



**US Army Corps  
of Engineers®**  
New York District

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# **Integrated Hurricane Sandy General Reevaluation Report and Environmental Impact Statement**

## **Atlantic Coast of New York**

### **East Rockaway Inlet to Rockaway Inlet and Jamaica Bay**

# **Sub Appendix A2-C: HFFRRF SCREENING LEVEL COST ESTIMATES SUPPORTING DATA**

**US Army Corps of Engineers**



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**East Rockaway Inlet to Rockaway Inlet and Jamaica  
Bay  
Reformulation Study**

**Draft Integrated Hurricane Sandy General  
Reevaluation Report  
and Environmental Impact Statement**

**Appendix A2-C  
Cost Engineering Screening Appendix**

## C.1 INTRODUCTION

This Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet Hurricane Sandy General Reevaluation Report Cost Engineering Screening Appendix summarizes the cost engineering and analyses applied to evaluate and compare alternative features for each planning reach within the study area. There are two reaches within the study area: 1) the Atlantic Shorefront, 2) Jamaica Bay. Since each planning reach is exposed to different risk mechanisms two engineering appendices are included within this GRR/EIS: Appendix A1 - Shorefront Engineering and Design Appendix, and Appendix A2 - Jamaica Bay High Frequency Flood Risk Reduction Features Engineering and Design Appendix.

This Cost Engineering Screening Appendix provides an overview of the cost analyses supporting both the screening process for the High Frequency Flood Risk Reduction Features (HFFRRF) for Jamaica Bay and the shorefront alternatives.

The initial study was initially limited to the Atlantic Ocean Shoreline Planning Reach and was conducted as a legacy study. The engineering analyses were conducted to satisfy a more rigorous design level and the Atlantic Ocean shorefront summary engineering documents were written to satisfy those study requirements (USACE-NAN, 2016). The Jamaica Bay Planning Reach analysis was added following Hurricane Sandy and was conducted to broaden the recommended plan to the entire authorized study area and was conducted under SMART planning guidelines.

As a result of the Agency Decision Milestone, the storm surge barrier component of the Tentatively Selected Plan was moved into the New York and New Jersey Harbor and Tributaries Study for further study and possible recommendation. Without the barrier, the communities surrounding Jamaica Bay still experience substantial risk for coastal flooding. Therefore, the study team sought to identify stand-alone features that could complement a potential future storm surge barrier, but also be economically justified on their own. Residents in many parts of the Back-Bay experience regular flooding due to rainfall events and high tides that occur frequently. Since the proposed barrier would not be closed at every high tide or rainfall event, there is an opportunity to recommend features to mitigate flood risk for high frequency flooding events where the proposed storm surge barrier would remain open yet inundation still occurs.

## **C.2 PROJECT DESCRIPTION**

### **2.1 Location**

Please refer to Figure 2-4 in the HFFRRF Engineering Appendix (Appendix A2) and Figure 1-1 of the Shorefront Engineering Appendix A1 for details relating to the project location.

### **2.2 Feature Descriptions**

The high frequency flood risk reduction features are detailed in Section 4 of the Engineering Appendix (A2), including typical sections for all features. The alternative development options for the shorefront are detailed in Section 7 of the Shorefront Appendix (A1).

## **C.3 HFFRRF FOR JAMAICA BAY COST FOR SCREENING**

### **3.1 Introduction**

In support of the first round of screening of the HFFRRF projects, the economic benefits were analyzed to determine which projects had a net benefit. Benefits modeling is detailed in the Economics Appendix (Appendix B), and the costs are included below. The Benefit Cost Ratio (BCR) of each of the alternatives was calculated and the project characteristics were tabulated to facilitate screening.

### **3.2 Basis of Estimate**

The initial costs were estimated on a per linear foot basis to allow for an easy comparison of the various features in different locations in Jamaica Bay. MCASESII (MII) software was utilized to estimate the costs of the various features and costs were estimated assuming stone was sourced from the NY / NJ area with local labor rates. Sheet pile costs from a comparable project were utilized, and NY DOT bid tabs were used where applicable. Blue Book Equipment rates were utilized for the equipment hourly rates, factoring in fuel usage and diesel prices of \$3.18 / gal for the NYC area.

### **3.3 Phase 1 Project Costs**

Cost estimates for the HFFRRF Phase 1 were developed in 2015 at a fourth quarter (4Q) 2015 price level for labor, material, and equipment using the MII files developed in support of the USACE-NAN. (2016) Appendix 2A. The prices were then escalated to 4Q 2017 using the Civil Works Construction Cost Index System (CWCCIS) for screening. The material quantities for the Features have been developed from the feature cross-sections shown in Section 4 of the Engineering Appendix (Appendix A-2). Labor rates for local union labor in Queens County was used based on published prevailing wage rates. Equipment rates were from Region 1 (Northeast) and nationally published Blue Book Rates.

