US Army Corps
of Engineers®
New York District

Passaic River Tidal Protection Area, New Jersey
Coastal Storm Risk Management
Feasibility Study

Final Integrated Hurricane Sandy
General Reevaluation Report
& Environmental Assessment

Appendix H
Cost

March 2019

TABLE OF CONTENTS

List of Tables

List of Figures

List of Attachments

1 INTRODUCTION

The Cost Appendix presents the supporting technical information used in updating the authorized design of features of the Passaic River, New Jersey, Tidal Flood Risk Management Project presented in the General Reevaluation Report (GRR) as well as the Recommended Plan, which is the Locally Preferred Plan (LPP). The New York District Corps of Engineers (NYD) produced a Draft General Design Memorandum (GDM) in 1995 and the first phase of a GRR for the entire Passaic River Watershed in 2013, both of which identified hurricane/storm surge/tidal risk management measures to help manage flood risks in portions of Harrison, Kearny and Newark, New Jersey. The three "tidal" levees and floodwalls have since been separated out from the Main Passaic Watershed GRR and have been identified for separate funding and analysis as part of a series of Authorized but Unconstructed (ABU) Hurricane Sandy-related projects. The Harrison, Kearny and Newark tidal levees were analyzed at a GRR level of study making full use of the data acquired in 1995 and 2013, as well as the latest hydrologic, hydraulic, topographic and structural information.

The ABU Hurricane Sandy-related project was evaluated by comparing multiple design elevations at a preliminary level of detail to compare costs and benefits to determine the optimum design height. The alternatives analyzed included the 1995 draft GDM levee elevations and alternative alignments with crest elevations 2 and 4 feet above the GDM elevation, as well as a smaller plan set back from the shoreline that provided flood risk management for the interior of the City of Newark. Preliminary typical levee and floodwall cross-sections were developed to calculate estimated quantities and costs.

After consideration of the potential Hazardous, Toxic, and Radioactive Waste (HTRW) impacts, potential environmental impacts, and the challenges associated with floodwall construction adjacent to several Superfund sites, the New Jersey Department of Environmental Protection (NJDEP), the non-Federal partner, selected a smaller alternative, known as the "Flanking Plan", as the LPP, which includes floodwall segments set back from the coastline. The U.S. Army Corps of Engineers (USACE) selected the LPP as the Recommended Plan.

This appendix provides the detailed cost estimate for the Recommended Plan, the LPP. The plan will provide flood risk management along portions of the Passaic River, and includes parts of Newark Bay in New Jersey.

A general project location map of the Passaic River Tidal Project Area (the ABU Project) is provided in **Figure 1**, which shows the 1995 alignment. The Recommended Plan is shown in **Figure 2**.

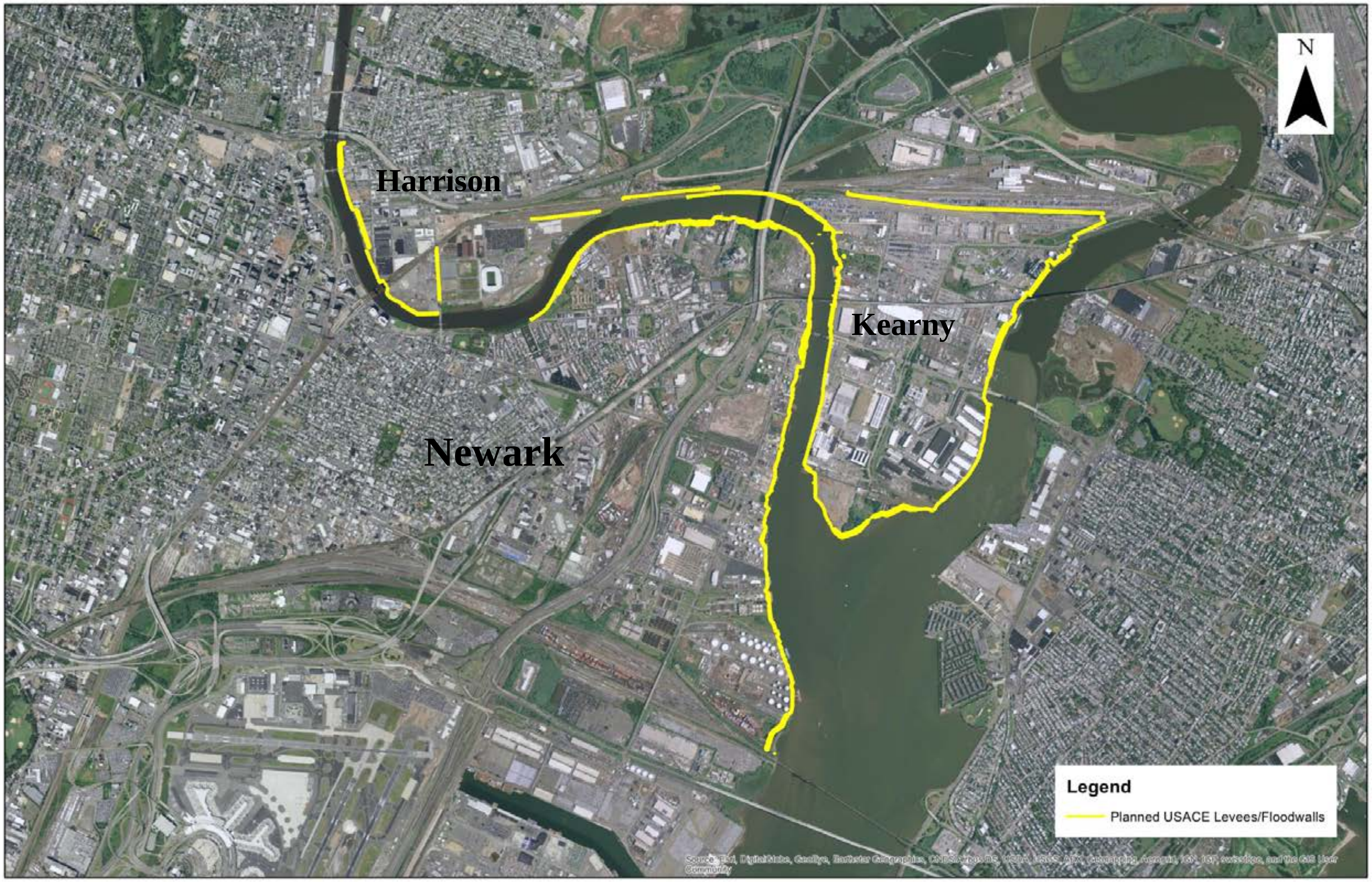

Figure 1: Passaic River Tidal Project Area – 1995 GDM Alignment

Figure 2: Passaic River Tidal Project – Recommended Plan

2 PROJECT PURPOSE

The purpose of the Passaic River, New Jersey, Integrated GRR and Environmental Assessment is to determine if the previously authorized or newly developed storm risk management projects in the study area are still in the federal interest.

3 PROJECT HISTORY

Flooding in the Passaic River Basin has been studied extensively over the past century at both the state and federal level. The State of New Jersey has produced numerous documents containing a variety of recommendation advancing flood storage as key to solving the problem in the Passaic River Basin. None of the local solutions were implemented upstream such that would reduce storm surge flooding in the tidal portion of the basin.

In 1936, the Corps of Engineers first became involved in the basin flood control planning effort as a direct result of the passage of the Flood Control Acts. Since that time, the Corps has issued reports containing recommendations eight times since 1939, the latest being 1995. Due to the lack of widespread public support, none of the basin-wide plans were implemented. Opposition was based on concerns of municipalities and various other interests throughout the basin.

The latest Feasibility Report was NYD's "General Design Memorandum, Flood Protection Feasibility Main Stem Passaic River, December 1987," which was the basis for project authorization. This project at the time included a system of levees and floodwalls with associated closure structures, interior drainage and pump stations within the tidal portion of the Passaic River Basin.

Since authorization, the planning and design efforts were conducted and presented in NYD's "Draft General Design Memorandum, Passaic River Flood Damage Reduction Project, Main Report and Supplement 1 to the Environmental Impact Statement, September 1995, and associated appendices." These efforts affirmed that the authorized project remained appropriate for the Passaic River Basin based on the problems, needs, and planning and design criteria at the time.

Since 1996, the State has requested that the Corps proceed with three elements of the Passaic River Basin project: the preservation of natural storage, the Joseph G. Minish Waterfront Park, and the Harrison portion of the tidal project area. In 2007, the NYD prepared a draft Limited Reevaluation Report to reaffirm federal interest in construction of the tidal portion in Harrison.

Following the impact of Hurricane Sandy on the region in 2012, the NYD initiated a general reevaluation of the entire Passaic River Basin project to reaffirm project viability and move to construction. Due to the lapse of time since the last study and the current emphasis on design resiliency when considering sea level change (SLC), the project was evaluated at the design elevation and two additional design elevations +2 feet and +4 feet higher. Due to potential challenges presented by HTRW and Superfund sites' proximity to the authorized alignment, an additional alternative, the smaller Flanking Plan, was also considered.

4 RECOMMENDED PLAN

The Passaic Tidal Recommended Plan consists of seven segments of concrete floodwalls and gates along three reaches as described below. The design elevation is 14 feet NAVD88. The typical ground elevation at each segment is 6 to 10 feet NAVD88. For areas with a wall height of six feet or less, the wall is a concrete I-wall or soil-founded T-wall; for areas where the wall is greater than six feet, the wall is a pile-supported, concrete T-wall. The project reaches are shown in **Figure 3** and described below.

