ENVIRONMENTAL IMPACT STATEMENT APPENDIX Q: Risk and Uncertainty in Environmental Evaluation Approach

SAVANNAH HARBOR EXPANSION PROJECT

Chatham County, Georgia and Jasper County, South Carolina

January 2012

US Army Corps of Engineers
Savannah District
South Atlantic Division

This page intentionally blank

Risk and Uncertainty Analysis

TABLE OF CONTENTS

This page intentionally blank

Risk and Uncertainty Analysis

1. Overview

There are numerous uncertainties associated with the evaluation of expected environmental impacts from the proposed harbor deepening, the performance of the selected plan and the associated mitigation features. Savannah District considered the uncertainties identified during the initial scoping process and throughout the entire evaluation period. The Corps also considered uncertainties that would exist should the project proceed to implementation. In addition, the risks associated with the uncertainties were also considered.

This analysis will address only the uncertainties and risks associated with the environmental aspects of the proposed harbor deepening project.

Uncertainties occur when knowledge is incomplete. In a harbor deepening project there are many uncertainties. Over the course of the study, the Corps took many actions to reduce the uncertainties and the associated risk.

The Tier II Environmental Impact Statement was prepared partially in response to public and agency concerns about the uncertainties contained in the Tier I EIS. At the beginning of the Tier II efforts, the Corps and GPA held scoping meetings to identify issues that warranted further investigation. Federal and State natural resource agencies participated in the scoping. A Stakeholders Evaluation Group provided information about specific studies that should be conducted. Those studies were intended to reduce the uncertainties in information concerning potential environmental impacts from a harbor deepening.

2. Reducing Risk

A. Biological Field Studies

Biological field studies were conducted to obtain information on environmental conditions in the harbor, including the following:

- Migration of Juvenile American Shad, Hickory Shad, and Blueback Herring in the Savannah River
- Assessment of spawning sites and reproductive status of striped bass in the Savannah River estuary
- Shortnose sturgeon field study
- Spawning Aggregations of Sciaenid Species
- Temporal and Spatial Distribution Study – SC DNR
- Temporal and Spatial Distribution Study – GA Cooperative Fish and Wildlife Resources Unit
- Tidal Wetlands Resource Utilization Studies Report
- Tidal Marsh Studies Data Report

These studies removed uncertainties about what species reside in the harbor and their abundance, and provided information about their importance within the estuarine ecosystem.

In addition to existing information, an extensive monitoring study in the SE US is being funded by NOAA on the Atlantic and shortnose sturgeon. This effort began in the spring of 2011 and is scheduled to last for 5 years. The work in the Savannah River is being conducted by SC DNR (http://www.nmfs.noaa.gov/pr/conservation/states/funded.htm). As information becomes available, the Corps and NOAA Fisheries will consider it.

B. Development of Predictive Tools

Much effort was spent developing hydrodynamic and water quality models that could reliably replicate existing conditions. Being able to use such models reduces the uncertainty surrounding predictions of how the system would behave if physical modifications, such as deepening or closing a channel were implemented. Without such tools, decision-makers would be forced to rely entirely on professional judgment. In brief, the model developer (Tetra Tech) had an uncertainty analysis performed by a separate independent modeler to assess the models' performance. The Corps conducted an independent technical review of the models to determine if they were adequate. The Corps also obtained concurrence from the natural resource agencies that these models were acceptable to evaluate environmental impacts from this project. Those independent reviews and agency concurrences also reduced the risk that the models were inappropriate and/or inaccurate.

An interagency team oversaw development of the hydrodynamic and water quality models intended to be used on this project. As part of their work, the team developed a Draft Expectations Document that described (1) the resources of primary concern in the estuary, (2) the locations and conditions under which project impacts should be evaluated for those resources, (3) the modeling approach to be taken, (4) the statistical analyses to be performed to document the model's performance, and (5) the evaluation criteria upon which the acceptability of the model would be based. The goals included parameters such as salinity, dissolved oxygen, temperature, current velocity, and flow volumes. With those performance goals, the strengths and weaknesses of the models could be identified. The direction and guidance reduced uncertainty during the model development phase and provided benchmarks against which the agencies could evaluate the performance of the models that were produced. The extent to which the models met or did not meet the benchmarks is included in the TetraTech's, "2005 Model Development Report," which can be found in the Engineering Appendix to the GRR. The agencies used those benchmarks during their review of the model before they separately concluded that the models were acceptable for impact evaluation use on this project. The Expectations Document developed by the interagency team reduced uncertainty by providing a framework against which to judge the performance of the models.

