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

- USFWS Savannah Coastal Refuges
- US EPA
- NOAA Fisheries - Habitat Protection Division
- NOAA Fisheries - Protected Resources Division
- GA DNR - Coastal Resources Division
- GA DNR - Wildlife Resources Division
- GA DNR - Environmental Protection Division
- GA Department of Transportation
- SC Department of Natural Resources
- SC Department of Health and Environmental Control
- Stakeholders Evaluation Group

The group identified measures that could conceivably be implemented to improve conditions for the following resources: wetlands; fisheries; water quality; groundwater; sediment placement & beach erosion; and cultural & historic resources. The complete list of conceptual mitigation measures can be found in EIS Appendix C.

9.2 Marsh Mitigation Plan Development

One of the major mitigation components of the design of the mitigation plan was recognition that tidal freshwater marshes are highly valued ecologically in the estuary. Measures were considered during the mitigation plan development to eliminate or reduce impacts to that resource. After considering several potential measures, rerouting of freshwater down Back and Middle Rivers was identified as a potentially feasible way to reduce salinity increases to tidal freshwater marshes located along those rivers. The following section discusses these efforts in some detail, but extensive hydrodynamic modeling was performed of potential flow rerouting measures, alternate sizes of those measures, and combinations of those measures. The Corps consulted with the Wetlands Interagency Coordination Team to assess the performance of those measures and help identify the best flow rerouting plan. One flow rerouting plan was identified as best reducing impacts from the 44-foot depth alternative, while a larger flow rerouting plan was identified as most cost effective in reducing freshwater wetland impacts from the other depth alternatives.

Another major component in the design of the mitigation plan was also intended to reduce impacts to tidal freshwater marshes along Back and Middle Rivers. That measure was filling the Sediment Basin (at the downstream end of Back River), which would reduce upriver movement of salinity to those marshes. During the initial interagency discussions about the potential filling of the Sediment Basin, the South Carolina Department of Health and Environmental Control and USFWS expressed substantial concern about the potential water quality impacts of filling the entire basin. They were concerned that the sediment placement operations would (1) exacerbate recurring low dissolved oxygen levels in that portion of the harbor, and (2) allow finegrained sediments to spread up into shallower portions of Back River, leading to sedimentation in that critical area. Because of these concerns, the Corps minimized the volume of material that would be included in the design to fill the Sediment Basin. Hydrodynamic modeling indicated that a narrow sill at the downstream end of the Basin would still allow salinity to cross over and move upstream. This would negate the intent of the measure, which is to reduce the movement of salinity up Back River. The final design consists of a broad sill that will restrict upstream salinity movement. New work sediments would be placed to construct the broad sill, but the extent of that placement was minimized to avoid the potential adverse impacts identified by the natural resource agencies.

The third major component in the design of the mitigation was recognition that dissolved oxygen levels in the harbor commonly reach critically low values during the summer months. Reductions in those levels from harbor deepening should be avoided or minimized. Section 9.3 will discuss actions taken to address this issue.

The fourth major component in the design of the mitigation was recognition of the threatened and endangered species that reside in the harbor or its entrance channel. Although the Corps regularly includes measures to protect these species in its construction contracts, it emphasized analysis of potential impacts from deepening the harbor on these species. Within the inner harbor, analyses were conducted to quantify potential adverse impacts to Shortnose sturgeon. Although one mitigation feature would improve the volume of Shortnose sturgeon acceptable habitat in the summer months, separate mitigation was found to be warranted for impacts to sturgeon winter habitat. Section 9.4 will discuss actions taken to address this issue. The design of the entrance channel extension included particular attention to potential impacts to whales and sea turtles which could be encountered in that area.

Tidal freshwater marshes were identified by the USFWS as the single most critical natural resource in the harbor; therefore, mitigation planning focused on reducing project impacts to that resource. Salinity is the primary determining factor in the conversion of tidal freshwater marshes, so that parameter was identified as the focus of the mitigation modeling efforts. In addition to directly determining the type of marsh that would occur on a site, salinity also affects dissolved oxygen levels, another parameter of high importance in deeper areas of the harbor. The intent was to identify alterations that could be made in rivers and tidal creeks to reduce salinity levels in critical areas of the estuary (Figure 9-1).

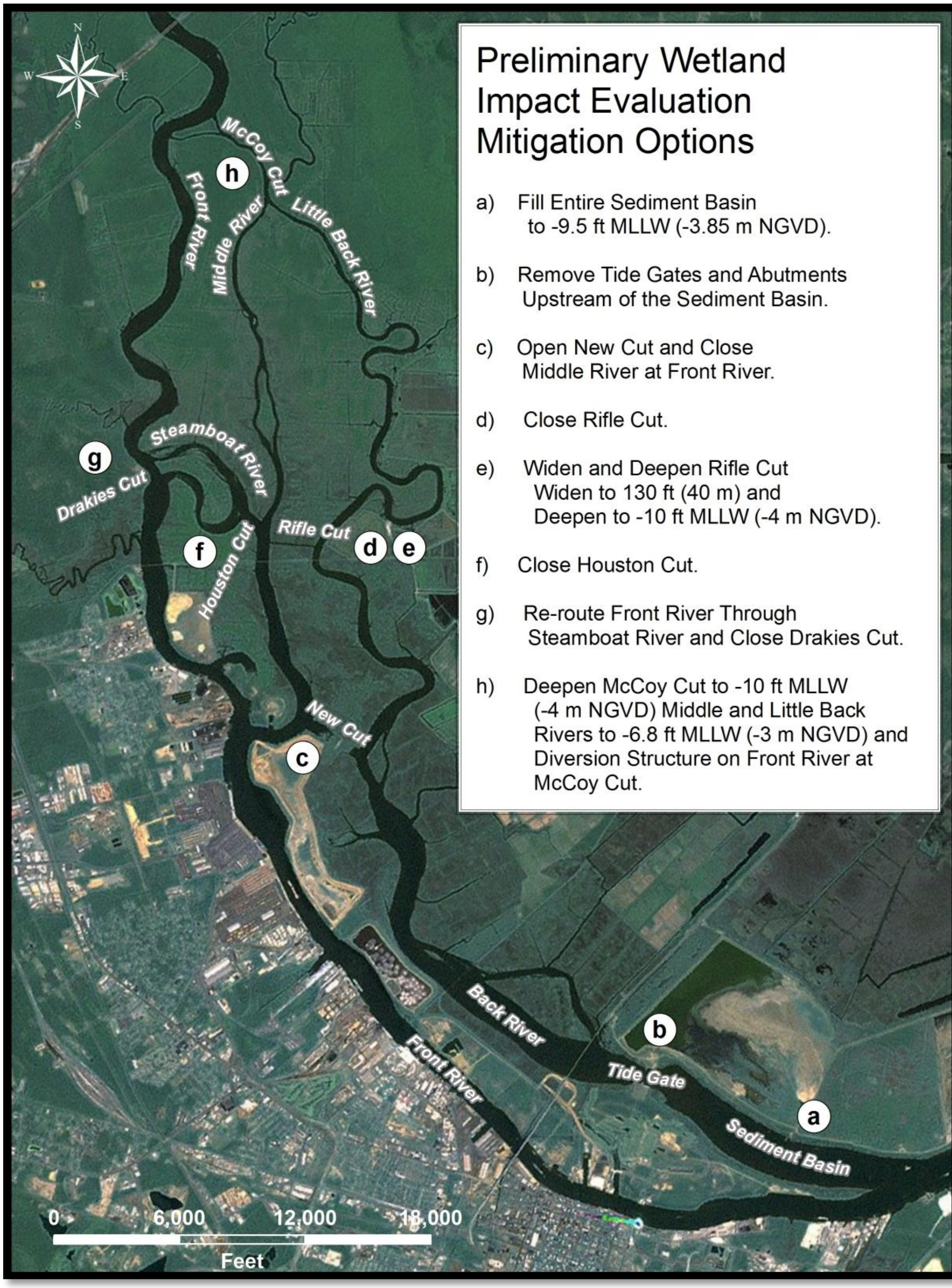

Figure 9-1: Mitigation Options

A total of 38 flow alterations at 7 locations were evaluated. Natural resource agencies reviewed initial modeling results in July 2006, and the interagency team jointly identified alterations to pursue further. Based on the effectiveness of each flow altering measure observed in the initial modeling and on the preliminary estimates of construction cost, the 5 best measures were ranked in the order of decreasing cost effectiveness (Table 9-1). Note that the naming conventions in Figure 9-1 do not match the naming conventions in Table 9-1. Different naming conventions were used intentionally to differentiate among actions being considered in different points in time during the mitigation planning process.

