8 Alternative Plan Evaluation: Environmental Impacts

This plan has been formulated and evaluated in accordance with Council on Environmental Quality (CEQ) Regulations for Implementing NEPA (40 CFR 1500-1508), and the Corps' NEPA compliance requirements (US Army Corps of Engineers NEPA implementing regulations, 33 CFR Part 230 (which incorporate the Council on Environmental Quality Regulations for Implementing NEPA, 40 CFR 1500-1508)). The planning of USACE-sponsored and other Federal projects must ensure that project-related adverse environmental impacts have been avoided or minimized to the extent practicable and that remaining unavoidable significant adverse impacts are mitigated. USACE regulations require a Cost Effectiveness/Incremental Cost Analysis (CE/ICA) be performed to identify the most cost-effective mitigation plan.

The plan was developed as directed in the authorization for the project. This study was conducted under authority provided by the Congress of the United States pursuant to the Water Resources Development Act of 1999 (Public Law 106-53, Section 102(b)(9)). The wording of the authorization is as follows:

> The project authorized by subparagraph (A) may be carried out only after— (i) the Secretary, in consultation with affected Federal, State of Georgia, State of South Carolina, regional, and local entities, reviews and approves an environmental impact statement for the project that includes—
>
> > (I) an analysis of the impacts of project depth alternatives ranging from 42 feet through 48 feet; and
> >
> > (II) a selected plan for navigation and an associated mitigation plan as required under section 906(a) of the Water Resources Development Act of 1986 (33 U.S.C. 2283(a)); and
> >
> > (III) the Secretary of the Interior, the Secretary of Commerce, the Administrator of the Environmental Protection Agency, and the Secretary approve the selected plan and determine that the associated mitigation plan adequately addresses the potential environmental impacts of the project.
>
> MITIGATION REQUIREMENTS- The mitigation plan shall be implemented before or concurrently with construction of the project.

Avoidance and minimization were pursued wherever that course of action presented itself as a feasible option. Avoidance and minimization efforts were integral to project planning and influenced channel design, dredged material placement locations, dredged material placement techniques, and mitigation plan formulation. The remaining unavoidable adverse impacts to ecological resources are addressed by the mitigation plan. Mitigation may include restoration, enhancement, creation, preservation, and compensation. Critical to the development of the mitigation plan is the identification of projected environmental impacts.

Analyses of potential environmental impacts commenced in the early phases of the General Re-Evaluation process and were one of the main focus areas as the study neared completion. The study process included both the Corps' NEPA compliance requirements and additional steps taken as a result of the conditional authorization of this project (WRDA 1999). The conditional authorization requires that the Secretary of the Interior, Secretary of Commerce, and Administrator of the Environmental Protection Agency, with the Secretary of the Army, approve the selected plan and determine that the associated mitigation plan adequately addresses the potential environmental impacts. Public involvement has been a major component of environmental impact assessment. The SEG, which includes concerned members of the general public and agency officials, was instrumental in identifying potential environmental impacts, identifying appropriate impact assessment tools and techniques, and identifying mitigation measures.

The environmental impact/mitigation planning process followed a general framework of:

- Impact avoidance;
- Impact assessment;
- Impact minimization;
- Identification of mitigation measures;
- Assessing mitigation measure effectiveness;
- Mitigation plan selection; and
- Monitoring and adaptive management.

The remainder of this chapter describes some of the key avoidance and impact assessment efforts conducted for this study.

8.1 Impact Avoidance

Three impact avoidance measures were identified and implemented in the project planning process. Impact avoidance measures include: modified channel design, dredged material placement location selection, dredged material placement technique selection, and mitigation plan design.

8.1.1 Modified Channel Design

Modification of typical navigation channel design is a major component of the impact avoidance measures developed in the study. Environmentally sensitive channel design for each of the alternative plans includes maintenance of the existing channel side slopes and extending them downward, thereby narrowing the channel slightly at each

alternative depth increment. More typically, channel design would maintain the existing bottom width and extend the side slopes outward. The channel cross section used for the Savannah Harbor deepening alternatives is shown in Figure 7-1. The major effect of this decision is a reduction in the amount of dredging and a reduction in disturbance to sediments adjacent to the upper slope of the existing channel. This avoidance measure also minimizes impacts to adjacent high ground and structures located along the riverbank. This design modification also reduces the effective width of the deepened navigation channel but not to an extent that impacts one-way navigation by the design vessel.

