

Rahway River Basin, New Jersey  
Coastal Storm Risk Management Feasibility Study

Appendix A.9  
Cost Effectiveness and Incremental Cost Analysis

## 1.0 Introduction

The U.S. Army Corps of Engineers (Corps), New York District (District) in partnership with the New Jersey Department of Environmental Protection (NJDEP) has developed feasibility level plans to provide coastal flood risk for the Township of Woodbridge and Borough of Carteret Middlesex County, New Jersey.

The Recommended Plan consists of the following elements: a) 4,540 ft of levee/floodwall along Rahway River b) raising of Engelhard Ave; and c) treatment of approximately 136 structures located within the 10-yr floodplain with nonstructural measures in the Township of Woodbridge and Borough of Carteret.

Corps guidance requires a cost effectiveness analysis and an incremental cost analysis for recommended environmental restoration and mitigation plans. A cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of environmental input. An incremental cost analysis of the solutions is conducted to reveal changes in costs for increasing levels of environmental outputs. In absence of a common measurement unit for comparing the nonmonetary benefits with the monetary costs of environmental plans, cost effectiveness and incremental cost analysis (CE/ICA) are valuable tools to assist in decision making.

The District utilized the Evaluation of Planned Wetlands (EPW) to evaluate the functions and values of open water systems impacted by the proposed project and determine compensatory mitigation needs and derive habitat units. The EPW was approved for regional use by the Corps Ecosystem Restoration Planning Center of Expertise in July 2016.

The District used the Institute for Water Resources Planning Suite (IWR Planning Suite 2.0.6.1) to evaluate multiple compensatory freshwater riverine scenarios to determine the most cost effective compensatory mitigation plan. The suite is a water resources investment decision support tool, built by the USACE Institute for Water Resources for the formulation and evaluation of ecosystem restoration alternative plans. The cost effectiveness/incremental cost analysis (CE/ICA) approach is consistent with the Principles and Guidelines planning paradigm.

### 1.1 Compensatory Mitigation Solutions

The District is proposing to conduct compensatory high and low marsh wetland mitigation along the Rahway River. Appendix A.8 discusses the mitigation solutions and scales that are to be analyzed in the incremental cost analysis and the mitigation site selected to conduct the compensatory mitigation. The scales used for each solution were 0, 1, 2 and 3 with 0 representing the No Action Plan, 3 expected to provide the greatest ecological uplift, and 1 which is expected to provide the least ecological uplift. Tables 1 through 3 summarize the average Functional Capacity Indices and Functional Capacity Units of each solution and scale.

**Table 1: High Marsh Solutions/Scales Average Functional Capacity Index and Average Functional Capacity Unit.**

Solution	Scale	Description	Average FCI	Average FCU
No Action (Existing Conditions)	0	1.13 acres	0.8	0.9
Small	1	1.13 acres	0.9	1
Medium	2	2.26 acres	0.9	2
Large	3	3.39 acres	0.9	3

**Table 2: Low Marsh Solutions/Scales Average Functional Capacity Index and Average Functional Capacity Unit**

Solution	Scale	Description	Average FCI	Average FCU
No Action (Existing Conditions)	0	1.29 acres	0.8	1.0
Small	1	1.29 acres	0.9	1.1
Medium	2	2.58 acres	0.9	2.3
Large	3	3.87 acres	0.9	3.4

**Table 3: Scrub Shrub Solutions/Scales Average Functional Capacity Index and Average Functional Capacity Unit**

Solution	Scale	Description	Average FCI	Average FCU
No Action (Existing Conditions)	0	0.57 acres	0.7	0.4
Small	1	0.57 acres	0.8	0.5
Medium	2	1.14 acres	0.8	0.9
Large	3	1.71 acres	0.8	1.4

Costs and habitat units were created for each solution and scale and then annualized. The annual costs and average annual habitat unit (AAHU) are presented in Tables 4 through 6.

