Appendix N

COST AND SCHEDULE RISK ANALYSIS

Houma Navigation Canal
Terrebonne Parish, Louisiana

Risk Analysis Report

August 2017

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A Risk Register

EXECUTIVE SUMMARY

This report presents a recommendation for the total project cost and schedule contingencies for the Houma Navigation Canal (HNC) Feasibility Project. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated June 30, 2016, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

The Project Delivery Team (PDT) conducted a series of brainstorming sessions in March 2017 to identify the risks associated with the project. Key project and risk assumptions reflected in the analysis were identified. The risk analysis was performed using the Monte Carlo technique, producing the contingencies and identifying key risk drivers.

Both the Construction and Operation and Maintenance (O&M) contingencies are based on an 80% confidence level, as per accepted USACE Civil Works guidance. For the HNC Project, the most likely total construction cost is estimated at approximately $140,408,000. For initial construction of the project, a cost contingency value of $28,617,728, or 21%, and a schedule contingency value of 17 months were determined. For O&M of the project a cost contingency of $97,681,092, or 22%, and a schedule contingency of 27 months were determined. The following Table 1 portrays the development of contingencies for the project. The individual contingencies based on the cost and the schedule analyses are shown followed by the combined project contingency.

Table 1 – Contingency Development Summary

Construction Contingency on Base Estimate	80% Confidence Project Cost
Baseline Estimate Cost ->	**$140,408,000**
Baseline Estimate Cost Contingency Amount ->	$29,485,538
Baseline Estimate Construction Cost (80% Confidence) ->	**$169,893,538**

Construction Contingency on Schedule	80% Confidence Project Schedule
Project Base Schedule Duration ->	**98.0 Months**
Schedule Contingency Duration ->	17.6 Months
Project Schedule Duration (80% Confidence) ->	**115.6 Months**

O&M Contingency on Base Estimate	80% Confidence Project Cost
Baseline Estimate Cost ->	**$450,266,000**
Baseline Estimate Cost Contingency Amount ->	$99,058,712
Baseline Estimate Construction Cost (80% Confidence) ->	**$549,324,712**

O&M Contingency on Schedule	80% Confidence Project Schedule
Project Base Schedule Duration ->	**296.0 Months**
Schedule Contingency Duration ->	26.6 Months
Project Schedule Duration (80% Confidence) ->	**322.6 Months**

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

Construction

An analysis of the relative impact of the key cost drivers on the cost and schedule contingency indicate that CA-1 (Limited Competition) has the greatest impact. This single factor accounts for 38% of the overall contingency value. The primary recommendation for the mitigation of cost risk on this project is to structure the contracts in a manner that would encourage increased competition. This could include the use of more contracts over smaller lengths of channel. The next most significant events on the overall contingency are ET-2 (Dredging Fuel Costs) and ET5 (Rock and Earthen Dike Fuel Costs). These cannot be controlled by the PDT but can be monitored as the construction period approaches to determine how current fuel prices may impact the project cost. Both Bid Competition and Fuel Prices impact the cost contingency most significantly. The most significant impacts on the schedule contingency are TL-1 (Rock and Earthen Dike Quantities), PM-4, and PM-3 (Funding). However, the schedule risks have a lower impact on the overall contingency relative to the cost risks.

O&M

An analysis of the relative impact of the key cost drivers on the cost and schedule contingency indicate that as with construction, CA-1 (Limited Competition) has the greatest impact. This single factor accounts for 53% of the overall contingency value. As with construction risks, the primary recommendation for the mitigation of cost risk on this project is to structure the contracts in a manner that would encourage increased competition. The next most significant event on the overall contingency is ET-2 (Dredging Fuel Costs). Once again, this cannot be controlled by the PDT but can be monitored as the construction period approaches to determine how current fuel prices may impact the project cost. The cost driver TL1 (Rock and Earthen Dike Quantities) provides a 12% impact on the overall contingency value. This could be mitigated by ensuring proper geotechnical investigations are conducted during the design phase of the project.

For the O&M phase, the most significant impacts on the schedule contingency are TL-1 (Rock and Earthen Dike Quantities) and PM-3 (Funding). As with the construction phase, the schedule risks have a lower impact on the overall contingency relative to the cost risks.

1. PURPOSE

This cost and schedule risk analysis (CSRA) determines a reliable and defensible contingency factor for the MCACES (MII) estimate for the Houma Navigation Canal (HNC) Feasibility Project. The contingency has been calculated at the 80 percent confidence as recommended by the "Cost and Schedule Risk Analysis Guidance (USACE 2009). The contingency was measured in terms of dollars for the cost analysis and in terms of months for the schedule analysis.

The Project Delivery Team (PDT) studied a variety of events that could impact the cost or schedule. The events were grouped into the following risk categories:

- Project and Program Management
- Contract Acquisition
- Technical
- Lands and Damages
- Regulatory and Environmental
- Construction
- Estimate / Schedule

2. BACKGROUND

The HNC Feasibility Project is a navigation improvement project designed for the HNC located in Terrebonne Parish, Louisiana.

The HNC is a 41-mile navigation channel which starts in Houma, LA and continues south into the Gulf of Mexico. The improvements include relocation of existing pipelines and facilities, hydraulic dredging a total of 41 miles of the waterway, construction of stone dikes along certain portions of the canal banks, and the construction of dikes and containment cells for upland and open water disposal. This project would improve access for ocean-going vessels transporting prefabricated deepwater topsiders to the Gulf of Mexico and decrease transportation costs for the nation. Several alternatives have been studied and a tentatively selected plan (TSP) has been recommended for further study and analysis. The TSP would deepen the Canal from and elevation of -15-ft (MLG) to -20-ft (NAVD88).

The following design documents are available for this project:

- Feasibility Report for the Houma Navigation Canal Navigation Improvement Project, Preliminary Draft, May 2017.
- Design Plates C1 thru C19 and G1 thru G53 for the Houma Navigation Deepening – General Reevaluation Report, May 2017

3. REPORT SCOPE

The scope of this risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated

by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The evaluation of cost and schedule risks was conducted for both the construction and O&M phases of the project.

3.1 Project Scope

By letter to the Assistant Secretary of the Army for Civil Works (ASA(CW)), dated January 10, 2012, the LADOTD recommended initiating this IFR/EIS under the authority granted by Section 203 of the 1986 WRDA (PL 99-662).

The MII Cost Estimate serves as the basis for the CSRA. The MII was developed by GEC, Inc. (GEC) under contract to the Louisiana Department of Transportation and Development.
In general terms, the construction scope consists of the following major project features: Lands and Damages (01), Utility Relocations (02), and Channel/Canal Improvements (09). These features have been developed to a feasibility level. The O&M scope consists of only Channel/Canal Improvements (09).

3.2 USACE Risk Analysis Process

The risk analysis process utilized in this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Directory of Expertise for Civil Works (Cost Dx). The risk analysis process reflected within this risk analysis report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. The risk analysis results are intended to serve several functions – one being the establishment of reasonable contingencies reflective of an 80 percent confidence level to successfully accomplish the project work within that established contingency amount. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

The risk analysis results included in this report are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analyses should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting, and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, the risk analysis is performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Dx.
- Memorandum from Major General Don T. Riley (US Army Director of Civil Works), dated July 3, 2007.

- Engineering and Construction Bulletin issued by James C. Dalton, P.E. (Chief, Engineering and Construction, Directorate of Civil Works), dated September 10, 2007.
- Engineering Regulation ER 1110-2-1150 dated August 31, 1999.
- Engineering Regulation ER 1110-2-1302 dated September 15, 2008.
- Engineering Technical Letter 1110-2-573 dated September 30, 2008.

4. METHODOLOGY/PROCESS

Risk analysis team included cost support from the cost engineer as well as coordination support from project management and the assigned project delivery team (PDT). The risk analysis team included the following members:

Member (not name but position)	Location
Project Manager	USACE MVN
Cost Engineer (CSRA)	USACE MVN
Cost Engineer (CEDEP & MII)	USACE MVN
Real Estate	USACE MVN
Cost Engineer	GEC
Biologist	GEC
Economist	GEC
Environmental Engineer	GEC

The risk analysis presented in this report is based on a Cost Engineering Report that is currently undergoing an Independent External Peer Review (IEPR) and Agency Technical Review (ATR). Changes made to the Cost Engineering Report as a result of these reviews will be incorporated into this Risk Analysis Report as appropriate.
The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve a desired level of cost confidence. The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel.

4.1 Identification and Assessment of Risk Factors

Identification of the risk factors via the PDT is considered a qualitative process that resulted in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Formal PDT meetings were held for the purposes of identifying and assessing risk factors. The participants in those meetings are identified above in Section 4.0. The team included capable and qualified representatives from multiple project team disciplines and functions. As a result of these meetings a series of risk/opportunity events were developed. These events have been

incorporated into the Risk Register included in Appendix A. The discussion of these events and concerns identified are also included on the Risk Register as are the team's assessment of the likelihood of occurrence for this event and the impact this event would have on the cost and schedule. The concerns and discussions support the team's decisions related to event likelihood, impact. The resulting risk level associated with each event was determined using the following table:

Risk Matrix						
		Impact or Consequence of Occurrence				
		Negligible	Marginal	Significant	Critical	Crisis
Likelihood of Occurrence	Certain	Moderate	Moderate	High	High	High
	Very Likely	Low	Moderate	High	High	High
	Likely	Low	Moderate	High	High	High
	Unlikely	Low	Low	Moderate	Moderate	High
	Very Unlikely	Low	Low	Low	Low	Moderate

4.2 Quantify Risk Factor Impacts

The quantitative impacts of the risk factors identified by the PDT were analyzed using a combination of professional judgment, empirical data, and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions), because risk factors are entered into the Crystal Ball software in the form of probability density functions.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency was analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations were performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each risk event is assigned a dollar-weighted relative risk as quantified by the Monte Carlo simulation. Standard deviation is used at the event-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of the contingency being allocated to risk events with a relatively higher estimated cost uncertainty.

5. KEY ASSUMPTIONS

The following key assumptions are reflected in this Risk Analysis Report:

- The Houma Navigation Canal project is in the Feasibility Design Stage. Several alternatives have been studied and a tentatively selected plan (TSP) has been

recommended for further study and analysis. The TSP would deepen the Canal from and elevation of -15-ft MLG to -20-ft NAVD88. The risk analysis in this report applies only to the TSP.

