Executive Summary

The purpose of this economic analysis is to identify the net benefits (benefits minus costs) of four shoreline management scenarios along the Delaware Bayshore, together with the distribution of these net benefits across communities and groups. For this study, the Delaware Bayshore is limited to seven communities: Pickering Beach, Kitts Hummock, Bowers Beach, South Bowers Beach (Kent County); and Slaughter Beach, Prime Hook, Broadkill Beach (Sussex County). For several decades, the State of Delaware has supported these communities through shoreline management activities to protect structures against coastal erosion, receding beaches, and flooding. These activities have focused on maintenance of the beaches through periodic sand nourishment and emergency beach fills from upland borrow sites (post-storm). However, it has become apparent to the State and these communities that relying solely on historical beach maintenance activities is not sustainable in the long term. Nonetheless, these activities have been successful in delaying severe impacts in most parts of these communities for the past several decades. Long term shoreline management adaptation measures are needed to prevent significant flooding and erosion impacts to these communities.

The State of Delaware commissioned this economic analysis to take advantage of both new and existing information on the physical outcomes, benefits and costs of various shoreline management alternatives. This analysis builds on the recently completed Management Plan for the Delaware Bay Beaches (PBSJ, 2010). The Plan considered an engineered beach/dune profile that would be sustainable for a 10-year period and would provide protection for 10-year storm events. The Plan drew attention to emerging trends in nourishment costs. It projected sand volumes and costs far exceeding shoreline management measures taken to date, suggesting that the cost of continuing past shoreline management strategies could be prohibitive. Based on these findings and the results of past economic analyses (e.g., Beaches 2000; DNREC 1988), the State of Delaware decided to requisition an economic analysis to assess shoreline management solutions for these seven bay communities.

Study Scope

This economic study evaluates three shoreline management scenarios against a base case of No Action. The three management scenarios are: Beach Nourishment, Strategic Retreat, and Enhanced Retreat. The estimated costs and benefits of each scenario are calculated over a thirty-year time horizon (2011 to 2041) with the focus on impacts limited to the immediate shoreline of the seven communities rather than the entire reach of the bay shoreline.

The study's scope and methodology was developed through a series of technical workshops with subject matter experts across several disciplines (e.g.; engineering, hydrology, and economics). The process also determined the suite of benefits to be quantified and the data requirements. The team subsequently collected and generated the analytic data necessary to measure three broad categories in which benefit changes are expected to be significant: housing services (i.e., houses lost due to erosion or removal), flood hazard reductions, and recreational uses. Data to evaluate the projected costs of shoreline management were also collected. Finally, the study evaluated local and county tax revenue implications.

Management Scenarios

This study considers three active management scenarios (beach nourishment and two retreat options). The net benefits (benefits minus costs) under each of these scenarios are compared to what would occur were the State to take no further action; this is denoted the No Action baseline. Under the baseline No Action Scenario, the State would not actively manage shoreline erosion, allowing it to occur unimpeded. Rather than maintaining the status quo (current nourishment activities), this scenario serves as the base

case for the analysis. The Beach Nourishment Scenario builds on the 10-year beach/dune system described in the 2010 Management Plan (i.e., beach fill placement and construction repeated every 10 years). It preserves the beach widths to support current visitation by beach goers and protects the existing structures from erosion and wave energy during flooding. The retreat scenarios are shoreline adaptation approaches based on current recommendations by coastal hazard mitigation planners. They allow shoreline erosion and migration to take place naturally with communities retreating from the shoreline by staging the purchase and removal of bay-front housing structures. These are denoted Basic Retreat and Enhanced Retreat. These differ in the timing and magnitude of property acquisition geared towards maintaining two alternative levels of amenities (beach width) for the public. Table ES.1 summarizes the four scenarios.

