Hampton Roads Beneficial Use of Dredged Material
Continuing Authorities Program, Section 204

Appendix C - Economics

Draft Detailed Project Report and Environmental Assessment

SEPTEMBER 2024

US Army Corps of Engineers®

VIRGINIA DWR

ECONOMICS APPENDIX

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EXECUTIVE SUMMARY

This section will analyze the economic benefits of beneficially reusing the dredged material within the Hampton Roads area to provide sustainable habitat to the displaced seabird population and to create habitat to oysters. A Letter of Intent was received on October 22, 2019, from the Virginia Department of Wildlife Resources (VDWR) requesting USACE to “investigate alternative solutions to identify a plan to restore or create aquatic and ecologically related habitat.”

ECONOMIC ANALYSIS

The purpose of the economic analysis supporting documentation is to evaluate and quantify the beneficial impacts of the alternative plans considered for the dredged material beneficial use within the Norfolk Harbor, its channels, and auxiliary areas. The assessment is primarily based on information provided by the non-federal sponsor, the project delivery team, and meetings. The proposed action involves using dredged material from Anchorage F, or other federal channels, to create seabird habitat and enhance public safety by reducing Bird Airstrike Hazards (BASH). Key benefit categories include ecosystem development and creation, habitat safety, and historical and cultural benefits. The evaluation of National Ecosystem Restoration (NER) benefits follows the guidelines outlined in the "Planning Guidance Notebook", ER 1105-2-100, dated April 22, 2000. The analysis uses 2026 as the base year, with a discount rate of 2.75%, and applies October 2023 price levels.

Description of the Study Area

The project is located within Norfolk Harbor, midway on the Atlantic Seaboard in the southeastern region of the Commonwealth of Virginia at the southern end of the Chesapeake Bay. The project will reuse dredged material be provided from the sand floor within the Norfolk Harbor and its channels during dredging maintenance and new channel deepening authorizations. Figure 1 shows a picture of the Study Area.

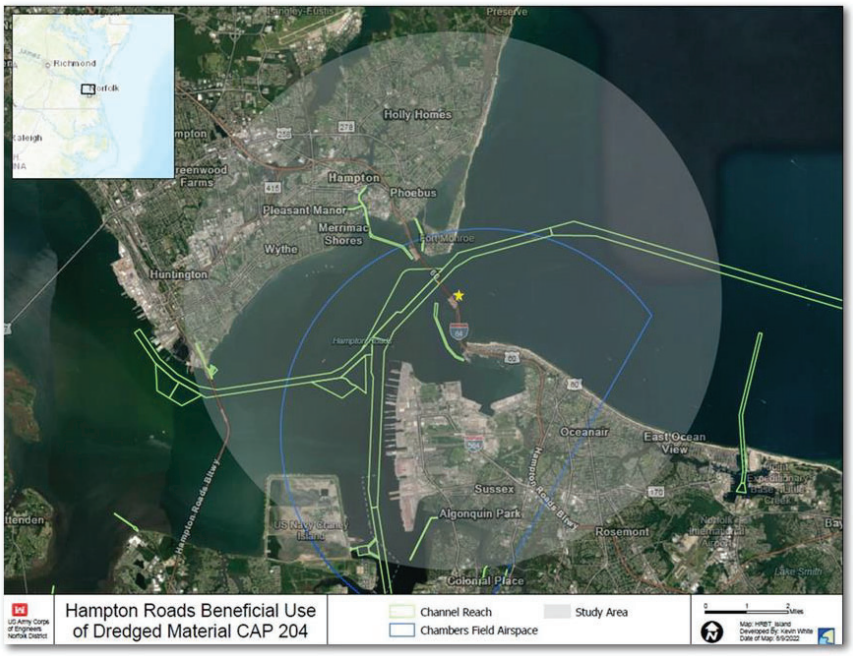

Figure 1: Study Area

Background Information

For the past 30 years, a large and diverse colony of seabirds nested on South Island, a 25-acre island that is part of the Hampton Roads Bridge-Tunnel in Virginia. Despite the unusual location, this colony became the largest in southeastern Virginia and a key nesting site for seabirds in the broader mid-Atlantic region. The colony includes five species of conservation concern in Virginia: the state-threatened Gull-billed Tern, Royal Tern, Common Tern, Black Skimmer, and Laughing Gull, along with other regionally important species like the Sandwich Tern.

The initiation of construction for the Hampton Roads Bridge-Tunnel Expansion Project in late 2019 displaced the South Island colony. While no formal mitigation was required for this displacement during the project's permitting process, the Virginia Department of Transportation (VDOT) sought to permanently remove the colony from South Island. This decision aimed to address worker health and safety concerns, increase space for oversized trucks during peak traffic periods, and reduce bird-vehicle collisions.

The Virginia Department of Wildlife Resources (DWR) and its partners temporarily relocated the seabird colony to Rip Raps Island—an island adjacent to South Island in the City of Hampton—and a series of sand-covered flat-top barges anchored in the embayment between the two islands. This relocation was undertaken to maintain breeding opportunities for the colony and to prevent the birds from dispersing and struggling to find suitable nesting areas in the highly urbanized Hampton Roads region.

In its current location, DWR has attempted to mimic the seabird habitat and nesting ground by maintaining vegetation and leasing barges, however, due to erosion, sea level rise, and coastal development likely contributed to the colony's growth on South Island over the past 30 years, this temporary habitat is no longer suitable for the least tern species. As an agency funded primarily by the sale of hunting and fishing licenses and grants from complementary federal grant programs, the DWR does not have the financial resources to make annual investments in this seabird colony at this level.

