the marsh succession modeling, the EFDC model will deliver output to the Model to Marsh (M2M), which in turn, will deliver output to the Marsh Succession Model. Tetra Tech has developed a linkage with the M2M that passes model predicted deltas of salinity and water level in an output file. Originally, the M2M was using only the USGS gaging stations, but now uses additional sites. The specific locations and vertical layers (k-index) are described in the Table 1 below. K-index of 1 is the bottom layer and K-index of 6 is the surface layer.

Table 1 – Locations of Output for M2M Application

No.	Name	I-index	J-index	K-index
1	'WL8840'	14	127	
2	'WL8920'	14	95	
3	'WL8979'	39	114	
4	'WL8977'	13	59	
5	'WLGPA10'	26	96	
6	'WLGPA11'	14	113	
7	'WLGPA11r'	14	106	
8	'WLGPA12'	26	117	
9	'WLGPA12r'	26	113	
10	'WLGPA13'	31	123	
11	'Sal8840'	14	127	4
12	'Sal89784'	39	114	4
13	'Sal8920'	14	95	4
14	'Sal89791'	30	106	4
15	'SalGPA10'	26	96	6
16	'SalGPA11'	14	113	1
17	'SalGPA11r'	26	106	1
18	'SalGPA12'	26	117	1
19	'SalGPA12r'	26	113	6
20	'SalGPA13'	31	123	1

COMMENT 4: [A & B] Ebb flows and currents:
a. Under prediction of the ebb flows and currents on the Little Back and Back Rivers

RESPONSE 4: Tetra Tech agrees that we are still under predicting the ebb flows only during spring tides. During neap and mid-tides, the model captures the flood and ebb flows well. During the spring tides, when we have a larger variation in water level from high to low tide, there is a significantly larger volume of water draining the estuary (ebbing) that the model is not capturing. We believe this is related to additional storage in the system in the marsh areas, irrigation ditches (Lucknow Canal), groundwater zones, etc. We are not sure why and have been comparing the measurements to explain where the additional water is coming from. We added more marsh storage to the model and did not see an improvement in our ebb flows. There is a longterm monitoring plan being developed by the federal agencies that will entail measuring continuous flow at the Front, Middle, and Little Back Rivers to improve our knowledge of the flow regime in the upper part of the estuary.

COMMENT 5: [A] Water level at SR-17 on the Upper Savannah River
a. Potential of adding marsh storage areas upstream of I-95 Bridge
b. Show comparisons at the USGS Hardeeville gage (show plot)

RESPONSE 5: Discussion of the EFDC model calibration raised the issue of the discrepancy in water surface elevation (stage) predictions at SR-17, which is an upstream site in the Savannah River, approximately 14 miles upstream of I-95. The model calibration under predicted stage and over predicted the magnitude of tidal oscillation, shown in Figure 7. It was hypothesized that the model was not accounting for the effects of marsh storage in the upper Savannah River (above I-95 Bridge). It was found that creating five marsh cells in the upper river dampens the tidal oscillation to the approximate range (~0.15 m or 0.5 ft) shown in the data (Figure 7). Furthermore, by increasing the bottom roughness on the Savannah River upstream of I-95, the baseline stage was increased resulting in an improved calibration at this site (Figure 8). The additional stage calibration in the upper Savannah River does not change the overall salinity results in the harbor. Based on the discussion and recommendations at the October 26 meeting, Tetra Tech will alter the EFDC model to improve the water surface elevation calibration in the upper Savannah River.

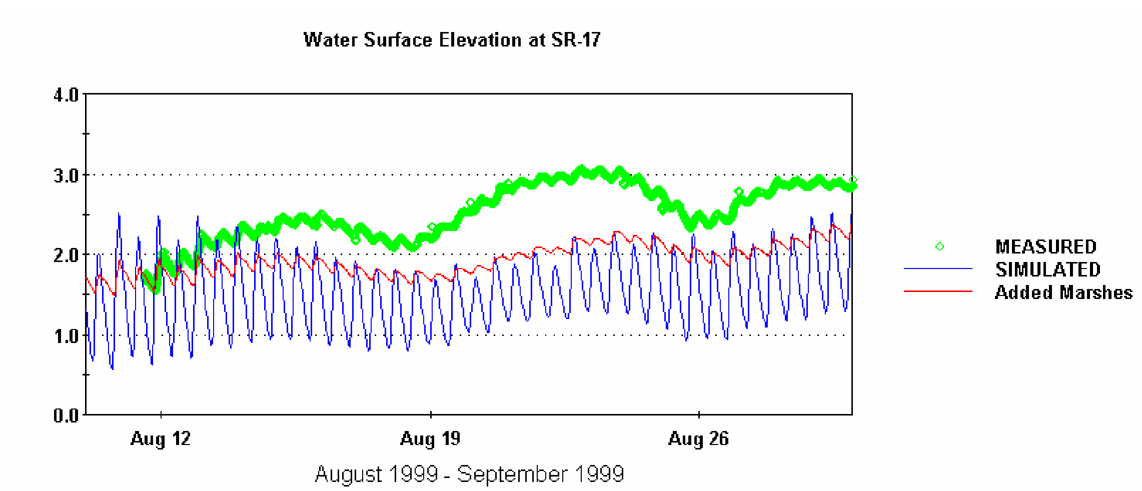

Figure 7 – Water Level at SR-17 with added marsh areas compared to May 2005 calibration

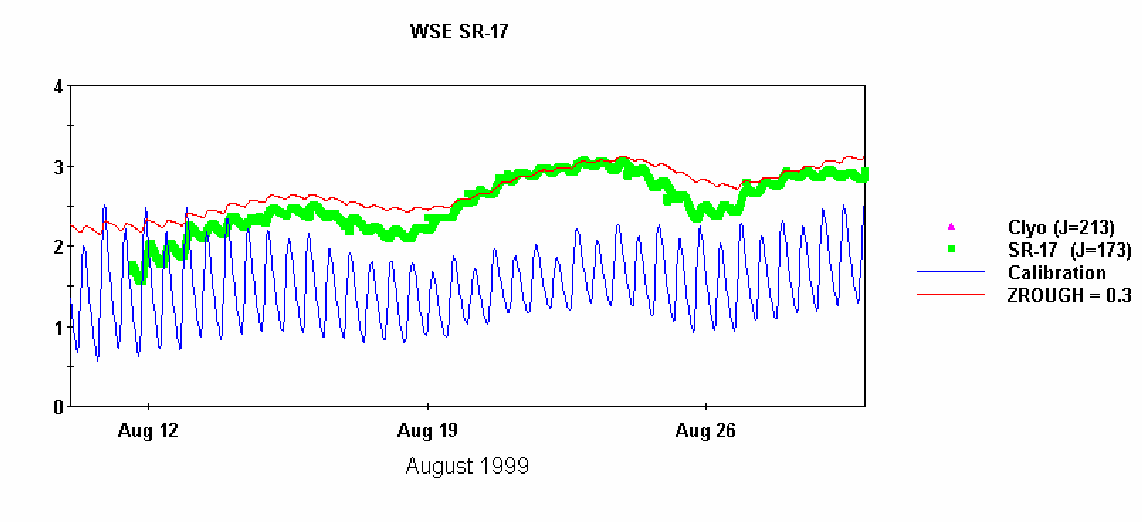

Figure 8 – Water Level at SR-17 with added marsh areas and added roughness on the Savannah River compared to May 2005 calibration

COMMENT 6: [C & A] Global versus source-specific BOD decay rates
a. Sensitivity of calibration
b. Sensitivity on allocation scenarios (more for TMDL)
RESPONSE 6: Tetra Tech has preliminarily setup two runs. The first run was a grouping in WASP according to the LTBOD results (decay rates). We used the WASP7 option that allows with three BOD classes and put the dischargers in the following categories:

- K = 0.02 per day (IP, Wilshire)
- K = 0.05 per day (Marshes, Fort James, Smurfit, President Street)
- K = 0.07 per day (Hardeeville, Garden City, Travis Field, Upstream, and Ocean)

The second run was done to split a large discharger such as the IP paper mill into a labile (fast reacting) and refractory (slow reacting) load category. CBOD decay rates were reassigned in following order:

- K = 0.06 per day (Marshes, Upstream and Ocean, all point sources except IP)
- K = 0.2 per day (IP 15% of discharge) = labile load
- K = 0.02 per day (IP 85% of discharge) = refractory load

Results of both scenarios showed no change in the calibration of the time series plots and minor changes in the calibration statistics. For demonstration purposes, the second run is shown below. Figures 9 through 11 show the same results as the May 2005 report calibration. In summary, the single rate approach will be used for deepening impacts. EPA will address the use and sensitivity of multiple BOD decay rates in the TMDL allocation scenarios. Conclusions of these runs can be summarized by salinity is still the dominating factor for DO deficit (Stations FR06 and FR22).

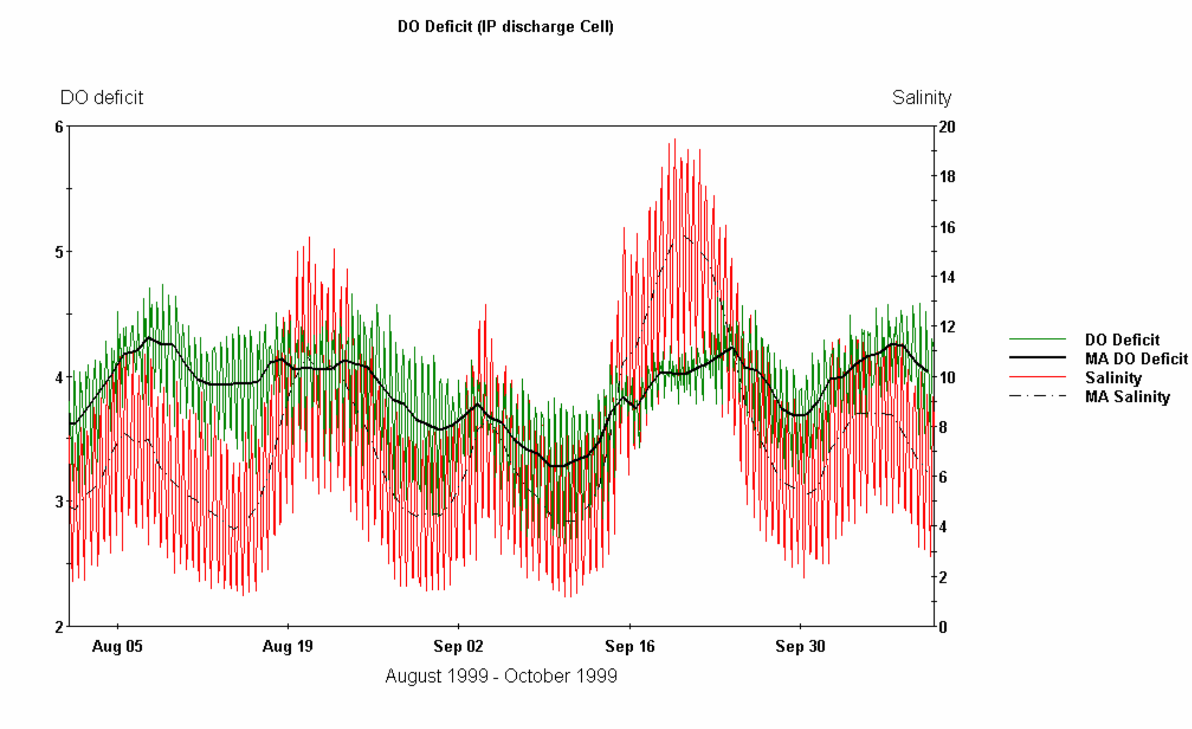

Figure 9 – DO deficit versus salinity at IP discharge (MA = Moving Average)

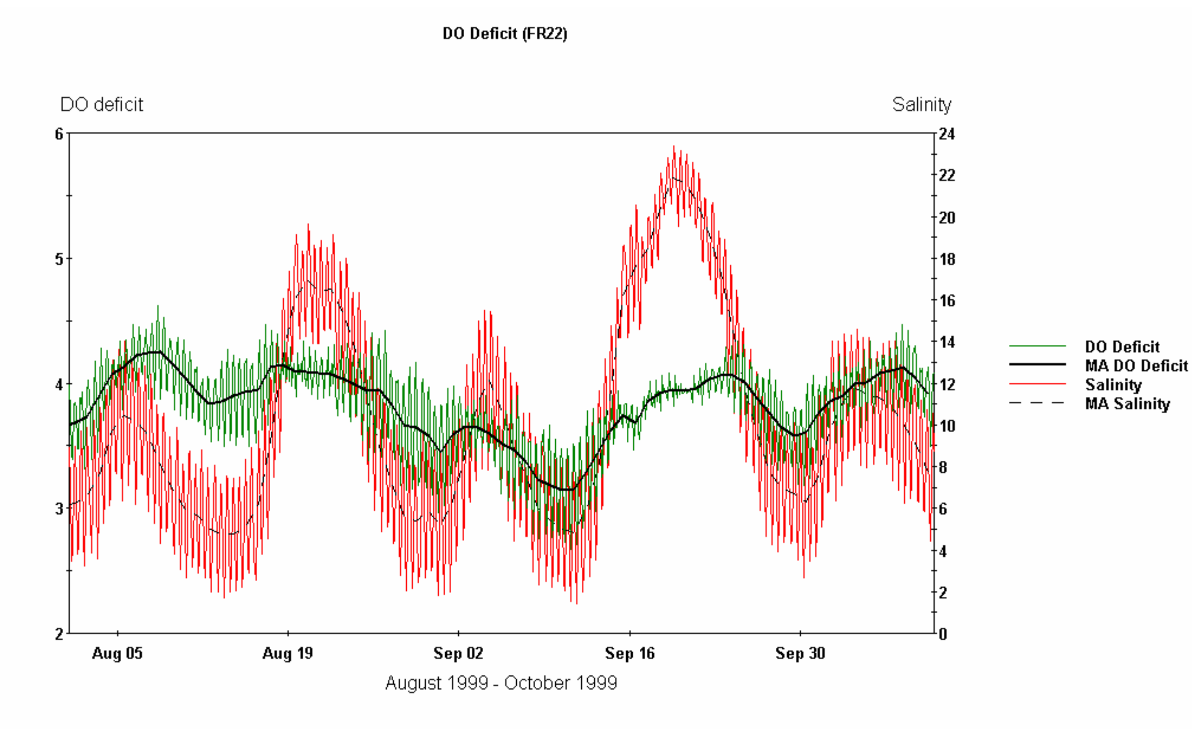

Figure 10 – DO deficit versus salinity at FR-22, downstream of IP Discharge (MA = Moving Average)

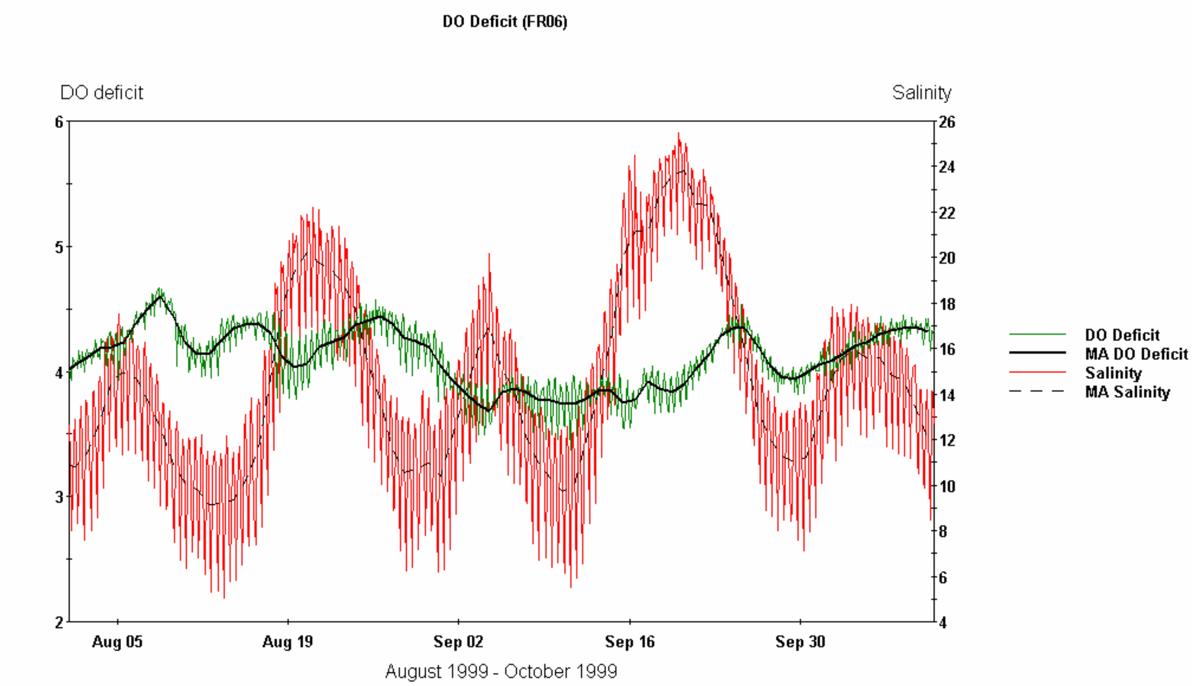

Figure 11 – DO deficit versus salinity at FR-06, downstream of IP discharge near Talmadge Bridge (MA = Moving Average)

COMMENT 7: [A] Check all point sources and heat loads, especially Plant MacIntosh (Harbor Committee will verify).
RESPONSE 7: We have not been able to verify the heat loads from MACTEC to date. From the previous comments, it appears that the flow used for Plan MacIntosh is lower than it should be. If the flows are adjusted higher, the delta temperature would be reduced to maintain their current heat load. The heat load table will be added to the report. Tetra Tech will contact Bob Scanlon and the Harbor Committee to verify.

COMMENT 8: [none] BOD loads from Corps' confined dredged sediment placement sites in SC and potential impacts on dissolved oxygen (future TMDL issue)
RESPONSE 8: No response needed at this time, may be included in the future as a TMDL issue. The clarification of the issue is presented in DHEC's June 2005 letter on the model review. The USACE will also collect data in these areas in the future.

COMMENT 9: [A] Grid convergence test:
a. Show results of the TMDL grid with the same depth;
b. Show results on TMDL grid, enhanced grid, and convergence grid on the same plots;
c. Show comparisons on the Middle and Little Back Rivers;
d. Perform moving average of results to reduce tidal noise; and
e. Quantification of grid convergence test results.

RESPONSE: In the May 2005 report, Figure A-2 shows bottom salinity at Houlihan Bridge, while Figure A-3 shows the surface salinity for comparison of Enhanced Grid and Convergence Grid results. The "slightly greater stratification" phrase should be modified to indicate that slightly less salinity (difference is more apparent at surface) is observed in the Convergence

Grid results. Quantification of the convergence grid test results has been performed and is presented in the following table (Table 2). Model spin up (15 days) has been excluded from these statistics.

Table 2 – Quantification of the Convergence Grid Test Results

Site	Layer	Enhanced Grid Average Salinity (ppt)	Convergence Grid Average Salinity (ppt)	Average Difference (ppt)	Average Percent Difference
FR-09	**Bottom**	27.27	26.83	-0.43	-1.6%
FR-09	**Surface**	6.78	5.69	-1.09	-16.2%
SR-17	**Bottom**	0.005	0.006	0.001	21.9%

A plot of the daily average salinity difference and percent difference at FR-09 Bottom shows no consistent trend of difference (no divergence with time), shown in Figure 12 and the minor difference in system response for each grid may depend more on hydrologic or tidal conditions.

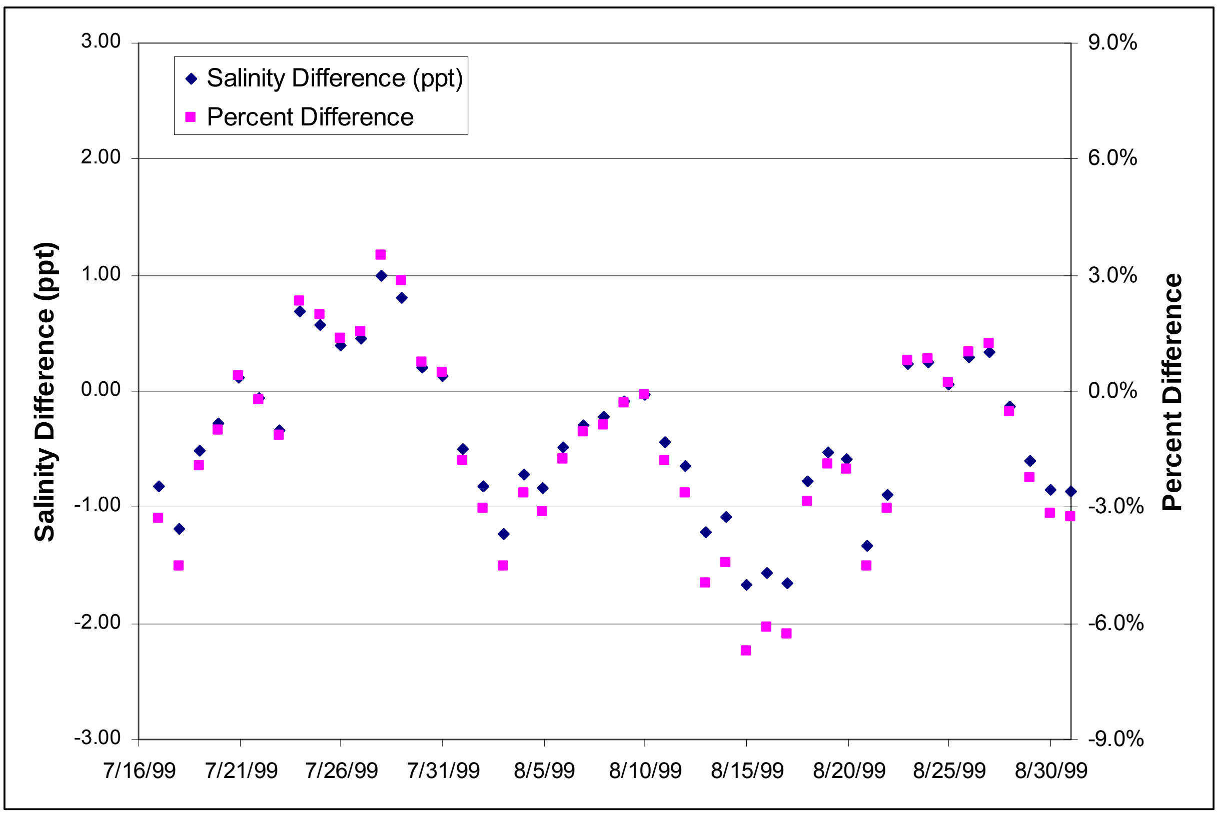

Figure 12 – Salinity and Percent Difference of Grid Convergence Results

The TMDL grid with equal bathymetry should not be compared because the surface area of the grid does not exactly match the enhanced or the convergence grid. The convergence grid is useful because the grid cells can be collapsed back to regenerate the enhanced grid. This could not be done with the TMDL grid.

COMMENT 10: [B & C] Delay in EFDC model salinity results at US F&W Dock comparisons of model versus data
RESPONSE 10: The model review group observed that the EFDC model shows a delay of salinity attenuation after high intrusion events in the Little Back River in the vicinity of the F&W Dock (USGS 021989791). Preliminary comments concerning the February 2005 draft EFDC model calibration described how the draft model completely flushed in the Little Back River (salinity dropped to zero in every tide cycle). The implementation of marshes in the final EFDC model calibration results in greater salinity retention in general. Attempts were made to modify the marsh parameters and dimensions to reduce the retention of salinity more within the range of measured data, however, no improvements from the draft calibration have been observed concerning this issue. Figure 13 below shows salinity at F&W Dock in the draft May 2005 calibration (without marshes) and in the final May 2005 calibration with marsh salinity retention.

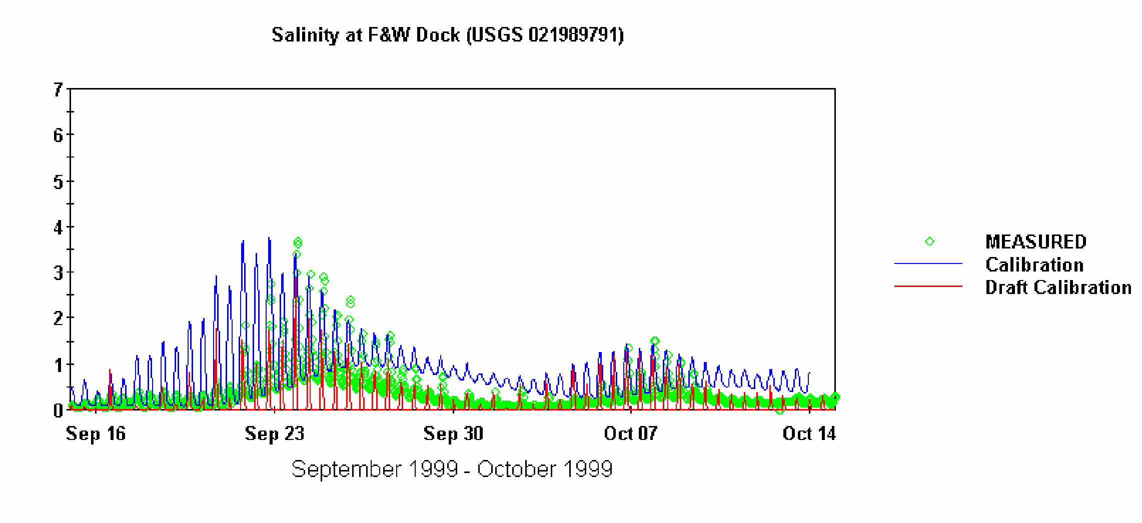

Figure 13 – Salinity and US F&W Dock with and without marshes

COMMENT 11: [A] Clearer description of 1999 versus 2002 bathymetry and why the 2002 bathymetry data is representative of 1997 through 2003 conditions in the harbor
RESPONSE 11: The 2002 and 1999 datasets were compared by analyzing cross-sections between the two surveys at many locations. Although there were some differences in alignment of the cross-sections, there was not a difference between the two surveys. Also, the survey data are grouped and averaged according to the model grid cell, and there was not a difference between 1999 and 2002 once this averaging occurred. Since dredging is a continuous operation in the navigation channel from year to year, the goal was to have a bathymetry that represents the current channel configuration, or depth, since the last deepening in 1994. It was determined that the 1999 and 2002 annual surveys are interchangeable in the model grid and best represent the existing (calibration) conditions. This text in the report has been modified.

COMMENT 12: UA/SA Analysis: The group concluded that the inability to run the models over a 7-year duration was the result of synthetic data that was developed to fill in a data gap around December 2000. The group concluded that the inability of the model to run over the entire 7-year period of data does not reflect on the structure of the model or its performance, and should not be a consideration of the model's usefulness for its intended purposes of predicting impacts of the Savannah Harbor Expansion Project, developing a dissolved oxygen TMDL, or permitting point source discharges.
RESPONSE 12: Tetra Tech agrees the 7-year run is important but in no way reflects on the

stability of the model. In Section 11 of the report, Tetra Tech comments on the results of the Uncerntainty Analysis. Tetra Tech performed stability and mass balance tests with the model. The model was crashing during mid-December because there was not enough water in the Little Back River during this event. The high tide on Dec 17, 2000 was only 4 feet (compared to usual 6 to 8 feet) and the low tide on Dec 19, 2000 was –2 feet (compared to usual 0 to –1 feet). See Figure 14 below for a plot of the same time period at the St. Simons Island NOAA tide gage. This proves the event was a real phenomenon and later USGS reported that the Fort Pulaski data during this time period have been checked and are real data, not synthetic data as previously discussed. The TMDL grid ran through this period because the Back and Little Back Rivers were deeper (Tetra Tech updated the bathymetry based on the 2004 USGS survey data). Therefore, Tetra Tech believes it is not a stability issue, but rather a reality issue. The model will not run when the river bed is dry, and it is believed that parts of the upper system were very shallow (or dry) during this time period.

It is evident that sections of the Back and Little Back Rivers go dry during extremely low flows and low tide range (as documented in Dec 2000). Tetra Tech has since modified the PSER.inp (time series water level boundary file) by adjusting 10 data points out of 245,280 (0.004%), which was only 5 hours out of a 7-year record, and the model now runs for 7 years without going dry. Since December 2000 is not a critical period for the modeling scenarios, we felt justified altering the water level boundary for these limited data points. Figure 15 shows the altered water level boundary file for this time period.

In summary, the data during December 2000 proved to be valid and a real phenomenon occurred during this time period (some kind of offshore wind or pressure system). Since the 7-year model run became a critical issue among the Stakeholder Evaluation Group (SEG), Tetra Tech modified the water level boundary file to receive a continuous 7-year model run.

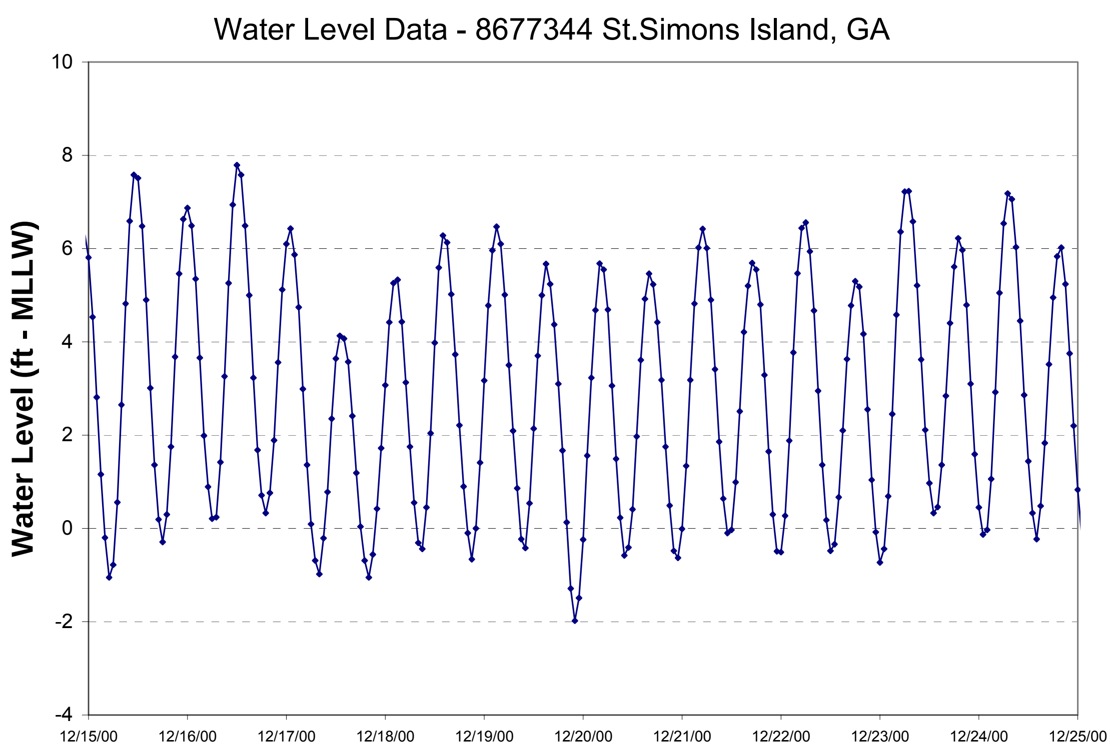

Figure 14 – Water level data measured at St Simons Island NOAA gage

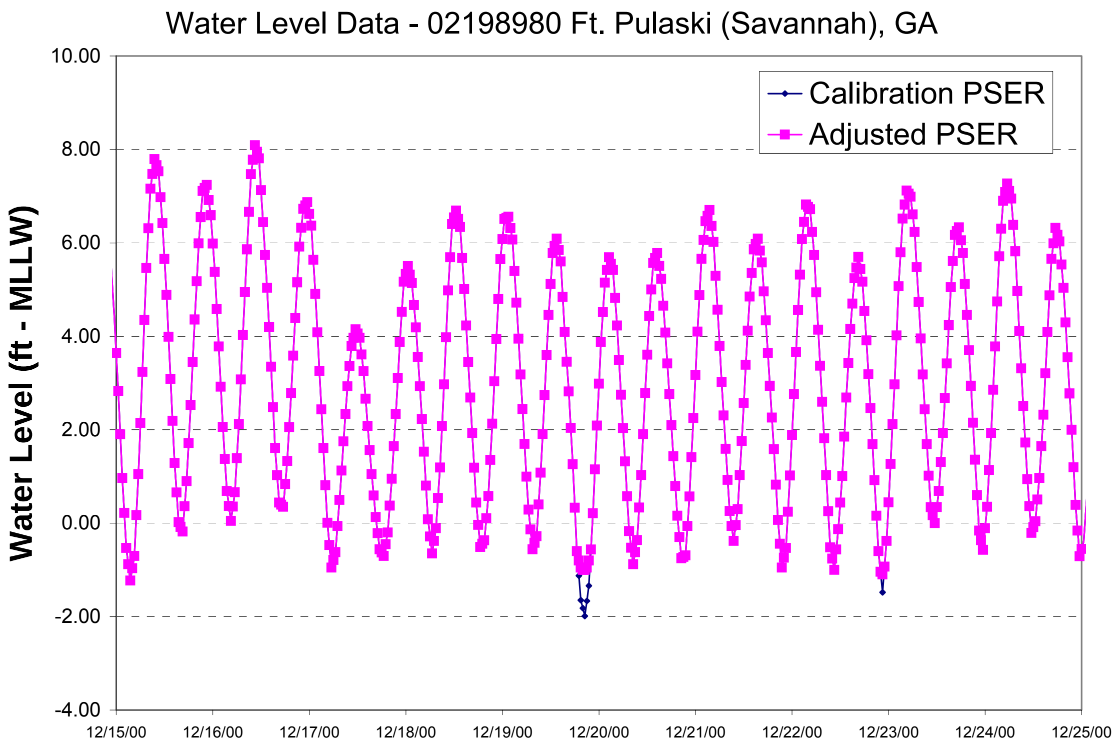

Figure 15 – Modified water level data for model boundary

Hydrodynamic and Water Quality Model Review Meeting
26 October 2005

Attendees, in person:
Will Anderson, Tetra Tech
Yuri Plis, Tetra Tech
Steven Davie, Tetra Tech
Bill Bailey, CoE-SAM
Jim Greenfield, EPA
Roy Burke, GA EPD
Paul Lamarre, GA EPD
Paul Conrads, USGS-SC
Alan Garrett, CoE-SAV
Joe Hoke, CoE-SAW
Larry Keegan, Lockwood-Green
Wade Cantrell, SC-DHEC
Kaiser Edmond, CoE-SAD
Susan Rees, CoE-SAM

Attendees, by telephone conference:
Ed Eudaly, USF&WS
Hope Moorer, GPA
Sung Chan Kim, CoE-ERDC

1. The meeting began with a review of the Tetra Tech responses to Dr. Kim's ITR comments. Dr. Kim has a slight concern with the .02 roughness coefficient used, but he says Tetra Tech's explanation is reasonable. He has also previously discussed the issue with Tetra Tech's John Hamrick, the author of the EFDC model. Dr. Kim accepts all of the Tetra Tech responses to his comments. After Tetra Tech corrects a few typos in the ITR document, Dr. Kim will provide a signed copy of the ITR response form indicating his concurrence.
2. Paul Conrads provided an update on the status of QA/QC of the ATM 1999 data set. ATM had originally done QA/QC of the data after they collected it. Jim Greenfield of the review committee had asked Paul to redo this activity so that data at the most critical stations would be QA/QC'd to the same standards and guidelines as the current USGS standards. This was begun during this past summer – three gages have been completed. The gages done first were the ones considered to have the most anomalies in the data. The process corrects for loss of calibration (or drift) to instruments as they are in place over periods of time, using the calibrated data at the time of servicing the gage to adjust the recorded data. What has been completed so far has resulted in changes (5 to 60% in some cases) to the recorded data plots. The outcome is slightly better agreement with the model calibration simulations. There are still 7 gages remaining to complete. This is not the highest priority project at the USGS – they are currently placing their greatest effort towards completing their annual report in a timely manner. This will not affect the uncertainty analysis, because the uncertainty analysis was performed on the seven years of USGS data, not

the 1999 ATM data. The consensus was that this should not hold up the alternatives analysis, but that the final calibration report should not be published until this activity is completed.

3. Tetra Tech responses to the written comments submitted by the review committee have been included in Tetra Tech Technical Memo #3. Based on discussion at the meeting, Technical Memo #3 will be revised and attached to these notes to document the resolution of those issues. To summarize the Tetra Tech actions to address comments and improve the calibrated model: They conducted sensitivity analyses on the boundary conditions and on the marshes, with no significant changes in salinity and dissolved oxygen in the harbor. They added additional marshes in the upper end of the harbor and increased friction on the river, which does improve the model's performance in the upper Savannah River area. Jim Greenfield agreed that these changes in the upper Savannah River, although not necessary for the harbor calibration, will improve the performance of the riverine part of the model. Therefore, the EFDC model will be adjusted based on this improvement. For the WASP water quality model, sensitivity analyses of decay rates and point sources showed no significant impact. However, redistributing the marsh loads into more than one vertical layer showed a direct improvement, thus the WASP model for the base condition was adjusted and improved. Tetra Tech has also modified the SOD in the Little and Back Rivers and just offshore of Fort Pulaski near Oyster Bed Island.
4. The two recommendations contained in the 17 October 2005 memo from Chuck Watson of Kinetic Analysis Corporation (KAC) were discussed.
    a. The first recommendation was to perform a perturbation analysis similar to that performed on the TMDL version of the model to address concerns of asymmetric model error with respect to tide phase and the December 2000 7-year run stability issue. Tetra Tech felt that the sensitivity analyses that they have performed adequately addressed concerns over the asymmetric model error with respect to tide phase. The review committee reiterated that they did not have any problem with the minor adjustment that TT made to the tidal boundary condition to allow the 7-year simulation to run through the December 2000 time period. They had no stability issues with the model. Tetra Tech also believes that with the improved bathymetry in the model and implementing the recommendations from KAC on the TMDL model, the model already has the perturbations in the enhanced grid. The review group did have some questions about the KAC recommendation. I summarized those questions and forwarded them to KAC via e-mail on 27 October 2005. Chuck Watson replied the same day and those questions and answers are copied at the bottom of this memo for review by the committee members.
    b. The second recommendation was to conduct a short-term data collection effort and then run the simulation models "real-time" for comparison of results to the collected data. The purpose of this is to improve confidence in the model. The review committee had no objection to obtaining more data, but the consensus was that for the data set to be meaningful, it would need to be collected by continuous recording gages rather than spot samples, and over a duration of at least 3 – 6 months. The reason for this

is with spot samples, collected by hand, you do not have simultaneous data points over the entire system. Also, any error cannot be readily determined whether it is a magnitude error or a phasing error. With contracting delays, data analysis, and report writing, the group estimated that a 3-6 month data collection effort would result in a 12-month period before a decision could be reached on the information obtained from another data collection effort. When considering the impact of this data collection effort on the overall progress of the study, the committee became less supportive. It was then pointed out that additional long-term gaging is already required to monitor and compare pre- and post-construction conditions. The USF&WS is a proponent of adaptive management of mitigation effort, whereby the results of mitigation projects are monitored and the project is adjusted to optimize results. The committee consensus was that the model is suitable for comparative analyses of impacts as it now stands. When data collection occurs in the future, it could be used to verify the mitigation plan modeling, in addition to the primary purpose of setting a baseline for the analysis of post-construction data. The Federal Agencies have already met and discussed long-term data collection efforts such as adding a dissolved oxygen instrument to some of the existing gages and continuous flow/velocity meters on the Front, Middle, and Little Back Rivers to better analyze the flow splits.

5. Tetra Tech presented a summary of their output post-processor. Tech Memo #4 was distributed which describes how the post-processor works and what the various output formats availability and appearance are. A copy of the software and sample input will be distributed to the review committee. Once they have an opportunity to familiarize themselves with the program, either an on-line or in-person training session will be set up.

D H E C

PROMOTE PROTECT PROSPER

C. Earl Hunter, Commissioner

Promoting and protecting the health of the public and the environment.

March 10, 2006

Pete Oddi, P.E., PMP
U.S. Army Corps of Engineers
Savannah District
P.O. Box 889
Savannah, GA 31402-0889

Dear Mr. Oddi,

The Department received and reviewed the 7-year monitoring data and model output used to generate report Figures M-1 through M-4, which we requested by letter dated February 15, 2006, and we have completed our review of the report "Development of the Hydrodynamic and Water Quality Models for the Savannah Harbor Expansion Project—Final, January 30, 2006."

The January 30, 2006 report replaces the previous draft dated May 20, 2005. The Department provided comments on the previous draft by letter dated July 1, 2005. The purpose of the current review was to determine if the final report addresses previous comments and to give our position on whether or not the hydrodynamic and water quality models are acceptable tools to evaluate potential impacts of Savannah Harbor Expansion Project.

The final report addresses previous comments to varying degrees. In summary:

1. The EFDC hydrodynamic and salinity model continues to under-predict ebb flows on Back, Middle, and Little Back Rivers based on comparisons to discrete, short-term flow measurements. Improvement would likely require continuous, long-term flow data not currently available. The large amount of continuous water level and salinity data, and the overall agreement between this data and the model, appears to compensate for the limited flow data in demonstrating overall model performance. Thus, this issue is not considered significant for model calibration and for application to deepening impacts; however, application to mitigation scenarios that alter channel connections—and attempt to predict resulting changes to the flow regime and the effect on salinity—may require additional evaluation of model capability.

2. The EFDC model continues to under-predict salinity on Middle River; however, we agree with Tetra Tech that the model achieves a reasonable balance between

Middle River, Front River (where the model does well), and Little Back River (where the model tends to over-predict salinity). We also agree that the 7-year simulation results are evidence that the salinity model performs well over a wide range of conditions during 1997 through 2003. Notably, during the drought years 2000 through 2002 when salinity intrusion on Little Back River was greatest, model correlation to data increases and model percent error decreases as compared to the 1999 calibration and 1997 confirmation periods. Overall, the salinity model is performing well, and this issue is not considered significant.

3. The report documents the QA/QC screening of the dissolved oxygen (DO) data completed by USGS, and the WASP water quality model incorporates the new dataset. Results were mixed. In general, DO model statistics (Tables P-1 and P-2) did not improve; however, model-data comparisons are complicated by gaps in the DO data. Along the Front River, the model does not simulate the short-term fluctuations (< 24 hours) and associated instantaneous minima shown in the DO data (Appendix P). The model does a better job on average as indicated by comparisons of measured and simulated 50th percentile DO, and it does a reasonable job of representing the spatial trends along Front River (Figures 9-1 and 9-2). Although DO data on the side channels are more limited, available data show the model over-predicts DO in these areas. Based on these characteristics, the model should do a reasonable job of predicting impacts in terms of relative change in DO. Impact evaluations involving predictions of absolute DO values would require consideration of, and accounting for, model bias.

4. The Corps has collected additional five-day BOD concentration data for confined disposal facility (CDF) discharges and provided the data along with estimates of BOD loading during the days sampling was performed. Estimated loads were relatively low for these days because effluent flows were relatively low; however, five-day BOD concentrations were relatively high (16 to 19 mg/L). Final impact analysis will require refined load estimates that take into account higher flow periods (including any increased flows expected to result from deepening and disposal activities) and the potential contribution of ammonia to the total oxygen demand.

5. We understand that development of the Model-to-Marsh (M2M) linkage and the Marsh Succession Model (MSM) continues. Ultimately, the plan is to use the M2M to connect the EFDC model to the MSM. We appreciate the Corps keeping us informed about these analyses. As indicated above, we believe the EFDC model is performing well; however, ultimately, it will need to be demonstrated that EFDC, M2M, and MSM together yield reliable predictions of wetland impacts.

6. We understand that adjustment of both the EFDC and WASP models continues. Impact analyses submitted to the Department for water quality certification for harbor deepening should be run on the final models.

Based on our review of the report and models, our position is the EFDC hydrodynamic and salinity model and the WASP water quality model are acceptable tools, subject to the comments above. As with any complex tool, issues may arise during application and interpretation. In this case, we would look forward to continued cooperation with the Corps and the other state and federal agencies involved with this project.

Thank you for the opportunity to participate in reviewing the modeling work. If we can be of any other assistance please contact me or, for modeling issues, please contact Wade Cantrell at (803) 898-3548.

Sincerely,

Alton C. Boozer

Alton C. Boozer
Chief, Bureau of Water

ACB/wmc

From:	Pace.Wilber
To:	Bailey, William G SAMatSAS
Cc:	smtp-Brownell, Prescott
Subject:	Re: Savannah Harbor Expansion - Hydrodynamic and Water Quality Models
Date:	Sunday, May 14, 2006 12:11:07 PM

Hi Bill.

Many thanks for all your effort to help me catch up on Savannah. Pres has been taking some well-deserved time off lately, and I don't know if he responded to you. We will continue to follow USFWS' lead on the hydro and WQ modeling. Do you need a letter? If so, please let me know and I will send this week (I'm on travel Tuesday and Wednesday).

Thanks,
Pace

Bailey, William G SAMatSAS wrote:

The USFWS recently sent us the attached letter (WORD document).

It was sent in response to a letter from the Corps dated 26 April (also attached – ADOBE, labeled "Document.pdf").

In the past you have relied on the USFWS for assessing the adequacy of the Hydrodynamic and Water Quality Models.

If you intend to continue to rely on the USFWS views for those two models, we'd appreciate an email stating so. That would allow us to say that all the agencies approve of the models' use for impact evaluation purposes.

Thanks.

BB

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PLEASE NOTE NEW MAIL ADDRESS AND PHONE NUMBERS

Pace Wilber
Atlantic Branch, Charleston (F/SER47)

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PO Box 12559
Charleston, SC 29422-2559

843-953-7200
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pace.wilber@noaa.gov

http://sero.nmfs.noaa.gov/dhc/habitat.htm

From: Bailey, William G SAM@SAS
To: "Jim Greenfield (E-mail) (E-mail)"; "pconrads@usgs.gov"; "Wade Cantrell"; ""Paul Lamarre" (E-mail)"; "Keith_Parsons@mail.dnr.state.ga.us"; "Kay Davy (kay.davy@noaa.gov)"; "Ed_Eudaly@fws.gov"; "Kelie_Moore@coastal.dnr.state.ga.us"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Priscilla Wendt"
Subject: Savannah Harbor Expansion Project - Interagency Water Quality Team -- EFDC/WASP input & output files
Date: Friday, May 18, 2007 3:15:01 PM

For those of you who are interested in running the EFDC ands WASP models, we put the input and output files on our ftp site. Wade Cantrell had requested this. Both he and Paul Conrads have been successful in downloading the files.

BB
-----Original Message-----
From: Williams, Laura E (Beth) SAW@SAS
Sent: Monday, May 07, 2007 7:34 AM
To: Bailey, William G SAM@SAS
Subject: Water Quality EFDC/WASP input & output files

Bill,

The water quality input and output EFDC/WASP files are posted on the ftp site. They should be available for download until the end of the month.

ftp://ftp.usace.army.mil/pub/sas/SHEP_Output/WQ/

Please let me know if you need any other files.

Thanks,
Beth

Beth Williams, PE
Hydraulic Engineer
US Army Corps of Engineers

From:	Bailey, William G SAM@SAS
To:	"greenfield.jim@epa.gov"; "Paul A Conrads"; "Ed_Eudaly@fws.gov"; "Kay Davy"; "Wade Cantrell"; Priscilla Wendt; ""Paul Lamarre" (E-mail)"; Keith Parsons; kelie_moore@dnr.state.ga.us
Cc:	Ted Bisterfeld (bisterfeld.ted@epa.gov); "Mueller.Heinz@epamail.epa.gov"; "Larry Turner"; "J. Christopher Beckham"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Bob Perry"; "Elizabeth Booth"; Jeff Larson; "Tim Barrett"; Tanner, Margaret; "Neal, Larry"; "Steven Davie"; Bradley, Kenneth P SAM; Garrett, Thomas A SAS; hmoorer@gaports.com
Subject:	Savannah Harbor Expansion Project -- Review of D.O. Demonstration Project Report
Date:	Wednesday, May 14, 2008 6:56:54 PM
Importance:	High

On 31 January, Hope Moorer from GPA sent most of you an email stating that the MACTEC report on the D.O. Demonstration Project that GPA conducted last summer in Savannah Harbor was complete and available for review. Hope's message said the report could be found at the following website: http://www.sav-harbor.com/Reox.html She has since provided copies of the original data to those of you who requested that information.

A concern has been expressed about the report and I would like the Interagency Water Quality Coordination Team to meet to start working through the issue. The concern is about how well the report supports its conclusions, but the issue goes to whether the proposed oxygen injection would be an effective method of increasing D.O. levels in the harbor and, thereby, be an effective mitigation technique for the harbor deepening project.

I would like to convene a meeting of the Water Quality Coordination Team so we could start the process of working toward a consensus on whether the proposed oxygen injection system would be a satisfactory mitigation technique for the harbor deepening project. At this point, I envision MACTEC being the primary presenter at this meeting, explaining what they saw during the demonstration period, their conclusions after reviewing the data, and how they explained their findings in their report. After the meeting, I would like each agency to review the report further and provide the Corps with your agency's position on the acceptability of oxygen injection as a D.O. mitigation technique for the harbor deepening project. We would likely request your agency's response after an additional 3-4 week review period.

At some point in the evaluation of this project, each agency will have to decide whether this mitigation technique is acceptable. Last summer some agencies expressed a reluctance to approve components of the overall mitigation plan without seeing the entire plan. We honored that position and worked to develop comprehensive mitigation plans without asking further for your agency's position on the acceptability of individual components. However, since a concern has been expressed about this mitigation technique, I am asking each agency to reach your decision on this issue at this time, rather than later this year when the Draft EIS is out for formal agency comment. Late last month the Corps provided you with what we see as the complete mitigation plan for each project depth, so you now have a picture of the complete mitigation package that the District intends to include in the Draft EIS.

I'd like to hold this meeting in Atlanta on 27 May. That location has worked well in the past for water quality folks. If no meeting rooms are available there, we can probably find a room somewhere else in that big city. I believe we found a 10:00 start to be workable.

Jim -- could you check on the availability of a room at the EPA building?

Please let me know if that date and time would be acceptable to you to meet to hear about MACTEC's report. I will be away from my desk quite a bit, so please email your response.

I would like to have this issue resolved prior to a public workshop the Corps intends to hold on the project in late June. At that workshop I intend to provide the public with the same information I provided the natural resource agencies on 28 April on what the Corps sees as the project impacts and our proposed mitigation plans.

Bill Bailey

CESAM-PD-E 7 Jun 2008

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 27 May meeting of the Interagency Water Quality Coordination Team

1. Attendees:

GA DNR-EPD	Liz Booth
SC DHEC	Wade Cantrell
	Larry Turner
	Chris Beckham
SC DNR	Priscilla Wendt (by phone)
COE	Bill Bailey
EPA	Jim Greenfield (by phone)
	Ted Bisterfeld
	Heinz Mueller
USFWS	Ed EuDaly (by phone)
USGS	Paul Conrads
Georgia Ports Authority	Hope Moorer
MACTEC	Margaret Tanner
	Larry Neal
Tetra Tech	Steve Davie

2. The meeting was held at the Corps' South Atlantic Division offices in Atlanta from roughly 1000 to 1400. The meeting was primarily an information meeting, but some recommendations were made. The primary issue was a review of the January 2008 report produced for GPA by MACTEC titled "Savannah Harbor ReOxygenation Demonstration Project Report". Paul Conrads had reviewed the report for the USFWS and had expressed concerns about its technical adequacy.

3. The following is a summary of the discussions and does not include all the information that was presented or all comments made during the discussion.

4. MACTEC reviewed the technical details of the demonstration project that GPA performed last summer of oxygen injection in Savannah Harbor. MACTEC had conducted the project and prepared the monitoring report. MACTEC also described the observations it made during the project about the technology and the effects it observed in the river. They went on to explain the findings that they had included in the report and their overall assessment of the demonstration project.

MACTEC agreed that their analysis of the monitoring data could have been more detailed. They agreed to examine the data further, with particular emphasis on the issues that Paul Conrads had raised. They would issue a supplemental report with their additional findings.

GPA also agreed to include use of the approved EFDC and WASP hydrodynamic and water quality models in this more detailed analysis to attempt to identify (1) how far the effects of the oxygen addition should have been observable, (2) what the D.O. levels would have been in the harbor had the oxygen not been added, and (3) whether the amount of oxygen that was added produced the level of improvement that the model would predict. The last of those three questions would address uncertainty in whether the oxygen addition produces the beneficial effects that the modeling predicts.

5. The Corps attempted to clarify the major issues associated with this report. It identified two major questions:

(1) Did the Demonstration Project alter the dissolved oxygen in the river? If the Demonstration Project found that the dissolved oxygen in the harbor was not altered and improved by the addition of oxygen, then the Corps would need to identify another technique to mitigate for expected adverse impacts to D.O. from a further harbor deepening.

(2) Did the Demonstration Project indicate that the oxygen transfer efficiency of the Speece cones should be revised in the final design to ensure the oxygen addition produces the beneficial effects that the modeling predicts? If the oxygen transfer efficiency observed during the Demonstration Project was substantially less than what was assumed by the designers, then additional oxygen would need to be added to produce the desired amount of beneficial effects.

No agency represented would disagree that the Demonstration Project beneficially altered the dissolved oxygen in the river. There was considerable uncertainty among the meeting attendees on the extent of that improvement. The agencies continue to believe that oxygen addition may be an effective method of mitigating for adverse impacts on D.O. from further deepening of the harbor. In light of that continued support for the mitigation technique, the Corps will continue to the addition of oxygen as mitigation as it writes the Draft EIS for the project.

The Corps will review the supplemental report issued by MACTEC and GPA to determine whether it should revise the oxygen transfer efficiency used in the final designs of the D.O. improvement systems.

// DRAFT //

William Bailey
Physical Scientist

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Subject:	Savannah Harbor Expansion Project - Interagency Water Quality Coordination Team -- Review of D.O. Demonstration Project Report
Date:	Monday, June 30, 2008 5:43:44 PM
Attachments:	Supplemental Report Proposal 062608.doc Modeling Scope of Work.doc

I've attached GPA's proposal for the additional evaluation of data obtained during last year's D.O. Demonstration Project. The proposal is comprised of two scopes of work.

Please review the two SOWs and let me know if you have any revisions to suggest so that the work can answer your questions. Provide any suggested revisions or comments that you may have by 10 AM Monday, 7 July.

Thank you.

Bill Bailey

CESAM-PD 30 Apr 2009

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Summary of 29 April meeting of the Interagency Water Quality Coordination Team

1. **<u>Attendees (in person)</u>:**

GA DNR-EPD	Liz Booth
	Jeff Larson
EPA	Jim Greenfield
	Ted Bisterfeld
	Heinz Mueller
COE	Bill Bailey
	Paul Bradley
Tetra Tech	Steve Davie

<u>By Phone</u>

SC DHEC	Wade Cantrell
	Larry Turner
SC DNR	Priscilla Wendt
NOAA Fisheries	Kay Davy
	Stephania Bolden
	Pace Wilber
USFWS	Ed EuDaly
	Bill Wikoff
	Chuck Hayes
USGS	Paul Conrads
Georgia Ports Authority	Hope Moorer

2. The meeting was held at EPA Region 4 from roughly 1230 to 1530. The Corps called the meeting to discuss the way forward with the dissolved oxygen systems, after the natural resource agencies had a chance to review the Supplemental Reports on GPA's 2007 Savannah Harbor ReOxygenation Demonstration Project. This MFR is a summary of the discussions and does not include all the information that was presented or all comments made during the meeting.

3. As background, the natural resource agencies have repeatedly expressed concern about the ability of the oxygen systems to effectively add oxygen to the water and have it distribute throughout the harbor. These questions go directly to whether the proposed systems would be effective in mitigating the impacts of a deeper channel. The concerns include two factors: (1) how much oxygen is added to the river, and (2) whether that

additional oxygen distributes through the impacted areas of the harbor. The Corps called this meeting to discuss ways the project could reduce the agencies' uncertainty on these two issues, while moving forward with the project. The Corps began by asking questions about some of the comments the agencies had provided, to gain a better understanding of the specific concerns.

4. SC DHEC stated that their concerns with the near-field plume modeling are to ensure the systems that are being proposed function effectively. Modeling of the injection plume would identify whether the oxygen being injected is likely to be fully absorbed into the water column with the design that is being proposed.

The plume modeling would include site and design-specific factors such as river depth, velocities, salinity, D.O. concentration of the discharge, and diffuser size, etc. This modeling would identify the required spacing and size of any needed diffusers. EPA and GA DNR-EPD explained that this modeling was not a complex analysis and was technical similar to one that TetraTech had performed for GPA in evaluating the D.O. Demonstration Project.

SC DHEC requested this modeling be performed during the EIS process. They would need the information produced from that analysis to be comfortable with the likely effectiveness of the proposed designs. GA DNR-EPD and EPA stated that this modeling would also be needed for their review.

All agreed that oxygen toxicity is no longer an issue. The Demonstration Project had shown that the injected oxygen would quickly disperse and not occur in high concentrations for a large area.

5. The Corps asked EPA about the Oxygen Transfer Efficiency Verification Study that it had requested in its comments on the latest reports. EPA explained that the actual efficiency at which a system would add oxygen to the waters could not be known until the system was operational. Design analyses are beneficial, but since dissolved oxygen is so critical to the aquatic ecosystem of the harbor, the actual ability of the systems to add oxygen should be confirmed.

This study would consist of monitoring D.O. levels in the river when the systems are operating. The monitoring would include both D.O. levels and a dye (rhodamine) introduced with the injected oxygen. It would need to be conducted over two tide cycles and would primarily be a near-field analysis. The dye would also be traced as it moved through the harbor to secondarily provide a way to assess the distribution of the oxygen throughout the harbor system.

The monitoring results would be used in a modeling analysis to show the near-field mixing and distribution of the injected D.O., as well as the distribution of the dye and its implications on the movement of the added oxygen throughout the harbor.

The Corps would use the results of the Oxygen Transfer Efficiency Verification Study to determine how it would operate the overall D.O. improvement system (# cones per site and the amount of oxygen from each cone) to produce the level of mitigation required (pounds of oxygen determined to be needed by the water quality modeling).

6. In a related issue, EPA had questioned the transfer efficiency used in the design of the D.O. systems. The present design assumed 100% efficiency, but also had additional capacity built in due to the 5,000 lb/day size increments of the Speece cones. The Corps had reviewed the various designs (sites and depths) and found the additional capacity to range from 5 to 36 percent. EPA stated that Dr. Speece had mentioned a 10 percent loss in efficiency with the cone itself. The Demonstration Project had shown additional losses to occur when the oxygenated water is introduced to the river. Those losses would vary with site-specific design factors. EPA suggested we assume the overall system is 80 percent efficient in getting oxygen into the water and into the river. TetraTech stated that this efficiency is not a modeling issue and may not affect the design of an individual Speece cone system, but could be used to identify the number of cones needed. The Corps asked the other agencies is they agreed with the Corps proceeding with the 80 percent figure for design and costing. GA DNR-EPD, SC DHEC and NOAA Fisheries agreed. The USFWS deferred to the views of the water quality permitting agencies (SC DHEC and GA DNR-EPD). GA DNR-CRD deferred to GA DNR-EPD. SC DNR deferred to SC DHEC. The Corps will revise the designs (primarily the # of cones and resulting costs) to include the 80 percent efficiency value.

7. EPA asked when the D.O. systems would be constructed. The Corps said they would all be constructed sometime during the 3-year construction period, with some mitigation features being implemented each year with funds obtained that year. After some discussion, the Corps agreed to provide the agencies with a list of the various mitigation features that it is proposing. The agencies would review that list and provide any recommendations on the order in which they would like to see those features implemented.

8. EPA asked about performance guarantees for the D.O. systems. The issue is what assurance would the agencies have that the Corps would operate the D.O. systems if the District does not receive all the funds it needs in a given year. As a mitigation feature, the Corps would consider the D.O. systems to be a “General Navigation Feature”, and thus considered eligible to receive any of the funds that Congress provides in a given year to operate and maintain the Savannah Harbor Navigation Project. The group agreed that the Record of Decision carries the most legal weight for operation of the project within its environmental approvals. The Corps agreed to work with EPA to develop specific language to include in the draft ROD to address this issue. The group agreed this is a legal issue and not a technical issue.

// DRAFT //

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Physical Scientist

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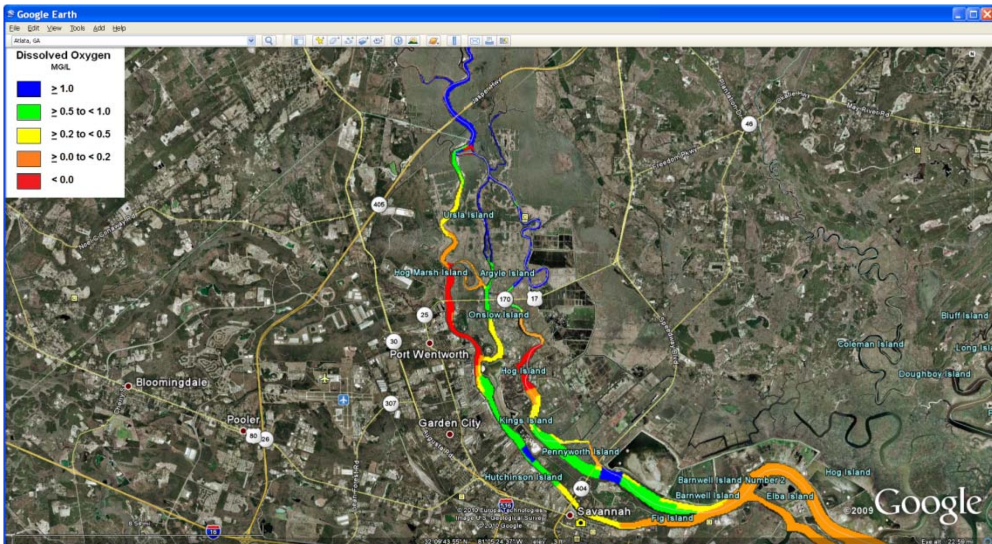
Subject:	Savannah Harbor Expansion Project - Interagency Water Quality Coordination Team: DO Injection Design Report
Date:	Wednesday, October 27, 2010 9:24:36 AM
Attachments:	SHEP Oxygen Injection Design Report (with Appendices).pdf

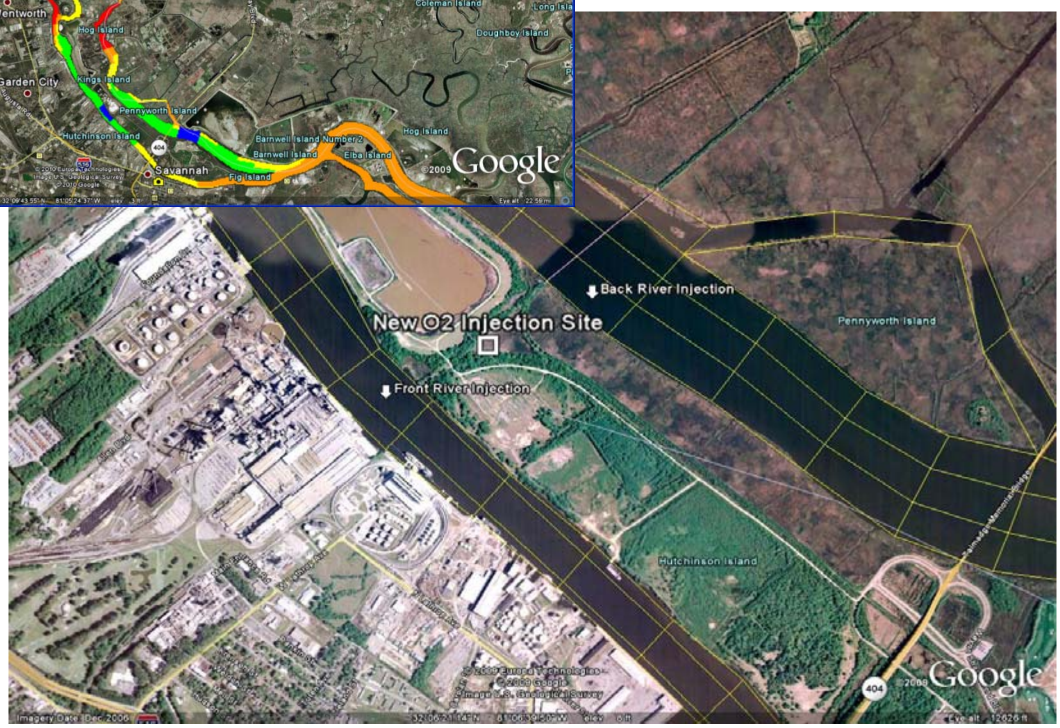
Here is the revised/final Savannah Harbor Oxygen Injection Design Report. It addresses the new locations for the systems and the near field plume modeling for those designs.

We've include this information in the Draft EIS that we expect to release next month and we'll include the report as an appendix in the overall project documents.

Bill Bailey

Oxygen Injection Design Report
Savannah Harbor Expansion Project
Savannah, Georgia





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Contract No: W912-HN-05-D-0014
Work Order 0025

FINAL
October 15, 2010

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1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE), Savannah District is working with the Georgia Ports Authority (GPA) to evaluate the deepening of the navigation channel in Savannah Harbor. This effort is called the Savannah Harbor Expansion Project (SHEP). The project is intended to identify the impacts and mitigation strategies of deepening the harbor from its presently authorized 42-foot depth Mean Lower Low Water (MLLW), up to a depth of 48-feet MLLW.

Hydrodynamic and water quality models were developed and determined to be acceptable in March 2006 by the United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Services (USFWS), Georgia Environmental Protection Division (GAEPD), and South Carolina Department of Health and Environmental Control (SCDHEC) to identify dissolved oxygen (D.O.) levels throughout Savannah Harbor. Studies have identified a dissolved oxygen injection system as being the most cost effective method to improve dissolved oxygen levels in the harbor (MACTEC 2005).

The SHEP is examining ways to mitigate for potential adverse effects on dissolved oxygen levels from proposed harbor deepening alternatives and will use oxygen injection systems for that mitigation. To meet those mitigation requirements, designs for an oxygen injection system were needed. This work effort uses the models to size and locate the system components and ensure the dissolved oxygen effectively mixes throughout the portions of the harbor that have the critical dissolved oxygen impacts.

The dissolved oxygen improvement designs are based on use of an off-stream (land-side) system to improve the dissolved oxygen of waters obtained from the harbor, and then reintroduce those oxygenated waters back into the harbor. The designs are based on the Speece cones to increase the oxygen levels.

The basic tasks included in this *Oxygen Injection Design Report* are as follows:

- Review siting of D.O. Injection Systems
- Optimize the D.O. discharge for mitigation purposes
- Accomplish near-field plume modeling for discharge sites
- Accomplish all necessary additional far-field model runs

2.0 TECHNICAL APPROACH

In developing the models for the Savannah River Estuary (Savannah Harbor), the Environmental Fluid Dynamics Code (EFDC) was selected for the hydrodynamic model. The Water Quality Analysis Simulation Program Version 7.0 (WASP7) was used for the water quality model development.

The EFDC model is part of the USEPA TMDL Modeling Toolbox due to its application in many TMDL-type projects. As such, the code has been peer reviewed and tested and has been freely distributed for public use. EFDC was developed by Dr. John Hamrick and is currently supported by Tetra Tech for USEPA Office of Research and Development (ORD), USEPA Region 4, and USEPA Headquarters. EFDC has proven to capture the complex hydrodynamics in Savannah Harbor and similar systems. The EFDC hydrodynamic and sediment transport model linked with the WASP water quality model provided the most appropriate combination of features necessary for this study. EFDC is a multifunctional, surface-water modeling system, which includes hydrodynamic, sediment-contaminant, and eutrophication components. The EFDC model is capable of 1, 2, and 3-D spatial resolution. The model employs a curvilinear-orthogonal horizontal grid and a sigma, or terrain following, vertical grid. The EFDC model's hydrodynamic component employs a semi-implicit, conservative finite volume-finite difference solution scheme for the hydrostatic primitive equations with either two or three-level time stepping (Hamrick 1992).

The EFDC hydrodynamic model can run independently of a water quality model. For this Savannah Harbor application the EFDC model simulates the hydrodynamic and constituent (salinity and temperature) transport and then writes a hydrodynamic linkage file for the water quality model WASP7 code. This model linkage, from EFDC hydrodynamics to WASP7 water quality, has been applied on many USEPA Region 4 projects in support of TMDLs and has been well tested (Wool 2003).

WASP7 is the new version of WASP with many upgrades to the user's interface and the model's capabilities. The major upgrades to WASP have been the addition of multiple BOD components, addition of sediment diagenesis routines, and addition of periphyton routines. WASP is an enhanced Windows version of the USEPA Water Quality Analysis Simulation Program (WASP), nonetheless, uses the same algorithms to solve water quality problems as those used in the DOS version. WASP is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program.

2.1 EFDC Application to the Savannah River Estuary

The EFDC model was developed to run for seven years – from January 1, 1997 through December 31, 2003. The model grid, which includes 931 horizontal cells, extends upstream to Clyo, Georgia (~ 61 miles from Fort Pulaski) and downstream to the Atlantic Ocean (~17 miles offshore from Fort Pulaski). The model also includes marsh cells, to simulate the extensive intra-tidal marsh areas in the system, increasing the number of total cells to 947. The man-made connections affecting the system were included in the model. These included McCoy Cut, Rifle Cut, Drakie's Cut, New Cut as closed, and the sill of the Tide Gate.

Figure 2-1 shows the grid, while Figure 2-2 shows a closer view of the upper estuary. The Savannah Harbor EFDC model was calibrated with graphical time series comparisons (qualitative) and statistical calculations (quantitative). The statistical calculations included percentiles at 5% intervals. It included: water surface elevation, currents, flow, temperature, and salinity.

The calibration objectives for the hydrodynamic model were to appropriately represent the transport processes by propagating momentum and energy through the system based upon freshwater inflow from the Savannah River and tidal energy from the Atlantic Ocean. Since vertical stratification plays a major role in the water quality of the lower harbor area, it was imperative to capture the effect of tides and fresh water flows on salinity and temperature over the appropriate spatial and temporal scales. The primary objective was to simulate the salinity and temperature stratification events and to demonstrate that the duration and magnitude of the events were appropriately represented in the model. The calibration period was the summer of 1999. The confirmation period was the summer of 1997. Long-term United States Geological Survey (USGS) data was also used for confirmation. The two summer periods were both low-flow conditions with several spring/neap tide events occurring throughout the period.

The model calibration and validation results are presented in the report "Development of the Hydrodynamic and Water Quality Models for the Savannah Harbor Expansion Project", January of 2006, prepared by Tetra Tech, Inc. for the USACE Savannah District.

Kinetic Analysis Corporation (KAC) performed a sensitivity/uncertainty analysis to quantify the sensitivity of the model simulations to uncertainty in values of model input data or calibration parameters. The results are presented in the January 2006 report as an appendix.

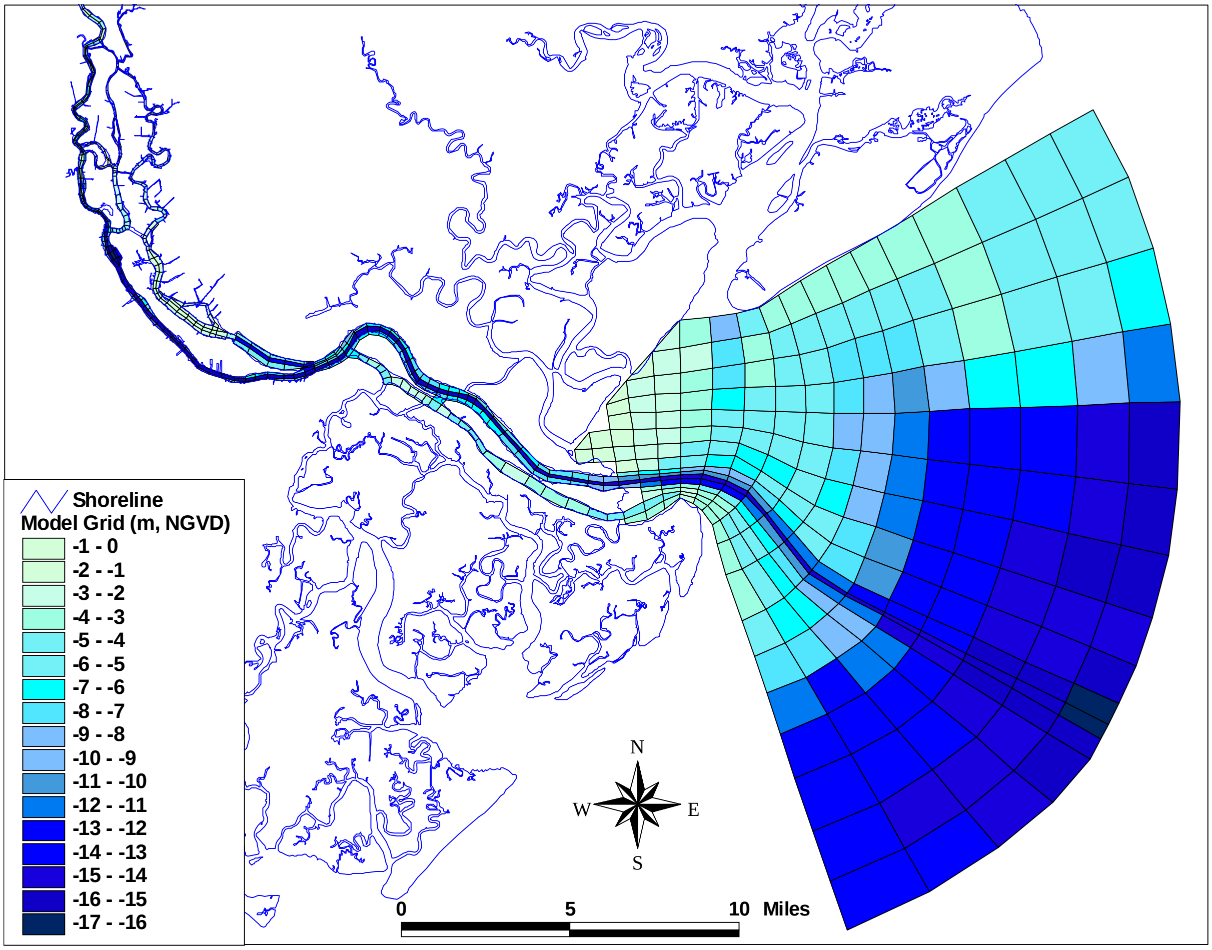

Figure 2-1 Model Grid and Bathymetry

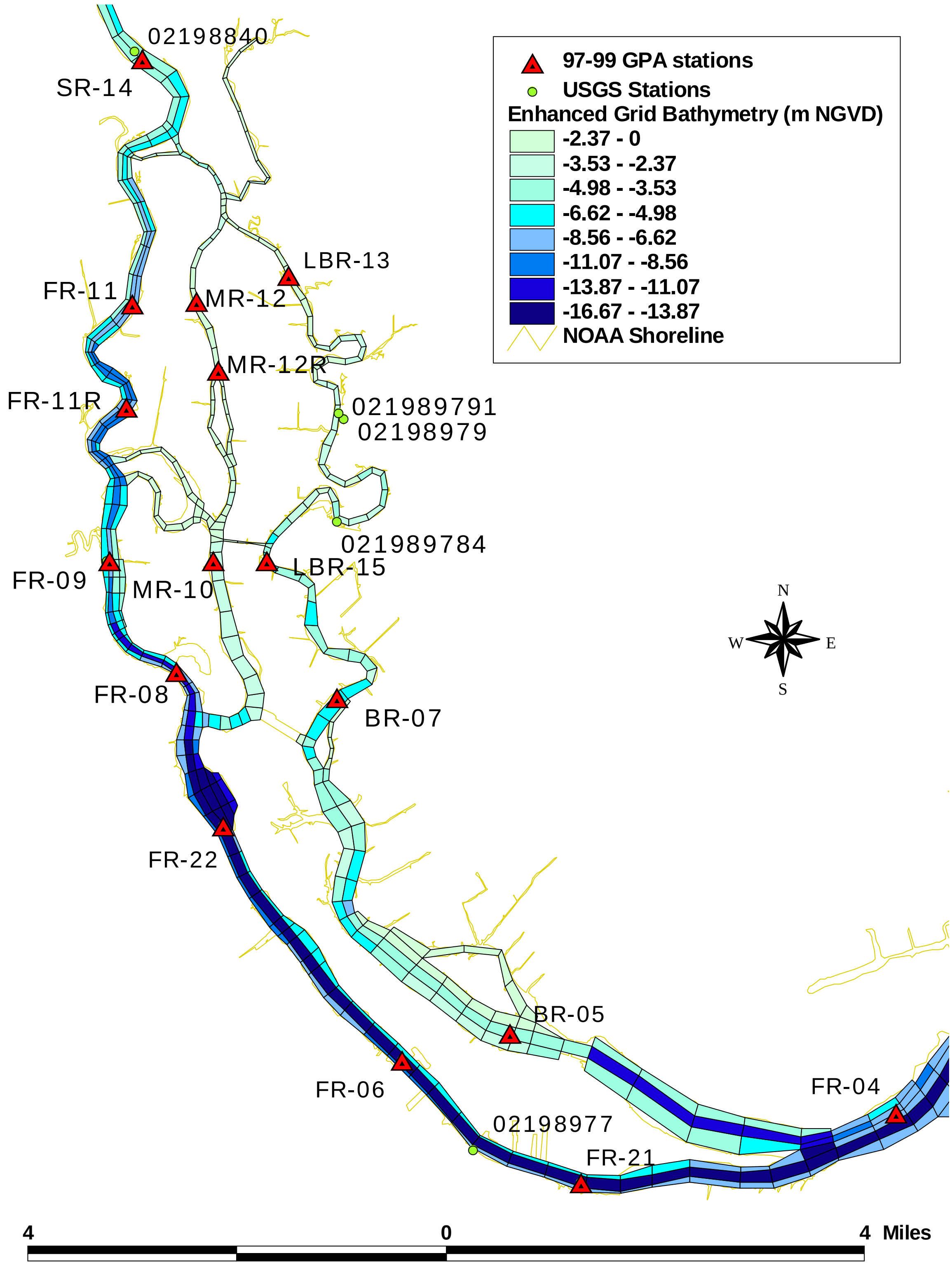

Figure 2-2 Model Grid and Bathymetry in the Upper Estuary

2.2 WASP Application to the Savannah River Estuary

The water quality model incorporated oxygen dynamics, including: reaeration, sediment oxygen demand (SOD), carbonaceous Biochemical Oxygen Demand (CBOD) and uptake, and Nitrogenous Biochemical Oxygen Demand (NBOD) and uptake. Since there is limited algal activity or primary production in the harbor, EPA Region 4 determined that nutrients were not a significant issue and they were not included in the water quality modeling scenarios.

The EFDC hydrodynamic model provides WASP with the flows between cells, the flows between cells and boundaries, cell volume, salinity, and temperature. This information is incorporated into the WASP model through the hydrodynamic linkage file.

The calibration was performed using the summer 1999 dataset. The WASP model was run from July 21, 1999 to October 13, 1999 with a 10-day spin up time. The measured values from the data collected during the 1999 summer survey were used for calibration of the WASP water quality model. Specifically, dissolved oxygen, BOD, and ammonia data were used for the calibration.

The time period for the WASP model confirmation was from July 5, 1997 through October 13, 1997. In addition to the 1999 summer data collection, the 1997 summer data collection represented the most recent dissolved oxygen and water chemistry data for the system.

Model calibration and validation results, as well as the sensitivity analysis for the water quality model, are also presented in the January 2006 report (Tetra Tech 2006a).

2.3 An Approach to Evaluation of Deepening Impacts and Mitigation Measures

The results of simulations that were performed under the project's Design of Dissolved Oxygen Improvement Systems in Savannah Harbor, Tasks I and II (Tetra Tech 2006b and 2006c) and their combination in Task III (Tetra Tech 2008) were used to develop the methodology to determine mitigation. This current work examines the impacts of the harbor deepening, Corps' mitigation plans, and the effects of oxygen injection system implementation based on average (August 1997) river flow conditions. The 2006 report identified average river flows as requiring more supplemental oxygen to meet harbor deepening mitigation requirements than do low river flow (August 1999) conditions (Tetra Tech 2006b and 2006c).

Figure 2-3 shows 27 spatial zones that delineate the estuary's simulated area. The zones cover the estuary area that can be affected by the harbor deepening. There are 11 zones for Front River (FR), 6 zones for Middle River (MR), 3 zones for Back River (BR), 3 zones for Little Back River (LBR), 2 zones for South Channel (SH), 1 zone for Steamboat River (StbR), and 1 zone for Savannah River (SR). The grid coordinates (I, J) zone boundaries are presented in Table 2-1.