C. Use of the Predictive Tools

The reliability of the hydrodynamic and water quality models is also dependent on how well they are applied. The Corps used Interagency Coordination Teams to define how the models should be used to predict physical changes from changes proposed in the harbor. The use of experts from several organizations reduces the risk of error from the limited perspective of just one or a few individuals. The Interagency Coordination Teams recommended that the models be applied over a range of conditions. Using the aforementioned approach reduces the risk of evaluating impacts based on just one set of conditions that may not be a good representation of conditions which are encountered in the future.

The Wetland Interagency Coordination Team recommended that analyses be conducted on average and drought river flows, and on two levels of potential sea level rise. Calculating environmental impacts using multiple input conditions allows identification of the sensitivity of the predictions to the input conditions. The team also identified the summer growing season as being when wetland vegetation is most stressed. This factor ensures the impact predictions are conducted during time periods that are critical to the survival of the vegetative communities.

The hydrodynamic modeling indicates that impacts to wetlands would vary not only with the channel depth selected, but also with river flows and sea level rise. The three sensitivity analyses that were conducted (in addition to the baseline evaluation) showed varying amounts of impacts, but the average river flow conditions with the existing sea level were the conditions which demonstrated the most adverse impacts from a harbor deepening. When compared to the baseline, the other conditions showed fewer acres impacted, primarily because the freshwater interface would have shifted further upstream under those other conditions and would not be as subject to additional impacts from a harbor deepening. So the baseline conditions (average river flow and present sea level) present the largest amount of impacts. The Wetland Interagency Coordination Team's recommendation to use those baseline conditions for mitigation determinations greatly reduces uncertainties that the predicted wetland impact values would be too low.

Corps engineering staff prepared the modeling report titled "Wetland/Marsh Impact Evaluation". That report documented the results of the impact and mitigation modeling for wetlands. The report explains that the model produces a range of salinity values for a given location over the duration of the model run. One must select which of those values to use as the salinity value for that cell for that model run. The Wetland Interagency Coordination Team requested the information be provided on salinity impacts at both the 10 and 50% exceedance levels. The report contains that information, and it shows that impacts are predicted to be higher if one uses the 50% exceedance salinity value for a given model cell. [Note – a 50% exceedance value would be close to the average value for a range of data points.] After reviewing the report, the Wetlands Interagency Coordination Team recommended we use the 50% exceedance values to determine impacts from the proposed project. The effect of that decision is to show higher impacts than would occur from more rare tidal, flow, or meteorological conditions (such as at the 10% exceedance level). The Team's selection of the 50% exceedance salinity values reduces uncertainty that the model's predicted level of impacts would be exceeded by other environmental conditions.

The Fisheries Interagency Coordination Team recommended that analyses be conducted over a range of river flows (20, 50 and 80 percent of historic frequencies) and a variety of seasons, to reflect the critical conditions for separate life stages of specific species. That team also recommended that the Corps evaluate impacts to several species of fish common in the estuary. This ensured that various fishery components of the estuarine ecosystem were considered. This broadening of the impact assessment to multiple species eliminates reliance on a narrow view of the ecosystem, thereby reducing the risk of not identifying a critical impact.

The Water Quality Interagency Coordination Team recommended that analyses be conducted using drought flows and over several months during the critical summer period. These analyses would ensure that the evaluation reflects critical flow and weather conditions and includes a wide range of tidal conditions. Using an expanded data set also reduces the uncertainties of the water quality predictions, which aggregate the values over that wide range of ecological conditions. As stated before, the use of multiple environmental input conditions allows identification of the sensitivity of the predictions to variations in those input conditions. Finally, the use of long modeling durations also reduces the risk of missing critical effects that may occur with a different combination of river flow or tidal conditions.

There is uncertainty regarding how biologic habitats are judged specific to the quality of fisheries. Although Federal and state resource agencies would like to easily differentiate between areas that provide good or poor habitat for a species, in practice it is often quite difficult to make those distinctions. There are and will be gradations in the quality of habitats. Some habitats will possess conditions that result in no stress to an individual fish. The other end of the spectrum includes habitats with conditions, which contribute to the stress of fish in that area. Ultimately, the fish species chooses not to stay in that location. Alternatively, the species stays and demonstrates decreased growth rates or a reduced response rates that lead to higher predation. (Of note: The previously described scenario does not consider variations between individual fish that comprise the population of a given fish species residing in the same general area.) After some discussion, the Fisheries Interagency Coordination Team recommended that fishery analyses be conducted using an “Acceptable” vs. “Unacceptable” criteria for fishery habitats. Such a procedure would allow easier use of the model results and help focus evaluation of the differences between the various depth alternatives. The Team subsequently determined the habitat conditions that would differentiate between these two categories (i.e., “Acceptable” vs. “Unacceptable”. Modeling then identified the location and quantified the aerial extent of the two habitat categories. The criteria that the Team chose was on the conservative side, so that areas shown as acceptable habitat were identified as providing little to no stress to a particular fish community. The conservative nature of the values used to differentiate between “Acceptable” and “Unacceptable” habitats likely reduced the risk of overstating what portions of the estuary provide acceptable habitat to that species.

