EDISTO BEACH

COASTAL STORM DAMAGE REDUCTION
GENERAL INVESTIGATION STUDY

APPENDIX B

ECONOMICS

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1. INTRODUCTION

FEDERAL INTEREST

Congress has authorized Federal participation in coastal storm damage reduction (CSDR) projects to prevent or reduce damages caused by wind and tidal generated waves and currents along the Nation's ocean coasts and Great Lake Shores.

STUDY AREA

The Town of Edisto Beach and Edisto Beach State Park are part of Edisto Island located in South Carolina. They are bounded by the South Edisto River and St. Helena Sound to the southwest and the Atlantic Ocean to the southeast. The Town of Edisto Beach occupies the central and southern portions of the island and is generally separated from Edisto Beach State Park by State Highway 174, which provides the only access to the island. Its beachfront extends approximately 4.5 miles between Highway 174 and the South Edisto River/St. Helena Sound. The town has been developed as a permanent and seasonal residential area with limited commercial development. Edisto Beach State Park occupies approximately 1,255 acres of the island and is structured around a dense live oak and maritime forest. It offers ocean and marsh side camping sites, as well as cabins, picnic areas, and nature and hiking trails. Its beachfront extends approximately 1.5 miles between Jeremy Inlet and Highway 174.

ASSUMPTIONS & CONSTRAINTS

The economic analysis is based on the following assumptions and constraints.

Assumptions:

- The FY 2013 Federal Discount rate of 3.75 percent is used in the economic evaluation.
- The period of analysis is 50 years, beginning in 2014 and concludes after the year 2063. There are 5 pre-base years from 2009-2014. The base year is 2014.
- The price level is in constant 2013 dollars.
- Structure values are based on depreciated replacement costs.
- Land use zoning and construction codes will not change during the period of analysis.
- Damaged or destroyed properties will be repaired to pre-storm conditions.
- Lost land will be valued at near shore prices.
- Empirical storm frequencies are based on historical records for the study area and are assumed to be predictive of the probability of future events.
- Existing state and county owned public park limits would remain the same in the future.

Constraints:

- For a project to be economically justified, the benefit to cost ratio needs to be greater than 1 to 1.
- The analysis recognizes the Threatened and Endangered Species Act and the Coastal Barrier Resources Act.
- Adequate Parking and Access

2. SOCIO-ECONOMIC OVERVIEW

DEMOGRAPHICS:

Edisto Island is a barrier island located at the mouth of the Edisto River in Colleton and Charleston Counties, South Carolina. It is approximately 45 miles southwest of Charleston, South Carolina and approximately 20 miles east-northeast of Beaufort, South Carolina. The incorporated Town of Edisto Beach is located on the island, as is Edisto Beach State Park and incorporates 2.3 square miles. Tourism is the largest industry on Edisto Island. Figure 1 is a map of South Carolina showing Colleton County in the southeastern region of the state which is where Edisto Beach can be found. This area of Colleton County is bordered by Beaufort County and Charleston County.

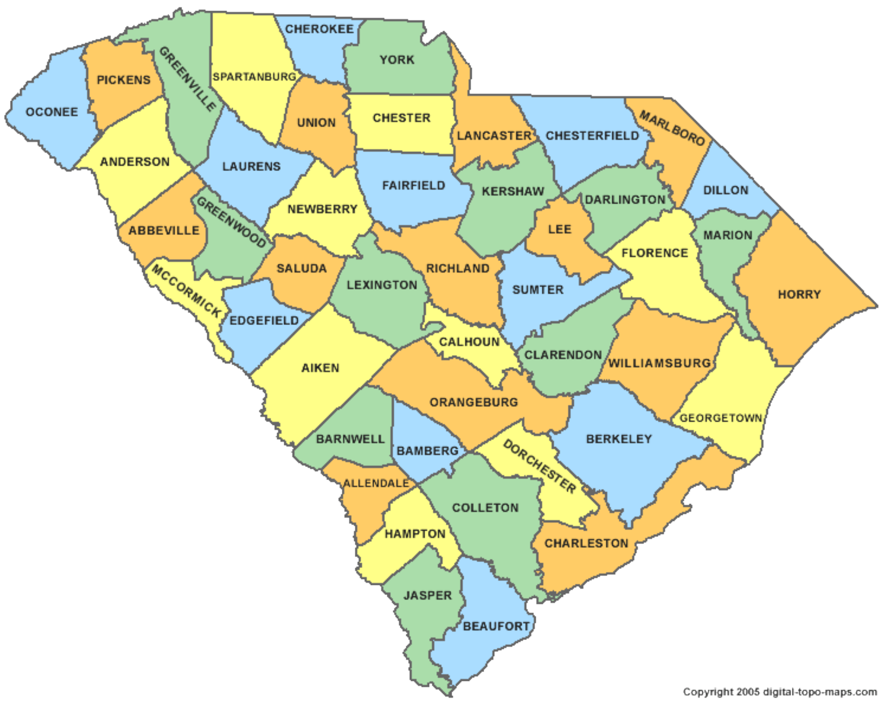

Figure 1
South Carolina Counties

POPULATION: As of the 2010 census data, there were 414 people in the Town of Edisto Beach which is a decrease of 35.4% since the 2000 census of 641 people. There were 2,181 housing units, with 10.6% being occupied and 89.4% being vacant housing units mainly for rent or seasonal use. There were 232 households out of which 3.4% had children under the age of 18 living with them, 62.9% were married couples living together, 1.7% had a female householder with no husband present, and 35.3% were non-families. The average household size was 1.78, and the average family size was 2.13. The population was spread out with approximately 4% under the age of 19, 1% from 19 to 24, 9% from 25 to 44, 41% from 45 to 64, and 45% who were 65 years of age or older. The median age was 64.6 years.

According to the Town of Edisto Beach representative, the 2010 population count of 414 has been challenged because the Town of Edisto Beach did not have a mail out census, just a door to door count during a season when many people are out of town. According to the sponsor, the voter registration is 704 people, a 10 percent increase from the 2000 census.

Table 1 shows the population characteristics for Colleton County and the surrounding southern counties. As a seasonal resort community, population in the Town of Edisto Beach fluctuates significantly during the year.

Table 1: Population Characteristics

	Population			Percent Change		
	1990	2000	2010	1990-2000	2000-2010	1990-2010
South Carolina	3,486,703	4,012,012	4,625,364	33%	15.3%	90%
Colleton County	34,377	38,264	38,892	46%	1.6%	171%
Charleston County	295,039	309,969	350,209	31%	13%	62%
Beaufort County	86,425	120,937	162,233	30%	34.1%	159%
Town of Edisto Beach	340	641	414	89%	-35%	22%

http://quickfacts.census.gov

EMPLOYMENT AND INCOME: In 2010, Edisto Beach had 261 people in the labor force. The occupations in Edisto Beach are as follows: management, business, science and arts (154 people), service occupation (22 people), sales and office (38 people), natural resources, construction and maintenance (12 people), and production, transportation and material moving (20 people). The unemployment rate was 5.7 percent.

In 2010, the per capita income was $51,628. The median income for a household in the town was $64,125, and the median income for a family was $96,250. About 2.9% of families were below the poverty line. Table 2 display the per capita income for Colleton County and the surrounding southern counties and Edisto Beach.

Table 2: Per Capita Income

Counties	Per Capita Income			Percent Change	Percent Change	Percent Persons
	1989	2000	2010	1989-00	2000-2010	Below Poverty Level - 2010
South Carolina	$11,897	$18,795	$23,443	58.0%	24.7%	16.4%
Colleton County	$9,193	$14,831	$17,842	61.3%	20.3%	21.3
Charleston County	$13,068	$21,393	$29,401	63.7%	37.4%	16.5%
Beaufort County	$15,213	$ 25,377	$ 32,731	66.8%	29.0%	10.5%

Edisto Beach	NA	$ 39,400	$51,628	NA	31.0%	2.9%

EDUCATION: According to the 2010 census, the education attainment in Edisto Beach for high school graduates is 20.8 percent. The population that attained an associate's degree is 6.5 percent, and the population percentage that received a bachelor's degree is 35.7, and 19 percent of the population has a graduate or professional degree.

HOUSEHOLDS: A household includes the related family members and all the unrelated people who share the housing unit. A person living alone in a housing unit, or a group of unrelated people sharing a housing unit such as partners or roomers, is also counted as a household. There were a total of 232 households in Edisto Beach in 2010, with an average household size of 1.78 people. Table 3 shows the number of households and the median household income for Colleton and surrounding counties.

Table 3: Select Household Characteristics

Counties	Households			Median Household Income
	1990	2000	2010	2010
South Carolina	1,258,044	5,134,869	2,137,683	$43,939
Colleton County	12,040	14,470	19,901	$33,263
Charleston County	107,069	123,326	137,844	$48,433
Beaufort County	30,712	45,532	93,023	$ 55,286
Edisto Beach	Not Available	329	232	$64,125

TRANSPORTATION & UTILITIES: The Town of Edisto is accessible from Edisto Island and the mainland via SC 174. The William McKinley Jr. Bridge connects Edisto Island to the mainland. Major local roads on the island include Palmetto Boulevard (SC 174), Lybrand Street, Jungle Road, Dock Site Road and Myrtle Street.

There is one company that supplies water to the Town of Edisto Beach from a well source. There is also one sewer plant for the Town of Edisto Beach.

According to the Town of Edisto Beach Local Comprehensive Beach Management Plan, the Town of Edisto is designated by the State Hurricane Plan as a Category 1 evacuation area. The evacuation route for residents and tourists from Edisto Beach is along SC 174 to US 17 South to SC 64 to Walterboro.

3. STUDY METHODOLOGY

EVALUATION FRAMEWORK

Coastal storm damage reduction projects are formulated to provide hurricane and storm damage reduction, with incidental recreation benefits. USACE participation in coastal storm damage reduction projects must produce economic justification from storm damage reduction benefits or a combination of storm damage reduction benefits and recreation benefits not to exceed 50 percent of the total benefits required for justification.

The specific methodologies that will be used for the study are based on the general principles and guidelines (P&G) documented in Engineering Regulation 1105-2-100, 22 April 2000, Planning-Planning Guidance Notebook, Section I – Hurricane and Storm Damage Reduction, and Appendix D – Economic and Social Considerations.

INCORPORATING RISK AND UNCERTAINTY

The P&G recommends a life-cycle approach and risk and uncertainty analysis. The benefits and costs of storm damage reduction measures are highly uncertain. Predicted costs and benefits are dependent upon a variety of engineering and economic assumptions and models. Future damages are dependent on the sequence of storms, their characteristics, property inventory, erosion, wind and wave effects and a multitude of other factors.

In order to provide analytical support for projects involving storm damage reduction, a unified risk-based engineering-economic model called Beach-*fx* is being applied to the Edisto Beach, SC coastal storm damage reduction project for estimation of expected annual benefits. Beach-*fx* incorporates triangular distributions in capturing uncertainty in value of structures and contents, first floor elevations and number of times a structure is rebuilt.

BEACH-FX HURRICANE AND STORM DAMAGE SIMULATION MODEL

The Beach-*fx* model is a USACE Certified engineering-economic event based, Monte Carlo simulation model that relates beach profile change to storms, coastal processes and nourishment programs. Beach-*fx* represents an improvement on previous models in this arena by being strongly based on representation of the coastal and engineering processes, incorporating the impact of multiple storms and incorporating uncertainty in damage functions, physical characteristics of structures and economic valuations. Expected structural damages generated through the simulations are expressed as losses due to flooding, erosion and waves. Beach-*fx* is run for multiple project life-cycles and provides statistics on probable benefits and costs of the evaluated hurricane and storm damage reduction design alternatives, which is used to determine the economic justification of the project.

Beach-*fx* simulates beach response over time as storms, natural recovery, and management methods alter the beach profile. Events of interest (storms, beach nourishment) take place at calculated times. As each event takes place, the model simulates the physical and economic responses associated with that event. A set of simplified beach profiles, as defined by key data points, are tracked by the simulation model as the beach profile evolves over time.

As each storm is processed, the shoreline response is determined, and a post-storm beach configuration is calculated, as well as profiles of maximum water level, wave height, and erosion during the storm. This information is used to determine economic damages, based on empirical curves (damage functions) relating the percentage loss of value of structure and contents to "damage-driving parameters" calculated from the aforementioned profiles and characteristics of the structure.

4. EXISTING CONDITION

The 2003 South Carolina Annual State of Beaches Report by South Carolina Department of Health and Environmental Control Ocean & Coastal Resource Management (SCDHEC- OCRM) categorizes Edisto Beach as "very vulnerable to beach erosion", with areas that "are among the most critical in the state."

In 1948, construction of timber groins began along Edisto's beachfront. Throughout the years, the groin field has been eroded and modified. In 1995, the town of Edisto maintained and repaired the existing groins and widened the beach for recreational use and increased the buffer zone between existing structures and the ocean. After project completion, monitoring was conducted from 1995-2001 and concluded that the project was successful. The groin field along Edisto Beach had reduced the long-term erosion rate to a fraction of the pre-groin rate in the area encompassed by most of the groin field. However, groin maintenance is an ongoing issue. Sand fencing is also used as a precaution; however erosion continues to be an ongoing problem with sand fencing as well.

LAND USE AND FUTURE DEVELOPMENT

Land use on Edisto Beach is primarily residential in the form of single and multiple family dwelling units. The west end of the island has been developed as a planned gated community. The Edisto Beach State Park occupies approximately one third of Edisto Beach at the northern end and offers numerous scheduled activities and educational opportunities. Edisto Beach has relatively few commercial units, and commercial development is limited. Approximately 34 acres, 2 percent, of the 1,531 acres on the beach is zoned for commercial use, excluding resort amenities within the gated section of Wyndham Resort. There are 4.67 miles of walking/biking trails that provide recreational activities to the public throughout the town.

Development is ongoing and continuous at Edisto Beach and likely to continue into the immediate and near future until the remaining limited beach front, except for the State Park, is developed. There are public structures on Edisto Island such as the Town Hall and other parks that have facilities. However, the public structures are not in the Edisto Beach Study Area.

STRUCTURE INVENTORY

The structure inventory is a collection of information for the structures that may be potentially impacted by flooding, waves and/or erosion. The existing condition structure inventory is the basis for estimating the expected annual damages to the study area. Beach front development is predominantly single family dwellings. A complete structure inventory was completed in 2010 of existing structures that may benefit from a storm damage reduction project. The depreciated replacement cost for the structure values were used to estimate damages. The purpose was to gather data required for Beach-*fx* inputs and to obtain a database that would facilitate the gathering of critical metrics that locate the structure spatially in relation to the shoreline as well as its elevation. Beach-*fx* considers the inventory of structures (damage elements) as items that are containerized in 'lots'. Lots form boundaries that contain damage elements. An aggregation of lots that are for the most part contiguous composes a reach. All reaches taken in aggregate compose the study area. The Beach-*fx* model currently has 23 reaches, largely based on the morphologically driven development of the representative profiles of Edisto Beach. Four planning reaches were identified to aggregate the Beach-*fx* reaches; Inlet Reach (Beach-fx reaches I1-I4), Atlantic Reach South (Beach-*fx* Reaches P1, P2, E1-E6), Atlantic Reach North (Beach-*fx* reaches E7-E15) and the State Park Reach.

Photos of structures along with pertinent information of construction and foundation type, number of floors, and accompanying detached structures that may benefit from a project were also collected. A summary of inventory is shown in Table 4. The 'SFR1' represents a single family residence, 'Walk' represents walkovers, 'Commercial' represents commercial structures and 'MFR' represent multi-family structures. The 'Road' damage element is Palmetto Boulevard. It has been divided based on reaches and modeled as a linear damage element. The 'Utility' damage element refers to the underground water pipes that run along the side of the road that have potential to be damaged. There are twice as many utilities as roads because the utilities run along both sides of the road.