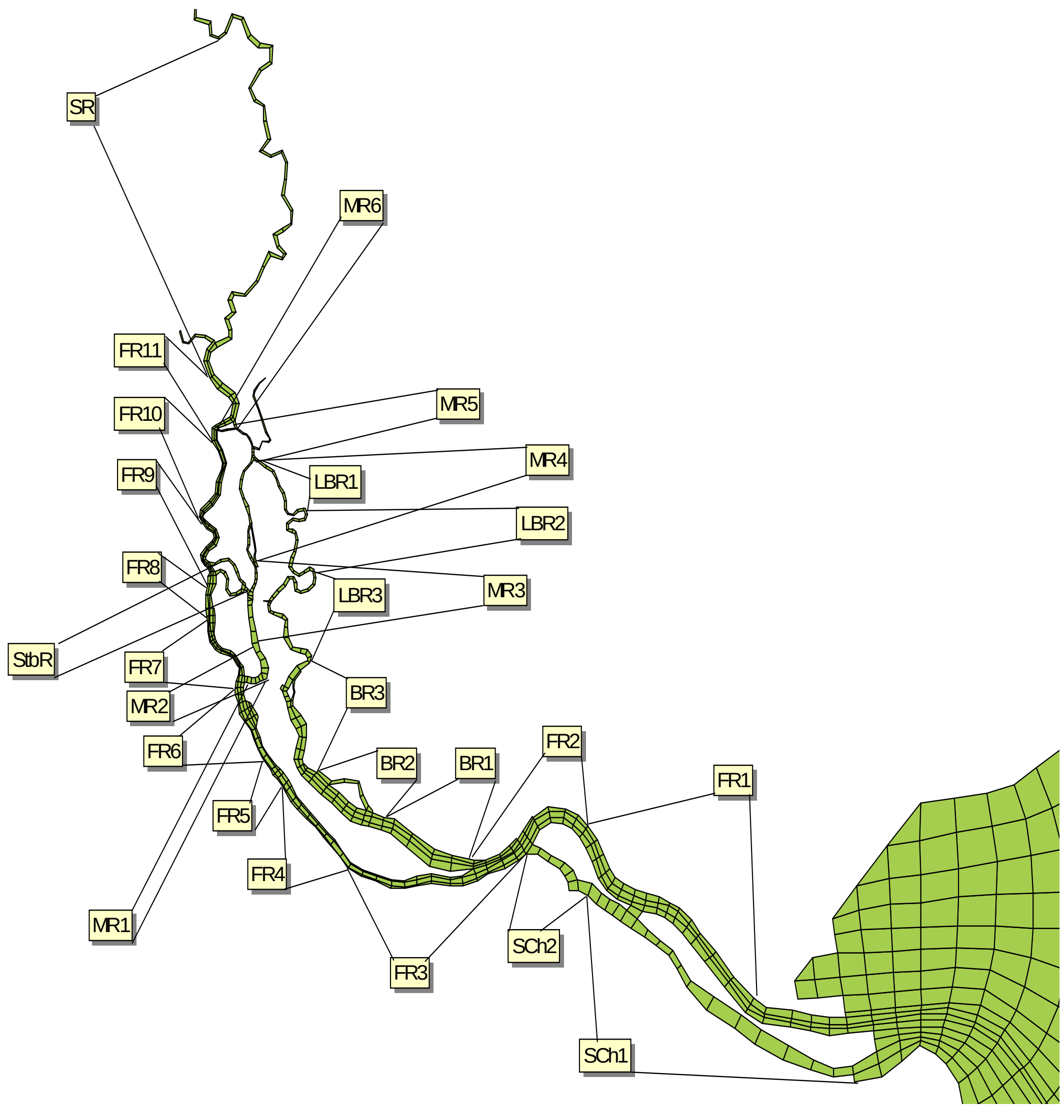

Figure 2-3 Zones' Delineation of Savannah Estuary Computational Grid

Table 2-1 Grid Coordinates and Volumes of Delineating Zones

Zone #	Zone Name	Grid Coordinates				Volume km3*1000	Relative Volume (%)
		I beg	J beg	I end	J end		
1	FR1	13	26	17	40	54.816	23.94
2	FR2	13	41	17	52	37.067	16.19
3	FR3	13	53	17	59	15.172	6.63
4	FR4	13	60	17	66	10.517	4.59
5	FR5	13	67	17	72	7.066	3.09
6	FR6	13	73	17	80	13.481	5.89
7	FR7	13	81	17	93	6.352	2.77
8	FR8	13	94	17	97	2.429	1.06
9	FR9	13	98	15	111	5.624	2.46
10	FR10	13	112	15	120	4.39	1.92
11	FR11	13	121	14	127	3.455	1.51
12	MR1	18	82	21	82	0.714	0.31
13	MR2	21	83	21	86	0.967	0.42
14	MR3	26	94	26	104	1.237	0.54
15	MR4	26	105	26	122	0.951	0.42
16	MR5	15	123	26	123	0.294	0.13
17	MR6	20	118	20	119	0.029	0.01
18	LBR1	27	123	38	123	0.401	0.18
19	LBR2	39	106	39	123	0.805	0.35
20	LBR3	30	86	30	109	2.766	1.21
21	BR1	30	59	34	63	8.16	3.56
22	BR2	30	64	34	70	4.988	2.18
23	BR3	30	71	32	85	5.572	2.43
24	SCh1	9	20	11	38	24.384	10.65
25	SCh2	7	45	12	46	4.761	2.08
26	SR	13	128	15	166	11.728	5.12
27	StbR	16	99	25	101	0.833	0.36

The model's postprocessor is described in Appendix D. The postprocessor outputs information for the following harbor's spatial objects:

- Critical Cell – cell with lowest D.O. concentrations during specified simulation period
- Critical Segment – an assemblage of cross section cells located at the critical cell's j-coordinate
- Zone – an assemblage of cells that are limited by specified horizontal and vertical boundaries

The postprocessor outputs allow evaluation of the impact and mitigation effects by:

- Comparing critical cells' D.O. concentrations for existing and project scenarios
- Comparing zones' volume-weighted D.O. concentrations for existing and project scenarios
- Calculating the percentage of water volume with the projected D.O. concentration that do not meet the existing bathymetry D.O. concentrations during the selected simulation periods

The basic criteria for assessing the success of mitigation measures was proposed by the USACE Savannah District based on results of numerous meetings and discussions with federal and local environmental agencies. The criteria require 97% of the estuary waters have D.O. concentrations equal or higher than the concentrations at existing (pre-project) conditions.

The selection of vertical boundaries of zones is the important factor of mitigation success calculations. The one boundary layer (1BL) and a mean of three boundary layers (3BL) criteria were selected and applied for the project. The 1BL is just the bottom layer and the 3BL is the three bottom layers of the model.

3.0 MITIGATION PLANS FOR SALINITY AND WETLANDS

The USACE Savannah District used the EFDC model to determine the appropriate measures to mitigate for salinity and wetland impacts. Based on analysis of the model output, the flow-altering mitigation plans that were found to be the most effective at reducing salinity impacts and protecting fresh water tidal marshes are Plan 6A for the 48-, 47-, 46-, and 45-foot channel depths and 6B for the 44-foot channel depth. Although the plans do not fully mitigate for all impacts to the estuary, they are expected to provide substantial benefits to the fresh water marsh ecosystems adjacent to the Back and Little Back Rivers.

Plan 6B is the proposed flow-altering mitigation plan for the 44-foot channel depth. The features of this plan include a diversion structure on Front River, closure of the lower (western) arm at McCoy Cut, closure of Rifle Cut, filling of the Sediment Basin, and removal of the tide gate abutments and piers. This plan provides potential for additional fresh water flows to enter the Back River System at McCoy Cut, without exiting through the lower (western) arm, and flow downstream through Middle, Back, and Little Back Rivers. It also has features that will limit saltwater intrusion to the Back River area through the sediment basin and Rifle Cut.

Plan 6A is the proposed mitigation plan for the 45-, 46-, 47-, and 48-foot channel depths. This plan includes all the features of Plan 6B and one additional feature, channel deepening on McCoy Cut, upper Middle, and Little Back Rivers. This additional feature in combination with the features in Plan 6B maximizes the potential for additional fresh water flows to enter the Back River System at McCoy Cut and flow downstream through Middle, Back, and Little Back Rivers.

Plan 6A includes the enlarged McCoy Cut only to the junction of Middle and Little Back Rivers. Plan 6B includes Plan 6A plus extending the enlargement 1,700 feet downstream of the junction of the two rivers. Figures 3-1 and 3-2 were provided by the USACE Savannah District and depict the different features for Plan 6A and 6B, respectively.

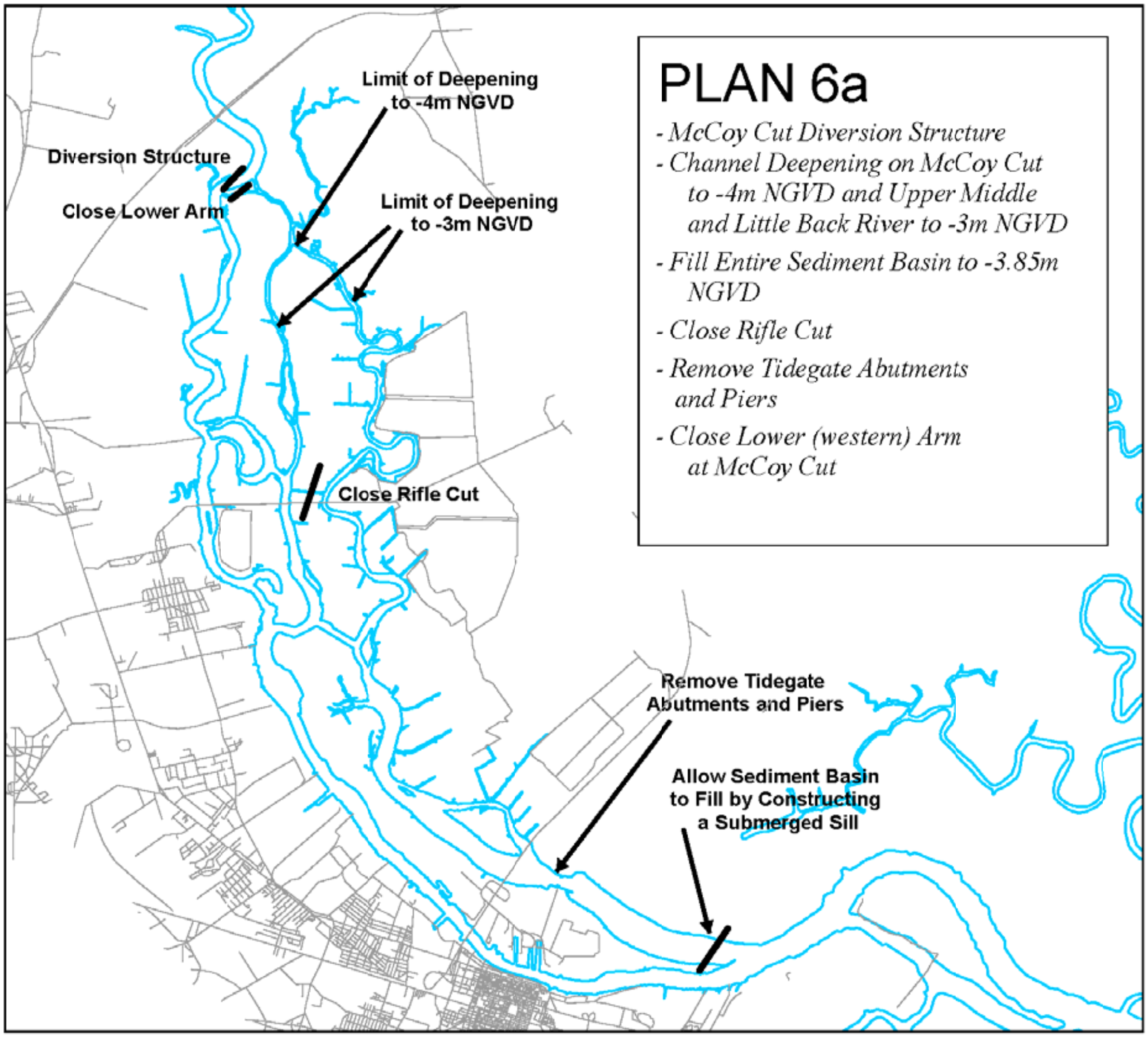

Figure 3-1 Mitigation Plan 6A (courtesy of the USACE Savannah District)

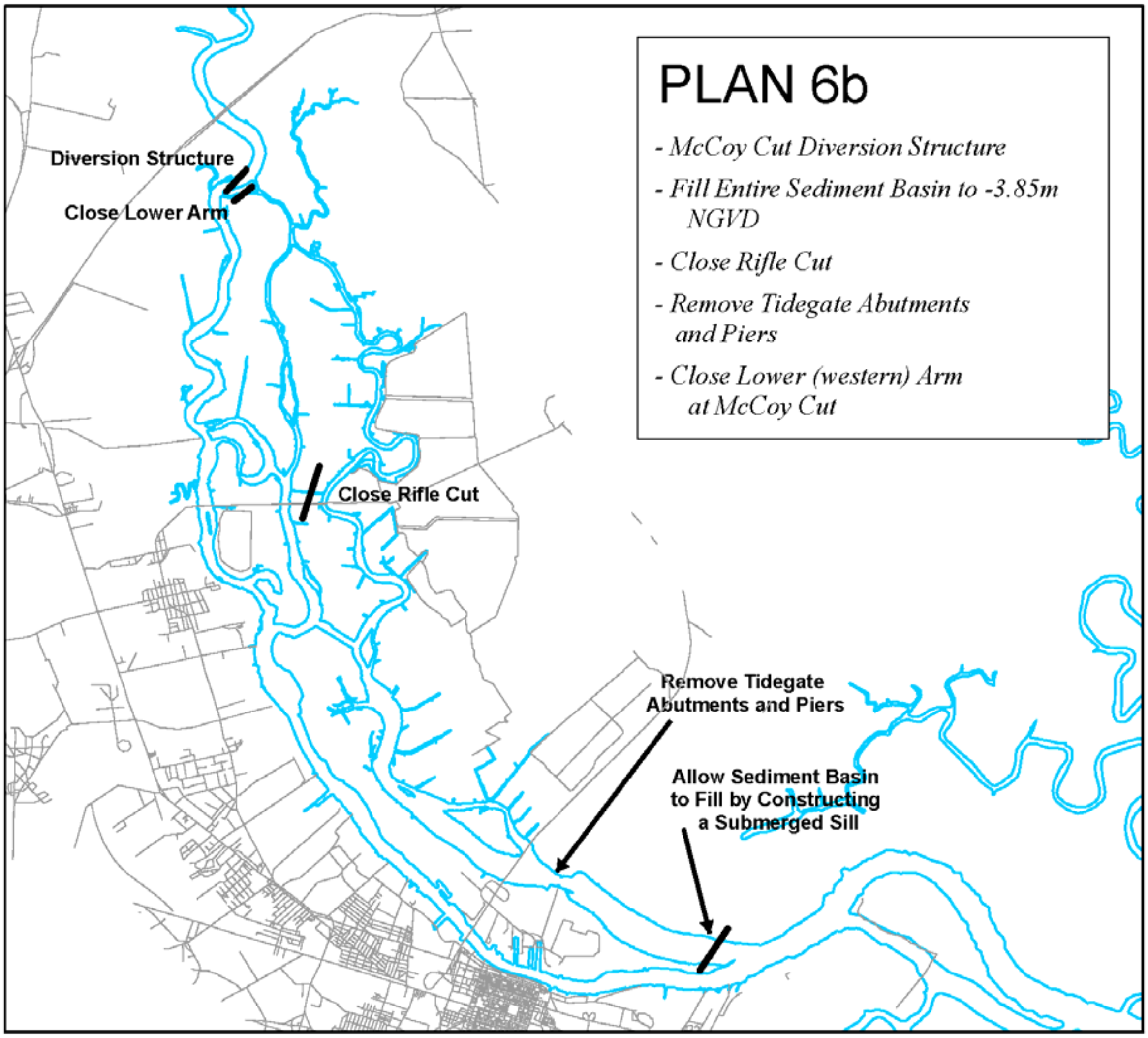

Figure 3-2 Mitigation Plan 6B (courtesy of the USACE Savannah District)

3.1 Impact of alternative deepening and mitigation plans on D.O. regime

Results of D.O. delta that were calculated by subtraction of existing bathymetry scenario outputs from the proposed mitigation plans alternative scenarios are presented in Table 3-1 and Appendix A.

Table 3-1 shows the percentage of water volumes where D.O. is not adversely affected by the proposed harbor deepening. The tables and figures presented in Appendix A allow identification of the harbor areas that are most affected by the deepening. These are zones F7, FR8, FR11, MR1, BR1, BR2, BR3, and LBR3 for mitigation plan 6A, and zones FR8, FR11, MR1, MR5, BR1, BR2, BR3, and LBR3 for mitigation plan 6B.

Such identification helps in selection of projected locations of components of the Oxygen Injection System.

Table 3-1 Volume of the harbor's water that was mitigated by plans 6A and 6B

Scenario Description	Injection	Volume mitigation (%) for the percentiles			
	kg/day	5%	10%	25%	50%
Plan 6A 6 ft deepening	0	68.1	73	68.8	43.8
Plan 6A 5 ft deepening	0	71	74.2	69.5	58.5
Plan 6A 4 ft deepening	0	71.2	73.4	72.9	10.4
Plan 6A 3 ft deepening	0	73.3	75.4	75.2	69.7
Plan 6B 2 ft deepening	0	65.1	68.7	63.1	68.4

4.0 OXYGEN INJECTION TECHNOLOGY

In order to inject oxygen into the system and to mitigate dissolved oxygen concentrations in the Savannah River Estuary that are below the standard, the technology developed by Dr. Richard Speece was used for design purposes. Dr. Speece invented the Speece Cone, a device originally used to add oxygen to the bottom of lakes to enhance downstream fisheries.

ECO2 SuperOxygenation systems (www.eco2tech.com) for water and wastewater treatment are designed and produced by Eco-Oxygen Technologies, LLC, an independent company headquartered in Indianapolis, Indiana.

The ECO2 SuperOxygenation method is a simple process based upon the scientific principle of Henry's Law. No chemicals and no moving parts other than standard municipal wastewater pumps are used. The result is a robust, reliable, economically competitive, and environmentally friendly technology.

This technology is appropriate when dissolved oxygen standards in the river are not attained, even if the industrial and municipal dischargers use the most advanced effluent treatments available. By superoxygenating directly to the river, water quality standards can be reached or maintained (Speece 2004).

This technology pulls a small sidestream of water from the river, superoxygenates it (using pure oxygen) and dilutes it back in the main river to satisfy dissolved oxygen deficiencies without treating the entire river. The sidestream is superoxygenated to achieve concentrations of 40 to 140 mg/L. Contrary to popular misconception, these high dissolved oxygen concentrations do not spontaneously effervesce, but can be kept in solution.

Cost comparisons with other traditional methods of oxygenation favor the use of this technology. Because pure oxygen and smaller sidestream flows used, less civil works and energy consumption are required than generally needed for aeration. Because the technology facilitates long residence times of gaseous oxygen in the oxygen transfer reactor, oxygen absorption efficiencies of 90 to 98% can be achieved.

The oxygen being dissolved can be supplied to the ECO 2 SuperOxygenation system in two ways:

1. Onsite oxygen generation either by Pulse Swing Absorption (PSA) or Vacuum Swing Absorption (VSA). Oxygen generation is a mature technology that has been used for decades and is widely used for wastewater treatment, medical facilities, and manufacturing. Oxygen generators operate by passing an air stream through a molecular sieve, which traps the nitrogen and discharges high purity oxygen for use. The nitrogen is then discharged into the atmosphere. The advantage to generating oxygen onsite is that oxygen is generated as it is being used, so there is no onsite bulk oxygen storage and it produces oxygen as a gas, not liquid. This eliminates issues centered on bulk liquid oxygen storage and truck delivery.
2. Bulk liquid oxygen (LOX). Bulk Liquid Oxygen is also widely used at wastewater treatment plants, manufacturing facilities and most noticeable medical hospitals. LOX systems are provided by a third party vendor that services, monitors, and delivers oxygen. LOX systems are comprised of a bulk oxygen storage tank and an evaporator. Liquid oxygen is trucked to the site and stored in the bulk oxygen tank. The liquid oxygen is piped through an evaporator that changes the liquid oxygen to gaseous oxygen.

High purity oxygen has been injected in water bodies in the past by various methods, such as pressurized sidestream, venturi aspirator, or turbine mixers, but inefficiently. The Downflow Bubble Contact Oxygenation equipment (Speece Cone) combines high oxygen absorption efficiency (>90%) with low unit energy consumption (<400 kwhr/ton D.O.), producing a superoxygenated discharge of >70 mg/L of D.O. The system can be placed out of the river channel without disrupting the water body, unlike aerators, or scouring the bottom.

Figure 4-1 shows a Speece Cone being installed at Newman Lake near Spokane, Washington. This cone was designed to add 3,300 pounds of oxygen per day (lbs/day) to a side stream of 13 million gallons per day (MGD) withdrawn from the hypolimnion of the lake.

Figure 4-2 shows a pictured of the Georgia Ports Authority (GPA) demonstration project managed by MACTEC. The results of the study are in the “Savannah Harbor Reoxygenation Demonstration Project, Savannah, Georgia” (MACTEC 2008) and, in summary, improve the dissolved oxygen levels in the mid-channel, average low-tide by about 0.6 mg/L along the three-mile-long target segment.

Figure 4-1 Speece Cone Being Installed in Newman Lake (from www.eco2tech.com)

Figure 4-2 Summer 2007 GPA Demonstration Project (MACTEC, 2008)

5.0 INJECTION QUANTITIES AND LOCATIONS

The SHEP model was used to determine the optimal quantities and locations of the oxygen injection facilities needed to mitigate for harbor deepening impact on dissolved oxygen. The problems with selection of optimal locations are complicated by limited availability of potential injection sites with easy transport and access.

5.1 Injection for Harbor Deepening Mitigation (IP site)

The USACE proposed the site on Hutchinson Island (near the International Paper (IP) aeration lagoon) as an oxygen injection facility for discharging oxygen into Front and Back Rivers. The results of D.O. mitigation for 6 ft deepening (Plan 6A) are presented in Table 5-1. The scenarios labeled m1 through m4 in Table 5-1 are different magnitudes of the 1BL (bottom layer only) criteria.

Table 5-1 Oxygen loads and mitigation results for IP facilities: 1BL criteria

Scenario		Coordinates	Injection	Sum	Mitigation (%) for the percentiles			
	Cell Location	(I, J)	(kg/day)	(kg/day)	5%	10%	25%	50%
	IP	FR (14,66)	30,000					
m1	IP	BR (31,70)	7,000	37,000	89.8	90.4	89.8	89.6
	IP	FR (14,66)	40,000					
m2	IP	BR (31,70)	17,000	57,000	91	91.7	90.9	91.7
	IP	FR (14,66)	50,000					
m3	IP	BR (31,70)	27,000	77,000	91.8	92.8	92.4	92.5
	IP	FR (14,66)	80,000					
m4	IP	BR (31,70)	60,000	140,000	93.3	93.9	93.7	93.6

The results of simulations under scenarios m1, m2, m3, and m4 demonstrate an inability of the Oxygen Injection Systems located only at the IP site to achieve the required 97% mitigation success criteria. So the IP Front and Back River injection sites alone do not mitigate all of harbor deepening impacts.

5.2 Injection for Harbor Deepening Mitigation (IP and GP sites)

The specifics of water circulation in Savannah River Estuary make oxygen discharge upstream of Savannah River very important. The Georgia Pacific (GP) site has high potential as an addition to the IP location for a combined Oxygen Injection System. Table 5-2 shows the results of D.O. mitigation for alternative deepening and 1BL criteria of success for locations near IP and GP.

Comparisons of results of Tables 5-1 and 5-2 demonstrate strong effect of upstream oxygen injection (GP) for FR and LBR zones. Such effect was not achievable by simply increasing of loads at the IP facility.

The Corps met with federal and state environmental agencies in February 2010 to discuss Tetra Tech's ongoing redesign of the oxygen injection systems. The agencies agreed that an upstream location appeared to be needed (in addition to the mid-harbor IP location) to meet the mitigation goals. The agencies agreed that the analysis could examine the effects in the lower half of the water column (bottom 3 layers of the model grid) rather than the bottom grid layer. D.O. generally decreases with channel depth, so analysis of conditions at the river bottom would represent worst-case conditions. Analysis of the bottom half of the water column would be more representative (but still somewhat conservative) of average conditions throughout the water column.

The results of simulations and assessment of D.O. improvement on the basis of the 3 bottom layer (3BL) criteria are presented in Table 5-3.

Table 5-2 Oxygen loads and mitigation results for IP and GP facilities: 1BL criteria

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Load (kg/day)	Sum	Volume mitigation (%) for the percentiles			
				(kg/day)	5%	10%	25%	50%
Plan 6A	IP (FR)	14, 66, 6	10,000					
6 ft deepening	IP (BR)	31,70, 6	7,000	27,000	98.4	98.6	98.4	97.1
(GP+IP_5)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	9,000					
5 ft deepening	IP (BR)	31,70, 6	3,000	22,000	97.3	97.3	98.1	97.3
(5F-7)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	6,000					
4 ft deepening	IP (BR)	31,70, 6	3,000	19,000	97.5	97.3	97.3	97.4
(4F-3)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	3,000					
3 ft deepening	IP (BR)	31,70, 6	3,000	18,000	97.1	98.2	98.5	98.8
(3F-13)	Georgia-Pacific	14, 171, 6	12,000					
Plan 6B	IP (FR)	14, 66, 6	6,000					
2 ft deepening	IP (BR)	31,70, 6	3,000	19,000	97.2	97.4	97	97.8
(2B-1)	Georgia-Pacific	14, 171, 6	10,000					

Table 5-3 Oxygen loads and mitigation results for IP and GP facilities: 3BL criteria

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Load (kg/day)	Sum	Volume mitigation (%) for the percentiles			
				(kg/day)	5%	10%	25%	50%
Plan 6A	IP (FR)	14, 66, 6	7,000					
6 ft deepening	IP (BR)	31,70, 6	2,000	18,000	97.9	97.8	98.1	97.3
(GP+IP_13m)	Georgia-Pacific	14, 171, 6	9,000					
Plan 6A	IP (FR)	14, 66, 6	3,000					
5 ft deepening	IP (BR)	31,70, 6	2,000	16,000	98.2	97.5	97.9	97.3
(5F-5m)	Georgia-Pacific	14, 171, 6	11,000					
Plan 6A	IP (FR)	14, 66, 6	2,000					
4 ft deepening	IP (BR)	31,70, 6	2,000	14,000	97.6	97.2	97.4	97.7
(4F-3m)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6A	IP (FR)	14, 66, 6	1,000					
3 ft deepening	IP (BR)	31,70, 6	2,000	13,000	98.1	97.4	97.7	98.5
(3F-3m)	Georgia-Pacific	14, 171, 6	10,000					
Plan 6B	IP (FR)	14, 66, 6	1,000					
2 ft deepening	IP (BR)	31,70, 6	4,000	15,000	97.2	97.3	97.6	97.8
(2B-6m)	Georgia-Pacific	14, 171, 6	10,000					

Table 5-3 shows the percent of the water volume where D.O. is at least as high as in the pre-project condition. The tables that show mitigation effect of Table 5-3 scenarios for every zone D.O. average and D.O. concentrations for critical cells are presented in Appendix B. The figures in Appendix B display 50^{th} percentile of D.O. delta (Project minus Existing scenarios).

Appendix C contains tables that demonstrate mitigation success (required for 5th, 10th, 25th, and 50th percentiles) for surface, middle, and bottom layers.

Table 5-4 displays depths and statistics of oxygen saturation using oxygen injection facilities near IP and GP. This information is necessary for the design of oxygen injection in the harbor using Speece supersaturating cones.

Table 5-4 D.O. Saturation (%) in locations of GP and IP facilities

Scenario Description	D.O. Discharge Location	Cell (I,J,K) Coordinates	Depth (m)	D.O. Saturation (%)		
				10 %ile	50 %ile	90 %ile
Plan 6A	IP (FR)	14, 66, 6	16.92	53	56	60
6 ft deepening	IP (BR)	31,70, 6	3.33	30	38	49
(GP+IP_13m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6A	IP (FR)	14, 66, 6	16.61	53	56	61
5 ft deepening	IP (BR)	31,70, 6	3.33	29	36	48
(5F-5m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6A	IP (FR)	14, 66, 6	16.31	53	56	62
4 ft deepening	IP (BR)	31,70, 6	3.33	28	35	48
(4F-3m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6A	IP (FR)	14, 66, 6	16	53	56	63
3 ft deepening	IP (BR)	31,70, 6	3.33	27	35	48
(3F-3m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80
Plan 6B	IP (FR)	14, 66, 6	15.7	52	57	65
2 ft deepening	IP (BR)	31,70, 6	3.33	19	29	45
(2B-6m)	Georgia-Pacific	14, 171, 6	3.62	65	74	80

The location of the injection facilities for mitigation of deepening impacts are shown in Figure 5-1. Figure 5-2 shows a close-up view of the IP Hutchinson Island location with injection sites on the Front and Back Rivers.

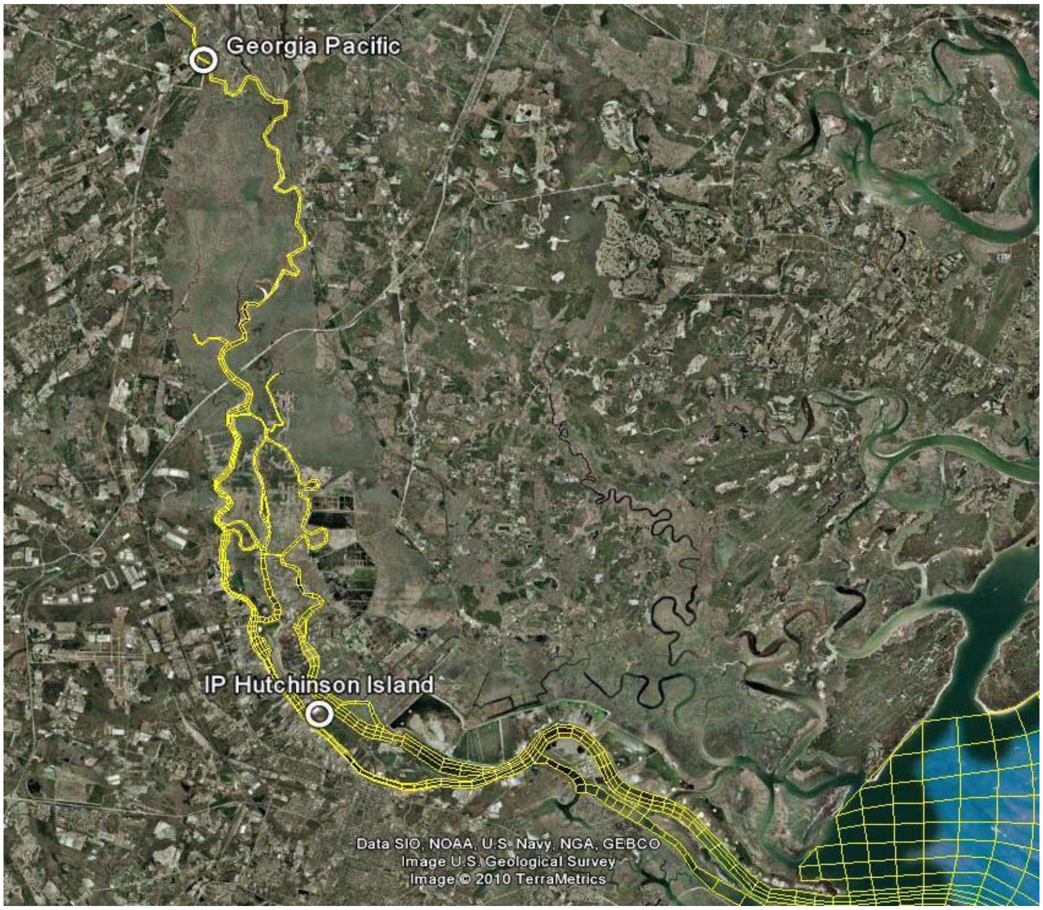

Figure 5-1 Location of Components of Dissolved Oxygen Injection System

Figure 5-2 Location at IP Hutchinson Island

6.0 NEAR-FIELD MODELING RESULTS

A mixing zone analysis was performed at each of the three locations to simulate the near-field results. A request was made by South Carolina DHEC to perform a similar mixing zone analysis to the one in the 2007 Demonstration Project report (Tetra Tech 2009). The analysis for the 2007 Demonstration Project showed a small plume and a relatively short mixing zone. DHEC desired this analysis to occur for the designed locations as well.

In order to predict the near-field plume dynamics so that accurate estimates of height of rise and fall and initial dilution can be calculated, near-field plume numerical descriptive models have to be used. One of the most widely used choices over the past several years have been Visual Plumes. Visual Plumes (VP) is a family of mixing zone models to simulate surface water jets and plumes for a range of temperature, depth, discharge buoyancy, and ambient velocity conditions.

The VP model is a Windows-based mixing zone modeling application designed to replace the DOS-based PLUMES program (Baumgartner et al. 1994). VP was developed by the USEPA and supports initial dilution models that simulate single and merging submerged plumes in arbitrarily stratified ambient flow. Predictions include dilution, rise and sink, diameter, and other plume variables. A more detailed description of the VP model is included in Appendix E of the 2007 injection modeling report (Tetra Tech 2009) and can be viewed at http://www.epa.gov/ceampubl/swater/vplume/. There are presently five recommended models in VP: DKHW, NRFIELD/FRFIELD, UM3, PDSW, and DOS PLUMES. For the present work the model UM3 was used. Figure 6-1 shows the output capabilities within the model after running scenarios (typical output).

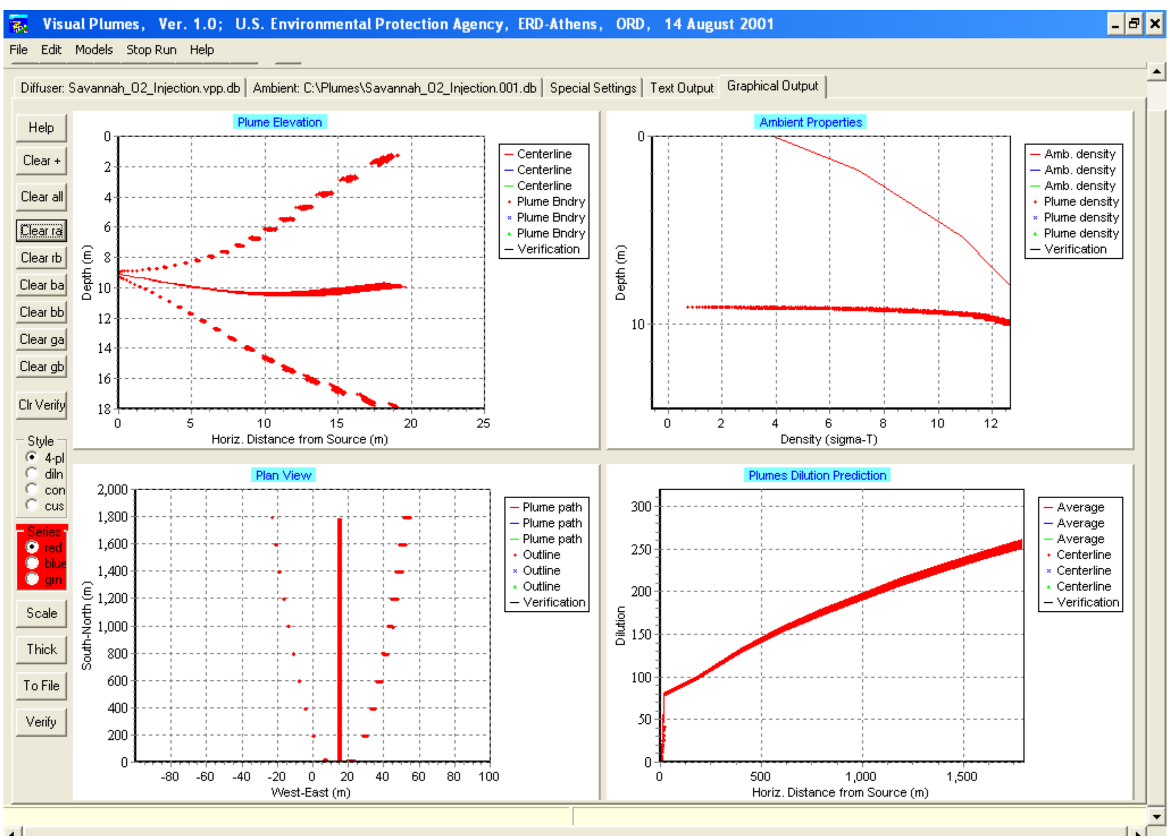

Figure 6-1 Typical Output using Visual Plumes Model

6.1 Plume Model

UM3 is an acronym for the three-dimensional Updated Merge (UM) model for simulating single and multi-port submerged discharges. UM3 is a Lagrangian model that features the projected-area entrainment (PAE) hypothesis. This established hypothesis quantifies forced entrainment, the rate at which mass is incorporated into the plume in the presence of current. In UM3, it is assumed that the plume is in steady state; in the Lagrangian formulation this implies that successive elements follow the same trajectory (Baumgartner et al. 1994). The plume envelope remains invariant while elements moving through it change their shape and position with time. To make UM three-dimensional, the PAE forced entrainment hypothesis has been generalized to include an entrainment term corresponding to the third-dimension: a cross-current term. As a result, single-port plumes are simulated as truly three-dimensional entities. Merged plumes are simulated less rigorously by distributing the cross-current entrainment over all plumes.

The average dilution factor, S_a , used in the UM model is the reciprocal of the volume fraction of effluent, v_e , contained in the diluted plume. An equivalent way of expressing this term is the ratio of effluent volume plus volume of ambient dilution water, v_a , to the effluent volume, as in the following equation:

$$S_a = 1 / (v_e / (v_e + v_a)) = (v_e + v_a) / v_e$$

Thus, in the region immediately outside the discharge orifice the volumetric dilution factor is very nearly 1. In some discussions of this term in other works, the factor is considered to be the ratio of the volume of ambient dilution water, v_a , to the volume of effluent discharged, v_e. In this definition, the volumetric dilution factor approaches zero near the orifice. Above a value of 30, the difference in the two definitions is progressively less than 3 %, an inconsequential amount for most regulatory purposes.

6.2 Near-Field Simulation Results

Tetra Tech used the three-dimensional EFDC Savannah Harbor model (Tetra Tech 2006a) to develop the flow and velocity field under which the simulations were performed. The three-dimensional model was run for the 1997 summer conditions based on earlier results that showed more oxygen is needed the summer of 1997 versus summer of 1999 due to slightly higher levels of flows (Tetra Tech 2006b, 2006c, and 2008). The ambient river time series of velocity, salinity, and temperature were obtained from the EFDC simulation results.

Other input information required by the near field model included the following:

- Physical setup of the discharge
- Physical schematization of the channel cross section at the injection location.

For each of the three locations, a VP model was developed and results presented in this section. The ambient conditions were developed by the EFDC model at each location by simulating the 6-feet deepening with mitigation Plan 6A.

For the effluent conditions of the effluent, the following parameters were assigned:

- Flow = 12,500 gallons per minute (gpm) for each cone
- Salinity = ambient conditions (intake = discharge)
- Temperature = ambient conditions (intake = discharge)
- Dissolved Oxygen = 140 mg/L (based on 2007 Demonstration Project)
- Depth = time series based water surface elevation (tides)

The salinity and temperature conditions for the effluent were set to the ambient conditions because we assumed the intake and discharge depth were equal. In the 2007 Demonstration Project, the intake was 10 feet below the surface and the discharge was 30 feet below the surface. The modeling of the Demonstration Project showed that the mixing zone of the plume was short (~ 60 feet) and was not buoyant because of the short distance. For the purposes of this design report, we assumed the intake and discharge depths would be the same depth but separated by a horizontal distance of 600 feet.

Ambient conditions were based on the following parameters:

- Salinity = time series from EFDC model
- Temperature = time series from EFDC model
- Dissolved Oxygen = time series from EFDC model
- Velocity = time series from EFDC model

Pipe conditions were based on the following parameters:

- Diameter = 18 inches
- Angle = varies
- Port Depth = varies
- Number of Ports = one
- Port Spacing (intake to effluent) = minimum of 600 feet

Table 6-1 summarizes the details of each of the three effluent designs and Figures 6-2 through 6-4 show the vertical mixing zone results for all three locations.

Table 6-1 Design parameters for each of the three locations

Location	Effluent Flow (MGD)	Effluent DO (mg/L)	Port Elevation* (m)	Pipe Diameter (inches)	Horizontal Angle (degrees)	Vertical Angle (degrees)
Front River IP	108	140	2	18	0	20
Back River IP	72	140	1	18	0	0
Savannah River GP	108	140	1	18	0	0

* Port Elevation is the distance from the bottom of the channel to the effluent pipe, so it is measured from the bottom.

At all three locations, the dissolved oxygen concentrations are close to background within 20 meters of the effluent discharge.

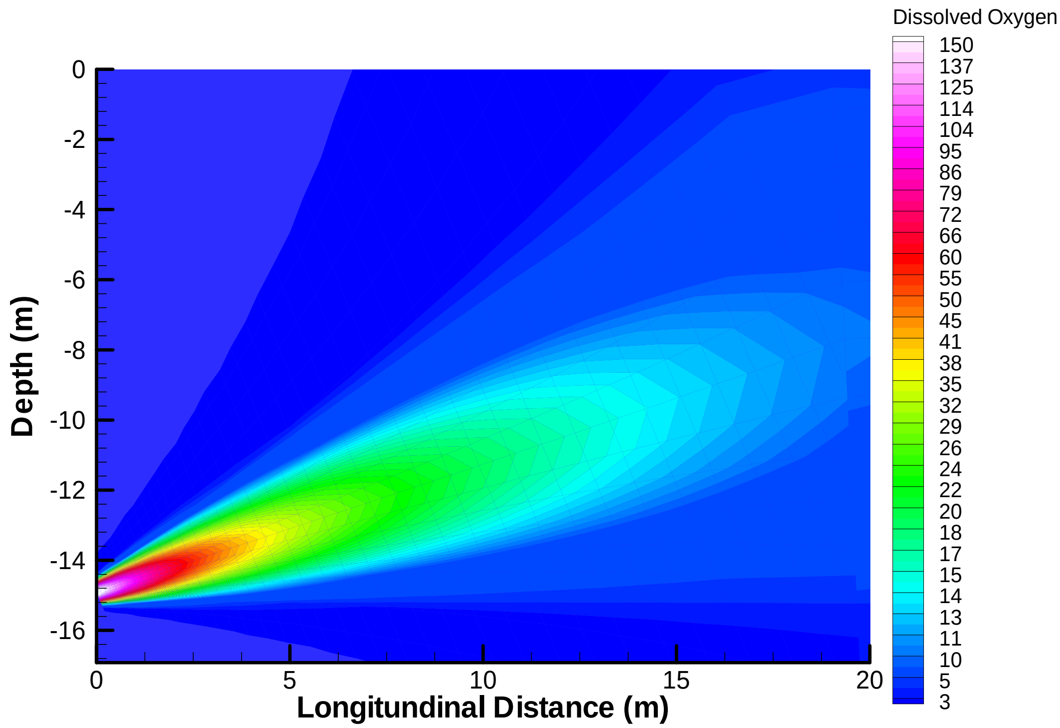

Figure 6-2 Visual Plume Model Results for Front River at International Paper

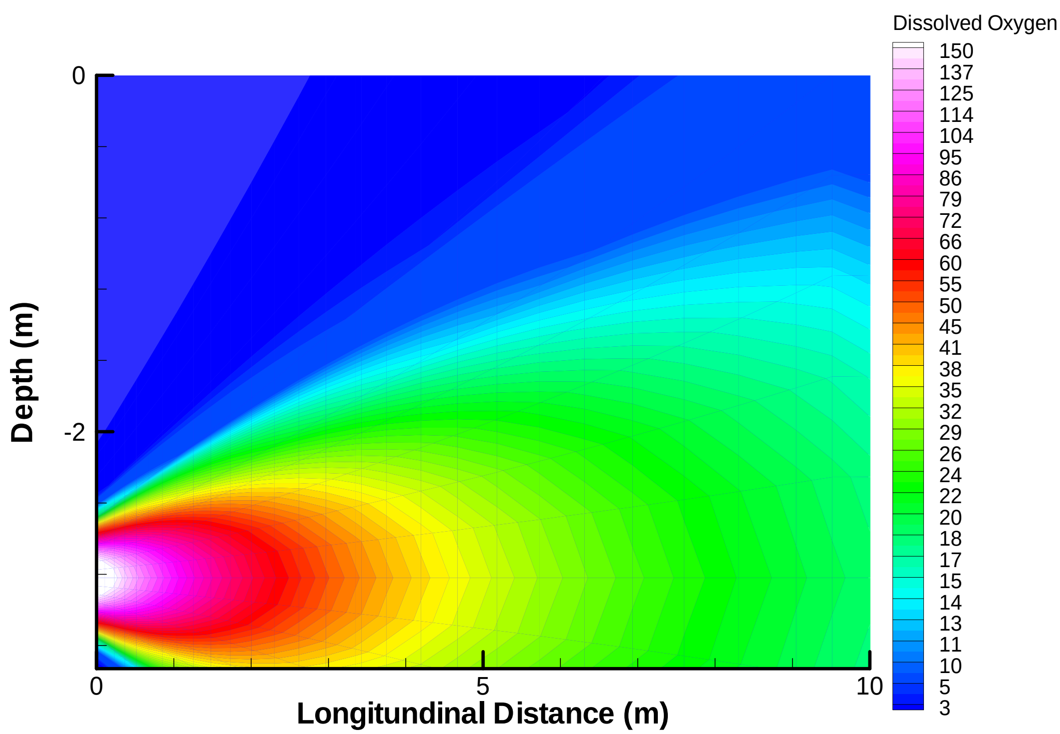

Figure 6-3 Visual Plume Model Results for Back River at International Paper

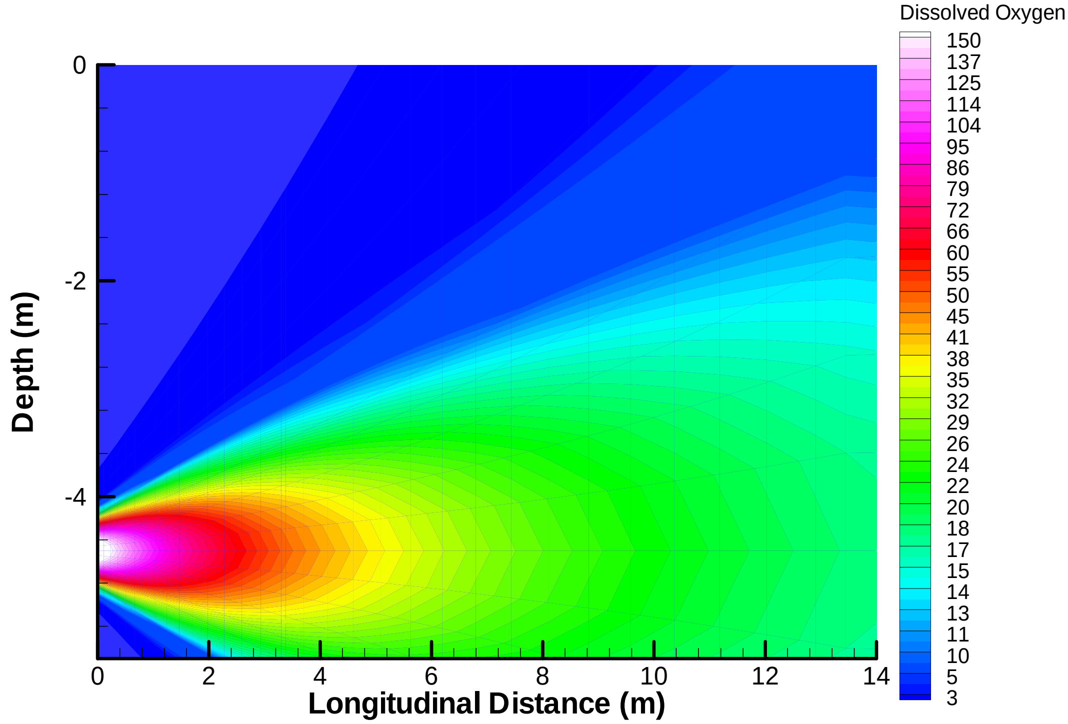

Figure 6-4 Visual Plume Model Results for Savannah River at Georgia Pacific

7.0 COST CONSIDERATIONS

This section describes cost considerations of installing and maintaining the oxygen injection systems. Capital costs include the purchasing, design, installing, and construction of the systems. Operating costs include the long-term maintenance of the systems. Tables 7-1 and 7-2 were developed to produce a cost estimate and summarize the installation and maintenance of one Speece Cone.

Table 7-1 Installation Cost Estimate of Speece Cone Land-Side Installation

Description of Work	Cost
One Speece Cone	$748,474
Design with Plans & Specs of grading, road, pad, house, & piping	$225,000
Construction (installation) of pumps, pipes, house, & cone	$342,500
Oxygen generator & compressor	$170,000
Subtotal	$1,485,974
Contingency (10%)	$148,597
TOTAL	$1,634,571

Table 7-2 Maintenance Cost Estimate of Speece Cone Land-Side Installation

Description of Work	Cost
Operating and energy cost (includes electrical, O&M, license)	$48,100
Maintenance of cone (labor of field technicians)	$43,000
TOTAL	$91,100

Therefore, the total cost of one cone is $1,634,571 (including contingency) and $91,100 per year in maintenance costs. Costs supplied by Eco2 (Eco2 2010) and previous MACTEC report (MACTEC 2008). See Appendix E for Eco2's quotation from March 17, 2010. These costs are based on generating oxygen on-site and supplying oxygen as needed. Therefore, no storage will be required.

Several assumptions were included and listed as the following:

- Above ground, land-side installation
- Oxygen generation on-site
- Speece Cone provides 5,000 lbs/day of oxygen
- Designed to consider 80% efficiency which is 4,000 lbs/day (regulators requested 80%)
- There would be a cost savings with more than one cone installed at a site (i.e., concrete pad, building, and piping may be overestimated)
- Design and construction considerations will be the elevation and soil conditions of the land, road and piping distances, and size of concrete pad
- Cones would run for approximately 180 days each year during the summer months

These costs do not include land procurement, utility installation, support building construction, or roadway construction as these are highly dependent on the sites selected. The support building would house equipment, control panels, oxygen generation equipment, and provide offseason storage of pumps, Speece Cone(s), and other equipment. Building costs will vary depending on the type (prefabricated, block, or concrete) and the finish required (some areas may have specific design requirements, i.e. brick, rock, etc.) for a specific location selected. These costs range from $150,000 to $300,000 or more. The below ground installation is more expensive because sheet piling and dewatering would be required during installation (MACTEC 2008).

8.0 CONCLUSIONS

The hydrodynamic and water quality models provided a tool to determine the amount of oxygen needed to mitigate for the deepening impacts on dissolved oxygen. With the expertise of Eco2, the designs were generated and summarized in Tables 8-1. The costs discussed in Section 7.0 were used to generate the cost at each of the three sites for each of the deepening scenarios. For each scenario, a mitigation plan (6A or 6B) was included.

Table 8-1 Summary of Dissolved Oxygen Loads and Cost (MITIGATION)

Scenario	Discharge Location	Load (kg/day)	Load (lb/day)	Cones	Cones (rounded)	Sum (kg/d)	Sum (lbs/d)	Cost at Each Site	Cost for Each Scenario
6 feet, Plan 6A	IP (FR)	7,000	15,432	3.86	4	18,000	39,683	$ 6,538,284	$ 16,345,710
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	9,000	19,842	4.96	5			$ 8,172,855	
5 feet, Plan 6A	IP (FR)	3,000	6,614	1.65	2	16,000	35,274	$ 3,269,142	$ 14,711,139
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	11,000	24,251	6.06	6			$ 9,807,426	
4 feet. Plan 6A	IP (FR)	2,000	4,409	1.10	1	14,000	30,865	$ 1,634,571	$ 13,076,568
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	10,000	22,046	5.51	6			$ 9,807,426	
3 feet, Plan 6A	IP (FR)	1,000	2,205	0.55	1	13,000	28,660	$ 1,634,571	$ 13,076,568
	IP (BR)	2,000	4,409	1.10	1			$ 1,634,571	
	Georgia-Pacific	10,000	22,046	5.51	6			$ 9,807,426	
2 feet, Plan 6B	IP (FR)	1,000	2,205	0.55	1	15,000	33,069	$ 1,634,571	$ 14,711,139
	IP (BR)	4,000	8,818	2.20	2			$ 3,269,142	
	Georgia-Pacific	10,000	22,046	5.51	6			$ 9,807,426	

*Three bottom layer criteria (3BL) were used to generate final results.

The costs for operating the dissolved oxygen injection systems are based on their continued operation for a period of 180 days per year. The operational costs are assumed to be uniform throughout that 180-day period. The operating costs would be less if the systems were operated for a shorter duration.

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APPENDICES

APPENDIX A

DISSOLVED OXYGEN REGIME OF SAVANNAH ESTUARY: AUGUST 1997 (AVERAGE FLOW), ALTERNATIVE DEEPENING WITH MITIGATION PLANS 6A AND 6B, NO D.O. INJECTION

TABLES AND FIGURES

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Table A-1 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 6 ft deepening, No injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.02	0.5	0.02	0.5	0.01	0.2	0	0.0	-0.03	-0.7	-0.05	-1.1	-0.09	-1.9	-0.11	-2.3	-0.1	-2.1
FR2	-0.06	-1.6	0.26	6.9	0.4	10.4	0.44	10.9	0.4	9.5	0.38	8.6	0.28	6.1	0.4	8.5	0.23	4.5
FR3	0.12	3.4	0.07	1.9	0.06	1.6	0.06	1.6	-0.03	-0.7	-0.13	-3.0	-0.25	-5.2	-0.11	-2.2	-0.24	-4.3
FR4	0.12	3.4	0.1	2.8	0.1	2.8	0.01	0.3	-0.02	-0.5	-0.16	-3.6	-0.38	-7.7	-0.31	-5.8	-0.03	-0.5
FR5	0.12	3.3	0.04	1.1	-0.04	-1.0	-0.06	-1.5	-0.16	-3.7	-0.61	-12.5	-0.75	-13.8	-0.79	-14.0	-0.75	-13.0
FR6	0.03	0.8	0.05	1.3	0	0.0	-0.06	-1.5	-0.08	-1.9	-0.45	-9.4	-0.83	-14.9	-0.84	-14.6	-0.76	-12.9
FR7	-0.18	-4.3	-0.13	-3.1	-0.14	-3.2	-0.29	-6.3	-0.54	-10.7	-1.11	-18.6	-0.65	-10.4	-0.31	-4.9	-0.19	-2.9
FR8	-0.3	-6.4	-0.3	-6.3	-0.42	-8.3	-0.62	-11.3	-0.4	-6.5	-0.12	-1.9	-0.15	-2.2	-0.13	-1.9	-0.27	-3.8
FR9	0.24	4.9	0.46	9.1	0.31	5.8	0.26	4.5	0.06	1.0	0.02	0.3	0.06	0.9	0.12	1.7	0.3	4.2
FR10	0.38	8.8	0.26	5.4	0.29	5.9	0.23	4.3	-0.01	-0.2	-0.1	-1.6	-0.09	-1.3	-0.16	-2.3	-0.06	-0.8
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.23	-5.2	-0.21	-4.6	-0.21	-4.5	-0.25	-5.1	-0.26	-5.0	-0.44	-7.9	-0.46	-7.8	-0.46	-7.7	-0.25	-4.0
MR2	0.19	4.7	0.2	4.8	0.14	3.2	0.08	1.7	-0.12	-2.4	-0.33	-6.0	-0.29	-5.0	-0.29	-4.9	-0.29	-4.8
MR3	0.49	13.2	0.45	11.6	0.44	11.0	0.42	10.0	0.42	9.3	0.08	1.6	-0.33	-5.8	-0.37	-6.2	-0.41	-6.6
MR4	0.46	11.8	0.41	10.2	0.45	10.9	0.37	8.4	0.44	9.5	0.43	8.8	0.53	10.5	0.52	10.0	0.58	10.7
MR5	0.71	47.7	0.73	35.8	0.71	29.5	0.82	26.9	0.39	7.8	-0.03	-0.5	-0.05	-0.8	-0.11	-1.6	-0.08	-1.1
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.5	14.0	0.47	10.8	0.35	7.4	0.37	7.2	0.37	6.8	0.46	8.2	0.35	5.9	0.38	6.2	0.23	3.6
LBR2	0.6	16.3	0.71	18.4	0.72	18.1	0.77	18.5	0.76	17.3	0.79	17.2	0.79	16.6	0.82	16.8	0.55	10.5
LBR3	-0.38	-13.1	-0.62	-18.9	-0.67	-19.3	-0.66	-17.9	-0.65	-16.5	-0.7	-16.1	-0.91	-19.2	-1.08	-21.6	-1.18	-22.5
BR1	-1.42	-41.2	-0.86	-24.4	-0.43	-12.0	-0.09	-2.3	0.25	6.2	0.39	9.2	0.25	5.5	0.23	5.0	0.27	5.8
BR2	-0.93	-36.5	-0.86	-30.3	-0.81	-27.1	-0.67	-20.7	-0.4	-11.6	-0.07	-1.9	0.09	2.3	0.09	2.3	0.11	2.7
BR3	-1.23	-40.6	-1.23	-37.7	-1.3	-37.8	-1.32	-36.5	-1.23	-32.5	-0.93	-23.5	-0.61	-15.0	-0.55	-13.3	-0.43	-10.1
SCH1	-0.15	-6.3	-0.04	-1.6	0.01	0.4	0.03	1.1	0.15	5.0	0.54	15.8	0.47	12.5	0.53	13.6	0.46	11.1
SCH2	-0.04	-1.1	-0.11	-2.8	-0.1	-2.5	-0.02	-0.5	-0.05	-1.2	-0.06	-1.3	-0.07	-1.5	-0.08	-1.7	-0.13	-2.7
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	-0.16	-4.2	0.09	2.1	-0.04	-0.9	0.03	0.6	-0.07	-1.2	-0.19	-3.1	-0.19	-2.9	-0.25	-3.8	-0.22	-3.2

Table A-2 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 5 ft deepening, No injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.01	0.3	0	0.0	0	0.0	-0.02	-0.5	-0.04	-0.9	-0.04	-0.9	-0.07	-1.5	-0.1	-2.1	-0.09	-1.9
FR2	-0.14	-3.8	0.2	5.3	0.38	9.9	0.44	10.9	0.39	9.2	0.38	8.6	0.3	6.5	0.41	8.7	0.23	4.5
FR3	0.12	3.4	0.07	1.9	0.06	1.6	0.04	1.0	-0.01	-0.2	-0.07	-1.6	-0.2	-4.2	0.02	0.4	-0.13	-2.3
FR4	0.11	3.1	0.1	2.8	0.08	2.2	0	0.0	-0.04	-1.0	-0.2	-4.5	-0.36	-7.3	-0.29	-5.5	0.03	0.5
FR5	0.11	3.0	0.04	1.1	-0.01	-0.3	-0.03	-0.7	-0.13	-3.0	-0.51	-10.4	-0.59	-10.9	-0.56	-9.9	-0.5	-8.7
FR6	0.03	0.8	0.07	1.9	0	0.0	-0.05	-1.2	-0.07	-1.6	-0.4	-8.4	-0.71	-12.7	-0.62	-10.7	-0.57	-9.6
FR7	0.23	5.5	0.28	6.6	0.32	7.4	0.28	6.1	0.42	8.3	-0.05	-0.8	0.05	0.8	0.19	3.0	0.63	9.7
FR8	-0.27	-5.8	-0.26	-5.4	-0.38	-7.5	-0.54	-9.8	-0.27	-4.4	-0.06	-0.9	-0.11	-1.6	-0.12	-1.8	-0.23	-3.2
FR9	0.03	0.6	0.29	5.8	0.15	2.8	0.25	4.4	0.1	1.6	0.09	1.4	0.17	2.5	0.18	2.6	0.17	2.4
FR10	0.38	8.8	0.26	5.4	0.28	5.7	0.23	4.3	-0.02	-0.3	-0.11	-1.7	-0.08	-1.2	-0.16	-2.3	-0.06	-0.8
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.21	-4.8	-0.19	-4.2	-0.19	-4.1	-0.23	-4.7	-0.22	-4.3	-0.42	-7.5	-0.42	-7.1	-0.34	-5.7	-0.23	-3.7
MR2	0.19	4.7	0.21	5.1	0.16	3.7	0.09	1.9	-0.09	-1.8	-0.29	-5.2	-0.25	-4.3	-0.22	-3.7	-0.25	-4.1
MR3	0.49	13.2	0.47	12.1	0.44	11.0	0.45	10.7	0.42	9.3	0.12	2.4	-0.3	-5.3	-0.33	-5.6	-0.36	-5.8
MR4	0.47	12.1	0.42	10.4	0.47	11.4	0.38	8.7	0.45	9.8	0.41	8.4	0.53	10.5	0.51	9.8	0.58	10.7
MR5	0.71	47.7	0.74	36.3	0.71	29.5	0.81	26.6	0.39	7.8	-0.04	-0.6	-0.04	-0.6	-0.11	-1.6	-0.08	-1.1
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.49	13.7	0.47	10.8	0.37	7.8	0.36	7.0	0.37	6.8	0.46	8.2	0.35	5.9	0.39	6.3	0.23	3.6
LBR2	0.79	21.4	0.71	18.4	0.72	18.1	0.76	18.3	0.75	17.1	0.78	17.0	0.79	16.6	0.8	16.4	0.55	10.5
LBR3	-0.35	-12.1	-0.61	-18.6	-0.65	-18.7	-0.64	-17.4	-0.63	-15.9	-0.71	-16.4	-0.91	-19.2	-1.1	-22.0	-1.22	-23.3
BR1	-1.53	-44.3	-1.01	-28.7	-0.54	-15.0	-0.11	-2.8	0.22	5.5	0.37	8.7	0.26	5.7	0.24	5.2	0.29	6.2
BR2	-0.96	-37.6	-1.04	-36.6	-1.01	-33.8	-0.88	-27.2	-0.68	-19.8	-0.64	-17.3	-0.52	-13.5	-0.52	-13.2	-0.47	-11.7
BR3	-1.31	-43.2	-1.31	-40.2	-1.39	-40.4	-1.4	-38.7	-1.31	-34.7	-1.03	-26.1	-0.68	-16.7	-0.62	-14.9	-0.51	-12.0
SCH1	-0.09	-3.8	-0.1	-3.9	0	0.0	0.08	2.8	0.04	1.3	-0.13	-3.8	-0.13	-3.4	-0.11	-2.8	-0.23	-5.6
SCH2	-0.06	-1.6	-0.11	-2.8	-0.09	-2.2	-0.05	-1.2	-0.05	-1.2	-0.04	-0.9	-0.05	-1.1	-0.07	-1.5	-0.06	-1.2
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	-0.09	-2.3	0.08	1.9	0.02	0.4	0.07	1.4	-0.02	-0.4	-0.15	-2.4	-0.17	-2.6	-0.19	-2.9	-0.18	-2.6

Table A-3 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 4 ft deepening, No injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0	0.0	-0.02	-0.5	-0.03	-0.7	-0.01	-0.2	-0.05	-1.1	-0.03	-0.7	-0.04	-0.9	-0.06	-1.3	-0.06	-1.3
FR2	-0.16	-4.4	0.19	5.1	0.37	9.6	0.43	10.7	0.4	9.5	0.4	9.1	0.31	6.7	0.42	9.0	0.24	4.7
FR3	0.1	2.9	0.05	1.4	0.04	1.1	0.06	1.6	0	0.0	-0.06	-1.4	-0.13	-2.7	0.09	1.8	-0.08	-1.4
FR4	0.09	2.6	0.08	2.2	0.08	2.2	0.01	0.3	-0.01	-0.2	-0.17	-3.9	-0.31	-6.2	-0.19	-3.6	0.1	1.8
FR5	0.1	2.8	0.01	0.3	-0.07	-1.8	-0.06	-1.5	-0.17	-3.9	-0.59	-12.1	-0.6	-11.1	-0.6	-10.7	-0.57	-9.9
FR6	0.05	1.4	0.07	1.9	0.01	0.3	-0.04	-1.0	-0.05	-1.2	-0.38	-7.9	-0.57	-10.2	-0.44	-7.6	-0.43	-7.3
FR7	0.51	12.2	0.58	13.6	0.7	16.2	0.73	15.8	0.82	16.3	0.31	5.2	0.27	4.3	0.4	6.3	0.63	9.7
FR8	-0.22	-4.7	-0.22	-4.6	-0.31	-6.1	-0.48	-8.7	-0.18	-2.9	-0.04	-0.6	-0.07	-1.0	-0.09	-1.3	-0.22	-3.1
FR9	-0.28	-5.7	-0.35	-7.0	-0.47	-8.8	-0.6	-10.5	-0.4	-6.4	-0.22	-3.3	-0.19	-2.8	-0.27	-3.8	-0.18	-2.5
FR10	0.38	8.8	0.26	5.4	0.27	5.5	0.24	4.5	-0.01	-0.2	-0.12	-1.9	-0.08	-1.2	-0.15	-2.1	-0.07	-1.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.17	-3.9	-0.16	-3.5	-0.14	-3.0	-0.2	-4.1	-0.19	-3.7	-0.37	-6.6	-0.32	-5.4	-0.27	-4.5	-0.12	-1.9
MR2	0.21	5.2	0.23	5.5	0.16	3.7	0.1	2.2	-0.06	-1.2	-0.26	-4.7	-0.22	-3.8	-0.18	-3.1	-0.2	-3.3
MR3	0.52	14.1	0.41	10.5	0.43	10.8	0.47	11.2	0.39	8.6	0.06	1.2	-0.37	-6.5	-0.47	-7.9	-0.48	-7.8
MR4	0.47	12.1	0.42	10.4	0.47	11.4	0.39	8.9	0.45	9.8	0.45	9.2	0.51	10.1	0.51	9.8	0.57	10.5
MR5	0.71	47.7	0.74	36.3	0.71	29.5	0.81	26.6	0.38	7.6	-0.03	-0.5	-0.04	-0.6	-0.11	-1.6	-0.07	-1.0
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.46	12.9	0.46	10.6	0.38	8.0	0.36	7.0	0.37	6.8	0.46	8.2	0.35	5.9	0.39	6.3	0.21	3.2
LBR2	0	0.0	0.7	18.1	0.71	17.9	0.77	18.5	0.75	17.1	0.78	17.0	0.78	16.4	0.8	16.4	0.54	10.3
LBR3	-0.3	-10.4	-0.6	-18.3	-0.63	-18.2	-0.62	-16.8	-0.62	-15.7	-0.7	-16.1	-0.92	-19.5	-1.1	-22.0	-1.2	-22.9
BR1	-1.63	-47.2	-1.18	-33.5	-0.61	-17.0	-0.16	-4.1	0.21	5.2	0.38	9.0	0.26	5.7	0.24	5.2	0.29	6.2
BR2	-1.14	-44.7	-1.05	-37.0	-1	-33.4	-0.82	-25.3	-0.51	-14.8	-0.15	-4.1	0.02	0.5	0.06	1.5	0.13	3.2
BR3	-1.41	-46.5	-1.41	-43.3	-1.45	-42.2	-1.46	-40.3	-1.37	-36.2	-1.13	-28.6	-0.74	-18.1	-0.66	-15.9	-0.59	-13.9
SCH1	-0.11	-4.6	-0.1	-3.9	0.02	0.7	0.07	2.5	0.04	1.3	-0.13	-3.8	-0.16	-4.2	-0.09	-2.3	-0.14	-3.4
SCH2	-0.04	-1.1	-0.05	-1.3	-0.06	-1.5	-0.05	-1.2	-0.06	-1.4	-0.07	-1.6	-0.06	-1.3	-0.06	-1.3	-0.05	-1.0
SR	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	-0.02	-0.5	0.1	2.4	0.07	1.5	0.11	2.2	-0.02	-0.4	-0.09	-1.5	-0.13	-2.0	-0.15	-2.3	-0.19	-2.8

Table A-4 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 3 ft deepening, No injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.01	0.3	-0.01	-0.3	-0.02	-0.5	-0.02	-0.5	-0.04	-0.9	-0.02	-0.4	-0.02	-0.4	-0.06	-1.3	-0.03	-0.6
FR2	-0.15	-4.1	0.19	5.1	0.38	9.9	0.43	10.7	0.4	9.5	0.41	9.3	0.31	6.7	0.43	9.2	0.23	4.5
FR3	0.1	2.9	0.05	1.4	0.05	1.4	0.08	2.1	0.03	0.7	0.01	0.2	-0.1	-2.1	0.13	2.6	-0.05	-0.9
FR4	0.1	2.9	0.08	2.2	0.07	1.9	0.05	1.3	0.01	0.2	-0.11	-2.5	-0.2	-4.0	-0.08	-1.5	0.11	2.0
FR5	0.1	2.8	0.03	0.8	-0.03	-0.8	-0.02	-0.5	-0.11	-2.6	-0.51	-10.4	-0.41	-7.6	-0.36	-6.4	-0.31	-5.4
FR6	0.07	1.9	0.08	2.1	0.02	0.5	0	0.0	-0.02	-0.5	-0.31	-6.5	-0.39	-7.0	-0.29	-5.0	-0.28	-4.7
FR7	-0.11	-2.6	-0.07	-1.6	-0.1	-2.3	-0.2	-4.3	-0.37	-7.4	-0.6	-10.0	-0.21	-3.4	-0.15	-2.4	-0.1	-1.5
FR8	-0.19	-4.1	-0.22	-4.6	-0.34	-6.7	-0.48	-8.7	-0.25	-4.1	-0.18	-2.8	-0.21	-3.1	-0.19	-2.8	-0.25	-3.5
FR9	-0.23	-4.7	-0.3	-6.0	-0.41	-7.7	-0.49	-8.6	-0.31	-4.9	-0.17	-2.6	-0.17	-2.5	-0.26	-3.7	-0.18	-2.5
FR10	0.38	8.8	0.26	5.4	0.27	5.5	0.23	4.3	-0.01	-0.2	-0.12	-1.9	-0.08	-1.2	-0.16	-2.3	-0.07	-1.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.13	-2.9	-0.13	-2.9	-0.09	-1.9	-0.15	-3.1	-0.14	-2.7	-0.3	-5.4	-0.21	-3.6	-0.18	-3.0	-0.08	-1.3
MR2	0.21	5.2	0.24	5.8	0.18	4.2	0.11	2.4	-0.05	-1.0	-0.2	-3.6	-0.17	-2.9	-0.1	-1.7	-0.13	-2.2
MR3	0.52	14.1	0.5	12.9	0.47	11.8	0.49	11.7	0.43	9.5	0.15	3.0	-0.22	-3.9	-0.25	-4.2	-0.3	-4.8
MR4	0.5	12.9	0.43	10.7	0.48	11.7	0.39	8.9	0.44	9.5	0.41	8.4	0.51	10.1	0.5	9.7	0.56	10.4
MR5	0.72	48.3	0.76	37.3	0.7	29.0	0.79	25.9	0.38	7.6	-0.04	-0.6	-0.05	-0.8	-0.11	-1.6	-0.07	-1.0
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	0.44	12.3	0.47	10.8	0.39	8.2	0.35	6.8	0.35	6.4	0.45	8.0	0.34	5.7	0.37	6.0	0.2	3.1
LBR2	0.79	21.4	0.73	18.9	0.73	18.4	0.76	18.3	0.75	17.1	0.79	17.2	0.79	16.6	0.82	16.8	1.22	23.2
LBR3	-0.3	-10.4	-0.58	-17.7	-0.61	-17.6	-0.61	-16.6	-0.6	-15.2	-0.7	-16.1	-0.91	-19.2	-1.09	-21.8	-1.2	-22.9
BR1	-1.76	-51.0	-1.32	-37.5	-0.77	-21.4	-0.21	-5.4	0.23	5.7	0.37	8.7	0.27	5.9	0.25	5.4	0.31	6.6
BR2	-1.26	-49.4	-1.31	-46.1	-1.25	-41.8	-1.02	-31.5	-0.79	-23.0	-0.74	-20.0	-0.64	-16.7	-0.63	-16.0	-0.57	-14.1
BR3	-1.55	-51.2	-1.51	-46.3	-1.57	-45.6	-1.54	-42.5	-1.44	-38.1	-1.21	-30.6	-0.8	-19.6	-0.74	-17.8	-0.61	-14.4
SCH1	-0.17	-7.1	0	0.0	0	0.0	0.04	1.4	0.2	6.6	0.62	18.2	0.56	14.9	0.56	14.4	0.47	11.4
SCH2	0	0.0	-0.06	-1.5	-0.03	-0.7	-0.04	-1.0	-0.04	-0.9	-0.04	-0.9	-0.05	-1.1	-0.04	-0.9	-0.04	-0.8
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	0.11	2.9	0.14	3.3	0.12	2.6	0.13	2.6	-0.01	-0.2	-0.07	-1.1	-0.11	-1.7	-0.11	-1.7	-0.12	-1.8

Table A-5 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6b, 2 ft deepening, No injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	-0.02	-0.5	-0.03	-0.8	-0.05	-1.2	-0.03	-0.7	-0.04	-0.9	0	0.0	-0.02	-0.4	-0.03	-0.6	-0.01	-0.2
FR2	-0.25	-6.8	0.12	3.2	0.28	7.3	0.41	10.2	0.38	9.0	0.41	9.3	0.35	7.6	0.45	9.6	0.26	5.1
FR3	0.09	2.6	0.02	0.6	0.05	1.4	0.07	1.8	0.03	0.7	0.03	0.7	0.07	1.5	0.18	3.6	0	0.0
FR4	0.07	2.0	0.06	1.7	0.06	1.7	0.03	0.8	0.03	0.7	-0.06	-1.4	-0.13	-2.6	-0.09	-1.7	0.03	0.5
FR5	0.08	2.2	0	0.0	-0.09	-2.3	-0.05	-1.2	-0.15	-3.5	-0.5	-10.2	-0.35	-6.5	-0.28	-5.0	-0.23	-4.0
FR6	0.06	1.6	0.08	2.1	0.02	0.5	0	0.0	0	0.0	-0.25	-5.2	-0.25	-4.5	-0.18	-3.1	-0.19	-3.2
FR7	0.38	9.1	0.4	9.4	0.47	10.9	0.45	9.8	0.58	11.5	0.13	2.2	0.12	1.9	0.17	2.7	0.54	8.3
FR8	-0.14	-3.0	-0.17	-3.6	-0.28	-5.5	-0.4	-7.3	-0.16	-2.6	-0.12	-1.9	-0.18	-2.7	-0.17	-2.5	-0.22	-3.1
FR9	0.28	5.7	0.61	12.1	0.47	8.8	0.44	7.7	0.18	2.9	0.15	2.3	0.21	3.1	0.16	2.3	0.16	2.2
FR10	0.3	7.0	0.23	4.8	0.19	3.8	0.16	3.0	-0.05	-0.8	-0.17	-2.6	-0.1	-1.5	-0.24	-3.4	-0.09	-1.2
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	-0.1	-2.3	-0.1	-2.2	-0.05	-1.1	-0.13	-2.7	-0.13	-2.5	-0.27	-4.8	-0.15	-2.5	-0.09	-1.5	-0.04	-0.6
MR2	0.16	4.0	0.17	4.1	0.07	1.6	0.02	0.4	-0.13	-2.6	-0.21	-3.8	-0.11	-1.9	-0.09	-1.5	-0.09	-1.5
MR3	0.41	11.1	0.32	8.2	0.34	8.5	0.32	7.6	0.28	6.2	0.01	0.2	-0.43	-7.5	-0.45	-7.6	-0.47	-7.6
MR4	-0.05	-1.3	0.65	16.1	0.79	19.2	0.82	18.7	0.86	18.7	0.88	18.0	1	19.8	1.07	20.7	1.31	24.2
MR5	-0.09	-6.0	-0.48	-23.5	-0.59	-24.5	-0.5	-16.4	0.04	0.8	-0.12	-1.9	-0.12	-1.8	-0.17	-2.5	-0.13	-1.8
MR6	3.32	157.3	3.37	135.3	3.16	105.0	3.03	86.3	1.19	21.2	0.79	12.4	0.58	8.5	0.41	5.8	0.25	3.4
LBR1	-0.39	-10.9	-0.14	-3.2	0.08	1.7	0.13	2.5	0.07	1.3	0.16	2.8	0.11	1.8	0.13	2.1	0.05	0.8
LBR2	0.14	3.8	0.26	6.7	0.24	6.0	0.25	6.0	0.25	5.7	0.27	5.9	0.25	5.2	0.3	6.1	0.43	8.2
LBR3	-1.13	-39.1	-1.32	-40.2	-1.4	-40.3	-1.29	-35.1	-1.21	-30.6	-1.25	-28.8	-1.43	-30.2	-1.56	-31.3	-1.71	-32.6
BR1	-2.32	-67.2	-1.76	-50.0	-1.04	-29.0	-0.37	-9.5	0.17	4.2	0.36	8.5	0.27	5.9	0.26	5.6	0.32	6.8
BR2	-1.93	-75.7	-1.95	-68.7	-1.83	-61.2	-1.41	-43.5	-1.06	-30.8	-1.02	-27.6	-0.87	-22.7	-0.82	-20.9	-0.75	-18.6
BR3	-2.22	-73.3	-2.19	-67.2	-2.21	-64.2	-2.14	-59.1	-2.03	-53.7	-1.57	-39.7	-1.08	-26.5	-0.97	-23.4	-0.87	-20.5
SCH1	-0.06	-2.5	-0.06	-2.3	0	0.0	0.02	0.7	0.04	1.3	-0.11	-3.2	-0.11	-2.9	-0.07	-1.8	-0.14	-3.4
SCH2	0	0.0	-0.04	-1.0	-0.04	-1.0	-0.04	-1.0	-0.04	-0.9	-0.04	-0.9	-0.04	-0.9	-0.04	-0.9	-0.01	-0.2
SR	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	0	0.0	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2	-0.01	-0.2
StbR	0.23	6.0	0.26	6.2	0.17	3.7	0.18	3.6	0.02	0.4	-0.06	-1.0	-0.07	-1.1	-0.07	-1.1	-0.06	-0.9

Table A-6 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 6 ft deepening, No injections

Zone Name	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.05	-0.07	-0.07	-0.04	-0.07	-0.09	-0.13	-0.11	-0.13	-1.2	-1.6	-1.7	-0.9	-1.5	-1.9	-2.6	-2.3	-2.5
FR2	0.03	-0.02	-0.04	-0.03	-0.07	-0.09	-0.14	-0.14	-0.14	0.7	-0.5	-1.0	-0.7	-1.6	-1.9	-2.8	-2.9	-2.8
FR3	-0.08	-0.07	-0.06	-0.08	-0.10	-0.16	-0.26	-0.39	-0.52	-2.0	-1.6	-1.4	-1.8	-2.1	-3.3	-5.3	-7.6	-9.9
FR4	-0.11	-0.10	-0.12	-0.12	-0.20	-0.37	-0.56	-0.71	-0.77	-2.6	-2.4	-2.9	-2.8	-4.4	-7.6	-10.7	-12.6	-13.1
FR5	-0.11	-0.15	-0.15	-0.19	-0.30	-0.52	-0.75	-0.71	-0.63	-2.7	-3.5	-3.5	-4.2	-6.3	-10.0	-13.2	-12.0	-10.4
FR6	-0.15	-0.19	-0.27	-0.32	-0.52	-0.74	-0.82	-0.57	-0.48	-3.6	-4.4	-6.0	-6.9	-10.3	-13.2	-13.6	-9.4	-7.8
FR7	-0.28	-0.36	-0.42	-0.53	-0.69	-0.45	-0.38	-0.37	-0.38	-6.0	-7.4	-8.4	-10.0	-11.5	-7.1	-5.8	-5.5	-5.5
FR8	-0.40	-0.54	-0.54	-0.60	-0.49	-0.29	-0.26	-0.35	-0.33	-7.8	-10.0	-9.8	-10.2	-7.7	-4.3	-3.8	-4.9	-4.6
FR9	-0.56	-0.50	-0.50	-0.37	-0.23	-0.19	-0.23	-0.19	-0.16	-9.7	-8.3	-8.1	-5.8	-3.5	-2.7	-3.1	-2.6	-2.2
FR10	-0.21	-0.09	-0.10	-0.12	-0.10	-0.08	-0.07	-0.07	-0.08	-3.6	-1.6	-1.6	-1.8	-1.5	-1.2	-0.9	-1.0	-1.0
FR11	-0.42	-0.40	-0.41	-0.44	-0.47	-0.46	-0.52	-0.51	-0.48	-7.3	-6.8	-6.9	-7.0	-7.1	-6.7	-7.1	-7.1	-6.5
MR1	-0.27	-0.28	-0.28	-0.30	-0.33	-0.45	-0.40	-0.39	-0.34	-5.6	-5.8	-5.6	-5.7	-6.0	-7.6	-6.7	-6.3	-5.5
MR2	-0.02	-0.04	-0.09	-0.15	-0.24	-0.40	-0.40	-0.39	-0.27	-0.4	-0.8	-1.7	-2.8	-4.3	-6.8	-6.5	-6.4	-4.3
MR3	0.24	0.16	0.14	0.12	0.05	-0.14	-0.31	-0.31	-0.36	5.3	3.4	3.0	2.4	1.0	-2.5	-5.1	-5.0	-5.7
MR4	0.13	0.06	0.13	0.18	0.16	0.17	0.21	0.29	0.30	2.6	1.2	2.5	3.2	2.8	2.9	3.5	4.7	4.8
MR5	0.04	0.14	0.15	0.14	0.03	-0.05	-0.07	-0.15	-0.07	1.1	3.1	3.2	2.8	0.6	-0.7	-1.0	-2.2	-0.9
MR6	-0.16	-0.25	-0.34	-0.44	-0.89	-1.16	-1.41	-1.48	-1.64	-3.8	-5.6	-7.1	-8.6	-15.1	-17.9	-20.2	-20.8	-22.3
LBR1	0.14	0.16	0.22	0.21	0.25	0.30	0.35	0.41	0.41	3.0	3.3	4.2	4.0	4.5	5.3	5.9	6.9	6.8
LBR2	0.33	0.29	0.28	0.35	0.36	0.37	0.46	0.45	0.43	7.5	6.4	6.1	7.2	7.0	7.0	8.6	8.3	7.8
LBR3	-0.28	-0.18	-0.14	-0.13	-0.09	0.01	0.10	0.14	0.23	-6.7	-4.4	-3.3	-2.9	-2.0	0.3	2.1	2.8	4.6
BR1	-0.86	-0.46	-0.28	-0.07	0.12	0.12	0.11	0.08	0.09	-23.1	-12.0	-7.0	-1.7	2.7	2.7	2.4	1.7	1.9
BR2	-1.08	-1.04	-1.01	-0.94	-0.63	-0.13	-0.05	-0.18	-0.12	-29.9	-28.3	-27.0	-24.5	-15.7	-3.0	-1.1	-4.0	-2.6
BR3	-1.07	-1.02	-1.00	-0.94	-0.94	-0.86	-0.72	-0.62	-0.63	-28.1	-26.8	-26.1	-24.0	-23.2	-20.5	-16.8	-14.3	-14.2
SCh1	-0.22	-0.20	-0.19	-0.14	-0.14	-0.18	-0.21	-0.21	-0.21	-5.2	-4.7	-4.5	-3.3	-3.2	-4.1	-4.5	-4.4	-4.3
SCh2	-0.17	-0.13	-0.16	-0.13	-0.13	-0.17	-0.19	-0.17	-0.23	-3.9	-3.0	-3.5	-2.9	-2.7	-3.4	-3.8	-3.4	-4.5
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.21	-0.14	-0.18	-0.22	-0.22	-0.25	-0.28	-0.35	-0.43	-3.9	-2.6	-3.3	-3.9	-3.6	-4.0	-4.3	-5.3	-6.4

Table A-7 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 5 ft deepening, No injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.06	-0.09	-0.07	-0.05	-0.08	-0.10	-0.12	-0.10	-0.12	-1.4	-2.0	-1.6	-1.2	-1.7	-2.0	-2.5	-2.1	-2.5
FR2	0.02	-0.03	-0.04	-0.03	-0.08	-0.08	-0.12	-0.14	-0.14	0.5	-0.7	-0.9	-0.7	-1.7	-1.6	-2.5	-2.8	-2.8
FR3	-0.08	-0.07	-0.06	-0.09	-0.10	-0.15	-0.23	-0.36	-0.49	-2.1	-1.8	-1.6	-2.1	-2.2	-3.3	-4.7	-7.1	-9.3
FR4	-0.11	-0.10	-0.12	-0.12	-0.20	-0.35	-0.50	-0.63	-0.63	-2.8	-2.5	-2.9	-2.8	-4.4	-7.2	-9.5	-11.2	-10.7
FR5	-0.11	-0.15	-0.15	-0.18	-0.28	-0.48	-0.64	-0.57	-0.50	-2.6	-3.5	-3.3	-4.0	-6.0	-9.3	-11.3	-9.7	-8.3
FR6	-0.14	-0.19	-0.27	-0.30	-0.49	-0.66	-0.67	-0.46	-0.37	-3.4	-4.3	-5.9	-6.5	-9.6	-11.9	-11.2	-7.5	-5.9
FR7	-0.26	-0.33	-0.38	-0.48	-0.61	-0.37	-0.33	-0.34	-0.38	-5.6	-6.8	-7.7	-9.1	-10.2	-5.9	-5.1	-5.1	-5.5
FR8	-0.36	-0.49	-0.51	-0.56	-0.38	-0.25	-0.24	-0.32	-0.25	-7.0	-9.1	-9.2	-9.5	-6.0	-3.8	-3.5	-4.5	-3.4
FR9	-0.49	-0.42	-0.42	-0.31	-0.20	-0.17	-0.20	-0.16	-0.13	-8.5	-7.0	-6.9	-4.8	-3.0	-2.5	-2.8	-2.1	-1.7
FR10	-0.22	-0.09	-0.10	-0.12	-0.10	-0.08	-0.05	-0.06	-0.07	-3.6	-1.6	-1.6	-1.8	-1.5	-1.2	-0.7	-0.8	-1.0
FR11	-0.42	-0.40	-0.41	-0.45	-0.47	-0.46	-0.52	-0.51	-0.48	-7.3	-6.8	-6.8	-7.0	-7.1	-6.7	-7.1	-7.1	-6.5
MR1	-0.26	-0.26	-0.26	-0.27	-0.30	-0.41	-0.36	-0.31	-0.35	-5.3	-5.4	-5.2	-5.2	-5.3	-7.0	-5.9	-5.1	-5.5
MR2	0.00	-0.03	-0.08	-0.12	-0.22	-0.35	-0.33	-0.32	-0.25	0.0	-0.6	-1.6	-2.3	-3.9	-5.9	-5.5	-5.2	-4.1
MR3	0.23	0.16	0.17	0.14	0.06	-0.14	-0.29	-0.29	-0.35	5.1	3.4	3.5	2.8	1.2	-2.3	-4.7	-4.7	-5.5
MR4	0.14	0.05	0.13	0.17	0.15	0.17	0.21	0.29	0.30	2.7	1.0	2.5	3.1	2.7	2.9	3.5	4.7	4.9
MR5	0.05	0.13	0.15	0.15	0.03	-0.05	-0.07	-0.15	-0.07	1.2	2.9	3.1	2.9	0.6	-0.7	-1.0	-2.1	-0.9
MR6	-0.15	-0.24	-0.34	-0.45	-0.90	-1.16	-1.40	-1.49	-1.64	-3.6	-5.4	-7.2	-8.8	-15.1	-17.9	-20.2	-20.8	-22.3
LBR1	0.14	0.17	0.22	0.21	0.24	0.29	0.35	0.41	0.40	2.8	3.4	4.4	4.0	4.4	5.1	6.0	6.9	6.7
LBR2	0.33	0.30	0.29	0.34	0.35	0.38	0.45	0.43	0.45	7.4	6.5	6.3	7.0	6.8	7.2	8.5	8.0	8.2
LBR3	-0.26	-0.17	-0.13	-0.12	-0.09	0.02	0.11	0.13	0.23	-6.2	-4.0	-2.9	-2.7	-2.0	0.5	2.1	2.5	4.5
BR1	-0.93	-0.52	-0.33	-0.11	0.09	0.12	0.11	0.09	0.11	-24.9	-13.7	-8.3	-2.7	2.1	2.7	2.4	2.0	2.2
BR2	-1.15	-1.09	-1.06	-1.01	-0.69	-0.17	-0.08	-0.18	-0.15	-31.8	-29.7	-28.3	-26.2	-17.3	-4.0	-1.7	-4.0	-3.2
BR3	-1.13	-1.07	-1.04	-0.97	-0.95	-0.87	-0.71	-0.61	-0.62	-29.7	-28.0	-27.1	-24.8	-23.5	-20.8	-16.6	-14.0	-14.0
SCh1	-0.22	-0.20	-0.19	-0.14	-0.15	-0.18	-0.20	-0.18	-0.17	-5.2	-4.8	-4.5	-3.4	-3.3	-3.9	-4.2	-3.9	-3.6
SCh2	-0.17	-0.12	-0.15	-0.13	-0.13	-0.16	-0.19	-0.16	-0.20	-3.9	-2.8	-3.3	-2.8	-2.7	-3.3	-3.7	-3.2	-3.8
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.17	-0.11	-0.17	-0.20	-0.19	-0.22	-0.24	-0.31	-0.35	-3.2	-2.1	-3.1	-3.4	-3.1	-3.5	-3.8	-4.7	-5.1

