APPENDIX B

ECONOMIC ANALYSIS

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ECONOMIC ANALYSIS

1.0 INTRODUCTION

The total economic impact area for Willoughby Spit and Vicinity is an important part of the city of Norfolk. The study area comprises the only beach front of the city of Norfolk. The study area for hurricane and storm damage reduction and regional economic development (RED) are described in the sections below.

1.1 Hurricane and Storm Damage Study Area

The shoreline at Willoughby Spit and Vicinity is subject to damages from hurricanes and storm related erosion. The study area includes 7.3 miles of shoreline along the southern shore of the Chesapeake Bay in the city of Norfolk, VA. The location and orientation of the study area shoreline at the southern boundary of the Chesapeake Bay and immediately within the mouth of the bay make the area highly susceptible to damages associated with coastal storm activity. A feasibility report completed in 1983 concluded that the most practical and efficient plan for addressing the problems and needs of the study area consisted of the construction of a beach berm along the entire 7.3 mile study area shoreline where an adequate berm does not exist, as well as periodic beach nourishment as needed. The hurricane and storm damage study area is divided into economic reaches shown on Plate B-1.

1.2 Recreation Day User Study Area

Based on surveys, discussions with City Parks and Recreation Department personnel, and beach counts accomplished by Corps of Engineers personnel, it is estimated that the existing beach provides sufficient capacity for peak day use. The data indicate that the three park beaches are the only sections of the study area where beach area would become more deficient in the future as demand increases in response to population growth in the surrounding area. A more detailed recreation analysis can be found in Section 9 of this Appendix and in Attachment B-1.

2.0 EXISTING ECONOMIC CONDITIONS

2.1 Basic Economic Assumptions

This study is in compliance with the evaluation procedures outlined in the Water Resource Council's Economic and Environmental Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies, dated 10 March 1983, and Corps of Engineers policy guidance on shore protection, ER 1105-2-100, dated 22 April 2000. The following basic economic assumptions were used in the analysis of damages, benefits, and costs.

- **Interest rate.** The FY 2012 Federal interest rate is 4.0 percent.
- **Price level**. October 2012 price levels.
- **Period of Analysis.** The analysis is based on a 50-year period.

2.2 Demographics

Demographics for the existing economic conditions for the study area include census data for population, housing, and personal income, which are shown in the following table.

Table B-1. POPULATION, INCOME, HOUSING SUMMARY

	City of Norfolk	Willoughby Spit and Vicinity
Population (2010 Census)	242,803	16,595
Ave. Household size	2.63	1.87
Housing Units	95,018	9,643
Per capita & Household Income		
Per capita money income	$23,773	$28,977
Median Household Income 2010	$42,677	$43,859

Source: U.S. Census Bureau (http://factfinder.census.gov
Willoughby Spit and Vicinity is the total of all census tracts covering the study area.

2.3 Shoreline Ownership

Public ownership of the shore at Willoughby Spit and Vicinity bottomlands below mean low water (MLW) are owned by the Commonwealth of Virginia. Other parcels are owned by the city of Norfolk including the beach itself and public access points. The primary ownership of the ocean front parcels is private except for the parks. Privately owned properties included in the project are considered to be in-fee simple ownership. Included within the project limits are single family residential units, multi-family and condominium units, and commercial properties, restaurants, motels and retail markets. Other information related to ownership of the shoreline is contained in the Real Estate Plan.

2.4 Development Added to Existing Condition

The without-project structure inventory assumes typical residential structures will be built on many but not all suitable vacant first row lots. Some of the lots have been vacant for some time and are not currently for sale. The vacant lots included in the East Beach Community that is part of the Norfolk Housing Redevelopment Authority efforts to revitalize the area are considered to have structures on them representative of the community. There is no typical construction type in the study area, although in recent years, larger, more expensive residential structures have been built, typically in excess of 3,000 square feet and two to three story structures. However, there are still many structures dating to the mid 20th century and some dating back to the late 19th century.

2.5 Storm Related Emergency Costs

2.5.1 City of Norfolk Emergency Costs. Emergency costs incurred by the city of Norfolk represent the average costs to the city for removing sand and debris from the ocean front roads in the study area following the storms. The city reported a onetime recent expenditure of $88,000 to remove pier debris after Hurricane Isabel. The pier has since been replaced with a concrete structure and no plans developed would provide protection to the pier. Therefore. costs of this nature will not be included in the benefit evaluation.

2.5.2 Damage to Public Property. Damages to public property include damages to the water and electric utility distribution systems, public access walkways, bath houses, and parking lots, etc. Since traditional structural and content damage curves do not apply to these types of damages, this damage prevented category is based on interviews with public works officials concerning storm related damages that could have been prevented by a large shore protection project.

2.6 Determination of Structure Values

The value of structures is limited to replacement cost less depreciation. Replacement value is the maximum cost to the owner if a structure is destroyed. Other measures of property value include fair market value and the income producing value. These measures are not considered appropriate for National Economic Development benefits to protection of beach property. Fair market value is influenced by proximity to the ocean or sound, corresponding views of the beach and ocean, and short-term fluctuations in the local real estate market. Basing value on income can also produce significantly higher estimates. It is assumed that rental income lost to the owner will be transferred to some other owner in an alternate location. Therefore, the loss of income is considered a regional economic loss and not a loss to the National Economic Development account.

2.6.1 Cost of Replacement. The cost of replacing residential structures was based on a sample of structures representative of those in the study area. The cost of replacing structures was based on the square footage and according to the quality of the initial construction. All residential structures were considered to be constructed at average quality. The cost per square foot is also a function of the size of the structure, the number of stories and construction material. Each structure then had a cost per square foot dependent upon its construction parameters. This cost was then depreciated based on age and condition of the structure. The costs per square foot were developed using RSMeans cost guide. The square footage areas for most structures were available at the city of Norfolk tax offices.

2.6.2 Commercial Structure Values. Values for commercial structures were based on visual surveys and calculations made using the Marshall and Swift cost guide. An average per foot cost of replacement was calculated for the different types of commercial structures and then applied to the other structures. This cost was then depreciated based on age and condition of the structure. An average cost per square foot was used as the number of commercial properties is quite small when compared to the number of residential structures. City of Norfolk tax data was also used for comparison.

2.6.3 Value of Structures by Reach. The value of structures within the hurricane and storm damage study area is estimated to be $198,200,000 with a total value, including contents, estimated at $247,300,000. The value of structures by reach is shown in the following table. The estimated value of residential and commercial contents is discussed in section 5.5.1 under the topic Variables Specific to Damage Element File.

Table B-2. VALUE OF STRUCTURES BY REACH

	Values October 2012*		
Economic Reach	Structures	Contents	Combined
1	$56,400,000	$14,200,000	$70,600,000
2	$85,100,000	$20,800,000	$105,900,000
3	$56,700,000	$14,100,000	$70,800,000
Total	$ $198,200,000	$ 49,100,000	$247,300,000

*Rounding may cause some calculations to vary slightly.

2.6.4 Value of Structures by Type. There are a total of 1,004 structures in the structure damage database as shown in the following table. There are 14 structure types in the study area that have values; however, only single family residences for two and three-story structures and multi-family structure types equal or exceed 10 percent of the total value. In addition, single story residences account for 137 structures and 7.8 percent of the total inventory value. Two-story residences account for 166 structures and 16.0 percent of total inventory value. Three-story residences account for 149 structures and 20.1 percent of total inventory value. Multi-family structures account for 372 structures and account for 40.7 percent of total inventory value.

Table B-3. VALUE OF STRUCTURES BY TYPE

Type	Count		Structures	Contents	Combined
SFR1	137		$ 15,400,000	$ 3,800,000	$ 19,200,000
SFR2	166		$ 31,700,000	$ 7,900,000	$ 39,600,000
SFR3	146		$ 39,900,000	$ 10,000,000	$ 49,900,000
APTMulti	372		$ 80,500,000	$ 20,100,000	$ 100,600,000
Condotower	5		$ 20,000,000	$ 4,700,000	$ 24,700,000
Motel	12		$ 6,400,000	$ 1,300,000	$ 7,700,000
Restaurant	7		$ 1,600,000	$ 800,000	$ 2,400,000
Retail	9		$ 500,000	$ 300,000	$ 800,000
Garage	120		$ 1,600,000	$ 200,000	$ 1,800,000
Dune Cross Over	12		$ 300,000	$ -	$ 300,000
Pool	4		$ 300,000	$ -	$ 300,000
Tennis Court	1		$ 27,000	$ -	$ 27,000
Park	6		$ -	$ -	$ -
Vacant	7		$ -	$ -	$ -
Total	1004		$ 198,200,000	$ 49,100,000	$ 247,300,000

2.7 Land Values

Land values in coastal Virginia are escalating, in general, due to increased population growth in the U.S. coastal regions. To prevent the influence of water view or proximity to the ocean overriding the value, only the interior lot values are used in the analysis. Following the November 2009 Nor’easter, the city of Norfolk spent $241,870 to place 47,100 cubic yards for emergency dune restoration on Willoughby Spit. This is not considered a long term solution or effective measure against long term erosion or hurricane and storm damage; therefore, it is not practical to equate the cost of fill to the land value lost due to long term erosion.

The improved property value to use in the evaluation of damages/losses to improved property was determined by comparing the market value of the land adjacent to the beach with nearshore land values. Corps of Engineers procedures require the use of nearshore land values to estimate the value of land lost. Nearshore land is defined as upland sufficiently removed from the shore to lose its significant increment of value because of its proximity to the shore when compared to adjacent parcels that are more inland. The market value of typical lots adjacent to the beach range from a low of $300,000 to over $1,500,000 with average values per square foot ranging from $26.80 to $75.72. In the study area, real estate investigations indicate that nearshore land values to be about 31.5 percent of market value of land located directly on the beach or a cost of $16.14 per square foot.

2.8 Local Costs for Shore Protection

The city of Norfolk has in place its own nourishment plans. However, these plans provide less than adequate shore protection. The shoreline has continued to experience erosion and suffered damages. From the period of 1982 thru 2010, the city of Norfolk expended approximately $13,489,000 on beach nourishment. That equates to approximately $21,065,000 at current price levels. This resulted in the placement of approximately 2.9 million cubic yards of material over the 29-year period. This results in an average cost of $726,000 annually on beach replenishment. This does not include funds used to replenish dunes or construct breakwaters. Including the costs to replenish dunes results in a total current cost of $21,352,000 and average annual costs of $736,000. Beach-*fx* modeling results predict an average annual costs of approximately $790,000 in local costs in the without-project condition. Additionally, the city of Norfolk expends approximately $250,000 annually on surveying, monitoring and maintenance.

3.0 WITHOUT-PROJECT FUTURE ECONOMIC CONDITIONS

3.1 Assumed Conditions at Beginning of Period of Analysis Without-Project Condition

The period of analysis begins when the project improvement is in place and the benefits to the public begin to accrue. It is assumed that this condition could occur by 2016. Many, but not all, suitable vacant lots are expected to be developed by the base year in 2016; however, no additional growth in the number of residential or commercial structures is projected during the period of analysis. Common practice and historical evidence allow for rebuilding structures lost in storms provided setback restrictions are met. However, the analysis presented in this report limits the number of replacements to two. After erosion has claimed enough distance in a lot to condemn it, Beach-*fx* ceases to reinstate the same property. This assumption will prevent the overestimation of the without-project hurricane and storm damages. There is one structure in which condemnation was eliminated, a condominium tower with exceptionally deep piles and an older, locally constructed seawall.

3.2 Assumed Replacement of Residential Structures During Period of Analysis

It is assumed that all structures replaced in the study area as a result of hurricane and storm erosion damages will be similar to the existing distribution of residential and commercial use.

It is assumed that residential structures removed by erosion on condemned lots will not be replaced during the 50-year period of analysis. Likewise, it is assumed that residential structures destroyed by wave, flood, or storm erosion will be replaced in the Beach-*fx* model by a residential structure that is similar to what was lost.

3.3 Assumed Replacement of Commercial Structures During Period of Analysis

Commercial structures that are replaced in the economic damage model during the period of analysis will be identical to the structure destroyed. It is assumed that commercial or multi-family zoning will remain the same for the replacement structures.

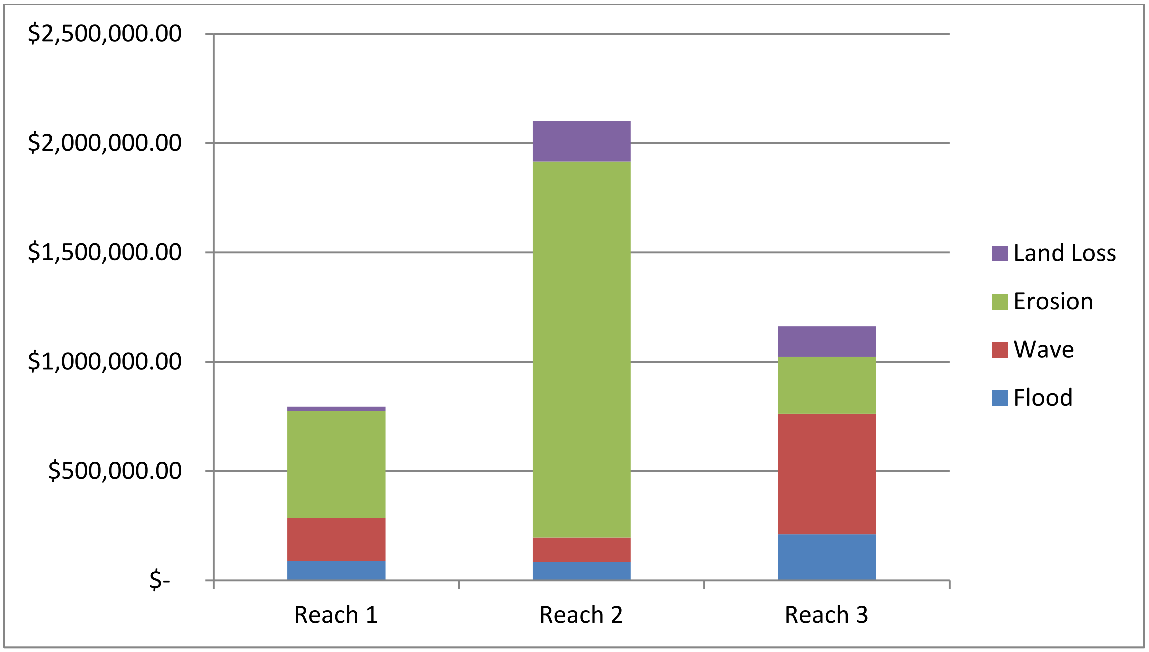
3.4 Summary of Future Without-Project Economic Conditions

In summary, the future economic conditions are assumed to have the same distribution of residential use and commercial development as the existing condition. All structures not damaged or destroyed are assumed to remain without any modification. No “teardowns” are allowed into the analysis where older structures are assumed to be torn down/demolished and replaced by more expensive units based on investment speculation related to the high demand for coastal real estate.