To establish a total cost per project feature, the quantities per linear foot for each feature were calculated. For example, it was determined that for the revetment 0.70 cubic yards (CY) of concrete is required per linear foot of wall. Project costs were then calculated by multiplying the feature length by the feature type costs per foot and summing all features.

#### **3.3.1 MII Cost Model**

##### **3.3.1.1 Work Breakdown Structure (WBS)**

The cost estimates were developed according to the Civil Works Work Breakdown Structure (CWWBS) and have been broken down to the sub-feature level or detailed construction activity elements. All feature cost items included in the MII estimate are assumed to be in the Levees & Floodwalls (#11) CWWBS. It should be noted that Relocations are to be provided separately by

the USACE and would be in a separate WBS. Planning, Engineering and Design (PED) and Construction management costs were not included in the MII estimate detail, and were incorporated in the spreadsheet cost summary as a percentage of construction costs, so they would not impact the plan selection.

### 3.3.1.2 Contractor mark-ups

The contract mark-ups included 12% for Job Office Overhead (JOOH), 8% for Home Office Overhead (HOOH), 10% profit, and 0.66% Bond. These markups are consistent with the previous work completed for the USACE-NAN. (2016).

### 3.3.2 Feature Costs

For the various features that are part of the HFFRRF projects, the total cost per linear foot (LF) is tabulated in Table 3-1, costs are provided without contingency. Costs are inclusive of drainage features.

**Table 3-1: Costs Per Linear Foot for Project Features**

<b>Feature</b>	<b>Cost</b>
Revetment	\$2,214
High Berm	\$1,262
Low Berm	\$495
Deep Bulkhead	\$4,970
Shallow Bulkhead	\$3,471
Deep Bulkhead (with developed upland considerations)	\$9,956
Shallow Bulkhead (with developed upland considerations)	\$8,415
Low Floodwall	\$1,589
Medium Floodwall	\$3,058
High Floodwall	\$4,564
NNBF Type 1A – Shoreline Extension with Intertidal Marsh	\$1,440
NNBF Type 1B – Shoreline Excavation for Phragmites Removal with Intertidal Marsh	\$1,581
NNBF Type 2A – Shoreline Extension with Intertidal and High Marsh	\$1,645
NNBF Type 2B – Shoreline Excavation for Phragmites Removal with Intertidal and High Marsh	\$1,793

A couple of projects have special features that are specific to a particular project and not a typical section that could be used in multiple places. The cost for these special features are provided in the table below.

**Table 3-2: Cost of Special Features**

	<b>Cost</b>	<b>Unit</b>
Head of Bay Flood Gate	\$301,305,000	Each
Shellbank Creek Flood Gate	\$68,658,000	Each
Hawtree Basin Flood Gate	\$64,105,000	Each
Vehicular Gate	\$792,000	Each

### **3.3.3 Project Cost Items**

In order to estimate the respective project costs, the following general approach was followed: Unit costs for material items such as steel, concrete, and fill were kept the same, with the same crews utilized as assumed in the USACE-NAN. (2016). Tasks were developed for new items such as different size sheet piles for some of the floodwalls and a task for hauling excavated materials offsite for disposal, however the crews (labor and equipment) used to complete the tasks were kept the same for consistency. The mobilization and demobilization was assigned to the contractor as an overhead cost so that it would be spread accordingly over the feature cost items. An additional mobilization and demobilization cost was included with the flood gates to account for the higher cost of marine work. Production rates from the previous estimate from Appendix A2 of the USACE-NAN. (2016) were used when applicable. Otherwise, production rates were estimated from similar project experience in the United States.

#### **3.3.3.1 Planning, Engineering and Design (PED)**

PED costs were estimated separately from the MII estimate. This includes permitting costs and final design of the features. 15% of construction costs was used for the PED costs for the initial screening, with updated PED costs estimated for the recommended plan. Separate PED costs were estimated for the shorefront and Jamaica Bay projects due to the different levels of PED required as a percentage of the project's construction values.

#### **3.3.3.2 Construction Administration**

Construction administration was also estimated separately from the MII and was estimated at 8% of construction costs. This cost was also updated for the recommended plan.

#### **3.3.3.3 Lands and Damages**

These costs are not included in MII or the cost estimates presented within this section at this time. Impacts will likely be similar between the difference features and not impact plan selection.

#### **3.3.3.4 Relocations**

These costs are not included in MII or the cost estimates presented within this section at this time. Impacts will likely be similar between the difference features and not impact plan selection.

### **3.3.3.5 Operation and Maintenance**

The operation and maintenance costs were estimated using the same cost per linear foot, \$19 / lf for passive measures and 0.50% for active measures, as utilized in Appendix A2 of the GRR report from August 2016.