Table A-8 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 4 ft deepening, No injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.06	-0.08	-0.09	-0.06	-0.06	-0.09	-0.12	-0.12	-0.15	-1.5	-1.9	-1.9	-1.2	-1.3	-1.9	-2.5	-2.4	-2.9
FR2	0.02	-0.03	-0.05	-0.02	-0.07	-0.06	-0.10	-0.11	-0.12	0.4	-0.7	-1.2	-0.5	-1.4	-1.3	-2.1	-2.2	-2.4
FR3	-0.12	-0.07	-0.06	-0.07	-0.09	-0.14	-0.18	-0.30	-0.43	-2.9	-1.8	-1.5	-1.6	-2.0	-3.0	-3.8	-5.9	-8.1
FR4	-0.12	-0.11	-0.13	-0.12	-0.18	-0.32	-0.44	-0.52	-0.51	-3.0	-2.8	-3.0	-2.6	-4.0	-6.6	-8.3	-9.2	-8.7
FR5	-0.12	-0.15	-0.14	-0.17	-0.26	-0.43	-0.56	-0.45	-0.41	-2.8	-3.5	-3.2	-3.7	-5.6	-8.3	-9.9	-7.5	-6.8
FR6	-0.13	-0.17	-0.25	-0.28	-0.45	-0.59	-0.55	-0.35	-0.29	-3.2	-4.0	-5.4	-6.0	-8.8	-10.5	-9.0	-5.7	-4.7
FR7	-0.23	-0.28	-0.34	-0.44	-0.49	-0.29	-0.28	-0.31	-0.33	-5.1	-5.9	-6.9	-8.2	-8.2	-4.6	-4.3	-4.6	-4.8
FR8	-0.34	-0.43	-0.46	-0.51	-0.30	-0.22	-0.20	-0.29	-0.27	-6.6	-8.0	-8.3	-8.6	-4.8	-3.3	-2.9	-4.1	-3.8
FR9	-0.42	-0.35	-0.34	-0.27	-0.15	-0.14	-0.18	-0.12	-0.11	-7.2	-5.8	-5.6	-4.3	-2.3	-2.1	-2.4	-1.6	-1.5
FR10	-0.22	-0.10	-0.10	-0.12	-0.10	-0.08	-0.05	-0.05	-0.07	-3.7	-1.6	-1.6	-1.8	-1.5	-1.2	-0.7	-0.7	-0.9
FR11	-0.42	-0.40	-0.41	-0.45	-0.47	-0.46	-0.52	-0.51	-0.48	-7.3	-6.8	-6.9	-7.0	-7.1	-6.7	-7.2	-7.0	-6.5
MR1	-0.23	-0.23	-0.24	-0.24	-0.27	-0.37	-0.31	-0.28	-0.29	-4.9	-4.7	-4.8	-4.7	-4.8	-6.2	-5.1	-4.6	-4.6
MR2	0.01	0.00	-0.06	-0.09	-0.17	-0.31	-0.29	-0.30	-0.24	0.2	0.0	-1.3	-1.7	-3.1	-5.2	-4.7	-4.8	-3.9
MR3	0.25	0.17	0.17	0.14	0.08	-0.12	-0.27	-0.29	-0.33	5.4	3.7	3.5	2.7	1.5	-2.1	-4.4	-4.7	-5.3
MR4	0.14	0.05	0.12	0.17	0.16	0.17	0.22	0.28	0.29	2.8	1.0	2.3	3.1	2.8	2.9	3.6	4.6	4.7
MR5	0.05	0.12	0.15	0.14	0.04	-0.05	-0.08	-0.15	-0.07	1.2	2.7	3.3	2.8	0.6	-0.8	-1.1	-2.1	-0.9
MR6	-0.14	-0.24	-0.34	-0.43	-0.90	-1.16	-1.40	-1.49	-1.64	-3.4	-5.3	-7.2	-8.4	-15.1	-17.9	-20.2	-20.8	-22.3
LBR1	0.13	0.17	0.22	0.21	0.24	0.30	0.36	0.41	0.40	2.7	3.3	4.3	4.0	4.4	5.2	6.2	6.9	6.6
LBR2	0.33	0.29	0.29	0.34	0.36	0.37	0.46	0.44	0.47	7.4	6.4	6.2	7.1	7.0	7.1	8.6	8.2	8.5
LBR3	-0.24	-0.16	-0.12	-0.12	-0.09	0.02	0.11	0.13	0.24	-5.9	-3.9	-2.8	-2.6	-1.9	0.5	2.1	2.6	4.7
BR1	-0.99	-0.59	-0.38	-0.13	0.09	0.13	0.13	0.10	0.11	-26.4	-15.6	-9.5	-3.1	2.1	3.0	2.7	2.1	2.4
BR2	-1.23	-1.16	-1.10	-1.06	-0.76	-0.19	-0.10	-0.23	-0.16	-34.0	-31.4	-29.4	-27.6	-19.0	-4.5	-2.2	-4.9	-3.4
BR3	-1.15	-1.11	-1.06	-0.98	-0.95	-0.87	-0.70	-0.60	-0.60	-30.3	-29.1	-27.6	-25.1	-23.4	-20.8	-16.2	-13.8	-13.5
SCh1	-0.20	-0.18	-0.17	-0.13	-0.13	-0.17	-0.19	-0.21	-0.20	-4.9	-4.3	-4.0	-3.1	-3.1	-3.8	-4.2	-4.5	-4.2
SCh2	-0.17	-0.13	-0.15	-0.13	-0.11	-0.14	-0.16	-0.14	-0.18	-4.0	-3.0	-3.3	-2.8	-2.3	-2.9	-3.2	-2.8	-3.5
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.13	-0.08	-0.14	-0.16	-0.15	-0.17	-0.21	-0.28	-0.31	-2.4	-1.5	-2.6	-2.8	-2.5	-2.8	-3.2	-4.2	-4.6

Table A-9 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 3 ft deepening, No injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.05	-0.08	-0.07	-0.05	-0.06	-0.08	-0.11	-0.11	-0.14	-1.2	-1.7	-1.5	-1.0	-1.3	-1.7	-2.2	-2.3	-2.7
FR2	0.02	-0.02	-0.03	-0.01	-0.06	-0.05	-0.08	-0.09	-0.09	0.5	-0.5	-0.8	-0.3	-1.3	-1.0	-1.7	-1.8	-1.8
FR3	-0.11	-0.07	-0.06	-0.05	-0.07	-0.12	-0.13	-0.23	-0.32	-2.7	-1.8	-1.4	-1.1	-1.5	-2.5	-2.6	-4.6	-6.0
FR4	-0.12	-0.11	-0.11	-0.09	-0.16	-0.28	-0.34	-0.36	-0.37	-3.0	-2.7	-2.6	-2.1	-3.5	-5.8	-6.5	-6.5	-6.3
FR5	-0.10	-0.14	-0.13	-0.14	-0.23	-0.36	-0.44	-0.31	-0.30	-2.5	-3.2	-3.0	-3.1	-4.9	-6.9	-7.7	-5.2	-5.0
FR6	-0.13	-0.16	-0.21	-0.24	-0.39	-0.48	-0.38	-0.24	-0.20	-3.1	-3.6	-4.7	-5.2	-7.7	-8.5	-6.3	-4.0	-3.2
FR7	-0.20	-0.26	-0.30	-0.37	-0.39	-0.21	-0.23	-0.25	-0.28	-4.3	-5.3	-5.9	-6.9	-6.5	-3.3	-3.4	-3.8	-4.1
FR8	-0.30	-0.36	-0.38	-0.42	-0.23	-0.18	-0.17	-0.28	-0.19	-5.9	-6.6	-6.9	-7.1	-3.6	-2.8	-2.5	-3.9	-2.6
FR9	-0.34	-0.28	-0.26	-0.20	-0.12	-0.12	-0.13	-0.09	-0.09	-5.8	-4.6	-4.3	-3.2	-1.9	-1.7	-1.7	-1.3	-1.2
FR10	-0.22	-0.09	-0.10	-0.11	-0.10	-0.08	-0.05	-0.05	-0.07	-3.6	-1.6	-1.6	-1.8	-1.5	-1.2	-0.7	-0.7	-0.9
FR11	-0.42	-0.40	-0.41	-0.44	-0.47	-0.46	-0.52	-0.52	-0.48	-7.3	-6.8	-6.9	-7.0	-7.1	-6.7	-7.2	-7.1	-6.5
MR1	-0.21	-0.20	-0.22	-0.19	-0.22	-0.28	-0.24	-0.22	-0.25	-4.4	-4.0	-4.4	-3.6	-4.0	-4.8	-4.0	-3.7	-3.9
MR2	0.05	0.04	-0.04	-0.05	-0.13	-0.26	-0.23	-0.24	-0.23	1.1	0.8	-0.8	-1.0	-2.3	-4.4	-3.9	-3.9	-3.7
MR3	0.26	0.19	0.19	0.15	0.08	-0.09	-0.26	-0.28	-0.31	5.6	4.0	3.9	2.9	1.5	-1.6	-4.3	-4.5	-4.9
MR4	0.13	0.06	0.12	0.16	0.16	0.17	0.21	0.28	0.29	2.6	1.2	2.2	3.0	2.8	2.8	3.4	4.6	4.6
MR5	0.05	0.11	0.15	0.13	0.04	-0.05	-0.08	-0.15	-0.07	1.2	2.5	3.1	2.6	0.6	-0.8	-1.2	-2.1	-0.9
MR6	-0.13	-0.23	-0.34	-0.45	-0.90	-1.16	-1.40	-1.49	-1.64	-3.1	-5.1	-7.2	-8.8	-15.2	-17.9	-20.1	-20.8	-22.3
LBR1	0.13	0.17	0.22	0.21	0.24	0.28	0.34	0.41	0.41	2.6	3.4	4.3	4.0	4.3	4.9	5.9	6.8	6.8
LBR2	0.33	0.30	0.29	0.34	0.34	0.38	0.46	0.43	0.44	7.5	6.5	6.2	7.0	6.8	7.3	8.7	8.0	8.0
LBR3	-0.23	-0.15	-0.11	-0.11	-0.08	0.02	0.10	0.13	0.24	-5.5	-3.6	-2.5	-2.5	-1.8	0.5	2.1	2.6	4.9
BR1	-1.04	-0.64	-0.42	-0.14	0.08	0.13	0.13	0.11	0.13	-27.8	-16.9	-10.7	-3.5	1.9	2.9	2.8	2.3	2.6
BR2	-1.31	-1.21	-1.17	-1.10	-0.82	-0.23	-0.12	-0.24	-0.16	-36.2	-32.9	-31.3	-28.8	-20.4	-5.5	-2.7	-5.2	-3.3
BR3	-1.19	-1.14	-1.10	-1.00	-0.96	-0.87	-0.69	-0.60	-0.59	-31.4	-29.8	-28.6	-25.6	-23.8	-20.7	-16.0	-13.7	-13.3
SCh1	-0.21	-0.19	-0.17	-0.13	-0.14	-0.18	-0.19	-0.20	-0.19	-5.0	-4.5	-3.9	-3.1	-3.2	-3.9	-4.2	-4.2	-3.9
SCh2	-0.16	-0.12	-0.15	-0.12	-0.10	-0.14	-0.15	-0.13	-0.18	-3.6	-2.8	-3.2	-2.5	-2.1	-2.8	-3.1	-2.6	-3.4
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.4	-2.1	-1.9	-2.4	-2.3	-2.3
StbR	-0.09	-0.05	-0.11	-0.12	-0.11	-0.13	-0.15	-0.24	-0.25	-1.8	-0.9	-2.0	-2.2	-1.9	-2.0	-2.4	-3.6	-3.7

Table A-10 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6b, 2 ft deepening, No injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	-0.07	-0.09	-0.09	-0.08	-0.06	-0.08	-0.11	-0.10	-0.13	-1.6	-2.1	-1.9	-1.8	-1.4	-1.6	-2.2	-2.1	-2.5
FR2	0.00	-0.04	-0.06	-0.04	-0.06	-0.04	-0.07	-0.07	-0.08	0.1	-0.9	-1.3	-0.8	-1.2	-0.9	-1.5	-1.5	-1.5
FR3	-0.13	-0.08	-0.07	-0.05	-0.08	-0.11	-0.10	-0.20	-0.23	-3.1	-2.1	-1.6	-1.2	-1.7	-2.3	-2.0	-3.9	-4.4
FR4	-0.13	-0.12	-0.12	-0.11	-0.16	-0.25	-0.27	-0.26	-0.26	-3.1	-2.9	-2.8	-2.5	-3.5	-5.2	-5.1	-4.6	-4.4
FR5	-0.11	-0.15	-0.14	-0.14	-0.21	-0.30	-0.32	-0.21	-0.21	-2.6	-3.4	-3.2	-3.1	-4.5	-5.8	-5.6	-3.6	-3.4
FR6	-0.12	-0.16	-0.20	-0.23	-0.35	-0.39	-0.26	-0.18	-0.14	-2.9	-3.6	-4.4	-4.8	-7.0	-6.9	-4.3	-2.9	-2.2
FR7	-0.16	-0.21	-0.26	-0.30	-0.28	-0.15	-0.19	-0.23	-0.27	-3.4	-4.4	-5.3	-5.7	-4.6	-2.3	-2.8	-3.4	-3.9
FR8	-0.22	-0.31	-0.31	-0.33	-0.16	-0.14	-0.15	-0.21	-0.16	-4.3	-5.7	-5.6	-5.7	-2.5	-2.1	-2.2	-2.9	-2.2
FR9	-0.26	-0.19	-0.17	-0.14	-0.09	-0.09	-0.09	-0.08	-0.06	-4.5	-3.1	-2.8	-2.2	-1.3	-1.3	-1.2	-1.1	-0.8
FR10	-0.22	-0.10	-0.12	-0.12	-0.10	-0.10	-0.06	-0.05	-0.06	-3.7	-1.6	-2.0	-1.8	-1.5	-1.4	-0.8	-0.7	-0.8
FR11	-0.44	-0.42	-0.43	-0.46	-0.48	-0.47	-0.53	-0.53	-0.50	-7.7	-7.1	-7.2	-7.2	-7.3	-6.9	-7.3	-7.2	-6.7
MR1	-0.18	-0.17	-0.19	-0.17	-0.24	-0.25	-0.21	-0.19	-0.22	-3.7	-3.5	-3.8	-3.3	-4.3	-4.3	-3.5	-3.1	-3.5
MR2	0.00	0.01	-0.08	-0.11	-0.14	-0.26	-0.22	-0.21	-0.19	0.0	0.2	-1.6	-2.1	-2.5	-4.5	-3.7	-3.4	-3.1
MR3	0.13	0.09	0.09	0.02	-0.01	-0.18	-0.29	-0.31	-0.34	2.9	2.0	1.8	0.3	-0.2	-3.2	-4.7	-5.0	-5.3
MR4	-0.03	-0.10	-0.04	-0.01	-0.04	-0.03	0.00	0.07	0.09	-0.5	-1.9	-0.7	-0.3	-0.7	-0.4	0.0	1.2	1.5
MR5	-0.73	-0.69	-0.58	-0.52	-0.10	-0.10	-0.15	-0.18	-0.10	-17.3	-15.4	-12.5	-10.4	-1.7	-1.6	-2.2	-2.6	-1.4
MR6	1.62	1.49	1.42	1.31	0.66	0.38	0.12	0.01	-0.18	39.0	33.1	29.9	25.8	11.2	5.8	1.7	0.1	-2.4
LBR1	-0.09	-0.06	-0.04	-0.02	-0.02	0.01	0.08	0.08	0.07	-1.9	-1.1	-0.7	-0.4	-0.3	0.1	1.4	1.3	1.2
LBR2	0.08	0.05	0.05	0.07	0.05	0.08	0.13	0.15	0.12	1.7	1.1	1.1	1.4	1.1	1.5	2.5	2.7	2.2
LBR3	-0.85	-0.78	-0.70	-0.62	-0.56	-0.39	-0.26	-0.21	-0.16	-20.4	-18.4	-16.3	-13.9	-11.9	-8.0	-5.3	-4.3	-3.1
BR1	-1.44	-0.92	-0.58	-0.26	0.07	0.13	0.13	0.12	0.14	-38.6	-24.0	-14.8	-6.4	1.5	2.9	2.9	2.6	2.8
BR2	-1.98	-1.84	-1.76	-1.58	-1.07	-0.34	-0.21	-0.29	-0.20	-54.8	-49.9	-47.2	-41.2	-26.6	-8.1	-4.7	-6.4	-4.3
BR3	-1.79	-1.73	-1.69	-1.64	-1.63	-1.59	-1.35	-1.28	-1.19	-47.4	-45.5	-44.1	-42.1	-40.1	-37.9	-31.4	-29.4	-26.9
SCh1	-0.17	-0.18	-0.17	-0.15	-0.15	-0.18	-0.19	-0.20	-0.19	-4.2	-4.2	-3.9	-3.4	-3.4	-4.0	-4.1	-4.3	-4.1
SCh2	-0.16	-0.12	-0.13	-0.13	-0.11	-0.13	-0.15	-0.13	-0.16	-3.5	-2.7	-2.9	-2.8	-2.2	-2.7	-3.1	-2.6	-3.1
SR	-0.15	-0.15	-0.15	-0.16	-0.15	-0.13	-0.18	-0.17	-0.18	-2.5	-2.6	-2.4	-2.5	-2.2	-1.9	-2.4	-2.3	-2.3
StbR	-0.05	-0.03	-0.06	-0.08	-0.08	-0.09	-0.13	-0.17	-0.20	-0.9	-0.5	-1.1	-1.4	-1.4	-1.4	-1.9	-2.6	-3.0

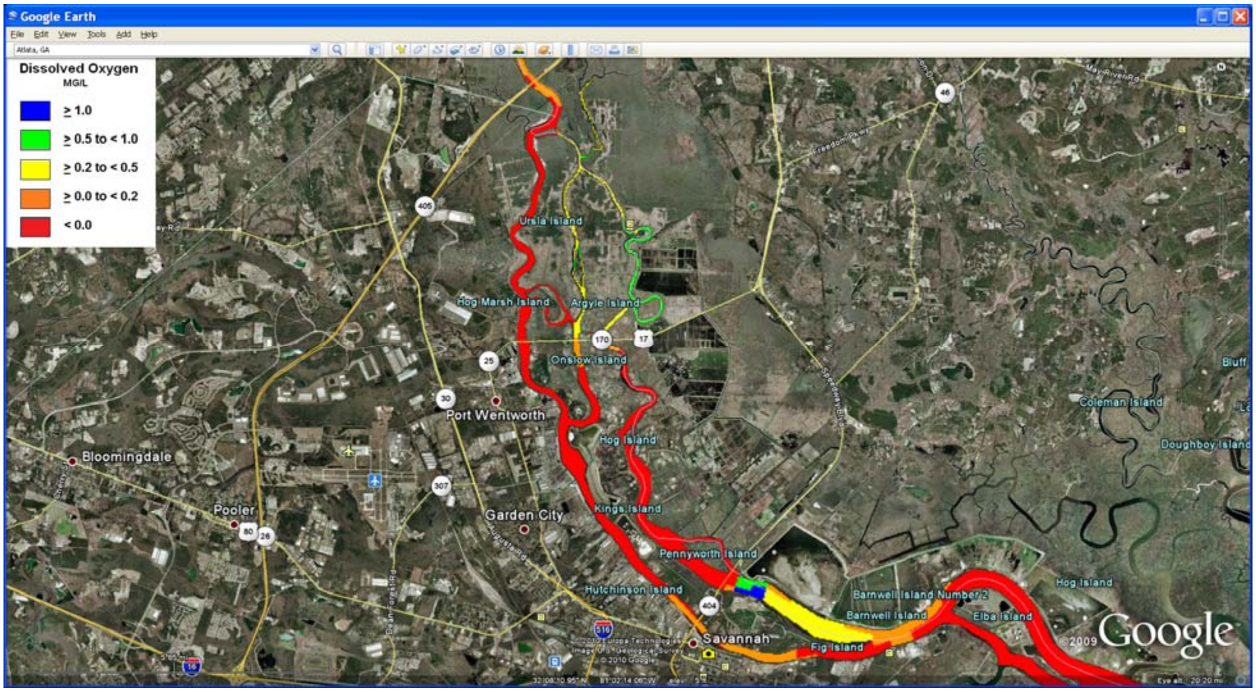

Figure A-1 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6a-6ft

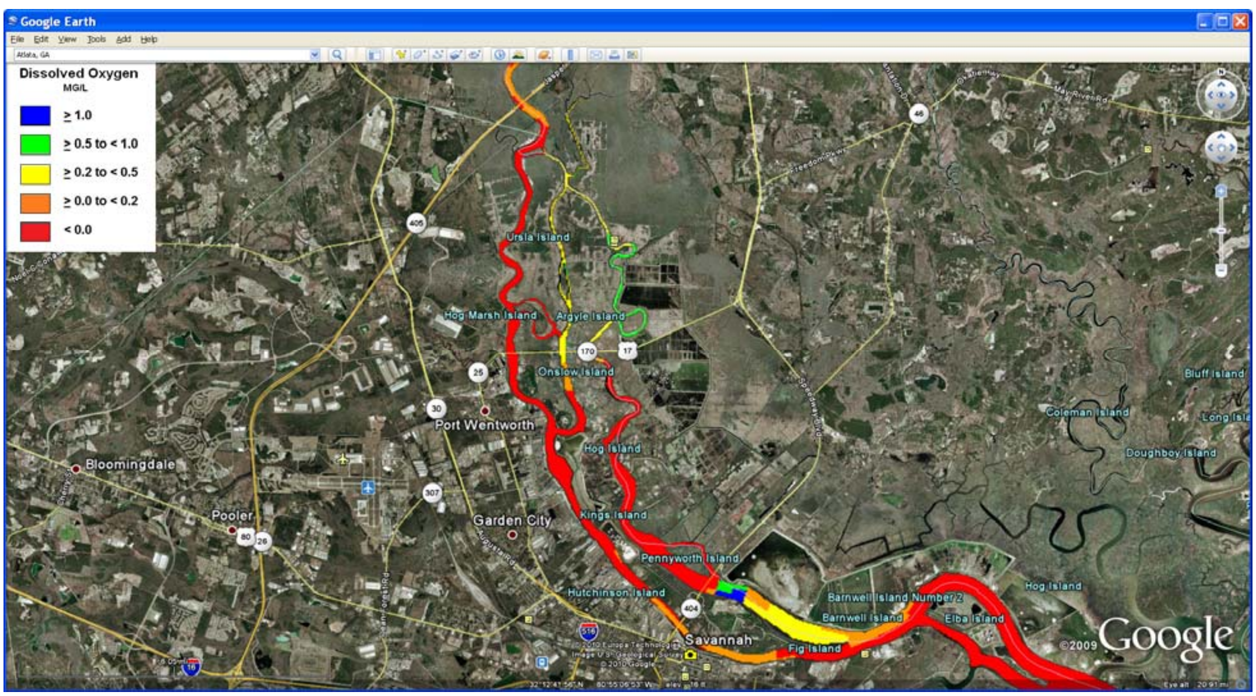

Figure A-2 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6a-5ft

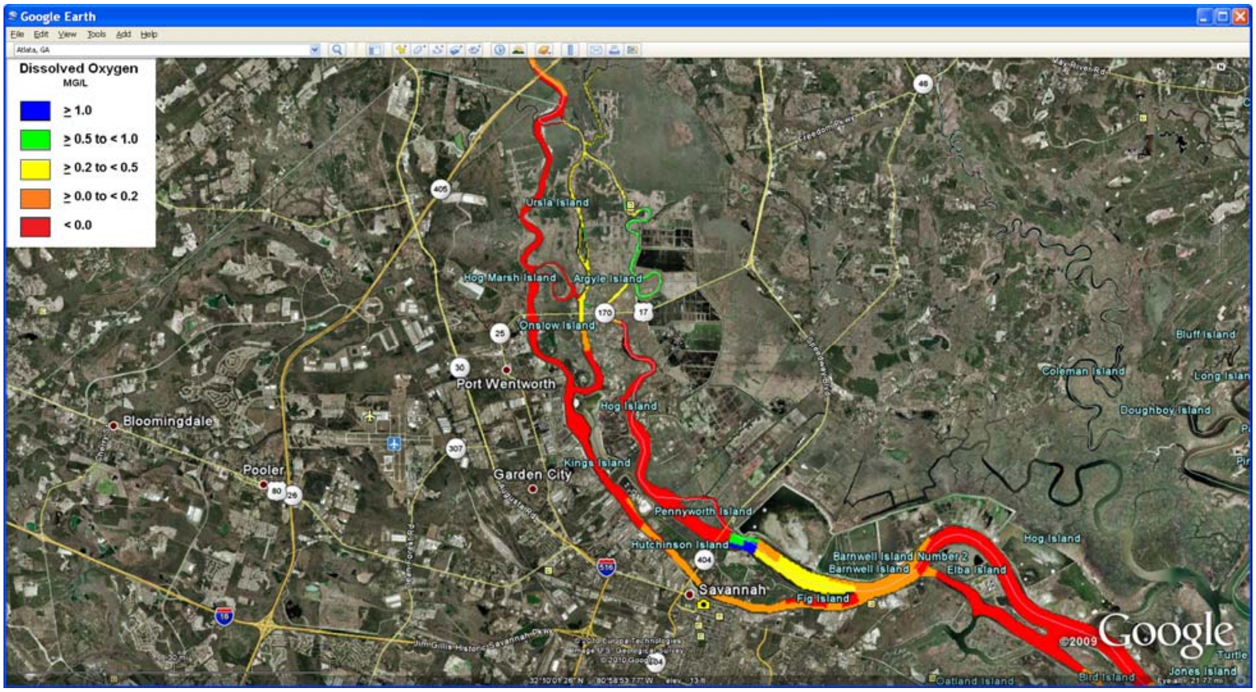

Figure A-3 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6a-4ft

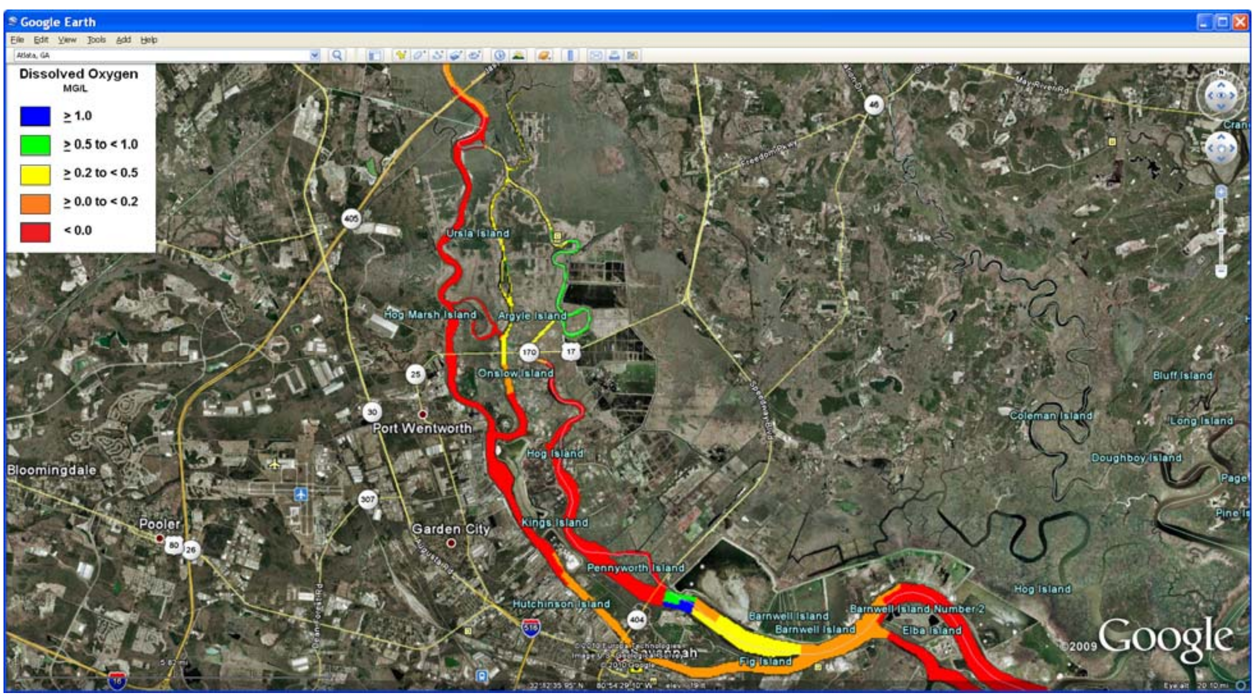

Figure A-4 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6a-3ft

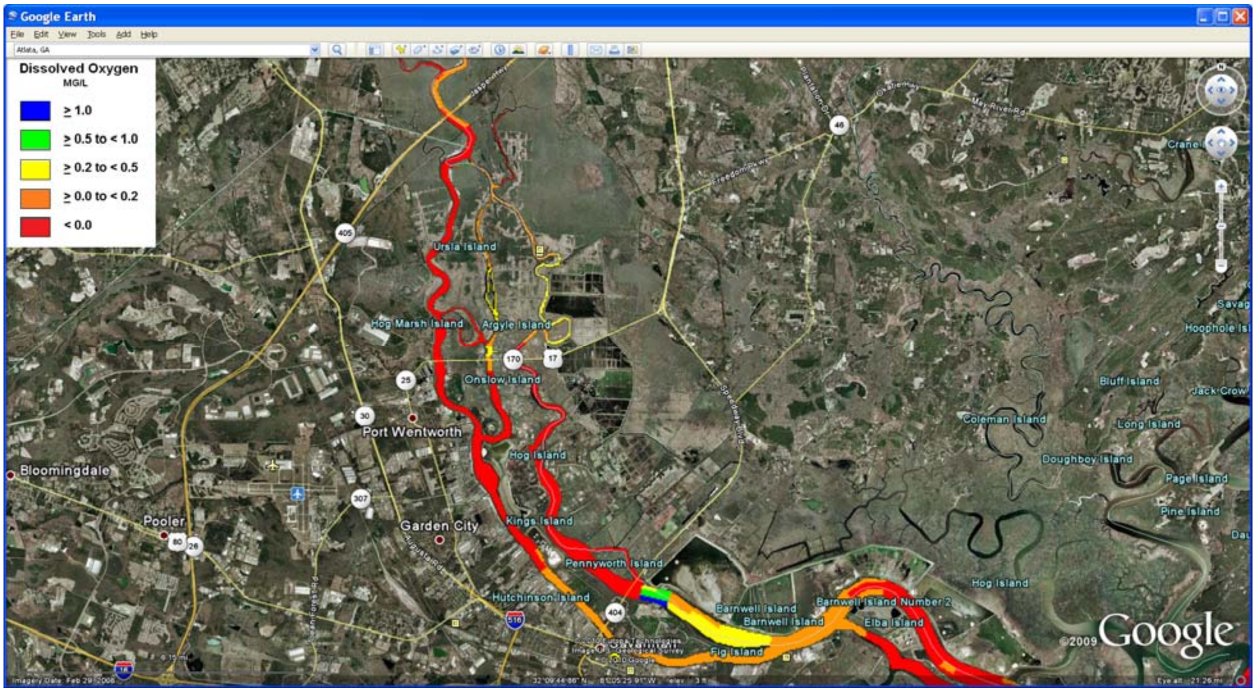

Figure A-5 Delta Bottom D.O. (50th percentile): Deepening and mitigation plan 6b-2ft

APPENDIX B

DISSOLVED OXYGEN REGIME OF SAVANNAH ESTUARY: AUGUST 1997 (AVERAGE FLOW), ALTERNATIVE DEEPENING WITH MITIGATION PLANS 6A AND 6B, D.O. DISCHARGE WITH MITIGATION PURPOSES

TABLES AND FIGURES

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Table B-1 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 6 ft deepening, and mitigation D.O. injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.07	1.8	0.06	1.5	0.05	1.2	0.06	1.4	0.03	0.7	0.04	0.9	0.01	0.2	-0.02	-0.4	0	0.0
FR2	0.18	4.9	0.17	4.5	0.15	3.9	0.18	4.5	0.17	4.0	0.14	3.2	0.12	2.6	0.13	2.8	-0.22	-4.3
FR3	0.26	7.4	0.23	6.4	0.27	7.4	0.3	7.8	0.29	7.2	0.43	10.0	0.28	5.9	0.54	10.7	0.35	6.3
FR4	0.28	8.0	0.28	7.9	0.38	10.5	0.29	7.4	0.34	8.4	0.43	9.8	0.2	4.0	0.3	5.6	0.48	8.7
FR5	0.53	14.6	0.57	15.2	0.54	13.9	0.52	12.7	0.56	13.0	0.33	6.7	0.14	2.6	0.09	1.6	0.19	3.3
FR6	0.58	15.7	0.67	17.8	0.72	18.5	0.63	15.3	0.73	17.1	0.5	10.5	0.06	1.1	0.08	1.4	0.1	1.7
FR7	0.51	12.2	0.55	12.9	0.6	13.9	0.47	10.2	0.29	5.8	-0.26	-4.3	-0.04	-0.6	0.19	3.0	0.25	3.9
FR8	0.27	5.8	0.24	5.0	0.08	1.6	-0.11	-2.0	-0.13	-2.1	-0.01	-0.2	0.03	0.4	0.04	0.6	-0.08	-1.1
FR9	0.66	13.5	0.87	17.3	0.74	13.9	0.66	11.5	0.41	6.5	0.38	5.8	0.47	6.9	0.56	8.0	0.69	9.6
FR10	1.83	42.5	1.55	32.4	1.49	30.1	1.46	27.4	1.11	18.8	0.84	13.1	1.04	15.6	0.77	11.0	0.69	9.6
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.37	8.4	0.4	8.8	0.42	9.1	0.32	6.5	0.26	5.0	0.08	1.4	0	0.0	0.03	0.5	-0.04	-0.6
MR2	0.66	16.4	0.78	18.8	0.71	16.4	0.58	12.6	0.34	6.7	0.11	2.0	0.08	1.4	0.08	1.4	0.19	3.2
MR3	0.98	26.5	0.92	23.7	0.92	23.0	0.94	22.4	0.89	19.7	0.55	10.8	0.12	2.1	0.02	0.3	-0.01	-0.2
MR4	0.95	24.4	0.91	22.6	0.92	22.3	0.91	20.7	0.97	21.0	1.08	22.1	1.21	23.9	1.27	24.5	1.3	24.0
MR5	1.52	102.0	1.55	76.0	1.56	64.7	1.57	51.5	1.46	29.4	0.92	14.8	1	15.2	0.85	12.3	0.75	10.5
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.24	34.7	1.07	24.6	1.1	23.2	1.06	20.7	1.02	18.8	1.2	21.3	1.13	18.9	1.12	18.2	1.17	18.1
LBR2	1.25	33.9	1.42	36.8	1.45	36.5	1.45	34.9	1.43	32.6	1.47	32.0	1.49	31.2	1.52	31.1	1.31	24.9
LBR3	0.25	8.7	-0.05	-1.5	-0.11	-3.2	-0.12	-3.3	-0.08	-2.0	-0.14	-3.2	-0.34	-7.2	-0.48	-9.6	-0.58	-11.1
BR1	0.29	8.4	0.36	10.2	0.34	9.5	0.2	5.1	0.37	9.2	0.37	8.7	0.24	5.3	0.22	4.8	0.27	5.8
BR2	0.21	8.2	0.25	8.8	0.27	9.0	0.3	9.3	0.47	13.7	0.49	13.2	0.55	14.3	0.5	12.7	0.54	13.4
BR3	-0.06	-2.0	-0.17	-5.2	-0.26	-7.6	-0.31	-8.6	-0.08	-2.1	0.33	8.4	0.4	9.8	0.46	11.1	0.47	11.1
SCH1	-0.04	-1.7	0.08	3.1	0.11	4.1	0.13	4.6	0.23	7.6	0.6	17.6	0.51	13.5	0.56	14.4	0.48	11.6
SCH2	0.1	2.7	0.04	1.0	0.05	1.2	0.13	3.1	0.09	2.1	0.09	2.0	0.07	1.5	0.07	1.5	0.02	0.4
SR	1.45	30.9	1.51	31.9	1.48	29.8	1.52	28.6	1.44	25.6	1.37	22.9	1.69	27.7	1.75	28.4	1.78	28.6
StbR	0.2	5.2	0.42	10.0	0.31	6.8	0.39	7.7	0.27	4.7	0.15	2.4	0.13	2.0	0.07	1.1	0.12	1.8

Table B-2 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 5 ft deepening, and mitigation D.O. injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.05	1.3	0.06	1.5	0.05	1.2	0.07	1.7	0.03	0.7	0.02	0.4	0	0.0	-0.02	-0.4	-0.03	-0.6
FR2	0.16	4.4	0.15	4.0	0.14	3.6	0.16	4.0	0.15	3.6	0.14	3.2	0.1	2.2	0.11	2.3	-0.22	-4.3
FR3	0.23	6.6	0.19	5.3	0.23	6.3	0.24	6.2	0.21	5.2	0.24	5.6	0.19	4.0	0.5	9.9	0.3	5.4
FR4	0.23	6.6	0.24	6.7	0.29	8.0	0.21	5.4	0.23	5.7	0.22	5.0	0.03	0.6	0.16	3.0	0.45	8.2
FR5	0.49	13.5	0.58	15.5	0.58	14.9	0.54	13.2	0.64	14.8	0.44	9.0	0.19	3.5	0.26	4.6	0.32	5.5
FR6	0.46	12.5	0.45	12.0	0.41	10.5	0.38	9.2	0.37	8.7	0.21	4.4	-0.22	-3.9	-0.15	-2.6	-0.05	-0.8
FR7	0.6	14.4	0.65	15.3	0.7	16.2	0.69	15.0	0.82	16.3	0.35	5.9	0.4	6.4	0.57	9.0	1.07	16.5
FR8	0.1	2.1	0.11	2.3	0.04	0.8	-0.12	-2.2	0.11	1.8	0.3	4.7	0.27	4.0	0.26	3.8	0.17	2.4
FR9	0.4	8.2	0.66	13.1	0.56	10.5	0.65	11.4	0.49	7.8	0.52	7.9	0.62	9.1	0.66	9.4	0.67	9.3
FR10	1.86	43.2	1.59	33.3	1.57	31.7	1.53	28.8	1.17	19.8	0.91	14.2	1.1	16.5	0.84	12.0	0.75	10.4
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.18	4.1	0.17	3.8	0.2	4.3	0.2	4.1	0.21	4.1	0.02	0.4	0.01	0.2	0.07	1.2	0.17	2.7
MR2	0.73	18.1	0.76	18.3	0.65	15.0	0.54	11.7	0.32	6.3	0.08	1.4	0.13	2.2	0.15	2.5	0.19	3.2
MR3	1.06	28.6	1	25.7	0.97	24.3	1	23.9	0.95	21.0	0.63	12.4	0.18	3.2	0.1	1.7	0.03	0.5
MR4	1.05	27.0	1	24.8	1.02	24.8	1.01	23.0	1.09	23.6	1.23	25.2	1.35	26.7	1.43	27.6	1.45	26.8
MR5	1.67	112.1	1.74	85.3	1.67	69.3	1.72	56.4	1.63	32.8	1.15	18.5	1.24	18.9	1.06	15.4	1.01	14.2
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.39	38.9	1.29	29.7	1.28	26.9	1.2	23.4	1.17	21.5	1.35	23.9	1.3	21.8	1.29	20.9	1.34	20.7
LBR2	1.62	43.9	1.59	41.2	1.59	40.1	1.57	37.7	1.57	35.8	1.6	34.8	1.66	34.8	1.67	34.2	1.48	28.1
LBR3	0.35	12.1	0.07	2.1	0.03	0.9	0	0.0	0.07	1.8	-0.03	-0.7	-0.22	-4.7	-0.37	-7.4	-0.47	-9.0
BR1	0.21	6.1	0.28	8.0	0.28	7.8	0.13	3.3	0.31	7.7	0.33	7.8	0.19	4.2	0.17	3.7	0.23	4.9
BR2	0.31	12.2	0.21	7.4	0.2	6.7	0.23	7.1	0.41	11.9	0.42	11.4	0.48	12.5	0.46	11.7	0.5	12.4
BR3	0	0.0	-0.12	-3.7	-0.25	-7.3	-0.25	-6.9	-0.09	-2.4	0.28	7.1	0.35	8.6	0.4	9.6	0.42	9.9
SCH1	0.02	0.8	0	0.0	0.1	3.7	0.16	5.7	0.14	4.7	-0.04	-1.2	-0.07	-1.9	-0.05	-1.3	-0.19	-4.6
SCH2	0.08	2.1	0.02	0.5	0.04	1.0	0.08	1.9	0.07	1.6	0.09	2.0	0.07	1.5	0.06	1.3	0.07	1.5
SR	1.45	30.9	1.51	31.9	1.49	30.0	1.53	28.8	1.45	25.8	1.37	22.9	1.7	27.8	1.75	28.4	1.79	28.7
StbR	0.33	8.6	0.5	11.8	0.44	9.6	0.45	8.9	0.35	6.2	0.23	3.7	0.19	2.9	0.18	2.7	0.2	2.9

Table B-3 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 4 ft deepening, and mitigation D.O. injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.04	1.0	0.02	0.5	0	0.0	0.04	0.9	0.01	0.2	0.03	0.7	0.04	0.9	0	0.0	0.04	0.8
FR2	0.14	3.8	0.14	3.7	0.13	3.4	0.16	4.0	0.14	3.3	0.14	3.2	0.1	2.2	0.13	2.8	-0.21	-4.1
FR3	0.19	5.4	0.17	4.7	0.21	5.8	0.22	5.7	0.19	4.7	0.22	5.1	0.18	3.8	0.48	9.5	0.28	5.0
FR4	0.2	5.7	0.22	6.2	0.26	7.2	0.19	4.8	0.19	4.7	0.14	3.2	0.05	1.0	0.18	3.4	0.45	8.2
FR5	0.44	12.2	0.54	14.4	0.52	13.4	0.49	12.0	0.58	13.5	0.4	8.2	0.19	3.5	0.27	4.8	0.34	5.9
FR6	0.38	10.3	0.36	9.6	0.34	8.7	0.3	7.3	0.27	6.3	0.08	1.7	-0.18	-3.2	-0.05	-0.9	-0.02	-0.3
FR7	0.82	19.7	0.87	20.5	1.03	23.8	1.05	22.8	1.16	23.1	0.64	10.7	0.6	9.6	0.75	11.8	0.98	15.1
FR8	0.08	1.7	0.1	2.1	0.01	0.2	-0.14	-2.5	0.17	2.8	0.3	4.7	0.29	4.3	0.29	4.2	0.15	2.1
FR9	0.01	0.2	-0.03	-0.6	-0.15	-2.8	-0.25	-4.4	-0.1	-1.6	0.12	1.8	0.15	2.2	0.09	1.3	0.15	2.1
FR10	1.85	42.9	1.57	32.8	1.52	30.7	1.49	28.0	1.13	19.1	0.88	13.7	1.06	15.9	0.81	11.6	0.73	10.1
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.13	2.9	0.15	3.3	0.18	3.9	0.16	3.3	0.19	3.7	0	0.0	0.05	0.8	0.09	1.5	0.21	3.4
MR2	0.67	16.6	0.73	17.6	0.62	14.3	0.51	11.0	0.31	6.1	0.07	1.3	0.14	2.4	0.15	2.5	0.2	3.3
MR3	1.03	27.8	0.96	24.7	0.93	23.3	0.97	23.2	0.92	20.4	0.6	11.8	0.13	2.3	0.1	1.7	0.01	0.2
MR4	1.02	26.2	0.96	23.8	0.99	24.0	0.97	22.1	1.04	22.6	1.16	23.7	1.29	25.5	1.3	25.1	1.34	24.8
MR5	1.6	107.4	1.65	80.9	1.61	66.8	1.63	53.4	1.55	31.2	1.03	16.5	1.12	17.0	0.94	13.6	0.87	12.2
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.28	35.9	1.26	29.0	1.18	24.8	1.11	21.6	1.09	20.1	1.27	22.5	1.21	20.3	1.2	19.5	1.23	19.0
LBR2	0.57	15.4	1.5	38.9	1.51	38.0	1.5	36.1	1.5	34.2	1.52	33.0	1.55	32.5	1.57	32.2	1.39	26.4
LBR3	0.32	11.1	0.01	0.3	-0.02	-0.6	-0.06	-1.6	-0.01	-0.3	-0.1	-2.3	-0.28	-5.9	-0.46	-9.2	-0.5	-9.5
BR1	0.16	4.6	0.2	5.7	0.21	5.8	0.06	1.5	0.28	6.9	0.31	7.3	0.16	3.5	0.14	3.0	0.2	4.3
BR2	0.15	5.9	0.12	4.2	0.13	4.3	0.14	4.3	0.35	10.2	0.39	10.5	0.44	11.5	0.43	10.9	0.46	11.4
BR3	-0.06	-2.0	-0.2	-6.1	-0.32	-9.3	-0.32	-8.8	-0.17	-4.5	0.23	5.8	0.3	7.4	0.36	8.7	0.36	8.5
SCH1	-0.05	-2.1	0.07	2.7	0.1	3.7	0.12	4.2	0.23	7.6	0.66	19.4	0.57	15.1	0.59	15.2	0.48	11.6
SCH2	0.07	1.9	-0.02	-0.5	0.04	1.0	0.09	2.2	0.07	1.6	0.09	2.0	0.08	1.7	0.09	1.9	0.07	1.5
SR	1.45	30.9	1.51	31.9	1.48	29.8	1.52	28.6	1.44	25.6	1.37	22.9	1.7	27.8	1.75	28.4	1.78	28.6
StbR	0.35	9.1	0.44	10.4	0.42	9.2	0.45	8.9	0.3	5.3	0.24	3.9	0.18	2.8	0.18	2.7	0.15	2.2

Table B-4 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6a, 3 ft deepening, and mitigation D.O. injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.05	1.3	0.03	0.8	0.01	0.2	0.03	0.7	0.01	0.2	0.05	1.1	0.06	1.3	0.03	0.6	0.06	1.3
FR2	0.15	4.1	0.15	4.0	0.12	3.1	0.17	4.2	0.16	3.8	0.13	3.0	0.14	3.0	0.17	3.6	-0.19	-3.7
FR3	0.19	5.4	0.16	4.5	0.17	4.7	0.22	5.7	0.2	4.9	0.21	4.9	0.21	4.4	0.48	9.5	0.27	4.8
FR4	0.2	5.7	0.19	5.3	0.21	5.8	0.2	5.1	0.19	4.7	0.14	3.2	0.13	2.6	0.2	3.8	0.43	7.8
FR5	0.31	8.6	0.27	7.2	0.22	5.7	0.24	5.9	0.16	3.7	-0.13	-2.7	0.01	0.2	0.05	0.9	0.15	2.6
FR6	0.27	7.3	0.28	7.4	0.23	5.9	0.23	5.6	0.22	5.2	-0.01	-0.2	-0.05	-0.9	0.05	0.9	0.07	1.2
FR7	0.6	14.4	0.62	14.6	0.69	15.9	0.67	14.5	0.81	16.1	0.4	6.7	0.42	6.7	0.53	8.3	1.04	16.0
FR8	0.08	1.7	0.11	2.3	0.03	0.6	-0.08	-1.5	0.22	3.6	0.35	5.4	0.32	4.8	0.3	4.4	0.24	3.4
FR9	0.02	0.4	-0.03	-0.6	-0.1	-1.9	-0.15	-2.6	0.06	1.0	0.28	4.2	0.25	3.6	0.22	3.1	0.37	5.1
FR10	1.84	42.7	1.57	32.8	1.52	30.7	1.48	27.8	1.14	19.3	0.88	13.7	1.06	15.9	0.81	11.6	0.72	10.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.11	2.5	0.11	2.4	0.17	3.7	0.15	3.1	0.2	3.9	0.02	0.4	0.1	1.7	0.16	2.7	0.27	4.3
MR2	0.7	17.4	0.71	17.1	0.65	15.0	0.58	12.6	0.41	8.1	0.2	3.6	0.19	3.3	0.25	4.2	0.19	3.2
MR3	1.02	27.6	0.98	25.2	0.95	23.8	0.96	22.9	0.95	21.0	0.62	12.2	0.17	3.0	0.12	2.0	0.03	0.5
MR4	1.01	26.0	0.96	23.8	1	24.3	0.96	21.9	1.04	22.6	1.14	23.3	1.26	24.9	1.31	25.3	1.33	24.6
MR5	1.6	107.4	1.68	82.4	1.6	66.4	1.63	53.4	1.56	31.4	1.03	16.5	1.12	17.0	0.94	13.6	0.87	12.2
MR6	0.53	25.1	0.16	6.4	-0.35	-11.6	-0.81	-23.1	-2.8	-49.9	-3.34	-52.5	-3.54	-52.1	-3.67	-52.0	-3.83	-52.3
LBR1	1.26	35.3	1.27	29.2	1.2	25.3	1.1	21.4	1.09	20.1	1.27	22.5	1.21	20.3	1.2	19.5	1.23	19.0
LBR2	1.6	43.4	1.5	38.9	1.53	38.5	1.5	36.1	1.49	33.9	1.53	33.3	1.58	33.1	1.64	33.6	2.14	40.7
LBR3	0.33	11.4	0.02	0.6	0	0.0	-0.04	-1.1	0.02	0.5	-0.06	-1.4	-0.28	-5.9	-0.42	-8.4	-0.52	-9.9
BR1	0.12	3.5	0.19	5.4	0.19	5.3	0.04	1.0	0.24	6.0	0.29	6.8	0.15	3.3	0.13	2.8	0.19	4.1
BR2	0.18	7.1	0.07	2.5	0.09	3.0	0.12	3.7	0.31	9.0	0.36	9.7	0.41	10.7	0.39	9.9	0.44	10.9
BR3	-0.06	-2.0	-0.17	-5.2	-0.28	-8.1	-0.32	-8.8	-0.22	-5.8	0.04	1.0	0.12	2.9	0.16	3.9	0.23	5.4
SCH1	-0.09	-3.8	0.07	2.7	0.06	2.2	0.1	3.5	0.25	8.3	0.66	19.4	0.59	15.6	0.58	14.9	0.49	11.8
SCH2	0.1	2.7	0.04	1.0	0.08	2.0	0.07	1.7	0.07	1.6	0.07	1.6	0.04	0.9	0.05	1.1	0.06	1.2
SR	1.45	30.9	1.51	31.9	1.49	30.0	1.53	28.8	1.44	25.6	1.37	22.9	1.7	27.8	1.75	28.4	1.78	28.6
StbR	0.45	11.7	0.48	11.4	0.46	10.1	0.47	9.3	0.31	5.4	0.27	4.4	0.21	3.2	0.22	3.3	0.23	3.4

Table B-5 Delta (Project – Existing) D.O. Percentiles for Critical Cells: Plan 6b, 2 ft deepening, and mitigation D.O. injections

Zone	Delta D.O. Percentile																	
	1%		5%		10%		25%		50%		75%		90%		95%		99	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%	mg/l	%
FR1	0.03	0.8	0.02	0.5	0	0.0	0.05	1.2	0.03	0.7	0.08	1.8	0.09	1.9	0.08	1.7	0.11	2.3
FR2	0.14	3.8	0.14	3.7	0.13	3.4	0.19	4.7	0.17	4.0	0.17	3.9	0.23	5.0	0.22	4.7	-0.08	-1.6
FR3	0.2	5.7	0.15	4.2	0.17	4.7	0.22	5.7	0.22	5.4	0.28	6.5	0.38	7.9	0.53	10.5	0.35	6.3
FR4	0.2	5.7	0.19	5.3	0.22	6.1	0.2	5.1	0.23	5.7	0.23	5.2	0.2	4.0	0.26	4.9	0.38	6.9
FR5	0.29	8.0	0.25	6.7	0.29	7.5	0.27	6.6	0.24	5.6	-0.03	-0.6	0.21	3.9	0.29	5.2	0.28	4.8
FR6	0.26	7.0	0.29	7.7	0.25	6.4	0.26	6.3	0.27	6.3	0.08	1.7	0.11	2.0	0.17	2.9	0.16	2.7
FR7	0.65	15.6	0.68	16.0	0.76	17.6	0.76	16.5	0.91	18.1	0.47	7.9	0.46	7.3	0.52	8.2	0.87	13.4
FR8	0.12	2.6	0.11	2.3	0	0.0	-0.07	-1.3	0.17	2.8	0.22	3.4	0.17	2.5	0.16	2.3	0.11	1.5
FR9	0.61	12.5	0.92	18.3	0.81	15.2	0.8	14.0	0.56	8.9	0.53	8.0	0.63	9.2	0.59	8.4	0.64	8.9
FR10	1.85	42.9	1.59	33.3	1.52	30.7	1.51	28.4	1.15	19.5	0.89	13.8	1.08	16.2	0.82	11.7	0.72	10.0
FR11	-1.46	-35.0	-1.99	-42.3	-2.21	-44.8	-2.5	-47.7	-2.89	-51.0	-3.25	-52.9	-3.47	-53.4	-3.53	-53.2	-3.95	-55.4
MR1	0.15	3.4	0.16	3.5	0.21	4.5	0.19	3.9	0.21	4.1	0.09	1.6	0.2	3.4	0.24	4.0	0.31	5.0
MR2	0.66	16.4	0.67	16.1	0.6	13.9	0.53	11.5	0.36	7.1	0.17	3.1	0.27	4.7	0.28	4.7	0.32	5.3
MR3	0.94	25.4	0.88	22.6	0.86	21.5	0.86	20.5	0.85	18.8	0.55	10.8	0.2	3.5	0.17	2.9	0.08	1.3
MR4	0.87	22.4	1.4	34.7	1.48	35.9	1.51	34.4	1.58	34.3	1.72	35.2	1.89	37.4	2.01	38.8	2.3	42.5
MR5	0.86	57.7	0.51	25.0	0.41	17.0	0.47	15.4	1.38	27.8	1.04	16.7	1.12	17.0	0.97	14.1	0.86	12.1
MR6	3.7	175.4	3.69	148.2	3.38	112.3	3.13	89.2	1.27	22.6	0.74	11.6	0.56	8.2	0.41	5.8	0.33	4.5
LBR1	0.53	14.8	0.71	16.3	0.95	20.0	0.9	17.5	0.86	15.8	1.04	18.4	1.05	17.6	1.05	17.0	1.23	19.0
LBR2	0.75	20.3	0.96	24.9	0.95	23.9	0.96	23.1	0.93	21.2	0.97	21.1	1	21.0	1.05	21.5	1.31	24.9
LBR3	-0.28	-9.7	-0.54	-16.5	-0.67	-19.3	-0.66	-17.9	-0.66	-16.7	-0.67	-15.4	-0.82	-17.3	-0.95	-19.0	-1.09	-20.8
BR1	0.31	9.0	0.47	13.4	0.59	16.4	0.41	10.5	0.48	11.9	0.46	10.8	0.31	6.8	0.33	7.1	0.45	9.6
BR2	0.44	17.3	0.42	14.8	0.57	19.1	0.62	19.1	0.76	22.1	0.71	19.2	0.73	19.0	0.73	18.6	0.86	21.3
BR3	-0.44	-14.5	-0.57	-17.5	-0.66	-19.2	-0.67	-18.5	-0.25	-6.6	1.15	29.1	1.49	36.5	1.61	38.8	1.82	42.8
SCH1	0.04	1.7	0.02	0.8	0.08	3.0	0.1	3.5	0.11	3.7	-0.04	-1.2	-0.07	-1.9	-0.01	-0.3	-0.09	-2.2
SCH2	0.11	2.9	0.08	2.0	0.09	2.2	0.08	1.9	0.07	1.6	0.09	2.0	0.08	1.7	0.07	1.5	0.09	1.9
SR	1.45	30.9	1.51	31.9	1.48	29.8	1.52	28.6	1.44	25.6	1.37	22.9	1.7	27.8	1.75	28.4	1.78	28.6
StbR	0.54	14.1	0.59	14.0	0.5	10.9	0.52	10.3	0.37	6.5	0.29	4.7	0.26	4.0	0.26	3.9	0.3	4.4

Table B-6 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 6 ft deepening, and mitigation D.O. injections

Zone Name	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.10	0.08	0.08	0.12	0.09	0.07	0.04	0.04	0.00	2.3	1.8	1.7	2.6	1.9	1.4	0.9	0.8	0.1
FR2	0.24	0.20	0.17	0.22	0.17	0.19	0.17	0.17	0.18	5.7	4.9	3.9	5.0	3.8	4.1	3.4	3.5	3.6
FR3	0.21	0.24	0.25	0.28	0.26	0.22	0.21	0.15	0.09	5.2	5.9	6.0	6.4	5.8	4.6	4.2	2.9	1.7
FR4	0.31	0.37	0.40	0.40	0.46	0.46	0.35	0.23	0.20	7.6	8.8	9.6	9.1	10.2	9.4	6.6	4.2	3.5
FR5	0.42	0.45	0.50	0.46	0.50	0.32	0.13	0.06	0.12	10.2	10.6	11.6	10.2	10.6	6.2	2.4	1.0	2.0
FR6	0.54	0.53	0.48	0.42	0.29	0.05	-0.06	0.03	0.08	12.9	12.3	10.6	8.9	5.8	0.8	-1.1	0.5	1.3
FR7	0.37	0.31	0.26	0.19	-0.05	0.03	0.05	0.01	-0.03	8.0	6.5	5.3	3.5	-0.8	0.5	0.8	0.1	-0.5
FR8	0.25	0.10	0.14	0.02	0.01	0.11	0.13	0.03	0.12	4.8	1.9	2.6	0.4	0.2	1.7	1.9	0.5	1.7
FR9	-0.02	0.03	0.00	0.05	0.14	0.18	0.16	0.23	0.27	-0.4	0.4	0.0	0.8	2.1	2.5	2.2	3.1	3.6
FR10	0.44	0.43	0.38	0.41	0.41	0.40	0.47	0.51	0.59	7.5	7.1	6.1	6.4	6.1	5.7	6.5	7.0	8.0
FR11	0.48	0.43	0.42	0.39	0.35	0.32	0.40	0.42	0.46	8.3	7.4	7.0	6.1	5.3	4.6	5.5	5.8	6.2
MR1	0.38	0.41	0.36	0.35	0.28	0.18	0.15	0.15	0.11	8.0	8.4	7.2	6.8	5.1	3.0	2.4	2.4	1.7
MR2	0.57	0.57	0.50	0.45	0.37	0.22	0.17	0.15	0.18	12.3	11.9	10.1	8.6	6.7	3.7	2.9	2.4	2.9
MR3	0.85	0.78	0.75	0.73	0.65	0.45	0.32	0.31	0.34	18.6	16.5	15.5	14.3	11.9	7.7	5.2	4.9	5.3
MR4	0.75	0.74	0.75	0.79	0.77	0.81	0.91	1.02	1.01	15.1	14.4	14.4	14.6	13.7	13.8	14.9	16.6	16.2
MR5	1.01	1.06	1.06	1.02	0.87	0.68	0.72	0.65	0.63	24.0	23.6	22.7	20.2	15.1	10.5	10.5	9.2	8.7
MR6	0.08	-0.02	-0.12	-0.22	-0.70	-0.94	-1.25	-1.28	-1.36	1.8	-0.4	-2.5	-4.3	-11.9	-14.5	-18.0	-17.9	-18.5
LBR1	0.91	0.87	0.91	0.91	0.93	0.97	1.11	1.12	1.13	19.0	17.4	18.0	17.2	16.8	17.0	18.9	18.7	18.6
LBR2	1.05	1.01	1.01	1.06	1.05	1.09	1.22	1.22	1.22	23.6	22.1	21.7	21.9	20.7	20.9	23.1	22.6	22.2
LBR3	0.43	0.55	0.58	0.60	0.64	0.77	0.88	0.94	1.07	10.4	12.9	13.5	13.5	13.5	15.8	17.9	18.7	21.2
BR1	0.38	0.48	0.42	0.49	0.51	0.48	0.46	0.42	0.42	10.1	12.5	10.7	11.8	11.7	10.7	9.7	8.9	8.6
BR2	0.37	0.38	0.39	0.39	0.41	0.55	0.59	0.43	0.41	10.2	10.4	10.3	10.2	10.1	13.2	13.5	9.4	8.7
BR3	0.07	0.15	0.17	0.19	0.16	0.16	0.21	0.29	0.29	1.9	4.0	4.4	4.8	3.8	3.9	4.8	6.7	6.7
SCh1	0.09	0.11	0.11	0.14	0.14	0.07	0.05	0.06	0.04	2.2	2.6	2.5	3.2	3.1	1.5	1.1	1.2	0.9
SCh2	0.15	0.17	0.14	0.16	0.18	0.14	0.13	0.11	0.08	3.4	3.8	3.2	3.4	3.7	2.8	2.5	2.3	1.6
SR	0.96	0.98	0.92	0.93	0.90	0.85	1.12	1.10	1.15	16.3	16.5	14.9	14.2	13.2	12.0	15.0	14.6	15.1
StbR	0.26	0.34	0.31	0.27	0.25	0.19	0.15	0.09	0.07	4.9	6.4	5.6	4.7	4.1	3.0	2.4	1.3	1.1

Table B-7 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 5 ft deepening, and mitigation D.O. injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.08	0.07	0.06	0.09	0.07	0.05	0.03	0.02	0.00	1.9	1.5	1.4	2.0	1.5	1.2	0.6	0.5	0.1
FR2	0.22	0.19	0.16	0.19	0.15	0.18	0.14	0.14	0.14	5.3	4.4	3.7	4.3	3.4	3.8	2.9	2.8	2.8
FR3	0.18	0.21	0.20	0.23	0.22	0.17	0.16	0.08	0.01	4.4	5.2	4.8	5.3	4.9	3.6	3.3	1.5	0.2
FR4	0.23	0.26	0.31	0.29	0.29	0.24	0.12	0.06	0.03	5.7	6.2	7.3	6.6	6.4	4.9	2.3	1.1	0.6
FR5	0.29	0.30	0.33	0.30	0.30	0.12	-0.04	-0.02	0.01	7.0	7.0	7.6	6.7	6.3	2.4	-0.8	-0.3	0.2
FR6	0.29	0.28	0.26	0.22	0.11	-0.05	-0.11	0.06	0.12	6.9	6.6	5.6	4.6	2.3	-1.0	-1.8	1.0	1.9
FR7	0.20	0.14	0.12	0.04	-0.07	0.09	0.12	0.09	0.04	4.2	2.8	2.4	0.7	-1.2	1.4	1.8	1.3	0.6
FR8	0.14	0.01	0.04	-0.01	0.07	0.18	0.20	0.12	0.23	2.6	0.2	0.8	-0.3	1.1	2.8	3.0	1.7	3.2
FR9	-0.01	0.05	0.05	0.13	0.22	0.26	0.23	0.32	0.37	-0.2	0.9	0.8	2.0	3.3	3.8	3.2	4.3	5.0
FR10	0.54	0.52	0.49	0.51	0.50	0.50	0.57	0.63	0.72	9.2	8.6	7.9	7.9	7.5	7.3	7.9	8.6	9.8
FR11	0.63	0.58	0.56	0.55	0.50	0.46	0.56	0.60	0.64	11.1	10.0	9.4	8.6	7.6	6.6	7.7	8.3	8.7
MR1	0.22	0.27	0.28	0.29	0.28	0.20	0.20	0.19	0.18	4.7	5.6	5.5	5.6	5.1	3.3	3.3	3.1	2.8
MR2	0.53	0.56	0.49	0.48	0.40	0.28	0.24	0.21	0.24	11.4	11.6	10.0	9.2	7.3	4.8	3.9	3.4	3.8
MR3	0.89	0.86	0.82	0.82	0.73	0.52	0.40	0.39	0.45	19.5	18.2	16.9	16.0	13.4	8.9	6.5	6.3	7.1
MR4	0.86	0.86	0.86	0.88	0.88	0.92	1.01	1.13	1.16	17.4	16.7	16.4	16.4	15.5	15.7	16.7	18.5	18.6
MR5	1.13	1.18	1.18	1.12	1.01	0.80	0.86	0.80	0.80	26.9	26.3	25.3	22.3	17.5	12.4	12.7	11.3	11.1
MR6	0.11	0.01	-0.10	-0.21	-0.68	-0.91	-1.22	-1.25	-1.31	2.6	0.2	-2.1	-4.2	-11.6	-14.1	-17.5	-17.5	-17.8
LBR1	1.02	1.01	1.03	1.03	1.04	1.08	1.22	1.25	1.26	21.5	20.1	20.3	19.4	18.9	18.9	20.8	20.9	20.7
LBR2	1.16	1.13	1.14	1.16	1.16	1.20	1.34	1.33	1.38	26.2	24.7	24.5	24.1	23.0	23.0	25.3	24.7	25.2
LBR3	0.56	0.66	0.69	0.71	0.74	0.88	0.99	1.05	1.17	13.4	15.7	16.2	15.8	15.8	18.2	20.1	21.0	23.2
BR1	0.33	0.42	0.37	0.43	0.46	0.45	0.43	0.39	0.38	8.8	11.1	9.2	10.4	10.6	10.0	9.1	8.3	7.7
BR2	0.35	0.36	0.38	0.36	0.36	0.49	0.53	0.38	0.36	9.7	9.8	10.1	9.4	9.1	11.8	12.2	8.3	7.7
BR3	0.11	0.18	0.19	0.23	0.19	0.20	0.29	0.38	0.39	2.9	4.8	5.0	5.8	4.7	4.7	6.8	8.8	8.8
SCh1	0.07	0.09	0.09	0.12	0.11	0.07	0.06	0.06	0.05	1.6	2.2	2.0	2.8	2.5	1.5	1.3	1.3	1.2
SCh2	0.14	0.15	0.13	0.14	0.15	0.12	0.11	0.11	0.10	3.2	3.4	2.9	2.9	3.2	2.4	2.1	2.1	1.9
SR	1.17	1.20	1.12	1.12	1.10	1.05	1.37	1.36	1.41	19.9	20.1	18.2	17.2	16.3	14.8	18.4	18.0	18.5
StbR	0.36	0.39	0.35	0.31	0.29	0.25	0.21	0.16	0.18	6.9	7.4	6.4	5.4	4.8	4.0	3.3	2.4	2.6

Table B-8 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 4 ft deepening, and mitigation D.O. injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.07	0.06	0.05	0.09	0.07	0.04	0.04	0.02	-0.02	1.6	1.4	1.1	2.1	1.6	0.9	0.7	0.4	-0.4
FR2	0.20	0.17	0.14	0.18	0.15	0.18	0.14	0.14	0.13	4.9	4.1	3.3	4.1	3.2	3.7	2.8	2.8	2.7
FR3	0.15	0.18	0.18	0.23	0.20	0.16	0.16	0.10	0.04	3.7	4.4	4.4	5.2	4.5	3.5	3.2	1.9	0.7
FR4	0.21	0.22	0.27	0.27	0.26	0.21	0.09	0.03	0.03	5.0	5.4	6.3	6.1	5.7	4.2	1.7	0.5	0.6
FR5	0.24	0.25	0.28	0.26	0.24	0.09	-0.04	0.04	0.05	5.7	5.9	6.5	5.7	5.1	1.8	-0.6	0.6	0.8
FR6	0.23	0.23	0.21	0.19	0.09	-0.05	-0.06	0.09	0.13	5.5	5.3	4.6	3.9	1.7	-0.9	-1.1	1.4	2.1
FR7	0.15	0.10	0.09	0.02	-0.05	0.11	0.13	0.08	0.05	3.3	2.1	1.9	0.4	-0.8	1.7	2.0	1.2	0.8
FR8	0.11	0.01	0.03	-0.02	0.09	0.19	0.18	0.15	0.17	2.2	0.1	0.5	-0.4	1.4	2.9	2.6	2.1	2.3
FR9	0.01	0.06	0.07	0.14	0.22	0.23	0.23	0.31	0.34	0.1	1.1	1.2	2.2	3.3	3.4	3.3	4.2	4.6
FR10	0.49	0.48	0.44	0.46	0.45	0.45	0.54	0.57	0.66	8.4	8.0	7.1	7.2	6.8	6.5	7.4	7.8	8.9
FR11	0.55	0.51	0.49	0.47	0.43	0.39	0.47	0.51	0.55	9.7	8.7	8.3	7.4	6.5	5.7	6.5	7.0	7.4
MR1	0.18	0.23	0.24	0.27	0.27	0.19	0.17	0.18	0.18	3.8	4.8	4.8	5.1	4.8	3.2	2.8	2.9	2.8
MR2	0.50	0.53	0.48	0.45	0.39	0.27	0.20	0.19	0.22	10.7	11.0	9.6	8.6	7.2	4.6	3.4	3.1	3.5
MR3	0.86	0.83	0.78	0.77	0.68	0.49	0.37	0.35	0.39	18.9	17.6	16.2	15.1	12.5	8.4	6.0	5.6	6.2
MR4	0.80	0.80	0.80	0.83	0.82	0.87	0.96	1.08	1.08	16.1	15.5	15.3	15.4	14.5	14.8	15.8	17.6	17.3
MR5	1.07	1.12	1.13	1.06	0.93	0.74	0.79	0.73	0.72	25.6	24.9	24.1	21.0	16.1	11.4	11.6	10.3	9.9
MR6	0.10	0.00	-0.11	-0.22	-0.69	-0.92	-1.24	-1.26	-1.34	2.5	0.0	-2.4	-4.2	-11.7	-14.2	-17.8	-17.7	-18.2
LBR1	0.95	0.93	0.97	0.96	0.98	1.03	1.16	1.18	1.19	20.0	18.6	19.0	18.1	17.8	18.0	19.8	19.8	19.7
LBR2	1.11	1.07	1.07	1.11	1.10	1.14	1.28	1.28	1.35	24.9	23.4	23.1	23.1	21.9	21.8	24.2	23.8	24.6
LBR3	0.51	0.62	0.65	0.67	0.69	0.83	0.94	1.00	1.12	12.4	14.7	15.2	14.8	14.7	17.0	19.1	19.9	22.3
BR1	0.27	0.37	0.32	0.38	0.43	0.42	0.40	0.37	0.38	7.2	9.6	8.0	9.2	10.0	9.3	8.5	7.8	7.8
BR2	0.28	0.30	0.32	0.30	0.31	0.45	0.49	0.34	0.33	7.7	8.2	8.5	7.9	7.8	10.7	11.3	7.4	7.0
BR3	0.06	0.13	0.15	0.18	0.15	0.16	0.26	0.34	0.35	1.5	3.3	3.8	4.6	3.7	3.8	5.9	7.8	7.9
SCh1	0.09	0.12	0.09	0.12	0.11	0.06	0.04	0.04	0.03	2.1	2.8	2.2	2.8	2.5	1.3	0.9	0.8	0.6
SCh2	0.11	0.14	0.11	0.12	0.15	0.12	0.10	0.11	0.09	2.5	3.1	2.5	2.6	3.1	2.5	2.0	2.2	1.7
SR	1.06	1.09	1.02	1.03	1.00	0.95	1.24	1.23	1.28	18.1	18.3	16.6	15.7	14.8	13.4	16.7	16.3	16.8
StbR	0.36	0.37	0.31	0.29	0.28	0.24	0.20	0.15	0.14	7.0	6.9	5.7	5.1	4.6	3.8	3.1	2.3	2.1

Table B-9 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6a, 3 ft deepening, and mitigation D.O. injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.08	0.06	0.07	0.09	0.07	0.05	0.03	0.02	-0.02	1.7	1.4	1.5	2.0	1.5	1.0	0.7	0.3	-0.5
FR2	0.19	0.17	0.14	0.19	0.15	0.18	0.14	0.15	0.14	4.7	4.1	3.3	4.2	3.2	3.9	2.9	3.1	2.9
FR3	0.14	0.18	0.18	0.23	0.20	0.17	0.18	0.15	0.10	3.4	4.3	4.3	5.2	4.5	3.6	3.7	2.9	1.9
FR4	0.19	0.21	0.22	0.24	0.22	0.19	0.11	0.09	0.09	4.6	5.0	5.3	5.5	4.9	3.9	2.1	1.6	1.5
FR5	0.21	0.20	0.24	0.23	0.19	0.10	0.00	0.11	0.11	5.0	4.7	5.6	5.1	4.1	2.0	0.0	1.8	1.8
FR6	0.17	0.18	0.17	0.15	0.08	0.00	0.03	0.16	0.19	4.0	4.1	3.8	3.2	1.5	0.0	0.5	2.6	3.0
FR7	0.13	0.08	0.08	0.03	0.02	0.17	0.15	0.15	0.09	2.8	1.7	1.6	0.6	0.4	2.6	2.2	2.2	1.3
FR8	0.11	0.03	0.05	0.01	0.14	0.21	0.20	0.13	0.25	2.1	0.5	1.0	0.2	2.3	3.2	2.9	1.8	3.5
FR9	0.05	0.12	0.13	0.18	0.24	0.25	0.27	0.32	0.37	0.9	1.9	2.2	2.8	3.7	3.7	3.8	4.4	4.9
FR10	0.49	0.47	0.44	0.46	0.45	0.45	0.53	0.57	0.65	8.4	7.8	7.1	7.2	6.8	6.5	7.3	7.7	8.8
FR11	0.55	0.51	0.50	0.47	0.43	0.39	0.47	0.51	0.55	9.7	8.7	8.3	7.4	6.5	5.6	6.5	7.0	7.4
MR1	0.16	0.22	0.23	0.27	0.29	0.23	0.20	0.22	0.18	3.3	4.4	4.5	5.2	5.2	3.8	3.4	3.6	2.9
MR2	0.50	0.57	0.50	0.48	0.42	0.30	0.24	0.21	0.26	10.7	11.9	10.1	9.2	7.6	5.1	4.0	3.4	4.1
MR3	0.88	0.85	0.80	0.79	0.69	0.50	0.38	0.36	0.38	19.3	17.9	16.5	15.4	12.8	8.6	6.2	5.8	6.0
MR4	0.80	0.79	0.80	0.82	0.81	0.87	0.95	1.06	1.07	16.2	15.3	15.2	15.1	14.4	14.8	15.6	17.3	17.2
MR5	1.08	1.11	1.13	1.06	0.93	0.74	0.79	0.73	0.72	25.6	24.8	24.1	21.1	16.1	11.5	11.6	10.2	9.9
MR6	0.11	0.01	-0.11	-0.22	-0.70	-0.92	-1.24	-1.26	-1.33	2.8	0.2	-2.3	-4.4	-11.7	-14.2	-17.8	-17.7	-18.1
LBR1	0.95	0.93	0.97	0.97	0.97	1.02	1.16	1.18	1.20	19.9	18.6	19.1	18.2	17.7	17.9	19.7	19.8	19.7
LBR2	1.11	1.07	1.07	1.11	1.10	1.15	1.28	1.27	1.30	24.9	23.4	23.0	22.9	21.8	22.1	24.1	23.6	23.6
LBR3	0.52	0.63	0.66	0.67	0.70	0.82	0.94	1.00	1.13	12.6	14.9	15.4	15.0	14.8	17.0	19.0	20.1	22.4
BR1	0.25	0.34	0.28	0.35	0.41	0.42	0.39	0.37	0.37	6.6	8.9	7.1	8.6	9.5	9.2	8.4	7.7	7.6
BR2	0.25	0.27	0.29	0.28	0.28	0.42	0.47	0.32	0.31	6.8	7.3	7.7	7.3	7.0	9.9	10.7	7.0	6.6
BR3	0.02	0.11	0.13	0.16	0.15	0.15	0.26	0.35	0.35	0.6	2.9	3.3	4.2	3.6	3.7	6.0	8.1	8.0
SCh1	0.05	0.08	0.08	0.11	0.10	0.05	0.02	0.02	0.02	1.2	2.0	1.9	2.5	2.2	1.1	0.5	0.5	0.5
SCh2	0.11	0.13	0.12	0.13	0.15	0.12	0.11	0.10	0.09	2.5	3.0	2.6	2.8	3.2	2.4	2.2	2.0	1.8
SR	1.06	1.09	1.02	1.03	1.00	0.95	1.24	1.23	1.28	18.1	18.3	16.6	15.7	14.8	13.4	16.7	16.3	16.8
StbR	0.38	0.38	0.34	0.30	0.31	0.29	0.23	0.21	0.20	7.2	7.2	6.2	5.2	5.1	4.6	3.6	3.1	2.9

Table B-10 Delta (Project – Existing) D.O. Percentiles for Zones' Averages: Plan 6b, 2 ft deepening, and mitigation D.O. injections

Zone	Project - Baseline Difference (mg/l)									Project - Baseline Relative Difference (%)								
Name	1%	5%	10%	25%	50%	75%	90%	95%	99%	1%	5%	10%	25%	50%	75%	90%	95%	99%
FR1	0.07	0.06	0.05	0.07	0.08	0.07	0.05	0.03	-0.01	1.7	1.3	1.2	1.6	1.7	1.4	1.0	0.5	-0.2
FR2	0.21	0.18	0.15	0.20	0.17	0.20	0.18	0.21	0.22	5.0	4.2	3.6	4.4	3.7	4.3	3.7	4.3	4.4
FR3	0.15	0.18	0.19	0.24	0.23	0.21	0.24	0.25	0.24	3.7	4.3	4.5	5.5	5.2	4.4	5.0	4.9	4.5
FR4	0.20	0.22	0.24	0.26	0.26	0.25	0.23	0.23	0.20	4.8	5.3	5.8	6.0	5.7	5.2	4.3	4.1	3.5
FR5	0.23	0.23	0.26	0.26	0.23	0.19	0.14	0.21	0.21	5.4	5.5	5.9	5.7	4.9	3.6	2.4	3.5	3.5
FR6	0.21	0.20	0.21	0.20	0.15	0.10	0.17	0.23	0.25	4.9	4.7	4.6	4.3	2.9	1.7	2.8	3.7	4.0
FR7	0.18	0.14	0.14	0.11	0.13	0.22	0.20	0.17	0.14	4.0	3.0	2.7	2.0	2.1	3.6	3.0	2.5	2.0
FR8	0.19	0.09	0.14	0.11	0.23	0.25	0.24	0.19	0.27	3.7	1.7	2.5	1.9	3.7	3.8	3.5	2.7	3.7
FR9	0.14	0.19	0.25	0.25	0.30	0.30	0.31	0.34	0.38	2.4	3.3	4.0	3.9	4.5	4.3	4.3	4.6	5.1
FR10	0.50	0.48	0.45	0.48	0.46	0.46	0.54	0.58	0.67	8.4	8.0	7.2	7.4	6.9	6.7	7.5	7.8	9.0
FR11	0.55	0.51	0.49	0.47	0.43	0.39	0.47	0.52	0.55	9.6	8.7	8.2	7.4	6.4	5.7	6.5	7.1	7.4
MR1	0.21	0.27	0.27	0.32	0.29	0.26	0.25	0.25	0.22	4.4	5.6	5.3	6.0	5.2	4.4	4.1	4.1	3.5
MR2	0.56	0.56	0.47	0.45	0.42	0.28	0.24	0.22	0.26	12.1	11.7	9.5	8.7	7.6	4.8	3.9	3.6	4.2
MR3	0.81	0.73	0.74	0.70	0.63	0.45	0.31	0.30	0.25	17.7	15.5	15.3	13.7	11.5	7.6	5.0	4.8	3.9
MR4	0.72	0.65	0.69	0.69	0.68	0.71	0.79	0.87	0.94	14.5	12.5	13.1	12.7	12.1	12.1	12.9	14.3	15.0
MR5	0.54	0.56	0.60	0.64	0.79	0.72	0.77	0.73	0.70	12.9	12.6	12.9	12.8	13.6	11.1	11.3	10.2	9.6
MR6	2.00	1.85	1.69	1.54	0.90	0.51	0.27	0.20	0.07	48.1	41.1	35.6	30.3	15.3	7.8	3.9	2.9	0.9
LBR1	0.75	0.74	0.75	0.75	0.73	0.73	0.88	0.87	0.86	15.6	14.8	14.8	14.2	13.3	12.8	15.0	14.6	14.2
LBR2	0.85	0.81	0.82	0.82	0.80	0.83	0.94	0.98	0.96	19.1	17.8	17.7	17.1	15.8	15.9	17.7	18.1	17.6
LBR3	-0.09	0.01	0.07	0.13	0.24	0.42	0.55	0.60	0.72	-2.1	0.2	1.5	2.8	5.0	8.6	11.1	12.0	14.3
BR1	0.60	0.63	0.57	0.52	0.49	0.50	0.46	0.44	0.43	16.2	16.6	14.4	12.5	11.5	11.0	9.9	9.3	8.9
BR2	0.68	0.72	0.74	0.76	0.74	0.76	0.71	0.56	0.53	18.9	19.5	19.8	19.9	18.4	18.1	16.2	12.2	11.3
BR3	-0.11	-0.05	-0.02	0.10	0.08	0.10	0.13	0.17	0.21	-2.9	-1.3	-0.5	2.4	2.1	2.3	2.9	4.0	4.6
SCh1	0.09	0.10	0.09	0.11	0.10	0.05	0.04	0.04	0.04	2.2	2.5	2.3	2.6	2.3	1.2	0.9	0.9	0.8
SCh2	0.13	0.15	0.13	0.14	0.16	0.13	0.12	0.12	0.11	2.9	3.3	2.8	2.9	3.4	2.7	2.5	2.4	2.2
SR	1.06	1.09	1.02	1.03	1.00	0.95	1.25	1.23	1.28	18.1	18.3	16.6	15.7	14.8	13.4	16.7	16.3	16.8
StbR	0.40	0.41	0.38	0.34	0.34	0.31	0.28	0.24	0.23	7.7	7.8	6.9	6.0	5.5	4.9	4.4	3.6	3.4

