ST. JOHNS COUNTY, FLORIDA

South Ponte Vedra Beach, Vilano Beach, and Summer Haven Reaches

COASTAL STORM RISK MANAGEMENT PROJECT

DRAFT INTEGRATED FEASIBILITY STUDY AND
ENVIRONMENTAL ASSESSMENT

APPENDIX C
Economics

February 2016

US Army Corps
of Engineers
Jacksonville District

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

THIS PAGE INTENTIONALLY LEFT BLANK.

0. EXECUTIVE SUMMARY

The St. Johns County, Florida Coastal Storm Risk Management Feasibility Study was authorized by House Resolution 2646, adopted June 21, 2000. Based on a reconnaissance study, completed in 2004, the feasibility study was initiated in 2005 to investigate alternatives for hurricane and storm damage reduction along the St. Johns County shoreline.

Alternative Evaluation

Upon conduct of a preliminary screening, followed by a detailed evaluation of a final array of alternatives, the project delivery team has determined a Tentatively Selected Plan (TSP) for reducing coastal storm and erosion damage to infrastructure. These plans were evaluated using FY 2015 price levels and the FY2016 federal water resources discount rate of 3.125%, and a 50 year period of analysis with a base year of 2020. See **Table 0-1** for more detail on the evaluation of the final array of alternatives.

Table 0-1: Final Alternative BCRs & Total Present Worth Net Benefits

Alternative Name	Brief Description	BCR	Net Benefits
0P60B 104to116 (TSP)	Initial and periodic nourishments of the existing dune profile and additional 60' extension of the berm along 2.6 miles from R-104 to R-116.	1.25	$ 8,573,000
10P60B 104to116	Initial and periodic nourishments of a 10' dune profile extension and additional 60' extension of the berm along 2.6 miles from R-104 to R-116.	1.20	$ 7,473,000

The Tentatively Selected Plan

The plan with the highest net benefits is "0P60B 104to116". Therefore, it is the Tentatively Selected Plan (TSP). This is also the plan with the highest Benefit-Cost-ratio (BCR).

The TSP will include initial construction and periodic nourishment of a 60 foot equilibrated berm (beach) extension. Additionally, for initial and periodic nourishment, the dune will be nourished where needed to maintain the average existing (2015) dune profile. The dune will be vegetated (where constructed) at initial construction only. These features will extend from R103.5 to R116.5 along 2.6 miles of shoreline. Tapers will extend 1,000 feet from the northern and southern ends of the berm extension, connecting the extension to the existing shoreline. With the inclusion of tapers, sand placement extends from R102.5 to R117.5 along 3 miles of shoreline. A hydraulic dredge will be used to fill the template with sand from the St. Augustine Inlet shoal complex.

The following table provides a summary of the TSP with and without incidental recreation benefits added at FY16 price levels discounted with the FY16 Water Resources Discount Rate (3.125%). See **Table 0-2** for more detail on the NED Plan.

Table 0-2: Economic Summary of the NED Plan

Economic Summary	Primary Storm Damage Reduction Benefits	Primary Storm Damage Reduction + Incidental Recreation Benefits
Price Level	FY16	FY16
FY16 Water Resources Discount Rate	3.125%	3.125%
Average Annual Structure & Contents Damage & Armor Costs Benefits	$ 1,709,000	$ 1,709,000
Average Annual Land Loss Benefits	$ 241,000	$ 241,000
Average Annual Incidental Recreation Benefits	$ -	$ 622,000
Average Annual Total Benefits	$ 1,950,000	$ 2,572,000
Average Annual Costs	$ 1,562,000	$ 1,562,000
Average Annual Net Benefits	**$ 388,000**	**$ 1,010,000**
Benefit Cost Ratio	**1.25**	**1.65**

TABLE OF CONTENTS

THE TABLES…….

THE FIGURES………..

1. INTRODUCTION

The purpose of this economics appendix is to tell the story of the economics investigation, and provide greater detail on the results of the analysis. The sections that follow will cover the following topics:

- **Existing Conditions:** Items discussed include an assessment of socio-economic conditions, spatial organization of the study area, and an inventory of the coastal infrastructure within the study area.

- **Coastal Storm Risk Management Benefits:** This section will cover the methods used to estimate the future without-project, and future with-project condition using Beach-fx, accounting for risk and uncertainty. The future without-project condition will cover the distribution of the damages in the following dimensions:
    - Spatial (Where)
    - Categorization of structures (What)
    - Damage driving parameter (How)
    - Temporal (When)

  The future with-project condition discussion will cover the extension of the authorized project and similar alternatives, and the analysis results. In addition, an analysis of alternative performance under the intermediate and high sea level change scenarios is provided.

- **NED & TSP Plan Selection and Performance:** This section addresses the rationale for NED and TSP selection. A detailed description of the performance of the NED Plan is provided with the same 4 dimensions given in the Hurricane & Storm Damage Reduction section. A discussion on the project's incidental recreation benefits is also provided.

2. EXISTING CONDITIONS

2.1 Overview of Existing Structures and Data Organization

Economists, real estate specialists, and engineers have collected and compiled detailed structure information stretch of shoreline to be modeled in Beach-fx for the for St. Johns County, Florida Coastal Storm Risk Management Feasibility Study (FDEP Monuments R-84 to R-122), which includes:

- 397 single family residences
- 37 multi-family residences
- 10 commercial structures
- 251 dune walks
- State Road A1A (SR A1A)
- Several parking lots, gazebos, garages, pools, tennis courts, and bath houses

In total, attribute information for 817 separate damage elements was populated for economic modeling using Beach-*fx*. The proximity of these buildings to the beach makes them potentially vulnerable to erosion, wave attack, and inundation.

The study area to be modeled in Beach-*fx* has been divided into two study reaches based on municipal boundaries. These two study reaches are South Ponte Vedra Beach and Vilano Beach. A "study reach" simply delineates sub-regions or municipal/political boundaries within an authorized study area.

The study area was disaggregated into 8 representative beach profiles, 37 model (Beach-*fx*) reaches, and 445 lots, for economic modeling and reporting purposes. **Figure 2-1** shows an aerial view of the Beach-*fx* model features in the vicinity of R-106 and R-107 which represent a typical stretch of shoreline in the study area modeled. This hierarchical structure is depicted as follows:

- **Beach Profiles:** Coastal beach profile surveys were analyzed by USACE Jacksonville District (SAJ) Coastal Engineering personnel to develop representative beach profiles that include the dune, berm and submerged portions of the beach. The representative beach profiles are used for shore response modeling in the SBEACH engineering numerical model, and only referred to in this section for informational purposes.
- **Beach-*Fx* (Model) Reaches:** Quadrilaterals with a seaward boundary that is parallel with the shoreline that contain the Lots and Damage elements, and that are used to incorporate coastal morphology changes for transfer to the lot level. Model reaches are also useful for developing study reaches into more manageable segments for analysis. After the FWOP conditions are modeled, the Beach-*fx* reaches will be grouped into "design reaches" to represent separable increments delineated based on shoreline condition and FWOP damages, where unique FWP alternatives could be implemented.
- **Lots:** Quadrilaterals encapsulated within model reaches used to transfer the effect of coastal morphology changes to the damage element. Lots are also repositories for coastal armor costs, specifications, and failure threshold information.
- **Damage Elements:** Represents the smallest unit of the existing condition coastal inventory and a store of economic value subject to losses from wave attack, inundation, and erosion damages. Damage elements are a primary model input and the topic of focus in this discussion. The primary structure categories are coastal armor and coastal structures.

More details on the establishment of the Profiles and Beach-*fx* Model Reaches, which is primarily based on physical shoreline characteristics, can be found in the Appendix A - Engineering.

Beach-*fx* handles economic considerations at the Lot and Damage Element levels. These considerations include armor construction costs at the Lot level, and the extent of damage and rebuilding costs at the Damage Element level. **Section 2.2** will provide further detail on the Lot and Damage Element attribute data that makes up the structure inventory for this project area.

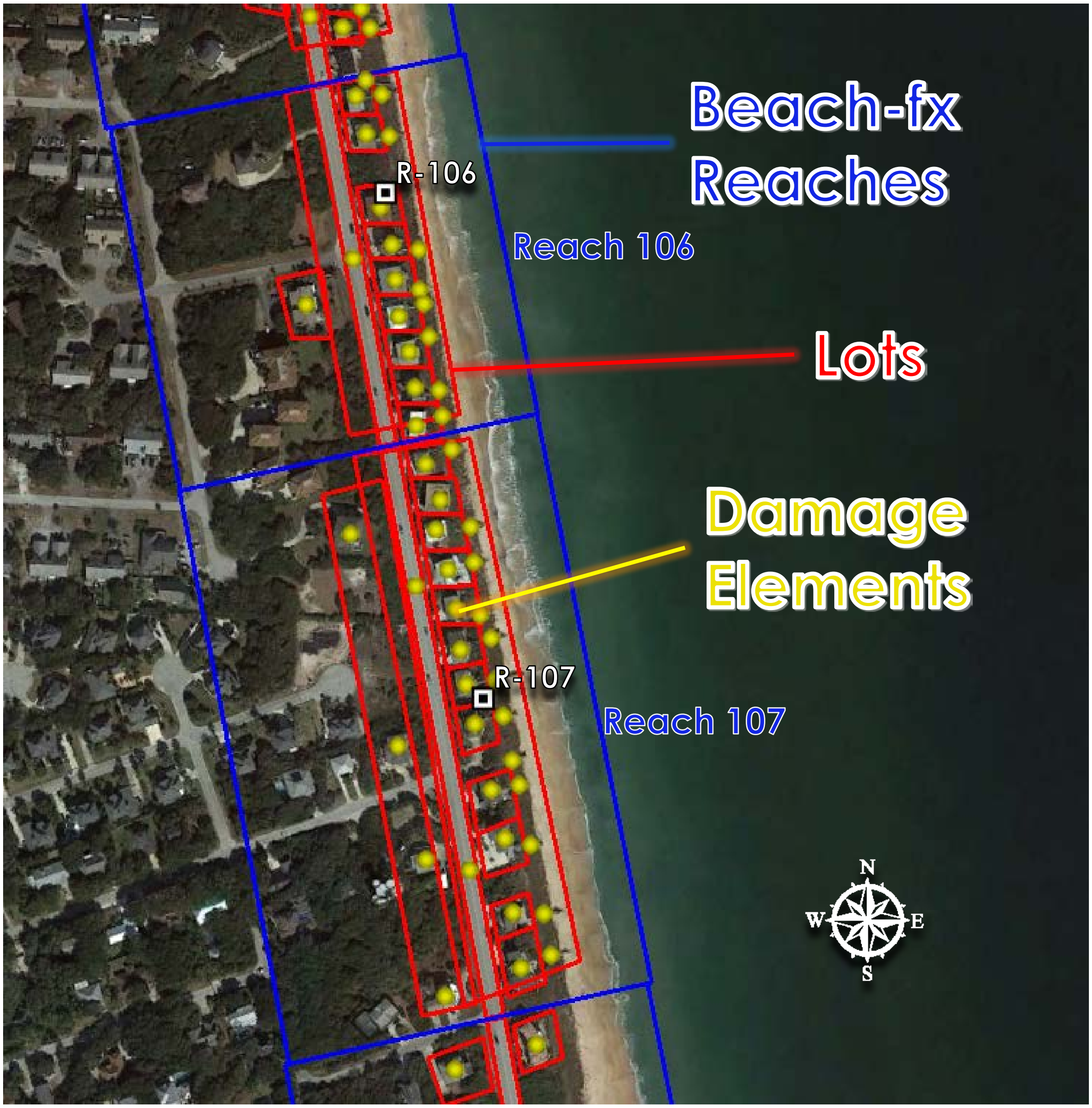


Figure 2-1: Typical Beach-fx Set Up (2014 Google Aerial)

2.2 Data Collection for Structure Inventory

Information on the existing economic conditions along the St. Johns County study area coastline was collected for economic modeling purposes using Beach-*fx*. The information on the coastal assets detailed in this section was collected from mapping resources, site visits, and contractors.

2.2.1 Lots - Coastal Armor

Beach-*fx* handles coastal armoring parameters and condemnation at the lot level. Lots are designated as being either armored, armorable in the future, or not armorable, based on coastal regulations that dictate armor construction and local history on armor permitting and construction. Since armoring forms one of the major roles of lots in Beach-*fx*, the location and length of potential future armoring dictates the seaward boundary of most lots.

Data on coastal armor within the project area was collected from a variety of sources including site visits, aerial photography, and USACE SAJ Coastal Engineering personnel. Coastal armor value was determined by USACE SAJ Cost Engineering personnel.

The area modeled contains several types of existing coastal armor including seawalls and revetments constructed of various materials. Most of this existing armor has been constructed to protect single family residences from erosion damages. **Figure 2-2** shows the lots color coded by armor status for a typical stretch of shoreline in the vicinity of R-87 and R-88. Lots that are already armored are shown in red.

The project area shoreline that is not currently armored has been categorized as being either armorable in the future or not armorable. This categorization is based on the assumed likelihood that armor would or would not be constructed by local interests in the future, should a Federal Project not be implemented.

Lots designated as armorable in the future are shown in yellow in **Figure 2-2**. It is assumed that certain structures along the shoreline would be armored by local interests in a similar manner to existing armor as erosion continues to threaten homes and property. In St. Johns County homes that were built before 1988, or that are located between armored properties less than 250 feet apart, are eligible for armor permits under Florida's Coastal Construction Control Line (CCCL) program. Seawalls to protect single family residences in the study area have been constructed as recently as 2015. It is also assumed that the Florida Department of Transportation (FDOT) would construct armor in order to protect State Road (SR) A1A if erosion threatened it. This road is the main north to south corridor in the study area and is an emergency evacuation route. FDOT already has plans and designs developed for armoring a section of SR A1A in the study area between R-115 and R-116.

SAJ Cost Engineering personnel developed cost estimates for 6 unique types of existing or potential future armor in the study area. **Table 2-1** shows the armor costs per linear foot used in the model.

Table 2-1: Armor Costs

Armor Type (Typical Length)	Cost/Linear Foot	Mob/Demob
Vinyl Sheetpile Seawall (75 LF)	$1,920	$20,000
Steel Sheetpile Seawall (75 LF)	$2,440	$20,000
Wood Bulkhead (75 LF)	$1,280	$20,000
FDOT Steel Sheetpile Seawall (1000 LF)	$5,726	$442,000
Wood Wall (68 LF)	$426	$6,000
Armor Stone Revetment (90 LF)	$2,178	$7,000

Not armorable lots are shown in green in **Figure 2-2**. It is assumed that these lots would not be armored in the future either because the property would not be eligible for armor construction under the CCCL criteria or the property owner would likely find that armor is more costly that the infrastructure being protected. In the area modeled, lots that are empty or contain only relatively low value structures such as dune walks or gazebos along the shoreline are assumed to be not armorable in the future.

Figure 2-2: Lot Armor Status

2.2.2 Damage Elements - Structure & Contents Value

Beach-*fx* handles economic considerations at the DE level. These considerations include extent of damage, cost to rebuild, and time to rebuild. Beach-*fx* uses pre-defined damage functions to calculate the extent of damage. For each damage element, the following information is input into Beach-*fx*:

- Geographical reference (northing and easting of center point)
- Alongshore length and cross-shore width
- Usage (e.g., single family, multi-family, commercial, walkover, pool, gazebo, tennis court, parking lot)
- Number of floors
- Construction type (e.g., wood frame, concrete, masonry)
- Foundation type (e.g., shallow piles, deep piles, slab)
- Armor type (e.g., seawall)
- Ground and/or first floor elevation
- Value of structure (replacement cost less depreciation)
- Value of contents

The geospatial location and footprint of the damage elements was verified using aerial photography in ArcMap. The construction and foundation type of each damage element was gathered from the St. Johns County property appraiser information and visual observations by Jacksonville district (SAJ) staff. First floor elevations of all the damage elements in the study area were surveyed. Real Estate professionals from SAJ provided updated depreciated replacement costs for all of the damage elements in March 2015. An uncertainty of +/- 15% was assigned to these costs. The value of contents was assumed to be 50% of the structure value for all habitable structures. Non-habitable structures (dune walks, bathhouses, pools, etc...) had zero contents value.

2.3 Structure Inventory Overview

The economic value of the existing structure inventory represents the depreciated replacement costs of damageable structures and their associated contents within the study area along the coastline. The damage element inventory includes 817 damageable structures with an overall estimated value of $268 M, with structure and content valuations of $188 M and $80 M respectively.

Values aggregated by Beach-*fx* Reach show only slight variation due to differentiation between the type, magnitude, and density of development. **Table 2-2** provides the distribution of structure and content values broken down by Beach-*fx* Reach.