**Table 4: High Marsh Compensatory Mitigation Solutions and Scales**

<b>Solution</b>	<b>Scale</b>	<b>Identifier</b>	<b>Annual Cost</b>	<b>Average Annual Habitat Unit (AAHU)</b>
High Marsh (No Action)	0	H0	N/A	N/A
High Marsh (Small)	1	H1	\$85,356	1.034
High Marsh (Medium)	2	H2	\$171,085	1.974
High Marsh (Large)	3	H3	\$255,447	2.914

**Table 5: Low Marsh Compensatory Mitigation Solution and Scales**

<b>Solution</b>	<b>Scale</b>	<b>Identifier</b>	<b>Annual Cost</b>	<b>Average Annual Habitat Unit (AAHU)</b>
Low Marsh (No Action)	0	L0	N/A	N/A
Low Marsh (Small)	1	L1	\$88,492	1.068
Low Marsh (Medium)	2	L2	\$195,308	2.136
Low Marsh (Large)	3	L3	\$265,446	2.759

**Table 6: Scrub Shrub Compensatory Mitigation Solution and Scales**

<b>Solution</b>	<b>Scale</b>	<b>Identifier</b>	<b>Annual Cost</b>	<b>Average Annual Habitat Unit (AAHU)</b>
Scrub Shrub (No Action)	0	S0	N/A	N/A
Scrub Shrub (Small)	1	S1	\$42,285	0.47
Scrub Shrub (Medium)	2	S2	\$70,200	0.851
Scrub Shrub (Large)	3	S3	\$105,201	1.27

Each solution and scale were then input into the IWR Planning Suite Generator function to generate plan combinations. A total of 64 plans were generated for analysis and are presented in Table 7. It should be noted that the scales of the High and Low Marsh solutions were combined to create the 16 plans, but scales within each solution were not combinable with each other.

**Table 7: Compensatory Mitigation Plans**

<b>Plan Name</b>	<b>Cost</b>	<b>Output</b>
No Action Plan	\$0.00	0
H1L0S0	\$85,356.00	1.034
H2L0S0	\$171,085.00	1.974
H3L0S0	\$255,447.00	2.914
H0L1S0	\$88,492.00	1.068
H0L2S0	\$195,308.00	2.136
H0L3S0	\$265,446.00	2.759
H1L1S0	\$173,848.00	2.102
H2L1S0	\$259,577.00	3.042
H3L1S0	\$343,939.00	3.982
H1L2S0	\$280,664.00	3.17
H2L2S0	\$366,393.00	4.11
H3L2S0	\$450,755.00	5.05
H1L3S0	\$350,802.00	3.793
H2L3S0	\$436,531.00	4.733
H3L3S0	\$520,893.00	5.673
H0L0S1	\$42,285.00	0.47
H0L0S2	\$70,200.00	0.851
H0L0S3	\$105,201.00	1.27

H1L0S1	\$127,641.00	1.504
H2L0S1	\$213,370.00	2.444
H3L0S1	\$297,732.00	3.384
H1L0S2	\$155,556.00	1.885
H2L0S2	\$241,285.00	2.825
H3L0S2	\$325,647.00	3.765
H1L0S3	\$190,557.00	2.304
H2L0S3	\$276,286.00	3.244
H3L0S3	\$360,648.00	4.184
H0L1S1	\$130,777.00	1.538
H0L2S1	\$237,593.00	2.606
H0L3S1	\$307,731.00	3.229
H0L1S2	\$158,692.00	1.919
H0L2S2	\$265,508.00	2.987
H0L3S2	\$335,646.00	3.61
H0L1S3	\$193,693.00	2.338
H0L2S3	\$300,509.00	3.406
H0L3S3	\$370,647.00	4.029
H1L1S1	\$216,133.00	2.572
H2L1S1	\$301,862.00	3.512
H3L1S1	\$386,224.00	4.452
H1L2S1	\$322,949.00	3.64
H2L2S1	\$408,678.00	4.58
H3L2S1	\$493,040.00	5.52
H1L3S1	\$393,087.00	4.263
H2L3S1	\$478,816.00	5.203
H3L3S1	\$563,178.00	6.143
H1L1S2	\$244,048.00	2.953
H2L1S2	\$329,777.00	3.893
H3L1S2	\$414,139.00	4.833
H1L2S2	\$350,864.00	4.021
H2L2S2	\$436,593.00	4.961
H3L2S2	\$520,955.00	5.901
H1L3S2	\$421,002.00	4.644
H2L3S2	\$506,731.00	5.584
H3L3S2	\$591,093.00	6.524
H1L1S3	\$279,049.00	3.372
H2L1S3	\$364,778.00	4.312
H3L1S3	\$449,140.00	5.252
H1L2S3	\$385,865.00	4.44
H2L2S3	\$471,594.00	5.38
H3L2S3	\$555,956.00	6.32
H1L3S3	\$456,003.00	5.063

