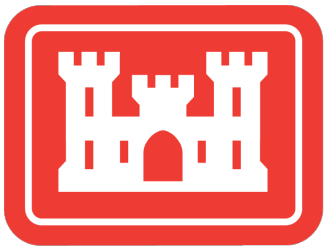
HUDSON RIVER HABITAT RESTORATION

ECOSYSTEM RESTORATION
FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

Appendix F: Cost Effectiveness and Incremental Cost Analysis (CE/ICA)



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CHAPTER 1: Introduction

The USACE ecosystem restoration mission was first authorized in the Water Resources Development Act of 1986, and the overarching purpose of the program is "...to restore significant structure, function and dynamic processes that have been degraded" (ER 1165-2-501). With this goal, USACE programs emphasize ecological outcomes (as opposed to social or economic outcomes). Generally speaking, ecological resources may be quantified in a variety of ways ranging from habitat suitability for a focal taxa (e.g., an endangered species) to changes in physical processes (e.g., sediment delivery from geomorphic instability) to changes in biological processes (e.g., carbon uptake and storage). In other USACE business lines (e.g., navigation), costs and benefits of actions are compared in monetary terms, and the benefit-cost ratio serves as a crucial decision metric. However, outputs of restoration are typically not monetized, and a different set of methods are required to inform restoration decision-making and address the issue of "Is ecosystem restoration worth the Federal investment?" In particular, cost-effectiveness and incremental cost analyses provide reliable techniques for comparing non-monetary ecological benefits relative to monetary costs of restoration (Robinson et al. 1995).

Cost-effectiveness and incremental cost analyses (CE/ICA) are analytical tools for assessing the relative benefits and costs of ecosystem restoration actions and informing decisions. Benefits and costs are assessed prior to these analyses using ecological models (e.g., the Evaluation of Planned Wetlands model) and cost engineering methods, respectively. CE/ICA may then be conducted at the site scale to compare alternatives at a single location (e.g., no action vs. dam removal vs. fish ladder vs. bypass) or at the system scale to compare relative merits of multiple sites (e.g., no sites vs. Site-A only vs. Site-B only vs. Site-A and Site-B). Within the USACE, the Institute of Water Resources (IWR) has provided a toolkit for conducting CE/ICA, the IWR Planning Suite (http://www.iwr.usace.army.mil/Missions/Economics/IWR-Planning-Suite/).

Cost-effectiveness analysis provides a mechanism for examining the efficiency of alternative actions. For any given level of investment, the agency wants to identify the plan with the greatest return-on-investment (i.e., the most environmental benefits), and for any given level of environmental benefits, the agency wants a plan with the least cost. An “efficiency frontier” identifies all plans that efficiently provide benefits on a per cost basis (i.e., cost-effective plans, CE).

Incremental cost analysis is then conducted on the set of cost-effective plans. This technique sequentially compares each plan to all higher cost plans to reveal changes in unit cost as output levels increase and eliminates plans that do not efficiently provide benefits on a per unit cost basis. Specifically, this analysis examines the slope of the cost-effectiveness frontier to isolate how the incremental unit cost (i.e., cost of the “next unit”) increases as the magnitude of environmental benefit increases. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish the objective relative to unit costs and are typically referred to as “best buys” (BB). Importantly, all “best buys” are cost-effective, but all cost-effective plans are not best buys.

The objectives of this Appendix are to:

- Annualize benefits and costs (from Appendices D and E, respectively) over a 50-year planning horizon for consistent comparison.
- Apply CE/ICA to inform decision-making at the site-scale (e.g., Binnen Kill) and the system-scale (e.g., all mosaic sites) as well as identify the Tentatively Selected Plan (TSP) based on CE/ICA.
- Confirm the recommendation following design optimization.
- Summarize the National Ecosystem Restoration (NER) Plan.

As described in Appendix C, HRHR restoration sites have been screened from more than 1,000 potential locations to a final array of six sites for feasibility level analysis. Three site types are generally represented in the final array of six. These sites are grouped based on their similarities relative to the types of ecological issues being addressed, basic strategy for formulating restoration actions, and methods for assessing environmental benefits. The types of sites can be summarized as follows:

- Shoreline Restoration - Charles Rider Park and Henry Hudson Park - These sites address locations of active bank erosion and shoreline retreat along the mainstem of the Hudson River. Restoration benefits are assessed using the Evaluation of Planned Wetlands (EPW) model.
- Large River Mosaics - Binnen Kill and Schodack Island State Park - These sites address the maintenance or creation of historically prevalent large river ecosystems, which would have included a diverse habitat mosaic of subtidal, intertidal, shoreline, and riparian ecosystems. Restoration benefits are assessed using the EPW model.
- Tributary Connectivity - Rondout Creek (Eddyville Dam) and Moodna Creek (three sequential barriers) - These sites restore connectivity between the Hudson River mainstem and ecologically important tributaries, with a particular emphasis on aquatic organism passage (AOP) issues. Restoration benefits are assessed using the Watershed-Scale Upstream Connectivity Toolkit (WUCT).

The HRHR project is a large-scale restoration effort, and multiple scales of analysis were required in project planning. In this Appendix, terms will be used as follows:

- Type - Refers to the type of restoration project (i.e., shoreline, mosaic, or connectivity).
- Site - Refers to the six restoration sites listed above.
- Component - Refers to a sub-site scale (e.g., North, South), which was required for planning the extremely large mosaic sites.
- Alternative - Refers to a proposed restoration action at either the site or the component scale.
- Patch - Refers to the level of measurement required for EPW assessments.

CHAPTER 2: Annualization

Restoration benefits and costs are often distributed through time across the planning horizon. For instance, the ecological benefits of a riparian planting scheme may not be realized until the trees reach a certain size or height threshold. Likewise, costs may be incurred differentially across the project life span such as the up-front cost of construction or annual operational costs. Annualization provides a mechanism for consistent comparison of benefits and costs, and this section describes the annualization process and outcomes. Appendices D and E provide additional detail on benefit and cost analyses, respectively.

2.1. BENEFIT ANNUALIZATION

HRHR restoration actions will produce two types of environmental benefits: (1) aquatic, wetland, and riparian functional benefits at mosaic and shoreline sites and (2) aquatic organism passage benefits at the connectivity sites. Both models were applied at four time intervals for all alternatives including future without project (FWOP): Year 0 (TY0- baseline conditions), Year-2 (TY2-an as built/post construction period reflecting initial ecological response), Year 20 (TY20- incorporates 19 full growing seasons and estimates long term outcomes), and Year-50 (TY50- end of the planning horizon). Habitat acreage (low marsh, high marsh, and floodplain) was projected 50 years beyond the design year (based on the annual elevation datum) for the intermediate sea level change scenario, and all benefits include the effects of sea level rise. Ecological benefits were annualized by computing the time-averaged benefits distributed over the entire planning horizon. Alternatives were compared using the net benefits (or “ecological lift”) over the future without project condition (i.e., Lift = Alt – FWOP).

First, the EPW model was used to assess aquatic, wetland, and riparian functional benefits at mosaic and shoreline sites. Each restoration site was divided into smaller sections for field data collection and ecological forecasting (i.e., patches). EPW is a rapid assessment procedure, which evaluates patch quality relative to six functional categories: shoreline bank erosion, sediment stabilization, water quality, wildlife, fish, and uniqueness / heritage (Bartoldus 1994, Bartoldus et al. 1994). The uniqueness / heritage parameters are beyond the scope of USACE ecosystem restoration missions and were not used in this analysis. The five remaining categories were averaged to obtain a functional capacity index for a given patch, which was subsequently multiplied by habitat area (in acres) to obtain a quality-weighted area metric (i.e., a functional capacity unit, FCU). For each wetland, FCUs were aggregated by site/component, alternative, and time.

EPW outputs were "annualized" to reflect the average annual units over the planning horizon. Models were applied at four time periods: Year-0 (2025), Year-2 (2027), Year-20 (2045), and Year-50 (2075). Benefits are annualized by computing the area under the benefits curve and dividing by the length of time in the planning horizon, assuming a linear trajectory between all time periods. Table 1 presents environmental benefits at each time period and average annual functional capacity units (AAFCUs from EPW).

Table 1: Benefits summary for mosaic and shoreline sites.

SITE	COMPONENT	ALTERNATIVE	FCU2025	FCU2027	FCU20245	FCU20275	AAFCU
Binnen Kill	North	FWOP	74.17	74.17	74.17	74.17	74.17
Binnen Kill	North	Alt1	74.17	76.62	80.21	80.21	79.37
Binnen Kill	North	Alt2	74.17	92.41	96.49	95.75	95
Binnen Kill	North	Alt3	74.17	76.63	80.22	80.22	79.38
Binnen Kill	North	Alt4	74.17	92.41	96.47	95.74	94.99
Binnen Kill	South	FWOP	23.42	23.42	23.42	21.44	22.83
Binnen Kill	South	Alt1	23.42	24	24.65	25.71	24.81
Binnen Kill	South	Alt2	23.42	35.17	35.98	35.89	35.54
Schodack Island	North	FWOP	10.98	10.98	10.98	12.97	11.58
Schodack Island	North	Alt1	10.98	13.37	15.17	15.21	14.74
Schodack Island	North	Alt2	10.98	17.09	19.48	18.83	18.64
Schodack Island	South	FWOP	2.24	2.24	2.24	2.59	2.34
Schodack Island	South	Alt1	2.24	2.79	3.15	3.71	3.22
Schodack Island	South	Alt2	2.24	3.62	4.15	4.13	4
Schodack Island	Wetlands	FWOP	5.71	5.71	5.71	4.94	5.48
Schodack Island	Wetlands	Alt1	5.71	6.92	7.81	7.26	7.43
Henry Hudson	All	FWOP	0.16	0.16	0.16	0.21	0.18
Henry Hudson	All	Alt1	0.16	2.38	2.47	2.49	2.41
Henry Hudson	All	Alt2	0.16	3.01	3.11	3.23	3.06
Charles Rider	All	FWOP	0.13	0.13	0.13	0.15	0.13
Charles Rider	All	Alt1	0.13	0.35	0.37	0.4	0.37

Second, tributary connectivity projects were designed around enhancing aquatic organism passage at four sites in the basin, which have the potential to enhance migratory connectivity for a broad assemblage of taxa utilizing the Hudson River. Benefits were quantified using the Watershed-Scale Upstream Connectivity Toolkit (WUCT). Briefly, WUCT provides a procedure for quantifying benefits associated with removal of organism movement barriers within a watershed (e.g., dam removal, culvert repair, and fish ladder installation) and is intended for application at the watershed-scale. The algorithm is based on four primary components: habitat quantity upstream of

a dam, habitat quality upstream of a dam, the passability of a structure for a given organism, and the shape/topology of the watershed. The model combines these data to estimate quality-weighted, accessible habitat at the watershed scale (i.e., a quality- and connectivity-weighted acre or habitat unit). For HRHR, benefits were computed as the average benefits for river herring and American eel. These taxa represent common focal outcomes for connectivity restoration projects in the region as well two different life histories and physiologies. As such, these taxa are considered representative of a broader migratory community, which is the focus of restoration objectives.

WUCT outputs were "annualized" to reflect the average annual units provided by a project over the planning horizon. Models were applied at four time periods: Year-0 (2025), Year-2 (2027), Year-20 (2045), and Year-50 (2075). Benefits from connectivity projects are highly dependent upon downstream actions, so Moodna Creek alternatives are presented as combinations of actions. Table 2 and Table 3 present environmental benefits for Rondout and Moodna Creeks, respectively, at each time period as well as the average annual habitat units (AAHUs from WUCT).

Table 2: Moodna Creek benefits summary.

MOODNA1	MOODNA2	MOODNA3	HU2025	HU2027	HU20245	HU20275	AAHU
FWOP	FWOP	FWOP	15.81	15.81	15.81	15.81	15.81
Alt1	FWOP	FWOP	15.81	18.66	18.66	18.66	18.6
Alt2	FWOP	FWOP	15.81	18.02	18.02	18.02	17.97
FWOP	Alt1	FWOP	15.81	17.5	17.5	17.5	17.46
Alt1	Alt1	FWOP	15.81	23.46	23.46	23.46	23.31
Alt2	Alt1	FWOP	15.81	22.18	22.18	22.18	22.05
FWOP	Alt2	FWOP	15.81	15.86	15.86	15.86	15.86
Alt1	Alt2	FWOP	15.81	18.92	18.92	18.92	18.86
Alt2	Alt2	FWOP	15.81	18.22	18.22	18.22	18.17
FWOP	FWOP	Alt1	15.81	16.68	16.68	16.68	16.67
Alt1	FWOP	Alt1	15.81	20.85	20.85	20.85	20.75
Alt2	FWOP	Alt1	15.81	19.99	19.99	19.99	19.91
FWOP	Alt1	Alt1	15.81	30.66	30.66	30.66	30.37
Alt1	Alt1	Alt1	15.81	65.16	65.16	65.16	64.17
Alt2	Alt1	Alt1	15.81	57.29	57.29	57.29	56.46
FWOP	Alt2	Alt1	15.81	17.62	17.62	17.62	17.58

Table 2 (cont.) Moodna Creek benefits summary.

MOODNA1	MOODNA2	MOODNA3	FCU2025	FCU2027	FCU20245	FCU20275	AAHU
Alt1	Alt2	Alt1	15.81	25.07	25.07	25.07	24.88
Alt2	Alt2	Alt1	15.81	23.27	23.27	23.27	23.12
FWOP	FWOP	Alt2	15.81	16.68	16.68	16.68	16.67
Alt1	FWOP	Alt2	15.81	20.85	20.85	20.85	20.75
Alt2	FWOP	Alt2	15.81	19.99	19.99	19.99	19.91
FWOP	Alt1	Alt2	15.81	30.66	30.66	30.66	30.37
Alt1	Alt1	Alt2	15.81	65.16	65.16	65.16	64.17
Alt2	Alt1	Alt2	15.81	57.29	57.29	57.29	56.46
FWOP	Alt2	Alt2	15.81	17.62	17.62	17.62	17.58
Alt1	Alt2	Alt2	15.81	25.07	25.07	25.07	24.88
Alt2	Alt2	Alt2	15.81	23.27	23.27	23.27	23.12

Table 3: Rondout Creek benefits summary.

ALTERNATIVE	HU2025	HU2027	HU20245	HU20275	AAHU
FWOP	15.81	15.81	15.81	15.81	15.81
Alt1	15.81	23.03	23.03	23.03	22.88
Alt2	15.81	145.78	145.78	145.78	143.18
Alt3	15.81	88.01	88.01	88.01	86.57

2.2. COST ANNUALIZATION

Cost estimates were compiled for each component-scale restoration action following standard cost engineering and real estate methods (Appendix E). Sub-total first cost represents a sum of expenses related to real estate, bank stabilization, cultural resources, pre-construction engineering and design, and construction management (Accounts 01, 16, 18, 30, and 31, respectively). Interest during construction was computed based on sub-total first costs, construction durations and the FY19 Federal discount rate (2.875%). Monitoring and adaptive management costs were estimated based on a five-year window. All costs were annualized over the 50-year planning horizon and combined with alternative-specific operations and maintenance costs to arrive at average annual cost (Table 4).

Table 4: Cost summary for all sites.

SITE	COMPONENT	ALTERNATIVE	CONSTRUCTION DURATION (mon)	SUB-TOTAL FIRST ($)	MON AND AD MAN ($)	TOTAL FIRST ($)	OMRR&R ($)	AVERAGE ANNUAL ($)
Binnen Kill	North	FWOP	0	0	0	0	0	0.00
Binnen Kill	North	Alt1	18	27,710,994	1,217,560	28,928,554	118,211	1,233,669
Binnen Kill	North	Alt2	24	34,181,905	1,537,356	35,719,261	148,049	1,534,710
Binnen Kill	North	Alt3	18	26,217,076	1,179,806	27,396,882	111,326	1,167,621
Binnen Kill	North	Alt4	24	33,689,272	1,504,379	35,193,651	145,896	1,512,712
Binnen Kill	South	FWOP	0	0	0	0	0	0.
Binnen Kill	South	Alt1	18	19,376,614	742,325	20,118,939	77,552	853,720
Binnen Kill	South	Alt2	24	21,404,501	732,445	22,136,946	85,556	945,843
Schodack Island	North	FWOP	0	0	0	0	0	0
Schodack Island	North	Alt1	24	12,976,252	481,323	13,457,575	45,836	568,677
Schodack Island	North	Alt2	24	18,646,693	610,104	19,256,797	73,636	822,106
Schodack Island	South	FWOP	0	0	0	0	0	0
Schodack Island	South	Alt1	18	7,494,791	341,039	7,835,830	21,062	323,161
Schodack Island	South	Alt2	18	9,365,506	349,948	9,715,454	30,278	405,123
Schodack Island	Wetlands	FWOP	0	0	0	0	0	0
Schodack Island	Wetlands	Alt1	6	8,826,803	245,819	9,072,622	30,727	376,249

Table 4 (cont.) Cost summary for all sites.