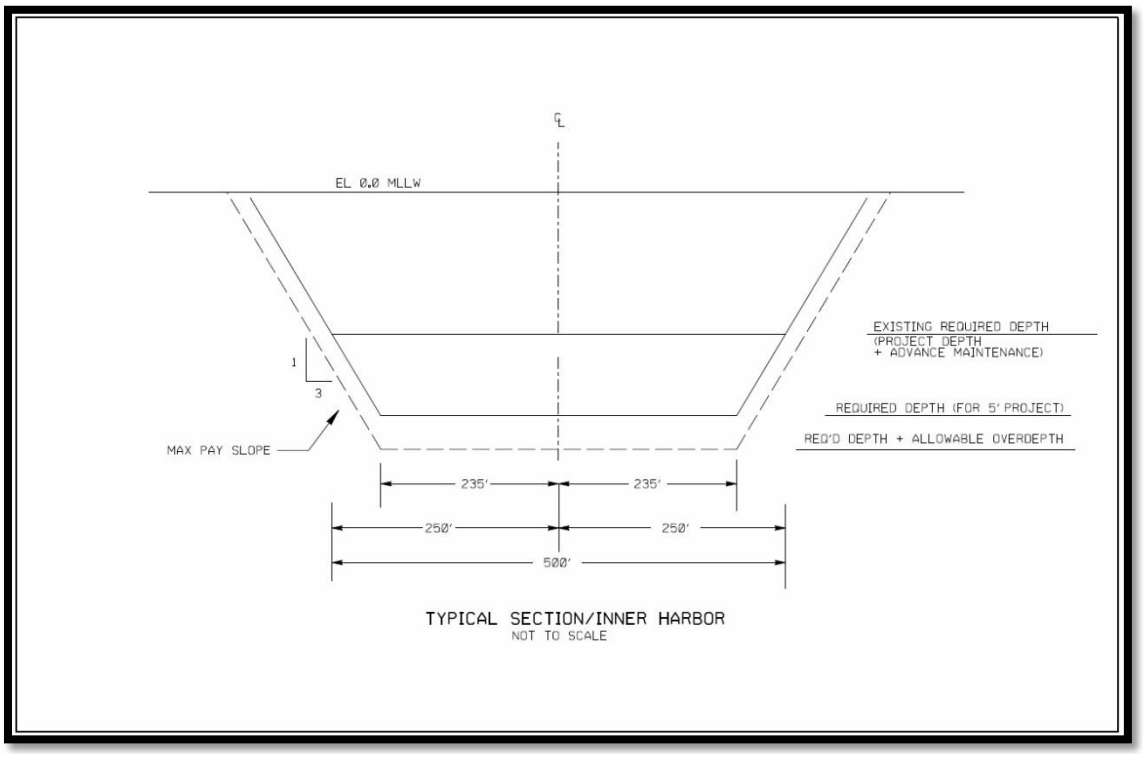

Figure 8-1: Typical Channel Cross Section

The Savannah District retained the ERDC to conduct a ship simulation study. That study is described in detail in the Engineering Appendix of the GRR. The study uses state-of-the-art computer models and Savannah Harbor ship pilots to identify how vessels would handle in various flow and weather conditions. The study identified the minimum size channel needed to safely pilot the design vessel through the harbor under a variety of weather conditions. This includes analysis of the width of the channel and required bend wideners. This study confirmed the need for most of the initial design features contained in the conditionally authorized plan (channel width, size of turning basin) but indicated that some bend wideners would not be necessary (see Table 6-6). These unnecessary bend wideners were removed from the alternative plans presented in this GRR. Minimizing channel dimensions, within the parameters

required for safe navigation, also avoids impacts associated from construction of unneeded features.

8.1.2 Dredged Material Placement Location Selection

Use of existing DMCAs, as opposed to creating one or more new DMCAs, avoids the environmental impacts associated with expanding the footprint of Savannah Harbor's existing network of containment areas. The Savannah Harbor Navigation Project has DMCAs that it has constructed over the years and uses on a regular basis (see Figure 1-2). Establishing a new DMCA is difficult in this harbor, and the adverse environmental impacts associated with a new area would likely be substantial and significant. Use of the existing sites requires coordination with ongoing operations and assessment of the effects of deposition of these sediments on the useful life of those DMCAs. Included in the project cost estimates is the cost of restoring lost O&M capacity due to deposition of new work materials.

8.1.3 Alternative Disposal Methods or Beneficial Use of Dredged Sediments

A number of alternative disposal methods or beneficial use of dredged sediments were evaluated, including nearshore placement and beach nourishment, creation of shorebird nesting habitat, restoration of the riverine shoreline, creation of tidal marsh and wetlands, production of bricks, capping of the cadmium-laden sediments, and use of material for future dike raisings. Beneficial use opportunities will be employed for a portion of the inner harbor dredged materials. Material from stations 67+000 to 80+125 and from 90+000 to 103+000 will be used as either capping material for cadmium-laden sediments in 14A/B or for future dike raising materials in 13A as detailed in the section below and in the Engineering Appendix Section 11.0. A discussion of the use of dredged materials for nearshore placement and beach renourishment is included later in this section. Other proposed beneficial uses of the inner harbor material that were considered as part of SHEP are detailed below:

- Using dredged material to create shorebird nesting habitat is a practice currently employed by the District. In accordance with past mitigation requirements, the District has created several "bird islands" within the existing DMCAs. When the DMCAs are maintained in a wet condition, these islands provide nesting and roosting habitat for shorebirds, including threatened and endangered species. Implementation of the proposed action will not affect this ongoing activity.

- To offset shoreline erosion, the Corps considered placement of dredged materials to restore and protect the riverine shoreline in the inner harbor. The Corps determined, however, that the size of the dredging equipment employed to remove the sediments could potentially cause adverse impacts (turbidity, destruction of habitat) if the sediments were pumped onto the riverbank in large quantities.

- Similar to shoreline restoration, the Corps evaluated using dredged materials to create tidal marsh or wetlands. The Corps determined that discharge of dredged material in open waters to create wetlands would result in adverse impacts to valuable fish and wildlife habitat in the inner harbor. Creation of such environments in the ocean is not cost effective, as the benefit of its construction would be offset by costs required to protect the created habitat from wave action.

- The non-Federal sponsor has funded studies to assess using dredged materials within the DMCAs to manufacture bricks. Should the non-Federal sponsor wish to pursue this option as beneficial use, then the Corps would support its implementation.

In light of the volume of new work sediments that would need to be removed to deepen the harbor and the limited window in which hopper dredges are allowed to work in Savannah, the Corps evaluated other equipment and placement options that could be used to reduce the total construction period and minimize new work dredging and deposition costs. Several alternative plans were considered, including beneficial uses of dredged sediments.

The Corps followed an iterative process to develop a plan for the new work entrance channel sediments. The work started with an engineering determination of sediment quantities to be removed at various channel depths and the composition (i.e., percent fines and percent sands) of those sediments. A review of previous information was conducted, including: the LTMS (USACE 1996); the Draft 2003 ERDC Report on Nearshore Placement at Tybee Island; and changes to the GA CZM Program that incorporate Georgia House of Representatives Bill 727 (HB 727).

The LTMS authorized placing maintenance sediments in feeder berm sites within the nearshore area off Tybee Island and adjacent to the entrance channel (see Figure 1-9). The LTMS also authorized placing maintenance sediments on eroded portions of Tybee Island.