Additionally, the placement of the barges does pose a threat to the island during storm events and the U.S. Coast Guard has placed requirements to remove the barges in the event of a named storm event during the nesting season. To date, the DWR and its contractor have not had to move the barges during the nesting season. However, concerns remain about the placement of unattended barges near the Hampton Roads Bridge Tunnel (HRBT) infrastructure and main navigation channel into and out of the Port of Virginia and Naval Station Norfolk.

Existing and Future Project Conditions

The future without project condition is the land use and related conditions likely to occur under existing improvements, laws, and policies. This serves as the baseline and provides the basis for the evaluation of alternatives that address the problems, needs and opportunities in the study area. In the absence of the federal project, it is likely that conditions as they currently exist would continue into the foreseeable future in efforts to maintain the seabird habitat.

For Rip Raps Island, DWR has invested a considerable number of resources to sustain the seabird colony and to make the island suitable for nesting. They removed woody vegetation on and around the parade ground, removed and curated interpretive signage, placed sand over the entire parade ground, implemented appropriate erosion and sediment control measures, and placed temporary barriers at the temporary nesting site. The DWR also contracts with U.S. Department of Agriculture's Wildlife Services to manage predators annually and leases barges during nesting season.

Future Without Project Condition

Empirical data was used to describe the future without-project costs for this study and provided by DWR. DWR solicits several annual contracts to sustain the seabird habitat at Rip Raps Island. This includes predator control, vegetation upkeep, and dock maintenance and repairs. Assuming the continuation of existing habitat management and sustainability practices, current annual costs were used and annualized for the period of analysis. The annual costs provided represent consistent expenditures and are used in the future without-project analysis. If these measures are not maintained, the seabird habitat and tern colonies could be at risk. All costs are based on 2024 price levels.

Each year, the DWR leases barges from a marine construction contractor during the nesting season to ensure sufficient nesting facilities for seabirds. These barges are anchored in the embayment under a Virginia Marine Resources Commission permit. The annual lease cost is approximately $2.6 million, which includes holding the barges during the off-season to ensure availability for the nesting period, given the high demand for marine construction in the Hampton Roads area. This cost is factored in as an NED (National Economic Development) benefit for this analysis.

In addition to barge leasing, the DWR conducts vegetation control, spending between $5,000 and $10,000 annually to manage vegetation at Fort Wool. Predator control costs around $68,000 annually through USDA Wildlife Services, and the Virginia Tech Shorebird Program (VT) incurs $1,000 annually for monitoring. Other costs include minor repairs and maintenance, as well as infrequent expenses like emergency barge removal and replacement during severe storms, which can cost up to $136,000 per instance, and pier repairs estimated at $500,000.

The total cost of maintaining the seabird habitat can be categorized into four main areas. Costs provided by the DWR were either contracted, typical, or ranged estimates, and for ranged costs, the median values were used in this analysis. It is expected that these annual expenditures will continue in the future without project condition.

Table 1: Costs to Main Fort Wool

Operating Measure	Frequency	Operating Cost (FY 24 Price Levels)
Vegetation Control	Annually	$7,500
Predator Control Monitoring	Annually	$68,000
Barge Rental	Annually	$2,600,000
Dock Maintenance	Annually	$1,000
Total Cost to Maintain Fort Wool		***$2,676,500***

NATIONAL ECOSYSTEM RESTORATION

Ecosystem restoration is a key mission of the U.S. Army Corps of Engineers Civil Works program. Contributions to National Ecosystem Restoration (NER) involve increasing the net quantity and/or quality of valuable ecosystem resources. NER is measured by changes in the quality of ecological resources, reflecting improvements in habitat quality and/or quantity, and is expressed in physical units or indexes, rather than monetary terms. Contributions to national improvements typically reflect increases in the net value of both marketable and non-marketable goods, services, and overall ecosystem integrity. This project evaluates the contributions to national improvements by enhancing the ecosystem integrity of seabird and oyster habitats.

To support this effort, the team identified measures to sustain the seabird habitat, ensuring continued viability in its environment. In doing this, the goal was to, at a minimum, mimic the current temporary habitat, with efforts to idealistically match the South Island habitat that the seabirds once inhabited for 30 years prior to the disruption of the HRBT. While cost constraints would limit its size, the quality transfer of the South Island-like environment would make adapting easier. This would be achieved by providing a nesting site at or greater than the temporary site up to the 25-acre South Island site, subject to cost constraints of the project.

From the measures evaluated, this would include creating partially armored habitat from beneficial reuse of dredged material. The decision of partially stabilized land formation from dredging material was the team's optimal solution as it provides a safe and permanent habitat, it provided ecological benefits to multiple species, and will potentially reuse an authorized project's dredged material. Depth, location, habitat size, and stone quantities for stabilization were identified as the major drivers of cost. The team recommended two, shallow enough locations that sand disposable would be suitable for land formation habitat, West of Hampton Flats at Newport News Bar and Hampton Bar. Considering that the measures would incur armoring the structure, the creation of oyster habitat could be developed and further contribute to ecosystem improvements. For the analysis, the team developed alternatives in half-acre increments to analyze iterative benefits as acreage increases. These alternatives include the following:

Table 2: Iterative Alternative Screening

Alternatives	Seabird Acreage	Footprint	Crest Height (above NAVD88)	Water Depths
4a.1 West of Hampton Flats	10.0	19.4	9.96	11.6
4a.2 West of Hampton Flats	7.0	14.9	9.96	11.6
4a.3 West of Hampton Flats	4.0	10.1	9.96	11.6
4b.1 Hampton Bar	10.0	16.5	9.96	5.6
4b.2 Hampton Bar	7.0	12.5	9.96	5.6
4b.3 Hampton Bar	4.0	8.2	9.96	5.6
4b.4 Hampton Bar	4.5	8.9	9.96	5.6
4b.5 Hampton Bar	5.0	9.7	9.96	5.6
4b.6 Hampton Bar	5.5	10.4	9.96	5.6
4b.7 Hampton Bar	6.0	11.1	9.96	5.6
4b.8 Hampton Bar	6.5	11.8	9.96	5.6

Environmental Evaluation of Benefits

To evaluate the benefits for this analysis ecological models were utilized to determine the overall impact to the project creation. Ecological models simulate anticipated ecological responses of the to changing environmental conditions and can be used to assess effects of human actions, such as construction or restoration actions. Habitat Suitability Indices (HSI) were used as a theoretical representation of the ecological system for the project. The HSI models used for this study were the Least Tern index, validated by Carreker in 1985, for the seabird colony, and the Eastern Oyster index, developed by Theuerkauf and Lipcius in 2016, for the oyster population.