- Major features of this project include: relocation of existing pipelines and facilities, dredging a total of 39.8 miles of the waterway, construction of stone dikes along certain portions of the canal banks, and the construction of containment cells for upland and open water disposal.
- For the contract acquisition strategy, this project would likely be let out in at least 8 separate contracts. The local sponsor would likely let out three contracts for the pipeline relocations. The remainder of the project would likely be let out in the following 5 Federal contracts; 1) channel improvements between miles 36.3 to 22.0, 2) channel improvements between miles 22.0 to 11.5, 3) channel improvements between miles 11.5 to 6.0, 4) channel improvements between miles 6.0 to 0.0, and 5) channel improvements between miles 0.0 to -3.5. Each of these contracts would likely be let out to one prime construction contractor. For estimating purposes, one prime construction contractor was used for each contract to reflect the prime contractor mark-up. The prime contractor would be responsible for the preparatory work, dredging, stone placement, and containment cell creation.
- This Feasibility study underwent the ATR and IEPR processes.
- The feature cost accounts for this project include; Lands and Damages, Relocation, Channels, Planning Engineering and Design, and Construction Management.
    - Lands and Damages: Costs for this account were developed by the Louisiana Department of Transportation and Development. These costs include $12,843,000 for real estate which includes easements required for mitigation. Additional costs of $824,000 for BLH mitigation bank and $93,000 for cypress mitigation bank were applied to the initial deepening contract and are not included in the Lands and Damages account. A cost of $9,000 for oyster lease mitigation is included.
    - Relocations: Costs for this account include an estimated 28 pipelines, ranging between 2.5-inches to 36-inches in diameter, and 5 cable crossings underneath HNC that would require relocation. These relocations would be required to ensure 8-feet of cover from the (-) 20.0-feet NAVD88 channel depth to the top of pipe.
    - Channels: Costs for this account include hydraulic dredging a total of 39.8 miles of the waterway, construction of stone dikes along certain portions of the canal banks, and the construction of dikes and containment cells for upland and open water disposal.
    - Planning Engineering and Design: Costs for this account were estimated at 15% of the construction cost. This account covers the preparation of Plans Specifications and Estimate for construction.
    - Construction Management: Costs for this account were estimated at 10% of the construction cost. This account covers construction management during the construction contract.

- Based on the available quantities and project information there is a relatively high degree of confidence in the cost estimate and schedule. The cost estimate is based on current labor, material and fuel costs. The construction schedule is based on production rates of the construction elements.
- The recommended contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.
- Only the high and moderate risk levels as determined by the PDT in the risk register have been studied within this risk analysis. The low risk levels were excluded based on the assumption that they would have a negligible impact in determining the contingency.

6. RISK ANALYSIS RESULTS

The following Table 2 tabulates the results of the risk analysis currently identified as a 13% (construction) and 12% (O&M) cost contingency amount based on an 80% confidence level.

Table 2 – Cost Contingency Summary

Contingency on Base Estimate	80% Confidence Project Cost
Baseline Estimate Cost ->	**$140,408,000**
Baseline Estimate Cost Contingency Amount ->	$29,485,538
Baseline Estimate Construction Cost (80% Confidence) ->	**$169,893,538**

Contingency on Schedule	80% Confidence Project Schedule
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Contingency on Base Estimate	80% Confidence Project Cost
Baseline Estimate Cost ->	**$450,266,000**
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Contingency on Schedule	80% Confidence Project Schedule
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Project Schedule Duration (80% Confidence) ->	**322.6 Months**

6.1 Risk Register

The complete Risk Registers for both construction and O&M are included in Appendix A. The Risk Register tabulates the risk events analyzed and the risk level associated with each event. The following Tables 3 and 4 are condensed versions of both Risk Registers included in Appendix A. They show the event, likelihood, impact, and risk level to both cost and schedule.

Also shown on the risk register are the correlations identified among various events. The following discussion describes the relationship among correlated events that have a moderate or high level of risk (i.e. those to be carried forward in the analysis) for either the cost or schedule analysis.

Events TL2 (Adequate Disposal Capacity) and LD1 (Acquire Additional Real Estate for Disposal Areas) were determined to capture the risk associated with Event PM1 (Scope Growth). Both events cover changes to the project scope that would occur due to a need for additional disposal areas and the associated real estate requirements.

Event CA1 (Limited Competition) was determined to capture the risk associated with Event CA-2 (Accelerated Schedule). It was determined that an aggressive schedule would limit a bidding contractor's ability to participate in the project or eliminate their interest in bidding for the work. Therefore, contractors (being aware of probable limited interest) will bid less on the project.

Event LD1 (Acquire Additional Real Estate for Disposal Areas) was determined to capture some of the risk associated with Event CO1 (Relocations). Changes in boring angle requirements that may increase real estate needs could result in coordination issues and schedule risk.

Event ET1 (Assumed Productivity - Dredging) was determined to capture the risk associated with Event CO2 (Maintaining Navigation Traffic). It was determined that the primary impact resulting from navigation interference would be reduced productivity, which is covered in ET1.

Events TL1 (Rock and Earthen Dike Quantities), TL2 (Adequate Disposal Capacity), TL3 (Dredge Quantity), and ET3 (Dredge Running Time) were determined to capture the risk associated with Event CO3 (Contract Modifications). It was determined that the most likely cause of contract modifications for a dredging project such as this one would involve changes in quantities or excessive debris or rock within the channel. Quantity modifications could include disposal material, containment dikes, or rock stabilization. Excessive debris within the channel would result in longer dredge running time. All of these quantity changes are accounted for in the aforementioned events.

Event CO3 (Contract Modifications) was determined to capture the schedule risk associated with CO4 (Adverse Weather). Event CO4 addresses the impacts as a result of inclement weather. The highest likelihood for an impact would be in Cat Island Pass, which would likely result in additional Mobilization. This would result in a contract modification, which is covered by Event CO3. If additional real estate needs arise, there would be schedule risks associated with the need for a new Environmental Impact Statement. This is also covered in CO3.

It was determined that Event LD1 would not need additional cost risk assigned to it since the real estate costs included in the overall project costs include a 25 percent contingency. Therefore, the cost risks associated with this Event are already accounted for.