Table 2-2: Distribution of Structures & Structure Value by Reach

Distribution of Structures & Structure Value by Reach					
Beach-Fx Reach	**DE Count**	**Structure Value**	**Content Value**	**Total Value**	**% of Total Value**
84	8	$ 1,108,437	$ 376,268	$ 1,484,705	**1%**
85	20	$ 3,175,145	$ 1,275,190	$ 4,450,335	**2%**
86	20	$ 3,627,217	$ 1,469,831	$ 5,097,048	**2%**
90	27	$ 3,928,659	$ 1,603,997	$ 5,532,656	**2%**
91	22	$ 3,149,707	$ 1,233,206	$ 4,382,913	**2%**
92	15	$ 2,085,649	$ 816,325	$ 2,901,974	**1%**
93	28	$ 4,067,044	$ 1,681,022	$ 5,748,066	**2%**
87	32	$ 6,612,213	$ 2,861,777	$ 9,473,990	**4%**
88	22	$ 3,851,535	$ 1,641,533	$ 5,493,068	**2%**
89	28	$ 6,237,679	$ 2,715,902	$ 8,953,581	**3%**
94	8	$ 844,758	$ 140,214	$ 984,972	**0%**
95	19	$ 2,015,648	$ 584,794	$ 2,600,442	**1%**
96	26	$ 4,281,210	$ 1,761,098	$ 6,042,308	**2%**
97	20	$ 3,430,500	$ 1,383,555	$ 4,814,055	**2%**
98	61	$ 16,869,267	$ 7,846,416	$ 24,715,683	**9%**
100	46	$ 11,714,035	$ 5,313,803	$ 17,027,838	**6%**
101	25	$ 4,181,708	$ 1,711,544	$ 5,893,252	**2%**
102	8	$ 10,049,865	$ 4,680,000	$ 14,729,865	**5%**
103	12	$ 13,796,355	$ 6,419,700	$ 20,216,055	**8%**
104	22	$ 5,035,899	$ 2,181,137	$ 7,217,036	**3%**
105	15	$ 3,488,390	$ 1,350,185	$ 4,838,575	**2%**
106	20	$ 3,880,670	$ 1,665,604	$ 5,546,274	**2%**
107	30	$ 4,970,238	$ 2,068,742	$ 7,038,980	**3%**
108	11	$ 2,723,804	$ 1,074,022	$ 3,797,826	**1%**
109	15	$ 3,003,386	$ 862,898	$ 3,866,284	**1%**
110	18	$ 2,510,368	$ 888,944	$ 3,399,312	**1%**
111	31	$ 5,272,445	$ 2,241,253	$ 7,513,698	**3%**
112	22	$ 5,522,167	$ 2,198,746	$ 7,720,913	**3%**
114	16	$ 5,263,067	$ 2,141,249	$ 7,404,316	**3%**
115	11	$ 3,216,410	$ 1,287,180	$ 4,503,590	**2%**
116	12	$ 2,077,290	$ 655,080	$ 2,732,370	**1%**
117	10	$ 1,285,292	$ 360,946	$ 1,646,238	**1%**
118	36	$ 5,326,818	$ 2,186,154	$ 7,512,972	**3%**
119	33	$ 4,767,243	$ 2,059,374	$ 6,826,617	**3%**
120	36	$ 16,351,882	$ 7,684,346	$ 24,036,228	**9%**
121	19	$ 5,315,967	$ 2,575,266	$ 7,891,233	**3%**
122	13	$ 2,588,949	$ 1,279,362	$ 3,868,311	**1%**
Total	**817**	**$ 187,626,916**	**$ 80,276,658**	**$ 267,903,574**	**100%**

3. COASTAL STORM RISK MANAGEMENT BENEFITS

This section of the appendix covers the approach used to estimate the economic benefits of reducing hurricane and storm related damages in St. Johns County using Beach-*fx*. The topics covered include:

- Benefit estimation approach using Beach-*fx*
- The future without-project condition
- The future with-project condition

3.1 Benefit Estimation Approach using Beach-fx

Beach-*fx* was developed by the USACE Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi. On April 1, 2009 the Model Certification Headquarters Panel certified the Beach-*fx* hurricane and storm damage reduction (HSDR) model based on recommendations from the HSDR - Planning Center of Expertise (PCX). The model was reviewed by the PCX for Coastal and Storm Damage and found to be appropriate for use in coastal storm damage reduction studies. The model links the predictive capability of coastal evolution modeling with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the costs and total damages under various shore protection alternatives. This output is then used to determine the benefits of each alternative.

Beach-*fx* fully incorporates risk and uncertainty, and is used to simulate lifecycle hurricane and storm damages and to compute accumulated present worth damages and costs. Storm damage is defined as the damage incurred by the temporary loss of a given amount of shoreline as a direct result of wave attack, erosion, and/or inundation caused by a storm of a given magnitude and probability. Beach-*fx* is an event-driven life-cycle model that estimates damages and associated costs over a period of analysis based on storm probabilities, tidal cycle, tidal phase, beach morphology and many other factors. Damages or losses to developed shorelines include buildings, pools, patios, parking lots, roads, utilities, seawalls, revetments, bulkheads, replacement of lost backfill, etc. Beach-*fx* also provides the capability to estimate the costs of certain future measures undertaken by state and local organizations to protect coastal assets, such as emergency beach/dune fill projects.

Data on historic storms, beach survey profiles, and private, commercial & public structures within the project area is used as input to the USACE Beach-*fx* model. The model is then used to estimate future project hurricane and storm damages.

The future structure inventory and values are the same as the existing condition. This conservative approach neglects any increase in value due to future development. Due to the uncertainty involved in projections of future development, using the existing inventory is preferable and considered conservative for Florida where coastal development has historically increased in density and value.

The future without-project damages will be used as the base condition. Potential alternatives are measured against this base condition. The difference between with and without-project damages will be used to determine project benefits.

Once benefits for each of the alternatives are calculated, they will be compared to the costs of implementing the alternative. Dividing the benefits of an alternative by the costs of the alternative yields a Benefit-to-Cost Ratio (B/C Ratio). This ratio must be greater than 1.0 in order for the alternative to be justified and implementable (i.e. the benefits must be greater than the costs). The federally preferred plan (NED – National Economic Development Plan) is the plan that maximizes net benefits. Net benefits are determined by subtracting the cost of any given alternative from the benefits of that alternative (Benefits – Costs = Net Benefits).

3.2 Model Assumptions

- **Start Year:** The year in which the simulation begins is 2015
- **Base Year:** The year in which the benefits of a constructed federal project would be expected to begin accruing is 2020
- **Period of Analysis:** 50 years (2020 to 2070)
- **Discount Rate:** 3.125% FY2016 Federal Water Resources Discount Rate
- **Damage Functions:** Damage functions developed by the Institute for Water Resources (IWR), Coastal Storm Damage Workshop (CSDW), Coastal Storm Damage Relationships Based on Expert Opinion Elicitation in 2002, were used.
- **Coastal Armor:**
    - Existing armor set at the lot level will protect the damage elements in that lot until failure is triggered. If the armor fails structures will be subject to damages until the armor is rebuilt.
    - When erosion reaches the seaward edge of armorable in the future lots, armor will be constructed at this location. Before the armor is built the damage elements are subject to damages. Once construction of the armor is completed, armor will function normally.
    - Shorefront properties that are not armorable will not be armored in the future because of either permitting restrictions, or the cost of armor would not likely be warranted to protect the relatively low value structures on these properties.
- **Number of Times Rebuilding Allowed:** The maximum number of structure rebuilds can be specified for damage elements. Based on the assumed likeliness that certain types of damage elements will eventually stop being rebuilt by property owners, the following are the number of times that rebuilding is allowed for certain types of damage elements:
    - Dune Walks: 10X
    - Remaining: 99X

3.3 Future Without-Project Condition (FWOP)

Over 100 iterations the future without-project condition damages across the study area modeled range between $46.8 and $149.8 M present value dollars. Descriptive statistics on the FWOP model damages are as follows:

- Mean: PV $97,132,960
- Standard deviation: $20,508,484
- Median: $95,674,130

Figure 3-1 provides an illustration of FWOP results as a probability distribution based on the *Iteration.csv* model output file. The distribution is characterized by a relatively low peak suggesting that there is a significant amount of uncertainty surrounding the damages.

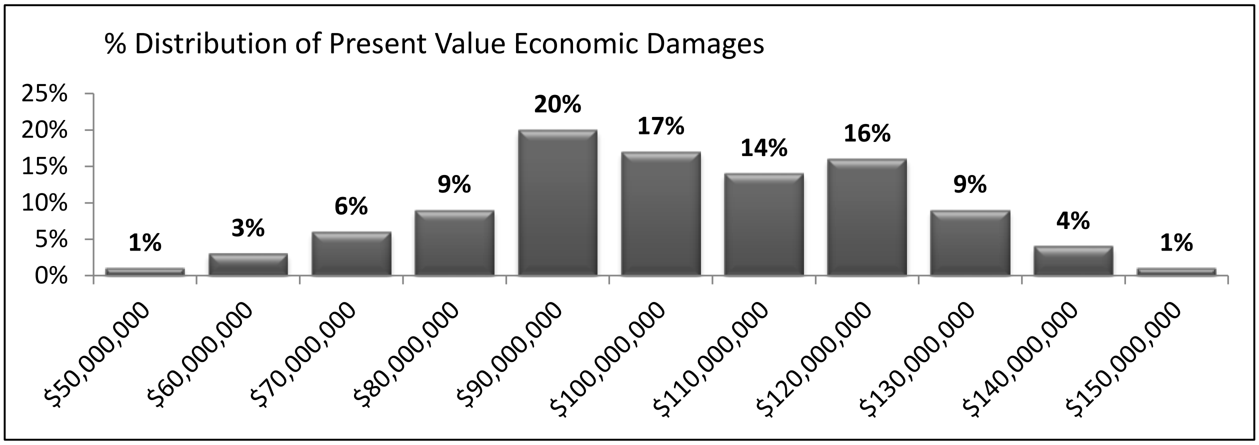


Figure 3-1: Probability Distribution of the Future Without-Project Condition Results

3.3.1 Damage Distribution by Structure Category and Type

Pursuant to estimating future without-project condition damages and associated costs for the St. Johns County study area, Beach-*fx* was used to estimate damages and costs in the following categories:

- Structure Damage: Economic losses resulting from the structures situated along the coastline being exposed to wave attack, inundation, and erosion damages. Structure damages account for approximately 53.7% of the total FWOP damages.
- Contents Damage: The material items housed within the aforementioned structures (usually air conditioned and enclosed) that are potentially subject to damage. Content damages make up approximately 21.5% of the total FWOP damages.
- Coastal Armor Cost: Beach-*fx* provides the capability to estimate the costs incurred from measures likely to be taken to protect coastal assets and or prevent erosion in the study area. Based on the existence of coastal armor units throughout the study area, Beach-*fx* was used to estimate the costs of erecting such measures throughout the period of analysis. Armor costs account for approximately 24.8% of the total FWOP damages.

Table 3-1 provides greater detail on the composition of the average FWOP damages by category and damage element type based on the *Iteration.csv* and *ReachYearlyDamagesByType.csv* model output files.

Table 3-1: Distribution of FWOP Damages by Category and Type

DE Type	Average PV Structure Damage	Average PV Content Damage	Average PV Armor Costs	Total Average PV Damages & Costs	% of Total
COMM	$ 1,861,712	$ 930,865	$ -	**$ 2,792,576**	3%
GAZEBO	$ 608,711	$ -	$ -	**$ 608,711**	1%
MFR1	$ 2,250	$ 1,125	$ -	**$ 3,375**	0%
MFR2	$ 808,674	$ 404,337	$ -	**$ 1,213,010**	1%
MFR3	$ 135,699	$ 68,225	$ -	**$ 203,924**	0%
PARKINGLOT	$ 442,541	$ -	$ -	**$ 442,541**	0%
POOL	$ 88,565	$ -	$ -	**$ 88,565**	0%
ROAD2	$ 4,835,406	$ -	$ -	**$ 4,835,406**	5%
ROAD3	$ 1,687,213	$ -	$ -	**$ 1,687,213**	2%
SFR1	$ 13,295,051	$ 6,623,894	$ -	**$ 19,918,946**	21%
SFR2	$ 20,055,501	$ 10,009,045	$ -	**$ 30,064,546**	31%
SFR3	$ 5,793,992	$ 2,892,867	$ -	**$ 8,686,859**	9%
TENNIS	$ 734	$ -	$ -	**$ 734**	0%
WALK	$ 2,522,672	$ -	$ -	**$ 2,522,672**	3%
ARMOR COST	$ -	$ -	$ 24,063,881	**$ 24,063,881**	25%
Total	**$ 52,138,722**	**$ 20,930,358**	**$ 24,063,881**	**$ 97,132,960**	100%
% of Total	53.7%	21.5%	24.8%	100%	

3.3.1.1 *Single Family Residences (SFR)*

Single family residences consist of 1-3 story structures of varying construction type and value. This category accounts for the majority of the damage elements in the study area. 61% of the total FWOP damages are associated with direct damages to these structures and their content.

3.3.1.2 *Armor Costs*

Armor costs are associated with the construction of new armor and rebuilding of damaged armor. The purpose of coastal armor is to protect coastal infrastructure from hurricane and storm damage. Armor costs account for 25% of the total FWOP damages.

3.3.1.3 *Roads*

Road damages make up about 7% of the overall FWOP damages. These damages are associated with damages to segments of SR A1A that are exposed to erosion.

3.3.1.4 *Public / Commercial*

Damage associated with public/commercial (COMM) structures and their contents make up about 3% of the overall FWOP damages. Structures within this category include 1-2 story buildings used for public or commercial purposes.

3.3.1.5 *Mulit-Family Residential*

Damage associated with multi-family residences (MFR) and their contents make up about 1% of the overall FWOP damages. Structures within this category tend to be more substantial in terms of construction, and contain the greatest amount of economic value per structure.

3.3.1.6 *Other Structures*

Other structures include the GARAGE, GAZEBO, PARKINGLOT, POOL, TENNIS, and WALK damage element types. These structures are rarely protected by coastal armor, are built for outdoor use, tend to be closer to the shoreline, and tend to be less costly to rebuild. As a result, these damage elements are hit by the damage driving parameters more often, and rebuilt with a greater frequency. With the exception of garages, these damage elements are not subject to contents damage. Other structures account for about 4% of the total FWOP damages.

3.3.2 Spatial Distribution of Without-Project Damages

There are several reaches within the area modeled where the FWOP damages and armor costs are the greatest. The segment that includes model reaches 96 – 100 accounts for about 22% of the overall FWOP damages, and the segment that includes model reaches 111 – 116 accounts for about 30% of the overall FWOP damages. These results are summarized in **Table 3-2**. **Figure 3-2** illustrates the spatial distribution of erosion rate, existing structure value, and FWOP damages and costs by reach. **Table 3-2** and **Figure 3-2** are based on the *ReachStatistics.csv* and *ArmorStatus.csv* model output files.

Table 3-2: FWOP present value damages by Category and Beach-fx Reach

Beach-fx Reach	Average Annual Erosion (-ft/yr)	Average PV Structure Damage	Average PV Content Damage	Average PV Armor Costs*	Total Average PV Damages & Costs	% of Total
84	-0.8	$ 375,421	$ 171,294	$ 29,434	**$ 576,149**	1%
85	-0.6	$ 387,424	$ 153,773	$ 582,413	**$ 1,123,610**	1%
86	-0.5	$ 194,176	$ 66,465	$ 840,648	**$ 1,101,289**	1%
87	-0.5	$ 924,351	$ 428,326	$ 579,429	**$ 1,932,106**	2%
88	-0.8	$ 132,154	$ 6,442	$ 14,947	**$ 153,542**	0%
89	-1.2	$ 91,835	$ 386	$ 13,649	**$ 105,870**	0%
90	-1.4	$ 195,611	$ 15,664	$ 108,687	**$ 319,962**	0%
91	-1.6	$ 144,462	$ -	$ -	**$ 144,462**	0%
92	-1.7	$ 2,243,397	$ 1,076,163	$ 516,555	**$ 3,836,116**	4%
93	-1.8	$ 2,920,996	$ 1,379,401	$ 960,862	**$ 5,261,258**	5%
94	-1.8	$ 230,338	$ 105,534	$ 344,429	**$ 680,301**	1%
95	-1.8	$ 1,595,891	$ 603,125	$ 4,227	**$ 2,203,243**	2%
96	-1.8	$ 3,910,423	$ 1,882,485	$ 4,507	**$ 5,797,415**	6%
97	-1.6	$ 2,028,330	$ 932,266	$ 1,933	**$ 2,962,528**	3%
98	-1.4	$ 3,588,286	$ 1,717,764	$ -	**$ 5,306,051**	5%
100	-1.3	$ 4,957,520	$ 2,333,828	$ 47,070	**$ 7,338,419**	8%
101	-1.3	$ 1,621,671	$ 682,001	$ -	**$ 2,303,672**	2%
102	-1.3	$ 36,615	$ 239	$ 81,856	**$ 118,710**	0%
103	-1.3	$ 1,157,672	$ 513,568	$ 114,792	**$ 1,786,033**	2%
104	-1.4	$ 3,167,351	$ 1,421,507	$ 14,676	**$ 4,603,534**	5%
105	-1.6	$ 2,410,012	$ 919,385	$ 56,334	**$ 3,385,731**	3%
106	-1.7	$ 2,500,772	$ 1,081,897	$ 21,065	**$ 3,603,734**	4%
107	-1.8	$ 2,792,717	$ 1,145,779	$ 567,255	**$ 4,505,751**	5%
108	-1.8	$ 531,719	$ 119,372	$ 469,274	**$ 1,120,366**	1%
109	-1.9	$ 1,140,633	$ 220,796	$ 450,694	**$ 1,812,123**	2%
110	-1.8	$ 811,124	$ 189,564	$ 1,348,534	**$ 2,349,222**	2%
111	-1.8	$ 2,522,822	$ 987,537	$ 1,131,931	**$ 4,642,290**	5%
112	-1.7	$ 2,698,139	$ 1,147,810	$ 1,164,313	**$ 5,010,261**	5%
114	-1.7	$ 2,558,600	$ 795,126	$ 5,362,279	**$ 8,716,006**	9%
115	-1.6	$ 1,485,160	$ 289,737	$ 2,742,730	**$ 4,517,628**	5%
116	-1.5	$ 1,297,118	$ 102,037	$ 5,058,869	**$ 6,458,024**	7%
117	-1.3	$ 237,272	$ 11,450	$ 1,221,097	**$ 1,469,820**	2%
118	-0.8	$ 817,198	$ 345,302	$ 582,751	**$ 1,745,251**	2%
119	0.0	$ 57,161	$ 12,228	$ 6,728	**$ 76,117**	0%
120	0.7	$ 106,945	$ 7,613	$ -	**$ 114,558**	0%
121	1.3	$ 131,791	$ -	$ -	**$ 131,791**	0%
122	1.5	$ 135,613	$ 64,495	$ -	**$ 200,108**	0%
	Total	**$ 52,138,722**	**$ 20,930,358**	**$ 24,443,970**	**$ 97,513,050**	100%

* The PV Armor Costs presented in this table were calculated for each reach based on the *ArmorStatus.csv* output file because Beach-fx does not output PV armor costs by reach. Therefore, they do not match exactly with the PV Armor costs presented in Table 3-1 and Table 3-3 which were direct model outputs from the *Iteration.csv* model output file which does not break out reach specific armor data.

