12 Uncertainty Considerations

Uncertainties are evaluated for economic benefits, costs, environmental impacts, mitigation effects, and sea-level change.

12.1 Economic Analysis Uncertainty

12.1.1 Jasper County Terminal Sensitivity Analysis

In this analysis of navigation improvements to Savannah Harbor, a proposed future Jasper County Terminal is not included as a without or with-project condition due to the high level of uncertainty concerning the proposed terminal (Section 5.2 US East Coast and Gulf Coast Port Configurations and Capacities). Nonetheless, a series of sensitivity analyses were conducted to identify the potential impact that a Jasper County terminal might have on the justification and recommendation of a proposed channel deepening to the Garden City Terminal.

Terminal Development Uncertainty

The JPO has estimated that Phase I of the terminal would become operational by 2025, with 3 berths, having a total capacity of 500,000 TEUs, turning basin, utility, road and rail access and supporting infrastructure on 1,500 acres in Jasper County, SC. Additional phases would be brought on line as needed to meet market demands. The terminal would eventually have 10 berths and a capacity of 7M TEUs. The estimated cost of the terminal and connecting land transportation corridors would be around $4B. However, there is a high degree of uncertainty regarding the development of a container terminal in Jasper County. There is some doubt about whether a terminal will be constructed, and if it is constructed, the timing of construction, the exact location where the terminal might be built and how it would operate. Although a draft Intergovernmental Agreement has been published and the states are continuing to work in a collaborative manner, numerous uncertainties still exist regarding the development of a new terminal at Jasper County. A terminal design has not been developed nor have permits been obtained or even sought for construction. Other unknowns include the terminal development costs, the number of ship berths that would be available, the amount of storage capacity, accessibility for rail and truck, and ultimate throughput capacity. In addition, impacts to Corps operations and maintenance of the existing Federal Savannah River channel are not known, nor are the impacts to the existing Dredged Material Management Plan for the harbor and the required environmental uses of these disposal areas. The areas serve not only as dredged material disposal sites but also as habitat for critical avian species.

In such situations of great uncertainty, Federal regulations at 40 C.F.R. 1502.22 call for an evaluation based what might be considered “reasonably foreseeable significant adverse environmental impacts.” Because of the uncertainty surrounding virtually all aspects of a potential Jasper terminal, an evaluation at the reconnaissance level was conducted, including quantitative evaluations in some areas and qualitative descriptions in others.

Scenario Evaluations

In order to properly address uncertainties related to a potential Jasper County terminal development, a set of three scenarios was evaluated. A range of options was included under each scenario. The purpose of these scenarios is to provide decision makers with a sense for the range of possible impacts, economic and environmental, on a determination of the feasibility of deepening the channel to Garden City if a Jasper County terminal is developed. Scenario One assumes that no terminal will be constructed at Jasper County during the period of analysis. This is the base case for the Savannah Harbor Expansion Project study and is considered the "most likely" future without project condition. Scenarios Two and Three are incremental evaluations intended to determine if construction of the channel segment between a proposed Jasper terminal and the existing Garden City Terminal is economically justified under the assumption that the terminal is constructed in Jasper County.

Scenario Two presents a "reasonable high impact" scenario. This scenario identifies the maximum potential impact to the Savannah Harbor Expansion Project that could reasonably be expected as a result of a proposed Jasper terminal development. This scenario assumes that a large 6.5 million TEU container facility would be constructed on DMCA 12A & 12B, the most upstream terminal development site under consideration.

Scenario Three is a "mid-range" scenario that will enable decision-makers to put into context the level of risk and uncertainty in the decision-making process. Scenario Three represents the District's best guess regarding potential impacts if a terminal were to develop at Jasper County. This scenario assumes a 2.6 million TEU facility would be constructed on DMCA 14A & 14B, which is located downstream from DMCA 12A & 12B site.

The location and capacity assumptions adopted for these scenarios are based on information contained in a preliminary siting report prepared for the Georgia and South Carolina Port Authorities in July 2007 and in "An Update on the Jasper Ocean Terminal", March 11, 2011 also prepared for the Georgia and South Carolina Ports Authorities, which is the most current information available at the time of this writing.

The updated Jasper Ocean Terminal Report estimates that there will be an eight year permitting process from 2012 to the end of 2019 followed by two years of final design, 2020 through 2022 and three years to construct. The earliest project on-line date would be early 2026 according to the Update on the Ocean Terminal. These scenarios assume that SHEP channel deepening project would be completed in 2017 and Garden City is expected to reach its capacity of 6.5 million TEU's in 2030, four years after the projected on-line date of Jasper's Ocean Terminal. Under these scenarios, no economic benefits accrue until the channel is completed. Construction costs that occur in the future are discounted to the beginning of the period of analysis to insure consistent comparisons of the scenarios.