SITE	COMPONENT	ALTERNATIVE	CONSTRUCTION DURATION (mon)	SUB-TOTAL FIRST ($)	MON AND AD MAN ($)	TOTAL FIRST ($)	OMRR&R ($)	AVERAGE ANNUAL ($)
Henry Hudson	All	FWOP	0	0	0	0	0	0
Henry Hudson	All	Alt1	12	8,568,894	304,315	8,873,209	29,783	368,870
Henry Hudson	All	Alt2	12	14,705,306	516,205	15,221,511	59,173	638,516
Charles Rider	All	FWOP	0	0	0	0	0	0
Charles Rider	All	Alt1	6	3,403,398	182,053	3,585,451	9,830	146,099
Moodna1	All	FWOP	0	0	0	0	0	0
Moodna1	All	Alt1	3	1,609,785	85,846	1,695,631	5,000	69,227
Moodna1	All	Alt2	3	1,766,331	92,363	1,858,694	5,000	75,409
Moodna2	All	FWOP	0	0	0	0	0	0
Moodna2	All	Alt1	6	3,511,137	110,846	3,621,983	7,664	145,562
Moodna2	All	Alt2	6	3,433,607	615,788	4,049,395	25,000	177,552
Moodna3	All	FWOP	0	0	0	0	0	0
Moodna3	All	Alt1	6	4,107,200	172,730	4,279,930	9,523	172,333
Moodna3	All	Alt2	6	3,271,685	403,975	3,675,660	10,000	148,982
Rondout	All	FWOP	0	0	0	0	0	0
Rondout	All	Alt1	3	3,600,348	620,732	4,221,080	25,000	183,602
Rondout	All	Alt2	3	3,821,542	110,846	3,932,388	8,429	157,659
Rondout	All	Alt3	3	4,392,403	242,267	4,634,670	12,882	188,411

CHAPTER 3: Cost-Effectiveness and Incremental Cost Analyses

Cost-effectiveness analysis provides a mechanism for examining efficiency of alternative actions. For any given level of investment, the agency wants to identify the plan with the greatest return-on-investment (i.e., the most environmental benefits for a given level of cost or the least cost for a given level of environmental benefit). An "efficiency frontier" identifies all plans efficiently providing benefits on a per cost basis.

Incremental cost analysis is then conducted on the set of cost-effective plans. This technique sequentially compares each plan to all higher cost plans to reveal changes in unit cost as output levels increase and eliminates plans that do not efficiently provide benefits on an incremental unit cost basis. Specifically, this analysis examines the slope of the cost-effectiveness frontier to isolate how the unit cost ($/unit) increases as the magnitude of environmental benefit increases. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish the objective relative to unit costs and are typically referred to as "best buys." Importantly, all "best buys" are cost-effective, but all cost-effective plans are not best buys.

For each alternative, net benefits were computed over the future without project (FWOP) condition to reflect the change in ecological condition associated with the restoration expenditure. This "lift" in benefits provides a consistent baseline for comparison. Notably, EPW and WUCT outputs remain separate throughout these analyses since sites will only be compared within a given type of restoration (i.e., "like with like" comparison).

CE/ICA can be applied multiple ways when examining a multi-site restoration project such as HRHR. First, recommendations can be made at the site-scale and combined logically with other recommended actions to develop different "portfolios" of projects (e.g., Alt-A at Site-1 and Alt-C at Site-2). Second, all combinations of sites and alternatives can be assessed to develop project portfolios. Here, we applied CE/ICA using both approaches with the logic that greater confidence may be placed in a recommendation arrived at through competing methods. The following sections apply CE/ICA using these approaches separately for each restoration type, and cross-type comparisons are not examined because of the uniqueness of each ecosystem type (e.g., shorelines and mosaics serve very different ecological roles and provide different types of habitat). Each section follows the same structure:

- CE/ICA is conducted at the site-scale and a recommendation developed for each site in isolation (e.g., Binnen Kill only).
- CE/ICA is conducted for all combinations of actions within a restoration type (e.g., mosaic sites) and recommendations developed, which are referred to as systems-scale plans.
- In light of both analyses, a recommended action is summarized for each restoration type.

The USACE Planning Guidance Notebook (USACE 2000) directs plan selection by stating, “Selecting the NER plan requires careful consideration of the plan that meets

planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness." Three decision rules derived from this language and applied when interpreting CE/ICA and identifying a recommended alternative, specifically:

- Does this alternative/plan meet the planning objectives?
    - "meets planning objectives and constraints"
- Which alternative/plan has the lowest unit cost (i.e., $/AAFCU or $/AAHU)?
    - "reasonably maximize environmental benefits"
- Which alternative reasonably maximizes environmental benefits in light of non-linearities in cost-benefit data, incremental cost associated with additional investment, cost affordability, and benefits not captured by ecological models?
    - "passing the tests of cost effectiveness and incremental cost analyses"

The Planning Guidance Notebook also states that, "Neither cost effectiveness analysis nor incremental cost analysis include a 'one plan' selection rule similar to the '[National Economic Development] plan' selection rule for [National Economic Development] evaluations. In the absence of such a decision-making rule, neither analysis dictates what choice to make. However, the information developed by both analyses can inform decision making by progressively proceeding through the available levels of output to ask whether the next level is 'worth it'; that is, whether the environmental benefit of the additional output in the next level is worth its additional cost." This implies that incremental cost per incremental benefit provides a key metric, and incremental cost analysis is used here as the primary mechanism for structuring decision-making.

3.1. LARGE RIVER MOSAIC SITES

The Binnen Kill site is a large-scale side channel, floodplain, and wetland complex on the right bank of the Hudson River in Bethlehem, New York. The site was divided into two components (North and South) and alternatives were developed separately for each component. These component-scale alternatives were then combined into site-scale alternatives. All possible combinations were considered, which resulted in 15 site-scale alternatives as shown in Figure 1 and Table 5. Five "best buy" alternatives were identified for the final decision array.

- BK1 = North-FWOP, South-FWOP - No action alternative.
- BK5 = North-Alt4, South-FWOP - Native plantings and invasive species removal over a large area in the North, but the lack of a side channel does not meet planning objectives.
- BK15 = North-Alt4, South-Alt2 - **RECOMMENDATION** - Native plantings and invasive species removal over a large area in the North and large side channel and wetland corridor in the south. Lowest incremental unit cost of actions that incorporate a side channel.
- BK13 = North-Alt2, South-Alt2 - Native plantings and invasive species removal over a large area in the North along with a culvert repair to enhance fish movement and large side channel and wetland corridor in the South. Large increase in unit cost over BK15.

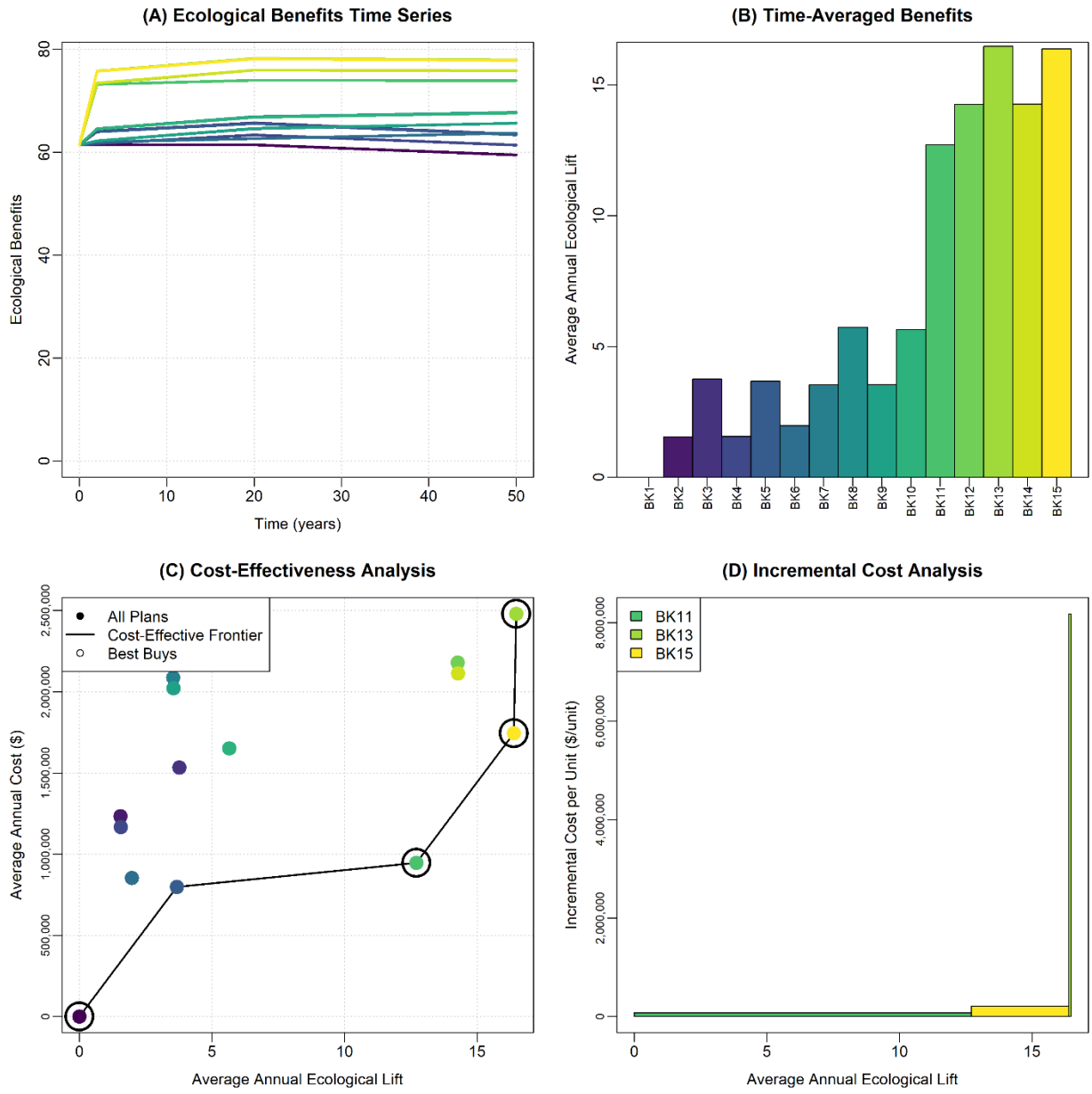

Figure 1: Binnen Kill CE/ICA summary.

Table 5: Binnen Kill site-scale alternatives.

SITE ALT	NORTH	SOUTH	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
BK1	FWOP	FWOP	97	0	0	0	0	1	1
BK6	FWOP	Alt1	98.98	1.98	853,720	431,172	20,118,939	1	0
BK2	Alt1	FWOP	102.2	5.2	1,233,669	237,244	28,928,554	0	0
BK4	Alt3	FWOP	102.21	5.21	1,167,621	224,112	27,396,882	0	0
BK7	Alt1	Alt1	104.18	7.18	2,087,389	290,723	49,047,493	0	0
BK9	Alt3	Alt1	104.19	7.19	2,021,342	281,132	47,515,821	0	0
BK11	FWOP	Alt2	109.71	12.71	945,843	74,417	22,136,946	1	0
BK12	Alt1	Alt2	114.91	17.91	2,179,512	121,692	51,065,500	0	0
BK14	Alt3	Alt2	114.92	17.92	2,113,465	117,939	49,533,828	0	0
BK5	Alt4	FWOP	117.82	20.82	1,512,712	72,657	35,193,651	1	1
BK3	Alt2	FWOP	117.83	20.83	1,534,710	73,678	35,719,261	1	0
BK10	Alt4	Alt1	119.8	22.8	2,366,432	103,791	55,312,590	1	0
BK8	Alt2	Alt1	119.81	22.81	2,388,430	104,710	55,838,200	1	0
BK15	Alt4	Alt2	130.53	33.53	2,458,555	73,324	57,330,597	1	1
BK13	Alt2	Alt2	130.54	33.54	2,480,553	73,958	57,856,207	1	1

The Schodack Island site is a large-scale side channel, floodplain, and wetland complex on the left bank of the Hudson River near Castleton-on-Hudson, New York. The site was divided into three components (North, South, and Pocket Wetlands) and alternatives were developed separately for each component. All possible combinations of components were combined into 18 site-scale alternatives as shown in Figure 2 and Table 6. The following “best buy” alternatives were identified for the final decision array.

- SI1 = North-FWOP, South-FWOP, Wetlands-FWOP - No action alternative.
- SI3 = North-Alt2, South-FWOP, Wetlands-FWOP - **RECOMMENDATION** - Side channel and wetland complex in the North that meets planning objectives. Lowest incremental unit cost of the best buys.
- SI12 = North-Alt2, South-FWOP, Wetlands-Alt1 - Side channel and wetland complex in the North and additional pocket wetlands.
- SI18 = North-Alt2, South-Alt2, Wetlands-Alt1 - Side channel and wetland complex in the North, Side channel and wetland complex in the South, and additional pocket wetlands. A recent proposal recommends mitigation activities in the South by other agencies. As such, these activities in the South will not be recommended.

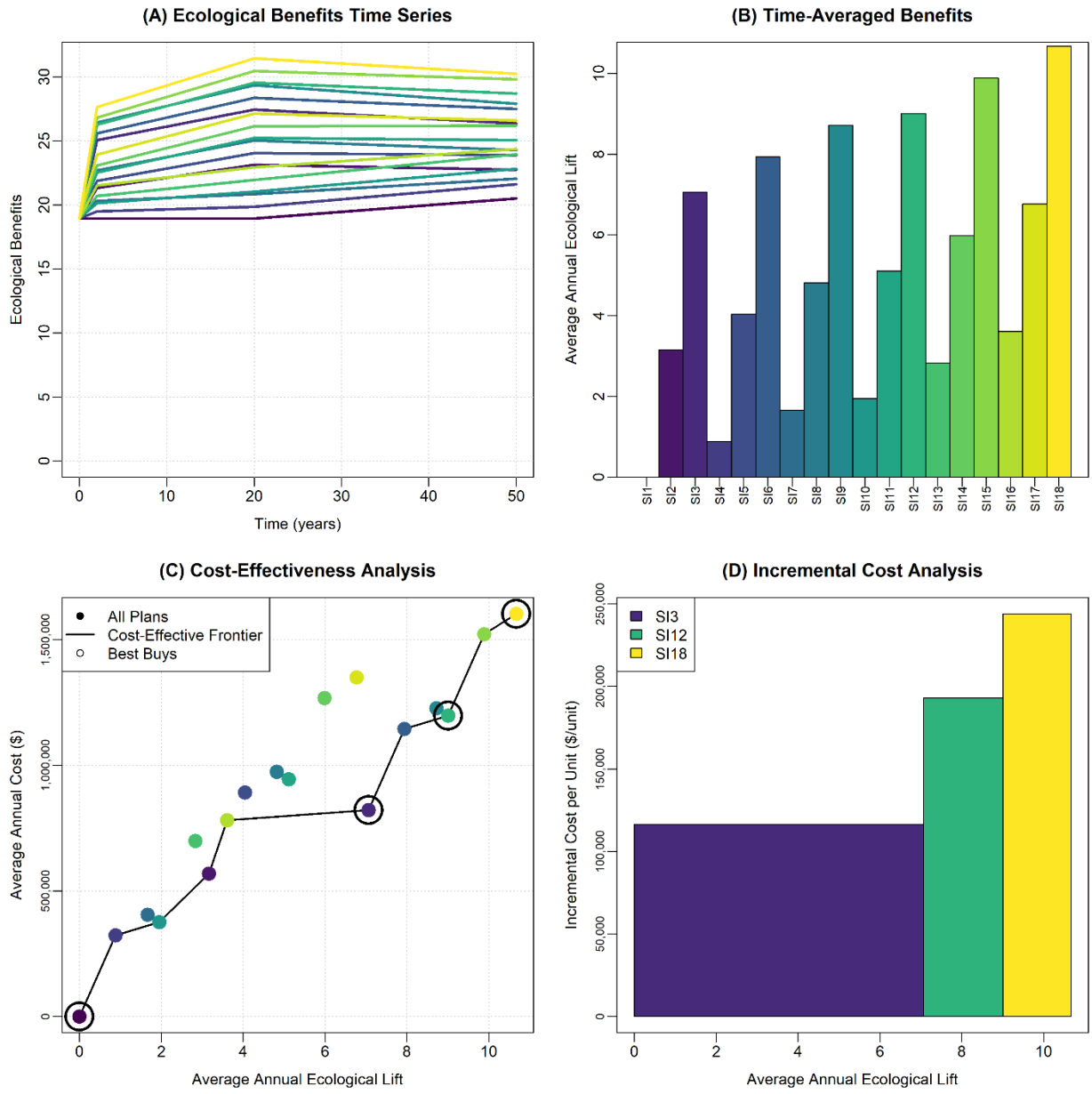

Figure 2: Schodack Island CE/ICA summary.

Table 6: Schodack Island site-scale alternatives.