Table 9-1: Preliminary Mitigation Measure Ranking

Mitigation Option	Added Mitigation Component
C	Deepen McCoys Cut
D	Fill Sediment Basin
A	Close Middle River and Houston Cut; Open New Cut
E	Remove Tidegate
B	Re-Route Flow Through Steamboat River

An incremental approach was implemented to evaluate the way measures could be effectively combined. Because some measures result in similar effects, the order in which they are combined is important. As a result of additional modeling performed after the interagency meeting and considering potential implementation difficulties, a dual approach (Table 9-2 below) was developed to evaluate the effectiveness for individual measures and combinations of measures. The dual approach primarily resulted from uncertainties about the potential adverse effects of (1) filling the Sediment Basin on harbor maintenance activities, and (2) relocating the downstream end of Middle River in Mitigation Option A. Additional modeling would be performed to determine whether the path including plans identified in Table 9-2 as Plans 1-2-3 or Plans 1-4-5 were more effective. After making that determination, two other Mitigation Options would be evaluated: (1) removing the Tidegate (Option E) and (2) rerouting flow through Steamboat River (Option B). The natural resource agencies concurred in this approach in August 2006.

Table 9-2: Mitigation Planning Dual Approach: Measures and Combinations

Mitigation Plan	Mitigation Option Combination	Added Mitigation Component
1	C	McCoys Cut
2	C + D	Sediment Basin
3	C + D + F	Rifle Cut
1	C	McCoys Cut
4	C + A	Middle River, New Cut, Houston Cut
5	C + A + D	Sediment Basin
6	3 or 5 + E	Tidegate
7	3 or 5 + B	Steamboat River

With the various channel depths considered, over 160 modeling runs were required to evaluate the effects of each mitigation plan. The modeling was conducted for each of the five depth alternatives. The results of the modeling are summarized in Table 9-3 prepared for the -48-foot deepening alternative (as an example).

Table 9-3: Preliminary Marsh Mitigation Evaluation: -48 foot Deepening Alternative

	Marsh Acreage	Net Acres Adversely Impacted
Existing Conditions	4,072	------
Deepening Only (No Mitigation)		1,932
Plan 1		988
Plan 2		988
Plan 3		834
Plan 4		1,334
Plan 5		325

Notes: Evaluation conducted assuming average river flows and 50% salinity exceedance values. The initial wetland mitigation analyses were conducted on the maximum depth alternative (48-foot) to assess the effectiveness of each plan in addressing the maximum impacts. The acres of freshwater marsh identified as being impacted could be affected by an increase in salinity over the 0.5 ppt threshold.

Similar information was developed for three alternate scenarios which were considered as sensitivity analyses. One scenario used 2001 drought flows, rather than the average river flows. Two other scenarios included different amounts of sea-level rise – 25 or 50 cm over the 50-year life of the project. The adverse impacts to freshwater wetlands were generally the same or less in the three sensitivity analyses. That trend did not always hold up when the 50-cm of sea-level rise was considered. Under that scenario, the flow re-routing plans would not be as effective in reducing adverse impacts to freshwater wetlands. Some of the wetlands that would be protected by the flow-altering mitigation measures would have already converted to brackish marsh as a result of the saltwater intrusion from the sea-level rise, even without a further harbor deepening. In general, of the four scenarios that were considered, the modeling shows the largest amount of adverse impacts to tidal freshwater wetlands would occur with average river flows and the existing sea level.

The results of this modeling were discussed at an interagency meeting in June 2007. Several agreements were reached at the meeting, including the following:

- 50%-tile exceedance value of salinity was identified as the best single measurement across the range of river stations and river flows;
- Use average river flows for the basic impact evaluation since that flow better represents the entire range of flows;
- Use existing sea level for the basic impact evaluation since it best represents what occurs near the time of construction;
- The path with Mitigation Plans 1-4-5 appears to be unacceptable because it substantially reduces the height of the tide range in critical areas of the estuary;
- Use Mitigation Plan 3 as a base for analysis of Plans 6 and 7;
- All tidal freshwater marshes within the estuary possess the same ecological value;
- Evaluate the feasibility of grading down a high ground site to produce tidal freshwater wetlands;
- An oxygen injection system should remove the impacts identified to American shad and likely result in net improvements in habitat volume;
- An oxygen injection system should remove the impacts identified to Southern flounder and likely result in net improvements in habitat volume;
- Average river flows (50%-tile) are appropriate for identifying project impacts to Striped bass;
- Further increases in flow are also not likely to be effective at increasing Striped bass habitat, since even flows at the 80% cumulative frequency level do not reduce the adverse effects of a harbor deepening;
- Training walls are not likely to be equally effective each year at increasing Striped bass habitat because the spawning location likely shifts with river flows, rendering the structures ineffective during some flow conditions;
- Examine closing the lower arm of McCoys Cut as a means of increasing Striped bass habitat; and
- Examine including a flow partitioning structure at the junction of Little Back and Middle Rivers as a potential adaptive management tool to increase Striped bass habitat.

The agencies suggested a slightly different methodology to graphically quantify impacts to the wetlands. The Corps used that alternate approach for the remainder of the study, so the numerical results of this iteration (Table 9-4) are not directly comparable with the initial impact quantification (Table 9-3). Additional modeling was conducted of the flow-altering components of the mitigation plans, and additional plans were developed to try to identify a plan that would be more effective in reducing wetland impacts. The additional modeling identified five new flow-altering plans: 3A, 3B, 3C, 6A, and 6B. Those plans are described in detail in both the Engineering Appendix and the EIS. The effectiveness of these plans at reducing adverse impacts to freshwater marshes (<0.5 ppt) that would result from construction of the 48-foot project is displayed in Table 9-4.

Table 9-4: Marsh Mitigation Plan Evaluation: -48 Foot Deepening Alternative

	Marsh Acreage	Net Acres Adversely Impacted
Existing Conditions	4,072	------
Deepening Only (No Mitigation)	2,860	1,212
Plan 3	3,584	488
Plan 3A	3,531	541
Plan 3B	3,406	666
Plan 3C	3,383	689
Plan 6	3,715	357
Plan 6A	3,735	337
Plan 6B	3,610	462
Plan 7	3,772	300

Note: The initial wetland mitigation analyses were conducted on the maximum depth alternative (48-foot) to assess the effectiveness of each plan in addressing the maximum impacts. The acres of freshwater marsh identified as being impacted could be affected by an increase in salinity over the 0.5 ppt threshold.

Preliminary cost estimates had been developed for each of the flow-altering measures and combined to assess each mitigation plan's cost effectiveness. Those costs were combined to estimate the cost of the entire flow-altering plan. The cost effectiveness of the marsh mitigation plans for the 48-foot depth alternative is presented in Table 9-5.

Table 9-5: Marsh Mitigation Plan Cost Effectiveness: -48 Foot Deepening Alternative

	Net Acres Adversely Impacted	Acres Mitigated	Preliminary Construction Cost (1,000s)	Cost/Acre Mitigated
Plan 3	488	724	$50,500	$70,000
Plan 3A	541	671	$51,700	$77,000
Plan 3B	666	546	$30,400	$56,000
Plan 3C	689	523	$32,600	$62,000
Plan 6	357	855	$51,600	$60,000
Plan 6A	337	875	$52,900	$60,000
Plan 6B	462	750	$32,800	$44,000
Plan 7	300	912	$196,400	$215,000

Note: The initial wetland mitigation analyses were conducted on the maximum depth alternative (48-foot) to assess the cost effectiveness of each plan in addressing the maximum impacts. The acres of freshwater marsh identified as being impacted could be affected by an increase in salinity over the 0.5 ppt threshold. The column showing "Acres Mitigated" is the reduction in acreage of marsh impacts resulting from the mitigation plan.

Although Plan 7 may have other possible ecological benefits, the preliminary cost estimate indicates that it would be quite expensive. The Corps expects the remaining impacts to other resources could be mitigated at a lower total cost than what would occur with Plan 7; therefore, this plan was deemed as not being cost-effective and was dropped from further consideration. For the 45-, 46-, 47- and 48-foot depth alternatives, Plan 6B was found to be the least cost per acre, but the impact acreage was determined to be unacceptable.