Table ES.1: Summary of Management Scenarios

Scenario	Description	Expected Outcome
No Action (Baseline)	State undertakes no action to manage shoreline erosion and flooding	• Of the current 1643 homes, 129 are lost to erosion. Lost homes in all communities except Slaughter • Extent of loss by community varies substantially • Limited costs to government, mainly clean/demolition • Beach recreation opportunities (for owners and visitors) continue but at a lower level due to narrowing beach conditions over time
Beach Nourishment (Scenario 1)	Construct and maintain 10-year storm beach/dune system based on the Management Plan for the Delaware Bay Beaches	• All properties protected (to design criteria) against flood and erosion damage (avoided damages) • Beach recreational opportunities (for owners and visitors) preserved and enhanced • Direct costs to government of beach nourishment activities
Basic Retreat (Scenario 3)	Strategic retreat designed to clear and conserve beach widths consistent with current conditions	• 244 selected houses removed over time with direct costs for the State in property buyout and demolition (an additional 115 homes lost compared to No Action) • Properties avoid erosion loss and avoid some coastal flooding damages • Beach recreational opportunities (for owners and visitors) preserved
Enhanced Retreat (Scenario 2)	Retreat designed to clear and conserve beach widths comparable to 10-year beach nourishment design	• 451 selected houses removed over time with direct costs for the State in property buyout and demolition (an additional 322 homes lost compared to No Action) • Properties avoid erosion loss and avoid some coastal flooding damages • Beach recreational opportunities (for owners and visitors) preserved and enhanced

Note: Scenario numbers reflect how each is referenced in the supporting assessments (Appendices D and E).

Approach to Benefit Cost Analysis

The economic analysis is grounded in established methods for benefit cost analysis (BCA). Within BCA, economic benefits are assessed only in comparative terms, relative to a well-defined baseline. Here, the baseline reflects what would occur under the No Action scenario. Established methods exist for measuring various types of benefits and costs within BCA, as realized by different groups. Economic benefits and costs may be realized by individuals or firms. For individuals, benefits are generally measured as the maximum amount of other goods or services that the individual is willing to forego or give up in order to obtain the outcomes resulting from the policy in question. This reflects the individual's willingness to pay (WTP) for the policy change. Economic costs, in turn, reflect the value of goods or

services foregone as a result of the policy. For example, government costs for materials and supplies (e.g., the cost of sand for nourishment) are considered economic costs, because they reflect opportunity costs (resources that cannot be used for other purposes). When measuring benefits and costs, it is important to recognize the distinction between total net benefits (all benefits minus all costs) and the distribution of net benefits. Policies that generate greater combined net benefits do not necessarily benefit all groups equally. This report recognizes that the State may also wish to consider the impacts on equity or the distribution of net benefits across groups. The analysis hence quantifies both total net benefits and the distribution of these benefits across various groups, where possible.

It is typically impossible to measure all possible benefits and costs from a given project. As a result, all BCAs must make initial decisions regarding which benefits and costs (1) can be quantified based on available data, and (2) are large enough to warrant attention. To determine which benefits would be quantified in present analysis, the team developed a preliminary matrix of potential resources and associated benefits/costs, which could potentially be affected by the management scenarios. A workshop was then conducted to help determine which of these were likely significant issues for the Bayshores analysis and could be quantified based on available data. Table ES.2 summarizes the resulting categories of benefit and cost quantified by the present BCA, the way they are quantified, and the economic intuition underlying their interpretation as a valid measure of benefit or cost.