The extent to which estimated channel deepening benefits may be allocated between the Garden City and Jasper County terminals is also unknown. For the purposes of this analysis three benefit allocations will be analyzed:

- 25% to Jasper County and 75% to Garden City;
- 50% to Jasper County and 50% to Garden City; and
- 75% to Jasper County and 25% to Garden City.

The same 50-year period of analysis, beginning in the year 2017 and ending in the year 2066, is used for all the scenarios. The current Federal discount rate of 4-1/8% is used. The analysis is based on the construction of the 47' deep channel. Note: Benefits are updated to 2012 values in Section 14, Selected Plan.

Cost Estimate

Cost estimates have been provided for each scenario described above. It is assumed that the non-Federal sponsor (GaDOT) will be responsible for making the Federal Government whole with regard to any negative impacts that development of a proposed Jasper County Terminal would have on the Corps ability to dispose of dredged material. It is recognized that there is uncertainty regarding the details associated with this assumption. Changes in construction, operation and maintenance costs may occur due to the construction of a proposed Jasper County Terminal. However, because of the extremely high level of uncertainty regarding future disposal locations, it is only possible to provide costs at a rough order of magnitude (ROM) level of detail. For this analysis, the financial costs of construction are adjusted to reflect economic costs, which include interest during construction, assuming a three-year construction period.

Environmental effects do not occur linearly in the Savannah River estuary. Different resources would be impacted to varying degrees depending on the location of the proposed terminal. Valuable environmental resources that could be impacted under one scenario may not be impacted at all in another scenario. Mitigation costs for the scenarios are based on a proportion of the total mitigation costs estimated for the deepening from the ocean to the Garden City Terminal.

The site proposed in Scenario Two (Site 12A/12B) is mutually exclusive with components of the harbor deepening alternatives that are being considered. The new terminal would be located adjacent to the Sediment Basin, which would be filled as one of the mitigation features proposed for deepening up to the Garden City Terminal. These two actions could not occur as presently envisioned. In this scenario, a Jasper County terminal would be constructed prior to deepening from this location up to the Garden City Terminal. With that approach, the mitigation plan for deepening to the Garden City Terminal would need to be modified. The extent of those changes would require substantial hydrodynamic modeling and are beyond the scope of this reconnaissance-level evaluation.

Mitigation costs for this scenario are based on a proportion of the total mitigation believed to be necessary to deepen from the ocean to the Garden City Terminal. For this scenario, those proportions are as follows, with these mitigation requirements being for the reach of the harbor between a Jasper County Terminal and the Garden City Terminal:

Dissolved Oxygen	60 %
Wetlands (salinity intrusion)	25 %
Shortnose sturgeon	80 %
Striped bass	50 %
Chlorides	100 %

The site proposed in Scenario Three (Site 14A/14B) is further downstream than the site in Scenario Two, so fewer impacts would be expected to the freshwater portions of the estuary. Mitigation costs for this scenario are based on a proportion of the total mitigation believed to be necessary to deepen from the ocean to the Garden City Terminal. For this scenario, those proportions are as follows, with these mitigation requirements being for the reach of the harbor between a Jasper County Terminal and the Garden City Terminal:

Dissolved Oxygen	100 %
Wetlands (salinity intrusion)	100 %
Shortnose sturgeon	100 %
Striped bass	100 %
Chlorides	100 %

Environmental impacts for both scenarios do not include impacts which would result from construction of a new container terminal in Jasper County, improvements to the transportation system that would be required to serve the new terminal, or actions required to make the Federal Government whole to release the dredged sediment disposal easement on the property that would allow the site to be used for a terminal. Those impacts could be substantial, but they are outside the scope of this evaluation.

Economic Analysis

It is anticipated that the greatest impact of the proposed terminal on economic benefits will be related to the increased throughput capacity that it provides to the region. This impact would be felt primarily during the later years of the period of analysis when commodity shipments are expected to increase to the point where the region could usefully employ additional terminal capacity.

It is anticipated that a proposed Jasper County Terminal will have relatively minor impacts on water and landside transportation costs, and that the landside transportation cost of shipping a container through a Jasper County Terminal may be somewhat higher than the landside transportation cost associated with shipping a container through Garden City Terminal. It is not known if the development of a proposed Jasper County Terminal will affect forecasted commodity growth or the vessel/fleet mix, except to the extent that the additional capacity afforded by the terminal will provide opportunities to ship additional goods later in the period of analysis. For this "reasonable high impact" scenario, it is assumed that the majority of the commerce moving through the Jasper County Terminal will be transferred from commerce that would otherwise have moved through the Garden City Terminal and there will be no additional increase in the commodity forecast or the vessel/fleet mix. Detailed incremental analysis of tidal delays and meeting areas that would normally be done for a feasibility level evaluation has not been conducted for these reconnaissance level evaluations.

