ST. LUCIE COUNTY, FLORIDA

COASTAL STORM RISK MANAGEMENT PROJECT

FINAL INTEGRATED FEASIBILITY STUDY AND ENVIRONMENTAL ASSESSMENT

APPENDIX C
Economics

US Army Corps of Engineers
Jacksonville District

1. EXECUTIVE SUMMARY

St. Lucie County is located on the central-east coast of Florida to the immediate south of Indian River County, and the immediate north of Martin County. Portions of St. Lucie County's 22 mile shoreline are subject to erosion caused by both storms and natural shoreline processes. A study was undertaken to assess the feasibility of providing Federal Coastal Storm Risk Management measures to portions of the county's shoreline. The local sponsor for this project, St. Lucie County, has indicated strong support for feasibility phase studies to address CSRM. They have also declared willingness and the capability to share applicable costs in the current study. In accordance with appropriate federal guidance, an investigation was performed to estimate the economic benefits of alleviating erosion, inundation, and wave-attack damage to coastal infrastructure.

⌗ Alternative Evaluation

Upon initiation of a preliminary screening, followed by a detailed evaluation of a final array of alternatives, the project delivery team (PDT) has determined a National Economic-Development Plan (NED) (i.e. a plan that maximizes net-benefits), and a recommended plan for reducing risks associated with coastal storm and erosion damage to infrastructure. These plans were evaluated using FY2017 price levels and the FY2017 federal water resources discount rate of 2.875%. The evaluation covered the span of a 50-year period of analysis with a base year of 2020. Alternatives were measured against the criteria of efficiency, effectiveness, and acceptability as well as being compared to the No Action Plan. Refer to **Table 1-1** for more detail on the evaluation of the final array of alternatives en route to discovering the NED. Benefit values in this table include those derived from land loss estimations and incidental recreation benefits. In order for a consistent and more accurate comparison to be made, costs for the final array of alternatives were more refined than the costs used during initial screening. Initial screening relied solely on Beach-Fx output costs (i.e. mobilization/demobilization and placement cost only, averaged over 100 iterations). The refined cost for the final array comparison, which are displayed in Table 1-1 below, took into account the defined nourishment interval, the placement cost for the estimated cubic yards to be placed for initial construction and future periodic nourishments, as well as costs incurred in non-nourishment years (e.g. monitoring).

Table 1-1: Alternative Net-Benefits & BCR's

Alternative Name	Brief Description	Total Costs[1] (AAEQ)	Net Benefits (AAEQ)	BCR
ABerm20DuneEx	Existing Dune and 20' sacrificial berm	$ 1,314,927	$ 1,650,356	2.26
ABerm30DuneEx	Existing Dune and 30' sacrificial berm	$ 1,462,493	$ 1,503,541	2.03
ABerm40DuneEx	Existing Dune and 40' sacrificial berm	$ 1,627,343	$ 1,335,742	1.82
ABERM10DuneEx	Existing Dune and 10' sacrificial berm	$ 1,411,990	$ 1,545,923	2.09
Dune10	10' Dune Extension	$ 1,485,348	$ 1,441,501	1.97
No Action	No Action	$ 0	$ 0	N/A

[1] ABerm20DuneEx costs in this table are certified costs. For each of the other alternatives costs were estimated based on certified cost information and information obtained from Beach-fx output files. A 28% cost contingency is included. At this point in the process OMRR&R and IDC were not included.

The plan with the highest net-benefits (NED), and the recommended plan, is the project that maintains the current dune and berm template while adding 20' of sacrificial fill (**ABerm20DuneEx)**. **Table 1-2** provides a summary of the recommended plan with and without land loss and incidental recreation benefits[2] and the total cost includes interest during construction (IDC) as well as operation, maintenance, repair, replacement and rehabilitation (OMRR&R) costs.

Table 1-2: Economic Summary of the Recommended Plan ($AAEQ)

ECONOMIC SUMMARY	STORM RISK MANAGEMENT BENEFITS ONLY	STORM RISK MANAGEMENT + LAND-LOSS BENEFITS (PRIMARY)	STORM RISK MANAGEMENT + LAND-LOSS + RECREATION
Price Level	FY17	FY17	FY17
FY17 Water Resources Discount Rate	2.875%	2.875%	2.875%
Storm Risk Management Benefits	$2,165,474	$2,165,474	$2,165,474
Land Loss Benefits	$0	$234,138	$234,138
Recreation Benefits	$0	$0	$565,671
Total Benefits	$2,165,474	$2,399,612	$2,965,283
Total Cost[3]	$1,348,623	$1,348,623	$1,348,623
Net-Benefits	$816,851	$1,050,989	$1,616,660
Benefit Cost Ratio	**1.61**	**1.78**	**2.20**

[2] Unlike incidental recreation benefits, land loss benefits are considered primary benefits in CSRM studies. Both benefit categories are discussed in detail in sections **4.1** and **4.2**.
[3] This cost includes IDC and OMRR&R

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1. INTRODUCTION

The purpose of this appendix is to tell the story of the economics investigation and resulting analysis. A detailed explanation of the qualitative rigor and the precise modeling efforts, from inputs to outputs, which gave rise to the recommended plan will be provided. The subsequent sections 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.
- **Future Without-project Condition (FWOP):** The FWOP is a forecast of the economic conditions and structure values located within the project area that are subject to the risks associated with coastal processes and coastal storms. The FWOP is the basis for alternative comparison in order to obtain the benefits from any potential federal project.
- **Coastal Storm Risk Management (CSRM) Benefits:** This section will cover the methods and assumptions used to estimate the future without-project and future with-project condition using Beach-fx, while also accounting for risk and uncertainty. The FWOP will cover the distribution of the damages in the following dimensions:
    - Spatial (Where)
    - Categorization of structures (What)
    - Damage driving parameter (How)
    - Temporal (When)

Discussion of the future-with project condition (FWP) will address the management measures and alternative plans evaluated. In addition, a sensitivity analysis of how the alternatives perform under varying sea-level rise scenarios is provided.

- **NED & Recommended Plan Selection and Performance:** This section addresses the quantitative analysis executed to determine which alternative maximizes NED and which alternative will be the recommended plan. A detailed description of the performance of the NED plan, including certified cost estimates, is provided with the same four dimensions described above in the CSRM section. The methodology underpinning the calculation of additional benefits provided by the project (i.e. land loss benefits, incidental recreation benefits) will be summarized as well.

2. EXISTING CONDITIONS

A key step in the planning process is to establish the existing (i.e. current) condition by developing an inventory and characterizing the critical resources within the project area. The existing condition is also a key component for forecasting the FWOP, which is described in detail in **Section 3.3**.

2.1 Socio-Economic Conditions

St. Lucie County is located in the central-east region of Florida and has approximately twenty-two miles of coastline along the Atlantic Ocean. The cities comprising the county are Ft. Pierce, Port St. Lucie and the communities of Hutchinson Island and St. Lucie Village. It is also one of four counties included in the Research Coast Economic Development Coalition[4].

2.1.1 Demographic Characteristics[5]

According to the US Census Bureau, the 2010 population of St. Lucie County was 277,789 with a land area of 571.93 square miles. Over the past several years, the county has seen rapid population growth. Between 2000 and 2010 the county grew by approximately 44%. Since then, the population has grown by 4.8% to reach an estimated 291,028 in July of 2014.

The ethnic makeup of St. Lucie County is relatively homogeneous. Caucasians make up approximately 71.8% of the population. The largest minority group is African American, which make up approximately 19.1%. All other racial groups comprise less than 10% of the total population. The median age for residents is 43.3 and those aged 60 years and over represent 27.4% of the population. Overall, St. Lucie County is largely an adult population with those aged 18 years and older at 77.7%.

2.1.2 Economic Characteristics

With several notable attractions located within its borders tourism is a critical component of the economy. St. Lucie County is a premier recreational fishing destination with a variety of species available for catch. Notably, the International Game Fish Association (IGFA) reports the record-setting spotted sea trout catch occurred within county waters (17 lbs. 7 oz., Ft. Pierce). In addition to the miles of pristine beaches and nature reserves, the county's Tradition Field is also host to the New York Mets Major League Baseball team for the entirety of spring training. As a result of this influx of tourists St. Lucie County has over 6,000 jobs in the service industry[6].

Additionally, agriculture, manufacturing and health care are all important drivers of economic activity in St. Lucie. According to the United States Department of Agriculture, the county has more than 75,000

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[4] For more information see *Research Coast Representatives Promote Region for Business*. Vero News. December 7, 2015

[5] All figures from this section are from source: United States Census Bureau, American Fact Finder. Unless otherwise specified, data references 2010 Census.

[6] Source: St. Lucie Economic Development Council

acres of crop land between grapes, citrus, and oranges alone[7]. Manufacturing accounts for 1,870 jobs and health care an additional 2,8906[6].

The income trends within St. Lucie County are very similar to that of the state of Florida overall. The following is a summary of those trends from the most recent year available (2014)[8]:

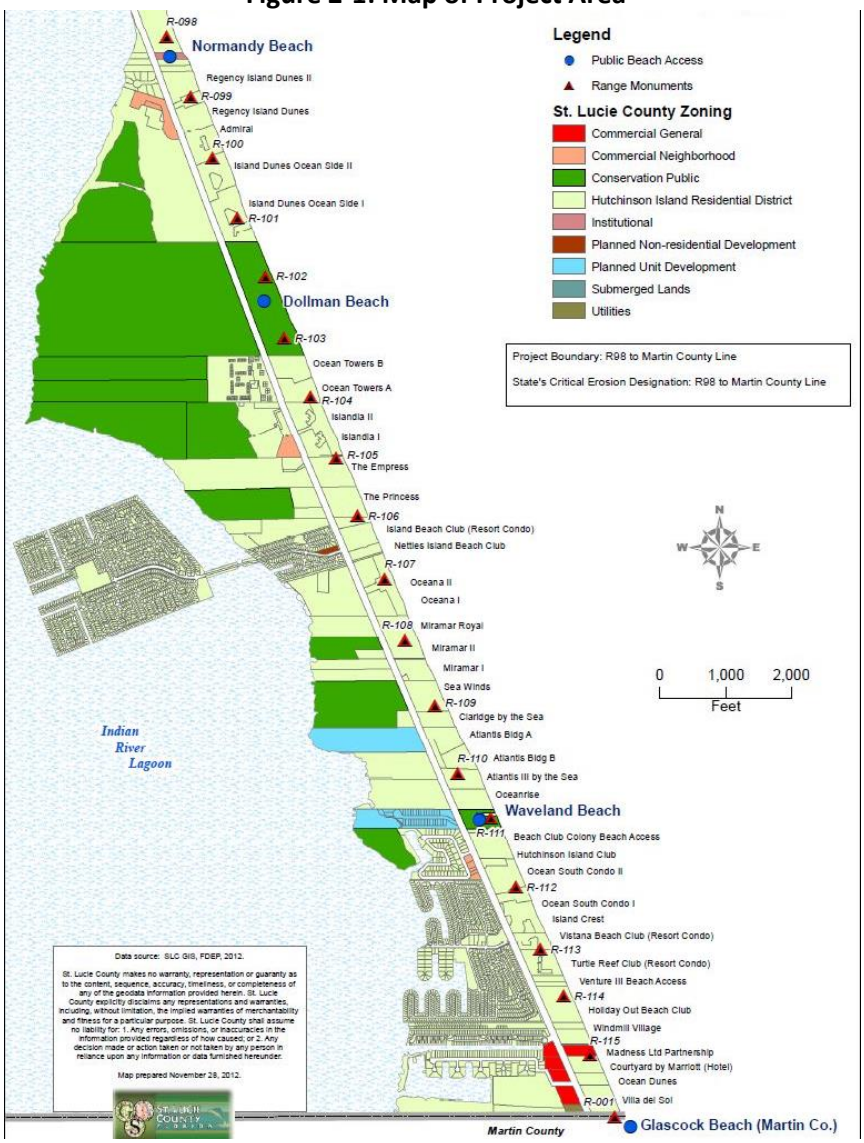
- Median Household Income: $42,665
- Per Capita Income: $23,422
- Individuals Below Poverty Line: 14.2%
- Unemployment Rate: 7.5%
- Individuals Receiving Social Security Income: 42.2%
- Individuals with Retirement Income: 22.8%

2.2 Study Area

The initial study area ranged from the Florida Department of Environmental Protection (FDEP) range monument (R) R-077 to the Martin County Line (R-001). Four study reaches were established within the 7.2 mile span of coastline: The Power Plant, North Hutchinson Island, Narrows of Hutchinson Island, and South Hutchinson Island. Preliminary modeling indicated that the federal project should focus exclusively on the South Hutchinson Island reach due to its erosive nature and dense development. Though the power plant represented a potential risk for damages, heavy existing fortification suggested further measures would prove redundant. As a result, the project area was refined to begin at R-98.5 and end at the Martin County line (R001) as displayed in **Figure 2-1.** All benefit and cost analysis performed and described in this appendix refer specifically to this project area[9].

[7] Source: CropScape – USDA National Agricultural Statistics Service
[8] Source: Us Census Fact Finder 2014
[9] The model reaches used to encompass this area are R-099 to R-115 which is explained more in Section **2.3.**

Figure 2-1: Map of Project Area



2.3 Data Collection

Economists and real estate specialists have collected and compiled detailed structure information for 3.25 miles[10] of St. Lucie County's coastline. In total, 241 damageable structures were collected for economic modeling using Beach-fx. The structure inventory includes all structures that are within 500 feet of the mean-high-water line.

Real estate professionals from the USACE Jacksonville District (SAJ), using geo-spatial parcel data from St. Lucie County, provided detailed data on each structure including: geographic location, structure type,

[10] Approximate length from R-98.5 to R-001

foundation type, construction type, width, length, number of floors, depreciated replacement value, and year built.

The St. Lucie County study area consists of seven profiles, 15 model reaches, and 59 lots for economic modeling and reporting purposes. This hierarchical structure is depicted as follows:

- **Profiles:** Coastal surveys of the shoreline modified by USACE SAJ Coastal Engineering personnel to apply coastal morphology changes to the model reach level. Profiles are strictly used for modeling purposes and only referred to in this section for informational purposes. Specific information regarding the makeup of the profiles can be found in the Engineering Appendix of this report.
- **Beach-Fx Model Reaches:** Quadrilaterals parallel with the shoreline used to incorporate coastal morphology changes for transfer to the lot level. In this study the model reaches use Florida Department of Environmental Protection (FDEP) range monuments. As mentioned above, the true length of the project is from R-98.5 to R-001 and is approximately 3.25 miles long. The Beach-fx model reaches incorporate that same 3.25 mile span but are labeled as R-99 to R-115 and will be referred to simply as "reaches" throughout this appendix. Each model reach is approximately 1,000' in length with the exception of R-115, which includes an additional 1,000' to the Martin County line. **Figure 2-1** above displays these reaches in the project area.
- **Lots:** Quadrilaterals encapsulated within reaches used to transfer the effect of coastal morphology changes to the damage element. Lots also ensure that the model does not overstate damages by placing value parameters around rebuilding (this is discussed further in section 3.2.2).
- **Damage Elements:** Represent a unit of coastal inventory in the existing condition 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 the following section.

2.4 Existing Condition Coastal Structure Inventory

Information on the existing economic conditions along the St. Lucie County coastline was collected for economic modeling purposes. The information on the coastal assets detailed in this section was collected from St. Lucie County mapping resources, site visits, and contractors. Each parcel along the beach was identified as developed or undeveloped, with streets and parks noted. USACE real estate specialists provided depreciated replacement value of existing structures within the study area.

2.4.1 Structure & Contents Value

The economic value of the existing St. Lucie County structure inventory represents the depreciated replacement costs of damageable structures (i.e. damage elements) and their associated contents along the coastline. Real Estate professionals from the USACE SAJ district worked together with economists and planners to provide economic valuations for all of the 236 damageable structures and their contents. These damage elements have an overall estimated value of $669.3M, with structure and content valuations of $579M and $91M respectively. Content values were established as a ratio to overall structure value. When applicable, content-to-structure ratios were based off the USACE final report "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study". For example, the ratios for one- and two-story residences from the study were used for St. Lucie properties (i.e. 70% and 67% respectively). However, the study did not contain any high-rise structures and therefore those ratios

were determined by SAJ economists based on available information from St. Lucie County and best professional judgment. Since high-rise buildings would receive minimal damage above the second floor the CSVR was conservatively estimated at 14%. Many items in the structure inventory had a CSVR of 0% (e.g. roads, dunewalks, parking lots). As a result, the average CSVR across the entire study area is roughly 16%. The overall distribution of value by reach is summarized in **Table 2-1**.