Using this information, including consideration of impacted acreage, the Corps determined that Plan 6A is the most cost-effective flow-altering component for the 45-, 46-, 47- and 48-foot depth alternatives, while Plan 6B is better for the 44-foot depth alternative. Plan 6A includes the following features, which are designed to change the hydraulics of the Middle, Little Back, and Back Rivers: McCoy Cut diversion structure, channel deepening on McCoy Cut to -4m NGVD and Upper Middle and Little Back Rivers to -3m NGVD, fill entire sediment basin to -3.85m NGVD by constructing a submerged sill, close Rifle Cut, remove Tidegate abutments and piers, and close the lower (western) arm of McCoy Cut.

As shown in Table 8-3, impacts to tidal freshwater marsh would remain (except for the 44-foot project) even with implementation of the flow rerouting plans. Residual impacts to tidal freshwater marshes would be -32 acres for the 45-foot project, -201 acres for the 46-foot project, -223 acres for the 47-foot project and -337 acres for the 48-foot project. Ideally, mitigation for these remaining impacts to tidal freshwater marsh would involve restoration or creation of tidal freshwater wetlands in the estuary. However, no feasible means could be identified by the Wetland ICT to accomplish this type of mitigation. Consequently, preservation was the mitigation option selected to satisfy the remaining tidal freshwater marsh mitigation requirements of the SHEP.

For impacts to freshwater wetlands, the Corps used Savannah District's Standard Operating Procedures (SOP), which is used on a daily basis by natural resources agencies in Georgia to evaluate impacts and mitigation on projects requiring Section 404 permits. Although the SOP was developed by the interagency Mitigation Banking Review Team for actions permitted through Savannah District's Regulatory Division, it can also serve as a framework to quantify impacts from civil works projects. USEPA Region 4 suggested the Corps consider use of the SOP for this project. The SOP uses several factors to quantify the ecological impacts and benefits expected from various project actions. For impacts, those factors include the type of impact, the duration of the impact, the type of vegetation being impacted, and the preventability of the impact. For restoration, the factors include the expected improvement in hydrology and vegetation, timing of the restoration, maintenance that is expected to be needed, monitoring which would be performed, and control over the land to reduce future impacts. For preservation, the factors include the degree of threat to the identified lands, the type of vegetation occurring on the lands, and the control over the land to control future impacts.

The Corps applied the SOP to this project, using the acreage outputs from the hydrodynamic model at various salinity levels. It also evaluated the extent of the impact that would occur to existing marshes -- conversion of one inter-tidal marsh type to another, and the benefit that would occur to marshes as a result of the flow-altering features. Development pressures on waterfront properties in this estuary were also factored into the assessment. In Georgia, the natural resource agencies' policy is that acceptable mitigation should consist of at least 50 percent restoration. For this project, restoration through the flow-altering features would comprise 58 percent of the total wetland mitigation for the 48-foot alternative, 60 percent for the 47-foot and 46-foot alternatives, and 65 percent for the 45-foot alternative. The following table (Table 9-6) summarizes the results of the SOP calculations for the 48-foot alternative to provide an example of how wetland mitigation requirements were calculated for the various project depth alternatives. The units shown in the table are calculated through use of the SOP to quantify the amount of mitigation required and the counter-balancing environmental value of various mitigation actions.

Table 9-6: Summary of SOP Calculations: 48-Foot Alternative

	Freshwater Marsh	Brackish Marsh	Salt	Total
Adverse Impact				
Acres	337		730	
SOP Units	3033		4672	7705
Restoration				
Acres		1068		
SOP Units		4485.6		
Preservation				
Acres		2683		
SOP Units		3219.6		

Mitigation (4485.6 + 3219.6= 7705) is equal to Impacts (7705)

The SOP calculations determine the minimum number of acres that need to be acquired and preserved to acceptably mitigate for the expected wetland impacts. Table 9-7 shows the amount of acres that would have to be acquired and preserved for each depth alternative.

Table 9-7: Wetland Preservation Calculations

Depth Alternative	Minimum Acres Needed
44-Foot	0
45-Foot	1,643
46-Foot	2,188
47-Foot	2,245
48-Foot	2,683

Savannah District consulted the USACE Center of Expertise for Ecosystem Restoration to confirm that the Regulatory SOP was a technically sufficient method of determining the amount of acres that the Project would need to acquire and preserve to compensate for adverse impacts to wetlands. The Center concurred that the SOP was a technically sound technique. They noted that -- as with other techniques -- its results depend heavily on the values assigned to specific parameters in the analysis. They also noted that with the approach followed in this application, much of the mitigation requirement was being driven by conversion of salt marsh to brackish marsh, an activity which was reportedly a goal of the natural resource agencies for this estuary.

9.2.1 Identification of Lands to be Acquired

The USFWS and the Savannah National Wildlife Refuge have identified properties within the estuary that they believe are ecologically valuable and provide positive contributions to the goals of the Refuge and enhance the area's fish and wildlife resources. The latest version of the Refuge's Acquisition Plan is dated July 2007 and is included in the document titled "Final Environmental Assessment and Land Protection Plan; Proposed Expansion of Savannah National Wildlife Refuge". This plan is being updated, and the USFWS has provided the Corps a Draft Map which reflects the latest approved expansion plan for the SNWR. The Corps proposes to acquire lands from the Refuge's Acquisition Plan and provide them to the USFWS to manage as additions to the Savannah National Wildlife Refuge, to mitigate for the remaining wetland impacts from this project. The USFWS previously identified the ecological value of those properties and believes they would be valuable additions to, and advance the goals of, the Savannah Refuge. The Refuge has the authority to accept these lands, since the lands are already included in the Refuge's approved Acquisition Plan. The USFWS would manage these properties using funds obtained through the Department of Interior's normal budget process.

Although there are 45,836 acres in the Refuge's approved Acquisition Plan, not all of those properties would provide the type of habitat that is desired as mitigation for this project. The project would acquire properties from the Refuge's Acquisition Plan that best meet the needs of the project. Those needs would be met by properties that are dominated by freshwater wetlands. The Corps has consulted with the Refuge and will lean heavily on the Refuge's identified priorities.

The Corps has completed its initial assessment of properties in the SNWR's Acquisition Plan to determine potential properties that could meet the wetland mitigation needs of the SHEP. This assessment (Consideration of 2008 USEPA/USACE Mitigation Rule) is in Appendix C of the Final EIS. The lands proposed for preservation consist of bottomland hardwoods, maritime forest and uplands dominated by deciduous forest and regrowth. The bottomland hardwoods are classified as palustrine, forested, broad-leaved deciduous systems that are both temporarily and seasonally flooded. Preserving these areas would ensure wildlife habitat is protected in perpetuity. Moreover, the additional lands would buffer the SNWR from future threats of development such that changes in land use would not occur immediately adjacent to existing areas of the Refuge that do contain estuarine emergent wetland characteristics. Thus, the acquisition and preservation of wetland and upland buffer would provide a functional replacement for the minor conversion of the only wetland function (i.e., fish and wildlife habitat) that would be expected as a result of the freshwater to brackish marsh conversion.

Due to the unique nature of the impact (i.e., vegetative conversion), the Corps would also conduct extensive monitoring to ascertain the magnitude of the marsh conversion that does occur. If impacts to tidal freshwater marsh exceed those expected, funds would be available to purchase additional lands for preservation. A monitoring plan has been developed (See Appendix D of the Final EIS) that would establish 12 marsh monitoring sites in transitional areas that are predicted to most likely experience a vegetative shift as a result of the channel deepening. Seven of the marsh monitoring sites have already been established and were monitored by the USGS Florida Fish and Wildlife Cooperative Research Unit. The five new monitoring locations were chosen to expand monitoring in highly sensitive marshes, in other areas of marsh where significant salinity changes are possible under a variety of scenarios, and to monitor community shifts both vertically (up and down river) and laterally (interior versus exterior). The data collected from this monitoring would be used along with the hydrodynamic and water quality models to quantify indirect impacts to freshwater marsh and saltmarsh. These sites would be monitored during the one year of Pre-construction monitoring, during construction and for 10 additional years of Post-Construction Monitoring.