Table 4: Structure Inventory Count by Beach-*fx* Reach

Reach	Beach-*fx* Reach	SFR1	Walk	Road & Utilities	Commercial	MFR
1	I1	68	33			16
2	I2	43	16			
3	I3	13	2			
4	I4	20	4			
5	P1	12	2			
6	P2	21	1			
7	E1	13				
8	E2	24	2			
9	E3	35	6			
10	E4	38	4			
11	E5	25	10			
12	E6	21	2			
13	E7	10				
14	E8	28	1	2		
15	E9	13		1		
16	E10	22		2		
17	E11	14		1		

Reach	Beach-*fx* Reach	SFR1	Walk	Road & Utilities	Commercial	MFR
18	E12	14		1		
19	E13	14		1		
20	E14	35	1	2	8	
21	E15	13		2	7	
22	S1					
23	S2	112	1	9	15	
	Total	**608**	**85**	**21**	**30**	**16**
	Grand Total	**760**				

VALUE OF COASTAL INVENTORY

Structure Value

The value of structures in the study area required for economic analysis to determine NED benefits should be expressed in terms of depreciated replacement costs. Staff from the Army Corps of Engineers Savannah District prepared the Edisto Beach Structure Inventory Analysis that determined the depreciated replacement cost for the structures using the Cost Approach. Tax Assessor's records were examined and analyzed on the current inventory to determine depreciated replacement cost using variables of interest relating to assessed value, date of construction, type of construction, number of floors, square footage, recent sales and selling prices, along with other information. Appendix C – Edisto Beach Structure Inventory Analysis gives further detail of the Cost Approach used to determine depreciated replacement cost. Walkovers were valued at an average of $100 per linear feet for the wood boardwalks also according to staff from the Army Corps of Engineers Savannah District.

Content Value

Content value was taken at 50% of the structure value. A web search of trade associations of homeowner casualty underwriters revealed that insurers generally use a content to structure ratio between 50 and 75 percent of replacement cost. For this analysis, the more conservative number of 50% was used. Table 5 presents the structure and content value of damageable property value based on depreciated replacement cost.

In conducting a sensitivity analysis for the content value, 40% and 60% were used to determine the range of content damages. The values are $50,403,000 and $75,604,000 respectively for all reaches.

Table 5: Edisto Beach Structure and Content Value by Reach

Reach	Beach-*fx* Reach	Structure	Content
1	I1	$ 30,533,000	$ 15,133,000

Reach	Beach-*fx* Reach	Structure	Content
2	I2	$ 10,142,000	$ 4,988,000
3	I3	$ 2,597,000	$ 1,287,000
4	I4	$ 4,897,000	$ 2,421,000
5	P1	$ 3,188,000	$ 1,585,000
6	P2	$ 5,962,000	$ 2,976,000
7	E1	$ 3,134,000	$ 1,567,000
8	E2	$ 5,321,000	$ 2,653,000
9	E3	$ 8,529,000	$ 4,241,000
10	E4	$ 5,272,000	$ 2,615,000
11	E5	$ 6,174,000	$ 3,060,000
12	E6	$ 4,590,000	$ 2,290,000
13	E7	$ 2,537,000	$ 1,268,000
14	E8	$ 6,456,000	$ 3,214,000
15	E9	$ 2,817,000	$ 1,402,000
16	E10	$ 3,359,000	$ 1,666,000
17	E11	$ 2,370,000	$ 1,179,000
18	E12	$ 2,443,000	$ 1,215,000
19	E13	$ 2,603,000	$ 1,295,000
20	E14	$ 9,393,000	$ 4,644,000
21	E15	$ 3,690,000	$ 1,832,000
22	S1	$ -	$ -
23	S2	$ -	$ -
	Total	$126,007,000	$62,531,000
	Grand Total	$188,537,900	

5. ECONOMIC BENEFIT EVALUATION

STORM DAMAGE REDUCTION

Beach-*fx* calculates the storm damage reduction from inundation, storm-induced erosion, long-term erosion and wave attack on a damage element-by-damage element basis for each storm event for the study period.

Damage Element

Damages are estimated based on the concept of a "damage element". A damage element represents any structure that can incur an economic loss such as structures, walkways, pools, etc. In Beach-*fx*'s system hierarchy reaches contain lots, and lots contain damage elements. For each storm, damages are estimated by examining the reach, lots, and damage elements within the lots. Thus, the basic unit on which damages are calculated at present is the damage element. Damage elements have attributes relating to type, geographic location, and value. Each damage element has information relating to structure and content value (treated as a three-parameter distribution for purposes of incorporating uncertainty). For location information, a structure's center point is referenced, as well as its width and length. A single value of ground elevation is specified, which also includes a three-parameter distribution for describing the first floor elevation and uncertainty.

Damage Functions

The damage functions used in Beach-*fx* were those developed for the Institute for Water Resources (IWR) – Coastal Storm Damage Relationships Based on Expert Opinion Elicitation. However, the expert opinion elicitation did not capture all damage element types and the additional curves were based on best professional judgment by the Project Delivery Team.

Damage functions for each damage type (erosion, inundation, and wave) are currently associated with damage element type (single family residential, multi-family residential, walkway, etc.) foundation type (shallow piles, deep piles, slab, etc.) construction type (wood frame concrete, masonry, etc.) and armor type (No armor, sheet pile, etc.) are used to select the appropriate damage function.

Damages are calculated at the damage element level, following each storm. For each damage type, a damage driving parameter is calculated for each damage element, and used as a lookup into stored damage functions.

LOST LAND REDUCTION

The land lost reduction benefit was determined for eroding reaches by calculating the amount of land that would be lost during the study period times the value of near shore upland.

LOSS OF LAND BENEFIT

With a project in place, land that would be lost in the without project future condition would be preserved by a project. The design template that represents the project that always provides full benefits to protected properties would be in place for the period of analysis preserved through the process of periodic renourishment. This benefit is based on the value of near shore lands. Normally, determination of the market value of the land losses is based on the value of near shore upland. Near shore upland is sufficiently removed from the shore to lose its significant increment of value because of its proximity to the shore, when compared to adjacent parcels that are more distant from the shore. These parcels have no gulf frontage or access point to the water as part of any deeded subdivision rights. For this project, near shore land values were estimated by the Army Corps of Engineers Savannah District from samples taken from recent land sales and calculated on cost per square foot and the above criteria applied. Appendix C – Edisto Beach Structure Inventory Analysis has further explanation and clarification on how the value per square foot was calculated for near shore land values. The near shore land value per square foot was determined to be $19.76.

RECREATION

To determine the recreation benefits of a plan, an economic value must be placed on the recreation experience at Edisto Beach. This value can be applied to the visitation which results from the project to determine the NED recreation benefits. For this report, unit day values (UDV's) are used to determine the economic value of recreation using a point system that takes into account the following factors: recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental (esthetics) quality. Parking at Edisto Beach is sufficient to support recreation for the general public and is reasonably near and accessible to the project beaches. Along with designated parking areas for beach access, public parking along the rights of ways of the Town's streets is permitted. The Town of Edisto Beach has 38 public beach access points that lie along Palmetto Boulevard, Point Street and Yacht Club Road. Each access point is identified with a reflective "Beach Access" sign. The longest distance between the access points is 1,425 feet, still less than one half mile.

REBUILDING

In Beach-*fx*, a triangular distribution (minimum, most likely and maximum) is defined for the number of days required for rebuilding at the damage element (DE) level, meaning that the distribution can be changed for each damage element. At the start of each iteration a value is drawn from the sample, setting the rebuilding time for the damage element for that iteration. The number of times rebuilding could occur was unlimited if there was sufficient room on the lot.

If a DE is damaged to any degree, and has not been "rebuilt" more times than the maximum allowable, then a "rebuilding event" is set at a time in the future corresponding to the random rebuilding time. When the simulation reaches that time the lot on which the DE exists is checked to see if it is buildable. At present, the model makes a simple check based on whether or not the landward toe of the dune has retreated past the center point of the lot. If so, the lot is not buildable, and rebuilding does not take place.

If the lot is rebuildable at the time of rebuilding, then structure and contents values are restored to their initial values at the start of the simulation, such that they are able to be taken as damages again at the next storm event, and the number of times the damage element is rebuilt is incremented by one.

COMBINING DAMAGES – COMPOSITE DAMAGE FUNCTION

Total damage element damages are calculated using a composite damage function that takes into account damages for all damage mechanisms present while avoiding double counting. Because a structure may be damaged by more than one storm damage hazard, a methodology was developed for combining the damages. This methodology was defined during the IWR workshop and is included in Attachment 1 – Coastal Storm Damage Relationships Based on Expert Opinion Elicitation.

6. FUTURE WITHOUT PROJECT CONDITION

In the future without project condition, it has been indicated by the local sponsor that the action taken would be to armor State Road 174 as it becomes increasingly threatened as it is the primary evacuation route, and perform emergency nourishment as necessary. Within Beach-*fx*, a trigger distance was specified at 20 feet from the road, meaning that when the seaward edge of the berm gets within 20 feet of the road, armoring will occur on an as needed basis. The economic consequences are measured as a range of average annual equivalent damages.

DAMAGES

In determining the future without project damages, Beach-*fx* was simulated for 300 iterations over a 50 year period of analysis to capture the variability of estimated damages with a discount rate of 4%. Table 6 displays the summary statistics of damages from Beach-*fx* showing existing average total damages and average annual (AA) damages to structure and content by model reach. Table 6 also shows the average emergency nourishment (EN) cost associated with each reach in the future condition. All alternatives will be compared and measured to the without project values. The benefits for plan comparison will be the reduction in other negative impacts or increases in positive impacts.

Table 6: Without Project Structure and Content Damage Summary Values

Reach	Beach-*fx* Reach	Avg Structure Damage	Avg Content Damage	Avg Total Damage	AA Damages	Avg Emergency Nourishment	AA Emergency Nourishment	Armor Cost	AA Armor Cost
1	I1	$6,318,000	$2,990,000	$9,308,000	$433,000	$0	$0	$0	$0
2	I2	$3,063,000	$1,115,000	$4,177,000	$194,000	$0	$0	$0	$0
3	I3	$718,000	$297,000	$1,015,000	$47,000	$0	$0	$0	$0
4	I4	$1,043,000	$417,000	$1,460,000	$68,000	$0	$0	$0	$0
5	P1	$370,000	$141,000	$511,000	$24,000	$437,000	$20,342	$0	$0
6	P2	$636,000	$272,000	$908,000	$42,000	$1,350,000	$62,843	$0	$0
7	E1	$253,000	$127,000	$379,000	$18,000	$507,000	$23,601	$0	$0
8	E2	$703,000	$289,000	$991,000	$46,000	$854,000	$39,754	$0	$0
9	E3	$848,000	$280,000	$1,129,000	$53,000	$1,320,000	$61,446	$0	$0
10	E4	$1,419,000	$645,000	$2,065,000	$96,000	$727,000	$33,842	$0	$0
11	E5	$1,047,000	$315,000	$1,363,000	$63,000	$665,000	$30,956	$0	$0
12	E6	$336,000	$145,000	$481,000	$22,000	$1,552,000	$72,246	$0	$0
13	E7	$123,000	$55,000	$178,000	$8,000	$645,000	$30,025	$0	$0
14	E8	$1,311,000	$641,000	$1,952,000	$91,000	$1,835,000	$85,420	$383,000	$17,829
15	E9	$1,444,000	$714,000	$2,158,000	$100,000	$743,000	$34,587	$182,000	$8,472
16	E10	$2,151,000	$1,058,000	$3,209,000	$149,000	$951,000	$44,269	$455,000	$21,180
17	E11	$2,196,000	$1,088,000	$3,284,000	$153,000	$626,000	$29,140	$210,000	$9,776
18	E12	$388,000	$184,000	$572,000	$27,000	$504,000	$23,461	$160,000	$7,448
19	E13	$1,113,000	$544,000	$1,656,000	$77,000	$738,000	$34,354	$183,000	$8,519
20	E14	$3,637,000	$1,791,000	$5,428,000	$253,000	$1,284,000	$59,770	$414,000	$19,272
21	E15	$1,482,000	$722,000	$2,204,000	$103,000	$2,757,000	$128,339	$224,000	$10,427
Total		$30,598,000	$13,830,000	$44,429,000	$2,068,000	$17,495,000	$814,396	$2,211,000	$102,922

7. WITH PROJECT CONDITION

NON-STRUCTURAL ALTERNATIVE

A non-structural measure, property acquisition, was considered as a hurricane and storm damage reduction measure. Property acquisition would involve the purchase of the damageable property and relocating the residents. Property acquisition would take place in the northern most reaches only because they are the most erosion- and damage-prone reaches in the study area. The reaches evaluated were E14 and E15, it was determined that additional reaches would be evaluated if these two reaches yielded the highest net benefits.

There were 19 shorefront houses located within reaches E14 and E15. The assumptions made for the non-structural alternative were compliance by the property owners and implementation of the plan at the start of the project. The benefits of the non-structural plan were calculated based on the assumption that the average future without project condition structure and content damages from the future without project condition Beach-*fx* runs as well as emergency renourishment cost avoidance.

Costs for the non-structural plan were based on an acquisition cost using the actual land and structure value taken from the Structure Inventory Analysis (Appendix C) for each structure, and a demolition cost for each structure. For simplification, an identical demolition/removal and land value acquisition cost was used for every structure and lot. Based on the average costs of some demolition/removal activities that took place recently at a similar beach project, a $100,000 per lot demolition/removal cost was used in this analysis.

NOURISHMENT ALTERNATIVES

Beach nourishment and periodic renourishment will meet the study objectives for shoreline erosion protection in the most economically efficient and environmentally acceptable manner. Hard structures would have negative impact on the environment and are forbidden by laws and regulations of the study area.

For the Edisto Beach with project condition, four alternatives were evaluated to compare against the future without project condition. The alternatives were formulated and evaluated on the basis of the most likely conditions expected to exist with implementation of each of the plans identified for analysis. The alternatives were formulated based on past knowledge and performance of what has been determined as the best with project plan. During formulation, alternative measures considered involved soft structures, hard structures and non-structural measures.

Alternative 1 was designed to resemble the dimensions of the 2006 local beach renourishment effort. Alternative 2 was considered to be the smallest practicable beachfill plan. Alternative 3 was considered to be the largest practicable plan. Therefore the minimum and maximum plan was captured in the analysis. Based on the results of the three alternatives, an Alternative 4 was analyzed to bracket the economic benefits. Table 7 shows the dimensions of each alternative.

Table 7: Alternative Dimensions

Reach	Alternative 1			Alternative 2 (Minimum)			Alternative 3 (Maximum)			Alternative 4		
	Beach & Dune Fill			Beach & Dune Fill			Beach & Dune Fill			Beach & Dune Fill		
	Berm Width	Dune Height	Dune Width	Berm Width	Dune Height	Dune Width	Berm Width	Dune Height	Dune Width	Berm Width	Dune Height	Dune Width
I1		12	15		10	15		14	15		14	15
I2		12	15		10	15		14	15		14	15
I3		12	15		10	15		14	15		14	15
I4		12	15		10	15		14	15		14	15
P1	Taper	12	15	Taper	10	15	Taper	14	15	Taper	15	15
P2	25	14	15	13	12	15	38	16	15	13	15	15
E1	50	14	15	25	12	15	75	16	15	25	15	15
E2	50	14	15	25	12	15	75	16	15	50	15	15
E3	50	14	15	25	12	15	75	16	15	50	15	15
E4	50	14	15	25	12	15	75	16	15	50	15	15
E5	50	14	15	25	12	15	75	16	15	50	15	15
E6	50	14	15	25	12	15	75	16	15	50	15	15
E7	63	14	15	38	12	15	88	16	15	63	15	15
E8	75	14	15	50	12	15	100	16	15	75	15	15
E9	75	14	15	50	12	15	100	16	15	75	15	15
E10	75	14	15	50	12	15	100	16	15	75	15	15
E11	75	14	15	50	12	15	100	16	15	75	15	15
E12	75	14	15	50	12	15	100	16	15	75	15	15
E13	75	14	15	50	12	15	100	16	15	75	15	15
E14	75	14	15	50	12	15	100	16	15	75	15	15
E15	75	14	15	50	12	15	100	16	15	75	15	15
SP	Taper			Taper			Taper			Taper		

PHYSICAL DAMAGES

Physical damages are expected to occur in the future on Edisto Beach, including structural damages, loss of contents and damages to the street and utility lines. Physical damages are evaluated separately for residential, commercial and road and utilities using different damage curves to estimate damages over the period of analysis. Depreciated replacements cost of the structure and contents are the basis for determining damages. The structure and content values are input as a minimum, maximum and most likely to address uncertainty. The cumulative damage for all the years from life-cycle modeling is presented as average damages and average annual damages equivalent values. Additional structural damages are also captured and include walkovers, pools and gazebos in the structure inventory of the study area. These structures are included in the total damage values.