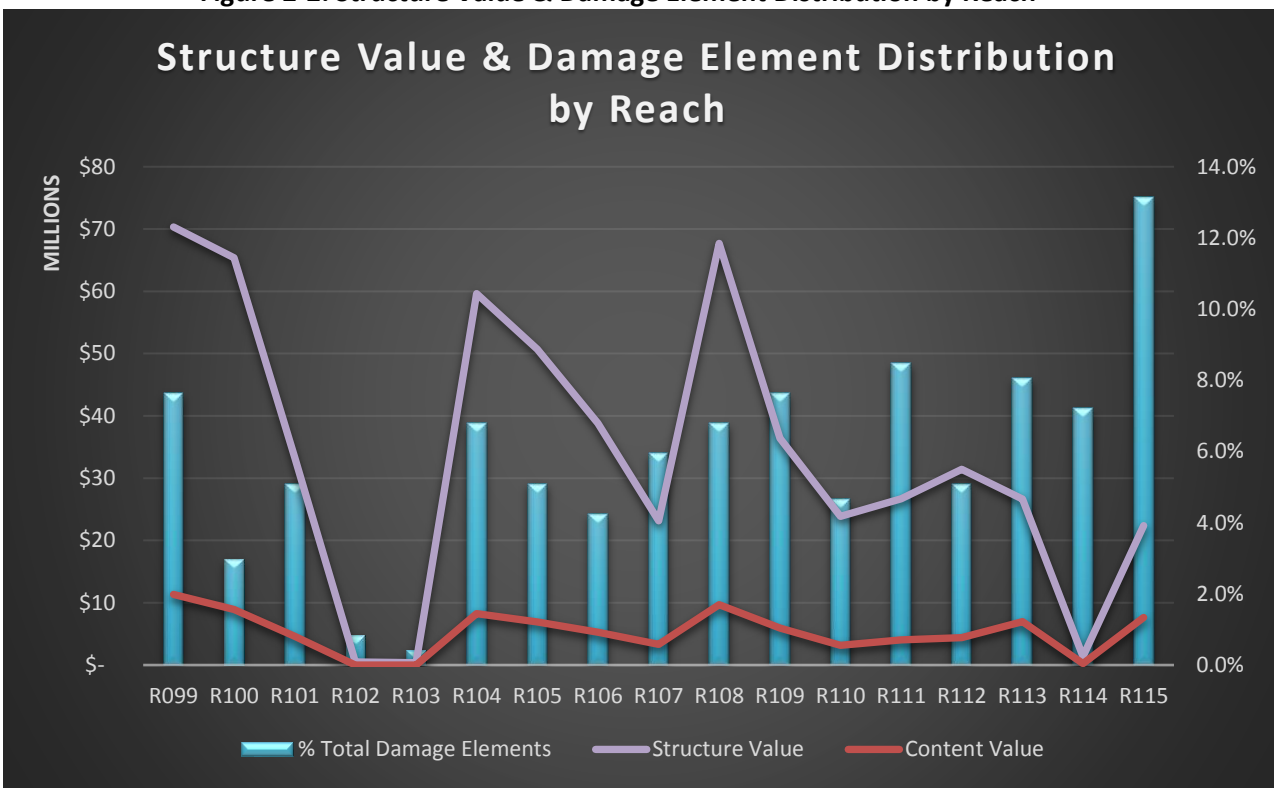
Table 2-1: Distribution of Structures & Structure Value by Study Reach

Reach	Structure Value	Content Value	% Total Value	# Damage Elements	% Total Damage Elements
Reach	Structure Value	Content Value	% Total Value	# Damage Elements	% Total Damage Elements
R099	$ 70,328,170	$ 11,335,909	12.2%	18	7.6%
R100	$ 65,393,015	$ 8,938,156	11.1%	7	3.0%
R101	$ 33,292,909	$ 4,583,021	5.7%	12	5.1%
R102	$ 510,685	$ 0	0.1%	2	0.8%
R103	$ 382,169	$ 0	0.1%	1	0.4%
R104	$ 59,638,936	$ 8,233,070	10.1%	16	6.8%
R105	$ 50,671,441	$ 6,935,733	8.6%	12	5.1%
R106	$ 38,827,604	$ 5,262,028	6.6%	10	4.2%
R107	$ 23,131,259	$ 3,342,885	4.0%	14	5.9%
R108	$ 67,674,190	$ 9,683,231	11.6%	16	6.8%
R109	$ 36,383,413	$ 5,941,502	6.3%	18	7.6%
R110	$ 23,862,725	$ 3,165,472	4.0%	11	4.7%
R111	$ 26,672,082	$ 4,018,670	4.6%	20	8.5%
R112	$ 31,434,922	$ 4,406,246	5.4%	12	5.1%
R113	$ 26,669,670	$ 6,969,432	5.0%	19	8.1%
R114	$ 1,393,215	$ 217,112	0.2%	17	7.2%
R115	$ 22,365,140	$ 7,626,235	4.5%	31	13.1%
Total	**$ 578,631,545**	**$ 90,658,701**	**100%**	**236**	**100%**

Despite the relatively uniform distribution of damage element count, the values aggregated by reach show significant variation, with four of the reaches (R099, R100, R104, R108) accounting for approximately 45% of total value. The variation is due mainly to differentiation between the types of development within the reach. Specifically, reaches with large commercial structures, such as R113 and R115 with Turtle Reef and Villa Del Sol condominium complexes, tend to contain greater value than neighboring reaches, such as R102-R103 which is a public conservation area. For modeling and reporting

purposes the structure inventory was separated into four different structure types. Table 2-2 provides a summary of these structure types and the associated inventory values[11].

Figure 2-2: Structure Value & Damage Element Distribution by Reach[12]



[11] Some of the high-rise structures and other condominiums in the project area are used for commercial activity and many are residential. For economic modeling purposes the delineation between commercial and residential may differ from that of SAJ real estate appendices. However, the total values of the structures do not vary and thus represent the same inventory. Most condos and high-rises were deemed commercial for damage aggregation.

[12] The percent score on the right axis corresponds with the damage element count, not the damage element dollar value.

Table 2-2: Economic Value of Structure Inventory by Structure Type

Structure Type	Structure Value	Contents Value	Total	% of Total	Structure Count
Commercial	$ 557,424,139.88	$ 90,315,788.35	$ 647,739,928.23	96.78%	59
Other	$ 10,995,345.80	$ 52,780.90	$ 11,048,126.70	1.65%	115
Public	$ 9,806,054.90	$ 18,109.24	$ 9,824,164.14	1.47%	61
Residential	$ 406,004.17	$ 272,022.79	$ 678,026.96	0.10%	1
Grand Total	*$ 578,631,544.75*	*$ 90,658,701.28*	*$ 669,290,246.03*	*100%*	*236*

2.4.2 Evacuation Route

The residents of South Hutchinson Island rely heavily on Florida State Road A1A as a means to evacuate during extreme hurricane events. Additionally, A1A provides residents with access to, and from, critical infrastructure and services located on the mainland such as fire departments, police departments, and hospitals. The project area impacts 3.25 miles of A1A since it parallels the coastline throughout South Hutchinson Island. A1A connects residents to the mainland via Northeast Causeway Boulevard to the south and Seaway Drive to the north. Any obstruction to A1A in the southern reaches that blocks access to Northeast Causeway Boulevard would result in traffic needing to be rerouted approximately 16 miles north to Seaway Drive. All of the nearest hospital services, which are located on the mainland, require clear access to A1A. An analysis of flood concerns impacting A1A and how a project ameliorates these effects will be discussed in subsequent sections.

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. Lucie County using Beach-fx. The topics covered include:

- Benefit Estimation Approach Using Beach-fx
- FWOP Condition
- The Future-With Project Condition (FWP)

3.1 Benefit Estimation Approach Using Beach-fx

Beach-fx was developed by the USACE Engineering Research and Development Center in Vicksburg, Mississippi. On April 1, 2009 the Model Certification Headquarters Panel certified the Beach-fx CSRM model based on recommendations from the Planning Center of Expertise (PCX) and in accordance with EC 1105-2-412 (Assuring Quality of Planning Models). The model was reviewed by the PCX for Coastal and Storm Damage and found to be appropriate for use in CSRM studies and is therefore the optimum model for use in the St. Lucie CSRM Study. 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. The output generated from the model is then used to determine the benefits of each alternative. As an event-based Monte Carlo life-cycle simulation, Beach-fx fully incorporates risk and

uncertainty. It is used to simulate future hurricane and storm damages at existing and future years and to compute accumulated present-worth damages and costs. Storm damage is defined as the ongoing monetary loss to contents and structures incurred as a direct result of waves, erosion, and inundation caused by a storm of a given magnitude and probability. The model also computes permanent shoreline reductions so that land-loss benefits can be derived exogenously. These damages and associated costs are calculated over a 50-year period of analysis based on storm probabilities, tidal cycle, tidal phase, beach morphology and many other factors. Beach-fx also provides the capability to estimate the costs of certain future measures undertaken by state and local organizations to protect coastal assets. Based on these attributes, Beach-fx is an ideal modeling tool for use in the St. Lucie CSRM study.

Of course, the abovementioned computations require inputs from USACE personnel in order to function accurately. Data on historic storms, beach survey profiles, and private, commercial and public structures within the project area are used as these inputs. Refer to sections **2.2** and **2.4** for detailed information on key input data specific to St. Lucie County.

The future structure inventory and values are the same as the existing condition. This conservative approach neglects any increase in value accrued from future development. Though Florida has historically experienced increases in density and value in real-dollar terms, using the existing inventory is considered preferable due to the uncertainty involved in projections of future development.

The FWOP damages are used as the base condition and potential project alternatives are measured against this base. The difference between FWOP and FWP damages will be used to determine primary CSRM benefits.

Once benefits for each of the project alternatives are calculated, they will be compared to the costs of implementing the alternative. Dividing the total benefits by the total costs of the alternative yields a benefit-to-cost ratio (BCR). This ratio must be greater than 1.0 (i.e. the benefits must be greater than the costs) in order for the alternative to be justified and implementable. The federally preferred plan, or NED, is the plan that maximizes net benefits. Net benefits are determined by simply subtracting the cost of any given alternative from the benefits of that alternative ($Benefits - Costs = Net\ Benefits$).

3.2 Assumptions

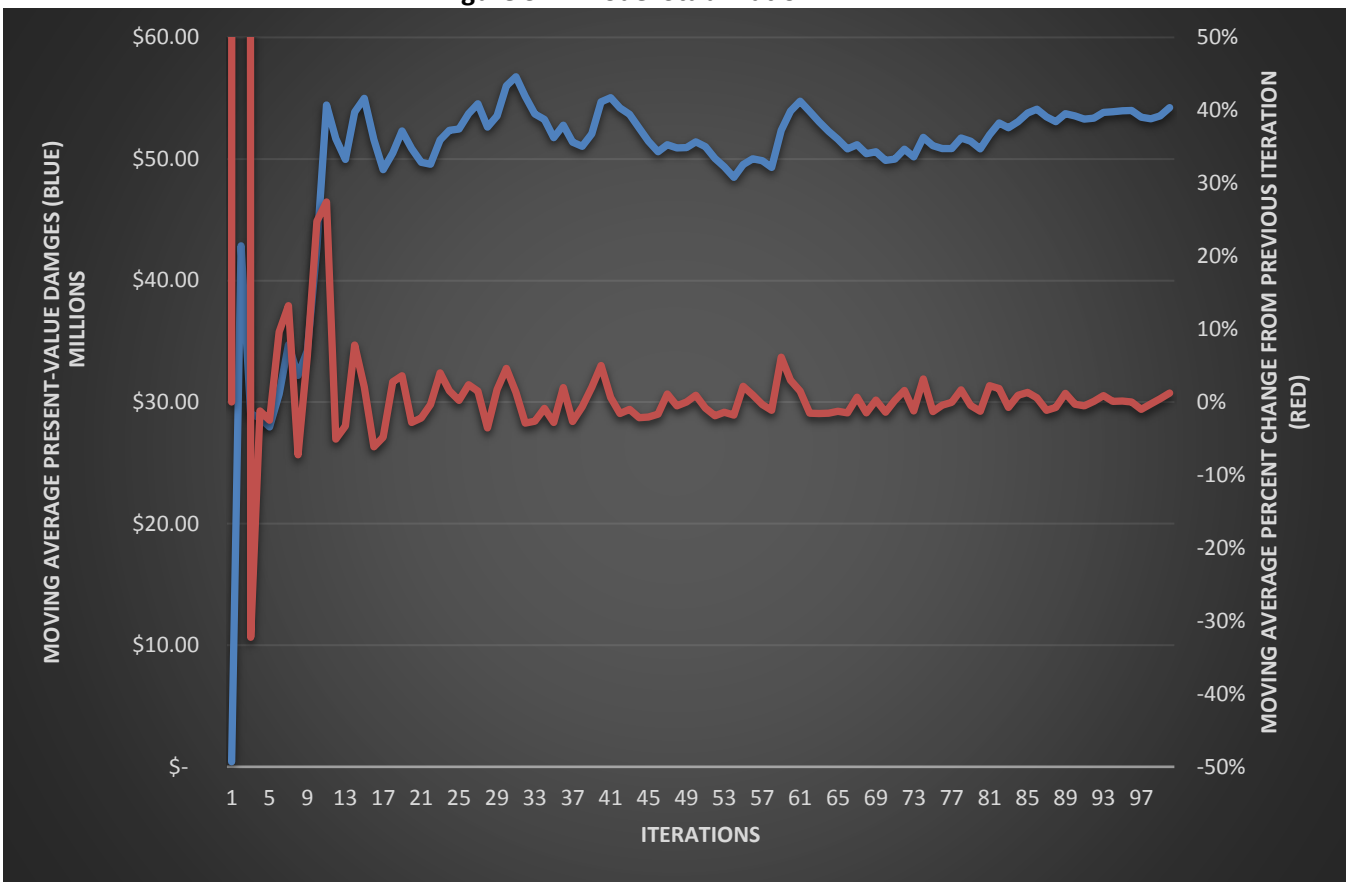
Beach-fx accuracy is not only dependent upon inputs but also requires a meticulous level of thought be given to the parameters (i.e. assumptions) under which the model is bound. This section describes some key assumptions specific to the St. Lucie County CSRM study and the resulting consequences.

3.2.1 Timeframe and Discount Rate

- **Start Year:** The year in which the simulation begins is 2019. This year determines the starting shoreline position which will be impacted by standard erosion and storm forces throughout the period of analysis. It is also the starting point for the sea-level rise projections.
- **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, from 2020 to 2069.
- **Discount Rate:** 2.875% FY2017 Federal Water Resources Discount Rate
- **Iterations:** Beach-fx was run using 100 iterations. The moving average of FWOP damages stabilized by this point and was thus determined an adequate number of iterations. **Figure 3-1** demonstrates the model stabilizing since the moving average does not vary by more than three percent after the

61 iteration. A sensitivity was conducted using the base FWOP condition and a 100 iteration run was compared to a 300 iteration run. Again, the moving average stabilizes around the 61 iteration but the standard error of the mean is reduced from $191,000 (AAEQ) to $110,000 (AAEQ) in the 300 iteration run without significant variation in the moving average of damages ($2,197,692 in the 100 iteration run VS $2,121,637 AAEQ in the 300 iteration run, a decrease of 3.5%). Given the numerous alternatives to be run and the time necessary for each model run, it was determined that 100 iterations was a sufficient balance of stabilization of the model and time required for all runs to be completed.

Figure 3-1: Model Stabilization



3.2.2 Rebuilding

The rebuilding parameter within Beach-fx allows the economic modelers to restrict the amount of monetary investment allocated to structural repair for any specific building type in order to most accurately reflect real-world behavior. Rebuilding does not refer to a total rebuild event (i.e. 100% of structure value), but rather a repair event (i.e. some non-zero percent of value intended to restore the structure). Allowing for an unlimited amount of rebuilding in the period of analysis may be unrealistic for a CSRM study and can potentially overstate damages in the FWOP. However, issuing emergency permits for rebuilding on lots meeting a minimal setback restriction is generally the rule, not the exception in Florida. Common practice and historical evidence also show that rebuilding lost structures, provided

setback restrictions are met, occurs frequently[13]. Additionally, county records dating back to 1994 demonstrate that there have been no known rejections to rebuilding requests. As a result, the number of rebuilds within the model has been limited to reflect this behavior as follows:

- **Number of Times Rebuilding Allowed Assumptions**
  - Public Access Structures[14]: 124X
  - Commercial Recreation Facilities[15]: 62X
  - Remaining: 31X

Additionally, after long-term erosion has claimed more distance on the oceanfront lot than the building requires, the model ceases to reinstate the same property. The model also considers a lot "condemned" once 50%[16] of the total value of that lot is damaged. There is also a control feature that allows an individual damage element to become condemned once 50% of the original structure value has been damaged at which point the damage element undergoes a "time to rebuild" period where no additional damages can accrue. These assumptions will continue to prevent overestimation of the FWOP damages while allowing for realistic rebuilding to occur.