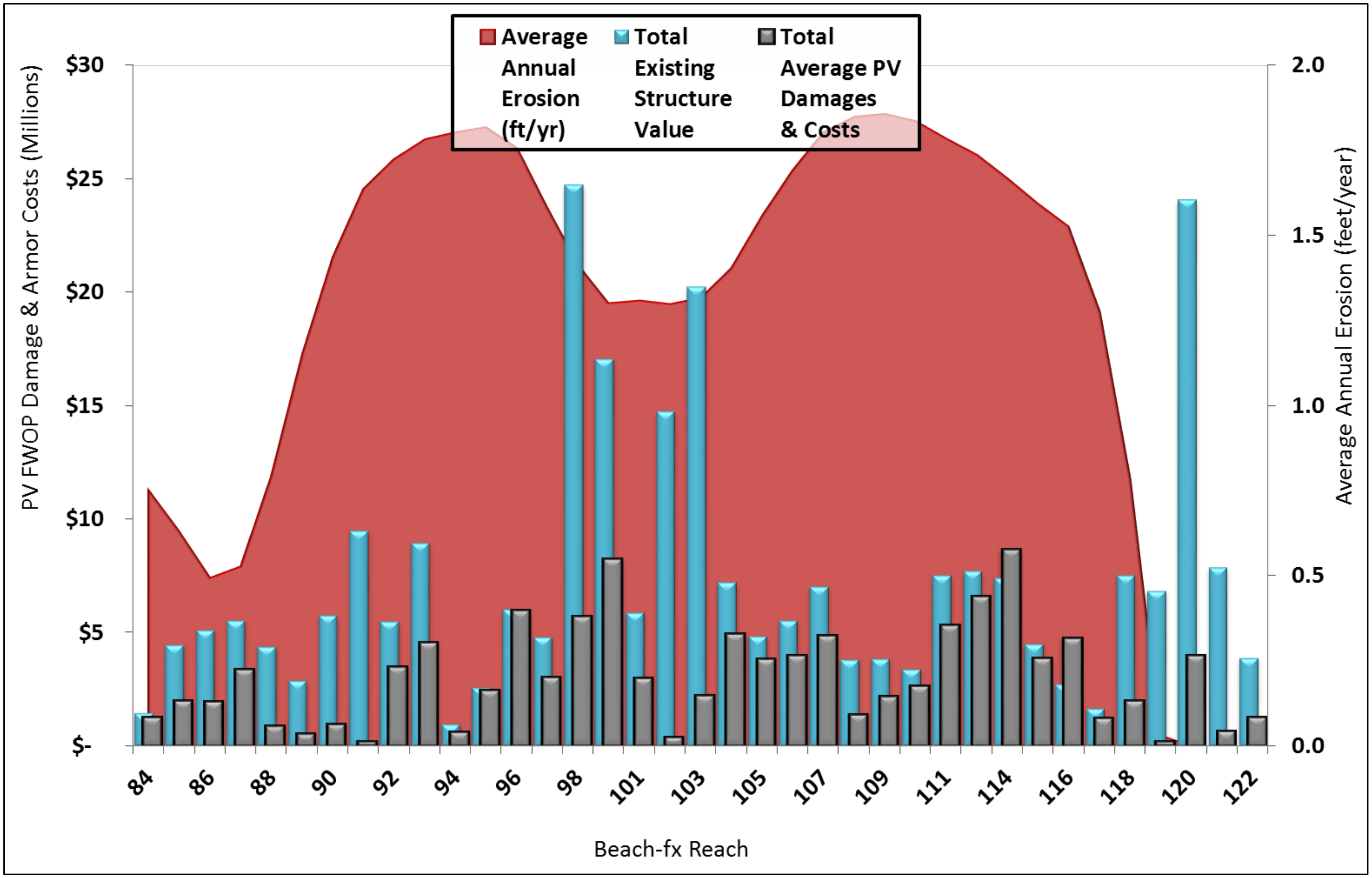


Figure 3-2: Spatial Distribution of Damages and Erosion Rates by Reach

3.3.3 Damage Distribution by Damage Driving Parameter

Just about all of the FWOP damages and costs are attributable to erosion. The distribution of damages by driving parameter based on the *ReachYearlyDamagesByType.csv* is as follows:

- Erosion: 99.56%
- Inundation: 0.13%
- Wave Attack: 0.32%

3.3.4 Temporal Distribution of Damages

Figure 3-3 illustrates the non-present value damages over time by study reach based on the *ReachYearlyDamages.csv* and *ArmorStatus.csv* model output files. The timing of FWOP damages and armor costs varies across the model reaches.

There is a great deal of variability in the amount of damages amongst the Beach-fx Reaches. This is explained by the large number of variables, all of which the Beach-*fx* model takes into account. Examples of variation between the reaches result from the following:

- Density and amount of development
- Typical size and value of structures
- Typical distance between structures and mean-high water
- Size, shape and location of the dunes and coastal morphology
- Rate of erosion for each reach
- Amount and type of coastal armoring present
- Timing that property owners construct coastal armoring in the future.

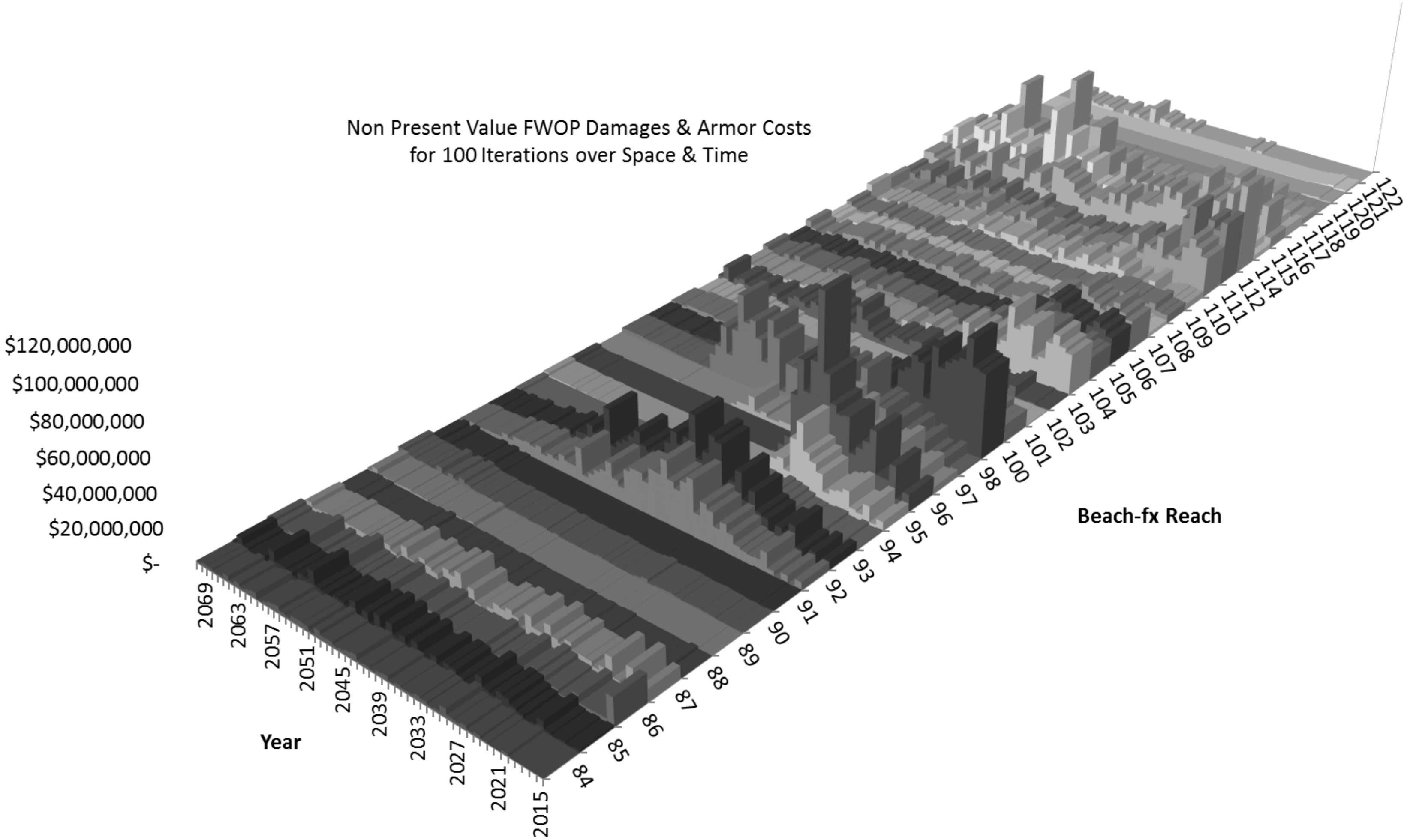


Figure 3-3: Non Present Value FWOP Damages & Armor Costs over Space and Time

3.3.5 FWOP Damages in alternative Sea Level Rise (SLR) scenarios

The FWOP condition was modeled for three sea level rise (SLR) scenarios. ER 1110-2-8162 provides both a methodology and a procedure for determining a range of sea level rise estimates based on the local historic sea level rise rate, the construction (base) year of the project, and the design life of the project. The Beach-*fx* results presented above refer to the baseline scenario, which is based on the historic erosion rate. The results associated with the other two SLR scenarios are presented here.

Table 3-3 and **Figure 3-4** provide an overall summary of FWOP average present value damage and armor costs in each SLR scenario based on the *Iteration.csv* model output files. Combined structure and content damages increase by 22% from the base to intermediate scenarios, and 51% from the base to high scenarios. Armor costs increase by 57% from the base to intermediate scenarios, and 149% from the base to high scenarios. The total damage and armor costs increase by 31% from the base to intermediate scenarios, and 75% from the base to high scenarios. Erosion is the primary damage driver, accounting for about 99% of the FWOP damage and armor costs in the intermediate and high SLR scenarios. **Figure 3-5** shows the distribution of average present value FWOP damages and armor costs by model reach and **Figure 3-6** shows the distribution of average non present value FWOP damages and armor costs over time respectively for the three SLR scenarios based on the *ReachYearlyDamages.csv* and *ArmorStatus.csv* model output files.

The SLR results suggest that damages increase as the erosion rate increases. With greater erosion, more structures become subject to damaged more quickly.

Table 3-3: FWOP Average PV Damage and Armor Costs by SLR Scenario

	Base SLR	Intermediate SLR	High SLR
FWOP Average PV Damages	$ 73,069,080	$ 89,203,284	$ 110,450,927
FWOP Average PV Armor Costs	$ 24,063,881	$ 37,790,225	$ 59,955,346
Total FWOP Average PV Damages & Armor Costs	$ 97,132,960	$ 126,993,508	$ 170,406,273