4.0 HURRICANE AND STORM DAMAGES WITHOUT-PROJECT

The accumulated average annual value of hurricane and storm damages and local costs to prevent storm damage over the 50-year period of analysis without a damage reduction project totals $5,101,000 in October 2012 price levels. The damages are shown by damage category and reach segment in the following figure. The figure does not show the $1.04 million in local cost foregone. This cost is considered a benefit to a Federal project and is counted as such in the analysis. Average annual damages (average annual equivalent amounts, 50-years, 4.0%) are calculated by using the 50-year interest and amortization.

Figure B-1. AVERAGE ANNUAL DAMAGES BY REACH



4.1 Damage Categories Defined

It should be noted that hurricane wind speed, the deciding factor in storm category by FEMA, does not determine the level of damages in the storm damage model. The impact of wind is not shown in the storm damage figure and wind damage is not estimated in the storm damage model. Hurricane and storm damages are calculated under with and without-project conditions for damages to structures and contents, roadways, and land lost due to long-term erosion.

In many cases damages are calculated for more than one category since storms frequently generate flood inundation, waves, and storm erosion simultaneously. Beach-*fx* calculates damages in all the appropriate categories and selects the category with the greatest damage and ignores the other damages. This technique prevents the overestimation or double counting of damages.

4.1.1 Storm Erosion. Storm erosion damages result from the undermining of structure pilings and foundations due to wave action during hurricane and tropical storms. Damages due to storm induced erosion are the major damages that are generally computed by the economic damage model. Beach-*fx* calculates the pre and post-storm profiles taking into account the dynamic effects of long term erosion, previous storm induced erosion, emergency and planned nourishments to determine the effects on the structure for each event.

The majority of structures located along the beach front in the study area are older and were not constructed on deep piles as most modern beach front structures are today. The pile foundations for the structures in the study area are relatively shallow as compared to those in coastal communities located on the Atlantic Ocean of Gulf of Mexico. Many of the structures are built on piles, but these are more similar to crawl space foundations with some pile component than they are to a strict definition of a typical deep pile foundation; therefore, they are more susceptible to structural damage caused by storm erosion.

While the vertical scour around the piles and foundations of beach front structures may not cause the building to collapse, the open exposure caused by the storm induced erosion and lowering of the beach fronting is often sufficient enough to result in complete loss of the economic value of the building, even though the building may be left standing. For this reason, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure if the structure is not on a pile foundation. If the structure is on piles, erosion needs to cause the beach to retreat entirely throughout the footprint before total damage is claimed. Before total failure for both foundation types, the percent damage claimed is equal to the proportion of erosion under the structure's footprint compared to the total footprint. However, certain structures were exempted from erosion damages due to the quality and depth of pile construction.

The economic value of the building may also be affected by erosion damage that results in the inability of the owner to reestablish a useable sewer system or obtain potable water. In some cases where erosion is significant enough to impact accessibility to basic utilities, the building will eventually have to be torn down. The damage associated with this condition has been broadly termed erosion damage; however, as demonstrated by the explanation provided above, the cause of the damage is not limited to erosion; rather it is due to the conditions created by the erosion that exposes the building to the maximum forces of the storm.

4.1.2 Flood. Flood damages are caused by inundation related to rises in tide and storm surge. Damages begin when flooding and overwash reaches the structure or enclosure.

4.1.3 Waves. Wave damages result from waves over and above the storm surge making contact with the structures. Waves impacting the structure three feet or more above the first living area elevation are expected to result in total loss of the structure.

4.1.4 Damages and Losses to Improved Property. Land losses result from long-term erosion based on the analysis of historical erosion including rises in sea level. Damages/losses to improved property were computed as the market value of the area expected to be lost. Nearshore land values are used to estimate the value of land lost. This analysis will focus on developed land lost to long term and storm erosion. As part of the Beach-*fx* output, land loss is calculated based on the width of the upland. The upland is the portion of the study area behind the dunes where structures are located; as this upland width changes, the amount of developable land changes. The difference in this change of upland width is used to calculate the amount of developable land loss. The output is provided for each 50-year iteration; therefore, it is possible to determine when the potential loss occurs over each iteration and calculate that loss in line with the event based calculations with-in the model.

5.0 Economic Variables, Assumptions, and Methodology Applied in Hurricane and Storm Damage Model (Beach-*fx*)

In the Beach-*fx* model the economic input includes a set of general global data that applies to the entire analysis, the estimated base year when damage reduction measures could be in place, flood damage curves, erosion damage curves and the variable inputs for each damage element in the structure inventory data base or damage element file.

5.1 General Global Data

Based on the general economic assumptions, the global values are as follows:

- Interest Rate: 4 percent
- Price Level: October 2012 price level
- Economic Period of Analysis: 50 years beyond the base year
- Wave damage Assumption: Waves three feet above the first floor elevation will result in the total loss of the structure.

5.2 Base Year

The Base Year is defined as the first year hurricane and storm damage reduction measures could be in effect. It is expected that damage reduction measures could be implemented by 2016.

5.3 Flood Damage Curves

Flood damages due to inundation are determined by the combined height of the storm still water level and a superimposed wave height. Based on the elevation of this combined height and the elevation of the structures first floor, the amount of inundation damage is determined from a set of inundation damage curves. The damage elements and their damage curves are described more fully in the damage element section of Attachment B-1 to this appendix.

5.4 Erosion Damage Curves

The erosion curves used are dependent upon the foundation type. As previously mentioned, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure if the structure is not on a pile foundation. If the structure is on piles, erosion needs to retreat entirely through the footprint before total damage is claimed. Before total failure for both foundation types, the percent damage claimed is equal to the proportion of erosion under the structure's footprint compared to the total footprint. Certain structures, however, were exempted from erosion damages due to the quality and depth of pile construction.

5.5 Wave Attack Damage Curves

Damages due to wave attack are based on the waves impacting the structure. Waves impacting the structure three feet or more above the first living area elevation are expected to result in total loss of the structure.

5.5.1 Variables Specific to Damage Element File. The damage element file describes the value of each structure and its contents to include a low, most likely and high value for each type. The damage element file also includes the horizontal and vertical location of the structure within the coastal damage model, and specifies which flood damage curve, wave attack curve, and erosion damage curve is appropriate for the structure. The structures are geo referenced and a width and length is given to provide the footprint of the structure.

5.5.2 Structure Type – flood damage curve. Structure type denotes the flood damage curve that is to be used with each structure. Residential structure types for all residential structures in the study area were based on visual observation by Corps of Engineers personnel including documentation with digital photographs. Descriptions included the number of levels (1, 2, or 3 story), type of foundation (P=on pilings, S=Slab). Commercial business types include hotels, motels, restaurants, and retail.

5.5.3 Structure Value. Structure values are entered in dollars based on the replacement cost less depreciation. Determinations of commercial structure values and description of the business type were made by Corps of Engineers personnel with additional checking against tax records. Structure values represent the replacement value less depreciation at the current price levels. While some information on structures was obtained from the city of Norfolk assessor's office; replacement costs are based on site-specific building cost for Norfolk.

5.5.4 Content Value. Contents of residential structures include personal possessions including furniture, clothing, dishes, cooking utensils, linens, jewelry, stereo equipment, etc. For homeowners' insurance coverage, the standard coverage for contents is 50 percent of the dwelling coverage. Contents for residential structures are estimated to be 25 percent of the structure value at its low, most likely, and high values. While guidance allows for the use of up to 50 percent empirical data is not available to support this.

Estimates of values of contents of commercial structures in the primary study area are based on the type of commercial activity. Each type of business has a unique content factor applied to its structural values. Given the relatively small number of commercial structures, this was deemed appropriate.

5.5.5 Elevation at ground. Ground elevations were taken during structure surveys and during profile surveys. The city of Norfolk conducts biannual profile surveys of the entire shoreline.

5.5.6 Elevation at First Floor. The first-floor elevations were surveyed by the location of the front entry threshold. First floor elevations were surveyed by Corps of Engineers personal. For vacant lots that are expected to be constructed on, the first floor elevation was assigned based on the most recent construction in that neighborhood.

5.6 Beachfill Evaluations

As explained previously the Beach-*fx* program is used to estimate benefits of alternative plans. To evaluate alternative plan storm damage reduction benefits, a comparison was made of without-project damages with the with-project residual damages. This difference defines the storm damage reduction benefits. These benefits were determined for each reach and for each alternative.

Beach-*fx* also estimates present worth costs for the alternative beachfill plans based on initial sand volumes and renourishment sand volumes needed to replenish sand lost due to long-term and storm erosion. Beach-*fx* applies unit costs for dredging these sand volumes and applies mobilization and demobilization costs for each job. Other estimated costs included are engineering and design costs and contract supervision and administration.

Three potential borrow sites were identified for Willoughby Spit and Vicinity. They are all located within the Chesapeake Bay. The Thimble Shoal site is located in the auxiliary channels of the Thimble Shoal Channel coming into the port. The Willoughby Banks site is located offshore of Willoughby Spit approximately one mile. The Hampton/Buckroe Beach site was an alternative site to the Chesapeake Bay Shoreline, Hampton, Virginia, Hurricane and Storm Damage Reduction Study. It is located across the Thimble Shoal navigation channel offshore of Hampton, VA approximately five miles away.

The Thimble Shoal site has a cost of $12.11 per cubic yard based on one million cubic yards of placement. The overfill ratio is 1.2. The Willoughby Banks site has a cost of $12.31 per cubic yard based on one million cubic yards of placement and an overfill ratio of 1.85. The Hampton/Buckroe Beach site has a cost of $12.62 per cubic yard based on one million cubic yards of placement and it has a an overfill ratio of 1.2.

To determine the optimal site, ten iterations were run in Beach-*fx* using an alternative with a 30-foot dune width, a 10-foot dune height and a 50-foot construction berm for each of the borrow sites. These iterations were run utilizing the same simulation seed so that the storm generation and impacts on the shoreline would be the same for each site considered. The cost of the planned nourishment output from Beach-*fx* is compared in the table below.

Table B-4. BORROW SITE ANALYSIS

Borrow Site	Average Annual Costs
Thimble Shoal	$ 1,326,000
Hampton/Buckroe Beach	$ 1,382,000
Willoughby Banks	$ 1,340,000

The lowest cost borrow site is the Thimble Shoal Auxiliary Channel and will be used in the evaluation of alternative plans. While the Willoughby Banks site is very close in cost, the nature of the material and its characteristics in relation to the native material preclude it from further consideration.

6.0 ALTERNATIVES TO REDUCE HURRICANE AND STORM DAMAGES

Expected storm and erosion related damages are first computed for the without-project condition, then again for the various plans of improvement over approximately 7.3 miles of the primary study area. Structural, non-structural, and no action alternatives were considered. Structural plans include beachfill plans which have potential to prevent the progressive erosion of the shoreline, reduce damages caused by erosion, flooding, and wave impact during coastal storms and decrease storm related emergency expenditures. No-action is also an alternative but does not preclude emergency measures of dealing with erosion, such as sandbagging; however, in the long run, these emergency measures are assumed to be ineffective.

6.1 Structural Plans

Various beachfill projects were evaluated for their effectiveness in reducing hurricane and storm damages. The authorized project was evaluated in addition to new alternatives. The authorized project consists of a berm with an average width of 60 feet constructed at an elevation of 3.5 feet, NAVD 88, with a foreshore slope of one on 15 extending to the natural bottom. The authorized project would require periodic nourishment in order to maintain the integrity of the protective berm. Although the actual nourishment requirements would be evaluated on an annual basis, nourishment cycles were projected in the original feasibility report to be 5, 10, and

15 years for East Ocean View, Central Ocean View, and West Ocean View – Willoughby Spit, respectively. The renourishment cycle would be approximately 9 years based on results of the Beach-*fx* model. Nourishment would occur when the 60-foot berm had eroded to a width of 30 feet. The city of Norfolk would continue to maintain the existing dunes at their expense.

In addition to the previously authorized plan, other structural alternatives were evaluated and included various combinations of berm and dune widths and dune heights, as well as different nourishment intervals. The naming convention uses the parameters of the alternative unless otherwise stated as the Authorized or Without-Project Condition. For instance, the alternative DW 30 H10 B 50 – 5 consists of a dune width of 30 feet, a dune height of 10 feet and a construction berm of 50 feet (construction berm is equal to twice the design berm) with a 5-year nourishment increment. The plans are shown in the following table.

Table B-5. ECONOMIC COMPARISONS

Alternative	Average Annual Benefits	Average Annual Costs	Benefit Cost Ratio	Net Remaining Benefits

Alternative	Average Annual Benefits	Average Annual Costs	Benefit Cost Ratio	Net Remaining Benefits
Without Project Condition	$ -	$ -	-	$ -
Authorized Project	$ 2,420,000	$ 1,830,000	1.32	$ 590,000
DW 30 H10 B 50 - 5	$ 3,090,000	$ 1,670,000	1.84	$ 1,420,000
DW30 H10 B100-5	$ 3,470,000	$ 2,710,000	1.28	$ 760,000
DW30 H10 B 150-5	$ 3,650,000	$ 3,510,000	1.04	$ 140,000
DW30 H14 B50-5	$ 4,570,000	$ 2,470,000	1.85	$ 2,100,000
DW30 H14 B100-5	$ 4,530,000	$ 3,480,000	1.30	$ 1,050,000
DW30H14B150-5	$ 4,490,000	$ 4,310,000	1.04	$ 180,000
DW30H10B50-7	$ 2,880,000	$ 1,910,000	1.51	$ 970,000
DW30 H10 B100-7	$ 3,320,000	$ 2,800,000	1.19	$ 520,000
DW30 H10 B150-7	$ 3,530,000	$ 3,580,000	0.99	$ (50,000)
DW30H14B50-7	$ 4,570,000	$ 2,500,000	1.83	$ 2,070,000
DW30H14B100-7	$ 4,540,000	$ 3,510,000	1.29	$ 1,030,000
Dw30 H14 B150-7	$ 4,490,000	$ 4,350,000	1.03	$ 140,000

All beach nourishment plans shown have positive NED benefits; however, the plan with the greatest net NED benefits is the Plan DW 30 H14 B 50 - 5. The NED Plan is defined as the alternative that maximizes net NED benefits. The plan consists of a dune width of 30 feet, a dune height of 14 feet and a berm width of 50 feet (construction berm). The analysis restricted the renourishment cycle to a minimum of 5 years. The average nourishment cycle was 11 years. The local sponsor has chosen to construct the locally preferred plan (LPP). Therefore, the economics of the LPP and the NED Plan will be presented. The benefits presented in Table 5 are further discussed in Tables B-8 and Tables B-9 in Section 7.2.