9.2.2 Salt Water and Brackish Wetland Compensation

Approximately 15.68 acres of brackish marsh would be lost as a result of various excavation requirements of the project (Table 9-8) for any of the project depth alternatives evaluated. The excavation requirements (in regards to the amount of wetlands that would be affected) for all five channel depth alternatives are the same. There are six locations where brackish marsh would be excavated. The first two locations are in the SNWR where approximately 2.2 acres would be removed at Station 102+600 and 0.8 acres would be removed as part of the Kings Island Turning Basin expansion. The project would remove brackish marsh from two locations on Hutchinson Island where approximately 3.4 acres would be excavated at Station 88+000 and 0.8 acres at Station 70+00. The project also provides for removal of the Tidegate Structure abutments on both the Georgia and South Carolina sides of the river. Removal of the Tidegate Structure abutment on the Georgia side would result in the loss of about 7.63 acres of brackish marsh while about 0.85 acres would be lost on the South Carolina side of the River.

Table 9-8: Impacted Wetland Characteristics

Location	Wetland Acres Affected by Excavation
Refuge Lands	
Station102+600	2.2
Kings Island Turning Basin - GA	0.8
Non-Refuge Lands	
Station 88+000 - GA	3.4
Station 70+000 - GA	0.8
Tidegate - GA	7.63
Tidegate - SC	0.85
Total	15.68

A previously-used sediment placement area (DMCA 1S) within Savannah Harbor was identified as having the greatest opportunity to support the long term success of a restored salt and brackish marsh system. DMCA 1S is located adjacent to the confluence of Front River and Middle River, and it is located within the boundaries of the Savannah National Wildlife Refuge. Much of the site is currently "high ground" as a result of the previous sediment disposal actions, which were terminated at least 20 years ago. The Corps hosted a site visit on August 10, 2009, and the natural resource agencies approved the concept of grading down the site to restore it to a marsh. The proposed restoration area is approximately 40.3 acres. A 1.7 acre site adjacent to the 40.3 acre SHEP mitigation site was graded down by GPA several years ago as mitigation for work at their facilities. The SHEP wetland mitigation site and GPA's existing saltmarsh acreage (1.7 acres) would provide a contiguous 42.0 acre wetland.

The USACE used the Regulatory SOP to determine the exact number of acres that would be required for restoration. The 15.68 acres of impact to salt and brackish marsh equates to approximately 138 mitigation credits. Calculations derived from the SOP indicate that approximately 28.8 acres of restored marsh would be required to mitigate for the 15.68 acres of impact. The Corps intends to restore approximately 40.3 acres of saltmarsh at DMCA 1S. The roughly 11.5 acres of excess restored saltmarsh would be credited to the Savannah Harbor Navigation Project as "advance mitigation" and used when the need arises for small amounts of marsh mitigation to compensate for wetland impacts from O&M actions. These excess wetland mitigation credits could also be used to for any additional wetland mitigation needs for the SHEP.

Restoration of the DMCA 1S site would occur by grading it down to an elevation that would allow the growth of *Spartina alterniflora* (i.e., +7.6 to +7.8 MLLW). The elevation range was selected after inspecting and surveying the elevations of natural marsh that is immediately adjacent to the proposed restoration site. Once the new elevations have been established, the approximately 40.3-acre site would be allowed to naturally vegetate at the expected rate shown in Table 9-9. As requested by the USFWS, a "feeder creek" system would be constructed toward the interior of the restored marsh. The creek would provide another mechanism of ensuring adequate exchange of brackish, surface water with pore waters that are located on the interior of the site.

Table 9-9: Re-Vegetation Rate for Created Marsh

Time Period	Percent Vegetative Cover
Construction	0
Year 1	15
Year 2	25
Year 3	40
Year 4	60
Year 5	80
Year 6	85
Year 7	90

The Corps would monitor the site for a period of seven years, and the success of the brackish marsh would be based on meeting or exceeding the annual values defined for the percent of vegetative coverage for *Spartina alterniflora* shown in the above table. The Corps would provide annual reports of the performance monitoring to the Wetland Interagency Coordination Team (ICT) for review. If the site does not revegetate at those rates, the Corps would plant *Spartina alterniflora* to provide the basis for subsequent growth across the entire site. The ICT would identify/recommend corrective actions.

The restoration of wetlands at DMCA 1S would also include a monitoring plan for invasive species and an invasive species control plan that could be implemented if required. If invasive species are identified, they would be removed from the site via hand grubbing or another method approved by the Wetland ICT.

The marsh restoration site (DMCA 1S) is located within the SNWR. However, the Corps and the GDOT still maintain a dredged material disposal easement on the site. The Corps and the GDOT would relinquish this easement.

9.3 Dissolved Oxygen Mitigation Plan Development

Dissolved oxygen is a critical resource in the harbor that experiences problematically low levels during the warm summer months. USEPA issued a "no discharge" TMDL for dissolved oxygen in the harbor in 2006 due to the severity of the problem. EPA issued a revised Draft TMDL in 2010 that would allow some discharge of oxygen depleting substances, but still requires a dramatic reduction in the basin-wide level of those discharges. The states of Georgia and South Carolina are working cooperatively with the point source dischargers and EPA to develop a plan that would fulfill the intent of EPA's revised TMDL.

Dissolved oxygen studies previously conducted for the Savannah Harbor Ecosystem Restoration Study were incorporated in this project. As part of that study, 25 different methods of improving dissolved oxygen levels in Savannah Harbor were examined. The analysis concluded that oxygen injection is the most cost-effective method for raising dissolved oxygen levels in the harbor.

After the flow re-routing components of the marsh mitigation plan were identified, additional hydrodynamic and water quality modeling was performed to refine the oxygen injection system design. The refined modeling indicated that three oxygen injection system sites, each with multiple Speece Cones, would be required. Facilities would be required at two locations to support three injection sites (Figure 9-2). The oxygen injection requirements for each depth alternative are summarized in Table 9-10.

Table 9-10: Dissolved Oxygen System Requirements

Depth Alternative	Number of Cones Operated	Number of Cones Installed	Capacity to Increase D.O. (lbs/day)
44-foot	9	11	36,000
45-foot	8	10	32,000
46-foot	9	11	36,000
47-foot	10	12	40,000
48-foot	11	13	44,000

All three oxygen injection sites (one near Georgia Power's Plant McIntosh, one at Hutchinson Island – west, one at Hutchinson Island – east) would be needed for each channel depth alternative. The systems would be land-based with water being withdrawn from the river through pipes, then super-saturated with oxygen and returned to the river. The water intake structure would include screens to reduce the intake of trash and other suspended solids. The screens would be sized to keep flow velocities from exceeding 0.5 foot per second to minimize entrainment of fish larvae. The intake and discharge would be located along the side of the river and would not extend out into the navigation channel.