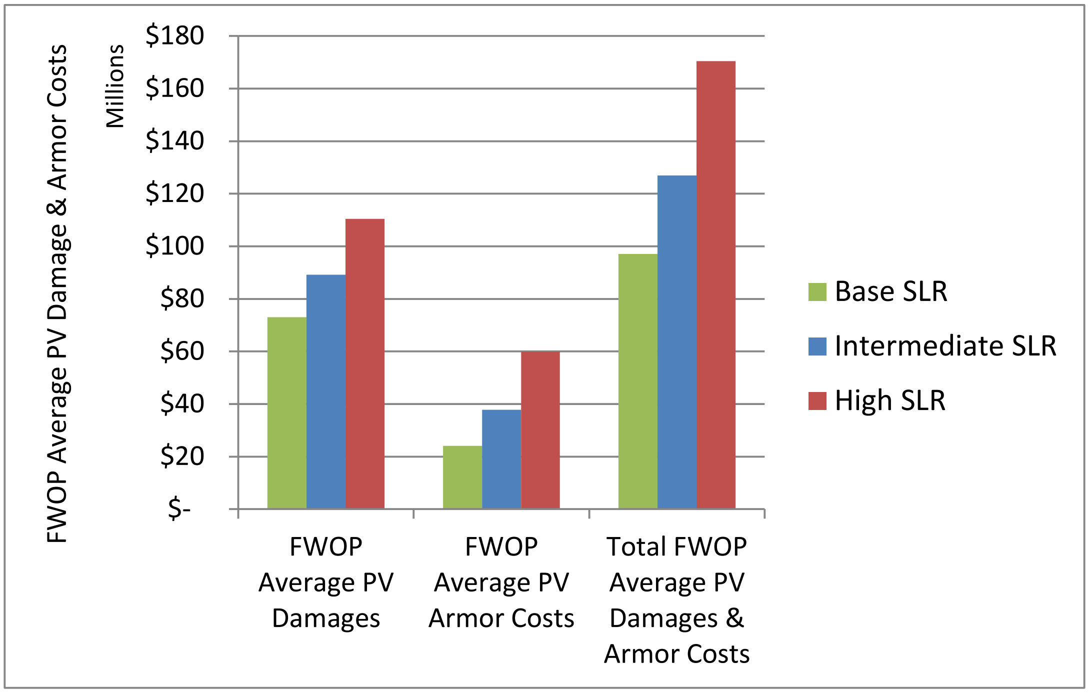


Figure 3-4: FWOP Average PV Damage and Armor Costs for SLR

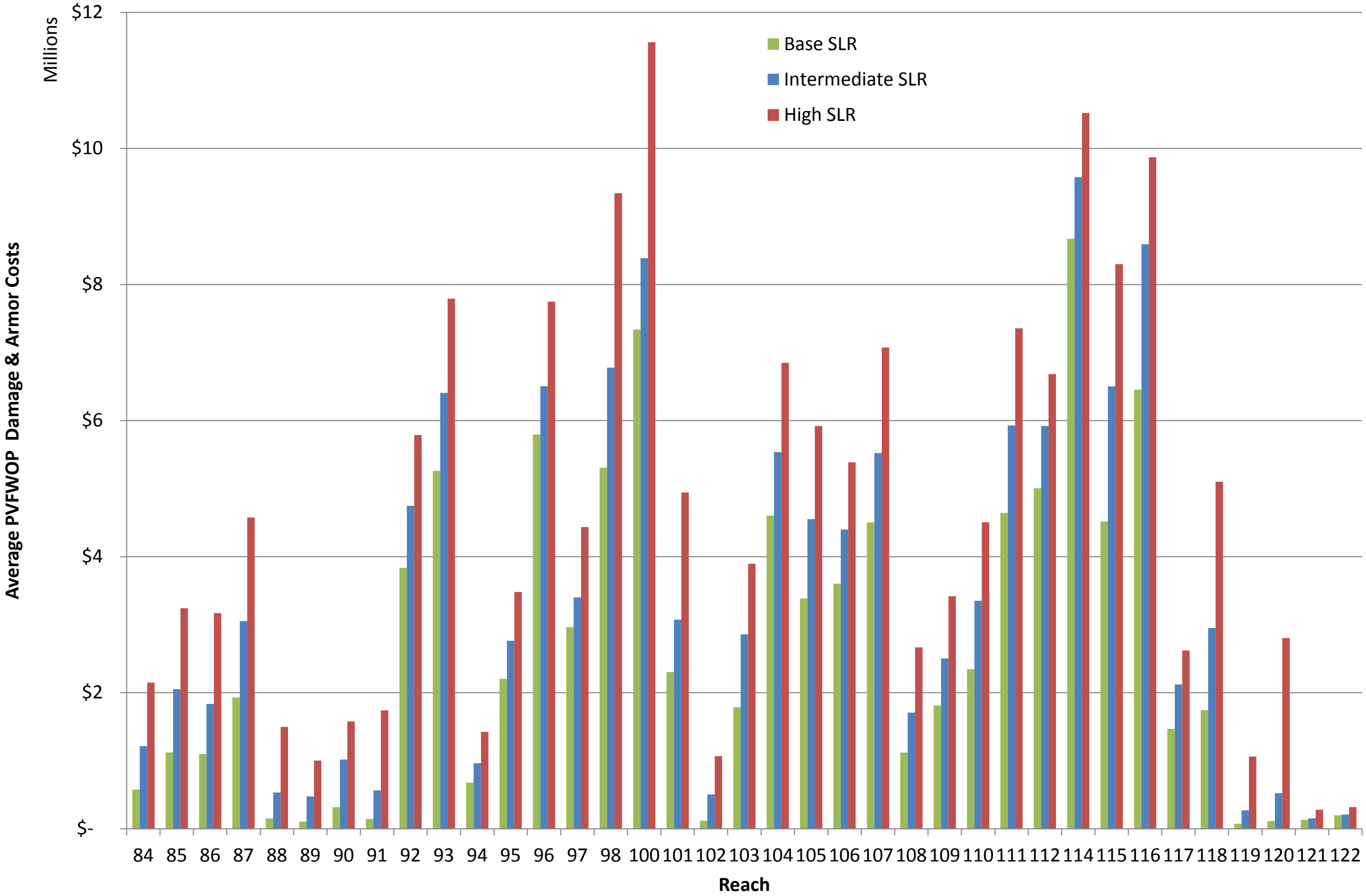


Figure 3-5: Average Non PV FWOP Damage & Armor Costs by Model Reach for SLR

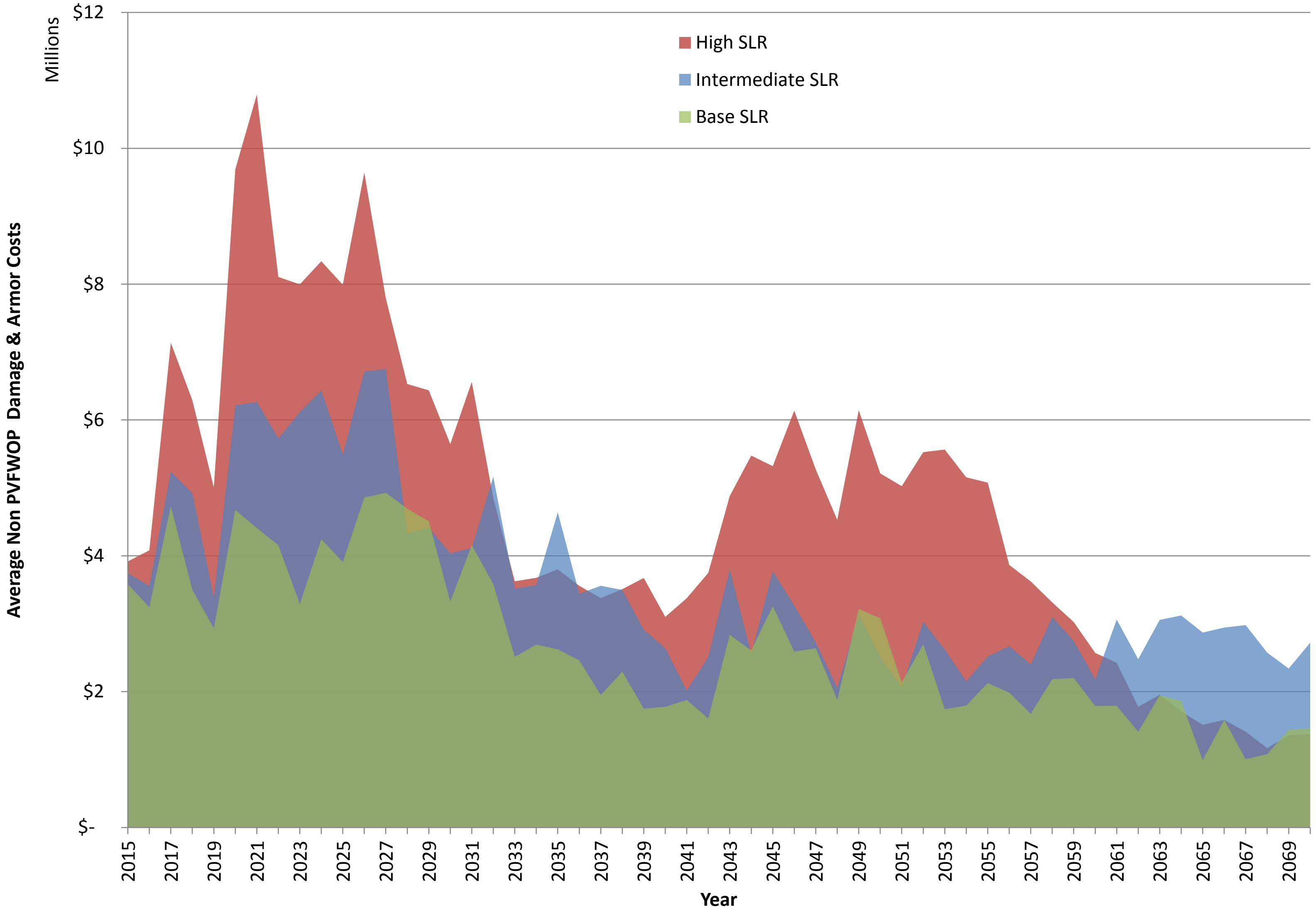


Figure 3-6: Average Non PV FWOP Damage & Armor Costs over Time for SLR

3.3.6 FWOP Condition Conclusion

- Most of the FWOP damages are associated with the single family residences located along the shoreline.
- The overwhelming majority of the damage and armoring is caused by erosion.
- Damages in the future without project condition increase in the accelerated sea level rise scenarios.

3.4 Future with Project Condition

This section of the appendix tells the story behind the evaluation and comparison of the St. Johns County HSDR study alternatives. A description of the alternatives and their performance in terms of benefits and costs are provided in the sub-sections that follow.

3.4.1 Management Measures

Management measures were selected to accomplish at least one of the planning objectives for the St. Johns County study. Both nonstructural (NS) measures and structural (S) measures were identified. All possible measures were considered, including those beyond the authority of USACE to implement. The following is a summary of the management measures considered for the study area.

- **Structural Measures:**
    - Seawalls
    - Revetments
    - Sand Covered Soft Structures
    - Beach Nourishment
    - Groins
    - Submerged Artificial Reef
    - Submerged Artificial Multi-Purpose Reef
    - Near shore sand placement
    - Emergent Breakwaters
    - Dunes and Vegetation
- **Non-structural Measures:**
    - No Action
    - Coastal Construction Control Line
    - Moratorium on Construction
    - No Growth Program
    - Relocation of Structures
    - Flood Proofing
    - Buyout and Land Acquisition

During the plan formulation process, management measures were screened against seven criteria. Benefits and costs were not calculated at this early stage of formulation, though a qualitative assessment of potential benefits was conducted. Ultimately, most of these measures were screened out. Buyout and Land Acquisition was the only non-structural measure carried forward to the modeling stage. Two structural measures were carried forward to the modeling stage: Dunes and Vegetation and Beach Nourishment. More information about each measure is provided below. More information about the management measure screening process is provided in the main report.

Buyout and Land Acquisition: This measure would allow the shoreline to erode in the study area with a loss of land. Structures within the study area vulnerable to storm damage would be identified for acquisition. These structures would be demolished and natural areas would be restored. Such parcels would become public property and would reduce the number of structures vulnerable to storm damages.

Dunes and Vegetation: This measure would include placement of beach compatible material, from either upland, inlet, or offshore sources, in a dune feature adjacent to the existing bluff. The top elevation of the dune would be such to tie into the bluff. The front slope of the dune would be a function of the material grain size and construction equipment. Vegetation would be planted after initial placement of the dune material where needed. Preliminary engineering design work concluded that the most feasible plan for dunes and vegetation would have the following characteristics:

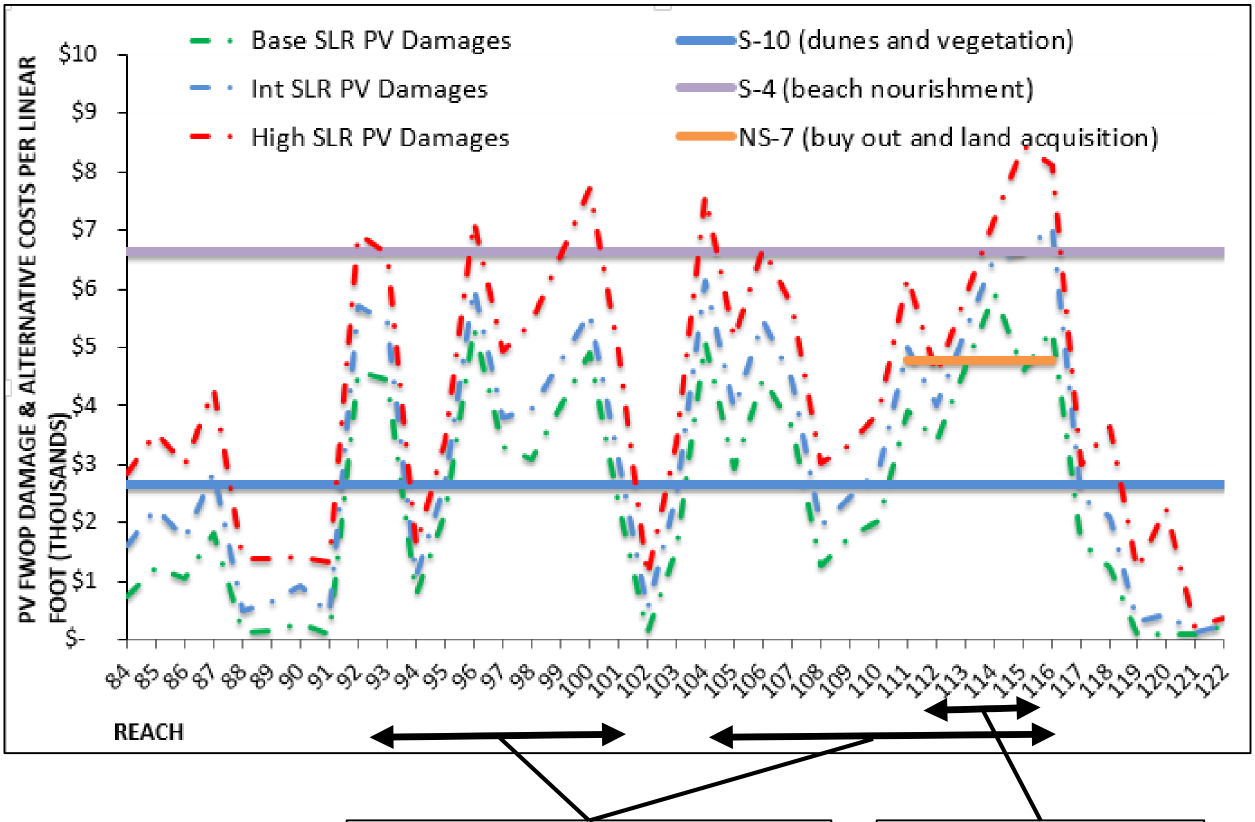
- Extension from the existing seaward face of the dune or existing armor (revetment/seawall).
- Construction such that the dune and beach profile out to the depth of closure will extend approximately 10 to 20 feet seaward from its existing location and the dune elevation will as closely as possible match the elevation of the existing dune elevation.
- Construction such that a berm feature will extend seaward from its existing location above the water line to account for the volume of material needed to fill the submerged portion of the beach profile extension.
- Periodic re-construction of the dune and beach profile extension.
- Construction using a hydraulic dredge to transport material from a borrow area.

Beach Nourishment: This measure includes initial construction of a beach fill and future re-nourishments at regular intervals. Re-nourishment of the beach would be undertaken periodically to maintain the erosion control features within design dimensions. Preliminary engineering design work and economic analysis suggested that the plan for beach nourishment would have the following characteristics:

- Maintaining the existing dune feature and extension of the berm feature from the existing seaward toe of the dune or existing armor (revetment/seawall).
- Construction such that the berm will extend approximately 20 to 100 feet seaward from its existing location and the berm elevation will as closely as possible match the elevation of the existing berm elevation.
- Periodic re-construction of the berm extension and occasional re-construction of the dune feature.
- Construction using a hydraulic dredge to transport material from a borrow area.

3.4.2 Alternative Development

An alternative plan is a set of one or more management measures functioning to address one or more objectives. Each project alternative is a combination of a selected measure and the reaches where it would be applied. Within the study area, segments were identified where economically justified alternatives could be implemented based on FWOP damages and alternative costs. These segments can be seen in **Figure 3-7**. Fully developed alternatives consisting of buyout and land acquisition in Beach-*fx* Reaches 111 to 116 (Vilano Beach), and the dune and beach nourishment measures in Beach-*fx* Reaches 92-101 (South Ponte Vedra) and 104-116 (Vilano Beach) were carried forward to be modeled in Beach-*fx*.



Dunes and Beach nourishment could be justified in Beach-fx Reaches 92-101 and 104-116.

Buyout and Land Acquisition could be justified in Beach-fx Reaches 111-116.

Figure 3-7: FWOP Damages per Linear Foot vs ROM Cost per Linear Foot of Alternatives Modeled in Beach-fx.

Modeling alternatives in Beach-*fx* is a time consuming process; a single 100 iteration simulation takes approximately eight hours. Therefore, it was not practical to fully model a large number of alternatives for screening purposes. A sensitivity analysis was performed showing that the average damages varied by less than 5% between 30 and 100 iteration runs. Therefore preliminary Beach-*fx* alternatives were run for 30 iterations rather than 100.

The non-structural alternative of Buyout and Land Acquisition (BLA) in Beach-*fx* Reaches 111 to 116 was modeled in Beach-*fx* by starting with a copy of the FWOP model setup, then deactivating all of the damage elements that were to be bought out and setting all of the lots to be bought out as not armorable. The FWP damages were compared to the FWOP damages to determine the benefits of this alternative over 50 years. This alternative only prevents 28% of the FWOP damages in reaches 111 to 116. Most of the FWOP damages in this area are associated with A1A and future armoring costs to protect the road. The BLA alternative does nothing to prevent these damages. SAJ Real Estate estimated the cost of this alternative to be $30,226,584. The results showed that this alternative would not be economically justified, with a BCR of 0.45.

The dune and beach nourishment alternatives were set up to be modeled in any of the Beach-*fx* Reaches for any combination of 0', 10', or 20' dune and profile extensions along with 0', 20', 40', 60', 80', or 100' berm extensions. More information on the development of the shoreline response database (SRD) and alternative templates can be found in the Appendix A - Engineering. The 'Planned Nourishment' inputs were entered into Beach-*fx* for the nourishment alternatives. The model was run for these FWP alternatives for the entire 7.6 mile length of the study area. The construction interval was set to 1 year so that every year the model checks if nourishment is needed, and constructs if the trigger and threshold requirements are met. In this way the project gets nourished when needed, and an average nourishment interval can be determined from the planned nourishment outputs. More information on the nourishment triggers and minimum volume thresholds used can be found in the Appendix A - Engineering. Plan formulation efforts determined that public access in South Ponte Vedra (Reaches 84 to 103) is negligible. Because this segment is a separable element that does not have public access, alternatives for reaches 92 to 101 were screened out. However nourishment alternatives were modeled for the continuous stretch of shoreline including reaches 92 to 116 to see if it would be justified, and couple possibly be implemented as a locally preferred plan.

Initial Beach-*fx* modeling showed that none of the dune and beach nourishment alternatives were economically justified using the offshore borrow areas. Several alternatives were economically justified using shoals in the vicinity of St. Augustine Inlet which could provide adequate volume for the alternatives and could be used in accordance with the Inlet Management Plan recommendations. The results of these alternatives are summarized in **Table 3-4**.