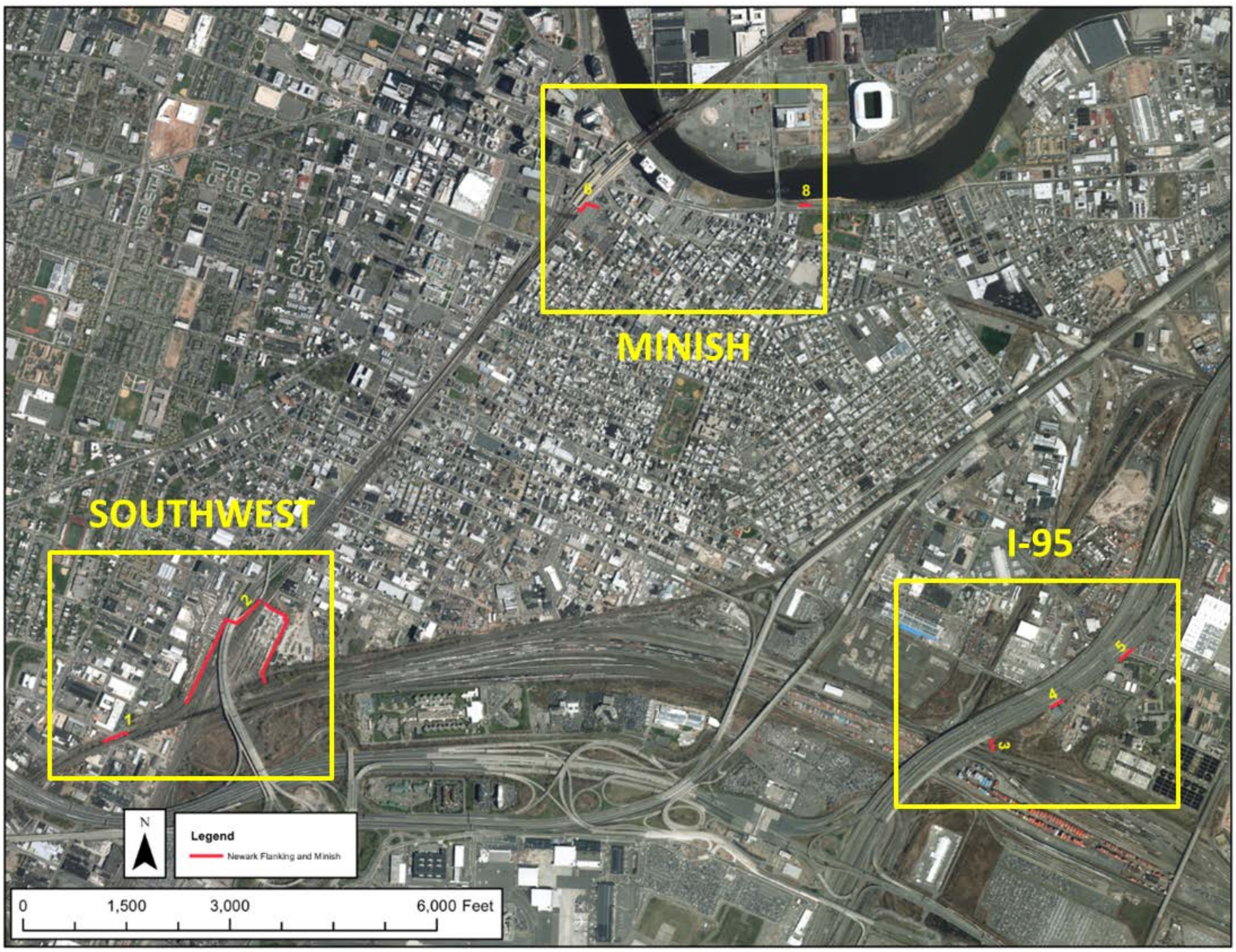

Figure 3: Passaic Tidal Project Reaches – Recommended Plan/Locally Preferred Plan

4.1 Southwest Reach

The Southwest Reach alignment consists of two wall and gate segments that cut off flanking of the South Ironbound area of Newark by flood surge entering the Perimeter Ditch around Newark Liberty International Airport.

Segment 1: 170 linear feet (LF) of floodwall with one closure gate: a 140 LF gate across the intersection of Frelinghuysen Avenue and East Peddie Street. The gate would be approximately 4.0 feet high above ground. The floodwall height above ground would range from approximately 2.6 to 4.0 feet and tie into the adjacent railroad embankment.

Segment 2A (western part of Segment 2): 1,990 LF of floodwall located between the main rail line to Newark Penn Station and the southern tie-off of the alignment. Segment 2A ties into the railroad embankments on each end of the wall. The Segment 2A alignment accommodates the proposed PATH railway extension from Newark Penn Station to the Newark Liberty Airport transit hub. Relocation of the Poinier Street ramp to McCarter Highway is planned to accommodate the PATH extension.

Segment 2B (eastern part of Segment 2): 1,450 LF of floodwall from the tie-in at the NJ Transit/Amtrak railroad to the southern alignment tie-in. This segment includes a gate at New Jersey Railroad (NJRR) Avenue and the southern rail line, and an additional gate north of the rail line for stormwater drainage during extreme rainfall events. Floodwall and gate height above ground along this segment would vary from 4.8 to 8.2 feet.

4.2 I-95 Reach

The I-95 Reach alignment includes three wall segments:

Segment 3: 135 LF of levee with three 36-inch culverts, headwalls, sluice gates, and backflow prevention devices. The levee crosses an unnamed tidal drainage ditch just east of the New Jersey Turnpike. The levee height above ground of this segment will be a maximum of approximately 9.4 feet.

Segment 4: 190 LF of floodwall across Delancy Street just east of the New Jersey Turnpike. The closure gate across Delancy Street would be approximately 70 LF and the floodwall height would range from approximately 4.1 to 4.8 feet.

Segment 5: 240 LF of floodwall across Wilson Avenue just east of the New Jersey Turnpike. The closure gate across Wilson Avenue would be approximately 85 LF and the floodwall height would range from approximately 3.1 to 3.2 feet above ground.

4.3 Minish Park Reach

The Minish Park Reach alignment includes one segment at Riverfront Park and one at Newark Penn Station:

Segment 6: 330 LF of floodwall along Edison Place and NJRR Avenue, and crossing NJRR Avenue to tie into the railroad embankment. The closure gate across NJRR Avenue would be approximately 30 LF. A closure gate was proposed along Edison Place at the Edison Park Fast. The height of the floodwall would range from approximately 0.9 to 3.1 feet above ground.

Segment 8: 150 LF of floodwall along the side of the off ramp from Raymond Boulevard to Jackson Street. This segment borders the sidewalk adjacent to Riverfront Park and would have a height ranging from approximately 1.3 to 3.4 feet above ground.

The total Recommended Plan alignment length is approximately 4,850 LF feet and includes eight closure gates and three 36-inch culverts. The Recommended Plan segments are shown in detail in Appendix J - Engineering and Design.

5 DETAILED COST ESTIMATE

5.1 Methods

For the detailed cost estimate, project quantities were developed using Microsoft Excel and manual calculations, where applicable. The cost estimate was compiled using the Micro-Computer Aided Cost Estimating System, Second Generation (MCACES, 2nd Generation or MII), shown in Attachment 1.

5.2 Cost Basis

The cost basis for the detailed cost estimate is a combination of MII's 2016 English Cost Book, 2016 Region 1 equipment book, estimator-created site specific cost items, local historic quotations, and quotations from local material suppliers. For the purposes of updating the cost book to present day pricing, a current, area-specific labor library was used to reflect market labor conditions. Major material costs were verified. For cost book material items that did not reflect current commodities pricing, vendor quotes were obtained and estimator judgment applied where warranted. Different aspects of the cost basis are outlined below.

5.2.1 Design Criteria / Quantity Development:

- Quantity take-offs were performed for the floodwall using end area methods. Wall heights of six feet or less are concrete I-walls or soil supported T-walls; wall heights greater than six feet are pile supported, concrete T-walls.
- Pile quantities were calculated based on monolith height and depth to bedrock. H-piles were used for all conditions.
- Epoxy-coated sheet pile cutoff, 24 feet below grade, was used in Segment 2 to prevent seepage.
- In constricted areas, a vertical pile design is assumed; however, the computations were not changed from battered to vertical as this change is expected to have only minimal effect on the pile cost.

- Permanent and temporary easements were set at 15 feet each, for each side of the wall.
- Relocation costs were estimated as an allotment for each reach.
- Mobilization and demobilization costs were estimated at 3 percent of the construction cost.
- Due to the locations of the project segments along major roadways, traffic maintenance costs were generally assumed to be 5 percent of the construction cost. Segments 3 and 8 expect to incur minimal traffic impacts and the traffic maintenance cost for those sections was set at 2 percent.
- Common fill is assumed to be reused material from the floodwall excavation. Hauling and disposal costs are included for the balance of the material.
- Due to the segmentation of the project, permanent electrical power along the project alignment is not feasible. Instead, the sluice gates' motors will be powered by a portable, truck mounted generator.

5.2.2 Lands and Damages

Two types of easements are required for the coastal risk management project: permanent easements, in locations where the construction, operation, maintenance, patrol, and repair and replacement of the alignment and features are required; and temporary easements, to allow right-of-way in, over and across the land for the planned construction.

5.2.3 Pre-construction, Engineering, and Design/Construction Management

Pre-construction, Engineering, and Design (PED), and Construction Management were calculated as 15 percent and 8 percent, respectively, of project construction costs.

5.2.4 Escalation

Escalation in the Total Project Cost Summary as based on Civil Works Construction Cost Index System tables as revised on March 31, 2018.

5.2.5 Contingencies

Cost contingencies for the Recommended Plan, with the exception of Land and Damages, were developed through a Cost and Schedule Risk Analysis (CSRA), shown in Attachment 2. The contingency for Lands and Damages was estimated to be 50 percent. The overall cost contingency was 29.5 percent.

5.3 First Costs

Detailed project first costs for the Recommended Plan are presented in **Table 1** and are shown in the MII in Attachment 1 (less Lands and Damages).

Table 1: Project First Costs

Description	Amount	Cont.%	Cont. $	Total
01 – Lands and Damages	$2,417,000	50.0%	$1,208,000	$3,625,000
02 – Relocations	$1,100,000	29.5%	$325,000	$1,425,000
06 – Fish and Wildlife	$500,000	29.5%	$148,000	$648,000
11 – Levees and Floodwalls	$20,102,000	29.5%	$5,930,000	$26,032,000
15 – Floodway Control & Diversion	$2,907,000	29.5%	$858,000	$3,765,000
18 – Cultural Resources	$1,600,000	29.5%	$472,000	$2,072,000
30 – Engineering & Design	$3,931,000	29.5%	$1,208,000	$5,091,000
31 – Construction Management	$2,096,000	29.5%	$618,000	$2,714,000
TOTAL	$34,653,000	30.9%	$10,718,000	$45,371,000

6 OPERATION AND MAINTENANCE

The performance of the Recommended Plan will continue to meet its design intent if it is properly maintained during normal (non-storm conditions) and properly operated during times of nor'easters and hurricane flooding events. The need for proper maintenance of the plan is critical given the potential damages to infrastructure in this urban area if deterioration or damage to structures occurs due to lack of maintenance. The operation and maintenance (O&M) regiment will be developed in detail during construction; however, a general outline is summarized below.

6.1 Emergency Operations

Emergency surveillance, communication and chain of responsibility for the project's structures and associated infrastructure will fall under existing protocols agreed upon by the New Jersey Department of Environmental Protection (NJDEP), property owners, and NYD. Particular attention should be given to monitoring the performance of the project structures during storms in the first few years of operation, to ensure that they function as designed. Coordination and communication with NYD, the National Weather Service and National Hurricane Center, and the State of New Jersey will be required during storms to initiate standard flood-fighting techniques.

6.2 Maintenance

Maintenance is defined as the upkeep and repair of structures to maintain the function of the structure after construction is complete.

6.2.1 Floodwall

Maintenance of the concrete I- and T-walls is based on maintaining the integrity of the structure, which may be reduced due to loss of material at the toe of the structure and/or liquefaction of soil due to poor drainage. In addition, repair of the concrete will be performed to minimize corrosion of the reinforcing steel within the concrete.

6.2.2 Closure Gates

Maintenance of moveable structures, elimination of rust, and removal of debris will be required regularly to ensure proper operation. Periodic deployment should occur to ensure proper operation, traffic maintenance, and other logistics.

6.3 Rehabilitation

Due to the steel construction of many of the outfall and gate features, and synthetic material in the backflow prevention devices, replacement or rehabilitation of these items is assumed to be required every 25 years. The cost to replace the aforementioned items has been estimated using present worth calculations and included in the O&M costs outlined below.

6.4 O&M Costs

To address the items above, the annual O&M cost includes annual inspections and maintenance of the project including pumps, gate chambers, closure gates, sluice gates and backflow prevention. Annual O&M costs are shown in **Table 2.**

Table 2: Annual O&M Costs

Item	First Cost	Present Worth	Capital Recovery	O&M
Southwest Reach				
Floodwall Inspect				$28,880
CLOSURE GATES				$7,000
Gate Replacement	$633,546	$153,563	$5,827	
Gate Test				$10,000
		Total O&M - Southwest	**$5,827**	**$45,880**
I-95 Reach				
Floodwall Inspect				$4,520
CLOSURE GATES				$9,750
Gate Replacement	$402,555	$97,574	$3,703	
BACKFLOW	$58,906	$29,001	$1,642	
Gate Test				$10,000
		Total O&M – I-95	**$5,345**	**$24,274**
Minish				
Floodwall Inspect				$3,840
CLOSURE GATES				$6,500
Gate Replacement	$103,458	$25,007	$952	
Gate Test				$2,000
		Total O&M - Minish	**$952**	**$12,340**
Existing Structures				
Structure Inspect				$9,000

Item	First Cost	Present Worth	Capital Recovery	O&M
SLUICE GATES				$9,750
Gate Replacement	$449,656	$108,990	$4,136	
BACKFLOW	$512,863	$252,496	$14,299	
		Total O&M – Interior Drainage	**$18,435**	**$18,750**
			Total Annual O&M	**$132,000**

7 ANNUALIZED COSTS

7.1 Project Life

The project life is 50 years.