SITE ALT	NORTH	SOUTH	WETLANDS	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
SI1	FWOP	FWOP	FWOP	19.4	0	0	0	0	1	1
SI4	FWOP	Alt1	FWOP	20.28	0.88	323,161	367,228	7,835,830	1	0
SI7	FWOP	Alt2	FWOP	21.06	1.66	405,123	244,050	9,715,454	0	0
SI10	FWOP	FWOP	Alt1	21.35	1.95	376,249	192,948	9,072,622	1	0
SI13	FWOP	Alt1	Alt1	22.23	2.83	699,410	247,141	16,908,452	0	0
SI2	Alt1	FWOP	FWOP	22.56	3.16	568,677	179,961	13,457,575	1	0
SI16	FWOP	Alt2	Alt1	23.01	3.61	781,372	216,446	18,788,076	1	0
SI5	Alt1	Alt1	FWOP	23.44	4.04	891,838	220,752	21,293,405	0	0
SI8	Alt1	Alt2	FWOP	24.22	4.82	973,800	202,033	23,173,029	0	0
SI11	Alt1	FWOP	Alt1	24.51	5.11	944,925	184,917	22,530,197	0	0
SI14	Alt1	Alt1	Alt1	25.39	5.99	1,268,086	211,701	30,366,027	0	0
SI17	Alt1	Alt2	Alt1	26.17	6.77	1,350,048	199,416	32,245,651	0	0
SI3	Alt2	FWOP	FWOP	26.46	7.06	822,106	116,446	19,256,797	1	1
SI6	Alt2	Alt1	FWOP	27.34	7.94	1,145,267	144,240	27,092,627	1	0
SI9	Alt2	Alt2	FWOP	28.12	8.72	1,227,229	140,737	28,972,251	0	0
SI12	Alt2	FWOP	Alt1	28.41	9.01	1,198,355	133,003	28,329,419	1	1
SI15	Alt2	Alt1	Alt1	29.29	9.89	1,521,516	153,844	36,165,249	1	0
SI18	Alt2	Alt2	Alt1	30.07	10.67	1,603,478	150,279	38,044,873	1	1

Binnen Kill and Schodack Island both represent large river mosaics restoration sites, and system-scale plans were developed examining all possible combinations of sites, components, and alternatives. Table 7 shows the results of CE/ICA for all 270 system-scale plans. The following system-wide plans for large river mosaic restoration were examined as the final array:

- MOS1 = BK North-FWOP, BK South-FWOP, SI North-FWOP, SI South-FWOP, SI Wetlands-FWOP - No action alternative.
- MOS5 = BK North-Alt4, BK South-FWOP, SI North-FWOP, SI South-FWOP, SI Wetlands-FWOP - No side channels included. Does not meet planning objectives.
- MOS15 = BK North-Alt4, BK South-Alt2, SI North-FWOP, SI South-FWOP, SI Wetlands-FWOP - Side channels are only included at Binnen Kill. Does not meet planning objectives.

- MOS45 = BK North-Alt4, BK South-Alt2, SI North-Alt2, SI South-FWOP, SI Wetlands-FWOP - **RECOMMENDATION** - Side channels are included at both Binnen Kill and Schodack Island. Meets planning objectives. Lowest incremental unit cost of plans meeting planning objectives.
- MOS180 = BK North-Alt4, BK South-Alt2, SI North-Alt2, SI South-FWOP, SI Wetlands-Alt1 - Moderate unit cost, but increase in incremental cost was very high ($192,948 for the next increment) and was not deemed "worth it" given MOS45's value.
- MOS268 = BK North-Alt2, BK South-Alt2, SI North-Alt2, SI South-Alt1, SI Wetlands-Alt1 - High unit cost.
- MOS270 = BK North-Alt4, BK South-Alt2, SI North-Alt2, SI South-Alt2, SI Wetlands-Alt1 - High unit cost.

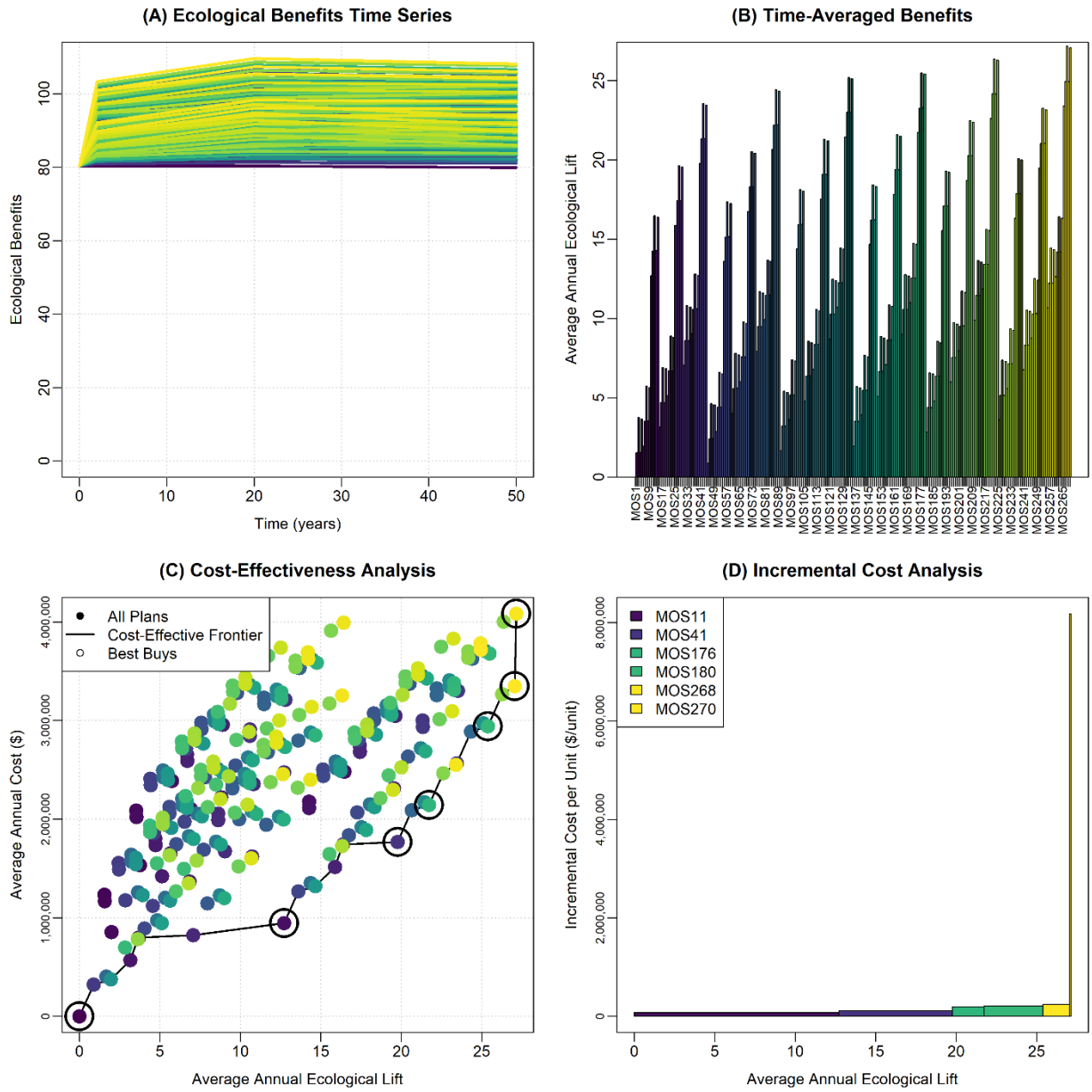

Figure 3: Large river mosaic CE/ICA summary.

CE/ICA was conducted for Binnen Kill and Schodack Island sites individually at the site-scale as well as together at the system-scale. The two CE/ICA approaches resulted in the same recommendation at both sites, lending confidence to plan selection. The recommended plan includes:

- Binnen Kill - North-Alt4, South-Alt2.
- Schodack Island - North-Alt2, South-FWOP, Wetlands-FWOP

