US Army Corps of Engineers®
New York District

NEW YORK AND NEW JERSEY HARBOR DEEPENING CHANNEL IMPROVEMENTS

NAVIGATION STUDY

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL ASSESSMENT

APPENDIX B4:

Cost Engineering

Contents

1. Introduction

The enclosed cost engineering analysis corresponds with deepening the major shipping channels of the NY/NJ Harbor for the two pathways studied to an authorized depth of -55FT MLLW. The two pathways include the larger “Sea to Elizabeth-Port Authority Marine Terminal (EPAMT) Pathway” and the smaller “Mid-Anchorage to Port Jersey-Port Authority Marine Terminal (PJPAMT) Pathway”.

The cost engineering process for this study relies heavily on the experience of the New York District’s completion of its most recent harbor expansion projects. Since 2016, the harbor has welcomed some of largest ocean-going vessels calling East Coast American ports. This study examines prospects for a next phase to further deepen, straighten and widen the harbor’s channels using the same methods that were employed during that earlier phase.

In addition to appropriate consideration of and reference to cost and schedule information available from this prior phase of harbor expansion, the cost engineering involved in this study also incorporates important insights into the changed terrain of the harbor bottom as a result of this previous expansion. The widespread use of drilling and blasting the hardest of the harbor’s rock-bottom channels targeting its current 50FT federally authorized depth, allows for some efficiencies and cost savings in the next phase. Specifically, it is expected that significant quantities of consolidated rock that were previously too competent to be dredged without pretreatment will be found ready for excavation, already fractured during the previous phase. That said, there may be some inefficiencies encountered as well: namely, in those areas where the subsurface is fractured but not fully dredgable to grade, drillers may encounter difficulties with blasting the deeper rock due to unstable surfaces.

Volumes, construction assumptions, anticipated means and methods and various supporting and mitigating activities as well as lifecycle maintenance costs are covered in “2. Basis of Costs” below. Construction duration assumptions, risks and estimates are covered in “3. Construction Schedule” and the relationship between assumptions and risks and calculated contingencies for each cost account are discussed in “4. Contingencies”. Finally, the total estimated costs for all accounts for the recommended alternative is summarized in “5. Cost Summaries”, the final section of this Cost Engineering appendix.

Table 1: First Costs Table

New York New Jersey Harbor Deepening Channel Improvement							
October 2021							
Fiscal Year 2022							
Feasibility Report Cost Estimate Summary							
Feat. Acct.	**Description**	**Qty**	**UoM**	**Subtotal**	**Cont. %**	**Cont $$**	**Total Cost**
01	**LANDS AND DAMAGES**	**1**	**LS**	**$10,865,000**	**1.1%**	**$123,000**	**$10,988,000**
02	**RELOCATIONS**	**1**	**LS**	**$1,035,000,000**	**26.0%**	**$269,100,000**	**$1,304,100,000**
06	**FISH& WILDLIFE FACILITIES**	**1**	**LS**	**$11,000,000**	**26.0%**	**$2,860,000**	**$13,860,000**
12	**NAVIGATION PORTS & HARBORS**	**1**	**LS**	**$2,769,586,000**	**26.0%**	**$720,092,000**	**$3,489,678,000**
19	**BUILDINGS, GROUNDS & UTILITIES**	**1**	**LS**	**$25,000,000**	**26.0%**	**6,500,000**	**$31,500,000**
30	**PLANNING, ENGINEERING AND DESIGN**	**1**	**LS**	**$422,464,000**	**26.0%**	**$109,841,000**	**$532,305,000**
31	**CONSTRUCTION MANAGEMENT**	**1**	**LS**	**$144,022,000**	**26.0%**	**$37,446,000**	**$181,468,000**
	TOTAL			**$4,417,937,000**	**25.9%**	**$1,145,962,000**	**$5,563,899,000**

2. Basis of Costs

2.1. Navigation Ports & Harbors (Account 12)

The basis of the majority of the cost estimate for the recommended plan rests with the work associated with the excavation and removal of material to deepen, widen and straighten the shipping channels that make up the pathways to EPAMT and PJPAMT. These construction activities involve dredging, hauling and placement of a minimum required 33 million cubic yards to authorize the channel to 55FT. Including rock and sediment from the designed overdepth templates, the total available pay volume is about 41 million CY.

This material to be removed includes recent sedimentation, much of which is expected to be non-HARS-suitable and to require upland placement and processing. Other sediment to be removed from the designed channel template is expected to be suitable for HARS placement and the remaining material is expected to be consolidated rock or till of various types. Some of the rock is expected to be sufficiently fractured from the previous deepening of the harbor and the remainder will require additional pretreatment before excavation will be feasible and this cost estimate assumes. It is assumed that all required pretreatment will be accomplished with the assistance of drilling and blasting techniques commonly employed by major contractors of the American dredging industry.

2.1.1. Drilling & Blasting

Based on the experience of the previous phase of deepening the harbor and available geotechnical information, it is anticipated that approximately 50% of the volume to be removed from the Sea to EPAMT pathway will require pretreatment before successful excavation with commonly available dredging equipment and techniques. None of the Mid-Anchorage to PJPAMT pathway is expected to require such pretreatment.

This study and the costs contained assume that the required pretreatment is to be accomplished by the same barge-based drilling and blasting techniques that were employed by more than one contractor during the previous phase of deepening. Other techniques for pre-treating hard rock may be available to industry, but are not widely enough used to match the Army Corps Cost Community of Practice's standards for what can be reasonably expected of an average contractor.

An important consideration within this study has been the legacy effects of the blasting performed during the previous phase of channel deepening. In particular, much of the harder rock to be removed in any future deepening projects has already been fractured by the drilling and blasting process. For this reason, it is assumed that 30-40% of the area to be deepened that contains rock that would, in its natural state, require pretreatment, will be clearable to grade without any new drilling and blasting. Should this project be approved for construction, it is strongly recommended that extensive subsurface investigations be applied during the PED phase in order to refine the anticipated template of rock that can be removed without unnecessary blasting. This may also require unique contracting tools and technical specifications to define available material quantities by "refusal" rather than by traditional templates and takeoff methods.

Drilling and blasting cost and schedule estimates were assembled based on offshore crewing, material, production and equipment assumptions consistent with the practices of the dredging industry, including the local restrictions on night-time and Sunday blasting.

Due to the proximity of the proposed blasting activities to developed population centers, a five-sensor vibration monitoring program will follow the blasting activities to facilitate the measurement and assessment of potential damages. These vibration monitoring costs are captured within the drilling and blasting portion of this estimate.

2.1.2. Dredging and Placement

The study's recommended plan involves expansion of the harbor's major shipping channels from the Sea to EPAMT and PJPAMT pathways to an authorized depth of -55FT, MLLW. The primary means for accomplishing such an expansion involves the dredging and removal sedimentary and consolidated earth from the bottoms of the channels.

To deepen to -55FT, MLLW, upwards of 50M CY of material will need to be removed. This includes the minimum required volume (approximately 33M CY), paid overdepth dredging (another 8M CY, standard to the industry, necessary for the efficiency of contracted dredging services) as well as the inevitable non-pay yardage reasonably expected to be dredged adjacent to and deeper than those within the pay template.

Based on the available geotechnical information, the study finds that the total volume of anticipated material will breakdown into approximately 40% HARS-suitable non-consolidated sediment, 20% non-HARS-suitable sediment to be dredged and delivered to an upland processing facility and 40% consolidated material or glacial till to be pre-treated where necessary (see "Drilling and Blasting" section) and dredged and placed either at the HARS or at offshore artificial reef sites.

This cost estimate assumes that all HARS-suitable sediment will be dredged and hauled to the HARS by Trailing Suction Hopper Dredges and that all remaining dredging will be completed by mechanical dredges, with material to be hauled either upland to the processing facilities or offshore to the reef sites in scows propelled by appropriate tugboats.