7.2 Interest and Amortization

The interest rate used in converting investment costs to equivalent annual costs is the rate set by the Water Resources Council for the evaluation of federal government water resources projects. This rate has been set at 2.875 percent for Fiscal Year 2019.

Amortization is the financial or economic process of recovering an investment in a project over a given period. The amortization period is the period of time assumed or selected for economic recovery of the net investment in a project (50-years). When combined, interest and amortization become the capital recovery factor which, when applied to project costs, will result in the annual cost of the project investment.

7.3 Monitoring Costs

The non-federal partner or its designee will be responsible for conducting the post-construction monitoring of the project mitigation site and any other environmental areas associated with the alignment. Three consecutive years of post-construction monitoring are planned at $50,000 per year. However, the plan should be adaptive and allow for a longer or shorter monitoring period depending on the annual results. The annual monitoring costs will be considered as part of the non-federal partners cost share; however, they are not included in the annual cost summary.

7.4 Interest During Construction

Interest during construction (IDC) was calculated to account for the cost of capital during the construction periods prior to the realization of project benefits. IDC was calculated for each project reach based on the following construction durations:

- Southwest: 12 months
- I-95: 12 months
- Minish: 6 months

The construction costs were assumed to be distributed evenly across the longest construction period. Project costs were amortized over the expected period of project construction at an interest rate of 2.875 percent.

7.5 Annual Costs

The Recommended Plan's annualized costs are shown in **Table 3**.

Table 3: Project Annual Costs

First Costs*	$45,371,000
Interest During Construction	$595,000
Total Investment Costs	**$45,966,000**
Annualized Investment Costs	$1,744,000
Annual Operations and Maintenance Costs	$132,000
Total Average Annual Costs	**$ 1,876,000**
*FY2019 Price level	

8 TOTAL PROJECT COSTS

The Total Project Cost Summary (TPCS) is shown in **Table 4**. The costs for each contract are escalated to the midpoint of construction.

Table 4: Total Project Cost Summary

PROJECT: **Passaic River Tidal GRR**
PROJECT NO: TBD
LOCATION: Newark, New Jersey

DISTRICT: New York District
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 3/11/2019

This Estimate reflects the scope and schedule in report; This Estimate reflects the latest plans, the Recommended Plan for the Passaic River Tidal GRR

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2019									
						Effective Price Level Date: 1 OCT 18									
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-18** ($K)	**TOTAL FIRST COST** ($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	$1,100	$325	29.5%	$1,425	0.0%	$1,100	$325	$1,425	$0	$1,425	10.4%	$1,214	$358	$1,573
06	FISH & WILDLIFE FACILITIES	$500	$148	29.5%	$648	0.0%	$500	$148	$648	$0	$648	10.4%	$552	$163	$715
11	LEVEES & FLOODWALLS	$20,102	$5,930	29.5%	$26,032	0.0%	$20,102	$5,930	$26,032	$0	$26,032	10.4%	$22,191	$6,546	$28,737
15	FLOODWAY CONTROL & DIVERSION STRU	$2,907	$858	29.5%	$3,765	0.0%	$2,907	$858	$3,765	$0	$3,765	10.4%	$3,210	$947	$4,157
18	CULTURAL RESOURCE PRESERVATION	$1,600	$472	29.5%	$2,072	0.0%	$1,600	$472	$2,072	$0	$2,072	10.4%	$1,766	$521	$2,287
	CONSTRUCTION ESTIMATE TOTALS:	$26,209	$7,732		$33,941	0.0%	$26,209	$7,732	$33,941	$0	$33,941	10.4%	$28,933	$8,535	$37,469
01	LANDS AND DAMAGES	$2,417	$1,208	50.0%	$3,625	0.0%	$2,417	$1,208	$3,625	$0	$3,625	7.2%	$2,590	$1,295	$3,885
30	PLANNING, ENGINEERING & DESIGN	$3,931	$1,160	29.5%	$5,091	0.0%	$3,931	$1,160	$5,091	$0	$5,091	7.2%	$4,213	$1,243	$5,456
31	CONSTRUCTION MANAGEMENT	$2,096	$618	29.5%	$2,714	0.0%	$2,096	$618	$2,714	$0	$2,714	13.9%	$2,388	$704	$3,092
	PROJECT COST TOTALS:	$34,653	$10,718	30.9%	$45,371		$34,653	$10,718	**$45,371**	$0	**$45,371**	10.0%	$38,124	$11,778	$49,901

ESTIMATED TOTAL PROJECT COST: $49,901

9 COST APPORTIONMENT

The estimated Total Project Cost is **$50,051,000** ($49,601,000 + $150,000 monitoring). The expected cost share for the Passaic River Tidal Protection Area Coastal Storm Risk Management project is $32,533,000 federal (65 percent) and $17,518,000 non-federal (35 percent), as shown in **Table 5**.

Table 5: Cost Apportionment

Federal Project Cost (65%)	**$32,533,000**
Non-Federal Project Cost (35%)	**$17,518,000**
LERR	
LER	$3,885,000
Relocations	$1,573,000
Cash Balance	$11,910,000
Monitoring	$150,000
Total Project Cost (100%)	**$50,051,000**

As the non-federal partner, NJDEP must comply with all applicable federal laws, policies and other requirements, including but not limited to:

a) Provide all lands, easements, rights-of-way, and relocations (LERR).

b) If the value of the partner's LERR contributions, plus the 5 percent minimum cash contribution, do not equal at least 35 percent of the total project cost, then the partner is required to provide an additional cash contribution necessary to equal a total of 35 percent. The partner is required to pay the additional cash contributions during construction at a rate proportional to federal expenditures. If the value of the partner's LERR contributions, plus the 5 percent minimum cash contribution, exceeds 35 percent of the total project cost, then the federal contribution is reduced accordingly. If the value of the partner's LERR contributions, plus the 5 percent minimum cash contribution, exceeds 50 percent of the total project cost, the project is cost shared at 50 percent federal, 50 percent non-federal cost.

c) For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and State laws and any specific directions prescribed by the government in the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R) manual and any subsequent amendments thereto.

d) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

e) Provide the non-federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement.

f) Do not use federal funds to meet the non-federal partner's share of total project costs unless the federal granting agency verifies in writing that the expenditure of such funds is authorized.

10 CONSTRUCTION SCHEDULE

The proposed construction schedule is shown in **Figure 4**.

Figure 4: Construction Schedule

ATTACHMENT 1
MII Summary

Estimated by AECOM

Designed by AECOM

Prepared by N. DeGraaff

Preparation Date 9/26/2018

Effective Date of Pricing 9/26/2018

Estimated Construction Time 365 Days

Designed by
AECOM

Estimated by
AECOM

Prepared by
N. DeGraaff

Design Document AECOM
Document Date 9/26/2018

District USACE - New York, NY
Contact AECOM

Budget Year 2018
UOM System Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost
OTHER

Timeline/Currency
Preparation Date 9/26/2018
Escalation Date 9/26/2018
Eff. Pricing Date 9/26/2018
Estimated Duration 365 Day(s)

Currency US dollars
Exchange Rate 1.000000

Costbook CB16EN: 2016 MII English Cost Book

Labor NLS2018: National Labor Library - Newark 2018

Note: http://www.wdol.gov is the website for current Davis Bacon & Service Labor Rates. Fringes paid to the laborers are taxable. In a non-union job the whole fringes are taxable. In a union jo pay frin

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP16R01: MII Equipment 2016 Region 01

01 NORTHEAST

Sales Tax	6.63
Working Hours per Year	1,360
Labor Adjustment Factor	1.16
Cost of Money	1.88
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00
Standby Depreciation Factor	0.50

Fuel

Electricity	0.143
Gas	3.010
Diesel Off-Road	3.140
Diesel On-Road	3.530

Shipping Rates

Over 0 CWT	17.43
Over 240 CWT	12.24
Over 300 CWT	9.98
Over 400 CWT	8.61
Over 500 CWT	7.45
Over 700 CWT	7.45
Over 800 CWT	10.71

Date	Author	Note
5/2/2016 3:15:04 PM	Location and Description	PROJECT LOCATION: The work is located in the City of Newark in Essex County, New Jersey.

DESCRIPTION OF WORK:

The Passaic Tidal LPP consists of concrete floodwalls and gates along three reaches as described below. The design elevation is 14 feet NAVD. The typical ground elevation at each segment is 6 to 10 feet NAVD. For areas with a wall height of four feet or less, the wall is typically a concrete I-wall; for areas where the wall is greater than four feet, the wall typically is a pile-supported, concrete T-wall.

The total LPP alignment length is approximately 4,850 LF feet and includes 6 closure gates and a tidal culvert.

Southwest Reach

The Southwest Reach alignment consists of two wall and gate segments that cut off flanking of the South Ironbound area of Newark by flood surge entering the Perimeter Ditch around Newark Liberty International Airport.

Segment 1: 170 linear feet (LF) of floodwall with one closure gate: a 140 LF gate across the intersection of Frelinghuysen Avenue and East Peddie Street. The gate would be approximately 4.0 feet high. The floodwall height would range from approximately 2.6 to 4.0 feet and tie into the adjacent railroad embankment.

Segment 2A (western part of Segment 2): 1,990 LF of floodwall located between the main rail line to Newark Penn Station and the southern tie-off of the LOP. Segment 2A ties into the railroad embankments on each end of the wall. The Segment 2A alignment accommodates the proposed PATH railway extension from Newark Penn Station to the Newark Liberty Airport transit hub.

Segment 2B (eastern part of Segment 2): 1,450 LF of floodwall from the tie-in at the NJ Transit/Amtrak railroad to the southern LOP tie-in. This segment includes a gate at New Jersey Railroad (NJRR) Avenue and the southern rail line, respectively. Floodwall and gate height along this segment would vary from 4.8 to 8.2 feet.

Date **Author** **Note**

I-95 Reach

The I-95 Reach alignment includes three wall segments:

Segment 3: 135 LF of levee with a culvert, headwalls, sluice gate, backflow prevention. The levee crosses an unnamed tidal creek just east of the New Jersey Turnpike. The levee height of this segment will be a maximum of approximately 9.4 feet.

Segment 4: 190 LF of floodwall across Delancy Street just east of the New Jersey Turnpike. The closure gate across Delancy Street would be approximately 70 LF and the floodwall height would range from approximately 4.1 to 4.8 feet.

Segment 5: 240 LF of floodwall across Wilson Avenue just east of the New Jersey Turnpike. The closure gate across Wilson Avene would be approximately 85 LF and the floodwall height would range from approximately 3.1 to 3.2 feet.

Minish Park Reach

The Minish Park Reach alignment includes one segment at Riverfront Park and one at Newark Penn Station:

Segment 6: 330 LF of floodwall along Edison Place and NJRR Avenue, and crossing NJRR Avenue to tie into the railroad embankment. The closure gate across NJRR Avenue would be approximately 30 LF. A closure gate was proposed along Edison Place at the Edison Park Fast; however, this gate is optional if the parking entrance is moved or may be a deployable structure, like a stop log structure. The height of the floodwall would range from approximately 0.9 to 3.1 feet.