For comparative analysis of the plans formulated, Beach-*fx* simulated 300 iterations for each alternative to determine the NED plan. Tables 8-11 show the structure and content damage for Alternatives 1-4. Land loss benefits are included in physical damage.

Table 8: Alternative 1 Physical Damage Benefits

Reach	Beach-*fx*Reach	Structure Damage	Content Damage	Total Damages	AA Damages	AA Damage Reduction	Land Loss Benefits	Total Physical Damages
1	I-1	$4,213,296	$1,993,071	$6,206,366	$288,908	$144,386	$0	$144,386
2	I-2	$1,756,450	$682,710	$2,439,160	$113,543	$80,917	$0	$80,917
3	I-3	$385,767	$171,584	$557,350	$25,945	$21,308	$0	$21,308
4	I-4	$624,051	$273,808	$897,859	$41,795	$26,184	$0	$26,184
5	P-1	$382,121	$138,457	$520,577	$24,233	-$456	$0	-$456
6	P-2	$1,313,875	$627,005	$1,940,880	$90,348	-$48,080	$0	-$48,080
7	E-1	$215,112	$107,761	$322,873	$15,030	$2,630	$1,656	$4,286
8	E-2	$610,672	$276,748	$887,420	$41,310	$4,839	$10,028	$14,867
9	E-3	$661,016	$264,636	$925,652	$43,089	$9,447	$26,358	$35,805
10	E-4	$715,402	$339,438	$1,054,840	$49,103	$47,001	$32,641	$79,641
11	E-5	$564,382	$229,762	$794,144	$36,968	$26,472	$26,950	$53,421
12	E-6	$247,466	$113,815	$361,281	$16,818	$5,566	$34,416	$39,981
13	E-7	$108,938	$54,617	$163,555	$7,614	$685	$20,383	$21,068
14	E-8	$446,931	$214,059	$660,991	$30,769	$60,084	$54,744	$114,828
15	E-9	$828,343	$408,040	$1,236,383	$57,554	$42,910	$23,146	$66,055
16	E-10	$551,284	$269,144	$820,428	$38,191	$111,182	$36,617	$147,799
17	E-11	$379,549	$186,560	$566,109	$26,352	$126,526	$21,289	$147,815
18	E-12	$87,051	$41,836	$128,887	$6,000	$20,636	$19,788	$40,424
19	E-13	$298,210	$144,637	$442,847	$20,615	$56,492	$20,678	$77,169
20	E-14	$945,209	$464,214	$1,409,424	$65,609	$187,073	$47,437	$234,509
21	E-15	$323,046	$155,389	$478,435	$22,271	$80,303	$67,577	$147,880
Total		**$15,658,169**	**$7,157,291**	**$22,815,460**	**$1,062,064**	**$1,006,104**	**$443,705**	**$1,449,809**

Table 9: Alternative 2 Physical Damage Benefits

Reach	Beach-*fx*Reach	Structure Damage	Content Damage	Total Damages	AA Damages	AA Damage Reduction	Land Loss Benefits	Total Physical Damages
1	I-1	$5,995,901	$2,842,965	$8,838,866	$411,451	$21,843	$0	$21,843
2	I-2	$2,847,417	$1,038,815	$3,886,233	$180,905	$13,556	$0	$13,556
3	I-3	$652,608	$271,770	$924,377	$43,030	$4,223	$0	$4,223
4	I-4	$968,426	$397,319	$1,365,745	$63,576	$4,404	$0	$4,404
5	P-1	$448,470	$153,493	$601,963	$28,022	-$4,244	$0	-$4,244
6	P-2	$930,185	$409,709	$1,339,894	$62,372	-$20,104	$0	-$20,104
7	E-1	$278,564	$139,478	$418,042	$19,460	-$1,801	$653	-$1,148

Reach	Beach-*fx*Reach	Structure Damage	Content Damage	Total Damages	AA Damages	AA Damage Reduction	Land Loss Benefits	Total Physical Damages
8	E-2	$807,645	$331,313	$1,138,958	$53,019	-$6,870	$3,606	-$3,264
9	E-3	$941,259	$297,382	$1,238,641	$57,659	-$5,123	$15,286	$10,164
10	E-4	$1,474,577	$668,464	$2,143,040	$99,759	-$3,655	$11,847	$8,192
11	E-5	$1,073,400	$316,885	$1,390,285	$64,718	-$1,279	$12,270	$10,991
12	E-6	$360,267	$151,766	$512,033	$23,835	-$1,452	$19,055	$17,603
13	E-7	$129,427	$64,835	$194,262	$9,043	-$745	$13,799	$13,054
14	E-8	$1,016,986	$493,482	$1,510,467	$70,313	$20,541	$40,313	$60,853
15	E-9	$1,527,956	$755,919	$2,283,875	$106,315	-$5,851	$16,234	$10,383
16	E-10	$1,595,008	$783,372	$2,378,380	$110,714	$38,659	$23,231	$61,890
17	E-11	$1,408,339	$695,509	$2,103,848	$97,935	$54,944	$14,095	$69,040
18	E-12	$211,806	$98,942	$310,748	$14,465	$12,171	$13,089	$25,260
19	E-13	$617,182	$298,040	$915,222	$42,604	$34,502	$19,194	$53,696
20	E-14	$2,309,518	$1,138,758	$3,448,276	$160,518	$92,164	$41,603	$133,766
21	E-15	$773,392	$375,404	$1,148,796	$53,477	$49,097	$59,921	$109,019
Total		**$26,368,334**	**$11,723,619**	**$38,091,953**	**$1,773,188**	**$294,980**	**$304,196**	**$599,176**

Table 10: Alternative 3 Physical Damages Benefits

Reach	Beach-*fx*Reach	Structure Damage	Content Damage	Total Damages	AA Damages	AA Damage Reduction	Land Loss Benefits	Total Physical Damages
1	I-1	$2,753,155	$1,310,263	$4,063,418	$189,153	$244,141	$0	$244,141
2	I-2	$983,528	$395,531	$1,379,059	$64,195	$130,265	$0	$130,265
3	I-3	$259,064	$118,341	$377,405	$17,568	$29,684	$0	$29,684
4	I-4	$406,137	$182,193	$588,330	$27,387	$40,593	$0	$40,593
5	P-1	$308,260	$114,313	$422,573	$19,671	$4,106	$0	$4,106
6	P-2	$1,043,389	$512,424	$1,555,813	$72,423	-$30,155	$0	-$30,155
7	E-1	$147,054	$73,781	$220,835	$10,280	$7,379	$1,656	$9,036
8	E-2	$501,977	$239,441	$741,417	$34,513	$11,636	$10,028	$21,664
9	E-3	$478,463	$211,003	$689,466	$32,095	$20,441	$26,358	$46,799
10	E-4	$490,933	$234,809	$725,742	$33,783	$62,320	$51,603	$113,924
11	E-5	$349,645	$147,926	$497,571	$23,162	$40,277	$40,238	$80,515
12	E-6	$141,468	$67,347	$208,815	$9,720	$12,663	$47,637	$60,300
13	E-7	$76,315	$38,259	$114,575	$5,333	$2,965	$26,369	$29,334
14	E-8	$288,301	$139,945	$428,246	$19,935	$70,918	$56,582	$127,500
15	E-9	$405,613	$200,172	$605,785	$28,199	$72,264	$29,428	$101,692
16	E-10	$264,071	$127,316	$391,387	$18,219	$131,154	$49,568	$180,722
17	E-11	$198,282	$96,548	$294,830	$13,724	$139,154	$25,196	$164,351
18	E-12	$47,976	$22,660	$70,635	$3,288	$23,348	$19,788	$43,136

Reach	Beach-*fx*Reach	Structure Damage	Content Damage	Total Damages	AA Damages	AA Damage Reduction	Land Loss Benefits	Total Physical Damages
19	E-13	$171,675	$83,364	$255,039	$11,872	$65,234	$20,678	$85,912
20	E-14	$465,053	$228,568	$693,621	$32,288	$220,393	$47,437	$267,830
21	E-15	$165,638	$79,997	$245,635	$11,434	$91,140	$67,577	$158,717
Total		**$9,945,997**	**$4,624,200**	**$14,570,197**	**$678,246**	**$1,389,922**	**$520,144**	**$1,910,066**

Table 11: Alternative 4 Physical Damage Summary

Reach	Beach-*fx*Reach	Structure Damage	Content Damage	Total Damages	AA Damages	AA Damage Reduction	Land Loss Benefits	Total Physical Damages
1	I-1	$2,753,155	$1,310,263	$4,063,418	$189,153	$244,141	$0	$244,141
2	I-2	$983,528	$395,531	$1,379,059	$64,195	$130,265	$0	$130,265
3	I-3	$259,064	$118,341	$377,405	$17,568	$29,684	$0	$29,684
4	I-4	$406,137	$182,193	$588,330	$27,387	$40,593	$0	$40,593
5	P-1	$230,876	$93,296	$324,171	$15,090	$8,687	$0	$8,687
6	P-2	$1,219,561	$593,141	$1,812,702	$84,382	-$42,113	$0	-$42,113
7	E-1	$231,907	$116,181	$348,088	$16,204	$1,456	$1,656	$3,112
8	E-2	$586,254	$270,364	$856,618	$39,876	$6,273	$10,028	$16,301
9	E-3	$604,129	$248,879	$853,008	$39,708	$12,829	$26,358	$39,186
10	E-4	$593,652	$283,899	$877,550	$40,850	$55,254	$35,266	$90,519
11	E-5	$468,267	$201,008	$669,276	$31,155	$32,284	$28,663	$60,948
12	E-6	$207,411	$98,009	$305,420	$14,217	$8,166	$36,409	$44,575
13	E-7	$96,035	$48,160	$144,195	$6,712	$1,586	$21,124	$22,710
14	E-8	$371,020	$178,778	$549,798	$25,593	$65,260	$56,209	$121,469
15	E-9	$648,160	$319,640	$967,800	$45,051	$55,412	$23,847	$79,259
16	E-10	$341,413	$165,789	$507,202	$23,610	$125,763	$38,535	$164,298
17	E-11	$239,574	$117,099	$356,672	$16,603	$136,276	$22,324	$158,599
18	E-12	$60,464	$28,795	$89,260	$4,155	$22,481	$19,788	$42,269
19	E-13	$255,023	$123,910	$378,933	$17,639	$59,467	$20,678	$80,144
20	E-14	$631,156	$310,547	$941,702	$43,836	$208,845	$47,437	$256,282
21	E-15	$241,714	$117,632	$359,346	$16,728	$85,847	$67,577	$153,424
Total		**$11,428,499**	**$5,321,454**	**$16,749,953**	**$779,714**	**$1,288,454**	**$455,898**	**$1,744,352**

EMERGENCY AND ARMOR COST

In the with project condition, the emergency nourishment and armoring cost avoided with the placement of planned nourishment become a benefit. Table 12 shows the emergency cost and armoring cost avoidance benefits.

Table 12: Emergency Cost and Armor Cost Avoidance Benefits

Reach	Alt 1	Alt 2	Alt 3	Alt 4
I-1	$0	$ -	$ -	$ -
I-2	$0	$ -	$ -	$ -
I-3	$0	$ -	$ -	$ -
I-4	$0	$ -	$ -	$ -
P-1	$14,593	$ 14,593	$ 14,593	$ 14,593
P-2	$46,174	$ 46,174	$ 46,174	$ 46,174
E-1	$17,182	$ 17,182	$ 17,182	$ 17,182
E-2	$32,006	$ 32,006	$ 32,006	$ 32,006
E-3	$49,960	$ 49,960	$ 49,960	$ 49,960
E-4	$31,705	$ 31,705	$ 31,705	$ 31,705
E-5	$29,403	$ 29,403	$ 29,403	$ 29,403
E-6	$64,126	$ 64,126	$ 64,126	$ 64,126
E-7	$25,955	$ 25,955	$ 25,955	$ 25,955
E-8	$89,139	$ 73,492	$ 90,060	$ 89,668
E-9	$34,008	$ 29,545	$ 38,005	$ 35,491
E-10	$55,867	$ 41,944	$ 61,238	$ 59,743
E-11	$36,237	$ 28,224	$ 36,882	$ 36,679
E-12	$30,270	$ 28,825	$ 30,308	$ 30,308
E-13	$38,819	$ 37,429	$ 38,819	$ 38,819
E-14	$74,563	$ 70,293	$ 74,563	$ 74,445
E-15	$124,954	$ 124,396	$ 124,954	$ 124,954
Total	**$794,960**	**$ 745,251**	**$ 805,933**	**$ 801,210**

NET BENEFITS

To determine the NED plan, the benefits were reduced by the cost to determine the plan that maximizes net benefits. Tables 13-16 show the net benefits of each alternative. For purposes of plan comparison, the cost included is the placement of planned nourishment, mobilization and demobilization cost and in some alternatives groin lengthening cost are associated with implementation of the plan.

Alternative 1 has average annual benefits of $2,244,770 and average annual cost of $907,200 resulting in net benefits of $1,337,570. The alternative requires a total of 1,090 feet of groin lengthening. The cost for the groin lengthening is included in the average annual cost.

Table 13: Alternative 1 Benefits and Costs

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
I-1	$144,386	$0	$144,386	$21,918	$122,469
I-2	$80,917	$0	$80,917	$23,359	$57,558
I-3	$21,308	$0	$21,308	$7,152	$14,156
I-4	$26,184	$0	$26,184	$7,077	$19,108
P-1	-$456	$14,593	$14,137	$4,480	$9,658
P-2	-$48,080	$46,174	-$1,906	$12,195	-$14,101
E-1	$4,286	$17,182	$21,467	$17,995	$3,472
E-2	$14,867	$32,006	$46,874	$25,025	$21,848
E-3	$35,805	$49,960	$85,765	$49,450	$36,315
E-4	$79,641	$31,705	$111,346	$29,606	$81,740
E-5	$53,421	$29,403	$82,824	$36,680	$46,145
E-6	$39,981	$64,126	$104,108	$45,175	$58,933
E-7	$21,068	$25,955	$47,023	$29,002	$18,021
E-8	$114,828	$89,139	$203,966	$73,938	$130,028
E-9	$66,055	$34,008	$100,063	$35,738	$64,325
E-10	$147,799	$55,867	$203,666	$67,971	$135,694
E-11	$147,815	$36,237	$184,052	$48,775	$135,277
E-12	$40,424	$30,270	$70,694	$55,471	$15,223
E-13	$77,169	$38,819	$115,988	$55,490	$60,498
E-14	$234,509	$74,563	$309,072	$114,629	$194,443
E-15	$147,880	$124,954	$272,834	$146,075	$126,759
Total	**$1,449,809**	**$794,960**	**$2,244,769**	**$907,201**	**$1,337,568**

Alternative 2 has average annual benefits of $1,344,430 and annual cost of $500,940 resulting in net benefits of $843,490. This alternative requires groin lengthening of 360 feet which is included in the average annual cost.