This estimate also assumes that the dredging of non-HARS-suitable sediment will require the extra precautions and costs which are traditionally involved in handling such materials (such as reduced speed hoisting through the water column, scow dewatering and mechanical land-side unloading methods).

All dredging estimates are produced with the Corps of Engineers Dredge Estimating Program and all drilling and blasting estimates are based on the NY District's labor, materials and equipment estimating tool for such operations. Production and cost assumptions are applied based on typical and reasonable performance of the work by a well-equipped dredging contractor.

Table 2: Depths and Estimated Required Quantities

	Proposed Maintained Channel Level[a] [ft MLLW]	Proposed Authorized Channel Level[b] [ft MLLW]	Total Depth[c] [ft MLLW]	Available Pay Quantity to be Dredged (cy)
	5 FOOT DEEPENING TO -55 FEET MLLW			
Ambrose Channel	58	58	59	8,743,000
Anchorage Channel	55	55	56.5	5,776,000
Port Jersey Channel	55	57	58.5	3,390,000
Kill Van Kull	55	57	58.5	6,162,000
Newark Bay	55	57	58.5	15,632,000
South Elizabeth Channel	55	57	58.5	488,000
Port Elizabeth Channel	55	57	58.5	1,278,000
Total Available Pay Volume	--	--		**41,470,000**

a) Maintained channel level includes the summer salt water draft, squat, salinity, wave motion and safety clearance. The channels will be maintained at this depth.
b) The authorized channel level includes additional safety clearance needed for hard bottom.
c) The total depth includes an additional dredging tolerance (paid overdepth).

2.1.3. Operations & Maintenance

Consistent with the estimated schedules and durations summarized below, construction completion for the 55FT recommended alternative is 2048. The costs of 50 years of additional necessary maintenance dredging is incorporated within the estimated annualized project cost.

The anticipated volume of additional maintenance dredging for each channel is calculated based on the estimated rate of sedimentation observed from past operation and maintenance of the harbor applied to any portions of the channel to be widened as part of this project.

Consistent with current New York District practice, the Port Jersey channel is anticipated to be maintained by dredging every 10 years, the Anchorage channel reaches to be maintained every 7 years and all other channels are assumed to be maintained every 3 years. No additional mob/demob costs are incorporated into the O&M estimate as these costs would be incurred independent of this project.

Table 3: Estimated Increase in Annual Sedimentation for Maintenance Dredging

Channel	Estimated Increase in Annual Sedimentation (CY)
Anchorage	5,318
Kill Van Kull	3,781
Port Jersey	7,409
Newark Bay	86,658
South Elizabeth	540

2.2. Lands & Damages

Cost estimates and contingencies for real estate activities associated with the recommended plan were provided by the Real Estate specialists of the Project Delivery Team. Consult the Real Estate Appendix for details.

2.3. Relocations and Removals

Total utility relocation (Account 02) and utility removal (Account 19) costs associated with this project were estimated in coordination with utility owners throughout the harbor. The total cost for such relocations analyzed in this study correspond with underwater placement techniques similar to their existing conditions. Final determinations will be made regarding the exact scope of any relocation and removal activities in the Planning, Engineering and Design phase of the project upon Congressional Authorization. If significantly more costly differing techniques are required upon further investigation, then additional mitigating approaches may be considered such as adjustments to the channel alignment or otherwise.

2.4. Environmental

Costs associated with environmental mitigation (Fish & Wildlife Facilities, WBS Account 06) were provided by biologists from the study Project Delivery Team. See the appropriate appendices for discussion of these costs.

2.5. Planning, Engineering and Design

The "PED phase" (Account 30) costs were developed for all activities associated with the pre-construction, engineering and design efforts anticipated for successful completion of this project. The cost for this account includes the preparation of Design Documentation Reports, plans, and specifications for the New York and New Jersey Harbor Deepening Channel Improvements, and all planning, project-management, real estate and engineering support before and during construction through project completion.

2.6. Construction Management

The Account 31 cost estimate was developed for all construction management activities from pre-award requirements through final contract closeout. The costs include the in-house labor based upon work-hour requirements, materials, facility costs, support contracts, travel and overhead. The cost was developed based on the input from the PDT in accordance with the Civil Works Breakdown Structure (CWBS) and includes, but not limited to, anticipated items such as the salaries of all government staff associated with the project; operation, maintenance and fixed charges for transportation and for other field equipment; field supplies; construction management, general construction supervision; and project office administration, distributive cost of area office and general overhead charged to the project.

For this study, the recent experience of the New York District's deepening of the harbor to its current federally authorized depth of 50FT, is applicable and this estimate is consistent with that experience.

2.7. Additional risk discussion related to Accounts 30 & 31

Given the significant risks associated with projects of such complexity and magnitude, the planning, preconstruction, design, engineering, and construction-management responsibilities (covered jointly by activities within Accounts 30 and 31) will be central to any successful completion of the recommended plan. The previous discussion reflects the typical percentage-based methods used for estimating costs associated with these government activities. Based on PDT discussions, the following list highlights some of the important specific efforts that must be resourced among these activities.

Within the scope of the program/project management and plan formulation activities, from a cost perspective, the major activities involve—but are not limited to—internal and external coordination, including public outreach and engagement with partners, management of the Project Delivery Team, and maintained consistency with authorization throughout the life of the project.

Within the anticipated scope of the environmental and cultural resource planning responsibilities, the major cost drivers will include maintaining compliance with all water quality requirements, additional public outreach and inter-agency coordination, preconstruction monitoring and mitigation-planning activities (such as MVERP emissions and shallow water impact mitigation, among others), mitigation construction works as required, a complete cultural resource survey and more.

Within engineering, a particularly important set of risk-mitigating pre-construction activities will fall to the geotechnical and other civil design disciplines to better identify the exact scope of the project, including the constructability of its demolition, relocation, dredging and blasting activities. Such preparations will necessarily include additional geophysical surveys (to include, e.g., marine electrical resistivity, LIDAR surveys and more borings), stability analysis as well as test-pit digging exercises to assess the quality of previously blasted (or otherwise fractured) rock portions of the harbor bottom. Recurring ship simulation modelling and development and review of plans and specifications (and any modifications thereof) will span both the PED and S&A phases.

The major anticipated costs among responsibilities within the Real Estate disciplines relate most of all to the activities required to coordinate with all utility owners adjacent to the project locations. Some of these utilities will require relocation and some will only require monitoring. This work must be prioritized early within the PED phase to mitigate schedule risk associated with delays to any necessary relocations. Additional Real Estate costs associated with PED and S&A may include relatively minor acquisition or right-of-way costs associated with some of the structures expected to be impacted by construction activities.

Upon the start of actual construction activities, the recommended project's supervision and quality assurance activities will need to include ongoing public engagement and project management activities, ongoing engineering adjustments such as maintaining the blast plan, material disposal plans and otherwise monitoring impacts on the environment and nearby structures and communities, and more.

2.8. Berth Deepening Costs

Similar to Interest During Construction (see below), the estimated costs of deepening the port's berths is a necessary consideration in the overall cost benefit analysis but is not part of the estimated total project cost. For the purpose of its appropriate consideration, these berth deepening costs are estimated based on the volumes provided applied to the average dredging costs (including upland placement and blasting where applicable) of the adjacent channel reach as estimated for the Navigation Ports and Harbors Account 12. Similar to utility relocation costs discussed above, these costs will not be borne by the government but will be the responsibility of the non-federal sponsor.

3. Construction Schedule

The enclosed estimated construction schedule assumes that dredging activities will begin at the start of Fiscal Year 2025 and be completed by the year 2049. This 23.8-year estimated duration includes a 52% schedule contingency. The base duration estimate (15.7 years) assumes that throughout the project life, on average 1.8 dredges will be actively working in the harbor at any given time and that during any blasting operations, one drillboat will be working in the harbor. It is assumed that all other required activities, such as utility relocations, any real estate acquisitions and mitigation activities will take place concurrent with the dredging activities required throughout the project.