H2L3S3	\$541,732.00	6.003
H3L3S3	\$626,094.00	6.943

The CE/ICA was conducted on plan to determine which alternative was considered the “Best Buy Plan” and the most cost effective compensatory mitigation alternatives. Costs were amortized at the FY2018 discount rate of 2.875% over a 50 year period of analysis.

The cost effectiveness analysis ensures that the least cost plan was identified for each possible level of environmental output; and that for any level of investment, the maximum level of AAHU output is identified. The “Best Buy” and cost effective plans are identified by an algorithm that measures plans along a frontier of higher output with lower costs (Table 8).

**Table 8: Best Buy Plans**

Plan Name	Annual Cost ( \$1000)	Average Annual Habitat Unit	CE/ICA Results
No Action	\$0	0	N/A
H0L0S2	\$70	0.85	Best Buy
H1L0S2	\$155	1.885	Best Buy
H1S1S2	\$244	2.953	Best Buy
H1L1S3	\$279	3.372	Best Buy
H3L1S3	\$449	5.252	Best Buy
H3L2S3	\$555	6.32	Best Buy
H3L3S3	\$626	6.943	Best Buy

Incremental Cost Analysis (ICA) calculates the cost per additional AAHU of the Best Buy plans only, which allows for comparison of Best Buy plans across the site study area. An ICA reveals changes in costs as output levels increase, and allows an assessment of whether the increase in output is worth the additional cost. The CE/ICA focuses on break points, where there is a marked increase in incremental costs, beyond the general range of preceding costs, for identifying which Best Buy Plans are Plans of Interest.