Based on the sites designated and approved in the LTMS for the deposition of maintenance material into nearshore feeder berm sites, the 2003 ERDC Report refined the analyses identified several specific nearshore sites that would feed sediment to Tybee Island beach and dampen wave action on the coastline. The sites were identified in locations that would minimize subsequent migration of the sediments into the navigation channel.

The Corps then developed a sediment placement plan with cost identified as a priority criterion. The plan was reviewed from an environmental perspective with consultation from the Georgia Department of Natural Resources-Coastal Resources Division (GA DNR-CRD), which provided additional placement scenarios to consider. The Corps also discussed the work with The City of Tybee Island's (Tybee Island) coastal

engineering consultant. The proposed plan was subsequently revised to incorporate the views of GA DNR-CRD and Tybee Island's consultant. During that period, Corps engineers were also consulted to determine pumping distances that could be achieved without the use of booster pumps (which would greatly increase cost) and what placement designs would not cause adverse currents or result in rapid migration of deposited sediments toward the shipping channel. The previously described information was then synthesized and integrated into a revised sediment placement plan.

The Corps provided GA DNR-CRD staff and Tybee Island's coastal engineering consultant with the updated plan at a meeting on July 13, 2006. Following the meeting, the plan was again revised to address items identified during the meeting. The plan was later presented to the Stakeholders Evaluation Group in September 2006 and the Corps again received comments.

The proposed plan was based on a compilation of information provided by Corps geotechnical engineers; discussions with Corps coastal engineers; discussions with GA DNR-CRD for information on CZM and HB 727 compliance, recreational and commercial boat usage off of Tybee Island, and general environmental acceptability issues; and information from Tybee Island's coastal engineering consultant concerning issues that directly affect the Tybee Island beaches.

The Corps included the following assumptions in the design of the sediment placement plan for the entrance channel sediments:

- A 30-inch pipeline dredge can pump sediment a total distance of about 3 miles without a booster pump and without substantially reducing its productivity. The placement design would be based on there not being a need for a booster pump.

- A loaded hopper dredge generally needs about 25 feet of water under its keel. Hopper dredges (with pump ashore capability) may not be able to reach all locations, since the nearshore water depths off Tybee Island are less than 15 feet mean high water.

- For each entrance channel reach from Stations 4+000 to -98+600, the dredge quantities in cubic yards for the greatest dredging depth (i.e., -48 foot depth) was used for all placement sites.

As a result of the extensive coordination with GA DNR-CRD and the City of Tybee Island, the Corps proposed in the DEIS to place new work and maintenance sediments in the nearshore area off Tybee Island which would provide beneficial use of dredged material and comply with the Georgia Coastal Management Program, including the changes that incorporate Georgia HB 727. The proposed dredged material placement

plan also included two sites (Site 11 and Site 12) which would have been constructed from material from the entrance channel extension to provide additional fish habitat in the area.

Most of the sites were authorized in the LTMS to receive maintenance material from the Savannah Harbor entrance channel. Sites 11 and 12 were developed during SHEP planning to provide fish habitat. The specific Site 2 Extension design was developed to provide a pathway for sediments to migrate to the shoreline. The ERDC Nearshore site is also a design development of the previously approved "feeder berm" and is considered a part of the feeder berm system approved under the LTMS.

The new work sediment that would have been placed into the nearshore feeder berm sites would have been material with a fines content of 20 percent or less. The GA DNR-CRD and the City of Tybee Island have since requested that these sites not be used for new work sediment from the project because they prefer material with a fines content of 10 percent or less. They also requested that Sites 11 and 12 not be used because of potential adverse effects to fish habitat and commercial and recreational fishing. Based on comments from EPA, Site 4, Site 5, Site 6, Site 11, and Site 12 are beyond the 3-mile line and would also require site designation studies. Consequently, use of these dredged material placement sites for new work material was removed from the project. New work dredged sediments from the SHEP would be placed into the existing DMCAs or the approved ODMDS.

8.1.4 Dredged Material Placement Technique Selection

Sediment testing and analyses performed in 1997 and 2001 indicated a potential for elevated levels of cadmium associated with Miocene-aged sediments underlying the navigation channel. Additional testing in 2005 specifically examined the concentration and distribution of cadmium within sediments which would be dredged according to alternative plans. Approximately 350 sediment samples were taken at 2-foot intervals from 45 cores distributed throughout the harbor, but concentrating in areas where initial analyses indicated higher cadmium concentrations were present. This core data was analyzed and used to estimate the potential average cadmium concentration in new work sediments by Station. The sediments between Stations 17+000 and 45+000 were estimated to contain an average cadmium concentration of 21.42 mg/kg. None of the other ranges had an average cadmium concentration of greater than 6.89 mg/kg, which is well below the Effects Range Median (ERM) of 9.6 mg/kg, indicating little potential for environmental impact.

The naturally-occurring cadmium is not uniformly distributed, but some locations showed concentrations at levels that would cause adverse environmental impacts if the sediments were exposed to oxidizing conditions. The original dredging plan was to excavate the new work sediments and deposit them in the closest DMCA that was available for this project. Such a plan would have resulted in the cadmium being deposited in several DMCAs, possibly resulting in adverse impacts at several sites. The initial modified placement plan isolated the cadmium-laden sediments in one

confined DMCA and covering it with a 2-foot capping layer, which is sufficient for biological protection purposes and to ensure that the sediments will not be disturbed during future dike raisings.