Scenario Results

Under all scenarios, construction of the channel increment from a proposed Jasper County terminal to the Garden City terminal is well justified. The large terminal located at Site 12A/12B actually would have less impact on incremental justification than the moderately sized terminal located at Site 14A/14B, because the channel increment between Site 12A/12B and Garden City is 2.84 miles shorter and the incremental costs, including mitigation costs, to go from Site 12A/12B to Garden City are much less than the costs to go from Site 14A/14B to Garden City. Timing of construction will have little impact to justification because Garden City is forecast to reach its 6.5M TEU capacity in 2030, four years after the projected construction of Jasper Ocean Terminal. As expected, the larger the distribution of benefits to Garden City, the greater is the economic justification for construction of the channel increment. Overall, justification of the channel increment between a Jasper County terminal and the Garden City terminal is not particularly sensitive to development of a terminal at Jasper County.

Tables 12-1 and 12-2 provide the results of the economic sensitivity analyses.

Table 12-1: Jasper County Terminal Sensitivity Analysis - 1

Incremental Analysis
Scenario Two - Reasonable High Impact
Assumes Development of Site 12A/12B, 6.5 Million TEU Capacity

Scenario Two Detail Description	Average Annual Incremental Benefits	Average Annual Incremental Costs	B/C Ratio
Jasper Co. 2026, 75% Benefits to Garden City	$111,510,000	$11,698,000	9.53 -to-1
Jasper Co. 2026, 50% Benefits to Garden City	$74,340,000	$11,698,000	6.35 -to-1
Jasper Co. 2026, 25% Benefits to Garden City	$37,170,000	$11,698,000	3.18 -to-1

Table 12-2: Jasper County Terminal Sensitivity Analysis - 2

Incremental Analysis Scenario Three - Mid Range Impact Assumes Development of Site 14 A/14B, 2.6 Million TEU Capacity			
Scenario Three Detail Description	**Average Annual Incremental Benefits**	**Average Annual Incremental Costs**	**B/C Ratio**
Jasper Co. 2026, 75% Benefits to Garden City	$86,236,000	$19,658,000	4.39 -to-1
Jasper Co. 2026, 50% Benefits to Garden City	$57,491,000	$19,658,000	2.92 -to-1
Jasper Co. 2026, 25% Benefits to Garden City	$29,694,000	$19,658,000	1.51 -to-1

12.1.2 Alternative Sensitivity Analyses

Seventeen sensitivity analyses were conducted for the transportation cost savings model (Table 12-3). These sensitivity analyses are grouped as: sensitivities to the commodity forecasts, sensitivities to vessel availability and loadings, and other sensitivities. The following is a listing of the sensitivity analyses:

<u>Sensitivities to Commodity Forecasts</u>

1. Increase annual commodity growth by 1%
2. Increase annual commodity growth by 3%
3. Decrease annual commodity growth by 1%
4. Decrease annual commodity growth by 3%
5. No growth in commodity forecast

<u>Sensitivities to Vessel Availability and Loadings</u>

6. Historical Sub-Panamax share of Capacity Calling
7. Reduce future Sub-Panamax share of Capacity Calling
8. Increase amount of Savannah Cargo carried on Post-Panamax Vessels
9. Full deployment of Post-Panamax Vessels in Without (42 ft) Project Condition
10. Reduce Post-Panamax Vessel Calls by 25%
11. Deployment of Post-Panamax Vessels by Unit Costs
12. Increase Post-Panamax Vessel Loading beyond Maximum Practicable Capacity

13. Reduce PPX 1 Replacement of PPX2 Vessels, Use historical Sub-Panamax share of capacity calling, and Deploy PPX Vessels by unit costs

Other Sensitivities

14. Increase Cargo density
15. Increase Savannah Share of Trade Route Cargo by 25%
16. Decrease Savannah Share of Trade Route Cargo by 25%
17. Draft Report Values – for comparison purposes

All sensitivity analyses result in positive benefits, including Sensitivity 5 (no growth in tonnage and TEUs imported and exported at Savannah). Benefits are maximized at a channel depth of 47 feet for all but Sensitivity 12, which shows maximum benefits at -48 feet. Sensitivity 12 demonstrates that there are two factors which could lead to maximization of benefits for most all sensitivities at 48 feet: (1) a reaction by carriers to take advantage of the larger tide window afforded by the 48-foot alternative by carrying more overall cargo when calling at Savannah, and/or (2) larger PPX2 vessels than the 47.6 feet design draft vessel used in this analysis. Another conjecture can be made regarding what factors and circumstances which could result in plan optimization at channel depths less than -47 feet. Such circumstances could include fewer PPX2 vessels deployed on the heavier cargo trade routes (RTW, ECUS MED, ECUS EU GULF PEN, FE SUEZ ECUS, and FE ECUS MED) which could lead to optimization at 46-foot channel depth. Additionally, in conducting these sensitivity analyses, one can conjecture that port rotation matters. When Savannah is a first or early port of call on the East Coast United States leg, vessels generally arrive with lighter cargo, thus sailing at shallower drafts (i.e., imports tend to be lighter than exports). Conversely, when Savannah is the last or near the end of the ECUS portion of their itinerary, they tend to carry proportionally more of the heavier export cargo and thus tend to sail deeper and make greater use of available channel depths.