Table 3 – Condensed Risk Register – Construction

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
	PROJECT & PROGRAM MGMT										
PM1	Scope Growth	Additional features added to the scope in later stages could change the project cost and schedule.	Changes to deepening scope will likely involve needing to dispose of material in additional areas. This would result in an impact to cost and schedule. The risks associated with changes in quantities and real estate issues related to new disposal areas are already considered in TL2 and LD1. Since the only potential for scope change involves changes to quantities (which are already accounted for), this risk is classified as negligible.	Likely	Negligible	LOW		Likely	Negligible	LOW	
PM2	Staff Issues	Staff could be over worked or insufficient to work on the project.	There are times of the year that staff is overtaxed. Work could be done to avoid the end of the FY push.	Likely	Negligible	LOW		Unlikely	Negligible	LOW	
PM3	Funding	Difficulty securing funding could delay project start or award of project.	If the funding stream is delayed then the construction of the project shall be delayed. Industry along the channel and the price of oil will determine this channels importance. Since funding is determined on a yearly basis, it is assumed that a delay in funding would result in a 12 month delay.	Unlikely	Marginal	LOW		Likely	Significant	HIGH	12 Months
PM4	Non-Federal Funding	Ability of Non-Federal sponsor to provide 10% cost share	The state (Non Federal Sponsor) is currently cash strapped and will have to determine itself the importance of this channel. Since funding is determined on a yearly basis, it is assumed that a delay in funding would result in a 12 month delay.	Unlikely	Negligible	LOW		Likely	Significant	HIGH	12 Months
	CONTRACT ACQUISITION RISKS										
CA1	Limited Competition	There is healthy competition for the upper reaches and the bay channel of HNC. However in Cat Island Pass competition is reduced because only a large cutterhead can successfully complete the work.	In periods of limited competition dredging contractor's will bid higher and in times of abundant competition more competitive bidding will be produced. Based on past dredging projects, it is assumed that this ranges from -15% to +20% in cost.	Likely	Significant	HIGH	$15,507,900 - $25,846,600	Likely	Negligible	LOW	
CA2	Accelerated Schedule	An aggressive work schedule required by this contract could limit the bidder's interest or willingness to bid on this contract.	Aggressive schedules could limit contractors ability to participate or eliminate their interest in bidding for the work, therefore contractors (being aware of probable limited interest)	Likely	Negligible	LOW		Very Likely	Negligible	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
			will bid closer to the 25% threshold of IGE. Reference CA-1.								
	TECHNICAL RISKS										
TL1	Rock and Earthen Dike Quantities	Overbank geotechnical data will addressed in PED. 20% settlement was assumed on bankline quantities for rock.	If existing conditions in the areas that receive earthen materials or stone are different than we assume then quantity changes will be incurred. From discussion with PDT the range of quantity adjustment could be 5% less and 25% more. Schedule would be impacted by 5% less and 10% more.	Likely	Marginal	MODERATE	$2,333,100 - $17,345,600	Likely	Significant	HIGH	5 mo; + 10 mo
TL2	Adequate Disposal Capacity	Due to changes in quantities, disposal areas could be undersized.	The project could encounter delays and cost increases as a result of unexpected losses of disposal areas. Most inland reaches are unconfined with additional capacity. A few upland sites are a low risk for capacity issues, but higher for RE if landowner issues occur. Disposal plan was reworked to accommodate estimated material needs, decreasing likelihood. No concerns for Terrebonne Bay - adjacent disposal.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW	
TL3	Dredge Quantity	There is high confidence in our construction for dredging however the maintenance quantity on top may vary.	The upper reaches are dredged much less and we have high confidence in this reach. The bay channel reach gets periodic dredging so the maintenance material is light and easily dredged. The bar channel could have a cost affected change in quantities due to increased shoaling rates. The PDT decided that a -5% to + 10% range would be appropriate for cost and schedule (negligible) for the Cat Island portion of construction.	Likely	Marginal	MODERATE	$408,077 - $2,870,323	Likely	Negligible	LOW	1 Month - 2 Months
	LANDS AND DAMAGES RISKS										
LD1	Acquire Additional Real Estate for Disposal Areas	When disposal areas fill to capacity within Inland Reach and Terrebonne Bay, additional areas need to be obtained. Some of the land owners may resist the projects needs.	A 25% contigency is included in Lands and Damages costs. Therefore, Account 01 costs were not included in the risk analysis costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
LD2	Oyster Lease Compensation	State may not wish to extinguish oyster leases for entire area requested, deeming it too expensive and politically charged.	Only one disposal area contains oyster leases. If leases are an issue, a new disposal area is likely to be identified. Therefore, project completion not likely to be impacted; construction would simply proceed with different disposal alternative. The risk associated with additional disposal need are accounted for in LD1.	Unlikely	Negligible	LOW		Unlikely	Marginal	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
	REGULATORY AND ENVIRONMENTAL RISKS										
REG1	Threatened & Endangered Species Identified	Unexpected Threatened and Endangered Species occurrence.	Schedule delays could occur if T&E species are identified in the project area before construction dredging. Federal and State agencies have weighed in on potential impacts, so the likelihood of observed risks is very low.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW	
REG2	Cultural Resources Encountered	Risk that some unidentified cultural resource could be identified prior to or during construction dredging.	The impact of encountering unknown cultural resources would influence cost and schedule cost, however likelihood of encounters in HNC are low. Disposal areas and access paths have been culturally cleared. Any disposal impacts would be small given material is placed and covered.	Very Unlikely	Marginal	LOW		Very Unlikely	Marginal	LOW	
	CONSTRUCTION RISKS										
CO1	Relocations	Existing utilities are to be relocated. Pipeline utilities cross the HNC. Some coordination and/or construction issues could occur. Utility locations could be off or require additional work.	All utilities are subsurface lines. A couple of relocations were identified. Based on depth of dredging along with directional drilling requirements. No coordination with Utilities Co., has occurred. No field investigations have been performed. A 30% increase in relocation costs was assumed to account for this cost risk. Schedule risk would be due to potential coordination issues or boring angle requirements that may increase real estate needs (covered in LD1). Assume an additional two more gas pipelines need relocations (one 30-inch in inland reach and one 3-inch line in Bay). Assume linear increase in duration from 23 to 25 utilities.	Likely	Marginal	MODERATE	(High) $2,529,900 Low and Base costs remain the same.	Likely	Marginal	MODERATE	23 utilities over 1,638 days results in 5 Mo for the two additional utilities
CO2	Maintaining Navigation Traffic	Navigation traffic interference during construction could be an issue.	Contractors and designers are experienced with traffic control under existing maintenance dredging program. This is currently captured conservatively in the dredging running time in CEDEP. Therefore likelihood is low. Navigation interference would reduce productivity, which is covered in ET1.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
CO3	Contract Modifications	There may be modification issues that have not been captured in current risks.	Requirement for new work material or decreased dredgability may result in change order requests, which would require contract modifications. It is assumed that such modifications would result in a 5% increse in costs, the low and base costs would remain the same. Potential of encountering excessive debris & trash, and rock (accounted for in ET3). Extended overhead, standby costs (ET3). Potential for differing site conditions due to coarse boring grid (accounted for in TL1). Cat Island Pass, waves and stiff material (new work). TL-1, TL-2 and TL-3 capture quantity risk. The likely requirement for modified contracts would result in additional time (since contracts are idendependant of each other time increase is assumed to be 4 months).	Likely	Marginal	MODERATE	(High) $5,169,300 Low and Base costs remain the same.	Likely	Marginal	MODERATE	4 Months
CO4	Adverse Weather	Severe weather may impact cost or schedule.	Most of project is in inland and bay areas, reduced impact from bad weather. The Cat Island Pass region could impact due to storms (Additional Mobilization) but is covered in CO-3	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW	
	ESTIMATE AND SCHEDULE RISKS										
ET1	Assumed Productivity-Dredging	The estimate's assumed productivity for dredging may be inaccurate. A small variance could impact overall cost as compared to the bid. Schedule has reduced impacts due to separate contracts per reach.	Dredging productivity developed by experienced estimators via CEDEP software. Dredge production ranging 20% higher to 10% less. Impacts were quantified by MII.	Likely	Marginal	MODERATE	$-5,267,700 - $3,855,015	Likely	Negligible	LOW	
ET2	Fuel-Dredging	Fluctuations in fuel costs can impact dredging costs. Schedule has reduced impacts due to separate contracts per reach.	Fuel costs could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed. Impacts were quantified by MII. Resulted in a low impact of 10% and a high impact of 17%.	Likely	Significant	HIGH	$-10,153,968 - $17,379,500	Likely	Negligible	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
ET3	Dredge Running Time	Variance in Dredge Running time shall impact dredging costs. Schedule has reduced impacts due to separate contracts per reach.	In the inland and bay channel reach running time could vary from 14 to 18 hours per day. In Cat Island Pass the dredge running time could vary from 14 to 10 hours. Impacts were quantified by MII. Resulted in a low impact of 2% and a high impact of 5%.	Likely	Marginal	MODERATE	$-2,182,768 - $2,977,215	Likely	Negligible	LOW	
ET4	Rock and Earthen Dike Productivity	The estimate's assumed productivity for rock installation may be inaccurate. A small variance could impact overall cost as compared to the bid.	To quantify this risk the rock and dike productivity was increased to 2,600 ton/day and decreased to 1,000 tons/day for low and high, respectively. Impacts were quantified by MII.	Likely	Marginal	MODERATE	$-2,218,263; $2,551,753	Likely	Negligible	LOW	
ET5	Fuel - Rock + Earthen Dike	Fluctuations in fuel costs can impact the cost for rock delivery as well as rock and earthen dike construction. Schedule has reduced impacts due to separate contracts per reach.	Fuel costs for rock delivery and construction of earthen dikes could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed.	Likely	Significant	HIGH	$-6,045,071 - $8,978,184	Likely	Negligible	LOW	

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.

2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).

3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.

4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.

5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.

6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.

7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.

8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."

9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.

10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.

11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

Table 4 – Condensed Risk Register – O&M

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
	PROJECT & PROGRAM MGMT										
PM1	Scope Growth	Additional features added to the scope in later stages could change the project cost and schedule.	Changes to O&M scope will likely involve needing to dispose of material in additional areas. This would result in an impact to cost and schedule. The risks associated with changes in quantities and real estate issues related to new disposal areas are already considered in TL2 and L1. Since the only potential for scope change involves changes to quantities (which are already accounted for), this risk is classified as negligible.	Likely	Negligible	LOW		Likely	Negligible	LOW	
PM2	Staff Issues	Staff could be over worked or insufficient to work on the project.	There are times of the year that staff is overtaxed. Work could be done to avoid the end of the FY push.	Likely	Negligible	LOW		Unlikely	Negligible	LOW	
PM3	Funding	Difficulty securing funding could delay project start or award of project.	If the funding stream is delayed then the O&M phase of the project shall be delayed. Industry along the channel and the price of oil will determine this channels importance. Since funding is determined on a yearly basis, it is assumed that a delay in funding would result in a 10% schedule delay (29 months).	Unlikely	Marginal	LOW		Likely	Significant	HIGH	29 Months

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
PM4	Non-Federal Funding	Ability of Non-Federal sponsor to provide Real Estate costs for additional disposal sites. This risk is covered in Risk LD1.	The state (Non Federal Sponsor) is currently cash strapped and will have to determine itself the importance of this channel. This risk is covered in Risk LD1.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW	
	CONTRACT ACQUISITION RISKS										
CA1	Limited Competition	There is healthy competition for the upper reaches and the bay channel of HNC. However in Cat Island Pass competition is reduced because only a large cutterhead can successfully complete the work.	In periods of limited competition dredging contractor's will bid higher and in times of abundant competition more competitive bidding will be produced. Based on past dredging projects, it is assumed that this ranges from -15% to +20% in cost.	Likely	Significant	HIGH	$-67,539,900; $112,566,500	Likely	Negligible	LOW	
CA2	Accelerated Schedule	An aggressive work schedule required by this contract could limit the bidder's interest or willingness to bid on this contract.	Aggressive schedules could limit contractors ability to participate or eliminate their interest in bidding for the work, therefore contractors (being aware of probable limited interest) will bid closer to the 25% threshold of IGE. Reference CA-1.	Likely	Negligible	LOW		Very Likely	Negligible	LOW	
	TECHNICAL RISKS										

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
TL1	Rock and Earthen Dike Quantities	Overbank geotechnical data will addressed in PED. 20% settlement was assumed on bankline quantities for rock.	Same assumptions were made for O&M quantities as for construction. If existing conditions in the areas that receive earthen materials or stone are different than we assume then quantity changes will be incurred. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, decreased quantities result in a 2% reduction in cost and increased quantities result in a 13% increase in base O&M costs. These percentages were applied directly to the base O&M costs. Schedule would be impacted by 5% less and 10% more.	Likely	Significant	HIGH	$-9,005,300; $76,545,300	Likely	Significant	HIGH	15 Months; 29 Months
TL2	Adequate Disposal Capacity	Due to changes in quantities, disposal areas could be undersized.	The project could encounter delays and cost increases as a result of unexpected losses of disposal areas. Most inland reaches are unconfined with additional capacity. A few upland sites are a low risk for capacity issues, but higher for RE if landowner issues occur. Disposal plan was reworked to accommodate estimated material needs, decreasing likelihood. No concerns for Terrebonne Bay - adjacent disposal.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
TL3	Dredge Quantity	Maintenance quantities could vary over duration of the work.	The upper reaches are dredged much less than the lower reaches, but shoaling is reduced as well. The bay channel reach gets periodic dredging so the maintenance material is light and easily dredged. The bar channel could have increased quantities due to increased shoaling rates. The PDT decided that for O&M a -5% to + 10% range would be appropriate for cost and schedule for the Bay and Cat Island Pass reaches during O&M. This represents an increased risk over construction.	Likely	Marginal	MODERATE	$-2,034,500; $35,892,500	Likely	Negligible	LOW	
	LANDS AND DAMAGES RISKS										
LD1	Acquire Additional Real Estate for Disposal Areas	When disposal areas fill to capacity within Inland Reach and Terrebonne Bay, additional areas need to be obtained. Some of the land owners may resist the projects needs.	A 25% contingency is included in Lands and Damages costs. Therefore, Account 01 costs were not included in the risk analysis costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
	REGULATORY AND ENVIRONMENTAL RISKS										