An evaluation of the DMCAs in this area of the harbor (14A, 14B, and Jones/Oysterbed) indicated that DMCA 14A was the best site to use for isolation of the cadmium-laden sediments for following reasons:

- Its elevation is lower than the adjacent disposal sites, which allows the cadmium-laden sediment to be placed at a lower elevation, leaving room for the capping material;
- After the sediment is capped, there would be greater future potential to extend the life of the disposal area by subsequent dike raisings than in other disposal areas that are presently at a higher elevation;
- Weirs are already located on the front side of the disposal area; thus, the cadmium-laden sediment could be pumped to the back side of the disposal area. This provides a greater factor of safety by having the material farther away from the navigation channel should the front side of the dike experience shoreline erosion which might compromise the dike; and,
- This area would also afford greater protection as almost the entire front side of the dike has erosion protection already in place, mostly in the form of rip rap.

The initial review of cadmium within the navigation channel (Savannah Harbor Expansion Project: Cadmium Report, August 2006) was based on average cadmium (mg/kg) per reach. The report identified the reach between Stations 17+000 and 45+000 with 5,015,846 cubic yards (CY) of cadmium-laden material as the only area in the harbor that needed special handling. That amount, plus the cap amount of 1,860,000 CY for a total for cadmium-related sediment of 6,875,846 CY easily fit in DMCA 14A (7,000,000 CY capacity). A later review of cadmium concentration, taking into account individual high points of concentration as well as average cadmium concentration per reach, resulted in additional reaches being designated as having high concentrations of cadmium and, therefore, requiring special handling.

The resultant increase in the amount of special handling material and differing locations of this material meant that all of the material could not be placed in DMCA 14A; therefore, another site for the placement of the excess cadmium-containing sediments (beyond what was to be placed in 14A) needed to be identified. Re-evaluation of DMCA's 14B and Jones/Oysterbed (Jones Island portion) indicated that the DMCA 14B was the best site based on costs and engineering requirements. Consequently, all cadmium-laden sediments would be placed in DMCA 14A and/or 14B.

8.2 Impact Assessment

Although the Corps hoped to avoid adverse impacts to the environment, rarely can a major construction project be implemented without causing some adverse effects. The type, location, and level of these impacts must be known before actions can be evaluated to avoid those impacts, reduce those impacts or provide appropriate mitigation. Most impacts that could be expected to occur from this proposed project would result from either loss of uplands adjacent to the (expanded) navigation channel or changes to the aquatic environment within the harbor. Other potential impacts could also result, such as changes in shoreline erosion, salinity intrusion into the groundwater, air emissions, etc.

For impacts to uplands adjacent to the deeper navigation channel, Savannah District retained the Corps' Engineering Research and Development Center (ERDC) to conduct a ship simulation study. That study is described in detail in the Engineering Appendix of the GRR. The study used (1) state-of-the-art computer models, and (2) ship pilots from the Savannah Pilots Association who maneuver vessels through the harbor on a daily basis to identify how vessels would handle in various flow and weather conditions. The study identified the minimum size channel needed to safely pilot the design draft vessel through the harbor. This includes the width of the channel and required bend wideners. It also provides information on the value of meeting areas within the channel. This study confirmed most of the initial design features (channel width, size of turning basin) and indicated that some bend wideners would not be necessary. This increased the confidence in the effectiveness and safety of the proposed design, while also minimizing impacts associated from construction of unneeded features. The District conducted a second ship simulation study of the entrance channel in 2010 to evaluate two designs for extending the entrance channel. The study confirmed either design would be acceptable from an engineering design criteria perspective.

The District conducted two studies to identify potential impacts to riverine shorelines. The first was a Ship Wake Study conducted by the Corps' Engineering Research and Development Center. They measured the waves produced at four critical locations in the harbor – Tybee North Beach, Fort Pulaski, South Carolina side of the Bight, and City Front – and predicted changes to those waves resulting from the fleet of larger vessels expected to call at the port with a deeper harbor. That study is described in detail in the Engineering Appendix to the GRR. Soils engineers within the District took that information and evaluated the effects on the adjacent shores from those changes in waves. Although most of those four locations presently experience substantial erosion, the District's soils engineers concluded that the proposed harbor deepening would not cause noticeable changes in the ongoing erosion.

For potential impacts to the nearby shorelines, Savannah District divided the issue into two distinct areas – one the ocean shoreline and the other the riverine shoreline. These two areas retain separate and distinct qualities from an engineering perspective, and the causes of erosion differ greatly between them. For the ocean shoreline, the District again secured the assistance of the Corps' Engineering Research and Development

Center (ERDC). That organization conducted a Coastal Erosion Study that is described in detail in the Engineering Appendix of the GRR. The study concluded that deepening of the entrance channel as envisioned in any of the deepening alternatives would not measurably increase erosion that is occurring at Tybee Island or other adjacent barrier islands.

For potential impacts to the groundwater, Savannah District conducted a substantial study of the geology beneath the river and the water moving through the various layers of that resource. The scope of the study was reviewed by natural resource agencies and scientists involved in the study of the Floridan aquifer prior to it being implemented to ensure those experts believed that it was sufficient to address the issues. The District performed much of the physical sampling, as it possessed the needed open-water drilling equipment, and it retained the consulting and engineering firm of CDM to conduct the computer modeling portions of the study. That study is described in detail in the Engineering Appendix of the GRR. The conclusions of the study are that the proposed channel deepening is not expected to increase the downward migration of salinity into the drinking water aquifer in any measurable amount. The study identified the large volume of water withdrawn in Savannah as the primary source of the present cone of depression that exists in the aquifer and extends outward from that location.

For potential impacts to air quality, Savannah District evaluated air emissions from container vessels using the harbor. After EPA reviewed the results of that study, the District expanded it to include all vessels calling at the port, the landside equipment that handle the cargoes transported by those vessels, and air toxics in those emissions. The evaluation is based on the vessel fleet and cargo projections developed for the economic analysis. The District followed procedures outlined by EPA for air quality analyses at ports. The analysis did not identify any significant adverse impacts to air quality that would result from implementation of the proposed harbor deepening alternatives. The Air Emission Inventory is included as a separate appendix (Appendix K) in the EIS.