In summary, the overall results of the sensitivity analyses confirm that improvements to Savannah Harbor are economically beneficial. The results of these sensitivity analyses also provide insight as to what conditions and circumstances would have to occur to change project benefits.

Table 12-3: Transportation Cost Model Sensitivity Analyses AAEQ Cost Savings

	-44 feet	-45 feet	-46 feet	-47 feet	-48 feet
Baseline					
Total Savings	$ 98,210,000	$133,150,000	$150,370,000	$155,040,000	$155,040,000
Incremental Savings	$ 98,210,000	$34,940,000	$ 17,220,000	$ 4,680,000	$0
Sensitivity 1					
Total Savings	$117,060,000	$158,490,000	$178,290,000	$184,340,000	$184,340,000
Incremental Savings	$117,060,000	$41,430,000	$19,800,000	$6,050,000	$0
Sensitivity 2					
Total Savings	$164,090,000	$222,280,000	$250,090,000	$258,560,000	$258,560,000
Incremental Savings	$164,090,000	$58,190,000	$27,800,000	$8,480,000	$0
Sensitivity 3					
Total Savings	$ 93,580,000	$126,390,000	$142,290,000	$147,470,000	$147,470,000
Incremental Savings	$93,580,000	$32,810,000	$15,900,000	$5,180,000	$0
Sensitivity 4					
Total Savings	$62,860,000	$84,840,000	$95,500,000	$98,970,000	$98,970,000
Incremental Savings	$62,860,000	$21,990,000	$10,660,000	$3,470,000	$0
Sensitivity 5					
Total Savings	$37,430,000	$50,640,000	$57,060,000	$59,250,000	$59,250,000
Incremental Savings	$37,430,000	$13,200,000	$6,430,000	$2,190,000	$0
Sensitivity 6					
Total Savings	$100,000,000	$135,410,000	$152,730,000	$157,200,000	$157,200,000
Incremental Savings	$100,000,000	$35,410,000	$17,310,000	$4,470,000	$0
Sensitivity 7					
Total Savings	$96,580,000	$131,090,000	$148,230,000	$153,090,000	$153,090,000
Incremental Savings	$96,580,000	$34,510,000	$17,140,000	$4,870,000	$0
Sensitivity 8					
Total Savings	$102,980,000	$135,000,000	$151,160,000	$155,440,000	$155,440,000
Incremental Savings	$102,980,000	$32,020,000	$16,160,000	$4,280,000	$0
Sensitivity 9					
Total Savings	$105,920,000	$140,860,000	$158,080,000	$162,760,000	$162,760,000
Incremental Savings	$105,920,000	$34,940,000	$17,220,000	$ 4,680,000	$0
Sensitivity 10					
Total Savings	$81,300,000	$112,960,000	$130,020,000	$135,050,000	$135,050,000
Incremental Savings	$81,300,000	$31,660,000	$17,060,000	$5,020,000	$0
Sensitivity 11					
Total Savings	$95,470,000	$128,170,000	$144,850,000	$149,530,000	$149,530,000
Incremental Savings	$95,470,000	$32,700,000	$16,680,000	$4,680,000	$0
Sensitivity 12					
Total Savings	$98,210,000	$143,480,000	$172,010,000	$183,080,000	$187,420,000
Incremental Savings	$98,210,000	$45,280,000	$28,530,000	$11,070,000	$4,340,000
Sensitivity 13					
Total Savings	$132,630,000	$175,480,000	$193,050,000	$198,370,000	$198,370,000
Incremental Savings	$132,630,000	$42,850,000	$17,570,000	$5,320,000	$0
Sensitivity 14					
Total Savings	$99,750,000	$149,630,000	$185,090,000	$212,620,000	$212,620,000

Table 12-3: Transportation Cost Model Sensitivity Analyses AAEQ Cost Savings

	-44 feet	-45 feet	-46 feet	-47 feet	-48 feet
Baseline					
Total Savings	$ 98,210,000	$133,150,000	$150,370,000	$155,040,000	$155,040,000
Incremental Savings	$ 98,210,000	$34,940,000	$ 17,220,000	$ 4,680,000	$0
Incremental Savings	$99,750,000	$49,880,000	$35,460,000	$27,520,000	$0
Sensitivity 15					
Total Savings	$122,760,000	$166,430,000	$187,960,000	$193,810,000	$193,810,000
Incremental Savings	$122,760,000	$43,670,000	$21,530,000	$5,850,000	$0
Sensitivity 16					
Total Savings	$73,660,000	$99,860,000	$112,770,000	$116,280,000	$116,280,000
Incremental Savings	$73,660,000	$26,200,000	$12,920,000	$3,510,000	$0
Sensitivity 17					
Total Savings	$93,010,000	$122,350,000	$134,930,000	$139,150,000	$139,150,000
Incremental Savings	$93,010,000	$29,340,000	$12,580,000	$4,220,000	$0