One concern for having a high number of rebuilds is that there may be many high-value repair events (i.e. rebuilds that cause more than 50% of the structure's value to be accrued as damage in a single event) that occur throughout the period of analysis which may overstate damages. On the opposite end, restricting rebuilds too low may exclude many of the lower-value repair events (i.e. rebuilds that cause less than 50% of the structure's value to be accrued as damage in a single event) that occur throughout the period of analysis which may not adequately capture expected damages. A sensitivity analysis was conducted during the modeling efforts for the St. Lucie CSRM in order to gauge the impact of this rebuilding assumption. The damage element type that was the greatest driver of damages, "BUILDING-1[17]", was used to test the sensitivity. Using rebuilding assumptions of 10, 15, 25, 31, and unlimited (999), a frequency distribution was obtained to gauge how a change in rebuilding shifts the proportion of rebuilds from high-value rebuilds to low-value rebuilds. The result of the sensitivity demonstrates that a change in the number of rebuilds for "Building-1" has a negligible effect on the proportion of high-value to low-value rebuilds. The only noticeable effect is a slight increase in the proportion of low-value repair events and a decrease in the proportion of high-value repair events (see **Table 3-1** and **Figure 3-2)**.

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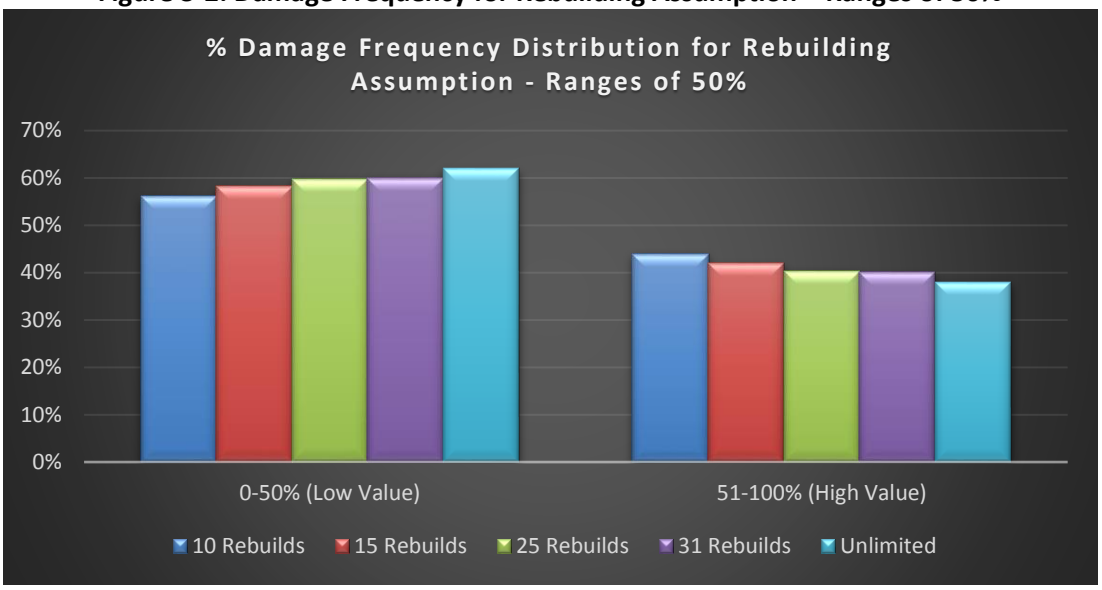
[13] Reference Florida Office of General Counsel order 12-1453 and 12-1264 as examples.
[14] Examples of public access structures include dune walks, shelters, guard shacks and roads.
[15] Examples of commercial recreation facilities include pools, parking areas, and tennis courts.
[16] This amount, the lot condemnation ratio, can be manipulated within the model as needed but is set to 50% for this study
[17] These damage elements are composed of various structures with slab-on-grade foundations. For the frequency distribution only the damage elements that had at least, on average, one rebuild across all iterations were included.

Table 3-1: Proportion of Damages Based on Rebuild Assumption

Damage Range (% of Initial Structure Value)	10 Rebuilds	15 Rebuilds	25 Rebuilds	31 Rebuilds	Unlimited
0-50% (Low Value)	56%	58%	60%	60%	62%
51-100% (High Value)	44%	42%	40%	40%	38%

Figure 3-2: Damage Frequency for Rebuilding Assumption – Ranges of 50%



The proportion of damages doesn't tell the whole story, though, so the sensitivity analysis was also used to review the absolute rebuild count across all of the iterations and across the 50-year period of analysis. When reviewing the rebuild assumption in this manner, there is a more noticeable impact as the number of rebuilds increases. From the 15 rebuild assumption to the 25 rebuild assumption the average number of rebuilds per year nearly doubles from .86 to 1.67. See **Table 3-2** for complete results. It is important to note, though, that this is the average rebuilds per year for all "BUILDING-1" damage elements which includes 21 different structures across the St. Lucie shoreline. So, given the current model assumption of 31 rebuilds, all "BUILDING-1" structures have an 8.7% chance of incurring a repair event in any given year and a 3.5% chance that the repair event will be greater than 50% of initial structure value.

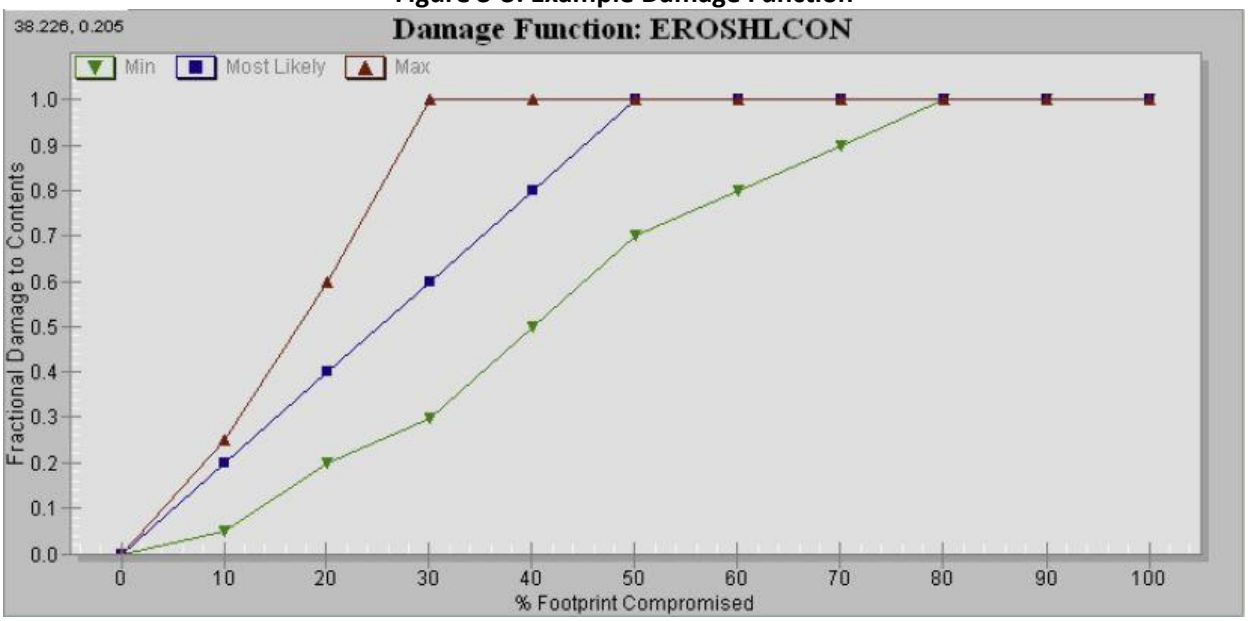
Table 3-2: Average Rebuilds Per Year Given Different Rebuilding Assumptions

	10 Rebuilds	15 Rebuilds	25 Rebuilds	31 Rebuilds	Unlimited Rebuilds
Total Average Rebuilds Per Year	**0.95**	**0.86**	**1.67**	**1.84**	**3.69**
0-50% (Low Value)	0.53	0.50	1.00	1.10	2.29
51-100% (High Value)	0.42	0.36	0.67	0.74	1.40

3.2.3 Damage Functions

Damage functions are used within the model to determine the extent of storm-induced damages attributable to any specific combination of damage element type, foundation type, and construction type. There are a total of six types of damage function which include erosion damages, inundation damages, and wave damages for both contents and structure. The functions are completely user-definable within the model and transfer damages to the individual damage elements. Damage is determined as a percentage of overall structure or content value using a triangular distribution (minimum, most likely, maximum). The range of percentage points used for the damage is determined by parameters dependent upon which function is being triggered. For erosion it is dependent upon the extent to which the structure's footprint has been compromised and inundation and wave-attack are dependent upon storm-surge heights in excess of first-floor elevation. An example diagram of how these damage functions operate is provided by **Figure 3-3**.

Figure 3-3: Example Damage Function



For the vast majority of aforementioned combinations within this study the damage functions used were those developed by the Institute for Water Resources (IWR), within the Coastal Storm Damage Workshop (CSDW), Coastal Storm Damage Relationships Based on Expert Opinion Elicitation in 2002. However, the various high-rise buildings located within the project area proved to be the exception since the IWR wave-damage function did not adequately address these structures[18]. Research to review damages associated with wave-attack to high-rise buildings was conducted and two sources were the focus for basing a new damage function. The first source considered was the Federal Emergency Management Agency's (FEMA) Mitigation Assessment Team Report (MAT) on Hurricane Sandy. Section

[18] Preliminary model runs were demonstrating massive damages (i.e. 100% of structure value) to high-rise buildings despite evidence of performance to the contrary.

4.2 of the FEMA Sandy MAT focused specifically on the structural performance of high-rise buildings and indicated that "Most of the high-rise buildings visited by the MAT had no structural damage…[and] physical damage observed was limited to the collapse of nonstructural concrete block partition walls in basements." These partition walls experienced damage due to inundation loads and not wave attack. Additionally, a look into FEMA's MAT on Hurricane Katrina documents similar structural soundness in the presence of wave attack. Section 4.1.5 similarly focuses on high-rise building performance and indicates that, due to the lack of erosion experienced, "the foundation stability of the large buildings was not affected…[and] although sited near the shoreline and experiencing the worst flood conditions, the high-rises were some of the better examples of successes". Based on these observations it was conservatively assumed that wave-attack damages would likely only affect the lower floors. As a result, the high-rise structures were separated into three categories:

- HIGHRISE1: Maximum of 6-10 floors
- HIGHRISE2: Maximum of 11-14 floors
- HIGHRISE3: Maximum of 16-20 floors

Once separated, a relationship between the structure value and maximum number of floors was established to create the triangular distribution of values for the model to more accurately calculate wave-attack damages.

3.2.4 Coastal Armoring

Beach-fx allows for assumptions surrounding coastal armoring (e.g. sandbags, breakwaters, seawalls) as well. A user can define the different types of armoring applied to individual damage elements as well as a distance trigger, applied at the lot level, which will prompt construction of said armor. However, in St. Lucie County the use of armoring is prohibited and is therefore omitted from the model.

3.3 Future without Project Condition (FWOP)

Descriptive statistics on the damages per the FWOP model results are as follows:

- Mean: $2,197,692 (AAEQ)
- Standard deviation: $1,909,139 (AAEQ)
- Coefficient of Variance: .869
- Median: $1,846,128 (AAEQ)

The nearness in value between the mean and standard deviation indicates some volatility of the FWOP damage incurred in the project area throughout the 100 iterations. This volatility is due to the fact that damages are primarily driven by storm occurrence and severity rather than annual erosion rates. In short, St. Lucie County's shoreline structures are highly susceptible to storm damage in the FWOP. Pursuant to estimating FWOP damages and associated costs for the study area in St. Lucie County, Beach-fx was used to estimate damages and costs in the following categories:

- Damages:

- 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 71% of the damages for the FWOP.
- Contents Damage: The material items housed within the structures (usually air-conditioned and enclosed) that are potentially subject to damage. Content damages are 29% of the total damages.

3.3.1 Damage Distribution by Structure Category and Type

This section addresses what is being damaged in the FWOP by structure category and type. The coastal inventory was categorized as 'Commercial', 'Public Access & Recreation', and 'Residential'. **Table 3-3** provides greater detail on the type of structures within each category as well as the composition of the FWOP damages within those categories. The distribution of the damages by category is as follows:

- Commercial: 88%
- Public Access & Recreation Structures: 12%
- Residential: >1%

Table 3-3: Distribution of Damages by Damage Category

Category	Type	Structure	Contents	Total	% of Total
Commercial	BUILDING-1	$ 1,250,403	$ 638,991	$ 1,889,395	85.97%
	COMM-1	$ 342	$ 127	$ 469	0.02%
	HIGHRISE-1	$ 9,828	$ 1,425	$ 11,253	0.51%
	HIGHRISE-2	$ 17,080	$ 2,447	$ 19,527	0.89%
	HIGHRISE-3	$ 19,390	$ 2,423	$ 21,813	0.99%
Commercial Subtotal		$ 1,297,044	$ 645,413	$ 1,942,457	88.39%
Public Access & Recreation Structures	DECK	$ 9,700	$ -	$ 9,700	0.44%
	DUNEWALK	$ 173,882	$ -	$ 173,882	7.91%
	GARAGE	$ 503	$ 378	$ 882	0.04%
	GARAGE-U	$ 639	$ 320	$ 959	0.04%
	GUARDSHACK	$ 192	$ 27	$ 219	0.01%
	PARKING	$ 16,019	$ -	$ 16,019	0.73%
	PATIO	$ 19	$ -	$ 19	0.00%
	POOL	$ 38,979	$ -	$ 38,979	1.77%
	POOLHEATER	$ 19	$ -	$ 19	0.00%
	PUBLIC-1	$ 21	$ 3	$ 24	0.00%
	SHELTER	$ 13,716	$ -	$ 13,716	0.62%
	STORAGE	$ 30	$ 19	$ 49	0.00%
	ROAD-1	$ -	$ -	$ -	0.00%

	TENNIS	$ 7	$ -	$ 7	0.00%
PA & Rec Subtotal		$ 253,728	$ 747	$ 254,475	11.58%
Residential	SFR-3	$ 455	$ 305	$ 760	0.03%
Residential Subtotal		$ 455	$ 305	$ 760	0.03%
GRAND TOTAL		**$ 1,551,227**	**$ 646,465**	**$ 2,197,692**	**100%**

3.3.1.1 *Commercial*

The St. Lucie shoreline is dotted with various commercial real estate subject to damage. The structures are primarily condominium complexes or large hotels and represent almost 90% of all the damages in the FWOP. Again, some of these condominiums may be used primarily as permanent residences and thus deemed residential in real estate appendices. However, for purposes of economic damage aggregation the delineation between condominiums was not made and they are deemed commercial.

3.3.1.2 *Residential*

The only type of residential structure in the project area is the three-story single-family residence (SFR-3 in **Table 3-3**). The damage incurred to these structures is minimal and makes up less than one-percent of overall damages.

3.3.1.3 *Public Access and Recreation Structures*

A public access structure refers to those that provide the general public with safe access to beaches and shorelines throughout St. Lucie County which include, but are not limited to, roads, dune walks, public shower and bathroom facilities, and life-guard stations. A recreation structure refers to items such as pools, patios and tennis courts.