Table 7: Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS1	FWOP	FWOP	FWOP	FWOP	FWOP	116.4	0	0	0	0	1	1
MOS46	FWOP	FWOP	FWOP	Alt1	FWOP	117.28	0.88	323,161	367,228	7,835,830	1	0
MOS91	FWOP	FWOP	FWOP	Alt2	FWOP	118.06	1.66	405,123	244,050	9,715,454	0	0
MOS136	FWOP	FWOP	FWOP	FWOP	Alt1	118.35	1.95	376,249	192,948	9,072,622	1	0
MOS6	FWOP	Alt1	FWOP	FWOP	FWOP	118.38	1.98	853,720	431,172	20,118,939	0	0
MOS181	FWOP	FWOP	FWOP	Alt1	Alt1	119.23	2.83	699,410	247,141	16,908,452	0	0
MOS51	FWOP	Alt1	FWOP	Alt1	FWOP	119.26	2.86	1,176,881	411,497	27,954,769	0	0
MOS16	FWOP	FWOP	Alt1	FWOP	FWOP	119.56	3.16	568,677	179,961	13,457,575	1	0
MOS226	FWOP	FWOP	FWOP	Alt2	Alt1	120.01	3.61	781,372	216,446	18,788,076	1	0
MOS96	FWOP	Alt1	FWOP	Alt2	FWOP	120.04	3.64	1,258,843	345,836	29,834,393	0	0
MOS141	FWOP	Alt1	FWOP	FWOP	Alt1	120.33	3.93	1,229,969	312,969	29,191,561	0	0
MOS61	FWOP	FWOP	Alt1	Alt1	FWOP	120.44	4.04	891,838	220,752	21,293,405	0	0
MOS186	FWOP	Alt1	FWOP	Alt1	Alt1	121.21	4.81	1,553,130	322,896	37,027,391	0	0
MOS106	FWOP	FWOP	Alt1	Alt2	FWOP	121.22	4.82	973,800	202,033	23,173,029	0	0
MOS151	FWOP	FWOP	Alt1	FWOP	Alt1	121.51	5.11	944,925	184,917	22,530,197	0	0
MOS21	FWOP	Alt1	Alt1	FWOP	FWOP	121.54	5.14	1,422,397	276,731	33,576,514	0	0
MOS2	Alt1	FWOP	FWOP	FWOP	FWOP	121.6	5.2	1,233,669	237,244	28,928,554	0	0
MOS4	Alt3	FWOP	FWOP	FWOP	FWOP	121.61	5.21	1,167,621	224,112	27,396,882	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS231	FWOP	Alt1	FWOP	Alt2	Alt1	121.99	5.59	1,635,092	292,503	38,907,015	0	0
MOS196	FWOP	FWOP	Alt1	Alt1	Alt1	122.39	5.99	1,268,086	211,701	30,366,027	0	0
MOS66	FWOP	Alt1	Alt1	Alt1	FWOP	122.42	6.02	1,745,558	289,960	41,412,344	0	0
MOS47	Alt1	FWOP	FWOP	Alt1	FWOP	122.48	6.08	1,556,830	256,058	36,764,384	0	0
MOS49	Alt3	FWOP	FWOP	Alt1	FWOP	122.49	6.09	1,490,782	244,792	35,232,712	0	0
MOS241	FWOP	FWOP	Alt1	Alt2	Alt1	123.17	6.77	1,350,048	199,416	32,245,651	0	0
MOS111	FWOP	Alt1	Alt1	Alt2	FWOP	123.2	6.8	1,827,520	268,753	43,291,968	0	0
MOS92	Alt1	FWOP	FWOP	Alt2	FWOP	123.26	6.86	1,638,792	238,891	38,644,008	0	0
MOS94	Alt3	FWOP	FWOP	Alt2	FWOP	123.27	6.87	1,572,744	228,929	37,112,336	0	0
MOS31	FWOP	FWOP	Alt2	FWOP	FWOP	123.46	7.06	822,106	116,446	19,256,797	1	0
MOS156	FWOP	Alt1	Alt1	FWOP	Alt1	123.49	7.09	1,798,645	253,688	42,649,136	0	0
MOS137	Alt1	FWOP	FWOP	FWOP	Alt1	123.55	7.15	1,609,917	225,163	38,001,176	0	0
MOS139	Alt3	FWOP	FWOP	FWOP	Alt1	123.56	7.16	1,543,870	215,624	36,469,504	0	0
MOS7	Alt1	Alt1	FWOP	FWOP	FWOP	123.58	7.18	2,087,389	290,723	49,047,493	0	0
MOS9	Alt3	Alt1	FWOP	FWOP	FWOP	123.59	7.19	2,021,342	281,132	47,515,821	0	0
MOS76	FWOP	FWOP	Alt2	Alt1	FWOP	124.34	7.94	1,145,267	144,240	27,092,627	0	0
MOS201	FWOP	Alt1	Alt1	Alt1	Alt1	124.37	7.97	2,121,807	266,224	50,484,966	0	0
MOS182	Alt1	FWOP	FWOP	Alt1	Alt1	124.43	8.03	1,933,078	240,732	45,837,006	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS184	Alt3	FWOP	FWOP	Alt1	Alt1	124.44	8.04	1,867,031	232,218	44,305,334	0	0
MOS52	Alt1	Alt1	FWOP	Alt1	FWOP	124.46	8.06	2,410,550	299,076	56,883,323	0	0
MOS54	Alt3	Alt1	FWOP	Alt1	FWOP	124.47	8.07	2,344,503	290,521	55,351,651	0	0
MOS17	Alt1	FWOP	Alt1	FWOP	FWOP	124.76	8.36	1,802,345	215,592	42,386,129	0	0
MOS19	Alt3	FWOP	Alt1	FWOP	FWOP	124.77	8.37	1,736,298	207,443	40,854,457	0	0
MOS121	FWOP	FWOP	Alt2	Alt2	FWOP	125.12	8.72	1,227,229	140,737	28,972,251	0	0
MOS246	FWOP	Alt1	Alt1	Alt2	Alt1	125.15	8.75	2,203,768	251,859	52,364,590	0	0
MOS227	Alt1	FWOP	FWOP	Alt2	Alt1	125.21	8.81	2,015,040	228,722	47,716,630	0	0
MOS229	Alt3	FWOP	FWOP	Alt2	Alt1	125.22	8.82	1,948,993	220,974	46,184,958	0	0
MOS97	Alt1	Alt1	FWOP	Alt2	FWOP	125.24	8.84	2,492,512	281,958	58,762,947	0	0
MOS99	Alt3	Alt1	FWOP	Alt2	FWOP	125.25	8.85	2,426,465	274,177	57,231,275	0	0
MOS166	FWOP	FWOP	Alt2	FWOP	Alt1	125.41	9.01	1,198,355	133,003	28,329,419	0	0
MOS36	FWOP	Alt1	Alt2	FWOP	FWOP	125.44	9.04	1,675,826	185,379	39,375,736	0	0
MOS142	Alt1	Alt1	FWOP	FWOP	Alt1	125.53	9.13	2,463,638	269,840	58,120,115	0	0
MOS144	Alt3	Alt1	FWOP	FWOP	Alt1	125.54	9.14	2,397,590	262,318	56,588,443	0	0
MOS62	Alt1	FWOP	Alt1	Alt1	FWOP	125.64	9.24	2,125,506	230,033	50,221,959	0	0
MOS64	Alt3	FWOP	Alt1	Alt1	FWOP	125.65	9.25	2,059,459	222,644	48,690,287	0	0
MOS211	FWOP	FWOP	Alt2	Alt1	Alt1	126.29	9.89	1,521,516	153,844	36,165,249	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS81	FWOP	Alt1	Alt2	Alt1	FWOP	126.32	9.92	1,998,987	201,511	47,211,566	0	0
MOS187	Alt1	Alt1	FWOP	Alt1	Alt1	126.41	10.01	2,786,799	278,401	65,955,945	0	0
MOS189	Alt3	Alt1	FWOP	Alt1	Alt1	126.42	10.02	2,720,751	271,532	64,424,273	0	0
MOS107	Alt1	FWOP	Alt1	Alt2	FWOP	126.42	10.02	2,207,468	220,306	52,101,583	0	0
MOS109	Alt3	FWOP	Alt1	Alt2	FWOP	126.43	10.03	2,141,421	213,502	50,569,911	0	0
MOS152	Alt1	FWOP	Alt1	FWOP	Alt1	126.71	10.31	2,178,594	211,309	51,458,751	0	0
MOS154	Alt3	FWOP	Alt1	FWOP	Alt1	126.72	10.32	2,112,547	204,704	49,927,079	0	0
MOS22	Alt1	Alt1	Alt1	FWOP	FWOP	126.74	10.34	2,656,066	256,873	62,505,068	0	0
MOS24	Alt3	Alt1	Alt1	FWOP	FWOP	126.75	10.35	2,590,018	250,243	60,973,396	0	0
MOS256	FWOP	FWOP	Alt2	Alt2	Alt1	127.07	10.67	1,603,478	150,279	38,044,873	0	0
MOS126	FWOP	Alt1	Alt2	Alt2	FWOP	127.1	10.7	2,080,949	194,481	49,091,190	0	0
MOS232	Alt1	Alt1	FWOP	Alt2	Alt1	127.19	10.79	2,868,761	265,872	67,835,569	0	0
MOS234	Alt3	Alt1	FWOP	Alt2	Alt1	127.2	10.8	2,802,713	259,510	66,303,897	0	0
MOS171	FWOP	Alt1	Alt2	FWOP	Alt1	127.39	10.99	2,052,075	186,722	48,448,358	0	0
MOS197	Alt1	FWOP	Alt1	Alt1	Alt1	127.59	11.19	2,501,755	223,571	59,294,581	0	0
MOS199	Alt3	FWOP	Alt1	Alt1	Alt1	127.6	11.2	2,435,708	217,474	57,762,909	0	0
MOS67	Alt1	Alt1	Alt1	Alt1	FWOP	127.62	11.22	2,979,227	265,528	70,340,898	0	0
MOS69	Alt3	Alt1	Alt1	Alt1	FWOP	127.63	11.23	2,913,179	259,410	68,809,226	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS216	FWOP	Alt1	Alt2	Alt1	Alt1	128.27	11.87	2,375,236	200,104	56,284,188	0	0
MOS242	Alt1	FWOP	Alt1	Alt2	Alt1	128.37	11.97	2,583,717	215,849	61,174,205	0	0
MOS244	Alt3	FWOP	Alt1	Alt2	Alt1	128.38	11.98	2,517,670	210,156	59,642,533	0	0
MOS112	Alt1	Alt1	Alt1	Alt2	FWOP	128.4	12	3,061,189	255,099	72,220,522	0	0
MOS114	Alt3	Alt1	Alt1	Alt2	FWOP	128.41	12.01	2,995,141	249,387	70,688,850	0	0
MOS32	Alt1	FWOP	Alt2	FWOP	FWOP	128.66	12.26	2,055,775	167,681	48,185,351	0	0
MOS34	Alt3	FWOP	Alt2	FWOP	FWOP	128.67	12.27	1,989,727	162,162	46,653,679	0	0
MOS157	Alt1	Alt1	Alt1	FWOP	Alt1	128.69	12.29	3,032,314	246,730	71,577,690	0	0
MOS159	Alt3	Alt1	Alt1	FWOP	Alt1	128.7	12.3	2,966,267	241,160	70,046,018	0	0
MOS261	FWOP	Alt1	Alt2	Alt2	Alt1	129.05	12.65	2,457,198	194,245	58,163,812	0	0
MOS11	FWOP	Alt2	FWOP	FWOP	FWOP	129.11	12.71	945,843	74,417	22,136,946	1	0
MOS77	Alt1	FWOP	Alt2	Alt1	FWOP	129.54	13.14	2,378,936	181,045	56,021,181	0	0
MOS79	Alt3	FWOP	Alt2	Alt1	FWOP	129.55	13.15	2,312,888	175,885	54,489,509	0	0
MOS202	Alt1	Alt1	Alt1	Alt1	Alt1	129.57	13.17	3,355,475	254,782	79,413,520	0	0
MOS204	Alt3	Alt1	Alt1	Alt1	Alt1	129.58	13.18	3,289,428	249,577	77,881,848	0	0
MOS56	FWOP	Alt2	FWOP	Alt1	FWOP	129.99	13.59	1,269,004	93,378	29,972,776	1	0
MOS122	Alt1	FWOP	Alt2	Alt2	FWOP	130.32	13.92	2,460,898	176,789	57,900,805	0	0
MOS124	Alt3	FWOP	Alt2	Alt2	FWOP	130.33	13.93	2,394,850	171,920	56,369,133	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS247	Alt1	Alt1	Alt1	Alt2	Alt1	130.35	13.95	3,437,437	246,411	81,293,144	0	0
MOS249	Alt3	Alt1	Alt1	Alt2	Alt1	130.36	13.96	3,371,390	241,504	79,761,472	0	0
MOS167	Alt1	FWOP	Alt2	FWOP	Alt1	130.61	14.21	2,432,023	171,149	57,257,973	0	0
MOS169	Alt3	FWOP	Alt2	FWOP	Alt1	130.62	14.22	2,365,976	166,384	55,726,301	0	0
MOS37	Alt1	Alt1	Alt2	FWOP	FWOP	130.64	14.24	2,909,495	204,318	68,304,290	0	0
MOS39	Alt3	Alt1	Alt2	FWOP	FWOP	130.65	14.25	2,843,448	199,540	66,772,618	0	0
MOS101	FWOP	Alt2	FWOP	Alt2	FWOP	130.77	14.37	1,350,966	94,013	31,852,400	0	0
MOS146	FWOP	Alt2	FWOP	FWOP	Alt1	131.06	14.66	1,322,092	90,184	31,209,568	1	0
MOS212	Alt1	FWOP	Alt2	Alt1	Alt1	131.49	15.09	2,755,184	182,583	65,093,803	0	0
MOS214	Alt3	FWOP	Alt2	Alt1	Alt1	131.5	15.1	2,689,137	178,089	63,562,131	0	0
MOS82	Alt1	Alt1	Alt2	Alt1	FWOP	131.52	15.12	3,232,656	213,800	76,140,120	0	0
MOS84	Alt3	Alt1	Alt2	Alt1	FWOP	131.53	15.13	3,166,609	209,293	74,608,448	0	0
MOS191	FWOP	Alt2	FWOP	Alt1	Alt1	131.94	15.54	1,645,253	105,872	39,045,398	0	0
MOS26	FWOP	Alt2	Alt1	FWOP	FWOP	132.27	15.87	1,514,520	95,433	35,594,521	0	0
MOS257	Alt1	FWOP	Alt2	Alt2	Alt1	132.27	15.87	2,837,146	178,774	66,973,427	0	0
MOS259	Alt3	FWOP	Alt2	Alt2	Alt1	132.28	15.88	2,771,099	174,502	65,441,755	0	0
MOS127	Alt1	Alt1	Alt2	Alt2	FWOP	132.3	15.9	3,314,618	208,467	78,019,744	0	0
MOS129	Alt3	Alt1	Alt2	Alt2	FWOP	132.31	15.91	3,248,571	204,184	76,488,072	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS172	Alt1	Alt1	Alt2	FWOP	Alt1	132.59	16.19	3,285,744	202,949	77,376,912	0	0
MOS174	Alt3	Alt1	Alt2	FWOP	Alt1	132.6	16.2	3,219,696	198,747	75,845,240	0	0
MOS236	FWOP	Alt2	FWOP	Alt2	Alt1	132.72	16.32	1,727,215	105,834	40,925,022	0	0
MOS71	FWOP	Alt2	Alt1	Alt1	FWOP	133.15	16.75	1,837,681	109,712	43,430,351	0	0
MOS217	Alt1	Alt1	Alt2	Alt1	Alt1	133.47	17.07	3,608,905	211,418	85,212,742	0	0
MOS219	Alt3	Alt1	Alt2	Alt1	Alt1	133.48	17.08	3,542,857	207,427	83,681,070	0	0
MOS116	FWOP	Alt2	Alt1	Alt2	FWOP	133.93	17.53	1,919,643	109,506	45,309,975	0	0
MOS161	FWOP	Alt2	Alt1	FWOP	Alt1	134.22	17.82	1,890,768	106,104	44,667,143	0	0
MOS262	Alt1	Alt1	Alt2	Alt2	Alt1	134.25	17.85	3,690,867	206,771	87,092,366	0	0
MOS264	Alt3	Alt1	Alt2	Alt2	Alt1	134.26	17.86	3,624,819	202,957	85,560,694	0	0
MOS12	Alt1	Alt2	FWOP	FWOP	FWOP	134.31	17.91	2,179,512	121,692	51,065,500	0	0
MOS14	Alt3	Alt2	FWOP	FWOP	FWOP	134.32	17.92	2,113,465	117,939	49,533,828	0	0
MOS206	FWOP	Alt2	Alt1	Alt1	Alt1	135.1	18.7	2,213,930	118,392	52,502,973	0	0
MOS57	Alt1	Alt2	FWOP	Alt1	FWOP	135.19	18.79	2,502,673	133,192	58,901,330	0	0
MOS59	Alt3	Alt2	FWOP	Alt1	FWOP	135.2	18.8	2,436,626	129,608	57,369,658	0	0
MOS251	FWOP	Alt2	Alt1	Alt2	Alt1	135.88	19.48	2,295,892	117,859	54,382,597	0	0
MOS102	Alt1	Alt2	FWOP	Alt2	FWOP	135.97	19.57	2,584,635	132,071	60,780,954	0	0
MOS104	Alt3	Alt2	FWOP	Alt2	FWOP	135.98	19.58	2,518,588	128,631	59,249,282	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS41	FWOP	Alt2	Alt2	FWOP	FWOP	136.17	19.77	1,767,949	89,426	41,393,743	0	0
MOS147	Alt1	Alt2	FWOP	FWOP	Alt1	136.26	19.86	2,555,761	128,689	60,138,122	0	0
MOS149	Alt3	Alt2	FWOP	FWOP	Alt1	136.27	19.87	2,489,713	125,300	58,606,450	0	0
MOS86	FWOP	Alt2	Alt2	Alt1	FWOP	137.05	20.65	2,091,110	101,264	49,229,573	0	0
MOS192	Alt1	Alt2	FWOP	Alt1	Alt1	137.14	20.74	2,878,922	138,810	67,973,952	0	0
MOS194	Alt3	Alt2	FWOP	Alt1	Alt1	137.15	20.75	2,812,874	135,560	66,442,280	0	0
MOS5	Alt4	FWOP	FWOP	FWOP	FWOP	137.22	20.82	1,512,712	72,657	35,193,651	1	1
MOS3	Alt2	FWOP	FWOP	FWOP	FWOP	137.23	20.83	1,534,710	73,678	35,719,261	1	0
MOS27	Alt1	Alt2	Alt1	FWOP	FWOP	137.47	21.07	2,748,189	130,431	64,523,075	0	0
MOS29	Alt3	Alt2	Alt1	FWOP	FWOP	137.48	21.08	2,682,141	127,236	62,991,403	0	0
MOS131	FWOP	Alt2	Alt2	Alt2	FWOP	137.83	21.43	2,173,072	101,403	51,109,197	0	0
MOS237	Alt1	Alt2	FWOP	Alt2	Alt1	137.92	21.52	2,960,884	137,588	69,853,576	0	0
MOS239	Alt3	Alt2	FWOP	Alt2	Alt1	137.93	21.53	2,894,836	134,456	68,321,904	0	0
MOS50	Alt4	FWOP	FWOP	Alt1	FWOP	138.1	21.7	1,835,873	84,602	43,029,481	1	0
MOS48	Alt2	FWOP	FWOP	Alt1	FWOP	138.11	21.71	1,857,871	85,577	43,555,091	1	0
MOS176	FWOP	Alt2	Alt2	FWOP	Alt1	138.12	21.72	2,144,198	98,720	50,466,365	0	0
MOS72	Alt1	Alt2	Alt1	Alt1	FWOP	138.35	21.95	3,071,350	139,925	72,358,905	0	0
MOS74	Alt3	Alt2	Alt1	Alt1	FWOP	138.36	21.96	3,005,302	136,853	70,827,233	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS95	Alt4	FWOP	FWOP	Alt2	FWOP	138.88	22.48	1,917,835	85,313	44,909,105	0	0
MOS93	Alt2	FWOP	FWOP	Alt2	FWOP	138.89	22.49	1,939,833	86,253	45,434,715	0	0
MOS221	FWOP	Alt2	Alt2	Alt1	Alt1	139	22.6	2,467,359	109,175	58,302,195	0	0
MOS117	Alt1	Alt2	Alt1	Alt2	FWOP	139.13	22.73	3,153,312	138,729	74,238,529	0	0
MOS119	Alt3	Alt2	Alt1	Alt2	FWOP	139.14	22.74	3,087,264	135,764	72,706,857	0	0
MOS140	Alt4	FWOP	FWOP	FWOP	Alt1	139.17	22.77	1,888,961	82,958	44,266,273	1	0
MOS138	Alt2	FWOP	FWOP	FWOP	Alt1	139.18	22.78	1,910,958	83,888	44,791,883	1	0
MOS10	Alt4	Alt1	FWOP	FWOP	FWOP	139.2	22.8	2,366,432	103,791	55,312,590	0	0
MOS8	Alt2	Alt1	FWOP	FWOP	FWOP	139.21	22.81	2,388,430	104,710	55,838,200	0	0
MOS162	Alt1	Alt2	Alt1	FWOP	Alt1	139.42	23.02	3,124,437	135,727	73,595,697	0	0
MOS164	Alt3	Alt2	Alt1	FWOP	Alt1	139.43	23.03	3,058,390	132,800	72,064,025	0	0
MOS266	FWOP	Alt2	Alt2	Alt2	Alt1	139.78	23.38	2,549,321	109,039	60,181,819	0	0
MOS185	Alt4	FWOP	FWOP	Alt1	Alt1	140.05	23.65	2,212,122	93,536	52,102,103	0	0
MOS183	Alt2	FWOP	FWOP	Alt1	Alt1	140.06	23.66	2,234,119	94,426	52,627,713	0	0
MOS55	Alt4	Alt1	FWOP	Alt1	FWOP	140.08	23.68	2,689,593	113,581	63,148,420	0	0
MOS53	Alt2	Alt1	FWOP	Alt1	FWOP	140.09	23.69	2,711,591	114,461	63,674,030	0	0
MOS207	Alt1	Alt2	Alt1	Alt1	Alt1	140.3	23.9	3,447,598	144,251	81,431,527	0	0
MOS209	Alt3	Alt2	Alt1	Alt1	Alt1	140.31	23.91	3,381,551	141,428	79,899,855	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS20	Alt4	FWOP	Alt1	FWOP	FWOP	140.38	23.98	2,081,389	86,797	48,651,226	1	0
MOS18	Alt2	FWOP	Alt1	FWOP	FWOP	140.39	23.99	2,103,386	87,678	49,176,836	1	0
MOS230	Alt4	FWOP	FWOP	Alt2	Alt1	140.83	24.43	2,294,084	93,904	53,981,727	1	0
MOS228	Alt2	FWOP	FWOP	Alt2	Alt1	140.84	24.44	2,316,081	94,766	54,507,337	1	0
MOS100	Alt4	Alt1	FWOP	Alt2	FWOP	140.86	24.46	2,771,555	113,310	65,028,044	0	0
MOS98	Alt2	Alt1	FWOP	Alt2	FWOP	140.87	24.47	2,793,553	114,162	65,553,654	0	0
MOS252	Alt1	Alt2	Alt1	Alt2	Alt1	141.08	24.68	3,529,560	143,013	83,311,151	0	0
MOS254	Alt3	Alt2	Alt1	Alt2	Alt1	141.09	24.69	3,463,513	140,280	81,779,479	0	0
MOS145	Alt4	Alt1	FWOP	FWOP	Alt1	141.15	24.75	2,742,681	110,815	64,385,212	0	0
MOS143	Alt2	Alt1	FWOP	FWOP	Alt1	141.16	24.76	2,764,679	111,659	64,910,822	0	0
MOS65	Alt4	FWOP	Alt1	Alt1	FWOP	141.26	24.86	2,404,550	96,724	56,487,056	0	0
MOS63	Alt2	FWOP	Alt1	Alt1	FWOP	141.27	24.87	2,426,547	97,569	57,012,666	0	0
MOS42	Alt1	Alt2	Alt2	FWOP	FWOP	141.37	24.97	3,001,618	120,209	70,322,297	0	0
MOS44	Alt3	Alt2	Alt2	FWOP	FWOP	141.38	24.98	2,935,571	117,517	68,790,625	0	0
MOS190	Alt4	Alt1	FWOP	Alt1	Alt1	142.03	25.63	3,065,842	119,619	72,221,042	0	0
MOS110	Alt4	FWOP	Alt1	Alt2	FWOP	142.04	25.64	2,486,512	96,978	58,366,680	0	0
MOS188	Alt2	Alt1	FWOP	Alt1	Alt1	142.04	25.64	3,087,840	120,431	72,746,652	0	0
MOS108	Alt2	FWOP	Alt1	Alt2	FWOP	142.05	25.65	2,508,509	97,798	58,892,290	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS87	Alt1	Alt2	Alt2	Alt1	FWOP	142.25	25.85	3,324,779	128,618	78,158,127	0	0
MOS89	Alt3	Alt2	Alt2	Alt1	FWOP	142.26	25.86	3,258,732	126,014	76,626,455	0	0
MOS155	Alt4	FWOP	Alt1	FWOP	Alt1	142.33	25.93	2,457,637	94,780	57,723,848	0	0
MOS153	Alt2	FWOP	Alt1	FWOP	Alt1	142.34	25.94	2,479,635	95,591	58,249,458	0	0
MOS25	Alt4	Alt1	Alt1	FWOP	FWOP	142.36	25.96	2,935,109	113,063	68,770,165	0	0
MOS23	Alt2	Alt1	Alt1	FWOP	FWOP	142.37	25.97	2,957,107	113,866	69,295,775	0	0
MOS235	Alt4	Alt1	FWOP	Alt2	Alt1	142.81	26.41	3,147,804	119,190	74,100,666	0	0
MOS233	Alt2	Alt1	FWOP	Alt2	Alt1	142.82	26.42	3,169,802	119,977	74,626,276	0	0
MOS132	Alt1	Alt2	Alt2	Alt2	FWOP	143.03	26.63	3,406,741	127,929	80,037,751	0	0
MOS134	Alt3	Alt2	Alt2	Alt2	FWOP	143.04	26.64	3,340,694	125,401	78,506,079	0	0
MOS200	Alt4	FWOP	Alt1	Alt1	Alt1	143.21	26.81	2,780,798	103,722	65,559,678	0	0
MOS198	Alt2	FWOP	Alt1	Alt1	Alt1	143.22	26.82	2,802,796	104,504	66,085,288	0	0
MOS70	Alt4	Alt1	Alt1	Alt1	FWOP	143.24	26.84	3,258,270	121,396	76,605,995	0	0
MOS68	Alt2	Alt1	Alt1	Alt1	FWOP	143.25	26.85	3,280,268	122,170	77,131,605	0	0
MOS177	Alt1	Alt2	Alt2	FWOP	Alt1	143.32	26.92	3,377,867	125,478	79,394,919	0	0
MOS179	Alt3	Alt2	Alt2	FWOP	Alt1	143.33	26.93	3,311,819	122,979	77,863,247	0	0
MOS245	Alt4	FWOP	Alt1	Alt2	Alt1	143.99	27.59	2,862,760	103,761	67,439,302	0	0
MOS243	Alt2	FWOP	Alt1	Alt2	Alt1	144	27.6	2,884,758	104,520	67,964,912	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS115	Alt4	Alt1	Alt1	Alt2	FWOP	144.02	27.62	3,340,232	120,935	78,485,619	0	0
MOS113	Alt2	Alt1	Alt1	Alt2	FWOP	144.03	27.63	3,362,230	121,688	79,011,229	0	0
MOS222	Alt1	Alt2	Alt2	Alt1	Alt1	144.2	27.8	3,701,028	133,130	87,230,749	0	0
MOS224	Alt3	Alt2	Alt2	Alt1	Alt1	144.21	27.81	3,634,980	130,708	85,699,077	0	0
MOS35	Alt4	FWOP	Alt2	FWOP	FWOP	144.28	27.88	2,334,818	83,745	54,450,448	1	0
MOS33	Alt2	FWOP	Alt2	FWOP	FWOP	144.29	27.89	2,356,816	84,504	54,976,058	1	0
MOS160	Alt4	Alt1	Alt1	FWOP	Alt1	144.31	27.91	3,311,357	118,644	77,842,787	0	0
MOS158	Alt2	Alt1	Alt1	FWOP	Alt1	144.32	27.92	3,333,355	119,390	78,368,397	0	0
MOS267	Alt1	Alt2	Alt2	Alt2	Alt1	144.98	28.58	3,782,990	132,365	89,110,373	0	0
MOS269	Alt3	Alt2	Alt2	Alt2	Alt1	144.99	28.59	3,716,942	130,008	87,578,701	0	0
MOS80	Alt4	FWOP	Alt2	Alt1	FWOP	145.16	28.76	2,657,979	92,419	62,286,278	0	0
MOS78	Alt2	FWOP	Alt2	Alt1	FWOP	145.17	28.77	2,679,977	93,152	62,811,888	0	0
MOS205	Alt4	Alt1	Alt1	Alt1	Alt1	145.19	28.79	3,634,518	126,242	85,678,617	0	0
MOS203	Alt2	Alt1	Alt1	Alt1	Alt1	145.2	28.8	3,656,516	126,962	86,204,227	0	0
MOS125	Alt4	FWOP	Alt2	Alt2	FWOP	145.94	29.54	2,739,941	92,754	64,165,902	0	0
MOS123	Alt2	FWOP	Alt2	Alt2	FWOP	145.95	29.55	2,761,939	93,467	64,691,512	0	0
MOS250	Alt4	Alt1	Alt1	Alt2	Alt1	145.97	29.57	3,716,480	125,684	87,558,241	0	0
MOS248	Alt2	Alt1	Alt1	Alt2	Alt1	145.98	29.58	3,738,478	126,385	88,083,851	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS170	Alt4	FWOP	Alt2	FWOP	Alt1	146.23	29.83	2,711,067	90,884	63,523,070	0	0
MOS168	Alt2	FWOP	Alt2	FWOP	Alt1	146.24	29.84	2,733,064	91,591	64,048,680	0	0
MOS40	Alt4	Alt1	Alt2	FWOP	FWOP	146.26	29.86	3,188,538	106,783	74,569,387	0	0
MOS38	Alt2	Alt1	Alt2	FWOP	FWOP	146.27	29.87	3,210,536	107,484	75,094,997	0	0
MOS215	Alt4	FWOP	Alt2	Alt1	Alt1	147.11	30.71	3,034,228	98,803	71,358,900	0	0
MOS213	Alt2	FWOP	Alt2	Alt1	Alt1	147.12	30.72	3,056,225	99,487	71,884,510	0	0
MOS85	Alt4	Alt1	Alt2	Alt1	FWOP	147.14	30.74	3,511,699	114,239	82,405,217	0	0
MOS83	Alt2	Alt1	Alt2	Alt1	FWOP	147.15	30.75	3,533,697	114,917	82,930,827	0	0
MOS260	Alt4	FWOP	Alt2	Alt2	Alt1	147.89	31.49	3,116,190	98,958	73,238,524	0	0
MOS258	Alt2	FWOP	Alt2	Alt2	Alt1	147.9	31.5	3,138,187	99,625	73,764,134	0	0
MOS130	Alt4	Alt1	Alt2	Alt2	FWOP	147.92	31.52	3,593,661	114,012	84,284,841	0	0
MOS128	Alt2	Alt1	Alt2	Alt2	FWOP	147.93	31.53	3,615,659	114,674	84,810,451	0	0
MOS175	Alt4	Alt1	Alt2	FWOP	Alt1	148.21	31.81	3,564,787	112,065	83,642,009	0	0
MOS173	Alt2	Alt1	Alt2	FWOP	Alt1	148.22	31.82	3,586,785	112,721	84,167,619	0	0
MOS220	Alt4	Alt1	Alt2	Alt1	Alt1	149.09	32.69	3,887,948	118,934	91,477,839	0	0
MOS218	Alt2	Alt1	Alt2	Alt1	Alt1	149.1	32.7	3,909,946	119,570	92,003,449	0	0
MOS265	Alt4	Alt1	Alt2	Alt2	Alt1	149.87	33.47	3,969,910	118,611	93,357,463	0	0
MOS263	Alt2	Alt1	Alt2	Alt2	Alt1	149.88	33.48	3,991,908	119,233	93,883,073	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS15	Alt4	Alt2	FWOP	FWOP	FWOP	149.93	33.53	2,458,555	73,324	57,330,597	1	1
MOS13	Alt2	Alt2	FWOP	FWOP	FWOP	149.94	33.54	2,480,553	73,958	57,856,207	1	0
MOS60	Alt4	Alt2	FWOP	Alt1	FWOP	150.81	34.41	2,781,716	80,840	65,166,427	1	0
MOS58	Alt2	Alt2	FWOP	Alt1	FWOP	150.82	34.42	2,803,714	81,456	65,692,037	1	0
MOS105	Alt4	Alt2	FWOP	Alt2	FWOP	151.59	35.19	2,863,678	81,378	67,046,051	0	0
MOS103	Alt2	Alt2	FWOP	Alt2	FWOP	151.6	35.2	2,885,676	81,979	67,571,661	0	0
MOS150	Alt4	Alt2	FWOP	FWOP	Alt1	151.88	35.48	2,834,804	79,899	66,403,219	1	0
MOS148	Alt2	Alt2	FWOP	FWOP	Alt1	151.89	35.49	2,856,802	80,496	66,928,829	1	0
MOS195	Alt4	Alt2	FWOP	Alt1	Alt1	152.76	36.36	3,157,965	86,853	74,239,049	0	0
MOS193	Alt2	Alt2	FWOP	Alt1	Alt1	152.77	36.37	3,179,963	87,434	74,764,659	0	0
MOS30	Alt4	Alt2	Alt1	FWOP	FWOP	153.09	36.69	3,027,232	82,508	70,788,172	1	0
MOS28	Alt2	Alt2	Alt1	FWOP	FWOP	153.1	36.7	3,049,230	83,085	71,313,782	1	0
MOS240	Alt4	Alt2	FWOP	Alt2	Alt1	153.54	37.14	3,239,927	87,236	76,118,673	1	0
MOS238	Alt2	Alt2	FWOP	Alt2	Alt1	153.55	37.15	3,261,925	87,804	76,644,283	1	0
MOS75	Alt4	Alt2	Alt1	Alt1	FWOP	153.97	37.57	3,350,393	89,177	78,624,002	0	0
MOS73	Alt2	Alt2	Alt1	Alt1	FWOP	153.98	37.58	3,372,391	89,739	79,149,612	0	0
MOS120	Alt4	Alt2	Alt1	Alt2	FWOP	154.75	38.35	3,432,355	89,501	80,503,626	0	0
MOS118	Alt2	Alt2	Alt1	Alt2	FWOP	154.76	38.36	3,454,353	90,051	81,029,236	0	0