For changes to the aquatic system, Savannah District followed a combined approach of consultants and in-house staff to enhance and apply state-of-the-art hydrodynamic and water quality models to assess potential impacts from the project. The District and the Cooperating Agencies followed this approach to produce the best information that could reasonably be developed to identify changes that could be expected from the project. Development and approval of use of these models on this project, which took from 1999 through 2005, is described in detail in the Engineering Appendix that accompanies the GRR. As the models were being developed, the Corps consulted with natural resource agencies to determine what type of information they would need to evaluate all aspects of the proposed project. After the agencies approved use of the models, the tools were applied and the modeling was performed (2006 and 2007). This was somewhat of an iterative process. On occasion, the agencies discovered their requested model runs and analysis were not helpful. Subsequently, the agencies identified other informational needs that did enable a thorough evaluation of project

impacts. Several reports were ultimately produced as a result of this process. On occasion, several versions of a particular report were produced as more information became available, or if the Corps later responded to agency requests for additional data and different perspectives. The hydrodynamic-related impacts predicted from the various alternatives are described in detail in the Environmental Consequences section of the EIS. The major hydrodynamic-related reports that were provided to the agencies during the course of the study are shown in Table 8-1.

Table 8-1. Savannah Harbor Expansion Project – Modeling Reports

Report	Title	Author	Date
Water Quality Mitigation	*Oxygen Injection Design Report Savannah Harbor Expansion Project*	Tetra Tech, Inc.	October 2010
Model Calibration (EFDC & WASP)	*Development of the Hydrodynamic and Water Quality Models for the Savannah Harbor Expansion Project*	Tetra Tech, Inc.	January 2006
Fishery Impacts	*Habitat Impacts of the Savannah Harbor Expansion Project*	Tetra Tech, Inc.	October 2006
Chloride Model Development (Superseded)	*Savannah Harbor Expansion Project – Chloride Data Analysis and Model Development*	Tetra Tech, Inc.	November 2006
Water Quality Impacts	*Water Quality Impacts of the Savannah Harbor Expansion Project*	Tetra Tech, Inc.	February 2007
Marsh Modeling Report	*Simulations 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*	US Geological Survey	June 2006
Chloride Impacts	*Chloride Impact Evaluation Impacts of Harbor Deepening Only*	USACE Savannah District SAS-EN	February 2007
Hurricane Surge Impacts	*Hurricane Surge Modeling*	USACE Savannah District SAS-EN	September 2005
Chloride Impacts (Superseded)	*Savannah Harbor Expansion Project Evaluation of Chloride Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	December 2007
Fishery Impacts (SNS Impacts Superseded)	*Savannah Harbor Expansion Project Evaluation of Fishery Habitat Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	January 2010
Hurricane Surge Impacts	*Savannah Harbor Expansion Project Evaluation of Hurricane Surge Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	December 2007
Wetland Impacts	*Savannah Harbor Expansion Project Evaluation of Marsh/Wetland Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	November 2007
Water Quality Impacts	*Savannah Harbor Expansion Project Evaluation of Water Quality Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS-EN	September 2009
Wetland Impacts	*Savannah Harbor Expansion Project Mitigation Evaluation for Marsh/Wetland Impacts*	USACE Savannah District SAS-EN	November 2007
Wetland Impacts (Sensitivity Analysis)	*Savannah Harbor Expansion Project Sensitivity Analysis of Proposed Navigation Meeting Areas*	USACE Savannah District SAS-EN	September 2009

Report	Title	Author	Date
Wetland Impacts (Sensitivity Analysis Obsolete)	*Savannah Harbor Expansion Project Sensitivity Analysis of Proposed Sill on Middle River*	USACE Savannah District SAS-EN	September 2009
Wetland Impacts	*Wetland/Marsh Impact Evaluation*	USACE Savannah District SAS-EN	February 2007
Wetland Impacts (Obsolete)	*Savannah Harbor Deepening Project ATM Marsh Succession Model Marsh/Wetland Impact Evaluation*	USACE Mobile District SAM	May 2007
Wetland Impacts (Obsolete)	*Savannah Harbor Deepening Project USGS/USFWS Marsh Succession Model Marsh/Wetland Impact Evaluation*	USACE Mobile District SAM	June 2007
Fishery Impacts	*Savannah Harbor Expansion Project Evaluation of Adult SNS (Summer) Habitat Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS	March 2011
Fishery Impacts	*Savannah Harbor Expansion Project Evaluation of Adult SNS (Winter) Habitat Impacts with Proposed Mitigation Plan*	USACE Savannah District SAS	March 2011
Fishery Impacts	*Savannah Harbor Expansion Project Evaluation of Juvenile SNS (Winter) Habitat Impacts with Proposed Mitigation*	USACE Savannah District SAS	March 2011
Chloride Model Development	*Chloride Modeling Savannah Harbor Expansion Project*	Tetra Tech, Inc. & Advanced Data Mining Services, LLC	December 2010
Chloride Impacts	*Assessment of Chloride Impact from Savannah Harbor Deepening*	Arthur Freedman Associates, Inc.	April 2011

Based on the results of the various studies, Table 8-2 on the following page summarizes the project-related impacts of the harbor deepening alternatives without mitigation.