6.2 Non-structural Plans

Non-structural plans consist of measures that are applied to threatened structures on an individual case-by-case basis. However, the non-structural plans are already in place and considered a part of the existing condition.

7.0 ECONOMICS OF NED PLAN (PLAN DW 30 H14 B 50 - 5) AND THE LOCALLY PREFERRED PLAN (AUTHORIZED PROJECT)

7.1 Economic Damages – remaining with plan

A major consideration in evaluating any plan is the estimated damages remaining with the project plan. The accumulated present value of remaining damages for the two plans is presented in Table B-6. A summary of average annual equivalent remaining damages is shown in Table B-7.

Table B-6. PRESENT VALUE OF REMAINING DAMAGES

Plan Name	Structure Damage	Content Damage
Authorized	$46,380,000	$11,310,000
DW 30 H14 B 50 – 5	$9,470,000	$2,270,000

Table B-7. REMAINING AVERAGE ANNUAL HURRICANE AND STORM DAMAGES

Plan Name	Structure Damage	Content Damage
Authorized	$2,160,000	$530,000
DW 30 H14 B 50 – 5	$440,000	$110,000

7.2 Economic Benefits

The primary benefits to the NED and Authorized Plan are the hurricane and storm damage reduction benefits. The total damage reduction benefits are computed by subtracting the remaining damages from the total without-project damages. Hurricane and storm damage reduction benefits total $1,040,000 for the Authorized Project and $3,180,000 for the NED Plan and are shown by type in Table B-8.

7.2.1 Hurricane and Storm Damage Reduction Benefits. The benefits for storm damage reduction are presented below and include reductions in damages to structures and reduction in the loss of developable land. These benefits are not the total benefits and do not include the local costs foregone, those are discussed in the next section.

Table B-8. AVERAGE ANNUAL HURRICANE AND STORM DAMAGE REDUCTION BENEFITS FOR THE NED PLAN AND THE AUTHORIZED PLAN

Plan	Damage Reduction Benefits	Land Loss Benefits	Total
NED Plan	$3,180,000	$340,000	$3,520,000
Authorized Plan	$1,040,000	$340,000	$1,380,000

7.2.2 Reduced Emergency Costs Benefits. Emergency costs occur with the preparation and response to storm events. These can include post-storm cleanup, emergency shelters, emergency response and housing for property owners. However, many of the costs for operating storm shelters, emergency response, and clean up are not specific to the project area and will continue with or without a project. While some of these costs could be reduced with the implementation of a storm damage reduction project, the accuracy and applicability of these costs are uncertain. Thus, while it is acknowledged that there could be a reduction in the emergency costs due to storms, the uncertainty is great enough that these benefits will not be used.

7.2.3 Local Costs Foregone. The city of Norfolk has in place its own nourishment plans. The continuation of the city's beach nourishment program would cost an expected $790,000 annually in beach nourishment. This cost is counted as a benefit for local costs foregone as the city of Norfolk would no longer have to expend these funds on its own program. Additionally, the city of Norfolk expends approximately $250,000 annually on surveys, monitoring and maintenance.

7.2.4 Summary of Benefits to NED and Authorized Plans. A summary of the hurricane and storm damage reduction benefits is shown in the following table.

Table B-9. SUMMARY OF BENEFITS TO NED AND AUTHORIZED PLANS

	Average Annual Amount in Dollars	
Benefit Category	NED Plan	Authorized Plan
Hurricane & Storm Damage Reduction	3,180,000	$1,040,000
Local Costs Foregone	$1,050,000	$1,040,000
Land Loss	340,000	$340,000
Total Average Annual NED Benefits	4,570,000	$2,420,000

7.3 Project Costs for the NED and Authorized Plans

Project first costs include the cost of construction, mobilization and demobilization, real estate, planning and engineering studies, supervision and administration, and interest during the four environmental dredging windows and construction period.

Determination of the economic costs of the plan consists of four basic steps. Project First Costs are computed and include expenditures for project design and initial construction and related costs of supervision and administration. First costs also include the lands, easements, and rights of way for initial project construction and periodic nourishment.

7.3.1 First Costs. Total First Costs are estimated to be $18,394,000 for the authorized project and $37,210,000 for the NED Plan as presented in Appendix A**.**

7.3.2 Interest During Construction. Details relative to costs are shown in Appendix A: Engineering, Design, and Cost Estimates. The cost of interest during construction was computed based on a 33 month installation period for the PED phase and the construction phase. The duration of PED is estimated to be 17 months, and expenditures would be spread evenly over this period. While the construction phase is estimated to be 16 months, actual project construction would occur over the last five months, and the expenditures would be distributed accordingly. The total interest during construction is estimated to be $1,385,000 for the authorized project and $2,016,000 for the NED plan.

7.3.3 Total Investment Costs. The total investment cost of the NED and Authorized plans is equal to the initial construction plus interest during construction. Therefore, total investment cost is equal to $39,226,000 for the NED Plan and $19,779,000 for the Authorized Plan as shown in Table B-10. The cost of future nourishment is shown separately.

Table B-10. TOTAL INVESTMENT COSTS

Total Investment Cost		
Alternative and Construction Item		Cost(1)
Authorized Project		
Beach Replenishment	$	16,886,000
Lands and Damages	$	-
Precon. Engineering and Design	$	754,000
Construction Management	$	754,000
Interest During Construction	$	1,385,000
Total Authorized Plan Investment Cost	$	19,779,000
NED Plan		
Beach Replenishment	$	34,640,000
Lands and Damages	$	-
Precon. Engineering and Design	$	1,523,000
Construction Management	$	1,523,000
Interest During Construction	$	2,016,000
Total NED Plan Investment Cost	$	39,226,000

(1) Some discrepancies may result due to rounding.

7.3.4 Present Value of Future Nourishment Costs. The accumulated present value of all nourishment cost is calculated by discounting all cash flows in future years back to the base year 2016 at the appropriate interest rate. The accumulated present worth of all future nourishment is $11,560,000 for the NED plan and $13,900,000 for the Authorized project. This is equivalent to an average annual cost of $538,000 for the NED plan and $647,000 for the Authorized Project.

7.4 Average Annual Project Costs for NED Plan

Average annual project costs are comprised of the interest and amortization of both the total investment (including interest during construction) and total accumulated present worth of the future nourishment. In addition to interest and amortization (I&A), annual costs include the operation and maintenance and the required annual monitoring cost.

7.4.1 Interest and Amortization of Total Investment. Total investment is converted to an average annual equivalent value by amortizing the investment over the 50-year period of analysis. The 50-year interest and amortization (I&A) factor at 3.75 percent is 0.0445742.

The annual interest and amortization of the total investment is $933,630 for the authorized project and $1,888,717 for the NED Plan.

7.4.2 Annual Monitoring. The non-Federal average annual monitoring cost refers to the sponsor's expense of periodic surveys and sampling of the beach and borrow areas and is estimated at $250,000 on an average annual equivalent basis.

7.5 Benefit/Cost Comparison for the NED and Authorized Plans

The NED Plan (DW 30 H14 B 50 – 5) is expected to decrease the estimated annual expected hurricane and storm damages from $4,060,000 to $540,000. The difference of $3,520,000 is storm damage reduction benefits. Local costs foregone benefits are $1,050,000. Total average annual benefits are $4,513,000.

The authorized plan has expected hurricane and storm damages of $2,680,000. The difference between this and the without-project condition are the storm damage reduction benefits of $1,380,000. Local costs foregone benefits are $1,040,000 and total average annual benefits are $2,383,000.

Total average annual equivalent benefits to the NED plan equal $4,513,000. Total average annual equivalent benefits to the Authorized Project equal $2,383,000. When comparing the benefits for the NED plan to the average annual cost of $2,393,000, the net benefits over cost equals $2,120,000 and the benefit cost ratio is 1.89. When comparing the benefits for the Authorized Project to average annual cost of $1,799,000, the net benefits over cost equals $584,000 and the benefit-to-cost ratio is 1.32 to 1.0.

7.6 Evaluation of Risk and Uncertainty

7.6.1 Residual Risks. The proposed beachfill plan would reduce average annual storm damages and the sponsor's local costs of storm damage protection. The tentatively selected plan, the authorized project, will reduce damages by an estimated 34 percent. Some wave and erosion damages will still occur, estimated to average $2,680,000 per year over the 50-year period of analysis. The NED Plan would reduce damages approximately 86 percent with residual damages of $540,000. The project is designed to protect mainly against storm waves and storm-induced erosion, two major categories of storm damage. The project will not prevent any damage from back-bay flooding, therefore any ground level floors of structures, ground level floor contents, vehicles, landscaping, and property stored outdoors on the ground in the Willoughby Spit area will still be subject to saltwater flooding that will flow in from Willoughby Bay and the end of Willoughby Spit beyond the terminal groin. Because the project is not claiming any benefits beyond Ocean View Ave, damages from flooding to structures past Ocean View have not been calculated. However, in major storm events, these structures on Willoughby Spit could be subject to back-bay flooding. Structures will also continue to be subject to damage from hurricane winds and windblown debris. Damages from flooding and winds will decrease as older structures are replaced with those meeting floodplain ordinances and wind hazard building construction standards. But even new construction is not immune to damage, especially from severe storm events. Also, the condition of the HSDR project at the time of storm occurrence can affect the performance of the project for that event.

The proposed beachfill reduces damages, but does not have a specific design level. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. The project purpose is storm damage reduction, and the berm-and-dune is not designed to prevent loss of life. Loss of life is prevented by the existing procedures of evacuating the area, thereby removing the residents from potential harm well before the expected hurricane or nor'easter landfall. This policy should be continued both with and without the storm damage reduction project.

Table B-11. RESIDUAL RISKS*

Plan	Residual Damages	HSDR Benefits
No Action	$4,060,000	$0
Authorized Project	$2,680,000	$1,380,000
NED Plan	$540,000	$3,520,000

*Average Annual Values, 50 year duration, 4 % interest rate, October 2012 cost levels.

The costs for achieving a greater reduction in benefits are shown in the following table.

Table B-12. COSTS OF ACHIEVING BENEFIT REDUCTIONS*

Plan	Average Annual Costs
No Action	$0
Authorized Project	$1,799,000
NED Plan	$2,393,000

*Average Annual Values, 50 year duration, 3.75% interest rate, October 2012 cost levels.

These costs are the average annual cost of initial construction and periodic nourishment over the period of analysis of 50 years. Thus an increase in benefits from the Authorized Project to the NED plan is a 42-percent increase in costs for an 88-percent increase in benefits.

7.6.2 Risk and Uncertainty in Economics. Beach-*fx*'s lifecycle approach to plan formulation explicitly incorporates risk and uncertainty into the formulation process. Several variables in Beach-*fx* have built-in risk and uncertainty as described below:

1) Structure valuation: Most likely value plus 5% and minus 10%
2) Content valuation: Most likely value plus 5% and minus 10%
3) Depth Damage curves: Most likely curve plus or minus 1 standard deviation (when available)

The following table utilizes the mean of the structure and content damages and applies the standard deviation to the without-project condition, the authorized project and the

NED plan to determine the range of possible benefit outcomes. This does not include any changes in benefits due to land loss.

Table B-13. STRUCTURE AND CONTENT DAMAGES

	Minus One Standard Deviation	Mean	Plus One Standard Deviation
Without-project	$2,390,000	$3,720,000	$5,050,000
Authorized Project	$1,660,000	$2,680,000	$3,720,000
Benefits	$730,000	$1,040,000	$1,330,000
Without-project	$2,390,000	$3,720,000	$5,050,000
NED Plan	$130,000	$540,000	$970,000
Benefits	$2,260,000	$3,180,000	$4,080,000

When minus one standard deviation was tested against all iteration values approximately 65 percent of all the iterations resulted in benefits for the Authorized project greater than $730,000 for structure and content damage. Conversely, when adding one standard deviation was tested 72.6 percent of all iterations resulted in benefits less than $1,330,000 for structure and content damage.

Considering the NED plan, when minus one standard deviation was tested against all iterations, 70 percent of all iterations resulted in benefits greater than $2,260,000 for structure and content damage. While adding one standard deviation, 76 percent of all iterations resulted in benefits for structure and content damage less than $4,080,000.

Given the probabilistic nature of the analysis, the alternatives were evaluated to determine the percent chance that the given alternative would have positive benefits, or conversely, the risk of having negative benefits. Based on analysis of 315 lifecycles, the

Authorized project (60-ft berm) has a 98.7 percent chance of having positive benefits and the NED plan has a 99.6 percent chance of having positive benefits.

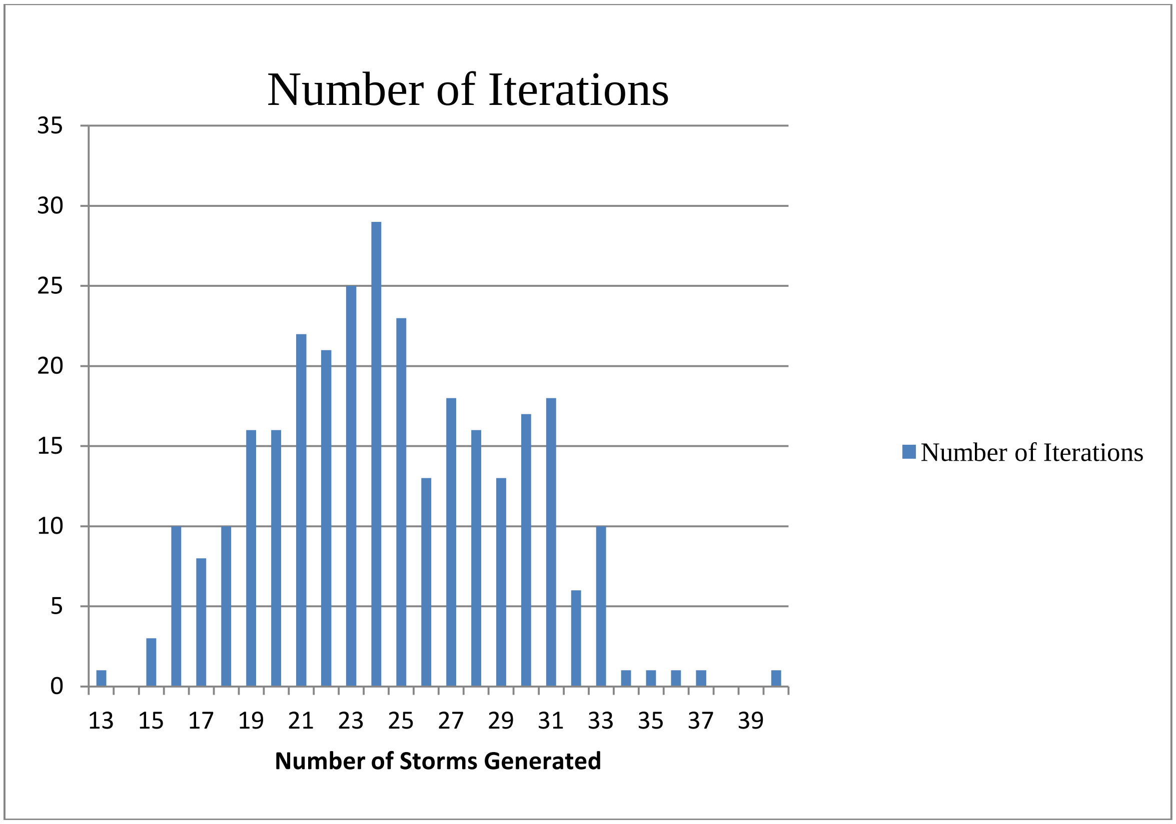
7.6.3 Risk and Uncertainty in Storm Generation. Over the period of record, dating back to 1928, 42 storms have impacted Norfolk, VA. This includes 12 hurricanes and 30 Nor'easters. Currently, the storm generation in Beach-*fx* has a mean of 24.5 storms over the 50 year period of analysis over 300 iterations. Looking at the period of record over the last 50 years and moving back in 10 year increments, the number of storms that has occurred is consistent with the storm generation of the model.