Table 7 (cont.) Mosaic system-scale plans.

SITE ALT	BK-N	BK-S	SI-N	SI-S	SI-WET	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MOS165	Alt4	Alt2	Alt1	FWOP	Alt1	155.04	38.64	3,403,480	88,082	79,860,794	0	0
MOS163	Alt2	Alt2	Alt1	FWOP	Alt1	155.05	38.65	3,425,478	88,628	80,386,404	0	0
MOS210	Alt4	Alt2	Alt1	Alt1	Alt1	155.92	39.52	3,726,641	94,298	87,696,624	0	0
MOS208	Alt2	Alt2	Alt1	Alt1	Alt1	155.93	39.53	3,748,639	94,830	88,222,234	0	0
MOS255	Alt4	Alt2	Alt1	Alt2	Alt1	156.7	40.3	3,808,603	94,506	89,576,248	0	0
MOS253	Alt2	Alt2	Alt1	Alt2	Alt1	156.71	40.31	3,830,601	95,029	90,101,858	0	0
MOS45	Alt4	Alt2	Alt2	FWOP	FWOP	156.99	40.59	3,280,661	80,824	76,587,394	1	1
MOS43	Alt2	Alt2	Alt2	FWOP	FWOP	157	40.6	3,302,659	81,346	77,113,004	1	0
MOS90	Alt4	Alt2	Alt2	Alt1	FWOP	157.87	41.47	3,603,822	86,902	84,423,224	1	0
MOS88	Alt2	Alt2	Alt2	Alt1	FWOP	157.88	41.48	3,625,820	87,411	84,948,834	1	0
MOS135	Alt4	Alt2	Alt2	Alt2	FWOP	158.65	42.25	3,685,784	87,237	86,302,848	0	0
MOS133	Alt2	Alt2	Alt2	Alt2	FWOP	158.66	42.26	3,707,782	87,737	86,828,458	0	0
MOS180	Alt4	Alt2	Alt2	FWOP	Alt1	158.94	42.54	3,656,910	85,964	85,660,016	1	1
MOS178	Alt2	Alt2	Alt2	FWOP	Alt1	158.95	42.55	3,678,908	86,461	86,185,626	1	0
MOS225	Alt4	Alt2	Alt2	Alt1	Alt1	159.82	43.42	3,980,071	91,664	93,495,846	1	0
MOS223	Alt2	Alt2	Alt2	Alt1	Alt1	159.83	43.43	4,002,069	92,150	94,021,456	1	0
MOS270	Alt4	Alt2	Alt2	Alt2	Alt1	160.6	44.2	4,062,033	91,901	95,375,470	1	1
MOS268	Alt2	Alt2	Alt2	Alt2	Alt1	160.61	44.21	4,084,031	92,378	95,901,080	1	1

3.2. SHORELINE RESTORATION

Henry Hudson Park is a small, publicly owned park on the right bank of the Hudson River in Bethlehem, New York. Two alternatives were developed, given the relatively finite size of the park. CE/ICA results are presented in Figure 4 and Table 8.

- FWOP - No action alternative.
- Alt1 - **RECOMMENDATION** - Installation of vegetated riprap along with wetland creation along the Vloman Kill. Avoids infringement on park property. Meets planning objectives. Lowest incremental unit cost.
- Alt2 - More extensive shoreline treatment with increased riparian buffer along with wetland creation along the Vloman Kill and two tidal wetlands along the Hudson.

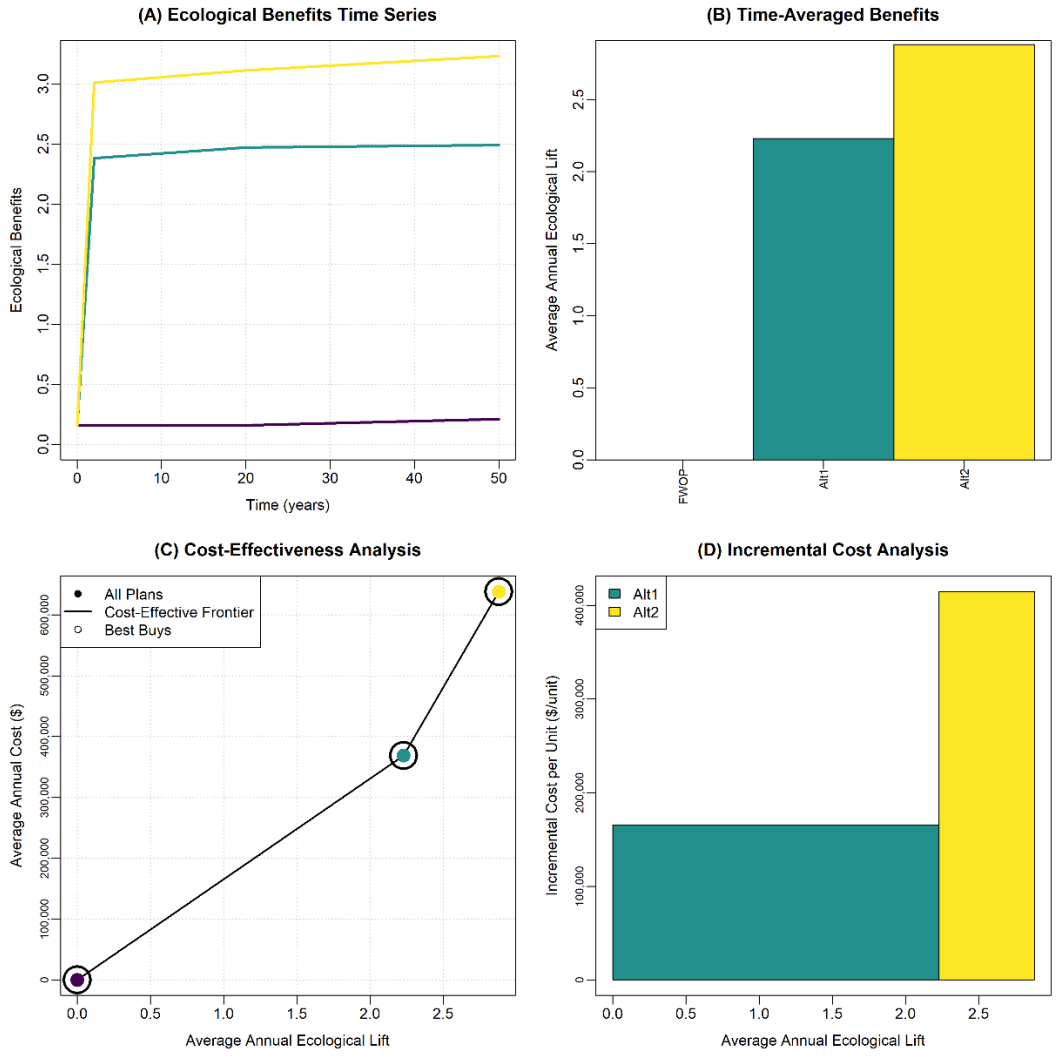

Figure 4: Henry Hudson CE/ICA summary.

Table 8: Henry Hudson site-scale alternatives.

SITE ALT	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
FWOP	0.18	0	0	0	0	1	1
Alt1	2.41	2.23	368,870	165,413	8,873,209	1	1
Alt2	3.06	2.88	638,516	221,707	15,221,511	1	1

Charles Rider Park is a small, publicly owned park on the right bank of the Hudson River in Kingston, New York. One alternative was developed, given the relatively finite size of the park. CE/ICA results are presented in Figure 5 and Table 9.

- FWOP - **RECOMMENDATION** - No action alternative.
- Alt1 - Creates a tidal wetland and protects the riverbank from additional erosion. Relatively minor change in ecological condition and substantial benefits for protection of the park from further erosion. High unit cost led to elimination of this alternative.