3.3.2 Spatial Distribution of Without Project Damages

FWOP damages really spike in the southern portion of St. Lucie's shoreline. Reaches R-113 and R-115 make up around 83% of the damages, while the remainder are relatively evenly distributed; R-098 and R-100 to R-103 are the only reaches that account for less than one-percent of damages each. R-115 accounts for the lion's share of total damage at 65% due in large part to several groups of valuable condominium complexes situated very near the dune that are on slab foundations instead of deep-pile. Structures on slab foundation are far more susceptible to damages from erosion than those with a deep-pile foundation and their location in the nearshore further compounds the damage risk. The spatial damage results are summarized in **Figure 3-4**. The concentration of damages in the southern section was a focal point for the PDT and resulted in an incremental analysis which will be discussed in **Section 4.3.3.**

Figure 3-4**: FWOP Damages by Reach (AAEQ $ and %)**

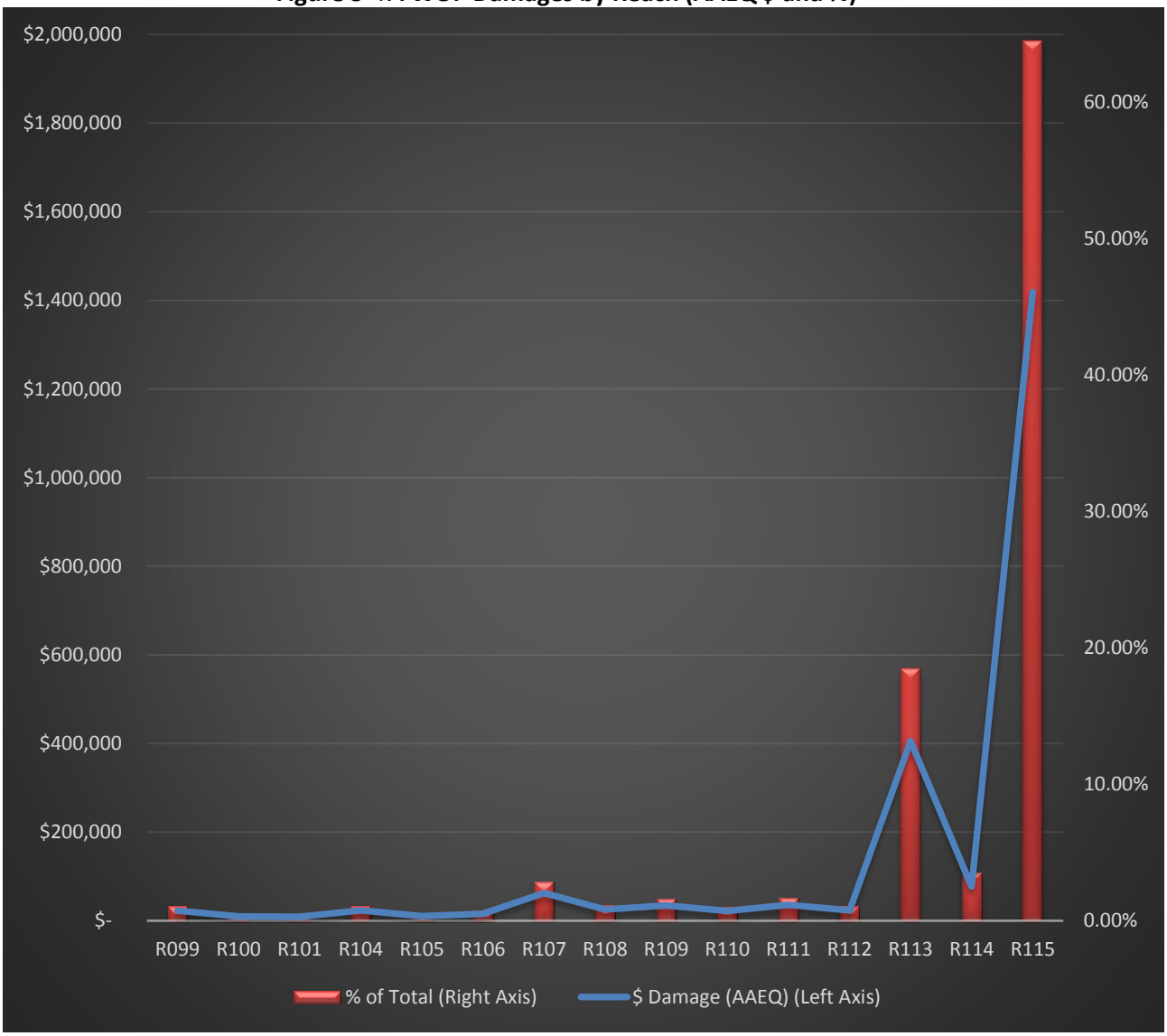


Figure 3-5 illustrates the spatial distribution of damages and erosion rates[19] by reach. Similar to **Figure 3-4** above,

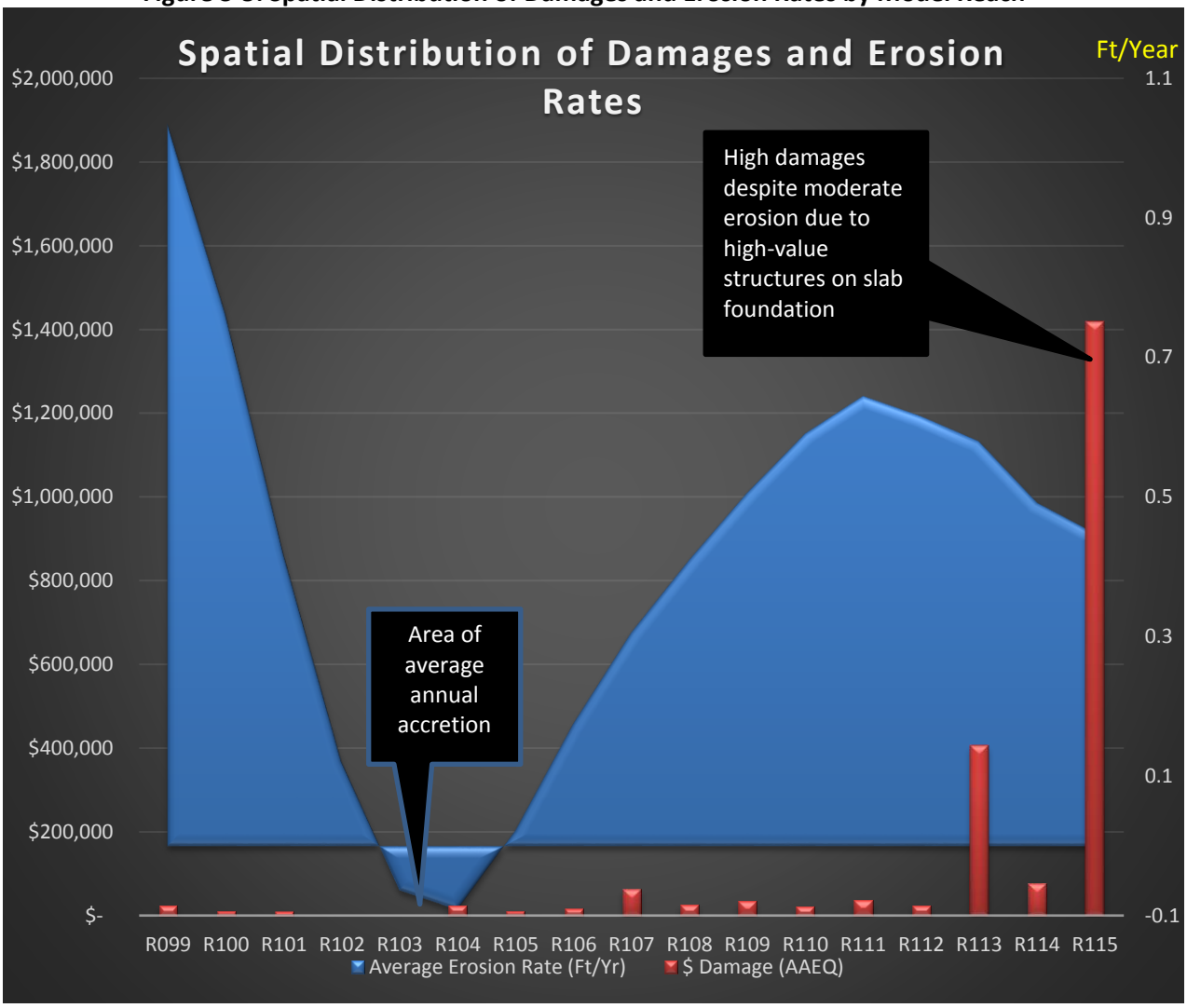
Figure 3-5 displays minor damages until R107 and then the spikes at R113 and R115. The spatial distribution of erosion and damage shows the following pattern:

[19] Negative erosion rates indicate areas of annual accretion

- **R-099 to R-101**: This stretch has the highest erosion rates averaging 0.74 ft/year but relatively low damages at around 2% of the total. R-099 is the main driver of damages in this range due to the presence of condominium complexes in the nearshore environment.
- **R-102 to R-103**: There are no damages occurring in these two reaches[20]. This is primarily due to the fact that there are only two damageable elements in these reaches and they are set back far enough from the shoreline to avoid all damages. Also, erosion rates are minimal and R103 sees annual accretion versus erosion.
- **R-104**: Despite having the highest level of accretion in the project area this reach still incurs a fair amount of damage. The average annual accretion is offset by the value and high density of structures susceptible to storm-based damages within the reach (roughly seven-percent of total damage elements, refer to previous Figure 2-2).
- **R-105 to R-112**: Erosion rates begin to rise throughout these southern reaches and culminate in a secondary peak of 0.65 ft/year at R-111. Despite the increasing erosion rates, the damages are fairly smooth in this area and hover around the average for all reaches excluding outliers (R-113 and R-115).
- **R-113 to R-115**: In these final reaches the erosion rate is stable and very near the mean. Again, the spike in damages is driven almost entirely by the many structures on slab foundations in the nearshore.

[20] Damages accrue only in the highest sea-level rise scenario, which will be discussed in greater detail below

Figure 3-5: Spatial Distribution of Damages and Erosion Rates by Model Reach



3.3.3 Damage Distribution by Damage Driving Parameter

It is very typical for Florida CSRM studies to find that most damages are due to erosion. St. Lucie is no exception as virtually all of the FWOP damages are attributable to erosion. The distribution of damage is as follows:

- Erosion: 97.29%
- Inundation: 2.55%
- Wave Attack: .16%

3.3.4 Temporal Distribution of Damages

Damages begin to rise steadily from the base year until 2042, beyond which they remain relatively constant on a yearly basis. The pattern is somewhat intuitive as one would expect the cumulative impact of erosion to take a toll on nearshore structures.

Figure 3-6 illustrates the damages over time by condensed reaches[21] in non-present value. In years 2036-2046 there are a series of small spikes in damages and that pattern continues throughout the remaining years culminating in a final peak in 2069. The pattern of damage spikes brings to light the frequent vulnerability of the St. Lucie shoreline to the powerful effects of storms and hurricanes. **Figure 3-7** displays similar information but converts the damages into present-value (PV). As would be expected due to the effects of discounting, the damages peak in the relative near-term (2042). However, it is important to note that despite discounting effects, damages remain relatively high in the final half of the period of analysis.

[21] For graphical display purposes the reaches were grouped as R-099 to R-107, R-108 to R-114, and R-115. R-102 and R-103 were not displayed as damages remain at zero throughout the period of analysis.

Figure 3-6: Non-PV Damages Over Time by Combined Reaches

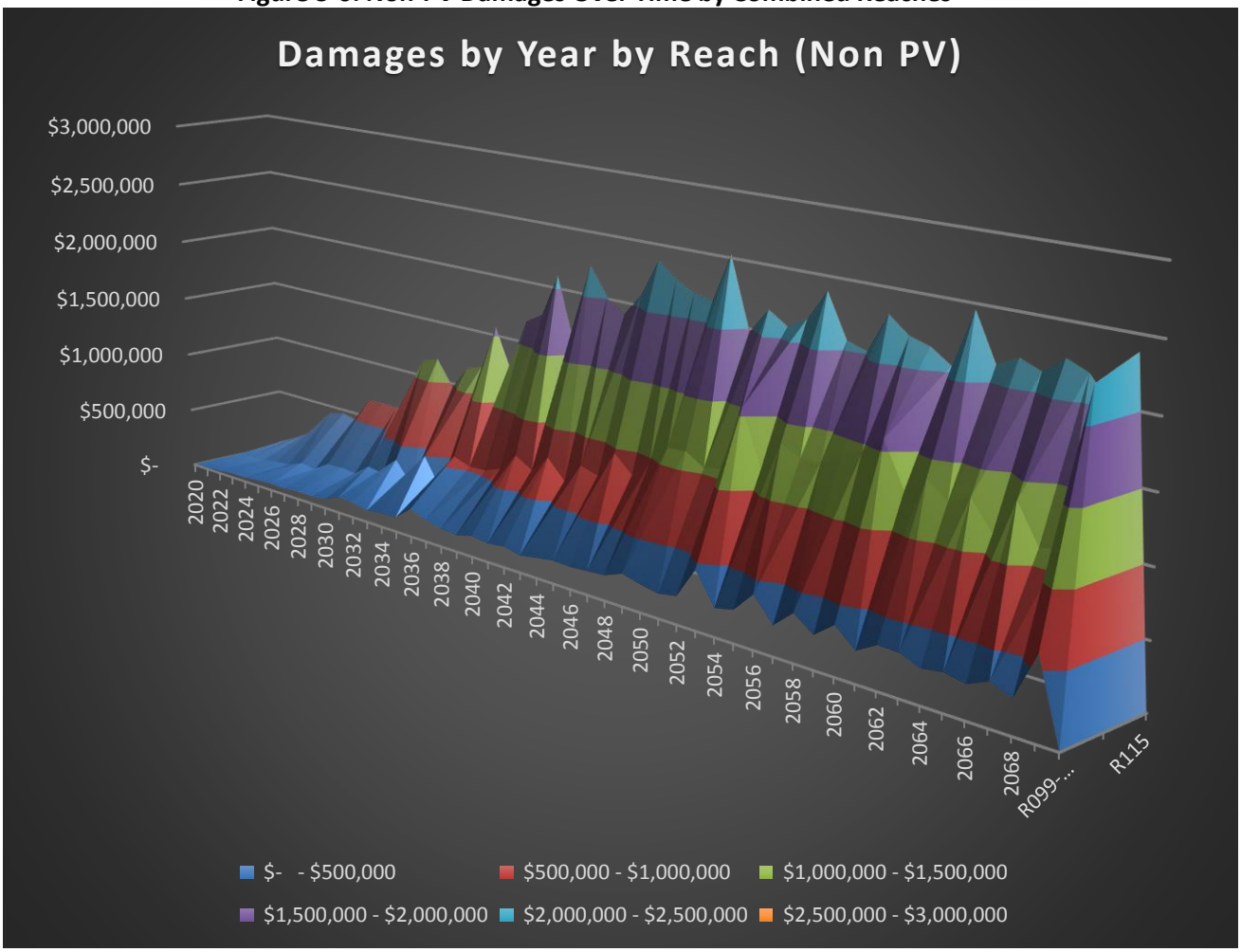
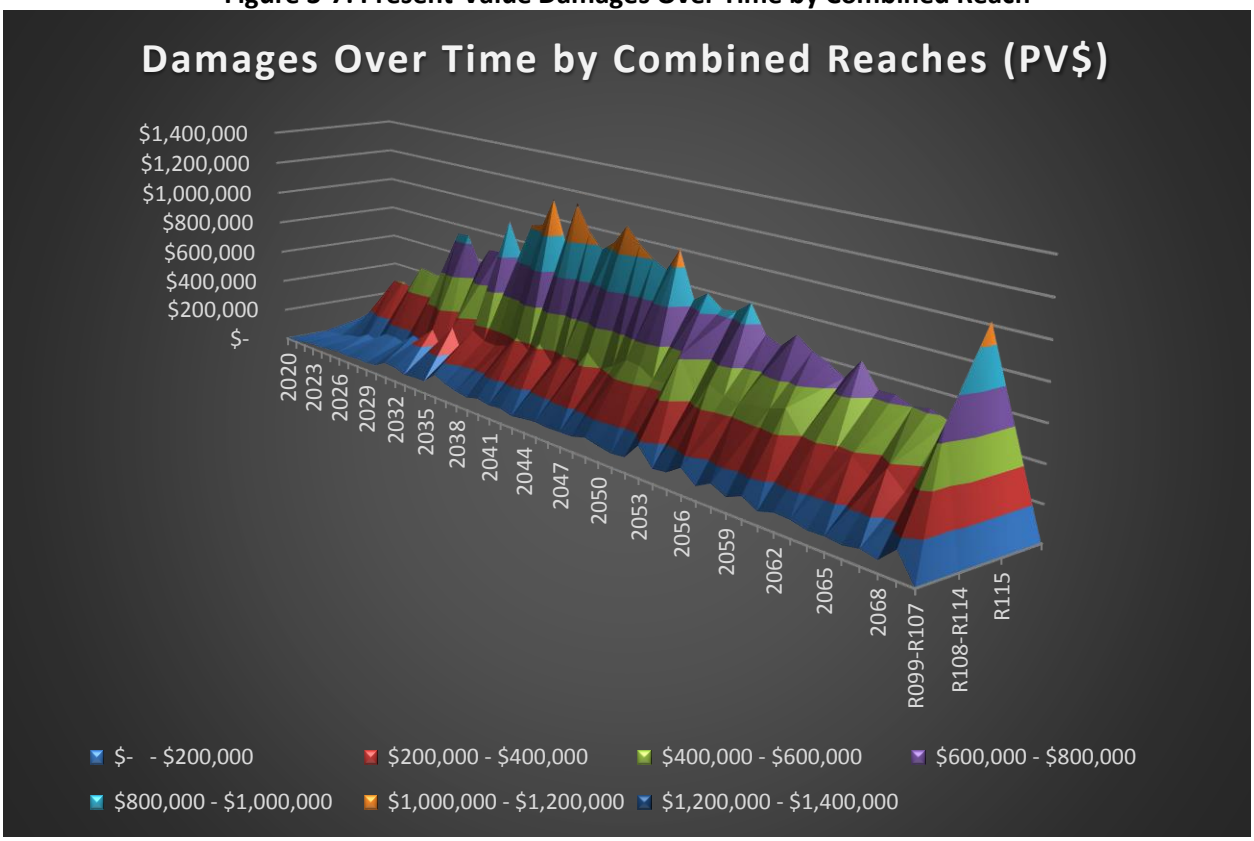


Figure 3-7: Present-Value Damages Over Time by Combined Reach



3.3.5 Evacuation Route Flooding

As described in section **2.4.2** Florida State Road A1A is South Hutchinson Island's hurricane evacuation route and provides vital access to critical infrastructure and services. Of additional importance, the Centers for Disease Control report that each year more deaths occur due to flooding than from any other thunderstorm related hazard and half of those fatalities occur when a vehicle is driven into hazardous flood water. The National Weather Service (NWS) reports that just 12 inches of rushing water can carry away a small car and two-feet can sweep away most vehicles.