Table 3-4: Results Summary for Initial Beach-fx FWP Modeling

Alternative Name	Project Length (miles)	Average Nourishment Interval (years)	Avg PV Total Project Cost	Avg PV Total Project Benefits	Benefit to Cost Ratio	Avg PV Project Net Benefits
0P100B 104to116	2.6	16	$ 41,456,554	$ 45,820,621	1.11	$ 4,364,067
10P80B 104to116	2.6	16	$ 39,808,729	$ 44,197,687	1.11	$ 4,388,959
0P80B 104to116	2.6	15	$ 37,992,737	$ 44,646,586	1.18	$ 6,653,849
10P60B 104to116	2.6	13	$ 37,903,309	$ 46,486,819	1.23	$ 8,583,510
0P60B 92to116	4.8	16	$ 61,191,715	$ 70,300,053	1.15	$ 9,108,337
0P60B 104to116	**2.6**	**12**	**$ 36,058,203**	**$ 46,361,471**	**1.29**	**$ 10,303,268**
10P40B 104to116	2.6	12	$ 35,371,886	$ 42,443,302	1.20	$ 7,071,416
0P40B 92to116	4.8	11	$ 57,196,494	$ 67,316,899	1.18	$ 10,120,406
0P40B 104to116	2.6	10	$ 34,667,275	$ 41,385,456	1.19	$ 6,718,180
20P20B 92to116	4.8	12	$ 59,714,320	$ 63,472,000	1.06	$ 3,757,680
20P20B 104to116	2.6	10	$ 35,303,226	$ 38,038,975	1.08	$ 2,735,749
10P20B 92to116	4.8	9	$ 58,364,711	$ 58,538,795	1.00	$ 174,085
10P20B 104to116	2.6	9	$ 34,668,712	$ 35,617,153	1.03	$ 948,441
Do Nothing (FWOP)	0	na	$ -	$ -	na	$ -
BLA 111to116	1.2	na	$ 30,226,584	$ 13,699,612	0.45	$ (16,526,972)

Notes:
BLA = Buyout & Land Acquisition
"P" = Profile Extension (preceding # indicates the horizantal seaward extension of the profile in feet)
"B" = Berm Extension (preceding # indicates the horizantal seaward extension of the berm in feet, in addition to the profile extension)
"##to##" indicates the beach-fx reaches in which the alternative is implemented

3.4.3 Alternative Comparison

The top two alternatives, with public parking and access, from the preliminary Beach-*fx* modeling were run in Beach-*fx* using 100 iteration simulations. The results of these simulations were used to determine the National Economic Development (NED) Plan and the TSP. The results of the alternative comparison are presented in **Table 3-5** and **Table 3-6**. Typically, the plan with the highest net benefits is the NED plan. This plan is the “0P60B 104to116” alternative.

The screening of alternatives was based on reduced structure, content, and armor damages. Land loss damages are primary benefits that could be included in the screening process. However, for this study land loss benefits were not used for screening because they would have approximately equal value for all alternatives of the same shoreline length, and make up a small portion of the overall primary benefits. Factoring in land loss benefits would not change the outcome of the screening or TSP selection.

Table 3-5: Damages for Final Array of Alternatives

Alternative Name	Project Length (miles)	FWOP Avg PV Damages ($)	FWP Avg PV Damages ($)	Avg PV Total Project Benefits ($)
0P60B 104to116	2.6	$ 97,543,424	$ 53,995,404	$ 43,548,020
10P60B 104to116	2.6	$ 97,543,424	$ 53,232,619	$ 44,310,805

Table 3-6: Benefits and Costs for Final Array of Alternatives

Alternative Name	Avg PV Benefits ($)	Avg PV Costs ($)	BCR	Net Benefits ($)
0P60B 104to116	$43,548,020	$34,975,499	1.25	$ 8,572,522
10P60B 104to116	$44,310,805	$36,837,502	1.20	$ 7,473,303

Table 3-7 shows the minimum, maximum, and median values of the net benefits for the final alternatives over all 100 iterations. **Table 3-8** shows the minimum, maximum, and median values of the benefit-cost ratios for the final alternatives over all 100 iterations. The TSP plan can be considered the safest of the final alternatives in the sense that it has the greatest minimum net benefits and BCR. The TSP also has the greatest median net benefits and BCR. The median (50th percentile) value separates the upper and lower half results of the 100 iterations simulated for each alternative.

Table 3-7: Range of Potential Net Benefit for Final Alternatives over 100 Iterations

Alternative Name	Minimum	Maximum	Median
0P60B 104to116	$ (10,987,927)	$30,525,832	$ 8,833,394
10P60B 104to116	$ (12,827,607)	$28,441,525	$ 7,441,113

Table 3-8: Range of Potential Benefit-Cost Ratios for Final Alternatives over 100 Iterations

Alternative Name	Minimum	Maximum	Median
0P60B 104to116	0.69	1.90	1.27
10P60B 104to116	0.65	1.79	1.21

3.4.4 Nourishment Volume Sensitivity and TSP Optimization

For the TSP, the berm width, dune width, and dune height planned nourishment triggers were set at 0.5, 0.91, and 0.9, respectively. The mobilization threshold was originally set to 650,000 cubic yards. Together, the triggers and the mobilization threshold allow for the optimization of the beach fill based on the physical dimensions of the project. The project template will be nourished less often and erode further landward with a larger minimum volume threshold. The project template will be nourished more often with a smaller minimum volume threshold. Sensitivity analysis of the nourishment triggers and mobilization threshold indicated that threshold volume was the dominant parameter for optimizing project costs and benefits. A mobilization threshold of 750,000 cubic yards was found to be (when combined with the above nourishment triggers), the most optimal threshold value to maximize net NED benefits. Decreasing the volume threshold results in increased benefits, but also results in a slightly greater increase to the costs. Increasing the volume threshold reduces costs, but results in a slightly greater reduction to the benefits. **Figure 3-8** provides added detail on model sensitivity to the mobilization volume threshold.

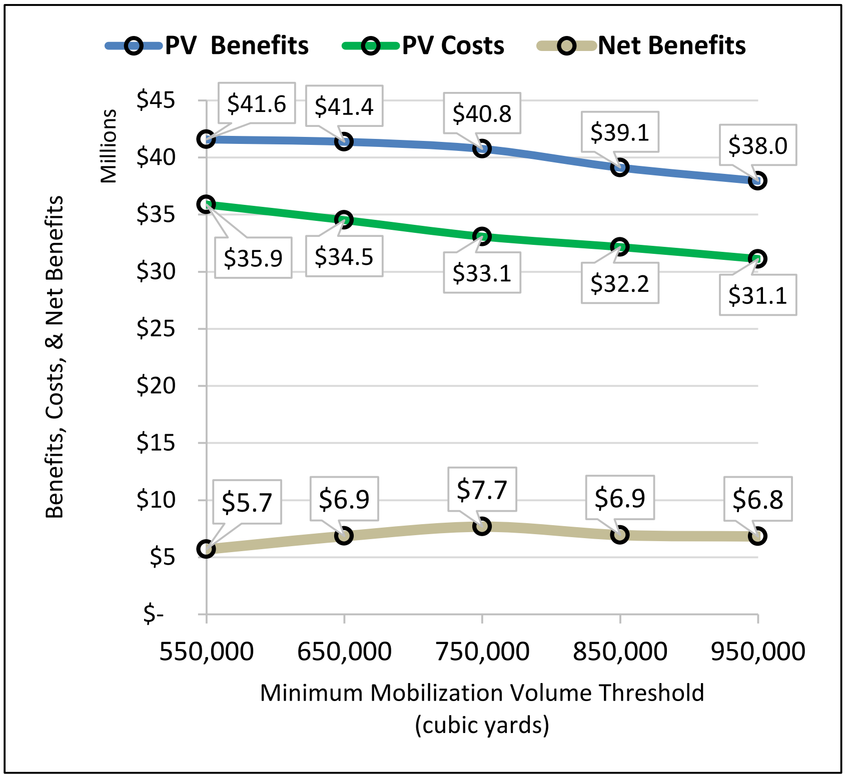


Figure 3-8: Minimum Mobilization Volume Sensitivity

4. THE TENTATIVELY SELECTED PLAN

The “0P60B 104to116” alternative is the Tentatively Selected Plan (TSP). The economic results presented in this section reflect the costs in the Total Project Cost Summary (TPCS) found in Appendix B – Cost Engineering and Risk Analysis. Therefore the results presented here will differ slightly from the values presented in previous sections.

4.1 Beach-fx Modeling and Project Costs

The Beach-fx model results describing the physical performance of the TSP will not change from the simulation run for the final array of alternatives. These results are independent of the project costs. The physical performance results most relevant to the economic analysis are the nourishment volumes and the timing of nourishment events.

Beach-fx is a life cycle simulation model. One iteration represents one 50 year life-cycle. These results are based on 100 iterations generating 442 observations of individual nourishment events. All iterations within the model simulation are unique. The values presented in **Table 4-1** and **Figure 4-1** are essentially probabilistic nourishment events.

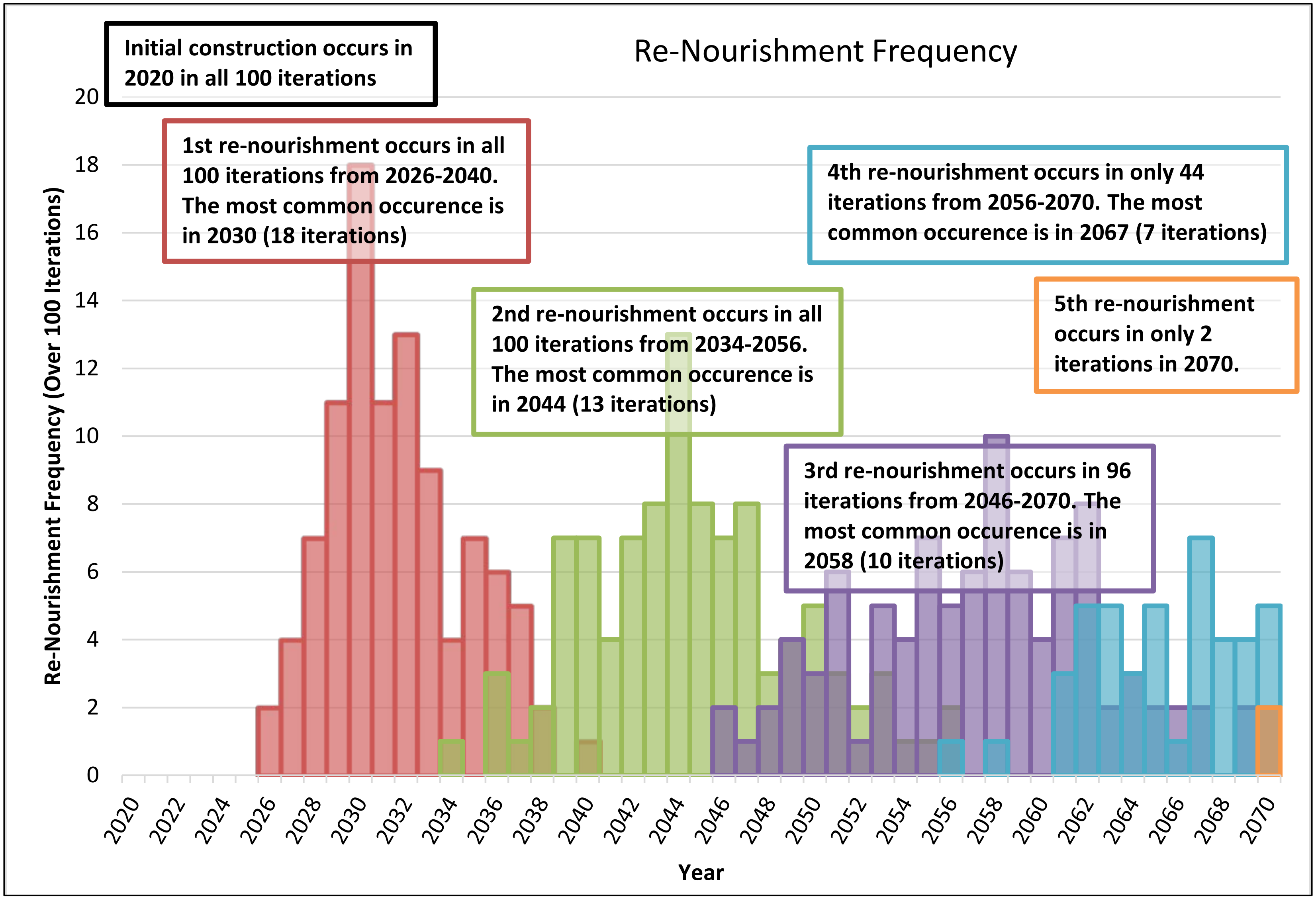
The average initial construction volume over 100 iterations is 1,310,000 cubic yards (cy). The average volume of all re-nourishments over 100 iterations is 866,000 cubic yards (cy). **Table 4-1** provides a summary on the volume of material per construction event over the 100 iterations modeled.

Table 4-1: Beach-fx Volume per Construction Event

Cycle	Event	Frequency	Average	Min	Max
1	Initial Construction	100	1,309,891	997,515	1,843,644
2	1st Re-Nourishment	100	863,393	750,392	1,298,719
3	2nd Re-Nourishment	100	865,239	762,712	1,305,486
4	3rd Re-Nourishment	96	864,010	751,512	1,183,744
5	4th Re-Nourishment	44	870,420	750,483	1,114,100
6	5th Renourishment	2	824,456	791,752	857,159

The average time interval between nourishment events over 100 iterations is 12 years. Assuming that re-nourishment events occurred at this average interval, the nourishment years would be 2020, 2032, 2044, 2056, & 2068.

However, the distribution of each nourishment event is noticeably flatter and less peaked than the prior event. Initial construction spreads just over 1 year. The re-nourishments are distributed over variable time spans. This is because the conditional nature of beach nourishment coupled with the interplay of all the variable factors in the model cause the number of possible nourishment years to vary relative to the average time interval between nourishment events. **Figure 4-1** shows the frequency distribution of nourishments over time for the TSP as modeled with Beach-*fx*.



Initial construction occurs in 2020 in all 100 iterations

1st re-nourishment occurs in all 100 iterations from 2026-2040. The most common occurence is in 2030 (18 iterations)

2nd re-nourishment occurs in all 100 iterations from 2034-2056. The most common occurence is in 2044 (13 iterations)

3rd re-nourishment occurs in 96 iterations from 2046-2070. The most common occurence is in 2058 (10 iterations)

4th re-nourishment occurs in only 44 iterations from 2056-2070. The most common occurence is in 2067 (7 iterations)

5th re-nourishment occurs in only 2 iterations in 2070.

Figure 4-1: Frequency Distribution of Nourishments over Time

Traditionally, in HSDR studies, a fixed re-nourishment interval is defined and optimized for the life of the project. This interval is based in part on a clear distinction between a design berm and advance fill. With Beach-*fx*, no such distinction is defined. Rather, re-nourishment events are triggered within the model when specific criteria are met. The triggers were set up to simulate a point at which the berm extension had eroded to at least half its equilibrated width in at least one reach, and a minimum volume of 750,000 cubic yards had eroded from the entire project template. Based on these parameters, the average time interval between nourishment events over all 100 iterations is 12 years. In reality, this interval could vary significantly depending erosion and storm events. More information about the re-nourishment triggers is provided in the Appendix A - Engineering. Ultimately, planning based on life-cycle modeling results in plans that are more resilient and adaptable. Life-cycle modeling allows planners to design projects while recognizing the inherent uncertainty that exists when future events are simulated.

A description of the TSP is as follows:

- **Name (Description):** "0P60B 104to116" (Construction of 60 foot equilibrated berm extension. The project template will include a dune feature that reflects the average 2015 dune position. A hydraulic dredge will be used to fill the template with sand from the St. Augustine Inlet and ebb shoal complex)
- **Average # Nourishment Events:** 1(ea)Initial Construction / 4(ea) Re-nourishments
- **# Nourished Reaches:** 12
- **Range of Nourished Reaches:** Beach-fx Reach 104 – Beach-fx Reach 116
- **Average Volume of Initial Construction**: 1,310,000 yd^3
- **Average Volume of Each Periodic Nourishment**: 866,000 yd^3
- **Average Periodic Nourishment Interval**: 12 years
- **Initial Construction Duration** ~ 3.3 months

The cost estimate for the TSP was developed by SAJ Cost Engineering. **Table 4-2** provides details on the distribution of cost by nourishment event. This estimate assumed that initial construction would occur in 2020 and re-nourishment events would occur at the average 12 year interval. These costs are in FY16 price levels and include a 24% contingency. Additional details on the project costs can be found in Appendix B - Cost Engineering and Risk Analysis.