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
REG1	Threatened & Endangered Species Identified	Unexpected Threatened and Endangered Species occurrence.	Schedule delays could occur if T&E species are identified in the project area before construction dredging. Federal and State agencies have weighed in on potential impacts, so the likelihood of observed risks is very low.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW	
REG2	Cultural Resources Encountered	Risk that some unidentified cultural resource could be identified prior to or during construction dredging.	The impact of encountering unknown cultural resources would influence cost and schedule cost, however likelihood of encounters in HNC are low. Disposal areas and access paths have been culturally cleared. Any disposal impacts would be small given material is placed and covered.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW	
	CONSTRUCTION RISKS										
CO2	Maintaining Navigation Traffic	Navigation traffic interference during O&M could be an issue.	Contractors and designers are experienced with traffic control under existing maintenance dredging program. This is currently captured conservatively in the dredging running time in CEDEP. Therefore likelihood is low. Navigation interference would reduce productivity, which is covered in ET1.	Unlikely	Negligible	LOW		Unlikely	Marginal	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
CO3	Contract Modifications	There may be modification issues that have not been captured in current risks.	Requirement for new work material or decreased dredgability may result in change order requests, which would require contract modifications. It is assumed that such modifications would result in a 5% increse in costs, the low and base costs would remain the same. Potential of encountering excessive debris & trash, and rock (accounted for in ET3). Extended overhead, standby costs (ET3). Potential for differing site conditions due to coarse boring grid (accounted for in TL1). Cat Island Pass, waves and stiff material (new work). TL-1, TL-2 and TL-3 capture quantity risk. The likely requirement for modified contracts would result in additional time (since contracts are idendependant of each other time increase is assumed to be 6 months).	Likely	Marginal	MODERATE	(High) $22,513,308 Low and Base costs remain the same.	Likely	Marginal	MODERATE	6 months
CO4	Adverse Weather	Severe weather may impact cost or schedule.	Most of project is in inland and bay areas, reduced impact from bad weather. The Cat Island Pass region could impact due to storms (Additional Mobilization) but is covered in CO-3	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW	
	ESTIMATE AND SCHEDULE RISKS										

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
ET1	Assumed Productivity-Dredging	The estimate's assumed productivity for maintenance dredging may be inaccurate. A small variance could impact overall cost as compared to the bid.	Dredging productivity developed by experienced estimators via CEDEP software. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. To evaluate the risk productivity was decreased by 10% and increased by 20%. The cost impacts were captured by MII software. Therefore, decreased production results in a 5.2% increase in cost and increased production results in a 3.8% decrease in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Marginal	MODERATE	$-21,902,200; $18,870,200	Likely	Negligible	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
ET2	Fuel-Dredging	Fluctuations in fuel costs can impact dredging costs.	Fuel costs could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, decreased fuel costs result in a 10% reduction in cost and increased fuel costs result in a 17% increase in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Significant	HIGH	$-45,380,894; $77,673,900	Likely	Negligible	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
ET3	Dredge Running Time	Variance in Dredge Running time shall impact dredging costs/schedule.	In the inland and bay channel reach running time could vary from 14 to 18 hours per day. In Cat Island Pass the dredge running time could vary from 14 to 10 hours. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, increased running time results in a 2% decrease in cost and increased running time results in a 3% increase in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Marginal	MODERATE	$-8,114,400; $14,947,100	Likely	Negligible	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
ET4	Rock and Earthen Dike Productivity	The estimate's assumed productivity for rock delivery/placement and earthen dike construction/maintenance may be inaccurate. A small variance could impact overall cost as compared to the bid.	Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. To evaluate the risk productivity was decreased by 10% and increased by 20%. The cost impacts were captured by MII software. Therefore, decreased production results in a 2.5% increase in cost and increased production results in a 2.2% decrease in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Negligible	LOW	$-1,746,500 $1,984,700	Likely	Negligible	LOW	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule			
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)
ET5	Fuel - Rock + Earthen Dike	Fluctuations in fuel costs can impact rock placement and dike construction.	Fuel costs could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, decreased fuel costs result in a 10% reduction in cost and increased fuel costs result in a 15% increase in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Marginal	MODERATE	$-7,927,929; $12,959,920	Likely	Negligible	LOW	

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.

2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).

3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.

5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.

6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.

7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.

8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."

9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.

10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.

11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

6.2 Cost Risk Analysis - Cost Contingency Results

The cost contingency results show a 21% contingency (or $28,617,728) at the 80% confidence level for the construction phase. For the O&M phase, the results show a 22% contingency (or $97,681,092) at the 80% confidence level. The contingency at various confidence levels are shown in Tables 5 and 6 followed by the Sensitivity Charts (Figures 1 and 2) for the cost analysis. These results reflect only those contingencies established from the cost risk analysis.

Table 5-1 – Construction Cost Contingency Summary

Most Likely Cost Estimate	$140,408,000	
Confidence Level	Value	Contingency
0%	119,346,701	-15.00%
5%	137,599,725	-2.00%
10%	144,620,119	3.00%
15%	146,024,198	4.00%
20%	148,832,356	6.00%
25%	150,236,435	7.00%
30%	151,640,514	8.00%
35%	154,448,671	10.00%
40%	155,852,750	11.00%
45%	157,256,829	12.00%
50%	158,660,908	13.00%
55%	160,064,987	14.00%
60%	162,873,144	16.00%
65%	164,277,223	17.00%
70%	165,681,302	18.00%
75%	167,085,381	19.00%
80%	169,893,538	21.00%
85%	172,701,696	23.00%
90%	175,509,854	25.00%
95%	179,722,090	28.00%
100%	195,166,957	39.00%

Table 5-2 – Construction Cost Contingency Summary

	Percentile	Baseline TPC	Model Output	Congingency Amount	Baseline w/ Contingency	Contingency %
PROJECT CONTINGENCY (BASELINE ESTIMATE)	0%	$140,407,883	-$20,164,158	-$21,061,182	**$119,346,701**	**-15%**
	5%	$140,407,883	-$1,587,895	-$2,808,158	**$137,599,725**	**-2%**
	10%	$140,407,883	$2,983,131	$4,212,236	**$144,620,119**	**3%**
	15%	$140,407,883	$5,210,981	$5,616,315	**$146,024,198**	**4%**
	20%	$140,407,883	$7,406,570	$8,424,473	**$148,832,356**	**6%**
	25%	$140,407,883	$9,326,070	$9,828,552	**$150,236,435**	**7%**
	30%	$140,407,883	$11,156,319	$11,232,631	**$151,640,514**	**8%**
	35%	$140,407,883	$13,019,421	$14,040,788	**$154,448,671**	**10%**
	40%	$140,407,883	$14,577,938	$15,444,867	**$155,852,750**	**11%**
	45%	$140,407,883	$15,889,879	$16,848,946	**$157,256,829**	**12%**
	50%	$140,407,883	$17,718,369	$18,253,025	**$158,660,908**	**13%**
	55%	$140,407,883	$19,501,448	$19,657,104	**$160,064,987**	**14%**
	60%	$140,407,883	$21,123,071	$22,465,261	**$162,873,144**	**16%**
	65%	$140,407,883	$22,923,642	$23,869,340	**$164,277,223**	**17%**
	70%	$140,407,883	$24,609,241	$25,273,419	**$165,681,302**	**18%**
	75%	$140,407,883	$26,297,666	$26,677,498	**$167,085,381**	**19%**
	80%	$140,407,883	$28,617,728	$29,485,655	**$169,893,538**	**21%**
	85%	$140,407,883	$31,368,297	$32,293,813	**$172,701,696**	**23%**
	90%	$140,407,883	$34,139,355	$35,101,971	**$175,509,854**	**25%**
	95%	$140,407,883	$39,253,746	$39,314,207	**$179,722,090**	**28%**
	100%	$140,407,883	$53,780,961	$54,759,074	**$195,166,957**	**39%**

Table 6-1 – O&M Cost Contingency Summary

Most Likely Cost Estimate	$450,266,000	
Confidence Level	Value	Contingency
0%	378,223,572	-16.00%
5%	432,255,511	-4.00%
10%	445,763,495	-1.00%
15%	459,271,480	2.00%
20%	468,276,803	4.00%
25%	477,282,126	6.00%
30%	481,784,788	7.00%
35%	490,790,111	9.00%
40%	499,795,434	11.00%
45%	504,298,096	12.00%
50%	508,800,757	13.00%
55%	513,303,419	14.00%
60%	522,308,742	16.00%
65%	526,811,404	17.00%
70%	535,816,727	19.00%
75%	544,822,050	21.00%
80%	549,324,712	22.00%
85%	558,330,035	24.00%
90%	571,838,019	27.00%
95%	589,848,666	31.00%
100%	670,896,574	49.00%

Table 6-2 – O&M Cost Contingency Summary

	Percentile	Baseline TPC	Model Output	Congingency Amount	Baseline w/ Contingency	Contingency %
PROJECT CONTINGENCY (BASELINE ESTIMATE)	0%	$450,266,157	-$71,489,034	-$72,042,585	**$378,223,572**	**-16%**
	5%	$450,266,157	-$15,778,770	-$18,010,646	**$432,255,511**	**-4%**
	10%	$450,266,157	-$2,991,404	-$4,502,662	**$445,763,495**	**-1%**
	15%	$450,266,157	$7,723,317	$9,005,323	**$459,271,480**	**2%**
	20%	$450,266,157	$15,411,166	$18,010,646	**$468,276,803**	**4%**
	25%	$450,266,157	$23,535,375	$27,015,969	**$477,282,126**	**6%**
	30%	$450,266,157	$31,087,911	$31,518,631	**$481,784,788**	**7%**
	35%	$450,266,157	$37,349,425	$40,523,954	**$490,790,111**	**9%**
	40%	$450,266,157	$45,082,175	$49,529,277	**$499,795,434**	**11%**
	45%	$450,266,157	$51,620,925	$54,031,939	**$504,298,096**	**12%**
	50%	$450,266,157	$57,473,210	$58,534,600	**$508,800,757**	**13%**
	55%	$450,266,157	$62,372,000	$63,037,262	**$513,303,419**	**14%**
	60%	$450,266,157	$68,570,478	$72,042,585	**$522,308,742**	**16%**
	65%	$450,266,157	$76,048,349	$76,545,247	**$526,811,404**	**17%**
	70%	$450,266,157	$83,830,765	$85,550,570	**$535,816,727**	**19%**
	75%	$450,266,157	$91,141,076	$94,555,893	**$544,822,050**	**21%**
	80%	$450,266,157	$97,681,092	$99,058,555	**$549,324,712**	**22%**
	85%	$450,266,157	$107,789,344	$108,063,878	**$558,330,035**	**24%**
	90%	$450,266,157	$119,486,815	$121,571,862	**$571,838,019**	**27%**
	95%	$450,266,157	$137,412,723	$139,582,509	**$589,848,666**	**31%**
	100%	$450,266,157	$216,225,648	$220,630,417	**$670,896,574**	**49%**