Table ES.2. Categories of Benefits, Costs and Transfer Payments Considered

BENEFIT, COST OR TRANSFER	HOW MEASURED	DESCRIPTION AND ECONOMIC INTERPRETATION
Sand, Fill and Demolition Costs	Change in costs paid by the State. Quantified using predicted market costs.	These reflect the opportunity cost of resources used for management.
Housing Service Benefits	Change in the net present value of services received from homes, as reflected in property values.	These reflect gains or losses to homeowners related to the continued existence of a housing structure into the future. According to economic theory, equilibrium property values should reflect the capitalized present value of future housing services.
Recreational Benefits	Change in the net present value of beach recreation, quantified using changes in discounted consumer surplus.	Beach recreation generates non-market use values. These values can be quantified using consumer surplus, defined as the difference between what an individual would be willing to pay for beach recreation and what is actually paid in travel and access costs.
Flood and Erosion Damages	Change in net damages to homes (repair and replacement costs).	Changes in beach management can influence the likelihood and severity of flood and erosion damage to homes. This is in addition to homes that are entirely lost. The true relationship between damage costs and the willingness to pay to avoid flood damage (a true measure of benefit) is generally undefined, although these are sometimes interpreted as an approximation of benefit losses.
Housing Acquisition Payments (Transfer)	Payments from the State to homeowners to compensate for lost housing services.	These reflect a transfer payment from the State to homeowners. That is, for each $1 paid by the State, $1 is received by homeowners; these payments are a simple transfer of funds from one group to another, the net benefit of which is zero.

Observations

Without any shoreline adaptation (the No Action baseline), the seven bay communities in this study will experience increasing damages from erosion and flooding. Each of the management alternatives considered would alter these "No Action" conditions, and hence would generate either positive or negative net benefits. Table ES.3 summarizes the net benefit of each shoreline management scenario option relative to the No Action Scenario. As shown by Table ES.3, the benefits of shoreline management do not outweigh the costs. In all cases, net benefits are negative when compared to No Action. The Beach Nourishment Scenario has the smallest shortfall; the estimated net loss is $24.1 million in present value (including damage avoidance). The Basic Retreat Scenario produces an estimated net loss of $29.8 million. The Enhanced Retreat Scenario has the highest net loss ($114.0 million).

Table ES.3: Net Benefits by Management Scenario Relative to No Action[1]

Scenario	(A) Sand, Fill and Demolition (PV, $mill)	(B) Housing Acquisition Payments (paid by State) (PV, $mill)	(C) Housing Acquisition Payments (received by property owners) (PV, $mill)	(D) Recreation (PV, $mill)	(E) Housing Services[2] (PV, $mill)	(F) Reduction in Additional Flood and Erosion Damages[3] (PV, $mill)	(G) Net Benefits (PV, $mill; sum of A through F)
Beach Nourishment (Scenario 1)	-$61.1	-$0	$0	$16.1	$18.2	$2.7	-$24.1
Basic Retreat (Scenario 3)	-$0.5	-$61.3	$61.3	$10.8	-$43.1	$3.0	-$29.8
Enhanced Retreat (Scenario 2)	-$4.5	-$149.1	$149.1	$10.8	-$130.9	$10.6	-$114.0

[1] Costs (or reduced benefits) enter as negative numbers. Benefits (or reduced costs) enter as positive numbers. All benefits and costs are relative to the No Action alternative.
[2] Change in benefits due to the total loss of housing structures.
[3] Damages to remaining housing structures. Although the beach width is similar under nourishment and enhanced retreat, damages avoided differ due to (a) the construction of additional protective dunes under beach nourishment and the removal of homes under enhanced retreat that would otherwise be subject to damage.

Study results also suggest that each community has its own distinct characteristics and that the data should be looked at on a community-by-community basis as well, not simply a scenario basis (Table ES.4). The patterns in Table ES.3, in general, carry over to each individual community. The community-level disaggregation illustrates that in all but two cases, the net benefits of the three management scenarios are consistently negative. However, the community disaggregation also suggests that trends for smaller linear waterfront communities will vary greatly from larger communities that are comprised of a larger or wider upland footprint. Finally, results in Table ES.4 illustrate that shoreline management action is potentially efficient for a small number of communities, in few cases.