4. Interest During Construction

Interest during construction (IDC) is the amount of interest the construction cost would earn were it invested from the beginning of construction until the accumulation of benefits begins. IDC cost has been added to the project cost to determine investment cost. Average annual cost was determined based on investment cost, which includes IDC. The pre-base year costs were estimated using the Federal interest rate of 2.25 percent (FY22).

Table 4: Annualized Costs Table

NY/NJ HARBOR DEEPENING & CHANNEL IMPROVEMENTS STUDY (5FT ALT)			
Annualized Cost Summary			
First Cost			$ 5,563,899,268
Sunk Cost			$ -
Investment Cost			
Sponsor costs (berth deepening)			$ 85,266,643
Interest During Construction (a)			$ 1,549,410,134
		Total Investment Cost:	$ 7,198,576,045
Annual Costs			
Annualized Investment Cost (b)			$ 241,284,455
Annualized Operation & Maintenance Repair, Replacement & Rehabilitation Cost			$ 3,521,165
Total Annual Cost*			**$ 244,805,620**
*October 2021 Price Level (Program Year 2022)			
(a) Based on construction duration @ 2.25% (IDC, E&D, RE and Sunk costs calculated separately and included in this total)			
(b) Annualized investment cost only includes the remaining features. For annualized investment cost with the sunk cost, please see the economic appendix. i = 2.25% and n = 50 yrs			

5. Contingencies

As stated in ER 1110-2-1302, the goal in contingency development is to identify the uncertainty associated with an item of work or task, forecast the cost/risk relationship, and assign a value to this task that would limit the cost risk to an acceptable degree of confidence. Consideration must be given to the details available at each stage of planning, design, or construction for which a cost estimate is being prepared. Contingencies may vary throughout the cost estimate and could constitute significant portion of the overall costs when the lack of investigated data or design details are available. Final contingency development and assignment that describes the potential for cost growth is included in the cost estimate. During development of the cost estimates, sufficient contingencies developed via PDT discussions during Cost and Schedule Risk Analysis (CSRA) were applied to develop the Total Project First Cost. The breakdown of items within each account. The contingency factors developed are 26% for cost risk and 52% for schedule risk.

Table 5: Contingencies

Element	Contingency Factor
Relocation	26%
Fish and Wildlife Facilities	26%
Navigation Ports & Harbors	26%
Buildings, Grounds & Utilities	26%
Total Construction Contingency	**26%**
Lands & Damages	1.1%
Planning, Engineering, and Design	26%
Construction Management	26%

6. Total Project Cost Summary

The Total Fully Funded Project estimated cost is $8,774,119,000.

Table 6: Total Project Cost Summary

PROJECT: **New York New Jersey Harbor Deepening Channel Improvement** **DISTRICT: NAN** **PREPARED: 1/27/2022**
PROJECT NO: 472473 **POC: CHIEF, COST ENGINEERING, Cynthia Zhang (Acting)**
LOCATION: NY/NJ Harbor

This Estimate reflects the scope and schedule in report; HDCI Feasibility Study

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2022 Effective Price Level Date: 1 OCT 21									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **1-Oct-21** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
02	RELOCATIONS	$1,035,000	$269,100	26.0%	$1,304,100	0.0%	$1,035,000	$269,100	$1,304,100	$0	$1,304,100	50.0%	$1,552,380	$403,619	$1,955,999
06	FISH & WILDLIFE FACILITIES	$11,000	$2,860	26.0%	$13,860	0.0%	$11,000	$2,860	$13,860	$0	$13,860	37.9%	$15,172	$3,945	$19,117
12	NAVIGATION PORTS & HARBORS	$2,769,586	$720,092	26.0%	$3,489,678	0.0%	$2,769,586	$720,092	$3,489,678	$0	$3,489,678	66.2%	$4,602,471	$1,196,642	$5,799,113
19	BUILDINGS, GROUNDS & UTILITIES	$25,000	$6,500	26.0%	$31,500	0.0%	$25,000	$6,500	$31,500	$0	$31,500	50.0%	$37,497	$9,749	$47,246
	CONSTRUCTION ESTIMATE TOTALS:	$3,840,586	$998,552		$4,839,138	0.0%	$3,840,586	$998,552	$4,839,138	$0	$4,839,138	61.6%	$6,207,520	$1,613,955	$7,821,475
01	LANDS AND DAMAGES	$10,865	$123	1.1%	$10,988	0.0%	$10,865	$123	$10,988	$0	$10,988	9.7%	$11,915	$135	$12,050
30	PLANNING, ENGINEERING & DESIGN	$422,464	$109,841	26.0%	$532,305	0.0%	$422,464	$109,841	$532,305	$0	$532,305	28.2%	$541,785	$140,864	$682,649
31	CONSTRUCTION MANAGEMENT	$144,022	$37,446	26.0%	$181,468	0.0%	$144,022	$37,446	$181,468	$0	$181,468	42.1%	$204,718	$53,227	$257,945
	PROJECT COST TOTALS:	$4,417,937	$1,145,962	25.9%	$5,563,899		$4,417,937	$1,145,962	**$5,563,899**	$0	**$5,563,899**	57.7%	$6,965,938	$1,808,181	$8,774,119

______________ **CHIEF, COST ENGINEERING, Cynthia Zhang (Acting)**

ESTIMATED TOTAL PROJECT COST: $8,774,119

______________ **PROJECT MANAGER, Mark Lulka**

______________ **ACTING CHIEF, REAL ESTATE, Allen Roos**

**** CONTRACT COST SUMMARY ****

PROJECT: New York New Jersey Harbor Deepening Channel Improvement
LOCATION: NY/NJ Harbor
This Estimate reflects the scope and schedule in report; HDCI Feasibility Study

DISTRICT: NAN
POC: CHIEF, COST ENGINEERING, Cynthia Zhang (Acting)