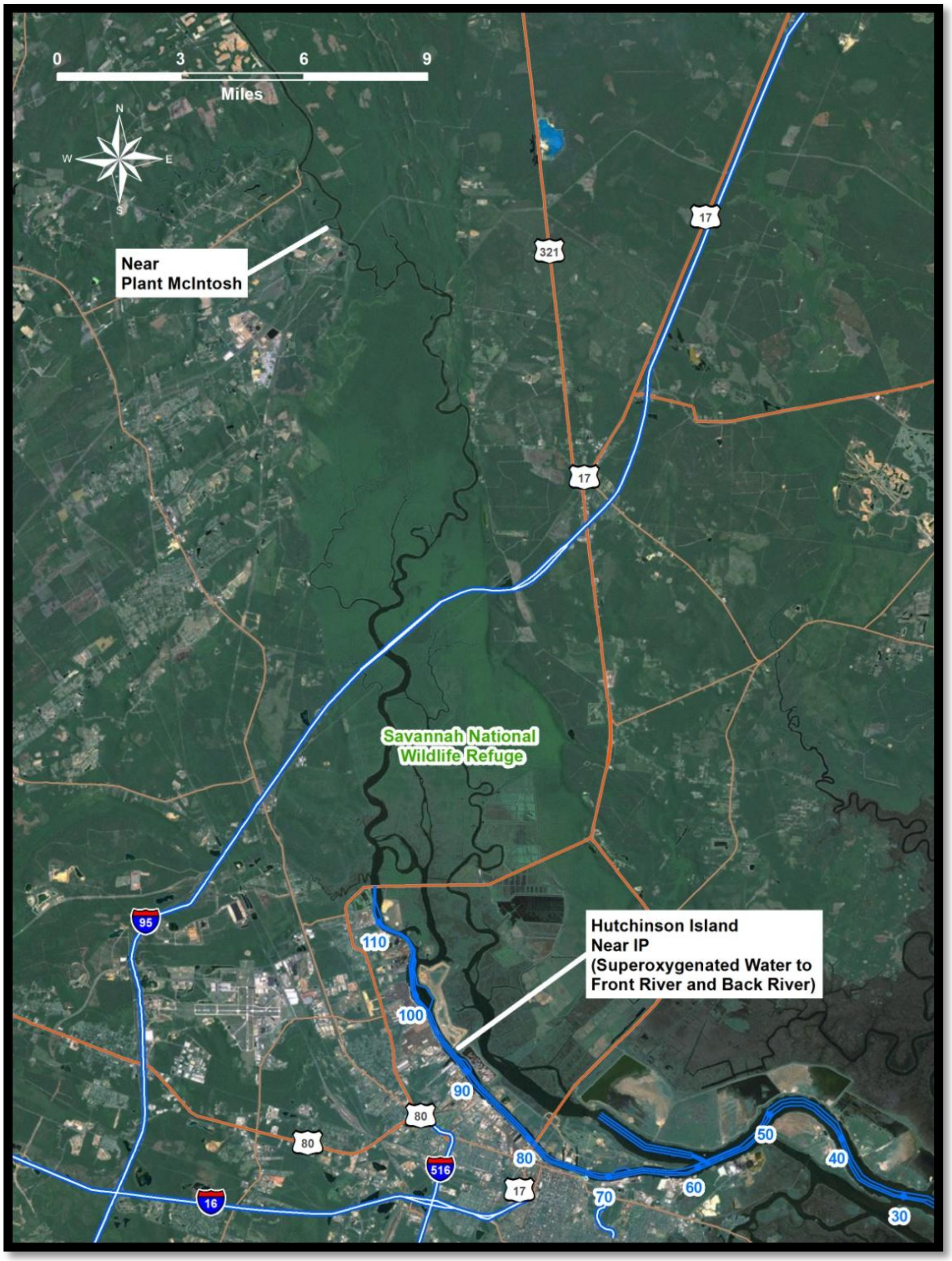

Figure 9-2: Proposed Locations for Dissolved Oxygen Improvement Systems

In the summer of 2007, the Georgia Ports Authority funded a full-scale demonstration project of an oxygen injection system. The summer is typically a time of low dissolved oxygen levels in the harbor. The demonstration was conducted to obtain information of the effectiveness of this design and address concerns expressed by natural resource agencies with application of this general design in an estuarine environment. Agencies had expressed concern about (1) whether an injection system could be effective in the harbor, and (2) whether dissolved oxygen levels would be too high near the discharge site and adversely affect fishery resources.

The demonstration project supported the following findings:

- The injection system could increase dissolved oxygen levels in the harbor;
- Oxygen injection takes about three days to begin to reduce mid-channel dissolved oxygen deficits and the oxygen improvement near the injection site extends for at least seven days after oxygen addition ceases;
- The super-oxygenated water dispersed quickly into the river and excessively high dissolved oxygen levels were not observed near the injection point; and
- Tidal flow brought new water into the injection area and no short-circuiting was observed.

The demonstration confirmed that the injection system effectively added the required mitigation amount of dissolved oxygen to the harbor and reduces in-stream dissolved oxygen deficits during critical summer conditions. The demonstration also confirmed the soundness of the prototype design.

Modeling to determine dissolved oxygen impacts in the harbor originally excluded point source dischargers. This was intentional to gain understanding of project impacts without any outside influences. However, after the dissolved oxygen mitigation was developed, the models were re-run with the point source discharges included (per request from NOAA to fully describe Shortnose sturgeon impacts) and it was discovered that mitigation goals for water quality were not achieved with the preliminary dissolved oxygen system design. Therefore, additional cones were added to meet the water quality mitigation goals throughout the harbor with a more real-world condition of point source loads being included. The final design also includes one additional Speece Cone at each site location, which would be used as a spare when maintenance or repairs are required.

9.4 Shortnose Sturgeon Mitigation Plan Development

As shown in Table 8-3, adverse impacts (increased salinity) to adult and juvenile winter habitat would remain even after the injection of oxygen and implementation of the flow rerouting measures for all project depths evaluated. The natural resource agencies were consulted about potential ways to address remaining impacts. Neither the natural resource agencies nor the Corps could identify any measures that could be implemented in the estuary that would restore sturgeon habitat or enhance existing habitats. The habitat suitability analysis indicated that the main issue determining the quantity of acceptable sturgeon habitat in the estuary is salinity. The reductions in volume of acceptable habitat stem from increases in salinity to unacceptable levels at sites that presently provide suitable habitat characteristics. The fish could move further upstream to areas possessing lower salinity levels. Those habitats may have excess carrying capacity, but that is unknown, and those upstream sites may possess other factors that make them less suitable or unsuitable to sturgeon. Since no measures to address remaining impacts to Shortnose sturgeon habitat could be identified in the estuary, it was decided to evaluate habitat improvement measures elsewhere in the Savannah River Basin. One potential measure is to provide Shortnose sturgeon access to traditional foraging and spawning habitat above the lowest dam (New Savannah Bluff Lock and Dam) on the river.

The Corps acknowledged that removal of the lowest dam on the river, the New Savannah Bluff Lock and Dam (NSBL&D) at Augusta, Georgia, which is operated by the Corps, would be the preferred method to allow sturgeon and other anadromous fish to access upstream habitat. The Corps also acknowledged that removal of the lock and dam would benefit the ecosystem. However, removal of the New Savannah Bluff Lock and Dam is not a feasible mitigation alternative for the following reasons:

- The lock and dam is a Congressionally-authorized project; therefore, the Corps is obligated to maintain the project as Congress provides funding for such actions.
- The current authorization language (WRDA 2000) amended in Omnibus Act 2001 calls for repair and rehabilitation of the lock and dam structure, construction of a fish passage, and conveyance of Lock and Dam to the City of North Augusta.
- Removal of the structure would adversely impact the freshwater supply of eight major users.

Since removal of the NSBL&D is not feasible, a fish passage structure around the NSBL&D at Augusta, Georgia, which is operated by the US Army Corps of Engineers, was recommended. A fish passage structure around the structure would allow migrating fish to move past the dam, which would initially open up an additional 20 miles of habitat upstream of the dam to reaches Shortnose sturgeon had used in the past. After some other actions (fish passage structures at two dams above the New Savannah Bluff Lock and Dam) are taken by others, an additional 30 miles of riverine habitat upstream of the dam would become available to Shortnose sturgeon. The structure would also open up the river to American shad and other anadromous fish species, thereby helping those impaired populations. There is also evidence that some of the Savannah Harbor Striped bass population spawn in upstream areas near the fall line which could also benefit from the fish passage structure. In June 2007, representatives of the resource agencies confirmed that the fish passage structure appears to be the best measure within the basin to effectively compensate for the predicted loss in Shortnose sturgeon habitats.

The previously approved horseshoe rock ramp design would also allow fish to move downstream, thereby ensuring young fish spawned upriver could access other habitats needed in later life stages. The horseshoe rock ramp bypass was designed to capture 5 percent of the river flow. Based on some of the comments received on the Draft EIS, some of the agencies believed the bypass would need to carry more of the river flow to successfully pass Shortnose sturgeon. Consequently, the Corps convened an interagency workshop on April 25-27, 2011 to discuss and evaluate mitigation options available. Numerous options were evaluated in regards to fish passage at the NSBL&D. Using the input from the agencies at the workshop, the Corps screened the potential fish passage options and prepared preliminary designs for three fish passage alternatives. Since all three designs would achieve the objective of Shortnose sturgeon passage at the NSBL&D and would also accommodate the larger Atlantic sturgeon and readily pass other anadromous species such as American shad and Striped bass, the Off-Channel Rock Ramp Design was selected as the preferred design because it is the most cost effective.

9.5 Striped Bass Mitigation Plan Development

As shown in Table 8-3, adverse impacts remain for Striped bass spawning, egg and larval habitat even with the flow rerouting measures for all of the project depth alternatives evaluated (except for Striped bass egg and larval habitat for the 46-foot Project). The adverse effects are most pronounced in the adult spawning habitat.

In general, salinity was the main factor in reducing the quantity of acceptable habitat. Some areas did fail the velocity criteria. The placement of structures to increase velocity in those locations was determined inadequate by the agencies. Therefore, they recommended that hard structures not be used to improve flow velocities to increase Striped bass habitats. The agencies could not identify any other measures that could be implemented in the estuary to restore or enhance Striped bass habitats.