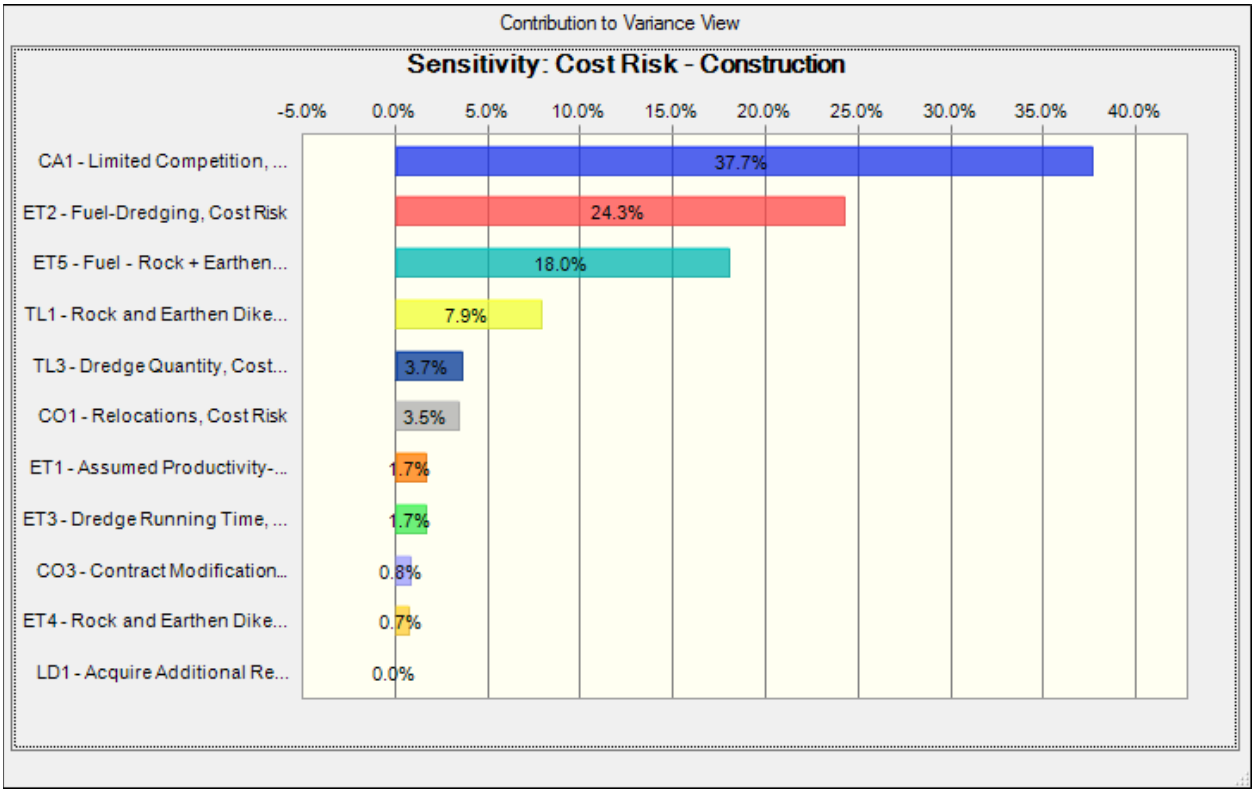

Figure 1 – Sensitivity Analysis (Construction Cost)

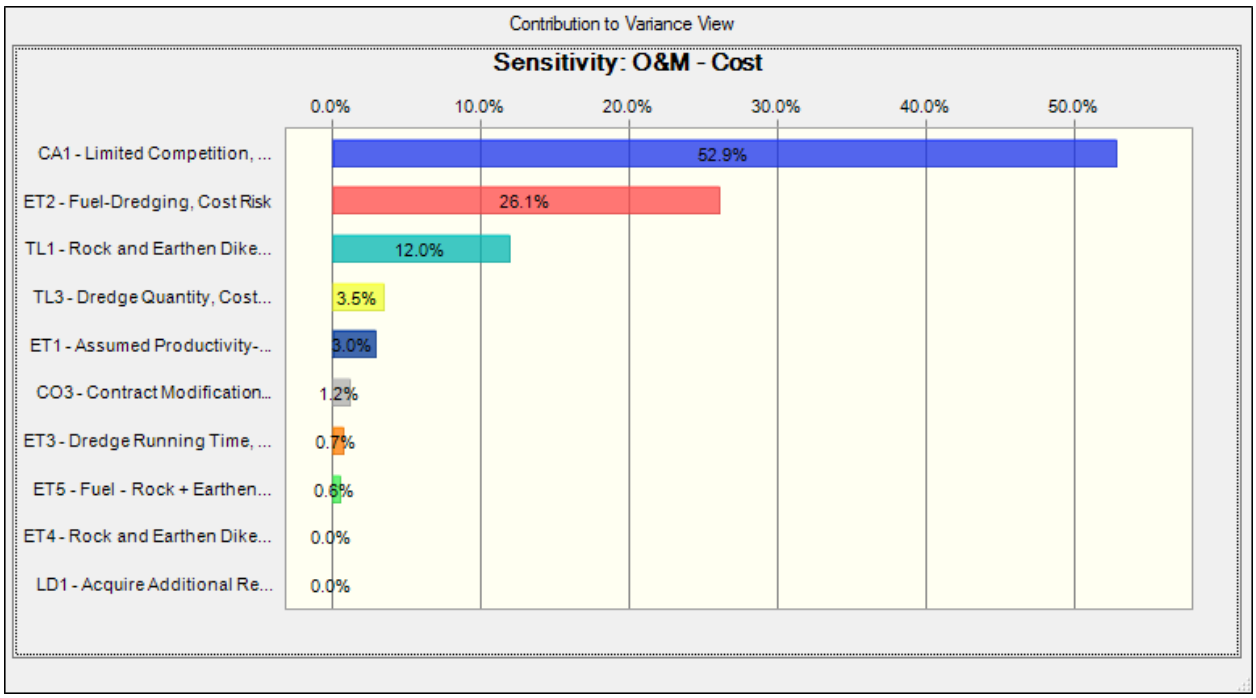

Figure 2 – Sensitivity Analysis (O&M Cost)

6.3 Schedule Risk Analysis - Schedule Contingency Results

The contingency results show a 17 month schedule contingency at the 80% confidence level for the construction phase. For the O&M phase, the results show a 27 month schedule contingency at the 80% confidence level. The contingency at various confidence levels are shown in Tables 7 and 8 followed by the Sensitivity Charts (Figures 3 and 4) for the schedule analysis. These results reflect only those contingencies established from the schedule risk analysis.

Table 7-1 – Construction Schedule Contingency Summary

Base Case Schedule	98.0 Months	
Confidence Level	Value	Contingency
0%	99.0 Months	1.00%
5%	102.9 Months	5.00%
10%	104.9 Months	7.00%
15%	105.8 Months	8.00%
20%	106.8 Months	9.00%
25%	106.8 Months	9.00%
30%	107.8 Months	10.00%
35%	108.8 Months	11.00%
40%	109.8 Months	12.00%
45%	109.8 Months	12.00%
50%	110.7 Months	13.00%
55%	111.7 Months	14.00%
60%	112.7 Months	15.00%
65%	113.7 Months	16.00%
70%	114.7 Months	17.00%
75%	114.7 Months	17.00%
80%	115.6 Months	18.00%
85%	116.6 Months	19.00%
90%	118.6 Months	21.00%
95%	120.5 Months	23.00%
100%	127.4 Months	30.00%

Table 7-2 – Construction Schedule Contingency Summary

PROJECT CONTINGENCY (BASELINE SCHEDULE)	Percentile	Baseline TPC	Model Output	Contingency Amount	Baseline w/ Contingency	Contingency %
	0%	98.0 Months	0	1.0 Months	**99.0 Months**	**1%**
	5%	98.0 Months	5	4.9 Months	**102.9 Months**	**5%**
	10%	98.0 Months	6	6.9 Months	**104.9 Months**	**7%**
	15%	98.0 Months	7	7.8 Months	**105.8 Months**	**8%**
	20%	98.0 Months	8	8.8 Months	**106.8 Months**	**9%**
	25%	98.0 Months	9	8.8 Months	**106.8 Months**	**9%**
	30%	98.0 Months	10	9.8 Months	**107.8 Months**	**10%**
	35%	98.0 Months	10	10.8 Months	**108.8 Months**	**11%**
	40%	98.0 Months	11	11.8 Months	**109.8 Months**	**12%**
	45%	98.0 Months	12	11.8 Months	**109.8 Months**	**12%**
	50%	98.0 Months	12	12.7 Months	**110.7 Months**	**13%**
	55%	98.0 Months	13	13.7 Months	**111.7 Months**	**14%**
	60%	98.0 Months	14	14.7 Months	**112.7 Months**	**15%**
	65%	98.0 Months	15	15.7 Months	**113.7 Months**	**16%**
	70%	98.0 Months	16	16.7 Months	**114.7 Months**	**17%**
	75%	98.0 Months	17	16.7 Months	**114.7 Months**	**17%**
	80%	98.0 Months	17	17.6 Months	**115.6 Months**	**18%**
	85%	98.0 Months	18	18.6 Months	**116.6 Months**	**19%**
	90%	98.0 Months	20	20.6 Months	**118.6 Months**	**21%**
	95%	98.0 Months	22	22.5 Months	**120.5 Months**	**23%**
	100%	98.0 Months	29	29.4 Months	**127.4 Months**	**30%**

Table 8-1 – O&M Schedule Contingency Summary

Base Case Schedule	296.0 Months	
Confidence Level	Value	Contingency
0%	284.2 Months	-4.00%
5%	293.0 Months	-1.00%
10%	299.0 Months	1.00%
15%	301.9 Months	2.00%
20%	301.9 Months	2.00%
25%	304.9 Months	3.00%
30%	307.8 Months	4.00%
35%	307.8 Months	4.00%
40%	310.8 Months	5.00%
45%	310.8 Months	5.00%
50%	313.8 Months	6.00%
55%	316.7 Months	7.00%
60%	316.7 Months	7.00%
65%	316.7 Months	7.00%
70%	319.7 Months	8.00%
75%	322.6 Months	9.00%
80%	322.6 Months	9.00%
85%	325.6 Months	10.00%
90%	328.6 Months	11.00%
95%	334.5 Months	13.00%
100%	352.2 Months	19.00%