Table 14: Alternative 2 Benefits and Costs

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
I-1	$21,843	$ -	$21,843	$5,961	$15,882
I-2	$13,556	$ -	$13,556	$6,534	$7,021
I-3	$4,223	$ -	$4,223	$1,989	$2,234
I-4	$4,404	$ -	$4,404	$1,988	$2,416

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
P-1	-$4,244	$ 14,593	$10,349	$1,273	$9,076
P-2	-$20,104	$ 46,174	$26,070	$3,612	$22,457
E-1	-$1,148	$ 17,182	$16,034	$3,017	$13,017
E-2	-$3,264	$ 32,006	$28,742	$6,272	$22,470
E-3	$10,164	$ 49,960	$60,124	$14,001	$46,123
E-4	$8,192	$ 31,705	$39,897	$11,675	$28,222
E-5	$10,991	$ 29,403	$40,395	$13,147	$27,247
E-6	$17,603	$ 64,126	$81,730	$15,206	$66,524
E-7	$13,054	$ 25,955	$39,009	$17,041	$21,968
E-8	$60,853	$ 73,492	$134,345	$29,912	$104,432
E-9	$10,383	$ 29,545	$39,928	$18,927	$21,001
E-10	$61,890	$ 41,944	$103,834	$33,734	$70,100
E-11	$69,040	$ 28,224	$97,263	$29,669	$67,594
E-12	$25,260	$ 28,825	$54,085	$39,515	$14,570
E-13	$53,696	$ 37,429	$91,125	$44,143	$46,982
E-14	$133,766	$ 70,293	$204,060	$90,872	$113,188
E-15	$109,019	$ 124,396	$233,414	$112,451	$120,963
Total	**$599,176**	**$ 745,251**	**$1,344,427**	**$500,940**	**$843,487**

Alternative 3 requires 1,970 feet of groin lengthening. The length is much greater for Alternative 3 because the berm width is greater for Alternative 3 and a higher dune width. The total average annual benefits are $2,716,000 and average annual cost of $1,183,500 resulting in net benefits of $1,532,500.

Table 15: Alternative 3 Benefits and Costs

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
I-1	$244,141	$ -	$244,141	$21,717	$222,424
I-2	$130,265	$ -	$130,265	$22,343	$107,922
I-3	$29,684	$ -	$29,684	$6,864	$22,820
I-4	$40,593	$ -	$40,593	$6,805	$33,788
P-1	$4,106	$ 14,593	$18,699	$4,263	$14,436
P-2	-$30,155	$ 46,174	$16,018	$17,203	-$1,185
E-1	$9,036	$ 17,182	$26,217	$30,953	-$4,736
E-2	$21,664	$ 32,006	$53,670	$42,357	$11,313

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
E-3	$46,799	$ 49,960	$96,759	$70,105	$26,654
E-4	$113,924	$ 31,705	$145,629	$47,313	$98,315
E-5	$80,515	$ 29,403	$109,919	$66,087	$43,832
E-6	$60,300	$ 64,126	$124,427	$71,059	$53,368
E-7	$29,334	$ 25,955	$55,289	$41,485	$13,804
E-8	$127,500	$ 90,060	$217,559	$95,861	$121,698
E-9	$101,692	$ 38,005	$139,697	$48,084	$91,613
E-10	$180,722	$ 61,238	$241,961	$96,594	$145,367
E-11	$164,351	$ 36,882	$201,233	$58,296	$142,937
E-12	$43,136	$ 30,308	$73,443	$65,457	$7,986
E-13	$85,912	$ 38,819	$124,730	$65,210	$59,520
E-14	$267,830	$ 74,563	$342,393	$134,569	$207,823
E-15	$158,717	$ 124,954	$283,671	$170,906	$112,765
Total	**$1,910,066**	**$ 805,933**	**$2,715,999**	**$1,183,534**	**$1,532,465**

Alternative 4 requires a total of 1,130 ft of groin lengthening and the cost included in average annual cost. The average annual benefits of Alternative 4 are $2,545,560, the average annual cost are $926,000 resulting in net benefits of $1,619,500.

Table 16: Alternative 4 Benefits and Costs

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
I-1	$244,141	$ -	$244,141	$21,717	$222,424
I-2	$130,265	$ -	$130,265	$22,343	$107,922
I-3	$29,684	$ -	$29,684	$6,864	$22,820
I-4	$40,593	$ -	$40,593	$6,805	$33,788
P-1	$8,687	$ 14,593	$23,280	$5,752	$17,528
P-2	-$42,113	$ 46,174	$4,060	$9,405	-$5,344
E-1	$3,112	$ 17,182	$20,294	$10,342	$9,951
E-2	$16,301	$ 32,006	$48,307	$26,330	$21,978
E-3	$39,186	$ 49,960	$89,146	$50,514	$38,632
E-4	$90,519	$ 31,705	$122,224	$28,502	$93,723
E-5	$60,948	$ 29,403	$90,351	$38,745	$51,606
E-6	$44,575	$ 64,126	$108,701	$49,485	$59,216
E-7	$22,710	$ 25,955	$48,665	$32,242	$16,423

Reach	Damage Reduction Benefits	Cost Avoidance Benefits	Total Benefits	AA Costs	Net Benefits
E-8	$121,469	$ 89,668	$211,137	$77,666	$133,471
E-9	$79,259	$ 35,491	$114,749	$38,659	$76,090
E-10	$164,298	$ 59,743	$224,042	$72,653	$151,388
E-11	$158,599	$ 36,679	$195,278	$49,326	$145,952
E-12	$42,269	$ 30,308	$72,576	$56,561	$16,015
E-13	$80,144	$ 38,819	$118,963	$57,217	$61,747
E-14	$256,282	$ 74,445	$330,727	$116,776	$213,951
E-15	$153,424	$ 124,954	$278,378	$148,185	$130,192
Total	**$1,744,352**	**$ 801,210**	**$2,545,562**	**$926,089**	**$1,619,473**

Table 17 shows the summary of net benefit comparison between all the alternatives. As shown, the plan that maximizes net benefits is Alternative 4. Alternative 4 is also bracketed by the net benefits of Alternative 1 which is a smaller plan and Alternative 3 which is a larger plan than Alternative 4. Alternative 5 is sand fencing and Alternative 6 is the non-structural property acquisition.

Table 17: Net Benefits for Plan Comparison

Reach	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
I-1	$122,469	$15,882	$222,424	$222,424	$126,686	
I-2	$57,558	$7,021	$107,922	$107,922	$69,198	
I-3	$14,156	$2,234	$22,820	$22,820	$18,070	
I-4	$19,108	$2,416	$33,788	$33,788	$22,476	
P-1	$9,658	$9,076	$14,436	$17,528		
P-2	-$14,101	$22,457	-$1,185	-$5,344		
E-1	$3,472	$13,017	-$4,736	$9,951		
E-2	$21,848	$22,470	$11,313	$21,978		
E-3	$36,315	$46,123	$26,654	$38,632		
E-4	$81,740	$28,222	$98,315	$93,723		
E-5	$46,145	$27,247	$43,832	$51,606		
E-6	$58,933	$66,524	$53,368	$59,216		
E-7	$18,021	$21,968	$13,804	$16,423		
E-8	$130,028	$104,432	$121,698	$133,471		
E-9	$64,325	$21,001	$91,613	$76,090		
E-10	$135,694	$70,100	$145,367	$151,388		
E-11	$135,277	$67,594	$142,937	$145,952		
E-12	$15,223	$14,570	$7,986	$16,015		
E-13	$60,498	$46,982	$59,520	$61,747		
E-14	$194,443	$113,188	$207,823	$213,951		($226,906)
E-15	$126,759	$120,963	$112,765	$130,192		($17,935)

Reach	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Total	**$1,337,568**	**$843,487**	**$1,532,465**	**$1,619,473**	**$236,430**	

Periodic nourishment is placement of suitable material on a beach at appropriate intervals of time to maintain the design template. Beach-*fx* examines all reaches to be nourished to determine if mobilization is warranted. The existing reach profile is compared to the design template, and a nourishment volume is determined. If the total nourishment volume for all reaches exceeds a user-defined threshold, then mobilization and nourishment take place. If nourishment is required, then nourishment time is determined based on placement rates. The cost of nourishment, including mobilization and placement costs, is calculated based on nourishment volumes and user-defined cost-related parameters.

Once the NED plan was determined, Beach-*fx* was used to optimize the renourishment cycle for the NED plan. Two year increments were analyzed for 4, 6, 8, 10 and 12 years and then for a 16 year renourishment cycle. Table 18 shows the average annual costs, benefits and net benefits for each of the renourishment cycles for comparison of the optimized renourishment interval. The FY13 discount rate of 3.75% was used over a 50 year period of analysis.

Table 18: Average Annual Net Benefits for Renourishment Cycles

Cycle (yrs)	AA Benefits	AA Placement Cost	AA Mob Cost	AA Groin Cost	Total AA Cost	AA Net Benefits
4	$2,529,665	$643,132	$ 448,070	$104,592	$1,195,794	$1,333,871
6	$2,502,654	$637,736	$ 313,366	$104,592	$1,055,694	$1,446,960
8	$2,478,624	$635,223	$ 246,196	$104,592	$986,011	$1,492,613
10	$2,406,228	$612,080	$ 196,579	$104,592	$913,251	$1,492,977
12	$2,402,784	$621,710	$ 179,388	$104,592	$905,690	$1,497,094
16	$2,351,070	$614,499	$ 146,343	$104,592	$865,434	$1,485,638

There is minimal difference in net benefits between the eight and 12 year renourishment cycle. Although the net benefits are maximized at the 12 year cycle, the average annual difference between the eight and 12 year cycle is only about $4,500, or 0.025% and the difference between the eight and ten year cycles are even less. From a risk based perspective, a shorter renourishment cycle reduces the likelihood that beach fill would be needed (based on the mobilization threshold) and substantial damages being incurred prior to a scheduled renourishment. Therefore, based on the consideration of risk and the minimal differences in the net benefits between the eight, ten and 12 year cycles, an average renourishment cycle of eight years was identified for the NED plan.

The NED plan was then updated to the FY13 discount rate of 3.75% using the eight year optimized renourishment interval. Table 19 shows the summary benefit analysis for the constructible NED plan presented by planning reach.

Table 19: NED Plan Benefits and Costs

NED Plan - Alternative 4			
Reach	**Total AA Benefits**	**AA Costs**	**Net Benefits**
Inlet Reach (I1-I4)	$459,455	$74,890	$384,564
Atlantic Reach South (P1, P2, E1-E6)	$534,116	$254,506	$279,610
Atlantic Reach North (E7-E15)	$1,489,028	$712,852	$776,177
All Reaches Total	**$2,482,599**	**$1,042,248**	**$1,440,351**

8. PROJECT COST

Once the NED plan was determined a more detailed project cost was conducted. The total project cost summary was prepared for Edisto Beach and the first cost of the project for initial construction and the renourishment cost were used to compare to project benefits to compute final net benefits and the benefit to cost ratio. The renourishment cost for each eight year interval was discounted to the present value. The initial construction cost of the project is $21,424,000 and the renourishment cost that is expected to occur every eight years is $7,058,000, with the present value totaling $17,088,400. The interest during construction is approximately $118,400 and operations and maintenance approximately $83,000. The total average annual cost is presented in Table 20.

Table 20: NED Cost

Initial Construction	$	21,424,000
2026 Renourishment	$	5,257,470
2034 Renourishment	$	3,916,260
2042 Renourishment	$	2,917,200
2050 Renourishment	$	2,173,010
2058 Renourishment	$	1,618,670
2066 Renourishment	$	1,205,740
Total First Cost	$	38,512,360
Interest During Construction	$	118,450
Total Project Cost	$	38,630,810
Average Annual First Cost	$	1,721,940
O&M	$	83,000
Total Average Annual Cost	**$**	**1,804,940**

9. CONSTRUCTIBLE NED PLAN

The FY13 initial construction costs are $21,424,000 and a single renourishment cost is $7,058,000. Renourishment costs are discounted using the FY13 discount rate of 3.75% to present worth each renourishment. Total project first cost including Interest During Construction

(IDC) for this plan is $38,512,400. The annualized cost of Operation and Maintenance (O&M) is $83,000. The annualized benefits are $2,482,600 for coastal storm damage reduction benefits. The benefit-to-cost ratio (BCR) is 1.38 to 1 which yields net benefits of about $677,700.

Table 21 summarizes the costs, benefits and other pertinent information on project justification for the NED Plan without recreation benefits.

Table 21: NED Summary of Benefits without Recreation Benefits

Average Annual CSDR Benefits	$ 2,482,600
Total Average Annual Cost	$ 1,804,940
Benefit-to-Cost Ratio	1.4
Net Benefits	$ 677,660

10. RECREATION BENEFITS

The evaluation procedure used for this report is the Unit Day Value method (UDV). This method relies on expert or informed opinion and judgment to estimate the average willingness to pay of recreational users. Unit Day Value (UDV) method was selected as the evaluation procedure because there are no specialized recreation activates for the area and the annual visits expected do not exceed 750,000. The recreational analysis can be found in Attachment 2.

In 2012, the Town of Edisto Beach area had approximately 371,000 beach visitors. Traffic counts combined with estimated rentals determine expected visitors per year. This estimate is based on data provided by the Town of Edisto Beach. Visitation is generally constrained by availability of beach area only during peak days and is not limited at other times of the year. The peak recreation season is Memorial Day through Labor Day. Recreational visitation reaches a peak four times a year. These times are Spring Break, Memorial Day, Independence Day and Labor Day.

PARKING

Edisto Beach provides sufficient parking for the general public. At some access points there are parking lots that provide for up to 150 cars. The other access points have parking along the streets that are permitted by the town. The State of South Carolina recognizes that in order participate in beach nourishment projects public access is a must and therefore protects and promotes public access to the state's beaches. Parking is a reasonable walking distance to the beach.

ACCESS

According to ER1105-2-100, reasonable access is access approximately every one-half mile or less. According to the Town of Edisto Beach Local Comprehensive Beach Management Plan, the Town has 38 public access points that lie along Palmetto Boulevard, Point Street and Yacht Club Road. Each access point is identified with "Beach Access" signs. The 38 access points are exclusive of the State Park. The average width of each access point is approximately 50 feet with an average distance between each access point of 400 ft. Provisions of reasonable public access rights of ways are present in Edisto Beach.

The following table shows the beach access location and facilities at each location.

Table 22: Parking & Access

	PARKING & ACCESS								
Location	Feet Between Access Points	Sign Number	Pedestrian Only	Boardwalk	Walkover	Off-Street Parking	On-Street Parking	Handicapped Access	Signage
Coral St	842	1					x		x
Fenwick St	807	1a	x				x		x
Mary St	829	2	x				x		x
Whaley St	791	3	x				x		x
Matilda St	797	4	x				x		x
Cupid St	787	5	x				x		x
Atlantic St	802	6	x				x		x
Portia St	797	7	x				x		x
Dawhoo St	300	8				6	x		x
Cheehaw St	288	9				11	x		x
Osceola St	290	10				8	x		x
Byrd St	300	11	x				x		x
Nancy St	302	12				5	x		x
Thistle St	317	13				11	x	x	x
Chancellor St	300	14	x				x		x
Dorothy St	300	15	x				x		x
Marianne St	284	16				10	x	x	x
Lybrand St	300	17		x	x	10	x	x	x
Catherine St	300	18	x	x			x		x
Mitchell St	303	19			x	15	x	x	x
Baynard St	300	20	x		x	2	x	x	x
Edings St	300	21		x	x	7	x	x	x
Jenkins St	300	22				4	x	x	x
Seabrook St	300	23				10	x	x	x
Murray St	300	24				10	x	x	x
Holmes St	308	25				10	x	x	x
Loring St	300	26				10	x	x	x
Laroche St	300	27				10	x	x	x
Neptune St	907	28	x				x	x	x
Billow St	300	29	x	x			x		x
White Cap St	350	30				9	x	x	x
Edisto St.	387	31				6	x	x	x
Mikell St.	599	32		x		2	x	x	x
Townsend St.	1249	33	x				x		x
Louise St.	600	34	x	x			x		x
Ebb Tide St.	1425	35		x	x	4	x	x	x
Yacht Club Rd.	865	36	x	x			x		x
Yacht Club Rd.		37		x		2	x		x

WITH AND WITHOUT PROJECT VALUES

To determine the recreation benefits of the tentatively selected plan, an economic value must be placed on the recreation experience at Edisto Beach. The value can then be applied to the expected visitation experience that results from the project to determine NED recreation benefits.