Oyster HSI

The Eastern Oyster HSI was derived from GIS layers to determine the relationship between depth (less than 4m = 1), salinity (range from 10-30 psu = 1), and bottom type (muddy sand, sand, hardbottom = 1). The HSI was tested using live adult density data of high and low vertical relief reefs in the sanctuary network in a tributary of the Chesapeake Bay. For the analysis, acreage of oyster habitat is computed surface area of the riprap that is below MLW added to the study area that oysters can attach to for habitat.

Tern HSI

Least Tern was used as proxy for tern species (royal, sandwich, common, and gull-billed) and is determined by the quality of foraging habitat and quality of nesting habitat. Variables for foraging habitat include: the percent aquatic area (<50% = 1); the number of disparate aquatic wetlands (+2 = 1) within maximum flight distance (assumed 3.2 km); and the suitability for nesting is assumed to equal the lower of the values obtained for vegetation cover and substrate type, and the variables for nesting habitat include: the vegetation cover (between 0% and 15% =1) and vegetation height (less than 10 cm = 1) and substrate type (% sand, silt/clay, and fragmentary material). The overall HSI is equivalent to the lower of these two values. For the analysis acreage of seabird habitat not only includes the footprint of the nesting habitat, but also the additional dry surface area for foraging from the rip rap and structural elements of the project.

Ecosystem Modeling Scoring and Summary of Benefits

To calculate the net Average Annual Habitat Unit (AAHU), the HSI value was multiplied by the habitat acreage provided by each alternative. The Total Net Average Annual Habitat Unit is the combined sum of the Least Tern and Eastern Oyster Net Average Annual Habitat Units. HSI values and habitat acreage, including sea level change (SLC) considerations, were annualized and averaged over the 50-year analysis period Table 3 outlines the results for both the Seabird Island and Oyster Reef Habitat units for each alternative, presenting the HSI calculations based on the habitat acreage associated with each alternative.

Table 3: Environmental Model Results Sorted by Average Annual Habitat Units (AAHUs)

		Seabird Island Habitat Units		Oyster Reef Habitat Units		Combined Habitats
	Alternatives	Average Annual HSI	Net Average Annual HU	Average Annual HSI	Net Average Annual HU	Total Net Average Annual HU
1	No Action (FWOP)	0.000	0.000	0.431	0.000	0.000
4a.1	West of Hampton Flats	0.997333	13.303	1.000	1.321	14.624
4a.2	West of Hampton Flats	0.997333	9.758	1.000	1.153	10.911
4a.3	West of Hampton Flats	0.997	6.076	1.000	0.942	7.018
4b.1	Hampton Bar	0.997333	13.303	1.000	0.624	13.926
4b.2	Hampton Bar	0.997333	9.758	1.000	0.538	10.297
4b.3	Hampton Bar	0.997	5.825	1.000	0.492	6.317
4b.4	Hampton Bar	0.997	6.438	1.000	0.514	6.952
4b.5	Hampton Bar	0.997	7.073	1.000	0.536	7.609
4b.6	Hampton Bar	0.997	7.647	1.000	0.557	8.203
4b.7	Hampton Bar	0.997	8.243	1.000	0.576	8.820
4b.8	Hampton Bar	0.997	8.837	1.000	0.595	9.433

Cost Effective & Incremental Cost Analysis

Cost-effectiveness and incremental cost analysis (CE/ICA) are two separate evaluations required by USACE policy to assess alternative plans. First, a cost-effectiveness analysis must demonstrate that no other plan can achieve the same output more cost-efficiently. A plan is considered cost-effective if, for a given level of non-monetary output (e.g., number of birds), no other alternative costs less, and no other

plan produces more output at a lower cost. Afterward, incremental cost analysis is conducted to compare a range of alternatives, including different sizes, to determine the "best" level of output, considering the capabilities of both the sponsor and USACE.

Period of Analysis

The Period of Analysis for this project is fifty years from 2027 to 2076. All construction and maintenance activities would need to align with dredging projects and maintenance in the federal channels in the vicinity of Hampton Bar when appropriated, scheduled, and contracted.

Costs

Initial costs were developed for each measure that progressed through the screening process. The key costs considered during this phase included construction, planning, engineering and design, real estate costs, and interest during construction. Interest during construction is an economic cost that accounts for the cost of interest that accumulates over the construction period, a time when project benefits are not yet been realized.

These combined cost inputs help produce preliminary cost estimates for each alternative, which are then evaluated in terms of both cost-effectiveness and the potential incremental benefits they offer. Preliminary costs for each plan are detailed in the Table 4.