Table 8-2. Summary of Project-Related Impacts without Mitigation

	---------- DEPTH ALTERNATIVES ----------				
	44-Foot	**45-Foot**	**46-Foot**	**47-Foot**	**48-Foot**
Salinity	Move further into estuary	Same effect, but greater amount	Same effect, but greater amount	Same effect, but greater amount	Same effect, but greater amount
Freshwater Wetlands	-551 acres	-967 acres	-1,057 acres	-1,177 acres	-1,212 acres
Brackish Marsh (Loss)	- 7.2 acres	Same	Same	Same	Same
Dissolved Oxygen	Reductions at mid-depth and bottom	Same effect, but greater amount	Same effect, but greater amount	Same effect, But greater amount	Same effect, but greater amount
Fisheries	**Loss (-) of Acceptable Habitat**				
- Striped bass spawning	- 8.0 % (-83.0 acres)	- 12.2 % (-127.0 acres)	- 13.0 % (-135.0 acres)	-18.1 % (-188.0 acres)	- 19.7 % (-205.0 acres)
- Striped bass eggs	-9.7 % (-163.0 acres)	- 11.2 % (-188.0 acres)	- 15.9 % (-266.0 acres)	-20.5 % (-344.0 acres)	-24.5 % (-411.0 acres)
- Striped bass larvae	-13.5% (-76.0 acres)	- 18.6 % (-105.0 acres)	- 21.0 % (-119.0 acres)	-13.8 % (-78.0 acres)	- 13.8 % (-78.0 acres)
- American shad (Jan)	0 %	0 %	0 %	0%	0 %
- American shad (May)	0 %	0 %	0 %	0%	0 %
- American shad (Aug)	0 %	0 %	0 %	0 %	0 %
- Shortnose sturgeon adult (January)	- 0.5% (-20.0 acres)	- 0.5 % (-20.0 acres)	-0.8 % (-32.0 acres)	-0.8% (-32.0 acres)	-1.1 % (-44.0 acres)
- Shortnose sturgeon adult (August)	- 3.2 % (- 45.0 acres)	- 6.4 % (- 89.0 acres)	- 9.5 % (- 132.0 acres)	-13.3 % (185.0)	- 15.80 % (- 220.0 acres)
- Shortnose sturgeon juvenile (January)	-5.0 % (-86.0 acres)	-10.4 % (-179.0 acres)	-15.9 % (-274.0 acres)	- 19.0 % (-328.0 acres)	- 21.6 % (-373.0 acres)
- Southern flounder	- 0.3 % (-6.0 acres)	- 2.4 % (-45.0 acres)	- 2.4 % (-45.0 acres)	-7.8 % (-146.0 acres)	0.0 %
Chlorides @ City's M&I Water Treatment Plant	Max hourly increase of 77 mg/L	Max hourly increase of 105 mg/L	Max hourly increase of 121 mg/L	Max hourly increase of 149 mg/L	Max hourly increase of 170 mg/L
Drinking Water Aquifer	Same type of effect, but less than 45-foot alternative	Same type of effect, but less than 46-foot alternative	Same type of effect, but less than 47-foot alternative	Same type of effect, but less than 48-foot alternative	Increase flow through confining unit by 3-4%
Hurricane Surge	Minor, max increase in WSE of 0.3 feet	Minor, max increase in WSE of 0.5 feet	Minor, max increase in WSE of 0.6 feet	Minor, max Increase in WSE of 0.8 feet	Minor, max increase in WSE of 0.9 feet
Beach Erosion	Minor; within accuracy of evaluation	Same	Same	Same	Same
Bank Erosion due to ship traffic	No measurable addition to ongoing erosion	Same	Same	Same	Same
Shoaling	Minimal upstream shift	Same	Same	Same	Same
Velocity	Theoretical reduction, but not measurable	Same	Same	Same	Same

Table 8-3 is a summary of project impacts of the harbor deepening alternatives after implementation of various mitigation measures designed to minimize adverse impacts of the SHEP. Because of predicted changes in the salinity regime, residual impacts remain to tidal freshwater marsh for the 45-, 46-, 47-, and 48-foot depth alternatives and salt marsh for all depth alternatives considered (see Table 8-3). Mitigation is also required to offset 15.68 acres of brackish marsh that would be lost due to excavation requirements of the project. Mitigation is included for impacts to Striped bass spawning, egg, and larval habitat, and adult and juvenile Shortnose sturgeon winter habitat. Mitigation is included to offset expected increases in chloride concentrations in Abercorn Creek at the City of Savannah's water intake, which would occur during high tides and low flow conditions.