Cargo Forecast Sensitivity

Sensitivity 1: One-Percent Increase In Annual Commodity Growth Rate

When adjusting the commodity growth rate upwards by 1 percent, the project benefits increase by approximately 19 percent. However, this increase in benefits would also require that the Garden City Terminal's capacity increase from 6.5 million TEUs in 2030 to 7.8 million TEUs, a condition which the Corps believes could not occur.

Sensitivity 2: Three-Percent Increase In Annual Commodity Growth Rate

When adjusting the commodity growth rate upwards by 3 percent, project benefits increase by 67 percent. However, this increase in benefits would also require that the Garden City Terminal's capacity increase from 6.5 million TEUs in 2030 to 11.4 million TEUs, a condition which the Corps believes could not occur.

Sensitivity 3: One-Percent Decrease In Annual Commodity Growth Rate

A decrease in the commodity growth rate by 1 percent reduces project benefits by 5 percent. However, the port's TEU capacity of 6.5 million TEUs is not achieved until 2037, but benefits are only computed through 2035, indicating that there are some additional benefits, which have not been quantified.

Sensitivity 4: Three-Percent Decrease In Annual Commodity Growth Rate

The model adjusted by decreasing the commodity growth rate by 3 percent per year with the minimum annual growth limited to zero growth. A negative growth rate is not used in this sensitivity analysis. A decrease in the commodity growth rate by 3 percent reduces project benefits by 36 percent. However, the port's TEU capacity of 6.5 million TEUs is not achieved until well beyond 2035, but benefits are only computed through 2035, indicating that there are some additional benefits, which have not been quantified.

Sensitivity 5: No Growth In The Commodity Forecast

In the no-growth sensitivity analysis commodity tonnage is held at baseline year-2010 values throughout the 50-year study period. The no-growth assumption reduces project benefits by 62 percent.

Vessel Availability and Loading

Sensitivity 6: Maintenance of Historical Sub-Panamax Share of Cargo

The baseline transportation cost savings analysis assumes a 33% drop in the Sub-Panamax share for cargo from the historical amount. Under the assumption of a historical Sub-Panamax share, the project benefits increase slightly because of a less efficient without project condition. Vessel calls by Sub-Panamax vessels increase under this sensitivity analysis and vessel calls by Panamax vessels are lower than that of the baseline condition.

Sensitivity 7: Reduction in Future Sub-Panamax Share of Cargo

The baseline transportation cost savings analysis assumes a 33% drop in the Sub-Panamax share for cargo from the historical amount. Under this sensitivity analysis, there is a 65% reduction in the Sub-Panamax share for cargo from the historical amount. Project benefits decrease slightly (2%) under this scenario because the analysis assumes that some Post-Panamax vessels will shift to less benefitting routes.

Sensitivity 8: Five-Percent Increase in Savannah Post-Panamax Vessel Capacity

The baseline analysis assumes that the future share of Savannah cargo carried on Post-Panamax vessels would comprise the same percent of the estimated maximum practicable capacity as observed in the 2005/07 data for Panamax and Post-Panamax vessels. This sensitivity analysis reflects the potential that carriers may reduce the number of ports on a rotation. This sensitivity analysis results in increases in annual benefits of about 5 and 1 percent respectively for channel depths of -44 and -45 feet while no change in benefits for depths of 46 feet and greater.

Sensitivity 9: Full Deployment of Post-Panamax Vessels in the Without-Project Condition

The baseline condition assumed that 50 percent of the "unconstrained" PPX2 vessels would call in the without project (-42 foot) condition. This sensitivity analysis assumes that essentially the same number of PPX 2 vessels would call Savannah Harbor in a -42 foot channel as would call in a -47- or -48-foot channel, but carry less cargo due to the channel constraints. Average annual benefits are about 5 to 8 percent higher than the baseline. Benefits generally increase under this sensitivity analysis because of the inefficient use of Post-Panamax vessels in the without-project condition.

<u>Sensitivity 10: Twenty-five Percent reduction in Post Panamax Vessel Calls</u>
Under a 25% reduction in the number of Post Panamax calls, benefits are significantly lower than the baseline condition, given the reduced pool of Post Panamax vessels to provide gains in efficiency. Average annual benefits would be about 13 to 17 percent lower than the baseline.