Table 4: Initial Evaluation of Costs

Alt	Sand Acres	Location	Total Construction Cost
1	0	(No Action) (FWOP)	0
4a.1	10.0	West of Hampton Flats	24,399,433
4a.2	7.0	West of Hampton Flats	20,528,622
4a.3	4.0	West of Hampton Flats	14,543,054
4b.1	10.0	Hampton Bar	18,120,157
4b.2	7.0	Hampton Bar	15,078,714
4b.3	4.0	Hampton Bar	11,592,099
4b.4	4.5	Hampton Bar	12,235,690
4b.5	5.0	Hampton Bar	12,847,599
4b.6	5.5	Hampton Bar	13,439,479
4b.7	6.0	Hampton Bar	14,003,008
4b.8	6.5	Hampton Bar	14,553,775

IWR Planning Suite II

The IWR Planning Suite II or IWR Planning Suite model was used for this analysis. This is a certified US Army Corps of Engineers model available for national use that assesses the investment decision to evaluate ecosystem restoration alternative plans. From its inputs, the IWR Planning Suite develops alternatives based on measures provided and describes these alternatives as “Not Cost-Effective”, “Cost Effective”, and “Best Buy”. “Cost Effective” plans are those that produce the greatest benefit at the lowest cost while the “Best Buy” plans produce the most efficient plans with the greatest incremental benefit.

Collectively, they offer the greatest increase in output for the smallest increase in cost, resulting in the lowest incremental cost per unit of output. Typically, there will be a series of best buy plans, where the relationship between output quantity and unit cost is clear. As the scale of these plans grows (in terms of output produced), both the average cost per unit of output and the incremental cost per unit tend to rise. However, incremental analysis alone does not determine the selection of a single plan. The results must be combined with other decision-making criteria—such as the significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, and reasonableness of costs—to guide the study team in selecting and recommending a specific plan. The subset of cost-effective plans is evaluated in order of increasing scale and output to determine which are the most efficient in producing environmental benefits.

In this analysis, twelve alternative plans, including the No Action Plan, were developed using screened measures, and the IWR-Planning Suite II software was used to perform a CE/ICA analysis on these alternatives. Two placement sites were included in the CE/ICA model and run through the planning suite. The analysis identified eight cost-effective plans (Alternatives 1, 4a.1, 4b.3, 4b.4, 4b.5, 4b.6, 4b.7, and 4b.8) and two that were not cost-effective (4a.2 and 4a.3), meaning other plans provided the same or more benefits at a lower cost. The No Action Plan is always considered a best buy. Two additional plans,

Alternatives 4a.1 and 4b.8, were identified as best buys, though Alternative 4a.1 exceeded the CAP cost threshold.

Table 5: Alternative Plan Cost Effectiveness

Alt	Acres	(A) Location	(B) AAC ($)*	(C) AAB (HU)	AC (C/B) ($)	Cost Effectiveness
1	0	(No Action) (FWOP)	0	0.00	0.00	Best Buy
4a.1	10.0	West of Hampton Flats	1,039,650	14.62	71,094	Best Buy
4a.2	7.0	West of Hampton Flats	874,976	10.91	80,192	Not Cost Effective
4a.3	4.0	West of Hampton Flats	620,379	7.02	97,936	Not Cost Effective
4b.1	10.0	Hampton Bar	772,608	13.93	55,479	Cost Effective
4b.2	7.0	Hampton Bar	643,205	10.30	62,467	Cost Effective
4b.3	4.0	Hampton Bar	494,869	6.32	78,302	Cost Effective
4b.4	4.5	Hampton Bar	522,249	6.95	75,144	Cost Effective
4b.5	5.0	Hampton Bar	548,282	7.61	72,048	Cost Effective
4b.6	5.5	Hampton Bar	573,463	8.20	69,935	Cost Effective
4b.7	6.0	Hampton Bar	597,438	8.82	67,737	Cost Effective
4b.8	6.5	Hampton Bar	620,871	9.43	65,839	Best Buy

*Costs are in 1 Oct 24 costs and do not include O&M costs. All annualized values are discounted using a Fiscal Year 2024 Federal discount rate of 2.75 percent and are assessed for a 50-year period of analysis.

For the initial array of alternatives considered, the No Action Alternative, Alternatives 4a.1 and Alternative 4b.8 are Best Buy plans and Alternatives 4b.3, 4b.4, 4b.5, 4b.6, and 4b.7 are all Cost-Effective Plans. Alternative 4a.2 and 4a.3 are not Cost-Effective and alternative 4b.1 and 4b.2 exceed the CAP limits. The below figure graphically describes the results of the CE/ICA analysis.

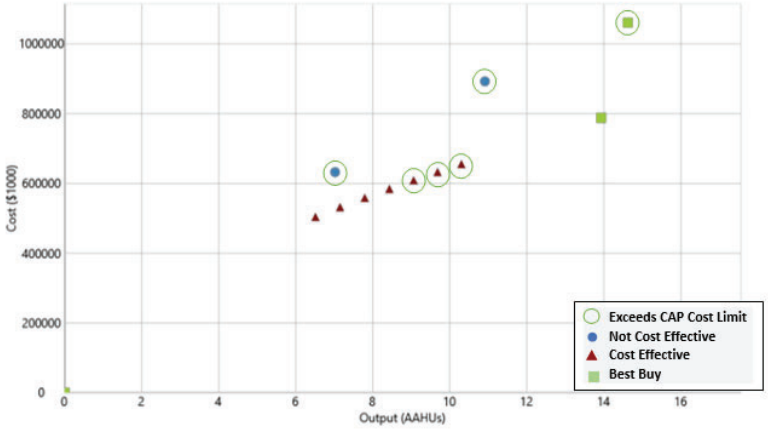

Figure 2: CE/ICA Analysis on Focused Array

Final Array of Alternative Costs

Considering the relationship of the seabird and oyster habitat to acreage, the objective of the project was to maximize habitat units given the CAP cost limitations. The creation of a final array of alternatives identified the Hampton Bar location as the most cost-effective alternative with the land area as a measure for the alternative analysis. During this screening phase, alternatives that did not meet the cost constraints set for CAP studies were eliminated. The remaining alternatives within the CAP guidelines were then further analyzed for their potential impacts and benefits, focusing on their ability to address the project's objectives effectively.