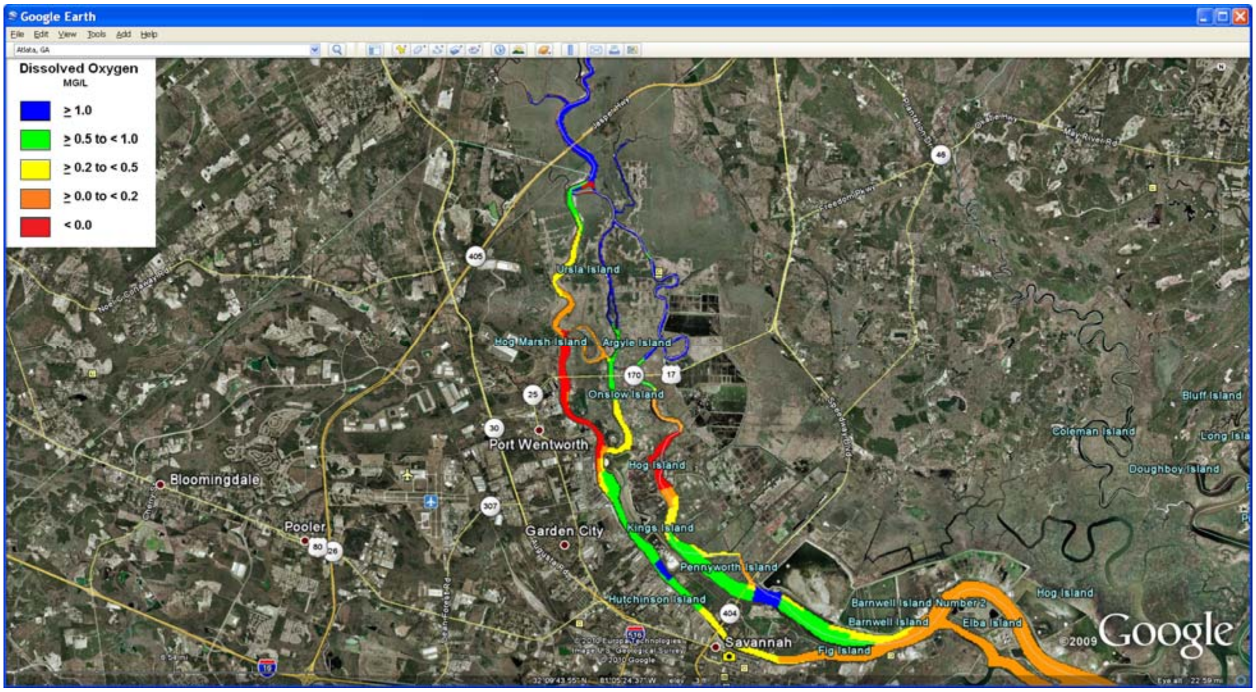

Figure B-1 Delta D.O. (50th percentile): Mitigation plan 6a-6ft and D.O. discharge

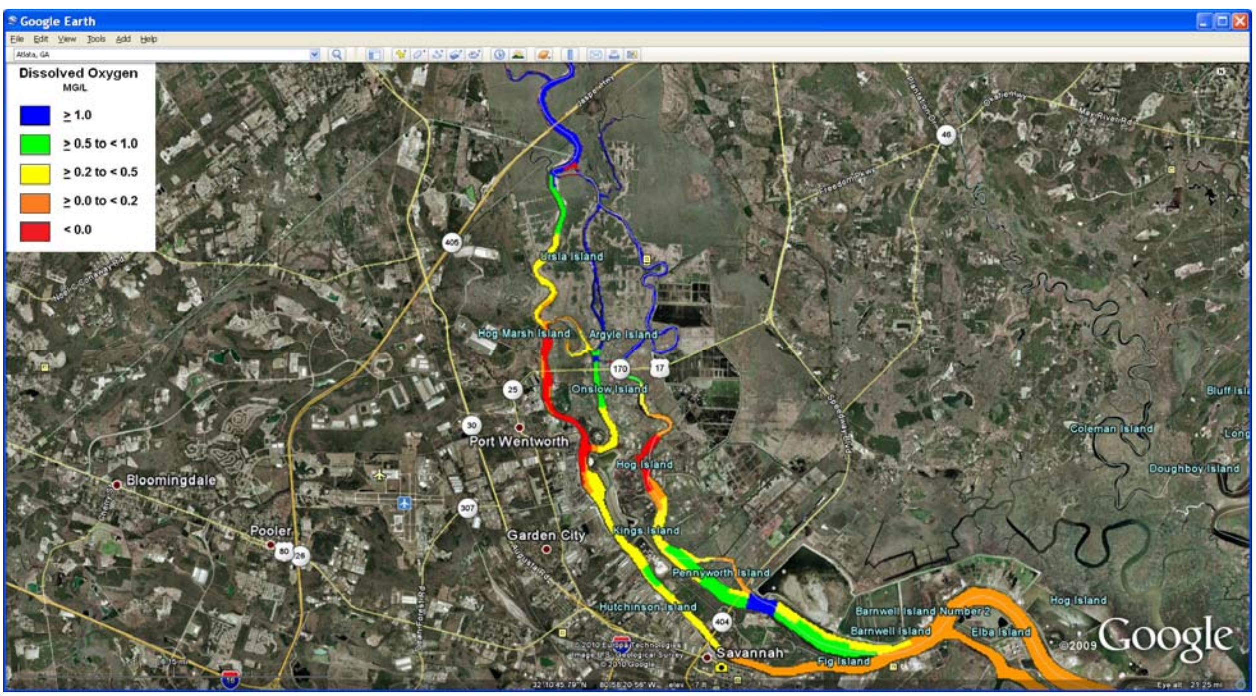

Figure B-2 Delta D.O. (50th percentile): Mitigation plan 6a-5ft and D.O. discharge

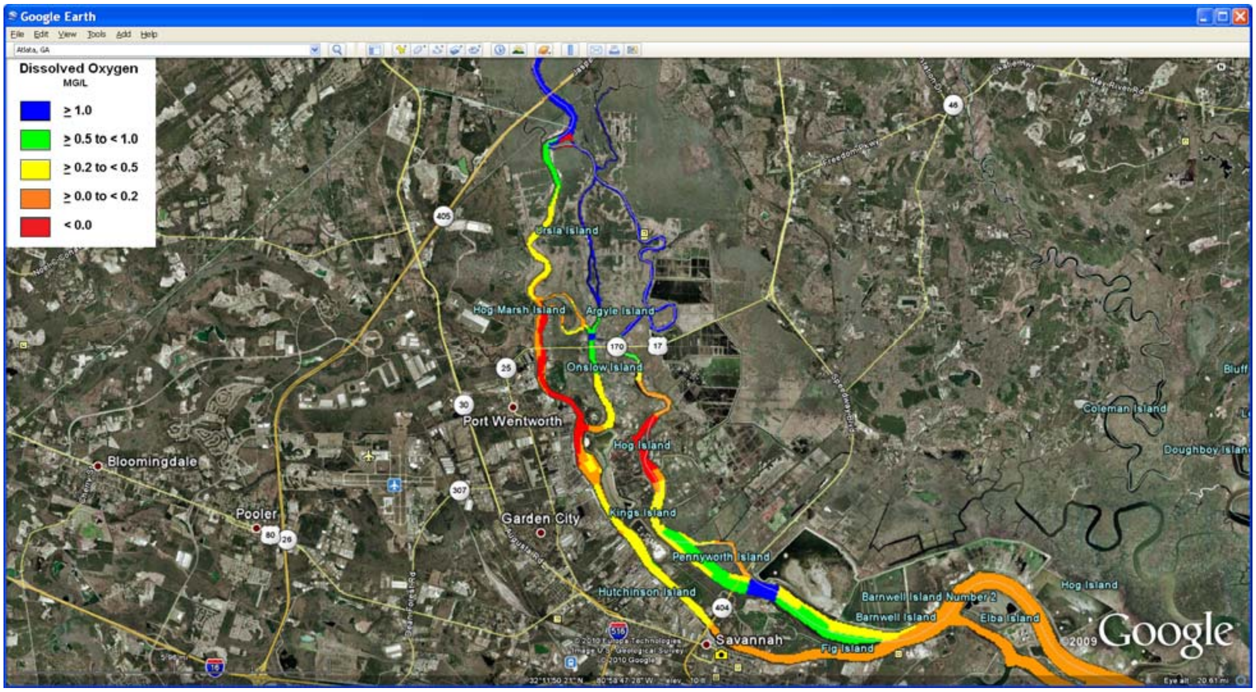

Figure B-3 Delta D.O. (50th percentile): Mitigation plan 6a-4ft and D.O. discharge

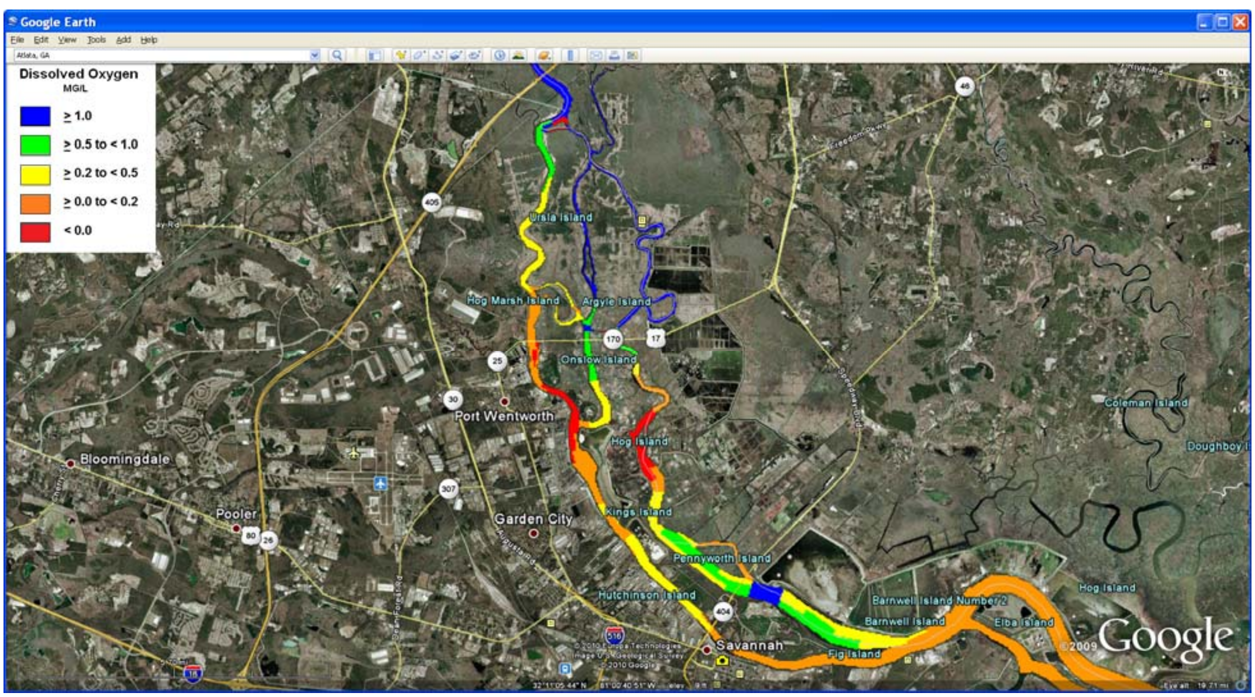

Figure B-4 Delta D.O. (50th percentile): Mitigation plan 6a-3ft and D.O. discharge

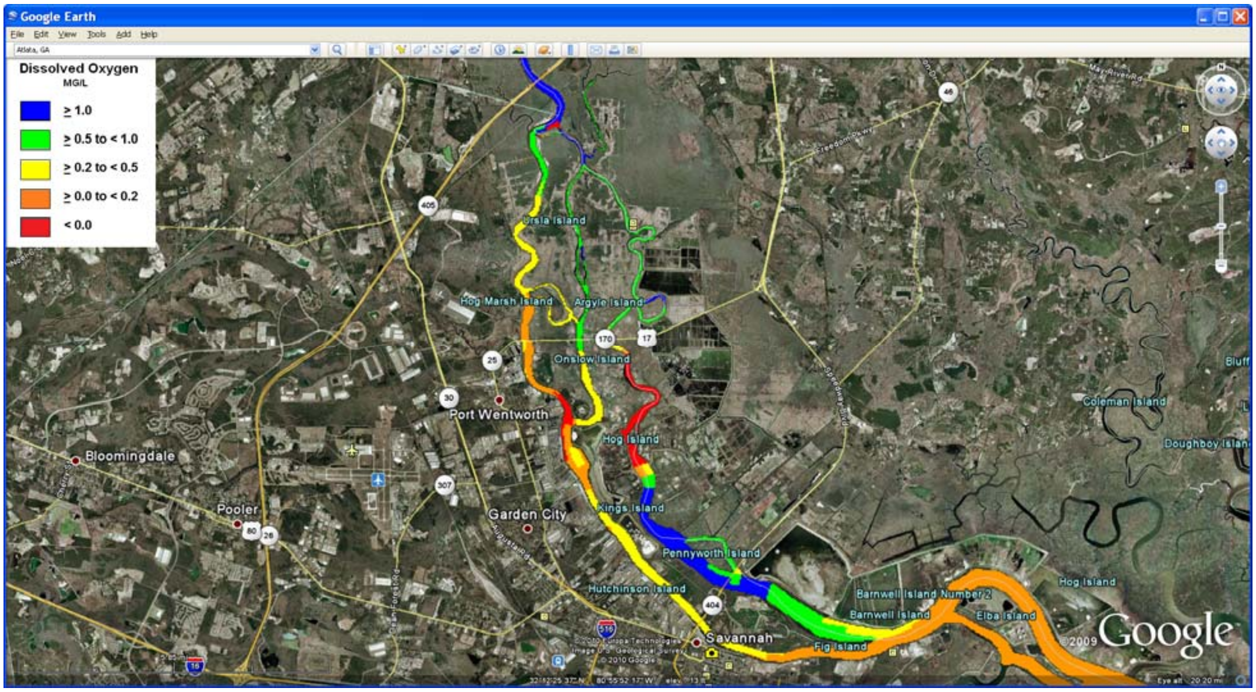

Figure B-5 Delta D.O. (50th percentile): Mitigation plan 6b-2ft and D.O. discharge

APPENDIX C

DISSOLVED OXYGEN MITIGATION RESULTS FOR OXYGEN IMPROVEMENT SYSTEMS LOCATED NEAR INTERNATIONAL PAPER AND GEORGIA PACIFIC

TABLES

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Table C-1 Mitigation success for facilities located near IP and GP: 1BL criteria, 5th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	98.9	99.8	99.8	99.8	99.8
Mid-Depth	93.3	98.4	98	98.1	98.2
Bottom	97.2	97.1	97.5	97.3	97
Water Column	97.6	99.9	99.9	99.9	99.9

Table C-2 Mitigation success for facilities located near IP and GP: 1BL criteria, 10th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.5	99.7	99.7	99.7	99.7
Mid-Depth	93.5	98.5	97.9	98	98.1
Bottom	97.4	98.1	97.3	97.3	98.6
Water Column	97.5	99.9	99.9	99.9	99.9

Table C-3 Mitigation success for facilities located near IP and GP: 1BL criteria, 25th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.9	99.8	99.9	99.9	99.9
Mid-Depth	94.5	98.7	98.4	98.3	98.5
Bottom	97	98.5	97.3	98.1	98.4
Water Column	97.7	99.9	99.9	99.9	99.9

Table C-4 Mitigation success for facilities located near IP and GP: 1BL criteria, 50th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.7	99.7	99.6	99.6	99.6
Mid-Depth	95.3	98.4	97.2	97.8	98
Bottom	97.8	98.8	97.4	97.3	97
Water Column	98.2	99.9	99.9	99.9	99.9

Table C-5 Mitigation success for facilities located near IP and GP: 3BL criteria, 5th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.3	98	98	98.4	99.2
Mid-Depth	94	94.5	94.5	96.2	95.1
Bottom	96.9	93.9	92.3	95.1	96.4
Water Column	98	99.9	99.8	99.8	99.7

Table C-6 Mitigation success for facilities located near IP and GP: 3BL criteria, 10th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.5	98.1	98.3	98.6	99.1
Mid-Depth	94.3	94.9	94.7	95.9	95.4
Bottom	96.6	95.2	95	95.1	95.9
Water Column	98	99.9	99.8	99.8	99.9

Table C-7 Mitigation success for facilities located near IP and GP: 3BL criteria, 25th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.8	98.6	98.9	99	99.9
Mid-Depth	94.9	95.9	95.9	96.6	96.5
Bottom	95.8	94.7	94.3	94.3	94.7
Water Column	98.4	99.7	99.6	99.5	99.9

Table C-8 Mitigation success for facilities located near IP and GP: 3BL criteria, 50th percentile

	DEPTH ALTERNATIVE				
Vertical Layer	44-foot	45-foot	46-foot	47-foot	48-foot
Surface	99.7	99.2	98.9	99.1	99.6
Mid-Depth	96.2	95.7	94.4	95	95.7
Bottom	96.9	94.4	93.1	94	93.5
Water Column	98.8	99.3	98.8	98.9	98.9

APPENDIX D

SAVANNAH ENHANCED MODEL (SHEP) POSTPROCESSOR

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The post-processor for Savannah enhanced hydrodynamic and water quality model (WAMS) is a stand-alone program that can read EFDC and WASP output files (BMD files) and generate required outputs in specific formats for impact analysis. The GUI of the current version of the postprocessor is presented on Figure D-1.

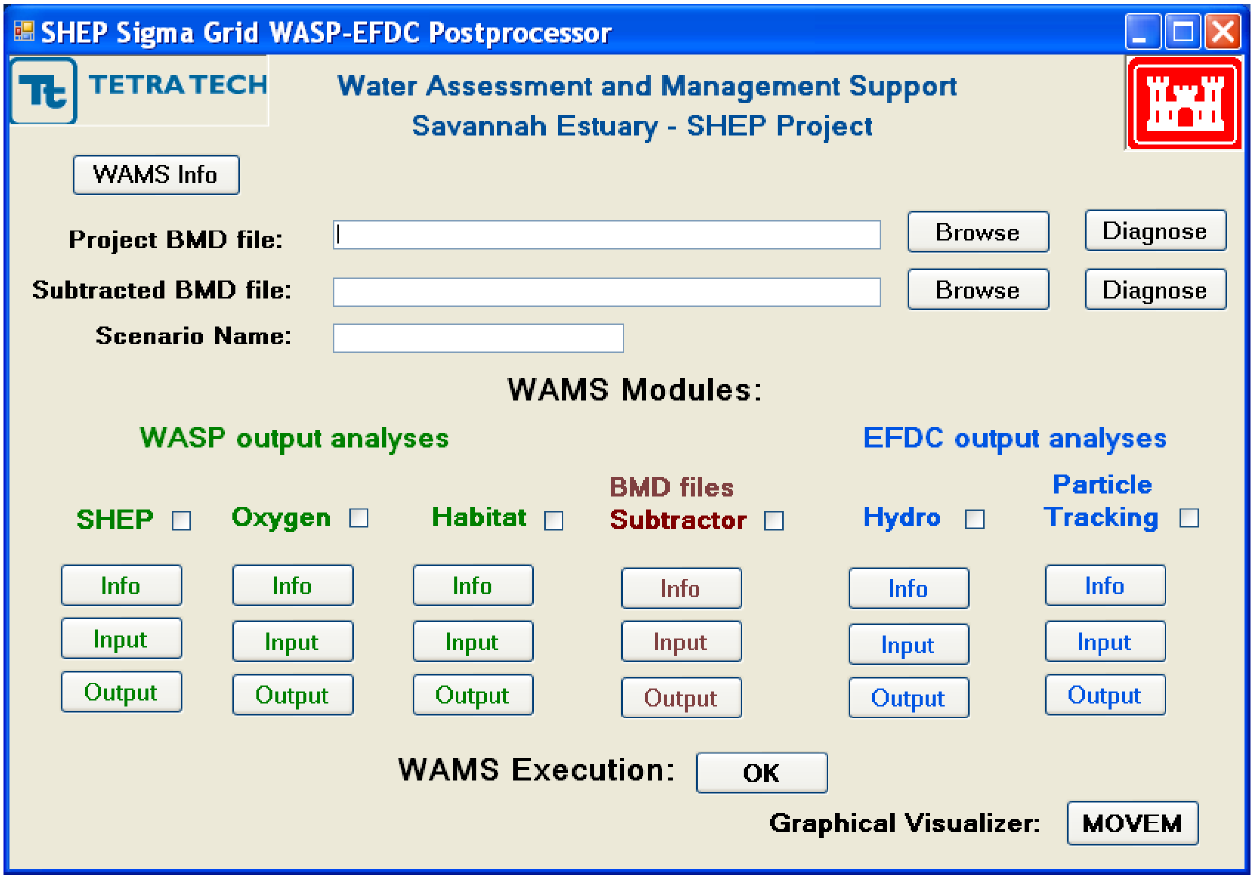

Figure D1 WASP-EFDC postprocessor for models developed for SHEP project

The module “Oxygenation” was developed for identification of parameters of dissolved oxygen improvement system and evaluation of effectiveness of SHEP mitigation measures.

The modified postprocessor outputs information for the following harbor’s spatial objects:

- Critical Cell – the cell with lowest D.O. concentrations during specified simulation period
- Critical Segment – an assemblage of cross section cells located at the critical cell’s j-coordinate
- Zone – an assemblage of cells that is limited by specified horizontal and vertical boundaries

The basic criteria for assessing the success of D.O. mitigation is the condition of meeting existing (pre-project) or higher values of D.O. concentrations for 97% of the estuarine waters at least. WAMS provides estimates of such waters volume for all user’s selected zones.

The postprocessor outputs the results of hydrodynamic and water quality simulations as a set of following files with tables:

1. File name: <Oxygen\Tables\><Scenario name><Mitigation success.CSV>. The tables contain the percentage of volume that meets 97% requirement for all cells of selected zones, all zones and the whole estuary for 1st, 5th, 10th, 25th, 50th, 75th, 95th, and 99th percentiles of D.O. concentrations.

2. File name: <Oxygen\Tables\><Scenario name><_CriticCell_DO_%.CSV>. The table contains D.O. percentiles distribution for a cell with lowest D.O. concentrations inside each zone. The information allows purposefully focusing the mitigation measures on most critical parts of the zones.

3. File name: <Oxygen\Tables\><Scenario name><_CriticCell_Sal_%.CSV>. The table contains salinity percentiles distribution for each zone's critical cell. It helps to identify salinity impact on formation of lowest D.O. concentrations inside each zone.

4. File name: <Oxygen\Tables\><Scenario name><_C_DO_Viol.CSV>. The table contains percentage of simulation records with D.O. standards' violations for each cell of the computational grid during the simulation period:

$$A_i^k = \frac{100}{N_t}\sum_{t=1}^{N_t}\delta_{it}^k, \qquad ,$$

$$\delta_{it}^k = 1, \quad if\ C_{it} \geq S^k;\ \delta_{it}^k = 0, \quad if\ C_{it} \prec S^k$$

where A_i^k is a number of violations of the *k*-th D.O. standard S^k for *i*-th cell; C_{it} is the D.O. concentration in *i*-th cell for *t*-th record; N_t is the number of time records in BMD WASP output file

5. File name: <Oxygen\Tables\><Scenario name><_C_DO_Viol_Analys.CSV>. The table contains numbers of cells that correspond to deciles of the cumulative distribution function of numbers of violation of D.O. standards

$$G_j^k = \sum_{i=1}^{N_c} Z_{ij}^k, \quad j = 1,...,10$$

$$if\ (j-1)*10 \prec A_i^k \leq j*10 \quad Z_{ij}^k = 1, \quad otherwise\ Z_{ij}^k = 0,$$

where G_j^k is the number of cells with *k*-th standard violation within a range of *j* and *j-1* deciles; N_c is the number of cells in the computational grid.

6. File name: <Oxygen\Tables\><Scenario name><_C_Viol_WC_Volume.CSV>. The table contains percentage of water volumes with violations of D.O. standards through the water column of each specified zone

$$B_m^k = \frac{\sum_{t=1}^{N_t}\sum_{n=1}^{N_v}\sum_{i=1}^{N_m} V_{tin}\delta_{tin}^k}{\sum_{t=1}^{N_t}\sum_{n=1}^{N_v}\sum_{i=1}^{N_m} V_{tin}} \cdot 100\% \qquad ,$$

$$\delta_{tin}^k = 1, \quad if\ C_{tin} \geq S^k;\ \delta_{tin}^k = 0, \quad if\ C_{tin} \prec S^k$$

where N_v is the maximum number of vertical layers; N_m is the number of horizontal cells in a zone *m*; V_{tin} is the volume of a cell with coordinates (*i, n*) at time *t*.

7. File name: <Oxygen\Tables\><Scenario name><_C_Viol_WL_Volume.CSV>. The table contains percentage of water volume with violations of D.O. standards for each specified zone and selected vertical layers

$$B_m^k = \frac{\sum_{t=1}^{N_t} \sum_{n=N_b}^{N_e} \sum_{i=1}^{N_m} V_{tin} \delta_{tin}^k}{\sum_{t=1}^{N_t} \sum_{n=N_b}^{N_e} \sum_{i=1}^{N_m} V_{tin}} \cdot 100 \quad ,$$

$$\delta_{tin}^k = 1, \quad if \ C_{tin} \geq S^k \ ; \delta_{tin}^k = 0, \quad if \ C_{tin} \prec S^k$$

where N_b and N_e are the beginning and ending of vertical *n*-coordinates for zone *m*; V_{tijn} is the volume of a cell with coordinates (*i, j, n*) at time *t*.

8. File name:< Oxygen\Tables\><Scenario name><_CriticSeg_DO_A_TS.CSV>. The table contains time series of 1-, 7-, and 30-day average D.O. for each critical segment's water column, and it's top and bottom halves

9. File name: <Oxygen\Tables\><Scenario name><_CriticSeg_Sal_A_TS.CSV>. The table contains time series of 1-, 7-, and 30-day average salinity for each critical segment's water column, and it's top and bottom halves

10. File name: <Oxygen\Tables\><Scenario name><_Z_DO_%. CSV>. The table contains volume-weighted D.O. percentiles distributions for each zone and specified vertical layers

11. File name: <Oxygen\Tables\><Scenario name><_Z_Sal_%.CSV>. The table contains volume-weighted salinity percentiles distributions for each zone and specified vertical layers

12. File name: <Oxygen\Tables\><Scenario name><_Z_DO_Viol.CSV>. The table contains percentages (F_m) of occurrences of D.O. standards violations by each zone's volume-weighted D.O.

$$R_{tm} = \frac{\sum_{i=1}^{N_m} \sum_{n=N_b}^{Ne} V_{tin} C_{tin}}{\sum_{i=1}^{N_m} \sum_{n=N_b}^{Ne} V_{tin}} ,$$

$$F_m = \frac{100\%}{N_t} \cdot \sum_{t=1}^{N_t} \delta_{tm}^k ,$$

$$\delta_{tm}^k = 1, \quad if \ R_{tm} \geq S^k ; \ \delta_{tm}^k = 0, \quad if \ R_{tm} \prec S^k ,$$

where R_{tm} is the volume-weighted D.O. concentration for zone m and time record t.

13. File name: <Oxygen\Tables\><Scenario name><_Z_DO_Mass.CSV>. The table contains D.O. deficit in reference to the current D.O. minimum standard St.4: average deficit over simulation period – D_m, as well as maximum instant D.O. deficit and time of this event for each specified zone

$$D_m = \frac{1}{N_t} \sum_{t=1}^{N_t} \sum_{n=N_b}^{N_e} \sum_{i=1}^{N_m} (S^k - C_{tin})$$

The tables (items 10 – 13) contain information about each selected zone volume-weighted D.O. and salinity concentrations' averages and their correspondence to D.O. standards. The information allows estimating the contribution of each zone into the general pattern of D.O. regime of the estuary.

APPENDIX E

ECO2 QUOTATION ON SPEECE CONE ON MARCH 17, 2010

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Eco2 quotation included below.

3/17/2010
Savannah Harbor, Oxygen Injection
ECO2 SuperOxygenation
Preliminary design & budget estimate
Steven Davie, Submitted by Eco Oxygen Technologies
Oxygen supply by on site oxygen generation PSA

Design Operating Conditions		**units**			
Oxygen Supply		lbs / day		5,000	
Electrical Unit Cost		$ / kwhr		$0.06	
Annual Usage		days		180	
ECO2 System Design and Capital Cost		**units**	**quantity**	**rate**	**cost**
ECO2 cone with PLC oxygen flow control	12	ft. Dia.	1	$748,474	$748,474
Oxygen dissolution	4,000	lbs / day	1	4,000	
Side Stream Flow	12,600	gpm	1	12,600	
Sub total					$748,474
Outsourced/3rd party Capital Cost		**units**	**quantity**	**rate**	**cost**
Installation (including side stream pump)			1	$250,000	$250,000
Oxygen Generator (PSA)	5,000	lbs / day	1	$170,000	$170,000
Sub total					$420,000
Annual Operating Cost		**units**	**quantity**	**rate**	**cost**
Electrical draw - Oxygen Generator	1,815	kwhr / day	1	$0.06	$19,600
Electrical draw - Side Stream Pump	75	hp	1	$0.06	$14,500
O&M - Oxygen Generator & Side Stream Pump				20%	$6,800
License fee - ECO2 process technology	4,000	lbs / day	1	$0.01	$7,200
Sub total					$48,100
Total Capital Cost Estimate including Onsite Oxygen Generation					**$1,168,474**
Total Annual Operating Cost Estimate (180 days)					**$48,100**

Notes:
The cost estimate for installation, side stream pump and oxygen generation equipment need to be validated.
Cost estimates valid for 30 days and do not include taxes or shipping
Cost estimates subject to verification of design data
Purchase subject to Terms & Conditions of Purchase Agreement and Process Technology License Agreement

ECO Oxygen Technologies
3939 Priority Way South Drive, Suite 400, Indianapolis, IN 46240
Tel: 317-706-6484 Fax: 317-816-0940 www.eco2tech.com

E. Groundwater/Aquifer

1. Memorandum. Resource Agency Meeting on Supplemental Aquifer Studies. SHEP. Meeting held on 25 October 2002 in Savannah District.

2. Memorandum, Resource Agency Meeting on Supplemental Aquifer Studies. SHEP. Meeting held on 12 March 2004 in Savannah District.

3. Memorandum. Resource Agency Meeting on Supplemental Aquifer Studies, SHEP. Meeting held 8 October 2004 in Savannah District.

1. Memorandum for Record concerning the "Savannah Harbor Expansion Project – Chloride Data Analysis and Model Development" dated November 15, 2006. Memorandum for Record dated 10 January 2007 and revised 13 February 2007. From Joseph T. Hoke, PE, Hydraulic Engineer, Reviewed by Greg Williams, PE, Chief, Coastal, Hydrology and Hydraulics Section, and Approved by Wayne Bissette, PE, Chief, Wilmington Regional Engineering Center.

Memorandum

Resource Agency Meeting
on
Supplemental Aquifer Studies

Savannah Harbor Expansion Project

A meeting was held on 25 October, 2002 at the office of the Savannah District, US Army Corps of Engineers to obtain input from two state and one federal agency regarding proposed additional studies relating to potential impacts to the Floridan aquifer as a result of the proposed Savannah Harbor Expansion Project (SHE).

The following persons attended the meeting:

Bill McLemore – GAEPD (GGS)
Camille Ransom - SCDHEC
John Clarke – USGS, Georgia District
Mark Maimone – Camp Dresser & McKee
John Cox – Applied Technology & Management
Doug Plachy – USACE, Savannah District
Cardwell Smith - USACE, Savannah District

The meeting began at 1300 with Mr. Smith introducing Mr. Maimone to the other attendees and explaining that the purpose of the meeting was based on the Corps' desire to coordinate with other state and federal agencies, to keep them informed of Corps plans, and to receive input relative to proposed supplemental studies. It is felt that if these agencies are involved in the study process they will be better informed when and if their approval authority is required for the project.

Mr. Smith then spent about an hour presenting a summary of project related background and studies performed to date. Following the presentation there was a period of general discussion on proposed project elements and how studies associated with the on-going Georgia Sound Science Initiatives might relate to supplemental studies for SHE.

Discussion was then focused on a Savannah District (USACE) draft proposal for additional aquifer-related studies. Mr. Smith re-iterated that Savannah District's ultimate goal was to acquire sufficient data to produce an appropriate EIS for potential project-related impacts to the aquifer.

Additional discussion was held on USACE's desire to have an Independent Technical Review (ITR) of project studies. A similar review of Georgia Sound Science Initiative studies was mentioned by Dr. McLemore and Mr. Clarke and possible review panel members were discussed.

The following action items resulted from the meeting:

1. Mr. Maimone was asked to provide written comments to Savannah District on the meeting and the proposed USACE study plan.
2. Mr. Clarke was asked to provide a proposal and cost estimate for USGS to provide technical assistance and review of project elements, particularly those related to ground-water modeling and GIS data.
3. Mr. Smith will forward Mr. Maimone's comments to the other attendees for review and comment. When final comments are received, Mr. Smith will compile and forward them to the other attendees.
4. Mr. Smith will begin contacting potential Independent Reviewers.
5. Mr. Smith will keep GAEPD, USGS and SCDHEC informed on proposed project study preparations and schedules.

It was decided that project coordination will be maintained via e-mail and telephone, and additional meetings will only be held as needed.

The meeting concluded about 1615.

CARDWELL SMITH, P.G.
Geology, Hydrogeology and HTRW Design Section

<u>Memorandum</u>

Resource Agency Meeting
on
Supplemental Aquifer Studies

Savannah Harbor Expansion Project

A meeting was held on 12 March, 2004 at the office of the Savannah District, US Army Corps of Engineers to update GAEPD, SCDHEC and USGS (Georgia and SC Districts) on recent progress and findings regarding supplemental studies relating to potential impacts to the Floridan aquifer as a result of the proposed Savannah Harbor Expansion Project (SHE).

The following persons attended the meeting:

Bill McLemore – GAEPD (GGS)
Camille Ransom - SCDHEC
John Clarke – USGS, Georgia District
Jim Landmeyer – USGS, South Carolina District
Mark Maimone – Camp Dresser & McKee
Paul Hossain – Camp Dresser &McKee
John Cox – Applied Technology & Management
Mackie McIntosh - USACE, Savannah District
Robert O'kelley - USACE, Savannah District
Cardwell Smith - USACE, Savannah District

The meeting began at 1000 with Mr. Smith introducing Mr. Hossain and Ms. McIntosh to the other attendees and explaining that the purpose of the meeting was to update the attendees on progress and findings to date, obtain feedback on the findings and discuss any potential changes that may be needed in the remainder of the proposed work.

Mr. Smith then spent about an hour presenting a summary of project related background and previous studies, as well as the findings of recent work. Particular emphasis was placed on the recent supplemental paleochannel seismic survey and the paleochannel/confining layer pore water investigation.

The seismic survey appears to have produced some exceptional data on paleochannels. Over 60 miles of survey were completed predominately in the area between Fields Cut and Tybee Island.

Pore water data collection is progressing well and it appears that the data will be very useful in the calibration of the model.

Following the presentation there was a period of general discussion on the progress of supplemental project elements and thoughts on any potential changes that might be warranted, based on findings to date. It was decided that one of the remaining channel borings, which have been focused in paleochannel areas, should be located in an area between two paleochannels to allow comparison of the pore water profiles below paleochannels with a profile below a non-paleochannel area.

Channel borings should be completed within the next few weeks and land borings are expected to begin soon thereafter. Construction details of the nested wells to be installed after land core borings are completed were discussed, and the consensus seems to lean toward using conventional 4-inch wells versus single installation multi-port wells.

After lunch, discussion was focused on data needs for the 3-D ground-water model that Mr. Maimone and Mr. Hossain (CDM) are working on. Mr. Hossain has been working with the USGS (Mr. Clarke's office) to develop the database for the model. CDM will use the GIS layering and hydraulic properties of the USGS Hilton Head/Savannah models as the basis for the Savannah Harbor model, combined with more recent USACE harbor-specific data in the immediate project area.

The following action items resulted from the meeting:

1. Mr. Smith and Ms. McIntosh will continue compiling and updating project data to be provided to CDM for the model.
2. CDM will continue with development of the model database and begin model calibration.
3. USACE will continue to keep GAEPD, USGS and SCDHEC informed on project findings.

Project coordination will continue to be maintained via e-mail and telephone, and additional meetings will be held as needed.

The meeting concluded about 1515.

CARDWELL SMITH, P.G.
Geology, Hydrogeology and HTRW Design Section

Memorandum

Resource Agency Meeting
on
Supplemental Aquifer Studies

Savannah Harbor Expansion Project

A meeting was held on 8 October, 2004 at the office of the Savannah District, US Army Corps of Engineers to update GAEPD, SCDHEC and USGS (Georgia and SC Districts) on recent progress and findings regarding supplemental studies relating to potential impacts to the Floridan aquifer as a result of the proposed Savannah Harbor Expansion Project (SHE).

The following persons attended the meeting:

Bill McLemore – GAEPD (GGS)
Camille Ransom - SCDHEC
John Clarke – USGS, Georgia District
Jim Landmeyer – USGS, South Carolina District
Mark Maimone – Camp Dresser & McKee
John Cox – Applied Technology & Management
Mackie McIntosh - USACE, Savannah District
Matthew Delano- USACE, Savannah District
Cardwell Smith - USACE, Savannah District

The meeting began at 0900 with Mr. Smith welcoming the other attendees and explaining that the purpose of the meeting was to update the attendees on progress and findings to date, obtain feedback on the findings and discuss any potential changes that may be needed in the remainder of the proposed work.

Mr. Smith then spent about an hour presenting the findings of recent work. Particular emphasis was placed on the supplemental paleochannel seismic survey and the latest data from the paleochannel/confining layer pore water investigation.

Data from the 60+ miles of seismic survey have allowed various profile sections and fence diagrams to be constructed of the paleochannel areas between Fields Cut and Tybee Island.

Pore water data collection along the Savannah Harbor channel is nearing completion and the data suggests that distinctive pore-water chloride (salinity) "profiles" exist through the surficial and confining unit sediments above the limestone of the upper Floridan aquifer.

Following the pore-water data presentation, Mr. Maimone spent about 30 minutes presenting the conceptual approach and construction of the 3-D solute-transport ground-water model CDM is working on. He explained that the modeling objectives were to:

- Develop a modeling tool to explore aquifer system response;
- Assess the full range of plausible aquifer responses to harbor dredging; and
- Provide information on expected impacts of dredging on Upper Floridan Aquifer water quality (worst case, most likely, best case).

The model will make use of data from regional USGS aquifer investigations and models and will replicate USGS model layering, properties, boundaries, and pumping conditions, but the model grid structure will focus on the Savannah Harbor channel.

The next step for the model will be to run various simulations to:

- Test the model's ability to simulate existing conditions;
- Test range of Miocene Kv (rate of salt water penetration, impact on heads);
- Test range of Miocene Confining Unit Thicknesses;
- Test range of values for porosity and storativity; and
- Examine feasibility of pump test

After lunch, Mr. Ransom gave a presentation on recent work SCDHEC has done regarding saltwater intrusion using GIS to map the results of analytical flow and transport calculations within the area of influence of the drawdown cone of depression created by pumping from the Floridan aquifer in the Savannah area.

The area within the "0" contour of the drawdown cone was divided into 4-square mile grid cells. A spreadsheet with analytical equations was used to calculate flow and transport values for each grid cell, based on heads, confining unit thickness and confining unit hydraulic properties. The resultant values were then contoured in a GIS to reveal areas that might be expected to be of concern regarding saltwater intrusion.

Following Mr. Ransom's presentation, Dr. Landmeyer presented several slides representing some initial work he has done on the analysis of pore-water samples from the upper Floridan confining unit, regarding the possible role of diffusion in the movement of pore-water through the confining unit.

A general discussion was then held on all of the presentations and the status of the SHE supplemental work. Mr. Smith noted that nested wells are presently being installed in the confining unit and surficial sediments near the Floridan well at SHE-10. These multi-level wells will be used to confirm potentiometric heads in these units. Ground-water samples for chlorides may also be taken from the wells.

The nested multilevel wells intended to be installed near the GGS Floridan wells on Hutchinson Island (across the river from IP) have been held up waiting on right-of-entry from CSX. Pore-water samples from the surficial and confining unit will also be collected at this location.

Nested wells may also be installed at the far western end of Cockspur Island (Ft. Pulaski) on property owned by GADOT.

The following action items resulted from the meeting:

1. Mr. Smith and Ms. McIntosh will continue installing nested wells and compiling sample data as it is received from the labs.
2. CDM will begin running simulations with the model and will prepare for a presentation on the model at an upcoming SEG Aquifer Committee meeting on 29 October.
3. USACE will continue to keep GAEPD, USGS and SCDHEC informed on project findings.

Project coordination will continue to be maintained via e-mail and telephone, and additional meetings will be held as needed.

The meeting concluded about 1530.

CARDWELL SMITH, P.G.
Geology, Hydrogeology and HTRW Design Section

F. **Mitigation Plans**

1. MFR dated 14 July 2006 and revised 24 July 2006, Meeting to Screen Mitigation Options.
2. E-MAIL form William G. Bailey dated 6 April 2007, SHEP, Wetlands Interagency Coordination Team – Wetland Mitigation Report
3. E-MAIL form William G. Bailey dated 19 March 2008, SHEP, Impacts to Striped bass
4. E-MAIL from William G. Bailey dated 19 March 2008, SHEP, Impacts to Shortnose sturgeon
5. E-MAIL from William G. Bailey dater 01 October 2010, SHEP, Fish bypass structure at New Savannah Bluff Lock & Dam

CESAM-PD-E

14 July 2006
Revised: 24 July 2006

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Summary of 12 July meeting to screen mitigation options

1. Participants:

COE:	Joe Hoke; John Hazelton; Beth Williams; Bill Bailey
USFWS:	Ed EuDaly; John Robinette
GA DNR-WRD	Matt Thomas; Tim Barrett
Tetra Tech	Steve Davie

Observers:

GPA	Hope Moorer; Larry Keegan

2. The following is a summary of the discussion and does not include all the comments that were made.

4. I gave a brief introduction of the purpose of the meeting – to screen down the individual mitigation options to a manageable number so the hydraulic modelers could continue their efforts. I explained that the individual options would be combined to create mitigation plans. To accomplish that, t he Corps would rank the options by their perceived cost-effectiveness. The present target number for different mitigation plans is five. We would run each of those five plans through the impact models (fisheries, water quality and wetlands) with the various channel depths. That procedure would allow us to identify what features are justified to mitigate for impacts from each channel depth alternative. There are additional potential mitigation measures which are being considered separately that do not require hydraulic modeling. These could be added to any mitigation plan to reduce impacts to a specific resource (wetlands, sturgeon, etc.).

5. John Hazelton presented a spreadsheet (attached) that shows the various mitigation measures that the modelers evaluated. The options were listed in the spreadsheet in the order that the modeling had been performed, not necessarily their effectiveness. John also distributed a group of figures, one for each mitigation option. The figures show a model output for an option – surface salinity; 50% exceedence; roughly between Old Fort Jackson and I-95. Each of the model runs used the same input conditions (average year river flows during the summer months; 48-foot channel alternative); the only difference is the mitigation option being considered.

We explained that we used salinity because that parameter is a major factor in identifying changes to several resources -- wetlands, fisheries and water quality. We selected surface salinity because that is the parameter that the Interagency Wetland Coordination Team is using to identify impacts to wetlands. Ed EuDaly expressed a desire to see also the results in terms of bottom salinity. We explained that the surface salinity is all that we have available to review at this meeting. We acknowledged that additional information may be gained by looking at other parameters. However, when we began the model runs, the Corps determined that since the Back / Little Back / Middle River areas are so shallow that no substantial salinity stratification occurs. This assessment is supported by information developed during the model development period.

During the meeting we used the convention of breaking Back River into two segments. We called the portion upstream of US 17 the Little Back River. The portion downstream of that highway we called Back River. I will continue that convention throughout this MFR.

We reviewed that previous interagency discussions identified the Back River, Little Back River, and Middle River areas as being more ecologically important at this point in time than the Front River along the City. The City Front area has already been extensively impacted by development and high salinity levels. Areas further upriver, but below I-95, still contain the intertidal wetlands which are so biologically diverse.

6. The group reviewed the mitigation options as they appeared on the list, observing the effects that they had on reducing salinity impacts from a channel deepening and sometime resulting in improvements beyond what presently occur at a site. Although we did not quantify the effectiveness of each option, we visually observed the number of grid cells that the option changes, the amount of change of specific cells, and the geographic location of the change. Each of these of these attributes is a component of identifying the ecological "effectiveness" of a potential change to the system. Using what John had developed as a base, I prepared a spreadsheet (attached) that consolidates the major comments and conclusions that the group had on the effectiveness of each mitigation option.

On the Sediment Basin options, the depths shown with the fill are in NGVD. Options with just a sill increase salinity just upstream, apparently due to momentum and turbulence over the sill. Options with a sill plus fill substantially reduce salinity in Back River. There group identified that there may be potential water quality concerns with filling the area behind a sill. A possibility would be to let the area fill in by itself. Waiting for the natural filling would delay the beneficial effects the design would have on salinity in Back River. The Corps will probably pursue filling the area behind the sill so that the beneficial effects of the design would be received as soon as possible. The Corps may consider filling less than the entire basin to potentially reduce impacts to O&M of the harbor. We would consult with Mike Wutkowski to determine how well the basin would function if its length were reduced.

On the Rifle Cut option, the group recognized that this cut is very important in the flow dynamics of the system. We should not alter it without being certain of the results. We could possibly retain it as a measure to implement as an adaptive management feature after the initial construction is complete and some monitoring has been conducted.

Concerning a diversion structure at McCoys Cut, the group recognized that some structure would probably be necessary to ensure that improved channels just downstream do not shoal, reducing their effectiveness. Adjustments to this structure could be needed once construction is complete and some monitoring performed. This could be conducted as adaptive management.

Concerning the depth of the rivers just downstream of McCoys Cut, the group agreed that a greater depth is not necessarily better. Too great a depth could lead to excessive shoaling in the area. Velocity is important to both shoaling and in establishing good habitat for Striped bass.

On the Steamboat River options, these would be major changes to the system we should not alter t his area without being certain of the results.

The results of the discussion were identification of the measures as the most effective potential mitigation options. These are shown in the following table. Some options were combined if that would be needed for the overall action to be a functional and complete unit – such as providing an alternate opening when the mouth of a river is plugged.

MITIGATION COMBINATION	MITIGATION OPTION
A	Opening New Cut & Closing Middle River
B	Opening New Cut & Closing Middle River Rerouting flow through Steamboat River Stabilizing Houston Cut Plugging Drakies Cut
C	Deepening McCoys Cut (4.0 M in upper arm and 3.0 m in lower two arms) Diversion structure at upper end (entrance to Savannah River)
C-1	Deepening McCoys Cut (4.0 M in upper arm and 3.0 m in lower two arms) Diversion structure at upper end (entrance to Savannah River) Modifying Rifle Cut
D	Fill Sediment Basin to depth of 3.85 m (submerged structure at lower end)
E	Fill Sediment Basin to depth of 3.85 m (submerged structure at lower end) Remove Tidegate (structure down to sill, including abutments)

7. Before the full modeling work begins, the Corps will first conduct the following three analyses:
   - Review the model performance related to New Cut and Middle River modifications. Ensure the model grid connections are correct and that the model results are reliable. Once we determine the results are reliable, reassess whether those flow modifications provide the types and level of salinity changes that we generally expect those changes to make. If the changes are not substantial, we would reassess whether these options should be included in the final array of mitigation options that we evaluate further as mitigation plans. If we find that the reliable results for these two options differ from what was presented at this meeting, we will send the new results to the agencies for information.
   - Identify the effectiveness of combination C-1. This would allow us to see whether adding Rifle Cut to measure C substantially reduces salinity impacts to the system. If modifying Rifle Cut is

found to be noticeably effective, we would proceed using that combination of measures (C-1) and not pursue the measures described above as combination C.

- Identify the effectiveness of combination E. This would allow us to see whether removing the restriction of the Tidegate structure substantially reduces salinity impacts to the system. If removing the restriction of the Tidegate structure is found to be noticeably effective, we would proceed using that combination of measures (E) and not pursue the measures described above as combination D.

8. Prior to the meeting I had developed preliminary cost estimates for several mitigation options that we were considering. Although EN has not yet completed the rough-order-of-magnitude (ROM) cost estimates for the mitigation options, some engineering information is available for these measures. Using recent local construction costs and percentages for other components such as contingencies (40%), E&D and S&A (12%), I developed preliminary cost estimates so that we could judge the comparative cost-effectiveness of the various final mitigation measures (A through E). The construction costs and percentages were applied uniformly to all of the measures, to keep from distorting the costs of individual measures. The estimates I developed were for comparative purposes only. We will use the ROM estimates that EN prepares when we select the best mitigation plan for each depth alternative. With the cost information I had prepared, I assigned the following costs to the final mitigation options:

MITIGATION COMBINATION	COMPARATIVE COST
A	$ 17 million
B	$ 87 million
C	$ 15 million
C-1	$ 15+ million
D	$ 9 million
E	$ 15 million

9. Using this information and the effectiveness which we had previously discussed, we then ranked the combinations according to their cost effectiveness.

MITIGATION PLAN	MITIGATION COMBINATION	COMPARATIVE COST
1	C	$ 15 million
2	C + D	$ 24 million
3	C + D + A	$ 41 million
4	C + D + A + E	$ 47 million
5	C + D + A + E + B	$117 million

The Corps will use the combinations identified in the ranking as mitigation plans and conduct our future analyses on those mitigation plans. Those analyses will include quantification of impacts to the various resources (fisheries, water quality and wetlands) for each of the various channel depth alternatives. When those analyses are complete, we will select the most appropriate mitigation plan to accompany each channel depth alternative. The Corps and agencies will then use the impact information in their decisions concerning those depth alternatives.

10. The Corps agreed to send the bottom salinity information to Ed EuDaly for the various mitigation options that EN had evaluated prior to the meeting.

11. The Corps will display the results of its initial analyses of these mitigation plans in the same format we reviewed at this meeting. We will provide those results to the agencies for their information. That format may or may not be included in the EIS, as we will display the information in formats that the agencies previously been identified by as being needed for them to make decisions on the project.

// ss //

William Bailey
Environment & Resources Branch

From:	Bailey, William G SAM@SAS
To:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Keith_Parsons@mail.dnr.state.ga.us"; "Matt Thomas (E-mail)"; "Wade Cantrell"; "beckhajc@dhec.sc.gov"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "Kay Davy (kay.davy@noaa.gov)"; "Ed_Eudaly@fws.gov"; "john_robinette@fws.gov"; "Lord.Bob@epamail.epa.gov"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"
Cc:	"jane_griess@fws.gov"; "kitchensw@wec.ufl.edu"; "kajumba.ntale@epamail.epa.gov"; "kirklagl@dhec.sc.gov"; "PRESTOHS@dhec.sc.gov"; "Pace Wilber"; "Brad_Gane@dnr.state.ga.us"; "_Jeff_Larson@dnr.state.ga.us"; "Ed Duncan"; Garrett, Thomas A SAS; Hoke, Joseph T SAW@SAS; "hmoorer@gaports.com"; "Larry.Keegan@ch2m.com"; Bradley, Kenneth P SAM; Heine, Hugh SAW; Small, Daniel L SAD; Barnett, Dennis W SAD
Subject:	Savannah Harbor Expansion Project: Wetlands Interagency Coordination Team -- Wetland Mitigation Report
Date:	Friday, April 06, 2007 1:52:50 PM
Attachments:	SHE-wetland_mitigation_report_4-5-07--INTRO---.pdf

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Here is some revised summary information and an explanation concerning the Wetland Mitigation Report we set out last week.

Bill Bailey

-----Original Message-----
From: Williams, Laura E (Beth) SAW@SAS
Sent: Friday, April 06, 2007 11:01 AM
To: Bailey, William G SAM@SAS
Cc: Hoke, Joseph T SAW@SAS
Subject: Marsh Mitigation Report

>Bill,
>
>Attached is the updated intro section of the Marsh/Wetland Mitigation Report. After reviewing Ed's comments I did find a few minor errors in the first table (deepening only- no mitigation). A few 50% and 10% values were transposed, as Ed suggested. The table has been corrected and the updated section is attached. The other sections for Wetland/Marsh Impacts AND Mitigation Plans 1-5 are ok. These files are dated February 2007.
>
>Ed was concerned about comparisons between the October 2006 and February 2007 reports. The reason we issued a new report in February was because during review of the October report we found an error in the post processor, which we have corrected. The error was in the way the duration of the report summations were specified in the program. The error was in the output processor only, and did not effect any of the EFDC runs. The October reports should be discarded and replaced with the attached file and the February 2007 reports.
>
>Thanks,
>Beth
>
>
>Beth Williams, PE
>Hydraulic Engineer
>US Army Corps of Engineers

Wetland/Marsh Mitigation Plan Evaluation

April 2007

Savannah Harbor Expansion Project
Wetland/Marsh Mitigation Plan Evaluation

MARSH Acreages Impacted ONLY

Deepening Only
No Mitigation Options

		Acreages Negatively Impacted (fresh to salt)		Acreages Postively Impacted (salt to fresh)		Net Impact (net negative), net postive	
		50% Exceedance	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*
Basic Evaluation 1997- Existing Sea Level	*44-ft*	1633.2	0	0	0	(1633.2)	0.0
	45-ft	1633.2	0	0	0	(1633.2)	0.0
	46-ft	1633.2	0	0	0	(1633.2)	0.0
	48-ft	1932.2	299	0	0	(1932.2)	(299.0)
Sensitivity Analysis #1 2001- Existing Sea Level	*44-ft*	469.2	494.2	0	0	(469.2)	(494.2)
	45-ft	768.2	494.2	0	0	(768.2)	(494.2)
	46-ft	768.2	494.2	0	0	(768.2)	(494.2)
	48-ft	768.2	494.2	0	0	(768.2)	(494.2)
Sensitivity Analysis #2A 1997- 25cm Sea Level Rise	*Existing*	1287.4	299	0	0	(1287.4)	(299.0)
	44-ft	1932.2	299	0	0	(1932.2)	(299.0)
	45-ft	1932.2	299	0	0	(1932.2)	(299.0)
	46-ft	1932.2	299	0	0	(1932.2)	(299.0)
	48-ft	1932.2	299	0	0	(1932.2)	(299.0)
Sensitivity Analysis #2B 1997- 50cm Sea Level Rise	*Existing*	1932.2	299	0	0	(1932.2)	(299.0)
	44-ft	1932.2	1210.8	0	0	(1932.2)	(1210.8)
	45-ft	1932.2	1457.9	0	0	(1932.2)	(1457.9)
	46-ft	1932.2	1457.9	0	0	(1932.2)	(1457.9)
	48-ft	1932.2	1457.9	0	0	(1932.2)	(1457.9)

1997 Conditions- Average Historic Flow, Temperature, and Tidal Conditons- March through October 1997
2001 Conditions- Historic Low Flow, Average Temperature and Tidal Conditons- March through October 1997

Savannah Harbor Expansion Project
Wetland/Marsh Mitigation Plan Evaluation

MARSH Acreages Impacted ONLY

Plan 1
-McCoy Cut Diversion Structure;
-Channel Deepening on McCoy Cut to -4m NGVD and Upper Middle and Little Back River to -3m NGVD

		Acreages Negatively Impacted (fresh to salt)		Acreages Postively Impacted (salt to fresh)		Net Impact (net negative), net postive	
		50% Exceedance	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*
Basic Evaluation 1997- Existing Sea Level	*44-ft*	988.4	0	0	0	(988.4)	0.0
	45-ft	988.4	0	0	0	(988.4)	0.0
	46-ft	988.4	0	0	0	(988.4)	0.0
	48-ft	988.4	0	0	0	(988.4)	0.0
Sensitivity Analysis #1 2001- Existing Sea Level	*44-ft*	469.2	0	0	664.7	(469.2)	664.7
	45-ft	469.2	0	0	664.7	(469.2)	664.7
	46-ft	469.2	0	0	664.7	(469.2)	664.7
	48-ft	469.2	0	0	417.6	(469.2)	417.6
Sensitivity Analysis #2A 1997- 25cm Sea Level Rise	*44-ft*	988.4	0	0	0	(988.4)	0.0
	45-ft	1287.4	0	0	0	(1287.4)	0.0
	46-ft	1287.4	0	0	0	(1287.4)	0.0
	48-ft	1633.2	299	0	0	(1633.2)	(299.0)
Sensitivity Analysis #2B 1997- 50cm Sea Level Rise	*44-ft*	1287.4	299	0	0	(1287.4)	(299.0)
	45-ft	1633.2	299	0	0	(1633.2)	(299.0)
	46-ft	1633.2	299	0	0	(1633.2)	(299.0)
	48-ft	1932.2	299	0	0	(1932.2)	(299.0)

1997 Conditions- Average Historic Flow, Temperature, and Tidal Conditons- March through October 1997
2001 Conditions- Historic Low Flow, Average Temperature and Tidal Conditons- March through October 1997

Savannah Harbor Expansion Project
Wetland/Marsh Mitigation Plan Evaluation

MARSH Acreages Impacted ONLY

Plan 2
-McCoy Cut Diversion Structure;
-Channel Deepening on McCoy Cut to -4m NGVD and Upper Middle and Little Back River to -3m NGVD;
-Fill Entire Sediment Basin to -3.85m NGVD

		Acreages Negatively Impacted (fresh to salt)		Acreages Postively Impacted (salt to fresh)		Net Impact (net negative), net postive	
		50% Exceedance	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*
Basic Evaluation 1997- Existing Sea Level	*44-ft*	988.4	0	0	0	(988.4)	0.0
	45-ft	988.4	0	0	0	(988.4)	0.0
	46-ft	988.4	0	0	0	(988.4)	0.0
	48-ft	988.4	0	0	0	(988.4)	0.0
Sensitivity Analysis #1 2001- Existing Sea Level	*44-ft*	469.2	0	0	664.7	(469.2)	664.7
	45-ft	469.2	0	0	664.7	(469.2)	664.7
	46-ft	469.2	0	0	417.6	(469.2)	417.6
	48-ft	469.2	0	0	0	(469.2)	0.0
Sensitivity Analysis #2A 1997- 25cm Sea Level Rise	*44-ft*	988.4	0	0	0	(988.4)	0.0
	45-ft	988.4	0	0	0	(988.4)	0.0
	46-ft	1287.4	0	0	0	(1287.4)	0.0
	48-ft	1633.2	299	0	0	(1633.2)	(299.0)
Sensitivity Analysis #2B 1997- 50cm Sea Level Rise	*44-ft*	1287.4	299	0	0	(1287.4)	(299.0)
	45-ft	1633.2	299	0	0	(1633.2)	(299.0)
	46-ft	1633.2	299	0	0	(1633.2)	(299.0)
	48-ft	1932.2	299	0	0	(1932.2)	(299.0)

1997 Conditions- Average Historic Flow, Temperature, and Tidal Conditons- March through October 1997
2001 Conditions- Historic Low Flow, Average Temperature and Tidal Conditons- March through October 1997

Savannah Harbor Expansion Project
Wetland/Marsh Mitigation Plan Evaluation

MARSH Acreages Impacted ONLY

Plan 3
-McCoy Cut Diversion Structure;
-Channel Deepening on McCoy Cut to -4m NGVD and Upper Middle and Little Back River to -3m NGVD;
-Fill Entire Sediment Basin to -3.85m NGVD;
-Rifle Cut Closed

		Acreages Negatively Impacted (fresh to salt)		Acreages Postively Impacted (salt to fresh)		Net Impact (net negative), net postive	
		50% Exceedance	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*
Basic Evaluation 1997- Existing Sea Level	*44-ft*	988.4	0	453	345.8	(535.4)	345.8
	45-ft	988.4	0	453	345.8	(535.4)	345.8
	46-ft	988.4	0	453	345.8	(535.4)	345.8
	48-ft	1287.4	0	453	345.8	(834.4)	345.8
Sensitivity Analysis #1 2001- Existing Sea Level	*44-ft*	469.2	0	345.8	417.6	(123.4)	417.6
	45-ft	469.2	0	345.8	417.6	(123.4)	417.6
	46-ft	469.2	0	345.8	417.6	(123.4)	417.6
	48-ft	768.2	494.2	345.8	0	(422.4)	(494.2)
Sensitivity Analysis #2A 1997- 25cm Sea Level Rise	*44-ft*	1287.4	299	453	345.8	(834.4)	46.8
	45-ft	1287.4	299	453	345.8	(834.4)	46.8
	46-ft	1287.4	299	453	0	(834.4)	(299.0)
	48-ft	2055.6	299	0	0	(2055.6)	(299.0)
Sensitivity Analysis #2B 1997- 50cm Sea Level Rise	*44-ft*	1586.4	299	0	0	(1586.4)	(299.0)
	45-ft	1586.4	299	0	0	(1586.4)	(299.0)
	46-ft	2055.6	299	0	0	(2055.6)	(299.0)
	48-ft	2055.6	299	0	0	(2055.6)	(299.0)

1997 Conditions- Average Historic Flow, Temperature, and Tidal Conditons- March through October 1997
2001 Conditions- Historic Low Flow, Average Temperature and Tidal Conditons- March through October 1997

Savannah Harbor Expansion Project
Wetland/Marsh Mitigation Plan Evaluation

MARSH Acreages Impacted ONLY

Plan 4
-McCoy Cut Diversion Structure;
-Channel Deepening on McCoy Cut to -4m NGVD and Upper Middle and Little Back River to -3m NGVD;
-Realign Middle River Outlet by Closing Middle River at Front River and Opening New Cut;
-Close Houston Cut

		Acreages Negatively Impacted (fresh to salt)		Acreages Postively Impacted (salt to fresh)		Net Impact (net negative), net postive	
		50% Exceedance	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*
Basic Evaluation 1997- Existing Sea Level	*44-ft*	1334.2	0	210.1	598	(1124.1)	598.0
	45-ft	1334.2	0	0	598	(1334.2)	598.0
	46-ft	1334.2	0	0	598	(1334.2)	598.0
	48-ft	1334.2	0	0	598	(1334.2)	598.0
Sensitivity Analysis #1 2001- Existing Sea Level	*44-ft*	469.2	0	345.8	417.6	(123.4)	417.6
	45-ft	469.2	0	598	716.6	128.8	716.6
	46-ft	469.2	0	598	0	128.8	0.0
	48-ft	469.2	494.2	598	0	128.8	(494.2)
Sensitivity Analysis #2A 1997- 25cm Sea Level Rise	*44-ft*	1334.2	0	0	598	(1334.2)	598.0
	45-ft	1803.4	0	0	598	(1803.4)	598.0
	46-ft	1803.4	0	0	598	(1803.4)	598.0
	48-ft	1803.4	0	0	598	(1803.4)	598.0
Sensitivity Analysis #2B 1997- 50cm Sea Level Rise	*44-ft*	1803.4	0	0	299	(1803.4)	299.0
	45-ft	1803.4	0	0	299	(1803.4)	299.0
	46-ft	1803.4	0	0	299	(1803.4)	299.0
	48-ft	1803.4	0	0	0	(1803.4)	0.0

1997 Conditions- Average Historic Flow, Temperature, and Tidal Conditons- March through October 1997
2001 Conditions- Historic Low Flow, Average Temperature and Tidal Conditons- March through October 1997

Savannah Harbor Expansion Project
Wetland/Marsh Mitigation Plan Evaluation

MARSH Acreages Impacted ONLY

Plan 5

-McCoy Cut Diversion Structure;
-Channel Deepening on McCoy Cut to -4m NGVD and Upper Middle and Little Back River to -3m NGVD;
-Realign Middle River Outlet by Closing Middle River at Front River and Opening New Cut;
-Close Houston Cut;

		Acreages Negatively Impacted (fresh to salt)		Acreages Postively Impacted (salt to fresh)		Net Impact (net negative), net postive	
		50% Exceedance	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*	*50% Exceedance*	*10% Exceedance*
Basic Evaluation 1997- Existing Sea Level	*44-ft*	988.4	0	663.1	1153.9	(325.3)	1153.9
	45-ft	988.4	0	663.1	1153.9	(325.3)	1153.9
	46-ft	988.4	0	663.1	1153.9	(325.3)	1153.9
	48-ft	988.4	0	663.1	1153.9	(325.3)	1153.9
Sensitivity Analysis #1 2001- Existing Sea Level	*44-ft*	469.2	0	1153.9	1015.6	684.7	1015.6
	45-ft	469.2	494.2	1153.9	598	684.7	103.8
	46-ft	469.2	494.2	1153.9	598	684.7	103.8
	48-ft	469.2	494.2	1153.9	0	684.7	(494.2)
Sensitivity Analysis #2A 1997- 25cm Sea Level Rise	*44-ft*	988.4	0	663.1	1153.9	(325.3)	1153.9
	45-ft	988.4	0	663.1	1153.9	(325.3)	1153.9
	46-ft	988.4	0	663.1	1153.9	(325.3)	1153.9
	48-ft	1457.6	0	663.1	1153.9	(794.5)	1153.9
Sensitivity Analysis #2B 1997- 50cm Sea Level Rise	*44-ft*	988.4	0	663.1	1153.9	(325.3)	1153.9
	45-ft	988.4	0	663.1	1153.9	(325.3)	1153.9
	46-ft	1457.6	0	663.1	808.1	(794.5)	808.1
	48-ft	1457.6	0	663.1	598	(794.5)	598.0

1997 Conditions- Average Historic Flow, Temperature, and Tidal Conditons- March through October 1997
2001 Conditions- Historic Low Flow, Average Temperature and Tidal Conditons- March through October 1997

From:	Bailey, William G SAM@SAS
To:	"Tim_Barrett@dnr.state.ga.us"; "Matt Thomas (E-mail)"
Cc:	Bradley, Kenneth P SAM; Garrett, Thomas A SAS
Subject:	Savannah Harbor Expansion Project - Impacts to Striped bass
Date:	Wednesday, March 19, 2008 6:10:54 PM

On Monday, I sent you a summary of the fishery impact information with the D.O. systems included and said we were finalizing the full report. I just sent out a notice for the ftp site where the Fisheries Impact Report is posted. That report includes figures that show the locations of Acceptable and Unacceptable habitat for Striped bass.

Please look over this information and let me know what your current thoughts are on mitigation for remaining impacts to Striped bass. The summary table shows that substantial adverse impacts would be expected to spawning habitat (up to -13 to -24 percent based on river flows). Impacts to other life stages would be mixed.

When we last spoke I mentioned an approach to determine funding for stocking. I hope you have had a chance to think about that -- or another approach -- some more. If you remember, I mentioned totally up the requirements and expenses for a Striped bass stocking program based on there being no natural recruitment -- that you would have to provide all the young into the system through stocking. Then if mitigation is necessary, we could use a percentage of that effort and expenses equivalent to the impacts expected from this project. So if the average annual cost to run a full stocking program is $400,000 a year and the project reduces the habitat by 50%, the mitigation would be 50% of the $400,000. That was my thought for an approach.

If you and Matt agree with that approach, you would need to put together the average annual costs for a full stocking program. Now that we have the impact numbers, we can discuss what impact number we believe is appropriate. As the summary table shows, the impacts vary by life stage, river flow, and channel depth. I am developing a mitigation plan for each depth alternative.

I will need to complete development of the preliminary mitigation plans within the next two weeks. So, if we could get together to talk about this soon, I would appreciate it. If you think there is no need to talk, just let me know what you think.

Do we get any credit for improving Flounder habitat? :)

Bill Bailey
912-652-5781

From:	Bailey, William G SAM@SAS
To:	"Stephania Bolden"
Cc:	"Kay Davy (kay.davy@noaa.gov)"; Bradley, Kenneth P SAM; Heine, Hugh SAW; Garrett, Thomas A SAS
Subject:	Savannah Harbor Expansion Project - Impacts to Shortnose sturgeon
Date:	Wednesday, March 19, 2008 5:33:25 PM
Attachments:	EXPAN Impacts to SNS Mar08.doc

I have attached a write-up that summarizes the impacts we expect to occur to Shortnose sturgeon habitat from implementation of the proposed Savannah Harbor Expansion Project. The document discusses mitigation for impacts remaining after the flow-altering features and dissolved oxygen system are included. Please review the document and provide me with your comments. I would specifically like answers to the following questions:

1. Based on the level of remaining impacts to Shortnose sturgeon, do you believe that mitigation is warranted and likely to be required by your agency?

2. If you believe mitigation is warranted, do you believe the proposed mitigation (fish passage at New Savannah Bluff Lock and Dam) is appropriate and sufficient for the 48-foot depth alternative?

3. Again if you believe mitigation is warranted, do you believe the proposed mitigation (fish passage at New Savannah Bluff Lock and Dam) is appropriate for the other depth alternatives or could some other mitigation be more suitable?

Although the answers will be helpful in our preparation of the Draft EIS, they will also be helpful for another document that I am to soon prepare for the Corps Headquarters. That document is to discuss the project's impacts to Shortnose sturgeon and the potential for using fish passage at New Savannah Bluff Lock and Dam as the mitigation for those impacts. I would include your views on the need for mitigation and the acceptability of NSBL&D as that mitigation in that document.

I just sent out a notice for the ftp site where the Fisheries Impact Report is posted. That report includes figures that show the locations of Acceptable and Unacceptable habitat for Shortnose sturgeon.

Call or email if you have questions.

Bill Bailey
912-652-5781

SAVANNAH HARBOR EXPANSION PROJECT

ASSESSMENT OF IMPACTS
TO
SHORTNOSE STURGEON

The Corps has completed the modeling to identify physical changes that are expected to occur as a result of implementation of the various channel deepening alternatives. That analysis was completed on 19 March 2008. The analysis includes both the flow-altering and Dissolved Oxygen (D.O.) components of the mitigation plans. The analysis used the model input parameters identified by the Fishery Interagency Coordination Team, as well as the definitions of Acceptable and Unacceptable habitat developed by that team.

The modeling results are summarized in the following table:

Suitable Habitat for Shortnose Sturgeon

	JUVENILES	---------------------- ADULTS ----------------------		
	SUITABLE HABITAT (km^2)			
	January50%flows	January50%flows	August Avg flows*	August Low flows*
Existing Conditions 42 ft Depth	**6.98**	**16.10**	**5.73**	**0.81**
44 ft depth Plan 6b	**7.05**	**15.08**	**6.34**	**-**
% difference	*1.1%*	*-6.4%*	*10.6%*	*-*
*% diff (Deepening Only)***	*-5.0%*	*-0.5%*	-26.20	-
45 ft depth Plan 6a	**7.15**	**14.97**	**5.55**	**-**
% difference	*2.4%*	*-7.0%*	*-3.1%*	*-*
*% diff (Deepening Only)***	*-10.4%*	*-0.5%*	-33.80	-
46 ft depth Plan 6a	**6.98**	**14.72**	**5.51**	**-**
% difference	*0.1%*	*-8.6%*	*-3.9%*	*-*
*% diff (Deepening Only)***	*-15.9%*	*-0.8%*	-39.10	-
48 ft depth Plan 6a	**6.86**	**14.33**	**5.17**	**6.21**
% difference	-1.6%	-11.0%	-9.7%	665.5%
*% diff (Deepening Only)***	-21.6%	-1.1%	-41.90	-

The following paragraphs describe the impacts to Shortnose sturgeon (SNS), as enumerated in the table.

Impacts would occur to both the juvenile and adult life stages as a result of the proposed project. The impacts are not uniform across all conditions, but generally become increasingly adverse with the larger channel depths.

Impacts to juvenile habitat were examined during the winter under average river flow conditions. The modeling indicates that project impacts to this life stage would be minimal. Increases in habitat volume (ranging from 0.1 to 2.4 percent) would occur with the smaller depth alternatives. The largest channel depth (48-foot alternative) would result in the loss of -1.6 percent of existing juvenile habitat. With the uncertainties inherent in the impact prediction process, these levels of impacts are not judged as being significant. Additional information could alter that assessment.

Impacts to adult habitat were examined during both winter and summer months under average river flow conditions. The modeling indicates that adverse impacts would occur to this life stage at a low level. A fairly constant loss of winter habitat would occur with the various depth alternatives, ranging between -6.4 and -11.0 percent. A wider range of impacts would occur to the summer habitat, ranging from +10.6 percent with the 44-foot depth to -9.7 percent with the 48-foot depth.

As part of the design process for the D.O. improvement system, the Corps developed information for summer adult habitat under drought conditions. The modeling showed that a substantial drought (13 percent chance of occurrence) would result in the smallest amount of suitable habitat (0.81 km2) being available of all the conditions that were examined. The results were produced as a result of modeling performed to design a D.O. system to meet water quality standards under the maximum dredging case, so results are only available for the 48-foot depth alternative. But the results indicate that the average river flow conditions are likely to represent the maximum project impact to SNS. Under conditions which would be much more stressful to sturgeon than normal, the proposed harbor deepening and mitigation would not adversely impact sturgeon in this harbor. Instead, it would increase suitable habitat by 665 percent.

If one considers an adverse impact threshold of -10 percent, the only life stage, season, and channel depth alternative that produces such substantial effects is the 48-foot depth on adult winter habitat. The 48-foot depth with adult summer habitat comes quite close, with an adverse impact of -9.7 percent. The 46-foot depth produces the next smaller impact, with an adverse impact of -8.6 percent on adult winter habitat.

Mitigation is believed to be warranted when adverse impacts exceed 10 percent to an endangered species. Before the impact results were completed, the Corps consulted the Fishery Interagency Coordination Team to identify measures which could improve SNS habitat in Savannah Harbor. This team of experts from the Federal and State natural resource agencies could not identify any physical action that could be taken within the harbor area to improve SNS habitat. They did identify one measure that could be taken to help the population of Shortnose sturgeon that resides in the harbor. The team stated that, in addition to the harbor, the Savannah SNS population uses upriver portions of the Savannah River for portions of its life cycle. Adults migrate upriver to spawn in the spring. That migration has been shortened by the dams that were constructed on the river. Restoration of some of that historic spawning area by removing dams or allowing passage past the dam would very likely help this endangered population.

In 1999, Savannah District had proposed removing the New Savannah Bluff Lock and Dam, the first dam encountered by fish migrating upriver. That is a low head dam located at river mile 187.4 near Augusta, Georgia, that is operated by the Corps. In WRDA 2000, Congress authorized rehabilitation of that dam, including the addition of a fish bypass channel. In 2001, the District prepared an addendum to its report recommending rehabilitation, as Congress had authorized. Because the lock would not serve a navigation need, its originally Congressionally-authorized purpose, funds to rehabilitate the lock have not been included in any President's Budget submitted to Congress. In the eight years since the rehabilitation was authorized, Congress has not funded substantial further work on that project. So after an initial 35 percent design was prepared in 2002, no further work has been completed on the fish bypass structure. An updated cost estimate indicates it would cost roughly $6 million to construct the fish bypass channel at NSBL&D.

The Corps has no indication when or if Congress may fund rehabilitation of the lock and the accompanying fish bypass channel. Funding the rehabilitation through the Corps normal budgetary process is very unlikely, given the present budget guidance.

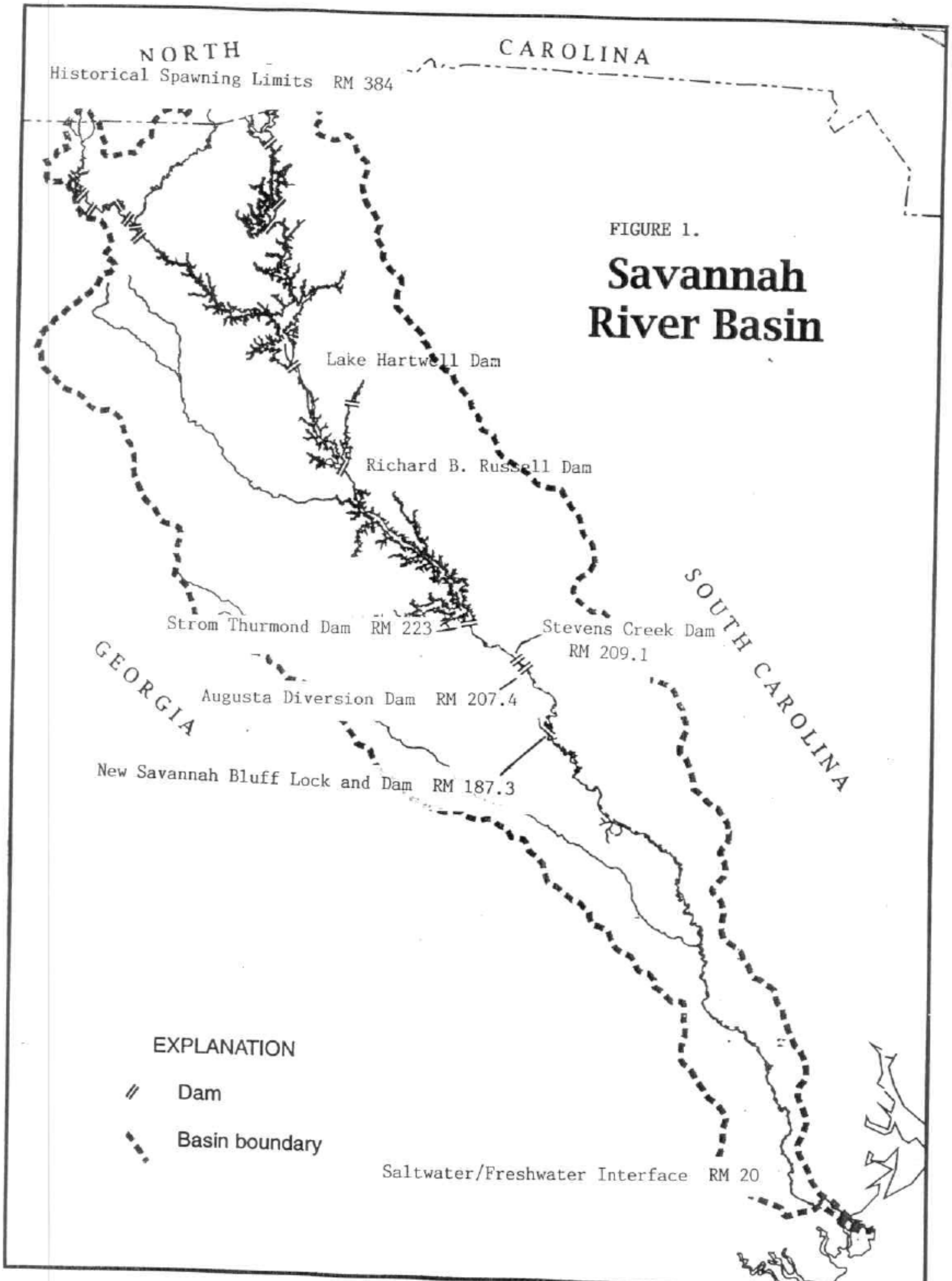
Rehabilitation of the lock and construction of the accompanying fish bypass channel is very uncertain. Savannah District believes that recent Corps and Congressional funding guidance provide no indication that this work is likely to be funded soon. In light of the uncertainty surrounding this funding, the District believes that one should not assume that construction of the fish bypass channel and lock rehab project will occur in the foreseeable future.

With no assurance that the fish bypass channel would be constructed in the foreseeable future, the bypass channel could be constructed as mitigation for the adverse impacts from the proposed harbor deepening project to the Savannah Shortnose sturgeon population.

Such mitigation would be out-of-kind, as it would provide spawning habitat instead of the summer and winter adult habitat that would be impacted by the project. But no in-kind mitigation opportunities could be identified by the natural resource agencies. The 1998 NMFS "Final Recovery Plan for the Shortnose Sturgeon" identified low recruitment as being a factor in the Savannah River population. Stocking occurred in the early 1990's, with stocked juveniles being collected later. This indicates that rearing habitat was present at that time. The continued presence of adults in the harbor indicates that some suitable habitat remains for that life stage. Therefore, expanding the amount of spawning habitat by constructing the bypass at the New Savannah Bluff Lock and Dam could remove a bottleneck in the overall population size. The additional spawning area would also decrease the species' reliance on the few spawning areas they presently use. The additional reach of river made available for spawning would provide the population with a buffer, should an existing spawning site become temporarily or permanently unusable.

Recently the next two dams located upstream of the New Savannah Bluff Lock and Dam received new operating licenses from FERC. Provisions were included in their license agreements that if fish passage occurred at NSBL&D, fish passage structures would also have to be installed at those dams. Providing fish passage at NSBL&D would open up more than 20 miles of river to the next upstream dam at Augusta Shoals. But with passage at the other two dams included, it would effectively result in fish being capable of moving past Augusta Shoals and the SCE&G Stevens Creek Dam all the way to the J. Strom Thurmond Dam, located 36 river miles upstream of NSBL&D. A map on the following page shows the locations of the dams near Augusta. The Augusta Shoals, probably the most ecologically-valuable single shoal area within that 36-mile reach, starts about 28 miles upstream of the NSBL&D. When the pools above NSBL&D and above the Stevens Creek Dam are subtracted from the length of main river that would be opened to sturgeon, fish passage at New Savannah Bluff should open 7 miles of free-flowing river to sturgeon which could serve as spawning habitat. When compared to the roughly 136 miles of river between Clyo (R.M. 61), which is just upstream of the head of tides, and New Savannah Bluff, one could say that providing passage at New Savannah Bluff would expand the amount of free-flowing river that could serve as spawning habitat by 5 percent. That percentage is less than the 10 - 11 percent loss in adult habitat that a 48-foot harbor deepening project is expected to produce. However, the Augusta Shoals area, which would be available for spawning, is considered the most ecologically-valuable remaining riverine portion of the Savannah River. In addition, other spawning habitats may be made available upstream of New Savannah Bluff if tributaries are included. Stevens Creek is a fairly substantial tributary flowing from the South Carolina side. It enters the river just above the Stevens Creek Dam and would be opened up for spawning. The quality of habitat in that creek is unknown.

Another physical measure could be provided in the Savannah River to enhance spawning of Shortnose sturgeon. That would be the construction of a gravel bed downstream of the first dam, to provide a new spawning site. The success of such a feature for SNS is unknown, but it could provide some additional spawning habitat at a lower cost than providing fish passage at NSBL&D. Such a measure may be appropriate if the level of impacts expected is more than minimal but less than substantial. It could also be used if the costs of constructing and operating a fish bypass channel at NSBL&D are deemed excessive.



NORTH CAROLINA
Historical Spawning Limits RM 384
FIGURE 1.
Savannah River Basin
Lake Hartwell Dam
Richard B. Russell Dam
Strom Thurmond Dam RM 223
Stevens Creek Dam RM 209.1
SOUTH CAROLINA
GEORGIA
Augusta Diversion Dam RM 207.4
New Savannah Bluff Lock and Dam RM 187.3
EXPLANATION
Dam
Basin boundary
Saltwater/Freshwater Interface RM 20

From:	Bailey, William G SAS
To:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Brad_Gane@dnr.state.ga.us"; "Tim Barrett"; "GADNR Ed Bettross"; "Priscilla Wendt"; "perryb@dnr.sc.gov"; "Bill Post"; "Chris Thomason"; "beckhajc@dhec.sc.gov"; "Curtis Joyner"; "mueller.heinz@epa.gov"; "Hoberg.Chris@epamail.epa.gov"; "Gagliano.Paul@epamail.epa.gov"; "walter_boltin@fws.gov"; "FWS Amanda Hill"; "Sandy_Tucker@fws.gov"; "Bill_Wikoff@fws.gov"; "jane_griess@fws.gov"; "Chuck Hayes"; "Ed Eudaly"; "Boyd Kynard"; smtp-Brownell, Prescott; Sykes, James A SAS; Eubanks, Michael J SAM
Cc:	"Kay Davy (kay.davy@noaa.gov)"; "Stephania Bolden"; Bradley, Kenneth P SAM; Okane, Jason D SAS; Hyatt, Scott M SAS; "Jeff Larson"; "hmoorer@gaports.com"
Subject:	Fish bypass structure at New Savannah Bluff Lock & Dam
Date:	Friday, October 01, 2010 3:42:27 PM
Attachments:	New Savannah L&D Fish Passage Dec 02.pdf

The Corps intends to propose construction and operation of a fish bypass structure around the New Savannah Bluff Lock & Dam as a mitigation feature in the Savannah Harbor Expansion Project. We intend to propose the same design we developed when we evaluated rehabilitating the lock and dam and giving it to local interests. The 35% design report that we had prepared in 2002 is the latest and most detailed design document on the proposed structure. The bypass was designed to pass shortnose sturgeon, which is the species of interest for the Savannah Harbor Expansion Project.