The loss of 10 percent of spawning, egg development or larvae habitats could limit the size of the Savannah River population of Striped bass. The agency representatives concluded that the only means of addressing that impact would be through a stocking program. Through such a program, the project would provide additional fish to the population to compensate for the limiting nature of the reduced spawning and early development habitats. The Wildlife Resources Division (WRD) of the Georgia Department of Natural Resources conducted a striped bass stocking program in this river in the late 1990's. The Corps coordinated with GA DNR-WRD and confirmed that a stocking program could compensate for the impacts identified to Striped bass.

The costs for a full stocking program to replace 100 percent of the young would be appropriate mitigation if the project were expected to adversely impact 100 percent of the existing spawning or early life stage habitat in the estuary. However, since the alternatives being considered are not expected to result in impacts that severe, the extent of the stocking that would be needed could be reduced to the amount of habitat predicted to be impacted by the project. The percentage of habitat loss could be multiplied by the cost for a full-scale stocking program to determine the amount of funding that would compensate for the habitat loss that is expected.

The potential adverse impacts to Striped bass habitat were quantified for three life stages and three river flows. That information must be consolidated to arrive at a single value to represent adequate compensation across all those conditions. It is appropriate to use the maximum impact value for a given river flow across the three life stages. An individual fish would have to pass through each of those life stages to enter the population, so the life stage that was impacted the most would define the maximum impact of the project for a given river flow.

Using that approach, the maximum adverse impacts expected to Striped bass habitat can be consolidated by river flow as shown in Table 9-11. A weighted average impact was calculated based on drought flows occurring 25 percent of the time, average flows occurring 50 percent of the time, and high flows occurring 25 percent of the time.

Table 9-11: Striped Bass Weighted Average Impact

Channel Depth Alternative	Spawning 50% Flows	Eggs 50% Flows	Larvae 50% Flows	Combined Adverse Impact
44-Foot	-2.9 %	-9.4 %	-5.6 %	17.0 %
45-Foot	-9.2 %	5.2 %	1.7 %	2.9 %
46-Foot	-10.0 %	-0.0 %	5.6 %	5.0 %
47-Foot	-11.1 %	-5.0 %	-13.5 %	26.9 %
48-Foot	-16.1 %	-10.8 %	-3.5 %	27.8 %

With that weighted average impact value and the costs of a complete stocking program, one can calculate the compensation required to mitigate for each depth alternative. The GA DNR-WRD provided information on the costs to rehabilitate and operate some of GA DNR-WRD's facilities at their Richmond Hill hatchery to conduct a Striped bass stocking program capable of producing 40,000 Phase II fish each year. The costs included initial expenses of $3.1 million, annual expenses of $203,000 to operate the program, and recurring costs of between $30,000 and $50,000 for equipment replacement. These costs represent an annualized cost of roughly $466,700 for a complete Striped bass stocking program. Based on that average annual value, compensation detailed in Table 9-12 would be required:

Table 9-12: Striped Bass Annual Mitigation Costs

Channel Depth Alternative	Weighted Average Impact	Annual Program Funding
44-Foot	17.0%	$79,335
45-Foot	2.9%	$13,534
46-Foot	5.0%	$23,334
47-Foot	26.9%	$125,536
48-Foot	27.8%	$129,737

The mitigation plan proposes to fund that compensation as a lump sum. Using an interest rate of 4.125 percent over 50 years to obtain the present worth of that annual funding stream, the lump sum payments detailed in Table 9-13 would be required:

Table 9-13: Striped Bass Lump Sum Compensation Value

Channel Depth Alternative	Annual Program Funding	Lump Sum Payment
44-Foot	$79,335	$1,668,000
45-Foot	$13,334	$285,000
46-Foot	$23,334	$491,000
47-Foot	$125,536	$2,640,000
48-Foot	$129,737	$2,728,000

Using the FY12 discount rate of 4 percent, the lump sum payment for the 47-foot depth alternative would be $2,672,000.

An evaluation of the impacts of SHEP on Striped bass habitat would be conducted during years 2, 4, and 9 of the Post-Construction monitoring to ensure that impacts do not exceed what is expected. The field data collected during the monitoring would be used in conjunction with the hydrodynamic and water quality models to conduct this assessment. Adaptive management funds would be available to provide further mitigation for Striped bass habitat should the study show that is warranted.

9.6 Chloride Mitigation Plan Development

9.6.1 Chloride Impacts to Savannah's Municipal and Industrial Water Treatment Plant

Deepening the Savannah River to the Garden City Terminal would allow salinity to move farther upstream to the extent that chloride concentrations would increase at the City of Savannah's water intake and at other industrial intakes. Impacts of increased chloride concentrations at the City of Savannah's water intake during periods of drought (low river flow) include potential increases in lead and disinfection by-product concentrations in the municipal water system and could increase maintenance costs for the City's municipal water distribution system. Increased chloride concentrations associated with the SHEP could also impact industrial production and maintenance costs for industrial users of Savannah River water.

The City of Savannah's 62.5 million gallon per day (MGD) capacity municipal and industrial water treatment plant obtains surface water through an intake on Abercorn Creek. The intake is located in Effingham County, Georgia about two miles from the confluence of Abercorn Creek and the Savannah River, and about 11 miles upstream of the SHEP upstream limits. The City presently operates the plant at around 30 MGD. That rate has increased in recent years as the western part of Effingham County has grown rapidly. Additionally, the City of Savannah is under a directive from the State of Georgia to decrease groundwater usage, which would increase future demand for surface water from the Abercorn Creek intake.

The City withdraws water from Abercorn Creek for both municipal and industrial uses. Municipal water requires that chlorides be within the 250 mg/l (or 250 ppm) drinking-water standard established by the EPA. This level is specified as a threshold of taste and odor detection and not as a health hazard. Distribution pipelines and some industrial processes are sensitive to chloride concentrations much lower than the drinking water standard. In the past, City contracts with industrial customers included a provision that chloride concentrations be below 12 mg/l (or 12 ppm). That criterion is not included in current contracts, but the industries still require water with very low chloride concentrations. The City's Water Treatment Plant does not treat for chlorides. Industrial users must bear the economic burden of any increased maintenance costs at their facilities due to chloride concentrations.

As part of the Savannah Harbor Expansion Project, the Savannah District conducted a number of studies to evaluate impacts to the City of Savannah's intake on Abercorn Creek. An impact prediction tool was developed. The details of the development are outlined in the report titled *Savannah Harbor Expansion Project - Chloride Data Analysis and Model Development* dated November 15, 2006 which is included in the Engineering Investigations Supplemental Materials. Projection of chloride impacts due to harbor deepening and wetland mitigation using this method are documented in two reports *Chloride Impact Evaluation Impacts of Harbor Deepening Only* dated February 2007 and *Savannah Harbor Expansion Project Evaluation of Chloride Impacts with Proposed Mitigation Plan* dated December 2007 which are both included in the Engineering Investigations Supplemental Materials.

Study findings predicted only negligible changes to the chloride concentrations from harbor deepening. The predicted impacts were less than 1 mg/l and would occur only during low river flows (less than 6,000 cfs measured at Clyo, GA). The impact analysis concluded that the impacts to chloride concentration in Abercorn Creek from a harbor deepening would not be significant. Both an independent technical reviewer and the City of Savannah expressed concern during their review of the impact prediction tool and the analysis. The predicted impacts were reported in the November 2010 Draft GRR and EIS documents.

In response to the City's concerns, the Corps decided to collect additional data which could be used to refine the predictive model. The Corps consulted with the City of Savannah to develop a scope of work for collection of additional chloride data that it could use to refine its tool to predict chloride levels with a harbor deepening. USGS and GPA participated in development of the scope of work. Data collection was performed from early 2009 through summer 2010. In addition to chloride data, velocity measurements and flow data were collected at Three Mouths, which is the confluence of Abercorn, Bear, and Little Collis Creeks, to better calibrate the flow split in the hydrodynamic model at that location. The Corps used this new data, the City's original chloride data, and subsequent daily chloride measurements collected by the City of Savannah, to refine the modeling methodology.

The revised modeling methodology, development and calibration, is described in the report titled *Chloride Modeling Savannah Harbor Expansion Project Savannah, Georgia* dated December 31, 2010, and is included in the GRR Engineering Appendix Supplemental Materials. A Corps Agency Technical Review (ATR) was performed on the updated model methodology and the report by a USACE South Atlantic Division Regional Technical Expert for Water Resources Engineering and ERDC staff. An Independent External Peer Review (IEPR) was conducted by Battelle, Inc. Comments from these rigorous reviews were incorporated into the modeling and analysis for SHEP impacts determination.