Table 8-2 – O&M Schedule Contingency Summary

PROJECT CONTINGENCY (BASELINE SCHEDULE)	Percentile	Baseline TPC	Model Output	Contingency Amount	Baseline w/ Contingency	Contingency %
	0%	296.0 Months	-11 Months	-11.8 Months	**284.2 Months**	**-4%**
	5%	296.0 Months	-1 Months	-3.0 Months	**293.0 Months**	**-1%**
	10%	296.0 Months	2 Months	3.0 Months	**299.0 Months**	**1%**
	15%	296.0 Months	4 Months	5.9 Months	**301.9 Months**	**2%**
	20%	296.0 Months	6 Months	5.9 Months	**301.9 Months**	**2%**
	25%	296.0 Months	8 Months	8.9 Months	**304.9 Months**	**3%**
	30%	296.0 Months	10 Months	11.8 Months	**307.8 Months**	**4%**
	35%	296.0 Months	11 Months	11.8 Months	**307.8 Months**	**4%**
	40%	296.0 Months	13 Months	14.8 Months	**310.8 Months**	**5%**
	45%	296.0 Months	15 Months	14.8 Months	**310.8 Months**	**5%**
	50%	296.0 Months	16 Months	17.8 Months	**313.8 Months**	**6%**
	55%	296.0 Months	18 Months	20.7 Months	**316.7 Months**	**7%**
	60%	296.0 Months	19 Months	20.7 Months	**316.7 Months**	**7%**
	65%	296.0 Months	21 Months	20.7 Months	**316.7 Months**	**7%**
	70%	296.0 Months	22 Months	23.7 Months	**319.7 Months**	**8%**
	75%	296.0 Months	24 Months	26.6 Months	**322.6 Months**	**9%**
	80%	296.0 Months	27 Months	26.6 Months	**322.6 Months**	**9%**
	85%	296.0 Months	29 Months	29.6 Months	**325.6 Months**	**10%**
	90%	296.0 Months	32 Months	32.6 Months	**328.6 Months**	**11%**
	95%	296.0 Months	37 Months	38.5 Months	**334.5 Months**	**13%**
	100%	296.0 Months	53 Months	56.2 Months	**352.2 Months**	**19%**

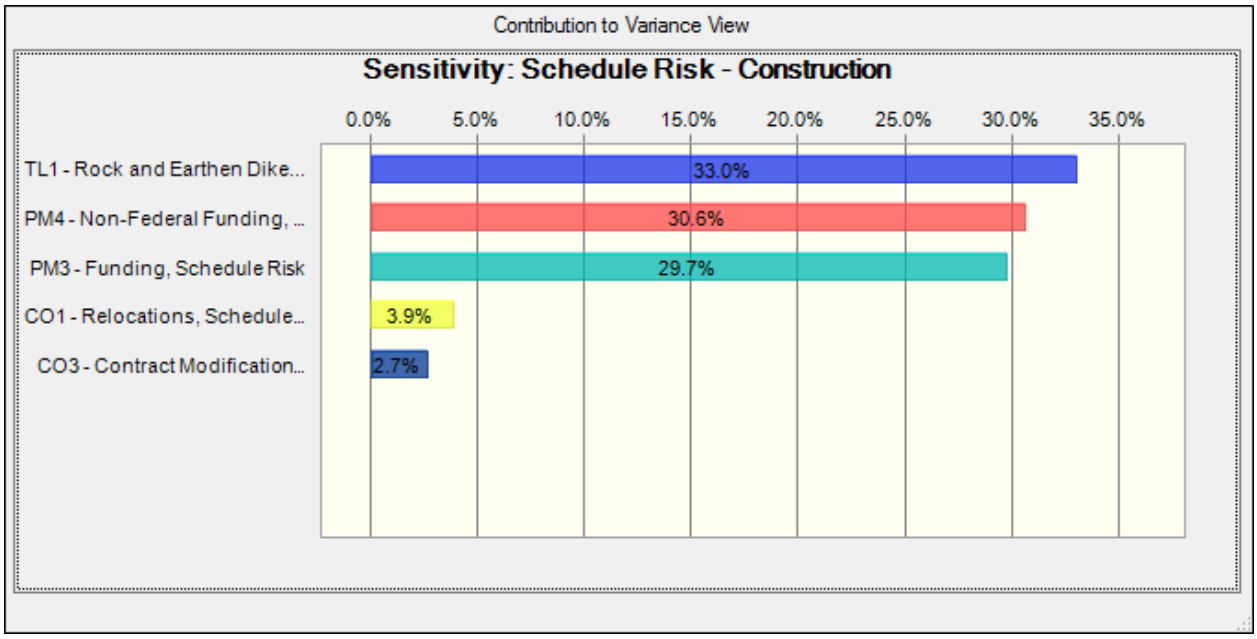

Figure 3 – Sensitivity Analysis (Construction Schedule)

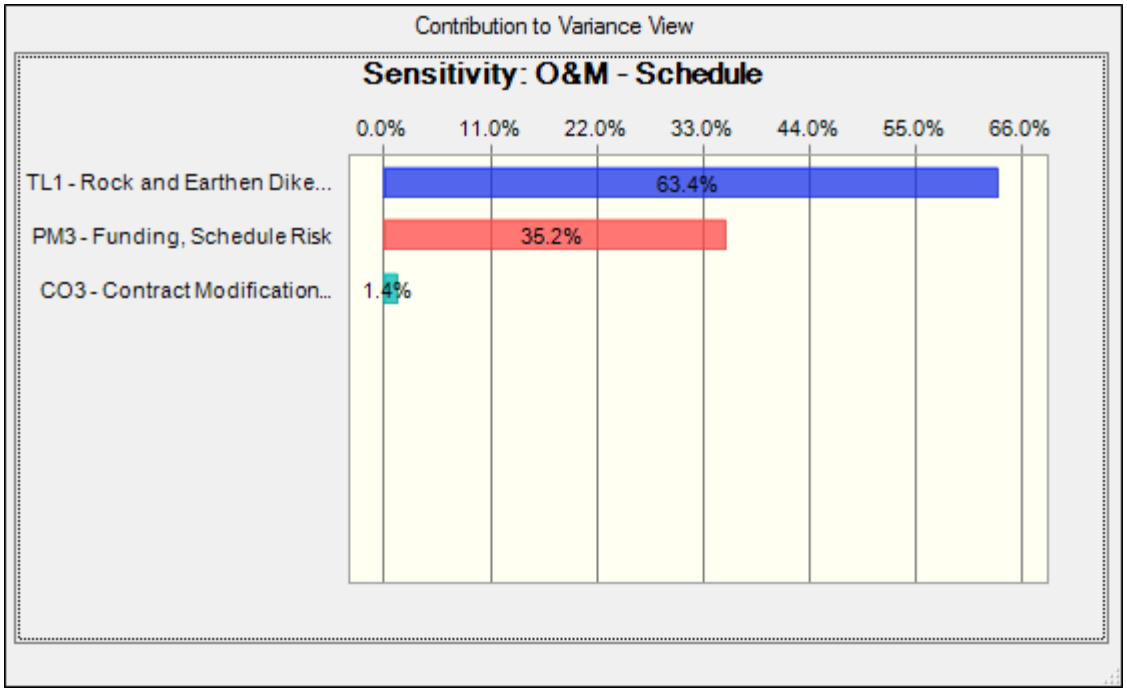

Figure 4 – Sensitivity Analysis (O&M Schedule)

7. MAJOR FINDINGS / OBSERVATIONS

The most significant cost risks for this project are CA1 (Limited Competition), ET2 (Fuel Prices), ET5 (Rock and Earthen Dike Fuel Prices), and TL1 (Rock and Earthen Dike Quantities). At the 80% confidence level Events CA1 and TL1 contribute $10,788,900 and $2,260,800 to the construction contingency respectively. At the 80% confidence level Events CA1 and TL1 contribute $51,673,300 and $11,721,800 to the O&M contingency respectively. The highest risks to the construction schedule are the TL1 (Rock and Earthen Dike Quantities – 6 Months), PM4 (Non-Federal Funding – 5 Months), and PM3 (Funding – 5 Months). The highest risks to the O&M schedule are the TL1 (Rock and Earthen Dike Quantities – 17 Months) and PM3 (Funding – 10 Months).

8. MITIGATION RECOMMENDATIONS

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The cost and schedule risk analysis indicate that the following factors have the most significant impact to the project contingency as shown in Table 9:

Table 9 – Factor Impact to Project Contingencies

Event	Cost Contingency	Schedule Contingency
Limited Competition	$62,462,200	n/a
Fuel Prices	$37,600,100	n/a
Rock and Earthen Dike Quantities	$13,982,600	23 Months
Dredging Quantities	$4,477,700	n/a
Dredging Productivity	$3,416,900	n/a
Relocation Costs	$1,001,600	1 Month
Federal Funding	n/a	15 Months
Non-Federal Funding	n/a	6 Months
Contract Modifications	n/a	1 Month

The most significant event impact to the risk of increased costs is the **Limited Competition**. To offset the impacts of this risk, contracts should be smaller in nature, over smaller reaches, to allow for more qualified dredging contractors the opportunity to bid. This would result in more competition and thereby, lower bids.

Another significant risk impact is **Fuel Prices**. This cannot be controlled or impacted by the PDT. As the project progresses closer to a construction date the fuel prices will be easier to predict and the contingency can be refined to reflect a narrower variation in the projected prices.

The next largest impact on the contingency for the project cost is related to the **Rock and Earthen Dike Quantities**. The risk can be reduced before construction by obtaining additional surveys within the disposal areas and along the bank of the HNC where rock stabilization will be utilized. More thorough geotechnical investigations would also provide a better understanding of the settlement rates and the rock required over the 50-year O&M phase. Schedule risks would

also be reduced by gaining a more accurate estimation of the quantities required for rock and dike work.

Dredging Quantities and Productivity also represents a cost risk to the project. To offset this risk additional geotechnical investigations, as well as topographic and bathymetric surveys should be conducted during the Pre-Construction Engineering and Design phase of the project.

Increases in **Relocation Costs** could also result in higher construction costs, along with schedule delays. This risk could be reduced by performing additional utility surveys and investigations during the design phase of the project.

Congressional and Non-Federal Funding is required to construct each segment of this project. The future funding of the U.S. Corps of Engineers (COE) or the Non-Federal Sponsors, including the Louisiana Department of Transportation and Development and the Terrebonne Port Commission, could be reduced such that funding available to either sponsor may not cover these contracts. Mitigation of this risk requires that District COE staff continue to make funding requests and the local sponsor continue to work with the congressional delegation to ensure project priority and adequate funding.

Contract Modifications are a risk if the contractor encounters unexpected conditions. The most likely change in conditions is the variability in material encountered during dredging operations. As discussed previously with regard to the dredging assumptions, additional soil studies will help mitigate this risk. Underwater surveys will also contribute to the reduction of risk of unknown conditions and all a more refined estimate of dredge quantities and rock placement quantities. Also at risk is encountering additional utilities or other existing facility relocations. Mitigation of this risk includes additional efforts in utility investigations during the design phase to improve the relocation plan.

9. REFERENCES

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U.S. Army Corps of Engineers, 2008b, *Construction Cost Estimating Guide For Civil Works, Engineering Technical Letter 1110-2-573,* Department of the Army, Washington D.C., 30 September 2008.

U.S. Army Corps of Engineers, 2009, *Cost and Schedule Risk Analysis Guidance,* Department of the Army, Washington D.C., 17 May 2009.