Once the final array of alternatives was compiled, total economic costs were further refined. The costs added to the gross investment during this analysis included adaptive management and operation and maintenance costs. Adaptive management costs for this study include design adjustments during the first six years of the project to adjust for project performance. Standard operation and maintenance costs were added annually after year 6 to adjust for regular maintenance for the project.

Table 6: Summary of Costs and NER Benefits of the Final Array of Alternatives

	4a.3	4b.3	4b.4	4b.5	4b.6	4b.7	4b.8
Total Project First Costs ($)	16,050,290	12,803,130	13,511,502	14,185,017	14,836,496	15,456,780	16,063,026
Interest During Construction ($)	256,795	204,842	216,176	226,952	237,375	247,299	256,999
Total Gross Investment ($)	16,307,085	13,007,973	13,727,678	14,411,969	15,073,871	15,704,080	16,320,025
Average Annual Cost of Total Gross Investment ($)	610,867	487,281	514,242	539,875	564,670	588,278	611,351
Annual IDC	9,512	7,588	8,007	8,407	8,793	9,160	9,519
Annual OMRR&R Cost ($)	66,932	66,932	68,158	69,383	70,608	71,834	73,059
Total Average Annual Costs ($)	687,311	561,801	590,407	617,665	644,071	669,272	693,930
Total NER Benefits (AAHU's)	7.02	6.32	6.95	7.61	8.20	8.82	9.43
Cost Per Habitat Unit ($1000)	102.5	92.9	88.7	84.9	82.1	79.3	76.9
CE/ICA Cost Effective	No	Yes	Yes	Yes	Yes	Yes	Yes

* Cost used for comparison are parametric costs.
*All monetary values are in Fiscal Year 2024 price levels. All annualized values are discounted using a Fiscal Year 2024 Federal discount rate of 2.75 percent and are assessed for a 50-year period of analysis.

Focused Array of Alternatives

After reviewing the final array of alternatives, a focused array of alternatives was provided to only include those alternatives that were cost-effective and within the CAP limits. This array of alternatives is carried forward to the evaluation of the four accounts.

Table 7: Focused Array of Alternatives

Alt	Acres	Location	AAC ($)	(C) AAB (HU)	AC (C/B) ($)	Incremental Cost ($)	Incremental Benefit (HU)	Incremental cost ($) / benefit	Cost Effectiveness
1		(No Action) (FWOP)	0	0.00	0.00	0	0	0	Best Buy
4b.3	4	Hampton Bar	494,869	6.32	76,046	494,869	6.32	88,680	Cost Effective
4b.4	4.5	Hampton Bar	522,249	6.95	72,993	27,380	0.65	50,515	Cost Effective
4b.5	5	Hampton Bar	548,282	7.61	70,340	26,033	0.64	49,250	Cost Effective

While Alternative 4b.8 is the Best Buy Plan, Alternative 4b.5 is the most Cost-Effective Plan within the CAP Program Limits. This plan includes 5 acres of sand deposited at Hampton Bar and has an average cost of $70,340 per habitat unit. The below image is the graphical reference for the CE/ICA analysis.

Table 8 shows the monetary investment layout and benefits gained towards the federal objective for alternatives within the CAP limits. Two locations were carried forward from the initial array of measures as suitable areas for seabird and oyster habitat. Of these two measures, the project was incremental justified by acreage to determine the alternative that provides the greatest NER benefit.

Table 8: Summary of Costs and NER Benefits of the Focused Array of Alternatives

	4b.3	4b.4	4b.5
Total Project First Costs ($)	12,803,130	13,511,502	14,185,017
Interest During Construction ($)	204,842	216,176	226,952
Total Gross Investment ($)	13,155,216	13,883,069	14,575,104
Average Annual Cost of Total Gross Investment ($)	520,489	549,287	576,668
Annual OMRR&R Cost ($)	66,625	66,625	66,625

Total Average Annual Costs ($)	587,114	617,176	645,821
Total NER Benefits (AAHU's)	6.32	6.95	7.61
Cost Per Habitat Unit ($1000)	92.9	88.8	82.9
CE/ICA Cost Effective	Yes	Yes	Yes

All monetary values are in 1 October 23 price levels. All annualized values are discounted using a Fiscal Year 2024 Federal discount rate of 2.75 percent and are assessed for a 50-year period of analysis.

Alternative 4b.5 provides the greatest NER benefits within the CAP limits, followed by Alternatives 4b.4 and 4b.3. Each of these alternatives involves relocating the bird habitat and placing it in Hampton Bar. The NER benefits are higher for these alternatives because of the capacity of the bird habitat. The relationship between the seabird and oyster habitat unit and acreage is linear. Cost incurred for mobilization and demobilization are fixed cost and any additional acreage will offset this cost.

The final array of plans considered several cost thresholds, including those outside the CAP limit, however this focused array only includes plans within the CAP limits. The habitat formation is a linear relationship based on acreage; therefore, economies of scale is observed with this project from the mobilization and demobilization fixed costs. As additional acreage increases, the mobilization and demobilization are balanced by additional acreage of sand, and therefore, the linear addition of seabird and oyster habitat is reduced. The plan within the CAP limit that provided the greatest habitat unit benefit would be the one with the greatest land mass subject to cost restrictions, Alternative 4b.5.