Segment 8: 150 LF of floodwall along the side of the off ramp from Raymond Blvd to Jackson Street. This segment boarders the sidewalk adjacent to Riverfront Park and would have a height ranging from approximately 1.3 to 3.4 feet.

Date	Author	Note
5/2/2016 3:38:53 PM	Cost Estimate	COST ESTIMATE: This cost estimate provides a planning-level approximation of the total cost necessary to construct the flood control features described. The estimate uses unit pricing for the primary components of the project, and lump sum costs for other items as identified. The Mii (Ver. 4.2) estimate uses the 2016 Cost Works Library, which is the newest available cost library for the Mii Program. ALLOWANCES: Allowance items are estimated as fully loaded. Therefore no no markups have been applied to allowance items.
5/2/2016 3:39:01 PM	Weather Delay	ENVIRONMENTAL CONCERNS: This estimate has provisions for Monthly Anticipated Adverse Weather Delays. Calculated using the Markups, 90% productivity and 10% unproductivity was set, therefore labor and equipment costs will be affected. This setting will account for delays due to inclement weather.
5/2/2016 3:39:09 PM	Exclusions	EXCLUSIONS: This estimate is not a guaranteed price. Costs for extraordinary market conditions, hazardous waste removal or disposal, rock excavation, unforseen subsurface or existing conditions, purchase of right of way, liquidated damages and permit costs have been excluded.
5/2/2016 3:39:20 PM	Equipment and Labor	EQUIPMENT: MII Equipment Region 1r 2016 Fuel Prices are current as of 10/22/18, and are based on www.eia.gov weekly retail prices. Off-road diesel is approximately 12.5% cheaper than on-road diesel LABOR: Set per http://www.lwd.dol.state.nj.us/labor State: New Jersey Construction Type: Heavy, GD Number NJ20180052 (08/31/2018) County: Essex in New Jersey

Date	Author	Note
5/2/2016 3:39:38 PM	Markups	DIRECT MARKUP: Taxes: Local taxes will be applied. NJ sales tax rate is 6.625%. CONTRACTOR MARKUPS: Job Office Overhead (Calculated), with 2% of Labor for small tools. JOOH/FOOH is developed based on indirect costs which are those costs which cannot be attributed to a single task of construction work. Indirect costs are also referred to as distributed costs by both the prime contractors and subcontractor. JOOH(Running%) is included at 10% at the Prime Contractor Level, and 5% at the Subcontractor level. Home Office Overhead (Running %) is included at 3.9% at the Prime Contractor Level, and 5% at the Subcontractor Level. Profit on Prime (Profit Weighted Guidelines) is included at 6.95%. Subcontractor Profit (Direct markup) is included at 10%. Bond is determined by the bond table for Class B bond. OWNER MARKUPS: Escalation is not included. SIOH is not included. Contingency is not included.
10/30/2018 10:29:42 AM	Sales Tax and Escalation	Material quotes do not include NJ sales tax. NJ state sales tax is included as a separate markup at 6.625% on all material costs. Material costs do not include escalation to midpoint of construction.

Direct Cost Markups		**Category**		**Method**		
Productivity		Productivity		Productivity		
Overtime		Overtime		Overtime		
	Days/Week	*Hours/Shift*	*Shifts/Day*	*1st Shift*	*2nd Shift*	*3rd Shift*
Standard	*5.00*	*8.00*	*1.00*	*8.00*	*0.00*	*0.00*
Actual	*5.00*	*8.00*	*1.00*	*8.00*	*0.00*	*0.00*

Day	*OT Factor*	*Working*	*OT Percent*	*FCCM Percent*
Monday	*1.50*	*Yes*	*10.00*	*0.00*
Tuesday	*1.50*	*Yes*		
Wednesday	*1.50*	*Yes*		
Thursday	*1.50*	*Yes*		
Friday	*1.50*	*Yes*		
Saturday	*1.50*	*No*		
Sunday	*2.00*	*No*		

Sales Tax	TaxAdj	Running % on Selected Costs
MatlCost		
Equipment Escalation	TaxAdj	Running % on Selected Costs
EQCost		

Gate Work		Overtime		Overtime		
	Days/Week	*Hours/Shift*	*Shifts/Day*	*1st Shift*	*2nd Shift*	*3rd Shift*
Standard	*5.00*	*8.00*	*3.00*	*0.00*	*0.00*	*8.00*
Actual	*7.00*	*8.00*	*3.00*	*0.00*	*0.00*	*8.00*

Day	*OT Factor*	*Working*	*OT Percent*	*FCCM Percent*
Monday	*1.50*	*Yes*	*82.14*	*(64.29)*
Tuesday	*1.50*	*Yes*		
Wednesday	*1.50*	*Yes*		
Thursday	*1.50*	*Yes*		
Friday	*1.50*	*Yes*		
Saturday	*1.50*	*Yes*		
Sunday	*2.00*	*Yes*		

Contractor Markups	**Category**	**Method**
JOOH Prime	JOOH	Running %
JOOH Small Tools (Small Tools)	Allowance	% of Labor
JOOH Small Tools	JOOH	JOOH (Calculated)
HOOH	HOOH	Running %
Profit	Profit	Direct %
Bond	Bond	Bond Table
Class B, Tiered, 24 months, 1.00% Surcharge		

Contract Price	*Bond Rate*
500,000	*15.84*

2,000,000	*9.57*
2,500,000	*7.59*
2,500,000	*6.93*
7,500,000	*6.34*

JOOH Sub	Allowance	Running %
HOOH Sub	HOOH	Running %
Sub Profit	Profit	Running %

Owner Markups	**Category**	**Method**
Contingency	Contingency	Running %

Description	Quantity	UOM	ProjectCost
Summary of Major Project Components			**26,209,312**
02 Relocations	**1**	**LS**	**1,100,000**
06 Fish and Wildlife Facilities	**1**	**LS**	**500,000**
11 Levees and Floodwalls	**1**	**LS**	**20,101,839**
15 Floodway Control and Diversion Structures	**1**	**LS**	**2,907,473**
18 Cultural Resource Preservation	**1**	**LS**	**1,600,000**

Description	Quantity	UOM	ProjectCost
Project Cost Summary			**26,209,312**
02 Relocations	**1**	**LS**	**1,100,000**
Segment 1	**1**	**LS**	**200,000**
Segment 2	**1**	**LS**	**200,000**
Segment 3	**1**	**LS**	**50,000**
Segment 4	**1**	**LS**	**200,000**
Segment 5	**1**	**LS**	**200,000**
Segment 6	**1**	**LS**	**200,000**
Segment 8	**1**	**LS**	**50,000**
06 Fish and Wildlife Facilities	**1**	**LS**	**500,000**
11 Levees and Floodwalls	**1**	**LS**	**20,101,839**
Southwest Reach	**1**	**LS**	**15,424,182**
I-95 Reach	**1**	**LS**	**3,670,351**
Minish Park Reach	**1**	**LS**	**1,007,307**
15 Floodway Control and Diversion Structures	**1**	**LS**	**2,907,473**
Stormwater 5	**1**	**LS**	**451,368**
Stormwater 6	**1**	**LS**	**426,375**
Avenue C	**1**	**LS**	**267,849**
Pierson Creek 2	**1**	**LS**	**450,984**
030 Wheeler 1	**1**	**LS**	**450,390**
023 Adams 1	**1**	**LS**	**450,984**
Existing Manholes	**1**	**LS**	**409,522**
18 Cultural Resource Preservation	**1**	**LS**	**1,600,000**

ATTACHMENT 2
Cost and Schedule Risk Analysis (CSRA) Report

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 the Passaic River (Tidal Portion) project. 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 project first 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.

The project involves the construction of flood risk management measures in the vicinity of the Passaic River. The Recommended Plan, is the Locally Preferred Plan (LPP).

The scope of the CSRA is the following project components:

The Passaic Tidal LPP alignment length is approximately 4,850 LF feet and includes 8 closure gates along three reaches as described below. The design elevation is 14 feet NAVD. The typical ground elevation at each segment is 6 to 10 feet NAVD. For areas with a wall height of six feet or less, the wall is typically a concrete I-wall; for areas where the wall is greater than six feet, the wall typically is a pile-supported, concrete T-wall.

Southwest Reach

The Southwest Reach alignment consists of two wall and gate segments that cut off flanking of the South Ironbound area of Newark by flood surge entering the Perimeter Ditch around Newark Liberty International Airport.

Segment 1: 170 linear feet (LF) of floodwall with one closure gate: a 140 LF gate across the intersection of Frelinghuysen Avenue and East Peddie Street. The gate would be approximately 4.0 feet high. The floodwall height would range from approximately 2.6 to 4.0 feet and tie into the adjacent railroad embankment.

Segment 2A (western part of Segment 2): 1,990 LF of floodwall located between the main rail line to Newark Penn Station and the southern tie-off of the LOP. Segment 2A ties into the railroad embankments on each end of the wall. The Segment 2A alignment accommodates the proposed PATH railway extension from Newark Penn Station to the Newark Liberty Airport transit hub.

Segment 2B (eastern part of Segment 2): 1,450 LF of floodwall from the tie-in at the NJ Transit/Amtrak railroad to the southern LOP tie-in. This segment includes a gate at New Jersey Railroad (NJRR) Avenue, the southern rail line, and one adjacent to the rail line. Floodwall and gate height along this segment would vary from 4.8 to 8.2 feet.

I-95 Reach

The I-95 Reach alignment includes three wall segments:

Segment 3: 135 LF of levee with a culvert, headwalls, three sluice gates, three outlet pipes, and backflow prevention. The levee crosses an unnamed creek just east of the New Jersey Turnpike. The levee height of this segment will be a maximum of approximately 9.4 feet.

Segment 4: 190 LF of floodwall across Delancy Street just east of the New Jersey Turnpike. The closure gate across Delancy Street would be approximately 70 LF and the floodwall height would range from approximately 4.1 to 4.8 feet.

Segment 5: 240 LF of floodwall across Wilson Avenue just east of the New Jersey Turnpike. The closure gate across Wilson Avenue would be approximately 85 LF and the floodwall height would range from approximately 3.1 to 3.2 feet.

Minish Park Reach

The Minish Park Reach alignment includes one segment at Riverfront Park and one at Newark Penn Station:

Segment 6: 330 LF of floodwall along Edison Place and NJRR Avenue, and crossing NJRR Avenue to tie into the railroad embankment. The closure gate across NJRR Avenue would be approximately 30 LF. A closure gate is proposed along Edison Place at the Edison Park Fast. The height of the floodwall would range from approximately 0.9 to 3.1 feet.

Segment 8: 150 LF of floodwall along the side of the off ramp from Raymond Blvd to Jackson Street. This segment boarders the sidewalk adjacent to Riverfront Park and would have a height ranging from approximately 1.3 to 3.4 feet.

The project is at a preliminary design stage.

The CSRA is based on information gathered at a formal risk workshop held on September 24, 2018, where participants identified risks and assessed their likelihood and possible cost and schedule impact. The CSRA then classified risks as low, moderate, or high risks, based on the combination of assessed likelihood and impact. For risks classified as moderate or high risks, the PDT estimated numeric values for low, most likely, and high impacts, so as to better quantify the magnitude and variability of the most important risks.