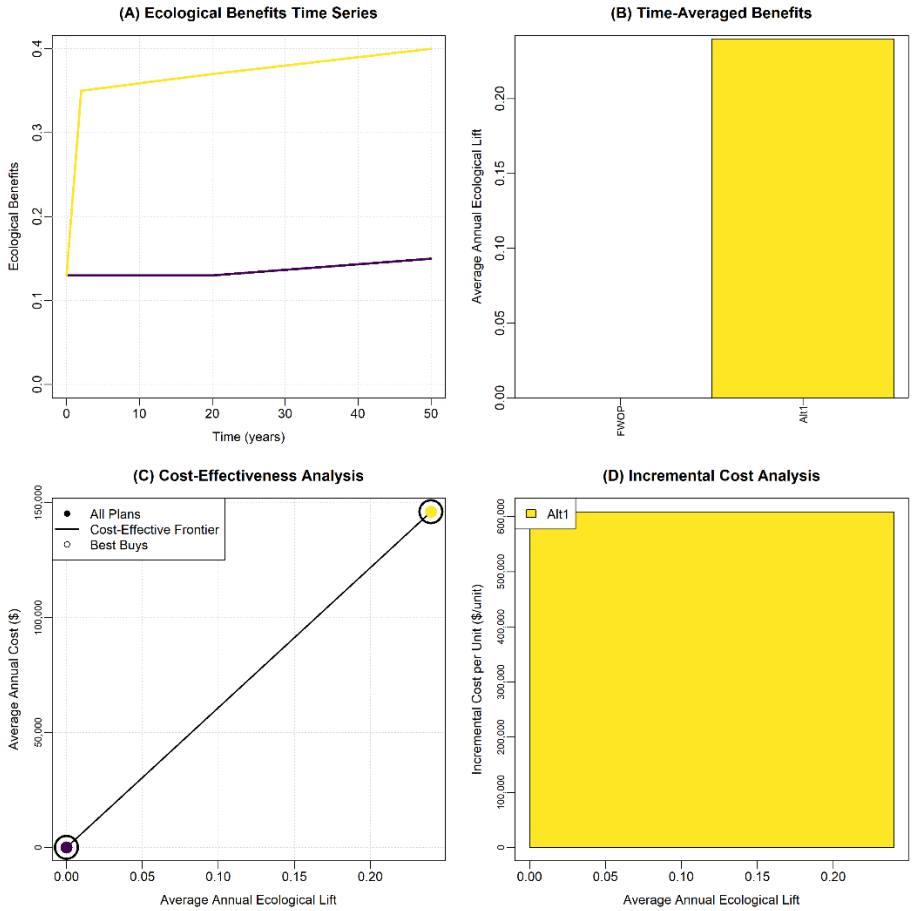

Figure 5: Charles Rider CE/ICA summary.

Table 9: Charles Rider site-scale alternatives.

SITE ALT	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
FWOP	0.13	0	0	0	0	1	1
Alt1	0.37	0.24	146,099	608,745	3,585,451	1	1

Henry Hudson and Charles Rider both represent relatively small shoreline restoration sites, and system-scale plans were developed examining all possible combinations of sites and alternatives. Figure 6 and Table 10 show the results of CE/ICA for all 6 system-scale plans. The following system-wide plans for shoreline restoration were examined as the final array:

- SHO1 = Henry Hudson-FWOP, Charles Rider-FWOP - No action alternative.
- SHO2 = Henry Hudson-Alt1, Charles Rider-FWOP - **RECOMMENDATION** - Lowest unit cost of the best buys.
- SHO3 = Henry Hudson-Alt2, Charles Rider-FWOP – Large increase in incremental cost ($414,840 for next increment) not deemed "worth it" due to small project footprint.
- SHO6 = Henry Hudson-Alt2, Charles Rider-Alt1 - Highest unit cost.

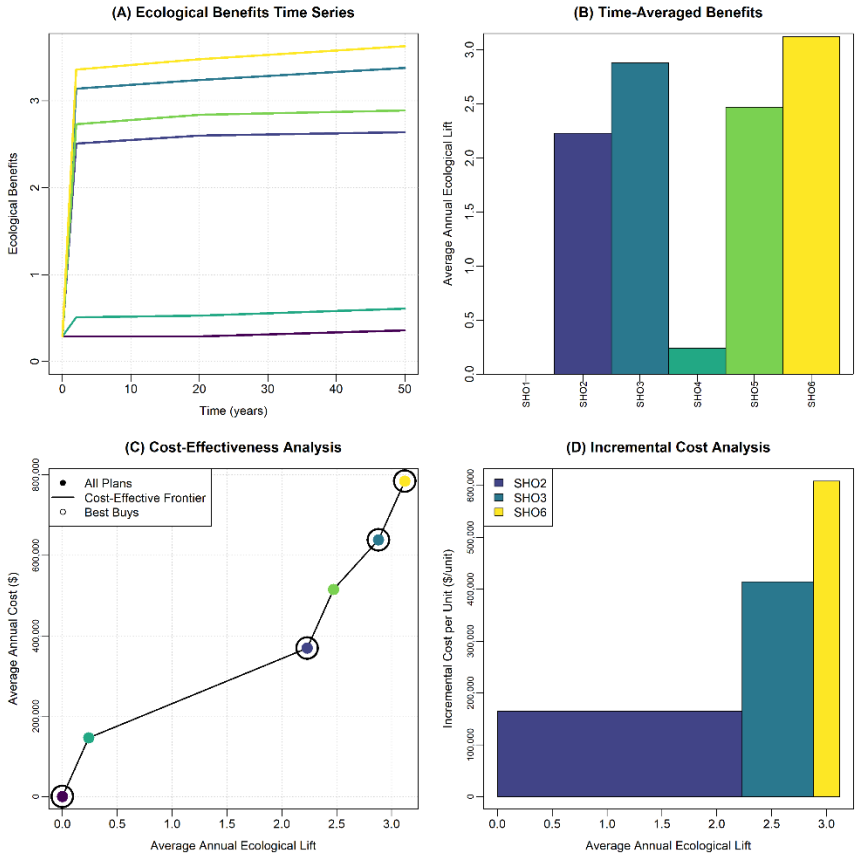

Figure 6: Shoreline system-scale CE/ICA summary.

Table 10: Shoreline system-scale plans.

SITE ALT	HENRY HUDSON	CHARLES RIDER	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
SHO1	FWOP	FWOP	0.31	0	0	0	0	1	1
SHO4	FWOP	Alt1	0.55	0.24	146,099	608,745	3,585,451	1	0
SHO2	Alt1	FWOP	2.54	2.23	368,870	165,413	8,873,209	1	1
SHO5	Alt1	Alt1	2.78	2.47	514,969	208,489	12,458,660	1	0
SHO3	Alt2	FWOP	3.19	2.88	638,516	221,707	15,221,511	1	1
SHO6	Alt2	Alt1	3.43	3.12	784,615	251,479	18,806,962	1	1

CE/ICA was conducted for Henry Hudson and Charles Rider sites individually at the site-scale as well as together at the system-scale. The two CE/ICA approaches resulted in the same recommendation at both sites, lending confidence to plan selection. The recommended plan includes:

- Henry Hudson - Alt1
- Charles Rider - FWOP

3.3. TRIBUTARY CONNECTIVITY SITES

Moodna Creek is a tributary to the Hudson River. Three connectivity barriers were identified moving upstream from the Hudson, and each barrier is treated as a separate component (analogous to the components at Schodack Island). Connectivity projects are highly dependent upon activities at the other sites, and the sites were formulated as non-separable elements. All possible combinations of components and alternatives were considered, which resulted in 27 site-scale alternatives as shown in Figure 7 and Table 11. The following “best buy” alternatives were identified for the final decision array.

- MO1 = AOP1-FWOP, AOP2-FWOP, AOP3-FWOP - No action alternative.
- MO23 = AOP1-Alt1, AOP2-Alt1, AOP3-Alt2 - **RECOMMENDATION** - Barrier removal at AOP1, barrier removal at AOP2, and partial barrier removal at AOP3. This plan is the lowest incremental unit cost of all 27 plans considered. The plan reconnects over seven miles of tributary habitat and directly addresses one of the primary project objectives. The plan also “reasonably maximizes benefits” given the unit cost (i.e., $7,500/AAHU).

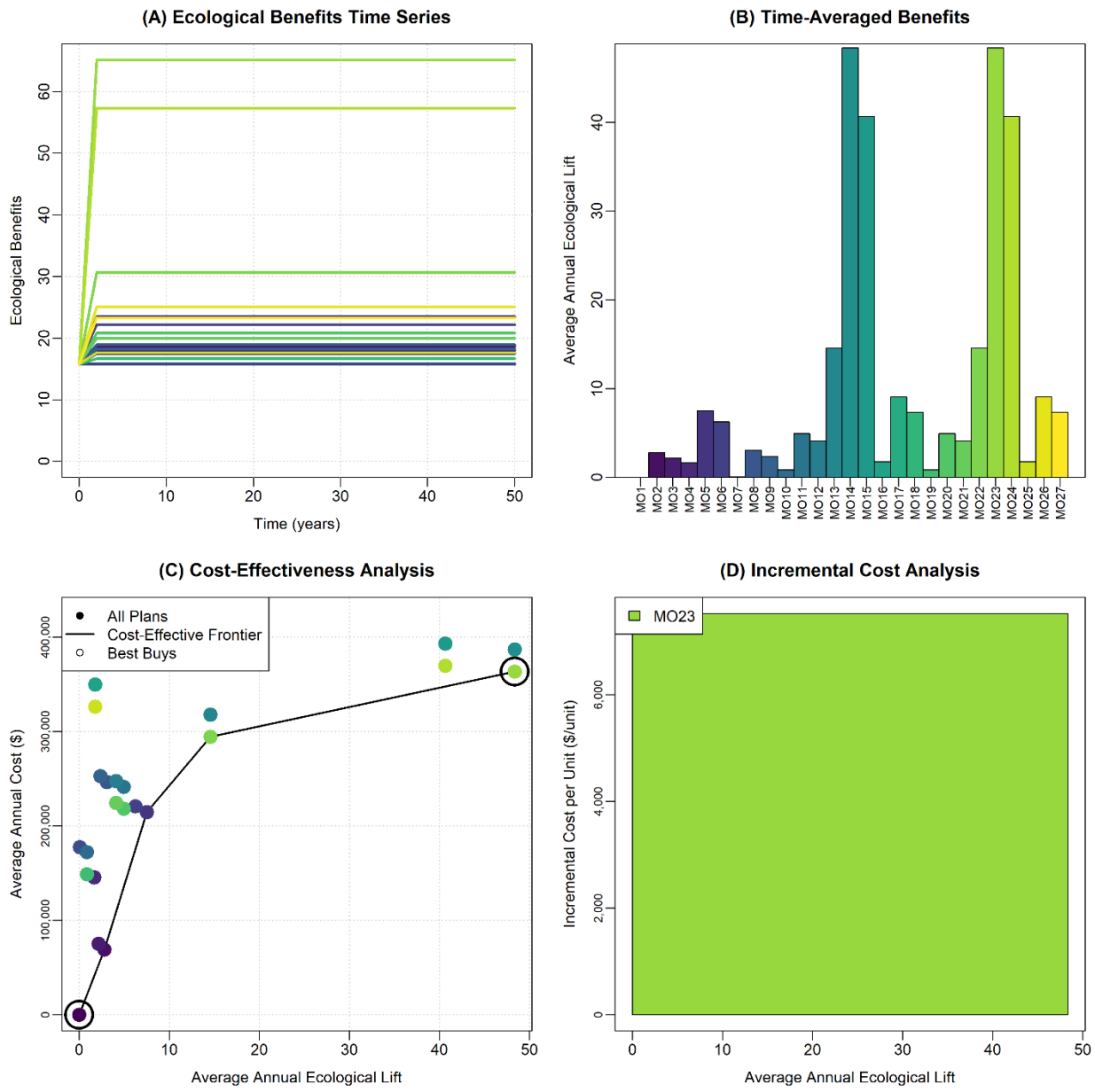

Figure 7: Moodna Creek CE/ICA summary.

The Eddyville Dam is the first structure upstream of the Hudson River on Rondout Creek. Three alternatives were identified at this structure for the final decision array (Figure 8 and Table 12).

- FWOP - No action alternative.
- Alt1 - Fishway. Unit cost is 18 times higher than Alt2.
- Alt3 - Dam notching. Concerns over dam modification and asset management issues led to elimination of this alternative.
- Alt2 - **RECOMMENDATION** - Dam removal. Reasonably maximizes benefits and is the only best buy.

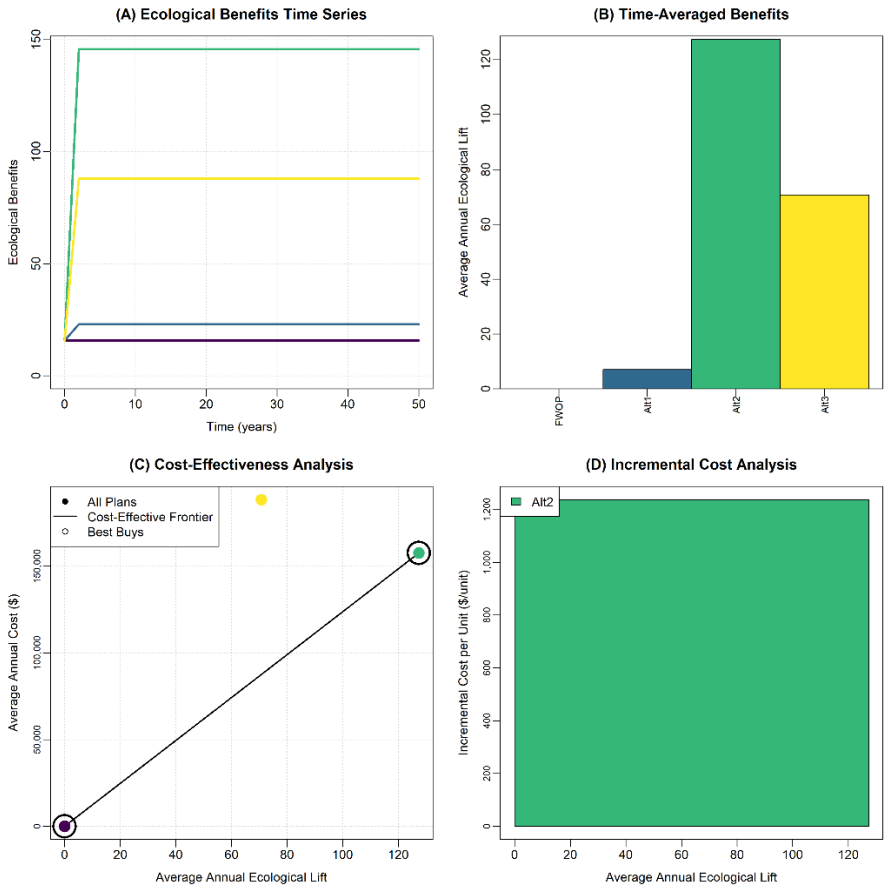

Figure 8: Rondout Creek CE/ICA summary.

System-scale plans were developed for all possible combinations of tributary connectivity sites and alternatives. Figure 9 and Table 13 show the results of CE/ICA for all 108 system-scale plans. The following "best buy" plans for were examined as the final decision array:

- CON1 = Rondout-FWOP, Moodna1-FWOP, Moodna2-FWOP, Moodna3-FWOP - No action alternative.
- CON3 = Rondout-Alt2, Moodna1-FWOP, Moodna2-FWOP, Moodna3-FWOP - Dam removal at Rondout only.

CON91 = Rondout-Alt2, Moodna1-Alt1, Moodna2-Alt1, Moodna3-Alt2 - **RECOMMENDATION** - Full or partial removal of all barriers. The increased incremental cost over CON3 is "worth it," given the reconnection of more than seven miles of ecologically valuable tributary habitat associated with the Moodna Creek sites. Actions are recommended for both tributaries in order to meet the planning objectives and reasonably maximize benefits by reconnecting two of the 90 tributaries blocked within the Hudson River watershed at low unit cost. A total of 17 additional miles (9 miles at Rondout and 7.8 miles along Moodna Creek) of high-quality spawning habitat would benefit important migratory fish species including American shad, striped bass, alewife, blueback herring, and American eel. Overall, this plan is a good value for a large amount of environmental benefits (~$2,967 / AAHU for 176 AAHUs).