Table B-14. STORMS IMPACTING THE CITY OF NORFOLK

Time Period	Number of Storms
2010-1960	27
2000-1950	24
1990-1940	20
1980-1930	22
Total Over Period of Record	42

As the model does incorporate a probabilistic approach to storm generation, not every iteration generates the same number of storms. The range of storms generated was from 13 at the lowest end to 40 storms at the highest end. The following graph illustrates the range of storm generation in Beach-*fx*.

Figure B-2. STORM GENERATION IN BEACH-*FX*



These results demonstrate that the probabilistic nature of the simulation is presenting a reasonable demonstration of what has occurred in the study area and is bracketing it appropriately to account for the uncertain nature of storm probabilities.

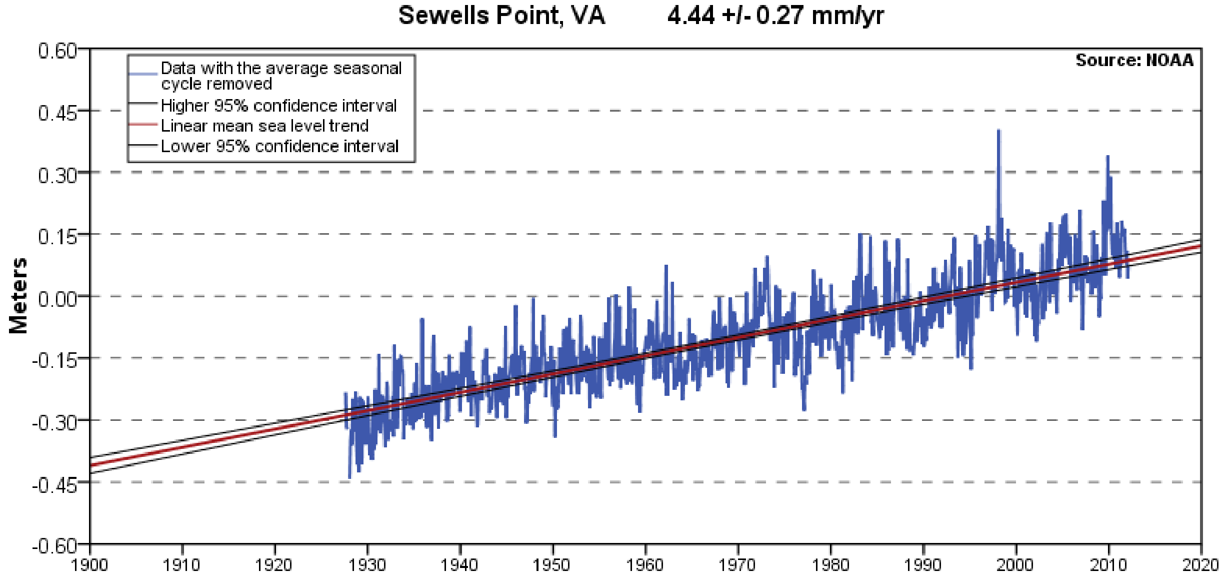
7.6.4 Risk and Uncertainty in Sea Level Rise Assumptions. Climate research has documented global warming during the 20th Century, and has predicted continued or accelerated global warming ultimately resulting in continued or accelerated rise in sea level. U.S. Army Corps of Engineers, Engineering Circular, EC 1165-2-212 provides the guidance for considerations of accelerated sea level rise (SLR) for Federal civil-works projects. The guidance uses the updated National Research Council (NRC) projections (updated from 1987) as well as the Intergovernmental Panel on Climate Change (IPCC 2007b) Fourth Assessment Report guidelines. USACE water resources management projects are planned, designed, constructed and operated locally or regionally. For this reason, it is important to distinguish between global mean sea level (GMSL) and local (or "relative") mean sea level (MSL). At any location, changes in local MSL reflect the integrated effects of GMSL change plus changes of regional geologic, oceanographic, or atmospheric origin.

Potential relative sea level change (SLC) must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative SLC in the starting water surface elevation for such profiles, where appropriate. The base level of potential relative SLC is considered the historically recorded changes for the study site. Areas already experiencing relative SLC or where changes are predicted should analyze this as part of the study.

Alternatives are evaluated using the "low" curve or the historical rate of SLC. The NED and tentatively selected plan are also then evaluated using the "intermediate" and "high" rates of future SLC for both "with" and "without" project conditions. The intermediate rate is calculated by adding any subsidence present in the local area to the modified NRC Curve I. The high rate is calculated by adding any subsidence present in the local area to the modified NRC Curve III.

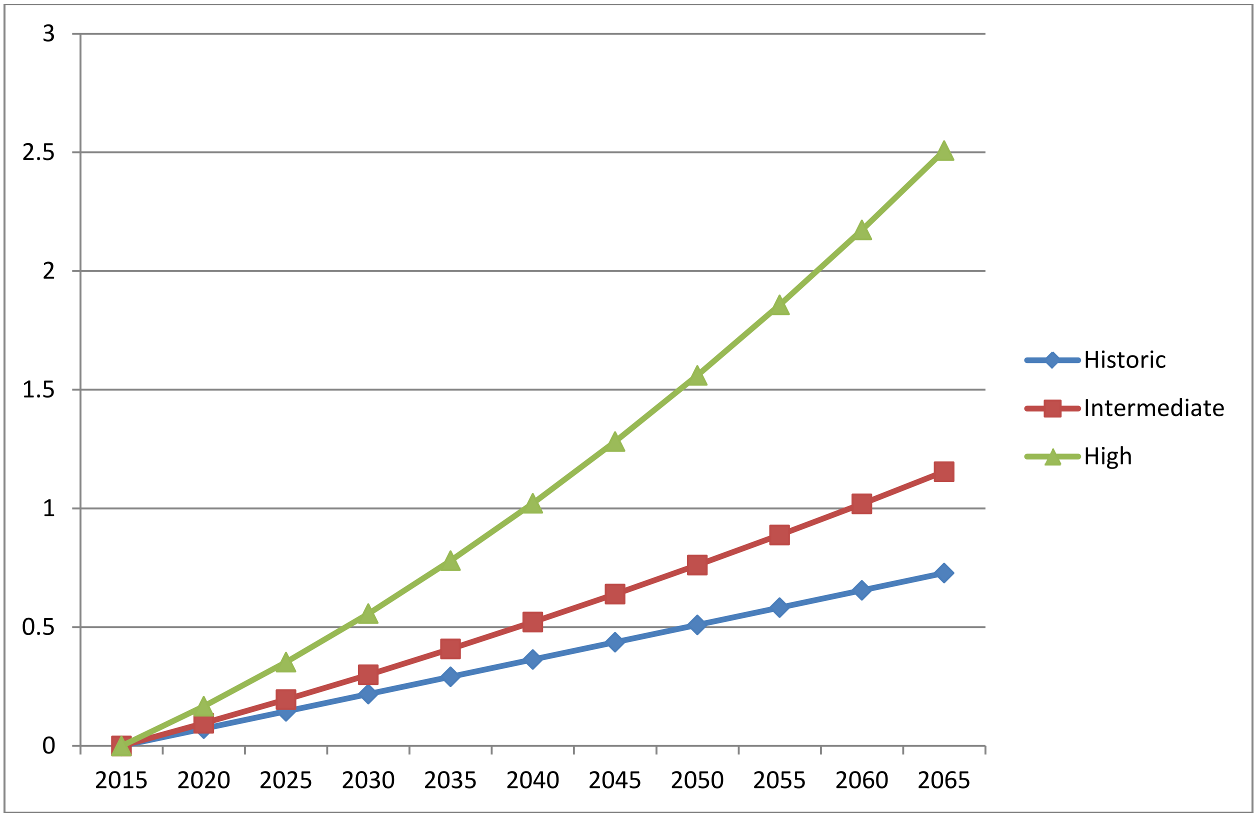
Historical trends in local MSL are determined using measurement data from tide gauge records. Tidal records from nearby National Ocean Service (NOS) tidal station at Sewell's Point in the city of Norfolk show a historical trend of 0.0145 feet per year from 1926 to 2009, as shown on Figure B-3. This is the low scenario. This planning study uses this historical SLR rate to formulate the project.

Figure B-3. HISTORICAL SLR RATE



The modified NRC SLC projections include three scenarios resulting in three curves of sea level rise thru 2100. The following figure shows the historic, intermediate, and high SLC scenarios in feet. The curves (labeled Curve 1 through Curve 3) represent global eustatic sea level rise values of 0.5 meters, 1.0 meters, and 1.5 meters over the next 125 years. In order to investigate the sensitivity of the NED plan and the locally preferred plan to sea level rise, Curves 1 and 3 are used to bracket estimates in SLR. Curve 1 projection indicates a SLC of 1.14 feet 50 years after construction (year 2065), while Curve 3 indicates 2.52 feet of SLC in 2065. For comparison, the historic SLC rate projects about 0.73 feet of SLR in 2064.

Figure B-4. PROJECTED SEA LEVEL CHANGE IN FEET



A sensitivity analysis of SLC effects upon the Tentatively Selected Plan and the NED Plan was conducted to estimate the with-project and without-project damages, benefits and costs under each scenario. In summary, with accelerated SLC scenarios, the without-project damages could increase about 3.9 percent from the historical SLC scenario to the intermediate SLC scenario. Under the high SLC scenario there could be increase of about 13.2 percent in without-project condition damages. Residual damages for the authorized project could increase about 2.7 percent from the historical SLC to the intermediate SLC scenario. Under the high SLC scenario there could be increase of approximately 9.7 percent in residual damages. For the NED plan, the residual damages could increase approximately 8.2 percent from the historical SLC scenario to the intermediate SLC scenario. Under the high scenario residual damages could increase approximately 37.5 percent. While this percentage seems high compared to the authorized project, total damages for the NED plan under the high scenario could be expected to be around

$750,000 compared to $550,000 under the historical scenario. This is still less than the Authorized Project. Total project costs for the Authorized Project could increase 27.5 percent due to additional erosion (using the most extreme estimate of 2.51 feet of SLR in 50 years) but the project provides an additional 41 percent of damage reduction benefits. The NED plan could cost an additional 32 percent using the same scenario but would provide 23 percent more damage reduction.

The proposed beach nourishment project is not a hard structure and adjusts to natural forces. Regardless of the rate of SLC, the beachfill project is monitored annually and renourished every 9 years. Monitoring data provides input to determining the details of each renourishment of the beach. If an accelerated SLC occurs, erosion volumes increase and renourishment volumes will increase, shortening the life of designated borrow areas. A Limited Reevaluation Report (LRR) on borrow sources would be conducted to investigate additional borrow sources. All alternative plans contain a 3.5-foot elevation berm and all would be affected similarly by accelerated SLC. Therefore, no change to the Selected Plan by accelerated SLC is expected other than minor modification of the berm elevation and possibly the dune elevation. There is no expectation that accelerated SLC would result in selection of other major categories of alternative plans such as the nonstructural plan or hard structure plans.

Accelerated sea level rise would increase the amount of borrow material needed for the project. Under the intermediate and high scenarios, approximately 0.3 million and 2 million extra cubic yards of material would be needed, respectively, for the authorized project. The NED plan would need an extra 1 million cubic yards and 3.2 million cubic yards for the intermediate and high scenarios, respectively.

8.0 REGIONAL ECONOMIC DEVELOPMENT (RED) IMPACTS

The following regional economic impacts will be addressed based on the interest of the local sponsor, the city of Norfolk. Local governments seek to preserve the tax base and encourage the growth in overall property values, to create stability in the labor force and the employment of the labor force. The steady growth of the local community and surrounding region is considered a worthy goal by the state and local governments. Displacement of people and businesses in the study area is not a desirable outcome that sometimes may result from either continued storm damages or even some types of construction.

8.1 Preserve Tax Base and Property Values

Real property, including land and structures, in the city of Norfolk is subject to property tax by the city. The tax base and property values will be preserved with implementation of a hurricane and storm damage reduction plan. Land loss and long-term erosion eventually renders lots unbuildable with a significantly lower economic value. Typically, the tax valuation of the ocean front lots is severely reduced to reflect the diminished utility of the land. Lower tax valuations may result in lower city tax revenues unless there is offsetting development in other areas. Given that the city is almost entirely built out with little opportunity for offsetting development, preserving the tax base is significant.

8.2 Employment Stability

It is unlikely that employment will be significantly impacted with or without storm damage reduction measures. Gains or losses in income or employment are considered regional impacts.

8.3 Community and Regional Growth

Implementation of effective damage reduction measures will ensure that the current growth trends in population will continue. Protection of the streets and highways in the study area preserve community cohesion.

8.4 Displacement of People and Businesses

Implementation of damage reduction measures under consideration is not expected to displace people or businesses.

9.0 RECREATION ANALYSIS

9.1 Introduction

This section of the Economic Appendix discusses and evaluates the incidental recreation benefits that would accrue from the shore protection plans under consideration. Since policy and cost sharing for recreation outputs differ significantly from hurricane and storm damage reduction outputs, and shore protection projects are formulated first to provide for hurricane and storm damage reduction, it is appropriate to evaluate recreation in a separate section and display recreation benefits independent of other project outputs.