The UDV are determined using a point system that takes into account the following factors: recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental (esthetics) quality. A good deal of judgment is required in the assessment of point values. A group of planning professionals and experts of the study area made independent judgments of the UDV values which were averaged. The differences in the values were applied to the estimated visitation. The difference in the Without and With project values of recreation determine the NED recreation benefits. The source of the value of recreation is obtained from the Economic Guidance Memorandum, 13-03, Unit Day Values for Recreation for Fiscal Year 2013. Table 24 shows the without project and with project points and their associated dollar values.

Table 23: UDV Project Points and Values

Criteria	W/O Project Points	W/ Project Points
Recreation Experience	16	28
Availability of Opportunity	16	18
Carrying Capacity	13	13
Accessibility	13	13
Environment (Esthetics)	4	15
Total Points	62	85
General Recreation Value	$9.02	$10.57

The UDV point totals convert to a recreation value of $9.02 in the Without project condition and the $10.57 in the With project condition. The difference in the Without Project condition and the With Project condition recreation value is $1.55.

Because Edisto Beach is already a public beach, it is not anticipated that public visitation numbers will change as a result of the Federal project. It is assumed that the 2012 visitation is indicative of future visitation given that the Edisto Island beach front is almost fully developed and generally no more room for parking areas. However, it is recognized that visitation could be much higher than reported due to the homes and vacation rentals being in walking distance from the beach and spillover from the State Park. Applying the unit day values of $9.02 in the Without project condition of 62 total points and $10.57 for the With project condition of 85 points results in annual recreation benefits of approximately $573,200.

Table 24 summarizes the costs, benefits and other pertinent information on project justification for the NED plan with recreation benefits.

Table 24: NED Plan Benefits with Recreation Benefits

Average Annual CSDR Benefits	$2,482,600
Average Annual Recreation Benefits	$573,200
Total Average Annual Benefits	$3,055,800
Total Average Annual Cost	$1,804,900
Benefit-to-Cost Ratio	1.7
Net Benefits	$1,250,900

11. TENTATIVELY SELECTED PLAN

The Tentatively Selected Plan was calculated at the Federal discount rate of 3.75% for a 50 year period of analysis. The total expected average annual coastal storm damage reduction benefits for the tentatively selected plan are $2,482,600. The recreation benefits for the TSP are estimated to be $573,200. The average annual cost is $1,804,900. Net benefits are $1,250,900 and the benefit-to-cost ratio is 1.7 to 1.

Attachment 1:

Part 1:

Coastal Storm Damage Relationships

Based on Expert Opinion Elicitation

&

Part 2:

Edisto Beach Damage Functions

Part 1:

Coastal Storm Damage Relationships

Based on Expert Opinion Elicitation

Institute for Water Resources, U.S. Army Corps of Engineers

Version1

Coastal Storm Damage Relationships Based on Expert Opinion Elicitation

(DRAFT)

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Abstract

This report documents the results of the Coastal Storm Damage Workshop on June 5, 6, 2002 in Alexandria, Virginia where expert-opinion was elicited for economic consequence assessment of coastal storm damage. The objectives of this workshop were to discuss and recommend damage relationships needed for predicting structural damage from coastal storms as functions of hazard intensity levels, with associated uncertainties, resulting from erosion, waves, inundation, and their combined effects. Because information on the relationship between residential structural damage and storm parameters is limited, this workshop used expert-opinion as a means of gaining information on these relationships (see Ayyub 2001). This report describes the results of the workshop both in terms of damage relationships and future information needs identified by the experts at the workshop.

This workshop is part of longer-term research effort whose objective is to develop a peer-reviewed, step-by-step methodology for estimating coastal storm damages. The methodology will be incorporated as part of the inputs to a new hurricane and storm damage reduction estimation model being developed by IWR. The methodology will be able to stand alone for use in Corps' districts or by other national or local agencies including potential incorporation as an option in FEMA's HAZUS model.

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Program Overview

The objective of this research is to develop a peer-reviewed, step-by-step methodology for estimating damages from coastal storms to property and improvements. The methodology will also be incorporated as part of the inputs to a new hurricane and storm damage reduction estimation model being developed by the Institute for Water Resources (IWR). The methodology will be able to stand alone for use in Corps' districts or by other national or local agencies including potential incorporation as an option in FEMA's HAZUS model.

The objective will be achieved using a two-stage process to elicit opinions from experts to develop damage functions to estimate storm damages. The first stage of this process consisted of developing framework to quantitatively describe the damage done to a structure from storm hazards such as inundation, waves, erosion, and wind. Preliminary damage relationships (curves) were also developed. As a starting point for the first stage, the project core team from IWR proposed a "strawman" framework to be modified by a small group of experts. Inputs for this first stage included the models presently in use by Corps' offices (e.g. Wilmington and Jacksonville) and other agencies around the country, as well as a framework that is being developed for this purpose for the Corps' Wilmington District. Experts were chosen from within the Corps', from contractors and academics with experience in coastal storm damage, and from the Federal Emergency Management Authority. Although a focus was on the hurricane-prone southeastern U.S., the workshop also included expertise from the North Atlantic and California.

The second stage will involve additional data collection through a full review of the initial framework and relationships by a review team, by Corps' offices, and by the professional community at-large, and from damage data collected in post-storm surveys. Experts will then be convened in a formal expert elicitation to use this additional information to modify the preliminary depth-damage relationships and develop final estimates of likely economic damages from a coastal storm.

Needs and Existing Storm Damage Information

This study was prompted by a widely-perceived need for better information on coastal storm damage relationships. A December 2000 letter from the Assistant Secretary of the Army to the Wilmington District requested a "Corps-wide-survey of damage functions used for all types of structures and the rationale for using them, for hurricane and storm damage reduction projects". The expectation was that "better guidance can be provided to field offices on the conduct of economic analysis if we have the benefit of … better tools to evaluate hurricane and storm damage projects". This research seeks to provide these better tools.

In investigating storm damage relationships, available sources of information can be divided into two general categories: 1) data on storm damages and on existing structures, and 2) models of the relationships between storm parameters and damage. Whereas the relationships between storm parameters and damage is the ultimate purpose of this investigation, the relationships need to be grounded in the data on actual storm damages. As background for the research and in preparation for the workshop, the project core team from IWR reviewed coastal damage methodologies from various sources including: Corps Districts in Jacksonville, Wilmington, New Orleans, Mobile, New York, Philadelphia; the HAZUS model - a natural hazard loss estimation methodology developed by the Federal Emergency Management Agency in partnership with the National Institute of Building Sciences; FEMA building performance studies; Federal Insurance claims data; USACE reports on Hurricane Fran and on Shoreline Protection and Beach Erosion Control; state data from HurricaneOpal (FL); the Heinz Center's Evaluation of Erosion Hazards, and various articles from the open literature (i.e. Bodge 1991, King et al. 1991, Urlich et al. 1994, Kato and Torii 2002, Thomalla et al. 2002).

Use of Expert Opinions

The primary reason for using expert opinions is provide "data" where little or no data exists about an issue or problem. It can also deal with uncertainty in selected technical issues related to a system of interest. Issues with significant uncertainty, issues that are controversial and/or contentious, issues that are complex, and/or issues that can have a significant effect on risk are most suited for expert-opinion elicitation. Here we used an informal, consensus-based elicitation process to promote creative thinking about potential frameworks and problem definition. The value of any expert-opinion elicitation comes from its initial intended uses as a heuristic tool, not a scientific tool, for exploring vague and unknowable issues that are otherwise inaccessible. It is not a substitute to scientific, rigorous research.

The identification of the need for the information developed during the elicitation process and its communication to experts are essential for the success of the elicitation. The need identification and communication should include the definition of the goal of the study and relevance of issues to this goal. Establishing this relevance would make the experts stakeholders and thereby increase their attention and sincerity levels. Relevance of each issue and/or question to the study needs to be established. This question-to-study relevance is essential to enhancing the reliability of collected data from the experts. Each question or issue needs to be relevant to each expert especially when dealing with subjects with diverse views.

The expert-opinion elicitation process can be defined as a formal, heuristic process of obtaining information or answers to specific questions about certain quantities, called issues, such as failure rates, unsatisfactory-performance consequences and expected service life. This process should not be used in lieu of rigorous reliability and risk analytical methods, but should be used to supplement them and to prepare for them. It should be preferably performed during a face-to-face meeting of members of an expert panel that is developed specifically for the issues under consideration. The meeting of the expert panel should be conducted after communicating to the experts in advance to the meeting background information, objectives, list of issues, and anticipated outcome from the meeting. The different components of the expert-opinion elicitation process are described in Ayyub (2001).

Recent USACE Expert-Opinion Elicitation Studies

Expert-opinion elicitation is a technique for using a panel of individuals with various areas of specialized knowledge for estimating parameters or addressing issues of interest based on their expertise. The March 2002 expert elicitation conducted by IWR on the Economic Consequence Assessment of Residential Flood Damage is a recent example of use of the technique. Expert-opinion elicitation has also been recently applied by the New Orleans District’s study of the Lower Atchafalaya Basin and reevaluation of the Morganza to the Gulf of Mexico feasibility studies, by Vicksburg District’s Pearl River study, and by the Sacramento District’s Feather River flood damage study. Building contractors, insurance adjusters, home decorators, and other individuals with knowledge of construction, prices, and typical home furnishings were used to estimate depth-damage and content-to-structure value ratios. Details on some of these studies are provided in Ayyub (1999 and 2001).

Residential Damage Due to Coastal Storms

The scope of this study consists of structural damage to single-family homes from coastal storms. These economic consequences can be described by mathematical functions that relate storm parameters such as wave crest height or the depth of still water flooding to the percent of damage that occurs to structures. The percent damage to structure refers to the percent of the depreciated replacement costs of the structure that is damaged. Coastal storms damage structures through wave action, still water flooding, wave run-up, erosion, and wind. These hazard types are described briefly below

Waves: Most of the energy delivered to the shore by the ocean originates from the wind acting on the ocean to produce waves. Wave characteristics are determined by the wind direction, wind speed, wind duration, how far the wind blows over water, and how far the wave travels before reaching land. Wave action can cause significant damage to coastal structures. Conventional wisdom is that if breaking waves strike at or above a building's first floor elevation, that structure will be severely damaged. This is the rationale for the National Flood Insurance Program's (NFIP) characterization of a highly vulnerable zone (V-zone) for damage from wave action. The ability to prevent wave damage is considered a major benefit of Corps' shore protection measures. Although FEMA demarks the V-zone as an area subject to breaking waves at least 3 feet high, recent, FEMA-sponsored tests indicate that 1.5-foot waves can break away walls. This research suggests that the V-zone might more appropriately extended to all areas subject to 1.5-foot high breaking waves.

Stillwater flooding: Storms can cause inundation of structures with still water either through overtopping of a dunes system (coastal flooding) or through flood waters coming from the bay side of a coastal island (bay-side flooding). Coastal flooding implies still-water level flooding of structures because of overtopping of a dune system or storm surge breaking through from the coastal side and inundating beach areas. A major benefit of Corps' shore protection measures may be reduced coastal flooding damages. Bayside flooding implies still water level flooding of structures, with flooding coming from the bayside. Natural or man-made structures may have prevented flooding from storm surge on the coastal side of an island, but high seas inundated structures from the bay or backside of an island. Structures on the bayside of islands are frequently constructed with a lower level of flood protection than structures across the island on the oceanfront. For example bayside houses may be built lower to the ground whereas oceanfront houses might be raised on piles. Damage from bayside flooding is generally not reduced through shore protection measures.

Erosion: On average, the nation's shorelines are receding at an annual rate of slightly more than one foot per year, although rates vary significantly across regions and across shoreline types. In addition to long-term erosion, erosion during a storm may destroy a dune and undermine shorefront structures. The extent of damage will depend on the amount of storm-induced erosion at the structure and structural characteristics such as foundation and piling embedment. Damages from storm-induced erosion can be significant, regardless of the long-term erosion rate or whether natural processes rebuild the dune in the months following a storm. Corps shore protection measures can provide significant reduction in damages attributable to erosion. Because erosion causes beaches to narrow over time, it is a major factor to consider in conducting a life cycle analysis of project benefits and costs.

Wave Run-up: Wave run-up is the upper level reached by a wave on a beach or coastal structure, relative to still-water level (Coastal Engineering Manual, 2002). Wave run-up applies pressure on a structure in both a vertical and horizontal direction and is a function of the water depth and the square of the water velocity. Wave run-up ceases to be a damage factor when breaking waves attack a structure.

Wind Damages: High winds associated with storms can cause significant damages to structures both on the coast and much further inland. High winds and associated flying projectiles can damage doors, windows or roofs. This damage to the integrity of the structure may combine with high winds to cause severe damage or structural failure. Such breaching also allows rainwater damage to the structure. Most of the damages from Hurricanes Andrew, Iniki, and Hugo were caused by wind and wind-related rainwater as opposed to waves, flooding, wave run-up, or erosion. Because Corps' projects do not significantly affect the wind speed of storms, wind damage is not reduced through shore protection measures. Nonetheless, wind damage plays a significant role in life cycle cost analysis for Corps' storm damage reduction projects.

Requirements

The IWR project core team has the lead responsibility for achieving the project objectives, but relied on input from a larger, working group of experts to develop appropriate damage relationships. The working group represented Corps' Districts that had been active in shoreline protection projects and represented different geographic regions. In addition, it included outside experts from the Federal Emergency Management Agency, universities, and the private sector who had expertise in coastal storm damage assessment.

Participants

A list of the IWR project core team and working group for the workshop is below.

PROJECT CORE TEAM

Affiliation	Name	Role
IWR	Stuart Davis	Project Leader
IWR	Hal Cardwell	Project Leader
IWR	David Moser	IWR Program Manager
USACE-HQ	Lillian Almodovar	HQ Program Manager
BMA Engr/Un. of MD	Bilal Ayyub	Facilitator

WORKING GROUP

Affiliation	Name	Role
USACE/Wilmington	Bob Finch	In-house Technical Advisor (S.Atlantic)
USACE/Wilmington	Mike Wutkowski	In-house Technical Advisor (S.Atlantic)

USACE/Jacksonville	Dan Peck	In-house Technical Advisor (S.Atlantic)
USACE/Jacksonville	Tom Smith	In-house Technical Advisor (S.Atlantic)
USACE/SAD	Gerald Melton	In-house Technical Advisor (S.Atlantic)
USACE/New Orleans	Brian Maestri	In-house Technical Advisor (Gulf)
USACE/Los Angeles	Dan Sulzer	In-house Technical Advisor (W.Coast)
USACE/Los Angeles	Susie Ming	In-house Technical Advisor (W.Coast)
USACE-HQ	Harry Shoudy	In-house Technical Advisor
USACE-HQ	Charlie Chesnutt	In-house Technical Advisor
USACE-HQ	Jay Warren	In-house Technical Advisor
URS	Bill Coulbourne	Outside Technical Advisor (N.Atlantic)
URS	Mike Cannon	Outside Technical Advisor (N.Atlantic)
Consultant	Chris Jones	Outside Technical Advisor (S.Atlantic)
NC SeaGrant	Spencer Rogers	Outside Technical Advisor (S.Atlantic)
FEMA	Paul Tertell	Outside Technical Advisor

Strawman Coastal Storm Damage Framework

The starting point for discussions of coastal storm damage processes was a "strawman framework" for structural damage estimation that was put forth by the IWR project core team. The strawman framework assumes as known, the physical parameters of the area and of the storm. These parameters include surface water elevation, ground elevation, shoreline type, wave heights, storm-induced erosion depth. Also assumed known are structural characteristics such as location, foundation type, height of lowest supporting beam of structures including their location. Long-term erosion is considered by progressively moving the shoreline landward, therefore increasing the storm-induced erosion and inundation potential from subsequent storms. Economic losses (damages) due to land lost are outside the scope. Wind damages are estimated outside of this framework; this estimate will be used to modify damage to structures from coastal flooding and erosion as appropriate. We also assume the surface water elevation accounts for bay-side flooding and dune breaches.