Table 8-3 Summary of Project-Related Impacts with Mitigation

	---------- DEPTH ALTERNATIVES ----------				
	44-Foot	**45-Foot**	**46-Foot**	**47-Foot**	**48-Foot**
Salinity	Move further into estuary up Front River	Same effect, but greater amount	Same effect, but greater amount	Same effect, But greater Amount	Same effect, but greater amount
Freshwater Wetlands (Conversion)	+ 322 acres	- 32 acres	- 201 acres	-223 acres	- 337 acres
Brackish Marsh (Conversion)	+ 488 acres	+ 861 acres	+959 acres	+964 acres	+1068 acres
Salt Marsh (Conversion)	- 808 acres	-828 acres	-757 acres	-740 acres	-730 acres
Brackish Marsh (Loss)	-15.68 acres	Same	Same	Same	Same
Dissolved Oxygen	Minimal Net improvement	Same	Same	Same	Same
Fisheries	**Loss (-) or Gain (+) of Acceptable Habitat**				
- Striped bass spawning	- 2.9 % (-30.0 acres)	- 9.2 % (-96.0 acres)	- 10.0 % (-104.0 acres)	-13.5 % (-140.0 acres)	- 16.1 % (-167.0 acres)
- Striped bass eggs	- 9.4 % (-157.0 acres)	+5.2 % (+87.0 acres)	0 %	-11.1 % (-186.0 acres)	-10.8 % (-181.0 acres)
- Striped bass larvae	-5.6 % (-32.0 acres)	+ 1.7 % (+9.0 acres)	+ 5.6 % (+32.0 acres)	-5.0 % (-28.0 acres)	-3.5 % (-20.0 acres)
- American shad (Jan)	-0.2 % (- 9.0 acres)	-0.2 % (-9.0 acres)	- 0.2 % (-9.0 acres)	-0.2 % (-9.0 acres)	- 0.2 % (-9.0 acres)
- American shad (May)	- 0.2 % (-12.0 acres)	- 0.2 % (-11.0 acres)	- 0.2 % (-11.0 acres)	-0.2 % (-11.0 acres)	- 0.2 % (-11.0 acres)
- American shad (Aug)	-0.3 % (-16.0 acres)	-0.3 % (-15.0 acres)	-0.2 % (-11.0 acres)	-0.2 % (-11.0 acres)	-0.2 % (-11.0 acres)
- Shortnose sturgeon adult (January)	-3.9 % (-153.0 acres)	-4.6 % (-179.0 acres)	-6.2 % (-240.0 acres)	- 6.9 % (-266.0 acres)	- 8.4 % (-326.0 acres)
- Shortnose sturgeon adult (August)	+19.0 % (+260.0 acres)	+9.8 % (+134.0 acres)	+7.3 % (+100.0 acres)	+6.5 % (+89.0)	+2.8 % (+39.0 acres)
- Shortnose sturgeon juvenile (January)	- 6.7% (-220.0 acres)	- 7.0 % (-231.0 acres)	-7.3 % (-238.0 acres)	-7.6% (-251.0 acres)	-11.5 % (-376.0 acres)
- Southern flounder	+74.1 % (+1387.0acres)	+ 54.2 % (+1014.0acres)	+ 57.3 % (+1072.0acres)	+57.3 % (+1072.0acres)	+ 52.9 % (+989.0 acres)
Chlorides @ City's M&I Water Treatment Plant	Max hourly increase of 4 mg/L	Max hourly increase of 4 mg/L	Max hourly increase of 4 mg/L	Max hourly increase of 4 mg/L	Max hourly increase of 4 mg/L
Drinking Water Aquifer	Same type of effect, but less than 45-foot alternative	Same type of effect, but less than 46-foot alternative	Same type of effect, but less than 47-foot alternative	Same type of effect, but less than 48-foot alternative	Increase flow through confining unit by 3-4%
Hurricane Surge	Minor, Max increase in WSEL = 0.5 ft	Minor, Max increase in WSEL = 0.6 ft	Minor, Max increase in WSEL = 0.7 ft	Minor, Max Increase in WSEL= 0.8ft	Minor, Max increase in WSEL = 0.8 ft
Beach Erosion	Minor; within accuracy of evaluation	Same	Same	Same	Same
Bank Erosion due to ship traffic	No measurable addition to ongoing erosion	Same	Same	Same	Same
Shoaling	Minimal upstream shift	Same	Same	Same	Same
Velocity	Theoretical reduction, but not measurable	Same	Same	Same	Same

Additional discussion of the various impact analyses and mitigation studies are provided in the paragraphs that follow.

8.2.1 Groundwater Impacts

To evaluate potential impacts to the groundwater, Savannah District conducted an aquifer evaluation study entitled *Supplemental Studies to Determine Potential Groundwater Impacts to the Upper Floridan Aquifer* (June 2007). This was a substantial study that examined the hydrogeologic framework beneath the navigation channel to determine how much proposed dredging activities would contribute to increased chloride levels in the Upper Floridan aquifer. The scope of the study was developed in cooperation with State and Federal natural resource agencies and the SEG prior to it being implemented to ensure those experts believed that it was sufficient to address the issues. The Savannah District performed much of the physical sampling and data analysis, as it possessed the needed open-water drilling equipment, and it retained a consulting engineering firm to conduct the computer modeling portions of the study. That study is described in detail in the Engineering Appendix of the GRR.

The study results indicated that increased salinity in the Savannah River and the reduced thickness of the confining layer associated with the proposed dredging (assuming a 6-foot improvement) will not significantly affect the timing of breakthrough of chlorides along the navigation channel in the Upper Floridan aquifer. Furthermore, the aquifer study results showed that the proposed dredging would have minimal impacts on water quality in production wells that tap the Upper Floridan aquifer in and around the City of Savannah. The study was subject to an Independent Technical Review and an External Peer Review, which concurred with the study findings.

Although construction of the SHEP is expected to have an insignificant effect on the downward migration of saltwater into aquifer, the Georgia DNR- EPD and SC DHEC requested that a monitoring plan be implemented to detect any potential chloride migration into the aquifer that could be caused from channel deepening. A copy of the Section 401 Water Certifications from both states is included in Appendix Z. Monitoring of chloride levels in the Upper Floridan aquifer would be conducted along critical groundwater flow paths to ensure that the SHEP does not result in the significant migration of chlorides downward through the confining layer that could move towards production wells in the Savannah area. A discussion of the groundwater monitoring requirements can be found in Paragraph 5.05 of Chapter 5 of the EIS and in EIS-Appendix L (Cumulative Impacts). The monitoring plan contains specific requirements in regards to how and when the monitoring is to be conducted, as well as the establishment of benchmark chloride concentrations to protect Savannah area production wells. The monitoring would involve the establishment of sentry wells along critical groundwater flow paths which would be installed near the top of the aquifer to monitor downward migration of chlorides through the confining unit and deeper in the aquifer to monitor how horizontal flow of freshwater mixes with and

dilutes the chloride. Monitoring wells would be established up-gradient of critical groundwater flow paths to provide information on the background chloride concentrations associated with groundwater withdrawals in the Savannah area independent of SHEP dredging activities. Annual monitoring of these wells would be conducted for the life of the project, and differences in the long-term trends of chloride concentrations in the sentry and background wells would be used to distinguish impacts of the SHEP from impacts of groundwater withdrawal on chloride concentrations in the aquifer.

8.2.2 Erosion Impacts

Savannah District conducted investigations to determine potential impacts to the nearby shorelines. The issue was divided into two distinct areas – the ocean shoreline and the riverine shoreline. These two areas retain separate and distinct qualities from an engineering perspective, and the causes of erosion differ greatly between them. For the ocean shoreline, the District secured the assistance of ERDC. ERDC conducted a Coastal Erosion Study (*Impacts of Savannah Harbor Expansion Project*, October 2006) which is described in detail in the Engineering Appendix of the GRR. The study concluded that deepening of the entrance channel as required by the channel deepening alternatives would not measurably increase erosion that is occurring at Tybee Island or other adjacent barrier islands. Computations show that channel deepening will not have any measurable effect on the North Tybee Island shoreline.