The CSRA modeled the identified risks, and their cost and schedule impacts in a Monte Carlo simulation that generated a large number of potential project outcomes. The CSRA then analyzed the distribution of these outcomes to estimate cost and schedule contingencies.

The CSRA excludes real estate costs and risks. Real estate contingencies will be developed separately outside of the CSRA. The CSRA excludes life cycle costs and operating and maintenance (O&M) costs. The CSRA is also based on other key assumptions detailed in Section 5.

The current project base cost estimate for remaining work, excluding real estate costs and contingencies, is approximately $32.2 million. Based on the results of the CSRA, this report recommends a contingency value of $9.5 million or approximately 29.5% of the base project cost at an 80% confidence level of successful execution. For reference, Table 1 shows the contingency results calculated for the 50%, 80%, and 90% confidence levels.

Table 1: Combined Cost and Schedule Contingency Results

Baseline Estimate Cost (without contingencies) =			**$32,237,466**
Confidence Level	**Contingency**	**Baseline Estimate Cost plus Contingency**	**Contingency (%)**
50%	$6,279,095	$38,516,561	19.5%
80%	**$9,513,220**	**$41,750,686**	**29.5%**
90%	$10,325,440	$42,562,906	32.0%

Cost risks make up a much greater portion of the contingency than schedule risks. At the 80% confidence level, the base cost contingency makes up 88.1% of the combined cost and schedule contingency.

Over one-third of the base cost contingency is due to uncertainties in one risk factor – TR5 Incomplete studies (geotechnical/structural). This risk factor represents the risk that detailed geotechnical data has not yet been collected for floodwall sites. Additional information will be required for further design which could require a more robust foundation design due to poor soils around the wall and gates.

After risk factor TR5, the next highest contributor to the base cost contingency is risk factor TR6 (Incomplete studies hydrology/hydraulic/interior drainage), at 26.3%. This risk factor represents the interior drainage plan and how it should be refined with the city's combined sewer system. There is uncertainty regarding the existing combined sewer system outside the line of protection that requires the sealing of manholes and other connections.

Table 2 lists other risk factors that contribute more than 2% to the base cost contingency.

Table 2: Other Top Cost Risk Factors

Risk No.	Risk Opportunity/ Event	Concerns	PDT Risk Conclusions, Justification	Contribution
CO4	Transportation / haul routes constricted or unusable during periods of time	Site areas are very congested. Production rates can be impacted due to the congestion.	Production rates may be lower than MII estimate, however, haul quantities are not large.	22.3%
EX1	Unexpected escalation on key materials	Steel and other prices have been rising.	Commodity prices may increase throughout the duration of the contract.	11.8%

The CSRA identifies a total of 31 risk factors or opportunities and quantifies their importance. The PDT should develop plans for responding to the identified risks and opportunities, ideally starting with the most important ones.

The PDT should conduct regular risk review meetings to review risks that have already been identified, and to identify and quantify new risks that arise as the project progresses. The CSRA should be repeated if there are any significant changes in risks or opportunities.

PDT should update the risk register (included in Appendix D) as designs, cost estimates, and schedule are further refined.

1 PURPOSE

The US Army Corps of Engineers (USACE), New York District presents the results of the cost and schedule risk analysis (CSRA) for the Passaic River (Tidal Portion) project. 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 BACKGROUND

The project involves the construction of flood risk management measures in the vicinity of the Passaic River in Newark, NJ.

The Passaic Tidal LPP alignment length is approximately 4,850 LF feet and includes 8 closure gates along three reaches as described below. The design elevation is 14 feet NAVD. The typical ground elevation at each segment is 6 to 10 feet NAVD. For areas with a wall height of six feet or less, the wall is typically a concrete I-wall; for areas where the wall is greater than six feet, the wall typically is a pile-supported, concrete T-wall.

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Segment 8: 150 LF of floodwall along the side of the off ramp from Raymond Blvd to Jackson Street. This segment boarders the sidewalk adjacent to Riverfront Park and would have a height ranging from approximately 1.3 to 3.4 feet.

The total LPP alignment length is approximately 4,850 LF feet and includes 8 closure gates and a tidal culvert.

3 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% 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.

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) MII cost estimate, 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 project features 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 METHODOLOGY/PROCESS

The Cost and Schedule Risk Analysis was performed with guidance and input from the PDT.

The analysis is intended to determine the probability of various cost and schedule outcomes and quantify the contingency needed in the cost and schedule estimate to achieve a desired level of confidence.

A contingency is an amount added to an estimate to allow for items, conditions, or events for which the occurrence or impact is uncertain but that experience suggests will likely result in additional costs being incurred or additional time being required. The contingency should reflect how willing project leadership is to accept the risk of project overruns. The less risk that project leadership is willing to accept, the greater the contingency should be. The risk of overrun is expressed in probabilistic terms using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis recommends using an 80% level of confidence for determining contingency. This means setting the contingency so that the base cost or schedule duration plus the contingency covers the lowest 80% of potential project outcomes. Using an 80% level of confidence is somewhat risk-averse, whereas using a 50% level of confidence would be risk-neutral, and using levels less than 50% would be risk-seeking. An 80% confidence level results in greater contingency as compared to a 50% 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 analysis used Monte Carlo simulation to generate a large number of potential cost and schedule outcomes in light of the identified risks, and then identified the contingency from the distribution of simulated outcomes.

The following subsections describe the primary steps of the analysis. Section 6 provides the results of the analysis.

4.1 Identify and Assess Risk Factors

The PDT held a formal risk workshop on September 24, 2018.

The workshop participants included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, geotechnical, environmental, and others.

Table 3 summarizes the workshop participants.

Table 3: Participants in September 24, 2018 Risk Workshop

Organization	Office/Role	Number of Participants
New York - USACE	Cost Engineering	1
New York - USACE	Economist	1
New York - USACE	Engineering Management	1
New York - USACE	Environmental	2
New York - USACE	Geotechnical	1
New York - USACE	Program Management	1
New York - USACE	Structural	2
New York - USACE	Planning	1
AECOM	Project Engineering	1
AECOM	Project Management	1
AECOM	Cost Estimating / Risk Analyst	1

The primary objective of the workshop was to gather inputs from the participants to answer the following questions:

1. **What could go worse or better than planned?**

   As a group, participants worked through the risk checklist provided in the USACE Cost and Schedule Risk Analysis Guidance document and identified risks and opportunities relevant to this project. The participants also discussed other risks and opportunities specific to this project or common to similar projects and in some cases identified these as relevant.

2. **How likely is it?**

   For each risk factor or opportunity identified in Step 1, participants as a group rated the likelihood that it would impact the project cost, and rated the likelihood that it would impact the project schedule. Participants rated likelihoods using the qualitative ratings shown in Table 4.

   Table 4: Qualitative Likelihood Ratings

Qualitative Likelihood Rating	Quantitative Probability Range
Very Likely	70% to 90%
Likely	30% to 70%
Possible	5% to 30%
Very Unlikely	0% to 5%

3. **What are the potential cost or schedule impacts?**

For each risk factor or opportunity identified in Step 1, participants as a group rated the potential impact on the project cost, and rated the potential impact on the project schedule. Participants rated impacts using the qualitative ratings shown in Table 5.

Table 5: Qualitative Impact Ratings

Qualitative Impact Rating	Quantitative Cost Impact Range (% of Baseline Cost Exceeded)	Quantitative Schedule Impact Range (% of Baseline Schedule Exceeded)
Negligible	0% to 0.5%	2% to 3%
Marginal	0.5% to 2%	3% to 5%
Significant	2% to 3%	5% to 10%
Critical	3% to 5%	10% to 20%
Crisis	Over 5%	Over 20%

The inputs are recorded in the risk register included in Appendix D and described in Section 6.1.

For each risk factor or opportunity and for each of cost and schedule, a qualitative risk level was assigned based the assigned likelihood and impact ratings and the criteria in Table 6.

Table 6: Qualitative Risk Levels

Qualitative Likelihood Rating	Qualitative Impact Rating				
	Negligible	Marginal	Moderate	Significant	Critical
Certain	RELOOK AT BASIS OF ESTIMATE				
Very Likely	Low	Medium	High	High	High
Likely	Low	Medium	Medium	High	High
Possible	Low	Low	Medium	Medium	High
Unlikely	Low	Low	Low	Medium	Medium

Following the risk workshops:

1. The PDT identified certain cases where one risk factor was already captured by or correlated with another risk factor.

The risk register included in Appendix D and described in Section 6.1 identifies these cases and describes how they were treated.

2. For each risk factor and opportunity, and for each of cost and schedule, the PDT estimated numeric values for the low, high, and most likely impacts as follows:
   a) For risk factors that had been assigned a qualitative risk level of Moderate or High, the PDT developed estimates are based on specific considerations of each risk factor.
   b) For risk factors that had been assigned a qualitative risk level of Low, the PDT used estimates equal to the lower and upper bounds defined in Table 5 for the assessed impact rating, or other estimates based on specific considerations of each risk factor.

The risk model included in Appendix E details the estimated numeric values for each risk factor. The rationale for each estimated value is documented in the Crystal Ball risk model that accompanies this document.

4.2 Model Risks

Using the Crystal Ball software, risks identified in the risk register as follows:

1. For each risk factor or opportunity, and for each of cost and schedule:
   a) If the risk factor or opportunity had been assigned qualitative risk level of Moderate or High, assume the risk factor or opportunity occurs.
   b) Otherwise:
      i) Simulate the probability of occurrence as a uniform random variable over the range defined in Table 4 for the assessed likelihood rating.
      ii) Simulate the occurrence as a Yes/No random variable with the probability simulated in Step i) above.
   c) If the risk factor or opportunity does not occur, assume the impact is zero.
   d) Otherwise:
      i) If the risk factor or opportunity had been assigned qualitative risk level of Moderate or High, simulate the impact as a triangular random variable between the estimated values for the low and high impacts, and with a peak (mode) at the estimated value for the most likely impact.
      ii) Otherwise, simulate the impact as a uniform random variable between the estimated values for the low and high impacts.
2. For each of cost and schedule, calculate total impacts over:
   a) All risk factors and opportunities, and,
   b) Only risk factors and opportunities where the corresponding cost or schedule quantitative risk level was Moderate or High, and,

Section 4.3 discusses the uses of these totals in more detail.

3. Repeat the simulation for a total of 200,000 trials.

The result was a set of 200,000 potential project outcomes that were analyzed as Section 4.3 describes to estimate cost and schedule contingencies.

Appendix E provides details of the risk model, including parameters used to model the likelihood and impact of each risk factor and opportunity.

4.3 Analyze Cost Estimate and Schedule Contingency

The base cost contingency was calculated as follows:

1. From the potential project outcomes generated by the simulation, identify the percentile of the total cost impact of all risk factors and opportunities that corresponds to the desired confidence level.
2. Calculate the percentage that the percentile identified in Step 1 represents of the base cost estimate.
3. Round the percentage calculated in Step 2 to the nearest whole percentage.
4. Calculate the contingency as the rounded percentage calculated in Step 3 multiplied by the base cost estimate.

The base schedule contingency was calculated in a similar fashion, except using the schedule impact and base schedule estimate in place of their cost counterparts.