3. Risk & Uncertainty in Salinity Predictions

During the development process for the hydrodynamic and salinity models, the models were reviewed by the Federal and States natural resource agencies. The agencies regularly use those types of models and are familiar with their benefits and limitations (such as uncertainties in their predicted values). All the agencies agree that these models are more accurate when used to identify the differences between two scenarios than when used to identify values at a given location at a point in time in a given scenario.

The Corps funded the Kinetics Analysis Corporation (KAC) to perform an uncertainty analysis of the models in 2005. KAC performed that analysis toward the end of the model development process and evaluated the ability of those models to accurately predict the observed data. A model is typically developed and calibrated using field data, and validation of a model is determined based on the similarity of data output to observations recorded in the field. If the output and field observations are in agreement, then a model may be used as a predictive tool provided the associated precision and accuracy requirements are acceptable. A copy of KAC's analysis can be found in the Engineering Appendix. KAC evaluated the models' ability to duplicate the field data for salinity, dissolved oxygen, river discharge, and tidal phase. River discharge and tidal phase are useful in evaluating how a model is constructed but are not discussed here because they do not aid in evaluating the reliability of the impact predictions.

KAC discussed model errors at four locations – the I-95 Bridge, Lucknow Canal, the USFWS Dock, and at Houlihan Bridge. We believe that only two of those locations are pertinent to the present discussion of risk and uncertainty. In brief, salinity levels are too low at I-95 to be meaningful in this assessment. All values reported by KAC for that location are below those that would result in impacts to vegetation or fish habitat. The Lucknow Canal station is located very close and upstream of the USFWS Dock, so the USFWS Dock provides a better site at which to evaluate the model for salinity.

KAC found the models generally predict salinity levels too high at the Houlihan Bridge and the USFWS Dock. In general, KAC found the models to predict salinity high along the entire gradient from 1 to 15 ppt. KAC evaluated the model using two river flow periods, so they produced multiple evaluations of the model's reliability for the same location, depending on flow. At the Houlihan Bridge, the errors typically range from ½ to 1 ppt when the observed salinity measured 2 ppt (pages 39 and 45 of their report). At the USFWS Dock, the errors typically range from 0.25 to 0.6 ppt when the observed salinity measured 1 ppt (page 51 of their report) and from 1.1 to 1.6 ppt when the observed salinity measured 2 ppt (page 57 of their report).

KAC also developed error bounds for the model's salinity predictions. At the Houlihan Bridge, they found that for salinity levels around 1 ppt, the model had between a 70 and 85 percent chance of over-predicting salinity (pages 40 and 46 of their report). Similarly, at the USFWS Dock they found that for salinity levels around 0.5 ppt, the model had an 83 to 85 percent chance of over-predicting salinity (pages 51 and 58 of their report).

SC DHEC provided the following in their final assessment of the model development:

> "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.
>
> 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."

The USFWS provided the following in their final assessment of the model development:

> "… we believe that salinity prediction performance is adequate to use in project planning. However, we must reiterate that there continues to be a limited understanding and modeling ability of the velocity and flow dynamics in the Middle River, Little Back River and Back River. This limitation will cause some uncertainty regarding salinity and water quality predictions for mitigation alternatives that involve channel modifications in the Savannah River system."

NOAA Fisheries did not provide specific comments on the model and stated that they would continue to follow the lead of the USFWS on the hydrodynamic modeling.

GA DNR-EPD did not provide specific comments on the model related to its uncertainties. They approved "the use of these models to assess the impacts and mitigation of the proposed Savannah Harbor deepening."

EPA Region 4 did not provide specific comments on the model related to its uncertainties. They stated that "The models are acceptable for continued use in the Savannah Harbor Expansion Project to identify the effects of potential changes the estuary water quality and hydrodynamics from proposed harbor activities."

Based on this information, the Corps recognizes that there are uncertainties in the salinity predictions of the hydrodynamic model, but believes that those uncertainties are reasonable and do not present any unacceptable risks.

4. Reliability of the Wetland Impact Predictions

There is uncertainty associated with any prediction of the future. There is also uncertainty in the ability of any model to accurately predict physical parameters as they would occur if the system were changed. Since the wetlands that could be adversely impacted by the proposed harbor deepening are highly valued by the USFWS and are part of a National Wildlife Refuge, there is substantial risk should the impact predictions be greatly inaccurate. In light of both the recognized uncertainties of predictive models and the risk of insufficiently identifying impacts, the Corps reviewed KAC's 2005 Uncertainty Analysis on the hydrodynamic, salinity, and water quality models. The following subsections discuss uncertainties of various components of the wetland impact predictions.