NOAA Fisheries has requested we re-coordinate the design with you. Please let me know if you are aware of any new technology or information that may have developed since 2002 that would result in a more effective or lower cost fish passage structure at this location for shortnose sturgeon.

Please provide this information by 15 October.

FYI -- Congress authorized rehabilitation of the lock and dam (with the fish bypass structure) in 2000, but they have not provided any funds to implement that work. The City of North Augusta is still pursuing taking over the lock and dam after the Corps rehabs it.

Bill Bailey
Chief, Planning Division

G. Multiple Resources

1. E-MAIL from William G. Bailey dated 7 March 2007, SHEP, Modeling Status Report
2. E-MAIL from William G. Bailey dater 28 April 2008, SHEP, Interagency Coordination

From:	Bailey, William G SAMatSAS
To:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Matt Thomas (E-mail)"; "Keith_Parsons@mail.dnr.state.ga.us"; ""Paul Lamarre" (E-mail)"; "beckhajc@dhec.sc.gov"; "Wade Cantrell"; "Curtis Joyner"; "Ed_Eudaly@fws.gov"; "john_robinette@fws.gov"; "pconrads@usgs.gov"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "Stephania Bolden"; "kay.davy@noaa.gov"; "kajumba.ntale@epa.gov"; "bisterfeld.ted@epa.gov"; "Jim Greenfield (E-mail) (E-mail)"
Cc:	"Larry Turner"; "kirklagl@dhec.sc.gov"; "PRESTOHS@dhec.sc.gov"; "Pace Wilber"; "linda_macgregor@dnr.state.ga.us"; " Jeff_Larson@dnr.state.ga.us"; Bradley, Kenneth P SAM
Subject:	Savannah Harbor Expansion - Modeling Status Report - Mar 07, 2007
Date:	Wednesday, March 07, 2007 2:01:45 PM
Attachments:	Modeling_Update.doc

FYI - Here is the latest status report of the engineering modeling efforts.

I just received the water quality impact report. We'll get copies made and sent out to you. Water quality with the mitigation is scheduled to be complete at the end of March.

I've also received another report on wetlands (using the 0.5 ppt contour) based on runs over the growing season. Apparently the previous one we provided was based on a 12-month salinity regime. I'll distribute that when I get copies made.

I expect to soon get the reports on fishery impacts and the mitigation analyses for fisheries.

BB

Completed or N/A   In Progress   Not Yet Started   Changes from previous update noted in **BOLD**   *****After MPD5-No Code in Schedule

Impacts		***Mitigation Plans 1-5***		***Mitigation Plans 6 & 7***		***USFWS Alternatives***	
Fish Habitat EFDC: Completed WASP: Completed Post Processing: Completed Mapping/Reporting: Completed Errors found and corrected- **waiting on CD with updated report from Tt.**	FIE2 99%	***Fish Habitat*** EFDC: Completed WASP: Completed Post Processing: Completed Mapping/Reporting: Completed. Errors found and corrected- **waiting on CD with updated report from Tt.**		***Fish Habitat*** Will be done for selected path ONLY	*	***Fish Habitat*** EFDC: Not Yet Started WASP: Not Yet Started	
Wetland/Marsh EFDC: Completed WASP: N/A Post Processing: Completed Mapping (EFDC output): Completed. M2M: Completed, but will need to be confirmed. CD and hardcopy given to planning for distribution to technical group.	FSMIE2 99%	***Wetland/Marsh*** EFDC: Completed WASP: N/A Post Processing: Completed Mapping (EFDC output): Completed. M2M: Completed, but will need to be redone for selected plans. CD and hardcopy given to planning for distribution to technical group. Received workplan from USGS. **Meeting scheduled for Thursday.**	MPD2 **85%**	***Wetland/Marsh*** EFDC: Not Yet Started WASP: N/A Post Processing: Not Yet Started Mapping (EFDC output): Not Yet Started M2M: Not Yet Started Waiting on Decision for Plan 6 & 7	MPD8 0%	***Wetland/Marsh*** EFDC: In Progress WASP: N/A Screening runs completed. Output given to planning to distribute to USFWS and others. Tidal influence output available.	MPD9 25%
Water Quality EFDC: Completed WASP: Completed Post Processing: Completed Mapping/Reporting: Completed. Received electronic copy of report and are currently reviewing.	WQDO2 99%	***Water Quality*** EFDC: Completed WASP: Completed Post Processing: Completed. Mapping/Reporting: In Progress. Contracting Issue Resolution Ongoing.		***Water Quality*** Will be done for selected path ONLY	*	***Water Quality*** EFDC: Not Yet Started WASP: Not Yet Started	
Chlorides EFDC: Completed WASP: N/A **Chloride Model: Completed** Mapping/Reporting: In Progress	CIE1 **75%**	***Chlorides*** EFDC: Completed WASP: N/A Chloride Model: Not Yet Started Mapping/Reporting: Not Yet Started		***Chlorides*** Will be done for selected path ONLY	*	***Chlorides*** N/A	
Sedimentation EFDC: Completed Post Processing: Completed Reporting: Completed	SA 100%	***Sedimentation*** N/A		***Sedimentation*** Will be done for selected path ONLY	*	***Sedimentation*** N/A	
Hurricane EFDC: Completed Reporting: Completed	HSE 100%	***Hurricane*** N/A		***Hurricane*** Will be done for selected path ONLY	*	***Hurricane*** N/A	

From:	Bailey, William G SAM@SAS
To:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Keith_Parsons@mail.dnr.state.ga.us"; "Tim Barrett"; "Wade Cantrell"; "beckhajc@dhec.sc.gov"; "Curtis Joyner (joynercm@dhec.sc.gov)"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "Bob Perry"; "Kay Davy (kay.davy@noaa.gov)"; "Stephania Bolden"; "Ed_Eudaly@fws.gov"; "john_robinette@fws.gov"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"
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Subject:	Savannah Harbor Expansion Project: Interagency Coordination
Date:	Monday, April 28, 2008 3:33:14 PM
Attachments:	EXPAN Monit & Adaptve Mgt Program 26Apr08.doc EXPAN Project Description Tables.doc EXPAN Dredging Quantities 26Apr08.xls

I am providing information on the proposed Mitigation Plans and the Monitoring Plan. This information will help you understand our present thoughts about the Project.

The USFWS will use this information to prepare a Planning Aid Report for inclusion in the Draft EIS we are preparing.

In August, we will meet with Corps Division and Headquarters-level representatives to review the project and the Draft Reports. The Corps will seek your views (verbal) at that time. About a month before the meeting we will send those Corps reviewers the Draft General Re-Evaluation Report and Draft EIS. We will provide you the same reports at that time. Soon after that August meeting, the Service will seek your views so they can revise the Planning Aid Report into a Draft Fish and Wildlife Coordination Act (FWCA) Report. We will include that FWCA Report in the Draft EIS that we send out in November for agency and public comment.

The documents I am providing give you a head start on your review of the decision portions of the EIS.

I am attaching the following three documents:
* Monitoring and Adaptive Management Plan
* Project Description Tables
* Dredging Quantities

I have posted the Mitigation Planning document to the following ftp site:
ftp.sam.usace.army.mil/outgoing/SavannahHarborExpansion/
The document is called EXPAN Mitigation Planning 26Apr08.doc. The document is too big (30 MB) to send by email. It will be on this ftp site for 7 days.

At this point our economic analysis is still underway, so we do not know what the Tentatively Recommended Plan will be. For your purposes, assume the 48-foot depth will be the Tentatively Recommended Plan.

We are not seeking formal comments on these documents, but if you find something in them that is not acceptable, please let me know.

Bill Bailey
912-652-5781

Table 1
Existing and Recommended Project Widths (feet)

Range Name	Station Limits Lower	Station Limits Upper	Existing Project Width	Recommended Project Width
Tybee	82+000B[A]	40+522B	600	564
0A	40+522B	38+186B	800	764
Bloody Point	38+186B	23+475B	600	564
1A	23+475B	20+832B	800	858[B]
Jones Island	20+832B	16+142B	700	758 [B]
2A	16+142B	13+771B	800	764 to 858[C]
Tybee Knoll Cut	13+771B	1+380B	500	464
4	1+380B	1+552	Varies	Varies
New Channel	1+552	9+526	500	464
6	9+526	11+385	600	600
Long Island Crossing	11+385	24+920	500	464
Long Isl. Meeting Lane[1]	*16+000*	*20+000*	*not applicable*	*564*
8	24+920	27+317	800	764
Lower Flats	27+317	31+037	600	658 [B]
10 through 12	31+037	36+948	600 to 700	732 to 832 [C]
Upper Flats	36+948	40+437	550	532
14	40+437	41+693	500 to 700	482 to 682
Bight Channel	41+693	49+489	700	700
Ft. Jackson Channel	49+489	53+127	Varies	Varies [C]
21	53+127	54+481	600	658 [B]
Oglethorpe	54+481	61+405	500	482
Oglethorpe Meeting Lane[2]	*55+000*	*58+500*	*not applicable*	*582*
23	61+405	63+277	500	464
24 through 25	63+277	69+734	500	464
26	69+734	71+128	600	582
City Front Channel	71+128	76+537	500	464
28	76+537	77+283	550	532
Marsh Island Channel	77+283	87+642	500	464
32	87+642	90+701	550	532
33 through 35	90+701	97+543	500	464
Kings Isl. Turing Basin	97+543	103+500	Varies	Varies [B]

Notes:
[1] Includes 1,000-foot transition, [2] Includes 500-foot transition
[A] Existing project starts at 60+000B, recommended project requires 22,000 linear feet of channel extension to 82+000
[B] Width expansion on north side of channel only
[C] Width expansion on south side of channel only

Table 2
Existing and Recommended Project Depths (feet below MLLW)

Station Limits		Existing Project Depths			Recommended Project Depths		
			Advance	Maint.		Advance	Maint.
Lower	Upper	Channel	Maint	Dredging	Channel	Maint	Dredging
82+000B	60+000B	Not applicable			50	0	50
60+000B	14+000B	44	0	44	50	0	50
14+000B	26+000	42	2	44	48	2	50
26+000	35+000	42	4	46	48	4	52
35+000	37+000	42	6	48	48	6	54
37+000	50+500	42	4	46	48	4	52
50+500	52+750	42	4	46	48	6	54
52+750	54+000	42	4	46	48	4	52
54+000	60+250	42	4	46	48	8	56
60+250	66+750	42	4	46	48	4	52
66+750	70+000	42	4	46	48	6	54
70+000	102+000	42	2	44	48	2	50
102+000	103+500	42	0	42	48	0	48
Kings Island Turning Basin		42	8	50	48	8	56

Range	New Work Sediment Placement Site	Average Annual Maint Yards		48 foot +AM+OD New Work-qtys only
ENTRANCE CHANNEL				
(-)85+000 to -57+000	**SITE 11**	10,000	0	1,974,509
(-)57+000 to -53+500	**ODMDS**	3,000		451,614
(-)53+500 to-40+000	**SITE 2 & 2 EXT**	54,000		1,811,713
(-) 40+000 to -30+000	**ERDC-SITE 2EXT**	325,000		1,419,199
(-)30+000 to -20+000	**ERDC-SITE 2EXT**	281,000		1,544,738
(-)20+000 to -10+000	**SITE 2**	163,000	0	1,499,974
(-) 10+000 to 0+000	**MLW 500**	155,000	0	1,051,036
0+000 to +4+000	**MLW 200**	76,000	0	375,403
Subtotal CY		**1,067,000**		10,128,186
INNER HARBOR				
4+000 to 24+000	**Jones Oyster Isl**	225,000		2,153,272
24+000 to 40+000	**14 B**	364,000		2,451,494
40+000 to 50+000	**14 A & 14 B**	900,000		2,186,062
50+000 to 70+000	**13 B & 13 A**	2,076,000		4,476,769
70+000 to 79+000	**13 A**	294,000		1,009,180
79+000 to 97+750	**12 B & 13 A**	605,000		2,011,696
97+750 to 102+000	**12 B**	1,456,000		1,991,152
102+000 to 103+000	**12 B**	51,000		125,000
Subtotal CY		**5,971,000**		16,404,625
Project Total CY		**7,038,000**		**26,532,811 CY**

Entrance Channel = Pipeline and Hopper Dredges
Inner Harbor = Pipeline Dredges

AM = Advance Maintenance
OD = Overdepth

46 foot +AM+OD New Work-qtys only	45 foot +AM+OD New Work-qtys only	44 foot +AM+OD New Work-qtys only
930,087	506,258	229,770
303,812	228,763	152,929
1,214,945	912,183	606,638
944,052	703,369	462,393
1,028,140	767,714	507,797
969,117	702,635	442,682
689,902	509,821	333,319
236,000	165,000	102,000
6,316,055	4,495,743	2,837,528
1,449,500	1,066,300	761,000
1,658,446	1,219,600	869,000
1,570,700	1,186,000	978,000
3,616,193	3,090,698	2,760,271
660,000	466,000	311,000
1,338,200	952,100	655,000
1,575,900	1,362,000	1,161,000
88,000	44,000	44,000
11,956,939	9,386,698	7,539,271
18,272,994 CY	**13,882,441 CY**	**10,376,799 CY**

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III. LEAD AND COOPERATING AGENCIES

III. Lead and Cooperating Agencies

1. MFR dated 25 April 2002, SHEP, LCA meeting. 22 April 2002
2. MFR dated 29 March 2004, SHEP, In-Progress Review Meeting held on 29 October 2004.
3. MFR dated 25 March 2005, SHEP, 2nd In-Progress Review Meeting
4. MFR dated 27 June 2005, SHEP, Lead and Cooperating Agency meeting. 16 June 05
5. MFR dated 26 June 07, Revised 29 June 07, Revised 03 August 07, SHEP, Interagency Coordination Meeting Record of20-21 June Meeting.
6. Vision of the Cooperating Agencies
7. MFR dated 27 June 2007, SHEP, In Progress Review Meeting
8. MFR dated 20 March 2007, SHEP, Lead and Cooperating Agency meeting. 8 Mar 07
9. MFR dated 20 September 2007, SHEP, In Progress Review Action Items IX
10. E-MAIL from William G. Bailey dated 22 March 2007, SHEP, Decision on Model-To-Marsh Revisions
11. E-MAIL from Ed Eudaly dated 27 March 2007, SHEP, Decision on Model-To-Marsh Revisions
12. E-MAIL from Heinz Mueller dated 02 April 2007, SHEP, Decision on Model-To-Marsh proposal
13. E-MAIL from Joseph T. Hoke dated 02 April 2007, SHEP, decision on M2M
14. E-MAIL from Thomas A. Garrett dated 02 April 2007, SHEP, decision on M2M
15. E-MAIL from William G. Bailey dated 26 March 2008, SHEP, Cooperating Agencies
16. E-MAIL from William G. Bailey dated 03 April 2009, SHEP, Monitoring and Adaptive Management Plan
17. E-MAIL from William G. Bailey dated 06 July 2009, SHEP, 30 April Executive Steering Committee Meeting
18. MFR dated 4 December 2008, Revised 11 December 2008, SHEP, Interagency Coordination Meetings
19. E-MAIL from Curtis M. Flakes dated 10 December 2008, SHEP, Executive Management Group, Steering Group Meeting
20. MFR dated 18 December 2008, Revised 16 February 2009, SHEP, Executive Management Group (EMG) Meeting
21. MFR dated 18 February 2009, Revised 31 March 2009, SHEP, 17 February 2009 Executive Steering Committee (ESC) Meeting
22. MFR dated 2 April 2009, Revised 6 April 2009, SHEP, Regional Federal Resources Agency Meeting
23. MFR dated 14 April 2009, SHEP, Technical meeting with EPA on 08 April 2009
24. MFR dated 21 August 2009, SHEP, Executive Steering Committee Meeting, August 20, 2009
25. MFR dated 3 December 2009, SHEP, Executive Steering Committee Meeting, 9 November 2009
26. LETTER from NOAA dated 4 February 2010
27. MFR dated 02 April 2010, SHEP, Executive Steering Committee Meeting, 2 April 2010
28. MFR dated 17 September 2010, SHEP, Executive Steering Committee Meeting, 17 September 2010

29. MFR dated 16 December 2010, SHEP, Executive Steering Committee Meeting, 16 December 2010

CESAS-PD-E 25 April 02

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
LCA meeting, 22 April 02

1. Doug was sick and not able to attend, so I chaired the meeting. We used the agenda that Doug had prepared and distributed.

2. We did not have a copy of the Action Items from the March meeting, so we skipped this item.

3. PMP.
The Corps and GPA continue to work on this. No updates have been distributed to the LCA since March. The USFWS, EPA and NMFS each stated that they had no major concerns with the contents of the March version.

4. Hydro Model.

- Letters from the agencies are to include any comments they may have on limitations on the application of the model.
- Letters are due to the Corps by the end of May.
- The USFWS stated there appears to be a lack of data for certain stations that were listed in the Expectations Document. Bill Bailey agreed to send an email requesting preliminary comments by Noon Thursday (25th) and forward them to GPA/ATM that day, so ATM could be prepared to discuss them at the SMART meeting on 1 May.
- Sea level – A height will need to be selected to model future conditions. ATM stated that a ½ foot rise had been observed at Savannah over the past 50 years. The Corps requested the agencies provide comments on using that same rate for future years on this project. GPA suggested someone check to make sure whatever value we select is consistent with the Federal (Washington-level) position on sea level rise. The Corps will check with HQUSACE.
- Agencies are to provide any suggested model runs to the Corps.

5. Agency Position Regarding SEG.

- The Corps informed the other agencies of what the SEG Operating Guidelines Committee intends to recommend to the SEG concerning development of a consensus mitigation plan. That recommendation is that the SEG (1) receive reports from GPA on the status of the project's investigations and evaluations, and (2) conduct a brainstorming session to identify mitigation options that the project's scientists could use when developing mitigation plans.

- NMFS stated that the SEG provides enhanced public input for this project, but that they cannot make decisions for the Federal agencies. The LCA agreed.
- The LCA agreed that the SEG is advisory to GPA.

6. General Reevaluation Scoping Meeting.

I informed the other Federal agencies that a meeting would be coming up – currently scheduled for mid-July – where all levels of the Corps would be gathering to review the PMP and the scope of the GRR/EIS. The Corps requested that the other Federal agencies participate in that meeting.

7. D.O. Model Schedule:

The Corps stated that because of EPA's needs, completion of the model on the schedule is VERY important. GPA said they were aware of the schedule's importance.

8. NEPA Scoping.

- We discussed the package the Corps had prepared and distributed prior to the meeting containing the public comments received and Savannah District's interpretation of the need for additional studies.
- The Corps requested the Agencies submit any comments they had on that package to me in a week – by 29 April.
- The Corps stated that we continue to receive additional letters, most of which address cultural resource issues. The letters raise no new issues. The Corps proposed that those letters would not be forwarded to the rest of the LCA unless a particular letter raised a new issue. The LCA agreed to that approach.
- The Corps distributed a document containing an initial list of commitments identified in the Tier I EIS Appendix H. Another version will be distributed later when the document is complete.

9. Plan Formulation.

I distributed another version of the Plan Formulation document. A previous version had been distributed to the LCA with a request for comments. The USFWS had submitted a comment, and it had been incorporated into the present version. The LCA was informed that this document represented only a "work in progress". They will be provided with another version when the Corps and GPA have made additional progress.

10. Vision Statement.

- The Agencies Vision statement had been incorporated into the Plan Formulation document. GPA it thought that some items in the statement were items that the project was required to accomplish, and that, therefore, they questioned whether those items should be in such a statement. GPA will continue to review the Vision Statement.
- The LCA agreed that some of the statements were not prescriptive requirements for the project, but instead were goals that they hoped the project could accomplish.

11. ACTION ITEMS.

a. Bill Bailey would send an email requesting preliminary comments from the Federal Agencies on the Hydro Model by Noon Thursday (25th). **STATUS:** Requested on 23 April.

b. Bill Bailey will forward the comments to GPA/ATM by COB 25 April. **STATUS:** Done on 25 April.

c. Bill Bailey will check with HQUSACE on both the Corps and Federal position concerning sea level rise.

d. Agencies are to provide any suggested Hydro Model runs to the Corps.

e. Agencies will submit any comments they have on the NEPA scoping package to the Corps by 29 April.

f. The Corps will forward to the rest of the LCA any new letter that raises a new issue.

g. The Corps will forward another version of the Plan Formulation document to the LCA when additional progress has been made.

William Bailey
Physical Scientist

CESAS-PD-E 27 June 05

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Lead & Cooperating Agency meeting, 16 June 05

1. Alan Garrett (PM) was not able to attend, so I chaired the meeting. A list of attendees is attached. We covered two main topics: (1) Overview of recently revised schedule, and (2) Overview of Corps presentation to Principal's Group.

2. Revised Schedule.

- The PDT had meet the previous two days to conduct a thorough review of the study schedule. The extended study duration continues to increase the study costs. The goal of the Savannah District Engineer is to shorten the schedule to allow him to send the Final Report out from the District by Jun 07.
- I explained that the 2-day review had resulted in us being able to shorten the schedule somewhat. The changes resulted from (1) starting some tasks earlier, and (2) a new philosophy for the document we would provide the Corps Headquarters prior to the Alternative Formulation Briefing. That document will now be a partial report instead of a full report. The Alternative Formulation Briefing is where the Corps decides whether the project has been sufficiently defined so that we can proceed and obtain the public's views on a Draft Report. No changes were made to the technical work to be performed.
- The USFWS stated that it did not object to a faster schedule as long as the scientific work and technical analyses are not compromised.
- The Corps requested the other agencies review the schedule and let us know if they can identify any other ways to advance the schedule.

3. Corps presentation to Principals Group.

- I went over the presentation the Corps intended to give to the Principals Group the following week (23 June).
- The coming meeting will basically be an information meeting – to inform the staff at the Washington level about this project.
- The presentation is an update of one that the Corps had given to the Executive Management Group in November 03.
- We would be saying that (1) we are trying to obtain agreements from agencies as we go along, instead of just at the end, (2) we think the interagency coordination is going well, and (3) we believe that the project is conducting good science.

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

LEAD & COOPERATING AGENCY MEETING
16 JUNE 2005

ATTENDEES

Ed EuDaly	USFWS - Charleston	
Tom Prusa	USFWS – Savannah Coastal Refuges	
John Robinette	USFWS – Savannah Coastal Refuges	
Susan Rees	USACE – Mobile	
Roger Burke	USACE – Mobile	
William Bailey	USACE – Savannah	
Hope Moorer	GPA	
Larry Keegan	Lockwood-Greene Engineers / GPA	
Tom Chase	Moffatt & Nichol / GPA	
John Lesnik	Moffatt & Nichol / GPA	
Gerald Miller	EPA	(by phone)
Miles Croom	NMFS	(by phone)

CESAM-PD-E 20 Mar 07

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Lead & Cooperating Agency meeting, 08 March 07

1. The meeting was called to learn more about a proposal (attached) to revise the Model-To-Marsh (M2M) component of the Marsh Succession Models. Alan Garrett, Corps Project Manager, chaired the meeting. A list of attendees is attached.

2. Bill Bailey provided an overview of the problem.

The Corps has successfully run the Marsh Succession Models to identify changes in wetlands from the various channel deepening scenarios. These are the "impact" runs. As we applied the models to the mitigation scenarios, we observed unexpected results. For some mitigation scenarios, the EFDC runs predict a decrease in salinity but the MSMs show shifts to more saline wetland species. Upon further inspection, we observed that on those runs the M2M component was providing higher root zone salinity values than were occurring in nearby rivers. The M2M extrapolates riverine salinity values from seven sites to root zone salinity values across the entire marsh surface. Apparently the limited number of points from which the M2M is starting its extrapolation leads to inaccuracies in mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers). The M2M takes higher salinity levels on the Front River and uses them as a basis for incorrectly predicting higher salinity levels in portions of Middle and/or Back Rivers.

3. We described two avenues through which the project could more forward.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the "impact" and "mitigation" runs. We would use the MSM to provide more detail on the vegetation changes on the "impact" runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for "mitigation" runs.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the "impact" and "mitigation" runs. We would revise the M2M as proposed and apply the MSM on both "impact" and "mitigation" runs.

4. Paul Conrads and Ed Roehl provided an overview of the proposed SOW to revise the M2M. This write-up is only a small part of the description Paul and Ed provided.

The present M2M starts with river flows and tidal conditions. It adds to that foundation riverine salinity values from the EFDC model. The present M2M could be considered more a far-field approach since it uses a limited number of riverine salinity values and extrapolates them across the entire marsh surface. It determines a relationship between river salinity and the well gages through time-delayed input signals and moving window averages between river salinity and pore-water salinity. The M2M was designed to primarily identify changes in root zone salinity that occur longitudinally in the estuary (along the length of the river).

The proposed revisions would allow the M2M to better identify lateral changes in root zone salinity that occur across the estuary (between different rivers or away from a single river). These revisions would start with a more detailed network of river salinity stations. It would then extrapolate those values to nearby areas of marsh. This could be considered more of a near-field approach. Additional marsh well data would be obtained to establish strong relationships between river and marsh root zone salinities. The Q-zone approach would be used as a starting point for the river to marsh flow paths. An interagency panel would be used to identify those pathways and guide the model revisions.

Uncertainty in the results of this M2M revision include three components: (1) Quality of the original data, (2) Quality of the data used to forecast or hindcast to fill in missing data, and (3) Quality of the data from EFDC. These are the same sources of uncertainty with use of the present M2M. This revision will require development of additional synthetic data to fill in records for the extra river sites that will be used.

5. The group then asked questions of Paul and Ed Roehl about the proposed work.

What will be the reliability of the results when using more synthetic data? Would the public accept the use of more synthetic data? RESPONSE: The reliability will not be known until the model is produced. However, data for the existing M2M show it is highly reliable for use with the present configuration of the estuarine rivers. As with any model, the ultimate accuracy of the revised model's predictions would not be known until after post-construction monitoring is performed.

What will be the reliability of the results when using data from the GPA stations? Those data were determined to be unacceptable in development of the existing M2M. RESPONSE: Data from the GPA stations were not used in the existing M2M primarily because of their short period of record. A much longer – and therefore more reliable – record exists for the USGS gages. The GPA stations would be used in the model revisions to provide a finer grid of river locations from which to extrapolate salinity levels across the marsh surface. The finer grid should increase the accuracy and reliability of the model predictions within specific marsh areas. The additional stations

would also allow a more detailed quantification of the sensitivity of marsh areas to local riverine conditions. The GPA stations also provide data obtained during 1997 – the flow conditions that are being modeled during the mitigation analyses. The reliability of the revised models would not be known until they are developed.

What are the differences between the GPA stations, marsh gages, and USGS gages? RESPONSE: The differences include both duration and density. The marsh gages provide salinity information in the marsh root zone at 7 sites from 1999 to 2005 and 10 GPA sites from 1999 to 2002. The GPA stations hare 14 riverine stations with data from portions of 1997 and 1999. The USGS gages provide salinity information at 4 riverine sites for many years.

What will be the reliability of the final predictions if the development of the revised model includes extensive synthetic data? RESPONSE: Models are regularly developed and applied when only limited actual data exists. Synthetic data is an accepted technique in the modeling community when insufficient historical data exists.

If new algorithms need to be developed for each mitigation plan, it could appear that we have developed a model just to show the results we want on the plan we want. If the same model is not used to evaluate all plans, how can we ensure we are evaluating all plans to the same degree of accuracy? RESPONSE: The same procedures would be followed to evaluate all plans, even if the models differ.

The existing M2M and its algorithms appear to work well with the present river configuration. If new algorithms only are effective for the mitigation plans that substantially modify river flows, how can we ensure their accuracy? RESPONSE: The change from a "far-field" approach to a "near-field" approach increases the likelihood that the revisions would be accurate when flows are substantially modified. The reliability of the results will not be known until the models are developed.

The MSM provides more detailed information on expected wetland changes than does the EFDC model. Do we really need those more detailed predictions for each mitigation scenario? RESPONSE: If reviewers want the detailed information, the revised M2M is the only way to obtain it.

Although a provisional version may be available in 5 months, the project will need a fully accepted version before it could release a report containing results using this approach. The final report is scheduled to be available in 12 months. If complications occur that delay the work, the date would extend further. A 12-month delay in the project would be a major impact to GPA. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

The proposed revisions would likely extend the duration of the project. That extension may decrease the reliability of other analyses, requiring they be updated. That would require additional time and money. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

Some of the mitigation scenarios appear to decrease the tidal range. The USFWS may not be able to support those plans as a substantial decrease in the depth of flooding over the marsh may adversely affect nekton use of those areas. The plans which have the most effect on tidal range are the ones that substantially alter flows between the three rivers. RESPONSE: The proposed M2M revisions would not be beneficial if the final mitigation plans do not include measures that substantially alter flows between the three rivers.

Have the status and trends of wetlands since the last harbor deepening been taken into account? RESPONSE: Both the M2M and the MSM are based on data obtained since the last deepening.

Would the proposed revisions be necessary for the post-construction monitoring and adaptive management? RESPONSE: The EFDC will be used to ensure that changes in riverine salinity that are predicted are not exceeded. The existing M2M and MSM could be used to provide a perspective on what should have been expected in the wetlands with the observed flows if no further deepening occurs.

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

LEAD & COOPERATING AGENCY MEETING
08 MAR 2007

ATTENDEES

Ed EuDaly	USFWS – Charleston	(by phone)
Ted Bisterfeld	EPA Region 4	(by phone)
Kay Davy	NOAA Fisheries - Charleston	(by phone)
Alan Garrett	USACE - Savannah	
Joe Hoke	USACE – Wilmington/Savannah	
Hugh Heine	USACE – Wilmington	(by phone)
Elizabeth Godsey	USACE – Mobile	(by phone)
William Bailey	USACE – Mobile/Savannah	
Hope Moorer	GPA	(by phone)
Larry Keegan	Lockwood-Greene Engineers / GPA	(by phone)
Morgan Rees	Rees Engineering / GPA	(by phone)
Paul Conrads	USGS – Columbia	(by phone)
Ed Roehl	Advanced Data Mining	(by phone)

Estimation of Pore-water Marsh Salinities for Harbor Reconfiguration Scenarios

By
Paul Conrads, U.S. Geological Survey – Water Resources Division
Edwin Roehl, Advanced Data Mining, LLC
Wiley Kitchens, U.S. Geological Survey – Biological Resources Division
Zachariah Welch, Florida Coop Unit, University of Florida,

INTRODUCTION

Under sponsorship from the U.S. Army Corps of Engineers (USCOE) and the Georgia Ports Authority (GPA), the Lower Savannah River Estuary and the surrounding freshwater tidal marshes of the Savannah National Wildlife Refuge (SNWR) have been studied for years by a variety of governmental agencies, water users, universities, and consultants. Their interests are in maintaining water quality and predicting the potential impacts of a proposed harbor deepening on the estuary and tidal wetlands. Two major initiatives were the development of a three-dimensional hydrodynamic model (3DM) by a team of hydrologists, and the development of a marsh succession model (MSM) by a team of plant ecologists. The 3DM predicts changes in riverine water levels and salinity in the system in response to potential harbor changes. The MSM predicts plant distribution in the tidal marshes in response to changes in the water-level and salinity conditions in the marsh. A mechanism for linking riverine and marsh behaviors was needed.

To support 3DM and MSM development, many disparate databases were created that described the natural system's complexity and behaviors, but these databases had not been compiled into a usable form. Variables having particular relevance include those describing bathymetry, meteorology, streamflow (Q), water level (WL), specific conductance (SC), water temperature (WT), and dissolved oxygen concentration (DO). Most of the databases were composed of time series that varied by variable type, periods of record, measurement frequency, location, and reliability. Scientists recognized that data-mining techniques, which include artificial neural networks (ANN), could be used to link riverine and marsh behaviors.

To link the riverine predictions of the 3DM to the MSM, a "model to marsh" (M2M) model was developed by the U.S. Geological Survey and Advanced Data Mining (ADM) using data mining techniques that included ANN models. The ANNs simulated riverine and marsh water levels and salinity in the vicinity of the SNWR for the full range of 11½ years of data from riverine and marsh gaging networks. With M2M, the 3DM and MSM comprise an integrated decision support system for use by various regulatory and scientific stakeholders. The development and application of the M2M is described in Conrads and others (2006).

The M2M has been successfully applied to evaluate the effects of deepening the harbor by generating the inputs to the MSM from the outputs of the 3DM. The M2M also has been used to evaluate potential mitigation scenarios for minimizing the impacts from

harbor deepening. These mitigation scenarios included minor and major changes in channel configuration and flow distribution in the system.

PROBLEM STATEMENT

Eight mitigation scenarios that involve major structural changes in the vicinity of the SNWR, such as the installation of flow diversion structures and the cutting and filling of channels, have been proposed for evaluation. The M2M was not designed to accommodate mitigation scenarios that involve major structural changes. Currently (2007) there is not a mechanism for reliably estimating pore-water salinities in the marsh from riverine inputs for these major mitigation scenarios.

The responses of the SNWR to major changes are very likely to be different from any behaviors ever manifest in the historical record. While the 3DM can be configured to estimate riverine WL and SC with the major changes, it is limited to riverine estimates and cannot be credibly configured to estimate pore-water salinities in the marsh. Using data mining techniques, Conrads and others (2006) found that pore-water salinities integrate riverine WL and salinity variability over several months and often there are long time delays between riverine salinity conditions and marsh pore-water salinity response. A new tool similar to the M2M, hereafter referred to as M2M.2, needs to be developed to estimate pore-water salinity concentrations to evaluate mitigation scenarios involving major structural changes. To provide the necessary technical input and agency review, it is proposed that a multi-agency and multi-disciplinary technical working group be formed of the USGS-S.C. Water Science Center (USGS-SCWSC), the USGS-Florida Coop Unit (USGS-FCU), U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACOE), and Advanced Data Mining (ADMi).

OBJECTIVES

There are three objectives for this project.

1. *Develop new marsh salinity estimation models* - for estimating pore-water salinities at marsh gaging sites for various mitigation model scenarios, using either measured or predicted river water level and specific conductance data at gage locations. It is possible that algorithms would have to be developed for each mitigation scenario.

2. *Develop new salinity spatial interpolation scheme(s)* – that estimate salinities throughout the SNWR from the USGS marsh gaging sites. The current scheme is embedded in the M2M's two-dimensional visualization and gridding application (2DVG). The new schemes must reflect greater lateral variation in the pore-water salinity than the current scheme. It is possible that new schemes would be created for each mitigation scenario.

3. *Develop M2M.2 2DVG and Simulator Applications* – to deploy the work products from Objectives 1 and 2. This includes adapting the 2DVG and the M2M Simulator, which estimates salinities at the USGS marsh gages.

SCOPE

The scope of this study is to address the relation between the riverine salinity and the pore-water marsh salinity for harbor deepening mitigation scenarios. The study's major tasks are described below.

Task 1 *Develop Pore-water Estimation Matrix* – that defines the usable permutations of input USGS or GPA river gages to estimate salinities at each marsh gaging station for each mitigation scenario. Consideration will be given to the proximities of gages and flow diversion structures, and the overall quality of input gage measured, forecasted, and hindcasted data used for developing or generated by the M2M.

Task 2 *Develop predictive models* - for each permutation defined in Task 1. This involves determining optimal time delays and moving window averages between river salinity and pore-water responses through correlation analysis. ANNs provide the best possible correlations in terms of the process information they provide and their prediction accuracy. The number of models to be developed depends on the permutations defined in Task 1.

Task 3 *Define area of influence and spatial gradient of the USGS marsh gages* - for the new salinity spatial interpolation scheme.

Task 4 *Develop M2M.2 2DVG application* - to reflect findings from Task 3. It is likely that multiple visualizations and grids will need to be developed to accommodate all of the mitigation scenarios.

Task 5 *Develop M2M.2 Simulator* – like M2M, it will integrate the 3DM with the MSM using the models from Task 2 and the M2M.2 2DVG application from Task 4, but tailored for the mitigation scenarios involving major structural changes.

Task 6 *Document the approach and results.*

RELEVANCE AND BENEFITS

An important part of the USGS mission is to provide scientific information for the effective water-resources management of the Nation. To assess the quantity and quality of the Nation's surface-water, the USGS collects hydrologic and water-quality data from rivers, lakes, and estuaries using standardized methods, and maintains the data from these stations in a national database. Often these databases are under utilized and under interpreted for addressing contemporary hydrologic issues. The techniques used to develop the M2M and models of the Cooper River (Conrads and Roehl, 1999), the Beaufort River (Conrads and others, 2003), and the Pee Dee River (Conrads and Roehl, 2006) demonstrate how valuable information can be extracted from existing databases to assist local, state and Federal agencies.

The project benefits the Georgia Ports Authority and the Army Corps of Engineers by providing data analysis needed by water-resource managers to make decisions concerning mitigation of the Savannah River Estuary to accommodate potential deepening of Savannah Harbor. The project builds on previous studies relating river salinity to marsh pore-water response. This is consistent with primary USGS activities that include providing knowledge and expertise to assist various levels of government in understanding and solving critical water-resources problems.

TECHNICAL APPROACH

The historical data do not contain information explicitly about the impacts of the proposed mitigation scenarios involving major structural changes. For these circumstances, the best available data, tools, and human expert knowledge and experience must be brought to the problem. The development and use of the M2M.2, and related findings will provide the best possible resources for evaluating the major mitigation scenarios.

Available Data and Utilities from M2M Study

The M2M is based on river and marsh WL and SC ANN models for the USGS and GPA gaging stations in the river and marshes. These are empirical models and for a system as complex as the Savannah River estuary, it was critical that measured, not estimated, data were used that cover the greatest range of hydrologic and tidal responses. For making predictions of pore-water salinity, the most valuable data for M2M development were from the long-term USGS river and marsh gaging stations, which covered over 11 years and 5 years respectively, and comprise a range of flow conditions from drought to floods. Of lesser value were the GPA river and marsh data, which were limited to short measurement periods and a small range of hydrologic conditions. The USGS river data are the major inputs for the final pore-water salinity models and a few of the GPA stations are used to reduce the error in the pore-water models.

The M2M Simulator and 2DVG applications will be valuable for estimating pore-water salinity for the major mitigation scenarios. The Simulator integrates a collection of individual models of the GPA and USGS river gages with the various field databases, such that all of the WL and SC data from the river gages were individually modeled. By hindcasting and forecasting the short-term data collection periods at the GPA sites, a complete database was generated for the 11½ year period from 1994 to 2005. This feature was incorporated to allow scientists and managers to simulate any period from the last deepening and analyze system responses at any gage location. The 2DVG provides spatial interpolation-extrapolation and visualization of the marsh responses across the marsh wells. It is easily modified to accommodate new pore-water estimates at the USGS marsh sites and new interpolation-extrapolation schemes across the marsh.

Pore-water Estimates for Mitigation Scenarios

The MSM models use the growing-season average pore-water salinity as input. The measured, forecasted, and hindcasted SC records at the GPA river sites can be used in conjunction with the USGS sites to determine the best estimates of the average pore-water salinity during the growing season. Estimates will be based on the assumption that a marsh gage responds to nearby river gage(s) and that the candidate river gage(s) may vary by mitigation scenario. Often good correlations between two time series, such as river and marsh SC, can be obtained by adjusting the time delay and moving window average of the explanatory variable (river SC) to achieve the highest correlation with the response variable (marsh SC). For highly dynamic SNWR, trend information proved invaluable for estimating inertia-driven behaviors. Representing trends requires at least two input variables whose values represent two different times or two different locations at the same time, or both.

To estimate pore-water responses to mitigation scenarios, river sites will be selected as candidate explanatory variables for each mitigation plan. For example, the schematic for Mitigation Plan 5 is shown in figure 1. In this scenario, it is believed that salinity intrusion occurs further up the Front River and that freshwater flows increase down the Little Back River. The riverine gages closest to the Middle River 1 (M1) for estimating its pore-water salinity are GPA12 and GPA12r. For Back River 2 (B2), gages 8979, 89784, and GPA15 appear to be good candidates. Final river site selection will be based on the quality of the measured, hindcasted, and forecasted GPA data.

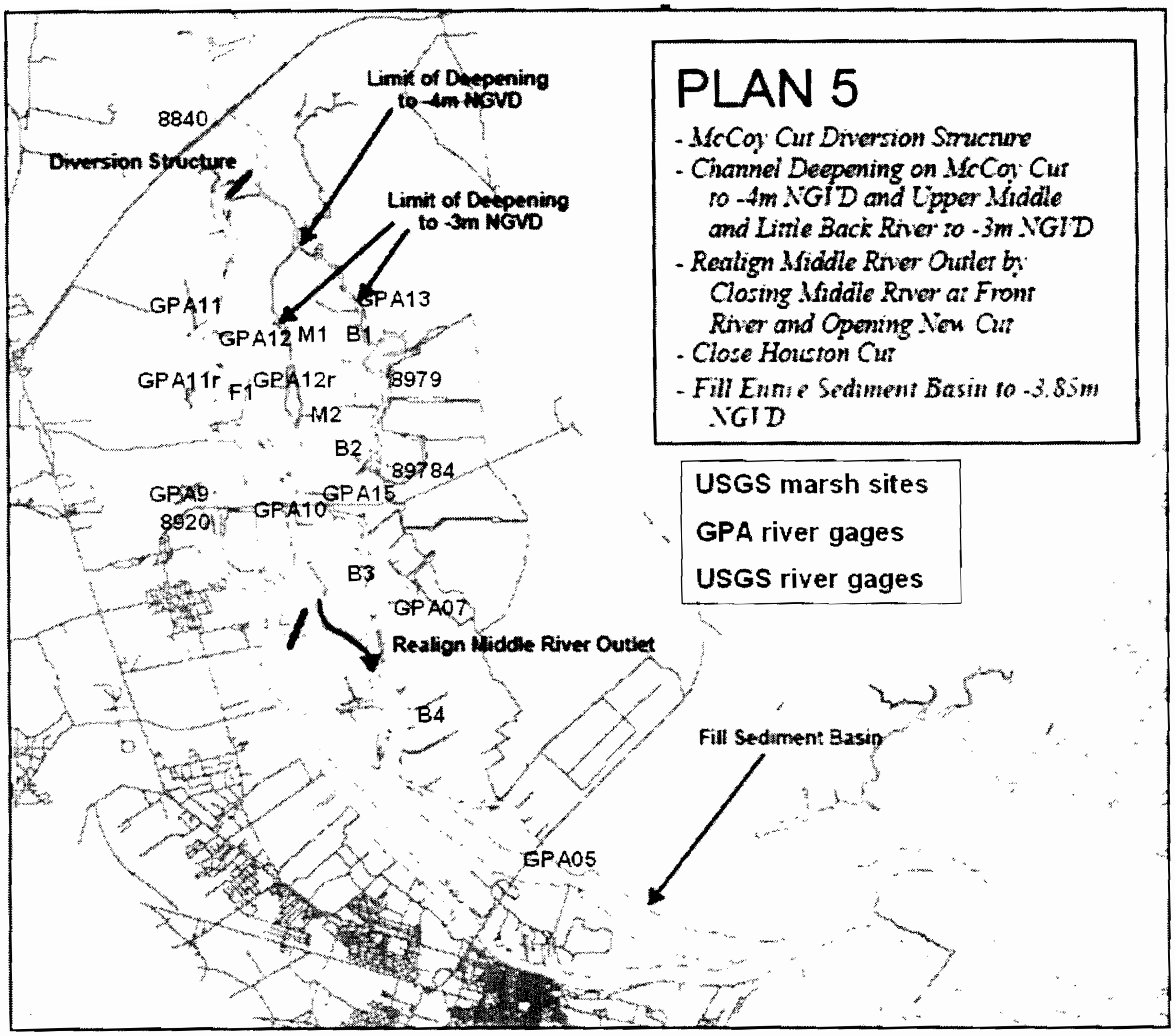


Figure 1. Locations of river and marsh gages and schematic of Plan 5 mitigation scenario

The Pore-water Estimation Matrix will be developed of mitigation plans, marsh gages, and candidate river sites. It is anticipated that some of the plans will share configurations of river gages to marsh gages. Pore-water estimates will be determined for each plan and the estimates will be compared with the predictions made with the original ANN models of the M2M.

Pore-Water Salinity Projections Across the Marsh

The time-series data of the individual marsh gages depict the longitudinal gradient of the system to various hydrologic and tidal conditions. The time-series data do not support the lateral gradients in the system. The M2M's 2DVG is based on estimates of the longitudinal variations from model predictions at the marsh sites. A simple interpolation scheme is used to estimate the lateral gradients.

For the mitigation scenarios, marsh wells will be assigned to the vegetative zones (Q-zones) depicted in Figure 2 and added to the Pore-water Estimation Matrix. Lateral variation across the marsh will be based on field experience and limited data taken during transect studies by the Florida Coop Unit (FCU) at the University of Florida.

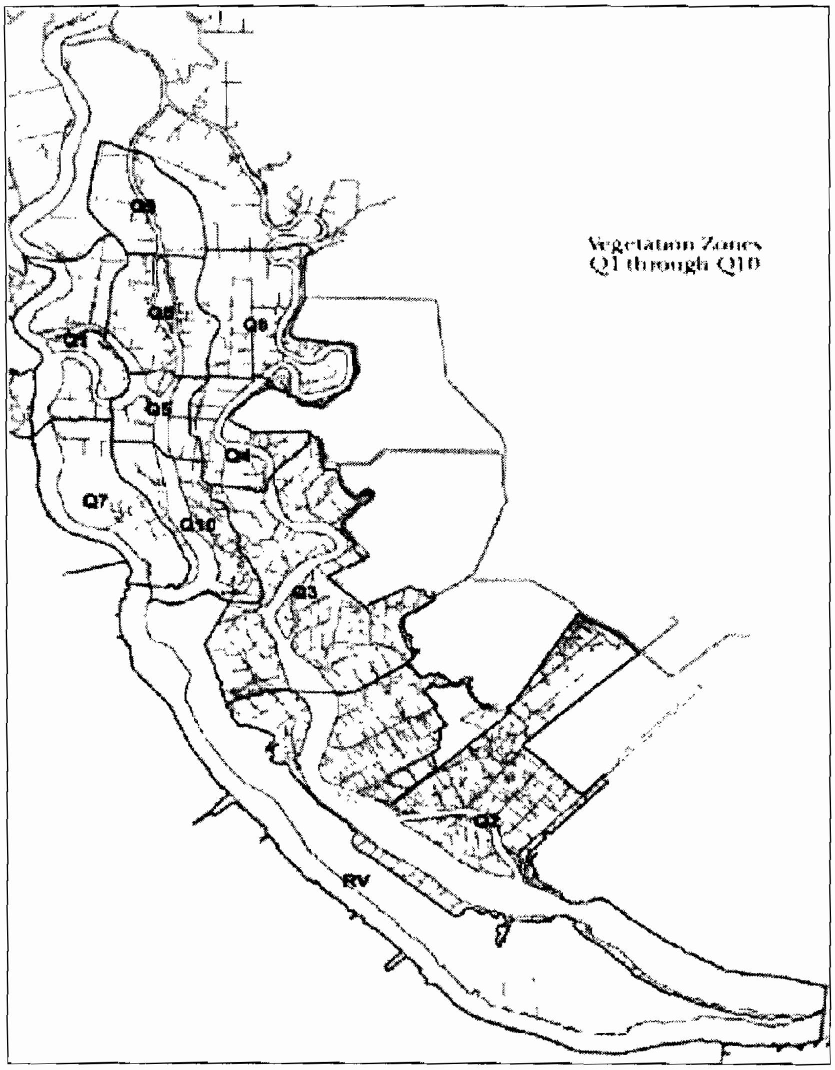


Figure 2. Locations of Q-zones in the tidal marsh in the vicinity of the Savannah National Wildlife Refuge

Integration of Hydrodynamic Model and Marsh Succession Models – M2M.2

Like M2M, M2M.2 will integrate output from the 3DM and generate the marsh salinity grid for input to the MSM. Linking the 3DM is accomplished by reading in a file of simulated differences in SC values for the river for the mitigation plan scenarios. The use of differences, or deltas, from the 3DM increases the prediction accuracy of the model. Mechanistic model, such as the 3DM, typically are better suited from predicting relative differences between two conditions rather than making absolute predictions for one

scenario. The differences (deltas) from the 3DM are added to the historical time series for the scenario and then used in the M2M.2. The application estimates pore-water salinity at the marsh gages and the salinity grid is generated for input to the MSM applications.

Figure 3 describes the data and workflow from the 3DM, through the M2M.2 Simulator and 2DVG applications, and to the MSM. Here, the eight mitigation scenarios are handled separately, providing each with completely customized solution bearing the best ideas of the multi-disciplinary team. At left the 3DM is run for each scenario and separate output files are generated. Next at top center, in the M2M.2 Simulator the user selects the scenario to be run, the appropriate 3DM output file is loaded, the appropriate prediction models are engaged, a simulation is run, and an output file of marsh specific conductivities is generated. Next at right, in the M2M.2 2DVG the user selects the scenario to be run, the M2M.2 Simulator output file is loaded, and an output file of spatially interpolated marsh salinities is generated, which can be loaded into the MSM.

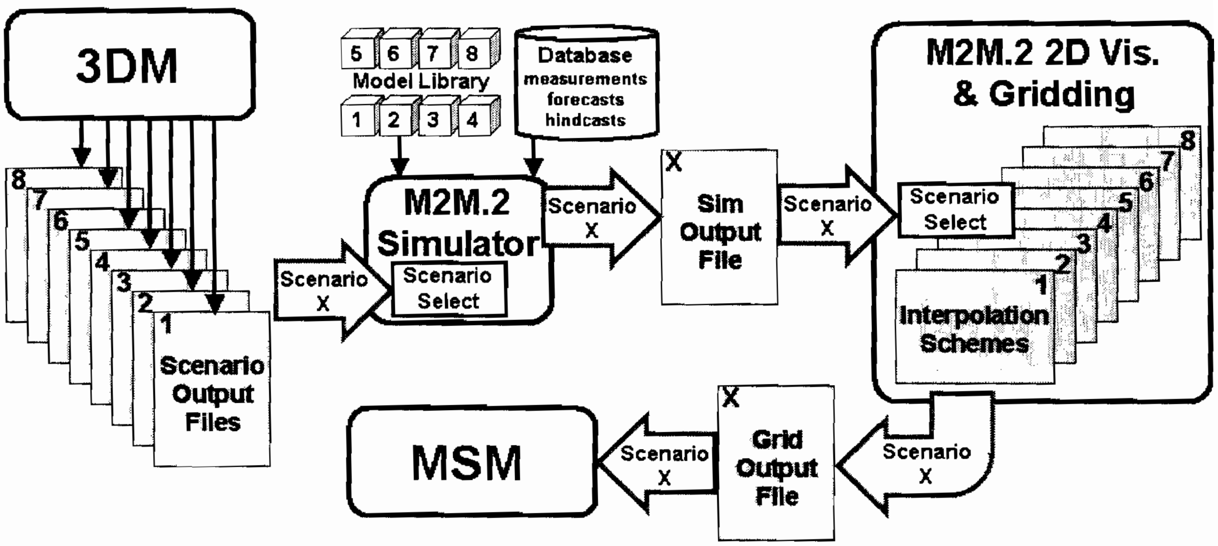


Figure 3. Schematic of data and workflow through the M2M.2.

UNCERTAINTY OF OUTCOME

In this technical approach, each scenario will have a custom solution developed by a multi-disciplinary technical team composed of the USGS-SCWSC, the USGS-FCU, the USFWS, USACOE, and ADMi personnel that are most knowledgeable in the issues, history, and science of the harbor deepening. As with the M2M, the behaviors and predictive performance of the new "local" models of the M2M.2 will be fully described to the technical team. The performance of the models is expected to be comparable to those of the M2M, with the major sources of uncertainty to be associated with the quality of the data collected from the GPA sites, the quality of the SC hindcasts and forecasts at the GPA sites, and the accuracy of the 3DM predictions.

Generally, the 3DM prediction accuracy of flow and salinity throughout the model domain are better on the Front River and lower portion of the system. The prediction

accuracy is not as good in the vicinity of the SNWF and farther inland in the system. This can be seen in the summary statistic of the model performance for the 50 percentile and the coefficient of determination for the 1999 calibration data and the 1997 validation data set (Tetra Tech, 2006). The accuracy of estimates made by the 3DM for scenarios involving major structural changes is unknowable *a priori*, but very likely to be less accurate that the calibration and validation prediction. The used of differences from the 3DM will reduce absolute prediction error by the model. The 3DM's performance will be the primary source of uncertainty, but significant reliance on its estimates inside the SNWR is unavoidable.

The technical team will leverage the tools in hand to formulate a process of mitigating deepening-related problems. The process may employ a succession of structural changes of varying impact severity. It is likely that each change will have surprising results that can only be determined *post priori* by continued field monitoring and data analysis. This suggests a conservative, iterative mitigation approach composed of these steps - hypothesize, change, test, review, and most importantly, learn will be required.

PROJECT COORDINATION

In making estimates of system responses to the structural changes in the SNWR, it is essential that the appropriate technical resources from the agencies be involved. It is proposed that periodic meetings of the technical working group (USCOE, USF&W, USGS-SCWSC, USGS-FCU, and ADMI) be scheduled to review interim products such as the pore-water estimation matrix, pore-water estimation models, and prototypes of the M2M.2 2DVG and M2M.2. Many of these meeting could be accomplished by teleconferencing.

REPORTING

The project will be documented in a USGS Open-File Report, tentatively titled "Estimation of Tidal Marsh Pore-water Salinity in the Vicinity of Savannah National Wildlife Refuge for Savannah Harbor Deepening Mitigation, Coastal South Carolina and Georgia." A provisional copy of the report will be available for colleague/cooperator review 3 months after the completion of the project. The review process will require an additional 5 months. A limited number of paper copies of the report will be provided to the cooperating agencies; however, the primary outlet for the publication will be the Internet. A link to the report will be posted on the USGS South Carolina Water Science Center web sites.

BUDGET AND SCHEDULE

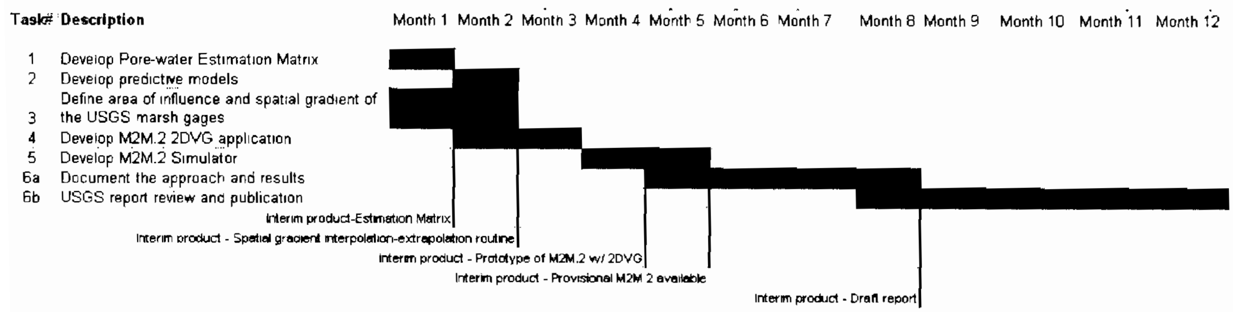
The Project will be collaboration between the USGS-SCWSC, the USGS-FCU, and ADMi. The project will take approximately 4-5 months to complete the technical analysis and develop the provisional M2M.2 from the start date. The final documentation of the project will be complete approximately 10-12 months from the start date. The total cost of the project will be $110,750. An itemized description of the tasks and required hours

are listed in Table 1 and a timeline for completion of the project from initiation is presented in Table 2.

Table 1. Tasks, description, notes, hours, and costs.

Task #	Description	Notes	USGS-SCWSC Hours	USGS-SCWSC Cost	USGS-FCU Hours	USGS-FCU Hours	ADMI Hours	ADMI Cost
1	Develop Pore-water Estimation Matrix	tooling up, evaluate data quality, matrix development, meeting with Agencies to finalize matrix	40	$4,400			40	$5,000
2	Develop predictive models	upper limit = 8 scenarios x 7 models per = 56 models, x 8hrs/model, use 50% - USGS-SCWSC to review	25	$2,750			224	$28,000
3	Define area of influence and spatial gradient of the USGS marsh gages	mostly USGS-FCU with assitence from USGS-SCWSC, ADMI to assimilate, meeting for concurance with Agencies prior to finalization	40	$4,400	64	$6,400	12	$1,500
4	Develop M2M.2 2DVG application	assume 8 interp schemes to program/integrate at 2days per - USGS-SCWSC to revew	25	$2,750			128	$16,000
5	Develop M2M.2 Simulator	assume 4 weeks for mostly new but derivative app programming and testing - USGS-SCWSC to rev	25	$2,750			160	$20,000
6	Document the approach and results	mostly USGS-SCWSC and USGS-Publications Unit, ADMI and USGS-FCU to assist	120	$13,200	16	1600	16	$2,000
		Totals	275	$30,250	80	$8,000	560	$72,500

Table 2. Timeline for completion of project.



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CESAS-PD-E

26 June 2007
Revised 29 June 2007
Revised 03 Aug 2007

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Interagency Coordination Meeting
Record of 20-21 June meeting

PARTICIPANTS:

NAME	**REPRESENTING**
Ed Eudaly	USFWS-Charleston
John Robinette	USFWS-Savannah NWR
Kay Davy	NOAA-Fisheries
Brad Gane	GA DNR-CRD
Kelie Moore	GA DNR-CRD
Matt Thomas	GA DNR-WRD
Tim Barrett	GA DNR-WRD
Paul Lamarre	GA DNR-EPD
Chris Beckham	SC DHEC-Columbia
Wade Cantrell	SC DHEC-Columbia
William Bailey	USACOE-Mobile
Paul Bradley	USACOE -Mobile
Joe Hoke	USACOE-Wilmington
Beth Williams	USACOE-Wilmington

OBSERVERS:

Hope Moorer	GPA
Larry Keegan	GPA/CH2M Hill

1. The meeting was held at the Armstrong Center in Savannah on June 20-21. The agenda is attached at the end of this document. This summary does not include all the items that were discussed during the meting, but summarize important points and decisions that were reached.

2. The meeting was called to (A) review information in the previously distributed impact and mitigation reports, (B) determine what information is most representative, and (C) identify appropriate mitigation.

3. We began by discussing impacts to **wetlands**. We first discussed the percent exceedence information on salinity. The Corps passed out handouts that USGS (Paul Conrads) had prepared that show the agreement between surface salinity values from the Model-To-Marsh (M2M) Model with those calculated by the hydrodynamic model (EFDC) and (when available) data measured in the marsh root zone. We reviewed data for stations in Front, Middle, and Back Rivers, and both average (1997) and low river flows (2001). The 50%-tile exceedence value was identified as being the best single measurement across the range of stations of flows. It was more accurate than the 10%-tile exceedence values (90% on distribution frequency) and therefore the best single exceedence value. Therefore, the group agreed for the Corps to use that parameter (50-%tile exceedence value) when assessing surface salinity levels for wetland effects.

4. We then reviewed **river flows**. Average river flows generally represent 50% of the flow distribution, while low flows and high flows each represent other 25% portions of the flow. Since average conditions represent more of the entire range of flows, the group reaffirmed our previous decision to use that condition in our basic impact evaluation.

5. We discussed **sea level rise**. As requested by the agencies, the reports contain information on conditions with both a 25 and 50-cm rise in sea level. The 25-cm rise is roughly the average of the range of sea level rise predictions for this area over the next 50 years. The 50-cm rise is at the high end of predictions for that time period. Both of those conditions would occur at the end of the 50-year planning time horizon. The group agreed that we should conduct our basic impact evaluation using conditions that would occur near the time of construction. Therefore, we decided to use the existing sea level for the basic impact evaluation.

6. We then discussed **mitigation for wetland impacts**. The evaluation procedure we have available uses the position of the 0.5 ppt surface salinity as the distinction between the locations of fresh and brackish marsh. The 0.5 ppt salinity value is a commonly accepted threshold between those two types of marsh vegetation. With the flows into tidal creeks that serve a large area of marsh, the procedure is essentially an ON/OFF switch for impacts. Because of this, the procedure shows irregular wetland impacts (rather than a smooth consistent increase) with increasing salinity levels. To address this we distributed information we had just prepared showing the effects of ranges of salinity (-0.5, 0.5-1, 1-2, 2-4, >4 ppt). This new format provides information on the effects on low salinity brackish marsh. This format requires someone to extend salinity contours from the rivers out into the marsh. Although drawing this contour is somewhat subjective, the group felt that it was acceptable if all the extrapolation is performed using the same criteria. Use of a single analyst (using the same criteria) would further normalize the results. One member suggested we graph the incremental wetland

acreage by river mile for each of the 3 rivers (Front, Middle, and Back). This could remove some of the subjectivity of drawing contours. The group requested we provide the salinity range information for all the depth alternatives and that we include columns showing the net acreage effect on each of these 5 wetland categories.

Plans that substantially reroute flows within the estuary were found to reduce the tide range upstream of the Houlihan Bridge. Some plans reduce the range 0.2-0.3 meters, while others reduce it 0.3-0.5 meters. USGS (Wiley Kitchens) measurements showed 1-1.5 feet of flooding of the freshwater marsh sites. One suggestion was to recalculate the marsh impacts with marsh elevations included. The USFWS expressed its opposition to conversion of freshwater wetlands to uplands. The USFWS also expressed concern that the loss of flooding over extensive marsh areas would eliminate use of those areas by small fish. Because of these concerns, we agreed to drop consideration of Plans 4, 5, and 8 and concentrate on Plans 1-3. The Corps would proceed with its modeling of Plans 6 and 7 using Plan 3 as a base.

The Corps provided the following information on the diversion of water from the Savannah River into the Middle and Back River system:

River Flow	48-foot Channel No diversion	48-foot Channel + Plan 1 (With Diversion Structure)
McCoys Cut	583 cfs	1130 cfs
Little Back River	429 cfs	646 cfs
Middle River	333 cfs	663 cfs

These numbers are based on average flows down the Savannah River.

We then discussed **restoration or compensation for wetland impacts**. The USFWS reiterated its position that because of previous losses over time, we cannot afford to lose additional tidal freshwater wetlands. They stated that due to the large historic loss of tidal freshwater wetlands within the estuary, they would not consider any out-of-kind replacement as acceptable mitigation for project impacts to the remaining tidal freshwater wetlands. Acquisition and conversion of the Poindexter property was discussed. The property~~site~~ is located on the eastern side of the Refuge and is ~~presently~~ managed by private landowners for waterfowl hunting. Diked portions of the site are seasonally flooded from the freshwater diversion canal. In the past, crops were grown in the diked areas during the summer before they were flooded in the fall. We understand that~~If the participants~~ the owners use ~~have shifted to~~ ~~moist~~ soil management practices similar to those used ~~, acquisition and management of the site~~ by the Fish and Wildlife Service to operate their impoundments. Based on that information, Federal acquisition and management would~~may~~ not provide substantially different environmental values. This would substantially reduce the number of ~~. In that case, few~~ wetland mitigation credits could be claimed ~~for Federal acquisition~~. In 2006, the owners were approached with an offer to sell the property for development, so there is a threat that the property may be developed in the near future. An imminent threat of development is a factor which increases the amount of mitigation credits which can be claimed for protecting a site. The USFWS is interested in ownership of the property, but the site is not presently within their approved acquisition boundary. If the property is acquired and the dikes retained, the Federal ownership would protect the site from development and result in the diked areas being considered managed wetlands. The dikes would control water access to the site, so that acreage could not be considered tidal freshwater wetlands. The controlled access would mean that those acres would not provide the fishery habitats provided by natural wetlands. Those fishery functions would have to be made up separately. If the property is acquired and the dikes removed, brackish marsh would move in and occupy the previously diked areas. Since nearby brackish marsh provides high ecological values for fisheries, removal of the dikes could receive substantial credit for fishery habitats. NOAA-Fisheries prefers removal of the dikes if the property is acquired. (Note: This wording reflects subsequent discussion between the USFWS, NOAA-Fisheries, SCDHEC, and the COE on 18 July.) ~~If crops are still grown during the summer, Federal acquisition would increase wetland functions and be creditable as mitigation. The USFWS, NOAA-Fisheries, and SCDHEC agreed that conversion of the diked agricultural lands into managed freshwater wetlands (like USFWS Refuge operations) could be credited as mitigation for wetland losses. We agreed that such conversion would not compensate for fishery functions provided by wetlands. Those impacts would have to be made up separately.~~

The USFWS is interested in acquisition of upriver areas that are already within their approved acquisition plan. They stated that such acquisition would not be acceptable for loss of tidal freshwater wetlands.

The vast majority of ~~All~~ the present tidal freshwater marshes are located within the Savannah National Wildlife Refuge. The group agreed that all tidal freshwater marshes within the Refuge possess the same ecological value.

The USFWS requested we include closing the lower (western) arm at McCoys Cut in future modeling of mitigation plans. They observed ebbing flows passing from McCoys Cut back out to the Savannah River. The hope is that closing that reach would increase flows down into the LBR/MR area. The Corps stated that if we pursue excavation of berms (previously deposited fill) along the banks of Little Back and/or Middle Rivers, placing those sediments in the lower arm would save substantial construction costs. Filling the arm would also result in creation of tidal freshwater wetlands. The USFWS said that the area needed to be surveyed for freshwater mussels. Subsequent to the meeting it was determined that a consulting firm with trained mussel divers would be required for this survey. The USFWS expressed concern about filling the lower arm and would rather see it plugged on the Little Back River side. That action would create a slough and provide fishery habitats for many years.

We discussed work at the Sediment Basin. The agencies have expressed concern about water quality (turbidity) impacts if sediments are directly deposited in the basin. The Corps said that initial modeling showed a narrow sill at the lower end of the basin would not stop salinity moving upstream with the tide. Momentum appears to carry the tidal flow over the top of a narrow sill and continue some distance upstream. The mitigation modeling is based on the Sediment Basin being filled to the same depth as upriver of the Tidegate (depth of -3.85 meters). Constructing only a sill would reduce the beneficial aspects on salinity of removing the Basin from operation. Sediments that would be excavated during a harbor deepening are primarily sands. The sediment composition does vary by station and depth. Placing silty or clay-dominated sediments in the Basin with a hydraulic dredge could produce extensive turbidity. Placement of clay-dominated sediments with a clamshell would produce substantially less turbidity. Operations that produce more turbidity could be conducted during winter months which are less stressful to biota. We agreed to continue this discussion later.

7. We discussed impacts to **fisheries**. We started with Shortnose sturgeon. The modeling shows a deepening could reduce sturgeon habitat substantially. The adverse effects are most pronounced in the adult life stage during August. The wetland mitigation plans do not reduce those impacts. The impacts appear to be salinity related and not caused by reductions in dissolved oxygen. One method of mitigating for those impacts is to construct the fish bypass channel that had previously been proposed at the New Savannah Bluff Lock & Dam (NSBL&D). The group felt that this structure would help sturgeon, as it would open up new areas upstream for spawning. They believe it would also help American shad and other anadromous fish species. From an ecological perspective, removal of the NSBL&D would be more effective than implementing bypassing fish around the structure. The Corps explained that although Congress has not funded rehabilitation of the lock and dam (with its bypass), local governments continue to position themselves for the continued existence of that dam. The Corps would not consider proposing removal of that structure as part of this project unless someone first discusses the concept with a local government representative and obtains an indication that they would not oppose such a proposal. The group could not identify a method other than action at NSBL&D to mitigate for adverse impacts to this species. The Corps will coordinate further on this issue with the St. Petersburg office of NOAA-Fisheries.

We reviewed impacts to **American shad**. Those range from <1% loss of habitat in January and May to a loss of 7% in August with Plan 3. The out-migration of juveniles to the ocean would commence late summer and continue through fall and winter. Since the criteria for acceptable habitat for this species consists of only a dissolved oxygen level, the oxygen injection system should remove these impacts and likely result in net improvements in habitat volume.

We reviewed impacts to **Striped bass**, which result in roughly a 25% loss in acreage of acceptable habitat across the three life stages we examined – spawning, eggs, and larvae (50% flow, 6-foot deepening, Plans 1-3). GA DNR-WRD believes that average river flows (50%-tile) are appropriate for identifying project impacts.

Although the habitat criteria include several parameters, velocity and salinity seem to be the most important ones. The Corps examined ways to increase velocity in the LBR and MR areas. This included use of pilings, rocks, and additional flow volume. Increasing flow in the Savannah River during April by 500 and 1000 cfs did not result in noticeable improvements. Further increases in flow are also not likely to be effectives, as even flows at the 80% cumulative frequency level do not reduce the adverse effects of a deepening. The Corps will check the actual velocity numbers to identify the level of effect, as well as examining whether the velocity is above or below the defined threshold.

GA DNR-WRD requested we examine inclusion of a flow partitioning structure at the junction of LBR and MR as a potential adaptive management tool. This could allow us to modify the distribution of flows in that system to improve areas that provide more and/or better habitats for striped bass.

The Savannah River striped bass population is currently not used as the sole source of broodfish for GA's statewide striped bass stocking program. Both SC and GA recently opened the recreational fishery for this species. The stocking program appears to have been successful, as a good number of large adult fish occur in the estuary. Records indicate that some natural spawning has resumed in the last 2 year classes checked (2003 and 2004). Sixty percent of the 2004 year-class was naturally spawned. Dr. Bill Daven's 1999 report of egg transport identified 3 locations in the spawning area with a silty bottom substrate. GA DNR did not believe that further field study of that issue was needed. Questions were raised about the potential value of cleaning the sediments in those areas to make that area more productive. Unknowns about the flow velocities keep anyone from knowing whether the sites would silt back in again.

GA DNR-WRD and USFWS suggested we further examine closing the lower arm of McCoys Cut during future modeling. Ebbing flows have been observed passing from the lower arm of McCoys Cut (original channel) back out to the Savannah River. The hope is that closing that reach would increase flows down into the LBR/MR area. They also requested we examine not deepening through McCoys Cut. This may be a way of increasing velocities through that upper LBR/MR area.

The group could not identify any other physical action that could be examined to increase Striped bass habitats in the project area. If the 25% loss in habitat remains in the final plans, funding a striped bass culture/stocking program may be the only way to compensate for the unavoidable impacts to this species.

We reviewed impacts to **Southern flounder**. Habitat losses for this species are substantial (up to 47% with 6-foot deepening and Plan 5). However, since the criteria for acceptable habitat for this species consists of only a bottom slope and dissolved oxygen components, the oxygen injection system should remove these impacts and likely result in net improvements in habitat volume.

8. We discussed impacts to **water quality**. GA DNR identified two statements on page 7 in the Impact Report that were questionable. The Corps concurred that the wording should be revised and said that we would revise the wording when it is published in the GRR or EIS.

EPA is considering revising the water quality model in LBR and MR (6 layers to 1). SC DHEC reiterated that the water quality model was not optimized for that area and that the D.O. results for that area are better used on a comparison basis. The Corps said that if the model is revised, it would need a new calibration report that was independently reviewed before it could vary from the present model which has gone through that process. No participant knew if EPA had obtained new SOD samples, as recommended by SC and previously proposed by EPA.

GPA is conducting a demonstration project of a dissolved oxygen injection system starting at the end of July and running for 6 weeks. They will produce a report with the results of their monitoring program. Agencies suggested that the Corps incorporate information obtained during the monitoring into the final predictions for performance of the proposed D.O. systems.

The Corps stated that the Water Quality Team had previously recommended that the upper two locations identified in the Task II Report on the D.O. system not be constructed. Those sites were identified as being best from a modeling perspective, with no consideration for land availability. One of the sites (McCoys Cut) is located within the Savannah National Wildlife Refuge with no land access or power. The other (Mill Stone Landing) is located at an upriver site. The Corps intends to combine the oxygen proposed from those sites into others located more in the harbor area. The site at Houlihan Bridge would likely be expanded to compensate for eliminating those upriver sites. Another site could be required around the Sediment Basin. The final modeling will identify the most cost effective tradeoff of number of stations vs. total volume of oxygen to be added.

The Corps will try to find information on the success of the demonstration project of oxygen injection in a California harbor.

One comment on the siting of the oxygen injection facility near the Houlihan Bridge is that if the facility is located between the Front and Middle Rivers, the same facility could be used to improve oxygen in both rivers with lines going to each river. The only high ground with road access between Front and Middle Rivers is CDF 1N, which is located within the Savannah National Wildlife Refuge. The USFWS would have to find that use of the site compatible with the overall goals of the Refuge.

9. We discussed **monitoring and adaptive management**. The Corps distributed a framework for a monitoring and adaptive management plan for the project. The group decided that agencies should be involved in decisions about implementing adaptive management features. The public should be informed of the results of the monitoring, but could not assist in making Federal and State decisions.

There was a recommendation that we monitor forested wetlands. This would be helpful in ensuring that the project does not unexpectedly impact this resource. Another recommendation is that we include a flow partitioning structure at the junction of LBR and MR. This could allow us to modify the distribution of flows in that system to improve areas that provide more habitats for Striped bass.

10. We discussed other **mitigation** measures. Filling the Sediment Basin (or allowing it to fill) would help low salinity marshes that provide extensive fishery benefits and display large species diversity. Removal of the Tidegate could affect the tide cycle and velocities upstream of that site.

The Corps should remove "Increase flows down the Savannah River" from its list of possible mitigation features. It should also remove "Modify Tidegate into fishing pier" from its list of possible mitigation features, as such a pier would have substantial liability concerns. It should also remove "Tybee NWR" from its list of possible mitigation features, as there is nothing this project could do to improve that Refuge. The Corps should move up in its priority list the measure to "Block western connection at McCoys Cut". We should add "Restore wetlands at CDF 1S" to the list. Depositing sediments in the nearshore area off Tybee would help Wassaw Island. Add as a possible Other Measure the cleaning of silty sediments in LBR and MR to restore the sandy bottom substrate so that it would be more suitable for Striped bass.

11. Kay recommended that the Corps initiate formal consultation with NOAA on Essential Fish Habitat and compliance with the Endangered Species Act, now that information on project impacts is available.

12. The meeting was beneficial. We were able to narrow the focus of our consideration of the data that has been produced. The Corps will perform some more modeling of project impacts. We agreed to evaluate the Tidegate (Plan 6) and Steamboat Cut features (Plan 7) based on Plan 3, rather than Plan 5. The Corps will evaluate the feasibility of grading down a high ground site to produce tidal freshwater wetlands. The Corps will provide the results of that work to the agencies when it becomes available.

// ss //

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY MEETING

JUNE 20 & 21, 2007

AGENDA

WEDNESDAY

OPENING & INTRODUCTIONS	**9:30 – 9:45**

- Purpose of Meeting
  - Review information in Impact and Mitigation reports
  - Determine what information is most representative
  - Identify appropriate mitigation

WETLANDS	**9:45 – 12:00**
LUNCH	**12:00 – 1:00**
WETLANDS (Cont)	**1:00 – 3:30**
FISHERIES	**3:30 – 5:00**

THURSDAY

FISHERIES (Cont)	**8:30 – 10:00**
WATER QUALITY	**10:00 – 12:00**
LUNCH	**12:00 – 1:00**
OTHER MITIGATION MEASURES	**1:00 – 2:00**
MONITORING & ADAPTIVE MANAGEMENT	**2:00 – 3:00**
WRAP-UP	**3:00 – 3:30**

SAVANNAH HARBOR EXPANSION PROJECT

VISION OF THE COOPERATING AGENCIES

THE TIER II PROCESS WILL:

- Determine the specific and differential incremental effects of each channel improvement alternative.
- Identify and evaluate impacts on the human environment, including impacts on natural resources, economics, and societal considerations (jobs).
- Contain studies that are conducted in a manner that leads to their technical acceptance by the scientific community.
- Clearly identify all benefits and costs for the decision-makers.
- Recognize that mitigation may be necessary for any or all of the identified impacts.
- If needed, recommend specific actions that should be taken outside the context of the Expansion Project to improve the local environment and/or compensate for past harbor improvement projects. The report would identify the process and participants to accomplish those specific needed actions.
- Be documented by a report that leads decision-makers to clear decisions on the project.

THE RECOMMENDED HARBOR IMPROVEMENT WILL:

- Produce positive economic benefits for the port community and have beneficial environmental effects.
- Include a mitigation plan that addresses unavoidable impacts to critical natural resources.
- Include post-project monitoring to ensure that the expected levels of adverse impacts are not exceeded.
- Be supported by most stakeholders.

CESAM-PD 27 June 2007

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; In-Progress Review Meeting

1. Savannah District hosted an In-Progress Review (IPR) meeting on 24 – 25 April 2007 on the Savannah Harbor Expansion General Re-evaluation Report (GRR). The meeting was held in Savannah with participation from HQUSACE, ASA(CW), CESAD, CESAM, CESAW, CESAS, and the Georgia Ports Authority (GPA). The meeting agenda is enclosure 1 and a list of participants is enclosure 2. The purpose of the IPR was to discuss the status of the project and to gain concurrence and/or direction on issues of vital importance to the project. This memorandum documents the discussions and decisions of the IPR.

2. **PROJECT OVERVIEW AND HISTORY.**

a. The meeting was called to order and the Project Manager provided an overview of the Savannah Harbor. It was noted that the annual maintenance quantity averaged 7.5 million cubic yards of mostly silt and fine grained clay materials. The location of the confined disposal areas totaling approximately 6000 acres were also pointed out on a map of the harbor. The reported location of the proposed Jasper County terminal was also highlighted with emphasis given on the need to utilize and maintain all the disposal areas in the inventory due to the quantity and nature of the fine-grained materials pumped from the harbor. In addition, it was explained that since the upstream disposal areas 1N, 1S and 2A have reached their storage capacity limits it is now necessary to pump materials downstream to the lower harbor disposal areas requiring expensive booster pumps which increases the cost of harbor maintenance.

b. The stationing of the harbor was explained with Station 0+000 at the shoreward end of the stone jetties and positive stationing up the river (Inner Harbor) to Station 112+500 with negative stationing out to Station -60+000B (Bar Channel). It was explained that the inner harbor is maintained with a dwindling fleet of small business cutterhead dredges while the bar or entrance channel is maintained with sea-going hopper dredges owned by large business concerns. The locations of the Georgia Ports Authority's Ocean and Garden City terminals were also pointed out in the upstream reaches of the inner harbor. There are 18 – 19 terminals besides Garden City and Ocean Terminal but vessels drafting 36 feet or better transit to the Ports Authority berths.

c. The location of several features of interest were identified including Tybee Island (location of a F ederal shore protection project at the mouth of the harbor), nearby Fort Pulaski owned by the US Department of the Interior, Old Fort Jackson and the CSS Georgia. It was explained that the channel is constricted from 500 to 400 feet wide in the vicinity of Old Fort Jackson and that the CSS Georgia will have to be removed prior to deepening the harbor. The concerns of the residents of Tybee Island were also explained as relates to the interruption by dredging of the littoral drift of sands that move in a North-South direction across the entrance channel.

3. **PROJECT BACKGROUND.**

a. The expansion project had originally been pursued by the Georgia Ports Authority under Section 203 of WRDA 1986 and was eventually authorized conditionally in the Water Resources Development Act of 1999 with a list of requirements to be completed before the project could be constructed. Most notable of the requirements is that four Federal Departments (Army, Interior, Commerce, and EPA) must approve the project documents before full authorization can be achieved.

b. It was stated that the purpose of this study is to examine the feasibility of deepening the currently authorized -42 foot mlw project to as deep as -48 feet mlw. It was also explained that this project is examining the incremental effects of deepening to --48 feet mlw and that it was not the purpose of this project to identify or address the incremental or cumulative impacts of prior harbor modifications except the identification of cumulative impacts required under the National Environmental Policy Act.

c. Timeframes for completion of the major milestones were presented with the scheduled goal of obtaining a Record of Decision (ROD) by Sept 2008 set as the ultimate PDT objective. It was mentioned that the Savannah Harbor Expansion Project had been included as one of the test projects in the Corps of Engineers' Lean Six Sigma (LSS) initiative and that after a thorough review of the lessons learned from South Florida projects, we will possibly be able to apply LSS such that the chance of accomplishing the scheduled ROD date will be improved.

d. A question was raised regarding the sponsorship of the harbor and it was pointed out that the Project Sponsor for operation of the Savannah Harbor Federal Project is the Georgia Department of Transportation (GaDOT). The GaDOT is also responsible for cost-sharing in the provision of suitable areas for disposal of dredged material for the existing project. The Georgia Ports Authority (GPA) is the non-federal interest for the Savannah Harbor Expansion Project but no Design Agreement has been executed and, hence, they are not officially a cost share sponsor. Under an MOA executed in April 2000, they have contributed in excess of $28 Million for technical underpinning work while the federal government has contributed approximately $6 million. On past and current projects, the GaDOT has served as the sponsor for construction and O&M this may also apply in the case of Savannah Harbor Expansion.

4. **ENVIRONMENTAL IMPACT AND MITIGATION PLANNING REVIEW.**

a. Mr. William Bailey provided a basin and project overview from an environmental perspective for the participants to gain an idea of the type and scale of the factors influencing the project. Viewed as a watershed, the Savannah River Basin contains three Federal reservoirs (Thurmond, Russell, and Hartwell), the New Savannah Bluff Lock and Dam at Augusta, the Savannah River Below Augusta (channel depth 9-feet all the way to Savannah), and most important to this project, the Savannah National Wildlife Refuge. Originally established as a freshwater refuge, the activities of man have converted portions of the freshwater marsh to a more saline habitat. The most obvious impact to the refuge is that with each deepening, saltwater has moved further inland reducing the amount of freshwater marsh. While over the years different projects have impacted Savannah Harbor and its environs, this project will only mitigate for the incremental effects of this recommended harbor improvement.

b. The Savannah Harbor Expansion GRR focuses the mitigation planning on potential mitigation features that modify flows in the estuary. The objective of modifying the flows is to reduce salinity impacts in terms of its affect on wetlands, dissolved oxygen and fisheries in a cost-effective manner. The goal of mitigation planning is to develop an optimum mitigation plan for each depth that addresses the impacts anticipated at that depth. In building each plan we will discuss the rationale for that plan.

c. The mitigation features that modify flows consist of a series of cuts in the Middle and Back Rivers that can be opened and closed to increase freshwater flows through those rivers. Currently, impact and mitigation analyses have been completed for depth increments at 44, 45, 46 and 48 feet. Discussions at this IPR meeting expressed a desire to look at the 43- and 47-foot depths. For this requirement the District suggested that we can interpolate between the bracketing depths, i.e., for 47 feet we would interpolate between 46 and 48 feet. There will be a significant cost to the project in terms of time and money if we are required to do the modeling and environmental analyses for those incremental depths.

d. Mitigation features that modify flows can affect each other. Therefore, the order in which they are evaluated and combined is important. The District and agencies selected an order based on a preliminary evaluation of their cost-effectiveness. We will evaluate all combinations of flow-modification features recommended by Corps modelers and resource agency team members. The Corps hosted an interagency meeting on June 20-21 to discuss the impact and mitigation reports. The agencies continue to work with the corps to evaluate impacts from the project. We reached technical agreement on ways to identify and calculate project impacts. The USFWS reiterated its position that the project result in no net impacts to tidal freshwater wetlands. Additional work will be conducted to develop comprehensive mitigation plans to mitigate project impacts.

e. While both the Corps and the agencies involved desire no net impacts, the Corps will evaluate each plan by: 1) the goal of no net impacts, and 2) cost effectiveness. The Corps will base its selection on cost-effectiveness. To do this we will need to know the cost of each unit of mitigation provided. In preparation for this requirement, costs are being developed for each likely mitigation feature. As features are added to a plan so are their costs. At the completion of each plan, we will have the cost of that plan. As part of this process, average annual costs will be developed for each plan (life cycle costs). It is understood that the cost of mitigation may limit the depth of deepening that is economically justified.

f. The Savannah River estuary is a complex system. In order to focus and more efficiently develop mitigation plans, we will coordinate with the resource agencies and establish a priority with regards to the value of the resources to be protected. The Corps is working with the agencies to determine the components of each plan. In the end, all four Federal Departments with approval authority on the project need to approve the recommended mitigation plan for the project to move forward.