In order to gauge the potential impact of flooding on Florida State Route A1A Beach-fx was adjusted to model two different scenarios with the statistics from the NWS used as a framework. In the first scenario, all damage element types were assigned a null damage function except inundation damages to A1A. In order to gauge the depth of flooding all damages were set to zero until inundation reached one-foot. In this model scenario, 38% of iterations experienced one foot or more of flooding at some point in the 50-year period of analysis. One of the southern reaches, R112, is flooded in 34% of the iterations. The importance of the southern reaches is as mentioned above in section **2.4.2**; an impassable A1A to the south could result in traffic needing to be rerouted approximately 16 miles during evacuations.

The second scenario followed the exact same methodology but damages were set to zero until inundation on A1A reached two feet. In this scenario 31% of iterations experienced two or more feet of flooding. Again, R112 was consistently inundated, having two or more feet in 27% of iterations.

This flooding represents a potential hazard to all residents of Hutchinson Island both within and outside of the project area boundaries. There are no alternative roads that run north to south and attempting to navigate flood waters in depths of one foot or more can prove to be fatal.

3.3.6 FWOP Damages in Alternative Sea-Level-Rise Scenarios

Evaluating sea-level rise (SLR) is a vital component in the planning process to ensure alternatives are selected based on risk-informed analysis. To incorporate risk into the analysis the FWOP must be run assuming three distinct future rates of SLR. EC 1165-2-211 provides both a methodology and a procedure for determining a range of SLR estimates based on the local historic rate, the construction (base) year of the project, and the design life of the project. In St. Lucie County the average baseline (SLR1), intermediate (SLR2) and high (SLR3) rates were found to be 0.0077 feet/year, 0.0163 feet/year, and 0.0439 feet/year, respectively. The Beach-fx results that were presented above refer strictly to SLR1, which is based on the historic rate. The results comparing the SLR scenarios are presented here. **Figure 3-8** provides an overall summary of damages in each SLR scenario and includes a trend line; Table 3-4 shows how those damages are distributed amongst the different structure types.

Figure 3-8: Total Damages by SLR Scenario

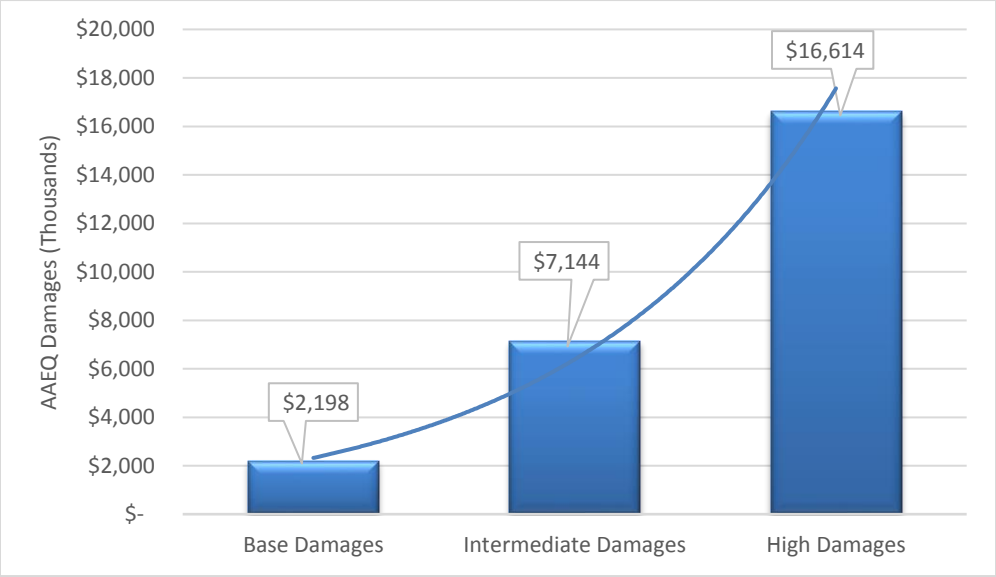


Table 3-4: Distribution of Damages by Category in the SLR scenarios

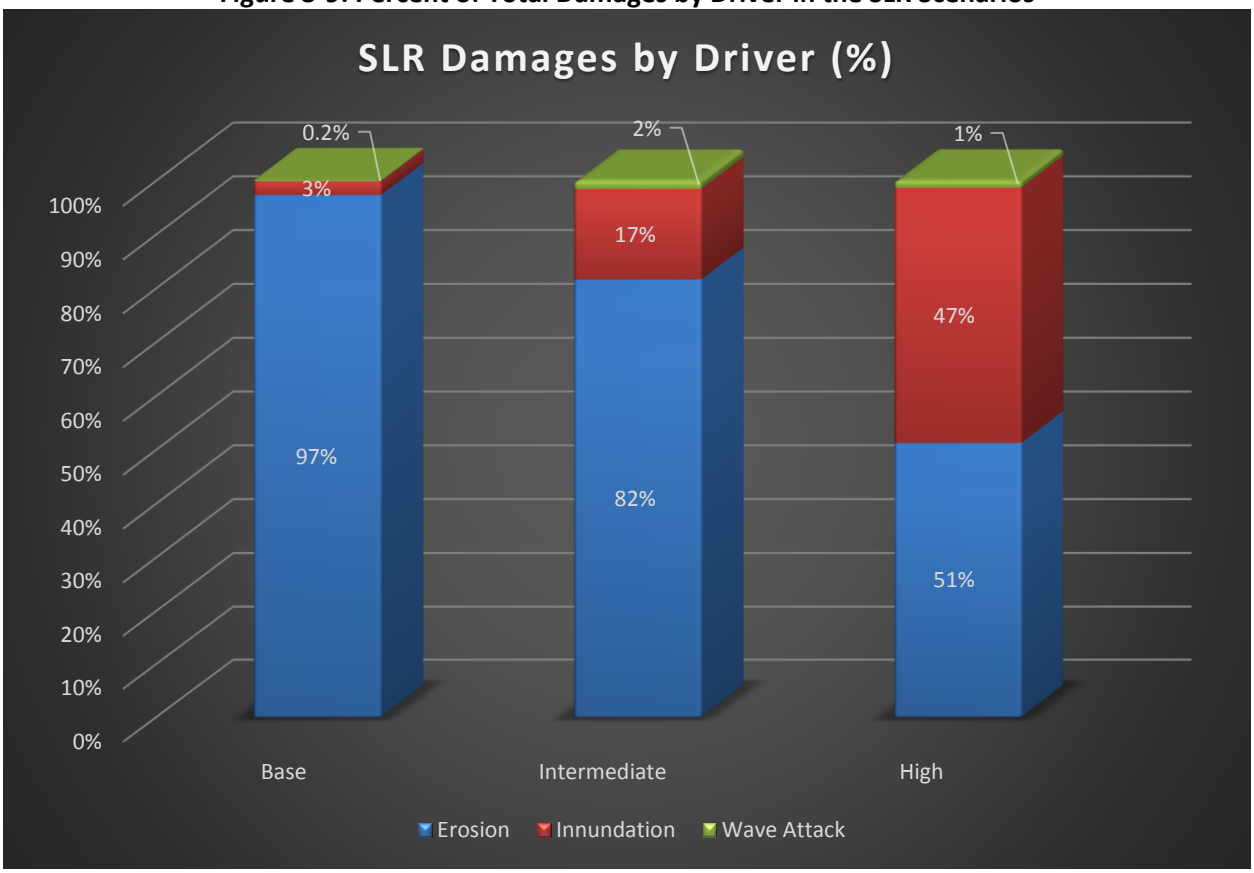
Category	Type	SLR1	SLR2	SLR3
Commercial	BUILDING-1	$ 1,889,395	$ 5,018,669	$ 6,842,697
	COMM-1	$ 469	$ 199,140	$ 464,632
	HIGHRISE-1	$ 11,253	$ 548,504	$ 865,782
	HIGHRISE-2	$ 19,527	$ 228,131	$ 2,231,231
	HIGHRISE-3	$ 21,813	$ 336,644	$ 4,647,021
Commerical Subtotal		$ 1,942,457	$ 6,331,088	$ 15,051,364
Public Access & Recreation Structures	DECK	$ 9,700	$ 24,989	$ 24,699
	DUNEWALK	$ 173,882	$ 320,933	$ 293,571
	GARAGE	$ 882	$ 23,629	$ 176,278
	GARAGE-U	$ 959	$ 60,347	$ 130,867
	GUARDSHACK	$ 219	$ 1,313	$ 2,680
	PARKING	$ 16,019	$ 69,126	$ 278,250
	PATIO	$ 19	$ 1,644	$ 30,227
	PAVED	$ -	$ 112	$ 1,044
	POOL	$ 38,979	$ 256,045	$ 533,736
	POOLHEATER	$ 19	$ 674	$ 2,405
	PUBLIC-1	$ 24	$ 2,288	$ 4,609
	SHELTER	$ 13,716	$ 28,381	$ 41,883
	STORAGE	$ 49	$ 1,467	$ 2,938
	ROAD-1	$ -	$ 39	$ 232
	ROAD-3	$ -	$ 88	$ 536
	TENNIS	$ 7	$ 329	$ 6,216
PA & Rec Subtotal		$ 254,475	$ 791,404	$ 1,530,170
Residential	SFR-3	$ 760	$ 21,498	$ 32,905
Residential Subtotal		$ 760	$ 21,498	$ 32,905
GRAND TOTAL		**$ 2,197,692**	**$ 7,143,991**	**$ 16,614,439**

The SLR results are intuitive in the sense that one would expect damages to be positively correlated with water levels (i.e. as water levels increase throughout the period of analysis so do damages). What is important to note, however, is the magnitude of the effect. From SLR1 to SLR2 the difference was a

mere .0086 ft./year in average SLR and resulted in an increase of roughly 225%, or roughly $5M AAEQ, worth of damages. From SLR2 to SLR3 there was a .0276 ft./year average rise with a corresponding increase of 133%, or $9.5M, in damages. From SLR1 to SLR3 damages increase over 655%.

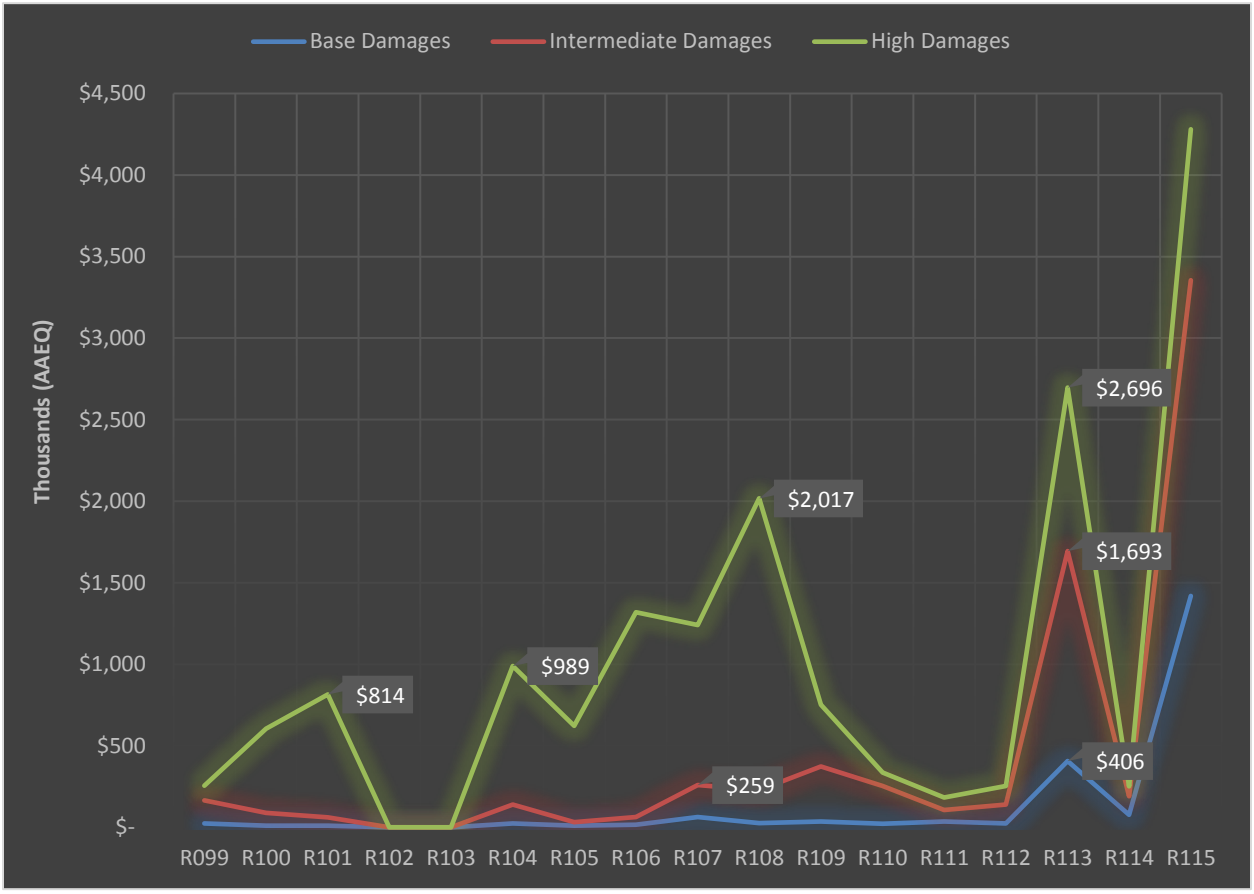
There is also an interesting shift in what drives the damages in each scenario. As mentioned in **section 3.3.3** above, it is very common for erosion to be the main cause of damages in Florida CSRM studies. However, as sea levels rise, inundation begins to take on more of the share of damages. By SLR3, damages caused by erosion have fallen from 97% to 51% with inundation accounting for most of the difference; coastal overstep is reducing the propensity for erosion. **Figure 3-9** displays the changing trend in how damages are occurring.

Figure 3-9: Percent of Total Damages by Driver in the SLR Scenarios



Coastal overstep is also causing an increasing number of lots to be determined condemned within the model and is shifting damage hot spots into areas that are more susceptible to flooding. Reaches 104-108 begin to see a larger increase in damages as high-value structures are increasingly inundated (**Figure 3-10**). Not only does this maintain the assertion that St. Lucie County is highly susceptible to storm damage but also demonstrates how critical a project would be in mitigating damages in the event sea levels continue to rise above and beyond baseline projections.

Figure 3-10: SLR Damages by Model Reach



3.4 FWOP Condition Conclusion

- Damages are largely driven by storm events instead of gradual erosion.
- The overwhelming majority of the damage is structural in nature. Commercial structures account for three-fifths of all damages.
- Proximity to the shoreline, vulnerability of structure type (i.e. slab foundation) and exposure to recurring damages are the most important factors for determining structure damage.
- Damages in the FWOP increase dramatically in the SLR scenarios.

3.5 Future with Project Condition

This section of the appendix tells the story behind the evaluation and comparison of the St. Lucie County CSRM study alternatives. A description of the alternatives, their performance in terms of benefits and costs, and the methods used for screening are provided in the sub-sections that follow.

3.5.1 Management Measures

Management measures were selected to accomplish at least one of the planning objectives for the St. Lucie County study. Both nonstructural and structural measures were identified. The following is a summary of the management measures considered:

- **Structural Measures:**
  - Beach Nourishment
  - Groins

- Submerged Artificial Reefs
- Dunes and Vegetation

- **Non-structural Measures:**
  - No Action
  - Condemnation 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. Two structural measures were carried forward to the modeling stage: Dunes and Vegetation and Beach Nourishment. The no-action plan was also weighed against the two structural measures. More information about each measure is provided below. More information about the management measure screening process is provided in the main report.

Dunes and Vegetation: This measure would include placement of beach compatible material, from either upland or offshore sources, into an extension of the existing dune feature. Vegetation would be planted after initial placement of the dune material. Preliminary engineering design work concluded that the most feasible plan for dunes and vegetation would be extending the existing dune by either 10 or 20 feet. These alternatives were named "Dune10" and "Dune20" respectively. Periodic nourishment triggers would occur once the extended dunes were fully eroded and construction would be completed using a hydraulic dredge or truck haul to transport material from an off-shore borrow source.

Beach Nourishment: This measure includes initial construction of a beach fill and future periodic nourishments at regular intervals. Periodic nourishment of the beach would be undertaken to maintain the erosion control features within design dimensions. There were several combinations of project dimensions initially considered for beach nourishment. Five different "design berm" templates were considered which included maintaining a zero-foot berm (A), 20-foot berm (B), 40-foot berm (C), 60-foot berm (D), and 80-foot berm (E). Using these design berm templates, a "sacrificial fill" amount was then considered in 20-foot increments. For example, one project option would be to maintain a 20-foot design berm with an additional 40-feet of sacrificial fill. Much like the dunes and vegetation measure, periodic nourishment triggers would occur once sacrificial berm lengths have been fully eroded. Using truck transportation of fill was considered as a possible option for beach nourishment as well as hydraulic dredging.