Shore protection projects, particularly those featuring beachfill, are innately conducive to beach and shoreline recreation activities. Provided that hurricane and storm damage reduction benefits, limited to an amount equal to the value of hurricane and storm damage reduction benefits, are sufficient in themselves for economic justification, the Federal Government will propose undertaking the project as a Hurricane and Storm Damage Reduction project. However, since recreation values are NED benefits, some or all recreation benefits are included in computation of the overall benefit – cost ratio. If an amount of recreation benefits greater than 50 percent of the benefits needed are required to be combined with hurricane and storm damage reduction benefits in order to demonstrate economic justification, the project is characterized as being primarily for recreation. As such, it is not proposed by the Corps of Engineers as a Federal undertaking, since recreation developments are not currently accorded priority in Civil Works budget decisions. For the same reason, separable recreation elements in a shore protection project are not recommended.

9.2 General

Norfolk's Chesapeake Bay beach front is a valuable natural resource that presents significant and substantial opportunities for public use. The beach front inventory consists of about seven miles of beach stretching along the Chesapeake Bay from Little Creek Inlet to and including Willoughby Spit. The beach front is an important locational asset that contributes greatly to the overall well-being of the residents of the surrounding area. Historically, the beaches in the study area have experienced steady and continuous erosion resulting in severe beach recession. From a recreational perspective, it is important that the beach be properly maintained in the future to ensure its availability for various activities. A vibrant beach opportunity cannot be enjoyed if the actual beach area becomes so small as to severely limit the number of users and related activities.

9.3 Study Area

As discussed in the Main Report, the study area consists of about 7.3 miles of beach front and adjacent landward area in the city of Norfolk extending along the Chesapeake Bay from the eastern limit of Little Creek Inlet westward to the terminal groin at the tip of Willoughby Spit. It includes the areas known as East Beach, Ocean View, and Willoughby Spit.

Beach use at Willoughby Spit and Ocean View occurs throughout the study area. The highest concentration of beach use is at the three city parks of Sarah Constant Shrine Park, Ocean View Beach Park and Community Beach Park.

Surveys of beach users in the summer of 2005, which are described in detail later in this section of the report, indicated 60 percent of user trips originate from within five miles of the study area; 50 percent originate from the city of Norfolk; 8 percent originate from Virginia Beach, and 5 percent coming from the rest of the Hampton Roads area including Newport News, Hampton, Portsmouth, and Chesapeake. Approximately 3 percent originate more than twenty miles away but less than fifty miles. Approximately 14 percent originate more than fifty miles away. These results generally agree with previous surveys, which indicate that the majority of beach use originates locally within a relatively short distance from the study area beach and confirm that Willoughby Spit and Ocean View are day-use recreational beaches with little overnight visitation.

9.4 Alternative Recreational Beaches

Several alternative saltwater recreational beaches are located within the region. Located within an hour's driving time are the Chesapeake Bay beaches in the cities of Hampton and Virginia Beach as well as the Atlantic Ocean beaches in Virginia Beach. Within several hours driving distance are the popular beaches of the Outer Banks of North Carolina. The beach surveys conducted in the summer of 2005 indicated that users of Willoughby Spit and Ocean

View made visits during the summer season to these alternative sites. The most frequently mentioned alternative beaches were Virginia Beach and the Outer Banks of North Carolina. However, the average respondent made 17 trips to Willoughby Spit and Ocean View during a typical recreational season compared to 4 trips to all other competing beaches.

Although Willoughby Spit and Ocean View users visit other area beaches during a typical recreational season, based on survey responses, the alternate beaches are not generally preferred for the day visitors who predominately originate from nearby residential areas. These users enjoy the easy access and nearness of the recreational opportunity when they have available leisure time during the week and on weekends. Due to the much larger sphere of influence exerted by the alternative beaches in the region such as Virginia Beach and the Outer Banks of North Carolina, which attract millions of visitors from all over the United States and Canada, use at Willoughby Spit and Ocean View has an insignificant impact on competing beach use within the region.

9.5 Without Project Condition

The without-project condition is described in detail in the "Without-Project Condition" section of the Main Report. Essentially it consists of the continuation of the city's beach nourishment project in the study area, on average renourishment has been done approximately in 7-year intervals to provide a minimum of a 12-foot wide beach berm along the study area with an initial 25-foot construction berm. However, proper formulation of alternative storm damage reduction plans requires that recreation benefits associated with the local project be evaluated. For economic evaluation purposes only, it is assumed that the local project would be maintained. Benefits attributable to the local project are estimated based on this assumed without condition.

9.6 Beach Use

Historically beach use within the study area has been concentrated in the areas of the three parks. Based on surveys conducted by Corps of Engineers personnel and discussions with city personnel, the beach is primarily a day-use recreational area with the majority of visitors coming from Norfolk and the immediate surrounding area. A significant number of visitors walk and bike to the beach. Beach counts were conducted at 10 am and 2 p.m. by Corps of Engineers personnel from 3 August 2005 through 5 September 2005 and from 5 May 2006 through 2 August 2006. These counts indicated that over 400 users on an average weekday and over 1200 users on an average weekend day engaged in swimming, sunbathing, sailing, picnicking, and volleyball. Based on the length of the recreational season and the estimate that 75 percent of daily users are on the beach at peak hours, the results of the 2005 and 2006 surveys indicate a total annual beach visitation of about 53,168. The following table shows a summary of the beach counts by the Corps of Engineers.

Table B-15. BEACH COUNTS BY REACH

Reach	Weekday AM	Weekday PM	Weekend AM	Weekend PM
1	326	466	1550	4291
2	1923	2959	5233	18383
3	232	501	1174	4609

9.7 Beach User Survey

Beach users were surveyed during the summer of 2005. The team completed 451 interviews on sampling days during the months August and September. A sample size of 451 respondents results in a margin of error of 4.6 percent, which is believed acceptable. A larger sample would reduce the margin of error but would not appreciably change the survey results. The use of stratified sampling with only individuals recreating on the beach selected provides a homogeneous population reducing the need for a large sample. The sample size is also reduced by the lack of complexity in the analysis, the relatively few variables involved, and the strong relationship exhibited between the variables. The survey was designed to obtain pertinent information regarding existing users of the study area beaches. Results indicate that on average 2.7 individuals make up a typical group visiting the beach. Average distance travel to the beach is about 53 miles with the majority of visitors coming from within 5 miles. Visitors originating from within 10 miles of the beach account for 75 percent of total annual trips. Most parties and individuals travel to the beach by private auto, about 83 percent; other modes of transportation used to reach the beach include 1.5 percent biking and 13 percent walking. Of those driving to the beach, 5 percent parked on side streets, 71 percent parked in the free public lots, and 9.5 percent parked in other areas. The average length of stay for a typical beach trip is 3.0 hours.

The average beach goer makes 17 trips to the Willoughby Spit and Ocean View beaches during a typical summer season and 3.6 trips to all other alternative beaches. The most popular alternative beaches are Virginia Beach and the Outer Banks of North Carolina. The average respondent is employed full-time, has some college education, and an annual family income of more than $57,500. The following table summarizes the result of the survey. The questionnaire survey form is included as an attachment to this section.

Table B-16. SUMMARY OF RECREATION SURVEY

Items expressed by number	Low	High	Mean
• Number of people in party	1	20	2.7
• Distance travel to beach (miles)	0.1	2000	53.7
• Time to walk from parking spot (minutes)	0.1	25	2.4
• Trips to WS/OV during a typical season	1	240	17.2
• Time spent on beach per trip (hours)	0.25	16	3.38
• Trips to alternative beaches	0	84	3.6
• Annual family income (dollars)	5,000	130,000 +	57,667
Items expressed by percent			**%**
• Transportation to beach			
Car			82.7
Bike			1.5
Walk			13.3
• Parking			
Side street			4.6
Public lot			71.4
Other			9.5
• Parking availability			
Excellent			50.6
Good			25.5

Table B-16. SUMMARY OF RECREATION SURVEY
(Cont'd)

Items expressed by percent	%
Fair	6.2
Poor	2.7
• Beach conditions	
Too crowded	2.0
Just right	78.3
Too few people	18.8
• Use alternative beaches	37.5
• Employment	
Full-time	62.5
Part-time	7.5
Retired	13.1
Not employed	2.0
Homemaker	7.8
Student	5.1
Other	1.5
• Marital Status	
Married	51.4
Single	31.2
Divorced/widowed	16.9
• Gender	
Male	42.3
Female	57.4

9.8 Beach Area Availability

9.8.1. General. Beach use now and in the future will continue to be distributed along the beach with high concentrations at the three parks. Access and public parking are located along the shoreline. Also lifeguards, bathhouses, the boardwalk, picnic tables, vendors, the public park, and other related activities are located at the parks to enhance the beach visit.

9.8.2. Without Local Project. As described in the "Without-Project Condition" section of the report, the existing local nourishment project, over the 50-year period of evaluation, will provide a minimum of a 12 to 25 foot wide beach berm along a length of 7.3 miles of beach front.

9.8.3. Without Federal Project. The Without-Project Condition is described in detail in the "Without-Project Condition" section of the report. It assumes that the city's local beach nourishment project will continue into the future but will provide less than minimum design parameters. The without-condition would provide for a berm width of 12 - 25 feet along the 7.3 mile shoreline. Accordingly, a recreational area of over 1,810,000 square feet, which is provided by the 12 foot wide beach berm plus approximately 35 feet available on the slope of the beach down to the mean high water exclusive of the swash zone, for a total width available for recreation of 47 feet along its 7.3 mile length, would continue to be available in the future. The 25 foot berm plus an additional 35 feet available on the slope of the beach down to the mean high water, exclusive of swash zone, provides for a total width available for recreation of 60 feet along its 7.3 mile length. This allows for 2,310,000 square feet of recreational area. On average, this would equate to approximately 2,060,000 square feet of recreational area. However, since the 12 foot wide berm is what would be maintained, the area for it will be used.

9.8.4. With Federal Project. A number of alternative nourishment plans are considered that would provide expected minimum beach berm widths of 25 feet, 30 feet, 50 feet, and 75 feet. These berm widths would correlate with alternatives that have berm widths of 50 feet, 60 feet, 100 feet and 150 feet. The maximum berm width is not expected to be continuously present over the period of analysis however, the renourishment triggers at 50 percent of the maximum berm width, thus this 50 percent width is used in calculating available beach area. Beach areas available for recreation would be provided ranging from over 2,310,000 square feet to 4,240,000 square feet as shown in the following table along with the constructed berm widths shown in parentheses.

Table B-17. RECREATIONAL BEACH AREA AVAILABILITY
WITH ALTERNATIVE FEDERAL PROJECT

Beach berm width (ft.)	Area (sq. ft.)
25 (50)	2,310,000
30 (60)	2,510,000
50 (100)	3,280,000
75 (150)	4,240,000

9.9 Future Use

9.9.1 General. Annual recreational use in the year 2012 is estimated at approximately 54,500 for the study area. The estimated use in 2016 is 55,300. Assuming adequate beach area availability and sufficient parking, it is reasonable to expect that beach use would increase in the future at a rate at least comparable to the modest population increases projected for the city's surrounding neighborhoods. Beach surveys indicate that the majority of beach visits are by users from this area. Based on this rate of population increase, the number of beach users would grow to 65,900 by year 2065 as shown in the following table.

Table B-18. ESTIMATED ANNUAL USE (1)

Year	Total number of users
2005	53,200
2010	54,200
2020	56,100
2030	58,200
2040	60,300
2050	62,500
2060	64,800
2065	65,900

(1) Based on a 100-day beach recreational season.

To properly evaluate future use, it is necessary to determine the portion of annual use that occurs on weekdays and peak days. The beach is primarily a day-use beach with the majority of visitors coming from Norfolk and particularly the nearby surrounding areas. The beach is generally not a vacation destination for tourists, and there is little overnight visitation. As a result, use is concentrated during weekends and holidays when nearby residents are not working and have leisure time available. Based on the beach counts and surveys conducted during the summer of 2005, it is estimated that 85 percent of annual visitation occurs on peak days, i.e., weekends and holidays, and 15 percent on weekdays. The following table shows the amount of annual use occurring on peak days and weekdays.

Table B-19. ANNUAL PEAK DAY AND WEEKDAY VISITATION

	Number of users		
Year	Weekday	Peak day	Total
2005	8,200	45,000	53,200
2010	8,300	45,900	54,200
2020	8,600	47,500	56,100
2030	9,000	49,200	58,200
2040	9,300	51,000	60,300
2050	9,600	52,900	62,500
2060	10,000	54,800	64,800
2065	10,100	55,800	65,900

Allocation of annual peak day and weekday use to daily values is shown in the following table based on a 100-day recreational beach season consisting of 23 peak days, 57 weekdays, and 20 inclement weather days.

Table B-20. AVERAGE DAILY PEAK DAY AND WEEKDAY USE

Year	Total peak day use	Number of peak days	Daily peak day use	Total weekday use	Number of weekdays	Daily weekday use
2005	45,000	23	1,957	8,200	57	144
2010	45,900	23	1,996	8,300	57	146
2020	47,500	23	2,065	8,600	57	151
2030	49,200	23	2,139	9,000	57	158
2040	51,000	23	2,217	9,300	57	163
2050	52,900	23	2,300	9,600	57	168
2060	54,800	23	2,383	10,000	57	175
2065	55,800	23	2,426	10,100	57	177

Use estimates shown in the previous table can be further refined to show peak hour use. For a 100-day recreation season between Memorial Day and Labor Day, an 8-hour day from 10 a.m. to 6 p.m., the beach survey indicates peak use to be from 1 to 3 p.m. The average time spent on the beach is 3.4 hours, and there is little turnover between 1 and 3 p.m. The survey further indicates that 75 percent of the daily users are on the beach during this time period. Peak hour use for both peak days and weekdays is shown in the following table.

Table B-21. PEAK HOUR USE

Year	Peak day use	% of use at peak hour	Peak hour use	Weekday use	% of use at peak hour	Peak hour use
2005	1,957	75	1,466	144	75	108
2010	1,996	75	1,495	146	75	109
2020	2,065	75	1,548	151	75	113
2030	2,139	75	1,603	158	75	118
2040	2,217	75	1,662	163	75	122
2050	2,300	75	1,724	168	75	126
2060	2,383	75	1,785	175	75	131
2065	2,426	75	1,818	177	75	133

The above estimates of future recreational use of the study area are based on the availability of an adequate beach area to accommodate the projected use. The impact on future use resulting from the implementation of one of the two assumed conditions i.e., (a) with the local project but without a Federal project; and (b) with a Federal project in place is discussed in the following paragraphs.