PREPARED: 1/27/2022

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 4-Jan-22				Program Year (Budget EC): 2022								
		Effective Price Level: 1-Oct-21				Effective Price Level Date: 1 OCT 21								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS	$1,035,000	$269,100	26.0%	$1,304,100	0.0%	$1,035,000	$269,100	$1,304,100	2035Q2	50.0%	$1,552,380	$403,619	$1,955,999
06	FISH & WILDLIFE FACILITIES	$11,000	$2,860	26.0%	$13,860	0.0%	$11,000	$2,860	$13,860	2032Q3	37.9%	$15,172	$3,945	$19,117
12	NAVIGATION PORTS & HARBORS	$83,293	$21,656	26.0%	$104,949	0.0%	$83,293	$21,656	$104,949	2026Q3	14.8%	$95,654	$24,870	$120,524
19	BUILDINGS, GROUNDS & UTILITIES	$25,000	$6,500	26.0%	$31,500	0.0%	$25,000	$6,500	$31,500	2035Q2	50.0%	$37,497	$9,749	$47,246
	CONSTRUCTION ESTIMATE TOTALS:	$1,154,293	$300,116	26.0%	**$1,454,409**		$1,154,293	$300,116	$1,454,409			$1,700,704	$442,183	$2,142,887
01	LANDS AND DAMAGES	$10,865	$123	1.1%	$10,988	0.0%	$10,865	$123	$10,988	2025Q1	9.7%	$11,915	$135	$12,050
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$11,543	$3,001	26.0%	$14,544	0.0%	$11,543	$3,001	$14,544	2025Q1	7.7%	$12,430	$3,232	$15,662
1.0%	Planning & Environmental Compliance	$11,543	$3,001	26.0%	$14,544	0.0%	$11,543	$3,001	$14,544	2025Q1	7.7%	$12,430	$3,232	$15,662
5.0%	Engineering & Design	$57,715	$15,006	26.0%	$72,720	0.0%	$57,715	$15,006	$72,720	2025Q1	7.7%	$62,152	$16,160	$78,312
0.5%	Reviews, ATRs, IEPRs, VE	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2025Q1	7.7%	$6,215	$1,616	$7,831
0.5%	risks)	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2025Q1	7.7%	$6,215	$1,616	$7,831
0.5%	Contracting & Reprographics	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2025Q1	7.7%	$6,215	$1,616	$7,831
1.0%	Engineering During Construction	$11,543	$3,001	26.0%	$14,544	0.0%	$11,543	$3,001	$14,544	2026Q3	11.8%	$12,900	$3,354	$16,253
0.5%	Planning During Construction	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2026Q3	11.8%	$6,450	$1,677	$8,127
0.5%	Adaptive Management & Monitoring	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2025Q1	7.7%	$6,215	$1,616	$7,831
0.5%	Project Operations	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2025Q1	7.7%	$6,215	$1,616	$7,831
31	CONSTRUCTION MANAGEMENT													
2.5%	Construction Management	$28,857	$7,503	26.0%	$36,360	0.0%	$28,857	$7,503	$36,360	2026Q3	11.8%	$32,249	$8,385	$40,633
0.5%	Project Operation:	$5,771	$1,501	26.0%	$7,272	0.0%	$5,771	$1,501	$7,272	2026Q3	11.8%	$6,450	$1,677	$8,127
0.8%	Project Management	$8,657	$2,251	26.0%	$10,908	0.0%	$8,657	$2,251	$10,908	2026Q3	11.8%	$9,675	$2,515	$12,190
	CONTRACT COST TOTALS:	$1,335,416	$344,506		$1,679,923		$1,335,416	$344,506	**$1,679,923**			$1,898,431	$490,629	**$2,389,060**

****** CONTRACT COST SUMMARY ******

PROJECT: New York New Jersey Harbor Deepening Channel Improvement
LOCATION: NY/NJ Harbor
This Estimate reflects the scope and schedule in report; HDCI Feasibility Study

DISTRICT: NAN
POC: CHIEF, COST ENGINEERING, Cynthia Zhang (Acting)

PREPARED: 1/27/2022

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Jan-22	Program Year (Budget EC):			2022					
		Effective Price Level:			1-Oct-21	Effective Price Level Date:			1 OCT 21					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 2													
12	NAVIGATION PORTS & HARBORS	$134,388	$34,941	26.0%	$169,329	0.0%	$134,388	$34,941	$169,329	2028Q2	21.1%	$162,782	$42,323	$205,106
	CONSTRUCTION ESTIMATE TOTALS:	$134,388	$34,941	26.0%	**$169,329**		$134,388	$34,941	$169,329			$162,782	$42,323	$205,106
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1,344	$349	26.0%	$1,693	0.0%	$1,344	$349	$1,693	2027Q2	13.8%	$1,530	$398	$1,928
1.0%	Planning & Environmental Compliance	$1,344	$349	26.0%	$1,693	0.0%	$1,344	$349	$1,693	2027Q2	13.8%	$1,530	$398	$1,928
5.0%	Engineering & Design	$6,719	$1,747	26.0%	$8,466	0.0%	$6,719	$1,747	$8,466	2027Q2	13.8%	$7,649	$1,989	$9,638
0.5%	Reviews, ATRs, IEPRs, VE	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2027Q2	13.8%	$765	$199	$964
0.5%	risks)	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2027Q2	13.8%	$765	$199	$964
0.5%	Contracting & Reprographics	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2027Q2	13.8%	$765	$199	$964
1.0%	Engineering During Construction	$1,344	$349	26.0%	$1,693	0.0%	$1,344	$349	$1,693	2028Q2	16.7%	$1,568	$408	$1,976
0.5%	Planning During Construction	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2028Q2	16.7%	$784	$204	$988
0.5%	Adaptive Management & Monitoring	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2027Q2	13.8%	$765	$199	$964
0.5%	Project Operations	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2027Q2	13.8%	$765	$199	$964
31	CONSTRUCTION MANAGEMENT													
2.5%	Construction Management	$3,360	$874	26.0%	$4,233	0.0%	$3,360	$874	$4,233	2028Q2	16.7%	$3,920	$1,019	$4,939
0.5%	Project Operation:	$672	$175	26.0%	$847	0.0%	$672	$175	$847	2028Q2	16.7%	$784	$204	$988
0.8%	Project Management	$1,008	$262	26.0%	$1,270	0.0%	$1,008	$262	$1,270	2028Q2	16.7%	$1,176	$306	$1,482
	CONTRACT COST TOTALS:	$154,210	$40,095		$194,305		$154,210	$40,095	**$194,305**			$185,548	$48,242	**$233,790**

****** CONTRACT COST SUMMARY ******

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PREPARED: 1/27/2022

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		Effective Price Level:			1-Oct-21	Effective Price Level Date:			1 OCT 21					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 3													
12	NAVIGATION PORTS & HARBORS	$946,414	$246,068	26.0%	$1,192,482	0.0%	$946,414	$246,068	$1,192,482	2034Q3	46.6%	$1,387,542	$360,761	$1,748,303
	CONSTRUCTION ESTIMATE TOTALS:	$946,414	$246,068	26.0%	**$1,192,482**		$946,414	$246,068	$1,192,482			$1,387,542	$360,761	$1,748,303
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$9,464	$2,461	26.0%	$11,925	0.0%	$9,464	$2,461	$11,925	2028Q4	18.2%	$11,186	$2,908	$14,095
1.0%	Planning & Environmental Compliance	$9,464	$2,461	26.0%	$11,925	0.0%	$9,464	$2,461	$11,925	2028Q4	18.2%	$11,186	$2,908	$14,095
5.0%	Engineering & Design	$47,321	$12,303	26.0%	$59,624	0.0%	$47,321	$12,303	$59,624	2028Q4	18.2%	$55,932	$14,542	$70,474
0.5%	Reviews, ATRs, IEPRs, VE	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2028Q4	18.2%	$5,593	$1,454	$7,047
0.5%	risks)	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2028Q4	18.2%	$5,593	$1,454	$7,047
0.5%	Contracting & Reprographics	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2028Q4	18.2%	$5,593	$1,454	$7,047
1.0%	Engineering During Construction	$9,464	$2,461	26.0%	$11,925	0.0%	$9,464	$2,461	$11,925	2034Q3	37.4%	$13,006	$3,382	$16,388
0.5%	Planning During Construction	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2034Q3	37.4%	$6,503	$1,691	$8,194
0.5%	Adaptive Management & Monitoring	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2028Q4	18.2%	$5,593	$1,454	$7,047
0.5%	Project Operations	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2028Q4	18.2%	$5,593	$1,454	$7,047
31	CONSTRUCTION MANAGEMENT													
2.5%	Construction Management	$23,660	$6,152	26.0%	$29,812	0.0%	$23,660	$6,152	$29,812	2034Q3	37.4%	$32,516	$8,454	$40,970
0.5%	Project Operation:	$4,732	$1,230	26.0%	$5,962	0.0%	$4,732	$1,230	$5,962	2034Q3	37.4%	$6,503	$1,691	$8,194
0.8%	Project Management	$7,098	$1,846	26.0%	$8,944	0.0%	$7,098	$1,846	$8,944	2034Q3	37.4%	$9,755	$2,536	$12,291
	CONTRACT COST TOTALS:	$1,086,010	$282,363		**$1,368,373**		$1,086,010	$282,363	**$1,368,373**			$1,562,096	$406,145	**$1,968,241**