The contingency for the cost of schedule delays was calculated as follows:

1. Use the following parameters:
   a) [Baseline Cost] = $32,237,466
   b) [Baseline Start Date] = November 29, 2021
   c) [Baseline Completion Date] = November 24, 2022
   d) [Current OMB Escalation Rate] = 1.8% (the current OMB nominal discount rate for a 10-year term)
   e) [Current Project Location Escalation Rate] = 2.20% (the product of the current OMB escalation rate and USACE CWCCIS 1.20 state adjustment factor for the state of New Jersey)
   f) [Assumed Annual Recurring Cost Amount] = $270,000, which assumes the equivalent of 1 full-time employee at $270,000/year
   g) [Maximum Anticipated Annual Amount] = [Baseline Cost] / ([Baseline Completion Date] – [Baseline Start Date]) * 365.25

2. Calculate unplanned escalation costs as follows:

   ([Current Project Location Escalation Rate] – [Current OMB Escalation Rate]) * [Maximum Anticipated Annual Amount] / 365 * [Schedule Contingency (in days)]

3. Calculate the unplanned recurring costs as follows:

   [Assumed Annual Recurring Cost Amount] / 365.25 * [Schedule Contingency (in days)]

4. Calculate the contingency as the sum of the costs calculated in Step 2 and 3.

The resulting contingency was added to the base cost contingency to calculate the total project cost contingency.

5 KEY ASSUMPTIONS

Key assumptions in the CSRA include the following:

1. **Level of Design** – The CSRA is based on designs that are at approximately a 20% to 30% level, (preliminary feasibility-level design).
2. **Cost Estimate** – The CSRA is based on an MII MCACES (Micro-Computer Aided Cost Estimating Software) cost estimate and dated September 2018.
3. **Real Estate Costs** – The CSRA excludes real estate costs (Account 01 – Lands & Damages) from the base cost estimate. Real estate contingencies will be developed separately outside of the CSRA.
4. **Life Cycle Costs** – The CSRA excludes life cycle costs.
5. **Operating and Maintenance Costs** – The CSRA excludes operating and maintenance costs.
6. **Cost of Schedule Delays** – The CSRA estimates the cost of schedule delays in terms of unplanned escalation and recurring costs as detailed in Section 4.3.
7. **All Risks Included** – The CSRA results include the effect of all identified risks. In risk analyses, it is common include only the effect of Moderate and High level risks. In this CSRA, the combined effect of Low level risks was found to be significant (see Sections 6.2 and 6.3), so these are also included.

6 RESULTS

The following sections provide the cost and schedule risk analysis results. These results include contingency calculation results, as well as sensitivity analyses that illustrate variability and the key contributors to it.

6.1 Risk Register

The risk register developed for this project is provided in Appendix D. The risk register includes all risks identified by the PDT, as well as additional information regarding the nature and impacts of each risk.

Specifically, for each risk factor and opportunity, the risk register identifies the following:

1. **Risk No.** – A code assigned to uniquely identify the risk factor or opportunity.
2. **Risk/Opportunity Event** – A short description of the risk factor or opportunity.
3. **Concerns** – A summary of the concerns discussed by the PDT relating to the risk factor or opportunity.
4. **PDT Risk Conclusions, Justification** – A summary of PDT discussions and/or subsequent modeler assumptions regarding the likelihood or impact of the risk factor or opportunity.
5. **Project Cost:**
   a) **Likelihood** – Qualitative rating assigned as to the likelihood that the risk factor or opportunity will impact the project cost.
   b) **Impact** – Qualitative rating assigned as to the potential impact of the risk factor or opportunity on the project cost.
   c) **Risk Level** – Qualitative cost risk level corresponding to the assigned likelihood and impact per Table 6.
6. **Project Schedule:**
   a) **Likelihood** – Qualitative rating assigned as to the likelihood that the risk factor or opportunity will impact the project schedule.
   b) **Impact** – Qualitative rating assigned as to the potential impact of the risk factor or opportunity on the project cost.
   c) **Risk Level** – Qualitative schedule risk level corresponding to the assigned likelihood and impact per Table 6.
7. **Responsibility/POC** – Individual or group identified by the PDT as responsible for managing the risk factor or opportunity.

6.2 Cost Contingency Results

This section discusses results discussed that exclude the cost of schedule delay. Section 7.4 discusses results that include the cost of schedule delay.

Table 7 shows the base cost contingencies for all risks calculated for the 50%, 80%, and 90% confidence levels.

The base cost contingency for all risks calculated for the 80% confidence level was approximately $8.3 million (26% of the baseline estimate for the total project cost).

Table 7: Cost Contingency Results (All Risks)

Baseline Estimate Cost (without contingencies) =			**$32,237,466**
Confidence Level	**Contingency**	**Baseline Estimate Cost plus Contingency**	**Contingency (%)**
50%	$2,256,623	$34,494,089	7.0%
80%	**$8,381,741**	**$40,619,207**	**26.0%**
90%	$9,026,490	$41,263,956	28.0%

For comparison, Table 8 shows the corresponding results if only Moderate and High risks are included. The base cost contingency for the 80% confidence level was approximately $7.09 million, which is $1.28 million less than the corresponding $8.38 million contingency calculated if all risks are included. The $1.28 million represents the effect of Low risks, and makes up 15.3% of the $8.38 million effect of all risks, which is somewhat significant. For this reason, this CSRA includes the effect of Low, Moderate, and High cost risks.

Table 8: Cost Contingency Results (Medium and High Risks Only)

Baseline Estimate Cost (without contingencies) =			**$32,237,466**
Confidence Level	**Contingency**	**Baseline Estimate Cost plus Contingency**	**Contingency (%)**
50%	$4,190,871	$36,428,337	13.0%
80%	**$7,092,243**	**$39,329,708**	**22.0%**
90%	$8,059,366	$40,296,832	25.0%

Figure 1 shows the base cost contingencies for all risks calculated for 0% to 100% confidence levels in 10% increments of confidence level.

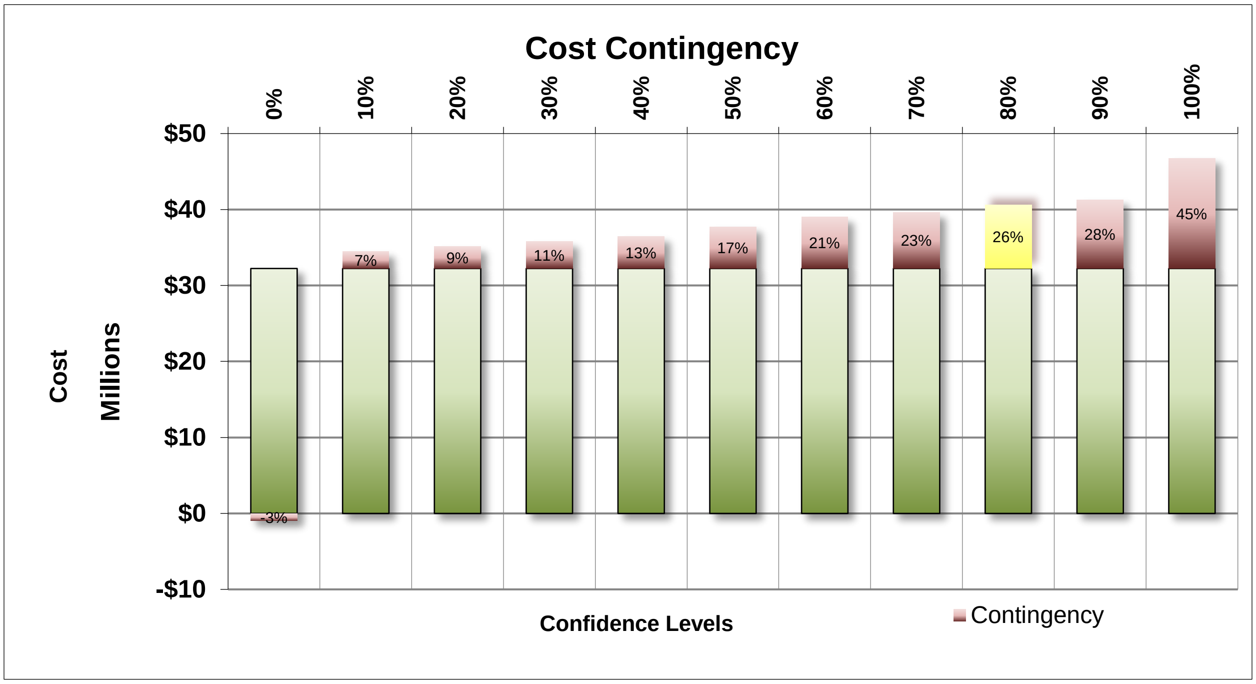

Figure 1: Cost Contingency Results (All Risks)

Figure 2 shows the sensitivity of the uncertainty in the total project cost to the individual uncertainties (probability, occurrence, and impact) of all cost risks and opportunities identified in the risk register. For each uncertainty, Figure 2 shows the approximate percentage of the variance in the total project cost that is due to that uncertainty. Figure 2 lists the uncertainties greater than 2% in descending order of sensitivity and groups the remaining uncertainties under "Other".

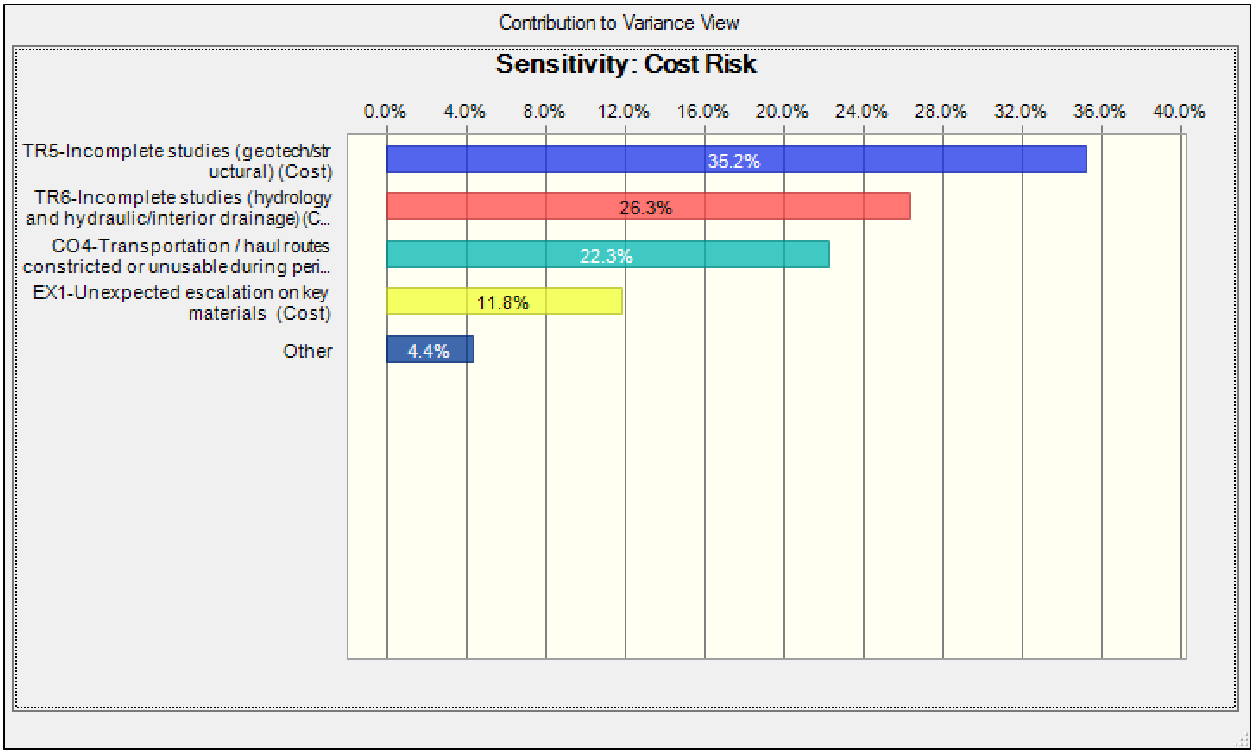

Figure 2: Cost Sensitivity Analysis (All Risks)

Figure 2 shows that one-third of the base cost contingency is due to uncertainties in one risk factor – TR5 (Incomplete studies geotechnical/structural).