A. Uncertainty in the Wetland Impact Predictions

As discussed above, there is uncertainty in the salinity values used to predict impacts to wetland vegetation. It is the low levels of salinity (<5 ppt) that are of primary concern in the wetland impact assessment. In particular, the impact assessment in this project concentrated on the movement of the 0.5 ppt salinity contour. Although there is uncertainty surrounding the hydrodynamic model's predicted salinity values, since the model was found to generally over-predict at low salinity levels, this should lead to an over-prediction of impacts to wetlands.

There is also uncertainty related to the procedure used to quantify the wetland impacts. This process involved taking results from the hydrodynamic modeling and transferring them to a map of the estuary. With the map providing geographic reference points, wetland areas that would be affected by changes in the location of salinity thresholds could be determined and the change quantified. In brief, the procedure involves hand contouring salinity levels across a map. Uncertainty in the impact determination was reduced by using the same individual perform all of these analyses. To examine and quantify the uncertainty that a given individual may introduce into the analysis, the Corps conducted a test to examine how well it could repeat the impact numbers that were calculated. First, the individual who had originally performed the work re-contoured three randomly-selected maps and re-calculated the acres of impact. The Corps also used a second individual to contour the salinity data for those same three maps and calculate the affected acreage. Those tests show the calculated wetland impact acreages to be reliable within +/- 2 percent, and the Corps considers the acreages valid within +/- 50 acres.

B. Uncertainty in the Amount of Sea Level Rise

Since the project's impact predictions must consider other ongoing trends that affect the estuary, there is uncertainty concerning how those trends continue in the future. One trend related to wetlands that is uncertain is sea level rise. The extent to which the sea level rises at Savannah will determine the composition of the tidal wetlands that are available to be impacted by a harbor deepening project. There has been extensive literature published concerning higher rates of sea level rise in various parts of the world. Much of that literature recognizes that the rate of future sea level rise will vary across the globe. Savannah District took several actions to address this uncertainty.

Early in the study process, the Wetlands Interagency Coordination Team recommended the District examine three levels of future sea level rise for Savannah – zero rise, 25 cm per 50-years and 50-cm per 50-years. The Corps conducted the wetland impact analyses for each of those scenarios. To comply with its own policies, the Corps also three other levels of future sea level rise – low, medium, and high. The impact analyses indicated that as sea level increases at Savannah, the amount of tidal freshwater wetlands will decrease. Since there have been continual records of sea level at Savannah for over 200 years, the District decided that it would rely heavily on that site-specific data in its prediction of future trends in sea level rise at this site. Examination of the historic information revealed that sea level has been rising relatively constantly at Savannah at an average 3 mm per year. The data indicate that the long term rate still apply to shorter, recent periods of time. Therefore, the District decided to use a continuation of the historic rate of sea level rise at Savannah (3 mm per year) in its predictions of future wetland distributions in the estuary. The historic rate would result in a rise in sea level of 0.3 feet in 25 years and 0.5 feet in 50-years. Those amounts of sea level rise are relatively minor in comparison to the 7-8 feet of daily tide range in Savannah and are within the accuracy of the wetland impacts for the proposed harbor deepening project.

Sea level rise would result in less project-induced impacts occurring in the future. A rise in the mean sea level would allow salty tidal waters to enter further into the estuary, adversely impacting the freshwater marshes. As this occurs, there would be fewer freshwater marshes remaining to be impacted by a harbor deepening project. The District calculated the effects of sea level rise on freshwater marsh impacts over the 50-year evaluation period (with the historic rate of sea level rise) using an average annual equivalent calculation methodology. The average annual equivalent freshwater marsh impact (285 acres for the 48-foot alternative) when compared to the base year prediction (337 acres for the 48-foot alternative) is within the degree of accuracy of the impact predictions. The proposed project would mitigate for wetland impacts that are predicted to occur once construction is complete (the base year). Impacts that would occur soon after the base year are those most likely to occur and least subject to uncertainty from more distant projections of future conditions. This approach also ensures the project fully mitigates for impacts that would occur over the entire period of analysis. Corps' guidance directs our designs to accommodate conditions expected to occur over the 50-year period of analysis, with the intention that the design be robust and reliable throughout the entire 50-year period. Mitigating based on the base year impacts ensures the project meets that intent and fully mitigates for wetland impacts that the project would produce.

C. Risk with Wetland Impact Predictions

As stated previously, the wetlands that could be adversely impacted by the proposed harbor deepening are highly valued by the USFWS and are part of a National Wildlife Refuge. Therefore, the risk of inaccurately predicting impacts to highly-valued resources would be that the impacts are not fully identified and appropriate amount of mitigation is not achieved.