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PREPARED: 1/27/2022

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 4-Jan-22 Effective Price Level: 1-Oct-21				Program Year (Budget EC): 2022 Effective Price Level Date: 1 OCT 21				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 4													
12	NAVIGATION PORTS & HARBORS	$924,328	$240,325	26.0%	$1,164,653	0.0%	$924,328	$240,325	$1,164,653	2039Q4	72.1%	$1,590,832	$413,616	$2,004,448
	CONSTRUCTION ESTIMATE TOTALS:	$924,328	$240,325	26.0%	$1,164,653		$924,328	$240,325	$1,164,653			$1,590,832	$413,616	$2,004,448
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$9,243	$2,403	26.0%	$11,647	0.0%	$9,243	$2,403	$11,647	2034Q1	35.6%	$12,535	$3,259	$15,794
1.0%	Planning & Environmental Compliance	$9,243	$2,403	26.0%	$11,647	0.0%	$9,243	$2,403	$11,647	2034Q1	35.6%	$12,535	$3,259	$15,794
5.0%	Engineering & Design	$46,216	$12,016	26.0%	$58,233	0.0%	$46,216	$12,016	$58,233	2034Q1	35.6%	$62,674	$16,295	$78,969
0.5%	Reviews, ATRs, IEPRs, VE	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2034Q1	35.6%	$6,267	$1,630	$7,897
0.5%	risks)	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2034Q1	35.6%	$6,267	$1,630	$7,897
0.5%	Contracting & Reprographics	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2034Q1	35.6%	$6,267	$1,630	$7,897
1.0%	Engineering During Construction	$9,243	$2,403	26.0%	$11,647	0.0%	$9,243	$2,403	$11,647	2039Q4	58.6%	$14,660	$3,812	$18,472
0.5%	Planning During Construction	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2039Q4	58.6%	$7,330	$1,906	$9,236
0.5%	Adaptive Management & Monitoring	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2034Q1	35.6%	$6,267	$1,630	$7,897
0.5%	Project Operations	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2034Q1	35.6%	$6,267	$1,630	$7,897
31	CONSTRUCTION MANAGEMENT													
2.5%	Construction Management	$23,108	$6,008	26.0%	$29,116	0.0%	$23,108	$6,008	$29,116	2039Q4	58.6%	$36,650	$9,529	$46,179
0.5%	Project Operation:	$4,622	$1,202	26.0%	$5,823	0.0%	$4,622	$1,202	$5,823	2039Q4	58.6%	$7,330	$1,906	$9,236
0.8%	Project Management	$6,932	$1,802	26.0%	$8,735	0.0%	$6,932	$1,802	$8,735	2039Q4	58.6%	$10,995	$2,859	$13,854
	CONTRACT COST TOTALS:	$1,060,666	$275,773		**$1,336,440**		$1,060,666	$275,773	**$1,336,440**			$1,786,877	$464,588	**$2,251,466**

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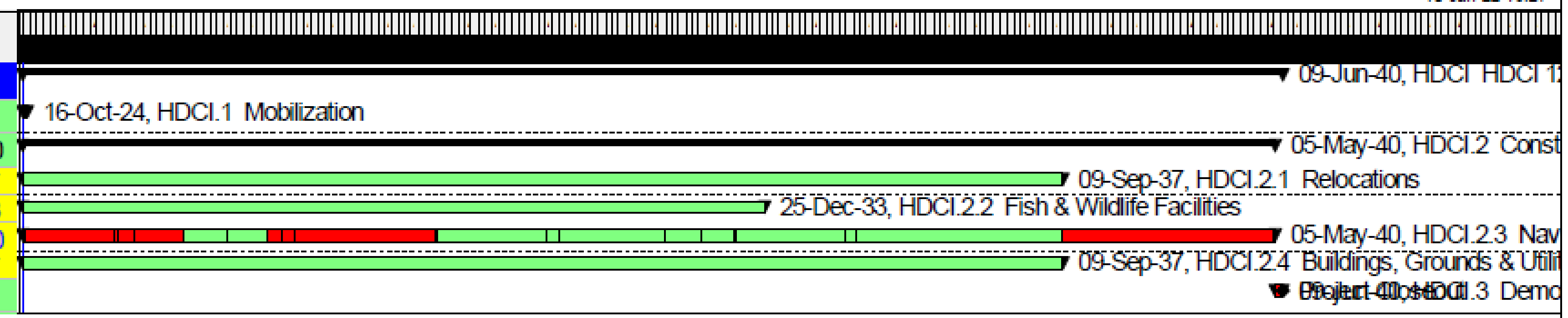
		Effective Price Level:			1-Oct-21	Effective Price Level Date:			1 OCT 21					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	P	L	M	N	O
	PHASE 5													
12	NAVIGATION PORTS & HARBORS	$681,163	$177,102	26.0%	$858,265	0.0%	$681,163	$177,102	$858,265	2044Q4	100.5%	$1,365,660	$355,072	$1,720,732
	CONSTRUCTION ESTIMATE TOTALS:	$681,163	$177,102	26.0%	$858,265		$681,163	$177,102	$858,265			$1,365,660	$355,072	$1,720,732
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$6,812	$1,771	26.0%	$8,583	0.0%	$6,812	$1,771	$8,583	2039Q3	57.5%	$10,729	$2,790	$13,518
1.0%	Planning & Environmental Compliance	$6,812	$1,771	26.0%	$8,583	0.0%	$6,812	$1,771	$8,583	2039Q3	57.5%	$10,729	$2,790	$13,518
5.0%	Engineering & Design	$34,058	$8,855	26.0%	$42,913	0.0%	$34,058	$8,855	$42,913	2039Q3	57.5%	$53,644	$13,948	$67,592
0.5%	Reviews, ATRs, IEPRs, VE	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2039Q3	57.5%	$5,364	$1,395	$6,759
0.5%	risks)	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2039Q3	57.5%	$5,364	$1,395	$6,759
0.5%	Contracting & Reprographics	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2039Q3	57.5%	$5,364	$1,395	$6,759
1.0%	Engineering During Construction	$6,812	$1,771	26.0%	$8,583	0.0%	$6,812	$1,771	$8,583	2044Q4	82.9%	$12,457	$3,239	$15,696
0.5%	Planning During Construction	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2044Q4	82.9%	$6,229	$1,619	$7,848
0.5%	Adaptive Management & Monitoring	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2039Q3	57.5%	$5,364	$1,395	$6,759
0.5%	Project Operations	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2039Q3	57.5%	$5,364	$1,395	$6,759
31	CONSTRUCTION MANAGEMENT													
2.5%	Construction Management	$17,029	$4,428	26.0%	$21,457	0.0%	$17,029	$4,428	$21,457	2044Q4	82.9%	$31,144	$8,097	$39,241
0.5%	Project Operation:	$3,406	$886	26.0%	$4,291	0.0%	$3,406	$886	$4,291	2044Q4	82.9%	$6,229	$1,619	$7,848
0.8%	Project Management	$5,109	$1,328	26.0%	$6,437	0.0%	$5,109	$1,328	$6,437	2044Q4	82.9%	$9,343	$2,429	$11,772
	CONTRACT COST TOTALS:	$781,635	$203,225		$984,860		$781,635	$203,225	$984,860			$1,532,986	$398,576	$1,931,562

7. Construction Schedule

HDCI — Construction Schedule — 10-Jan-22 16:27

Activity ID	Activity Name	Planned Duration	Start	Finish
HDCI	HDCI 12-29-2021	5731	01-Oct-24	09-Jun-40
HDCI.1	Mobilization	16	01-Oct-24	16-Oct-24
HDCI.2	Construction	5696	01-Oct-24	05-May-40
HDCI.2.1	Relocations	4727	01-Oct-24	09-Sep-37
HDCI.2.2	Fish & Wildlife Facilities	3373	01-Oct-24	25-Dec-33
HDCI.2.3	Navigation Ports & Harbors	5696	01-Oct-24	05-May-40
HDCI.2.4	Buildings, Grounds & Utilities	4727	01-Oct-24	09-Sep-37
HDCI.3	Demobilization	35	06-May-40	09-Jun-40