9.9.2. Without Federal Project. This is essentially the "Without-Project Condition," which assumes the local beach nourishment project would be continued into the future. Based on this condition, a beach area of 1,810,000 square feet would be available for recreational use into the foreseeable future and over the 50-year planning period. Optimum beach capacity at peak periods is estimated to be about 24,000 users based on the existing length and width of the beach and using an ideal recreation standard of 75 square feet per user. For a hundred-day season between Memorial Day and Labor Day and an 8-hour day from 10 a.m. to 6 p.m., peak use is estimated to be from 1 to 3 p.m. The average time spent on the beach based on survey of users is 3.4 hours. Accordingly, a turnover factor can be calculated that indicates how many people could make optimum use of a given area of beach during a day. For an 8-hour day and an average stay of 3.4 hours, the turnover factor is 2.4. For the study area a total of 57,100 people could use the beach during the day if use was evenly distributed. However, use is not evenly distributed during the day. It increases to a maximum at about 1 p.m. and remains there until about 3 p.m. when it begins to decline. At peak use time between 1 and 3 p.m., there is little turnover. The beach counts indicated that 15 percent of total weekly use occurs on weekdays and 85 percent on peak days (holidays and weekends). Also, 75 percent of weekday and peak day users are on the beach during the peak hour. Accordingly, beach capacity would not be restricted at peak day or peak hour. The existing local project could adequately accommodate existing and projected beach visitation, and no recreation benefits would be attributable to alternative Federal beach nourishment plans. Some numbers have been rounded after calculations have been completed.

Table B-22. FUTURE BEACH USE WITHOUT FEDERAL PROJECT

Year	Total annual use	Annual peak day use	Annual weekday use	Average daily peak day use	Average daily weekday use	Peak hour use		Beach capacity	
						Peak day	Weekday	Peak day	Peak hour
2005	53,200	45,000	8,200	1,957	144	1,466	108	32,200	24,200
2010	54,200	45,900	8,300	1,996	146	1,495	109	32,200	24,200
2020	56,100	47,500	8,600	2,065	151	1,548	113	32,200	24,200
2030	58,200	49,200	9,000	2,139	158	1,603	118	32,200	24,200
2040	60,300	51,000	9,300	2,217	163	1,662	122	32,200	24,200
2050	62,500	52,900	9,600	2,300	168	1,724	126	32,200	24,200
2060	64,800	54,800	10,000	2,383	175	1,785	131	32,200	24,200
2065	65,900	55,800	10,100	2,426	177	1,818	133	32,200	24,200

9.9.3 With Federal Project. As previously discussed, a number of alternative nourishment plans are considered that would provide expected minimum beach berm widths varying from 25 feet to 75 feet. These widths correlate with alternatives that have berms of twice the width. The following table shows the potential number of users that could be optimally accommodated on peak days and at peak hour by the recreational beach capacity made available with alternative beach nourishment plans. The constructed widths are shown in parentheses.

Table B-23. POTENTIAL USERS

Beach berm width (feet)	Recreational beach width (feet) (1)	Beach capacity	
		Peak day users	Peak hour users
25 (50)	60	41,100	30,800
30 (60)	65	44,500	33,400
50 (100)	85	58,200	43,700
75 (150)	110	75,400	56,500

(1) Includes berm width plus usable beach slope width of 35 feet.

As shown on Table B-21, Peak Hour Use, unrestricted peak hour use would increase from 1,466 in 2005 to 1,818 in 2065. Beach use with alternative plans providing beach berm widths of 30 feet and greater would be identical to the use estimates shown on Table B-22, Future Beach Use Without Federal Project, since the existing local beach nourishment project can accommodate all future use. There would be no recreation benefits attributable to alternative Federal beach nourishment plans, since no incremental use is estimated for the alternative Federal plans over that estimated for the existing local beach nourishment project.

9.10 Parking and Accessibility

Adequate parking and access must be provided to the public beach to accommodate existing and future recreational use. Parking must be sufficient to accommodate peak hour demand and reasonable public access must be provided within one-half mile of each other. In the area of the park, adequate access and parking are not a problem. Based on the recreation survey of beach users conducted in the summer of 2005, neither parking nor accessibility was identified as problems. More than 82 percent of users rated parking as fair, good, or excellent.

Based on the summer 2005 beach survey, approximately 83 percent of users travel to the beach by car with an average of 2.8 people per car. As shown in Table B-21, peak hour use was 1,466 in 2005 and is expected to increase to 1,818 by the year 2065. Accordingly, peak hour parking requirements would be approximately 435 spaces in 2005 and are expected to increase to approximately 539 spaces in 2065.

Accessibility is not a problem along the beach with access points located continuously along the study area. Also located at the beach parks are bathhouses, the boardwalk, picnic facilities, vendors, lifeguards, and other related facilities.

9.11 Unit Day Value Methodology

Unit day value is based on informed opinion and judgment to estimate the average willingness to pay of recreational users. It is selected as the appropriate method to use to estimate benefits attributable to recreational use of Willoughby Spit and Ocean View for the following reasons:

(a) Estimated annual use is less than 150,000 visits;

(b) Most of use is by day users from the surrounding neighborhoods;

(c) Recreation benefits have no impact on project formulation and/or plan selection;

(d) No incremental recreation benefits are attributable to any of the Federal alternative plans;

(e) There are no specific costs for recreation facilities;

(f) There are no specialized recreational activities involved;

(g) There is no applicable regional model available; and

(h) Recreation benefits are not required for project justification.

The additional time and costs of conducting Comprehensive Contingent Valuation Method or Travel Cost Method analyses are not believed warranted in view of the relative low priority of recreation benefits and the likelihood that the quality of the results of the Unit Day Value Methodology would not be significantly improved. Unit day recreation values are determined from guidelines that have been established based on the following five criteria: recreation experience, availability of opportunity, capacity, accessibility, and environment. Within these criteria, a range of judgment factors have been developed that assigns points to five levels ranging from 0 to 30 points. The following table shows the guidelines for assigning point values to general recreation activity.

Table B-24. GUIDELINES FOR ASSIGNING POINTS FOR GENERAL RECREATION

Criteria	Judgment factors				
(1) Recreation experience (a) Total Points: 30 Point value:	Two general activities (b) 0-4	Several general activities 5-10	Several general activities; one high quality value activity (c) 11-16	Several general activities; more than one high quality high activity 17-23	Numerous high quality value activities; some general activities 24-30
(2) Availability of opportunity (d) Total Points: 18 Point value:	Several within 1 hr. travel time; a few within 30 min. travel time 0-3	Several within 1 hr. travel time; none within 30 min. travel time 4-6	One or two within 1 hr. time; none within 45 min. travel time 7-10	None within 1 hr. travel time 11-14	None within 2 hr. travel time 15-18
(3) Carrying Capacity (e) Total Points: 14 Point value:	Minimum facility for development for public health and safety 0-2	Basic facility to conduct activity(ies) 3-5	Adequate facilities to conduct without deterioration of the resource or activity experience 6-8	Optimum facilities to conduct activity at site potential 9-11	Ultimate facilities to achieve intent of selected alternative 12-14
(4) Accessibility Total points: 18 Point value:	Limited access by any means to site or within site 0-3	Fair access, poor quality roads to site; limited access within site 4-6	Fair access, fair road to site; fair access; good roads within site 7-10	Good access, good roads to site; fair access, good roads within site 11-14	Good access, high standard road to site; good access within site 15-18
(5) Environmental Total points: 20 Point value:	Low esthetic factors (f) that significantly lower quality (g) 0-2	Average esthetic quality; factors exist that lower quality to a minor degree 3-6	Above average esthetic quality; any limiting factors can be reasonably rectified 7-10	High esthetic quality; no factors exist that lower quality 11-15	Outstanding esthetic quality; no factors exist that lower quality 16-20

(a) Value for water-oriented activities should be adjusted if significant seasonal water level changes occur.

(b) General activities include those that are common to the region and that are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality.

(c) High quality value activities include those that are not common to the region and/or Nation and that are usually of high quality.

(d) Refers to the availability of other recreational beaches.

(e) Value should be adjusted for overuse.

(f) Major esthetic qualities to be considered include geology and topography, water, and vegetation.

(g) Factors to be considered to lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.

Point values for each criterion appropriate for the recreation experience at Willoughby Spit and Ocean View have been selected in accordance with the guidelines shown on the previous table. Selection was based on the Corps of Engineers' recreation survey during the summer of 2005, discussions with city personnel familiar with Willoughby Spit and Ocean View including lifeguards, and the judgment of planners knowledgeable of the study area and other recreational beaches in the region. These point values are shown in the following table.

Table B-25. POINT VALUE SELECTION FOR WILLOUGHBY SPIT AND OCEAN VIEW

Criteria	Factor	Points
Recreation experience	Several activities including picnicking, fishing, boardwalk, pier, bathhouse, park, and a quality beach with lifeguards	15
Availability of opportunity	One beach within one hour drive	9
Capacity	Optimum facilities to conduct beach activities	10
Accessibility	Excellent access and parking	17
Environment	High esthetic quality	14
Total points		65

As the previous table shows, the total point value for Willoughby Spit and Ocean View is 65. Unit day values range from a minimum of $3.72 to a maximum of $11.17. Based on guidelines for selecting unit day recreation value, a 65-point rating translates to a unit day value of $8.85. No adjustment to this value is believed necessary to account for transfers of recreational users from alternative beaches in the region. The beach survey indicated that users of the Willoughby Spit and Ocean View beaches also visit alternative beaches in the region, the most popular being Virginia Beach and the Outer Banks of North Carolina. However, the implementation of the Federal plans considered would not attract users from those alternative beaches. As previously stated, use of the Willoughby Spit and Ocean View beaches is predominantly by nearby residents with little use originating from outside of the city. Use at the Willoughby Spit and Ocean View beaches has an insignificant impact on alternative beaches within the region such as Virginia Beach and the Outer Banks of North Carolina, which attract millions of visitors from all parts of the United States and Canada.

9.12 Average Annual Benefits

9.12.1 General. The estimates of use, described previously, are combined with the selected unit day value to get an estimate of recreation benefits. For this analysis, benefits are estimated for the alternative Federal beach nourishment plans considered. Recreation benefits attributable to Federal alternative beach nourishment plans are based on the local project's being in place in the future.

9.12.2 Without-project Condition. The without-project recreational use would increase from 53,200 in 2005 to 65,900 in 2065 as shown on the following table, Future Beach Use Without Federal Project. The following table shows the incremental annual use and annual value estimated of the without-project condition by decades beginning in 2010 and ending in 2065.

Table B-26. USE AND VALUE OF WITHOUT-PROJECT CONDITION

Year (1)	Estimated use without project	Unit day value	Total annual value (2)
2010	54,200	$8.85	$479,399
2020	56,100	$8.85	$496,205
2030	58,200	$8.85	$514,779
2040	60,300	$8.85	$533,354
2050	62,500	$8.85	$552,813
2060	64,800	$8.85	$573,156
2065	65,900	$8.85	$582,886

(1) Base year is 2016.
(2) There may be some variations in the values due to rounding.

Based on the above table, the annual value of incremental recreational use would increase from 54,200 in 2010, the base year, to 65,900 in 2065. Based on a discount rate of 4.0 percent and a 50-year period of analysis, the average annual recreational value, attributable to the Without-Project Condition, are estimated at $520,000.

9.12.3 With Federal Project. The basis for the benefit analysis with the Federal alternative beach nourishment plans is that the local beach nourishment project would be in place. Federal plans considered would provide no incremental recreation benefits over those provided by the local nourishment project since beach use would be identical. While a larger recreational area may theoretically increase the quality of the recreation experience, this is not supported by the results of the recreation survey conducted during the summer of 2005. In this survey, as shown on Table B-16, 78 percent of the respondents indicated the recreation area to be just right; more than 18 percent indicated too few people were on the beach; and less than 2 percent indicated the beach was too crowded.

9.12.4 Summary. The following table summarizes average annual recreation benefits attributable to the local beach nourishment project and to alternative beach nourishment plans, which provide beach widths from 12 feet to 75 feet.

Table B-27. AVERAGE ANNUAL RECREATION BENEFITS

	Average annual values ($)		
Plans	Base year	50-year life (1)	Total
Without-Project project			
12-25-foot berm width	489,000	31,000	520,000
Federal plans			
25-foot berm width (2)	0	0	0
30-foot berm width (2)	0	0	0
50-foot berm width (2)	0	0	0
75-foot berm width (2)	0	0	0

(1) Based on average annual equivalent factor of 0.04655 using 50-year period of analysis, 50-year growth, and 4.0 percent discount rate.
(2) No incremental recreation benefits over without-project condition.


Chesapeake Bay
3
2
1
Willoughby Bay
City of Norfolk
US Army Corps of Engineers
Norfolk District
Willoughby Spit & Vicinity, Norfolk, Virginia
Hurricane and Storm Damage Reduction
Economic Reaches
January 2013
0 0.25 0.5 1 Miles
Projection:
Virginia State Plane
South Zone - NAD 83
U.S. Survey Feet
Base Map:
ESRI Online Bing Maps Aerial
Project Manager: Robert Pretlow
E-mail: robert.n.pretlow@usace.army.mil
Phone: (757) 201-7385
Fax: (757) 201-7036
Prepared by: Karin Dridge, Geospatial Section
Map File: EconomicReachesApr_12.mxd
Map Date: 27 Apr 2012

Plate B-1

ATTACHMENT B-1
BEACH-FX ANALYSIS

Description

Beach-*fx* is a life cycle risk analysis model for hurricane and storm damage reduction (HSDR) planning and is the only USACE certified model for HSDR studies. It allows for the life-cycle analysis of alternatives through an event driven Monte Carlo simulation. This simulation models coastal processes, economics, as well as planned and emergency management measures for each event as they occur.

Process

Each life-cycle or iteration of a Beach-*fx* simulation has a unique probability associated with the storm events that occur. It utilizes the randomness of the Monte Carlo simulation to determine which storms hit the study area. For each iteration, it can be a different number of storms. The impact of each storm event is based on dynamically evolving beach profile. As each life-cycle moves thru the simulation, it accounts for changes over time in the beach profile. These changes can be due to erosion, storm impacts or nourishments. Thus the profile change of each storm event is dependent upon the pre-storm profile and the storm's characteristics. The following sections discuss inputs of the model specific to this study.

Shoreline Data Inputs

Beach-fx has many different inputs. The following pages describe the inputs data needs for the different shoreline items that consists of profiles, reaches, lots, and damage elements.

Profile Specific Inputs – Existing

This analysis consisted of thirteen hydrodynamic reaches that were combined into three economic reaches. This information was provided by the Hydraulics and Hydrodynamics Section at the Norfolk District and was based on profile surveys conducted by the City of Norfolk on a bi-annual basis. These surveys consisted of up to 119 individual profile lines that were then combined into an idealized profile for each hydrodynamic reach. Each of the hydrodynamic reaches was delineated based on its individual characteristics. Some of those characteristics were the presence of breakwaters, shoreline orientation, and presence of groins or curvature in the shoreline. Below are descriptions of the inputs into Beach-fx for the existing shoreline profiles.