As discussed above, the hydrodynamic model has roughly an 80 percent chance of over-predicting salinity levels at low salinity levels, thus leading to an over-prediction of salinity-induced impacts to wetlands. Therefore, the model is considered to present little risk for decision-makers evaluating salinity impacts to wetlands.

5. Reliability of the Dissolved Oxygen Impact Predictions

A. Uncertainty in Dissolved Oxygen Predictions

As with the hydrodynamic and salinity models, the Federal and States natural resource agencies reviewed the models during their development period and commented on their performance at the completion of that work.

In their final comments on the model development, EPA Region 4, NOAA Fisheries, and GA DNR-EPD did not provide specific comments on the model concerning uncertainties in the dissolved oxygen predictions.

SC DHEC provided the following in their final assessment of the model development:

> "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."

The USFWS provided the following in their final assessment of the model development:

> "… with regard to dissolved oxygen, the model has limited ability to simulate the variability and trends in the data. However, we believe that the dissolved oxygen model is adequate for harbor deepening impact assessment, if these limitations are accounted for during project planning."

As with the hydrodynamic model, the Corps funded the Kinetics Analysis Corporation (KAC) to perform an uncertainty analysis of the models in 2005. KAC performed that analysis toward the end of the model development process and evaluated the ability of those models to accurately predict the observed data. KAC found the model to generally under-predict dissolved oxygen levels at the Houlihan Bridge and the USFWS Dock. Those two stations are the most downstream locations considered by KAC, and are therefore the closest to the area of the harbor which typically experiences DO problems in the summer. In general, KAC found the model to under-predict dissolved oxygen along the gradient of DO from 1 to 8 mg/L. At the Houlihan

Bridge, the errors typically range from 0.025 to 0.075 mg/L across that range depending on river flow (pages 17 and 25). At the USFWS Dock, the errors typically range from 0.01 to 0.02 when the observed DO measured less than 1.6 mg/L (upper extent of KAC's analysis on DO at this station). At the Lucknow Canal, KAC found the errors to range up to 0.01 when the observed DO measured less than 0.7 mg/L (pages 21 and 29 of their report). Those errors are quite small and within the general range of reliability of field and laboratory measurements.

B. Risk with Dissolved Oxygen Predictions

The fact that the model under-predicts dissolved oxygen by quite small amounts indicates that the model should be a good predictor of dissolved oxygen-related impacts. The model's errors in predicting dissolved oxygen levels present little risk for decision-makers. No adjustment to the predictions or mitigation procedure appears to be warranted in response to the risk of error in the models' predictions.

6. Reliability of the Dissolved Oxygen Improvement Technique

A. Uncertainty in Dissolved Oxygen System Effectiveness

Use of oxygen injection in an estuarine environment is relatively new. The technology has been used for years in industrial applications (single pipes) and in lakes. It has not been used before to treat the large volumes of water typically associated with tidal estuaries. Since this technology has not been applied before to this situation, there is substantial uncertainty about whether the system will be as effective as it is intended. Concerns were expressed by members of natural resource agencies and the public. The concerns were both general in nature (What would the system look like? How much noise would it make when operating?), and specific (Would high DO levels at the discharge kill fish?).

To address these concerns, the Georgia Ports Authority conducted a demonstration project in 2007 to show how oxygen injection could work in Savannah Harbor. The demonstration was conducted to increase understanding about the technology and to confirm that concerns/problems expressed by some individuals would not occur if the technology was used in the harbor. Additionally, the demonstration was conducted to reduce uncertainties expressed about the technology being proposed for use on the project.

Substantial monitoring was conducted during the demonstration to document the effects of adding oxygen to the river. Observations were also taken about issues that had been raised about those unfamiliar with the technology (size of equipment, noise, etc.).

The engineering firm of MACTEC produced a report in 2008 that described the demonstration project, observations they made during the operation, the data they collected during the 6-week operational period, and their assessment of the technology. The report was provided to natural resource agencies and made available to the general public.

At the request of the USFWS, a member of the USGS reviewed the report and issued a letter of their findings. The USGS stated that they did not believe that the report supported the conclusions of the writers. In light of that letter, the Corps convened a meeting of the Water Quality Interagency Coordination Team to listen to a presentation by MACTEC and discuss the issue. As a result of that meeting, GPA agreed to have engineering consultants perform additional analyses. Additionally, MACTEC agreed to analyze and review the 2007 data in accordance with recommendations by USGS. GPA engaged a firm to use the agency-approved hydrodynamic and water quality model to simulate conditions during the demonstration project, which would identify the extent the harbor's DO deficit would be improved with the addition of oxygen during a demonstration project. In brief, a 2009 supplemental report concluded DO deficits and spatial gradients were reduced during periodic slack-tide events, and this result was not observed before or after the demonstration project. Thus, conducting the study or demonstration project provided another means of reducing risks associated with implementation of a harbor deepening.