EVALUATION OF THE REMAINING ACCOUNTS

The evaluation of the four accounts begins once alternative formulation is complete and initial evaluations have identified acceptable plans. This step is to identify and analyze benefits equally across a full array of benefit categories including National Ecosystem Restoration (NER), National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE). These four accounts encompass all significant effects of a plan on the human environment as required by NEPA (42 U.S.C. 4321 et seq.) and social well-being as required by Section 122 of the Flood Control Act of 1970 (Pub. L. 91-611, 84 Stat. 1823).

Consistent with the goal of an ecosystem restoration study, the Norfolk District's objective is to recommend a NER plan. This NER recommendation was discussed in the previous section, with the NED, RED, and OSE accounts described below. The evaluation of the four accounts uses the alternatives provided in the final array for comparison purposes.

National Economic Development Account

The NED account details any changes the economic value of the national output of goods and services. NED benefits are discussed below and assessed, however, were not the objective of the study. Future costs were not developed for this study, yet empirical data was used to explain the future without project condition with the assumption that the existing techniques of habitat control and sustainability will continue. The DWR has several annual contracts to sustain the seabird habitat, manage predators, control vegetation, and maintenance and repair at Fort Wool. For the NED analysis, annual operating costs described in the FWOP condition are applied to Alternative 1, the No Action Alternative. It is assumed that all annual expenses currently incurred will continue through the period of analysis. Below lists the incurred costs used for the future without project and the annualized costs.

Table 9: FWOP O&M Costs

Annual Maintenance	**Cost**
Predator Control	$68,000
Dock Repair	$1,000
Vegetation	$7,500
Barge Lease	$2,600,000
Total	**$2,676,500**
Annualized O&M Costs	*$2,580,013*

*In FY 2024 dollars

Using the annualized FWOP costs as the No Action alternative, the below table compares the annual costs associated with this alternative to the Average Annual Costs (AAC) to the remaining project alternatives.

Table 10: Summary of Future O&M, Repair and Replacement Costs

Alt	Acres	Location	AAC-Construction w/ IDC ($)	AA- O&M ($)	Total AAC ($)	Net Annual Benefit ($)
1		(No Action) (FWOP)	0	2,580,013	2,580,013	0
4a.3	4 .0	West of Hampton Flats	620,379	66,932	687,311	1,892,702
4b.3	4	Hampton Bar	494,869	66,932	561,801	2,018,212
4b.4	4.5	Hampton Bar	522,249	68,158	590,407	1,989,607
4b.5	5	Hampton Bar	548,282	69,383	617,665	1,962,349
4b.6	5.5	Hampton Bar	573,463	70,608	644,071	1,935,942
4b.7	6	Hampton Bar	597,438	71,834	669,272	1,910,741
4b.8	6.5	Hampton Bar	620,871	73,059	693,930	1,886,083

In addition to the above stated costs, there are additional unquantifiable costs related to project that would be incurred in the No Action Alternative. These include dock repair, predator control, and barge removal. Dock repair was not costed or included due to the lack of empirical data to estimate an actual cost and frequency of these repairs. Additionally, barge removal during storm events was not considered in this analysis due to the probability of occurrence and the potential offset of repair costs for the project conditions. Other project costs not considered include dredge material recovery for sand diverted from Craney Island. While this will delay the time that Craney Island capacity is reached, the Federal objective costs were already established when costs were developed.

While the project is expected to have positive NED benefits, plan formulation did not specifically target NED benefits because of the NER study objectives.

Regional Economic Development

The Regional Economic Development account considers changes in the distribution of regional economic activity that result from each alternative plan. USACE policy allows a scaled analysis of comprehensive benefits analysis commensurate the size of the project. In this case, a qualitative summary of RED benefits, instead of a full RED analysis, is included in this report.

Each alternative included in the final array will provide regional economic benefits, though the amounts of those benefits vary between alternatives. During construction, RED benefits include money spent by the construction company and workers in the Hampton Roads region and will positively impact the local economy. These benefits will be temporary and will end when construction has been completed. Long term RED benefits are not expected to change significantly because the project is not expected to alter the nature or access to recreational opportunities. While there is a new opportunity for birdwatching activities, it is inconclusive as to if these opportunities will command onsite support.

Creating a Sustainable Economic Development

In addition to the contributions considered above, sustainable economic development, one of the guiding principles of the Federal objective and is also considered. Sustainability was quantitatively assessed in the NED account as a reduction of the continued maintenance necessary to maintain the habitat environment, however, in the regional economic development account, the opportunity cost of limiting or eliminating predator control and island maintenance would be support for other regional efforts. Fort Wool allocates additional resources for canine patrol to protect the seabirds on the island. This could amount to up to $450,000 and is a result of the federal Migratory Bird Treaty Act and derivative regulations in which the least tern is listed (National Archives, 2024). With the project, this amount would not be required and funds and could be used elsewhere in the region. For the RED analysis, these benefits are assigned a Boolean value of 0 and 1 with 0 being no benefits (or the cost when canine patrol is required), and 1 being a cost benefit, which eliminates canine patrol for the seabirds.

For a comprehensive analysis of RED benefits, short term labor benefits resulting from construction would be produced by each construction alternative. Table 10 provides a qualitative summary of RED benefits that would be produced by each alternative in comparison to the other alternatives included in the array. Alternatives predicted to have higher RED benefits involve larger amounts of construction (or additional acres of sand), meaning that the period of construction will be longer and will require more workers, while those alternatives with lower levels of RED benefits involved less construction and therefore will contribute less to the local economy. Income received would contribute to the local and

regional economy though indirect benefits by way of spending. Benefits were ranked accordingly from 0 to 6 where 0 indicated no RED benefits and 6 would have the greatest number of benefits.