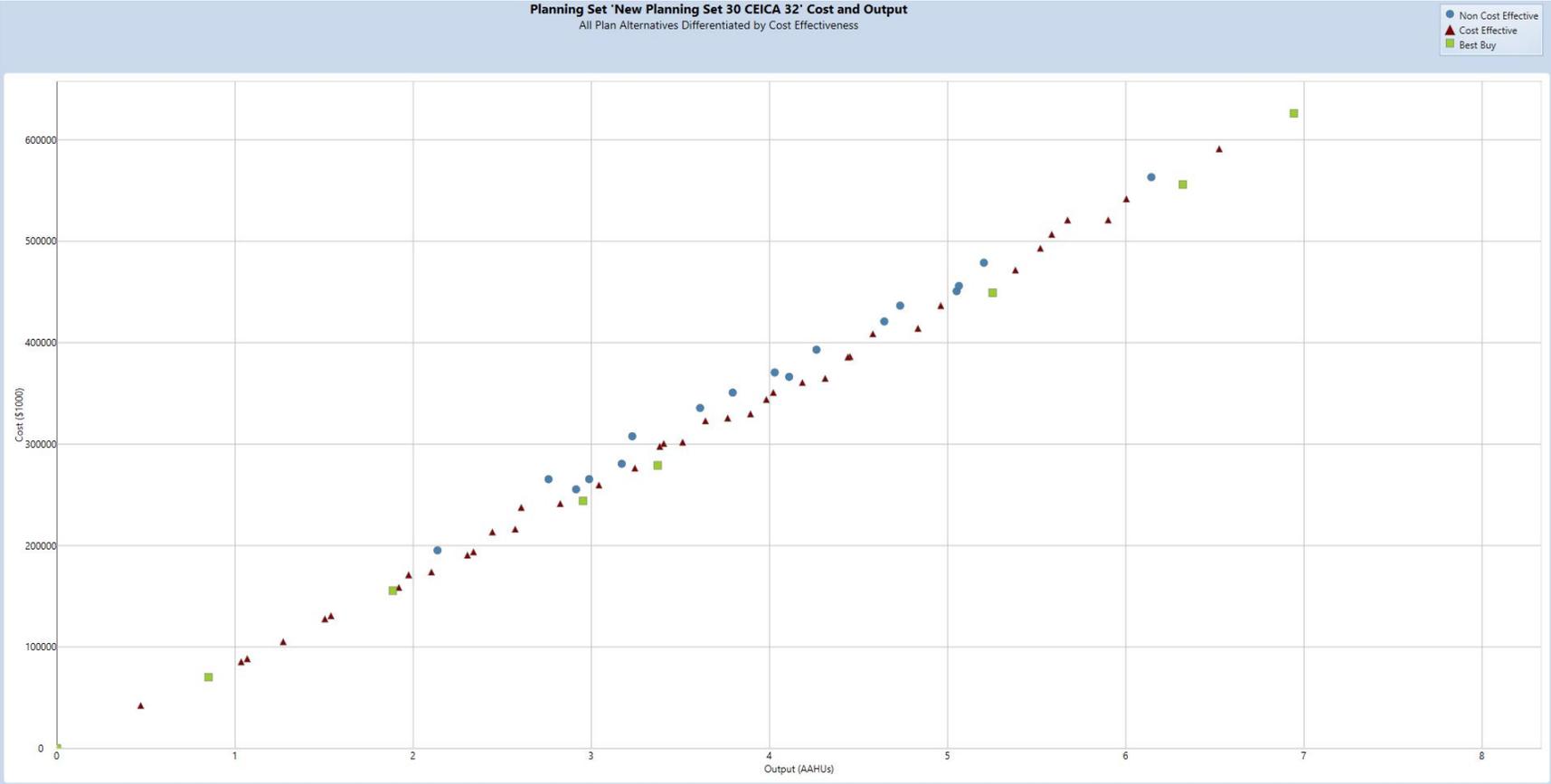
## 2.0 CE/ICA Results

Table 9 and Figures 1 and 2 present the results of the CE/ICA for each plan, the best buy and cost effective plans. A total of eight plans, including the No Action Plan were identified as Best Buy Plans. Of the eight plans, five – H1L1S2, H1L1S3, H3L1S3, H3L2S3 and H3L3S3 - were identified as Plans of Interest. The other No Action and plans H0L0S2 and H1L0S2 do not meet the minimum ecological thresholds to compensate for direct adverse impacts to marsh wetland habitat from the Recommended Plan. The minimum threshold is defined as finding the most cost effective plan that achieves the federal wetland objective of no net loss of functions. The first Best Buy Plan that at least meets the minimum threshold for both the high and low marsh wetlands is Plan H1L1S2. Although it exceeds the minimum threshold for scrub shrub wetlands, benefits achieved by selecting this as the recommended compensatory mitigation plan include providing habitat connectivity to the existing scrub shrub wetlands and providing nature based shoreline erosion control that will help protect the levee while complying with the vegetation free zone policy requirements established by Engineering Technical Letter (ETL) 1110-2-583 Guidelines for Landscape Planting and Vegetation Management at Levees, Embankment Dams and Appurtenant Structures. Plan H1L1S2 will involve restoring 1.13 acres of High Marsh, 1.29 acres of Low Marsh and 1.14 acres of Scrub Shrub

**Table 9: Incremental Cost Analysis**

<b>Plan Name</b>	<b>Incremental Cost (\$1000)</b>	<b>Incremental Output</b>	<b>Incremental Cost / Incremental Output</b>	<b>Is it worth it?</b>
No Action	\$0	0	N/A	Minimum unmet
H0L0S2	\$70	0.85	\$82.35	Minimum unmet
H1L0S2	\$155	1.885	\$82.23	Minimum unmet
H1L1S2	\$244	2.953	\$82.63	Yes
H1L1S3	\$279	3.372	\$82.74	Yes
H3L1S3	\$449	5.252	\$85.49	Yes
H3L2S3	\$555	6.32	\$87.82	Yes
H3L3S3	\$626	6.943	\$90.16	Yes

Figure 1: CE/ICA Analysis of All Plans



**Figure 2: Best Buy Plans**