### **3.3.3.6 Contingency**

The project contingency was estimated at 40% for budgeting purposes. It was deemed appropriate by the USACE and project design team to use the 40% average contingency previously determined using the abbreviated risk analysis (ARA) process. The features included in this estimate are largely the same or of smaller magnitude than previously considered, so the contingency should be conservative, but applicable. A CSRA will be completed for the recommended plan using USACE guidelines.

### **3.3.3.7 Total Project Cost Calculation**

The total project cost was developed in MII and summarized in Table 5-2 of the engineering appendix and in Table 3-3 below. PED, Construction Management, Lands & Damages, and Relocations were then added to the total, with contingency added to the subtotal of the costs. This cost is then escalated from 4Q 2015 to 4Q 2017. The cost is then converted to an annual cost to calculate the benefit to cost ratio for the projects and presented in the next section.

## **3.3.4 Phase 1 Project Cost Summary**

Before the Phase 1 Project Costs are presented it is important to note the study described herein is in accordance with USACE's SMART Planning principles. The level of detail required to make planning decisions was still expected to grow over the course of the study, as the study team moved from a large array of alternatives to a select set of recommended project alternatives. The PDT made progressively detailed analyses for this smaller array of alternatives until finally identifying the recommended plan. The PDT reduces uncertainty with greater detail, but only when necessary to reduce unacceptable risk.

The initial phase 1 cost estimate included MII cost estimates of HFFRR-Features, but did not include details in the MII for some items including:

- Utilities
- Drainage
- Pump Stations

These items were not included as details had not been determined yet and it was assumed that they would not impact plan selection, as they would be similar in magnitude for all the features considered. A summary of the project cost calculated per the methodology described herein is provided Table 3-3.

**Table 3-3: Total Preliminary Project Cost for All Projects without inclusion of Natural and Nature Based Features—used for Preliminary Screening (\*Does not include real estate costs)**

Project ID	Project Name	Perimeter Length (ft)	Initial Project Costs (\$) Cost Code 11	PED Cost Code 30	Construction Administration Cost Code 31	Total Project Cost (2015 Q1 price level)	Contingency	Total Project Cost (Q4 2017 price level)
				15%	8%		40%	
1	Hammels	3,100	\$9.6 M	\$1.4 M	\$0.8 M	\$11.9 M	\$4.9 M	\$17.2 M
2	Arverne	12,300	\$32.6 M	\$4.9 M	\$2.6 M	\$40 M	\$16.6 M	\$58.1 M
3	Edgemere	6,300	\$14.4 M	\$2.2 M	\$1.2 M	\$17.8 M	\$7.4 M	\$25.8 M
4	Norton Basin	2,400	\$7.3 M	\$1.1 M	\$0.6 M	\$9 M	\$3.7 M	\$13 M
5	Bayswater Park	1,500	\$0.7 M	\$0.1 M	\$0.1 M	\$0.9 M	\$0.4 M	\$1.3 M
6	Motts Basin S	3,800	\$12.3 M	\$1.8 M	\$1 M	\$15.1 M	\$6.3 M	\$21.9 M
7	Motts Basin N	700	\$1 M	\$0.1 M	\$0.1 M	\$1.2 M	\$0.5 M	\$1.7 M
8	Inwood Harbor	2,700	\$7.3 M	\$1.1 M	\$0.6 M	\$9 M	\$3.7 M	\$13.1 M
9	Head of Bay Gate	3,000	\$441.7 M	\$66.2 M	\$35.3 M	\$543.2 M	\$225.1 M	\$787.9 M
10	Old Howard Beach	3,700	\$145.4 M	\$21.8 M	\$11.6 M	\$178.8 M	\$74.1 M	\$259.4 M
11	Canarsie	2,700	\$4.7 M	\$0.7 M	\$0.4 M	\$5.8 M	\$2.4 M	\$8.4 M
22	Lawrence-Cedarhurst	1,800	\$4.7 M	\$0.7 M	\$0.4 M	\$5.8 M	\$2.4 M	\$8.4 M
23	Meadowmere	6,700	\$24.8 M	\$3.7 M	\$2 M	\$30.6 M	\$12.7 M	\$44.3 M
24	Meadowmere N	4,800	\$19.5 M	\$2.9 M	\$1.6 M	\$24 M	\$10 M	\$34.8 M
25	Meadowmere E	1,600	\$7.9 M	\$1.2 M	\$0.6 M	\$9.7 M	\$4 M	\$14.1 M
26	Rosedale	1,900	\$5.8 M	\$0.9 M	\$0.5 M	\$7.1 M	\$2.9 M	\$10.3 M

**Table 3-4: Preliminary Project Cost for All Projects with inclusion if Natural and Nature Based Features—used for Preliminary Screening (\*Does not include real estate nor mitigation costs)**