8. MII

Print Date Mon 10 January 2022
Eff. Date 11/12/2021

U.S. Army Corps of Engineers
Project : HDCI
New York New Jersey Harbor Deepening Channel Improvement

Time 16:56:03

Summary Page 1

Description	UOM	Quantity	ContractCost
Summary			3,840,586,000.00
New York New Jersey Harbor Deepening Channel Improvement	LS	1.0000	3,840,586,000.00
Account 02 Relocations	LS	1.0000	1,035,000,000.00
Account 06 Fish & Wildlife Facilities	LS	1.0000	11,000,000.00
Account 12 Navigation Ports & Harbors	LS	1.0000	2,769,586,000.00
Account 19 Buildings, Grounds & Utilities	LS	1.0000	25,000,000.00

Labor ID: NLS2016 EQ ID: EP18R01 Currency in US dollars TRACES MII Version 4.4

WALLA WALLA COST ENGINEERING
MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 472473

NAN – New York New Jersey Harbor Deepening Channel Improvement Navigation Study

The New York New Jersey Harbor Deepening Channel Improvement Navigation Study, as presented by New York District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of January 27, 2022, the Cost MCX certifies the estimated total project cost:

FY22 Project First Cost: $5,563,899,000
Fully Funded Amount: $8,774,119,000

Cost Certification assumes Efficient Implementation (Funding). It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal Participation.

®

Michael P. Jacobs, PE, CCE
Chief, Cost Engineering MCX
Walla Walla District

US Army Corps
Of Engineers®

New York and New Jersey Harbor Deepening and Channel Improvements (NYNJHDCI)
The Port of New York and New Jersey
Project Cost and Schedule Risk Analysis Report

Prepared by:
U.S. Army Corps of Engineers
Cost Engineering, New York District

January 2022

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), New York District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for New York and New Jersey Harbor Deepening Channel Improvements (NYNJHDCI) project located in the Port of New York and New Jersey. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

New York and New Jersey Harbor Deepening Channel Improvements (NYNJHDCI) project is located in the Port of New York and New Jersey. It consists of drilling and blasting of rocks, dredging of various materials from clean sediment to upland sediment, as well as rock materials from Kill Van Kull, South Elizabeth, Newark Bay South, Newark Bay South, Port Elizabeth, Port Jersey, Anchorage, and Ambrose channels. The project also consists of relocation of any obstructions from cultural artifacts to underwater utility lines. The project would deepen the pathways from sea to Elizabeth – Port Authority Marine Terminal and Port – Jersey Port Authority Marine Terminal to a maintained depth of -55 feet MLLW.

Specific to NYNJHDCI, the current project base cost estimate, pre-contingency, approximates $4.46B. Since the Real Estate office provided a separate 1.1% contingency for its real estate requirements, the Cost MCX performed study on the estimated remaining construction costs of $4.45B. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (MCX located in Walla Walla District) recommends a contingency value of $1.11B or approximately 26% of the remaining construction cost at an 80% confidence level of successful execution. This contingency excludes a separate contingency of 123K for Real Estate. The most likely constant dollar program year (First Cost at FY22 price level) is estimated at approximately $5.61B, including a total contingency value of $1.16B.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency percent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

		FIRST COST						FULLY FUNDED COST					
Account No.	Feature Description	Cost ($K)		Cont. ($K)		First Cost ($K)		Cost ($K)		Cont. ($K)		Fully Funded Cost ($K)	
02	Relocation	$	1,060,000	$	275,600	$	1,335,600	$	1,487,739	$	386,812	$	1,874,551
06	Fish and Wildlife Facilities	$	11,000	$	2,860	$	13,860	$	14,349	$	3,731	$	18,080
12	Navigation Ports & Harbors	$	2,769,586	$	720,092	$	3,489,679	$	4,266,904	$	1,109,395	$	5,376,299
	Total	$	3,840,586	$	998,552	$	4,839,139	$	5,768,992	$	1,499,938	$	7,268,930
01	Lands & Damages	$	10,865	$	123	$	10,988	$	11,715	$	133	$	11,847
30	Planning, Engineering & Design	$	462,147	$	120,158	$	582,305	$	541,785	$	140,864	$	682,649
31	Construction Management	$	144,022	$	37,446	$	181,468	$	204,718	$	53,227	$	257,945
	Total	$	4,457,620	$	1,156,279	$	5,613,900	$	6,527,210	$	1,694,162	$	8,221,371

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register in September 2021. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $1.11B and schedule risks adding a potential of 99 months to the schedule, both at an 80% confidence level.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- RE2: Additional NEPA documentation – NEPA regulations being revised to fit into smart planning.
- RE4: Additional Coordination / Outreach Expected – Environmental Justice / Social Justice.
- TD2: Remaining Civil Design – Uncertainties associated with widening.
- TD6: Rock Quantities – Rock quantities were based on available data in keeping with smart planning principals.
- TD7: Incomplete studies (Geotech, H&H, Structural, HTRW, etc.) – Lack of Geotech analysis, H&H analysis, structural analysis, and HTRW data.
- TD8: Survey late and/or Survey in question – Low resolution bathymetric data in critical areas.

Moderate risks, when combined, can also become a cost impact.

- CA1: Limited Dredge Equipment – Limited dredges could change projects priorities within the district.
- LD2: Easement and permit for Bulkheads – Likelihood of bulkhead in the private property.
- CO1: Conflicts with other contracts and/or operations – Dock in KVK.
- CO2: Weather Impacts – Weather impact is always a concern.
- CO3: Historic change order or modification growth – Change order / modification is common on all construction projects.
- CO6: Differing site conditions / Unknown utilities – Design and analysis are currently in feasibility phase.

- CO7: Rock unfractured – Previously fractured rock turns out not to be as easily dredged as anticipated.
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- TD11: Structure analysis / investigation in question – Bulkhead
- TD12: Structure analysis / Investigation in question – Exxon pier.
- EX3: Political opposition / threat of lawsuits - Potential for Litigation.
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- EX1: Acts of God (seismic events; volcanic activity, earthquakes, tsunamis; or severe weather: freezing, flooding or hurricane) - Nature disasters can change priorities and ability of workers to perform work.

Recommendations: As detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the remaining construction and proactive monitoring and control of risk identified in this study.

MAIN REPORT

1.0 PURPOSE

The US Army Corps of Engineers (USACE), New York District presents the results of the cost and schedule risk analysis for New York and New Jersey Harbor Deepening Channel Improvements (NYNJHDCI). The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost and schedule contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

New York and New Jersey Harbor Deepening Channel Improvements (NYNJHDCI) project is located in the Port of New York and New Jersey. It consists of drilling and blasting of rocks, dredging of various materials from clean sediment to upland sediment, as well as rock materials from Kill Van Kull, South Elizabeth, Newark Bay South, Newark Bay South, Port Elizabeth, Port Jersey, Anchorage, and Ambrose channels. The project also consists of relocation of any obstructions from cultural artifacts to underwater utility lines. The project would deepen the pathways from sea to Elizabeth – Port Authority Marine Terminal and Port – Jersey Port Authority Marine Terminal to a maintained depth of -55 feet MLLW.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for 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 construction features. The CSRA excludes Real Estate cost and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES), Second Generation (MII), project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the District. Consequently, these documents serve as the basis for the risk analysis. The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. 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.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to 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 analysis 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, this risk analysis was 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 Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The New York District assembled an assigned project delivery team (PDT) to further augment labor, expertise and information gathering. The Cost Engineering representative was Cynthia Zhang.

Cost Engineering facilitated a risk identification and qualitative analysis meeting with the

PDT from September 13th, 2021 to September 16th, 2021. The risk identification and qualitative analysis process did result in some revisions to the estimate.