APPENDIX A

Project Delivery Team Risk Register

Houma Navigation Canal Deepening Project - Construction Phase

Risk Matrix

Likelihood of Occurrence	Impact or Consequence of Occurrence				
	Negligible	Marginal	Significant	Critical	Crisis
Certain	Moderate	Moderate	High	High	High
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	Moderate

Overall Project Scope
Construction Phase of HNC Deepening Project - Construction Phase

SEE ASSUMPTIONS TAB FOR COST VALUE RANGES DEVELOPMNENT

Negligible--- ***Less than***			**$702,040**	**3 Months**	
Marginal ---*between*	**$702,041**	**and**	**$2,808,160**	**3 Months**	**and 5 Months**
Significant ---*between*	**$2,808,161**	**and**	**$4,212,240**	**5 Months**	**and 10 Months**
Critical--- *between*	**$4,212,241**	**and**	**$7,020,400**	**10 Months**	**and 20 Months**
Crisis ---*Over*	**$7,020,401**			**20 Months**	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)														
	PROJECT & PROGRAM MGMT														
PM1	Scope Growth	Additional features added to the scope in later stages could change the project cost and schedule.	Changes to deepening scope will likely involve needing to dispose of material in additional areas. This would result in an impact to cost and schedule. The risks associated with changes in quantities and real estate issues related to new disposal areas are already considered in TL2 and LD1. Since the only potential for scope change involves changes to quantities (which are already accounted for), this risk is classified as negligible.	Likely	Negligible	LOW		Likely	Negligible	LOW		Triangular			
PM2	Staff Issues	Staff could be over worked or insufficient to work on the project.	There are times of the year that staff is overtaxed. Work could be done to avoid the end of the FY push.	Likely	Negligible	LOW		Unlikely	Negligible	LOW		Triangular			
PM3	Funding	Difficulty securing funding could delay project start or award of project.	If the funding stream is delayed then the construction of the project shall be delayed. Industry along the channel and the price of oil will determine this channels importance. Since funding is determined on a yearly basis, it is assumed that a delay in funding would result in a 12 month delay.	Unlikely	Marginal	LOW		Likely	Significant	HIGH	12 Months	Triangular			
PM4	Non-Federal Funding	Ability of Non-Federal sponsor to provide 10% cost share	The state (Non Federal Sponsor) is currently cash strapped and will have to determine itself the importance of this channel. Since funding is determined on a yearly basis, it is assumed that a delay in funding would result in a 12 month delay.	Unlikely	Negligible	LOW		Likely	Significant	HIGH	12 Months	Triangular			
	CONTRACT ACQUISITION RISKS														
CA1	Limited Competition	There is healthy competition for the upper reaches and the bay channel of HNC. However in Cat Island Pass competition is reduced because only a large cutterhead can successfully complete the work.	In periods of limited competition dredging contractor's will bid higher and in times of abundant competition more competitive bidding will be produced. Based on past dredging projects, it is assumed that this ranges from -15% to +20% in cost.	Likely	Significant	HIGH	$15,507,900 - $25,846,600	Likely	Negligible	LOW		Triangular			
CA2	Accelerated Schedule	An aggressive work schedule required by this contract could limit the bidder's interest or willingness to bid on this contract.	Aggressive schedules could limit contractors ability to participate or eliminate their interest in bidding for the work, therefore contractors (being aware of probable limited interest) will bid closer to the 25% threshold of IGE. Reference CA-1.	Likely	Negligible	LOW		Very Likely	Negligible	LOW		Triangular			
	TECHNICAL RISKS														
TL1	Rock and Earthen Dike Quantities	Overbank geotechnical data will addressed in PED. 20% settlement was assumed on bankline quantities for rock.	If existing conditions in the areas that receive earthen materials or stone are different than we assume then quantity changes will be incurred. From discussion with PDT the range of quantity adjustment could be 5% less and 25% more. Schedule would be impacted by 5% less and 10% more.	Likely	Marginal	MODERATE	$2,333,100 - $17,345,600	Likely	Significant	HIGH	5 mo; + 10 mo	Triangular			
TL2	Adequate Disposal Capacity	Due to changes in quantities, disposal areas could be undersized.	The project could encounter delays and cost increases as a result of unexpected losses of disposal areas. Most inland reaches are unconfined with additional capacity. A few upland sites are a low risk for capacity issues, but higher for RE if landowner issues occur. Disposal plan was reworked to accommodate estimated material needs, decreasing likelihood. No concerns for Terrebonne Bay - adjacent disposal.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW		Triangular			

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
TL3	Dredge Quantity	There is high confidence in our construction for dredging however the maintenance quantity on top may vary.	The upper reaches are dredged much less and we have high confidence in this reach. The bay channel reach gets periodic dredging so the maintenance material is light and easily dredged. The bar channel could have a cost affected change in quantities due to increased shoaling rates. The PDT decided that a -5% to + 10% range would be appropriate for cost and schedule (negligible) for the Cat Island portion of construction.	Likely	Marginal	MODERATE	$408,077 - $2,870,323	Likely	Negligible	LOW	1 Month - 2 Months	Triangular			
	LANDS AND DAMAGES RISKS														
LD1	Acquire Additional Real Estate for Disposal Areas	When disposal areas fill to capacity within Inland Reach and Terrebonne Bay, additional areas need to be obtained. Some of the land owners may resist the projects needs.	A 25% contigency is included in Lands and Damages costs. Therefore, Account 01 costs were not included in the risk analysis costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW		Triangular			
LD2	Oyster Lease Compensation	State may not wish to extinguish oyster leases for entire area requested, deeming it too expensive and politically charged.	Only one disposal area contains oyster leases. If leases are an issue, a new disposal area is likely to be identified. Therefore, project completion not likely to be impacted; construction would simply proceed with different disposal alternative. The risk associated with additional disposal need are accounted for in LD1.	Unlikely	Negligible	LOW		Unlikely	Marginal	LOW		Triangular			
	REGULATORY AND ENVIRONMENTAL RISKS														
REG1	Threatened & Endangered Species Identified	Unexpected Threatened and Endangered Species occurrence.	Schedule delays could occur if T&E species are identified in the project area before construction dredging. Federal and State agencies have weighed in on potential impacts, so the likelihood of observed risks is very low.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW		Triangular			
REG2	Cultural Resources Encountered	Risk that some unidentified cultural resource could be identified prior to or during construction dredging.	The impact of encountering unknown cultural resources would influence cost and schedule cost, however likelihood of encounters in HNC are low. Disposal areas and access paths have been culturally cleared. Any disposal impacts would be small given material is placed and covered.	Very Unlikely	Marginal	LOW		Very Unlikely	Marginal	LOW		Triangular			
	CONSTRUCTION RISKS														
CO1	Relocations	Existing utilities are to be relocated. Pipeline utilities cross the HNC. Some coordination and/or construction issues could occur. Utility locations could be off or require additional work.	All utilities are subsurface lines. A couple of relocations were identified. Based on depth of dredging along with directional drilling requirements. No coordination with Utilities Co., has occurred. No field investigations have been performed. A 30% increase in relocation costs was assumed to account for this cost risk. Schedule risk would be due to potential coordination issues or boring angle requirements that may increase real estate needs (covered in LD1). Assume an additional two more gas pipelines need relocations (one 30-inch in inland reach and one 3-inch line in Bay). Assume linear increase in duration from 23 to 25 utilities.	Likely	Marginal	MODERATE	(High) $2,529,900 Low and Base costs remain the same.	Likely	Marginal	MODERATE	23 utilities over 1,638 days results in 5 Mo for the two additional utilities	Triangular			
CO2	Maintaining Navigation Traffic	Navigation traffic interference during construction could be an issue.	Contractors and designers are experienced with traffic control under existing maintenance dredging program. This is currently captured conservatively in the dredging running time in CEDEP. Therefore likelihood is low. Navigation interference would reduce productivity, which is covered in ET1.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW		Triangular			
CO3	Contract Modifications	There may be modification issues that have not been captured in current risks.	Requirement for new work material or decreased dredgability may result in change order requests, which would require contract modifications. It is assumed that such modifications would result in a 5% increse in costs, the low and base costs would remain the same. Potential of encountering excessive debris & trash, and rock (accounted for in ET3). Extended overhead, standby costs (ET3). Potential for differing site conditions due to coarse boring grid (accounted for in TL1). Cat Island Pass, waves and stiff material (new work). TL-1, TL-2 and TL-3 capture quantity risk. The likely requirement for modified contracts would result in additional time (since contracts are idendependant of each other time increase is assumed to be 4 months).	Likely	Marginal	MODERATE	(High) $5,169,300 Low and Base costs remain the same.	Likely	Marginal	MODERATE	4 Months	Triangular			
CO4	Adverse Weather	Severe weather may impact cost or schedule.	Most of project is in inland and bay areas, reduced impact from bad weather. The Cat Island Pass region could impact due to storms (Additional Mobilization) but is covered in CO-3	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW		Triangular			
	ESTIMATE AND SCHEDULE RISKS														

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
ET1	Assumed Productivity-Dredging	The estimate's assumed productivity for dredging may be inaccurate. A small variance could impact overall cost as compared to the bid. Schedule has reduced impacts due to separate contracts per reach.	Dredging productivity developed by experienced estimators via CEDEP software. Dredge production ranging 20% higher to 10% less. Impacts were quantified by MII.	Likely	Marginal	MODERATE	$-5,267,700 - $3,855,015	Likely	Negligible	LOW		Triangular			
ET2	Fuel-Dredging	Fluctuations in fuel costs can impact dredging costs. Schedule has reduced impacts due to separate contracts per reach.	Fuel costs could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed. Impacts were quantified by MII. Resulted in a low impact of 10% and a high impact of 17%.	Likely	Significant	HIGH	$-10,153,968 - $17,379,500	Likely	Negligible	LOW		Triangular			
ET3	Dredge Running Time	Variance in Dredge Running time shall impact dredging costs. Schedule has reduced impacts due to separate contracts per reach.	In the inland and bay channel reach running time could vary from 14 to 18 hours per day. In Cat Island Pass the dredge running time could vary from 14 to 10 hours. Impacts were quantified by MII. Resulted in a low impact of 2% and a high impact of 5%.	Likely	Marginal	MODERATE	$-2,182,768 - $2,977,215	Likely	Negligible	LOW		Triangular			
ET4	Rock and Earthen Dike Productivity	The estimate's assumed productivity for rock installation may be inaccurate. A small variance could impact overall cost as compared to the bid.	To quantify this risk the rock and dike productivity was increased to 2,600 ton/day and decreased to 1,000 tons/day for low and high, respectively. Impacts were quantified by MII.	Likely	Marginal	MODERATE	$-2,218,263; $2,551,753	Likely	Negligible	LOW		Triangular			
ET5	Fuel - Rock + Earthen Dike	Fluctuations in fuel costs can impact the cost for rock delivery as well as rock and earthen dike construction. Schedule has reduced impacts due to separate contracts per reach.	Fuel costs for rock delivery and construction of earthen dikes could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed.	Likely	Significant	HIGH	$-6,045,071 - $8,978,184	Likely	Negligible	LOW		Triangular			
	Programmatic Risks	(External Risk items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)													