The District conducted two studies to identify potential impacts to riverine shorelines. The first was a Ship Wake Study, *Ship Forces on the Shoreline of the Savannah Harbor Project* (August 2006), conducted by the Corps' Engineering Research and Development Center. The analysis measured the waves produced at four critical locations in the harbor: Tybee North Beach, Fort Pulaski, SC side of the Bight, and River Front. The analysis predicted changes to waves resulting from the fleet of more deeply loaded vessels expected to call with a deeper harbor. That study is described in detail in the Engineering Appendix to the GRR. Geotechnical engineers within the Savannah District took that information and evaluated the effects on the adjacent shores from changes in waves (*Savannah Harbor Expansion Bank Erosion Study*, November 2006 and updated in 2011with a revised fleet forecast).

Erosion along River Street is not considered a factor because the shoreline there is already adequately protected by bank protection and structures. The Bight area (from about Stations 40+000 to 50+000) was also not considered a factor because the area is currently being stabilized. The shoreline at Fort Jackson was stabilized in 2003 and therefore is not projected to experience increased erosion due to channel deepening. Erosion losses at Fort Pulaski have been measured to be as much as three feet of shoreline lost per year under without-project and with-project conditions. Under current traffic predictions and forecasts, the bank erosion at Fort Pulaski expected to result from harbor deepening would be less than 1/2 inch at the end of the 50-year project life, an amount that would not be measureable in the field in light of the erosion caused by other factors.

In addition, the Savannah District has recently constructed shoreline protection at the DMCAs along the river: therefore, DMCAs 13A, 14A, and 14B are protected from long-term shoreline erosion. The District expects to implement bank protection on Jones/Oysterbed Island in the near future, so it can be assumed to be protected in the without project condition. With a deepened harbor, fewer ships are expected to call (when compared to without project condition). As a result, the proposed deepening is not expected to impact the shoreline of the confined disposal areas to any measurable degree.

Based on these factors, the Corps believes that the proposed harbor deepening alternatives would not result in major or significant adverse impacts to ocean or river shorelines.

8.2.3 Air Quality Impacts

Georgia and South Carolina each have a State Implementation Plan ("SIP") approved or promulgated under Section 110 of the CAA. A Conformity Determination is not required because 40 CFR 93.153 (b) states, "For Federal actions not covered by paragraph (a) of this section, a conformity determination is required for each pollutant where the total of direct and indirect emissions in a nonattainment or maintenance area (emphasis added by the writer) caused by a Federal action would equal or exceed any of the rates in paragraphs (b)(1) or (2) of this section." Since both Chatham and Jasper Counties have been designated by the States as attainment areas, a Conformity Determination is not required. Over the life of the project (from 2016 to 2066) the proposed harbor deepening will not interfere with the area remaining in attainment of the NAAQS under Section 110 of the Clean Air Act.

To identify potential impacts to air quality from the proposed harbor deepening, the Corps conducted an air quality analysis in 2006. The investigation quantified emissions from deep-draft containerships that call at the port, are expected to call in the future, and considered how those emissions would change as a result of the proposed harbor deepening. The Corps provided its report to the US Environmental Protection Agency (EPA) Region 4 office for review and comment. As a result of their review, EPA requested the analysis be expanded.

In response to EPA Region 4's request, the Corps prepared an Air Emission Inventory for the Port of Savannah (*Air Emissions Inventory Report for the Port of Savannah*, August 2011). The objective of the inventory was to expand the Corps' 2006 air quality analysis to the entire harbor to more completely assess air quality impacts from the proposed harbor deepening. This more detailed assessment evaluates the air emissions from all cargo-carrying vessels and landside cargo handling equipment at both the GPA and privately-operated terminals at the port. It also compares these emissions for both the "With" and "Without Project" (No Action) alternatives. In addition to the criteria pollutants that are traditionally evaluated when one discusses air emissions, estimates of "air toxics" emitted at the Port were also calculated. The Air Emission Inventory for the Port of Savannah, dated August 2011 can be found in Appendix K of the Final EIS.

Any of the proposed harbor deepening alternatives would reduce air emission levels in the Port of Savannah from what they would be with the present 42-foot navigation channel, because under each alternative fewer vessels would be transiting the harbor. The beneficial effect increases with the amount of deepening. Harbor deepening would result in temporary increases in air emissions during the initial construction. However, since those temporary increases would be distributed along the length of the channel -- roughly a third of which is in the ocean on the entrance channel -- they would not require mitigation.

9 Alternative Plan Evaluation: Mitigation Planning

As discussed in the preceding paragraphs, the SHEP is not expected to have any measurable effect on groundwater (upper Floridan aquifer), shoreline erosion, beach erosion at Tybee Island, or air quality. However, studies conducted during the SHEP indicated that the project would adversely affect tidal freshwater marsh, saltmarsh, brackish marsh, the dissolved oxygen regime in Savannah Harbor (without mitigation), Striped bass habitat, Shortnose sturgeon habitat, and cause an increase in chloride levels at the City of Savannah's water intake on Abercorn Creek during low flows and high tides. A mitigation plan was developed to address the remaining significant adverse impacts of the various harbor deepening alternatives under consideration that could not be avoided.

9.1 Mitigation Measure Identification

The mitigation planning process began early in the General Re-evaluation process, and it became one of the main focus areas as the General Re-Evaluation study progressed. The process included working with the SEG to identify and evaluate potential mitigation measures. A list of conceptual mitigation measures was collaboratively developed in 2002, with input from the natural resource agencies identified on the following page, as well as the SEG and the public.

- USFWS Ecological Services