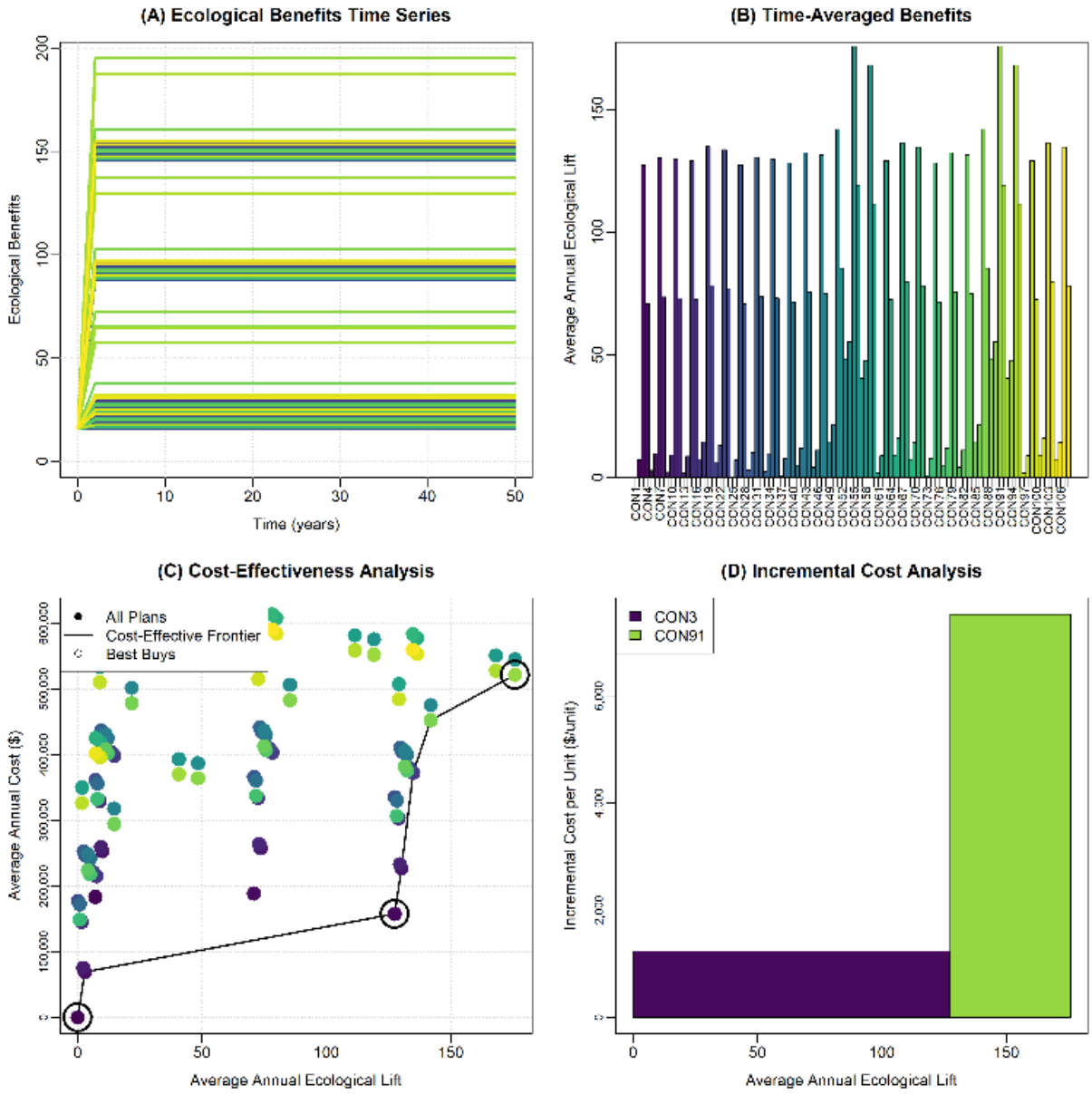

Figure 9: Connectivity system-scale CE/ICA summary.

CE/ICA was conducted for all combinations of actions on Moodna and Rondout Creeks individually at the site-scale as well as together at the system-scale. The two CE/ICA approaches resulted in the same recommendation at both sites, lending confidence to plan selection. The recommended plan includes:

- Moodna Creek AOP1 - Alt1
- Moodna Creek AOP2 - Alt1
- Moodna Creek AOP3 - Alt2
- Rondout Creek - Alt2

Table 11: Moodna Creek site-scale alternatives.

SITE ALT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MO1	FWOP	FWOP	FWOP	15.81	0	0	0	0	1	1
MO7	FWOP	Alt2	FWOP	15.86	0.05	177,552	3,551,038	4,049,395	0	0
MO10	FWOP	FWOP	Alt1	16.67	0.86	172,333	200,387	4,279,930	0	0
MO19	FWOP	FWOP	Alt2	16.67	0.86	148,982	173,235	3,675,660	0	0
MO4	FWOP	Alt1	FWOP	17.46	1.65	145,562	88,219	3,621,983	0	0
MO16	FWOP	Alt2	Alt1	17.58	1.77	349,885	197,675	8,329,325	0	0
MO25	FWOP	Alt2	Alt2	17.58	1.77	326,534	184,483	7,725,055	0	0
MO3	Alt2	FWOP	FWOP	17.97	2.16	75,409	34,912	1,858,694	0	0
MO9	Alt2	Alt2	FWOP	18.17	2.36	252,961	107,187	5,908,089	0	0
MO2	Alt1	FWOP	FWOP	18.6	2.79	69,227	24,813	1,695,631	1	0
MO8	Alt1	Alt2	FWOP	18.86	3.05	246,779	80,911	5,745,026	0	0
MO12	Alt2	FWOP	Alt1	19.91	4.1	247,742	60,425	6,138,624	0	0
MO21	Alt2	FWOP	Alt2	19.91	4.1	224,392	54,730	5,534,354	0	0
MO11	Alt1	FWOP	Alt1	20.75	4.94	241,560	48,899	5,975,561	0	0
MO20	Alt1	FWOP	Alt2	20.75	4.94	218,210	44,172	5,371,291	0	0

Table 11 (cont.) Moodna Creek site-scale alternatives.

SITE ALT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
MO6	Alt2	Alt1	FWOP	22.05	6.24	220,971	35,412	5,480,677	0	0
MO18	Alt2	Alt2	Alt1	23.12	7.31	425,294	58,180	10,188,019	0	0
MO27	Alt2	Alt2	Alt2	23.12	7.31	401,943	54,985	9,583,749	0	0
MO5	Alt1	Alt1	FWOP	23.31	7.5	214,789	28,639	5,317,614	1	0
MO17	Alt1	Alt2	Alt1	24.88	9.07	419,112	46,209	10,024,956	0	0
MO26	Alt1	Alt2	Alt2	24.88	9.07	395,761	43,634	9,420,686	0	0
MO13	FWOP	Alt1	Alt1	30.37	14.56	317,895	21,833	7,901,913	0	0
MO22	FWOP	Alt1	Alt2	30.37	14.56	294,544	20,230	7,297,643	1	0
MO15	Alt2	Alt1	Alt1	56.46	40.65	393,304	9,675	9,760,607	0	0
MO24	Alt2	Alt1	Alt2	56.46	40.65	369,953	9,101	9,156,337	0	0
MO14	Alt1	Alt1	Alt1	64.17	48.36	387,122	8,005	9,597,544	0	0
MO23	Alt1	Alt1	Alt2	64.17	48.36	363,771	7,522	8,993,274	1	1

Table 12: Rondout Creek site-scale alternatives.

ALTERNATIVE	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
FWOP	15.81	0	0	0	0	1	1
Alt1	22.88	7.07	183,602	25,969	4,221,080	0	0
Alt3	86.57	70.76	188,411	2,663	4,634,670	0	0
Alt2	143.18	127.37	157,659	1,238	3,932,388	1	1

Table 13: Connectivity system-scale plans.

SITE ALT	RONDOUT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
CON1	FWOP	FWOP	FWOP	FWOP	15.81	0	0	0	0	1	1
CON25	FWOP	FWOP	Alt2	FWOP	15.86	0.05	177,552	3,551,038	4,049,395	0	0
CON37	FWOP	FWOP	FWOP	Alt1	16.67	0.86	172,333	200,387	4,279,930	0	0
CON73	FWOP	FWOP	FWOP	Alt2	16.67	0.86	148,982	173,235	3,675,660	0	0
CON13	FWOP	FWOP	Alt1	FWOP	17.46	1.65	145,562	88,219	3,621,983	0	0
CON61	FWOP	FWOP	Alt2	Alt1	17.58	1.77	349,885	197,675	8,329,325	0	0
CON97	FWOP	FWOP	Alt2	Alt2	17.58	1.77	326,534	184,483	7,725,055	0	0
CON9	FWOP	Alt2	FWOP	FWOP	17.97	2.16	75,409	34,912	1,858,694	0	0
CON33	FWOP	Alt2	Alt2	FWOP	18.17	2.36	252,961	107,187	5,908,089	0	0
CON5	FWOP	Alt1	FWOP	FWOP	18.6	2.79	69,227	24,813	1,695,631	1	0
CON29	FWOP	Alt1	Alt2	FWOP	18.86	3.05	246,779	80,911	5,745,026	0	0
CON45	FWOP	Alt2	FWOP	Alt1	19.91	4.1	247,742	60,425	6,138,624	0	0
CON81	FWOP	Alt2	FWOP	Alt2	19.91	4.1	224,392	54,730	5,534,354	0	0
CON41	FWOP	Alt1	FWOP	Alt1	20.75	4.94	241,560	48,899	5,975,561	0	0
CON77	FWOP	Alt1	FWOP	Alt2	20.75	4.94	218,210	44,172	5,371,291	0	0
CON21	FWOP	Alt2	Alt1	FWOP	22.05	6.24	220,971	35,412	5,480,677	0	0
CON2	Alt1	FWOP	FWOP	FWOP	22.88	7.07	183,602	25,969	4,221,080	0	0
CON26	Alt1	FWOP	Alt2	FWOP	22.94	7.13	361,154	50,653	8,270,475	0	0

Table 13 (cont.) Connectivity system-scale plans.

SITE ALT	RONDOUT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
CON69	FWOP	Alt2	Alt2	Alt1	23.12	7.31	425,294	58,180	10,188,019	0	0
CON105	FWOP	Alt2	Alt2	Alt2	23.12	7.31	401,943	54,985	9,583,749	0	0
CON17	FWOP	Alt1	Alt1	FWOP	23.31	7.5	214,789	28,639	5,317,614	0	0
CON38	Alt1	FWOP	FWOP	Alt1	23.74	7.93	355,935	44,885	8,501,010	0	0
CON74	Alt1	FWOP	FWOP	Alt2	23.74	7.93	332,585	41,940	7,896,740	0	0
CON14	Alt1	FWOP	Alt1	FWOP	24.54	8.73	329,164	37,705	7,843,063	0	0
CON62	Alt1	FWOP	Alt2	Alt1	24.66	8.85	533,487	60,281	12,550,405	0	0
CON98	Alt1	FWOP	Alt2	Alt2	24.66	8.85	510,137	57,643	11,946,135	0	0
CON65	FWOP	Alt1	Alt2	Alt1	24.88	9.07	419,112	46,209	10,024,956	0	0
CON101	FWOP	Alt1	Alt2	Alt2	24.88	9.07	395,761	43,634	9,420,686	0	0
CON10	Alt1	Alt2	FWOP	FWOP	25.05	9.24	259,012	28,032	6,079,774	0	0
CON34	Alt1	Alt2	Alt2	FWOP	25.25	9.44	436,564	46,246	10,129,169	0	0
CON6	Alt1	Alt1	FWOP	FWOP	25.68	9.87	252,830	25,616	5,916,711	0	0
CON30	Alt1	Alt1	Alt2	FWOP	25.93	10.12	430,382	42,528	9,966,106	0	0
CON46	Alt1	Alt2	FWOP	Alt1	26.98	11.17	431,345	38,616	10,359,704	0	0
CON82	Alt1	Alt2	FWOP	Alt2	26.98	11.17	407,994	36,526	9,755,434	0	0
CON42	Alt1	Alt1	FWOP	Alt1	27.83	12.02	425,163	35,371	10,196,641	0	0
CON78	Alt1	Alt1	FWOP	Alt2	27.83	12.02	401,812	33,429	9,592,371	0	0

Table 13 (cont.) Connectivity system-scale plans.

SITE ALT	RONDOUT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
CON22	Alt1	Alt2	Alt1	FWOP	29.13	13.32	404,574	30,373	9,701,757	0	0
CON70	Alt1	Alt2	Alt2	Alt1	30.19	14.38	608,897	42,343	14,409,099	0	0
CON106	Alt1	Alt2	Alt2	Alt2	30.19	14.38	585,546	40,719	13,804,829	0	0
CON49	FWOP	FWOP	Alt1	Alt1	30.37	14.56	317,895	21,833	7,901,913	0	0
CON85	FWOP	FWOP	Alt1	Alt2	30.37	14.56	294,544	20,230	7,297,643	0	0
CON18	Alt1	Alt1	Alt1	FWOP	30.39	14.58	398,392	27,325	9,538,694	0	0
CON66	Alt1	Alt1	Alt2	Alt1	31.96	16.15	602,715	37,320	14,246,036	0	0
CON102	Alt1	Alt1	Alt2	Alt2	31.96	16.15	579,364	35,874	13,641,766	0	0
CON50	Alt1	FWOP	Alt1	Alt1	37.44	21.63	501,497	23,185	12,122,993	0	0
CON86	Alt1	FWOP	Alt1	Alt2	37.44	21.63	478,146	22,106	11,518,723	0	0
CON57	FWOP	Alt2	Alt1	Alt1	56.46	40.65	393,304	9,675	9,760,607	0	0
CON93	FWOP	Alt2	Alt1	Alt2	56.46	40.65	369,953	9,101	9,156,337	0	0
CON58	Alt1	Alt2	Alt1	Alt1	63.54	47.73	576,907	12,087	13,981,687	0	0
CON94	Alt1	Alt2	Alt1	Alt2	63.54	47.73	553,556	11,598	13,377,417	0	0
CON53	FWOP	Alt1	Alt1	Alt1	64.17	48.36	387,122	8,005	9,597,544	0	0
CON89	FWOP	Alt1	Alt1	Alt2	64.17	48.36	363,771	7,522	8,993,274	0	0
CON54	Alt1	Alt1	Alt1	Alt1	71.25	55.44	570,725	10,294	13,818,624	0	0
CON90	Alt1	Alt1	Alt1	Alt2	71.25	55.44	547,374	9,873	13,214,354	0	0

Table 13 (cont.) Connectivity system-scale plans.

SITE ALT	RONDOUT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
CON4	Alt3	FWOP	FWOP	FWOP	86.57	70.76	188,411	2,663	4,634,670	0	0
CON28	Alt3	FWOP	Alt2	FWOP	86.62	70.81	365,963	5,168	8,684,065	0	0
CON40	Alt3	FWOP	FWOP	Alt1	87.43	71.62	360,744	5,037	8,914,600	0	0
CON76	Alt3	FWOP	FWOP	Alt2	87.43	71.62	337,393	4,711	8,310,330	0	0
CON16	Alt3	FWOP	Alt1	FWOP	88.22	72.41	333,972	4,612	8,256,653	0	0
CON64	Alt3	FWOP	Alt2	Alt1	88.34	72.53	538,296	7,422	12,963,995	0	0
CON100	Alt3	FWOP	Alt2	Alt2	88.34	72.53	514,945	7,100	12,359,725	0	0
CON12	Alt3	Alt2	FWOP	FWOP	88.73	72.92	263,820	3,618	6,493,364	0	0
CON36	Alt3	Alt2	Alt2	FWOP	88.93	73.12	441,372	6,036	10,542,759	0	0
CON8	Alt3	Alt1	FWOP	FWOP	89.36	73.55	257,638	3,503	6,330,301	0	0
CON32	Alt3	Alt1	Alt2	FWOP	89.62	73.81	435,190	5,896	10,379,696	0	0
CON48	Alt3	Alt2	FWOP	Alt1	90.67	74.86	436,153	5,826	10,773,294	0	0
CON84	Alt3	Alt2	FWOP	Alt2	90.67	74.86	412,802	5,514	10,169,024	0	0
CON44	Alt3	Alt1	FWOP	Alt1	91.51	75.7	429,971	5,680	10,610,231	0	0
CON80	Alt3	Alt1	FWOP	Alt2	91.51	75.7	406,620	5,371	10,005,961	0	0
CON24	Alt3	Alt2	Alt1	FWOP	92.81	77	409,382	5,317	10,115,347	0	0
CON72	Alt3	Alt2	Alt2	Alt1	93.88	78.07	613,705	7,861	14,822,689	0	0
CON108	Alt3	Alt2	Alt2	Alt2	93.88	78.07	590,354	7,562	14,218,419	0	0

Table 13 (cont.) Connectivity system-scale plans.