Table 8: A Qualitative Summary of RED Benefits for the Array of Alternatives (0 –6 ranking)

Alternative	(A) RED Foregone Costs (0 = no; 1= yes)	(B) Income Generation for Construction Labor (C) (0-6 rank; 0=none)	RED Benefit Total (A+B)
1	0	0	0
4b.3	1	1	2
4b.4	1	2	3
4b.5	1	3	4
4b.6	1	4	5
4b.7	1	5	6
4b.8	1	6	7

Other Social Effects

The Other Social Effects account evaluates project alternatives in respect to measures of social well-being, such as health and safety, community identity, and life satisfaction; considerations related to urban, rural, and community impacts; and displacement and long-term productivity. As it relates to community identity, the location of the temporary seabird colony site has posed social challenges due to cultural resource concerns. Concerns exist about long-term impacts of maintaining suitable nesting habitat for the colony on Rip Raps Island, home to historic Fort Wool. Additionally, the City of Hampton has expressed its desire to re-open the island to public visitation, which was suspended in 2020 to accommodate the birds. While the island is owned by the Commonwealth of Virginia and managed by the Department of Conservation and Recreation, an agreement between that agency and the City of Hampton provided public access to the island and interpretive programming to visitors. By not relocating the seabird habitat, this historical exhibit will remain unattended. A citizen group, The Coalition for Historic Fort Wool, has also organized and is lobbying for a permanent nesting solution for the seabird colony away from Rip Raps Island and its historical resources.

Furthermore, the South Island, and the temporary nesting site at Rip Raps Island, are within the low-elevation flight zone of Chambers Field at the Naval Station Norfolk. The installation commander has indicated that as the number of birds specifically at Rip Raps Island or South Island increases, there is an increased potential for bird-air strikes with jets and other aircraft. This could not only impact seabird population but could potentially have an impact on national security. Because the placement of the Focused Array of alternatives is the same, each of the construction alternatives will benefit the OSE account and will contribute to community connectivity, will restore a cultural attraction, and will benefit national security, equally.

Environmental Justice

Executive Order (E.O.) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires the federal government to achieve environmental justice by identifying and addressing high, adverse, and disproportionate effects of its activities on minority and low-income populations. E.O. 12898, Environmental Justice, states that the proposed action would not result in adverse human health or environmental effects. Any impacts of the action would not be disproportionate towards any minority or low-income population. The activity does not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. The activity would not impact "subsistence consumption of fish and wildlife." It requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by environmental actions. It also requires federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns, and the communication of associated risks to the public.

According to the Climate and Economic Justice Screening Tool, the Hampton Roads region has several census tracts adjacent to the study area that are identified as disadvantaged (CEJ 2024). In the Hampton Roads metropolitan area, over 8% of the population is within the poverty threshold (ACS 2024). Additionally, the Hampton Roads region has a large percentage of people that claim minority ethnicity. Of the residents in the region in 2023, nearly half of the population was minority (ACS2024). The

environmental benefits provide quality of life improvements to all people and primarily to people in the communities within the study area. By the nature of design, restoration will improve environmental quality. This would improve the quality of human life as well by providing increased wildlife activity; a positive attribute for those who appreciate seeing increases in wildlife near an urban setting. This logically translates to the increased benefits in enjoyment, aesthetics, and economics for recreational activities.

Summary Evaluation of the Four Accounts

While the four accounts were presented and analyzed, the *National Ecosystem Restoration (NER)* account is the governing authority for ecosystem restoration. NER factors included in this project considered habitat units produced by both seabird and oysters though the reuse of dredged sand material. Each of the Focused Alternatives, were cost effective, however, incrementally justified, the alternative with the largest sand placement was the Best Buy Plan, Alternative 4b.8. This is due to economies of scale and the sunk cost of mobilization and demobilization cost allocated to more benefits. This alternative had the largest number of habitat units for both the seabird and oyster population and is the only identified best buy plan that maximizes efficiency.

National Economic Development factors analyzed were the reduction in O&M costs, replacement costs, and repair costs for the period of analysis. Alternatives 4b.3 provided the greatest O&M cost savings and the highest NED benefits. *Regional Economic Development* benefits will stem from project construction incurred and canine control reduced. All construction alternatives outside of Fort Wool exhibited RED outputs, due to both construction benefits and benefits foregone at Fort Wool. Similarly, alternatives outside of the Fort Wool location provided signification social effect benefits due to the historic nature of the site and national security.

A comparison of the effects of various plans must be made and tradeoffs among the differences observed and documented to support the final recommendation.

SENSITIVITY, RISK, AND UNCERTAINTY ANALYSIS

Uncertainty and variability are inherent in water resources planning. The risk and uncertainty aspects associated with the restoration project cannot be characterized by probability distributions based on existing empirical data. Therefore, the potential uncertainty lies in any deviations to sea level change (SLC) at the project area. Relevant assumptions are varied where appropriate to measure potential impacts on project costs and benefits.

The original cost/benefits analysis was completed using an intermediate parameter for habitat units of the seabird and oyster population, however, due to uncertainty, low and high SLC are modeled and assessed using the North American Vertical Datum of 1988 (NAVD 88). To assess the outcome of the CE/ICA analysis using varied of sea level rise, a sensitivity analysis was modeled on the screened array of alternatives.