DECISION: Headquarters recognizes that the number of potential combinations of mitigation features is immense. They concur with present Pyramid Approach of evaluating mitigation features sequentially to identify their individual effectiveness. The District will explain the rationale it used for building each mitigation plan. Headquarters recommended that the District look at the mitigation impacts at 43 and 47 feet (we are already looking at the impacts at 44, 45, 46, and 48 feet).

ACTION: The District will look at mitigation costs for a 47-foot project.

5. **PLAN FORMULATION PROCESS AND REQUIRED MODIFICATIONS OR ACTIONS**

a. **Formulation of Alternatives.** The scope of the GRR was developed considering the conditional authorization issues raised in the Chief's Report on the feasibility study, and issues raised in the lawsuit filed by the Southern Environmental Law Center. The GRR conducted a significant re-formulation evaluation in which navigation problems and opportunities were identified and a wide array of alternatives addressing those problems and opportunities were identified and evaluated. That effort was documented in an interim document referred to as the "Formulation of Alternatives" report (dated April 2005) which recommended the detailed evaluation of channel deepening alternatives.

b. **Without Project Conditions.** The "Formulation of Alternatives" report documented the major assumptions pertaining to the "without project future condition". The development of additional information has caused some of those assumptions to be revised. The following is a list of the major assumptions in the "without project condition":

- Continue existing maintenance as defined in Dredged Material Management Plan (DMMP)
- Continue using all of the Confined Disposal Facilities (CDFs) in Jasper County
- Continue operating the Savannah National Wildlife Refuge as a freshwater refuge
- Maintain current Dissolved Oxygen levels
- Panama Canal will be expanded
- There will be continued growth in the size of container ships
- Continued growth of container traffic
- Hinterland transport will not limit commodity flows
- GPA will continue to provide landside improvement in accordance with their Capital Improvement Program
- Throughput capacity will continue to increase as GPA makes capacity and efficiency improvements

Although the "Formulation of Alternatives" report was reviewed and approved by HQUSACE in conjunction with the IPR held in December 2004, there are additional aspects of the "without project condition" that have not been discussed or approved and some assumptions required further discussion in light of new information. The District has tentatively scheduled an Issue Resolution Conference (IRC) (perhaps a televideo conference) for 15 August 2007 specifically to review and approve the "without project condition".

The project features being considered for further study are as follows:

- Deepen and extend entrance channel
- Maintain existing side slopes (450 ft rather than 500 ft impact to channel widths)
- Deepen GPA berths
- Deepen and expand the turning radius of the Kings Island Turning Basin (KITB) – verify the design vessel used to establish turning basin dimensions.
- Use bend wideners in areas indicated by the Ship simulation study.
- Location and need for advance maintenance
- Passing lanes
- Raise dikes on disposal areas
- Effects on O&M of the existing navigation project

- NED plan will be identified and MCACES baseline cost estimate will be developed.

Although the general formulation process for completing the GRR was acceptable, HQUSACE made some specific suggestions/recommendations. HQUSACE recommended that the GRR present the project and its development in terms of the entire Savannah River system (from Tybee Island up through the Corps reservoirs). Currently, the study appears to be too focused on National Economic Development (NED) and a more thorough discussion of other accounts (Regional Economic Development, Environmental Quality, and Other Social Effects) is needed. The GRR also needs to use a systems approach that takes risk and uncertainty into account in definitive ways, for example, asking the questions "What is the risk if we do not deepen?" and "What are the environmental risks if we do deepen?" The report should review the global eastern coast containership situation – without project conditions, deepening of the Panama Canal, drafts of containerships, and implications to answering these questions.

During earlier discussions on environmental impact and mitigation planning HQUSACE recommended that the District look at the mitigation impacts at 43 and 47 feet. While the benefits and costs for these channel depths can be determined relatively easily, a full analysis of the mitigation impacts and costs for these depth s will be costly and time-consuming to determine. In order minimize impacts to the schedule and costs to the project the District will evaluate mitigation costs for a 47-foot project by interpolating between the bracketing depths of 46 and 48 feet. Only if it appears that the 47-foot Project will be the NED Plan will a full analysis be scheduled. The 43-foot depth is eliminated since GPA would not partner a one-foot deepening increment.

d. **Dredged Material Management Plan.** HQUSACE stated that the GRR will need to demonstrate that there is a viable dredged material disposal plan for the 50-year project life. This plan for the Savannah River CDFs should be detailed for the first 20 years and conceptually thereafter. Analyses to date indicate that there will not be a substantial increase in maintenance sediments from a further harbor deepening. The GRR must evaluate the effects of deepening on the DMMP and O&M costs, and demonstrate that there is a viable dredged material placement plan for operation of the harbor. The deepening project will bear the costs of dike raisings associated with disposal of new work sediments. The time when these costs will be incurred will depend on the conditions of the CDFs when the construction of the deeper channel in the river is initiated. HQUSACE suggested that major capacity increases (dike raising is a cost-shared activity funded by the Construction General program) be budgeted as part of Savannah Harbor Expansion Project and that the PCA be written to include several dike raising events. This would be a more efficient process by eliminating the need for separate DMPs/PCAs later. HQ stated that the costs of that additional dike construction (beyond replacing the capacity used during the initial construction) should not be included in the project BCR unless there are incremental increases in maintenance costs die to deepening. Similarly, it would not by credited against the project's Section 902 cost limit. The District will evaluate this opportunity in light of geotechnical considerations and limitations in the Dredged Material Containment Area (DMCA) system.

e. **Nearshore Disposal.** The plan for depositing sediments from the entrance/bar channel in the nearshore zone in compliance with the Georgia Coastal Zone Management Plan (CZMP) was discussed. HQUSACE stated that the GRR needs to demonstrate that the recommended placement plan is the least cost plan consistent with Federal environmental laws. The GRR will address any incremental costs beyond the Federal Standard. At present, we believe the nearshore placement is the lowest cost environmentally acceptable method of disposing of the new work sediments. We will document our findings on this issue in the Draft GRR. A small increase in maintenance volumes is expected when the entrance channel is extended to deeper water . Those sediments are not proposed for nearshore placement because of the large distance (and cost) required to transport them back to the nearshore area. CESAD suggested that the nearshore placement plan be documented and be coordinated with the Vertical Team for review.

f. **Advance Maintenance.** Advance maintenance will be needed as a management tool for the deepened channel. The shoaling pattern of the deepened project may differ from the existing project. CE SAD suggested that the GRR should identify and justify the advance maintenance that is expected to be needed for the deepened channel, understanding that the existing advance maintenance program is attributed to the without project condition. The engineering work to date indicates little change would be needed to the existing advance maintenance in the inner harbor.

The District has an advance maintenance feature approved in the entrance channel but has not received funding to implement that feature. HQUSACE stated that the District could include construction of that feature as part of the Expansion Project if it is still warranted with the deepened project. Since that feature would reduce O&M costs and not be required to deepen the harbor, it could be excluded from the project BCR and Section 902 cost limit.

g. **Passing Lanes.** Ship Simulator studies indicated that passing lanes were beneficial at two locations; however, an economic analysis is needed to determine if they are incrementally justified. If the passing lanes are part of the locally preferred plan, that plan must be economically justified, although the passing lanes do not necessarily have to be incrementally justified. Costs are counted towards the total project cost. Currently, the Corps has available a Harbor Simulation (economic) model that can be used for this purpose. This analysis has not been done. The District will re-look at the cost of what it takes to do this analysis (study requirements and time). Todd Nettles (Mobile District) has used this model. This analysis will include an assessment of whether or not the harbor pilots believe they need passing lanes and in-turn will use them. GPA is willing to fund passing lane construction 100-percent. During previous coordination, the pilots had expressed a desire for passing lanes.

DECISIONS:

- The District will schedule an Issue Resolution Conference (IRC) (perhaps a televideo conference) specifically to review and approve the "without project condition".
- The GRR will present the project in terms of the larger system/watershed (from Tybee Island up to the Federal reservoirs).
- The GRR will include a thorough discussion of other accounts (Regional Economic Development, Environmental Quality, and Other Social Effects).
- The GRR will use a systems approach that takes risk and uncertainty into account in definitive ways, for example, asking the questions "What is the risk if we do not deepen?" and "What are the environmental risks if we deepen?"
- The report will review the global and US east coast containership situation – without project conditions, deepening of the Panama Canal, drafts of containerships, implications to answering these questions.
- The District will evaluate the 47-foot depth. The District will interpolate between the 46- and 48-foot depths to get the mitigation costs for the 47-foot depth alternative. If this depth is tentatively identified as the NED Plan, the District will run the environmental models and develop detailed information from that specific depth alternative before submitting the final report.
- The GRR will demonstrate that there is viable dredged material disposal plan for a 20-year period and a conceptual plan to complete the 50-year project life.
- The nearshore placement plan will be documented and coordinated with the Vertical Team for review.
- The GRR will identify and justify the advance maintenance that is expected to be needed for the deepened channel.
- The District will re-coordinate with the harbor pilots to learn their present views on passing/meeting areas.
- The District will consider including other features in the project (such as dike raisings or advance maintenance) that are not required for the deeper channel but would improve the efficiency or effectiveness of the harbor maintenance practices. These additional features will be excluded from the project BCR and Section 902 cost limit.

6. ENGINEERING REVIEW

a. **Channel Design.** Two design vessels were used for the Ship Simulation studies, one existing and one future. The recommended channel was designed based on plots of pilot runs from the ship simulation study. The design also included maintaining the existing side slopes. This reduces needs for adjacent land and impacts to channel velocity and existing sedimentation patterns. The dimensions of the Kings Island Turning Basin (KITB) were also developed from the study (dimensions needed to turn the design vessel). Using the needed dimensions the footprint of the turning basin increased by 5.5 acres. The location of the bend wideners was determined by ship simulation studies.

b. **Sedimentation.** Our investigations indicate that upstream of Station 28+000 all of the sediment entering the project area is from upriver and the amount of sedimentation depends on river discharge. Mixing zones determine where the shoaling areas will be. Downstream of Station 28+000 to the entrance channel acts as a sediment sink for littoral sand transport. A small increase in total shoaling volume is expected in the entrance channel because of the increase in the length of bar channel. Increasing in depth does not increase the total shoaling volume in the inner harbor. It does, however, increase the cost for O&M due to location of shoaling areas. Removal of which depends on the availability of disposal areas (pumping distance). At this time the District will not shift the present advance maintenance areas until it has a better understanding of the shoaling areas created by deepening.

c. **Dredged Material Disposal.** The Dredged Material Management Plan (DMMP) divides the harbor into two sections, the inner harbor and the outer harbor or bar channel. The existing upland CDF's are adequate to contain the new work material provided the plans for raising the dikes as described in the existing DMMP and 2007 Work Plan are followed. The costs for the replacement of lost capacity for the new work material have already been calculated and given to the cost estimators. HQUSACE suggested that there are possible efficiencies to be gained for the O&M Program by increasing disposal area capacity for O&M material during construction of the Expansion Project. Another possibility is the use of CG funds to construct the approved advance maintenance widener in the bar channel. These efficiencies will not impact the Projects Section 902 limit and will not be included in the cost of the project unless they represent incremental increases in maintenance costs over the maintenance costs at current depths. Identify possible saving in overall costs by doing this.

(1) **Bar Channel.** Minimize pumping distance and take advantage of good quality sediments to be placed in the intertidal and nearshore zones. The District must either show this the least costly most environmentally acceptable plan or include cost-sharing for the incremental costs if not already included as a requirement under the CZMP.

(2) **Offshore Disposal**. The Corps has the environmental clearances to use the EPA approved ocean disposal site (ODMDS). For the extension of the bar channel, (Station -65+000 to Station -85+000) for new work placement, the Corps is considering constructing a mound on the side of the channel with the new work sediment. Placement of this dredged material adjacent to the channel would be accomplished under Section 404 of the Clean Water Act. Use of this dredged material to construct a mound would be beneficial, therefore outside the Section 103 requirements. There is no Section 103 approval required for this since our placement would create a feature. The present design is currently being reviewed in terms of O&M requirements. Presently, all O&M material goes to ODMDS.

(3) **Clarify CZM rules for Georgia**. Georgia's CZMP considers each project separately. Part of the rules state that if we remove beach quality sand from the littoral zone we are required to replace it. Currently, the nearshore sites have been evaluated for new work only. Tybee expects O&M material to be placed here if it is beach quality sand. The nearshore sites would be available for use by the existing project as well as the Deepening Project, as long as the sediments are suitable for such placement. We concur that the O&M program also has to comply with the GA Coastal Management program Tybee wants to bank sand taken from inshore zone until it reaches a pre-established threshold. The DMMP (or update) will look into the possibility of placing beach quality O&M material into the nearshore sites currently approved for new work material. The DMMP will also demonstrate that there is viable dredged material disposal plan for the 50-year project life. The completed DMMP (or update) and the disposal plan concept will be coordinated with the vertical team.

d. **Cadmium Containment.** There is naturally enriched cadmium consolidated in the Miocene clay layer in portions of the harbor scheduled to be deepened. At this point we are looking into disposal scenarios to identify whether special measures for containment of the contaminated material are required.

e. **Cost Engineering.** The district has developed cost estimates for 2-foot incremental depths including ROM estimates for the mitigation options. These cost estimates will be used for screening purposes (NED Plan selection), a process we have not begun as of yet. Contingencies for dredge work were set at 25% as prescribed in the ER 1110-2-1302. The Walla Walla District will be doing the ITR on this cost estimate.

f. **Wake Analysis/Bank Erosion Study.** Four areas were looked at including City Front, North Tybee Island, the Bight Channel, and Ft. Pulaski. There was no increase in bank erosion due to ship wakes associated with this project to City Front, North Tybee Island or the Bight Channel. At Ft. Pulaski overall erosion in the area is 3.1 feet per year. Of this erosion less than 0.1% is due to ship wakes associated with project

g. **Beach Erosion Study.** The present environment at Tybee Island will not change if the project is deepened.

h. **Aquifer Study.** Downward movement of salt water through the cap material due to dredging is very small. This study has undergone external peer review. Three non-Corps affiliated reviewers were selected (2 USGS employees and one university professor). While they had questions about our methodology they did agree that our conclusions were justified.

i. **Hydrodynamic and water quality modeling.** Both the EFDC Model (hydrodynamics) and the WASP Model (water quality) were ITR'd and approved by natural resource agencies for use by this project.

j. **Storm surge.** Engineering modeling was performed to determine if deepening would have an impact on hurricane surge in the area. The results of the modeling indicated that deepening does not have an impact on hurricane surge.

DECISIONS:

- The District will schedule an ITR of the Project Cost Estimates by the Walla Walla District.
- The District will evaluate the proposed nearshore dredged material placement sites for both new work and O&M material.
- The District will review and obtain clarification on the coastal zone management rules for the State of Georgia with regard for our DMMP.
- The DMMP will confirm that there is a 50-year project life for our O&M dredged material placement sites after accommodating the new work material.

7. ECONOMICS ANALYSIS REVIEW

a. The Savannah District contracted with GEC to produce the following analyses:

- commodity forecast - completed March 2005;
- fleet forecast - completed August 2005;
- benefits calculation methodology and model - completed May 2006;
- multiport analysis - completed August 2006
- regional port analysis was completed on 9 July 2007.

Each analysis has gone through the ITR process and final reports have been submitted on all except the summary report for the Regional Port Analysis.

b. Input provided by the GEC, Inc. economic analysis contract serves as an excellent foundation for the report; however this work did not address project related uncertainties as required by Corps guidance. Additionally, changes in containership and container port operations are occurring at a rapid pace superseding previous estimates and making even recently completed work outdated. Therefore, carrier interviews were conducted in the summer of 2006 in effort to confirm and update information previously gathered. Additionally, representatives of the Panama Canal Authority were interviewed regarding proposed expansion plans. As a result of the interviews, as well as other events transpiring since GEC's original work, the following are being included in economic updates.

(1) **Changes in Port Rotations.** Possible changes in port rotations are being investigated. There were several carriers that indicated that channel modification could result in reordering of ports of call along the east coast in effort to operate more fully loaded at Savannah. These operational possibilities are not factored into the existing GEC report.

(2) **Panama Canal.** GEC efforts assumed no expansion of the Panama Canal. Accordingly, the vessel fleet forecast and resulting NED benefits are constrained by this assumption. In November of last year, the Panamanians passed a national referendum to expand the canal. Expansion plans include a third lane that would be able to accommodate vessels that are 1,200 ft long, 160 ft wide and drafting 50 feet. Proposed plans have construction being completed in 2014. The economic analysis is being revised to include several scenarios which address the effects of Panama Canal modification. Under without and with project conditions, it is now being assumed that the Panama Canal will be modified as planned. However, to address risk and uncertainty related to the proposed expansion plans, sensitivity runs will include once scenario where the expansion does not occur, another where project improvements come on line after 2014 and several scenarios regarding the timing of fleet shifts resulting from the expansion (i.e., shifting from panamax to post panamax vessels).

(3) **New York Harbor's Bayonne Bridge.** The GEC analysis assumed that the Bayonne Bridge in New York would be a constraint to services which called on New York and Savannah in their port rotations (i.e., limiting vessel size due to air draft restrictions imposed by the bridge). The New York Harbor study recommended and was approved for deepening the channel to 50 feet. Benefits were claimed for container vessels being able to load to the maximum operating drafts for the 50-foot controlling depth without any air draft restriction being imposed on vessel traffic. Carrier interviews conducted in 2006 confirmed this assumption as vessels are either being equipped with hinged masts in effort to avoid air draft restrictions or other design changes are being implemented on new vessel orders. Accordingly, it is being

assumed under both without and with project conditions that the Savannah Harbor container traffic which includes New York Harbor in the port-rotation will not incur those restrictions either.

(4) **Vessel Operating Costs.** The existing benefits model utilizes 2004 vessel operating costs. It is anticipated that new vessel operating costs will be released during the spring of this year. We plan to use the newly released costs. However, in the event that 2007 vessel operating costs are not provided, the 2004 costs will be utilized. Note, of concern is the negligible difference in IWR published hourly operating costs between a panamax and post panamax vessel ($0.0003/TEU) and the resultant impacts to the NED analysis.

(5) **Data Inputs to Benefits Model.** The Data inputs and model assumptions for the benefits model are being updated as appropriate (e.g., estimated cargo density, the number of crane moves per hour, etc.).

(6) **Commodity and Fleet Forecasts.** GEC commodity and fleet forecasts began in 2004 and extended through the life of the project. Three additional years of data are now available. Recorded information shows that actual commerce and vessel calls far exceeded that estimated for those early pre-project years upon which the forecasts were based. Accordingly, this information is being updated and forecasts are being revised. Risk and uncertainty of the commodity and fleet forecasts will be assessed using a scenario based approach (e.g., with and without Panama Canal expansion; with and without Jasper County facility development; assuming no commodity growth beyond a certain point; etc.).

(7) **Benefiting Service Updates.** The GEC analyses determined that there would be 3 container services that would benefit from channel modification. Analysis was limited to these three services due to the restrictions imposed by the Panama Canal as well as the Bayonne Bridge. Benefiting services will be expanded to include, as appropriate, those previously omitted. Although the analysis is not complete, it is currently estimated that 7 services will benefit from the proposed channel expansion project. Additionally, the possibility of changes in service calls between without and with project conditions will be investigated. During the 2006 carrier interviews, a few carriers indicated that without channel deepening, Savannah Harbor could lose some services. This scenario will be investigated further as part of the without project condition (i.e., landside benefits evaluation).

(8) **LNG Evaluation.** Under with project conditions, containerships will be less tide restricted. With these vessels being able to operate more freely through the tidal cycle, there will be less competition for transit at high tide between the LNG tankers and the large containerships. The LNG vessels need to transit up-river on the high tide for maneuverability reasons, and will retain this requirement regardless of channel depth. LNG vessels typically have a design draft of 38 feet and are loaded between 35 and 37 feet. Vessel loading and the number of LNG vessel calls will be the same for both without and with project conditions. However, the deeper channel will reduce the need for containerships to wait for high tide, which will thereby reduce competition for high tide transit. The deeper the channel depth, the more significant the degree to which that competition is reduced. The reduced competition for high tide for incoming vessels will result in a reduction in traffic-related delays experienced by LNG tankers. The channel depth that provides the largest reduction in wait time for the LNG carriers is the 48-foot channel, which has a reduction in delay cost of approximately $556,000 annually.

(9) **Passing Lanes.** Detailed evaluation of passing lanes has not been performed to date. Based upon information provided by the harbor pilots and carriers, passing lanes are needed to improve vessel operations in the channel. Passing lanes will be evaluated as a component of future with project conditions.

(10) **Regional Economic Development.** An assessment of Savannah Harbor's impacts on the regional economy has not been performed. Accordingly, the description of the project's impact is limited by only looking at NED impacts. Therefore, the final report document will include a description of the harbor's regional impacts.

DECISION: HQUSACE concurred with approach for updating the economic analysis. Additionally, an evaluation of passing lanes as well as an RED evaluation should be included in the final report document. Upon its completion, the final Regional Port Analysis Report should be coordinated with the vertical team.

ACTIONS:

1. Passing Lane Analysis – The costs of an incremental evaluation of passing lanes will be determined and the PDT will decide whether to conduct that analysis.

2. Regional Economic Development (RED). A regional impact evaluation will be included in the study document.

3. Analyze Landside Benefits. David Miller and Associates will develop a Draft Scope of Work for this effort.

4. Headquarters will pursue the June 2007 completion date for updating the vessel operating costs and forward concerns about adequate recognition of large vessel efficiencies in operating cost date. (action Item for Tom Waters). Concerns were forwarded to IWR 26 April.

8. INTERNAL and EXTERNAL REVIEW PLANS

a. A draft Review Plan was presented at the IPR that complied with the direction provided during the 2004 in progress review.

b. External Peer Review. To date External Peer Review has been completed on the following 3 critical portions of the study:

- The EFDC & WASP Models
- The Marsh Succession (M2M) Models
- The Aquifer Model

External Peer Review of the Economics Analysis is planned but not yet completed. No External Peer Review of the entire document was planned. Our external peer review process employed sole source contracting procedures and simple purchase orders.

c. Independent Technical Review. A very thorough independent technical review is ongoing as products are developed for the study. For example, each piece of the economic analysis has been reviewed by Kevin Knight, the regional technical special for deep draft economics in SPD. The Chief of Engineering (SAW/SAC/SAS) will make a recommendation of who should accomplish the ITR of the Engineering Appendix to the Deep Draft Navigation PCX. The PCX will approve the recommendation and manage the review. The Cost Estimating Center of Expertise in Walla Walla District will be used for ITR of the cost estimate. The PCX requests that an external peer review of the Deep Draft Vessel Operating Costs be performed to insure their accuracy.

d. The need to conduct an External Peer Review on the entire draft GRR was discussed. HQUSACE indicated that the EPR will be needed for the entire report, not just major components. Accordingly, External Peer Review will be completed on the entire document (the District will probably use Battelle for this effort). The review will cover the draft report as a whole. The reviewers will not go back to individual pieces that have already been externally reviewed. They will however look at how the information from those previously reviewed sections is being used in the report. The external peer reviews will be asked to focus on the mitigation plan. In addition, the external peer review of the economic analysis will be rolled into the overall review.

DECISIONS:

- Conduct an agency review of the mitigation plan and then overall external peer review on the entire report with emphasis on the mitigation plan and the economic analysis.
- Previously completed external peer reviews will not be duplicated.
- A revised review plan will be provided to South Atlantic Division for approval.
- HQUSACE agreed to explore the need for an external peer review of the Deep Draft Vessel Operating Costs.

9. **MODELS**

a. A handout was provided listing the models being used in the study.

b. This handout identifies what the PDT believe is a Planning model and what is an Engineering model. Engineering models are certified through their establish process, Planning are certified through the appropriate PCX.

c. No Planning models have been certified at this time. The Planning models have been ITR'd through the PCX.

d. No external peer review of models is required. Independent technical review of models is considered to have met the intention of EC 1105-2-407.

DECISIONS:

- The Deep Draft Navigation Planning Center of Expertise will insure that Independent Technical Review are conducted on all "planning" models. HQUSACE recognizes that no "certified" planning models are available at this time. Planning models include those developed for economic analysis and marsh succession analysis.
- The Chief, Engineering Division, Wilmington District, will insure that review of "engineering" models follows Engineering and Construction Bulletin 2007-6.

10. **OTHER ISSUES**

a. **Cumulative Regional Port Development Impacts**

(1) **Issue** – The District has been question about cumulative Regional Port Development impacts (SELC complaint). How should we respond in the GRR?

(2) **Discussion** – To address the cumulative impacts of deepening other east coast ports appears to be beyond the scope of this study and is beyond what the National Environmental Policy Act (NEPA) requires. Without authorization and funding from Congress the Corps has no authority to evaluate this. The district cannot be charged with carrying out what this litigant wants if there is no authority. This is a legal question and Counsel at HQUSACE has been requested to become involved. District Counsel together with HQUSACE Counsel should develop a legal opinion regarding the expectation of NEPA. An Agency position needs to be developed.

DECISION: The District should formally transmit up through the chain a request for legal and policy review of this. Mr. Richard Worthington will coordinate this issue with HQUSACE Counsel.

b. **Jasper County Terminal**

(1) **Issue** – How should the proposed Jasper County port be evaluated in the Savannah Harbor GRR?

(2) **Discussion** – The "Formulation of Alternatives" report considered alternative port sites and associated channel deepening as alternatives to deepening the channel to the Garden City terminal. The evaluation contained in the report considered port development costs, dredging costs, and an estimate for mitigation. It did not include an evaluation of the impact on the ability to maintain the channel. The Jasper County site was one of those considered and would utilize two disposal areas utilized in maintaining Savannah Harbor. The conclusion of the "Formulation of Alternatives" report was that all of the alternative port sites, including the Jasper County site, were more expensive than deepening the channel to the Garden City terminal.

More recently, the Governors of Georgia and South Carolina, recognizing that the capacities of the terminals at Savannah and Charleston are finite, have agreed to jointly develop a terminal at the Jasper County site. There was significant discussion on the impact of the Jasper County port on the economic evaluation of the Savannah Harbor deepening. A number of problems were identified. The likelihood that a port will be constructed is speculative. There is no certainty that this will ever happen. It is proposed in the economic analysis to develop a scenario analysis. The analysis will be based on professional judgment and assumptions. The possibility of developing an alternative without project condition was also discussed. With any decision we will have to disclose the thought processes we used in making the decisions.

The report will also need to determine the impacts to the management of the disposal areas. The Corps holds the easements on the disposal areas and the non-Federal sponsor must compensate the Government for the loss of these areas. Compensation may take the form of new disposal areas and/or payment in perpetuity of the additional incremental costs of maintaining the channel without the areas to be occupied by the Jasper County port. HQUSACE recommended that a risk and uncertainty analysis with respect to a Jasper County terminal be conducted as part of the GRR. There was no consensus on how to conduct the risk and uncertainty analysis.

ACTION: The District will convene a select group to develop a strategy for dealing with the Jasper County port alternative and coordinate it with the Vertical Team.

11. **WASHINGTON LEVEL REVIEW PROCESS**

a. Issue – Determine how the Lean Six Sigma principles will be applied to the Savannah Harbor GRR Washington Level Review Process to result in approval of the report in a timely manner.

b. Discussion – The Table included in the read-ahead material for the IPR was discussed. The SAD and HQUSACE representatives were asked to review the list of Washington Level Review steps from the AFB through the signing f the Record of Decision and provide any comments on overlooked steps, timeframes that were unrealistically short, etc. The District and HQ had previously agreed that Savannah Harbor will be a test of the Lean Six Sigma principles. The level of detail in the AFB read ahead information was discussed and it was determined that a preliminary draft report will be prepared as the read-ahead. The AFB is currently scheduled to be held in the October 2007 timeframe with 30 days for producing the PGM. The goal at the AFB is to have the PGM 90% completed at the end of the meeting. This will allow greater flexibility in the schedule after completion of the AFB.

Whether this report needs to be presented to the Civil Works Review Board was also discussed. It was strongly recommended that this project be subject to the CWRB. If determined necessary the CWRB can be held in the June 2008 time frame. This board determines whether the document should be release for State and agency review. Normally this process is only for feasibility reports. This is an authorized project so presentation to the CWRB is not mandatory. HQUSACE recommended that the report be presented to the CWRB as a means of developing a corporate commitment to project and include the Washington level resource agencies in the CWRB as well.

ACTION: The District will convene a VTC with the vertical team (Tom Waters and Margaret Johanning at HQ) on VTC to further discuss this schedule. An After Action Review of the IPR was held on 11 May to assess the application of Lean Six Sigma recommendations to the IRC.

12. DECISION MATRIX

ID #	OUTSTANDING DECISIONS /ACTIONS	RESPONSIBLE ORGANIZATION	COMPLETION DATE
1.	Is Interpolation for mitigation costs between 46 and 48 foot depths for the 47-foot depth acceptable	SAM-PD	Completed Answer (Yes)
2.	Determine the number and location of passing lanes	SAM-PD	
3.	Cost Engineering Risks and Contingencies	SAW-EN	
4.	Vessel Operating Costs- IWR Update	HQUSACE	
5.	Regional Port Development and Cumulative Impacts	HQUSACE	
6.	Civil Works Review Board	HQ(A)&HQUSACE	
7.	Jasper County & Without Project Condition determination	SAM-PD	
8.	Will the CSS Georgia be removed with O&M or CG funding?	HQ(A)	
9.	Schedule IRC for Without Project Conditions.	SAM-PD	
10.	GRR to include discussion of other accounts: Regional Economic Development, Environmental Quality, Other Social Effects.	SAM-PD	
11.	Risks and uncertainties of deepening, not deepening.	SAM-PD	
12.	Review Giobal and U.S. east coast containership situation.	SAM-PD	
13.	Nearshore placement of new work and O&M material.	SAM-PD/SAW-EN	
14.	Analyze landside benefits.	SAM-PD	
15.	External Peer Review of Draft GRR		
16.	Independent Technical Review of all Planning Models.	SAM-PD/PCX	
17.	Review of Engineering Models	SAW-EN	

JUN-11-2008 10:02 FROM REAL ESTATE DIV TO 89102514744 P.02

04/04/2005 08:26 FAX 404 562 5218 CESAD Civil Works Divisi 001

DEPARTMENT OF THE ARMY
SOUTH ATLANTIC DIVISION, CORPS OF ENGINEERS
ROOM 9M15, 60 FORSYTH ST., S.W.
ATLANTA, GEORGIA 30303-8801

REPLY TO
ATTENTION OF

CESAD-PD-PP 25 March 2005

MEMORANDUM FOR Commander, SAVANNAH DISTRICT (CESAS-PM)

SUBJECT: Memorandum for Record, Savannah Harbor Expansion Project, In-Progress Review Meeting

1. Reference CESAS-PD Memorandum for Record (MFR) dated 4 January 2005, revised 2nd February 2005, subject Savannah Harbor Expansion Project, 2nd In-Progress Review Conference (enclosed).

2. The reference MFR adequately documents the issues discussed by Savannah District and the Georgia Ports of Authority, and the policy guidance provided by the Office of the Assistant Secretary of the Army for Civil Works, Headquarters-USACE, and the South Atlantic Division, during the 2nd in progress review (IPR) conference held by video tele-conferencing (VTC) on 9 December 2004. Based on the policy guidance provided in the MFR, you may proceed with preparation of the draft General Reevaluation Report and Environmental Impact Statement (GRR/EIS). The district is reminded to begin coordinating with the National Planning Center of Expertise for Deep Draft Navigation to initiate the process for independent technical review of the GRR/EIS. It is important that you discuss with the Center any external reviews activities planned and/or ongoing.

3. We are coordinating with the HQUSACE SAD-RIT to begin planning for hosting a meeting among the three agencies that must approve the Savannah Harbor Expansion project, along with Corps of Engineers. These three agencies are the Environmental Protection Agency, Department of Interior and Department of Commerce. We will work arrangements for this meeting concurrently with your staff.

4. Finally, during the last conference we agreed that an IPR would be conducted prior to the end of FY 05. Please let us know when you feel this IPR should be scheduled.

5. The point of contact for this action is Mr. Daniel Small at 404-562-5224.

Wilbert V. Paynes

Encl

WILBERT V. PAYNES
Chief, Planning and Policy Community
of Practice

TOTAL P.02

Savannah Harbor Expansion
In-Progress Review Action Items
20 September 2007

1. Advanced Maintenance. Advanced maintenance in conjunction with the deepening will require documentation and economic justification in the GRR. Carrying over the existing O&M advanced maintenance features is not acceptable. The GRR must demonstrate the need for advance maintenance after the project is deepened. Provide better identification of existing advance maintenance locations including where it has already been authorized and accomplished. As a point of clarification, for the With Project condition, it was stated that the Expansion Project had to demonstrate the continued need for advance maintenance from an economic standpoint. **Lead: SAS (Bailey, Garrett, Wiederhold)**

2. Lateral Advance Maintenance. In Table 2 the lateral advance maintenance widener on the outer part of the channel was shown as having been dredged. It will be removed from the table and the write-up. As recommended in the In-Progress Review of April 2007; this feature will be discussed in the General Reevaluation Report (GRR) since it may represent a cost efficiency for the O&M of the deepened project. **Lead: (Wiggins)**

3. O&M DMMP and DMMP for Deepening Work. The Future Without Project Conditions should address existing DMMP requirements and the fact that the existing project has sufficient disposal capacity in exis ting sites for the 20 year planning horizon. **Lead: SAS (Bailey, Garrett)**

4. Related Dredging Activities in Savannah Harbor. The Future Without Project Conditions should document how on-going agitation dredging at private berths impacts the Federal navigation channel. How the dredging is done along with the associated costs, and operational techniques, should be addressed in the GRR Without Project Condition. **Lead: SAS (Wiederhold/Bailey)**

5. City of Savannah Water Intake Structure. The Existing condition with the City of Savannah water intake structure on the Savannah River relative to the proposed deepening project should be address in the GRR. **Lead: SAS (Bailey)**

6. Dissolved Oxygen (DO) Standards and EPA TMDL. The Existing Conditions section should address the existing DO conditions and existing DO standard. Future Without Project Conditions should address improvements expected from implementation of the DO TMDL. Our base conditions should include some idea of what future conditions may be as industries attempt to address the TMDL issue. The mitigation should address the incremental impacts of channel deepening. We need to include the effectiveness of the mitigation plan under various assumptions about what the DO will be in the future. The base conditions could change and make it more costly. **Lead: SAS (Bailey)**

7. Channel Deepening and Impacts on Tybee Island. The PDT should incorporate into the GRR, the outcome of discussions relative to the 2005 GA CZM changes as they relate to Tybee Island as well as any finalized and peer reviewed documents related to the channel impacts study. The recently released executive summary by ERDC, stating that bar channel dredging is adversely impacting Tybee Island will have to be addressed as part of the Future without Project Conditions. Since the GRR for the Expansion Project will be written well prior to completion of the Tybee Island (Channel Impacts) Feasibility Study, the GRR will only be able to address the issue in a general way or by using an approach to mitigate the impact that is feasible but may later be found to not be the most economically efficient or environmentally sustainable. **Lead SAS: (Parrott, Garrett)**

8. CSS GEORGIA. The Future Without Project Conditions should be rewritten to state that the CSS Georgia is a separable element that is a Federal responsibility. The mitigation activities could be conducted at the same time as the Expansion Project is implemented and funded by Construction General. Since it is an ongoing Federal responsibility, those mitigation costs could be included for Construction

General funding but would not be subject to the Section 902 limit or part of the B/C ratio. **Lead: SAS (Garrett, Wood, Premo)**

9. Economic Projections. The Economic section summary should be supplemented with additional, but existing information to help present its case. No new information is needed, just what is available. HQ said the risk and uncertainty analysis should be accompanied by some observations about what is actually happening. **Lead SAM (Claseman)**

10. Economic Growth Projections. GPA expressed concerns about the conservative nature of the long term growth projections and the abrupt nature in which they are included in the economic evaluation of the project. Johnny Grandison (SAM) will arrange a meeting within the next couple of weeks in Mobile with Kevin Knight, Dr Moser, Beck Moyer, and Kevin Horne, to discuss the accuracy and reliability of growth projections and rates for Savannah Harbor. **Lead SAM (Grandison)**

11. Panama Canal Assumptions. Ian Mathis is familiar with the assumptions being proposed for the Panama Canal. Our assumptions should be validated by having him review the assumptions we have made about the Panama Canal deepening and widening. **Lead: SAM (Otto)**

12. Fleet Forecast and Vessel Operating Costs. Kim Otto will contact Becky Moyer regarding assumptions being made about fleet forecasts. Marianne Matheney–Katz will also talk to Ian Mathis (IWR) and provide feedback. **Lead: SAM (Otto)**

Bailey, William G SAS

From: Bailey, William G SAM@SAS
Sent: Thursday, March 22, 2007 12:20 PM
To: bisterfeld.ted@epa.gov; ed_eudaly@fws.gov; Kay Davy (kay.davy@noaa.gov); Garrett, Thomas A SAS; Hoke, Joseph T SAW@SAS
Cc: 'mueller.heinz@epamail.epa.gov'; 'Pace Wilber'; Bradley, Kenneth P SAM
Subject: Savannah Harbor Expansion Project: Decision on Model-To-Marsh Revisions
Attachments: EXPAN LCA M2M revision decision -- Mar 07 V2.doc

I have attached a decision document with my recommendation to (1) continue using movement of the 0.5 ppt point from the EFDC model, and (2) not pursue modifying the Model-To-Marsh link that we discussed on 8 March. Not revising the M2M will mean that we will use the Marsh Succession Models to identify wetland impacts from a harbor deepening (checking the predictions of the EFDC Model), but not with the various mitigation scenarios.

I have spoken to each of you separately and each expressed preliminary support for this approach.

Please let me know if you concur in the recommended course of action. If you want to sign the attached document, you may. But if you prefer, you can just send me an email letting me know whether you Concur or Non-Concur with the recommendation.

William Bailey

CESAM-PD-E 22 March 07

DECISION DOCUMENT

SUBJECT: Savannah Harbor Expansion Project;
Proposed revision to Model-To-Marsh linkage

1. A problem has developed with use of the Marsh Succession Models (MSMs) on some of the mitigation scenarios. The scenarios affected are those that substantially modify flows between the Front, Middle, and Back Rivers. The problem results in an overstatement of salinity in the Middle and Back Rivers, rendering the MSMs unreliable to evaluate wetland impacts on those scenarios. We've identified the Model-To-Marsh linkage (M2M) as the source of the problem.

2. The following two courses of action are available.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the "impact" and "mitigation" runs. We would use the MSM to provide more detail on the vegetation changes on the "impact" runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for "mitigation" runs. This Option describes our present condition and plan for proceeding with the wetland evaluations.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the "impact" and "mitigation" runs. We would revise the M2M as described in the enclosed proposal and apply the MSM to both "impact" and "mitigation" runs.

3. The Lead and Cooperating Agencies discussed this issue on 8 March 2007. The MFR, which summarizes the discussions of the meeting, are attached.

4. The USGS would lead the work to revise the M2M. They estimate it would take $110,750 and 12 months to produce a final product (including internal review). The work would include participation of an interagency team to identify flow paths from the rivers to specific locations in the marsh.

5. The following summarizes the pros and cons of proceeding with the proposed revisions (Option 2):

PROS

- The revisions would allow the Marsh Succession Models to be applied to all mitigation scenarios presently being considered. At this time, the MSMs do not give reliable results when applied to mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers).

- The revisions would include the use of an interagency team, increasing the likelihood of those agencies approving the final product.

CONS

- The EFDC model in conjunction with spatial data can acceptably be used to identify movement of the 0.5 ppt contour, allowing predictions of change between freshwater and brackish marsh. Use of the MSM on the impact runs will provide a comparison of the EFDC and MSM impact predictions (without mitigation).

- Revision of the M2M would cost roughly $110,000 and possibly delay decisions on the project by a year. The 1998 Feasibility Report estimated project net benefits (benefits – costs) to be about $35,000,000 per year.

- The effectiveness of the proposed revisions and the reliability of the MSM results will not be known until after the work is performed. The proposal acknowledges substantial uncertainty regarding accuracy of salinity predictions even with the proposed revisions.

- The revised M2M may have to be further modified if additional mitigation scenarios are developed. The further modifications would require additional costs and possibly further delay decisions on the project.

6. Conclusions.

The project has one accepted method of identifying potential impacts to wetlands (using EFDC to identify movement of the 0.5 ppt contour).

The accuracy of that model can be judged by use of the Marsh Succession Models for impacts from deepening scenarios without mitigation.

Therefore, the revised M2M – and the Marsh Succession Models – are not required to identify wetland impacts from the various harbor deepening alternatives (with mitigation).

Implementation of the proposed M2M revisions would cost roughly $110,000 and possibly delay decisions on the project by a year.

The additional information that may be obtained by revising the M2M does not appear to be sufficient to justify the cost of the modifications or delay to the project.

7. Recommendation.

Based on the information provided in this document and its enclosures, I believe that implementation of the proposed Model-To-Marsh revision is not warranted and recommend that the modifications not be pursued.

William G. Bailey

William Bailey
Physical Scientist
Mobile/Savannah Regional Planning Center

8. Concurrence:

	CONCUR	NON-CONCUR	INITIALS
Joseph Hoke Hydraulic Engineer USACE Wilmington/Savannah Engineering	_________	_____________	_________
T. Alan Garrett Project Manager USACE Savannah District	_________	_____________	_________
Ed EuDaly Senior Biologist USFWS Charleston	_________	_____________	_________
Ted Bisterfeld Ecologist EPA Region 4	_________	_____________	_________
Kay Davy Fishery Biologist NOAA Fisheries Charleston	_________	_____________	_________

CESAM-PD-E 20 Mar 07

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project;
Lead & Cooperating Agency meeting, 08 March 07

1. The meeting was called to learn more about a proposal (attached) to revise the Model-To-Marsh (M2M) component of the Marsh Succession Models. Alan Garrett, Corps Project Manager, chaired the meeting. A list of attendees is attached.

2. Bill Bailey provided an overview of the problem.

The Corps has successfully run the Marsh Succession Models to identify changes in wetlands from the various channel deepening scenarios. These are the “impact” runs. As we applied the models to the mitigation scenarios, we observed unexpected results. For some mitigation scenarios, the EFDC runs predict a decrease in salinity but the MSMs show shifts to more saline wetland species. Upon further inspection, we observed that on those runs the M2M component was providing higher root zone salinity values than were occurring in nearby rivers. The M2M extrapolates riverine salinity values from seven sites to root zone salinity values across the entire marsh surface. Apparently the limited number of points from which the M2M is starting its extrapolation leads to inaccuracies in mitigation scenarios that substantially alter flows between the three rivers (Front, Middle and Back Rivers). The M2M takes higher salinity levels on the Front River and uses them as a basis for incorrectly predicting higher salinity levels in portions of Middle and/or Back Rivers.

3. We described two avenues through which the project could more forward.

In Option 1, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would do this by examining what marshes change from <0.5 ppt to > 0.5 ppt salinity. We would apply that technique to both the “impact” and “mitigation” runs. We would use the MSM to provide more detail on the vegetation changes on the “impact” runs, thereby checking the EFDC results and increasing our confidence in the EFDC results. We would not use the MSM for “mitigation” runs.

In Option 2, we would use the EFDC salinity model to identify wetlands that shift from fresh to brackish species. We would apply that technique to both the “impact” and “mitigation” runs. We would revise the M2M as proposed and apply the MSM on both “impact” and “mitigation” runs.

4. Paul Conrads and Ed Roehl provided an overview of the proposed SOW to revise the M2M. This write-up is only a small part of the description Paul and Ed provided.

The present M2M starts with river flows and tidal conditions. It adds to that foundation riverine salinity values from the EFDC model. The present M2M could be considered more a far-field approach since it uses a limited number of riverine salinity values and extrapolates them across the entire marsh surface. It determines a relationship between river salinity and the well gages through time-delayed input signals and moving window averages between river salinity and pore-water salinity. The M2M was designed to primarily identify changes in root zone salinity that occur longitudinally in the estuary (along the length of the river).

The proposed revisions would allow the M2M to better identify lateral changes in root zone salinity that occur across the estuary (between different rivers or away from a single river). These revisions would start with a more detailed network of river salinity stations. It would then extrapolate those values to nearby areas of marsh. This could be considered more of a near-field approach. Additional marsh well data would be obtained to establish strong relationships between river and marsh root zone salinities. The Q-zone approach would be used as a starting point for the river to marsh flow paths. An interagency panel would be used to identify those pathways and guide the model revisions.

Uncertainty in the results of this M2M revision include three components: (1) Quality of the original data, (2) Quality of the data used to forecast or hindcast to fill in missing data, and (3) Quality of the data from EFDC. These are the same sources of uncertainty with use of the present M2M. This revision will require development of additional synthetic data to fill in records for the extra river sites that will be used.

5. The group then asked questions of Paul and Ed Roehl about the proposed work.

What will be the reliability of the results when using more synthetic data? Would the public accept the use of more synthetic data? RESPONSE: The reliability will not be known until the model is produced. However, data for the existing M2M show it is highly reliable for use with the present configuration of the estuarine rivers. As with any model, the ultimate accuracy of the revised model's predictions would not be known until after post-construction monitoring is performed.

What will be the reliability of the results when using data from the GPA stations? Those data were determined to be unacceptable in development of the existing M2M. RESPONSE: Data from the GPA stations were not used in the existing M2M primarily because of their short period of record. A much longer – and therefore more reliable – record exists for the USGS gages. The GPA stations would be used in the model revisions to provide a finer grid of river locations from which to extrapolate salinity levels across the marsh surface. The finer grid should increase the accuracy and reliability of the model predictions within specific marsh areas. The additional stations

would also allow a more detailed quantification of the sensitivity of marsh areas to local riverine conditions. The GPA stations also provide data obtained during 1997 – the flow conditions that are being modeled during the mitigation analyses. The reliability of the revised models would not be known until they are developed.

What are the differences between the GPA stations, marsh gages, and USGS gages? RESPONSE: The differences include both duration and density. The marsh gages provide salinity information in the marsh root zone at 7 sites from 1999 to 2005 and 10 GPA sites from 1999 to 2002. The GPA stations hare 14 riverine stations with data from portions of 1997 and 1999. The USGS gages provide salinity information at 4 riverine sites for many years.

What will be the reliability of the final predictions if the development of the revised model includes extensive synthetic data? RESPONSE: Models are regularly developed and applied when only limited actual data exists. Synthetic data is an accepted technique in the modeling community when insufficient historical data exists.

If new algorithms need to be developed for each mitigation plan, it could appear that we have developed a model just to show the results we want on the plan we want. If the same model is not used to evaluate all plans, how can we ensure we are evaluating all plans to the same degree of accuracy? RESPONSE: The same procedures would be followed to evaluate all plans, even if the models differ.

The existing M2M and its algorithms appear to work well with the present river configuration. If new algorithms only are effective for the mitigation plans that substantially modify river flows, how can we ensure their accuracy? RESPONSE: The change from a “far-field” approach to a “near-field” approach increases the likelihood that the revisions would be accurate when flows are substantially modified. The reliability of the results will not be known until the models are developed.

The MSM provides more detailed information on expected wetland changes than does the EFDC model. Do we really need those more detailed predictions for each mitigation scenario? RESPONSE: If reviewers want the detailed information, the revised M2M is the only way to obtain it.

Although a provisional version may be available in 5 months, the project will need a fully accepted version before it could release a report containing results using this approach. The final report is scheduled to be available in 12 months. If complications occur that delay the work, the date would extend further. A 12-month delay in the project would be a major impact to GPA. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

The proposed revisions would likely extend the duration of the project. That extension may decrease the reliability of other analyses, requiring they be updated. That would require additional time and money. RESPONSE: Reaching a timely decision on this project is a goal of all the Cooperating Agencies.

Some of the mitigation scenarios appear to decrease the tidal range. The USFWS may not be able to support those plans as a substantial decrease in the depth of flooding over the marsh may adversely affect nekton use of those areas. The plans which have the most effect on tidal range are the ones that substantially alter flows between the three rivers. RESPONSE: The proposed M2M revisions would not be beneficial if the final mitigation plans do not include measures that substantially alter flows between the three rivers.

Have the status and trends of wetlands since the last harbor deepening been taken into account? RESPONSE: Both the M2M and the MSM are based on data obtained since the last deepening.

Would the proposed revisions be necessary for the post-construction monitoring and adaptive management? RESPONSE: The EFDC will be used to ensure that changes in riverine salinity that are predicted are not exceeded. The existing M2M and MSM could be used to provide a perspective on what should have been expected in the wetlands with the observed flows if no further deepening occurs.

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

LEAD & COOPERATING AGENCY MEETING
08 MAR 2007

ATTENDEES

Ed EuDaly	USFWS – Charleston	(by phone)
Ted Bisterfeld	EPA Region 4	(by phone)
Kay Davy	NOAA Fisheries - Charleston	(by phone)
Alan Garrett	USACE - Savannah	
Joe Hoke	USACE – Wilmington/Savannah	
Hugh Heine	USACE – Wilmington	(by phone)
Elizabeth Godsey	USACE – Mobile	(by phone)
William Bailey	USACE – Mobile/Savannah	
Hope Moorer	GPA	(by phone)
Larry Keegan	Lockwood-Greene Engineers / GPA	(by phone)
Morgan Rees	Rees Engineering / GPA	(by phone)
Paul Conrads	USGS – Columbia	(by phone)
Ed Roehl	Advanced Data Mining	(by phone)

Estimation of Pore-water Marsh Salinities for Harbor Reconfiguration Scenarios

By
Paul Conrads, U.S. Geological Survey – Water Resources Division
Edwin Roehl, Advanced Data Mining, LLC
Wiley Kitchens, U.S. Geological Survey – Biological Resources Division
Zachariah Welch, Florida Coop Unit, University of Florida,

INTRODUCTION

Under sponsorship from the U.S. Army Corps of Engineers (USCOE) and the Georgia Ports Authority (GPA), the Lower Savannah River Estuary and the surrounding freshwater tidal marshes of the Savannah National Wildlife Refuge (SNWR) have been studied for years by a variety of governmental agencies, water users, universities, and consultants. Their interests are in maintaining water quality and predicting the potential impacts of a proposed harbor deepening on the estuary and tidal wetlands. Two major initiatives were the development of a three-dimensional hydrodynamic model (3DM) by a team of hydrologists, and the development of a marsh succession model (MSM) by a team of plant ecologists. The 3DM predicts changes in riverine water levels and salinity in the system in response to potential harbor changes. The MSM predicts plant distribution in the tidal marshes in response to changes in the water-level and salinity conditions in the marsh. A mechanism for linking riverine and marsh behaviors was needed.

To support 3DM and MSM development, many disparate databases were created that described the natural system's complexity and behaviors, but these databases had not been compiled into a usable form. Variables having particular relevance include those describing bathymetry, meteorology, streamflow (Q), water level (WL), specific conductance (SC), water temperature (WT), and dissolved oxygen concentration (DO). Most of the databases were composed of time series that varied by variable type, periods of record, measurement frequency, location, and reliability. Scientists recognized that data-mining techniques, which include artificial neural networks (ANN), could be used to link riverine and marsh behaviors.

To link the riverine predictions of the 3DM to the MSM, a "model to marsh" (M2M) model was developed by the U.S. Geological Survey and Advanced Data Mining (ADM) using data mining techniques that included ANN models. The ANNs simulated riverine and marsh water levels and salinity in the vicinity of the SNWR for the full range of 11½ years of data from riverine and marsh gaging networks. With M2M, the 3DM and MSM comprise an integrated decision support system for use by various regulatory and scientific stakeholders. The development and application of the M2M is described in Conrads and others (2006).

The M2M has been successfully applied to evaluate the effects of deepening the harbor by generating the inputs to the MSM from the outputs of the 3DM. The M2M also has been used to evaluate potential mitigation scenarios for minimizing the impacts from

harbor deepening. These mitigation scenarios included minor and major changes in channel configuration and flow distribution in the system.

PROBLEM STATEMENT

Eight mitigation scenarios that involve major structural changes in the vicinity of the SNWR, such as the installation of flow diversion structures and the cutting and filling of channels, have been proposed for evaluation. The M2M was not designed to accommodate mitigation scenarios that involve major structural changes. Currently (2007) there is not a mechanism for reliably estimating pore-water salinities in the marsh from riverine inputs for these major mitigation scenarios.

The responses of the SNWR to major changes are very likely to be different from any behaviors ever manifest in the historical record. While the 3DM can be configured to estimate riverine WL and SC with the major changes, it is limited to riverine estimates and cannot be credibly configured to estimate pore-water salinities in the marsh. Using data mining techniques, Conrads and others (2006) found that pore-water salinities integrate riverine WL and salinity variability over several months and often there are long time delays between riverine salinity conditions and marsh pore-water salinity response. A new tool similar to the M2M, hereafter referred to as M2M.2, needs to be developed to estimate pore-water salinity concentrations to evaluate mitigation scenarios involving major structural changes. To provide the necessary technical input and agency review, it is proposed that a multi-agency and multi-disciplinary technical working group be formed of the USGS-S.C. Water Science Center (USGS-SCWSC), the USGS-Florida Coop Unit (USGS-FCU), U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACOE), and Advanced Data Mining (ADMi).

OBJECTIVES

There are three objectives for this project.

1. *Develop new marsh salinity estimation models* - for estimating pore-water salinities at marsh gaging sites for various mitigation model scenarios, using either measured or predicted river water level and specific conductance data at gage locations. It is possible that algorithms would have to be developed for each mitigation scenario.

2. *Develop new salinity spatial interpolation scheme(s)* – that estimate salinities throughout the SNWR from the USGS marsh gaging sites. The current scheme is embedded in the M2M's two-dimensional visualization and gridding application (2DVG). The new schemes must reflect greater lateral variation in the pore-water salinity than the current scheme. It is possible that new schemes would be created for each mitigation scenario.

3. *Develop M2M.2 2DVG and Simulator Applications* – to deploy the work products from Objectives 1 and 2. This includes adapting the 2DVG and the M2M Simulator, which estimates salinities at the USGS marsh gages.

SCOPE

The scope of this study is to address the relation between the riverine salinity and the pore-water marsh salinity for harbor deepening mitigation scenarios. The study's major tasks are described below.

Task 1 *Develop Pore-water Estimation Matrix* – that defines the usable permutations of input USGS or GPA river gages to estimate salinities at each marsh gaging station for each mitigation scenario. Consideration will be given to the proximities of gages and flow diversion structures, and the overall quality of input gage measured, forecasted, and hindcasted data used for developing or generated by the M2M.

Task 2 *Develop predictive models* - for each permutation defined in Task 1. This involves determining optimal time delays and moving window averages between river salinity and pore-water responses through correlation analysis. ANNs provide the best possible correlations in terms of the process information they provide and their prediction accuracy. The number of models to be developed depends on the permutations defined in Task 1.

Task 3 *Define area of influence and spatial gradient of the USGS marsh gages* - for the new salinity spatial interpolation scheme.

Task 4 *Develop M2M.2 2DVG application* - to reflect findings from Task 3. It is likely that multiple visualizations and grids will need to be developed to accommodate all of the mitigation scenarios.

Task 5 *Develop M2M.2 Simulator* – like M2M, it will integrate the 3DM with the MSM using the models from Task 2 and the M2M.2 2DVG application from Task 4, but tailored for the mitigation scenarios involving major structural changes.

Task 6 *Document the approach and results.*

RELEVANCE AND BENEFITS

An important part of the USGS mission is to provide scientific information for the effective water-resources management of the Nation. To assess the quantity and quality of the Nation's surface-water, the USGS collects hydrologic and water-quality data from rivers, lakes, and estuaries using standardized methods, and maintains the data from these stations in a national database. Often these databases are under utilized and under interpreted for addressing contemporary hydrologic issues. The techniques used to develop the M2M and models of the Cooper River (Conrads and Roehl, 1999), the Beaufort River (Conrads and others, 2003), and the Pee Dee River (Conrads and Roehl, 2006) demonstrate how valuable information can be extracted from existing databases to assist local, state and Federal agencies.

The project benefits the Georgia Ports Authority and the Army Corps of Engineers by providing data analysis needed by water-resource managers to make decisions concerning mitigation of the Savannah River Estuary to accommodate potential deepening of Savannah Harbor. The project builds on previous studies relating river salinity to marsh pore-water response. This is consistent with primary USGS activities that include providing knowledge and expertise to assist various levels of government in understanding and solving critical water-resources problems.

TECHNICAL APPROACH

The historical data do not contain information explicitly about the impacts of the proposed mitigation scenarios involving major structural changes. For these circumstances, the best available data, tools, and human expert knowledge and experience must be brought to the problem. The development and use of the M2M.2, and related findings will provide the best possible resources for evaluating the major mitigation scenarios.

Available Data and Utilities from M2M Study

The M2M is based on river and marsh WL and SC ANN models for the USGS and GPA gaging stations in the river and marshes. These are empirical models and for a system as complex as the Savannah River estuary, it was critical that measured, not estimated, data were used that cover the greatest range of hydrologic and tidal responses. For making predictions of pore-water salinity, the most valuable data for M2M development were from the long-term USGS river and marsh gaging stations, which covered over 11 years and 5 years respectively, and comprise a range of flow conditions from drought to floods. Of lesser value were the GPA river and marsh data, which were limited to short measurement periods and a small range of hydrologic conditions. The USGS river data are the major inputs for the final pore-water salinity models and a few of the GPA stations are used to reduce the error in the pore-water models.

The M2M Simulator and 2DVG applications will be valuable for estimating pore-water salinity for the major mitigation scenarios. The Simulator integrates a collection of individual models of the GPA and USGS river gages with the various field databases, such that all of the WL and SC data from the river gages were individually modeled. By hindcasting and forecasting the short-term data collection periods at the GPA sites, a complete database was generated for the 11½ year period from 1994 to 2005. This feature was incorporated to allow scientists and managers to simulate any period from the last deepening and analyze system responses at any gage location. The 2DVG provides spatial interpolation-extrapolation and visualization of the marsh responses across the marsh wells. It is easily modified to accommodate new pore-water estimates at the USGS marsh sites and new interpolation-extrapolation schemes across the marsh.

Pore-water Estimates for Mitigation Scenarios

The MSM models use the growing-season average pore-water salinity as input. The measured, forecasted, and hindcasted SC records at the GPA river sites can be used in conjunction with the USGS sites to determine the best estimates of the average pore-water salinity during the growing season. Estimates will be based on the assumption that a marsh gage responds to nearby river gage(s) and that the candidate river gage(s) may vary by mitigation scenario. Often good correlations between two time series, such as river and marsh SC, can be obtained by adjusting the time delay and moving window average of the explanatory variable (river SC) to achieve the highest correlation with the response variable (marsh SC). For highly dynamic SNWR, trend information proved invaluable for estimating inertia-driven behaviors. Representing trends requires at least two input variables whose values represent two different times or two different locations at the same time, or both.

To estimate pore-water responses to mitigation scenarios, river sites will be selected as candidate explanatory variables for each mitigation plan. For example, the schematic for Mitigation Plan 5 is shown in figure 1. In this scenario, it is believed that salinity intrusion occurs further up the Front River and that freshwater flows increase down the Little Back River. The riverine gages closest to the Middle River 1 (M1) for estimating its pore-water salinity are GPA12 and GPA12r. For Back River 2 (B2), gages 8979, 89784, and GPA15 appear to be good candidates. Final river site selection will be based on the quality of the measured, hindcasted, and forecasted GPA data.

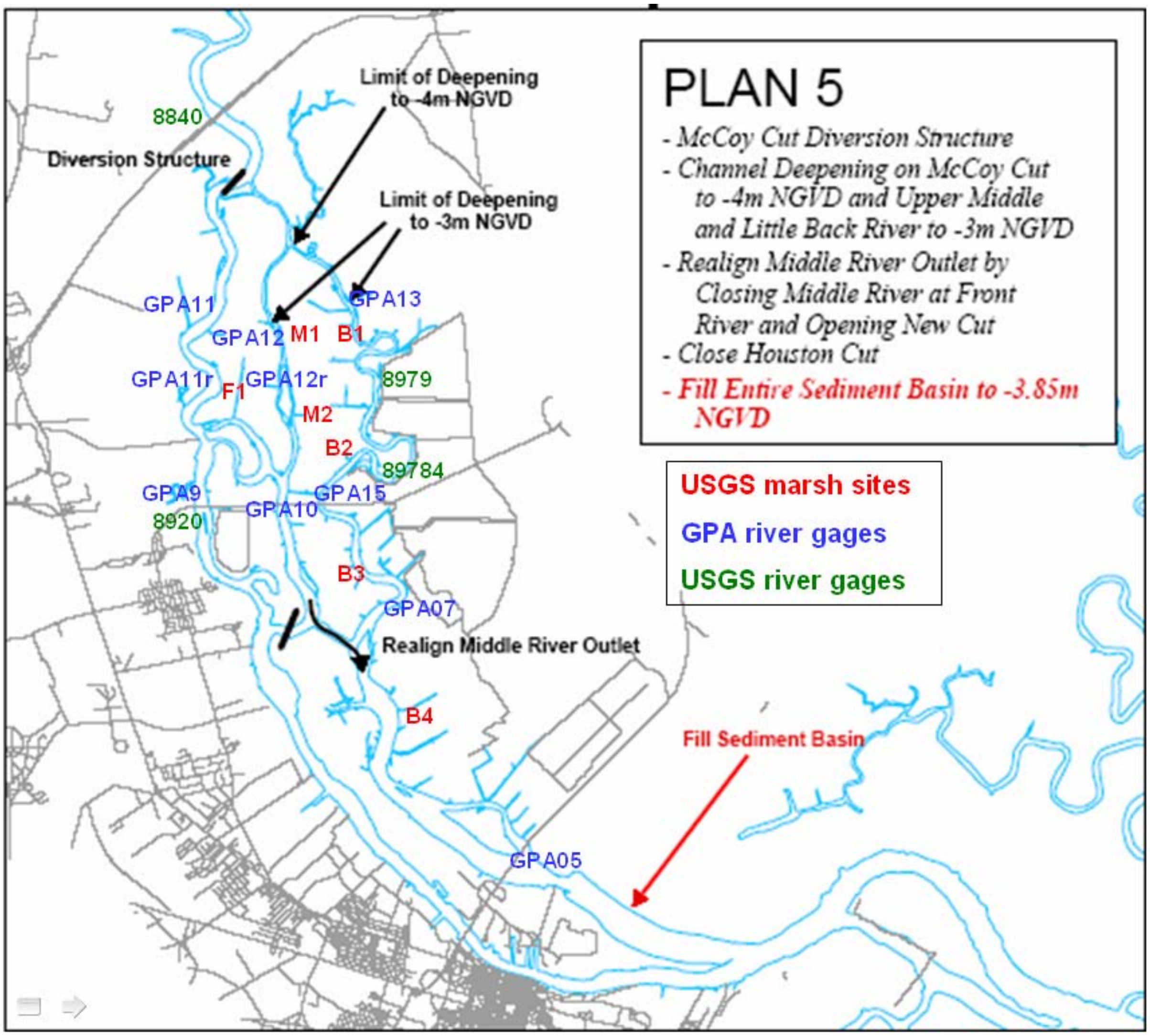


Figure 1. Locations of river and marsh gages and schematic of Plan 5 mitigation scenario

The Pore-water Estimation Matrix will be developed of mitigation plans, marsh gages, and candidate river sites. It is anticipated that some of the plans will share configurations of river gages to marsh gages. Pore-water estimates will be determined for each plan and the estimates will be compared with the predictions made with the original ANN models of the M2M.

Pore-Water Salinity Projections Across the Marsh

The time-series data of the individual marsh gages depict the longitudinal gradient of the system to various hydrologic and tidal conditions. The time-series data do not support the lateral gradients in the system. The M2M's 2DVG is based on estimates of the longitudinal variations from model predictions at the marsh sites. A simple interpolation scheme is used to estimate the lateral gradients.

For the mitigation scenarios, marsh wells will be assigned to the vegetative zones (Q-zones) depicted in Figure 2 and added to the Pore-water Estimation Matrix. Lateral variation across the marsh will be based on field experience and limited data taken during transect studies by the Florida Coop Unit (FCU) at the University of Florida.

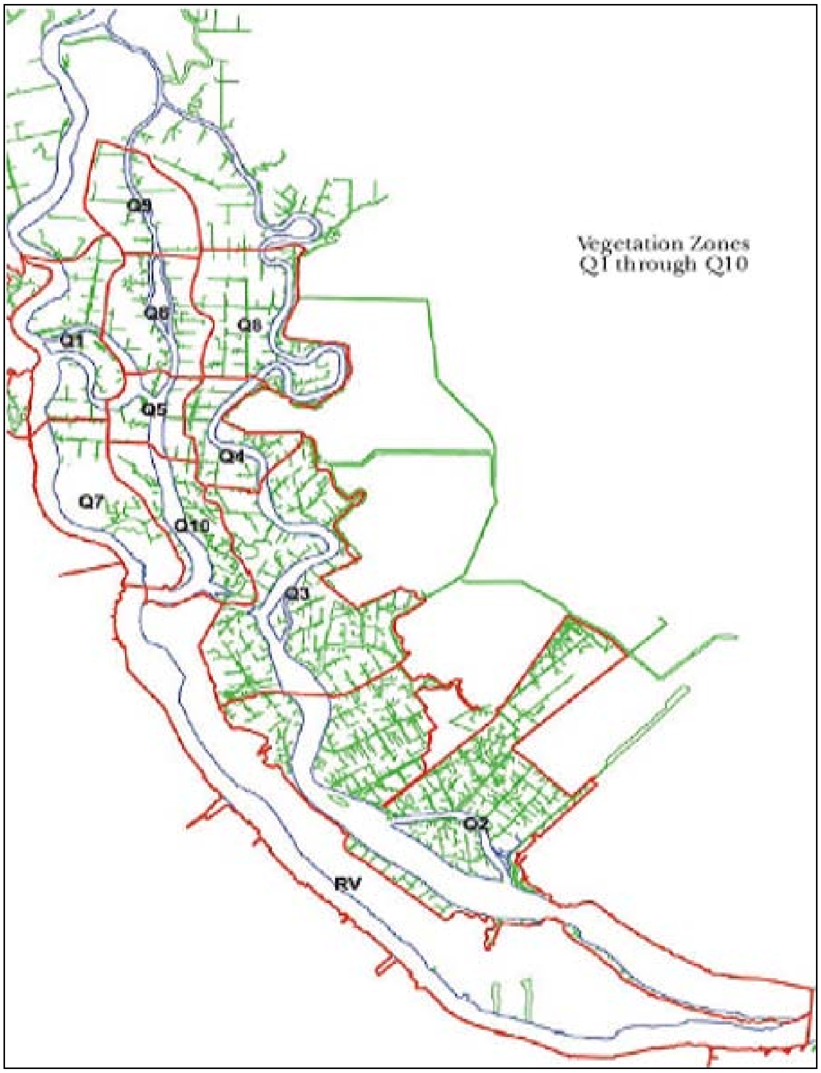


Figure 2. Locations of Q-zones in the tidal marsh in the vicinity of the Savannah National Wildlife Refuge

Integration of Hydrodynamic Model and Marsh Succession Models – M2M.2

Like M2M, M2M.2 will integrate output from the 3DM and generate the marsh salinity grid for input to the MSM. Linking the 3DM is accomplished by reading in a file of simulated differences in SC values for the river for the mitigation plan scenarios. The use of differences, or deltas, from the 3DM increases the prediction accuracy of the model. Mechanistic model, such as the 3DM, typically are better suited from predicting relative differences between two conditions rather than making absolute predictions for one

scenario. The differences (deltas) from the 3DM are added to the historical time series for the scenario and then used in the M2M.2. The application estimates pore-water salinity at the marsh gages and the salinity grid is generated for input to the MSM applications.

Figure 3 describes the data and workflow from the 3DM, through the M2M.2 Simulator and 2DVG applications, and to the MSM. Here, the eight mitigation scenarios are handled separately, providing each with completely customized solution bearing the best ideas of the multi-disciplinary team. At left the 3DM is run for each scenario and separate output files are generated. Next at top center, in the M2M.2 Simulator the user selects the scenario to be run, the appropriate 3DM output file is loaded, the appropriate prediction models are engaged, a simulation is run, and an output file of marsh specific conductivities is generated. Next at right, in the M2M.2 2DVG the user selects the scenario to be run, the M2M.2 Simulator output file is loaded, and an output file of spatially interpolated marsh salinities is generated, which can be loaded into the MSM.

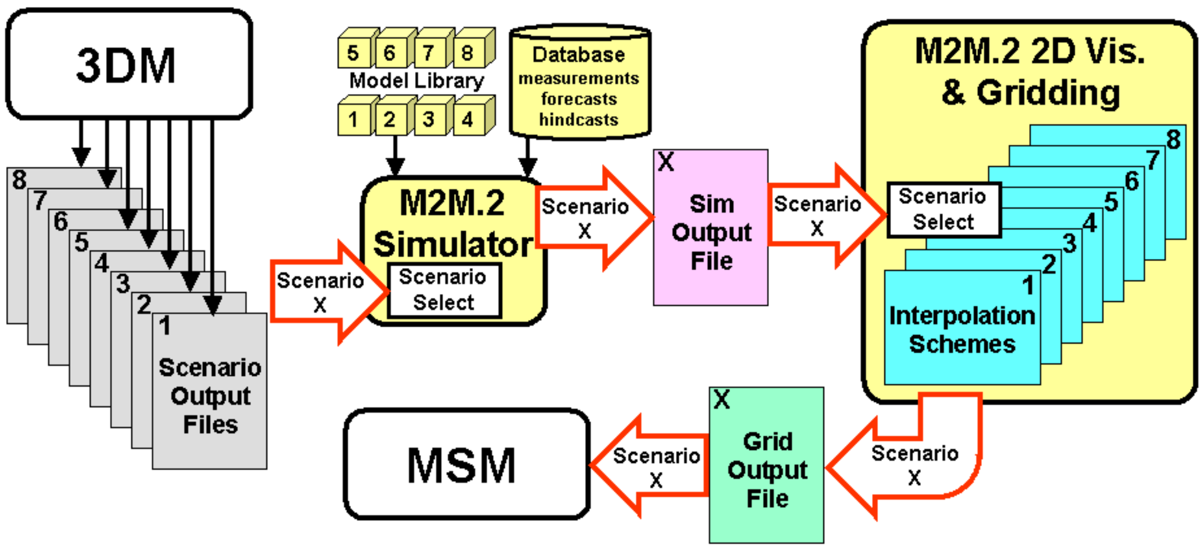


Figure 3. Schematic of data and workflow through the M2M.2.

UNCERTAINTY OF OUTCOME

In this technical approach, each scenario will have a custom solution developed by a multi-disciplinary technical team composed of the USGS-SCWSC, the USGS-FCU, the USFWS, USACOE, and ADMi personnel that are most knowledgeable in the issues, history, and science of the harbor deepening. As with the M2M, the behaviors and predictive performance of the new "local" models of the M2M.2 will be fully described to the technical team. The performance of the models is expected to be comparable to those of the M2M, with the major sources of uncertainty to be associated with the quality of the data collected from the GPA sites, the quality of the SC hindcasts and forecasts at the GPA sites, and the accuracy of the 3DM predictions.

Generally, the 3DM prediction accuracy of flow and salinity throughout the model domain are better on the Front River and lower portion of the system. The prediction

accuracy is not as good in the vicinity of the SNWF and farther inland in the system. This can be seen in the summary statistic of the model performance for the 50 percentile and the coefficient of determination for the 1999 calibration data and the 1997 validation data set (Tetra Tech, 2006). The accuracy of estimates made by the 3DM for scenarios involving major structural changes is unknowable *a priori*, but very likely to be less accurate that the calibration and validation prediction. The used of differences from the 3DM will reduce absolute prediction error by the model. The 3DM's performance will be the primary source of uncertainty, but significant reliance on its estimates inside the SNWR is unavoidable.

The technical team will leverage the tools in hand to formulate a process of mitigating deepening-related problems. The process may employ a succession of structural changes of varying impact severity. It is likely that each change will have surprising results that can only be determined *post priori* by continued field monitoring and data analysis. This suggests a conservative, iterative mitigation approach composed of these steps - hypothesize, change, test, review, and most importantly, learn will be required.

PROJECT COORDINATION

In making estimates of system responses to the structural changes in the SNWR, it is essential that the appropriate technical resources from the agencies be involved. It is proposed that periodic meetings of the technical working group (USCOE, USF&W, USGS-SCWSC, USGS-FCU, and ADMI) be scheduled to review interim products such as the pore-water estimation matrix, pore-water estimation models, and prototypes of the M2M.2 2DVG and M2M.2. Many of these meeting could be accomplished by teleconferencing.

REPORTING

The project will be documented in a USGS Open-File Report, tentatively titled "Estimation of Tidal Marsh Pore-water Salinity in the Vicinity of Savannah National Wildlife Refuge for Savannah Harbor Deepening Mitigation, Coastal South Carolina and Georgia." A provisional copy of the report will be available for colleague/cooperator review 3 months after the completion of the project. The review process will require an additional 5 months. A limited number of paper copies of the report will be provided to the cooperating agencies; however, the primary outlet for the publication will be the Internet. A link to the report will be posted on the USGS South Carolina Water Science Center web sites.

BUDGET AND SCHEDULE

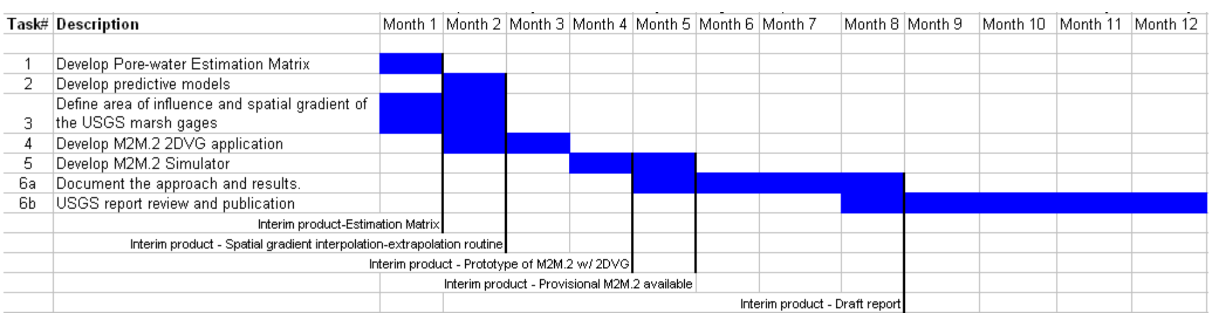
The Project will be collaboration between the USGS-SCWSC, the USGS-FCU, and ADMi. The project will take approximately 4-5 months to complete the technical analysis and develop the provisional M2M.2 from the start date. The final documentation of the project will be complete approximately 10-12 months from the start date. The total cost of the project will be $110,750. An itemized description of the tasks and required hours

are listed in Table 1 and a timeline for completion of the project from initiation is presented in Table 2.

Table 1. Tasks, description, notes, hours, and costs.

Task #	Description	Notes	USGS-SCWSC Hours	USGS-SCWSC Cost	USGS-FCU Hours	USGS-FCU Hours	ADMI Hours	ADMI Cost
1	Develop Pore-water Estimation Matrix	tooling up, evaluate data quality, matrix development, meeting with Agencies to finalize matrix	40	$4,400			40	$5,000
2	Develop predictive models	upper limit = 8 scenarios x 7 models per = 56 models, x 8hrs/model, use 50% - USGS-SCWSC to review	25	$2,750			224	$28,000
3	Define area of influence and spatial gradient of the USGS marsh gages	mostly USGS-FCU with assitence from USGS-SCWSC, ADMI to assimilate, meeting for concurance with Agencies prior to finalization	40	$4,400	64	$6,400	12	$1,500
4	Develop M2M.2 2DVG application	assume 8 interp schemes to program/integrate at 2days per - USGS-SCWSC to revew	25	$2,750			128	$16,000
5	Develop M2M.2 Simulator	assume 4 weeks for mostly new but derivative app programming and testing - USGS-SCWSC to rev	25	$2,750			160	$20,000
6	Document the approach and results.	mostly USGS-SCWSC and USGS-Publications Unit, ADMI and USGS-FCU to assist	120	$13,200	16	1600	16	$2,000
		Totals	275	$30,250	80	$8,000	580	$72,500

Table 2. Timeline for completion of project.



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Conrads, P.A., Roehl, E.A., and W.P. Martello, 2003, Development of an empirical model of a complex, tidally affected river using artificial neural networks, Water Environment Federation TMDL Specialty Conference, Chicago, Illinois, November 2003.

Conrads, P.A., Roehl, E.A., Daamen, R.C., and W.M. Kitchens, 2006, Simulation of water levels and salinity in the rivers and tidal marshes in the vicinity of the Savannah National Wildlife Refuge, Coastal South Carolina and Georgia, U.S. Geological Survey Scientific Investigations Report 2006-5187.

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Tetra Tech, 2006, Development of the hydrodynamic and water quality models for the Savannah Harbor Expansion Project. Prepared for the U.S. Army Corps of Engineers – Savannah District, Tetra Tech, Inc. Atlanta, Georgia.

From:	Ed_Eudaly@fws.gov
To:	Bailey, William G SAM@SAS
Cc:	bisterfeld.ted@epa.gov; Hoke, Joseph T SAW@SAS; kay.davy@noaa.gov; Bradley, Kenneth P SAM; mueller.heinz@epamail.epa.gov; Pace Wilber; Garrett, Thomas A SAS; John_Robinette@fws.gov; Jane_Griess@fws.gov; Russell_Webb@fws.gov
Subject:	Re: Savannah Harbor Expansion Project: Decision on Model-To-Marsh Revisions
Date:	Tuesday, March 27, 2007 8:56:50 AM

Bill:

I concur with your recommendation to not pursue modification of the model-to marsh link. I have coordinated with Savannah NWR and they also concur. Please consider this e-mail as Service concurrence with your recommendation.

Ed EuDaly
U.S. Fish and Wildlife Service
176 Croghan Spur Road, Suite 200
Charleston, SC 29407
843-727-4707 ext. 227
FAX 843-727-4218

"Bailey, William G SAM@SAS" <William.G.Bailey@sas02.usace.army.mil>

03/22/2007 12:19 PM To
<bisterfeld.ted@epa.gov>, <ed_eudaly@fws.gov>, <kay.davy@noaa.gov>, "Garrett, Thomas A SAS" <Thomas.A.Garrett@sas02.usace.army.mil>, "Hoke, Joseph T SAW@SAS" <Joseph.T.Hoke@sas02.usace.army.mil>
cc
<mueller.heinz@epamail.epa.gov>, "Pace Wilber" <Pace.Wilber@noaa.gov>, "Bradley, Kenneth P SAM" <Kenneth.P.Bradley@sam.usace.army.mil>
Subject
Savannah Harbor Expansion Project: Decision on Model-To-Marsh Revisions

I have attached a decision document with my recommendation to (1) continue using movement of the 0.5 ppt point from the EFDC model, and (2) not pursue modifying the Model-To-Marsh link that we discussed on 8 March. Not revising the M2M will mean that we will use the Marsh Succession Models to identify wetland impacts from a harbor deepening (checking the predictions of the EFDC Model), but not with the various mitigation scenarios.

<<EXPAN LCA M2M revision decision -- Mar 07 V2.doc>>
I have spoken to each of you separately and each expressed preliminary support for this approach.

Please let me know if you concur in the recommended course of action. If you want to sign the attached document, you may. But if you prefer, you can just send me an email letting me know whether you Concur or Non-Concur with the recommendation.

William Bailey [attachment "EXPAN LCA M2M revision decision -- Mar 07 V2.doc" deleted by Ed Eudaly/R4/FWS/DOI]

From: Mueller.Heinz@epamail.epa.gov
To: Bailey, William G SAM@SAS
Cc: Welborn.Tom@epamail.epa.gov
Subject: RE: Savannah Harbor Expansion Project - Decision on Model-To-Marsh proposal
Date: Monday, April 02, 2007 11:20:02 AM

Bill, per our earlier e-mail, R4 concurs with your proposed approach.
Heinz

"Bailey, William
G SAM@SAS"
<William.G.Baile
y@sas02.usace.ar
my.mil>

To
Heinz Mueller/R4/USEPA/US@EPA
cc

04/02/2007 11:12
AM

Subject
RE: Savannah Harbor Expansion
Project - Decision on
Model-To-Marsh proposal

Did you hear anything from Water Mgt Division?

BB
-----Original Message-----
From: Mueller.Heinz@epamail.epa.gov
[mailto:Mueller.Heinz@epamail.epa.gov]
Sent: Thursday, March 29, 2007 11:47 AM
To: Bailey, William G SAM@SAS
Cc: Hamilton.John@epamail.epa.gov
Subject: Re: Savannah Harbor Expansion Project - Decision on
Model-To-Marsh
proposal

Yes Bill, the way Ted left it that unless I hear from the W ater Div to
the
contrary by COB today, we will send you a concurrence e-mail tomorrow
morning. HM

"Bailey, William
G SAM@SAS"
<William.G.Baile
y@sas02.usace.ar
my.mil>

To
Heinz Mueller/R4/USEPA/US@EPA
cc

03/29/2007 10:42 AM

Subject

Savannah Harbor Expansion Project - Decision on Model-To-Marsh proposal

Ted Bistereld said he would be out of the office this week and next. Is someone continuing actions to obtain an EPA position on my recommendation
concerning the USGS proposal to modify the Model-To-Marsh linkage?

BB

Sent from my BlackBerry Wireless Device

From:	Hoke, Joseph T SAW@SAS
To:	Bailey, William G SAM@SAS; Garrett, Thomas A SAS
Cc:	Bradley, Kenneth P SAM
Subject:	RE: SH Expansion - decision on M2M
Date:	Monday, April 02, 2007 7:44:02 AM

I concur that we do not need to modify the M2M. The alternatives that it was designed to address appear to be of little interest to the agencies now, given their impacts on tide range.

Joseph T. Hoke, Jr., P.E.
Hydraulic Engineer
U.S. Army Corps of Engineers
Wilmington District (SAW-TS-EC)
100 West Oglethorpe Ave.
Savannah, GA 31401
912-652-5516

-----Original Message-----
From: Bailey, William G SAM@SAS
Sent: Tuesday, March 27, 2007 5:11 PM
To: Garrett, Thomas A SAS
Cc: Hoke, Joseph T SAW@SAS; Bradley, Kenneth P SAM
Subject: SH Expansion - decision on M2M

I've received concurrence in my recommendation from 2 of the 3 agencies. The one I have not heard from is now out of the office for 2 weeks.

I have not heard from either of the 2 Corps folks included on the concurrence/non-concurrence list.

BB

Sent from my BlackBerry Wireless Device

From:	Garrett, Thomas A SAS
To:	Bailey, William G SAM@SAS
Subject:	FW: SH Expansion - decision on M2M
Date:	Monday, April 02, 2007 10:40:53 AM

Based on the meetings held on this subject and the opinions of the technical modellers, I concur that modification of the M2M is not necessary.