3.5.2 Alternative Development

An alternative plan is a set of one or more management measures functioning in tandem to address project-area objectives. Though the team only carried forward two management measures there were a total of 42 alternatives for initial modeling. The two dune extension options (10' and 20') were modeled individually and also in combination with the beach nourishment berm extensions. The alternative names were descriptive and followed a convention of design template (A-C as described above), berm width (20-100'), and the width of the dune extension (0-20'). So for example, a project that maintains a 0-foot design template, 40-foot berm extension, and maintains the existing dune would be labeled: ABerm40DuneEx. For a more detailed explanation of nourishment triggers and the various alternative specifications please refer to the **Engineering Appendix (APPENDIX A)** of this report.

After initial modeling it was apparent that the only economically justifiable design template was maintaining a zero-foot berm extension (A), and only sacrificial fill extensions up to 40-feet. The various alternatives provided nearly the same level of total benefits but the costs increased greatly with the size of the project. Dune extensions in combination with beach nourishments were also unjustifiable but a stand-alone project of Dune10 was carried forward to the final array. Upon realizing larger projects had no economic justification, the decision was made to add alternatives and model sacrificial-fill amounts in 10-foot increments. The alternatives carried into the final array for Beach-fx modeling (100 iterations) were as follows:

- ABerm10DuneEx[22]
- ABerm20DuneEx
- ABerm30DuneEx
- ABerm40DuneEx
- Dune10[22]

3.5.3 Alternative Comparison

All of the alternatives described above were modeled in Beach-fx using full (100 iteration) life-cycle simulations in order to calculate benefits and costs. Additionally, land-loss benefits of $234,138 (AAEQ) were added to the total project benefits for each of the alternatives. For a full discussion on how land-loss benefits were calculated please refer below to section **4.1**. The results of these simulations, which were used to discover the NED plan, are presented in **Table 3-5**, **Table 3-6**, and shown graphically in **Figure 3-11**. All values are in FY17 dollars (AAEQ). The alternative with the highest BCR and net-benefits is ABerm20DuneEx making it the NED Plan and the recommended plan. It is important to note that, during the evaluation of the final array, costs for OMRR&R and IDC had not yet been calculated and are therefore only added to the recommended plan during the cost certification process.

Table 3-5: AAEQ Damages for Final Array of Alternatives (AAEQ $)

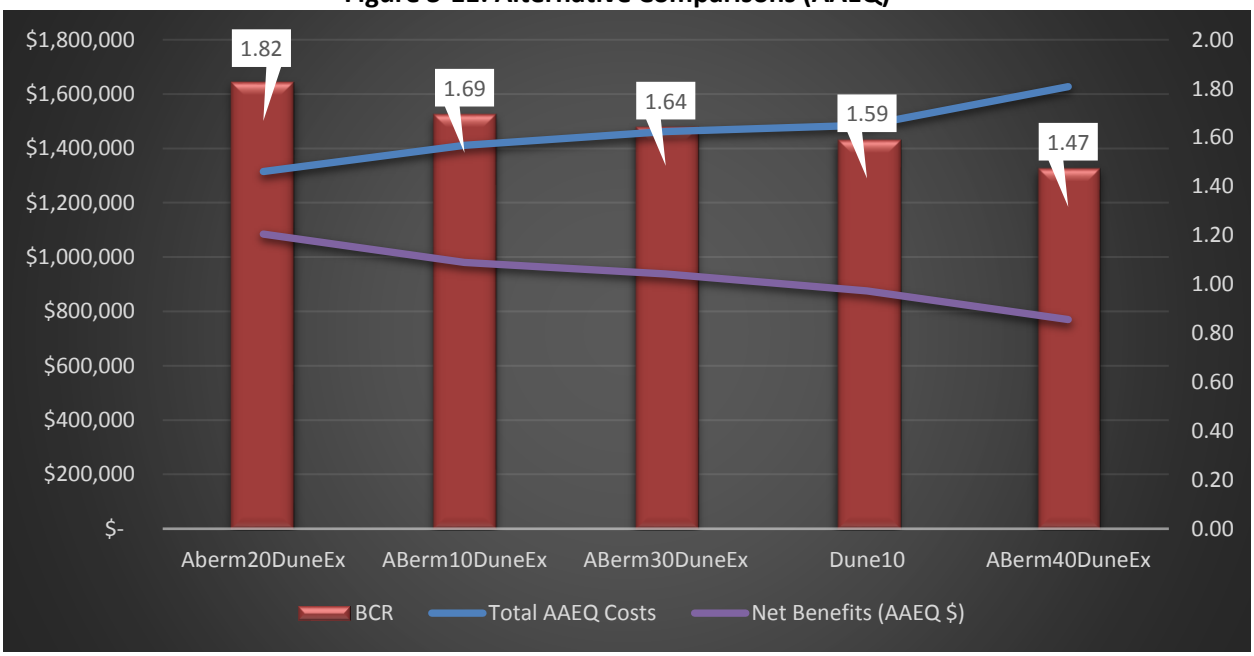
Alternative Name	FWOP Damages	FWP Damages	Land Loss Benefits	Total Primary Benefits
Aberm20DuneEx	$ 2,197,692	$ 32,218	$ 234,138	$ 2,399,612
ABerm40DuneEx	$ 2,197,692	$ 34,415	$ 234,138	$ 2,397,415
ABerm10DuneEx	$ 2,197,692	$ 39,587	$ 234,138	$ 2,392,243
ABerm30DuneEx	$ 2,197,692	$ 31,467	$ 234,138	$ 2,400,363
Dune10	$ 2,197,692	$ 70,651	$ 234,138	$ 2,361,179

[22] These alternatives were determined too small for dredging so trucking costs were used in Beach-fx modeling and final cost estimation.

Table 3-6: Benefits and Costs for Final Array of Alternatives (AAEQ $)

Alternative Name	Total Primary Benefits	Total Costs[23]	Primary Net-Benefits	BCR
Aberm20DuneEx	$ 2,399,612	$ 1,314,927	$ 1,084,685	1.82
ABerm10DuneEx	$ 2,392,243	$ 1,411,990	$ 980,253	1.69
Aberm30DuneEx	$ 2,400,363	$ 1,462,493	$ 937,870	1.64
Dune10	$ 2,361,179	$ 1,485,348	$ 875,831	1.59
ABerm40DuneEx	$ 2,397,415	$ 1,627,343	$ 770,072	1.47

Figure 3-11: Alternative Comparisons (AAEQ)[23]



3.5.4 Performance of NED/Recommended Plan in the SLR Scenarios[24]

An important question when evaluating a final array of alternatives is performance under different SLR scenarios. Intuitively, given the protection a plan provides, total benefits will increase as sea-levels begin to rise and damages in the FWOP increase.

While this is true (see **Table 3-7**), costs also begin to increase since nourishment events are triggered more frequently. Also, a project must provide sufficient protection to establish enough benefits in each scenario. Each of the SLR scenarios are considered equally likely to occur so a project must perform satisfactorily across all three in order to be considered effective and robust.

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[23] The total cost for the comparison of the final array of alternatives does not contain OMRR&R or IDC costs. As such, BCR totals for the ABerm20DuneEx plan (i.e. recommended plan) will differ from refined summary BCR tables that do include IDC and OMRR&R.

[24] Costs calculated for the SLR scenarios include certified costs for SLR1 (without OMRR&R or IDC) and model-projected costs for SLR2 and SLR3 with a 28% contingency added. Benefits do not include land loss or recreation.

The recommended plan performs satisfactorily in each SLR scenario and establishes itself as a robust option in the face of risk and uncertainty. Benefits increase at a much greater magnitude than costs and the BCR grows by 57% from SLR1 to SLR2. From SLR2 to SLR3 the magnitude of the increase is less but there is still a significant increase in BCR. The main reason for the diminishing returns is explained by the nourishment interval column in **Table 3-8**. The interval indicates that under the SLR3 scenario the recommended plan will have a number of nourishments such that the increase in costs grows faster than the increase in benefits compared to SLR2. That said, the recommended plan remains an efficient and effective plan for any of the three possible SLR scenarios. **Figure 3-12** demonstrates this completeness with a side-by-side comparison of the BCRs. Again, at this point in plan evaluation costs had not yet been determined for OMRR&R and IDC so they do not appear in the "Total Cost" column of the figures. The cost figures for IDC and OMRR&R will be introduced for the recommended plan in Section **4**.

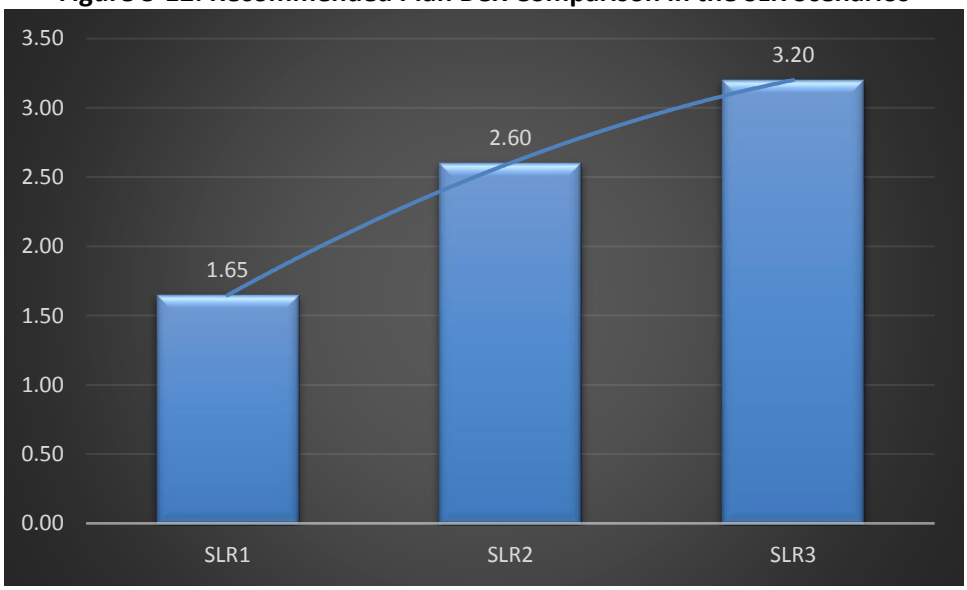
Table 3-7: FWOP and Recommended Plan Damages in SLR Scenarios

	FWOP Damages	FWP Damages	Total Benefits
SLR1	$ 2,197,692	$ 32,218	$ 2,165,474
SLR2	$ 7,143,991	$ 45,522	$ 7,098,469
SLR3	$ 16,614,439	$ 67,488	$ 16,546,952

Table 3-8: AAEQ Benefits and Costs for Recommended Plan in SLR Scenarios

	Nourishment Interval (Years)	Total Cost	Total Benefits	Net Benefits	BCR
SLR1	19	$ 1,314,927	$ 2,165,474	$ 850,547	1.65
SLR2	7	$ 2,729,218	$ 7,098,469	$ 4,369,251	2.60
SLR3	4	$ 5,169,728	$ 16,546,952	$ 11,377,224	3.20

Figure 3-12: Recommended Plan BCR Comparison in the SLR Scenarios



4. THE NED/RECOMMENDED PLAN COST DETAILS

Once all of the alternatives have been compared, a NED has been identified, and a plan recommended the costs that have been used in modeling require certification under ER 1110-1-1300. Costs are refined to a higher level of accuracy and include a contingency during this process. The costs previously mentioned in this document for the recommended plan are the total certified costs but this section aims to provide more detail on the composition of the total. **Table 4-1** provides a breakdown of the component parts making up the costs including OMRR&R and IDC. **Table 4-2** details the year the costs are estimated to occur and the type of cost but does not include OMRR&R nor IDC. It is important to note that the exact year in which periodic nourishment may occur will vary based on monitoring and project area needs.

The cost of OMRR&R for each year following initial construction was estimated at $20,000 with an increase to $100,000 every fifth year at FY17 price levels. The equivalent total present-value is $833,033 annualized to $31,612. Estimation of OMRR&R took into account tasks such as escarpment removal, vegetation maintenance, and beach tilling. The increase to $100,000 accounts for any necessary major regrading and rebalancing of beach fill.

Table 4-1: NED Project Cost Refinements (AAEQ)

	Initial Construction[25]	IDC	First Periodic Nourishment	P&S, PED	Second Periodic Nourishment	Monitoring	OMRR&R	Total
Quantity (CY)	422,000	N/A	390,000	N/A	390,000	N/A	N/A	1,202,000
Cost	$ 654,074	$ 2,084	$ 312,012	$ 22,086	$ 187,324	$ 139,431	$ 31,612	$ 1,348,623

Table 4-2: NED Costs By Type and Year (PV $)

Year	Cost	Cost Type
2020	$ 17,236,023	Initial Construction
2021	$ 777,643	Monitoring
2022	$ 169,324	Monitoring
2023	$ 164,592	Monitoring
2024	$ 45,712	Monitoring
2025	$ 155,521	Monitoring
2026	$ 43,193	Monitoring
2027	$ 146,950	Monitoring
2028	$ 40,812	Monitoring
2029	$ 138,851	Monitoring
2030	$ 38,563	Monitoring

[25] Initial construction cost includes plans and specs and PED leading up to initial construction

2031	$ 131,199	Monitoring
2032	$ 36,438	Monitoring
2033	$ 123,968	Monitoring
2034	$ 34,430	Monitoring
2035	$ 117,136	Monitoring
2036	$ 32,532	Monitoring
2037	$ 363,664	P&S PED
2038	$ 8,222,071	1st Nourishment
2039	$ 104,581	Monitoring
2040	$ 101,658	Monitoring
2041	$ 98,817	Monitoring
2042	$ 27,444	Monitoring
2043	$ 93,371	Monitoring
2044	$ 25,932	Monitoring
2045	$ 88,225	Monitoring
2046	$ 24,503	Monitoring
2047	$ 83,363	Monitoring
2048	$ 23,152	Monitoring
2049	$ 78,768	Monitoring
2050	$ 21,876	Monitoring
2051	$ 74,427	Monitoring
2052	$ 20,671	Monitoring
2053	$ 70,326	Monitoring
2054	$ 19,531	Monitoring
2055	$ 218,335	P&S PED
2056	$ 4,936,327	2nd Nourishment
2057	$ 62,788	Monitoring
2058	$ 61,033	Monitoring
2059	$ 59,327	Monitoring
2060	$ 16,477	Monitoring
2061	$ 56,058	Monitoring
2062	$ 15,569	Monitoring
2063	$ 52,968	Monitoring
2064	$ 14,711	Monitoring
2065	$ 50,049	Monitoring
2066	$ 13,900	Monitoring
2067	$ 47,291	Monitoring
2068	$ 13,134	Monitoring
2069	$ 57,451	Monitoring
TOTAL	**$ 34,650,683**	

4.1 Land-Loss Benefits

In outlining the process and procedures to be used in the evaluation of CSRM projects, ER-1105-2-100 details 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 benefits and is computed based on output data from Beach-fx. Land loss benefits must be added to the structure and content benefits as computed by Beach-fx to obtain the total CSRM benefits of the project.

Following the guidance provided, two key pieces of information are needed to calculate land loss benefits of a CSRM 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. Lucie County, annual reduction in dune width and upland 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 and upland 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.

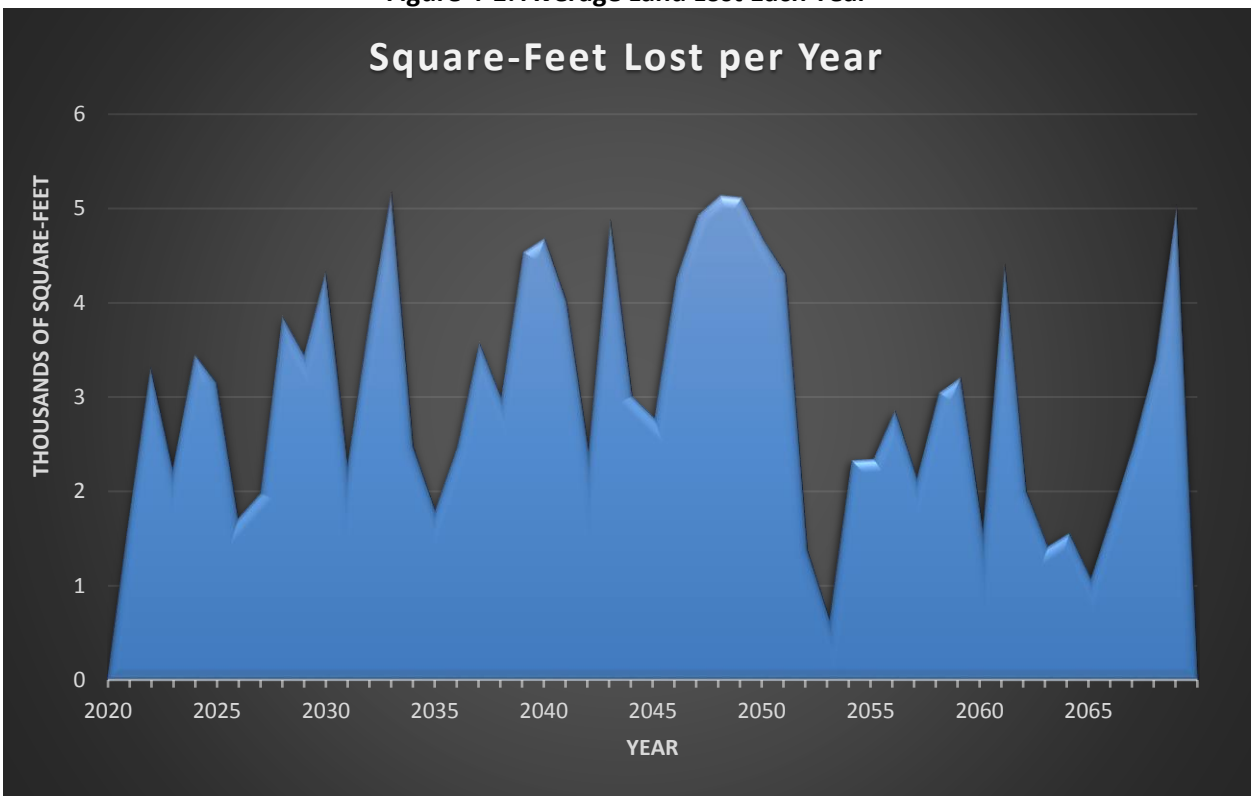
For Beach-fx reaches located within the project area (reaches R-099 to R-115), the basis of the annual changes in dune and upland width calculation is the width in each reach in the model start year (2019), which is the template assumed to be maintained throughout the period of analysis in the FWP. The difference between the constant with-project width and the without-project width in a given year results in the *cumulative* loss of dune and upland width given the profile of that specific reach. However, for the purpose of calculating land loss benefits, the *annual* loss of width is needed. This is obtained by taking the cumulative change in width in a given year and subtracting from it from the cumulative change in width from the previous year. This calculation results in the yearly incremental change in dune and upland width for a given reach.