B. Risk with Dissolved Oxygen System Effectiveness

A reduction in D.O. levels in the harbor, which result from further deepening of the harbor, is a major issue when evaluating the economic feasibility and environmental acceptability of the proposed project. D.O. levels are already critical in the harbor in the summer months, and further reductions in D.O. could adversely affect fishery and benthic resources. Improving D.O. in a deep-draft harbor is a difficult task. The constantly-used channel precludes many methods of raising D.O. levels. Similarly, the relative shallowness of the harbor reduces the number of viable options when compared to the relatively deeper waters found in lake environments.

The Corps engaged a private engineering firm to review available techniques and technology that would raise D.O. levels in Savannah Harbor. The firm reviewed 24 methods/techniques of increasing D.O., assessed their strengths and weaknesses, and evaluated their cost effectiveness. They identified oxygen injection as the best method for the present situation in Savannah Harbor. It has been used for years in industrial applications and some environmental situations. This independent review reduced some of the risk of selecting a technology that may not work or provide the D.O. improvement that is needed to mitigate for project impacts.

The demonstration project that GPA conducted in 2007 illustrated what the operation of an oxygen injection system would look and sound like. The demonstration removed some risk that such a system could be operated satisfactorily in the harbor. In brief, a 2009 supplemental report concluded DO deficits and spatial gradients were reduced during periodic slack-tide events, and this result was not observed before or after the demonstration project. Thus, this study provides another means of reducing risks associated with project implementation.

Post-construction monitoring is proposed as part of this project. Water quality monitoring – including dissolved oxygen levels – would be a part of that monitoring. Such monitoring would confirm if the anticipated D.O. effects that are intended by the proposed mitigation feature (i.e., D.O. Improvement Systems) are occurring. This level of monitoring substantially reduces the risks associated with the effectiveness of the Dissolved Oxygen Improvement Systems.

7. Biological Responses

A. Uncertainty in Biological Responses

There is considerable uncertainty associated with the biological responses to changes in the physical environment. These changes are greatest at the individual organism level and are less at the species and ecosystem levels. With respect to the individual organisms, there are no known ways to establish the uncertainties, which are inherent to the impact predictions made during the evaluation of this project. Biologic responses typically vary around a norm, and the variation of an individual from that norm is not of primary concern in this evaluation. Instead, we are more concerned with the response of the biologic communities that reside in the harbor and depend on it to provide habitat for some portion of their life. The Interagency Coordination Teams developed procedures that capture the important biologic criteria for certain critical natural resources which could be affected by this project. The criteria are a matter of professional judgment and were intended to describe good habitat conditions for species of interest. However, field studies with specific evaluation criteria identified individual organisms residing in areas of the harbor that are considered outside the range of what would be considered good habitat. The level of observed variability indicates that some individuals are likely to find acceptable habitat, or be able to accept marginal habitat for short periods of time. However, for those individuals with a narrower range of acceptability as compared to the normal range, the harbor may provide less acceptable habitat than the calculations indicate. The effect of this range on individual behavior is unknown. However, it is not thought to be a concern since we are primarily interested in the response of the entire biologic community rather than individuals.

There is some uncertainty that the biologic parameters used to define acceptable habitat are incorrect. If the parameters are incorrect or incomplete and the values selected for those parameters are wrong, the extent of acceptable habitats would be in error. This possibility was reduced through interagency consultation when the parameters of interest were identified. In brief, the natural resource agencies provided representatives to the Interagency Coordination Teams based on an individual's experience and familiarity with similar constriction projects. The Interagency Teams first identified which species they believe to be most critical in the harbor or best represent important guilds or communities. Next, they identified those species most likely to be impacted by the changes expected from a harbor deepening. The teams then reviewed professional literature to identify parameters that were previously found to differentiate "acceptable" and "unacceptable" habitat for the species of interest. We believe that this collaborative and deliberate approach minimized the uncertainty in the species evaluated, the biologic parameters selected to define acceptable habitat, and the values selected for those parameters to differentiate between acceptable and unacceptable habitats.

B. Risk with Biological Responses

As previously described, there is uncertainty associated with the anticipated response of individual organisms to environmental changes that would occur as a result of the proposed project. While the risk to a given individual fish or plant may be high if it can't respond to environmental changes, the overall risk is considered low because the project is generally evaluated with respect to impacts at the community level. Thus, a specific individual plant may not be able to accommodate a change in salinity, for example, but the community of similar plants is very likely to respond as that community has been observed to in the past.