- Default Dune Height (feet). The height of the dune, measured from datum (elevation 0).
- Default Dune Width (feet). The width of the top of the dune in feet.
- Default Berm Height (feet). The height of the berm, measured from datum (elevation 0).
- Default Berm Width (feet). The width of the top of the berm.
- Dune Slope. The side slope of the dune. The landward and seaward dune slope is assumed to be constant and equal.
- Foreshore Slope. The beach slope from the berm to datum.
- Upland Elevation (feet). Representative ground elevation landward of the dune, measured from datum (elevation 0).
- Depth of Closure (feet). Depth below datum to which nourishment material is distributed.

- Detailed Submerged Profile. The detailed submerged profile can consist of up to 100 points and was utilized in this analysis.

Reach Specific Inputs

Reaches are contiguous stretches of the shoreline that share a common morphological makeup with a particular Profile. The shoreline of a study can be broken up into any number of Reaches. Reaches are defined in Beach-*fx* by two straight lines, oriented parallel to the local shoreline, which denote the landward and seaward boundaries of the Reach. The Reach boundary lines are defined by start and end point coordinates, rather than by a set of four points defining a quadrilateral in a clockwise or counterclockwise sequence. Below are descriptions of the reach specific data inputs.

- Length (feet). The shore-parallel distance represented by the Reach.
- Applied Erosion Rate (feet/year). Feet/year erosion (-) or accretion (+), calibration parameter. The expected rate of shoreline change in the absence of storm events. This is calculated based on simulations of the existing conditions without any planned or emergency nourishments occurring. The goal is to arrive at the applied erosion rate necessary for the model to achieve the long term erosion rate and requires repetitive simulations.
- Back-Bay Flooding indicator. This indicates whether or not back bay flooding will occur in the reach.
- Planned Nourishment indicator. This indicates if the reach will be subject to planned nourishment.
- Emergency Nourishment indicator. This indicates if the reach will be subject to emergency nourishment.
- Upland Width (feet). The width of the upland area behind the dune.
- Flooding Threshold (feet). The threshold elevation at which back-bay flooding is initiated. When the water surface elevation for inundation reaches this point inundation damages are no longer calculated as the shoreline alternatives are not designed to stop back bay flooding.
- Economic Reach Number. This is the economic reach that the hydrodynamic reach is a member of.
- Control Line Offset. Threshold distance in feet measured from Lot centroid to the seaward toe of the dune at which Lots in the Reach will be marked as condemned prohibiting the rebuilding of Damage Elements in that Lot.
- Start Point Easting. GIS coordinate of X (easting) of Reach Start Point on Reference Line.
- Start Point Northing. GIS coordinate of Y (northing) of Reach Start Point on Reference Line.
- End Point Easting. GIS coordinate of X (easting) of Reach End Point on Reference Line.
- End Point Northing. GIS coordinate of Y (northing) of Reach End Point on Reference Line.
- Shoreward Start Point Easting. GIS coordinate of X (easting) of Reach Start Point Shoreward

- Shoreward Start Point Northing. GIS coordinate of Y (northing) of Reach Start Point Shoreward
- Shoreward End Point Easting. GIS coordinate of X (easting) of Reach End Point Shoreward
- Shoreward End Point Northing. GIS coordinate of Y (northing) of Reach End Point Shoreward
- SBEACH Landward Boundary Easting. GIS coordinate of X (easting) of SBEACH Landward Boundary.
- SBEACH Landward Boundary Northing. GIS coordinate of Y (northing) of SBEACH Landward Boundary.
- SBEACH Seaward Boundary Easting. GIS coordinate of X (easting) of SBEACH Seaward Boundary.
- SBEACH Seaward Boundary Northing. GIS coordinate of Y (northing) of SBEACH Seaward Boundary.
- Berm Width Recovery Factor. Percent of storm-induced berm width change that is restored due to post-storm recovery processes. The berm recovery factor in this analysis was supplied by the H&H section in Norfolk District and is 90 percent at 45 days after the storm event.

Lot Specific Inputs

Lots are an organizational feature in the system for Damage Elements. A Lot can be the entire size of the Reach or the size of an actual plot of land in the study area. Lots should be designed in a way that best suits the needs of the study. The lots in this analysis were designed to represent rows of a neighborhood or sections of the shoreline depending on the area where each was located. A Lot is defined by the specification of four points marking each corner of a quadrilateral.

- Type. Lots can be Occupied, Vacant, or Park.
- Armoring Status. The valid choices in this analysis are: Armorable In The Future, Already Armored, or Not Armorable. Most of the lots in the study area are not armored.
- Erosion (armor failure threshold). Magnitude of vertical erosion (feet) at the cross-shore location of the armor that will cause the armor to fail. In this analysis, 2-feet is used.
- Flooding (armor failure threshold). Water-surface elevation at the crossshore location of the armor that will cause the armor to fail. In this analysis, 3-feet is used.
- Wave Damage (armor failure threshold). Wave height at the cross-shore location of the armor that will cause the armor to fail. In this analysis, 4-feet is used.
- Distance Trigger (armor construction). Offset distance (feet) between the seaward edge of the berm and the seawardmost lot corner that will trigger armor construction on the Lot. This feature is not used in this analysis.
- Length (armor construction). Length of armor to be constructed on Lot (feet). This feature is not used in this analysis.
- Mobilization Cost (armor construction). All costs associated with armor construction not included in the Armor Construction Cost per Foot specification (e.g., engineering and design, equipment rental, backfill material, etc.). This feature is not used in this analysis.

- Cost Per Foot (armor construction). Estimated cost of armor construction per foot of armor length. This feature is not used in this analysis.
- Mobilization Time (armor construction). Estimate of time lag between trigger for armor construction and actual initiation of armor construction. This feature is not used in this analysis.
- Time per Foot (armor construction). Estimate of the time required for constructing armor, expressed as days per foot of armor length. This feature is not used in this analysis.

Damage Element Specific Inputs

A Damage Element represents any item where damages can be incurred. This could be a house, deck, pool, walkover structure, etc. Damage Elements are members of a Lot and are defined by a single, representative central point (X,Y coordinates) with an accompanying width and length.

- Type. This is the type of structure represented by the damage element. There are 15 types of structures used in this analysis. The type SFR1-P represents a single family, one story structure on piles. The structure types are presented in more detail in the discussion on damage curves in the Damage Functions section of this attachment.
- Foundation Type. This can be piles or slab.
- Construction Type. This can be wood frame or masonry.
- Armor Type. This can be a bulkhead, revetment or seawall.
- Length (feet). Length of the structure measured perpendicular to the shoreline. GIS is used to determine this.
- Width (feet). Width of the structure measured parallel to the shoreline. GIS is used to determine this.
- Number of Floors. Number representing the total number of floors in the Damage Element.
- Time to Rebuild (rebuild attributes). Triangular distribution of rebuild time in days (minimum, most likely, maximum). This is represented by 180, 360, and 540 days in this analysis.
- Number of Rebuilds (rebuild attributes). Maximum number of times the Damage Element can be rebuilt. In this analysis the maximum number of rebuilds allowed is two. However, if the lot is condemned, then rebuilding is not allowed. A condemnation ratio of 50% is used for the damage elements.
- Representative Point Easting. The X coordinate of the Damage Element. GIS is used to determine this.
- Representative Point Northing. The Y coordinate of the Damage Element. GIS is used to determine this.
- Contents Value. Triangular distribution of contents value (minimum, most likely, maximum). Content values are equal to 25% of the corresponding structure value.
- Structure Value. Triangular distribution of structure value (minimum, most likely, maximum). Structure values are described more fully in the economic appendix. They represent the most likely value, as well as the most likely value plus 5% and minus 10%.

- First Floor Elevation. This input can be a triangular distribution. In this analysis each individual structure was surveyed. Thus, the triangular distribution is only used for those structures added to vacant lots. These structures are representative of the most recently built structures nearby.

Planned Nourishment Alternatives

The present implementation of Planned Nourishment within Beach-*fx* (periodic-tested) involves nourishment trigger specifications expressed as a percent of specified nourishment template values along with a target renourishment interval, start date, mobilization threshold, and mobilization costs. On the start date, the required nourishment volume is estimated for all Reaches in which at least one of the threshold trigger specifications is satisfied. If the required nourishment volume exceeds the mobilization threshold volume, then a Planned Nourishment activity is scheduled. When nourishment occurs, all Reaches are restored to the specified nourishment template regardless of the nourishment threshold triggers. Renourishments are processed in a similar manner at the specified renourishment interval. If the mobilization threshold volume is not exceeded, nourishment does not take place. The next Planned Nourishment check will occur at the end of the renourishment interval. Planned Nourishment Alternatives are used to define scheduled nourishment cycles and design templates for each Reach. Nourishment cycles are defined as periodic intervals (e.g., every 3 years), which the Reaches can, if needed, be renourished.

Planned Nourishment specific data requirements

- Name. A textual identifier for the Planned Nourishment Alternative.
- Start Date. The date the nourishment alternative goes into effect.
- Time Increment (years). Planned renourishment cycle (i.e., the time between Planned Nourishment events). This varies among the different alternatives for this analysis.
- Mobilization Cost ($). Mobilization Cost, per nourishment. In this analysis, planned nourishments are accomplished by dredging. The mobilization cost reflects this and was determined to be $1,000,000.
- Default Borrow to Placement Ratio. Estimated volume of borrow material required to produce a unit volume of stable fill material on the project beach. This is a Reach-specific attribute and is set at the Reach level. For this analysis, a 1.2 fill ratio is used.
- Mobilization Threshold. Minimum number of cubic yards of nourishment material to be placed to justify project mobilization costs. In this analysis the minimum number of cubic yards for mobilization is 75,000.
- Type. Periodic-Tested. This nourishment implementation type assumes testing on a regular cycle. If at the time of testing, the volumetric nourishment need is less than the mobilization threshold, then testing for project mobilization is not reattempted until the next Planned Nourishment cycle. Periodic-Tested is currently the only nourishment type implemented in Beach-*fx*.
- Unit Placement Cost ($). The estimated cost of constructing a Planned Nourishment project expressed as a cost per cubic yard of fill material. This cost is $12.11 in this analysis. This is based on a borrow site comparison for dredging one million cubic yards of material.
- Borrow To Placement Ratio. The estimated volume of borrow material required to produce a unit volume of stable fill material on the project beach. This ratio is often

referred to as the overfill ratio and accounts for volumetric losses due the sorting and winnowing of fines contained in the fill material. The selected borrow site has an overfill ratio of 1.2.

- Production Rate (cubic yards/day). The rate at which fill volume is placed on the beach to construct the Planned Nourishment project expressed in units of cubic yards per day. This is 10,000 yards per day.
- Processing Order. An integer value indicating the order Reaches will be processed for nourishment if multiple Reaches are set to receive nourishment at the same time.
- Mobilization Cost ($). The costs associated with Reach-specific mobilization costs related to the nourishment event and not included in the Unit Placement Cost attribute. This is not utilized in this analysis.
- Dune Height (feet) (nourishment trigger). Fractional amount of template dune height that denotes requirement for renourishment. This is set at fifty percent of the constructed dune height.
- Dune Width (feet) (nourishment trigger). Fractional amount of template dune width that denotes requirement for renourishment. This is set at fifty percent of the constructed dune width.
- Berm Width (feet) (nourishment trigger). Fractional amount of template berm width that denotes requirement for renourishment. This is set at fifty percent of the constructed berm width.
- Dune Height (feet) (template). The post-construction dune height. This is the dune height in the alternative.
- Dune Width (feet) (template). The post-construction dune width. This is the dune width in the alternative.
- Berm Width (feet) (template). The post-construction berm width. This is the berm width in the alternative.

Emergency Nourishment

The present implementation of Emergency Nourishment within Beach-*fx* is limited to specification of a nourishment fill density (cubic yard/feet) that acts to increase dune width (at the current dune elevation) at the expense of berm width. However, if the current beach morphology is in a scarping condition, the fill material is first used to restore the berm for the deficit volume represented by the scarping condition. It is possible that the scarping-induced volume deficit may be greater than the specified Emergency Nourishment fill density. In this case, the scarping condition is reduced but not entirely restored and the dune width will remain unchanged.

Reach level Emergency Nourishment data requirements

- Emergency Nourishment Alternative. The Emergency Nourishment Alternative to be assigned to the parent Reach. This is selected from a drop-down list containing all Emergency Nourishment Alternatives defined at the project level.
- Unit Placement Cost ($). The estimated cost of constructing an Emergency Nourishment project expressed as a cost per cubic yard of fill material. It is assumed that Emergency Nourishment will be done by truck and a cost $38 per yard is used.
- Borrow To Placement Ratio. The estimated volume of borrow material required to produce a unit volume of stable fill material on the project beach. This ratio, often

referred to as the overfill ratio, accounts for volumetric losses due the sorting and winnowing of fines contained in the fill material. Since this is by truck the ratio is 1.

- Production Rate. The rate at which fill volume is placed on the beach to construct the Emergency Nourishment project expressed in units of cubic yards per day. The rate utilized for truck fill is 1,500 yards/day.
- Mobilization Cost ($). The Reach-specific costs associated with the nourishment event not included in the Unit Placement Cost attribute. In this analysis, $3,100 is used for each reach.
- Mobilization Time (days). The estimated time lag between the triggering event and the initiation of Emergency Nourishment construction. The time lag is set at 45 days.
- Priority Order. An integer value which will determine which Reach receives nourishment first, if more than one Reach is triggered for Emergency Nourishment at the same time. Ordering should begin at 1 and assigned values should be unique. The order is based on the reaches with the most severe erosion occurring in the model.
- Dune Width (feet) (Emergency Nourishment Trigger). A specified dune width that will trigger the first Emergency Nourishment. Subsequent Emergency Nourishments are triggered when the post Emergency Nourishment dune width is further reduced by an amount exceeding the Emergency Nourishment Trigger Adjustment value specified in the Configuration Settings table. The dune width trigger is set at half of the dune width.
- Emergency Nourishment Fill Density Specification. The Emergency Nourishment Fill Density Specification (cubic yard/feet). In this analysis, the fill density ratio of 5 is used to match the minimum FEMA standard.
- Emergency Nourishment Trigger Adjustment. The additional dune width loss (feet) that will trigger a subsequent Emergency Nourishment action after construction of the initial Emergency Nourishment project. This is set at 1.
- Emergency Nourishment Mobilization Time Threshold. A time window specification (days) beyond which any subsequent Emergency Nourishment will incur another project level mobilization cost. This was left at the default of 20 days.
- Emergency Nourishment Scheduled Nourishment Blackout Window Multiplier. A multiplier (factor) that is applied to the Emergency Nourishment mobilization time and checked against the start date of any Planned Nourishment activity. If a Planned Nourishment activity is scheduled to begin on or before the calculated date then the Emergency Nourishment activity is canceled. This is a necessary scheduling issue that will prohibit an overlapping of Emergency Nourishment and Planned Nourishment activities. Users can enter appropriate values for these settings by editing the value column. These specifications are global to the project and do not vary by Reach. This is set at 4 to make sure emergency nourishment does not run up against a planned nourishment.