Using the annual decrease in 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. **Figure 4-1** graphically displays the square-feet lost in St. Lucie County each 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. Lucie County Beach Restoration Estimated Depreciated Replacement Costs of Damage Elements* report, the SAJ Real Estate Department estimated a nearshore land value of $14.00 per square foot for the St. Lucie study area.

Using the analysis technique described, the total present value of land-loss benefits over the 50 year period of analysis is estimated at $6,169,968 (PV), or $234,138 in average annual equivalent (AAEQ) terms.

Figure 4-1: Average Land Lost Each Year



4.2 Incidental Recreation Benefits

According to ER-1105-2-200, incidental recreation benefits that result from the construction of a project can be calculated and added to overall project benefits in CSRM studies. Recreation benefits are not to be used in plan formulation, but they can be included in total project benefits so long as primary benefits (i.e. CSRM and land loss benefits) constitute 51% of the benefits required for economic justification. Recreation benefits represent a vital component of a CSRM project and access for the public to use and recreate on the beach is the foundation for federal interest in the project. Though recreation cannot be used for plan formulation, and though the recommended plan is economically justified on primary benefits alone, recreation benefits play a significant role in increasing net-benefits.

Typically in coastal studies, recreation benefits are calculated using the travel cost method (TCM). The basis for this method is that by increasing the carrying capacity of a particular recreation resource, a project may reduce the travel time and costs associated with recreation visits. In this case, preliminary investigations concluded that there is no excess demand for recreation in St. Lucie County. Therefore, TCM is not applicable.

However, even though a project in St. Lucie County would not increase the *availability* or *quantity* of recreation in the project area, there may be some benefits associated with increasing the *quality* of recreation that is already occurring. Thus, in the St. Lucie County Feasibility study, recreation benefits were calculated using the Unit Day Value method, as described in EGM 09-03 and in Appendix E of ER 1105-2-100. The Unit Day Value (UDV) method estimates a user's willingness to pay for a given

recreational opportunity (i.e. a dollar amount the recreational experience would be worth to them were they required to pay). This value is estimated via a series of criteria applied to the various recreation facilities and opportunities provided by the project; criteria gauging the overall quality of the experience, availability, carrying capacity, accessibility, and environmental factors. Each criterion can be assigned a score selected from one-of-five possible ranges which represents rating from low to high. These point values are summed together and applied a dollar value based on the current UDV guidance. The current unit-day values, provided by USACE Economic Guidance Memo #17-03, *Unit Day Values for Recreation*, FY 2017, are presented in **Table 4-3.** Linear interpolation was used to estimate the dollar value of point scores between ranges. So, for example, a point score of 2 in General Recreation corresponds with a dollar value of $4.11. The recreation point values assigned to St. Lucie vary by year. They are summarized in **Table 4-4.**

Table 4-3: Current Unit Day Values for Recreation (FY17)

Point Values	General Recreation Values (1)	General Fishing and Hunting Values (1)	Specialized Fishing and Hunting Values (2)	Specialized Recreation Values other than Fishing and Hunting (2)
0	$3.96	$5.70	$27.73	$16.10
10	$4.70	$6.44	$28.48	$17.09
20	$5.20	$6.93	$28.97	$18.32
30	$5.94	$7.68	$29.71	$19.81
40	$7.43	$8.42	$30.46	$21.05
50	$8.42	$9.16	$33.43	$23.77
60	$9.16	$10.15	$36.40	$26.25
70	$9.66	$10.65	$38.63	$31.70
80	$10.65	$11.39	$41.60	$36.90
90	$11.39	$11.64	$44.57	$42.10
100	$11.89	$11.89	$47.05	$47.05

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

Year	Without Project	With Project
2020	45	53
2030	43	53
2040	41	53
2050	39	53
2060	38	53
2069	38	53

The point assignments are based on qualitative criteria; they depend on best professional judgment (i.e. "judgment criteria"). The differences in the assigned point scores vary for each category depending on the relevant recreation facilities. The following list briefly explains the logic behind the judgment criteria

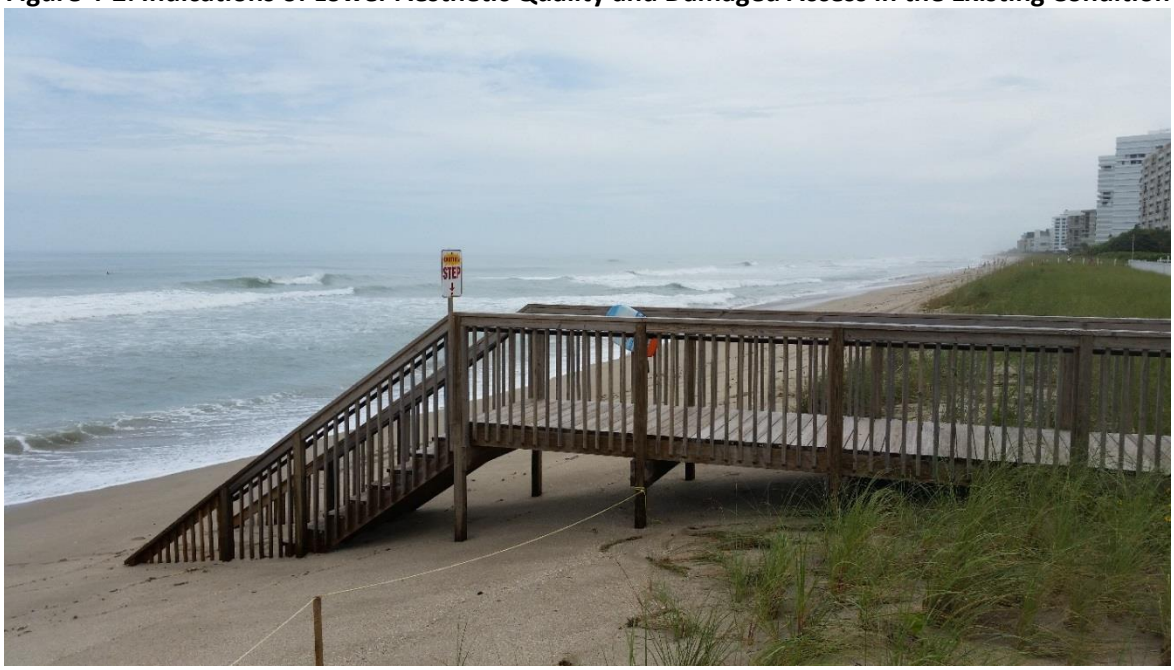
applied to St. Lucie County and **Table 4-5** summarizes the point comparison halfway through the period of analysis (2045).

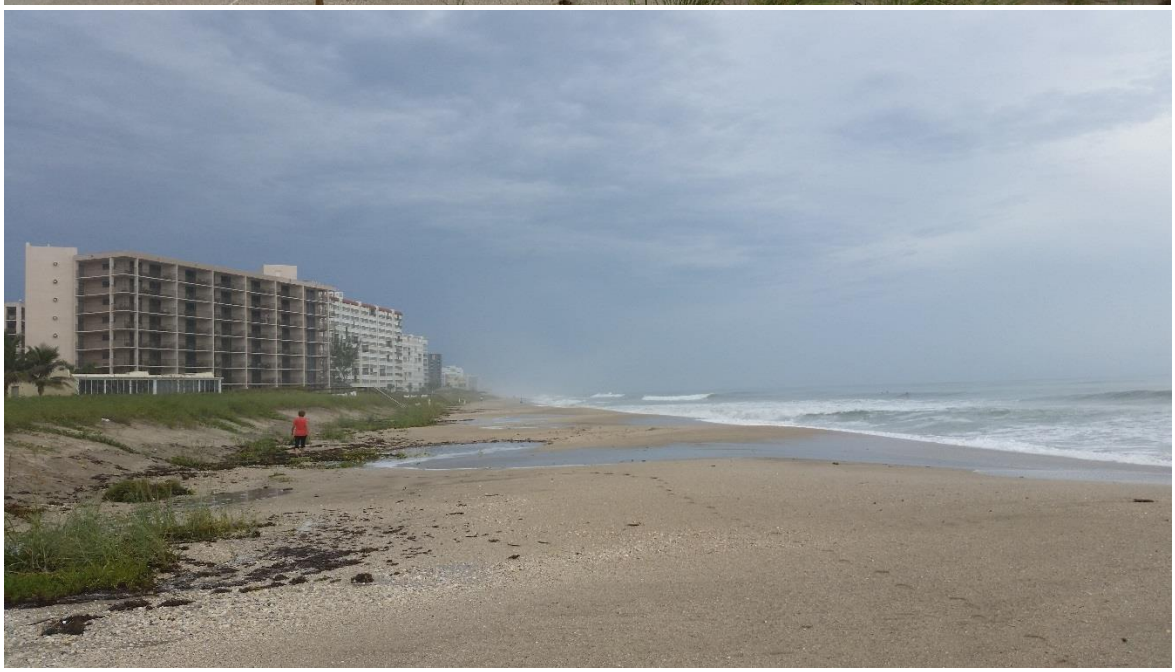
- **Recreation Experience:** St. Lucie County beaches were assigned a point score of 19 in the FWOP, which corresponds to "several general recreation activities; more than one high quality activity". The beaches offer visitors the opportunity to experience several general activities, including swimming, surfing, fishing and hiking. As for high quality activities, the beaches of St. Lucie County are a premier destination for wildlife viewing (specifically turtle nesting) and regional triathlon competitions. The value in the FWP is assigned a 23 since the project will not create any additional recreation experiences but will improve upon the quality of those experiences. The value for the FWOP declines throughout the period of analysis as further degradation of quality is anticipated.
- **Availability of Opportunity:** The county beaches were assigned a point score of 1, which corresponds to "several opportunities within one hour of travel time and a few within 30 minutes". All of the project area beaches are within easy driving distance of several other popular beaches, including Glascock and Pepper Park. This point score does not change between the FWOP and FWP because the proposed project would have no effect on the availability of other recreation opportunities.
- **Carrying Capacity:** In both the FWOP and FWP the carrying capacity was assigned a point score of 5, indicating basic facilities to conduct activities. This score remains throughout the lifecycle as the project is not anticipated to improve the basic facilities nor are damages anticipated to degrade the facilities such that they'd be determined as "minimum development".
- **Accessibility:** Again, the FWOP and FWP do not change in this category. A point score of 14 for "good access, good roads to site; fair access, good roads within site" was assigned to both scenarios. Damages to roads in the FWOP are not enough to qualify a reduction in score throughout the period of analysis and the project is not expected to improve on the access quality.
- **Environmental Quality:** In the base year the FWOP was assigned a score of 6 as there exist some factors which lower quality to a minor degree (see **Figure 4-2** as an example). Over time, the aesthetic quality of the project area beaches are expected to deteriorate a significant degree as damages are inflicted on the dune and the dune walks. By 2069, the score assigned to St. Lucie County was reduced to 3. In the FWP, the point score was held constant at 10 as the project is expected to prevent most of the damage in the project area.

Table 4-5: Criteria Score Comparison in Year 2045

Judgment Criteria	FWOP Score (Year 2045)	FWP Score
Recreation Experience	17	23
Availability of Opportunity	1	1
Carrying Capacity	5	5
Accessibility	14	14
Environmental Quality	4	10

Figure 4-2: Indications of Lower Aesthetic Quality and Damaged Access in the Existing Condition





After assigning point scores and dollar values, these values must be assigned to expected recreation visits over the life of the project. In 2009, a study was published by Dr. William Stronge[1] on behalf of the county to gauge beach visitation estimates. The study was conducted across the entire county. For the purposes of this recreation analysis only the beaches that fall within the project area were extracted from Dr. Stronge's study and are summarized in detail in **Table 4-6**. The total number of visitors in that year was estimated at 186,268.

Table 4-6: Beach Visitations

Beach Name	Visits	Percent of Total
S. of Normandy-to Island Dunes	17,509	9%
Dollman Public	27,163	15%
Ocean Towers-Nettles Island	31,423	17%
Oceana-North of Waveland	19,297	10%
Waveland Public	46,822	25%
Island Crest S to County Line	44,054	24%
Total	186,268	100%

[1]Visitation estimates based on 2009 study- *South St. Lucie County Beaches Recreational Use and Economic Impact 2007-08*

In order to project visitation over the life of the project we used a growth rate that was in step with that of overall visitation trends to the state of Florida. According to Visit Florida, visitation grew at an average of 2.99% from 2002-2014[26]. Therefore, in an unconstrained environment visitation to all of the project-area beaches was expected to reach 1,088,619 by 2069.

However, it is reasonable to assume that there will be capacity constraints pertaining to each stretch of beach and visitation estimates should not exceed that ceiling. In order to estimate those constraints SAJ Economists used parking availability for the public beaches displayed in **Figure 4-3** (i.e. Waveland, Dollman) and for the remaining stretches the number of rental or privately-owned units located on the beach were used. For parking we assumed a maximum of four people per car with each available spot receiving up to two cars per day for the entire year. In the case of rental or privately-owned units, a conservative double-occupancy per unit for the entire year was assumed. The maximum visitation resulting from these constraints is summarized in **Table 4-7**. None of the beaches in the project area are estimated to reach their cap. As a result, total constrained visitation in the year 2069 was estimated at 1,088,619.

[26] In 2009, Visit Florida adjusted their visitation estimate methodology. As a result, only years using the same methodology were compared to establish the average growth rate.