Since biologic communities respond to the sum of the influences bearing upon them, there is uncertainty specific to the impacts of this project and the addition of other ecological factors that may stress the community. Assessing the project-related impacts required the analysis of several alternate conditions along with the basic set of conditions suggested by the resource agencies. These alternate conditions included such things as alternate river flows for fishery, wetland, and dissolved oxygen impacts, and two variations of sea level rise for wetland impacts. These alternate conditions were included as sensitivity tests in conjunction with the basic impact evaluation. The sensitivity tests provide information on how the project would function under environmental conditions that are outside the norm. Using this approach in the overall analysis substantially reduces the risk that the project would produce impacts that attain unacceptable levels, even under uncommon circumstances.

8. Air Quality Analysis

A. Uncertainty in air emission input data

There are numerous sources of uncertainty associated with the Air Quality Analysis. Because of the expected low level of impacts on air emissions from the proposed project, the Corps chose to conduct a mid-tier assessment of air emissions in the harbor. EPA identifies three possible approaches to conducting a harbor emissions inventory, and a mid-tier assessment is one of those accepted approaches. In brief, a mid-tier assessment allows one to use relationships identified at other locations and apply them to this site.

For instance, a detailed assessment was not conducted for the landside equipment used in Savannah by non-GPA terminals. Instead, the Corps identified the Ports of Tacoma and Seattle as being similar in size and composition to the Port of Savannah. Compared to all other ports with detailed air emission inventories, the aforementioned ports had the most similar cargo volume and fleet composition. Thus, the relationship between number of non-container vessels and emissions from landside equipment that service those ships was calculated in detail for those ports and used to calculate emissions for similar operations in Savannah.

A mid-tier assessment (as defined by EPA's guidance on air emission inventories) was deemed appropriate because the proposed harbor deepening project would be expected to affect only container vessels that call at GPA's Garden City Terminal. Other types of vessels that call at GPA's Ocean Terminal, and vessels that call at the other eighteen non-GPA terminals in the harbor, are not expected to be affected by the proposed project. Since their operations would not be affected, air emissions from those operations would also not be affected. Since the air emissions from those other terminal operations would not be affected, precise information about those emissions is not required. Instead, only a reasonable assessment of those emissions is required when evaluating the changes in emissions that could occur as a result of changes to GPA's Garden City container operations.

Alternatively, the District used site-specific, detailed information where changes could occur as a result of the proposed harbor deepening. Thus, detailed information was sought and obtained with respect to: (1) the movement of container vessels within the harbor; (2) operation of equipment on terminal grounds; (3) equipment associated with loading/unloading of ships; and (4) trucks and rail operations that move those containers from the terminal to the existing transportation system. With that previously described information, the Corps could more accurately identify potential changes to air emissions from the proposed deepening alternatives.

In summary, the Corps' approach to evaluating air quality allows for greater uncertainty in the levels of air emissions for portions of the harbor operations that would not be affected by the proposed project, while including more accurate information in those areas that could change as a result of the project.

B. Risk with Air Emission Analysis

As stated above, certain elements of the analysis have more uncertainty as a result of the methodology used to calculate air emissions. It should also be noted that those elements with greater uncertainty are not expected to change as a result of the proposed project. Thus, the risk of deriving an incorrect decision with respect to air impacts is low. With respect to air, a reviewer always has two benchmarks to consider – (1) the total emission volume reported by EPA for all of Chatham County, and (2) the threshold of Non-Attainment, where the total emission volume for the region would result in air quality being at levels determined by EPA to be unacceptable and harmful to humans. That said, impacts to air emission were evaluated for the proposed project and were judged by those two benchmarks. Neither benchmark would be violated by the proposed action, so the ultimate risk from expected changes in air emissions is low.

9. Sediment Quality Analysis

A. Uncertainty in Sediment Composition and Quality

As with any dredging project, there are concerns about the characteristics of the sediments that would be excavated. For example, rock requires special equipment that works slowly and has high operating costs. Likewise, toxic sediments may produce adverse environmental impacts if dredged. Because of these type concerns, investigations are typically conducted to determine the characteristics of dredged sediment prior to the physical act of dredging.

With respect to this project, the Corps conducted a geotechnical investigation to determine the physical characteristics of the sediment that would be excavated when deepening the harbor. Borings were taken and laboratory analyses were performed. These steps provided information which was useful in determining the type of equipment that would be needed to remove the sediments as well as the likely efficiency of that equipment. Such information reduced uncertainties about how the deepening could be accomplished and how long it would take to complete the work.