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

Houma Navigation Canal Deepening Project - O&M Phase

Risk Matrix

Likelihood of Occurrence	Impact or Consequence of Occurrence				
	Negligible	Marginal	Significant	Critical	Crisis
Certain	Moderate	Moderate	High	High	High
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	Moderate

Overall Project Scope
Construction Phase of HNC Deepening Project - Construction Phase

-
SEE ASSUMPTIONS TAB FOR COST VALUE RANGES DEVELOPMNENT

Negligible--- ***Less than***		**$2,251,330**		**9 Months**	**9 Months**
Marginal ---*between*	**$2,251,331**	**and $9,005,320**		**9 Months**	**and 15 Months**
Significant ---*between*	**$9,005,321**	**and $13,507,980**		**15 Months**	**and 30 Months**
Critical--- *between*	**$13,507,981**	**and $22,513,300**		**30 Months**	**and 59 Months**
Crisis ---*Over*	**$22,513,301**			**59 Months**	

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)														
	PROJECT & PROGRAM MGMT														
PM1	Scope Growth	Additional features added to the scope in later stages could change the project cost and schedule.	Changes to O&M scope will likely involve needing to dispose of material in additional areas. This would result in an impact to cost and schedule. The risks associated with changes in quantities and real estate issues related to new disposal areas are already considered in TL2 and L1. Since the only potential for scope change involves changes to quantities (which are already accounted for), this risk is classified as negligible.	Likely	Negligible	LOW		Likely	Negligible	LOW		Triangular			
PM2	Staff Issues	Staff could be over worked or insufficient to work on the project.	There are times of the year that staff is overtaxed. Work could be done to avoid the end of the FY push.	Likely	Negligible	LOW		Unlikely	Negligible	LOW		Triangular			
PM3	Funding	Difficulty securing funding could delay project start or award of project.	If the funding stream is delayed then the O&M phase of the project shall be delayed. Industry along the channel and the price of oil will determine this channels importance. Since funding is determined on a yearly basis, it is assumed that a delay in funding would result in a 10% schedule delay (29 months).	Unlikely	Marginal	LOW		Likely	Significant	HIGH	29 Months	Triangular			
PM4	Non-Federal Funding	Ability of Non-Federal sponsor to provide Real Estate costs for additional disposal sites. This risk is covered in Risk LD1.	The state (Non Federal Sponsor) is currently cash strapped and will have to determine itself the importance of this channel. This risk is covered in Risk LD1.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW		Triangular			
	CONTRACT ACQUISITION RISKS														
CA1	Limited Competition	There is healthy competition for the upper reaches and the bay channel of HNC. However in Cat Island Pass competition is reduced because only a large cutterhead can successfully complete the work.	In periods of limited competition dredging contractor's will bid higher and in times of abundant competition more competitive bidding will be produced. Based on past dredging projects, it is assumed that this ranges from -15% to +20% in cost.	Likely	Significant	HIGH	$-67,539,900; $112,566,500	Likely	Negligible	LOW		Triangular			
CA2	Accelerated Schedule	An aggressive work schedule required by this contract could limit the bidder's interest or willingness to bid on this contract.	Aggressive schedules could limit contractors ability to participate or eliminate their interest in bidding for the work, therefore contractors (being aware of probable limited interest) will bid closer to the 25% threshold of IGE. Reference CA-1.	Likely	Negligible	LOW		Very Likely	Negligible	LOW		Triangular			
	TECHNICAL RISKS														

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
TL1	Rock and Earthen Dike Quantities	Overbank geotechnical data will addressed in PED. 20% settlement was assumed on bankline quantities for rock.	Same assumptions were made for O&M quantities as for construction. If existing conditions in the areas that receive earthen materials or stone are different than we assume then quantity changes will be incurred. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, decreased quantities result in a 2% reduction in cost and increased quantities result in a 13% increase in base O&M costs. These percentages were applied directly to the base O&M costs. Schedule would be impacted by 5% less and 10% more.	Likely	Significant	HIGH	$-9,005,300; $76,545,300	Likely	Significant	HIGH	15 Months; 29 Months	Triangular			
TL2	Adequate Disposal Capacity	Due to changes in quantities, disposal areas could be undersized.	The project could encounter delays and cost increases as a result of unexpected losses of disposal areas. Most inland reaches are unconfined with additional capacity. A few upland sites are a low risk for capacity issues, but higher for RE if landowner issues occur. Disposal plan was reworked to accommodate estimated material needs, decreasing likelihood. No concerns for Terrebonne Bay - adjacent disposal.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW		Triangular			
TL3	Dredge Quantity	Maintenance quantities could vary over duration of the work.	The upper reaches are dredged much less than the lower reaches, but shoaling is reduced as well. The bay channel reach gets periodic dredging so the maintenance material is light and easily dredged. The bar channel could have increased quantities due to increased shoaling rates. The PDT decided that for O&M a -5% to + 10% range would be appropriate for cost and schedule for the Bay and Cat Island Pass reaches during O&M. This represents an increased risk over construction.	Likely	Marginal	MODERATE	$-2,034,500; $35,892,500	Likely	Negligible	LOW		Triangular			
	LANDS AND DAMAGES RISKS														
LD1	Acquire Additional Real Estate for Disposal Areas	When disposal areas fill to capacity within Inland Reach and Terrebonne Bay, additional areas need to be obtained. Some of the land owners may resist the projects needs.	A 25% contingency is included in Lands and Damages costs. Therefore, Account 01 costs were not included in the risk analysis costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW		Yes/No			
	REGULATORY AND ENVIRONMENTAL RISKS														
REG1	Threatened & Endangered Species Identified	Unexpected Threatened and Endangered Species occurrence.	Schedule delays could occur if T&E species are identified in the project area before construction dredging. Federal and State agencies have weighed in on potential impacts, so the likelihood of observed risks is very low.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW		Triangular			
REG2	Cultural Resources Encountered	Risk that some unidentified cultural resource could be identified prior to or during construction dredging.	The impact of encountering unknown cultural resources would influence cost and schedule cost, however likelihood of encounters in HNC are low. Disposal areas and access paths have been culturally cleared. Any disposal impacts would be small given material is placed and covered.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW		Triangular			
	CONSTRUCTION RISKS														
CO2	Maintaining Navigation Traffic	Navigation traffic interference during O&M could be an issue.	Contractors and designers are experienced with traffic control under existing maintenance dredging program. This is currently captured conservatively in the dredging running time in CEDEP. Therefore likelihood is low. Navigation interference would reduce productivity, which is covered in ET1.	Unlikely	Negligible	LOW		Unlikely	Marginal	LOW		Triangular			

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
CO3	Contract Modifications	There may be modification issues that have not been captured in current risks.	Requirement for new work material or decreased dredgability may result in change order requests, which would require contract modifications. It is assumed that such modifications would result in a 5% increse in costs, the low and base costs would remain the same. Potential of encountering excessive debris & trash, and rock (accounted for in ET3). Extended overhead, standby costs (ET3). Potential for differing site conditions due to coarse boring grid (accounted for in TL1). Cat Island Pass, waves and stiff material (new work). TL-1, TL-2 and TL-3 capture quantity risk. The likely requirement for modified contracts would result in additional time (since contracts are idendependant of each other time increase is assumed to be 6 months).	Likely	Marginal	MODERATE	(High) $22,513,308 Low and Base costs remain the same.	Likely	Marginal	MODERATE	6 months				
CO4	Adverse Weather	Severe weather may impact cost or schedule.	Most of project is in inland and bay areas, reduced impact from bad weather. The Cat Island Pass region could impact due to storms (Additional Mobilization) but is covered in CO-3	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW		Triangular			
	ESTIMATE AND SCHEDULE RISKS														
ET1	Assumed Productivity-Dredging	The estimate's assumed productivity for maintenance dredging may be inaccurate. A small variance could impact overall cost as compared to the bid.	Dredging productivity developed by experienced estimators via CEDEP software. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. To evaluate the risk productivity was decreased by 10% and increased by 20%. The cost impacts were captured by MII software. Therefore, decreased production results in a 5.2% increase in cost and increased production results in a 3.8% decrease in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Marginal	MODERATE	$-21,902,200; $18,870,200	Likely	Negligible	LOW		Triangular			
ET2	Fuel-Dredging	Fluctuations in fuel costs can impact dredging costs.	Fuel costs could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, decreased fuel costs result in a 10% reduction in cost and increased fuel costs result in a 17% increase in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Significant	HIGH	$-45,380,894; $77,673,900	Likely	Negligible	LOW		Triangular			
ET3	Dredge Running Time	Variance in Dredge Running time shall impact dredging costs/schedule.	In the inland and bay channel reach running time could vary from 14 to 18 hours per day. In Cat Island Pass the dredge running time could vary from 14 to 10 hours. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, increased running time results in a 2% decrease in cost and increased running time results in a 3% increase in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Marginal	MODERATE	$-8,114,400; $14,947,100	Likely	Negligible	LOW		Triangular			

Risk No.	Risk/Opportunity Event	Concerns	PDT Risk Conclusions, Justification	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
ET4	Rock and Earthen Dike Productivity	The estimate's assumed productivity for rock delivery/placement and earthen dike construction/maintenance may be inaccurate. A small variance could impact overall cost as compared to the bid.	Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. To evaluate the risk productivity was decreased by 10% and increased by 20%. The cost impacts were captured by MII software. Therefore, decreased production results in a 2.5% increase in cost and increased production results in a 2.2% decrease in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Negligible	LOW	$-1,746,500 $1,984,700	Likely	Negligible	LOW		Triangular			
ET5	Fuel - Rock + Earthen Dike	Fluctuations in fuel costs can impact rock placement and dike construction.	Fuel costs could result in either lower or higher costs, resulting in some risk. Fuel variance of $4.00 to $1.50 per gallon shall be analyzed. Due to the similar nature of construction methodology between deepening and maintenance, impacts were developed by applying the same percentage of cost and schedule impacts as observed in the construction risk. Therefore, decreased fuel costs result in a 10% reduction in cost and increased fuel costs result in a 15% increase in base construction costs. These percentages were applied directly to the base O&M costs.	Likely	Marginal	MODERATE	$-7,927,929; $12,959,920	Likely	Negligible	LOW		Triangular			
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)													

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.