Storm Seasons

Storm Seasons are defined for the study area. The Storm Seasons are used during the simulation when selecting Specific Storms to run. Storm Seasons are defined to cover the entire year, meaning every day of the year should belong to exactly one Storm Season (leap years are not handled). The table below shows the storm seasons used for this analysis. The minimum storm arrival time is also included as a part of the storm seasons. This is the minimum time allowed between storms. For this analysis, the minimum time between nor'easters is two days.

The study area has experienced twin nor'easters more than once in the storm record. The minimum arrival time between hurricanes is 7 days. The probabilities are based on the storm record dating back to 1928.

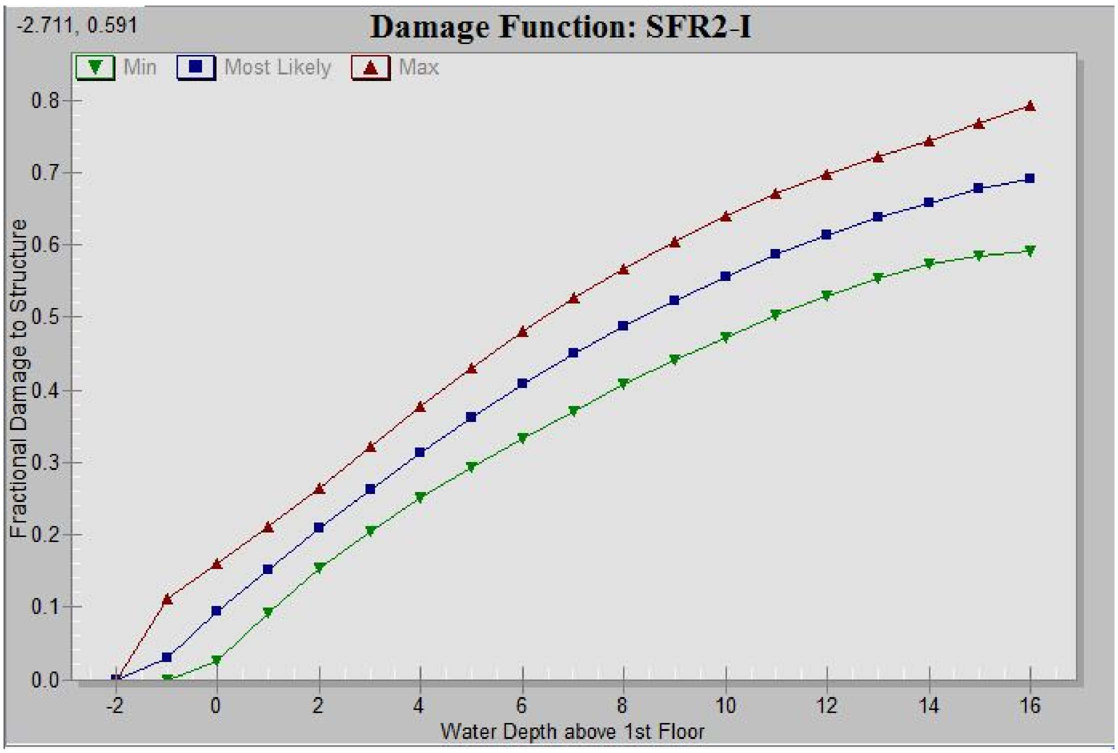
Storm Season specific data requirements

- Number. Unique identifier.
- Description. Textual description for the season (i.e., extra tropical only).
- Start Month. Month the season starts.
- Start Day. Day the season starts.
- End Month. Month the season ends.
- End Day. Day the season ends.
- Previous Season Overlap (days). The number of days prior to the specified season start month and day for purposes of identifying the population of storms from which the random sample will be taken. Overlap is not used in this analysis.
- Next Season Overlap. The number of days after the specified season end month and day for purposes of identifying the population of storms from which the random sample will be taken. Overlap is not used in this analysis.
- Probability of Extra Tropical Storm. Probability of occurrence of extratropical storms during that season.
- Probability of Tropical Storm. Probability of occurrence of tropical storms during that season.
- Minimum Storm Arrival Time (days). Minimum inter-arrival time for storms in season. For extra tropical seasons the inter-arrival time for storms is two days. For tropical seasons, the inter-arrival time is 7 days.
- Probability Active. True or False, this makes the season active or inactive.
- Maximum Extra-Tropical Storms In Season. The maximum number of extra-tropical storms that can occur in the season. This is set at 30, the inter-arrival times precludes this from occurring.
- Maximum Tropical Storms In Season. The maximum number of tropical storms that can occur in the season. This is set at 30, the inter-arrival time precludes this from occurring.

Storm Season	Storm Season Description	Storm Season Start Month	Storm Season Start Day	Storm Season End Month	Storm Season End Day	Probability Of Extra Tropical Storm	Probability Of Tropical Storm
1	Extra-Tropical	1	1	1	31	0.0625	0
2	Extra-Tropical	2	1	2	28	0.0375	0
3	Extra-Tropical	3	1	3	31	0.0125	0
4	Extra-Tropical	4	1	4	30	0.0375	0
5	No Storms	5	1	5	31	0	0
6	No Storms	6	1	6	30	0	0
7	Extra-Tropical	7	1	7	31	0.0125	0
8	Tropical	8	1	8	31	0.0125	0.04
9	Tropical	9	1	9	30	0.0125	0.12
10	Extra-Tropical	10	1	10	31	0.125	0
11	Extra-Tropical	11	1	11	30	0.0375	0
12	Extra-Tropical	12	1	12	31	0.025	0

Damage Functions

Damage Functions are completely user-definable within Beach-*fx*. A total of six types of Damage Functions are used in this analysis. These types include erosion damage (contents and structure), inundation damage (contents and structure), and wave damage (contents and structure). The figure below represents the inundation curve for structural damages for a two-story single family residence. Blue is the most likely curve, while red and green represent plus one and minus one standard deviation, respectively.



Storms

One or more storms need to be defined within Beach-*fx*. These storms will comprise the plausible storm suite used by Beach-*fx* during simulations. Storms have different features that are entered for each individual event.

Storm specific data requirements

- Identifier. A textual name/description that uniquely identifies the storm. This must be identical to the storm name used in the SBEACHsimulations.
- Type. The type of storm tropical is represented by the number 1 and extra tropical is represented by the number 0.

- Relative Probability. The relative probability between the storms in the plausible storm suite. For instance a storm with a relative probability of 2 is twice as likely to be selected as a storm with a relative probability of 1. Each type of storm is relative to itself. The relative probability does not apply across storm types.
- Peak Surge Plus Tide. The elevation of flooding from the back bay.
- Date of Storm. The historical date of the storm. This date is used to assign the storm to a defined Storm Season.

The following table shows the hurricanes on record since 1928. The highlighted storms are used in the storm suite for this analysis.

HURRICANES

Rank	Date	Name	Peak Stage	Hurricane Return Interval	Hurricane Frequency
1	8/23/1933	Aug '33	7.51	166.00	0.0060
2	9/18/2003	Isabel	6.37	64.00	0.0156
3	9/18/1936	Sep '36	6.17	58.00	0.0172
4	9/16/1933	Sep '33	5.61 (P)	43.00	0.0233
5	9/27/1956	Flossy	5.08 (P)		
6	9/12/1960	Donna	5.02	33.00	0.0303
7	9/19/1928	Sep '28	4.88		
8	9/13/1964	Dora	4.66		
9	9/16/1999	Floyd	4.50	26.00	0.0385
10	9/25/1992	Danielle	4.20		
11	8/28/1998	Ivan	4.09		
12	8/17/1986	Charley	4.04	22.00	0.0455

Source: Norfolk District H&H Section

The following table shows the Nor'easters to have hit the study area. The highlighted storms are used in the storm suite for this analysis.

NORTHEASTERS

Rank	Date	Name	Peak Stage	Extra Tropical Return Interval	Extra Tropical Frequency
1	3/7/1962	Ash Wed.	6.29	32	0.0313
2	11/12/2009		6.12	26	0.0385
3	4/11/1956		5.48	10	0.1000
4	4/27/1978		5.25	5	0.2000
5	2/5/1998	Twin N.E.	5.13		
6	11/22/2006		5.06		
7	10/7/2006		4.95 (P)		
8	10/6/1957		4.76		
9	10/5/1948		4.69		
10	10/25/1982		4.68	3	0.3333
11	1/28/1998	Twin N.E.	4.59 (P)		
12	12/19/2009		4.54 (P)		
13	11/4/1930		4.45		
14	10/21/1958		4.45	2.5	0.4000
15	7/3/1933		4.41 (P)		
16	1/24/1940		4.31		
17	10/21/1961		4.31 (P)		
18	4/13/1988		4.29		
19	10/14/1977		4.27	2.2	0.4545
20	9/25/2008		4.26		
21	1/1/1987		4.14	2	0.5000
22	2/6/2010		4.13		
23	8/30/1999		4.11 (P)		
24	10/19/1997		4.10		
25	12/5/1945		4.04		
26	10/12/1942		4.03		
27	1/17/1946		4.02		
28	2/11/1973		3.99		
29	1/25/2000		3.99		
30	10/31/1991		3.98	1.8	0.5556

Source: Norfolk District H&H Section

The following table shows the suite of storms used in this analysis.

Storm Identifier	Storm Number	Storm Type	Relative Probability	Peak Surge Plus Tide	Date Of Storm
Sep-03	1	1	2.59	6.76	9/18/2003
Sep-99	2	1	6.38	4.78	9/16/1999
Aug-86	3	1	7.55	4.43	8/17/1986
Sep-60	4	1	5.03	4.75	9/12/1960
Sep-36	5	1	2.86	6.56	9/18/1936
Sep-33	6	1	3.86	6.01	9/16/1933
Aug-33	7	1	1	7.91	8/23/1933
Oct-91	8	0	17.78	4.34	10/31/1991
Jan-87	9	0	16	4.53	1/1/1987
Oct-82	10	0	10.67	5.08	10/25/1982
Apr-78	11	0	6.4	5.64	4/27/1978
Oct-77	12	0	14.55	4.63	10/14/1977
Mar-62	13	0	1	6.68	3/3/1962
Oct-58	14	0	12.8	4.84	10/21/1958
Apr-56	15	0	3.2	5.87	4/11/1956
Nov-09	16	0	1.23	6.42	11/12/2009

Source: Norfolk District H&H Section

Reach Planform Rate

The final step in completing the Planned Nourishment specification is to provide Reach level estimates of the project-induced shoreline rate of change. Beach nourishment is the placement of relatively large quantities of high quality fill material (sand with grain size characteristics similar to the natural beach) on a beach to advance the shoreline seaward and to provide elevation by way of a dune feature adequate for the protection of the upland area. The beach nourishment project represents a planform perturbation on the natural shoreline and is characterized as seaward displacement of the shoreline. This disequilibrium in the planform induces sediment flows that over time reduce the extent of the planform disequilibrium, resulting in the beach nourishment project approaching equilibrium through alongshore dispersion of the fill material. This spreading-out (or dispersion) process of beach nourishment material from the placement area is captured within Beach-*fx* by way of specification of project-induced shoreline change rates or the Reach Planform Berm Width Change Rate. This rate is typically estimated using a shoreline change model such as GENESIS. The rate of shoreline change due to the dispersion process varies with location along the placement area, with greater rates of change near the lateral ends of the project and lesser rates of change near the center of the placement area. Consequently, the Reach planform rates of change are specified at the Beach-*fx* Reach level. Further, because the rate of fill material dispersion changes with maturation (age) of the nourishment project, this input is further specified to vary by nourishment cycle. Based on numerical model simulations, the user should estimate the average rate of project-induced shoreline rate of change by nourishment cycle for each Reach within and adjacent to the nourishment placement area. The beach at Willoughby Spit and Vicinity has had some regular nourishments from the local sponsor. These nourishments are not much less, at times, than the potential Federal project. Thus, the planform rate is kept consistent with the Applied Erosion Rate.

Scenarios

Beach-*fx* simulation parameters are defined using a Scenario. Individual simulation Scenarios are created by the user to specify a desired set of simulation parameters.

Scenario specific data requirements:

- Name. Scenario names should be unique.
- Description. A textual description of the Scenario.
- Start Year. The simulation start year for the Scenario. The last profile data available was for 2011, thus the simulation starts in 2011.
- Start Month. The simulation start month of the Scenario.
- Base Year. Reference year for present value calculations. This must be greater than the simulation Start Year. This is the year that benefits are expected to begin generating.
- Emergency Nourishment Flag. This determines whether or not Emergency Nourishment will take place.
- Planned Nourishment Alternative. Defined Planned Nourishment Alternative that will be applied for this Scenario simulation.
- Emergency Nourishment Alternative. Defined Emergency Nourishment Alternative that will be applied for this Scenario simulation.
- Step Flag. A Boolean flag indicating if the simulation should enter Step Mode to allow the user to single step the simulation.
- Iterations. The number of life-cycles or simulations to be performed. This analysis uses 300 iterations.
- Duration. The number of years spanned in each iteration/life cycle. The life-cycle duration should equal the number of years between the simulation start year and the base year (the year the Planned Nourishment Alternative is in place and producing benefits) plus the economic analysis study period (typically 50 years for the U.S. Army Corps of Engineers Hurricane and Storm Damage Reduction projects). In this analysis, 55 years is used. The start year is 2011 and the end of the period of analysis is 2065.
- Interest. The interest rate for present value calculations. The FY 2012 interest rate is 4.0%.
- Seed. Integer seed value for the random number generator which is used to generate the storm sequence during a simulation. It is recommended that the seed be specified as a large prime number. It is important to understand that the declared seed value for successive simulations must be identical in order for those simulations to experience the same sequence of storm events. If different Scenarios are to be inter-compared (e.g., with and without project) the seed value must be the same to ensure the same random

sequence of storms is encountered in each Scenario. The seed value in this analysis is 300007.

- Scarping. An indicator of whether the Scenario should include detailed treatment of dune scarping (recommended). The maximum recoverable scarp is 5-feet.
- Calibration. If checked, simulation will involve only morphology change calculations and preclude all economic related calculations.