<u>Sensitivity 11: Deployment of Post-Panamax Vessels by Unit Costs</u>
This sensitivity analysis employs the same basic assumptions as were presented in a previous draft of the Economics Appendix and GRR (December 2010). The primary assumption for this sensitivity analysis is that PPX 2 vessels would deploy in accordance a strict unit cost comparison by trade route. Average annual benefits are about 3 to 4 percent lower than the baseline, and there is no change in incremental benefits between -46 and -47 feet.

<u>Sensitivity 12: Increase Post-Panamax Vessel Loading Beyond Baseline Maximum Practicable Loading Estimates</u>
This sensitivity analysis assumes that vessels would load more deeply, in response to a deeper channel, than estimated by the baseline maximum practicable loading analysis. The result is a shift of overall sailing draft distributions with deeper channels. Average annual benefits are the same at 44 feet but begin to increase substantially at -45 feet, when the effects of the increased loading assumption begin to take effect. The incremental benefit from -47 to -48 feet is more than $4 million in this sensitivity analysis. This sensitivity analysis also reflects, at least in a general sense, the effects on project benefits and channel depth optimization that would likely occur if vessels with drafts greater than -48 ft called on Savannah on a regular basis..

<u>Sensitivity 13: Reduce PPX1 Replacement of PPX2 Vessels, Use Historical Sub-Panamax Cargo Share, and Deploy Post-Panamax Vessels by Unit Costs</u>
This sensitivity analysis employs some basic assumptions that were used during development of the transportation cost savings model. First, it assumes the deployment by unit cost depths as presented in Sensitivity 11 and presented in the draft report. Secondly, it assumes the historic Sub-Panamax share of capacity calling as presented in Sensitivity 6. And finally, it assumes that when PPX2 vessels do not call on a particular route due to channel constrants, they will be replaced on a vessel for vessel basis rather than a capacity for capacity basis as included in the baseline condition. These were all assumptions used prior to refinements that have evolved throughout the SHEP study as more information became available. Annual benefits and vessel calls increase substantially over the baseline ranging from 28 to 35 percent greater.

<u>Other Sensitivity Analyses</u>
<u>Sensitivity 14: Increase Cargo Density</u>
This sensitivity analysis is based on the assumption that cargo density, i.e., tonnage per container, may increase in the future as shippers look for ways to cut costs by increasing packing efficiency. Under this sensitivity analysis the TEU forecast decreases slightly and the port's TEU capacity is not achieved until 2031, one year

after the baseline result. Average annual benefits increase from 2 to 37 percent with the greater increases occurring at greater depths.

<u>Sensitivity 15: Increase Savannah's Share of Trade Route Cargo by 25%</u>
The base line estimate of benefits used 2005 and 2007 vessel calls, Savannah cargo and empty containers, and sailing draft information combined with the Load Factor Analysis to estimate the amount of vessel capacity utilized when vessels called at Savannah Harbor. While a number of variables in the baseline analysis were updated from 2005/07 by incorporating information from 2008 and 2010, sailing drafts were not analyzed for these years, therefore newer estimates of total cargo carried has not been revised. The amount of Savannah cargo carried as a percent of total cargo carried could vary considerably. For this sensitivity analysis, it was assumed that the amount of Savannah cargo carried relative to total cargo is 25% greater than observed and calculated from the 2005 and 2007 estimates with the result that benefits are 25 percent greater than baseline.

<u>Sensitivity 16: Decrease Savannah's Share of Trade Route Cargo by 25%</u>
For this sensitivity analysis, the estimated amount of Savannah cargo relative to total cargo was decreased by 25%. The purpose of this analysis is the same as described in Sensitivity 15; Savannah's cargo share is a highly uncertain factor in the benefits analysis. This sensitivity analysis results in annual benefits and incremental benefits decreasing by 25 percent from the base line.

<u>Sensitivity 17: November 2010 Draft Report Values</u>
Sensitivity 17 is presented primarily for comparison purposes. The average annual benefits are 5 to 10 percent lower than the current baseline in this final report; however, there are offsetting assumptions, some of which increase benefits and others which decrease benefits. While the overall commodity forecast tonnage is lower in the this report than in the November 2010 Draft Report, the forecast number of TEUs is higher due to more empty containers and changes in cargo weights that resulted from incorporating 2008 – 2010 actual shipments at Savannah. Also, the new Post-Panamax vessel call forecast resulted in an increase in the number of PPX 2 vessels in the early years of the analysis period. Additionally, a 2017 base year is used in the final report baseline compared to a 2015 year base year in the draft report, resulting in higher early year benefits. The discount rate of 4.125 percent for FY 2011, as compared to the 4.375 percent discount rate used in the November 2010 Draft Report, likewise results in an upward adjustment of benefits. And finally, including deployment of PPX 2 vessels in the without project condition, as is occurring presently, results in an increase in benefits.