Risk factor TR5 represents the risk factor represents the risk that there detailed geotechnical analysis has not yet been completed. Additional information will be required for further design which could require a more robust foundation design due to poor soils around the wall and gates.

The CSRA modeled the cost impact of risk factor TR5 as a triangular random variable distributed as follows:

1. *Low Value* – Assume only three-quarters of the sheeting is required and no H-piles are required for Segment 2. No other segments are expected to require sheeting or sheet piling.
2. *Most Likely Value* – Assume the value as estimated.
3. *High Value* – Assume H-piles will be required for the entire length of Segment 2.

After risk factor TR5, the next highest contributor to the base cost contingency is risk factor TR6 (Incomplete studies hydrology/hydraulic/interior drainage), at 26.6%. This risk factor represents the interior drainage plan and how it should be refined with the city's combined sewer system. There is uncertainty regarding the existing combined sewer system outside the line of protection that requires the sealing of manholes and other connections. The CSRA modeled the cost impact of risk factor TR6 as a triangular random variable distributed as follows:

1. *Low Value* – Assume an opportunity that 50 less manholes will need to be sealed compared with the estimate.
2. *Most Likely Value* – Assume the value is an average of the low and high conditions.
3. *High Value* - Assume the cost impact as an additional 100 manholes will need to be sealed as compared to the estimate.

Table 9 lists other risk factors that contribute more than 2% to the base cost contingency.

Table 9: Other Top Cost Risk Factors

Risk No.	Risk Opportunity/ Event	Concerns	PDT Risk Conclusions, Justification	Contribution
CO4	Transportation / haul routes constricted or unusable during periods of time	Site areas are very congested. Production rates can be impacted due to the congestion.	Production rates may be lower than MII estimate, however, haul quantities are not large.	22.3%
EX1	Unexpected escalation on key materials	Steel and other prices have been rising.	Commodity prices may increase throughout the duration of the contract.	11.8%

6.3 Schedule Contingency Results

Table 10 shows the base schedule contingencies for all risks calculated for the 50%, 80%, and 90% confidence levels.

The base schedule contingency for all risks calculated for the 80% confidence level was approximately 58.9 months.

Table 10: Schedule Contingency Results (All Risks)

Baseline Estimate Cost (without contingencies) =			11.8 Months
Confidence Level	**Contingency**	**Baseline Estimate Cost plus Contingency**	**Contingency (%)**
50%	20.7 Months	32.5 Months	174.5%
80%	**30.4 Months**	**42.3 Months**	**257.0%**
90%	35.7 Months	47.6 Months	302.0%

For comparison, Table 11 shows the corresponding results if only Moderate and High risks are included. The base schedule contingency for the 80% confidence level was approximately 40.1 months, which is 2.3 months less than the corresponding 42.4-month contingency calculated if all risks are included. The 2.3 months represents the effect of Low risks, and makes up 5.4% of the 42.4-month effect of all risks, which is fairly significant. For this reason, this CSRA includes the effect of Low, Moderate, and High schedule risks.

Table 11: Schedule Contingency Results (Medium and High Risks Only)

Baseline Estimate Cost (without contingencies) =			11.8 Months
Confidence Level	**Contingency**	**Baseline Estimate Cost plus Contingency**	**Contingency (%)**
50%	18.5 Months	30.3 Months	156.0%
80%	**28.2 Months**	**40.0 Months**	**238.0%**
90%	33.6 Months	45.4 Months	284.0%

Figure 3 shows the base schedule contingencies for all risks calculated for 0% to 100% confidence levels in 10% increments of confidence level.

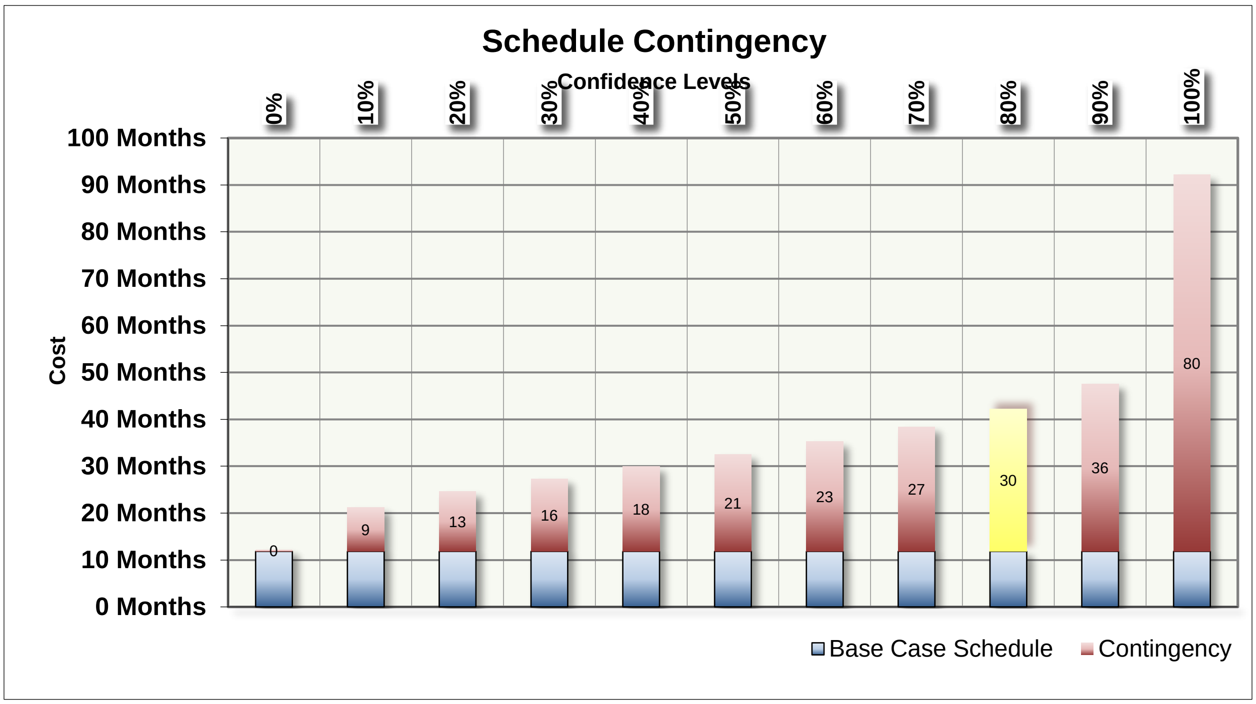

Figure 3: Schedule Contingency Results (All Risks)

The contingency calculations effectively assumed that, when schedule risk events occur, they directly impact the project duration. This might be considered conservative. It is possible that some schedule risk events may not impact the project duration, or may only partly impact it, depending on whether or not the activities they affect are on the critical path. Schedule contingencies should therefore be used with caution.

Figure 4 shows the sensitivity of the uncertainty in the total project schedule to the individual uncertainties (occurrence and impact) of the schedule risks and opportunities identified in the risk register. For each uncertainty, Figure 4 shows the approximate percentage of the variance in the total project schedule that is due to that uncertainty. Figure 4 lists the top 8 uncertainties in descending order of sensitivity and groups the remaining uncertainties under "Other".

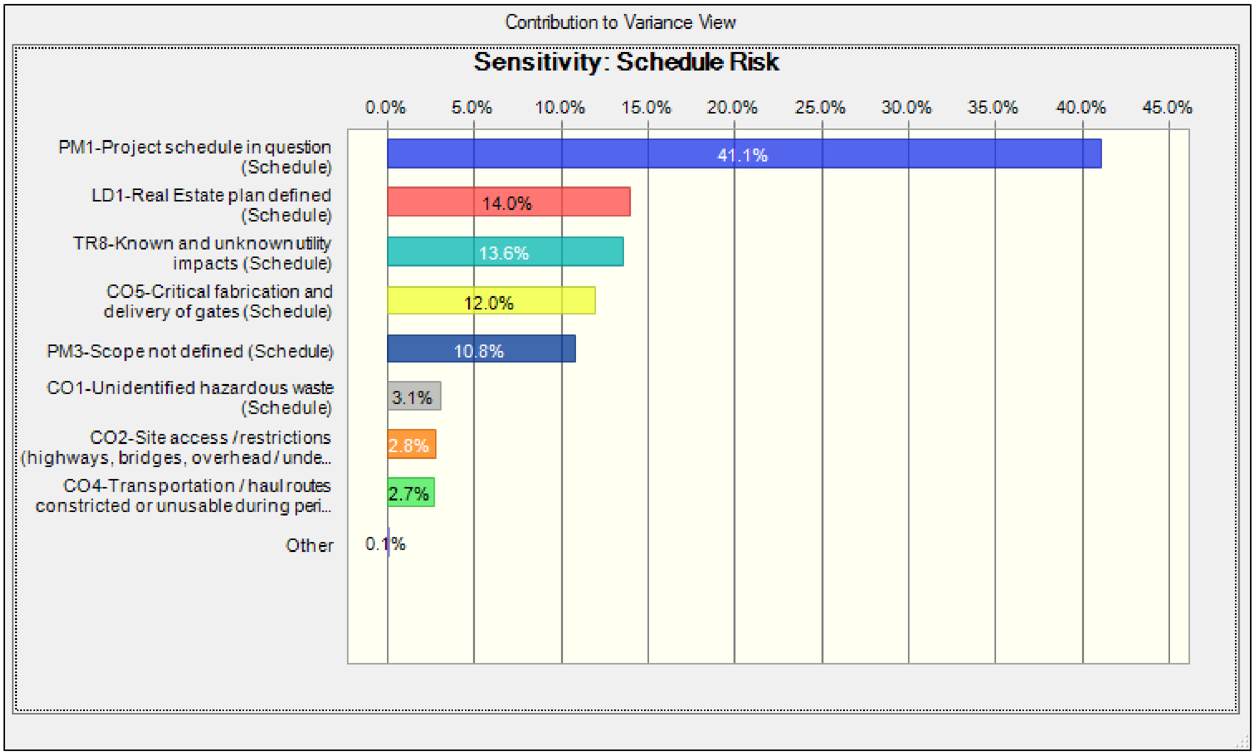

Figure 4: Schedule Sensitivity Analysis (All Risks)

Figure 4 shows that 41.1% of the uncertainty in the total project schedule is due to uncertainties in one risk factor PM1 – (Project Schedule in question). This risk factor represents that contaminated material may be discovered during the planning, engineering, and design phase of the project.

The CSRA modeled the schedule impact of risk factor CO1 as a triangular random variable distributed as follows:

1. *Low Value* – Assume schedule is as estimated.
2. *Most Likely Value* – Assume some sites will be delayed, making the overall project moderately delayed.
3. *High Value* – Assumes some sites will be delayed and that the overall start of construction of the project will be delayed by two years while waiting for the contamination to be cleaned up.

After risk factor PM1, the next highest contributor to the schedule contingency is risk factor LD1 (Project Schedule in question), at 14.0%. This risk factor represents the risk that there will be delays in acquiring easements (including around the railroad) which can cause a delay in bidding and construction.

The CSRA modeled the schedule impact of risk factor LD1 as a triangular random variable distributed as follows:

1. *Low Value* – Assume schedule is as estimated.
2. *Most Likely Value* – Assume schedule is as estimated.
3. *High Value* – Assume twelve additional months will be required to receive all required easements and access permits.