Figure 4-3: Public Beach Access in Project Footprint

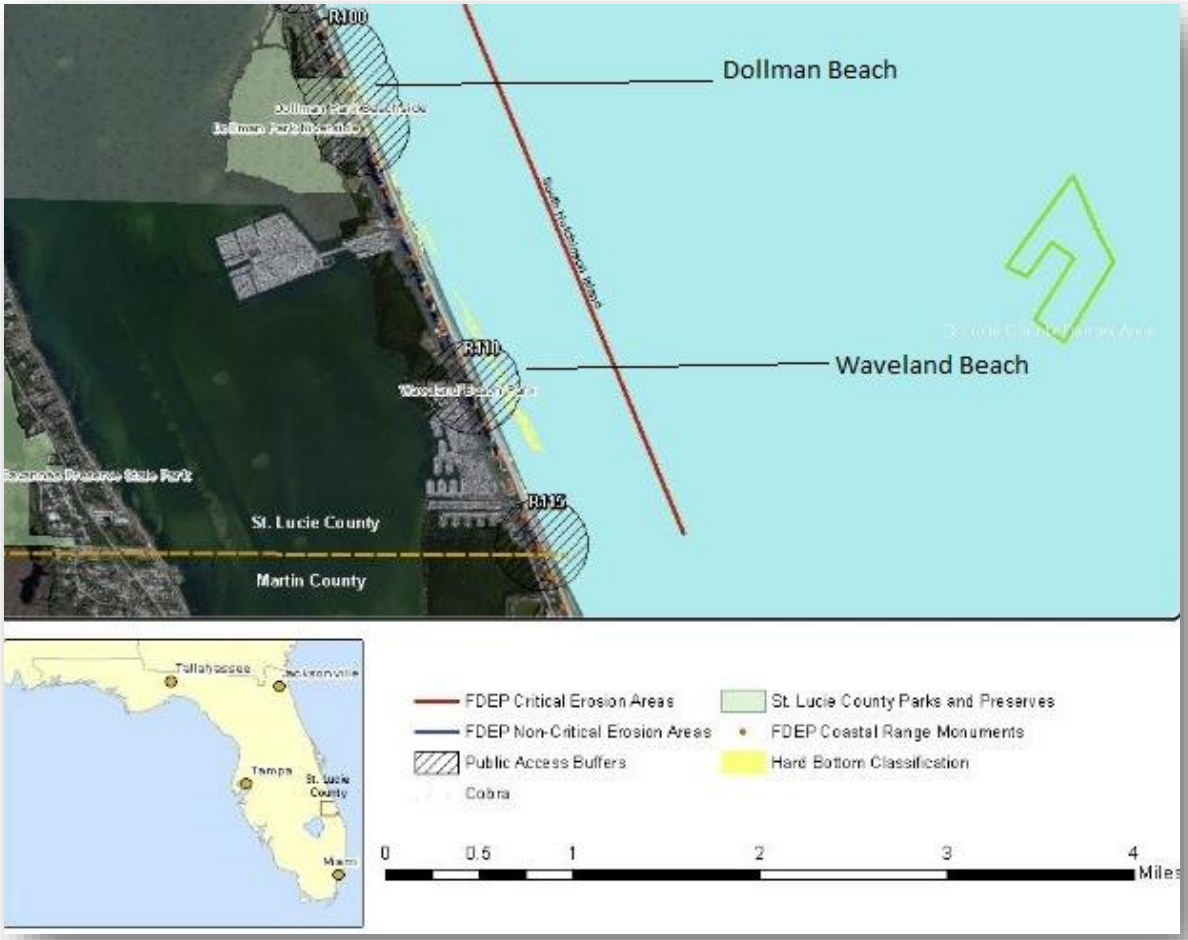


Table 4-7: Visitation Constraints

Beach Name	Parking	Rental Units	Max Visitation
S. of Normandy-to Island Dunes	N/A	274	200,020
Dollman Public	102	N/A	297,840
Ocean Towers-Nettles Island	N/A	540	394,200
Oceana-North of Waveland	N/A	757	552,610
Waveland Public	100	N/A	292,000
Island Crest S to County Line	N/A	950	693,500
Total	**218**	**2521**	**2,476,890**

The total annual visitation numbers combined with the relevant UDV in each year resulted in total recreation benefits for St. Lucie County to be calculated at **$14,906,431 (PV)**, or **$565,671** in AAEQ.

4.3 Benefits of the NED Plan

The CSRM primary economic benefits of the plan are generated by reductions in erosion, wave, and inundation damages. As described in **Table 4-8**, the model results suggest that the NED is highly effective at reducing nearly all damages. The FWP condition under the NED protects St. Lucie County from 98.5% of all damages in the period of analysis. In model reaches R-113 and R-115, where damages in the FWOP were the most dramatic due to high-value structures on slab foundation, 99.4% and 98.5% of damages are avoided respectively.

Table 4-8: Benefits (AAEQ) and % Damage Avoided by Reach

Model Reach	Model Reach CSRM[27] Benefits	Percent Damages Avoided
R099	$22,793	99.3%
R100	$9,526	97.8%
R101	$8,982	98.5%
R102	$0	N/A
R103	$0	N/A
R104	$23,287	99.5%
R105	$10,069	97.3%
R106	$15,379	97.3%
R107	$61,818	98.3%
R108	$24,926	97.7%
R109	$33,844	97.6%
R110	$21,834	98.4%
R111	$33,564	93.4%
R112	$23,040	98.6%
R113	$403,677	99.4%
R114	$75,730	98.2%
R115	$1,397,005	98.5%
TOTAL	**$2,165,474**	**98.5%**

Additionally, the project is reducing the number of structure types that are receiving damage. In the FWOP, 20 different structure types were being damaged (**Table 3-3**) whereas under the NED only six different structure types receive damage (

Table 4-9). Important to note is the complete absence of residential property, roads, and all high-rise structure damage.

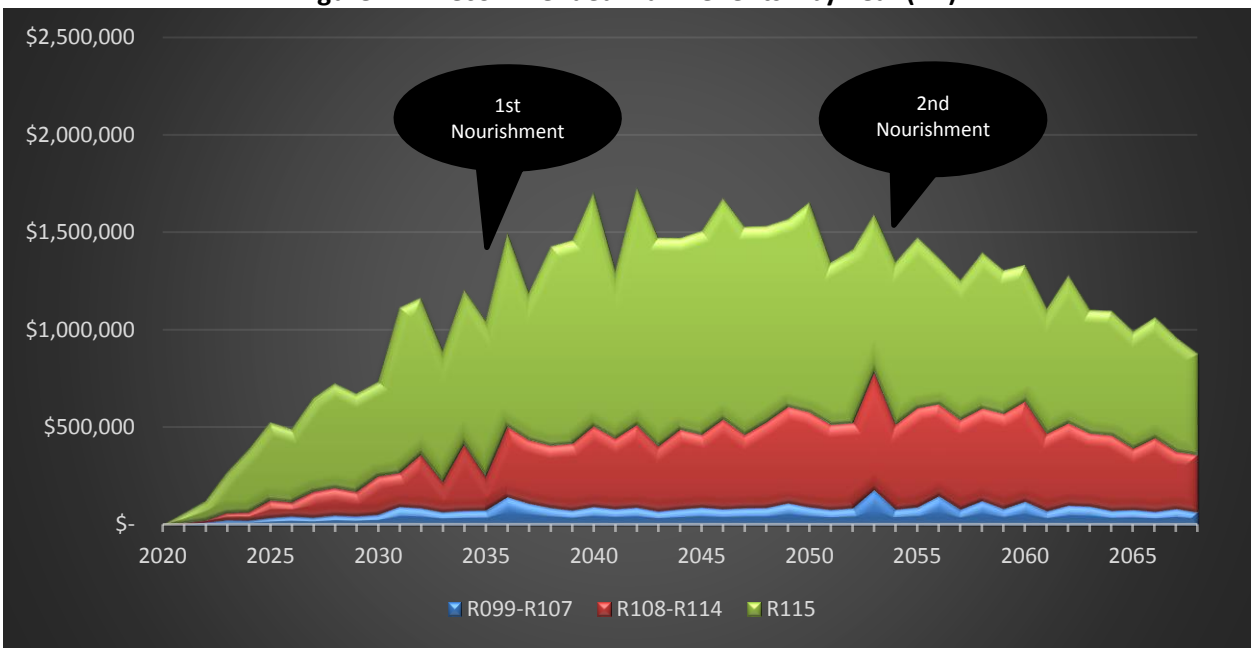
[27] Land loss and recreation benefits are not included

Table 4-9: NED Damages by Category (AAEQ)

Type	Structure	Contents	Total	% of Total
BUILDING-1	$ 16,104	$ 8,262	$ 24,366	76%
DECK	$ 82	$ -	$ 82	0%
DUNEWALK	$ 5,973	$ -	$ 5,973	19%
PARKING	$ 172	$ -	$ 172	1%
POOL	$ 200	$ -	$ 200	1%
SHELTER	$ 1,425	$ -	$ 1,425	4%
Grand Total	**$ 23,956**	**$ 8,262**	**$ 32,218**	**100%**

The NED is also effective over time and requires only two periodic nourishment events throughout the 50-year period of analysis. Benefits begin to accrue immediately after initial construction and spike initially in 2036 at $1.5M (PV) before reaching a peak in 2042 when the project provides $1.73M (PV) in benefits. Between 2036 and 2055 benefits remain steady and relatively high, hovering between $1.2M (PV) and $1.7M (PV). Benefits begin to gradually decline until reaching a relative low in 2068 of $877K (PV). **Figure 4-4** summarizes these annual results.

Figure 4-4: Recommended Plan Benefits[28] by Year (PV)



[28] Without land loss and recreation benefits

Total CSRM benefits for the recommended plan amount to $2,165,474 in AAEQ. Adding land loss benefits of $234,138 AAEQ (**Section 4.1)** and recreation benefits of $565,671 AAEQ (**Section 4.2**) brings the total project benefits to $2,965,283 AAEQ. Section **4.3.2** will summarize how these benefits compare to the refined costs to determine the final BCR.

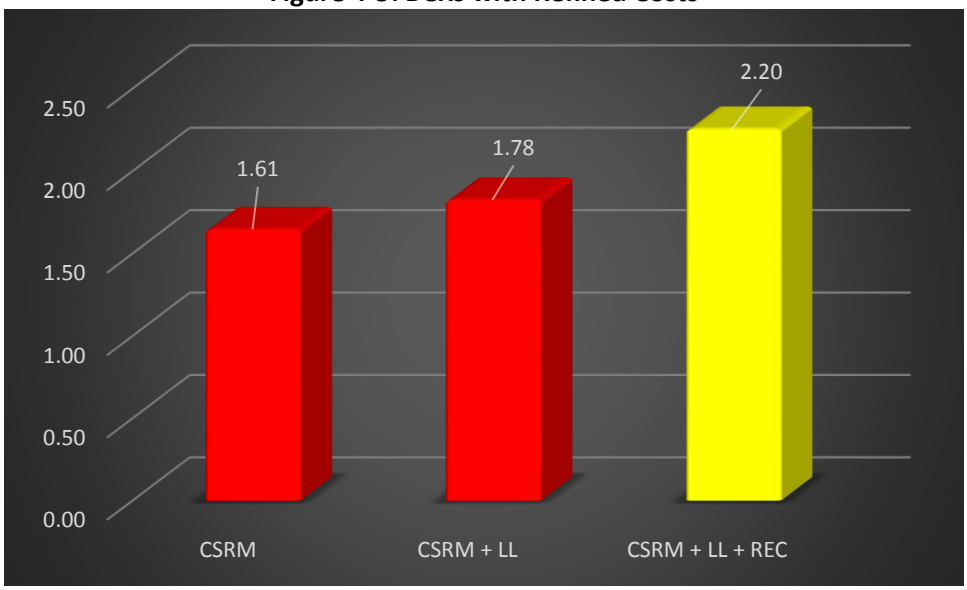
4.3.1 Benefits of the Recommended Plan on Evacuation Route Inundation

Following the same methodology used in section **3.3.5,** the recommended plan was modeled to obtain how effective it would be at preventing flooding of both one foot or more and two feet or more to Florida State Route A1A. The plan was incredibly effective in achieving both of these goals since 0% of the iterations experienced flooding of either one or two feet. Thus, the recommended plan performs satisfactorily in keeping A1A accessible as an evacuation route.

4.3.2 Recommended Plan Benefit-Cost Ratio

Comparing the $2,965,283 AAEQ in benefits with the $1,348,623AAEQ in costs yields a BCR of 2.20. **Figure 4-5** summarizes the BCRs with a delineation between primary benefits and incidental benefits.

Figure 4-5: BCRs with Refined Costs



4.3.3 Incremental Analysis of the Recommended Plan

As previously mentioned, the concentration of damages in the southern section of the project area lead to an in-depth analysis of incremental economic justification for the recommended plan. SAJ Engineers and Economists collaborated to determine the proper number of increments to be analyzed. Ultimately, best professional judgement lead to the determination that no increment less than a mile long would be feasibly constructed as a standalone project and, thus, the 3.25-mile stretch of project area was separated into three different increments. Since, as mentioned in **Section 2.3**, each model reach is approximately 1,000' long except R-115 (2,000'), increments one and two are composed of six model reaches (R-99 to R-104, R-105 to R-110) and increment three is composed of five model reaches (R-111 to R-115).

Once the increments were established SAJ economists compared the marginal costs to the marginal benefits to determine justification. For a beach nourishment project such as the recommended plan, the marginal costs are the placement costs per cubic-yard for nourishing any particular increment. In order to determine the quantity of placement attributable to each increment, the Beach-Fx *reachstats.csv* output file was used. Using this output file SAJ Economists were able to determine the overall percentage of cubic-yards placed in each increment and then multiply that percentage by the total placement costs (AAEQ) derived from the certified cost schedule.

The marginal benefits are the sum of the storm damages prevented, land loss prevented, and recreation benefits for each individual increment. Proper guidance was followed with regard to recreation benefits in that recreation benefits were only applied to an increment if that increment required less than 49% of those recreation benefits to be economically justified (i.e. the primary BCR must be greater than .51).

The incremental analysis determined that all three increments were economically justifiable and would remain part of the recommended plan. Increments two and three had primary (i.e. without recreation benefits) BCR's greater than 1.0, whereas increment one had a primary BCR of .64. Since all increments had primary BCR's greater than .51 recreation benefits were added to determine final BCR's, all of which are greater than 1.0. See **Table 4-10** for a summary of the incremental analysis.

Table 4-10 Incremental Analysis of Recommended Plan

Increment	Model Reach	Marginal Cost	Primary Benefits	Rec Benefits	Incremental Primary Net-Benefits	Incremental Net-Benefits (With Rec)	Primary BCR	BCR With Rec
1	R-99	$ 39,695	$ 41,029	$ 17,724	$ 1,334	$ 19,058	0.64	1.45
	R-100	$ 41,340	$ 24,789	$ 17,724	$ (16,551)	$ 1,174		
	R-101	$ 34,735	$ 19,593	$ 17,724	$ (15,142)	$ 2,582		
	R-102	$ 28,390	$ -	$ 41,245	$ (28,390)	$ 12,855		
	R-103	$ 22,939	$ -	$ 41,245	$ (22,939)	$ 18,306		
	R-104	$ 30,719	$ 41,477	$ 23,857	$ 10,758	$ 34,615		
	Total1	*$ 197,818*	*$ 126,888*	*$ 159,520*	*$ (70,930)*	*$ 88,590*		
2	R-105	$ 26,373	$ 22,292	$ 23,857	$ (4,082)	$ 19,775	1.24	1.90
	R-106	$ 29,544	$ 29,084	$ 23,857	$ (460)	$ 23,397		
	R-107	$ 32,435	$ 73,208	$ 23,857	$ 40,773	$ 64,630		
	R-108	$ 35,219	$ 38,871	$ 19,534	$ 3,652	$ 23,186		
	R-109	$ 39,573	$ 48,915	$ 19,534	$ 9,342	$ 28,876		
	R-110	$ 36,628	$ 36,276	$ 19,534	$ (352)	$ 19,182		
	Total2	*$ 199,771*	*$ 248,645*	*$ 130,173*	*$ 48,873*	*$ 179,046*		
3	R-111	$ 39,585	$ 49,887	$ 71,096	$ 10,303	$ 81,399	11.35	12.90
	R-112	$ 44,032	$ 53,202	$ 71,096	$ 9,171	$ 80,267		
	R-113	$ 34,892	$ 416,623	$ 44,595	$ 381,731	$ 426,326		
	R-114	$ 31,440	$ 87,652	$ 44,595	$ 56,212	$ 100,808		
	R-115	$ 28,324	$ 1,416,715	$ 44,595	$ 1,388,391	$ 1,432,986		
	Total3	*$ 178,272*	*$ 2,024,080*	*$ 275,978*	*$ 1,845,808*	*$ 2,121,786*		
GRAND TOTAL		$ 575,861	$ 2,399,612	$ 565,671	$ 1,823,751	$ 2,389,422		

4.4 Conclusion

St. Lucie County is highly susceptible to hurricane and storm damage. This is particularly true for the large and high-value commercial structures and more pronounced in the southern section of the project area. Beach-fx modeling has demonstrated that, in the absence of a federal project, significant economic damage from coastal forces can be expected to occur over the next 50-years. When factoring in the potential for sea levels to rise in excess of baseline projections those economic damages could average almost half of a billion dollars in present-value terms.

In an effort to reduce as much damage as possible this CSRM project team considered a multitude of management measures. Years of technical expertise, best professional judgment and rigorous modeling efforts were all leveraged to determine a plan that maximizes net-benefits and contributes to national economic development. This plan, ABerm20DuneEx, prevents an estimated 98% of economic damages across 50-years with only two periodic nourishments and nets $$1,616,660AAEQ worth of benefits. The project yields $2.20 in benefits for every $1.00 spent (i.e. BCR is 2.20). **Table 4-11** provides a summary of the recommended plan CSRM benefits with land loss and recreation added.

Table 4-11: Economic Summary of Recommended Plan (AAEQ)

ECONOMIC SUMMARY	STORM RISK MANAGEMENT BENEFITS ONLY	STORM RISK MANAGEMENT + LAND-LOSS BENEFITS (PRIMARY)	STORM RISK MANAGEMENT + LAND-LOSS + RECREATION
Price Level	FY17	FY17	FY17
FY17 Water Resources Discount Rate	2.875%	2.875%	2.875%
Storm Risk Management Benefits	$2,165,474	$2,165,474	$2,165,474
Land Loss Benefits	$0	$234,138	$234,138
Recreation Benefits	$0	$0	$565,671
Total Benefits	$2,165,474	$2,399,612	$2,965,283
Total Cost[29]	$1,348,623	$1,348,623	$1,348,623
Net-Benefits	$816,851	$1,050,989	$1,616,660
Benefit Cost Ratio	**1.61**	**1.78**	**2.20**

[29] This cost includes IDC and OMRR&R

The plan is efficient, acceptable and complete. It is also robust and increasingly efficient in the face of rising sea levels. Though the recommended plan is relatively small in scope and scale, it represents the most prudent investment of Federal and sponsor dollars.