12.2 Cost Risk Analysis

A Cost Risk Analysis is a systematic and comprehensive method to evaluate uncertainty and risks that may affect the estimated project costs. Risks were characterized by the magnitude of possible uncertainties and the probability of occurrence for each item or event. In compliance with Engineer Regulation 1110-2-

1302 Civil Works Cost Engineering, dated September 15, 2008, the Corps performed a formal risk analysis to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated project cost. The Cost Risk Analysis for this project was conducted by the Corps' Cost Engineering Center of Expertise at Walla Walla District. Details of the analysis can be found in the Engineering Appendix.

The Corps' Cost Engineering Center of Expertise recommends a contingency value of 25% based on an 80% confidence level, as per USACE Civil Works guidance. The contingency amount for the Selected Plan accounts for cost and schedule growth potential due to risk analyzed in the baseline cost estimate of 47-foot design depth. Schedule slippage risk is calculated at 1 to 2 years. The Cost and Schedule Risk Model is based on 1.5-year risk slippage. The 25% contingency has been applied to all project costs.

12.3 Environmental Impact and Mitigation Uncertainty

Consideration was given to uncertainties that exist in the ability to predict the impacts from the proposed harbor deepening alternatives. Uncertainties occur when knowledge is incomplete. In the case of this project, there are uncertainties in such things as the accuracy of the model predictions and the biological response to physical parameters. The major risks for an environmental analysis are (1) that the predicted level of impacts understates the actual impacts that will occur, and (2) that such understatement would alter a decision-maker's conclusions on whether the project should be constructed.

The Corps reviewed the Uncertainty Analysis that was prepared by Kinetics Analysis Corporation (KAC) in 2005 on the hydrodynamic, salinity, and water quality models. That analysis was conducted toward the end of the model development process and evaluated the ability of those models to accurately predict the observed data. A model is typically developed to represent the observed field data, and its ability to duplicate that data is often used to assess its accuracy and the reliability of its predictions. A copy of KAC's analysis can be found in the Engineering Appendix. KAC evaluated the model's ability to duplicate the field data for salinity, dissolved oxygen, river discharge, and tidal phase. River discharge and tidal phase are useful in evaluating how a model is constructed but are not discussed here because they do not aid in evaluating the two risks mentioned earlier.

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

12.3.1 Uncertainty in Salinity Predictions

KAC found the model to generally predict salinity levels too high at the Houlihan Bridge and the USFWS Dock. KAC found the model to predict salinity too high along the entire gradient from 1 to 15 ppt. KAC evaluated the model using two river flow periods, so they produced multiple evaluations of the model's reliability for the same location, depending on flow. At the Houlihan Bridge, the errors typically range from 0.5 to 1 ppt when the observed salinity measured 2 ppt. At the USFWS Dock, the errors typically range from 0.25 to 0.6 ppt when the observed salinity measured 1 ppt and from 1.1 to 1.6 ppt when the observed salinity measured 2 ppt.

KAC also developed error bounds for the model's salinity predictions. At the Houlihan Bridge, they found that for salinity levels around 1 ppt, the model had between a 70 and 85 percent chance of over-predicting salinity, when predicting at and below the 1 ppt level. At the USFWS Dock, they found that for salinity levels around 0.5 ppt, the model had an 83 to 85 percent chance of over-predicting salinity. At that location, there is a 5 percent chance that the predictions would be between 0.12 and 0.25 ppt too low (0.19 ppt average error). There is roughly a 5 percent chance that the model's predictions would be 0.19 ppt too low when predicting values at that low level (0.5 ppt).

12.3.2 Risk with Salinity Predictions

As discussed above, the hydrodynamic model has roughly an 80 percent chance of over-predicting salinity levels at low salinity levels, thus leading to an over-prediction of salinity-induced impacts. Therefore, the model is considered to present little risk for decision-makers evaluating salinity impacts to wetlands. However, some risk still exists. At the upper 95 percent confidence level, the model could be from 0.25 to 1.6 ppt too low when salinity is predicted to be less than 2 ppt. To acknowledge this risk, USACE proposes to expand the wetland mitigation that would be implemented, but only if post-project monitoring determines that such expanded mitigation is warranted.

12.3.3 Uncertainty in Dissolved Oxygen Predictions

KAC found the model to generally predict dissolved oxygen levels too low at the Houlihan Bridge and the USFWS Dock. Those two stations are the most downstream locations considered by KAC and are, therefore, the closest to the area of the harbor which typically experiences D.O. problems in the summer. In general, KAC found the model to under-predict dissolved oxygen along the gradient of D.O. from 1 to 8 mg/l. At the Houlihan Bridge, the errors typically range from 0.025 to 0.075 mg/l across that range depending on river flow. At the USFWS Dock, the errors typically range from 0.01 to 0.02 mg/l when the observed D.O. measured less than 1.6 mg/l (upper extent of KAC's analysis on D.O. at this Station). At the Lucknow Canal, KAC found the errors to range up to 0.01 mg/l when the observed D.O. measured less than 0.7 mg/l. Those errors are quite small and within the general range of reliability of field and laboratory measurements.