Project ID	Project Name	Perimeter Length (ft)	Initial Project Costs (\$) Cost Code 11	PED Cost Code 30	Construction Administration Cost Code 31	Total Project Cost (2015 Q1 price level)	Contingency	Total Project Cost (Q4 2017 price level)
				15%	8%		40%	
<b>2N</b>	Arverne	12,300	\$39 M	\$5.9 M	\$3.1 M	\$48 M	\$19.9 M	\$69.6 M
<b>3N</b>	Edgemere	6,300	\$19.2 M	\$2.9 M	\$1.5 M	\$23.6 M	\$9.8 M	\$34.2 M
<b>4N</b>	Norton Basin	2,400	\$11.6 M	\$1.7 M	\$0.9 M	\$14.3 M	\$5.9 M	\$20.7 M
<b>5N</b>	Bayswater Park	1,500	\$2.9 M	\$0.4 M	\$0.2 M	\$3.6 M	\$1.5 M	\$5.2 M
<b>6N</b>	Motts Basin S	3,800	\$14.5 M	\$2.2 M	\$1.2 M	\$17.8 M	\$7.4 M	\$25.8 M
<b>7N</b>	Motts Basin N	700	\$3.3 M	\$0.5 M	\$0.3 M	\$4.1 M	\$1.7 M	\$5.9 M

### 3.4 Phase 2 Projects

#### 3.4.1 Introduction

HFFRRF costs were further refined in Phase 2 to ultimately select the recommended plan. This included separating the rock sills and plantings out from the NNBFs, adding pump stations, addition of utility costs to each feature, as well as further design of the drainage systems, which were previously established on a per linear foot basis and are not quantified for each feature.

#### 3.4.2 Phase 2 Project Features Cost

Table 3-5 below presents the updated feature costs with the refined quantities for the rock sills and drainage costs, as well as utilities.

**Table 3-5: Feature Costs**

<b>Feature</b>	<b>Cost</b>	<b>Unit</b>
Low Floodwall	\$1,513.17	\$/LF
Medium Floodwall	\$2,455.58	\$/LF
High Floodwall	\$3,873.48	\$/LF
Low Berm	\$612.55	\$/LF
Medium Berm	\$ 857.97	\$/LF
High Berm	\$ 2,085.32	\$/LF
Hybrid Berm	\$4,036.12	\$/LF
Shallow Bulkhead	\$2,170.20	\$/LF
Shallow Bulkhead Urban	\$7,018.74	\$/LF
Deep Bulkhead	\$3,356.13	\$/LF
Revetment	\$2,879.85	\$/LF
Rock Sill	\$1,726.52	\$/LF
Vehicular Gate	\$797,530.47	\$/EA
Road Ramp	\$90,110.87	\$/EA

#### 3.4.3 HFFRRF Phase 2 Project Cost Summary

A total of four HFFRRF projects were delineated and refined during the second phase of the HFFRRF feasibility study as detailed in Table 6-1 of the Engineering Appendix. Each project consists of a single or multiple alignment(s), which in turn consist of one single or multiple HFFRR-Feature(s). A summary of project costs at the 2Q2018 price level by project are included in Table 3-6 and table 3-7 below.

**Table 3-6: Phase 2 Project Costs**

Project	Project Cost
Mid-Rockaway Backbay with NNBF (Summary of the three Project Areas)	\$194 M
Motts Basin N	\$ 2.6 M
Canarsie	\$ 27.7 M
Cedarhurst Lawrence	\$13.6

**Table 3-7: Total Project Cost for All Phase 2 Projects—used for Screening (\*Does not include real estate costs)**

Project ID	Project Name	Perimeter Length (ft)	Initial Project Costs (\$) Cost Code 11	Pump Station Costs (\$) Cost Code 13	PED Cost Code 30	Construction Admin. Cost Code 31	Total Project Cost (2017 Q4 price level)	Contingency	Total Project Cost (Q4 2017 price level)
					15%	8%		40%	
	Mid-Rockaway Backbay with NNBFs	21,700	\$83.3 M	\$29.4 M	\$16.9 M	\$9.0 M	\$138.6 M	\$55.4 M	\$194.0 M
<b>7</b>	Motts Basin N	700	\$1.5 M	\$0 M	\$0.2 M	\$0.1 M	\$1.9 M	\$0.7 M	\$2.6 M
<b>11</b>	Canarsie	2,700	\$8.4 M	\$7.7 M	\$2.4 M	\$1.3 M	\$19.8 M	\$7.9 M	\$27.7 M
<b>22</b>	Lawrence-Cedarhurst	1,800	\$4.3 M	\$3.6 M	\$1.2 M	\$0.6 M	\$9.7 M	\$3.9 M	\$13.6 M