SITE ALT	RONDOUT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
CON20	Alt3	Alt1	Alt1	FWOP	94.07	78.26	403,200	5,152	9,952,284	0	0
CON68	Alt3	Alt1	Alt2	Alt1	95.64	79.83	607,523	7,610	14,659,626	0	0
CON104	Alt3	Alt1	Alt2	Alt2	95.64	79.83	584,172	7,318	14,055,356	0	0
CON52	Alt3	FWOP	Alt1	Alt1	101.13	85.32	506,305	5,934	12,536,583	0	0
CON88	Alt3	FWOP	Alt1	Alt2	101.13	85.32	482,955	5,661	11,932,313	0	0
CON60	Alt3	Alt2	Alt1	Alt1	127.22	111.41	581,715	5,221	14,395,277	0	0
CON96	Alt3	Alt2	Alt1	Alt2	127.22	111.41	558,364	5,012	13,791,007	0	0
CON56	Alt3	Alt1	Alt1	Alt1	134.93	119.12	575,533	4,832	14,232,214	0	0
CON92	Alt3	Alt1	Alt1	Alt2	134.93	119.12	552,182	4,636	13,627,944	0	0
CON3	Alt2	FWOP	FWOP	FWOP	143.18	127.37	157,659	1,238	3,932,388	1	1
CON27	Alt2	FWOP	Alt2	FWOP	143.23	127.42	335,211	2,631	7,981,783	0	0
CON39	Alt2	FWOP	FWOP	Alt1	144.04	128.23	329,992	2,573	8,212,318	0	0
CON75	Alt2	FWOP	FWOP	Alt2	144.04	128.23	306,641	2,391	7,608,048	0	0
CON15	Alt2	FWOP	Alt1	FWOP	144.83	129.02	303,221	2,350	7,554,371	0	0
CON63	Alt2	FWOP	Alt2	Alt1	144.95	129.14	507,544	3,930	12,261,713	0	0
CON99	Alt2	FWOP	Alt2	Alt2	144.95	129.14	484,193	3,749	11,657,443	0	0
CON11	Alt2	Alt2	FWOP	FWOP	145.34	129.53	233,068	1,799	5,791,082	0	0
CON35	Alt2	Alt2	Alt2	FWOP	145.54	129.73	410,620	3,165	9,840,477	0	0

Table 13 (cont.) Connectivity system-scale plans.

SITE ALT	RONDOUT	MOODNA1	MOODNA2	MOODNA3	BENEFITS (AAFCU)	LIFT (AAFCU)	AVERAGE ANNUAL ($)	Unit Cost ($/AAFCU)	TOTAL FIRST ($)	CE?	BB?
CON7	Alt2	Alt1	FWOP	FWOP	145.97	130.16	226,886	1,743	5,628,019	1	0
CON31	Alt2	Alt1	Alt2	FWOP	146.23	130.42	404,438	3,101	9,677,414	0	0
CON47	Alt2	Alt2	FWOP	Alt1	147.28	131.47	405,401	3,084	10,071,012	0	0
CON83	Alt2	Alt2	FWOP	Alt2	147.28	131.47	382,051	2,906	9,466,742	0	0
CON43	Alt2	Alt1	FWOP	Alt1	148.12	132.31	399,219	3,017	9,907,949	0	0
CON79	Alt2	Alt1	FWOP	Alt2	148.12	132.31	375,869	2,841	9,303,679	0	0
CON23	Alt2	Alt2	Alt1	FWOP	149.42	133.61	378,630	2,834	9,413,065	0	0
CON71	Alt2	Alt2	Alt2	Alt1	150.49	134.68	582,953	4,328	14,120,407	0	0
CON107	Alt2	Alt2	Alt2	Alt2	150.49	134.68	559,603	4,155	13,516,137	0	0
CON19	Alt2	Alt1	Alt1	FWOP	150.68	134.87	372,448	2,762	9,250,002	1	0
CON67	Alt2	Alt1	Alt2	Alt1	152.25	136.44	576,771	4,227	13,957,344	0	0
CON103	Alt2	Alt1	Alt2	Alt2	152.25	136.44	553,421	4,056	13,353,074	0	0
CON51	Alt2	FWOP	Alt1	Alt1	157.74	141.93	475,554	3,351	11,834,301	0	0
CON87	Alt2	FWOP	Alt1	Alt2	157.74	141.93	452,203	3,186	11,230,031	1	0
CON59	Alt2	Alt2	Alt1	Alt1	183.83	168.02	550,963	3,279	13,692,995	0	0
CON95	Alt2	Alt2	Alt1	Alt2	183.83	168.02	527,612	3,140	13,088,725	0	0
CON55	Alt2	Alt1	Alt1	Alt1	191.54	175.73	544,781	3,100	13,529,932	0	0
CON91	Alt2	Alt1	Alt1	Alt2	191.54	175.73	521,430	2,967	12,925,662	1	1

3.4. TENTATIVELY SELECTED PLAN (TSP)

Table 14 briefly summarizes the alternatives recommended in the TSP within the Draft Integrated FR/EA. Two different types of CE/ICA were applied to the mosaic, shoreline, and connectivity restoration types, and consistent alternatives were recommended by these competing approaches, lending confidence to the recommendation. The Draft FR/EA main report provided a more thorough description of the proposed actions, ecological benefits, and associated costs.

Table 14: Summary of the Tentatively Selected Plan (TSP).

TYPE	SITE	COMPONENT	ALTERNATIVE	BRIEF DESCRIPTION
Mosaic	Binnen Kill	North	Alt4	Native plantings and invasive species removal over a large area in the North and large side channel and wetland corridor in the south
		South	Alt2	Large side channel and wetland corridor
	Schodack Island	North	Alt2	Side channel and wetland complex
		South	FWOP	No action.
		Wetlands	FWOP	No action.
Shoreline	Henry Hudson		Alt1	Installation of vegetated riprap and wetland creation along the Vloman Kill
	Charles Rider		FWOP	No action.
Connectivity	Moodna Creek	AOP1	Alt1	Removal of the utility crossing
		AOP2	Alt1	Removal of Firth Cliff Dam
		AOP3	Alt2	Partial removal of Orr's Mill
	Rondout Creek		Alt2	Dam Removal

CHAPTER 4: Confirmation of the Recommended Plan

Two sites were removed from the Tentatively Selected Plan based on public input:

- *Binnen Kill*: The owner of the northern parcel stated that proposed restoration actions would be incompatible with personal agricultural uses of the land. Two land owners adjacent to the southern site expressed concerns that proposed side channels could increase flood risk and were unwilling to provide real estate interests required for project implementation. The Binnen Kill site was ultimately eliminated due to the reduced project footprint and ecological benefits.
- *Rondout Creek*: Public feedback largely indicated strong opposition to removal of Eddyville Dam. The public was supportive of a fishway at the site, but this action resulted in higher costs and lower ecological benefits. Rondout Creek was subsequently removed from the TSP.

Restoration designs were optimized at the remaining three sites (Schodack Island, Henry Hudson Park, and Moodna Creek) with accompanying reassessment of ecological benefits and costs, where needed. Here, ecological benefits and costs were annualized for final restoration designs. Changes in unit cost are then examined at a site-scale to confirm the National Ecosystem Restoration Plan, which is summarized in Chapter 5 of this appendix.

4.1. OPTIMIZED BENEFITS AND COSTS

Restoration designs were optimized at the remaining three sites with accompanying reassessment of ecological benefits and costs. Following methods from Section 2.1, optimized benefits were annualized for the recommended alternative (Table 15).

Table 15: Summary of ecological benefits for the optimized restoration designs.

SITE	ALT	TY0	TY2	TY20	TY50	BENEFITS (AAFCU)	LIFT (AAFCU)
Schodack Island (North)	Alt2	10.97	19.82	20.60	20.48	20.21	8.49
Henry Hudson	Alt1	0.16	2.56	2.65	2.67	2.59	2.38
Moodna Creek	AOP1 (Alt1) AOP2 (Alt1) AOP3 (Alt2)	15.81	65.16	65.16	65.16	64.17	48.36

Cost estimates were revised for the optimized designs. Project first costs were estimated using standard cost engineering and real estate methods (Appendix E). Monitoring and adaptive management costs were amortized over a five year period. OMRR&R costs were $0 for the three Moodna Creek sites. Average annual economic costs were computed based on project first cost as well as interest during construction (IDC). Cost annualization calculations are shown in Figure 10 for Moodna AOP1 as a demonstration of these methods. Fully funded costs were projected to the mid-point of

construction (Appendix E). Table 16 presents optimized costs for the recommended alternatives.

Given the following costs in present value (PV):

Project First Cost w/out M&AM	$2,130,006
Monitoring w/contingency	$40,010
Adaptive Management w/contingency	$32,249
Project First Cost	$2,202,265
OMRR&R	$0
Construction Duration (mon, n_{mon})	3
Economic Time Period (years, n_{ann})	50
FY20 Discount Rate (annual, r_{ann})	0.0275
FY20 Discount Rate (monthly, r_{mon})	0.002263

Cost Annualization:

Annual Project First Cost w/out M&AM = $(PV * r_{ann})/(1-(1+r_{ann})^{-n_{ann}})$

= $(2{,}130{,}006 * 0.0275)/(1-(1+0.0275)^{-50})$ = $78,897

PV Monitoring and Adaptive Management = $\sum_{t=1}^{t=5}\left(\frac{1}{(1+r_{ann})^t}\right)\left(\frac{PV_{mon}+PV_{adman}}{5}\right)$ = $66,660

Annual Monitoring and Adaptive Management = $(PV_{MAM} * r_{ann})/(1-(1+r_{ann})^{-n_{ann}})$

= $(66{,}660 * 0.0275)/(1-(1+0.0275)^{-50})$ = $2,469

PV Interest During Construction = $\sum_{t=1}^{t=dur}((1+r_{mon})^{dur-t}-1)\left(\frac{PV_{First}}{dur}\right)$ = $4,824

Annual Interest During Construction = $(PV_{IDC} * r_{ann})/(1-(1+r_{ann})^{-n_{ann}})$

= $(4{,}824 * 0.0275)/(1-(1+0.0275)^{-50})$ = $179

PV O&M = $\sum_{t=6}^{t=15}\left(\frac{1}{(1+r_{ann})^t}\right)\left(\frac{PV_{O\&M}}{10}\right)$ = $0

Annual OMRR&R = $(PV_{O\&M} * r_{ann})/(1-(1+r_{ann})^{-n_{ann}})$ = $0

Total Annual Economic Cost = $78,897 + $2,469 + $179 + $0 = $81,545

Figure 10: Example of cost annualization calculations for Moodna AOP1.

Table 16: Summary of costs for the optimized restoration designs.

SITE	ALT	MONITORING ($)	ADAPTIVE MANAGEMENT ($)	PROJECT FIRST ($)	TOTAL OMRR&R ($)	ANNUAL OMRR&R ($)	TOTAL IDC ($)	ANNUAL ECONOMIC COST ($)	FULLY FUNDED COST ($)
Schodack Island (North)	Alt2	305,045	688,874	19,848,972	195,565	4,541	498,997	755,396	29,295,514
Henry Hudson	Alt1	139,162	169,731	11,288,044	232,315	5,125	187,320	427,074	13,724,838
Moodna1	Alt1	40,010	32,249	2,202,265	0	0	4,824	81,545	3,654,055
Moodna2	Alt1	40,010	32,249	4,526,819	0	0	25,281	168,407	7,419,124
Moodna3	Alt2	240,059	56,998	5,336,757	0	0	28,602	197,885	8,690,832
All Moodna Creek		320,079	121,495	12,065,841	0	0	58,707	447,837	19,763,961

4.2. CONFIRMATION OF RECOMMENDATION

Table 17 summarizes changes in the ecological lift, average annual costs, and unit costs of each site as well as percent change in unit cost. The unit cost at Schodack Island decreased due to increases in benefits and decreases in costs. A decline in unit cost increases the competitiveness of this site, which was previously justified in Section 3 of this Appendix. As such, this site is assumed to be even more competitive and easily confirmed as part of the recommended plan. Unit costs increased at Henry Hudson Park and Moodna Creek sites, but these increases are acceptable for the following site-specific reasons. Notably, increases in costs and benefits should be considered relative to other project uncertainties (e.g., contingency estimates ranging from 10-32%, ecological model outputs, sea level change, etc.).

- *Henry Hudson Park*: Benefits increased at this location as a result of design optimization, but costs increased substantially as well. This site and alternative were originally selected based on incremental cost analysis over the next "Best Buy," which was Alternative-2 at Henry Hudson Park with an incremental cost of $221,000. As such, this site and alternative would still be considered not only a "Best Buy," but also preferred relative to other potential shoreline restoration actions on an incremental basis. See Section 3.2 for additional details about the prior incremental analysis.
- *Moodna Creek Barriers*: Unit cost increased substantially at these three dams, but unit cost remains extremely low and the regional ecological value of three barrier removals in series is high.

Table 17: Summary of initial and optimized benefits and costs.

SITE	INITIAL LIFT (AAFCU)	FINAL LIFT (AAFCU)	INITIAL ANNUAL COST ($)	FINAL ANNUAL COST ($)	INITIAL UNIT COST ($/AAFCU)	FINAL UNIT COST ($/AAFCU)	CHANGE IN UNIT COST (%)
Schodack Island (North)	7.06	8.49	822,106	755,396	116,446	88,974	- 23.6
Henry Hudson	2.23	2.38	368,870	427,074	165,413	179,443	+ 8.5
Moodna Creek	48.36	48.36	363,771	447,837	7,522	9,260	+ 23.1
ALL	57.65	59.23	1,554,747	1,630,307	26,969	27,525	+ 2.1

CHAPTER 5: Summary of the National Ecosystem Restoration Plan

Per the Planning Guidance Notebook (ER 1105-2-100, Appendix E, Page E-163), the National Ecosystem Restoration Plan "meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness" with additional factors related to public support, partnership context, and reasonableness of costs.

This appendix has sequentially presented the development of the National Ecosystem Restoration Plan for the Hudson River Habitat Restoration. This recommendation was developed based on multiple planning steps and analyses, specifically:

- An initial array of six sites across three habitat types was proposed in the Draft Feasibility Report, all of which had multiple components and alternatives. Benefits and costs were assessed at each of these locations and annualized over a 50-year planning horizon for consistent comparison across the diverse study area (This Appendix, Section 2).
- Cost-effectiveness and incremental costs analyses (CE/ICA) were conducted at the site-scale with annualized benefits and costs, and a recommended alternative was identified for each proposed restoration site. Additionally, all combinations of actions were examined in system-scale groupings of large river habitat mosaics, shoreline restoration, and connectivity actions. The two methods of CE/ICA led to the same recommendations, which ultimately were identified as the "Tentatively Selected Plan" (TSP) with eight actions at five sites (Section 3).
- Two sites (Binnen Kill and Rondout Creek) were subsequently removed from the recommendation based on public comments and sponsor input. Designs at the remaining three sites (Schodack Island, Henry Hudson Park, and Moodna Creek) were optimized, and benefits and costs reassessed to confirm the recommendation (Section 4).

These analyses ultimately led to the National Ecosystem Restoration Plan, which is summarized in Table 18. This plan "reasonably maximizes" ecological benefits in a cost-effective and cost-efficient manner. The plan recommends three nationally significant sites, which provide a substantial contribution to the overall ecological integrity of the Hudson River ecosystem. The project first cost of these actions is $43.14M ($62.788M fully funded), which provide 59 habitat units in lift. Across all sites, the unit cost is $27,500/unit.

SITE	ALT	MONITORING ($)	ADAPTIVE MANAGEMENT ($)	PROJECT FIRST ($)	TOTAL OMRR&R ($)	ANNUAL OMRR&R ($)	TOTAL IDC ($)	ANNUAL ECONOMIC COST ($)	FULLY FUNDED COST ($)
Schodack Island (North)	Alt2	305,045	688,874	19,848,972	195,565	4,541	498,997	755,396	29,295,514
Henry Hudson	Alt1	139,162	169,731	11,288,044	232,315	5,125	187,320	427,074	13,724,838
Moodna1	Alt1	40,010	32,249	2,202,265	0	0	4,824	81,545	3,654,055
Moodna2	Alt1	40,010	32,249	4,526,819	0	0	25,281	168,407	7,419,124
Moodna3	Alt2	240,059	56,998	5,336,757	0	0	28,602	197,885	8,690,832
All Moodna Creek		320,079	121,495	12,065,841	0	0	58,707	447,837	19,763,961

Table 18: Summary of the National Ecosystem Restoration (NER) Plan.

	SCHODACK ISLAND (NORTH)	HENRY HUDSON PARK	MOODNA CREEK	ALL SITES
Recommended Alternative	Alt2	Alt1	AOP1 (Alt1) AOP2 (Alt1) AOP3 (Alt2)	
Ecological Lift	8.5 AAFCU	2.4 AAFCU	48.4 AAHU	10.9 AAFCU 48.4 AAHU
Annual Economic Cost ($)	755,000	427,000	448,000	1,630,000
Unit Cost ($/AAFCU)	89,000	179,400	9,300	27,500
Monitoring Cost ($)	305,000	139,000	320,000	764,000
Adaptive Management Cost ($)	689,000	170,000	121,000	980,000
Project First Cost ($)	19,849,000	11,288,000	12,066,000	43,143,000
Fully Funded Cost ($)	29,296,000	13,725,000	19,764,000	62,784,000
Annual OMRR&R Cost ($)	4,541	5,125	0	9,666

CHAPTER 6: References

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