T. Alan Garrett
Project Manager

-----Original Message-----
From: Hoke, Joseph T SAW@SAS
Sent: Monday, April 02, 2007 7:44 AM
To: Bailey, William G SAM@SAS; Garrett, Thomas A SAS
Cc: Bradley, Kenneth P SAM
Subject: RE: SH Expansion - decision on M2M

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BB

Sent from my BlackBerry Wireless Device

From:	Bailey, William G SAM@SAS
To:	ed_eudaly@fws.gov; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"; "Kay Davy (kay.davy@noaa.gov)"; hmoorer@gaports.com
Cc:	Garrett, Thomas A SAS; Bradley, Kenneth P SAM; Small, Daniel L SAD; Barnett, Dennis W SAD; Kopecky, Steven A HQ02; Matusiak, Mark HQ02
Subject:	Savannah Harbor Expansion Project: Cooperating Agencies
Date:	Wednesday, March 26, 2008 6:23:50 PM
Attachments:	EXPAN Mitigation Plan Summary 26Mar08.doc

I've attached a summary of the preliminary mitigation plans. We have not fleshed-out all the details of the various features, but I believe this summary is sufficient to use for plan comparison/selection purposes. Some items are shown on the second page as being included with a "YES". Those items would not change by channel depth alternative.

These plans have not yet been coordinated with the natural resource agencies or the public. This distribution to you is the first they have been seen beyond those who participate regularly in the weekly PDT meetings. We're sending this to you as representatives of the Cooperating Agencies. We will make a wider distribution later when we have firmed up more details.

My next mitigation task is to write up a description of these plans (and hopefully the rationale we used to develop them) so that the USFWS can prepare a Planning Aid Report. That PAR will be available for the AFB and is intended to be an early version of the multi-agency Fish and Wildlife Coordination Act Report. I should be sending our description out in about 3 weeks.

Bill Bailey

SAVANNAH HARBOR EXPANSION PROJECT

SUMMARY
OF
MITIGATION PLANS

During development of the project, numerous means were taken to avoid and/or minimize adverse environmental impacts. Those means were included in the various depth alternatives and are to be incorporated into the recommended plan. Where adverse impacts to natural resources could not be avoided, mitigation of significant adverse impacts was included. The natural resource mitigation plan consists of the following components:

- Constructing and operating flow re-routing features in and near the Savannah National Wildlife Refuge to reduce salinity impacts to tidal freshwater and brackish wetlands;

- Acquiring bottomland hardwoods/freshwater wetlands to compensate for salinity increases to tidal freshwater wetlands. The acquired lands would become part of the Savannah National Wildlife Refuge and be managed by the US Fish and Wildlife Service;

- Constructing and operating a dissolved oxygen system to remove the incremental effects of this harbor deepening project;

- Constructing and operating a fish bypass channel at the New Savannah Bluff Lock and Dam to compensate for impacts to Shortnose sturgeon habitats;

- Funding a striped bass stocking program to compensate for adverse impacts to striped bass spawning and nursery habitats within estuary;

- Constructing a secondary water intake line, located further upstream, to address uncertainties in the predictions of impacts to the City of Savannah's municipal and industrial water withdrawal from Abercorn Creek;

- Monitoring prior to, during, and after construction to (1) ensure that any major unexpected adverse impacts are identified early, and (2) provide information to assess whether the project and mitigation are functioning as expected. The monitoring would vary over time and generally include hydrodynamics, water quality, wetlands and Shortnose sturgeon;

- Implementing adaptive management features if post-construction monitoring shows them to be needed. Those features consist of removing the Tidegate sill, enlarging the diversion structure at the mouth of McCoy's Cut, a diversion structure at the junction of Middle and Back Rivers, and acquisition of up to another 10 percent of freshwater wetlands. Implementation of any or all of these features may not be needed, but the project would include funding sufficient to implement all of them. Which of these features would be implemented would depend on the findings of the monitoring.

The mitigation plan is designed to address adverse impacts to tidal wetlands (including freshwater, brackish, and salt marshes), levels of dissolved oxygen in the harbor, endangered Shortnose sturgeon habitat, Striped bass spawning and nursery areas, and chloride levels at a City of Savannah water intake.

A cultural resource mitigation plan is included for the CSS Georgia, a site listed on the National Register of Historic Places. The CSS Georgia is a Confederate ironclad that rests on the bottom of the river adjacent to the navigation channel near Back River. The wreck was found to be in poor condition. The District determined that the wreck must be removed, recovered to the extent possible, documented, and items of historic significance curated to prevent further loss to any remaining components of the site. These actions would be performed during construction of the harbor deepening.

The mitigation plans would vary by channel depth alternative as follows:

	CHANNEL DEPTH ALTERNATIVE			
	44-FOOT	**45-FOOT**	**46-FOOT**	**48-FOOT**
FLOW RE-ROUTING	Plan 6B	Plan 6A	Plan 6A	Plan 6A
WETLAND ACQUISITION	136 Acres	1,129 Acres	1,219 Acres	2,230 Acres
DISSOLVED OYXGEN SYSTEM	52,800 lbs/day	39,600 lbs/day	46,200 lbs/day	61,600 lbs/day
FISH BYPASS CHANNEL	Yes	Yes	Yes	Yes
STRIPED BASS STOCKING PROGRAM	$54,800 Per Year	$44,500 Per Year	$49,500 Per Year	$69,100 Per Year
SECONDARY WATER INTAKE LINE	Yes	Yes	Yes	Yes
CSS GEORGIA	Yes	Yes	Yes	Yes
POST-CONSTRUCTION MONITORING	Yes	Yes	Yes	Yes
ADAPTIVE MANAGEMENT -- FLOW CHANGES	Yes	Yes	Yes	Yes
ADAPTIVE MANAGEMENT -- LAND ACQUISITION	14 Acres	113 Acres	122 Acres	223 Acres

NOTE: Where "Yes" is included, the feature would not vary by channel depth.

From:	Bailey, William G SAM@SAS
To:	"Ed Eudaly"; "Kay Davy (kay.davy@noaa.gov)"; "Ted Bisterfeld (bisterfeld.ted@epa.gov)"
Cc:	"Kelie_Moore@coastal.dnr.state.ga.us"; "Brad_Gane@dnr.state.ga.us"; "Keith_Parsons@mail.dnr.state.ga.us"; "Tim_Barrett@dnr.state.ga.us"; "_Jeff_Larson@dnr.state.ga.us"; "Wade Cantrell"; "beckhajc@dhec.sc.gov"; "Priscilla H Wendt (wendtp@dnr.sc.gov)"; "Larry Turner"; "Rheta Geddings"; "Bob Perry"; "pconrads@usgs.gov"; "Pace.Wilber"; "Stephania Bolden"; "Mueller, Heinz J."; "greenfield.jim@epa.gov"; "Bill_Wikoff@fws.gov"; Bradley, Kenneth P SAM; Okane, Jason D SAS; Flakes, Curtis M SAM
Subject:	Savannah Harbor Expansion Project - Monitoring and Adaptive Management Plan
Date:	Friday, April 03, 2009 1:07:41 PM
Attachments:	DEIS Appendix D Monitoring and Adaptive Management Plan.pdf

Some of you have asked for our proposed Monitoring and Adaptive Management Plan. I've attached what was in the 90% version of the DEIS that we provided last summer. We have not yet updated these documents, but we will as part of our preparation of the full DEIS. If you have specific changes you would like us to consider, please let me know.

Bill Bailey

From:	Bailey, William G SAM@SAS
To:	"meiburg.stan@epa.gov"; "giattina.jim@epa.gov"; "mueller.heinz@epa.gov"; Semonite, Todd T BG SAD; Kertis, Edward COL SAS; "roy.crabtree@noaa.gov"; "david.bernhardt@noaa.gov"; "sam_hamilton@fws.gov"; "Jeff_Weller@fws.gov"; "sgreen@gaports.com"; "steve@sgreenproperties.com"
Cc:	"jack_arnold@fws.gov"; Flakes, Curtis M SAM; Oddi, Peter A SAS; Dixon, Lester S SAD; Paynes, Wilbert V SAD; Small, Daniel L SAD; "hmoorer@gaports.com"; Okane, Jason D SAS; "mmattingly@comcast.net"
Subject:	Savannah Harbor Expansion Project - 30 April Executive Steering Committee Meeting
Date:	Monday, July 06, 2009 9:53:00 AM
Attachments:	Sav Harbor Expansion EMG 30 Apr Agenda.doc EXPAN Exec Steering Committee MFR 30Apr09 (Rev 27Jun).doc SHEP Issue Tracking 30April ESC mtg.xls

I am providing the Corps' final MFR of the 30 April meeting. It includes revisions that we made in response to your review of the Draft MFR.

We have highlighted portions of the MFR that documented particularly important discussions and where the Corps or others committed to a future action.

I have also attached a spreadsheet that shows the issues that were raised, the responses taken, and whether the agency considers the issue closed. We would like your staff's assistance in keeping this spreadsheet current. We highlighted portions of the spreadsheet in Yellow to show areas where some response is still needed. Other portions will be highlighted in another color (Blue) to show when an issue has been satisfactorily resolved. If we have provided a response that addresses your concern, we need your staff to let us know that the issue is resolved. Hopefully, the staffs can keep this file up to date. Then we would then be able to use this tool at the ESC meetings to track progress. We are expanding this spreadsheet to include all issues that you and your staff raise concerning this project. We will coordinate that larger spreadsheet with your technical staffs.

The next meeting of the Executive Steering Committee is scheduled for 20 August in Savannah. GPA has agreed to provide a tour of their terminals prior to the meeting, as well as provide a conference room for the ESC to meet. The following is a preliminary schedule for that day:

0900 Meet at GPA to tour terminals
0930-1030 Tour
1030-1100 Back to GPA office
1100-1500 ESC Meeting (includes working lunch)
1500-1530 Wrap-up
1530 Adjourn

Directions to GPA's Administration Building can be found at the following website:
http://www.gaports.com/Facilities/GardenCityTerminal/AddressDrivingInstructions/tabid/258/Default.aspx

Bill Bailey

>____
>From: Rees, Shirley M SAD
>Sent: Friday, April 24, 2009 8:27 AM
>To: 'meiburg.stan@epa.gov'; Kertis, Edward COL SAS; 'roy.crabtree@noaa.gov'; 'sam_hamilton@fws.gov'; 'mmattingly@comcast.net'; 'sgreen@gaports.com'; 'steve@sgreenproperties.com'
>Cc: 'jack_arnold@fws.gov'; 'giattina.jim@epa.gov'; 'mueller.heinz@epa.gov'; Flakes, Curtis M SAM; Oddi, Peter A SAS; Bailey, William G SAM@SAS; Dixon, Lester S SAD; Paynes, Wilbert V SAD; Small, Daniel L SAD; 'hmorrer@gaports.com'; 'david.bernhardt@noaa.gov'; Okane, Jason D SAS
>Subject: SHEP Executive Steering Committee Meeting - 30 April
>
> << File: Sav Harbor Expansion EMG 30 Apr Agenda.doc >> << File: SH Expansion Exec Steering Com MFR 27 Feb 09.doc >>

>
>Gentlemen,
>
>I am sending this on behalf of BG Joseph Schroedel as a reminder of the SHEP Executive Steering Committee Meeting to be held in Atlanta, SAD Headquarters, 10th floor Executive Conference Room from 1300 - 1600. I have attached the agenda for the meeting on 30 April and the minutes from the last meeting, held 17 Feb.
>
>The incoming SAD Commander, BG Todd T. Semonite will also attend this meeting.
>
>The POC for the meeting is Mr. Daniel Small, 404-562-5224 or daniel.l.small@usace.army.mil
>
>Thanks for your time and attention.
>
>v/r
>Shirley
>
>Shirley M. Rees
>Executive Assistant
>South Atlantic Division
>US Army Corps of Engineers
>404-562-5005
>
>

CESAM-PD-E 4 December 2008
Revised 11 December 2008

MEMORANDUM FOR RECORD: Savannah Harbor Expansion Project;
Interagency Coordination Meetings

1. The Corps called an interagency coordination meeting on 1 December in Charleston, SC. EPA could not attend that meeting. The District met with them and GA DNR-EPD on Wednesday, 3 December, in Atlanta. The attendees for both meetings are shown at the end of this MFR.

2. The meetings were held as both a continuation of our ongoing coordination on this project and as preparation for a meeting of the Executive Management Group in mid-December.

3. I began with information about the upcoming EMG meeting. The details are still being determined, so I stated that I would provide them with a copy of the meeting goals when they were finalized and distributed.

4. We then began by going through the 12 recommendations included in the November 2008 Draft Fish and Wildlife Coordination Act Report (FWCAR). The first recommendation is "*In order to reduce impacts to fish and wildlife resources, limit any channel deepening project to the 44 foot or 45 foot alternative.*" The agencies stated that they believe that the various alternatives are not environmentally equivalent. They believe that since the impacts increase with project depth, the alternative with the least amount of deepening had to be the best for the environment. I stated that with the mitigation included, the Corps considered the alternatives to be environmentally equivalent. I stated that unless an agency felt that the mitigation for a particular depth was unacceptable, the Corps would consider the alternative to be acceptable from an environmental perspective. We agreed that the Coordination Act Report should identify the plan(s) which would result in the least impacts to the environment. The ultimate decision on the best plan would include consideration of other factors, such as economic impacts.

5. Recommendation #2 is "*Initiate repair of the Savannah NWR freshwater supply system no later than initiation of harbor construction and complete repair in a timely manner (within two years of start.*" I stated that the Corps was still evaluating this issue, but that guidance from HQUSACE in the Planning Guidance Memorandum (PGM) from the August 2008 Alternative Formulation Briefing (AFB) was that we should include this as a project feature if it had not already been accomplished or underway using other Corps funds (pages 39/40).

6. Recommendation #3 is "*Prior to or concurrent with harbor deepening, implement flow and channel modification mitigation as described in the Corps plan, with the exception of the "broad berm" in Back River. Continue coordination with regulatory agencies to determine potential impacts of the berm and evaluate alternatives to the berm.*" We clarified that there is both a technical and a policy issue. The technical concerns are with water quality (low dissolved oxygen) and off-site sedimentation (fines moving offsite during construction and settling upstream in Back River). The Corps reiterated that the placement of new work sediments within the basin was not as an alternate disposal site, but was intended to speed the filling of the Sediment Basin so that it would provide its mitigation function of blocking upstream movement of saltwater up Back River as soon as possible. I stated that our cost estimates included construction of the sill using sediments from the confined upland sediment containment areas, not from the bottom of the river. SC DNR asked that we clarify in the DEIS the purpose of the sill – to limit upstream movement of salinity and encourage subsequent natural sedimentation within the basin. SC has a policy against open-water disposal of sediments. All agencies recommended we provide more explanation of the construction technique. The agencies recommended we use as coarse of sediments as possible. The DEIS presently contains an acceptability criteria of 75% sands. I stated the Corps would examine if we could increase that threshold to 85% without greatly increasing costs. I stated that the Corps may want to use a small hydraulic dredge to construct some of the sill using sediments that become available when we remove the abutments of the Tidegate. The agencies thought that would be acceptable, as the sediment should very sandy. The agencies asked about altering the construction sequencing, with the blocking of Rifle Cut occurring very early in the process. The belief is that this blockage may reduce flow volumes up Back River, thereby reducing the possibility of distributing fines up that river. The agencies questioned whether the sediment that accumulates in the Sediment Basin is suspended in the water column or is transported along the bottom. Their concern is whether the sill would increase or decrease the subsequent filling rate of the basin. They asked that the Corps' hydraulic engineers make a statement of their belief about whether the sill would increase or decrease the subsequent filling rate of the basin or increase the shoaling rate in Back River upstream of the basin. Note – the basin is now 4-feet above the adjacent navigation channel (it was not deepened during the last harbor deepening), so it is unlikely that it receives sediments that move along the bottom of the river.

7. Recommendation #4 is "*Fully fund Georgia DNR to produce striped bass for mitigation stocking as described in this report*". GA DNR-WRD stated that it is conducting its Striped bass stocking to counter the effects of previous harbor deepening projects. The Striped bass population has increased over the years, primarily as a result of their stocking, but the population is not yet self-sustaining. WRD confirmed that it intends to continue the stocking program to ensure a population of Striped bass continues to exist in this estuary. Because it is stocking as a result of prior actions by the Corps, WRD requests that the Federal Navigation Project fund all the costs of that stocking program. I reiterated the Corps Headquarters' early guidance that the SH Expansion Project could not be used as a vehicle to mitigate for impacts from previous harbor improvement projects. Therefore, I did not believe the Corps would concur in WRD's request.

The DEIS proposed to pay a portion of WRD's Striped bass stocking program based on the percentage of habitat that the proposed project would impact. GA DNR-WRD is proposing a slightly different approach to calculating the impact numbers than was included in the DEIS. The different approach is explained in the Draft FWCA Report. The Corps will examine the different approach proposed by WRD for calculating the level of impact. If the Corps finds that WRD's approach is technically sound, it would include it in the DEIS.

8. Recommendation #5 is "*Initiate land acquisition, in the amount recommended by the Service in this report (Table 17), no later than initiation of harbor construction and complete acquisition in a timely manner (within two2 years of start).*" I stated that the Corps concurred in starting the land acquisition early in the construction process. The Draft FWCA Report indicates that the DEIS may have incorrectly calculated the number of acres needed to be acquired. I stated that I my initial review agreed with the procedure included in the FWCA Report, but that I needed to examine documents in my files before I could fully agree with the recommended changes. I need to confirm that the wetland acreages used in the FWCA Report are based in the latest version of the impact numbers. If my examination confirms the numbers in the FWCA Report, we will revise the DEIS.

I highlighted on item in the SOP calculations to the agencies. The Draft FWCA Report recommends using the maximum value for the existing hydrology of the tidal freshwater marshes. The DEIS had used a lower value to reflect the existence of the man-made rice canals. The agencies confirmed that they believe that the rice canals should not be viewed as an unnatural alteration of the hydrology of the area. They believe that the canals have become naturalized after being in place for more than 150 years; that they do not hinder tidal flows to and through those marshes; and that the canals provide the full ecological functional of a natural creek.

9. Recommendation #6 is "*Provide in-kind restoration of estuarine emergent wetlands within the lower Savannah River Basin system for the 7.2 acres of wetlands that would be excavated because of channel or turning basin widening.*" The Corps agrees to provide in-kind mitigation for the direct losses of saltmarsh. The Corps has attempted to identify a site to restore or create saltmarsh. It first considered saltmarsh along the lower portion of the channel, but concluded that the narrow river would make such a measure would be very expensive on a per acre basis. The Corps then sought recommendations from the agencies. GA DNR-CRD suggested a couple of sites that had previously been identified along the Intracoastal Waterway (grading down old disposal mounds) and in the Savannah area (removing small dams that now create ponds in residential areas). The USFWS suggested options around the ends of the Tidegate. The Service also identified grading down a previous disposal site (Area 1S). Area 1S is quite close to the impact area and appears to contain sufficient size to allow 40-50 acres of marsh to be restored without needing to remove the large trees that exist close to the Savannah River side of the site. The Corps will pursue use of this site. It will have its geotechnical engineers provide a statement on the type of sediment expected to exist on the site. If the sediments are primary sand, the USFWS is open to their being deposited in CDF 1N, where the

material could be reused. The agencies also stated that if the sediments were predominantly sand, they may be suitable for creating the sill at the mouth of the Sediment Basin.

10. Recommendation #7 is "*Cap all new work sediment containing elevated cadmium concentrations (identified as "high" and "low" in the risk assessment) with clean material.*" The Corps continues to believe that covering all the cadmium-enriched sediments is unnecessary. It has prepared responses to the USFWS comments and will be providing that to the Service soon. SC DNR expressed support for the Service's position and will be provided a copy of the Corps' responses.

11. Recommendation #8 is "*Dispose of all suitable (meeting Georgia DNR criteria) new work sediments in the intertidal or near shore area off Tybee Island.*" This comment basically supports the new work placement plan proposed in the DEIS. The DEIS recommends placing suitable new work sediments within the nearshore area. Because of guidance received at the AFB concerning CZM compliance, the DEIS will be revised to remove placement of some O&M sediments in the nearshore area. Those sediments would now continue to be deposited in the ODMDS.

12. Recommendation #9 is "*Install a fish passage facility at New Savannah Bluff Lock and Dam or remove the dam to restore the river. Continue coordination with resource agencies to optimize design of any fish passage facility.*" This comment basically supports the mitigation proposed in the DEIS for Shortnose sturgeon. The focus of the design of the fish passage structure should be SNS. The agencies agreed that a structure that successfully passes SNS would also allow passage of other anadromous species. The Corps agreed to coordinate further with the agencies on the design of the structure. That coordination would occur if/when the project is approved and would concentrate on whether the state-of-the-art has improved since the bypass was originally designed so that it should be adjusted to improve its ability to pass sturgeon.

13. Recommendation #10 is "*Expand the proposed adaptive management plan to include potential modifications of the oxygen injection system and adequate contingency funding for the modifications.*" The Corps agrees to revise the adaptive management plan to include funds to modify oxygen injection systems. We will include funds at the same rate as fore the other mitigation features – 10% of initial construction costs.

The agencies expressed continued concern about the ability of the oxygen injection systems to improve D.O. levels throughout the harbor. They questioned whether the Corps would continue to provide funds to operate the systems if O&M funding levels are insufficient for both dredging and mitigation needs. I stated that we recognized that failing to operate the systems would result in the project being out-of-compliance with it Section 401 water quality certifications. The Corps agreed to check with GPA and request that their consultants complete the update to their report on the 2007 D.O. Demonstration Project. NOAA-Fisheries stated that review of that report by a National Academy (the Marine Board) may be appropriate because this is such a critical component of the mitigation plan and a fairly large investment ($50 million capital cost). The Corps stated that it intended to have ERDC review the report and agreed to ask ERDC if review by a National Academy would more appropriate.

14. Recommendation #11 is "*Investigate the feasibility of constructing a public boat ramp, dock, and parking area on the South Carolina side of Back River at the tide gate site to compensate for this lost recreational use.*" Since the AFB, the Corps has investigated the feasibility of constructing a boat ramp. It has been unable to identify lands which are suitable for placement of a ramp. A site along US Highway 17 which is available does not provide sufficient depths at all tides. Lands which appear to be suitable are not readily available. Other sites would require filling of wetlands, which the agencies say they do not want. The Corps agreed to again ask about use of the Tidegate site. The agencies stated that Jasper County would likely be willing to take ownership of the underlying land, which had been a concern of the present landowner – the GA DOT. Security of the adjacent confined sediment placement sites had been a concern previously identified by the Corps staff. We will re-examine that issue.

The agencies stated that their may be a possibility of working with GA DOT on a nearby project – the replacement of the bridge over Back River. During the meeting, the USFWS contacted GA DOT and found that the new bridge would not provide suitable area underneath it for use as a ramp, that the project would use the existing alignment for 2 of the new lanes, and that the project had been put on hold due to budget concerns. Due to these issues, the Corps will not pursue the potential of combining these projects.

15. Recommendation #12 is "*Implement the proposed comprehensive monitoring program to document project impacts. Continue coordination with resource agencies to develop a data analysis and information delivery plan as part of the monitoring program.*" This comment basically supports the proposed monitoring plan and recommends further coordination to refine it further. The Corps agreed to continue to work with the agencies on the monitoring and adaptive management plan. It recognized that the plan is not perfect and welcomed suggestions on specific wording that would clarify or refine the plan.

The agencies suggested that more detail be included in the plan. It requested the plan address how the data would be used. (That is already addressed to some degree in the plan.) The success criteria should be as clear as possible. NOAA-Fisheries suggested the agencies hold meetings once or twice a year to review the monitoring results.

The agencies questioned how we would evaluate the effectiveness of the mitigation features. The Corps stated that the data would be compared to what the models predict would occur under the conditions that are experienced (river flows, temperature, etc). The variation of the models from the data would be viewed in light of the acceptability criteria used to assess the initial acceptability of the model (Federal Expectations Document).

16. We then reviewed the guidance provided by the Corps' Headquarters at the AFB or in the subsequent PGM. The Corps stated that it would be deleting the additional 50 acres of wetland mitigation proposed in the DEIS to address inaccuracies in the impact analysis procedures. Since the inaccuracy is both + and -, Headquarters did not believe it was appropriate to only add additional acres to the mitigation requirement.

The Corps will be removing the additional value assigned to wetlands that would be lost just because they occurred on the National Wildlife Refuge. The agencies agreed that following the SOP would be sufficient.

The Headquarters' guidance is that only benefits to the O&M dredging program could be included in assessing the viability of the advance maintenance features on the entrance channel. Impacts to other projects or resources are not to be included. The District stated that with those criteria, that advance maintenance feature would not be economically justified and would be deleted from the DEIS.

In response to Headquarters' guidance concerning CZM compliance, the Corps will be removing nearshore placement of some O&M sediments. The District was not able to identify any non-Federal sponsor willing to pay the incremental costs of such placement. Nearshore placement of new work sediments would remain as proposed in the 90% version of the DEIS. The DEIS will say that all O&M sediments would be deposited in the ODMDS after the harbor is deepened, just as they are now.

Corps Headquarters had concluded that fish passage at New Savannah Bluff Lock and Dam would be an acceptable mitigation feature for this project. They resolved their previous policy concerns about including that action as part of this project.

The Headquarters' guidance is that restoration of the Freshwater Control System should be a part of this project if it is not constructed prior to the Base year by the O&M Project. The Corps is still examining the appropriate funding source for that work, but the Headquarters guidance clarifies that the work will be performed by the Corps if the SH Expansion Project is approved and constructed.

17. We then reviewed the comments provided by the agencies at the AFB.

NOAA-Fisheries stated that it considered as necessary to evaluate project impacts a benthic or sediment survey of the area to which the Shortnose sturgeon would move. This is the area just upstream of where the fish generally reside now. NOAA gave the name of Gary Ray at ERDC as a potential technical source of information for such a survey. The Corps agreed to consult with Mr. Ray.

The Corps said that it was working with NOAA to evaluate whether modifications to the criteria of acceptable SNS habitat are appropriate. The present criteria do not show as "Acceptable" areas where recent studies have found sturgeon to reside. If NOAA and the Corps believe such changes are warranted, we will coordinate with the other agencies that originally developed the criteria to ensure they agree with the changes.

NOAA again requested figures (maps) that show the extent of the D.O. impacts. The Corps had been working on that information and intended to include it in the revised DEIS. The agencies said that if their management would be asked for their position on the acceptability of the mitigation prior to release of the DEIS, the staff would need that information prior to release of the document. A sample of D.O. information was emailed to agency staff on 4 December for review.

The Corps asked about the purpose of the nearshore monitoring if the nearshore deposition was revised to being only a one-time placement. GA DNR-CRD stated that their initial request was based on the design in the 90% version of the DEIS which called for nearshore placement of O&M sediments. CRD continues to support the use of the MLW200 and MLW500 placement sites, as well as the other nearshore placement sites. CRD believes that annual monitoring would still be appropriate for 2 years to provide information on the direction and rate of migration of the deposited sediments. They noted that some of this monitoring may already be conducted as part of the Tybee Island Shore Protection Project.

18. At the 3 December meeting in Atlanta, EPA stated that they had not participated in preparation of the Draft Fish and Wildlife Coordination Act Report or reviewed its recommendations. I agreed to provide them a copy of the document. GA DNR-EPD could not remember reviewing the draft document and also requested a copy.

At the AFB, EPA had suggested the use of a mitigation bank to provide the saltmarsh mitigation needs. They reiterated that suggestion at the interagency meeting and noted that the 2007 WRDA included language that states that the Corps is to first consider the use of mitigation banks to meet the mitigation needs of civil works projects. The District agreed to review the Corps guidance on that portion of the WRDA. The guidance states that the Corps civil works projects should consider mitigation banks first as the means of meeting a mitigation commitment. The USFWS believes that because of the cumulative losses within the estuary over time, this mitigation should be performed with in the basin, as is the other mitigation. The one operating saltmarsh bank within the Savannah River basin presently does not have any credits available for sale. The timing and amount of the availability of additional credits are uncertain. The Corps believes that it can successfully perform an on-site saltmarsh restoration project of a size that would provide substantial ecological benefits to the estuary, and intends to pursue the restoration described above in section 9.

EPA raised the possibility of a link between harbor deepening and the berth deepening for which GPA is presently seeking approval through the Regulatory Program. EPA questioned whether the berth deepening was a stand-alone project that possesses independent utility, or just the first step of an overall harbor deepening. The District stated that the economic revisions that the Corps was performing would only consider the berths at their present depth and would not include any additional traffic volume that a deeper berth may produce.

In comments provided at the AFB, EPA had suggested adding a magnitude factor to the wetland SOP procedures. The SOP used in SC contains such an additional factor for large construction projects. GA DNR-EPD had also suggested adding a magnitude factor to the Georgia SOP procedures. The District raised this issue for discussion at the interagency meeting. EPA acknowledged that the majority of the wetlands that would be impacted by the project would result in a conversion of one wetland type to another – freshwater to brackish or brackish to saltmarsh. They stated that they were uncertain what most functional assessments would show for such an action, as the same wetland functions would exist in both the Before and After conditions. One type of marsh would be higher in some functions and lower in others, but the overall ecological difference may be difficult to determine. It would likely result in a tradeoff between one wetland function and another, which would be a value judgment. Without a strong belief that a magnitude factor is technically supportable and likely to be helpful in clearly identifying the difference between the Before and After conditions, the District will not pursue this issue further.

19. The District agreed to prepare a record of the meetings and distribute it to the participants for review. It is hoped that the record would be useful to the agency staff in briefing their management for the 16 December meeting of the Executive Management Group.

William G. Bailey

William Bailey
Physical Scientist

SAVANNAH HARBOR EXPANSION PROJECT

INTERAGENCY MEETING

ATTENDEES

Monday, 1 December, Charleston, SC

USFWS	
Ed EuDaly	843-727-4707, X227
Bill Wikoff	912-265-9336
Jane Griess	912-652-4415
Mark Caldwell	843-727-4707, X215
NOAA Fisheries	
Pace Wilber	843-953-7200
Kay Davy	843-953-7202
Stephania Bolden	727-824-5312
SC DNR	
Priscilla Wendt	843-953-9305
SC DHEC	
Chris Beckham	803-898-4261
GA DNR-WRD	
Tim Barrett	912-727-2112
GA DNR-CRD	
Kelie Moore	912-264-7218
US Army Corps of Engineers	
William Bailey	912-652-5781
Jason O'Kane	912-652-5276
Paul Bradley	251-694-4101 (by phone)

Wednesday, 3 December, Atlanta, GA

<u>EPA</u>	
Heinz Mueller	4-4-562-9611
Ted Bisterfeld	404-562-9621
Bob Lord	404-562-9408
Jim Greenfield	404-562-9238 (by phone)
<u>GA DNR-EPD</u>	
Keith Parsons	404-675-1631
<u>US Army Corps of Engineers</u>	
William Bailey	912-652-5781

From: Flakes, Curtis M SAM
To: Garrett, Thomas A SAS; Bailey, William G SAM@SAS; O''kane, Jason D SAS; Parrott, Daniel L SAS; Bradley, Kenneth P SAM; Moseby, Bernard E SAM; Boatman, Todd H; giattina.jim@epa.gov; cox.williaml@epa.gov; greenfield.jim@epa.gov; mueller.heinz@epa.gov; bisterfield.ted@epa.gov; miles.croom@noaa.gov; kay.davy@noaa.gov; pace.wilber@noaa.gov; hmoorere@gaports.com; dschaller@gaports.com
Subject: FW: Savannah Harbor Expansion Executive Management Group, Steering Group Meeting
Date: Wednesday, December 10, 2008 6:52:20 PM
Attachments: SHEP EMG Charter.doc

All

This charter was emailed to the EMG members or their designees today for discussion on the 16th Dec.. Please share as needed.

Curtis

-----Original Message-----
From: Flakes, Curtis M SAM
Sent: Wednesday, December 10, 2008 5:36 PM
To: Kertis, Edward COL SAS; Schroedel, Joseph BG SAD; jack_arnold@fws.gov; christy.don@epa.gov; roy.crabtree@noaa.gov; sgreen@gaports.com; 'Cindy Graves'
Cc: Dixon, Lester S SAD; Oddi, Peter A SAS; Paynes, Wilbert V SAD
Subject: Savannah Harbor Expansion Executive Management Group, Steering Group Meeting

Dear EMG Member:

Enclosed is the proposed charter for the Savannah Harbor Expansion Executive Management - Steering Group (EMG. This will be discussed at the meeting on 16 December.

Thanks!

Curtis

-----Original Message-----
From: Flakes, Curtis M SAM
Sent: Monday, December 01, 2008 5:08 PM
To: Kertis, Edward COL SAS; Schroedel, Joseph BG SAD; jack_arnold@fws.gov; christy.don@epa.gov; roy.crabtree@noaa.gov; sgreen@gaports.com
Cc: Dixon, Lester S SAD; Oddi, Peter A SAS; Paynes, Wilbert V SAD
Subject: Savannah Harbor Expansion Executive Management Group, Steering Group Meeting

Dear EMG Member:

Please find enclosed the proposed agenda for the next Executive Management - Steering Group (EMG) meeting scheduled for December 16, 2008 in Atlanta, Georgia. The meeting will be held at our South Atlantic Division Headquarters, Sam Nunn Federal Center, 10th floor Mid-rise Building, Main Conference Room located at 60 Forsyth Street, SW. Additional read-head information will be sent to you prior to the meeting.

If you have any questions concerning the meeting, please call me at (251) 690-2777.

Curtis M. Flakes
Chief, Planning and Environmental Division
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Recommended Overarching Goal of Executive Management Group (EMG)

To facilitate interagency concurrence on the analysis conducted on the proposed Savannah Harbor Expansion Project and to facilitate timely decisions on the feasibility of the proposed project.

Charter of the Executive Management Group (EMG)

1. Provide senior executive-level leadership and guidance to Federal interagency staffs working on the SHEP.

2. Serve as a forum to raise, discuss, and resolve major issues.

3. Participate in each meeting and represent respective agency's views.

4. Remain informed on respective agencies' position on issues within the study.

5. Communicate openly, clearly, and rapidly all issues or concerns that could render any recommended plan unacceptable.

6. Jointly develop solutions to problems and issues that could adversely impact the EMG's overarching goal.

7. Provide necessary resources for timely and complete participation issue resolution.

CESAS-PM-C 18 December 2008
Revised 16 February 2009

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Executive Management Group (EMG) Meeting

1. The Corps held an interagency coordination meeting on 16 December 2008, at the US Army Corps of Engineers (USACE) South Atlantic Division (SAD) office in Atlanta, Georgia. Attendees included Brigadier Gen. Schroedel (USACE, SAD), Col. Kertis (USACE, Savannah District (USACE, SAS)), Mr. Don Christy (US EPA), Mr. Jack Arnold (USFWS), Mr. Buck Sutter (NOAA Fisheries), and Mr. Steve Green, Mr. David Schaller, Ms. Hope Moore (Georgia Ports Authority). Former U.S. Senator Mack Mattingly, who is working on GPA's behalf, attended by phone. A sign in sheet identifying all attendees for this meeting is attached at the end of this MFR.

2. The meeting was held as both a continuation of the ongoing coordination on the Savannah Harbor Expansion Project General Reevaluation Report and Tier II EIS and to assure effective and efficient communication between resource agency executive managers in anticipation of the need for future decisions.

3. A meeting notebook was provided that contained an agenda, group charter, meeting objectives, project status, project schedule and other supporting materials. This notebook is for reference in both this meeting and future EMG meetings.

4. The meeting began with an introductions and a welcome from Gen. Schroedel and Col. Kertis. Col Kertis stated that the purpose of the meeting was to update the agency executive managers on the project status and issues. This "baseline" of knowledge is to prepare the executives for future meetings of this group, including one in mid-February 2009. The group reviewed and approved the meeting goals and charter.

5. Mr. Steve Green asked how would our new January 2009 Presidential administration affect agency representation within this group. He also stated that one of the purposes of this group was to provide continuity of people as each agency changes. Mr. Christy (EPA) was unsure how the administration change would affect their positions. The representatives of the USFWS and NOAA Fisheries indicated that their agencies would not be affected by a new administration.

6. A PowerPoint presentation reviewing the project purpose and background was given by Mr. Alan Garrett (USACE, SAS). Topics include the Panama Canal expansion in 2014/2015, history of project authorization and development, studies completed, and funds expended. Mr. Bill Bailey (USACE, SAM) then presented a summary of interagency coordination that had occurred to date, the methodology for the development of the proposed mitigation plan, and the Corps' understanding of the current status of the environmental issues. His presentation ended with a

list of the remaining environmental issues. A table near the end of this document summarizes the Corps' understanding of those issues. Mr. Jason O'Kane (USACE, SAS) then presented a look ahead at major future milestones that would require action on the part of the resource agencies. During these presentations, several points were discussed by the various participants.

7. Mr. David Schaller commented during the presentation on the numerous Stakeholders Evaluation Group (SEG) meetings which have been held since this phase of the project began in 1999. He stated that in addition to federal agency involvement, there has been numerous meetings with Non-Governmental Organization such as the Georgia Conservancy, the Sierra Club, the Center for a Sustainable Coast, as well as local and state government such as the City of Tybee, City of Savannah, Georgia Department of Natural Resources, South Carolina DHEC, and myriad members of the general public. He characterized the Stakeholders Evaluation Group, managed by the Georgia Ports Authority, as an open public and transparent process that occurs on a frequent basis. It was also stated that the next presentation to the SEG in February 2009 will include a presentation on the need for additional economics work.

8. Gen. Schroedel asked how adaptive management could be used to implement the proposed mitigation. Mr. Bill Bailey stated that we would implement the mitigation necessary to offset our best assessment of adverse impacts. Adaptive management is the process by which changes would be made should monitoring indicate mitigation to be inadequate or to need modification. The environment will benefit if we over-mitigate.

9. Mr. Bill Bailey mentioned that the project included a monitoring and adaptive management plan. The current cost of the proposed mitigation is approximately $170 million which is nearly a third of the total project construction cost. The overall mitigation includes monitoring of project impacts, with regular agency meetings to evaluate the monitoring data collected against what would have occurred without the project. The agencies would review the monitoring data and decide if adjustments to the mitigation features are required. The adaptive management plan includes up-front budgeting that allows the modifications to be implemented if needed. The Corps is willing to refine the monitoring and adaptive management plan by incorporating suggested specific agency revisions as we move forward. The USFWS commented that the important thing was the commitment to adaptive management and that the details could be worked out as planning continues.

10. Sen. Mack Mattingly asked why the adverse impact to South Carolina recreational boating/fishing access was a Federal issue. Col. Kertis responded that when a state registered such a concern on an impact from a Federal project, that it must be considered and that he had received several comments from the public with concern over the issue.

11. EPA commented that they understood the concern over the construction of the Back River sill, but requested a more through and complete explanation on the construction method. Mr. Bill Bailey responded that we were working to develop additional information and that it would be provided to EPA.

12. Col. Kertis mentioned that Speece Cone Oxygenation technology/effectiveness was well documented and that these units are in use around the world. He asked that any criticism of this mitigation technique be fair and if there are comments regarding the system's unacceptability, that the agencies' be prepared to defend their positions from a technical standpoint. NOAA asked to be provided any locations that are similar in character to Savannah Harbor where Speece Cones have been used, and suggested that the National Academy of Science provide a review of the test results. The District stated that it intended to have the Corps' Engineering Research and Development Center (ERDC) review the test results and seek ERDC's opinion on whether review by a National Academy would be more appropriate. Ms. Hope Moorer (GPA) commented that the supplemental report on the additional modeling and interpretation of the Speece Cone testing data was expected in January 2009. The additional analysis has been prepared with the input and assistance of Mr. Paul Conrads, USGS, who is advising USFWS on modeling and water quality issues.
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13. Col. Kertis asked if we investigated oxygen injection further upstream. Mr. Bill Bailey commented that we had and that EPA had stated that oxygen injection further upstream would not be as effective.

14. The USFWS commented that the USFWS Coordination Act report recommends the Corps mitigate in-kind for wetland losses resulting from the channel widening efforts. According to the Refuge Improvement Act (not included in the FWCA Report) is that if the widening impacts/destroys wetlands currently on and managed by the Refuges System - a compatibility determination would have to be completed before that act could be authorized. As this activity is inappropriate on National Wildlife Refuges, a land exchange is the only way that the Service can allow this activity to move forward. Compatibility is only required when the Service authorizes a use or activity that supports the purpose of the refuge, in this case Savannah, and project mitigation cannot be considered when making that determination. The harbor deepening does not support refuge purposes therefore leaving a land exchange as the Service's only option to facilitate this project. Where uses or activities associated with the project support refuge purposes on refuge lands or waters and will be authorized, a compatibility determination will be prepared. Mr. Bill Bailey responded that he would contact the Refuge personnel to clarify this issue and provide needed information. The USFWS added that this would require additional work on their part but they would start it as necessary.

15. Mr. Bill Bailey presented that we are seeking a way to repair the Freshwater Control System constructed as mitigation for the 38-foot Harbor Deepening, however, the source of funding is problematic. Ms. Hope Moorer announced that the GPA had approached the Governor's office with a request to include restoration of the Freshwater Control System in the Federal stimulus package as a means of accomplishing the work expeditiously. Mr. Les Dixon offered to facilitate a separate meeting with the USFWS to resolve the freshwater control structure issue. It

was concluded that the repairs will be included in the SH Expansion Project, if not addressed beforehand.

16. NOAA Fisheries has requested that additional post-construction monitoring be conducted. The Corps stated that it needed a defined period of time to be able to calculate and include monitoring costs. Ms. Hope Moorer (GPA) asked if there was a standard monitoring period for similar Civil Works projects. Mr. Bill Bailey responded that 5 years was the maximum allowable up a few years ago. The Corps believes that 5 years is reasonable for this project.

17. One of the recommendations in the November Draft Fish and Wildlife Coordination Act Report is to deepen to only 44 or 45-feet to lessen environmental impacts. The Service stated that they recommend limiting the deepening to -45 feet because that alternative minimizes the impacts to the environment with a higher level of certainty and confidence. The level of impacts and other uncertainty increases with greater depths. All of the other concerns would apply to all alternatives. Senator Mattingly asked the USFWS about the mitigation proposed for the various depth alternatives, especially the -48 foot project. Mr. Jack Arnold (USFWS) stated that the Service was cooperating with the Corps to develop mitigation plans for the alternatives depths that would make each plan acceptable to their agency and that their position for each depth is contained in the November Draft Fish and Wildlife Coordination Act Report.

18. Col. Kertis explained the importance of a thorough and well documented economic analysis.

19. Mr. Les Dixon (USACE, SAD) commented that ideally, all four agencies should be in support of whatever is recommended in the District Commanders' report submitted to HQUSACE for review and approval in January 2010. The other important date to keep in mind is when the report is sent out for Public Review – presently scheduled to be August 2009.

20. Mr. Steve Green (GPA) commented that a year delay seemed extraordinarily long given that we have completed the lion's share of the technical work and had already undergone numerous reviews as required by the Corps' planning process. He stated that the economics of the entire region will be significantly impacted if we further postpone this project. Gen. Schroedel (USACE, SAD) expressed similar concern and asked that the schedule be reviewed and reduced wherever possible prior to the next meeting of this group.

21. The USFWS commented, in summary, that impacts should be mitigated as effectively as possible after all avoidance and minimization has taken place. Water quality, project uncertainties, the dissolved oxygen system and the Freshwater Control System are their primary concerns. Mr. Arnold stated that a thorough adaptive management plan was absolutely essential. Colonel Kertis agreed and suggested that we have experts from the University of Georgia Ecology Lab participate in the actual monitoring phase. Mr. Arnold stated that the Freshwater Control System needed to be repaired soon, since they have obligations to provide freshwater to downstream private landowners.

22. Mr. Don Christy (EPA) commented, in summary, that impacts to air quality, wetlands, TDMLs, and the project's overall effects in a large sensitive system as the Savannah River Basin are their concerns. The EPA needs additional information on the "new" ship traffic that would occur if the harbor is deepened, since they would impact air quality. They are also skeptical of the Speece Cones effectiveness and the project's overall impacts to a range of species. They are advocates of "avoidance mitigation." In addition, any implications of the proposed Port of Jasper concerns them as well. The GPA commented that the Jasper Port was very hypothetical at this point and that the SHEP project should not be penalized for the existence of an idea. Mr. Christy asked specifically that Air Quality and Jasper Port issues be placed on the next EMG agenda.

23. GPA commented on their recent application to deepen four container berths in the harbor in advance of the Expansion Project. They explained that this was necessary to keep shipping lines from going elsewhere and that it was standard industry practice. There were no additional comments.

24. In closing, topics for the next mid-February 2009 meeting of this group in Savannah include air quality, the Port of Jasper, frequency of additional meetings, continuity of the group and a pre-meeting informal get together. The next meeting will also include a tour of the GPA facility along with maps of pertinent harbor features. The GPA's existing command briefing and operational overview of port facilities will also be presented. An April meeting was discussed to review the results of the economic analysis.

25. After the meeting, NOAA provided written comments which are attached.

26. The District agreed to prepare a record of the meetings and distribute it to the participants for review. The record can be used for agencies to inform their staff of discussions at this meeting and expectations for the next meeting.

JASON O'KANE
Project Manager

Agenda items for future meetings:

1) Air quality
2) Potential Jasper Terminal
3) Frequency of EMG meetings
4) GPA Presentation
5) Economic Analysis Presentation
6) NOAA Fisheries December 08 Position Paper

ENVIRONMENTAL ISSUES

	Issue	Resource Agency Recommendation	Corps Response	Resolution Anticipated
1	Monitoring	Develop a data analysis and information delivery plan as part of the monitoring program	DEIS contains information on proposed data analysis and information delivery. Will continue to coordinate with resource agencies to refine the plan.	Yes
2	Boat Ramp	Constructing a boat ramp on the SC side of Back River	If no sites found that meet all criteria. Could provide funds equivalent to the cost of constructing a ramp or fill saltmarsh.	Yes, staff still working issue
3	Adaptive Management	Expand adaptive management plan to include potential modifications of the oxygen injection system and modification contingency funding	Concur. Corps will include in DEIS.	Yes
4	NSBL&D Fish Passage	Install a fish passage facility at New Savannah Bluff Lock and Dam of acceptable design	Concur. Corps will coordinate with agencies after project approval for final design review.	Yes
5	Near Shore Disposal	Dispose of suitable new work sediments (meeting Georgia DNR criteria) in the nearshore area off Tybee Island	Concur. This is included in proposed project.	Yes
6	Cadmium Containment	Cap all new work sediment containing elevated cadmium concentrations ("high" vs. "low") with clean material	Corps provided detailed responses to agencies in December.	Yes, staff still working issue
7	Tidal Marsh Impacts	Provide in-kind restoration of estuarine emergent wetlands for 7.2 acres that would be excavated	Concur. Corps is pursuing restoration of a previous sediment disposal site within the harbor.	Yes, staff still working issue
8	Land Acquisition	Initiate land acquisition no later than initiation of harbor construction and complete acquisition within two years	Concur. Expect to acquire the lands within the requested time frame. Acreage yet to be finalized.	Yes
9	Striped Bass Stocking	Fully fund Georgia DNR's striped bass stocking program	Corps HQ stated that this project cannot resolve env issues from previous deepening projects, but only mitigate for the incremental effect of this proposed deepening. Corps will fund stocking equal to level of impacts.	Yes
10	Flow Modifications	Prior to or concurrent with harbor deepening, implement flow/channel modification, continue coordination of	Concur. Corps will include intent of berm and proposed construction technique in DEIS	Yes

		berm impacts and alternatives		
11	Freshwater Supply System	Initiate repair of the Savannah NWR freshwater supply system no later than initiation of harbor construction and complete within two years of start	Concur. Corps will include in the project if not implemented prior to that time.	Yes
12	Depth Selection	In order to reduce impacts, limit channel deepening project to 44 or 45 foot	The Corps will recommend the best depth alternative considering all evaluation factors (environmental, social, and economic).	Not a technical issue
13	Sturgeon Forage Habitat	Survey portion of the river where Shortnose sturgeon would likely move in response to harbor deepening	Concur. will conduct a sediment survey to confirm suitable substrates present. Will provide SOW to agencies for approval prior to conducting the survey.	Yes
14	Sturgeon Habitat Criteria	Modify the criteria for acceptable habitat for Shortnose sturgeon	Still evaluating the effects of modifications to the criteria. Any revision of the criteria would be coordinated with the agencies.	Yes, staff still working issue
15	Dissolved Oxygen Data	Display dissolved oxygen levels more clearly, visually	Data from the feasibility report was provided to agencies for review. Awaiting response as to its acceptability.	Yes
16	Monitoring Period	Longer post-construction monitoring period (undefined length)	Monitoring period must be defined to ensure sufficient costs are included and acquired. Corps believes 5 years is sufficient.	Yes
17	New Work Sediment Monitoring	Monitoring of new work sediments deposited in the nearshore area requested	Agency concurrence that 2 years would be sufficient.	Yes
18	Magnitude Factor	Magnitude factor be added to the procedures described in the Regulatory SOP	Direct impacts to wetlands would be <20 acres. Corps does not believe that adding a magnitude factor is warranted.	Yes
19	Economic Analysis	Economic analysis of the project be technically strong	Corps is updating its economic analysis to strengthen it and allow examination of additional scenarios.	Yes
20	Speece Cones	Uncertainty about the dissolved oxygen systems effectiveness to provide the intended amount of improvement	GPA’s consultants are conducting additional analysis of data from the 2007 Demonstration Project. Will produce a supplemental report.	Yes, staff still working issue

			Corps believes the system can provide the beneficial effects intended.	
21	Air Quality	Uncertainty about the evaluation of the project's impacts to air quality	Corps believes existing air quality evaluation is sufficient. Evaluation will be updated to reflect the revised fleet forecast.	Yes

POSITION PAPER PROVIDED BY NOAA FISHERIES SERVICE

Savannah Harbor Expansion Project (SHEP)
16 December 2008
NOAA Fishers Service, Southeast Regional Office

NOAA Position:

- At this time, we cannot complete our analysis of the alternatives until the re-examination of the DO injection study is completed. If we do not have reasonable assurance that the DO injection will yield the results predicted, we likely would not support any of the deepening alternatives.
- Assuming sufficient assurance is provided that the DO injection would be effective, we would require a near-real-time monitoring program for DO at locations within the harbor most important to shortnose sturgeon and sufficient capacity within the DO injection system to increase output as needed to avoid impacting shortnose sturgeon habitat.

NOAA Needs:

1. Impact acreage tables (similar to tables 3-5 and 3-6 of the DEIS) that report the net effect to sturgeon and flounder of the mitigation under two scenarios: hydrologic alterations only and hydrologic alterations plus the DO injection.
2. In light of seemingly contradictory results to that reported by Hall et al. (1999) and Collins (2000), further discussion within the technical team of the habitat suitability model used to predict sturgeon habitat under project conditions.
3. Modeling for construction of the lower Middle River sill as a mitigation alternative should be based on the updated parameters for sturgeon habitat (from 2).
4. Map of project area with cells analyzed in model denoting DO impacts overlaid with placement of Speece Cones.
5. Point source discharges location and assessment of their effect on DO concentrations.
6. For the upriver areas that (based on salinity) are projected to become new foraging habitat for shortnose sturgeon, an assessment of the likelihood of sturgeon prey becoming established in the area. The assessment should include examinations of substrate and colonization rates and monitoring that would indicate if additional corrective actions are necessary.
7. NOAA recommends that COE perform a new pilot study to evaluate the effectiveness of the Speece Cones at elevating DO concentrations during the time of year and at the locations most important to shortnose sturgeon. This new pilot study would be in addition to re-evaluations of results from the 2007 study. NOAA staff will work with the COE to indentify the locations and time most important to shortnose sturgeon and the DO parameters that would help NOAA most effectively evaluate the impact to this species.
8. Refinement to the adaptive management program that will gauge impacts from the project in a timely manner and recommend corrective actions should the ecosystem respond negatively and differently than predicted. NOAA offers to lead development of this program.

MEETING ATTENDEES

S.H.E.P.
Dec 16th, 2008

	Name	Rep	Phone
1.	Don Christy	USEPA	404/562-8357
	Jack Arnold	USFWS	404/679-7311
	COL Ed Kertis	USACE	912-652-5226
	Buck Sutter	NOAA Fisheries	727-824-5301
	BG Joe Schroedel	USACE	404-562-5006
	BERNARD MOSEBY	CORPS/ECONOMICS	251 694 3884
	Steve Green	GPA / State of Ga	912-341-0077
	DAVID Schaller	Georgia Ports Authority	912 964 3877
	Hope Moorer	GPA	912-964-3883
	MAJ David London	USACE	912-652-5225
	PETE ODDI	USACE/SAVANNAH	912/652-5332
	Dan Parrott	USACE/ SAVANNAH	912/652-5219
	Les Dixon	USACE	404 562 5200
	EDEN GATWOOD	USACE / SAD	404 562 5226
	Jason O'Kane	USACE/SAS	912/652-5276
	Alan Garrett	USACE/SAS	912/652-5172
	Bill Bailey	USACE/SAS	912/652-~~5587~~ 5781
	Paul Bradley	USACE/SAM	(251) 694-4101
	Todd Boatman	USACE/SAM	251-690-3143
20.	Curtis Flakes	USACE/SAM	251-690-2777
21.	Daniel Small	USACE/SAD	

by phone Senator Mattingly

CESAS-PM-C 18 February 2009
Revised 31 March 2009

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; 17 February 2009 Executive Steering Committee (ESC) Meeting

1. The Corps held the second in a series of interagency Executive Steering Committee meetings on 17 February 2009, at the US Army Corps of Engineers (USACE) South Atlantic Division (SAD) office in Atlanta, Georgia. Attendees included Brigadier Gen. Schroedel (USACE, SAD); Col. Kertis (USACE, Savannah District (USACE, SAS); Stan Meiburg, Mr. Heinz Mueller and Mr. Jim Giattina (US EPA); Mr. Jack Arnold, Mrs. Jane Griess and Mr. Ed Eudaly (USFWS),;Mr. David Bernhart (NOAA Fisheries); Steve Cone (USACE Institute for Water Resources); and Mr. Steve Green, Mr. David Schaller, Ms. Hope Moore and Mr. Jamie McCurry (Georgia Ports Authority (GPA)). Former U.S. Senator Mack Mattingly, who is working on GPA's behalf, attended by phone. A sign in sheet identifying all attendees for this meeting is attached at the end of this MFR.

2. The meeting was held as a continuation of the ongoing coordination on the Savannah Harbor Expansion Project General Reevaluation Report and Tier II EIS, to engage the leadership of each agency on all critical issues, insure open communication, and manage expectations.

3. The Corps provided a meeting notebook that contained an agenda, group charter, meeting objectives, project status, project schedule and other supporting materials.

4. The meeting began with an introductions and a welcome from Col. Kertis. Col Kertis stated that the purpose of the meeting was to update the agency executive managers on the project status and issues and facilitate open honest communications, while the technical staffs work to resolve the remaining issues. Col. Kertis asked GPA to brief the group on their container facility and the entire Port of Savannah.

5. David Schaller, GPA Chief Administrative Officer, presented details on the significance of the Port of Savannah and the GPA facilities, strengths of the existing navigation project, and the need for deepening to meet the demands of the shipping industry's move to larger, deeper-draft container vessels, on local, regional and national levels. The group discussed that the Panama Canal will be a major driver for larger container vessels on the East Coast, the resulting need for harbor deepenings, and that Canal expansion was scheduled to be complete in July 2014. Other East Coast ports that have been deepened or are in the process to be deepened were mentioned as including Miami, Jacksonville, New York, and Charleston.

6. Stan Meiburg with EPA asked how a potential terminal in Jasper County, SC, factored into this need. The group discussed the many uncertainties, environmental, engineering and economic challenges for any terminal in Jasper County. The dependency of a new container terminal on Jasper County on a deeper channel was also mentioned.

7. The USFWS expressed their concern for immediate repair of the freshwater control structure located on the Savannah National Wildlife Refugee (SNWR). Salinity impacts on the SNWR are critical under both the "with" and "without project" conditions. The Service has petitioned the Corps to provide a solution to the deterioration of that existing mitigation structure, which was constructed as part of a previous deepening of Savannah Harbor. The USFWS discussed how the Corps' ability to honor past commitments for mitigation affects agency expectations for the success of future project mitigation. The Corps stated that we had received HQUSACE approval to include the rehabilitation in the Expansion Project if it is not performed sooner. The Service stated that they need a quicker solution. The Corps is also working to implement a plan to address the needed rehabilitation parallel, but separate from the current deepening studies. CESAD advised they had a strategy to resolve this issue and more details would be provided soon.

8. The agencies expressed considerable uncertainty with the project's dissolved oxygen mitigation approach and the effectiveness of the Speece Cones. The results of GPA's 2007 D.O. Demonstration Project have been analyzed, but NOAA stated that the initial report did not demonstrate that the system would be effective. At this point NOAA Fisheries is not convinced that this system would be effective mitigation method. GPA's consultants are preparing a supplemental report on the 2007 test. The report is due out by 2 March. It may well be that an integral part of resolving uncertainty with this mitigation feature will include agreed upon post-construction monitoring and adaptive management measures. The agencies agreed to let the Corps know their specific concerns with the D.O. systems (getting oxygen into the water, spread of oxygenated water through the harbor, etc), so the Corps could address them.

9. The agencies commented on the importance of developing a comprehensive monitoring plan to shape potential adaptive management actions and that this plan must be reviewed and concurred in by each agency. Bill Bailey stated that the Corps included comprehensive monitoring and adaptive management plans in the 90% version of the Draft GRR and EIS, and that the Corps welcomed specifics on how to refine and improve those documents. The current proposed monitoring period is five years. The Corps has included contingency funding to implement adaptive management measures in project funding. It was discussed that for certain effects, such as the effects of the project on a species' reproductive success, five years may not be adequate. However, it was also acknowledged that some reasonable time period had to be chosen for cost estimation purposes and it was agreed five years was an adequate compromise. NOAA Fisheries agreed to review that duration and let the group know if it believed that some other duration may be needed to identify impacts to some specific resource.

10. The revised overall scheduled was discussed. Each agency was given an opportunity to review and comment on the schedule prior to the meeting. The recent slip in the Economics Analysis was discussed and Steve Cone elaborated on the reason the fleet forecast was delayed. It was also mentioned the IWR understands the sense of urgency of this effort. All, except EPA, concurred in the revised schedule. EPA expressed a need to continue to review the schedule and

provide comments subsequent to the meeting in light of some of the technical discussions occurring among their staff and the Corps. We shared with all the reality of the schedule as it compares to timing of the administrative budget process. Based on the current schedule for submittal of the final GRR and EIS to HQUSACE in Jan 2010, the earliest the project would be eligible to be budgeted for construction funding would be in 2012. General Schroedel reminded the group that a schedule can bring about action, but it is the resolution of substantive issues that drives the schedule forward. Steve Green reminded the group of the importance in resolving issues now and that there are no surprises as we continue forward. The incorporation into the schedule of three of four requests by USFWS was also discussed. Later in the meeting, USFWS commented that the schedule was acceptable and that their fourth recommendation need not be incorporated if it would delay the schedule.

11. The expected effects of Stimulus Bill passage were discussed. Depending on the detailed requirements within the just-passed Stimulus Bill, all agencies recognized that the manpower resources they would need to allocate towards this project to meet their commitments may be redirected elsewhere, adversely affecting their ability to meet the schedule.

12. Col. Kertis asked how a request to approve the project would be handled by agency representatives who were temporarily appointed or acting/not permanent. EPA predicted that temporary positions would likely complicate their approval of the project, but all agreed this is an unprecedented authorization and an unknown approval process. The Corps asked agencies to (A) Define their agency's approval process for both approval of the GRR and EIS and approval as required in the project's WRDA 1999 authorization, (B) Determine if combining these two approvals is possible and establish a process to accomplish, and (C) Determine if delegation of approval down to the Regional level is possible and establish a process to accomplish that delegation. The Corps proposed that the final agency determination on the project (possibly project approval) be provided as part of the agency's comments on the final GRR and EIS. That would eliminate the need for a separate approval process.

13. Bill Bailey covered issues that are considered to be resolved or that the Corps expects to soon be resolved at the technical level. They included the following: hydrodynamic modeling, extent of funding for adverse impacts to Striped Bass, extent of land acquisition to mitigate for adverse impacts to freshwater wetlands, placement of new work sediments from the entrance channel, fish passage at New Savannah Bluff Lock and Dam as mitigation for adverse impacts to Shortnose sturgeon, wetland mitigation magnitude factor, and in-kind mitigation for loss of saltmarsh. An updated table of the outstanding environmental issues is attached to this MFR.

14. The group discussed the Corps' on-going efforts to address USFWS and SCDNR comments regarding excavation and placement of new work Cadmium-laden sediments. The Corps stated that monitoring cadmium in effluents from the placement site during the construction period would be added to the project and that it was continuing to evaluate the latest USFWS comments.

15. The Corps stated that it would continue to try to resolve the boat access to Back River issue (requested construction of a boat ramp). The Federal agencies did not identify this as a critical mitigation feature.

16. Bill Bailey stated the Corps was working the NOAA Fisheries request for a survey of near up-river Shortnose Sturgeon forage habitat. The Corps agreed to perform that survey. Mr. Bailey also stated that the Corps had recently provided NOAA with information they had requested concerning point source discharges and would like confirmation that the information meets NOAA's needs.

17. Bill Bailey provided a summary of the environmental issues, followed by a statement by Steve Green reminding the group of the importance of this harbor deepening project on the regions economy, which is especially important during this economic downturn.

18. The Corps informed the agencies that we will have a funding shortfall by mid-April 2009; and that approximately $600 K was needed for the balance of this fiscal year. We advised the group that we are aggressively working to insure that the needed funds are obtained.

19. The Corps proposed holding these meetings on a quarterly basis. The group agreed, and tentatively scheduled the next meeting for 30 April in Atlanta.

20. The District agreed to prepare a record of the meeting and distribute it to the participants for review. The record can be used for agencies to inform their staff of discussions at this meeting and expectations for the next meeting.

21. The Federal agencies provided comments on the draft MFR that the District prepared. Those comments have been incorporated into this version of the MFR. We have attached at the end of this document detailed technical comments that EPA as a result of their review. The Corps' staff will be coordinating directly with EPA staff to address those comments.

JASON O'KANE
Project Manager

ENVIRONMENTAL ISSUES

	Issue	Resource Agency Recommendation	Corps Response	Resolution Anticipated
1	Monitoring	Develop a data analysis and information delivery plan as part of the monitoring program	DEIS contains information on proposed data analysis and information delivery. Will continue to coordinate with resource agencies to refine the plan.	Yes
2	Boat Ramp	Constructing a boat ramp on the SC side of Back River	Two sites in GA are still being pursued. If no sites are found that meet all the criteria, the project could provide funds equivalent to the cost of constructing a ramp.	Yes, staff still working issue
3	Adaptive Management	Expand adaptive management plan to include potential modifications of the oxygen injection system and modification contingency funding	Concur. Corps will include in DEIS.	Yes
4	NSBL&D Fish Passage	Install a fish passage facility at New Savannah Bluff Lock and Dam of acceptable design	Concur. Corps will coordinate with agencies after project approval for final design review.	Yes
5	Near Shore Disposal	Dispose of suitable new work sediments (meeting Georgia DNR criteria) in the nearshore area off Tybee Island	Concur. This is included in proposed project.	Yes
6	Cadmium Containment	Cap all new work sediment containing elevated cadmium concentrations ("high" vs. "low") with clean material	Corps agrees to monitor CDF effluent during construction. Corps is evaluating the 23 January USFWS comments.	Staff still working issue
7	Tidal Marsh Impacts	Provide in-kind restoration of estuarine emergent wetlands for 7.2 acres that would be excavated	Concur. Corps is pursuing restoration of a previous sediment disposal site within the harbor.	Yes, staff still working issue
8	Land Acquisition	Initiate land acquisition no later than initiation of harbor construction and complete acquisition within two years	Concur. Expect to acquire the lands within the requested time frame. Corps agrees to acreage in Draft FWCA Report.	Yes
9	Striped Bass Stocking	Fully fund Georgia DNR's striped bass stocking program	HQUSACE stated that this project cannot resolve env issues from previous deepening projects, but only mitigate for the incremental effect of this proposed deepening. Corps will fund stocking equal to level of impacts.	Yes
10	Flow Modifications	Prior to or concurrent with harbor deepening, implement flow/channel modification, continue coordination of	Concur. Corps will include intent of berm and proposed construction technique in DEIS	Yes

		berm impacts and alternatives		
11	Freshwater Supply System	Initiate repair of the Savannah NWR freshwater supply system no later than initiation of harbor construction and complete within two years of start	Concur. Corps will include in the project if not implemented prior to that time. Corps continues to work to identify a funding source to conduct the repairs sooner.	Yes, staff still working issue
12	Depth Selection	In order to reduce impacts, limit channel deepening project to 44 or 45 foot	The Corps will recommend the best depth alternative considering all evaluation factors (environmental, social, and economic).	Not a technical issue
13	Sturgeon Forage Habitat	Survey portion of the river where Shortnose sturgeon would likely move in response to harbor deepening	Concur. Corps will conduct a sediment survey to confirm suitable substrates present.	Yes, staff still working issue
14	Sturgeon Habitat Criteria	Modify the criteria for acceptable habitat for Shortnose sturgeon	Still evaluating the effects of modifications to the criteria. Any revision of the criteria would be coordinated with the agencies.	Yes, staff still working issue
15	Dissolved Oxygen Data	Display dissolved oxygen levels more clearly, visually	Corps provided data from the feasibility report to agencies for review. No agency expressed a need for a different format. Corps considers this issue closed.	Yes
16	Monitoring Period	Longer post-construction monitoring period (undefined length)	Monitoring period must be defined to ensure sufficient costs are included and acquired. Corps believes 5 years is sufficient.	Yes
17	New Work Sediment Monitoring	Monitoring of new work sediments deposited in the nearshore area requested	GA DNR-CRD concurred that 2 years would be sufficient. Corps considers this issue closed.	Yes
18	Magnitude Factor	Magnitude factor be added to the procedures described in the Regulatory SOP	Direct impacts to wetlands would be <20 acres. Corps does not believe that adding a magnitude factor is warranted.	Yes
19	Economic Analysis	Economic analysis of the project be technically strong	Corps is updating its economic analysis to strengthen it and allow examination of additional scenarios.	Yes, staff still working issue
20	Speece Cones	Uncertainty about the dissolved oxygen systems effectiveness to provide the intended amount of improvement	GPA’s consultants are conducting additional analysis of data from the 2007 Demonstration Project. Will	Yes, staff still working issue

			produce a supplemental report by 2 March. Corps believes the system can provide the beneficial effects intended.	
21	Air Quality	Uncertainty about the evaluation of the project's impacts to air quality	Corps believes existing air quality evaluation is sufficient. Evaluation will be updated to reflect the revised fleet forecast.	Yes, staff still working issue

MEETING ATTENDEES

February 17, 2009 Executive Steering Committee Meeting

Name	Agency
1. Jason O'Kane	USACE
2. Bill Bailey	USACE
3. Heinz Mueller	USEPA
4. Jim Giattina	US EPA
5. David Bernhart	NOAA Fisheries Service
6. Joe Schroedel	USACE, SAD
7. Stan Meiburg	US EPA
8. Ed Keritz	USACE
9. Jack Arnold	USFWS
10. Steve Green	GPA
11. David Schaller	GPA
12. Jane Griess	USFWS
13. Ed Eudaly	USFWS
14. Wilbert V. Paynes	USACE-SAD
15. Daniel Small	USACE-SAD
16. Sen. Mattingly by phone	
17. Steve Kopp	USACE-IWR
18. Jamie McCurry	GPA
19. Hope Moorer	GPA

U.S. Environmental Protection Agency
Comments on February 17, 2009
Memorandum for Record

<u>Comments on the Status of Technical Issues in Table of Environmental Issues</u>

Mr. Stan Meiberg, Acting Regional Administrator, provided comments earlier, under separate cover, on the draft Meeting Summary Minutes. Attached to those draft Minutes from the Corps was a tabular summary of environmental issues. We offer the following comments to further clarify our understanding and position on the key issues of the study, and provide suggested next steps where appropriate. There have been many interim work products provided to the agencies by the Corps over the recent years. A summary of available information would help clarify the status of information pertaining to the issues.
EPA feels strongly that a meeting is needed of the technical work group prior to the preparation of the preliminary DEIS.

1. Monitoring: EPA is waiting on the updated monitoring plan for the potential alternatives to assure that all the concerns (DO impacts in harbor; salinity and velocity impacts in Middle and Back Rivers; chloride impacts for upstream water supplies; effectiveness monitoring of the Speece Cones; etc) are adequately addressed. The monitoring plan must be specifically designed to address the selected potential alternatives. EPA concurred with the specific concerns which Georgia EPD provided on the proposed oxygen injection monitoring plan. However, these concerns were not addressed in the Speece Cone demonstration and this resulted in inadequate data collection for determining the effectiveness of the Speece Cones in Savannah Harbor.

Additional coordination is needed after receipt of the monitoring plan to resolve any remaining concerns.

2. Boat Ramp: EPA has no comment on this issue.

3. Adaptive Management: A defined Adaptive Management Plan has not been provided. The agencies and the States need to come up with agreed upon methods for monitoring the harbor impacts for each potential alternative, and for monitoring and evaluating the impacts of each proposed mitigation strategy. Each project's component will have a subtle impact on the DO, salinity and velocities of harbor system, therefore an ongoing detailed data and modeling analysis of the system will have to occur over the 5 year construction and 5 year post construction monitoring.

Additional coordination is needed after receipt of the Adaptive Management Plan to resolve any remaining concerns.

4. **NSBL&D Fish Passage**: EPA has not taken a position on this issue although we expressed concern at the Corps' August 26-27, 2008, Alternatives Formulation briefing, concerning the stated inability of the Corps to fully fund "off-project" mitigation. Striper spawning success is closely related to the need for river water quality in order to not inhibit this important aquatic function.

This issue is unresolved at this time.

5. Near Shore Disposal: EPA needs to review all available data on the testing of the dredged materials from the Bar Channel to be placed near-shore, and based on these data, may request that additional testing be conducted, e.g., elutriate chemistry, elutriate and whole sediment bioassays, and bioaccumulation testing. Furthermore, EPA would like to review Georgia DNR Criteria for near-shore placement of these materials. Available data from testing dredged materials to be placed near-shore must demonstrate that there will be no violations of State Water Quality Standards or Federal Water Quality Criteria during the placement of the material.

This issue is unresolved at this time.

6. Cadmium Containment: EPA shares SCDNR's and USFWS's concerns, as outlined in their January 14, 2009 and January 23, 2009, respectively, comments. EPA needs to further investigate all aspects of the proposed plans for cadmium containment. EPA requests a written plan on the long-term maintenance of the cadmium containment facilities – to include information on the monitoring plan, adaptive management of the facilities in the event of problems, and information regarding the full disclosure of the disposal and maintenance plans for the Jasper County disposal sites. EPA also shares SCDNR and USFWS concerns regarding Cd concentrations in remaining exposed surfaces in the Savannah Harbor after dredging. EPA will work with the Corps in developing necessary monitoring and management plans.

This issue is unresolved at this time.

7. Tidal marsh impacts: The impacts of dredging for bend widening and turning basin expansion are essentially the same for all alternative depths. The Savannah District Standard Operating Procedure (SOP) may be appropriate to apply to the 7.2 acres of salt marsh dredging since this type of impact is specifically covered by the SOP adverse impact table. For impacts less than 10 acres, a correction for the scope of the impacts the "magnitude factor") is not needed.

This issue is resolvable with additional detail about the proposed restoration of the proposed site.

7a. Tidal Freshwater Wetland Alteration: This major impact should be included in the Meeting Minutes'attached table of Environmental Issues. EPA has a responsibility to independently review the impacts of the project. EPA needs to review the saltwater intrusion impacts of each of the Harbor deepening alternatives and mitigation options in consideration of the new low flow data now available**.** Each of the mitigation plans should be comprehensive and in full compliance with the "Compensatory Mitigation for Losses of Aquatic Resources (Rule), Final Rule", 40 CFR Part 230, issued on April 10, 2008. The mitigation plans for the alternatives should include the information as outlined in the Rule's twelve basic requirements, including watershed assessment and functional assessments, preservation area requirements, financial assurances, monitoring and adaptive management, and a clearly described rationale for the proposed project-specific mitigation siting (versus an approved mitigation bank), etc. The documentation for the mitigation plans for each of the alternatives should be at the level of information equivalent to a "prospectus" as described by the Rule and as required by all commercial mitigation banks. The Corps of Engineers Charleston District has available an outline of the information that they require in a "prospectus" and this should be of valuable assistance in the preparation of the mitigation plans.

This issue is unresolved at this time.

8. Land Acquisition: This issue is relevant to the impacts to tidal freshwater wetlands addressed in issue 7a. The Savannah District' Standard Operating Procedures (SOP) is not designed to quantify the adverse impacts to wetlands due to changes in salinity and thus conversion of one wetland type to another. This is the larger wetland adverse impact associated with the project. Changes from any natural or baseline condition are considered to be "adverse" even though the altered wetlands will have their own suite of functions, some of which may be in common with the previous wetland type. Also, the scope of these impacts will vary over the impact area. Normally one would use a functional assessment to look at the lost functions due to the adverse impacts and then apply the same functional assessment to the functional gain due to the mitigative action. However, currently the Savannah District is proposing wetland preservation as the type of compensatory mitigation (at an approximate 8:1 ratio for the 48-foot alternative). This does not replace any lost functions and is less than EPA's recommended 10:1 to 60:1 ratios for preservation cited in the EPA Region 4 Mitigation Policy. However, it should be noted that the wetlands impacted will still retain some of the original functions and will still be functioning wetlands, albeit of a different type. Without a functional assessment, the use of preservation and the determination of the appropriate quantity of mitigation are policy, not technical, issues.

One further note regarding the SOP. Morphological changes to a stream are covered by the SOP, and the proposed dredging of the Savannah River is clearly a morphological change that will increase channel instability. This is a substantial adverse impact under the stream portion of the

SOP. There is some debate as to whether tidally influenced streams are “streams” similar to freshwater streams with unidirectional flow. So there is some debate as to how to treat these types of systems under the SOP. Regardless of this debate, it appears the subsequent channel instability and associated impacts with the actual dredging and other channel modifications have not been fully assessed, let alone considered for mitigation.

This issue is unresolved at this time.

9. Striped Bass Stocking: EPA has no comment on this issue.

10. Flow Modification: Our assumption is that this issue is related to the diversion of flow from the main river into the Little Back River as shown in various mitigation alternatives, and the impacts to the Refuge management. The effectiveness of this diversion in preventing the salinity intrusion into the freshwater wetlands and preventing its conversion is a significant unknown.

Note that the States, in conjunction with USGS, have completed some velocity and flow monitoring (fall 2008) of the Middle and Back Rivers and Georgia has contracted to continue this monitoring starting in July 2009 to help address impacts in the Middle and Back Rivers. Evaluation of the available fall of 2008 monitoring data and detailed evaluation of the alternatives’ modeling must be completed before resolution can be expected. Additional coordination is needed after receipt of the USACE technical analysis, including all the pertinent modeling runs.

This issue is unresolved at this time.

11. Freshwater Supply System: This is a proposed mitigation for a previous deepening project that was but never fully implemented in the SNWR. EPA has no comment on this issue at this time.

12. Depth Selection: EPA agrees that this is not an issue for technical resolution at this time. However, this will be the major decision for the project. The appropriate point in the review of this issue is after the Draft EIS is issued and has been reviewed by all the agencies; with hopeful interagency consensus on the depth and all mitigation.

13. Sturgeon Forage Habitat: The Short-nose sturgeon is a listed species and its success is closely related to river water quality. EPA will require assurances that harbor deepening will not inhibit this aquatic use of the river.

14. Sturgeon Habitat Criteria: This is a NMFS/FWS issue closely related to the preceding issue and EPA will require assurances that the updated criteria will be protective of the Short-nose sturgeon's use of the river

15. Dissolved Oxygen Data: We recommend that USACE provide the data and model outputs to the federal and State agencies in binary files which the models can easily produce. This will allow review of the data in the detail that is appropriate.

16. Monitoring Period: Five-year monitoring during construction and 5 years of post construction monitoring should be adequate, as long as the adaptive management approach and the mitigation methods are working. If there is a problem or issue with the proposed mitigation in that it's not working appropriately then additional monitoring may be needed after the mitigation methods are updated.

This issue appears resolved at this time.

17. New Work Sediment Monitoring: EPA would like to review the 2-year monitoring plan for placement of sediments in the near shore area. Additionally, if any material is to be taken offshore for placement in the Savannah ODMDS, it must go through established procedures under the MPRSA and EPA's Ocean Disposal Criteria, and there must be documented demonstration of compliance with the Ocean Dumping Criteria, including a MPRSA Section 103 Evaluation and written concurrence from EPA for disposal in the Savannah ODMDS.

This issue is partially resolved.

18. Magnitude Factor: Please refer to EPA's response to issue #7.

19. Economic Analysis: This is not a technical issue but rather a NEPA requirement of disclosure. EPA said at the AFB meeting that we had questions about the clarity of the rationale and as did the Corps' headquarters staff. EPA has not been provided any additional data to review at this time.

Resolution is uncertain.

20. Speece Cones: EPA is awaiting receipt of a final report. EPA's technical position is that the Speece Cones may work but we are unsure how effective they will be in a tidal system. Note that EPA, the States and dischargers are also looking at oxygen injection systems as a wastewater treatment alternative, and based on the available data on the O2 injection systems we can expect 75 to 80 percent transfer efficiency. Again for proper evaluation of the USACE proposed O2 injection system there are additional details that need to be identified (e.g., where the injectors are located, at what depth and with what kind of diffuser pipe). All these variables must be evaluated for all the alternatives.

Additional coordination is needed after receipt of the USACE technical analysis and the modeling scenarios of the potential alternatives with and without the O2 injection. In addition, the Corps needs to address in the DEIS the legal mechanism that will be used to ensure that, if O2 injection systems are put in place, they will be properly operated and maintained in perpetuity. The proposed TMDL will allow the dischargers to lower the DO in the system up to 0.1 mg/l, compared to the 0.8 mg/l impact they are presently causing. The proposed deepening without the O2 injection will lower the DO in the harbor approximately 1.0 mg/l, therefore if the oxygen injection systems are not kept in operation serious water quality issues will occur.

This issue is unresolved at this time.

21. Air Quality – This is a concern regarding direct and indirect impacts of port expansion. EPA requests a detailed quantitative analysis for the DEIS of the impacts of port expansion on criteria air pollutants.

Region 4 continues to encourage the Corps to include in the DEIS an evaluation of the potential local impacts of the proposed actions associated with air toxics - both during construction and associated with operations of the port. This evaluation should follow the tiered risk-based approach outlined in the Air Toxics Risk Assessment Reference Library, Volume 1, Section 3.3.3 (http://epa.gov/ttn/fera/risk_atra_main.html), including a detailed emissions inventory of mobile and stationary sources of air toxics at the port followed by dispersion modeling and evaluation of the potential health impacts. The DEIS should also address alternatives to mitigate potential impacts of air toxics during construction and operation. This process was carried out for an expansion effort at the Port of Los Angeles and is provided here as an example: (http://www.portoflosangeles.org/EIR/ChinaShipping/DEIR/deir_china_shipping.asp).

General Technical Comments

USACE, EPA and States of Georgia and South Carolina, along with the other Federal Agencies jointly developed and/or reviewed the data and modeling on which the deepening water quality analyses are based. This culminated in a January 2006 data and modeling report that used 1999 as a critical condition (low flow and high temperature) year. All agreed that the 2006 model and data report were adequate to make initial screening projections and evaluations of the potential deepening alternatives; however now we have new low flow data for 2007/08 which must be considered in the alternatives analysis.

EPA agrees that a reasonable suite of port expansion depth alternatives are being addressed. However, EPA wishes to stress the importance of a comprehensive alternatives evaluation of potential port sites in the DEIS. The site selection criteria need to be equal across all alternatives in order to compare sites objectively. There should not be a presumption that the Savannah River would be deepened to Garden City in the evaluation of potential sites down-river.

CESAD-PDS-P 2 April 2009
(revised 6Apr 09)

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project – Regional Federal Resources Agency Meeting

1. BG Schroedel, South Atlantic Division Commander, called and held a meeting on 31 March 2009, with the three other Federal Agencies named in the subject project authorization that must all concur in the analysis and recommendations for deepening (or not) the harbor at any depth beyond the currently existing 42 feet depth. The agencies participating, in addition to the Corps, were US Fish and Wildlife Service, US Environmental Protection Agency – Region 4, and NOAA Fisheries Service.

2. Purpose of meeting was to discuss and insure that all agencies are aware of each others primary concerns associated with the evaluation of alternatives; processing of the draft and final environmental and project documents; near term actions; and overall commitment to the "Savannah Harbor Executive Steering Group" process (given the unique authorization).

3. The participants:

a. BG Joseph Schroedel – SAD Commander
b. COL Ed Kertis – Savannah District Commander
c. Wilbert Paynes – SAD Planning Chief
d. Jim Giattina – Director Water Protection Division, US EPA Region 4
e. Heinz Mueller- US EPA Region 4
f. Sam Hamilton – Regional Director, US Fish & Wildlife Service
g. Dr. Roy Crabtree – Regional Administrator NMFS - via phone
h. Dr. Stephania Bolden – NOAA Fisheries – via phone
i. William Bailey – Mobile/Savannah Regional Planning Center - via phone

4. Highlights:

a. All agencies are committed to the Executive Steering Group process and value that forum as a means of insuring that the leadership of each agency is aware of major issues, outcomes, procedural methods, and facilitation actions and decisions.

b. All agencies expressed concurrence for an objective evaluation and assessment of alternatives and are not predisposed to any particular outcome. They expressed the need to display all impacts, mitigation and benefits by incremental channel depths. This would permit each agency to describe their assessment of alternatives and discuss greater or lesser risk and uncertainty by increments.

c. While the schedule is important, it was considered equally important that a full airing of technical issues occur and that the schedule reflect the needed agency reviews and technical review meetings. Additionally, given the unique project authorization and because all three resource agencies are "Cooperating Agencies" on the EIS, they requested the schedule reflect a review by their agency of the initial draft report and EIS (60 days) before distribution to the public for review. The Corps agreed to send each agency a copy of the current General Reevaluation Report and EIS schedule for their review and input and to continue to work with the Federal resource agencies to get the technical issues analyzed and resolved. The resource agencies agreed to review the schedule by 30 April and to share where they see gaps in the science/information that will likely lead to longer review time and impacts to the schedule, at the next Executive Steering Group meeting.

d. The US Fish and Wildlife Service was very clear that a prerequisite to any decision by them on further deepening was a firm demonstration by the Corps that the existing mitigation (water control system on the Savannah National Wildlife Refuge) will be or are repaired. The Service views action by the Corps on the existing mitigation systems as providing assurance that future mitigation will be implemented and maintained in the future.

e. EPA indicated that they had just received supplemental information from the Georgia Port Authority 2007 Oxygen Injection Demonstration Project. This information will be reviewed by EPA, NMFS, and USFWS (through USGS). The Corps reiterated that it would distribute the draft Adaptive Management Plan for each agency to review. The Corps committed to proactively track the transmission and receipt of key scientific information to the resource agencies.

f. The Corps committed to sending minutes of the Executive Steering Group meeting to each agencies within 24 hours of the meeting for their review. When finalized the minutes would then be sent to Governor Perdue to keep him informed.

g. During the 17 February 2009 Executive Steering Group meeting the resource agencies agreed to get confirmation within their agency of who/what level will issue the agencies final position per the project authorization. It was reemphasized that each agency would continue to check with their organization and report on this at the next meeting.

h. It was agreed among all agencies that technical meetings would be convened among their representatives to ensure we are working systematically through the issues/concerns remaining. EPA provided the Corps a summary of their views on remaining technical issues/concerns to begin to frame the discussions. The Savannah District will to set up the first meeting and coordinate with all agencies.