Table 12 lists other risk factors that contribute more than 2% to the base schedule contingency.

Table 12: Schedule Contingency Results

Risk No.	Risk Opportunity/ Event	Concerns	PDT Risk Conclusions, Justification	Contribution
TR8	Known and unknown utility impacts	Required relocations of overhead electric, pipelines, fiber optics, and other unknown utilities may result in costs or delays that are not included in the current cost estimate or schedule. The current cost estimate is based upon an allowance (fixed amount).	Required relocations of overhead electric, pipelines, fiber optics, and other unknown utilities may result in costs or delays that are not included in the current cost estimate or schedule. The current cost estimate is based upon an allowance (fixed amount).	13.6%
CO5	Critical fabrication and delivery of gates	Gates fabrication time	Gates will require time to fabricate and deliver. May impact the schedule.	12.0%
PM3	Scope not defined	Scope not defined for relocation of on-ramp at Segment 2	The Poinier Street ramp should be relocated to accommodate the proposed PATH extension. If Segment 2 construction precedes the PATH construction, relocation of the roadway will have to be coordinate, schedule-wise and funding, with the PANYNJ/PATH.	10.8%
CO1	Unidentified hazardous waste	There will be sites that are discovered during construction that are contaminated.	If the site is contaminated with HTRW or if CERCLA-regulated materials, there will be delays while the site is cleaned up. Otherwise, additional costs will be part of project cost of proper disposal.	3.1%

Risk No.	Risk Opportunity/ Event	Concerns	PDT Risk Conclusions, Justification	Contribution
CO2	Site access / restrictions (highways, bridges, overhead / underground utilities)	Site access via railroad property will likely require MOAs or the like.	Access, construction, jacking, etc. on railroad property will require an MOA and close coordination, similar to other flood risk reduction projects in NJ.	2.8%
CO4	Transportation / haul routes constricted or unusable during periods of time	Site areas are very congested. Production rates can be impacted due to the congestion.	Production rates may be lower than MII estimate, however, haul quantities are not large.	2.7%

6.4 Combined Cost and Schedule Contingency Results

This section discusses results that combine the base cost contingency results (discussed in Section 6.2) with a contingency for the cost of schedule delay.

Table 13 shows the schedule contingencies calculated for the 50%, 80%, and 90% confidence levels. For each confidence level, Table 13 also shows the corresponding cost of schedule delay, rounded to three significant digits.

The schedule contingency calculated for the 80% confidence level was approximately 42.1 months (256% of the baseline estimate for the total project duration). This represents a cost of schedule delay of approximately $798 thousand.

Table 13: Schedule Contingency Results (All Risks)

Baseline Estimate Duration (without contingencies)				**11.8 Months**		
Confidence Level	**Contingency**	**Baseline Estimate Duration Plus Contingency**	**Contingency (%)**	**Cost of Schedule Delay**		
				Escalation	**Recurring Costs**	**Total**
50%	20.7 Months	32.5 Months	175.0%	$345,274	$453,452	$798,726
80%	***30.4 Months***	***42.3 Months***	***257.0%***	**$361,597**	**$487,479**	**$849,077**
90%	35.7 Months	47.6 Months	302.0%	$377,921	$521,507	$899,427

Table 14 shows the combined cost and schedule contingency results calculated for the 50%, 80%, and 90% confidence levels. These add base cost contingencies from Table 7 to the corresponding costs of schedule delay from Table 13. Table 14 rounds dollar amounts.

Table 14: Combined Cost and Schedule Contingency Results

Baseline Estimate Cost (without contingencies) =			$32,237,000
Confidence Level	**Contingency**	**Baseline Estimate Cost plus Contingency**	**Contingency (%)**
50%	$6,279,000	$38,516,000	19.5%
80%	$9,513,000	**$41,750,000**	**29.5%**
90%	$10,325,000	$42,562,000	32.0%

The combined cost and schedule contingency calculated for the 80% confidence level was approximately $9.5 million (29.5% of the baseline estimate for the total project cost). Of the $9.5 million, $8.3 million (or 88.1%) represents the base cost contingency, and the remaining 11.9% represents the contingency for the cost of schedule delay.

Figure 5 shows the combined cost and schedule contingencies calculated for 0% to 100% confidence levels in 10% increments of confidence level.

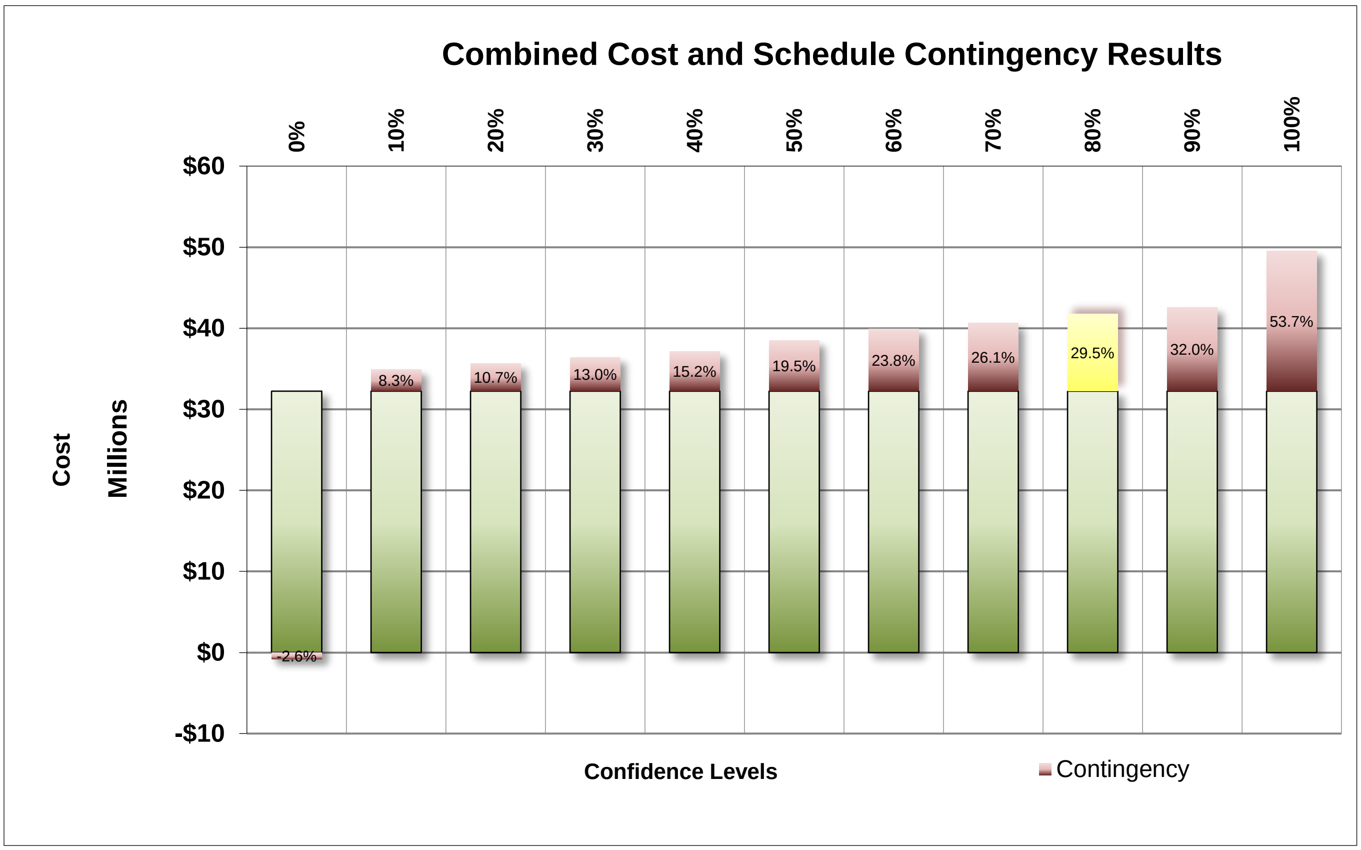

Figure 5: Combined Cost and Schedule Contingency Results

7 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

Table 15 shows the combined cost and schedule contingency results calculated for 0% to 100% confidence levels in 10% increments of confidence level. The results shown earlier in Table 14 are a subset of these results, in that Table 14 shows the same results, but for the 50%, 80%, and 90% confidence levels only.

The combined cost and schedule contingency calculated for the 80% confidence level was approximately $8.3 million (29.9% of the baseline estimate for the total project cost).

Table 15: Combined Cost and Schedule Contingency Results

Confidence Level	Contingency ($)	Baseline Estimate Cost Plus Contingency	Contingency (%)
0%	-$833,903	$31,403,563	-2.6%
10%	$2,688,664	$34,926,130	8.3%
20%	$3,434,115	$35,671,581	10.7%
30%	$4,179,565	$36,417,031	13.0%
40%	$4,889,990	$37,127,456	15.2%
50%	$6,279,095	$38,516,561	19.5%
60%	$7,669,295	$39,906,761	23.8%
70%	$8,414,746	$40,652,212	26.1%
80%	**$9,513,220**	**$41,750,686**	**29.5%**
90%	$10,325,440	$42,562,906	32.0%
100%	$17,304,291	$49,541,757	53.7%

Over one-third of the base cost contingency is due to uncertainties in one risk factor – TR5 Incomplete studies (geotechnical/structural). This risk factor represents the risk that there are gaps in the geotechnical data. Additional information will be required for further design which could require a more robust foundation design due to poor soils around the wall and gates.

After risk factor TR5, the next highest contributor to the base cost contingency is risk factor TR6 (Incomplete studies hydrology/hydraulic/interior drainage), at 26.6%. This risk factor represents the interior drainage plan and how it should be refined with the city's combined sewer system. There is uncertainty regarding the existing combined sewer system outside the line of protection that requires the sealing of manholes and other connections.

Contingencies for the cost of schedule delay are relatively small compared to the base cost contingencies. At the 80% confidence level, the base cost contingency makes up 88.1% of the combined cost and schedule contingency. As a result, the risk factors (TR5 and TR6) that account for most of the uncertainty in the base cost (excluding the cost of schedule delay) also account for most of the uncertainty in the combined cost (including the cost of schedule delay).

The results are based on information gathered is based on information gathered at a formal risk workshop held on September 24, 2018, and on the key assumptions detailed in Section 5.

This report makes the following recommendations:

1. **Assign Responsibility/POC** – So far, the PDT has not assigned responsibility or point of contact (POC) for any of the 31 risk factors or opportunities listed in the risk register. As a first step to developing response or mitigation plans (see below), the PDT should assign responsibility/POC for the remaining risk factors or opportunities as the project enters the next phase.

2. **Develop Response/Mitigation Plans** – The CSRA identifies the risks and opportunities and quantifies their importance. The PDT should develop plans for responding to the identified risks and opportunities, ideally starting with the most important ones. These plans could involve avoiding, transferring, or mitigating risks (or alternatively exploiting, sharing, or enhancing opportunities). Some residual risk could remain even after response. Responses might also introduce new risks themselves.

3. **Monitor and Control Risks** – The PDT should conduct regular risk review meetings to review risks that have already been identified, and to identify and quantify new risks that arise as the project progresses. The CSRA should be repeated if there are any significant changes in risks or opportunities.

4. **Use the Risk Register** – The risk register can be an effective tool for managing identified risks throughout the project. The PDT should update the risk register as designs, cost estimates, and schedule are further refined. Recommended uses of the risk register going forward include:

    a) Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact,

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

    c) Communicating risk management issues,

    d) Providing a mechanism for eliciting feedback and project control input, and,

    e) Identifying risk response plans.