The updated impact analysis indicates that the proposed harbor deepening would increase chloride levels at the City's water intake under drought conditions during high tide. Under those conditions, maximum daily average chloride levels are predicted to be 62 mg/l with a maximum hourly chloride level projected as185 mg/l for the 47-foot project. However, the long-term average chloride level is only predicted to increase from 11 to 13 mg/l. The predicted chloride concentrations with harbor deepening do not approach the drinking water standard (250 mg/l), even under the worst-case drought conditions (drought-of-record).

Analyses were also conducted to assess the potential corrosion impacts of increased chloride concentrations. Corrosion of steel water distribution pipes could result in increased life-cycle costs for the pipe distribution networks and corrosion of lead and copper could cause unsafe levels of copper and lead ions in the water. In their February 2011comment letter to the Corps, the City estimated a 12% decrease in life expectancy of pipelines corresponded to an increased replacement cost of $22 million. The City owns and maintains about 750 miles of water distribution pipeline, 60% of which is steel.

Consequently, an investigation and analysis of water system chloride concerns was conducted. That report, completed April 29, 2011 is titled *Assessment of Chloride Impact from Savannah Harbor Deepening* and is included in the Engineering Supplemental Materials. The conclusion of the analysis was that copper and lead corrosion were likely not an issue and that steel corrosion could be controlled by raising the pH of the treated water supplied to the distribution system. The study also recognized that increasing pH to reduce corrosivity could result in the formation of disinfection byproducts (DBPs), such as trihalomethanes and bromates, which are suspected carcinogens and regulated by the National Primary Drinking Water Standards.

The Assessment of Chloride Impact from Savannah Harbor Deepening suggested additional laboratory analyses to confirm its conclusions. Consequently, more detailed laboratory analyses were performed at the water treatment plant to replicate the City's current water treatment process and evaluate the impact of increasing chlorides on the plant water and treatment process, including analysis of DBP formation. The report titled *City of Savannah Seawater Effects Study* dated December 2011 which is included in the GRR Engineering Appendix Supplemental Materials presented evidence that two significant impacts could be expected to drinking water quality from increased chlorides – increased lead concentrations and formation of disinfectant byproducts (DBPs).

Based on laboratory analyses, lead concentrations in the water samples were shown to increase 2-4 times compared to existing conditions as chloride concentrations increased from 10 mg/l to 50 mg/l. Although additional investigations would be required to assess lead concentrations for the end user, the ideal concentration of lead in drinking water is zero. Therefore, it is not acceptable to increase lead concentration in drinking water even though the regulatory threshold is not exceeded. Any increase in lead concentration is considered an increased health risk.

The City of Savannah uses free chlorine as a disinfectant against pathogens in their water treatment process, as do many water suppliers. However, free chlorine can react with dissolved natural organic matter present in the water to form byproducts. These disinfection byproducts (DBPs) are regulated under the Disinfectants and Disinfection Byproducts Rule (D/DBPR). The D/DBPR is a Federal regulation that limits the concentration of DBPs that water suppliers can allow in public drinking water. Potential cancer, reproductive and developmental health risks can result from exposure to DBPs.

The lab analysis presented in *City of Savannah Seawater Effects Study* showed that DBPs are affected by increasing chlorides in two ways:

- Increasing chloride concentrations due to SHEP causes an increase in chlorine required to treat the water. The additional disinfectant required to achieve treatment goals causes the formation of additional byproducts; and
- As chlorides are pushed further upstream with harbor deepening, bromides, which are another component of seawater, are pushed further upstream as well. Brominated compounds can react with chlorine to form bromine-containing DBPs. The rate of DBP formation is also affected by the presence of bromide in the source water.

Both of these conditions are expected to occur under SHEP, with some DBPs projected to increase above the permitted level when chlorides exceed about 60 mg/l.

9.6.2 Mitigation for Impacts at City of Savannah's Water Treatment Plant

Several chloride mitigation options were identified early in the study process, in the event that mitigation for increased chloride concentrations due to harbor deepening would be warranted. These potential chloride mitigation options include:

- Increased flows at Bear Creek (tributary to Abercorn Creek);
- Increased groundwater withdrawals;
- Increased releases from Thurmond Dam;
- Desalination and other water treatment options;

- Construction of a supplemental water intake farther upstream; and
- Storage impoundment construction.

Mitigation for chloride impacts will be accomplished through construction and operation of a storage impoundment, which will provide raw water to the City of Savannah treatment plant during periods of high chloride spikes (low flow in the Savannah River accompanied by high tides). The storage impoundment will be located on GPA property at the Savannah International Trade Park (Figure 9-3). Operation and maintenance activities associates with this mitigation feature would be the responsibility of the City of Savannah.
Based on extensive updated modeling efforts to predict chloride increases by frequency, concentration, and duration, along with multi-variable bench-scale laboratory analysis on-site at the City's water treatment plant, the best solution to mitigate for chloride impacts due to harbor deepening is to remove the influence of the increased seawater intrusion. This can be accomplished most cost-effectively by a storage impoundment, which would store acceptable raw water for use during periods of high chloride spikes, which occur during very low river flows and high tides. The Engineering Appendix discusses the alternatives considered and concludes that the raw water storage alternative (including the proposed design capacity) is the more cost-effective option to mitigate against both increasing lead corrosion and increasing DBP formation that is expected to occur with higher chloride concentrations. For more detail, the CDM report entitled "Savannah Seawater Effects Study", included in the Engineering Supplemental Materials, contains a description of the alternatives considered and their implementation costs.

The Corps identified 6 potential locations between the City's water intake and its treatment plant for siting a raw water storage impoundment. The District provided its initial assessment of the locations to the City for comment and inspected each site. As a result of those assessments, the Corps eliminated 4 of the sites (see Section 5.02.15 of the EIS, which discusses the site alternatives in detail). The City of Savannah expressed concerns about the future availability of specific tracts in this rapidly-developing portion of the County. In response, the Corps identified Parcel 3 of the Savannah International Trade Park, located near Mulberry Grove, which is already owned by the Georgia Ports Authority (Figure 9-3). Selection of that parcel would ensure the site is available when needed.

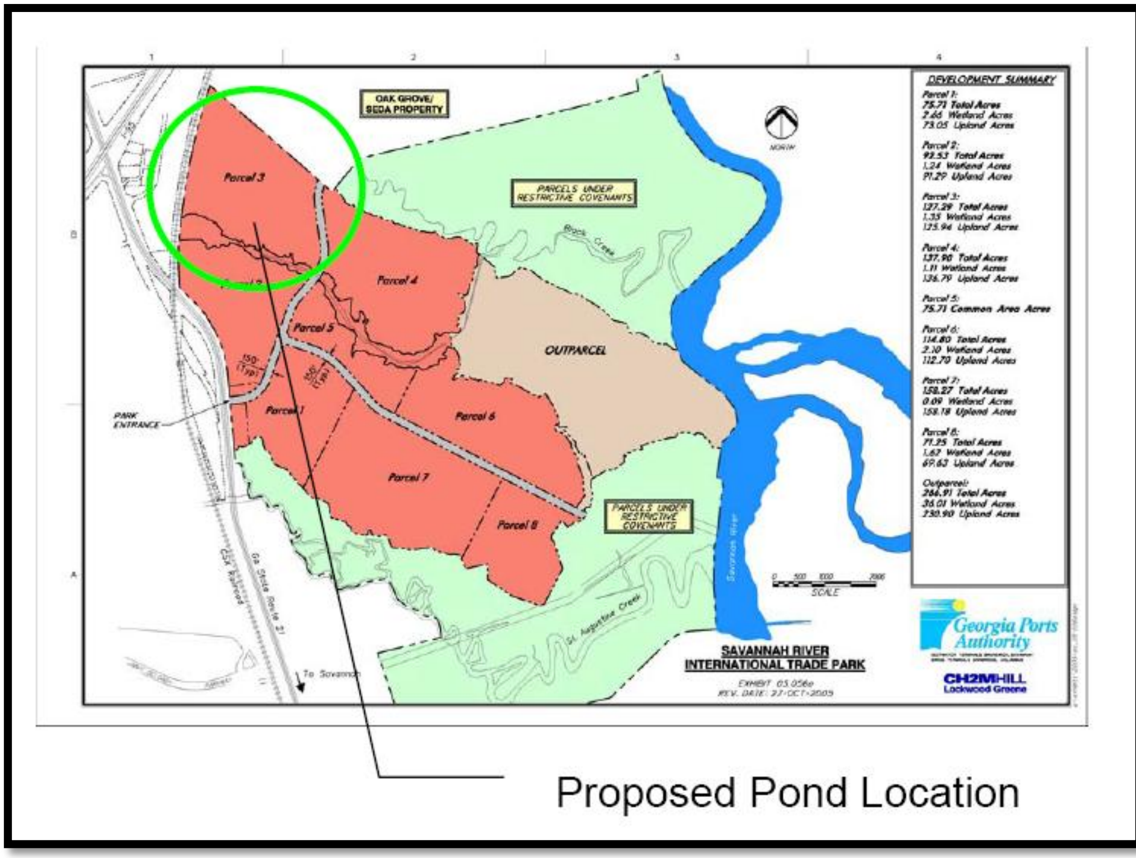

Figure 9-3: Proposed Impoundment Location

Design considerations for the raw water storage impoundment include:

- The GA DNR-EPD, in their Section 401 Water Quality Certification for Savannah Harbor Expansion, stated that any mitigation remedy selected shall be based on the maximum plant capacity of 62.5 mgd. They also stated that any mitigation remedy shall be constructed in conjunction with the channel deepening;
- A firm raw water pumping capacity of 75 mgd at the existing Abercorn Creek intake. Design constraints based on firm pumping capacity as opposed to the actual pumping capacity of 100 mgd is standard engineering practice and is required by the GA DNR-EPDs *Minimum Standards for Public Water Systems* published in May of 2000;
- 20% of the storage volume will be unusable due to access limitations and sedimentation;
- A performance goal of limiting the chloride concentration at the treatment plant to 40 mg/l during the model predicted worst-case scenario and to 25 mg/l 99 percent of the time.

A series of statistical analyses were used to determine the appropriate size for a raw water impoundment for use at the City's drinking water supply plant for all project depths under these design considerations noted previously. The impoundment required would range from 28.0 million gallons (total impoundment volume) for a project depth of 44 feet, 38.0 million gallons for the 45-foot project, 58.0 million gallons for the 46-foot project, 97.0 million gallons for the 47-foot project to 150 million gallons for the 48-foot project.

Details of the design can be found in the report titled *City of Savannah Seawater Effects Study* included in the GRR Engineering Appendix Supplemental Materials. Important aspects of the design include:

- Dual 36" influent and effluent pipes to connect the impoundment to the existing raw water pipeline (to provide redundancy at the tie-in points and allow for maintenance to occur during times when the impoundment is in use);
- A pump station containing four vertical turbine pumps to convey flow out of the impoundment and back into the raw water lines;
- A mechanical mixer in the center of the impoundment to help maintain oxygen levels throughout the impoundment's depth, reducing the likelihood of algae growth and the associated taste and odor issues;
- A powdered activated carbon silo and feed system to be used on an intermittent basis during severe taste and odor episodes;
- A 24" drain pipe to be used to empty the impoundment during periodic maintenance cleaning; and,
- One or more in-situ chloride meters to be installed in Abercorn Creek to provide data for operational decision making.

Model predictions indicate that high chloride levels will occur diurnally, coincident with high tide. An early warning system on Abercorn Creek would be required to provide data to the operator in a timely manner to know when valve and pump changes are needed.

Operation of the impoundment consists of pumping raw water from the existing Abercorn Creek intake to the storage impoundment during occurrences of low chlorides. The raw water would then be pumped from the storage impoundment to the City's water treatment plant. During occurrences of high chloride levels in Abercorn Creek, pumping from Abercorn Creek would cease, avoiding the high chloride levels in the creek. Water from the impoundment would continue to be pumped to the City's existing water treatment plant to meet the industrial and municipal demands. When chloride concentrations on Abercorn Creek return to acceptable levels during low tide, pumping from the creek would resume and the storage impoundment would be refilled and be available for use during the next high tide.

Based on the drought-of-record flow conditions experienced in November 2008, that worst-case event would have required use of the storage impoundment for 14 consecutive days. The total impoundment storage volume represents only about 32 hours of water usage at plant capacity. However, the chloride content of Abercorn

Creek will rise and fall with each tidal cycle; so the impoundment would be partially refilled during low tide twice each day. The impoundment was designed such that the minimum volume needed to limit the maximum concentration to 40 mg/l and the 99^{th} percentile concentration to 25 mg/l at the City's water treatment plant (see Engineering Appendix Section 7.7.11, which contains a discussion regarding determination of optimum impoundment capacity).

Although it would be located on high ground in an existing industrial park, construction of the storage impoundment (including its pumping station and inflow and outflow pipes) may result in minor adverse impacts to wetlands. Savannah District will conduct detailed surveys during the final design and follow the interagency-approved Savannah District Regulatory SOP to quantify the extent of any mitigation that may be needed. The Corps would coordinate the results of the SOP calculations with GA and the Federal natural resource agencies.

9.7 Secondary Impacts

It is important to note that the total cargo handled at Garden City Terminal is not projected to change due to implementation of the SHEP. Therefore, secondary impacts associated with additional cargo traffic are not anticipated. The project will allow vessels that use the channel to sail more deeply and more efficiently. This will be especially important as the larger Post-Panamax vessels replace older, smaller vessels. Fewer vessel calls would be required to deliver the same total volume of cargo. These vessels are projected to be loaded with cargo for Savannah as well as other ports, as is currently the case.

The number of TEUs handled at the GCT is expected to increase in the without project condition until the facility reaches its capacity of 6.5 million TEUs around 2020. Improvements at the Garden City Terminal, improvements of highway infrastructure, construction of distribution centers, etc. are expected to continue in the without project condition to support the growth of the terminal. These secondary impacts will occur with or without construction of the SHEP.

9.8 Cumulative Impacts

The environmental impacts from deepening the harbor were examined on a cumulative basis. Significant resources which could be affected by a harbor deepening were examined. The District considered the effects of past, present, and expected future impacts to those resources. That allowed the impacts from the proposed harbor deepening to be placed in a proper context, so that one can better identify the significance of the effects predicted by the proposed action.

Tidal freshwater wetlands were identified as being significant in the harbor. They have experienced substantial declines in acreage over the years as a result of many factors, including human development of the lowlands surrounding the river. Dissolved oxygen levels in the harbor are at a critical threshold. This parameter is being strictly managed by the Federal and State natural resource agencies to ensure the harbor's waters can provide its desired uses. The drinking water aquifer is a resource of major concern. Substantial impacts to that resource would have major economic and possibly environmental effects. Erosion of Tybee Island, located adjacent to and down-drift from the entrance channel, is a concern. Fishery resources in the harbor are a concern. The harbor contains numerous species that are managed on both the Federal and State level. Endangered species which reside in or use the harbor are a concern. The cumulative impact analysis for the SHEP is found in Appendix L in the EIS.

Savannah District believes the proposed harbor deepening could be accomplished in an environmentally-acceptable manner. The proposed alternatives contain mitigation plans for all significant adverse impacts.

10 Alternative Plan Evaluation: Costs

This chapter presents the detailed alternative plan evaluation that was conducted to identify the NED plan. The detailed alternative plan evaluation was prepared in accordance with Corps' guidance on formulation and evaluation of deep draft navigation projects as described in:

- The Planning Guidance Notebook, ER 1105-2-100 (22 April 2000);
- National Economic Development Procedures Manual: Deep Draft Navigation, IWR Report 10-R-4 (November 1991);
- Digest of Water Resource Policy and Authorities, EP 1165-2-1 (30 July 1999);
- Policy for Implementation and Integrated Application of the USACE Environmental Operating Principles and Doctrine, ER 200-1-5 (30 October 2003);
- Engineering and Design for Civil Works Projects, ER 1110-2-1150 (31 August 1999); and
- Planning in a Collaborative Environment, EC 1105-2-409 (31 May 2005).

10.1 Identification of Alternative Plan Elements

Each of the alternative plans carried forward for detailed analysis includes shared elements, which are integral to the project design, and incremental elements which constitute the differences between the alternatives. The shared elements are included in each of the alternative plans. Shared plan elements include:

- Preparation and restoration of DMCA 14A & 14B so that these disposal areas can be used to isolate cadmium-laden sediments. Preparation and restoration activities include clearing, grubbing, dike improvements, drainage modifications, geotextile placement in support of dike improvements, and habitat restoration;