5. Lastly, BG Schroedel reminded the participants that the next Federal Executive Steering group meeting, 30 April 2009 at SAD, would be his last official meeting before retiring. He expressed his appreciation to this group and shared that the new SAD Commander, BG Todd T. Semonite, will participate in the next meeting.

WILBERT V.PAYNES
Chief, Planning and Policy
South Atlantic Division

CESAM-PD 14 April 2009

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project; Technical meeting with EPA on 08 April 2009

1. EPA Region 4 and the Corps held a meeting on 08 April 2009 for the technical staff to discuss concerns that EPA had previously identified about the project. The meeting was held at EPA from 0930 to 1600 EST. The participants included the following:

EPA: Jim Giattina – Director, Water Protection Division
Tom Wellborn – Branch Chief, Water Protection Division
Ken Mitchell – Section Chief, Air Division
Paul Wagner – Air Quality
Jim Greenfield - Water Mgt (Modeling, TMDL, D.O.)
Ted Bisterfield – NEPA Review (Office of Policy Mgt)
Doug Johnson – Ocean Disposal, Sediment Quality

Corps: Daniel Small - CESAD
Vechere Lampley - CESAD
Bill Bailey – CESAM-PD

2. I started with an overview of the status of the Savannah Harbor Expansion Study (SHEP) and development of the DEIS and GRR. EPA had provided comments on the Corps' 90% version of those documents in August 2008. I explained the purpose of the meeting – for the technical staffs to discuss comments and concerns that EPA had recently expressed about the technical analyses for the project and their conclusions. The Corps envisions this as the first of possibly several meetings between the staffs to address and resolve EPA's concerns.

As a basis for the discussions, we primarily used the written concerns that EPA had provided the Corps on 13 March and the draft responses that Savannah District had prepared and provided EPA the day before the meeting. The Comments and draft Responses are attached at the end of this MFR in a single document. We concentrated our discussions on the following issues: (1) air quality, (2) dissolved oxygen mitigation, (3) water quality, and (4) sediment quality and management. Several other issues were also discussed to lesser extents.

Additional meetings of the technical staff will be needed before EPA is satisfied that the project reports reflect that sufficient analyses have been conducted and they can support their conclusions. The USFWS and NOAA Fisheries expressed some overlapping concerns, so meetings with those agencies will likely also be required. Joint meetings may be useful for some issues, primarily mitigation for dissolved oxygen and wetlands.

3. We discussed EPA's role in this unique project – as an approving agency instead of just as a reviewing agency. The Corps will provide a copy of the authorizing legislation by email. EPA will review that legislation and determine whether that changes how they view the impact analyses and mitigation plan proposals. The question is whether EPA approval means that the documents need to contain analyses as EPA would perform them if they were the proponent and funding were not a factor. That is a higher standard than determining that an analysis is sufficient to reach a decision on a project. Heinz Mueller (Chief of NEPA Office) will need to review the authorizing language and would provide any additional input on EPA's role in assessing the project, reviewing the project documents (GRR and EIS), and making a final decision on the acceptability of the project.

4. EPA stated that it will be critical that incremental analyses and mitigation measures be developed for all depths, not just the 48-foot depth. The Corps reiterated that the environmental analyses are being performed and mitigation plans developed for each of the project depth alternatives: 44-, 45-, 46-, and 48-foot authorized depth.

5. The group discussed the following specific items:

A. Air Quality. The Corps summarized its 2008 Air Emission Inventory (Appendix K of the DEIS) as having incorporated additional analyses that EPA had requested after their review of a previous version. The additional information includes air emissions from vessels calling at other terminals, landside equipment serving GPA and private berths, tugs serving all vessels, and other equipment using or servicing the harbor. EPA reiterated its comments on the 90% version of the EIS that the Corps model the localized (hot spot) effects of air emissions associated with the harbor. They recommended that the Port of Los Angeles air quality assessment be used as a model/template. The Corps asked why detailed analysis of the localized effects would be required since the analyses conducted so far indicate that air emissions would decrease if the harbor were deepened from those that would occur if the harbor is not deepened. EPA agreed to review the need for analyses of localized effects.

EPA was surprised that the conclusion of the project's air quality analysis indicates a reduction in air emissions if the project is implemented. The Corps explained that its analyses show that air emissions would increase in the future as cargo volumes through the harbor increase as a result of population growth. The Corps agreed that the project documents would need to explain why cargo volumes and vessel transits are expected to increase in the future in the Without Project Conditions (no harbor deepening). In light of statements made by the various ports concerning the purpose for deepening a harbor, EPA requested information on the Corps' expectations of how a deepening project would affect the volume of cargo that moves through a port. The Corps stated that such information would be within its economic analysis.

B. Water Quality. EPA feels that GPA's Supplemental Report on their 2007 Dissolved Oxygen Demonstration Project is not conclusive. Since there is still some uncertainty concerning the performance of the D.O. systems, EPA believes that model verification will be needed. They recommended that if the project is constructed, that a Transfer Efficiency Study be performed immediately after construction to identify how well the oxygen is getting transferred to the water and distributed through the harbor. The Corps would then need to operate the systems to provide the amount of oxygen identified by the model as being needed. EPA agreed to provide draft language on what is needed for the Transfer Efficiency Study.

EPA questioned how the Corps would guarantee that the D.O. systems would be operated in the future to provide the mitigation that would be needed by the project. The Corps explained that as a mitigation feature, the D.O. systems would be considered a General Navigation Feature. That means that the Corps would be responsible for operation of the systems. The Corps' O&M budget is expected to continue to be tight. EPA questioned what the Corps would do if it did not receive sufficient funds to both maintain authorized depths in the navigation channel and operate the D.O. systems. The staff agreed to work to develop language to help define what the Corps would do if Congress did not provide sufficient funds for all budgeted project needs in a given year.

The Corps conducted the water quality modeling analyses based on 1999 conditions. When the agencies requested that 1999 be used for that purpose, that year was the lowest flow that had experienced in recent history. The 2007/2008 drought has since produced lower flows and EPA is now believes the Corps should consider the 2007/2008 flow condition in the water quality analyses. This would require some amount of additional modeling. One possibility is for someone to model the 2007/2008 flow for one depth alternative and compare it to the results using the 1999 flows. If the results differ by only a small amount – 5 to 10% – the difference may be within the accuracy of the model. If the results differ more than 25%, then reanalysis of all project depths using the 2007/2008 flows may be warranted. The amount of difference will not be known until the preliminary modeling is conducted using the 2007/2008 low flows. EPA will perform the preliminary modeling.

EPA stated that it would like the Corps to provide the following EFDC and WASP input and output files:

- 44-foot depth alternative using flow rerouting Plan 6A
- 45-, 46, and 48-foot depth alternative using flow rerouting Plan 6B

It would also like the EFDC and WASP input files for the 48-foot depth alternative using flow rerouting Plan 7.

C. Sediment Quality. EPA's primary concerns are for the management of the cadmium-laden sediments and potential impacts from the exposed surfaces remaining along the navigation channel. EPA requested more information to help them understand how the dredged channel would be managed with exposure of the cadmium-laden sediment, as well as how overdepth dredging and advanced maintenance would affect the exposed surfaces. The Corps stated that the contractor's report was fairly conclusive about the low risk of environmental impact from exposure of sediment surfaces along the navigation channel. EPA agreed to review the recent sediment testing reports and the Corps' evaluation and determine whether they agree with the conclusions.

EPA requested information on how the confined disposal facilities (CDFs) would be managed over the long term to ensure that future activities would not destroy the integrity of the managed disposal site where the cadmium sediments would be deposited and covered. The concern is both for the potential use of the CDFs by the Jasper Ocean Terminal and for use by normal O&M activities once those presently engaged in the process have retired. The Corps stated that it prepares a Dredged Material Management Plan for each project that is intended to provide continuity over the years on what work is to be performed within the project, including at the CDFs. That document would be the Corps' primary traditional mechanism to transmit environmental clearance and compliance information to future employees. The Corps said it had been asked to release its dredged material disposal easement on the sites presently identified for placement of the cadmium-laden sediments. The Corps said it would investigate what mechanism it may have to place restrictions on the future use of a site if/when it releases its disposal easement.

EPA requested information on the proposed nearshore placement sites and plans. That plan was in the 90% version of the DEIS and the Corps will separately provide it to Doug Johnson.

EPA stated that biological testing of new work sediments would be needed prior to their disposal in the Savannah Ocean Dredged Material Disposal Site (ODMDS) (Section 103 Evaluation) unless we found that sediments that had been biologically tested within the last 10 years was similar physically and chemically to these new work sediments. EPA stated that a new Site Management and Monitoring Plan is needed for the Savannah ODMDS. EPA cannot concur in a new Section 103 Evaluation until a new SMMP is approved. The SMMP will likely be developed as part of the O&M Program, since they will need to use the ODMDS prior to any harbor deepening being constructed.

6. The group also briefly discussed the following items:

- **Monitoring and Adaptive Management Plan.** EPA said they had received the Monitoring and Adaptive Management Plan and will be providing comments on that document.
- **Boat Ramp**: EPA did not intend to provide any comments on this issue. They consider this issue resolved.
- **Striped Bass Stocking**: EPA did not intend to provide any comments on this issue. They consider this issue resolved.
- **Freshwater Supply System**: EPA did not intend to provide any comments on this issue. They consider this issue resolved.

- **Monitoring Period**: EPA stated that the proposed monitoring during construction and 5 years of post-construction monitoring should be adequate, as long as the adaptive management approach and the mitigation methods are working. They consider this issue resolved.

7. Not all pertinent EPA staff were available to discuss the project on 8 April. EPA recommended the Corps host an interagency meeting to discuss its wetland concerns (impacts to tidal freshwater wetlands, loss of saltmarsh, and proposed wetland mitigation features).

William Bailey
Savannah Unit Chief

------ DRAFT ------

Corps Responses
to
U.S. Environmental Protection Agency
Comments on February 17, 2009
Memorandum for Record

<u>Comments on the Status of Technical Issues in Table of Environmental Issues</u>

Mr. Stan Meiberg, Acting Regional Administrator, provided comments earlier, under separate cover, on the draft Meeting Summary Minutes. Attached to those draft Minutes from the Corps was a tabular summary of environmental issues. We offer the following comments to further clarify our understanding and position on the key issues of the study, and provide suggested next steps where appropriate. There have been many interim work products provided to the agencies by the Corps over the recent years. A summary of available information would help clarify the status of information pertaining to the issues.
EPA feels strongly that a meeting is needed of the technical work group prior to the preparation of the preliminary DEIS.

1. Monitoring: EPA is waiting on the updated monitoring plan for the potential alternatives to assure that all the concerns (DO impacts in harbor; salinity and velocity impacts in Middle and Back Rivers; chloride impacts for upstream water supplies; effectiveness monitoring of the Speece Cones; etc) are adequately addressed. The monitoring plan must be specifically designed to address the selected potential alternatives. EPA concurred with the specific concerns which Georgia EPD provided on the proposed oxygen injection monitoring plan. However, these concerns were not addressed in the Speece Cone demonstration and this resulted in inadequate data collection for determining the effectiveness of the Speece Cones in Savannah Harbor.

Additional coordination is needed after receipt of the monitoring plan to resolve any remaining concerns.

RESPONSE: The Corps envisions the monitoring to be the same no matter which depth alternative is selected, if any. We would consider specific comments or suggested refinements to the Monitoring and Adaptive Management Plan that we included in the 90% version of the DEIS at any time. We intend to include an updated monitoring plan in the DEIS.

2. Boat Ramp: EPA has no comment on this issue.

RESPONSE: Does EPA expect to comment on this issue? We would like to know if further coordination is needed to resolve any concerns your agency may have on this issue.

3. Adaptive Management: A defined Adaptive Management Plan has not been provided. The agencies and the States need to come up with agreed upon methods for monitoring the harbor impacts for each potential alternative, and for monitoring and evaluating the impacts of each proposed mitigation strategy. Each project's component will have a subtle impact on the DO, salinity and velocities of harbor system, therefore an ongoing detailed data and modeling analysis of the system will have to occur over the 5 year construction and 5 year post construction monitoring.

Additional coordination is needed after receipt of the Adaptive Management Plan to resolve any remaining concerns.

RESPONSE: Appendix D of the 90% version of the DEIS contained a Monitoring and Adaptive Management Plan. The early part of the plan describes how the various resources would be monitored and when reports would be available for review. The later part describes how and by whom decisions would be made based on that monitoring data. The District would consider any specific comments that an agency may provide, but understands that they are likely to provide additional comments during the formal review when the DEIS is made available to the public.

4. **NSBL&D Fish Passage**: EPA has not taken a position on this issue although we expressed concern at the Corps' August 26-27, 2008, Alternatives Formulation briefing, concerning the stated inability of the Corps to fully fund "off-project" mitigation. Striper spawning success is closely related to the need for river water quality in order to not inhibit this important aquatic function.

This issue is unresolved at this time.

RESPONSE: The District would construct the mitigation features concurrently with any harbor deepening that is implemented. This would include this fish passage structure. This structure would be implemented as mitigation for impacts to Shortnose sturgeon, not Striped bass. We consider the mitigation features to be part of the needed construction and would request funds to construct the entire project as quickly as possible.

Does EPA expect to take a position on this issue? We would like to know if further coordination is needed to resolve any concerns your agency may have on this issue.

5. Near Shore Disposal: EPA needs to review all available data on the testing of the dredged materials from the Bar Channel to be placed near-shore, and based on these data, may request that additional testing be conducted, e.g., elutriate chemistry, elutriate and whole sediment bioassays, and bioaccumulation testing. Furthermore, EPA would like to review Georgia DNR Criteria for near-shore placement of these materials. Available data from testing dredged materials to be placed near-shore must demonstrate that there will be no violations of State Water Quality Standards or Federal Water Quality Criteria during the placement of the material.

This issue is unresolved at this time.

RESPONSE: The Corps provided Doug Johnson at EPA with the various sediment testing reports prepared for this new work material. Appendix M of the 90 % version of the DEIS contains our Sediment Quality Evaluation. Appendix H contains the Section 404(b)(1) Evaluation, which includes information on the quantities of sediment to be excavated and deposited in various nearshore sites. We have attached a document "Nearshore Placement Plan" that we prepared in 2008 that describes the process we used to develop our plan for depositing new work sediments in the nearshore area. That document contains the following statements: "GA DNR-CRD concluded that we should evaluate nearshore placement of sediments exceeding an 80 % sand content (including shell hash). The District committed to identify areas along the entrance channel that meet that criteria and quantify the volume of O&M sediments normally removed from those areas. ….. The Corps would not try to create a high beach (above MHW), since the sand content did not approach the 95% threshold normally desired of such sediments." EPA should contact GA DNR-CRD directly for specific information on GA DNR criteria. Kelie Moore (912-264-7218) has been their technical POC on the SH Expansion Project.

6. Cadmium Containment: EPA shares SCDNR's and USFWS's concerns, as outlined in their January 14, 2009 and January 23, 2009, respectively, comments. EPA needs to further investigate all aspects of the proposed plans for cadmium containment. EPA requests a written plan on the long-term maintenance of the cadmium containment facilities – to include information on the monitoring plan, adaptive management of the facilities in the event of problems, and information regarding the full disclosure of the disposal and maintenance plans for the Jasper County disposal sites. EPA also shares SCDNR and USFWS concerns regarding Cd concentrations in remaining exposed surfaces in the Savannah Harbor after dredging. EPA will work with the Corps in developing necessary monitoring and management plans.

This issue is unresolved at this time.

RESPONSE: The Corps provided Doug Johnson at EPA with the various sediment testing reports prepared for this new work material. Appendix M of the 90 % version of the DEIS contains our Sediment Quality Evaluation. That Evaluation describes why the Corps has concluded that the exposed surfaces in the river do not present significant concern to fish or wildlife resources. The DEIS will contain a description of our proposed sediment placement plans. The basic plan is for the cadmium-laden sediments to be deposited in an existing CDF and covered and not disturbed in the future. The initial cover would be 2-foot thick layer of sediments which contain cadmium below levels of concern. Future deposition of additional O&M sediments would further isolate the cadmium-laden sediments. The DEIS will also contain a description of the monitoring we propose during the construction period.

7. Tidal marsh impacts: The impacts of dredging for bend widening and turning basin expansion are essentially the same for all alternative depths. The Savannah District Standard Operating Procedure (SOP) may be appropriate to apply to the 7.2 acres of salt marsh dredging since this type of impact is specifically covered by the SOP adverse impact table. For impacts less than 10 acres, a correction for the scope of the impacts the "magnitude factor") is not needed.

This issue is resolvable with additional detail about the proposed restoration of the proposed site.

RESPONSE: The Corps has provided information on the proposed restoration of Area 1S and will provide additional technical information soon.

7a. Tidal Freshwater Wetland Alteration: This major impact should be included in the Meeting Minutes' attached table of Environmental Issues. EPA has a responsibility to independently review the impacts of the project. EPA needs to review the saltwater intrusion impacts of each of the Harbor deepening alternatives and mitigation options in consideration of the new low flow data now available**.** Each of the mitigation plans should be comprehensive and in full compliance with the "Compensatory Mitigation for Losses of Aquatic Resources (Rule), Final Rule", 40 CFR Part 230, issued on April 10, 2008. The mitigation plans for the alternatives should include the information as outlined in the Rule's twelve basic requirements, including watershed assessment and functional assessments, preservation area requirements, financial assurances, monitoring and adaptive management, and a clearly described rationale for the proposed project-specific mitigation siting (versus an approved mitigation bank), etc. The documentation for the mitigation plans for each of the alternatives should be at the level of information equivalent to a "prospectus" as described by the Rule and as required by all commercial mitigation banks. The Corps of Engineers Charleston District has available an outline of the information that they require in a "prospectus" and this should be of valuable assistance in the preparation of the mitigation plans.

This issue is unresolved at this time.

RESPONSE: The Corps has provided EPA with information on the salinity impacts to freshwater wetlands as that data has been developed over the years. EPA staff has had the opportunity to participate in the Wetland Interagency Team that worked on this issue since 2003. The 90% version of the DEIS contains a description of how the impact and mitigation evaluations were conducted, as well as their outputs.

The compensatory mitigation "Final Rule" is part of 33 CFR, Part 325, which is titled "**PROCESSING OF DEPARTMENT OF THE ARMY PERMITS**". The stated purpose of the Rule is to establish standards and criteria "to offset unavoidable impacts to waters of the United States authorized through the issuance of Department of the Army (DA) permits". It applies individual permits, not civil works projects such as the Savannah Harbor Expansion

Project. Since the proposed wetland mitigation is being used for a single project, it is not considered a wetland bank like those developed by private interests for profit and application in the Regulatory Program. Much of the information sought about proposed mitigation in the "Reviewer's Checklist for Mitigation Bank Documents", dated 6-18-08 and provided by Bob Lord is already included in the DEIS. It may not be in the format those who review proposed individual regulatory permits are accustomed to seeing, but the same type of information is in the DEIS or GRR.

8. Land Acquisition: This issue is relevant to the impacts to tidal freshwater wetlands addressed in issue 7a. The Savannah District' Standard Operating Procedures (SOP) is not designed to quantify the adverse impacts to wetlands due to changes in salinity and thus conversion of one wetland type to another. This is the larger wetland adverse impact associated with the project. Changes from any natural or baseline condition are considered to be "adverse" even though the altered wetlands will have their own suite of functions, some of which may be in common with the previous wetland type. Also, the scope of these impacts will vary over the impact area. Normally one would use a functional assessment to look at the lost functions due to the adverse impacts and then apply the same functional assessment to the functional gain due to the mitigative action. However, currently the Savannah District is proposing wetland preservation as the type of compensatory mitigation (at an approximate 8:1 ratio for the 48-foot alternative). This does not replace any lost functions and is less than EPA's recommended 10:1 to 60:1 ratios for preservation cited in the EPA Region 4 Mitigation Policy. However, it should be noted that the wetlands impacted will still retain some of the original functions and will still be functioning wetlands, albeit of a different type. Without a functional assessment, the use of preservation and the determination of the appropriate quantity of mitigation are policy, not technical, issues.

One further note regarding the SOP. Morphological changes to a stream are covered by the SOP, and the proposed dredging of the Savannah River is clearly a morphological change that will increase channel instability. This is a substantial adverse impact under the stream portion of the SOP. There is some debate as to whether tidally influenced streams are "streams" similar to freshwater streams with unidirectional flow. So there is some debate as to how to treat these types of systems under the SOP. Regardless of this debate, it appears the subsequent channel instability and associated impacts with the actual dredging and other channel modifications have not been fully assessed, let alone considered for mitigation.

This issue is unresolved at this time.

RESPONSE: The District's use of the Regulatory Standard Operating Procedures to quantify the number of acres required as preservation to compensate for the conversion of freshwater and brackish wetlands stems from Bob Lord's 2007 recommendation to use that approach on this project. Replacement ratios are unacceptable to HQUSACE, and the SOP provides a rationale for determining the extent and acceptability of proposed mitigation actions. Preservation is an accepted procedure in the SOP and the SOP quantifies the mitigation need through evaluation of the functional value of both the impacted lands and the lands to be acquired. The Corps agrees that the impacted marshes will retain many of the same functions that they presently possess. As discussed with EPA staff, that would make a detailed functional assessment to determine the extent of the lost wetland functions very difficult from a technical perspective.

The District does not concur that the proposed deepening of the navigation channel would be a morphological change that leads to channel instability. In general, no dredging is proposed of the existing side slopes. The dredging would create a deeper channel by extending the existing side slopes lower. This would effectively decrease the bottom width of the channel. The decision to not widen the existing channel cross-section was a conscious one that the PDT took to preserve the stability of the side slopes and limit impacts to adjacent high ground. EPA is incorrect in stating that channel instability and associated impacts with the actual dredging and other channel modifications have not been fully assessed or considered for mitigation. The Engineering Appendix of the GRR, which was provided to EPA in July 2008, contains the slope stability analysis, the bank erosion analysis, and the coastal erosion analysis that the Corps has conducted to assess the channel and shoreline stability effects of the various depth alternatives.

9. Striped Bass Stocking: EPA has no comment on this issue.

RESPONSE: Does EPA expect to take a position on this issue? We would like to know if further coordination is needed to resolve any concerns your agency may have on this issue.

10. Flow Modification: Our assumption is that this issue is related to the diversion of flow from the main river into the Little Back River as shown in various mitigation alternatives, and the impacts to the Refuge management. The effectiveness of this diversion in preventing the salinity intrusion into the freshwater wetlands and preventing its conversion is a significant unknown.

Note that the States, in conjunction with USGS, have completed some velocity and flow monitoring (fall 2008) of the Middle and Back Rivers and Georgia has contracted to continue this monitoring starting in July 2009 to help address impacts in the Middle and Back Rivers. Evaluation of the available fall of 2008 monitoring data and detailed evaluation of the alternatives' modeling must be completed before resolution can be expected. Additional coordination is needed after receipt of the USACE technical analysis, including all the pertinent modeling runs.

This issue is unresolved at this time.

RESPONSE: EPA states that the effectiveness of the proposed flow modifications is a significant unknown. There will be unknowns about any engineered structure until it has been constructed and operated under different conditions. Your letter mentions additional data that was recently gathered by the States and USGS and some that is scheduled to be gathered in 2009. If you could provide that information, we would be glad to evaluate it.

Your comments state that “Evaluation of the available fall of 2008 monitoring data and detailed evaluation of the alternatives’ modeling must be completed before resolution can be expected.” Is that an evaluation that EPA intends to perform?

Your comments state that “Additional coordination is needed after receipt of the USACE technical analysis, including all the pertinent modeling runs.” We believe we have provided all the technical modeling information that you have requested. If that is not the case, please let us know. If it is the case, is the EPA staff ready to begin that specific coordination?

11. Freshwater Supply System: This is a proposed mitigation for a previous deepening project that was but never fully implemented in the SNWR. EPA has no comment on this issue at this time.

RESPONSE: The Freshwater Control System is located on lands within the Savannah National Wildlife Refuge. The USFWS manages that property. When the system was being constructed, the USFWS reversed its previous approval and requested we not construct one aspect of the system.

Does EPA expect to take a position on this issue? We would like to know if further coordination is needed to resolve any concerns your agency may have on this issue.

12. Depth Selection: EPA agrees that this is not an issue for technical resolution at this time. However, this will be the major decision for the project. The appropriate point in the review of this issue is after the Draft EIS is issued and has been reviewed by all the agencies; with hopeful interagency consensus on the depth and all mitigation.

RESPONSE: No response needed.

13. Sturgeon Forage Habitat: The Short-nose sturgeon is a listed species and its success is closely related to river water quality. EPA will require assurances that harbor deepening will not inhibit this aquatic use of the river.

RESPONSE: The Corps is coordinating with NOAA-Fisheries on this issue, as they are the Federal agency who oversees compliance with the Endangered Species Act on this species. The proposed harbor deepening would adversely affect Shortnose sturgeon habitats and mitigation is proposed to compensate for those impacts.

14. Sturgeon Habitat Criteria: This is a NMFS/FWS issue closely related to the preceding issue and EPA will require assurances that the updated criteria will be protective of the Short-nose sturgeon’s use of the river

RESPONSE: At NOAA Fisheries request, the Corps is assessing whether different habitat suitability criteria may better reflect recent data on the locations at which Shortnose sturgeon are found in the harbor. If we and NOAA find that revised criteria are better indicators of observed acceptable SNS habitat, the Corps would approach the Fishery Interagency Coordination Team to determine if they concur. It would only be after approval of the group that developed the initial habitat suitability criteria, that the Corps would implement it for impact and mitigation purposes.

15. Dissolved Oxygen Data: We recommend that USACE provide the data and model outputs to the federal and State agencies in binary files which the models can easily produce. This will allow review of the data in the detail that is appropriate.

RESPONSE: The Corps believes that we have provided all the technical modeling information that you and the States have requested. If that is not the case, please let us know. If that is the case, please let us know when your review will be complete.

16. Monitoring Period: Five-year monitoring during construction and 5 years of post construction monitoring should be adequate, as long as the adaptive management approach and the mitigation methods are working. If there is a problem or issue with the proposed mitigation in that it's not working appropriately then additional monitoring may be needed after the mitigation methods are updated.

This issue appears resolved at this time.

RESPONSE: The Monitoring and Adaptive Management Plan (Appendix D in the 90% version of the DEIS) describes how additional monitoring would be performed if an adaptive management measure is implemented.

17. New Work Sediment Monitoring: EPA would like to review the 2-year monitoring plan for placement of sediments in the near shore area. Additionally, if any material is to be taken offshore for placement in the Savannah ODMDS, it must go through established procedures under the MPRSA and EPA's Ocean Disposal Criteria, and there must be documented demonstration of compliance with the Ocean Dumping Criteria, including a MPRSA Section 103 Evaluation and written concurrence from EPA for disposal in the Savannah ODMDS.

This issue is partially resolved.

RESPONSE: The monitoring plan will be included in the DEIS. It will focus on identifying movement of the deposited new work sediments. The placement plan does include some deposition within the ODMDS. The DEIS will contain a Section 103 Evaluation.

18. Magnitude Factor: Please refer to EPA's response to issue #7.

RESPONSE: The Corps is glad to hear EPA' concurrence that a correction to the SOP to address the scope of the impacts (a "magnitude factor") is not needed. The Corps will show this issue as "Resolved".

19. Economic Analysis: This is not a technical issue but rather a NEPA requirement of disclosure. EPA said at the AFB meeting that we had questions about the clarity of the rationale and as did the Corps' headquarters staff. EPA has not been provided any additional data to review at this time.

Resolution is uncertain.

RESPONSE: The economic work is still underway. We will provide that additional information to EPA when it becomes available.

20. Speece Cones: EPA is awaiting receipt of a final report. EPA's technical position is that the Speece Cones may work but we are unsure how effective they will be in a tidal system. Note that EPA, the States and dischargers are also looking at oxygen injection systems as a wastewater treatment alternative, and based on the available data on the O2 injection systems we can expect 75 to 80 percent transfer efficiency. Again for proper evaluation of the USACE proposed O2 injection system there are additional details that need to be identified (e.g., where the injectors are located, at what depth and with what kind of diffuser pipe). All these variables must be evaluated for all the alternatives.

Additional coordination is needed after receipt of the USACE technical analysis and the modeling scenarios of the potential alternatives with and without the O2 injection. In addition, the Corps needs to address in the DEIS the legal mechanism that will be used to ensure that, if O2 injection systems are put in place, they will be properly operated and maintained in perpetuity. The proposed TMDL will allow the dischargers to lower the DO in the system up to 0.1 mg/l, compared to the 0.8 mg/l impact they are presently causing. The proposed deepening without the O2 injection will lower the DO in the harbor approximately 1.0 mg/l, therefore if the oxygen injection systems are not kept in operation serious water quality issues will occur.

This issue is unresolved at this time.

RESPONSE: The data which the manufacturers have provided the Corps indicate a much higher on the transfer efficiency rate than that cited by EPA. We would like to review the information you have on the efficiency of these D.O. injection systems.

The details of the D.O. systems that you request are normally detailed design information that is developed during preparation of contract plans and specifications. If you have specific guidance for the Corps on specific locations, depths and type of injectors, please let us know. The EPA 3-D models that we all agreed were sufficient for impact and mitigation purposes do not require or provide the level of detail you have identified for their calculations on the effects of the proposed D.O. addition.

21. Air Quality – This is a concern regarding direct and indirect impacts of port expansion. EPA requests a detailed quantitative analysis for the DEIS of the impacts of port expansion on criteria air pollutants.

Region 4 continues to encourage the Corps to include in the DEIS an evaluation of the potential local impacts of the proposed actions associated with air toxics - both during construction and associated with operations of the port. This evaluation should follow the tiered risk-based approach outlined in the Air Toxics Risk Assessment Reference Library, Volume 1, Section 3.3.3 (http://epa.gov/ttn/fera/risk_atra_main.html), including a detailed emissions inventory of mobile and stationary sources of air toxics at the port followed by dispersion modeling and evaluation of the potential health impacts. The DEIS should also address alternatives to mitigate potential impacts of air toxics during construction and operation. This process was carried out for an expansion effort at the Port of Los Angeles and is provided here as an example: (http://www.portoflosangeles.org/EIR/ChinaShipping/DEIR/deir_china_shipping.asp).

RESPONSE: Appendix K of the 90% version of the DEIS contain an Air Emission Inventory that we prepared at the request of EPA. That analysis includes an identification of the amount of air toxics that would result With and Without the proposed project. At your request we expanded an initial version of that analysis to include air emissions in the port that are not affected by the proposed action. That additional information provides a context from which one can judge the effects of the proposed action on the overall emissions in the harbor and the County. Since our analyses show that emissions would decrease if the harbor is deepened (With vs. Without Project), we do not believe that dispersion modeling and evaluation of the potential health impacts are warranted. Similarly, since overall air emissions, including air toxics, would decrease if the harbor is deepened (when compared to the Without Project condition), we do not believe that any mitigation is warranted.

General Technical Comments

A. USACE, EPA and States of Georgia and South Carolina, along with the other Federal Agencies jointly developed and/or reviewed the data and modeling on which the deepening water quality analyses are based. This culminated in a January 2006 data and modeling report that used 1999 as a critical condition (low flow and high temperature) year. All agreed that the 2006 model and data report were adequate to make initial screening projections and evaluations of the potential deepening alternatives; however now we have new low flow data for 2007/08 which must be considered in the alternatives analysis.

RESPONSE: As you stated, the agencies agreed to use 1999 as the critical condition for water quality analyses. If your agency has new additional requirements, please let us know what you need. While the present drought is worse that 1999 in some portions of the basin, the effect has not been uniform throughout the basin. Conditions in the harbor have not been nearly as severe as those in the upper basin. The drought is not yet over, so if one wants to look at the drought of record for a certain location (would that be the harbor or the river), we would need to wait until the drought is complete to be able to fully assess the effects of that once-in-a-lifetime event.

B. EPA agrees that a reasonable suite of port expansion depth alternatives are being addressed. However, EPA wishes to stress the importance of a comprehensive alternatives evaluation of potential port sites in the DEIS. The site selection criteria need to be equal across all alternatives in order to compare sites objectively. There should not be a presumption that the Savannah River would be deepened to Garden City in the evaluation of potential sites down-river.

RESPONSE: EPA approved the Formulation of Alternatives Report prior to the public release of that document in May 2005. That document contained our detailed analysis of potential alternatives to address the navigation problems occurring in Savannah Harbor. We included that information in the 90% version of the Draft GRR, which EPA reviewed. If you now believe that site selection criteria are not equal across all alternatives, please let us know the specifics behind that concern.

The Corps does not presume that the Savannah River would be deepened to Garden City in our basic evaluation of potential sites down-river. Our Without Project assumption is that the navigation channel would remain as it presently exists and continue to be maintained at its 42-foot authorized depth. The 2005 Formulation of Alternatives Report concluded that deepening to only a new terminal located downriver, such as one in Jasper County, was not the most economically efficient means of addressing the harbor's navigation problems. The sensitivity analysis that we are now conducting of a potential terminal in Jasper County will identify the effects that a new terminal downriver could have on the Federal decision to deepen to the Garden City Terminal. As such, it does assume that someone other than the Federal Government would construct a new terminal after we deepen the channel to the Garden City Terminal. The analysis would identify how sensitive the economic justification of the Federal decision is to a range of potential future actions of others.

CESAS-PM-C August 21, 2009

Memorandum for Record

Subject: Savannah Harbor Expansion Project: Executive Steering Committee Meeting, August 20, 2009.

1. The fourth Savannah Harbor Expansion Executive Steering Committee Meeting was held on August 20, 2009, at the Georgia Ports Authority offices in Garden City (Savannah), Georgia. In attendance were: Gen. Todd Semonite, Col. Ed Kertis, Wilbert Paynes, Jason O'Kane, Sharon Haggett, Bill Bailey, Paul Bradley, Pete Oddi, Curtis Flakes (USACE); Stan Meiburg, Jim Greenfield and Heinz Mueller (US EPA); David Bernhart (NOAA Fisheries); Patrick Leonard, Jane Griess and Ed EuDaly (USFWS); Steve Green, Jamie McCurry and Hope Moorer (GPA).

2. The meeting was opened with introductions and welcome by Col. Kertis. He also emphasized the need to work toward resolution of issues as much as possible. Gen. Semonite discussed the benefits of this vertical interagency team, how he was pushing for an expedited Civil Works process, and his desire for us to identify any outstanding issues now rather than later. He closed by stating the need for timely deliverables by everyone.

3. David Bernhart stated the quarterly meetings helped to focus on the project considering all of their other competing priorities. Leornard Patrick stated he was new to this group and would be representing the new Regional Director, who had another commitment, for the day. He also added that former Regional Director Sam Hamilton had recently been promoted to the National Director of USFWS. EPA mentioned that they would probably never have the project approval authority delegated to their Regional office.

4. Jason O'Kane reviewed the agenda and discussed outstanding tasks from the April 30, 2009, meeting. Bill Bailey then began a review of environmental issues and their status. As Mr. Bailey reviewed the goals of this group, Col. Kertis stated the intent of the group should be to resolve as many issues as possible prior to the first official comment period, with no new issues being raised from this point forward.

5. Mr. Bailey stated that after the 10 August site visit, EPA expressed concern about the nature of the habitats expected at the proposed marsh restoration site (1S) and that occurring at the impact site (whether it would be in-kind mitigation). He expects this comment would be resolved once the habitat types (brackish marsh) and proximity (1.2 km) were better explained.

6. There was discussion about the acceptable level of monitoring of the cadmium disposal areas. The Corps stated the latest draft disposal plan would be provided to the agencies by approximately August 28 for review. EPA reiterated their desire that the

Corps describe how long term operation of the site would ensure the cadmium doesn't leave the site. The Draft EIS will address this issue.

7. Discussions continued regarding Shortnose Sturgeon modeling habitat criteria – the Corps would coordinate with the Fisheries Interagency Coordination Team concerning proposed (NOAA Fisheries-approved) revisions to the SNS habitat criteria.

8. It was discussed that the Corps would ensure the Draft EIS includes the information required proposals by the new "mitigation rule" in Section 404 Regulatory permit program for mitigation banks.

9. On air quality, Mr. Bailey stated that since the project would result in fewer (but larger) container ships calling at the port, long term air emissions would be reduced as a result of the project. Temporary increases in emissions would result from the dredges that deepen the river and implement that mitigation. The Corps did not believe that a dispersion analysis was required because the additional air pollutants would be temporary (occur only during construction), would be mobile (move along the river for dredging), and would already be distributed along the 36 miles of channel to be dredged as the dredge moved to deepen then entire length of channel. The increased emissions would also be only a small increase when compared to the existing emissions in the County, which is an Attainment area. EPA stated they disagreed and although the effects may be negligible, the dispersion analysis/modeling was a relatively easy process to verify this assumption. The Corps agreed to pursue the dispersion analysis and EPA agreed to assist.

10. EPA is still reviewing the Sediment Quality reports. They agreed to provide a status on their review at the next ESC meeting.

11. Mr. Bailey explained the various issues with the monitoring and adaptive management plan and that we were reviewing NOAA Fisheries recent comments on the plan. The Committee discussed including identifying impact thresholds that would trigger certain mitigation actions, but they recognized that it would be problematic to determine what factors or resources would be measured for such a complicated system and project. They also discussed the fact that adding costs for any possible adaptive management measure regardless of the likelihood of occurrence increases the cost of the project and hurts the benefit to cost ratio. Typically, mitigation costs are 2% of project cost, with 10% being considered high. The mitigation costs for this project now range from 33 to 50% of the total project costs. This does not in itself make the project unacceptable, but makes it very important that the report clearly state why each mitigation expense is required and the best value to offset the environmental impact. At some point, the congressional legislative process should be considered the mechanism to correct any severe unforeseen environmental impacts.

12. Wilbert Paynes explained we were working with Headquarters USACE to identify how we could, or if we could, assure O&M funding for the project's mitigation features such as the dissolved oxygen injection systems.

13.   Curtis Flakes reviewed the status of the economic analysis. NOAA Fisheries, David Bernhart, agreed to find out who within the Department of Commerce or NOAA would be concerned with evaluating the commercial navigation aspects of the project. We agreed to carefully consider that person's involvement before an effort was made to engage their interaction.

14. Mr. O'Kane reviewed changes to the schedule since the April 30, 2009 ESC meeting. The agencies expressed concern that the period for their review of the documents prior to public release of the reports had been reduced from 60 to 30 days. The Corps agreed to investigate providing components of the environmental documents earlier to effectively provide the agencies with more review time.

15. The Corps agreed to draft a proposed approval process for coordination among the other agencies at the next ESC meeting.

16. It was suggested we hold the next Executive Steering Committee meeting November 9, 2009, in Atlanta at the USACE's CESAD office.

-- DRAFT --

Jason O'Kane
Project Manager

CESAS-PM-C 3 December 2009

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project (SHEP) Executive Steering Committee Meeting, 9 November 2009.

1. The fifth Savannah Harbor Expansion Executive Steering Committee Meeting was held 9 November 2009 at the US Army Corps of Engineers (USACE), South Atlantic Division, downtown Atlanta, Georgia. In attendance were: BG Todd Semonite, Les Dixon, COL Edward Kertis, Wilbert Paynes, Jason O'Kane, William Bailey, Pete Oddi, Todd Boatman, Daniel Small, Jeff King (USACE); Stan Meiburg, Heinz Mueller, Jim Greenfield (EPA); David Bernhart (NOAA Fisheries); Jack Arnold (USFWS); Gregory Hogue (Department of the Interior); Doug Marchand, Steve Green, Jamie McCurry and Hope Moorer (GPA). Action items are underlined to aid identification.

2. The meeting was opened with introductions and welcome by BG Semonite. Jason O'Kane discussed action items still pending from past meetings. Mr. Bill Bailey then presented an update on environmental issues.

3. It was agreed that <u>USACE will coordinate a meeting with EPA regarding assurances for the Dissolve Oxygen (D.O.) mitigation</u>. The goal would be to determine some minimal level of D.O. mitigation (D.O. injection). Corps representatives at the meeting did not think absolute assurances could be given on funding. Meeting should include necessary Programs and Operations staff.

4. It was agreed that <u>USACE will coordinate a meeting with EPA regarding air quality</u>. The resolution from this meeting would also be covered in the 21 Dec 09 monthly SHEP IPR.

5. It was agreed that the <u>USACE will coordinate a meeting with the USFWS regarding monitoring for cadmium, physical vs. biological, and present the outcome at the next ESC meeting</u>. One idea was offered that we perform physical testing until some predetermined level is found that would then trigger biological testing.

6. It was agreed there would be a <u>16 Dec 09 meeting between the USACE (Mr. Steve Calver) and EPA to discuss EPA's sediment quality analysis</u>. <u>Freshwater marsh impacts from the project will also be discussed at this meeting.</u>

7. Agencies were reminded that a large portion of project costs are mitigation; thus increasing the need to clearly justify all costs. The agencies agreed to support the USACE in the justification of all mitigation and its adequate documentation.

8. Mr. O'Kane presented an update on the project schedule and an engineering update. It was discussed that the agency will be asked for input for two Federal Principles meetings in the Washington, DC, area with invitations going out at the regional Senior Executive Service level, one for the Senior Leaders Panel and one for the Civil Works Review Board. Current scheduled dates for these and other important milestones to the agencies would be sent out by the USACE later in the week.

9. An economics update was presented by Mr. Bernard Moseby. He discussed the on-going modeling, benefit calculations, (USACE) technical review of the partial products, primary issues we are working to resolve, sailing draft distributions and data averaging. These factors effect benefit calculations. Mr. Steve Green added that these issues, along with the feasibility of using tides into the future, are the main GPA issues also at this point. The USACE agreed to provide an estimate of the additional work required to resolve recent concerns and updated schedule by 13 Nov 09.

10. NOAA Fisheries, David Bernhart, recommended the USACE perform a Right Whale analysis in conjunction with our other channel design investigations and include the finding with the EIS. He recommended using the same team as other recent similar analysis for other harbors such as Jacksonville. The USACE agreed to perform a Right Whale analysis.

11. It as agreed the USACE would provide an update on the Sea Level Rise Engineering Circular at the next meeting.

12. It was agreed that the USACE would work with NOAA to refine the completion of their Biological Opinion prior to any major meetings or decision points such as the Senior Leaders Panel.

13. It was agreed we hold the next Executive Steering Committee meeting would be held on 26 Feb 09 in Atlanta at the USACE CESAD office.

Jason O'Kane
Project Manager

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

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F/SER31: KBD

FEB 4 2010

William Bailey
Savannah Unit Chief
Mobile-Savannah Planning Center
Savannah District, Corps of Engineers
P.O. Box 889
Savannah, GA 31402-0889

Dear Mr. Bailey:

This is in response to your letter received by the National Marine Fisheries Service (NMFS) on December 9, 2009, regarding your rationale for selection of a preferred alignment of the proposed ocean bar channel extension associated with the Savannah Harbor Expansion Project (SHEP). The extension and alignment are needed to address avoidance of potential shoaling areas located within the present channel alignment that could become problematic with the proposed 48-foot deepening alternative and associated channel extension from Station -60+000B to Station -85+000B (S-1). Your analysis finds that there would be a negligible effect to the North Atlantic right whale (*Eubalaena glacialis*) with the implementation of the re-aligned channel extension (S-8). The channel extension and re-alignment are new features that are being added to the SHEP and will need to be included in the NEPA analysis.

We are providing comments and questions on the analysis for your consideration in finalizing the biological assessment for threatened and endangered species and draft Environmental Impact Statement, which will provide the basis, in part for our biological opinion for SHEP. In our biological opinion, we will analyze the project impacts to right whales, including the proposed alignment and location of the channel extension, and will conduct a review of the data on the number of transits to and from the port by cargo vessels. Usage of the channel and adjacent area by other vessels associated with SHEP and the port (e.g., construction vessels, pilot boats, and dredges) will also be analyzed. We will also look at effects from dredging and construction activities. These data will be used to determine the risk to individual whales and then right whales as a population, based on our knowledge of right whale usage of the action area and the expected direction of ship traffic. When information is unknown or in doubt we will err on the side of the species. Until we receive a specific request for consultation with an effects determination for federally-listed species including the endangered North Atlantic right whale, we offer this initial response to your analysis.

Questions about analysis

1. For your analysis, you assume that a hopper dredge with a capacity of 3,600-4,000 CY would most likely be used during the dredging of the channel extension. You also state that the range of hopper dredge volumes that may be used is as small as 2,000 CY. Unless such a small dredge is unrealistic, would it not be more conservative to conduct the analysis assuming smaller dredges with more transits?

2. The report states the project is likely to take anywhere from 9 to 26 months. Could the timing of construction activities be structured to avoid calving seasons?

3. Where is the "placement area" that is referred to in the comparison of dredge movement distances between the S-1 and S-8 bar channel alignments?

4. It is unclear how much longer the channel will be or how much farther offshore the pilot boarding area will be located. Could a clearer map or shapefile be provided that shows these areas?

5. How will a channel extension affect harbor pilot operation? What is the frequency of trips to the boarding area and how fast does the pilot boat travel to and from its destination?

Specific comments

- We know ship collisions are one of two primary human-induced sources of mortality in right whales. The number of documented deaths may be as little as 17% of the actual number of deaths (Kraus et al., 2005). Additionally, when right whale carcasses are discovered, the location represents where the carcass was discovered and not where the mortality occurred. Therefore, no reports of right whale ship strikes in the Savannah area does not mean the approach and departure vectors are aligned to minimize risk to right whales from ship strikes or that right whales have not been ship struck in that area.

- Garrison's analysis did not include air survey data from the upper coast of Georgia and lower South Carolina coast; these data should be included when considering the Savannah area. Without looking at those data, we don't know if right whale distribution there is even or clumped (i.e., S-8 or S-1 alignment may/may not funnel traffic over an area with a higher occurrence of right whales).

- Speed restrictions to protect North Atlantic Right Whales (50CFR224.105) will only be a temporary protection measure because the speed rule is effective only through Dec. 9, 2013, but the channel will be long-lasting/permanent.

- Aerial surveys in Savannah are not considered "Early Warning System" surveys because surveys over Savannah are flown too infrequently.

The risk of collision with ocean-going vessels is a continuing challenge to the recovery of the endangered North Atlantic right whale. Perhaps less than 400 individuals remain. NMFS is concerned that much of their habitat coincides with areas of high commercial shipping traffic (Ward-Geiger et al. 2005), which includes areas located offshore of the Georgia coast and the Savannah Harbor. In order to protect the few remaining individuals, it is critical that measures be taken to avoid often fatal collisions with ships.

We thank you for the opportunity to provide these comments and look forward to further cooperation with you on this project to ensure the conservation of our threatened and endangered marine species. If you have any questions, please contact Barb Zoodsma at (904) 321-2806 and by e-mail at Barb.Zoodsma@noaa.gov or Kay Davy at (954) 356-6791 and by e-mail at Kay.Davy@noaa.gov .

Sincerely,

D M Bernhart

David M. Bernhart
Assistant Regional Administrator
for Protected Resources

File: 1514-22 f. 3

CESAS-PM-C 2 April 2010

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project (SHEP) Executive Steering Committee Meeting, 2 April 2010.

1. The sixth Savannah Harbor Expansion Executive Steering Committee Meeting was held 2 April 2010 at the US Army Corps of Engineers (USACE), South Atlantic Division, downtown Atlanta, Georgia. In attendance were: MG Todd Semonite, Les Dixon, Col. Edward Kertis, Wilbert Paynes, Jason O'Kane, William Bailey, Pete Oddi, Curtis Flakes, Todd Boatman, Daniel Small, Terry Stratton, Dylan Davis, Jeff King (USACE); Miles Croom (NMFS), Stan Meiburg, James Giattina, Jim Greenfield and Heinz Mueller (USEPA Region 4), Gregory Hogue (Department of the Interior), and Mark Musaus and Jack Arnold (USFWS). Action items are underlined to aid identification.

2. The meeting was opened with introductions and welcome by MG Semonite and Col. Kertis. Jason O'Kane discussed action items still pending from past meetings. Discussion indicated there was still uncertainty about the proposed approval project for purposes of both the final report and the conditional authorization. <u>It was agreed the next ESC would include a summary of the approval process</u>. The agencies express gratitude for the 26 Mar 10 meeting and site visit to the disposal areas hosted by the Savannah District USACE.

3. The disposal plan for the cadmium-laden materials was discussed. <u>USFWS agreed they were developing an agency position and would provide comments to the Corps</u> as early as possible. Of most concern were any possible high concentration "hot-spots" that may exist in the materials and are the cap cadmium levels low enough. They advised it may be submitted as part of their comments on the draft EIS. MG Semonite asked that a course action leading to resolution be clearly identified by the 27 May 10 Senior Leaders Panel (SLP) so that this could be considered an issue on its way to being resolved.

4. It was agreed the fleet forecast was necessary to further discuss the impacts on air quality impacts. Heinz Mueller added that EPA would be expecting a Tier I or inventory air quality analysis even if impacts with the project were less than the without project condition. Wilbert Paynes asked for clarification on this point and Stan Meiburg restated the need and explained that recent changes to the air quality standard and the fact that any change would be occur both made the analysis necessary. <u>It was agreed this would be further discussed at the technical level.</u>

5. Dr. King stated that the project had been give guidance that post-construction monitoring and adaptive management would be funded through the Corps normal budget process. Mr. Stan Meiburg stated this was of great concern, and several other agency

representatives agreed, since the normal budget process doesn't guarantee or even reasonable assure funding. Mr. Les Dixon restated that the normal budget process is all we could offer and MG Semonite asked what other options were available. Hope Moorer asked would it be possible for the sponsor to set aside creditable funds for this purpose. Mr. Les Dixon and Mr. Wilbert Paynes both agreed it likely was possible but were not sure of the exact mechanism. Mr. Curtis Flakes agreed that Mobile Planning would research how the sponsor could set aside creditable funds for post-construction monitoring and adaptive management and feedback would be provided back to the group and GPA by 1 May 10.

6. Mr. Jack Arnold also added to the post-construction monitoring and adaptive management discussion that the triggers for additional monitoring or adaptive management were poorly define. Dr. King responded that the draft EIS would include an updated monitoring or adaptive management plan with more clearly defined triggers for their review and comment.

7. Mr. Bernard Moseby gave an update on the economics analysis. It was agreed the agency representatives would be notified by phone calls when we have identified the NED.

8. Mr. O'Kane provided the Engineering update including the work to assure the report clearly complies with all sea level rise guidance. The importance of agreement on a clear and concise path forward as a result of the sea level rise meeting on 6 Apr was stressed.

9. Agencies agreed to keep 13 May 10 ESC meeting as scheduled to allow for a huddle prior to the 27 May 10 SLP in Washington DC.

10. In the closing remarks, it was asked by the agencies if we could just remove the New Savannah Bluff Lock and Dam rather than constructing the fish by-pass structure. It was stated by the Corps that this was not possible due to legislation that requires the rehabilitation and turn-over to the City of North Augusta pending the availability of funds.

11. MG Semonite re-emphasized the sensitivity and preliminary nature of any documents or information we shared with the agencies and asked they do not share it outside their organizations.

DRAFT

Jason O'Kane
Project Manager

CESAS-PM-C 17 September 2010

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project (SHEP) Executive Steering Committee (ESC) Meeting, 17 September 2010.

1. The seventh Savannah Harbor Expansion Executive Steering Committee Meeting was held 17 September 2010 at the US Army Corps of Engineers (USACE), South Atlantic Division, downtown Atlanta, Georgia. In attendance were: MG Todd Semonite, Les Dixon, Col. Edward Kertis, Wilbert Paynes, Neil Purcell, Daniel Small, Dylan Davis, Cole Gatwood, Pete Oddi, William Bailey, Alan Garrett, Sharon Haggett, Jason O'Kane, Curtis Flakes, Todd Boatman, (USACE); Miles Croom (NMFS), Stan Meiburg, Tom Welborn, Bill Melville and Heinz Mueller (USEPA Region 4), Joyce Stanley (Department of the Interior), Mark Musaus and Jack Arnold (USFWS), Hope Moorer, Jamie McCurry Steve Green, Alec Pointevint and Curtis Foltz (GPA). The sign-in sheet it attached for reference. Action items are underlined to aid identification.

2. The meeting was opened with introductions and welcome by MG Semonite and COL Hall. It was noted this was COL Hall's first ESC since taking command of the Savannah District in June 2010. MG Semonite summarized the progress that has been made to date. He continued by discussing the collaboration that has taken place and will continue to occur between the cooperating Federal Agencies on the SHEP. The recent arrival of the Figaro, the largest container vessel to call at the Port of Savannah, was discussed. Mr. Curtis Foltz, Georgia Ports Authority (GPA) Executive Director reiterated how the vessel was extremely light loaded and still required an 18 hour delay due to tidal restrictions which were further hampered by inclement weather conditions, a common afternoon thunderstorm.

3. Ms. Sharon Haggett then presented the project status update as outlined the attached presentation. Mrs. Haggett reviewed the internal USACE review process including District Quality Control (DQC), Agency Technical Review (ATR) and Preliminary Independent External Pier Review (IEPR) that has taken place since the last ESC meeting conducted 2 April 2010. This included a brief summary of the comments, resolutions and the associated documentation of the process. Ms. Haggett also indicated some of the economics comments were elevated within the USACE for resolution.

4. Economics Summary: Mr. Bernard Moseby, USACE lead economist, indicated that the likely resolution of the remaining comments would require that the USACE vertical review teams, including the Office of Water Policy Review, agreed to disagree on approximately 3 of the 13 open comments. The remaining 10 open comments will reach resolution when the reviewers are able to see the full response in the report which was expected soon. Generally, the recommendations from the open comments do not affect the selected plan.

Economic Taskers:

a) MG Semonite tasked the vertical team (Mr. Paynes) to facilitate resolution of the outstanding Economics comments within two weeks.
b) MG Semonite commented on the outstanding economics modeling comments and requested that all comments be provided to and coordinated with GPA

5. Engineering Summary: Ms. Haggett summarized the Engineering comments indicating that the GRR/EIS package submitted incorporated all but the Costs comments. The resolution of the cost comments has been completed and submitted to OWPR for review as of the 14 September. In summary, the Cost changes required by the ATR resulted in a decrease of 0.15% in the Total Project Costs at the mid-point of construction across all alternatives. It was concluded that these changes do not affect the NED Plan identification or any other project decisions, are insignificant and will be incorporated prior to public review. There were no Engineering taskers.

6. Environmental Summary: Ms. Haggett summarized the Environmental Impact Statement review comments indicating that all were addressed and closed. The ESC discussed the funding of Monitoring and Adaptive Management and Ms. Moorer from GPA articulated the GPA position on providing an assurance and escrow of non-Federal funds to perform Monitoring and Adaptive Management. ESC attendees understand that USACE is not allowed to escrow Federal funds but that there is nothing prohibiting the non-Federal sponsor from escrowing their portion of funds needed for Monitoring and Adaptive Management. This will be captured in the Project Partnership Agreement when it is prepared for execution.

Environmental Tasker: Ms. Moorer (GPA) will provide a letter to USACE articulating the GPA's position that they are willing to establishing a non-Federal escrow account for the non-Federal portion of the Monitoring and Adaptive Management costs.

7. Schedule Review: Ms. Haggett reviewed the overall Project Schedule indicating the date for the CWRB and ROD had moved forward as a result of guidance received from OWPR and HQUSACE following the 27 May 2010 Senior Leaders Panel. In accordance with Section 2033(g) of WRDA 2007, the ASA (CW) has 120 days after the date of completion of a Chief's Report to review the report and provide any recommendations of the Secretary regarding the water resources project to Congress. Also, per the FY08 Consolidated Appropriations Act, OMB has not more than 60 days in which to perform budgetary policy reviews of water resource matters on which the Chief of Engineers has reported.

Schedule Tasker: MG Semonite tasked Mr. Paynes with providing source of the above guidance to Ms. Moorer with GPA within two weeks. COMPLETED - Mr. Paynes provided the information above before the ESC meeting concluded.

7. Others and Mr. Stan Meiburg discussed how mitigation for freashwater marsh was to account for sea level rise and how the low/historical rates of rise were considered the most likely future condition for impact calculations. Mr. Les Dixon mentioned that discussion within the USACE were still on-going as to how to incorporate sea level rise and one concern was that if sea level rise was greater than the historical rate, how would the project's over mitigation be handled. Mr. Hope Moorer asked that all Federal cooperating agencies be involved in the discussions and Mr. Dixon assured that they would continue to be included.

8. Mrs. Haggett stated that the USACE has investigated funding assurances for post-construction monitoring and adaptive management and that the USACE policy as a Federal Government agency, prohibits the escrow of any funds for future purposes. However, it is possible for the sponsor to escrow such funds to assure their non-Federal portion would be available. MG Semonite asked if GPA has agreed to escrow their non-Federal funds for this portion of the project. Ms. Moorer and Alec Pointevint agreed that GPA would be willing to fund such an escrow account. Mr. Mark Musaus stated that USFWS was pleased with this commitment but it still concerned based on the time it has taken for mitigation for past Savannah Harbor deepening project's, the on-going freshwater control structure rehabilitation, to occur.

9. Mrs. Haggett reviewed the schedule changes that had occurred since the last ESC meeting, 2 April 2010. The overall project schedule was shown along with agency interaction points. Mr. Pete Oddi summarized these changes as the additional time required for the economic analysis and increased durations for the USACE Civil Works process reviews for good faith and transparency. Increased review durations show those required by statute and not the optimistic dates used in the 2 April 2010 ESC schedule. MG Semonite asked the cooperating agency staff if they could support this schedule. David Bernhart said that NOAA Fisheries could meet these dates for their Biological Opinion (BO) if their preliminary comments were resolved prior to public review. However, he was concerned as some of these comments are very substantial.

10. MG Semonite then asked the agencies to brief slides summarizing their preliminary draft comments.

11. Mr. David Bernhart stated that they understood that the channel extension was a relatively new component of the project that they were still working to fully evaluate. Mr. Bernhart also stated that the issue of nearshore and offshore dredge material placement offshore dredging and how it would be covered under SHEP or the programmatic agreement permit for dredging was still on-going. Under the permit is usually preferred, but in this case it that creates some problems such as the BO being several years old. Mr. Bernhart stated that authorization should be sought in the SHEP EIS/BO. Mr. Bernhart also added that Shortnose sturgeon would be impacted by SHEP through habitat changes and they have been working with the modeling efforts and how outputs are displayed. Model outputs still need to be shown in a better way to meet their needs for the BO. It was added that they would like to see more detailed plans of the fish-bypass at the New Savannah Bluff Lock and Dam and maintain that removal of this structure is a better

alternative in the long run. They would also like to see additional detail in the monitoring and adaptive management plan included the identification of triggers and the corresponding corrective measures.

12. MG Semonite asked Mr. Bill Bailey to briefly summarize the Corps response. Mr. Bailey responded to some of the comments and it was agreed the technical staff would meet to discuss.

13. Mr. Mark Musaus stated they still prefer the -45-foot alternative and agreed a GPA escrow as a good step. Mr. Jack Arnold added that they are concern about greater impacts to wetlands than anticipated as a result of model limitations. In particular, concerns of the conversion of ecologically diverse tidal freshwater marsh to monotypic stands of Spartina.

14. MG Semonite asked how a compromise on depth be achieved. Mr. Curtis Foltz and Mr. Steve Green stated that they understood the on-going freshwater control structure rehabilitation work was to help resolve some of the concerns with the -48-foot alternative through discussions with the former US Senator Mack Mattingly and the late Sam Hamilton. Mr. Mark Musaus stated that the rehabilitation was just to get to where they could considering the SHEP project. Ms. Hope Moorer reminded everyone that the -48-foot alternative net benefits were only ¼ of a percent less than -47-foot alternative and that there were greater benefits at 48'. Mr. Jamie McCurry added that the benefits of the Port are National just like the benefits of the Savannah National Wildlife Refuge. MG Semonite stated the importance of going into the Civil Works Review Board with a plan all could support. Mr. Bailey added that the USFWS seems to be willing to support the NED Plan but there are still several questions outstanding that could alter which depth is the NED Plan. Mr. Bailey asked the USFWS if they would object if the Corps sent out the draft reports for public comment recommending the -48-foot LPP. Mr. Musaus stated they would not oppose that.

16. Mr. Stan Meiburg compliment the Corps for the work to date but stated that their issue with dissolved oxygen is not new and added that EPA's policy for wetland preservation at a given ratio is not being met with this mitigation plan, that they still had concerns that sufficient air quality analysis had not been shown, for example the impacts from vessels, trucks and other equipment operating, that other impacts would be of great concern to the public such as those to noise, and that long term funding for mitigation features and sea level were uncertain factors that create concern from both sides. Mr. Bill Bailey responded that it was important to understand the with and without project conditions and that additional discussion would be held to resolve the issue.

17. The agency approval process was discussed, working towards the CWRB where agencies would verbally provide their agency positions. Mr. Stan Meiburg stated it would be hard to approve a project when you don't know how comments have yet to be addressed and the proposal is not final. MG Semite asked the team <u>(PM-C, O'Kane) work to reword the approval process and determine how some time for approval can be worked in</u>.

18. The dates for future ESC meetings were reviewed. MG Semonite asked the team (PM-C, O'Kane) to look at moving the 16 December 2010 date back and consider holding it by VTC. He also directed the team to keep the CWRB on 17 March 2011 even if just another Senior Leaders Panel with possibly the ASA (CW) or Chief of Engineers attending for special attention.

19. Mrs. Sharon Haggett reviewed that all action items from the previous ESC were completed. MG Semonite asked that PM-C (O'Kane) brief the status of each agency issue at the USACE 18 October In-Progress Review and coordinate the schedule with the FWS.

20. Curtis Foltz expressed disappointment in seeing the new extended Record of Decision date, driving out the time at which economic benefits to nation would be realized from the project. MG Semonite stated he understand the frustration but added that Savannah is at front of line for deepening and further along than any other port and that these SHEP ESC meetings are a template for how future Corps projects will be collaborated with the agencies.

FINAL

Jason O'Kane
Project Manager

US Army Corps of Engineers

Project: Savannah Harbor Expansion

Meeting/Location: ESC/SAD Atlanta and VTC

Date: 17-Sep-13

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(4)	William Bailey	Savannah Corps Planning	Chief, PD	912-652-5781	
(5)	Hope Moorer	GPA	GPA	912-964-3883	hmoorer@gaports.com
(6)	Jamie McCurry	GPA	Director of Admin.	912 964-3877	jmccurry@gaports.com
(7)	Steve Green	GPA	GPA Board	912-341-4077	steve@[illegible].com
(8)	Curtis Foltz	GPA	Exec. Director	912-963-5526	CFoltz@gaports.com
(9)	Pete Oddi	USACE, SAV	DDPM	912-652-5332	PETER.A.ODDI@USACE.ARMY.MIL
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CESAS-PM-C 16 December 2010

MEMORANDUM FOR RECORD

SUBJECT: Savannah Harbor Expansion Project (SHEP) Executive Steering Committee (ESC) Meeting, 16 December 2010.

1. The seventh Savannah Harbor Expansion Executive Steering Committee Meeting was held 17 September 2010 at the US Army Corps of Engineers (USACE), South Atlantic Division, downtown Atlanta, Georgia. In attendance were: Stacey Brown, Les Dixon, Col. Hall, Wilbert Paynes, Barbara Altera, Daniel Small, Pete Oddi, Bitsy Sloan, Warren Swartz, Mike Saltalamachea, William Bailey, Alan Garrett, Sharon Haggett, Jason O'Kane, Curtis Flakes, Todd Boatman, Bernard Moseby, Steve Cone (USACE); Miles Groom (NMFS), Roy Crabtree and David Bernhart (NOAA Fisheries), Tom Welborn, and Heinz Mueller (USEPA Region 4),), Mark Musaus and Jack Arnold (USFWS), Alec Pointevint, Jamie McCurry, Steve Green, Alec Pointevint and Curtis Foltz (GPA). The sign-in sheet it attached for reference. Action items are underlined to aid identification.

2. The meeting was opened with introductions and welcome by Les Dixon and COL Hall. Les Dixon commended the team on the progress that has been made to date. He continued that this meeting would be to continue that progress and assure all efforts were headed in the right direction. COL Hall agreed and noted the District had awarded the second option on the freshwater control structure contract, which would complete the rehabilitation of all structures on government-owned lands. He also stated we would be granting a 15-day extension to the public comment period by the end of the week and mentioned the public workshop that had been held in Savannah the day before, 15 December 2010.

3. Jason O'Kane then presented the project status update as outlined in the meeting presentation slides. Updates were provided for the Agency Technical Review, Office of Water Project Review and Preliminary Independent External Peer Review progress that has taken place since the last ESC meeting conducted 17 September 2010. This included a brief summary of the review team composition, review comments, resolutions status and the associated documentation of the process. Updates on the ongoing economics, engineering and environmental work were also provided. The agency approval process was reviewed and there was some discussion regarding how the details of the process would work.

4. The meeting was opened for agency comments at this time. USFWS commented that their reviews were continuing and they anticipated having their comment in on time. They voiced continued concern (1) For the Federal funding for monitoring and adaptive management due to the uncertainty of project mitigation, (2) Their desire for 10 years of post-construction monitoring instead of the proposed 5 years, (3) Their desire for more details on the adaptive management implementation details,

5. EPA expressed concerns over; (1) Inadequate wetland preservation, (2) Their desire for more detail in the salt vs. freshwater functional system analysis, (3) Their desire to have the dissolved oxygen mitigation system on-line prior to dredging (Bill Bailey explained this was shown in the construction sequencing plan in the EIS) and (4) Their desire for additional air quality analysis, particularly with regards to toxics. They stated that the Environmental Justice analysis was much improved. EPA also stated they may wish to review the public comments prior to submitting their comments. It was discussed that public and agency comments are due concurrently, so this would need to be planned out if it was to not impact the schedule.

6. NOAA Fisheries expressed concerns over; (1) The adequacy of the information they require to perform their Threatened and Endangered Species impact evaluation and in particular the Shortnose sturgeon habitat suitability criteria used, (2) The interpolated 47' alternative model runs (Bill Bailey explained that the 47' model runs in the draft report were actual and not interpolated). NOAA stated they need to evaluation the latest EIS's 10-knot hopper dredge speed restrictions during construction, (3) The New Savannah Bluff Lock and Dam fish by-pass structure cost is under estimated, (4) Essential Fish Habitat consultation would take additional time beyond that scheduled by several months NOAA Fisheries stated they have not started their Threatened and Endangered Species analysis as they are awaiting adequate information. As a result of this delay, they would not be able to provide their Biological Opinion until several months after the scheduled date of 25 Jan 2011. NOAA Fisheries stated they were working on providing the Corps a description of the information they require to begin their review.

7. COL Hall then reviewed the overall Project Schedule, indicating the date for the CWRB and ROD had moved forward slightly. He also reviewed future agency interaction dates on the schedule. The Federal agency Washington, D.C., Secretary-level meetings that are scheduled for January and February 2011 were also discussed.

8. GPA representatives stated it was our obligation to the American citizens to complete the project and start realizing the significant benefits to the Nation through increased transportation efficiencies. They added that progress needed to continue if we want to make this project's unprecedented level of interagency collaboration appear desirable for similar projects in the future.

9. In conclusion, COL Hall and Les Dixon stated that work would continue as discussed and extended appreciation to all agencies for their continued cooperation.

FINAL

Jason O'Kane
Project Manager

US Army Corps of Engineers

Project: Savannah Harbor Expansion

Meeting/Location: ESC/SAD Atlanta and VTC

Date: 16-Dec-10

	Name	Organization	Title	Phone	Email Address
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IV. EXECUTIVE MANAGEMENT GROUP

IV. Executive Management Group

1. MFR dated 28 September 2007. SHEP Issue Resolution Conference- Without Project Condition, Thursday, September 20, 2007.

MEMORANDUM FOR RECORD 28 September 2007

SUBJECT: Savannah Harbor Expansion Project; Issue Resolution Conference – Without Project Condition, Thursday, September 20, 2007

1. **Opening Remarks**: Wilbert Paynes (South Atlantic Division) opened the meeting. The primary purpose of the meeting was to hear from the Project Delivery Team in terms of what they have established as the future without project condition and to open dialogue on any specific areas of concern. Mr. Paynes highlighted the importance of ensuring that the vertical team agrees with the direction the PDT is heading because the pace of progress was quickening. He stated that the focus must be on the needs of the team and the specific areas of concern on the without project condition statement such that they can be identified early and allow the PDT to address them.

2. **Overview and status of the project.** Alan Garrett (CESASPM) stated that most of the technical studies are complete, with the exception being those that need to be finalized after we select the mitigation plan. The mitigation plan selection has been an issue over the last two months. The PDT has been trying to model a plan, known as Plan 7, that the agencies had proposed. This past week, a request was sent to the agencies for them to make a decision by 1 October on whether we could proceed with development of the mitigation plans prior to having the modeling results for that Plan, given its forecasted high cost of implementation. The project is at a pivotal point in terms of being able to proceed forward with a selected plan chosen from among the six different plans being considered. The economics team in Mobile District is in the process of finalizing the economic studies. Wilmington District has finished the rough order of magnitude costs with the exception of the mitigation plans. The team expects to wrap everything up around the February 2008 timeframe.

3. **Advance Maintenance**. Lee Ware (HQUSACE) asked about the degree of advance maintenance in some areas and how that relates to operating vessel draft and any risk taking that might be happening. Alan Garrett explained that Savannah Harbor has an annual shoaling of over seven million cubic yards per year. Over the last 20 years, Savannah District has pursued and obtained justification through SAD for required advance maintenance for different sections of the channel. The advance maintenance is necessary to provide the depths for the ships due to the high volume of siltation. With funding constraints, inflexible contracting procedures and environmental windows, the District had to have advance maintenance to get through critical periods so ships would not have to light load any more than they currently light load. Seventy percent of ships calling on Savannah Harbor are operationally restricted at this time. The advance maintenance is very important to the Savannah Harbor. **It was recommended to the PDT, that better identification of existing advance maintenance locations be provided including where already authorized and accomplished. As a point of clarification for the With Project condition, it was stated that the Expansion Project had to demonstrate the continued need for advance maintenance from an economic standpoint.**

   Angie Premo (CESAD) pointed out in the write-up and in Table 2 that the lateral advance maintenance widener on the outer part of the channel was shown as having been dredged. The PDT agreed that this is not part of the existing project. It will be removed from the table and the write-up and per the In-Progress Review of April 2007; this feature will be discussed in the General Reevaluation Report (GRR) since it may represent a cost efficiency for the O&M of the deepened project.

4. **DMMP**. Alan Garrett (CESASPM) explained that most of the materials pumped out of the inner Savannah Harbor are very fine silts and clays and that they are distributed among the 7 confined disposal areas along the North side of the channel. The materials from the Savannah Entrance Channel are disposed of in the EPA approved offshore disposal site. The materials that are pumped into the system of confined disposal areas are dried out on a three-year rotational basis and then borrowed to build the dikes. These areas also incorporate environmental mitigation components by providing flooded areas for waterfowl and nesting islands for migratory shore birds. With the existing disposal areas and the present method of rotating their use for borrow and mitigation purposes, there is 50 years

of capacity. As part of the GRR, the DMMP portion will cover where the new work material will be placed and what actions the project would take to ensure the sediment storage capacity of the existing project is made whole.

5. **Berth Dredging**. There are 18 different agitation dredging permittees (berth owners) along the Savannah River. The agitation dredging permits allow the berth owners to drag a beam alongside the berth to displace shoaled materials into the channel or along the side slopes of the channel. There is one permit which allows the dredger to use a hydraulic cutter head dredge to pump into the navigation channel in areas which are shown to be below project depth. The Federal Government then dredges those materials into the disposal areas at a later date. The permittees do pay an agitation dredging fee to the US Treasury on a per cubic yard basis. **HQUSACE advised that this non-Federal dredging work be addressed in the without project condition to explain what is happening right now in the harbor in terms of use of the disposal areas.**

6. **Public Involvement**. Hope Moorer (Georgia Ports Authority) explained that there has been a great deal of public involvement in this project. The Stakeholders Evaluation Group has met 56 times in addition to many committee meetings. This has been very good from a public involvement and public education standpoint on how the Corps' process works.

7. **Agency Involvement**. Bill Bailey (CESAMPD) explained that the District has provided the agencies information as it has been developed. The agencies have helped on the front end by telling the District what information they want to see to make decisions.

8. **Commerce.** Kim Otto (CESAMPD) explained that Savannah is the second largest port on the East Coast in TEU volume and the fourth largest in the nation. After planned and funded improvements at Garden City Terminal are completed in 2015, the terminal will be the largest single container handling facility in the nation. Under the without project condition, the volume of TEU's projected for Garden City Terminal will continue to increase. Likewise, the fleet calling at Savannah will continue to include larger vessels. It is projected to shift from being predominately Panamax-size vessels to Post-Panamax size vessels. Vessels operating at drafts greater than 38 feet will continue to be constrained at Savannah harbor.

9. **Environmental Resources**.

   a. Bill Bailey (CESAM-PD-E) explained that the District is conducting studies to find out the extent of the naturally-occurring Cadmium. The team is assuming they will have to put the material in a confined disposal area and cap it. This is the highest cost plan. In the existing condition, the District does not know if they have a problem with existing Cadmium levels. The issue for Expansion is where to put the new work materials and how to protect the environment after the deposition occurs.

   b. The City of Savannah has a raw water intake on Abercorn Creek. This is upstream of the harbor, but it is taking water off a tributary to the Savannah River. The City has said the present depth of the harbor has impacted the quality of the water they withdraw. The issue is one of chloride levels in the water. The District has done some detailed modeling work to address this concern.

   c. Water Quality. The Savannah Harbor violates the existing water quality standard for dissolved oxygen (DO). The EPA has issued a TMDL for DO for the harbor that prohibits discharge of oxygen-depleting substances into the river from Augusta all the way down to the ocean. The States are trying to figure out how to implement this TMDL as it restricts existing and future development. The PDT will have to address the effects of additional deepening on the DO problem and is not considering existing impacts resulting from the many point sources up and down the river system or the current harbor configuration.

   The District's goal is to identify any effect that the Expansion Project would have on dissolved oxygen and then mitigate for that incremental impact. The assumption is that as the State implements the TMDL, the DO should improve. The District will assume the present level of DO is constant. **In addition to recognizing the regulatory requirement, our base conditions should include some idea of what future conditions may be as industries attempt to address the TMDL issue. We need to address the effectiveness of the mitigation plan under various assumptions about what the DO will be in the future. The base conditions could change and make it more costly.**

d. Fish Species. There are certain fish species that are important in the Savannah River. Shortnose Sturgeon is an endangered species and Striped Bass is important for recreational use. American Shad and Flounder are also being evaluated for impacts.

e. Savannah National Wildlife Refuge. Bill Bailey explained that the Refuge is in the upper end of the harbor, almost across the river from GPA's terminal. It extends upriver from there. It is a fresh-water refuge at the head of a salt-water harbor. The Fish and Wildlife Service has identified tidal fresh-water marsh as being a critical resource and that is their biggest issue in this project. The project will have to address this with mitigation.

10. **Floridan Aquifer**. Cardwell Smith (CESASEN-G) explained that most of the drinking water for coastal Georgia and South Carolina area comes from the Floridan Aquifer. Due to pumping in Savannah there is a cone of depression around Savannah that tends to pull salt water through a confining layer above the aquifer down into the aquifer. The studies conducted under the Savannah Harbor Expansion Project proved the relationship between industrial drawdown and the Aquifer for the first time. There was concern about potential effects to the confining layer above the aquifer due to dredging the harbor. From what the District has determined from their studies and work that others have done, the process is ongoing now. The state is trying to cut back on the pumping to decrease this effect. Nowhere along the length of this channel would the confining layer ever be breached. The only effect would be reducing the thickness of the confining layer due to dredging. This small incursion would have minimal to no effect on the existing drawdown situation or the quality of water in the aquifer.

11. **Tybee Island**. Alan Garrett (CESAS-PM) submitted that although it was not included in the report at present, some mention needed to be made about Tybee Island and the current existing situation with the 2005 revisions to the Georgia Coastal Zone Management Program. Since about 2000 there have been ongoing studies on the impacts of the existing channel on Tybee Island with respect to littoral drift. The current Tybee Island Feasibility Study is not part of SHEP. There is an authorized shore protection project at Tybee and there is an on-going study looking at expanding or having another shore protection project there as well. ERDC has determined that the existing ship channel and training walls have truncated the littoral drift. A study done by ATM showed that after the channel was dredged to below -38 feet mlw it began to trap most of the sand (70%-80%), so there are no additional impacts beyond those occurring with the existing authorized channel. Tybee Island officials are looking at the Federal Government to recognize the channel's impact on their down-drift beach. SAD explained that the way the Corps is currently handling shore protection projects where there are navigation impacts from the adjacent navigation channel, is that the cost sharing formula is permanently adjusted for the existing Federal shore protection project. Since this is an existing condition, we would probably take a Section 111 type approach and permanently adjust the cost sharing to have a greater Federal share on those projects. SAD said the Tybee Island Feasibility Study report should have the same level of technical assurance and review as the aquifer. **This issue will be added as a part of the without project condition.**

12. **Beneficial Use of Dredged Material**. SHEP did address this as a sediment placement issue for all of the offshore bar materials. There are expectations from residents of Tybee Island and the State of Georgia with respect to OCGA 52-9-1 and 52-9-2 (HB727) which has been incorporated into the State CZM. This is under review at Headquarters. HQ stated that generally, the Corps' stance has been that States can put these requirements into their CZM but it does not obviate the Corps' own rules with

regard to cost sharing of incremental costs. For example it might cost more to insure these sediments are placed in the near shore zone. **The issue of H.B. 727 should be addressed in the Without Project Condition.**

13. **Cultural Resources**. All surveys of project impact areas have been completed with the exception of the mitigation areas. Those are covered under a Programmatic Agreement.

    a. CSS Georgia is the only major cultural resource issue remaining. In 2003, the Operations and Maintenance Program and the SHEP co-funded the costs of a study to identify past, present and future O&M impacts and investigate the incremental impact of SHEP. Those studies revealed that O&M operations in 1983 had caused a massive impact to the CSS Georgia; therefore mitigation of the CSS Georgia was an O&M responsibility. However, for SHEP there would be additional studies needed if O&M removed the wreck because they could not guarantee that all the live ordinance was removed. The District has been unsuccessful in getting O&M funding to perform the CSS Georgia mitigation. This has to be taken care of before deepening occurs through that reach. SAD explained that mitigation must be performed prior to or concurrent with the project. If the District continues to be unsuccessful in getting funds to do this mitigation, and if we are ready to move ahead with SHEP, this might be one of the first items done as part of SHEP. The cost sharing could be adjusted with respect to this item because it is an O&M responsibility. We could have a plan to execute a PCA to do this part and begin to move forward. Most of the costs would be 100% Federal with the incremental costs associated with further deepening being shared. This is not really part of the SHEP, so it would not be part of a Section 902 limit. GPA, as local sponsor, said it would support this position since that cost would not be part of the project, not included in the total project cost, and therefore not included in the benefit:cost ratio or the Section 902 limit.

    b. Old Ft. Jackson. A few years ago the Corps and GA DNR implemented a project consisting of sheet piling and bank stabilization. That action protected the eroded shoreline of the historic fort. At that time the Corps determined that there would be no further impact from a deepened harbor.

    c. Ft. Pulaski National Monument. The Corps has conducted studies to determine the incremental shoreline erosion from deepening and determined that there would be minimal impact from the project.

14. **Economic Analysis.**

    a. Existing Conditions. The Economic Analysis primarily focuses on container trade. It also includes LNG traffic. With the current berth expansion, the LNG vessels are expected to increase to 118 by 2009 and with a third expansion to 213 vessels per year. In 2006, Savannah Harbor handled approximately 2.2 million TEU's. Between 1988 and 2006, the Garden City Terminal annual total TEU volume increased by 490%. Approximately 45% of vessels calling Savannah are drafting more than 35 feet (sailing draft). Of the total numbers of calls, approximately 71% are services that transit the Panama Canal. A clarification was made about the sailing and design drafts of the vessels.

    b. Commodity Forecast. In 2004, GEC produced a commodity forecast for Savannah Harbor. It has proven to be too conservative. The actual export TEU's for 2004 were 899,339. This volume was not forecasted in GEC's report to occur until between 2030 and 2040. SAM believes the recent growth should be used as a baseline upon which the future trade should be projected. They updated the baseline conditions through 2006 and the long-term growth rates that were developed by GEC were then applied to this baseline to determine future levels of trade. GPA expressed concern with using these very conservative growth rates since the port has experienced an average growth rate from 1995 of 12% and average growth rate of about 15% in the last five years.

c. Risk and Uncertainty Analysis. Risk and uncertainty will be incorporated into the analysis. There will be several scenarios: 1) constraining the forecast in 2041 based upon assumption that port will reach capacity during this forecast year; 2) an unconstrained forecast; 3) a forecast based upon doubling growth rates used; 4) a forecast based upon cutting growth rates in half; and 5) based upon guidance requirements, constraining the forecast 20 years after the project comes on line. It is anticipated that the forecasts based upon doubling the growth rate and cutting the growth rates in half will give a band to see how the project performs. **HQ said the risk and uncertainty analysis should be accompanied by some observations about what is actually happening.** Also some observations that the original projections are conservative and the benefits tend to be greater than those projections indicated. GPA expressed concern about how the low growth rate would affect the ranking for funding of the project.

Jerry Diamantides suggested taking the most recent existing growth rate and smooth it down to the projected long term growth rate in a linear fashion. For example, transition over a five-year period so that you are going from 14% and blend into the much lower long-term projection. Ken Claseman noted that the forecasting approach developed by Kevin Horne (GEC) is the accepted procedure and expressed a concern that other procedures may not be acceptable. He also noted that long term forecasting techniques do not do a good job of forecasting short term fluctuations in commodity shipments. **It was suggested that this be discussed with Dr. Dave Moser. A meeting will be held with the key people (Dr. Dave Moser, Kevin Knight, Kevin Horne, Becky Moyer, Marianne Matheny-Katz and members of the PDT), to make sure we are reflecting what is actually occurring at the Port of Savannah. Johnny Grandison is arranging the meeting.** Ken Claseman noted that any changes in the commodity forecast may result in substantial additional economic analysis, which would result in significant schedule impacts.

d. Panama Canal. Adjustments have been made to the original model to include the consideration of the expanded Panama Canal. **The report should contain a discussion about the assumptions of the Panama Canal.**

e. Fleet Forecast. **The fleet forecast and other economic information should be discussed with Becky Moyer. Kim Otto will set up a conference call with Becky to go over these assumptions.**

15. Jasper County Proposed Terminal. As discussed in previous IPRs, this project will address the possibility of a terminal being developed in Jasper County. Previous work evaluated a new terminal as an alternative to deepening up to the Garden City Terminal. The present efforts consist of a scenario approach to evaluate the economic effects of a new terminal on the decision to deepen the harbor. There are enormous uncertainties about this possible terminal. A set of scenarios (up to 26) will be evaluated at a reconnaissance level. These scenarios will give decision makers information concerning (1) whether the incremental investment between a port at Jasper County and Garden City is worthwhile, and (2) whether deepening to the Garden City Terminal is justified if a new terminal is developed at Jasper County. There are so many scenarios because of the present number of unknowns related to development of a terminal. So far it appears the increment is economically justified. Jasper Terminal is not in our future most likely without project condition, but it is being addressed in these scenarios. **Include a statement in the GRR that this is assuming an investment of $XXX M to make a Jasper Terminal a reality. Also include that there is likely to be substantial mitigation required for development of the terminal.**

16. **<u>Environmental Resources.</u>** Bill Bailey (CESAMPD) said the PDT is looking at acquiring some lands on the border of the Savannah National Wildlife Refuge as mitigation. These lands are undeveloped but they are in an area that is experiencing substantial residential development. In the without project condition, these lands are likely to be developed. These lands will likely be in a mitigation plan so it is important that the without project condition description talk about what would happen to those lands to set the stage for mitigation credit or benefits that will be identified with the plan to buy those lands.