Participants in the risk identification meeting from September 13th, 2021 to September 16th, 2021 included:

Name	Organization	Title
Alexander Ring	USACE-CENAN-EN-C	Cost Engineer
Catherine Alcoba	USACE-CENAN-PL-EC	Biologist
Cherly Alkemeyer	USACE-CENAN-PL-EW	Physical Scientist
Christopher Dols	USACE-CENAN-EN-C	Cost Engineer
Christopher Hagerman	USACE-CENAN-EN-D	Structural Engineer
Clark Ryan	USACE-CENAN-PL-E	Archeologist
Cynthia Zhang	USACE-CENAN-EN-C	Cost Engineer / Risk Facilitator
Jamal Sulayman	USACE-CENAN-EN-M	Technical Manager
Jenine Gallo	USACE-CENAN-PL-E	Wildlife Biologist, Section Chief
Jesse Miller	USACE-CENAN-PL-EC	Biologist
Karen Baumert	USACE-CENAN-PL-FC	Project Planner
Katherine Pijanowski	USACE-CENAN-PL-EC	Biologist
Mark Lulka	USACE-CENAN-PP	Project Manager
Michael Chen	USACE-CENAN-EN-DE	Structural Engineer
Michael Morgan	USACE-CENAN-PL-H	Hydraulic & Hydrology Engineer
Paul Fitzpatrick	USACE-CENAN-RE-M	Reality Specialist
Peter Weepler	USACE-CENAN-PL-E	Chief Environmental Analysis Branch
Prasanna Rachakatla	USACE-CENAE-EDW	Geotechnical Engineer
Stephen Potts	USACE-CENAE-EDG	Geo-Environmental Engineer

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 the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions, or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criterion is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a

P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

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. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results 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.

A formal PDT meeting was held with the New York District office for the purposes of identifying and assessing risk factors. The meeting conducted on from September 13th, 2021 to September 16th, 2021 included capable and qualified representatives from multiple project team disciplines and functions, including hydraulic & hydrology, cost engineering, environmental compliance, project planning, project management, realty specialist, structural engineering, and technical management.

The initial formal meeting focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans 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.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are 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 option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 KEY ASSUMPTIONS

Key assumptions are those that are most likely to affect significantly the determinations and/or estimates of risk presented in the risk analysis. The key assumptions are important to help ensure that project leadership and other decision makers understand the steps, logic, limitations, and decisions made in the risk analysis, as well as any resultant limitations on the use of outcomes and results. The following data sources and assumptions were used in quantifying the costs associated with the project.

a. Level of Design: The cost comparisons and risk analyses performed and reflected within this report are based upon design scope and estimates that are at conceptual level.

b. Design Scope: Some areas of scope are not fully developed and significant assumptions were required to be made by the cost estimator.

c. Operation and Maintenance: Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full lifecycle risk analysis was not performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included. It is assumed that incorporation of operation and maintenance activities in the risk analysis would not result in significantly different conclusions for the construction acquisition.

d. Contract Acquisition Strategy: Acquisition strategy is currently undefined. Cost estimate and schedule assumed that the contract acquisition strategy is firm fixed price. However, the final determination on acquisition strategy may change depending on funding availability. Use of other acquisition strategies may impact costs and schedules.

e. Confidence Levels: The Cost Engineering DX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criterion is a moderately risk adverse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to completely capture actual project costs.

f. Impacts Studied: Moderate and High impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Moderate and high-level risk impacts were only applied to critical path and near critical path schedule tasks for the purposes of calculating schedule contingency. Low and moderate level risk impacts should be maintained in project management documentation and reviewed at each project milestone to determine if they should be placed on the risk "watch list" for further monitoring and evaluation.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk. It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50, P80 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks (including schedule impacts converted to dollars) was quantified as approximately $1.11 Billion at the P80 confidence level (26% of the baseline construction cost estimate).

Table 1. Construction Cost Contingency Summary

Base Case Construction Cost Estimate	$4,446,755,393	
Confidence Level	**Construction Value ($$)**	**Contingency (%)**
50%	$921,740,734	21%
80%	**$1,113,770,054**	**26%**
90%	$1,190,581,782	27%

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6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

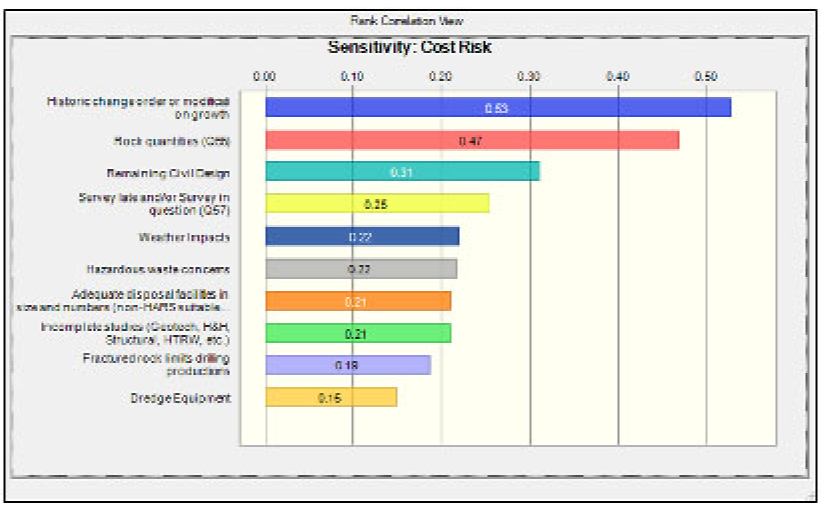
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept, or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high-level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high-level schedule risks identified in the risk register.

Figure 1 – Cost Sensitivity Analysis



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6.3 Schedule and Contingency Risk Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

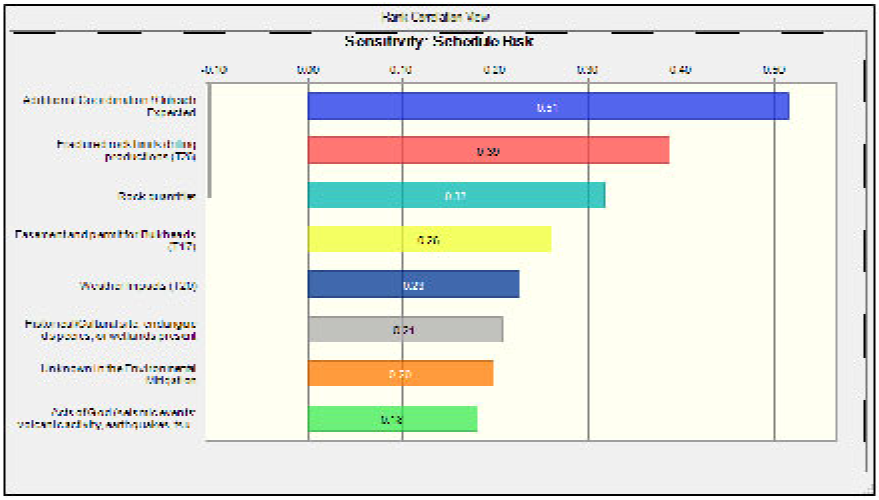
Schedule duration contingency was quantified as 98 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high-level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2 - Schedule Duration Contingency Summary

Risk Analysis Forecast (base schedule of 188 months)	Duration w/ Contingencies (months)	Contingency (months)
50%	273 Months	85 Months
80%	**286 Months**	**98 Months**
90%	293 Months	105 Months

Figure 2 – Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost and schedule comparison summaries are provided in Table 3 and Table 4 respectively. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on: September 13th, 2021 to September 16th, 2021. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $1.11B and schedule risks adding a potential of 99 months to the schedule, both at an 80% confidence level.