Inundation: Damage to both contents and structures from wave run-up, breaking waves, and still water flooding is assumed to be captured through the use of FIMA[1] V-zone curves for all areas that experience breaking waves of 1.5 ft above the lowest structural horizontal member of the structure. For areas that experience less than 1.5 feet of flooding, FIMA A-zone curves will be used for structure damage.

Storm-induced erosion: A curve relating damage to the depth of vertical erosion at the center of building will be developed for various foundation types. This curve will be applied for sandy beaches with small dunes (as defined by FEMA). An additional relationship for high dunes and sandy bluff shoreline types will describe storm-induced damages from near-vertical erosion scarps.

[1] The Federal Insurance and Mitigation Administration (FIMA – formerly the Federal Insurance Administration - FIA) developed and uses depth-damage curves to estimate actuarial premiums for flood insurance. FIMA has two sets of curves, A-zone curves for riverine and coastal areas without high wave velocity, and V-zone curves for coastal areas that are expected to experience wave action. FIMA defines the V-zone as those coastal areas expected to experience a 3-foot high breaking wave.

Combined Damage vectors: The total damage to a structure will be the sum of the inundation damages and the storm-induced erosion damages, with the total not to exceed the value of the structure.

Revised Framework

Discussion at the workshop produced consensus on a revised framework for structural damage estimation. Once the damage hazards were identified, the experts focused on determining the appropriate storm variable that would relate to damage for each hazard type. For example, depth of water above the walking surface for the lowest main floor was selected as the best variable to relate to still water flooding damages. This is the X-axis in a depth (or other variable) versus damage curve. The experts then agreed on the number of relationships that would have to be developed to properly predict damages to different foundation types (e.g. slab on grade or pile) or materials (wood, concrete, masonry) were appropriate for each damage hazard. Discussion then moved to different ways to combine the damages across hazards, and how to account for regional differences in shorelines, with a focus on estimating damages to bluffs. We describe the discussions and decisions in this section. Appendix A contains results in the form of quantified relationships (curves) for storm damages.

Inundation Damage

For damages from still water inundation the workshop determined that the appropriate storm variable to use was the "Depth of water above the walking surface of the lowest main floor". Although damages to the floors of a structure occur before the water depth reaches the walking surface, using the depth of water surface is an easier variable to use for data collection. **Structural damages that occur from inundation of the floors at slightly lower depths can be included by assigning positive values to damages when depth of water above the walking surface is negative.**

The workshop determined that damages from inundation also depend on the foundation type, on material, number of floors, and, for structures on piles, on the existence of ground-level enclosures. Separate relationship (although using the same X-axis) would need to be developed for each of the following cases:

- Wood frame with piles (with & without enclosures – small medium and full)
- Wood frame without piles
- Concrete & masonry with piles (with & without enclosure – small medium and full)
- Concrete & masonry without piles
- Number of floors (1, 1.5 and 2)

The workshop considered various existing data sources to quantify the relationships for inundation. These data sources included FIMA coastal A-zone curves, curves from New Orleans District for structures on piles and on piers, and curves issued by the Corps in 2000 based on post-flood surveys of actual damages in various parts of the United States.

Waves Damage

For damages due to breaking waves the workshop determined that the appropriate storm variable to use was the "difference between the top of wave (crest) and the bottom of the lowest horizontal member". The workshop considered using the walking floor elevation as the datum for comparison with the top of the wave height for consistency with the measure suggested for inundation. However the workshop decided that the framework would be clearer and more rigorous if it used the bottom of the lowest horizontal member as the reference point because it is at this point that waves can start to damage the structure. If practical considerations preclude measurements of the bottom of the lowest horizontal member, this value can be estimated based on the elevation of the walking surface.

The workshop determined that damages from inundation also depended on the foundation type for structures on piles and on the existence of ground-level enclosures. Separate relationships (although using the same X-axis) would need to be developed for each of the following cases:

- Structures on piles (with & without enclosures – small medium and full)
- Structures not on piles

Wave Run-up Damage

The workshop concluded that damages from wave run-up were attributable to the "Difference between the top of water and the bottom of the lowest horizontal member, and its velocity at the seaward face of the structure". The force applied by wave run-up could be described as directly dependent on the depth of the water and the square of the velocity. Forces would likely act in both a horizontal and vertical direction and be measured in lbs/linear foot. However the workshop participants did not feel that the there was enough known about the damage from wave run-up to determine an appropriate storm variable to use, and opted to delay development of a damage relationship as a long-term need.

Erosion Damage

For damages from storm-induced erosion, the workshop determined that the appropriate storm variable to use both for structures with shallow foundations and ones on piers was the "percent of footprint compromised." Shallow foundation structures were defined as structures that are on slabs or on piers. Houses on bluffs that experience erosion can be considered as structures with shallow foundations. When a shallow foundation experiences vertical erosion such that it loses support from the ground, the foundation is compromised. Six inches of vertical erosion or undermining has been conventionally considered to cause a loss of support. Whereas the workshop participants felt that this definition was relatively straightforward for shallow foundations, the selection of a variable for deep or pile-supported foundations was more contentious.

The distinction was made between a structure that was undermined by erosion and one that had its foundation “compromised”. Whereas for structures on shallow foundations undermining (six vertical inches of erosion) is equivalent to compromised, pile structures can be extensively undermined with little or no damage. In these cases the entire footprint could experience vertical erosion of six inches yet no damage would occur because, although undermined, the erosion does not compromise the ability of the foundation to support the structure. Conversely, a compromised pile can be defined as one whose remaining embedment depth renders it ineffective against lateral forces such as wind and waves. Using, as the independent variable (X-axis) the “percent of footprint compromised” would allow correct categorization of damages done to a pile-support house that, because of erosion, might have its entire footprint in the surf zone (and hence undermined), but yet had minimal damage because its foundation was not compromised. The workshop noted that relating storm parameters to the percent of footprint compromised would be difficult and likely be regionally and structurally specific. Comment: This percent of footprint compromised is pretty useless to predict damage from a storm unless this can be predicted from the extent of vertical erosion at the structure. I don't think there will be any model that keeps track of all piles of a pile-founded structure. We will have to make assumptions about where piles are located and the extent of embedment.

Because the appropriate storm variable was defined so broadly, the workshop only called for two separate relationships to be developed for erosion damages: one for shallow foundation and one for deep foundations (piles). More relationships may need to be developed as definitions of “footprint compromised” are developed for specific regions and projects.

Combining Damages

Because a structure may be damaged by more than one of the four storm damage hazards identified by the workshop, a methodology must be developed for how to combine the damages. The Strawman Framework proposed a simple additive combination with a constraint that the total damages to a structure could not exceed its value. The can be expressed as %A + %B. A more commonly used rule for combining damages is to simply use the maximum percent damage from any hazard, or Max [%A, %B]. Whereas the first rule assumes that there is no common damage caused by different hazards, the latter rule assumes the other extreme - that no damage occurs that is not covered by the most damaging hazard. A third rule to consider would be the sum of the hazard percentages minus their product: %A + %B -%A%B. This framework was used in the Portland District and is akin to the probability of occurrence at least one of two independent events A and B.

The workshop concluded that the combination rule must be dependent on the types of hazard that cause damages. If both waves and inundation cause damage the workshop suggested the rule be to only use the damages caused by waves (this is consistent with FIMA's V-zone definition). If both erosion and inundation cause damage the proposed rule is to use the sum of the damages minus their product. Similarly, if both erosion and run-up cause damage the rule is to use the sum of the damages minus their product. For the case where both run-up and erosion cause damages, the workshop proposed two definitions, one for shallow foundation structures, where the rule is to use the maximum of the two damages, and one for pile foundation structures where the rule is to use the sum of the damages minus their product. We summarize these relationships below for the various cases of combination

Case 1 – Inundation + Waves	%W
Case 2 – Run-up + Waves	%W
Case 3 – Inundation + Run-up	will not occur
Case 4 – Inundation + Erosion	%I + %E - %I*%E
Case 5 – Run-up + Erosion	%R + %E - %R*%E
Case 6 – Waves + Erosion	Max %W, %E (shallow foundation)
	%W + %E - %W*%E (pile foundation)

These cases cover all likely combinations of hazards because a structure would not be subject to both moving water (run-up) at the same time as still-water inundation, and waves damages would subsume run-up as it does inundation damages. The workshop noted as a long term need, better information as to when to "switch" from the inundation damage curve to the wave damage curve. Similarly this could be one area of investigation when determining the run-up damage relationships.

Discussion at the workshop included concerns on how to calibrate damage relationships from multiple sources, and noted that the structure should permit direct data collection for the calibration

Coastlines with of Bluffs

Storm damages on coastlines with bluffs differ from those on a beach and dune coastline. Inundation is not an issue for bluffs, and neither are waves or run-up except as they promote erosion. Also, all foundations on bluffs can be treated as shallow foundations or slabs, because erosion from a bluff will undermine a deep pile foundation in the same way as a shallow foundation. Failure of a bluff can be from top to bottom, or from bottom to top.

Long-term and Short-term Needs / Next Steps

The following table summarizes the long-term and short-term needs and future steps in this area:

Priority	Long-term and Short-term Needs / Next Steps
High	Methodology (including authority) for post storm data collection to determine flood conditions during event and erosion conditions at the end of an event.
High	Define/issue guidance for "Compromised" regional Differences
High	Beach profile translation
High	Contents
High	Land Loss/estimated value
High	Post storm data – wave crest water level elevations, lower limit (elevation) of wave damage.
High	Pre-storm building inventory
High	Collection of Existing loss information (including analysis of data from Fran)
Medium	Wave damage height threshold (1.5 ft vs 3 ft) – When do we abandon the inundation curve? How far inland is wave damage an issue?
Medium	RUN-UP RELATIONSHIPS - HOW TO QUANTIFY (WEST COAST)
Medium/Low	Sedimentation damage during inundation
Medium/Low	Duration of inundation
Low	Bluff Erosion processes
Low	Curves/response of engineered buildings, and other non residential structures
Low	Salt versus fresh water inundation damage

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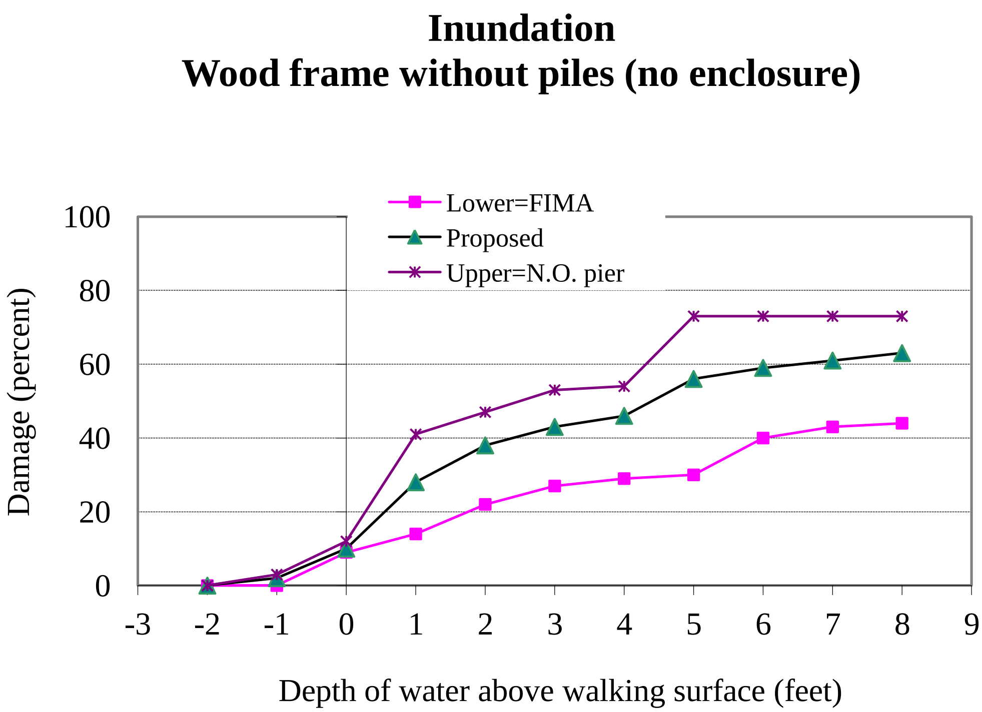
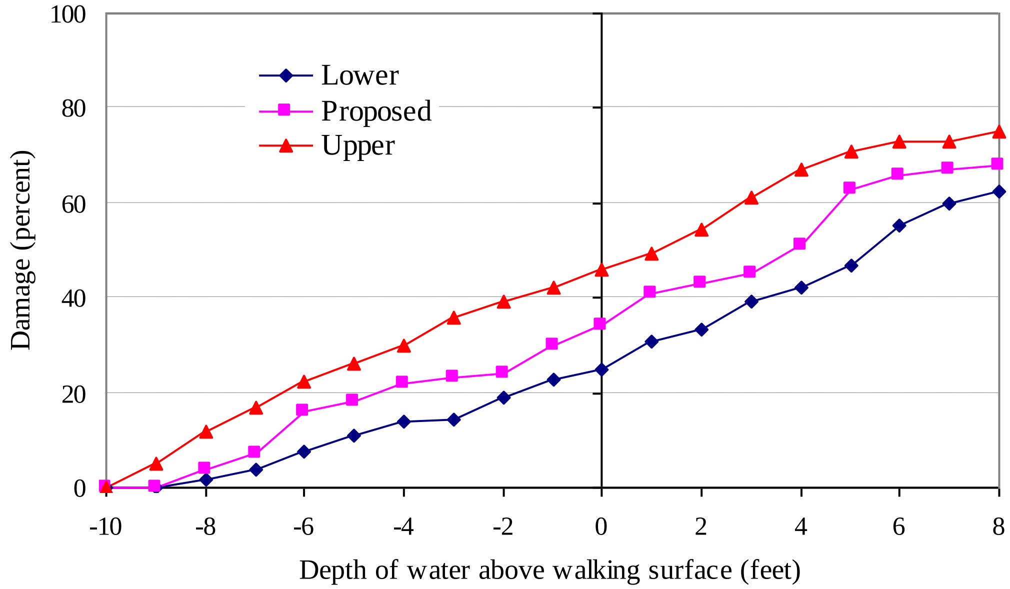
Appendix A. Damage Relationship Details

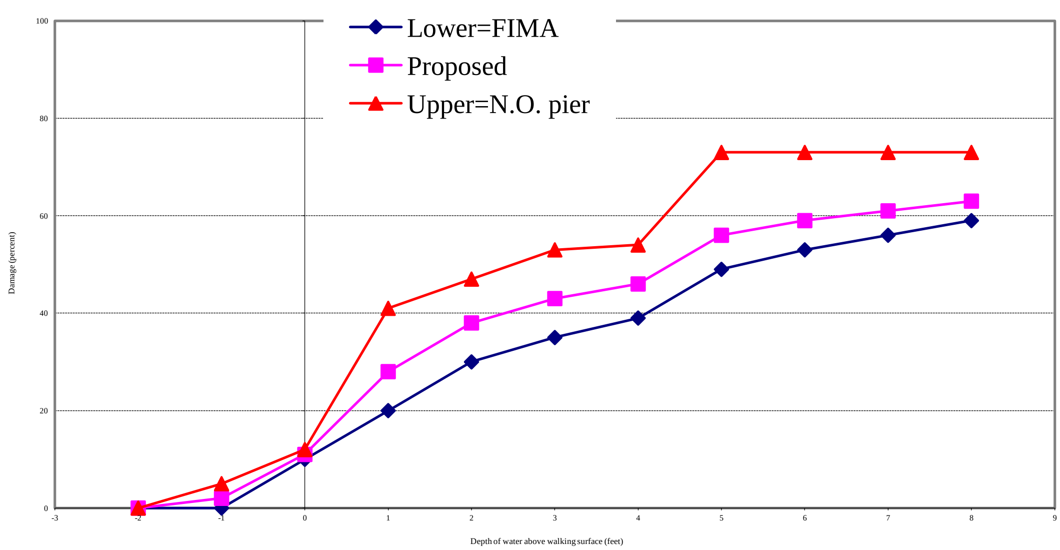
The following figures contain the details of the damage relationships developed in the workshop. The "Proposed" curve represents the experts' median estimate of damages, whereas the upper and lower represent estimates of the range of the damages. Here, 75 percent of the time damages will be less than the "Upper" curve and 25 percent of the time damages will be lower than the "Lower" curve. For the inundation curves, the upper and lower bounds were set equivalent to the estimates used by New Orleans district for structures on piers (N.O. pier), and by the FIMA coastal A-zone curves, respectively. For damages from inundation, the workshop only developed curves for the selected cases noted below. The workshop assumed that estimates for inundation damages in structures with partial enclosures would flow from the curves developed here. Likewise all curves apply for single story houses.