12.3.4 Risk with Dissolved Oxygen Predictions

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

12.3.5 Uncertainty in Biological Responses

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

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

12.3.6 Risk in Biological Responses

As discussed above, there is uncertainty about the responses of individual organisms to the changes that would occur as a result of the proposed project. However, the risk that accompanies that uncertainty is low because we are generally concerned about impacts at the community level.

Since biologic communities respond to the sum of the influences bearing upon them, there is uncertainty with how the impacts of this project would combine with other ecological factors that may stress a community. The impact process included several alternate conditions along with the basic set of conditions for which the resource agencies requested this project be evaluated. These alternate conditions included such things as alternate river flows for fishery, wetland, and dissolved oxygen impacts, and two variations of sea-level rise for wetland impacts. These alternate conditions were included as sensitivity tests to the basic impact evaluation. The sensitivity tests provide information on how the project would function under environmental conditions that are outside the norm. Their inclusion in the overall analysis substantially reduces the risk that the project would produce impacts that would occur at unacceptable levels, even under uncommon circumstances.

12.4 Risk in Sea-Level Change Assumptions

Table 15-2 of the Engineering Appendix outlines details on risk and uncertainty for possible sea level changes in Savannah Harbor. Analysis and rates are based on EC 1165-2-212, *Sea-level Change Considerations for Civil Works Programs*, dated October 1, 2011. Three alternative rates of sea-level rise were computed, and the "low" rate was selected for use as the most likely future condition. For mitigation features, the base year sea-level rise, at the completion of construction, was used. This ensures that the project fully mitigates for impacts produced over the entire period of analysis.

Areas considered where uncertainty of sea-level rise estimates may have impacts are: dredging, mitigation structural features, freshwater wetland loss mitigation, and upstream chlorides at the City of Savannah water supply intake.

The dredging scenarios include new work dredging, maintenance dredging of the deepened channel, and mitigation dredging of McCoys Cut and Middle and Back Rivers. No impact from sea-level rise uncertainty is anticipated because the authorized dredging depths are relative to the Mean Lower Low Water (MLLW) datum. As sea level changes, the MLLW datum will be adjusted periodically, thus additional depth from sea-level rise will fill in with sediment. Therefore, there is very low risk associated with sea-level rise and dredging - whether new work, maintenance, or mitigation.

Structural features such as sills or plugs also carry minimal risk from sea-level rise uncertainty. They are designed to function over a wide variation of tidal stage, and the sea-level rise uncertainty is small compared to the tidal range. It is possible that a structure's effectiveness could be reduced slightly with greater than projected sea-level rise rates, but this could be readily addressed through adaptive management of the mitigation features.

Sea-level rise uncertainty results in a minor level of risk. A different rate of sea-level rise could affect the purchase of mitigation wetlands and the mitigation for chloride impacts to the City of Savannah Abercorn Creek water supply intake. A higher rate of sea-level rise than that assumed would result in a lesser need for mitigation. This is due to the without-project condition, which also includes sea-level rise, impacting the same freshwater wetlands that are projected to be impacted by the harbor deepening project. The mitigation based on the recommended sea-level rise assumptions result in the lowest risk to the resources impacted by the project. That is, the sea-level rise uncertainty could result in more mitigation lands being acquired than are actually necessary, which is preferable to the alternative of assuming too much sea-level rise and then finding that less sea-level rise resulted in unmitigated ecosystem damage from a harbor deepening project. Similarly, if sea-level rise is greater than assumed, then impacts from the project on the water supply intake would be reduced. That is not to say that chlorides would not impact the intake, but that the cause of the chloride increase would be sea-level rise rather than harbor deepening. The risk, then, is that the project may have over-mitigated.

13 Public Involvement, Review, and Consultation

13.1 Public Involvement Program

This study was conducted as a partnership between the USACE Savannah District, as the lead Federal agency, representatives of three other Federal agencies that need to approve the project (EPA Region 4, NMFS-Southeast Regional Office, and the USFWS-Southeast Region), and the Georgia Ports Authority (for their shipping expertise). Representatives from the Cooperating Agencies met on a regular basis to reach decisions on technical work to be conducted and review results of evaluations.

Savannah District coordinated technical aspects of the project with technical staff of Federal and State resource agencies through a series of Interagency Coordination Teams. The Savannah District generally developed those groups around specific natural resources, as follows:

- Wetlands;
- Water Quality;
- Fisheries;