Table 4-2: TSP Project Costs

Cost Description	Initial Construction	1st Re-Nourishment	2nd Re-Nourishment	3rd Re-Nourishment	4th Re-Nourishment
Quantity (cy)	1,310,000	866,000	866,000	866,000	866,000
Mobilization	$ 3,336,000	$ 3,336,000	$ 3,336,000	$ 3,336,000	$ 3,336,000
Dredging	$ 8,514,000	$ 6,078,000	$ 6,078,000	$ 6,078,000	$ 6,078,000
Lands & Damages	$ 3,106,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
PED	$ 2,765,000	$ 1,649,000	$ 1,649,000	$ 1,649,000	$ 893,000
Construction Management	$ 889,000	$ 706,000	$ 706,000	$ 706,000	$ 1,487,000
Total Cost	$18,611,000	$11,795,000	$11,795,000	$11,795,000	$11,819,000

These estimated project costs were modified further for entry into the Beach-*fx* user interface. The beach nourishment cost information that can be input to Beach-*fx* is limited to a single unit construction cost ($/cy) and a single mobilization cost. The Beach-*fx* model applies these two costs in the same way for each nourishment event regardless of if it is initial construction or a periodic re-nourishment. Non-dredging costs (Lands & Damages, PED, and Construction Management) need to be accounted for, so they are entered as part of the mobilizations cost. The unit cost and mobilization cost used for the Beach-*fx* input reflect the re-nourishment costs. The additional cost associated with the initial construction are added back into the life cycle cost outputs in the base year (2020) when initial construction occurs in all 100 iterations. There is a small difference between the final re-nourishment event because of additional construction management and reduced PED activities associated with the end of Federal participation. This difference is considered negligible for the cost modifications for Beach-*fx*. The methods for modifying the costs for use in Beach-fx is summarized in **Table 4-3**. Modeling the TSP with these modified cost inputs allows for the uncertainty of the projects performance to be quantified with respect to costs and net benefits.

Table 4-3: Representing the Project Costs in Beach-*fx*

Cost Description	Initial	Renourishment	Difference
Quantity (cy)	1,310,000	866,000	444,000
Mobilization	$ 3,336,000	$ 3,336,000	$ -
Dredging	$ 8,514,000	$ 6,078,000	$ 2,436,000
Unit Cost ($/cy)	$ 6.50	$ 7.02	$ (0.52)
Lands & Damages	$ 3,106,000	$ 25,000	$ 3,081,000
PED	$ 2,765,000	$ 1,649,000	$ 1,116,000
Construction Management	$ 889,000	$ 706,000	$ 183,000
Unit Cost Input to Beach-fx		**$ 7.02**	
Mob Cost Input to Beach-fx		**$ 5,716,000**	
Initial Dredging Cost Using Beach-fx Input (1,310,000cy*$7.02)			$ 9,196,200
Estimated Dredging Cost			$ 8,514,000
Beach-fx Initial Dredging Overestimate			$ 682,200
Beach-fx Initial Mob Underestimate			$ 4,380,000
Additional Initial Cost Added Back Into the Life Cycle Cost Outputs in the Base Year (2020)			**$ 3,697,800**

Even though Beach-*fx* models cost variability by tabulating costs when nourishment events occur for each unique iteration, the final net benefits and BCR presented in the conclusion of this appendix will reflect re-nourishment costs occurring at the average 12 year interval. In that way the costs used to calculate the project economics will match the costs presented in the TPCS found in Appendix B – Cost Engineering and Risk Analysis.

4.2 Benefits of the NED Plan

The economic benefits of the plan are generated by reductions in coastal storm damages. The benefits described in this section do not include land loss and recreation benefits, which are discussed later in this appendix. As described in **Table 4-4**, the model results suggest that the alternative is effective at reducing coastal storm damages in the study area, caused primarily by erosion. In the with-project condition, 44% of damages are prevented within the entire study area. Within the 2.6 mile TSP fill area, spanning Beach-*fx* reaches 104 to 116, 71% of damages are prevented.

Table 4-4: PV of Damages in the Study Area

Reach	PV FWOP Damages	PV FWP Damages	PV Benefits	% Damage Prevented
84	$ 576,149	$ 578,022	$ (1,873)	0%
85	$1,123,610	$1,118,685	$ 4,925	0%
86	$1,101,289	$1,105,683	$ (4,394)	0%
87	$1,932,106	$1,903,112	$ 28,994	2%
88	$ 153,542	$ 147,971	$ 5,571	4%
89	$ 105,870	$ 98,537	$ 7,333	7%
90	$ 319,962	$ 314,409	$ 5,553	2%
91	$ 144,462	$ 137,744	$ 6,718	5%
92	$3,836,116	$3,572,752	$ 263,364	7%
93	$5,261,258	$4,849,364	$ 411,894	8%
94	$ 680,301	$ 651,671	$ 28,629	4%
95	$2,203,243	$2,128,544	$ 74,699	3%
96	$5,797,415	$5,533,828	$ 263,587	5%
97	$2,962,528	$2,730,022	$ 232,506	8%
98	$5,306,051	$3,596,574	$1,709,477	32%
100	$7,338,419	$6,537,622	$ 800,797	11%
101	$2,303,672	$1,769,097	$ 534,575	23%
102	$ 118,710	$ 23,229	$ 95,481	80%
103	$1,786,033	$ 684,918	$1,101,115	62%
104	$4,603,534	$1,468,136	$3,135,398	68%
105	$3,385,731	$ 990,040	$2,395,691	71%
106	$3,603,734	$1,330,654	$2,273,080	63%
107	$4,505,751	$1,512,542	$2,993,208	66%
108	$1,120,366	$ 201,531	$ 918,835	82%
109	$1,812,123	$ 548,901	$1,263,222	70%
110	$2,349,222	$ 311,445	$2,037,776	87%
111	$4,642,290	$1,848,908	$2,793,382	60%
112	$5,010,261	$2,161,821	$2,848,440	57%
114	$8,716,006	$2,651,425	$6,064,580	70%
115	$4,517,628	$ 599,913	$3,917,715	87%
116	$6,458,024	$1,267,624	$5,190,400	80%
117	$1,469,820	$ 920,713	$ 549,107	37%
118	$1,745,251	$1,214,548	$ 530,703	30%
119	$ 76,117	$ 56,196	$ 19,921	26%
120	$ 114,558	$ 114,558	$ -	0%
121	$ 131,791	$ 131,791	$ -	0%
122	$ 200,108	$ 200,108	$ -	0%

Most of the benefits are associated with reductions in damage to single family residences and reductions to future armor costs to protect ocean front residences and SR A1A. **Table 4-5** provides a breakdown of the damages prevented for each damage element type across the entire study area and the TSP fill area.

Table 4-5: PV Damages by Type

	7.5 Mile Study Area				2.6 Mile TSP Fill Area			
DE Type	FWOP PV Damage	FWP PV Damage	PV Benefits	% Damage Prevented	FWOP PV Damage	FWP PV Damage	PV Benefits	% Damage Prevented
COMM	$ 2,792,576	$ 621,598	$ 2,170,978	78%	$ 834,660	$ -	$ 834,660	100%
GAZEBO	$ 608,711	$ 498,907	$ 109,804	18%	$ 150,909	$ 116,908	$ 34,001	23%
MFR1	$ 3,375	$ 1,559	$ 1,816	54%	$ -	$ -	$ -	na
MFR2	$ 1,213,010	$ 587,918	$ 625,092	52%	$ 794,086	$ 384,066	$ 410,020	52%
MFR3	$ 203,924	$ 22,838	$ 181,086	89%	$ 121,093	$ -	$ 121,093	100%
PARKING LOT	$ 442,541	$ 189,189	$ 253,352	57%	$ 446,966	$ 191,081	$ 255,885	57%
POOL	$ 88,565	$ 13,558	$ 75,008	85%	$ 3,514	$ -	$ 3,514	100%
ROAD2	$ 4,835,406	$ 841,432	$ 3,993,974	83%	$ 4,066,922	$ 412,804	$ 3,654,118	90%
ROAD3	$ 1,687,213	$ 452,391	$ 1,234,822	73%	$ 1,672,918	$ 456,915	$ 1,216,003	73%
SFR1	$19,918,946	$15,810,320	$ 4,108,626	21%	$ 3,044,379	$1,263,939	$ 1,780,440	58%
SFR2	$30,064,546	$21,754,723	$ 8,309,823	28%	$ 8,151,970	$4,043,565	$ 4,108,405	50%
SFR3	$ 8,686,859	$ 4,468,475	$ 4,218,384	49%	$ 4,100,139	$1,422,769	$ 2,677,370	65%
TENNIS	$ 734	$ -	$ 734	100%	$ 742	$ -	$ 742	100%
WALK	$ 2,522,672	$ 2,349,445	$ 173,227	7%	$ 767,030	$ 638,367	$ 128,664	17%
ARMOR COST	$24,063,881	$ 7,268,513	$16,795,368	70%	$18,387,956	$2,531,269	$15,856,686	86%

Figure 4-2 graphically illustrates the accumulation of benefits over time and space within the TSP fill area spanning Beach-*fx* reaches 104 to 116.

Figure 4-3 provides detail on the accumulation of damages, benefits, and estimated costs over time. The costs presented in this figure match the TPCS found in Appendix B – Cost Engineering and Risk Analysis. The final net benefits and BCR presented in the conclusion of this appendix reflects these re-nourishment costs occurring at the average 12 year interval. In that way the costs used to calculate the project economics will match the costs presented in the TPCS.

Figure 4-4 provides detail on the accumulation of damages, benefits, and modified Beach-*fx* costs over time. These costs reflect each unique nourishment event using the mobilization and unit costs entered into Beach-*fx* based on the TPCS. These costs are described in **Table 4-3**. These Beach-*fx* cost outputs provides a more accurate representation of lifecycle costs by accounting for the natural variability in re-nourishment timing as modeled by Beach-*fx*.