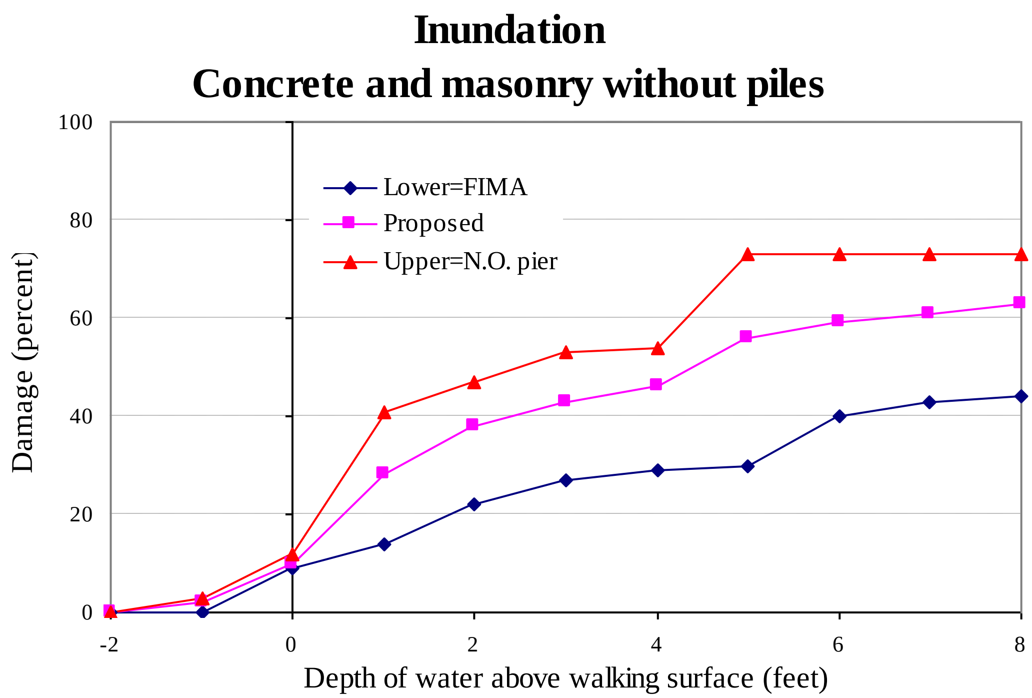


Inundation
Wood frame with piles (full enclosures)

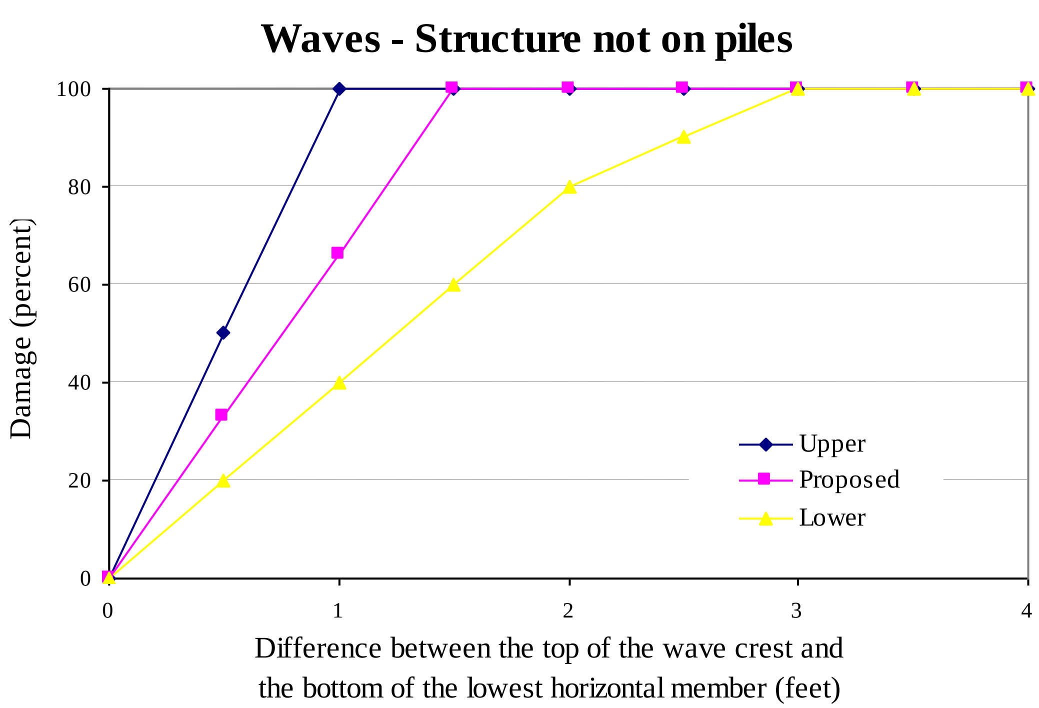


Inundation
Wood frame with piles (no enclosures)

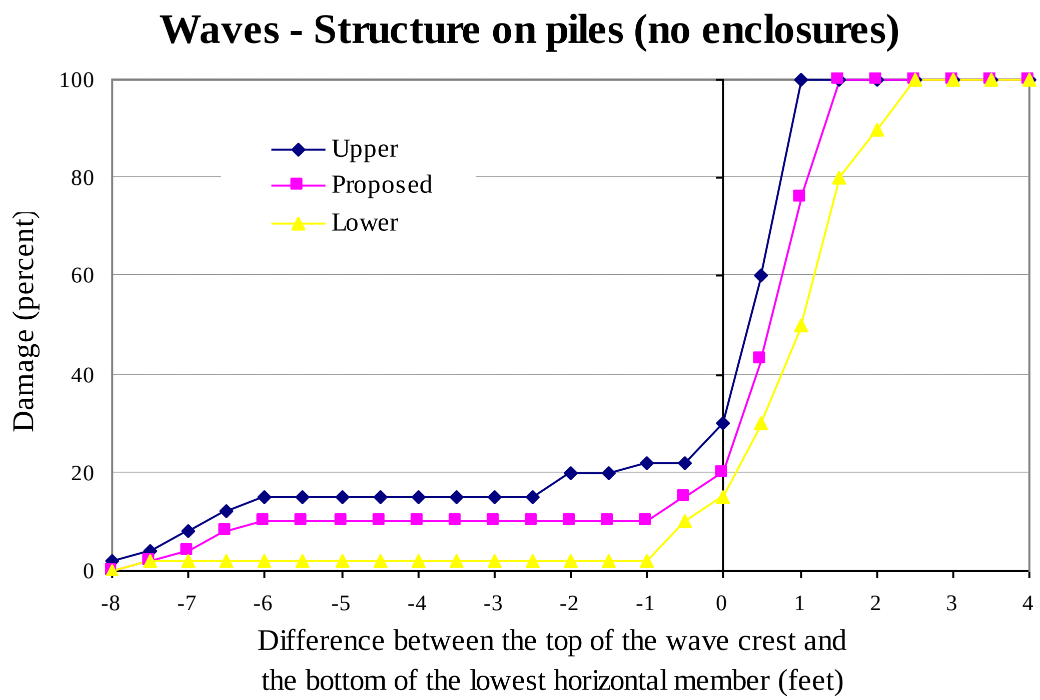


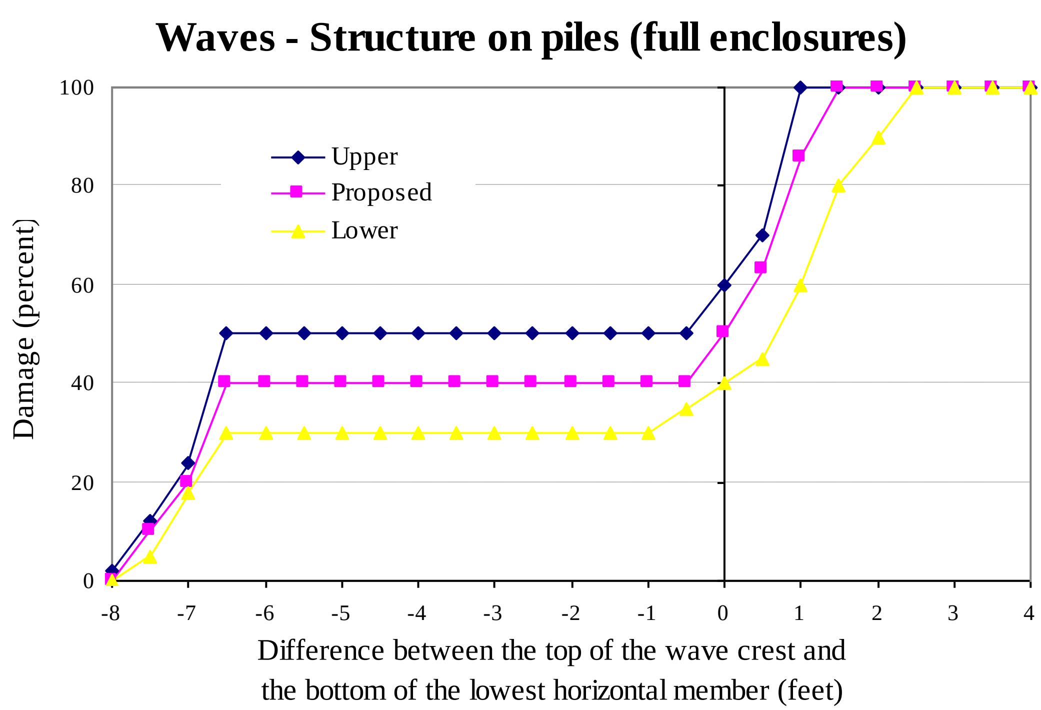


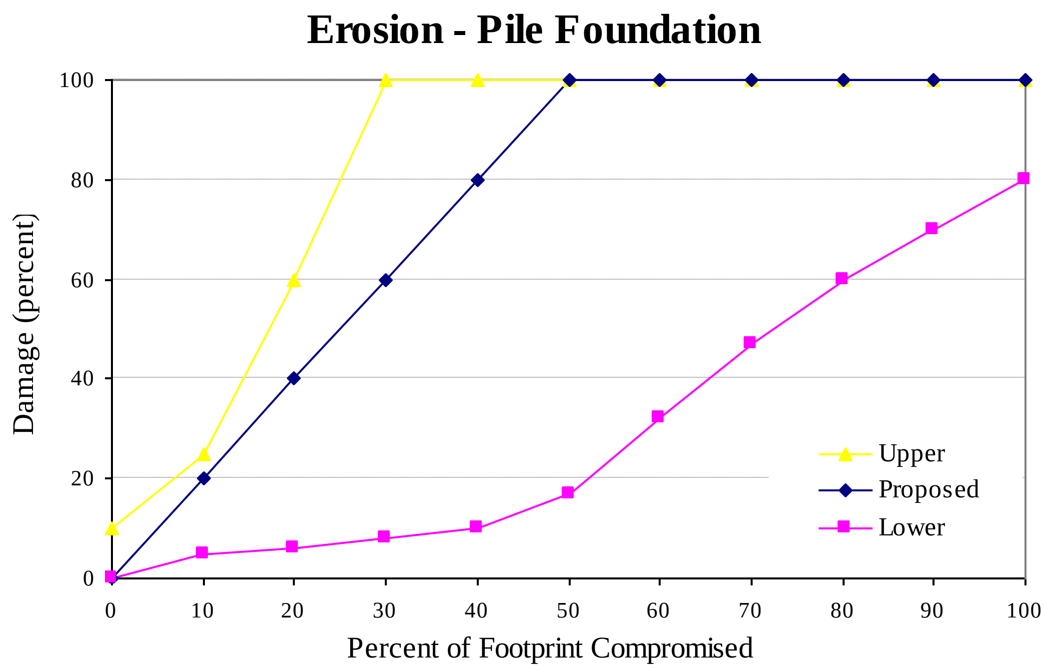
Inundation
Concrete and masonry without piles
100
80
60
40
20
0
Damage (percent)
Lower=FIMA
Proposed
Upper=N.O. pier
-2
0
2
4
6
8
Depth of water above walking surface (feet)

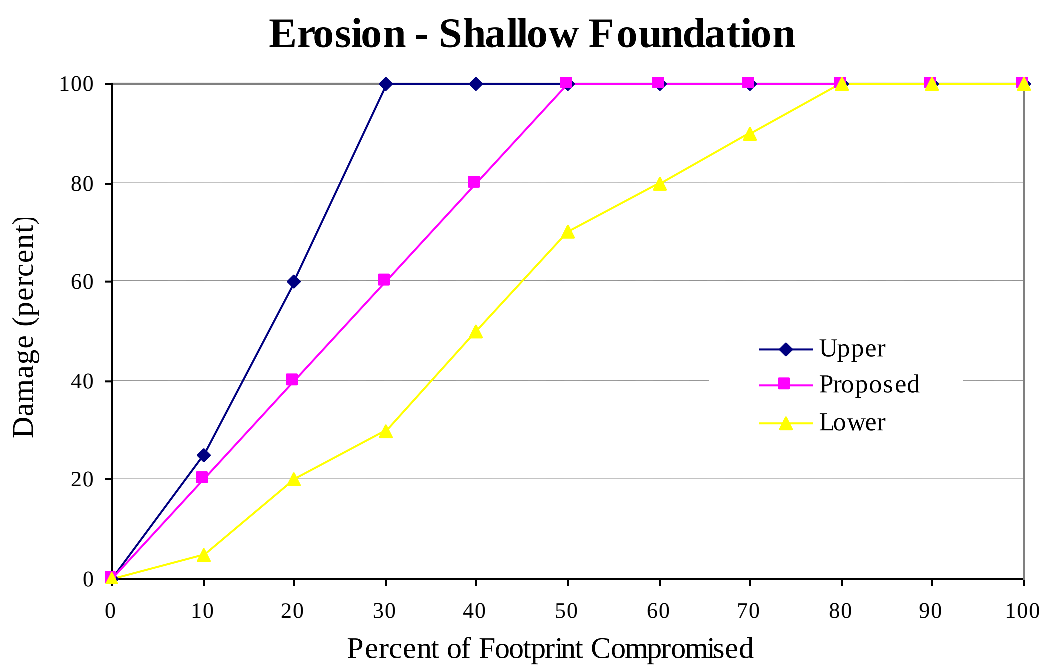


Waves - Structure not on piles
100
80
60
40
20
0
Damage (percent)
Upper
Proposed
Lower
0
1
2
3
4
Difference between the top of the wave crest and
the bottom of the lowest horizontal member (feet)