Table ES.4: Net Benefit by Scenario and Community

Community	Nourishment	Basic Retreat	Enhanced Retreat
	Net Benefit (PV, $mill)	Net Benefit (PV, $mill)	Net Benefit (PV, $mill)
Pickering	-$3.2	-$0.5	-$1.8
Kitts Hummock	-$4.6	-$1.6	-$6.9
Bowers	-$3.1	-$2.9	-$5.8
South Bowers	-$3.8	-$0.4	-$1.4
Slaughter	-$11.6	$0.7	-$8.5
Prime Hook	-$4.6	-$3.4	-$36.4
Broadkill	$6.8	-$21.9	-$53.2
Total	**-$24.1**	**-$29.8**	**-$114.0**

Notes: Net benefits calculated relative to the No Action Scenario. The table reports all figures in 2011 dollars. The reported values are the present value of the stream of annual estimates aggregated across 30 years (from 2011 to 2041) and discounted at 4%.

The community-specific nature of the management scenarios is best illustrated by Slaughter Beach and Broadkill Beach. Broadkill Beach and Slaughter Beach are the only two communities with a positive net impact for any management scenario. Broadkill Beach was the only community with a positive net impact under the Beach Nourishment Scenario. The Beach Nourishment Scenario produces negative net impacts ranging in value from $3.1 million (Bowers Beach) to as large as $11.6 million (Slaughter Beach) for the other six bay communities, while Broadkill Beach's benefits outweigh management costs by $6.8 million. Impacts to recreational use and avoided flood damage drive the positive gains at Broadkill Beach. Broadkill Beach has the highest visitation levels out of all the communities and largest development. The Nourishment Scenario not only preserves the beach widths to support current visitation by beach goers, but also protects the existing structures from erosion and flooding.

Under the Basic Retreat Scenario, however, Broadkill Beach displays the highest negative net impact. This reflects the substantial loss of housing services in this area, which overwhelms all other costs and benefits in this case. Only one community, Slaughter Beach, experiences a predicted gain under basic retreat. Benefits outweigh cost by $0.7 million. Additionally, two communities, Pickering Beach and South Bowers, have net impacts that are only marginally negative. The Basic Retreat and No Action Scenarios both involve 38 out of the community's 43 buildings being lost. However, the two scenarios differ in the timing of when these structures are lost. The negative net impact mainly arises as a result of the Basic Retreat Scenario bringing forward the timing of when some structures would be lost in Pickering Beach. As a result of the earlier timing, Pickering Beach experiences housing service losses sooner relative to the No Action Scenario.

Community-by-community results for enhanced retreat are similar in general pattern but larger than those for basic retreat. This difference is particularly notable for Prime Hook, whose predicted negative net benefits increase by more than a factor of ten under enhanced retreat, compared to basic retreat. Losses for Slaughter beach also increase greater than ten-fold. In both cases, this is due to the location of community houses, such that housing service losses are much greater in these two communities under enhanced retreat. In contrast to nourishment and basic retreat, under which at least one community realizes net benefits, all communities realize net losses under enhanced retreat. Again, this is due to the large losses of housing services under this scenario.

Finally, the economic analysis provides information on the distribution of costs and benefits among various groups. To date, the State of Delaware (reflecting all Delaware taxpayers) has borne almost exclusively the costs for shoreline adaptation in these communities while the communities and property owners have realized the benefits. These patterns, in general, would be continued under each of the three management scenarios – with the State (taxpayers and non-residents) bearing the majority of the costs and community residents receiving the majority of benefits. Hence, the net benefits for community residents are positive, while the overall net benefit to all Delaware residents (taxpayers and community residents) is negative. This discrepancy shows the importance of an analysis of the distribution of benefits and costs across different groups.

Table ES.5 reports the distribution of net benefits (benefits minus costs) between local community residents and general taxpayers and non-residents. As shown by the table, local community residents are the primary beneficiaries of beach management. In all cases, the net benefits of shoreline management are positive for residents of the Delaware Bay communities, yet are negative for non-residents and taxpayers. The primary reason is that nourishment and demolition costs are borne by the State, along with the cost of housing service losses for properties acquired by the state. Most benefits of management, however, are realized by Bayshore community residents. The sole exception is recreation, for which the majority of benefits are realized by non-residents.