The following habitat unit parameters were used in the analysis:

Table 11: Sea Level Curve Sensitivity Output Comparison

			Seabird		Oyster		
	Alternatives	**Acres**	**AA HSI**	**AAHU**	**AA HSI**	**AAHU**	**Total AAHU**
	Alt 1 (No Action) (FWOP)	0	0.000	NA	0.431	N/A	0
USACE 2013 Low SLC Curve	Alt 4b.3 Hampton Bar	4.0	0.997	5.913	1.000	0.471	6.384
	Alt 4b.4 Hampton Bar	4.5	0.997	6.531	1.000	0.493	7.024
	Alt 4b.5 Hampton Bar	5.0	0.997	7.143	1.000	0.513	7.656
	Alt 4b.6 Hampton Bar	5.5	0.997	7.750	1.000	0.533	8.283
	Alt 4b.7 Hampton Bar	6.0	0.997	8.351	1.000	0.552	8.903
	Alt 4b.8 Hampton Bar	6.5	0.997	8.950	1.000	0.570	9.520
USACE 2013 Intermediate SLC Curve	Alt 4b.3 Hampton Bar	4.0	0.997	5.825	1.000	0.492	6.317
	Alt 4b.4 Hampton Bar	4.5	0.997	6.438	1.000	0.514	6.952
	Alt 4b.5 Hampton Bar	5.0	0.997	7.073	1.000	0.536	7.609
	Alt 4b.6 Hampton Bar	5.5	0.997	7.647	1.000	0.557	8.203
	Alt 4b.7 Hampton Bar	6.0	0.997	8.243	1.000	0.576	8.820
	Alt 4b.8 Hampton Bar	6.5	0.997	8.837	1.000	0.595	9.433
USACE 2013 High SLC Curve	Alt 4b.3 Hampton Bar	4.0	0.997	5.552	1.000	0.554	6.106
	Alt 4b.4 Hampton Bar	4.5	0.997	6.179	1.000	0.580	6.758

	Alt 4b.5 Hampton Bar	5.0	0.997	6.799	1.000	0.604	7.404
	Alt 4b.6 Hampton Bar	5.5	0.997	7.189	1.000	0.628	7.817
	Alt 4b.7 Hampton Bar	6.0	0.997	7.759	1.000	0.650	8.410
	Alt 4b.8 Hampton Bar	6.5	0.997	8.327	1.000	0.672	8.999

Based on the above habitat unit output table, the Low SLC, would provide more average annual habitat units compared to the intermediate SLC for each of the screened alternatives. With cost unchanged, the shift in habitat units increases upward with each plan being a Cost-Effective Plan and the Best Buy Plans being Alternative 1, the No Action alternative and Alternative 4b.8, 6.5 acres of beneficial sand at Hampton Bar.

The below table describes the CE/ICA Analysis for the Low SLC.

Table 12: USACE 2013 Low SLC – CE/ICA Analysis

Alternatives	Acres	AA Cost ($)	Seabird AAHU	Oyster AAHU	Total AAHU	Incremental Cost/ Benefit	Cost Effectiveness
Alt 1 (No Action) (FWOP)	0	0	NA	N/A	0	0	Best Buy
Alt 4b.3 Hampton Bar	4.0	561,801	5.913	0.471	6.384	88,001	Cost Effective
Alt 4b.4 Hampton Bar	4.5	590,407	6.531	0.493	7.024	84,056	Cost Effective
Alt 4b.5 Hampton Bar	5.0	617,665	7.143	0.513	7.656	80,677	Cost Effective
Alt 4b.6 Hampton Bar	5.5	644,071	7.750	0.533	8.283	77,758	Cost Effective
Alt 4b.7 Hampton Bar	6.0	669,272	8.351	0.552	8.903	75,174	Cost Effective
Alt 4b.8 Hampton Bar	6.5	693,930	8.950	0.595	9.520	72,892	Best Buy

Similarly, the High SLC would provide less average annual habitat units compared to the intermediate SLC for each of the screened alternatives. With cost unchanged, the shift in habitat units decreases with each plan being a Cost-Effective Plan and the Best Buy Plans being Alternative 1, the No Action alternative and Alternative 4b.8, 6.5 acres of beneficial sand at Hampton Bar.

Table 13;USACE 2013 High SLC – CE/ICA Analysis

Alternatives	Acres	AA Cost ($)	Seabird AAHU	Oyster AAHU	Total AAHU	Incremental Cost/ Benefit	Cost Effectiveness
Alt 1 (No Action) (FWOP)	0	0	NA	N/A	0	$0	Best Buy
Alt 4b.3 Hampton Bar	4.0	561,801	5.552	0.554	6.106	92,008	Cost Effective
Alt 4b.4 Hampton Bar	4.5	590,407	6.179	0.580	6.758	87,364	Cost Effective
Alt 4b.5 Hampton Bar	5.0	617,665	6.799	0.604	7.404	83,423	Cost Effective
Alt 4b.6 Hampton Bar	5.5	644,071	7.189	0.628	7.817	82,394	Cost Effective
Alt 4b.7 Hampton Bar	6.0	669,272	7.759	0.650	8.410	79,580	Cost Effective
Alt 4b.8 Hampton Bar	6.5	693,930	8.327	0.672	8.999	77,112	Best Buy

CONCLUSION

Each of the ecosystem restoration alternatives provide a cost-effective benefit. Alternative 4b.8 Hampton Bar provides the highest incremental benefit, however, Alternative 4b.5 Hampton Bar is the most cost-effective plan within the CAP limits.

Cost Refinement

Following the team's plan recommendation, cost refinement was required to address associated risks and cost savings. The cost refinement was performed during the Abbreviated Risk Analysis (ARA) to manage potential risks of unexpected additions in cost. With costs close to the Federal threshold limits of the CAP authority, the team decided it was necessary to have a better understanding of all costs so that the risk of exceeding the CAP limits could be mitigated. Including the feasibility study costs, the project is within the CAP limits and maximizes the study objectives. The below table considers the cost refinement and the benefit to cost per habitat unit of the most cost-effective plan.

Table 14: Plan Cost Refinement

Alt 4b.5 Hampton Bar

Acres	5.0
AAHU	7.609
Construction Costs	11,546,000
Annualized Construction	$439,436
IDC	$6,005
O&M Costs	$69,383
Total AAC	$514,824
Cost Per AAHU	*$67,660*

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