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Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

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- RE4: Additional Coordination / Outreach Expected – Environmental Justice / Social Justice.
- TD2: Remaining Civil Design – Uncertainties associated with widening.
- TD6: Rock Quantities – Rock quantities were based on available data in keeping with smart planning principals.
- TD7: Incomplete studies (Geotech, H&H, Structural, HTRW, etc.) – Lack of Geotech analysis, H&H analysis, structural analysis, and HTRW data.
- TD8: Survey late and/or Survey in question – Low resolution bathymetric data in critical areas.

Moderate risks, when combined, can also become a cost impact.

- CA1: Limited Dredge Equipment – Limited dredges could change projects priorities within the district.
- LD2: Easement and permit for Bulkheads – Likelihood of bulkhead in the private property.
- CO1: Conflicts with other contracts and/or operations – Dock in KVK.
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- PM3: Local agency/regulator issues – Regulatory, permit, and funding issues.
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- RE7: Historical/Cultural site, endangered species, or wetlands present – Activity from blasting / resources from land (mitigation of the unknown resource).
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- TD8: Survey late and/or Survey in question - Quantities in question for specific areas.

- TD9: Hazardous waste concerns - Insufficient Geotech and HTRW data.
- EX1: Acts of God (seismic events; volcanic activity, earthquakes, tsunamis; or severe weather; freezing, flooding or hurricane) - Nature disasters can change priorities and ability of workers to perform work.

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

Most Likely Cost Estimate	$4,446,755,393		
Confidence Level	**Baseline w/ Contingency**	**Contingency**	**Contingency %**
10%	$5,138,060,943	$691,305,551	16%
20%	$5,214,872,671	$768,117,279	18%
30%	$5,291,684,399	$844,929,006	20%
40%	$5,330,090,263	$883,334,870	20%
50%	$5,368,496,127	$921,740,734	21%
60%	$5,445,307,855	$998,552,462	23%
70%	$5,483,713,719	$1,036,958,326	24%
80%	**$5,560,525,447**	**$1,113,770,054**	**26%**
90%	$5,637,337,175	$1,190,581,782	27%
100%	$6,175,019,270	$1,728,263,877	39%

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Most Likely Schedule Duration	188 Months		
Confidence Level	**Baseline w/ Contingency**	**Contingency**	**Contingency %**
10%	254 Months	66 Months	35%
20%	259 Months	71 Months	38%
30%	265 Months	77 Months	41%
40%	269 Months	81 Months	43%
50%	273 Months	85 Months	45%
60%	276 Months	88 Months	47%
70%	280 Months	92 Months	49%
80%	**286 Months**	**98 Months**	**52%**
90%	293 Months	105 Months	56%
100%	329 Months	141 Months	75%

7.2 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 intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

Cost Risk: The key cost risk drivers identified through sensitivity analysis are CO3 Historic change order or modification growth, TD6 Rock quantities, TD2 Remaining Civil Design, TD8 Survey late and/or survey in question, TD7 Incomplete studies (Geotech, H&H, Structural, HTRW, etc.), TD9 Hazardous waste concerns, CO2 Weather impacts, TD8 Survey late and/or Survey in question, CO8 Fractured rock limits drilling productions, TD3 Adequate disposal facilities in size and numbers (non-HARS suitable), and ES1 Dredge Equipment. As the design progresses through plans and specification, the staff priority raises, the risk associated with CO3, TD6, TD2, TD7, TD9, CO2, TD8, CO8, TD3, and ES1 factors will be reduced. Weather factors are typically beyond the PDT's scope of influence and with the project being so long in duration, unforeseen weather impacts are likely to occur.

Schedule Risk: The key schedule risk drivers identified through sensitivity analysis are RE4 Additional Coordination / Outreach Expected, CO8 Fractured rock limits drilling productions, TD6 Rock quantities, CO2 Weather Impacts, RE1 Unknown in the Environmental Mitigation, EX1 Acts of God, and CO3 Historical Change Order or Modification Growth. However, as the design progresses through the plans and specification, the risk associated with RE4, CO8, TD6, LD2, CO2, RE1, EX1, and CO3 factors will be reduced. Acts of God are typically beyond the PDT's scope of influence and with the project being so long in duration, unforeseen events are likely to occur. Contractors' means and methods are typically differed slightly above and below the national average.

Risk Management: Cost Engineering DX recommends use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings. As an example, recommended uses of the risk register include:

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- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.

- Providing project sponsors, stakeholders and leadership/management with a documented framework from which risk status can be reported in the context of project controls.

- Communicating risk management issues.

- Providing a mechanism for eliciting risk analysis feedback and project control input.

- Identifying risk transfer, elimination or mitigation actions required for implementation of risk management plans.

Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

Contract Acquisition (CA)

Lands and Damages (LD)

Construction (CO)

Cost and Schedule

Project & Program Management (PM)

	Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	Risk Quantification Discussion
[illegible]	Local agency/regulator issues	Regulatory, permit, and funding issues	[illegible]	[illegible]
[illegible]	Intermittent Funding	[illegible]	[illegible]	[illegible]
[illegible]	PED Funding - BUD Cost Will Vary Significantly from Estimate (At Award)	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Unplanned work that must be accommodated	[illegible]	[illegible]	[illegible]
[illegible]	ABSC Consultant or Contractor delays	[illegible]	[illegible]	[illegible]
Regulatory & Environmental (RE)				
[illegible]	Unknowns in the Environmental Mitigation	[illegible]	[illegible]	[illegible]
[illegible]	Additional NEPA documentation	[illegible]	[illegible]	[illegible]
[illegible]	HTRW	[illegible]	[illegible]	[illegible]
[illegible]	Additional Coordination / Outreach Expected	Environmental Justice / Social Justice	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Community Benefit Features	[illegible]	[illegible]	[illegible]
Technical Design (TD) / Project Scope Growth				
[illegible]	Remaining Geotech Design	Channel Template	[illegible]	[illegible]
[illegible]	Remaining Civil Design	[illegible]	[illegible]	[illegible]
[illegible]	Adequate disposal facilities in size and numbers [illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Adequate disposal facilities in size and numbers (HARS)	[illegible]	[illegible]	[illegible]
[illegible]	Adequate disposal facilities in size and numbers (NBEP)	[illegible]	[illegible]	[illegible]

Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	[illegible]	Risk Quantification Discussions
Rock quantities	Insufficient data	[illegible]	[illegible]	[illegible]
Incomplete studies (Geotech, H&H, Structural, HTRW, etc.)	Incomplete studies	[illegible]	[illegible]	[illegible]
Survey data and/or Survey in question	Low resolution bathymetric data in critical areas	[illegible]	[illegible]	[illegible]
Hazardous waste concerns	Insufficient Geotech and HTRW data	[illegible]	[illegible]	[illegible]
Structure analysis / investigation in question	Complex (Building, Chimney, wharf/pier)	[illegible]	[illegible]	N/A
Structure analysis / investigation in question	Bulkhead	[illegible]	[illegible]	[illegible]
Structure analysis / investigation in question	Stone pier	[illegible]	[illegible]	[illegible]
Structure analysis / investigation in question	Elizabeth Marine Terminal	[illegible]	[illegible]	N/A
External				
Acts of God (pandemic events, volcanic activity, earthquakes, tsunamis or severe weather, flooding or hurricanes)	Natural disasters can change priorities and ability of contractors to perform work	[illegible]	[illegible]	[illegible]
Political factors change at local, state, or federal level	Change of political leadership at local level can jeopardize support for the project or result in schedule change	[illegible]	[illegible]	N/A
Political opposition / threat of lawsuits	Potential for Litigation	[illegible]	[illegible]	[illegible]
Unexpected escalation in fuel	There is inherent risk of impact to cost due to fluctuation in fuel rate	[illegible]	[illegible]	[illegible]
END				