Table ES.5: Distribution of Net Benefits by Management Scenario

Metric	Units	Beach Nourishment		Basic Retreat		Enhanced Retreat	
		Taxpayers & Non-Residents	Residents	Taxpayers & Non-Residents	Residents	Taxpayers & Non-Residents	Residents
Net Benefits	PV, $mill	-$48.1	$24.0	-$52.3	$22.5	-$143.7	$29.7

Notes: All values reported in 2011 dollars. The figures are the present value of the stream of costs and benefits aggregated across 30 years (from 2011 to 2041) and discounted at 4%. In Appendix D and E, Scenario 1=Beach Nourishment; Scenario 2=Enhanced Retreat; Scenario 3=Basic/Strategic Retreat; Scenario 4=No Action

Table ES.6 illustrates the distribution of these benefits across communities. In all cases, the same pattern holds. Residents of Bayshore communities universally benefit from beach management options, whereas taxpayers and non-residents almost always realize negative net benefits.

Table ES.6: Distribution of Net Benefits by Management Scenario, By Community

Community	Beach Nourishment (PV, $mill)		Basic Retreat (PV, $mill)		Enhanced Retreat (PV, $mill)	
	Taxpayers & Non-Residents	Residents	Taxpayers & Non-Residents	Residents	Taxpayers & Non-Residents	Residents
Pickering	-$5.8	$2.6	-$3.3	$2.8	-$5.1	$3.2
Kitts Hummock	-$7.3	$2.7	-$4.5	$2.9	-$11.1	$4.2
Bowers	-$4.1	$1.0	-$3.6	$0.7	-$7.2	$1.4
South Bowers	-$4.2	$0.5	-$0.8	$0.4	-$2.2	$0.8
Slaughter	-$12.9	$1.2	$0.2	$0.5	-$9.4	$0.9
Prime Hook	-$6.7	$2.1	-$4.7	$1.3	-$39.0	$2.6
Broadkill	-$7.1	$13.9	-$35.8	$13.9	-$69.7	$16.6
Total	**-$48.1**	**$24.0**	**-$52.3**	**$22.5**	**-$143.7**	**$29.7**

Notes: All values reported in 2011 dollars. The figures are the present value of the stream of costs and benefits aggregated across 30 years (from 2011 to 2041) and discounted at 4%.

Report Structure

The content and structure of the report is as follows.

- **Purpose and Objectives (Chapter 1).** Chapter 1 informs the reader on why this study was prepared, and briefly describes the long-term (30-year) management plan that is the foundation for performing an economic analysis of shoreline management alternatives and public involvement.
- **Background (Chapter 2).** Chapter 2 provides context and background. It first provides a brief history of the State of Delaware's bay shoreline management activities and discusses some of the technical and fiscal challenges of maintaining these activities. The chapter then describes each of the seven bay communities.
- **Approach to this Study (Chapter 3).** Chapter 3 sets out the study's approach and data collection and modeling efforts; describes the project scope, management scenarios, and approaches to measuring physical and economic impacts; and details the data collection process.
- **Management Costs (Chapter 4).** Chapter 4 presents estimated costs of shoreline management for each scenario.
- **Benefits Analysis (Chapter 5).** Chapter 5 details the approach and estimates for each of the broad benefits categories considered in this analysis. These benefits are:
    - Lost Housing services
    - Flood damage
    - Recreation
    - Taxes

- **Key Findings/Results (Chapter 6).** Chapter 6 discusses the net impact of each management scenario. It provides summary tables of the results by cost and benefit category and by community.
- **References (Chapter 7).** Chapter 7 includes a list of references contained in the document.