Samples were analyzed for their chemical properties. The sampling area covered the entire vicinity proposed for harbor deepening, which extended from deep water in the ocean to the Kings Island Turning Basin (Station 103+000). Chemical parameters that were evaluated include: metals, PCBs, PAHs, petroleum hydrocarbons, phenols, pesticides, dioxin congeners, cyanide, organotins, and nutrients. In brief, most of the sediments were considered safe for dredging and placement with no concern for contaminant-related impacts. However, three potential issues were identified.

One issue involved sediments near the old RACON Tower site, where high levels of PAHs where found. Subsequent sampling conducted in 2005 revealed that sediments at that location contained low levels of PAHs, so they do not pose potential contaminant-related environmental impacts.

The second issue pertained mostly to whether the sediment chemistry data for pesticides, polyaromatic hydrocarbons (PAHs) and phenols, and the associated detection limits, were adequate for comparison to screening criteria. This issue was addressed in 2005 when confirmatory sampling within the channel revealed there is no concern with respect to sediment contamination as it pertains to pesticides, PAHs, phenols, or metals other than cadmium.

The final issue involved elevated concentration and distribution of naturally occurring cadmium within the new work sediments. Sampling was conducted in 2005 to address this issue. Cadmium was found to occur naturally in unusually high levels within Miocene clays that would be excavated during the SHEP dredging. Evaluation of the laboratory results could not rule out the potential for adverse impacts from sediments with elevated cadmium levels in some reaches of the channel.

Additional sampling and detailed analyses were conducted in 2007, and the potential pathways by which cadmium might enter the environment were evaluated. Pathways of particular concern include the exposure of cadmium-containing clays in the channel with subsequent movement of cadmium into the river ecosystem and potential environmental impacts associated with placement of cadmium-containing sediments within the confined disposal facilities (CDFs).

About 7.1 MCY of dredged sediment contain higher levels of naturally-occurring cadmium (from Stations 6+375 to 45+000, 51+000 to 57+000, and 80+125 to 90+000). The Corps proposes to place and retain all of the cadmium laden sediment in existing confined disposal facilities (CDFs) 14A and 14B. Once disposal is complete, the site would be covered with about 2 -feet of clean dredged sediment taken from the Federal navigation channel. All new work dredged sediment within CDFs 14A and 14B will not be used for future dike raisings or used for borrow material.

B. Risk with Sediment Composition and Quality

Inaccurate cost estimates are the basic risk associated with incorrect assumptions or conclusions about the physical composition of the sediment. The sampling and analyses that the Corps performed reduced those risks to acceptable levels.

Unexpected, adverse environmental impacts are the risk associated with incorrect assumptions or conclusions about the chemical properties of the sediment. To ensure adequate testing protocols were achieved, the Savannah District utilized a tiered evaluation and decision process that reduced the risk of an incorrect decision. Three sets of sampling and laboratory analysis were performed for this project. The analyses became more specific and more technically complex with each iteration. The final (biological) tests were the most rigorous and were established by joint EPA/Corps protocols for sediment testing.

Prior to the start of sampling, the Corps had the natural resource agencies review the sediment testing and analysis scopes of work before they were conducted. This measure ensured that a general consensus was achieved concerning the sampling methodology, and the agencies agreed that correct tests would be performed and in the proper manner. Likewise, the same agencies reviewed the test results to determine whether additional steps would be needed. The District also employed an independent firm to collect the samples and perform the laboratory tests to increase the reliability of the results. The District provided its evaluation to the Corp's Engineering Research and Development Center (ERDC) (the Corps' national research arm) to ensure its technical conclusions were valid. This review reduced the risk that the District reached unsupported findings, which could lead to higher environmental impacts. The Corps provided their evaluation to the natural resource agencies prior to release of the Draft EIS to further reduce the risk of the EIS containing a sediment placement plan that would be unacceptable and lead to unacceptable environmental risk.

Improper information, and decisions based on a present understanding of sediment composition and quality, could lead to higher than expected construction costs and higher than expected environmental impacts. The risks associated with those two items were reduced to acceptable levels through the multiple sediment testing iterations, the review by natural resource agencies, and the review by the Corps' national experts in sediment evaluation (ERDC).

Post-construction monitoring is proposed as part of this project. Cadmium levels in the CDFs would be a part of that monitoring. Such monitoring would confirm if the cleaner sediments successfully covered the cadmium-laden sediments. The Corps has agreed to take further actions until it demonstrates that clean sediments cover the surface of those CDFs. This monitoring substantially reduces the risks associated with relocating the naturally-occurring cadmium sediments. The post-construction monitoring includes monitoring of cadmium levels in birds that use the CFS where cadmium-laden sediments have been deposited. Although no impacts are expected to birds, this biological monitoring would ensure the deposited sediments are not impacting birds that use the site(s).