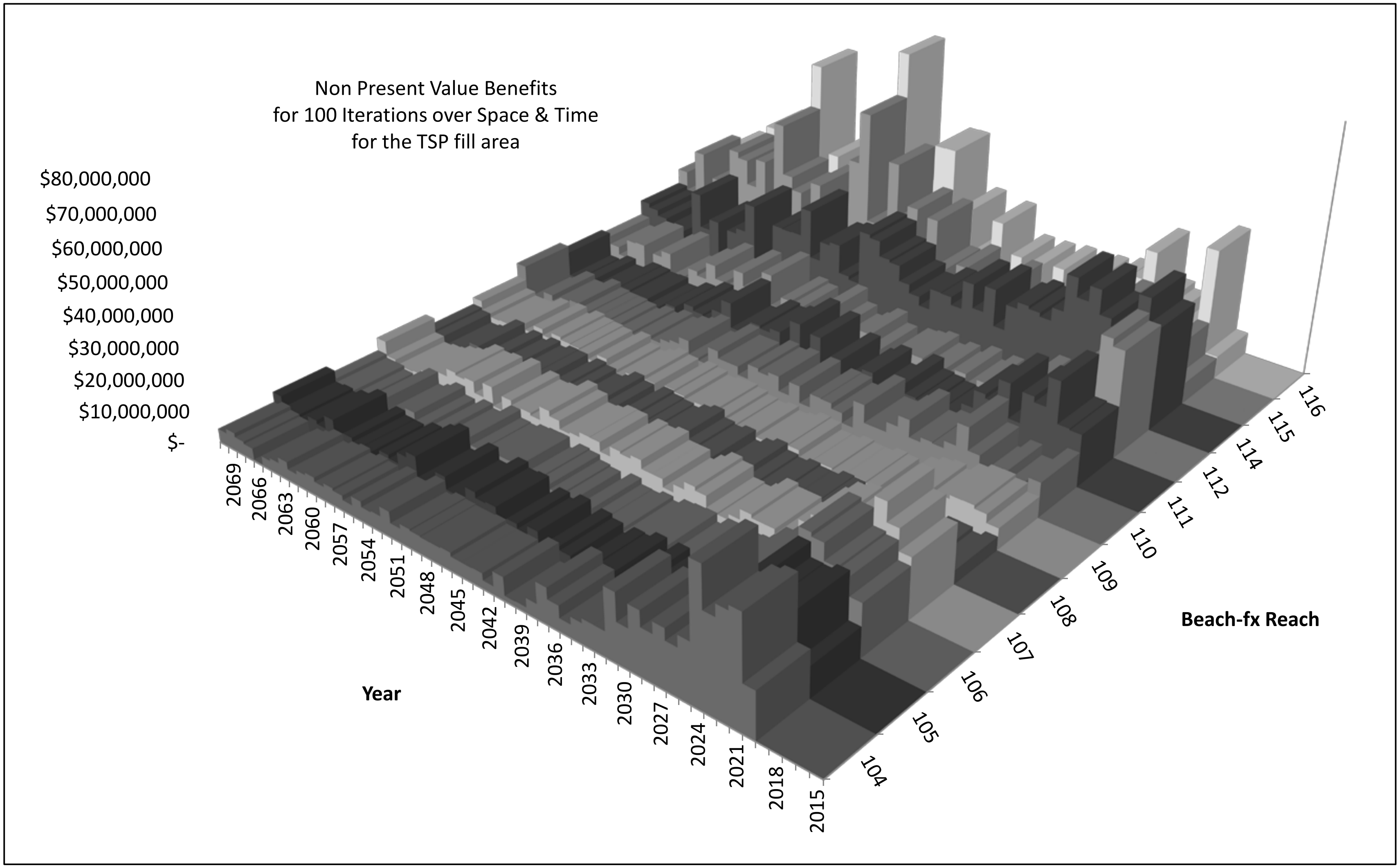


Figure 4-2: Non Present Value Benefits over Space & Time

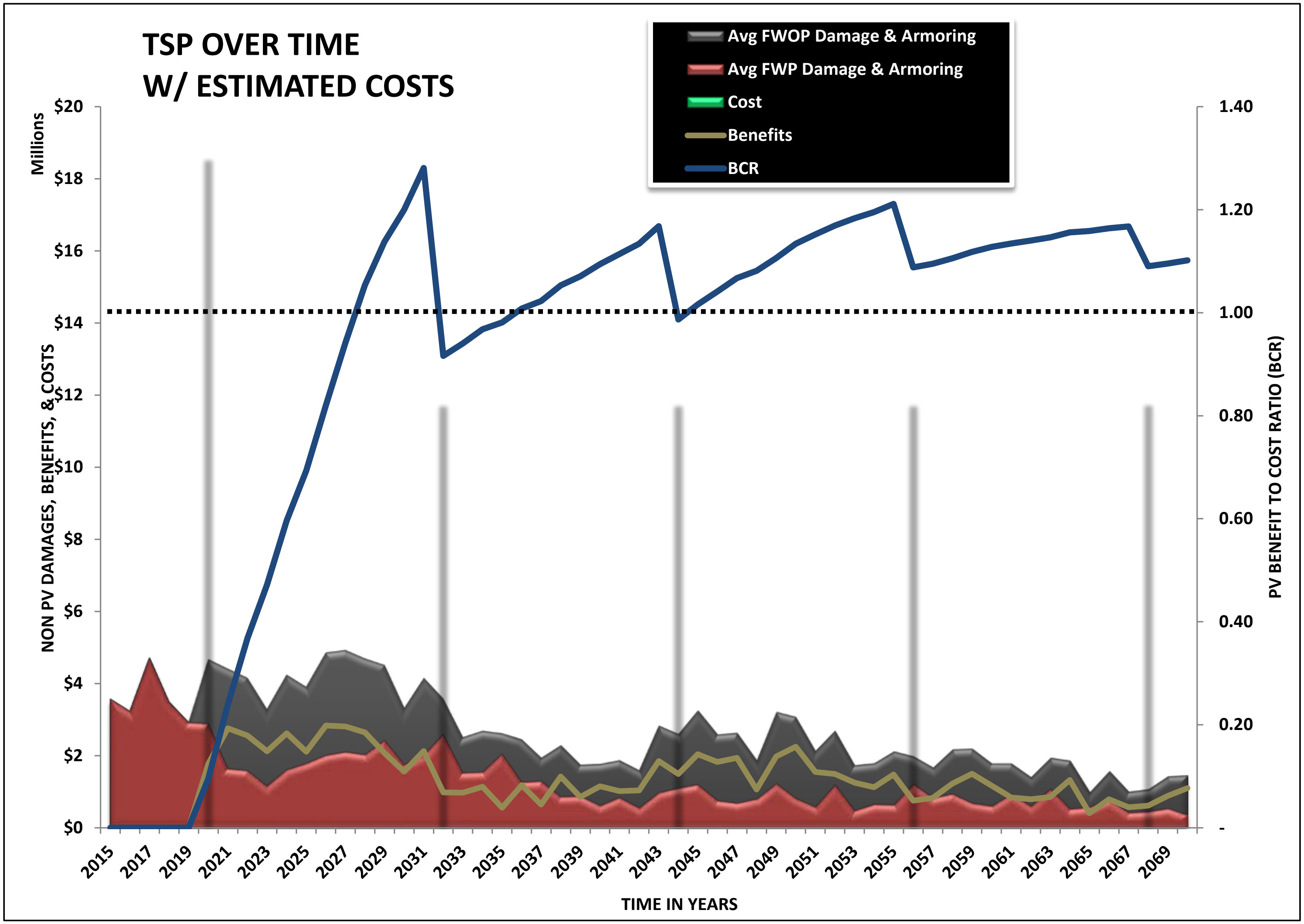


Figure 4-3: Non Present Value Damages, Benefits, and Estimated Costs over Time

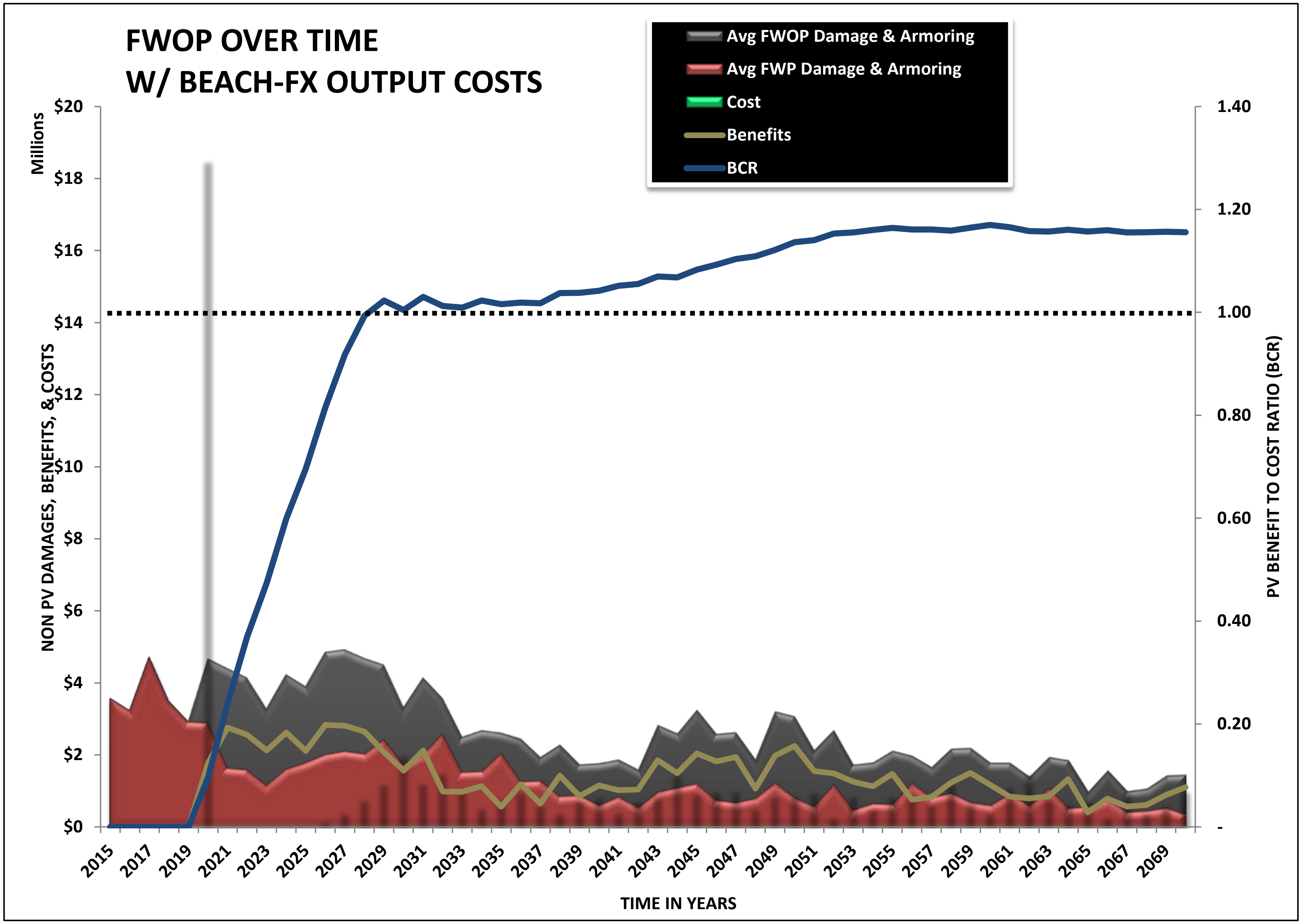


Figure 4-4: Non Present Value Damages, Benefits, and Modified Beach-fx Costs over Time

4.3 Sea Level Rise Considerations

An important question about the TSP is its performance under different SLR scenarios. Each of the SLR scenarios described in the main report are considered equally likely to occur. Therefore, if the project does not perform, then it cannot be considered a completely effective plan. The SLR results presented in this section are based on the Beach-fx *iteration.csv* output files, and therefore will not exactly match the values presented in other sections of this appendix. The benefits presented in this section do not include land loss or recreation benefits. **Table 4-6** shows the average BCRs and net benefits of the plan in the different SLR scenarios.

Table 4-6: Average PV Benefits and Costs for NED Plan in different SLR scenarios

SLR Scenario	PV Benefits	PV Costs	BCR	Net Benefits
Baseline	$42,252,095	$37,165,962	1.13	$ 5,086,133
Intermediate	$54,025,561	$43,769,677	1.23	$10,255,884
High	$65,160,941	$55,916,017	1.17	$ 9,244,925

As shown in **Table 4-6**, though the average benefits of the project increase significantly in the SLR scenarios, the average costs also increase. The costs increase because re-nourishment is triggered more frequently. Thus, the project performance (in terms of the benefit-cost ratio) is relatively constant throughout the SLR scenarios. The average re-nourishment intervals and damages are summarized in **Table 4-7**.

Table 4-7: Average Nourishment Intervals and Damages in the SLR scenarios

SLR Scenario	Average Periodic Norishment Interval	Average FWOP PV Damages	Average FWP PV Damages
Baseline	12 years	$ 97,132,960	$ 54,880,865
Intermediate	10 years	$126,993,508	$ 72,923,866
High	7 years	$170,406,273	$105,245,332

Because both costs and benefits are increasing, the net benefits actually increase with increasing rates of sea level rise. Overall, these SLR results suggest that the NED Plan is effective in all three simulated SLR scenarios.

4.4 Uncertainty and Reliability of the TSP

Beach-*fx* is a life-cycle model that outputs a range of possible results from implementing the TSP. This range of outputs can be used to quantify the uncertainty associated with the performance of the TSP. Quantifying this uncertainty allows for a more complete understanding of how the TSP should be expected to perform, compared to only considering the average results. This section will present the uncertainty associated with the TSP and show how reliable the TSP is expected to be. The results presented in this section are based on the Beach-fx *iteration.csv* output files, and therefore will not exactly match the values presented in other sections of this appendix. The benefits presented in this section do not include land loss or recreation benefits.

Table 4-8 shows the range of possible costs and benefits over the 100 life cycles (iterations) modeled in Beach-*fx*. **Figure 4-5** shows the frequency distribution of net benefits provided by the TSP over the 100 life cycles modeled.

Table 4-8: Range of TSP Costs and Benefits in the Base SLR Scenario

TSP Results (Base SLR)	PV Costs	PV Benefits	Net Benefits	BCR
Average	$ 37,165,962	$ 42,252,095	$ 5,086,133	1.13
Min	$ 27,173,100	$ 18,338,310	$ (14,695,898)	0.56
Max	$ 46,874,482	$ 66,064,633	$ 25,946,127	1.66
Std Dev	$ 3,465,632	$ 10,132,312	$ 9,012,395	0.24

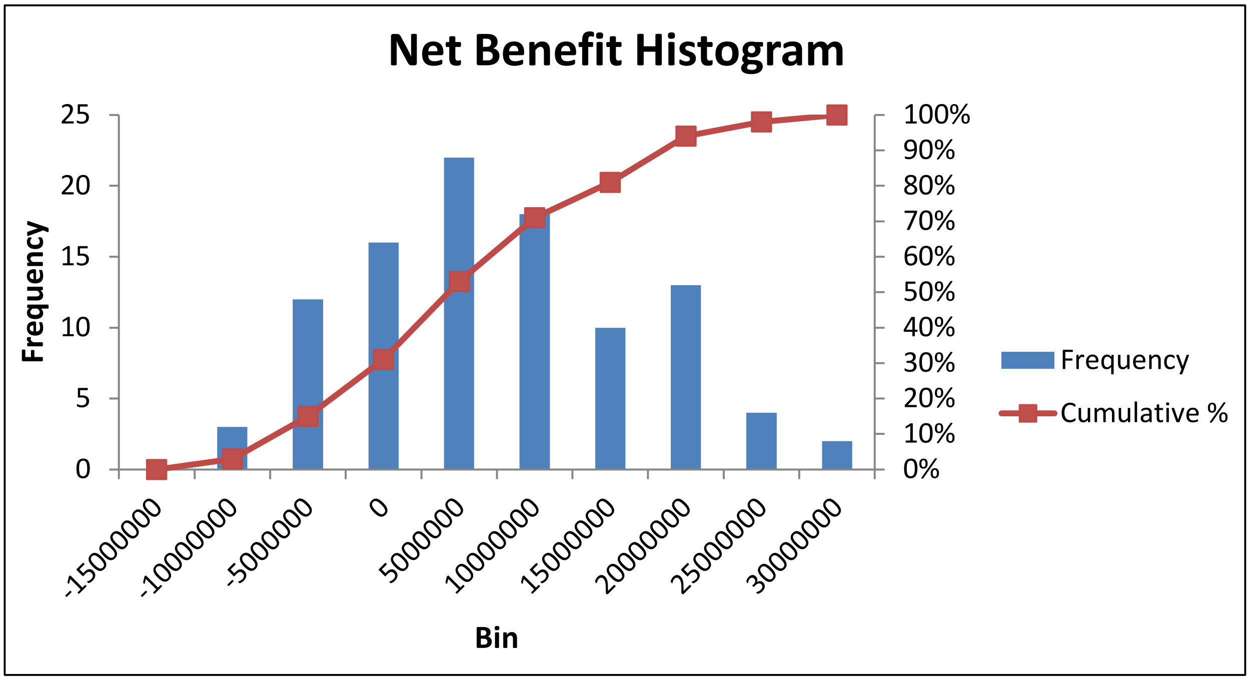


Figure 4-5: Frequency Distribution of TSP Net Benefits in the Base SLR Scenario

The results show that in 69 out of the 100 life cycles modeled for the base SLR scenario, the TSP will produce positive net benefits. Therefore the reliability of the TSP is 69%, with respect to producing positive net benefits. **Table 4-9** shows the reliability of the TSP for several benefit and cost considerations.

Table 4-10 shows how the reliability of the TSP varies for the three SLR scenarios.

Table 4-9: TSP Reliability in the Base SLR Scenario

With Respect to Having…	TSP Reliability
> Average Net Benefits	47%
> 0 Net Benefits	69%
> Average BCR	47%
> Average Cost	45%
> Average +20% Cost	3%

Table 4-10: TSP Reliability for All SLR Scenarios

With Respect to Having…	Base SLR TSP Reliability	Intermediate SLR TSP Reliability	High SLR TSP Reliability
> Average Net Benefits	47%	52%	48%
> 0 Net Benefits	69%	90%	84%
> Average BCR	47%	55%	48%
> Average Cost	45%	48%	49%
> Average +20% Cost	3%	34%	100%

Figure 4-6 shows the costs and net benefits for each iteration sorted in order of the life cycles having the greatest FWOP damages after 2020. The results show that life cycles having the greatest FWOP damages generally have the greatest net benefits, while costs are relatively constant. This means that the TSP is resilient, because it performs above average with respect to net benefits in those life cycles experiencing the greatest coastal storm damages. **Table 4-11** presents the results of the TSP in the 25 life cycles having the greatest FWOP damages compared to the results for all 100 life cycles. The average net benefits for the top 25 FWOP damage life cycles are more than double the average net benefits for all the life cycles, while the average costs increased by only 6%.

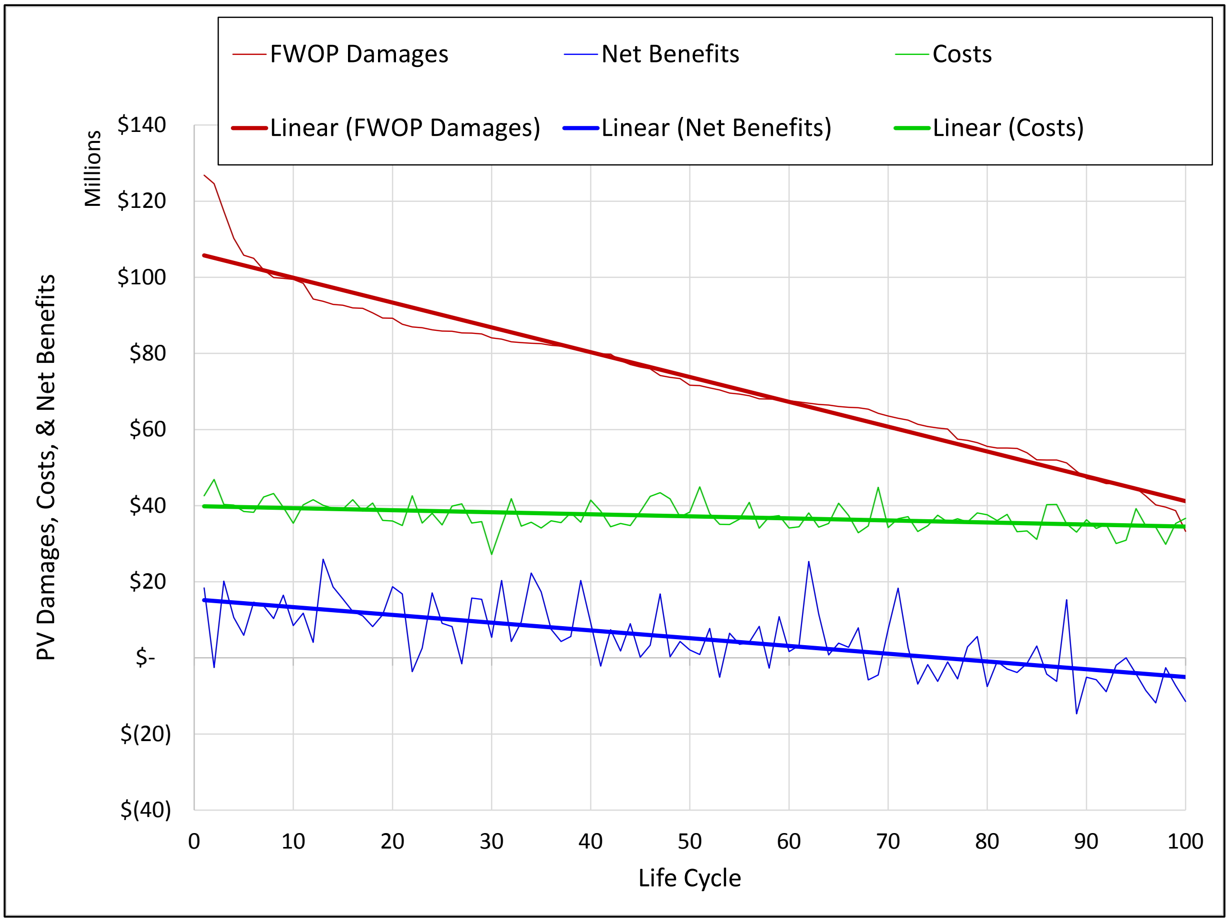


Figure 4-6: TSP Life Cycle Costs and Benefits Sorted By FWOP Damages

Table 4-11: TSP Performance in Life Cycles with Greatest FWOP Damages

Results	All 100 Life Cycles	Top 25 FWOP Damage Life Cycles
Average Net Benefits	$ 5,086,133	$11,829,414
Average Cost	$ 37,165,962	$39,441,101
Average BCR	1.13	1.30
% Reliability wrt > Average Net Benefits	47%	84%
% Reliability wrt > Average Costs	45%	76%

4.5 Land Loss Benefits

In outlining the process and procedures to be used in the evaluation of hurricane and storm damage prevention projects, ER-1105-2-100 mentions the inclusion of land loss due to erosion, stating that such damages should be computed as the market value of the average annual area expected to be lost. Prevention of land loss is a component of primary storm damage reduction benefits but is not computed within the Beach-*fx* model. Thus, calculation of land loss benefits must be completed outside of the model and added to the structure and contents damage and armor costs benefits as computed by Beach-*fx* to obtain the total storm damage reduction benefits of the project.

Following the guidance provided, two key pieces of information are needed to calculate land loss benefits of a storm damage reduction project: (1) the square footage of the land lost each year and (2) the market value of land in the project footprint.

In the case of St. Johns, annual reduction in dune width across all Beach-*fx* study reaches was obtained from the Beach-*fx LandLoss.csv* FWOP and FWP output files based on modeled changes to the shoreline. ER 1165-2-130 does not allow land loss benefits be claimed for beach areas subject to temporary shoreline recessions. Thus, changes in dune width (rather than changes in berm width) are used as the appropriate measure of land loss. Beach-*fx* measures dune width from the seaward toe of the dune to the landward toe of the dune.

For Beach-*fx* reaches located within the TSP (reaches 104-116, excluding tapers), the basis of the annual change in dune width calculation is the dune width in each reach in the model start year (2015), which is the template assumed to be maintained throughout the project life in the with project condition. The difference between the constant with project dune width and the without project dune width in a given year results in the cumulative loss of dune width given the profile of that specific reach. However, for the purpose of the calculating land loss benefits, the annual loss of dune width is needed. This is obtained by taking the cumulative change in dune width in a given year and subtracting from it the cumulative change in dune width from the previous year. This calculation results in the yearly incremental change in dune width for a given reach.

In addition to land loss within the TSP footprint, differences in dune widths between the with and without project condition in study area reaches located outside of the TSP area (reaches 84-103 and 117-122) are included in the analysis. This is necessary because movement of sand from the project footprint to other reaches within the study area can yield shoreline benefits that would not have occurred had the project not been implemented. For shoreline outside of the TSP, a constant base dune width cannot be assumed in the with project condition since some level of erosion is expected in the absence of direct placement of sand on the beach. To account for changes in both the with and without project shorelines, dune width in a given year in the without project condition is subtracted from the dune width in that same year in the with project condition. If the described difference is greater than zero, then that difference is considered the cumulative land loss as of the specified year. Yearly incremental dune width lost is the difference in this cumulative change between a given year and the prior year.

Once annual change in dune width is calculated, the length of the affected shoreline is needed to compute the square footage of the land lost. Because armor prevents the shoreline from eroding landward beyond the point where the armor is placed, land loss is not counted for any lots already armored or for any lots armorable in the future under current County permitting regulations. The Beach-*fx ArmorStatus.csv* output file was used to make this determination. After subtracting the already armored and armorable in the future shoreline lengths, the remaining shoreline length is eligible for land loss benefits. Note that the elimination of lots that may be armored in the future from receiving any land loss benefits between the project base year and the year the lot is armored in the model is a conservative assumption. While the land loss benefits here may be slightly understated, review of the data indicates very little loss in dune width between the start of the Beach-*fx* simulation and the triggering of armor construction for armorable lots. Thus, the effect of the exclusion of these lots from receiving land loss benefits is assumed to be minimal.

Using the annual decrease in dune width for a specific reach and the corresponding length of shoreline eligible for land loss benefits, the total annual square footage of land lost is obtained on a reach-by-reach basis and then summed across all study reaches for a given project year.

As the second component of the land loss benefits calculation, ER 1105-2-100 instructs that nearshore land values be used to estimate the value of land lost. In the St Johns County Beach Restoration Estimated Depreciated Replacement Costs of Damage Elements report, the SAJ Real Estate Department estimated a nearshore land value of $10.00 per square foot for the St Johns study area.

Using the analysis technique described, the total present value of land loss benefits over the 50 year project life is estimated at $6,051,000, or $241,000 in average annual terms.

4.6 **Incidental Recreation Benefits**

According to ER-1105-2-100, incidental recreation benefits can be calculated in shore protection studies. Recreation benefits are not to be used in plan formulation, but they can constitute up to 50% of total project benefits.

Additionally, ER-1105-2-100 specifies that benefits arising from recreation opportunities created by a project be measured in terms of willingness to pay. Three acceptable calculation methods are outlined: (a) the travel cost method (TCM), (b) the contingent valuation method (CVM), and (c) the unit day value method (UVD).

The travel cost method is based on the concept that by increasing the carrying capacity of a particular recreation resource, a project may reduce the travel time (and travel cost) associated with recreation visits. In this case, preliminary investigations concluded that there is no excess demand for recreation in St. Johns County due to the availability of numerous public beaches in close proximity. Therefore, the travel cost method is not applicable. The contingent valuation method, which measures recreational benefits by asking individual households how much they would be willing to pay for improvements to the recreational opportunities provided at a specific site, can be time consuming and costly. Thus, it was ruled out for the St. Johns study area in favor of the unit day value method, which requires less money and time to complete without compromising the quality of the analysis.

The unit day value method estimates a user's willingness to pay for a given recreational opportunity by assigning ratings to five criteria designed to measure the quality of the overall recreation experience provided in the project area. According to ER-1105-2-100 Appendix E, UDV is appropriate in several scenarios, including cases where plan formulation or selection is not materially influenced by recreation benefits and where annual visitation to the project area does not exceed 750,000. In the case of St. Johns both of the aforementioned guidelines are met; the TSP was chosen prior to the calculation of recreation benefits and visitations used in the recreation benefits calculation cannot exceed 592,687 visits per year due to capacity limitations explained below. Also, the benefits to beach recreation provided by the St. Johns project are related to improvements in the *quality* rather than an increase in the *quantity* of recreation enjoyed in the project footprint, which also supports the selection of UDV as the method for the analysis.

As mentioned above, the UDV method uses five criteria to gauge the overall quality of the experience, availability, carrying capacity, accessibility, and environment in the project area. Each criterion can be assigned to one of five possible scoring ranges rated from low to high. Within each range a specific point value is also chosen. These point values are summed together and applied a dollar day value based on the current UDV guidance. The current unit day values, provided by USACE Economics Guidance Memorandum #16-03, *Unit Day Values for Recreation for Fiscal Year 2016*, are presented in **Table 4-12**. Linear interpolation was used to estimate the dollar value of point scores not published. For example, a point score of 2 corresponds with a dollar value of $4.05.

Table 4-12: Current Unit Day Values for Recreation

Point Values	General Recreation Values (FY16)
0	$ 3.90
10	$ 4.64
20	$ 5.12
30	$ 5.86
40	$ 7.32
50	$ 8.30
60	$ 9.03
70	$ 9.52
80	$ 10.49
90	$ 11.23
100	$ 11.71

The recreation point values assigned to the St. Johns County project area vary by year and between the with and without project scenarios. They are summarized in **Table 4-13.**

Table 4-13: Total Unit Day Point Scores applied to St. Johns County

Year	Without Project	With Project
2020	47	52
2030	43	52
2040	37	52
2050	36	52
2060	35	52
2070	35	52

*Base year is 2020.

The point assignments are based on qualitative criteria and depend on best professional judgment (also referred to as "judgment criteria") and knowledge of the project area. In order to learn more about recreation in St. Johns County (SJC), SAJ economists met with members of SJC Beach Services and Parks and Recreation in November of 2015. This collaboration helped in the assignment of the following judgment criteria applied to the project footprint.

- **Recreation Experience:** For both the with and without project conditions, the TSP area was assigned a score of 16 in the project base year (2020), which corresponds with "several general activities; one high quality value activity". General activities common to the area include swimming, surfing, and sunbathing, among others. On the coast of northeast Florida, horseback riding is unique to St. Johns County and is thus considered a "high quality value activity". Over the 50 year project life, the score of 16 is held constant in the with project condition because periodic nourishments guarantee sufficient berm width for on-beach recreation. However, in the without project condition, flat, traditional berm area is reduced leading to recreation on a more sloped profile less conducive to sunbathing, horseback riding, and other on-beach activities.

- **Availability of Opportunity:** A score of 0, “several within 1 hr. travel time; a few within 30 minutes” was assigned to the project footprint in both the with and without the project conditions because several other beaches with public access are available within close proximity of the Vilano project area (Jacksonville Beach, St. Augustine Beach, etc.). Also, within Vilano Beach but outside of the reaches included in the recommended plan, there are several commonly used public access points with parking (e.g., Surfside Park, etc.) and on-beach parking at the Vilano Vehicle Access Ramp. Availability of opportunity does not change at any point during the project life.
- **Carrying Capacity:** In the project base year in both the with and without project conditions, the TSP area was assigned a point value of 11, “optimum facilities to conduct activity at site potential”. The North Beach public parking area includes restrooms and a small pavilion (for picnics, shade, etc.). There are also several public access points within the project area that have boardwalks leading to the beach. Vilano Beach has a “roaming patrol” that takes care of safety in the area and employees at fire stations throughout the study area are trained in rescue. In the without project condition, the score associated with carrying capacity, falls to a 9 (low end of “optimum facilities to conduct activity at site potential”) over the project life due to deterioration of public boardwalks as beach erosion occurs and sand (and/or water) potentially covers/damages portions of the boardwalks. In the with project condition, no such decline is carrying capacity is expected.
- **Accessibility:** Currently, there is “good access, good roads to site; fair access, good roads within site”, resulting in a unit day point value of 14 both with and without implementation of the project. A1A runs parallel to the study area. Boardwalks and footpaths provide beach access. Special Use permits also allow driving and horseback riding with entrance at R-119 (Surfside Park, outside TSP area) extending to R-104 (northern end of project footprint). If the project is implemented (FWP), there will be more beach to drive on and to ride horses on than if the project is not implemented and erosion continues. Thus, the without project accessibility score declines from 14 to 11 over the project life.
- **Environmental Quality:** In the without project condition, a score of 6 (“average aesthetic quality; factors exist that lower the quality to minor degree”) was assigned in the base year and is expected to decline to 4 by the end of the project life (2070). The score was assigned based on the fact that there is little berm in R-104 to R-116 (TSP area) at high tide, which results in minimal area for recreation. From an environmental perspective, the small berm size could have adverse effects on the potential for sea turtles to nest in the area. There is also substantial debris on the beach in some areas. Sea grass and other native plants have suffered as the dune and beach areas have eroded. In the FWP, holding sand on the beach creates habitat for native species/helps upland habitat, which earns a score of 11 in the “high aesthetic quality; no factors exist that lower quality” category throughout the project life. **Figure 4-7** is a picture taken in November of 2015 during a site visit to the project area. Note the limited berm and the quantity of debris on the beach.

Figure 4-7: 2015 Beach Conditions

After assigning point scores and dollar values, these values must be applied to expected recreation visits over the life of the project. Because St. Johns County does not conduct beach counts in the project area, estimated beach visitation was calculated using data from the 2011 report entitled *Outdoor Recreation in Florida: Survey for the State Comprehensive Outdoor Recreation Plan*, which was conducted by Responsive Management for the Florida Department of Natural Resources and used as the basis for the 2013 Florida State Comprehensive Outdoor Recreation Plan (SCORP).

Several key pieces of information are taken from the 2011 Responsive Management and the 2013 SCORP reports. First, the reports provide the estimated number and percentage of both Florida residents and Florida tourists that participated in specific outdoor recreation activities in the state in the past 12 months (2011). One of the specified recreation categories is “saltwater beach activities”, which is the activity most closely associated with beach visitation. The SCORP survey found that approximately 63% of Florida residents and 49% of Florida tourists had participated in saltwater beach activities within a year of being surveyed. Note that “saltwater beach activities” exclude fishing. Thus, saltwater fishing is not captured as a source of beach visitation here in the St. Johns County project area.

In addition to estimating saltwater beach participation statewide, the survey also asked Florida residents that reported participating in a saltwater beach activity in last 12 months in which counties they had participated. Approximately 4% of resident respondents reported taking part in a saltwater beach activity in St. Johns County at least once in the past year. Similarly, tourists were asked about where they had participated in saltwater beach activities in the state in the last year. However, instead of asking that tourists specify the counties in which they participated, the survey question grouped counties/portions of counties into regions that would be more easily identifiable by tourists that may not be familiar with county names. St. John's County and the project area are included in the Jacksonville Area (south to St. Augustine and Fort Matanzas) where approximately 5% of tourists reported participating in one or more saltwater beach activities in the preceding 12 months.

In order to estimate annual visitation, the number of days each year that individuals spend taking part in saltwater activities is also needed. The SCORP survey results report the median days of participation in saltwater beach activities by Florida residents that participated at least once in the previous 12 months at 8.0 days, while the mean was 21.4 days. For tourists the median was 3.0 days and the mean was 4.9 days. For visitation estimates calculated in the present study, the median number of participation days for both residents and tourists was used to avoid placing extra weight on outliers.

The method applied thus far gives an estimated number of saltwater beach visitations for St. Johns County by Florida residents and for the Jacksonville Area (south to St. Augustine and Fort Matanzas) by Florida tourists. Now, the number of county and area visitations must be adjusted to include only the visits to the project footprint. Data from the Florida Department of Environmental Protection estimates 41.1 miles of sandy beaches in St. Johns County. Of that 41.1 miles, approximately 2.55 miles, or 6.2%, lie in the TSP footprint. Thus, 6.2% of all saltwater beach visits to St. Johns County by Florida residents are applied to the study area. Note that shoreline area was chosen as the proxy for visitations by Florida residents to account for pedestrian visitations that would not necessarily require public parking. However, this decision is not expected to have a significant impact on estimated visitations since the percentage of St. Johns County beach parking spaces in the TSP area is very similar at 6.05%. For Florida tourists, the number of Jacksonville Area saltwater beach visitations taking place in the TSP footprint is estimated as the approximate proportion of all public parking spaces with beach access from Nassau County to southern St. Johns County that are located in the TSP, or 1.86%.

Applying these factors to Florida residents and tourists, respectively, results in an estimated 353,462 visitors to the study area in 2011. In order to estimate beach visitation by Florida residents over the project life, population projections for the state are used. The Bureau of Economic and Business Research at the University of Florida publishes historical U.S. Census data and provides population projections through 2040. Projections beyond 2040 were calculated by running a linear regression using time series data back to 2010. Similarly, Florida tourism estimates for 2020 through 2070 were calculated using linear regression on historical data (2009 through 2014) provided by VISIT FLORIDA. Using the combined techniques outlined here, the total number of beach visits within the TSP area is projected to increase to 427,588 by 2020 and to 832,648 by 2070.

In order to verify the reasonableness of the recreation benefits, total projected visitation must be compared to total recreation capacity. In the case of the St. Johns TSP, total recreation capacity has two key components, (1) parking capacity and (2) residential/hotel capacity within walking distance of the beach. Note that due to the residential nature of the study area and the limited availability of parking, pedestrian visitation is an important component of total visitation and pedestrian public access points are located throughout the TSP area.

Parking capacity was established using data provided by the County, which reports a total of 102 public parking spaces within the project footprint. In estimating beach visitations, the County assumes that on average each car that parks at the beach carries 2.4 people and that a parking space turns over 3 times per day. Here the County's assumptions are borrowed to establish an upper bound on the number of visitors that could park in a public beach space in the TSP footprint in a year. If parking is full 365 days per year, the public spaces in the TSP can accommodate 268,056 visitors annually.

Maximum visitation by those within walking distance of the TSP beach takes into account residences, condos, and hotels that are located from the shoreline landward to one block west of A1A. This is a relatively conservative proxy since it is likely that people living greater than one to two blocks from the beach would also walk or ride a bike. Using 2014 Google Earth imagery, an estimated 228 single family residences and 88 condominium units are found within the specified boundaries. Data prepared by the U.S. Census Bureau from the American Community Survey estimates an average household size of owner-occupied and renter-occupied units in St. Johns County. Here, the owner-occupied average (2.670 occupants in 2014) is applied to residences and the renter-occupied average (2.530 occupants in 2013) is applied to condos. Assuming that each of these individuals goes to the beach one time each day of the year, a maximum possible number of 303,461 visitations from nearby home and condo occupants is established. Empty lots are not considered in establishing this cap.

There is also one hotel, the Ocean Sands Beach Inn, located directly across the street from the project footprint. The hotel has 29 rooms, each of which has either one king-sized or two queen-sized beds. To estimate the maximum number of annual beach visitations possible by hotel occupants, an average of 2 occupants per room, each of which visits the beach once per day all year long, is assumed. This yields an annual maximum hotel capacity of 21,170. It should be noted that there is also a large RV and camping area directly west of A1A (Beach-*fx* reach 109) called the North Beach Camp Resort that has 3 cabins and 159 RV spots for rental and covers 30 acres. Because no clear data was available regarding occupancy or the percentage of these accommodations within reasonable walking distance of the beach, this potential source of beach visitations in not factored into the maximum beach capacity.

The sum of estimated maximum possible visitations from public parking and from home, condo, and hotel occupants is 592,687. This number exceeds the projected TSP visitation over the 50 year project duration. Therefore, visitation was capped in year 2041 at 592,687 and left constant throughout the remainder of the project life.

Using these methods and applying the visitation cap, results in an estimated total present value of recreation benefits of $15,624,000, or $622,000 in average annual terms.

5. CONCLUSION

Table 5-1 provides a summary of the NED Plan with land loss and recreation benefits added expressed in average annual equivalent terms.

Table 5-1: Economic Summary

Economic Summary	Primary Storm Damage Reduction Benefits	Primary Storm Damage Reduction + Incidental Recreation Benefits
Price Level	FY16	FY16
FY16 Water Resources Discount Rate	3.125%	3.125%
Average Annual Structure & Contents Damage & Armor Costs Benefits	$ 1,709,000	$ 1,709,000
Average Annual Land Loss Benefits	$ 241,000	$ 241,000
Average Annual Incidental Recreation Benefits	$ -	$ 622,000
Average Annual Total Benefits	$ 1,950,000	$ 2,572,000
Average Annual Costs	$ 1,562,000	$ 1,562,000
Average Annual Net Benefits	**$ 388,000**	**$ 1,010,000**
Benefit Cost Ratio	**1.25**	**1.65**

Portions of St. Johns County’s shoreline are vulnerable to coastal erosion and storm damage. Beach-*fx* modeling has demonstrated that significant economic damage from coastal forces can be expected to occur over the next 50 years in the future without project condition. In the two alternative Sea Level Rise scenarios, damages increase substantially.

In order to reduce future damages, a large number of management measures were considered. After a detailed investigation and extensive modeling effort, a plan was selected that maximizes expected future net benefits. This plan, “0P60B 104to116”, involves initial and periodic nourishment of 60 foot equilibrated berm extension. The project template will include a dune feature that reflects the average 2015 dune profile. A hydraulic dredge will be used to fill the template with sand from the St. Augustine Inlet and ebb shoal complex. The average annual net benefits of the TSP are $1,010,000.