Waves - Structure on piles (no enclosures)
Upper
Proposed
Lower
Damage (percent)
100
80
60
40
20
0
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
Difference between the top of the wave crest and
the bottom of the lowest horizontal member (feet)


Waves - Structure on piles (full enclosures)
Upper
Proposed
Lower
Damage (percent)
100
80
60
40
20
0
-8
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
Difference between the top of the wave crest and
the bottom of the lowest horizontal member (feet)


Erosion - Pile Foundation
Damage (percent)
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Percent of Footprint Compromised
Upper
Proposed
Lower


Erosion - Shallow Foundation
Damage (percent)
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Percent of Footprint Compromised
Upper
Proposed
Lower

Part 2:

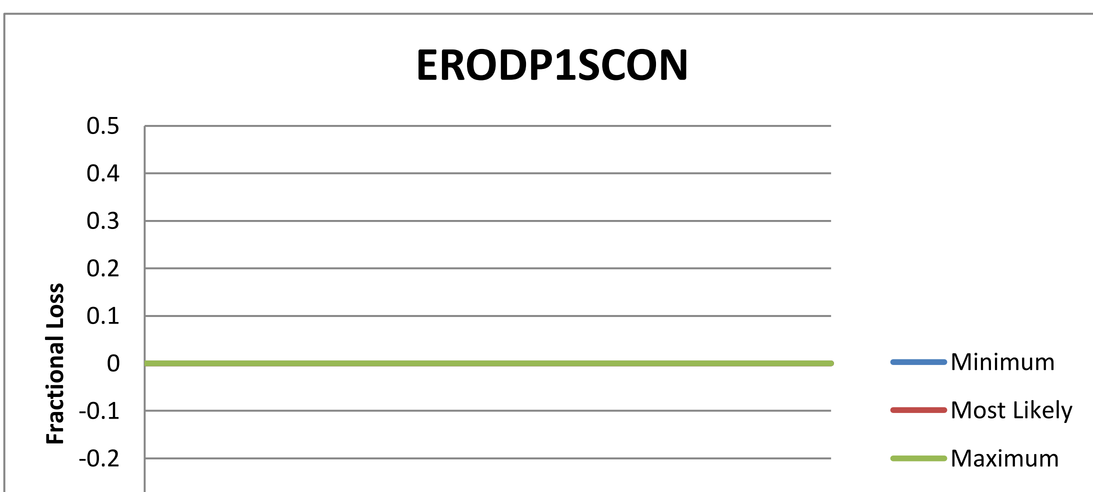
Edisto Beach Damage Functions

EDISTO BEACH DAMAGE FUNCTIONS

Erosion/Contents/Deep Piles

Multi-Family and Single Family

% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0
10	0	0	0
20	0	0	0
30	0	0	0
40	0	0	0
50	0	0	0
60	0	0	0
70	0	0	0
80	0	0	0
90	0	0	0
100	0	0	0

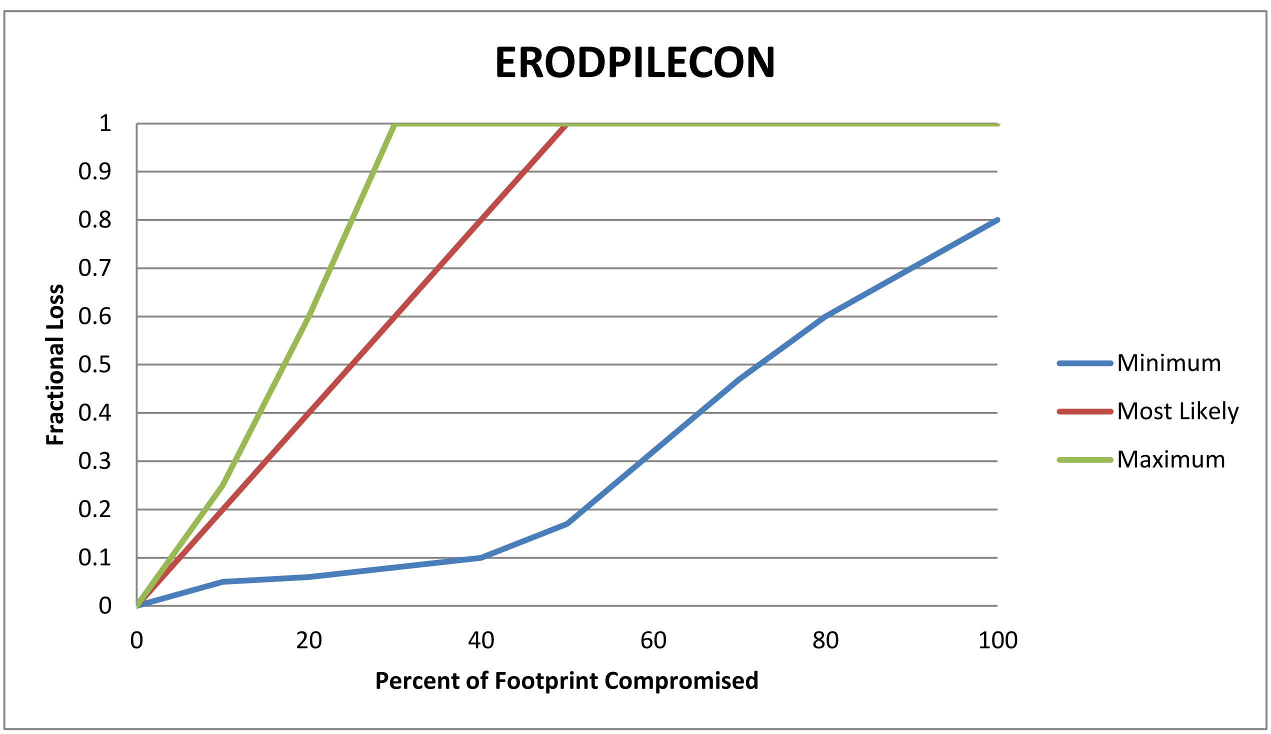


Erosion/Contents/Piles

Single Family and Walkovers

% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0

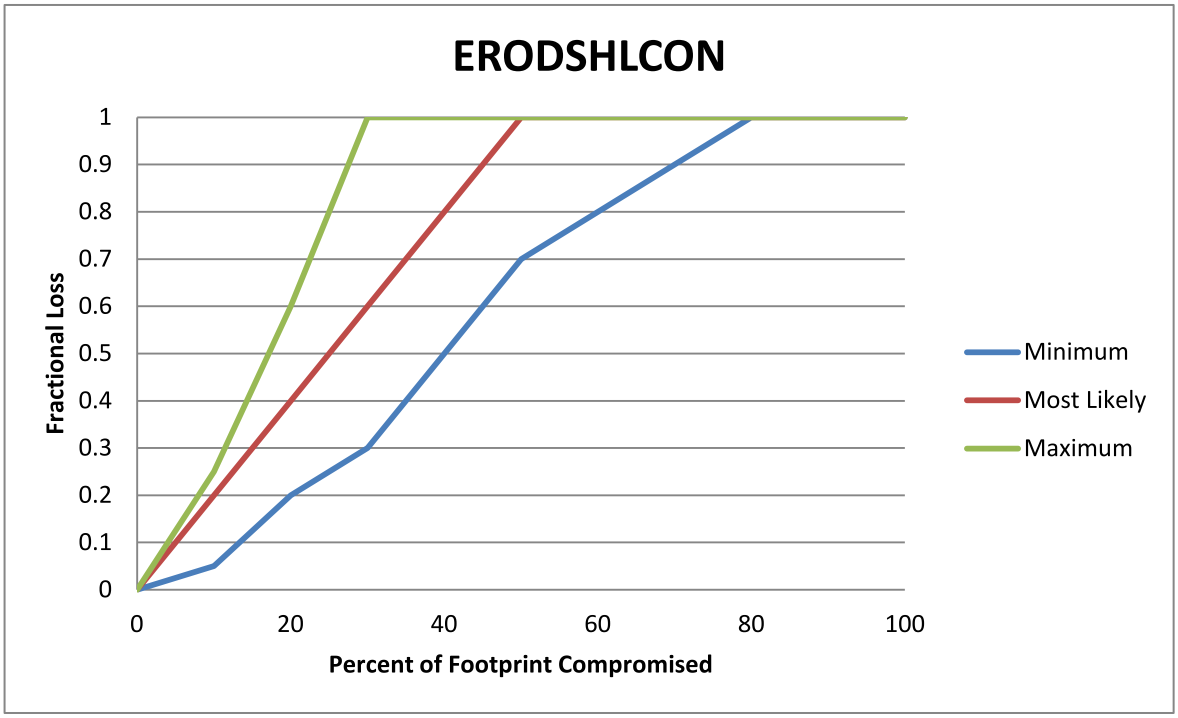
10	0.05	0.2	0.25
20	0.06	0.4	0.6
30	0.08	0.6	1
40	0.1	0.8	1
50	0.17	1	1
60	0.32	1	1
70	0.47	1	1
80	0.6	1	1
90	0.7	1	1
100	0.8	1	1



Erosion/Contents Shallow Foundation

Single Family and Walkovers

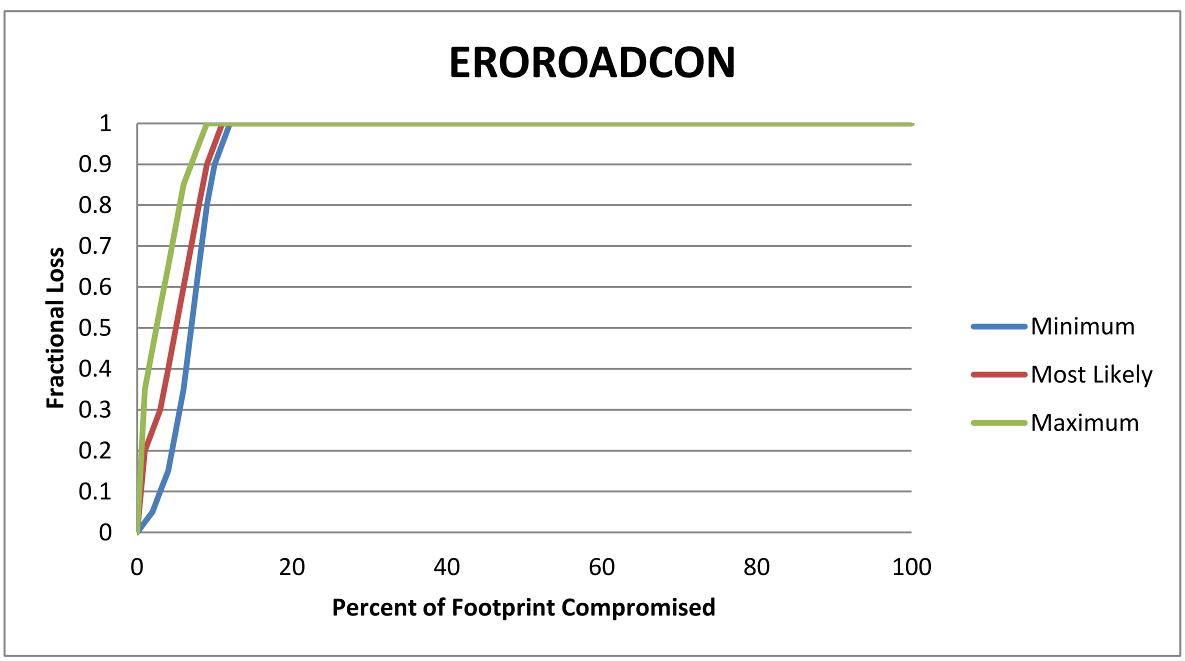
% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0
10	0.05	0.2	0.25
20	0.2	0.4	0.6
30	0.3	0.6	1
40	0.5	0.8	1
50	0.7	1	1
60	0.8	1	1
70	0.9	1	1
80	1	1	1
90	1	1	1
100	1	1	1



Erosion/Contents (Water Main Adjacent to Road)

% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0
1	0.025	0.2	0.35
2	0.05	0.25	0.45

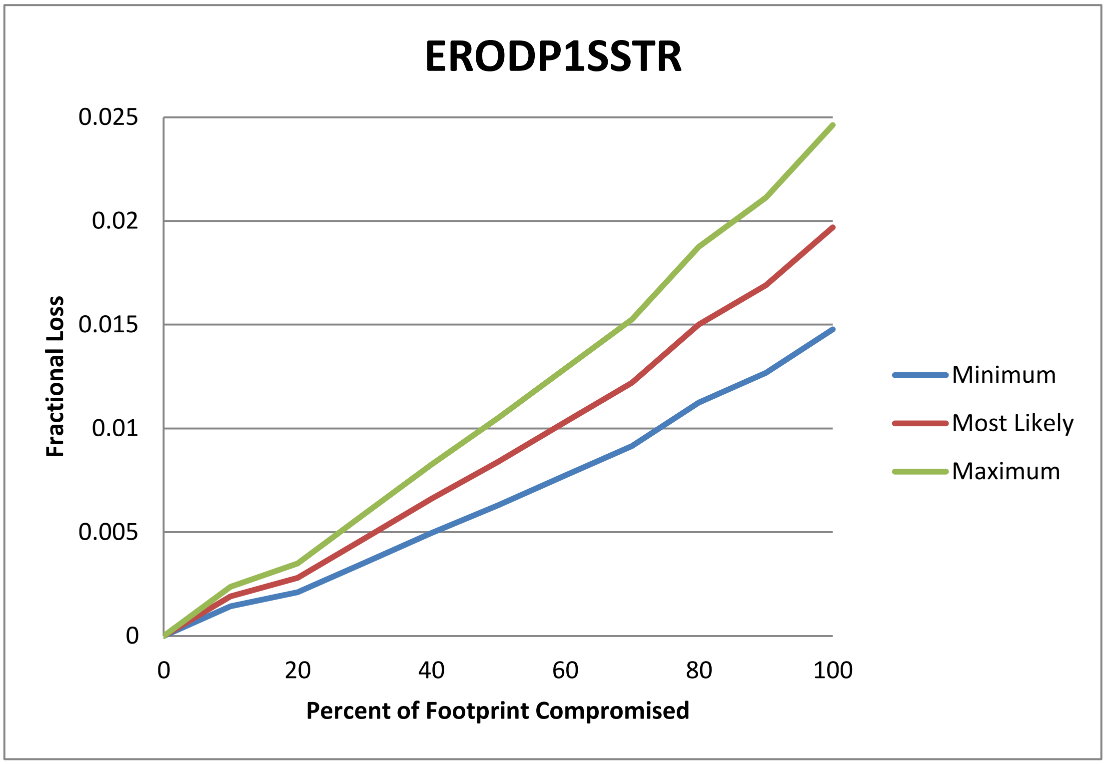
3	0.1	0.3	0.55
4	0.15	0.4	0.65
5	0.25	0.5	0.75
6	0.35	0.6	0.85
7	0.5	0.7	0.9
8	0.65	0.8	0.95
9	0.8	0.9	1
10	0.9	0.95	1
11	0.95	1	1
12	1	1	1
100	1	1	1



Erosion/ Structure Deep Piles

Multi-Family and Single Family Dwelling

% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0
10	0.001425	0.0019	0.002375
20	0.0021	0.0028	0.0035
30	0.003525	0.0047	0.005875
40	0.00495	0.0066	0.00825
50	0.0063	0.0084	0.0105
60	0.007725	0.0103	0.012875
70	0.00915	0.0122	0.01525
80	0.01125	0.015	0.01875
90	0.012675	0.0169	0.021125
100	0.014775	0.0197	0.024625

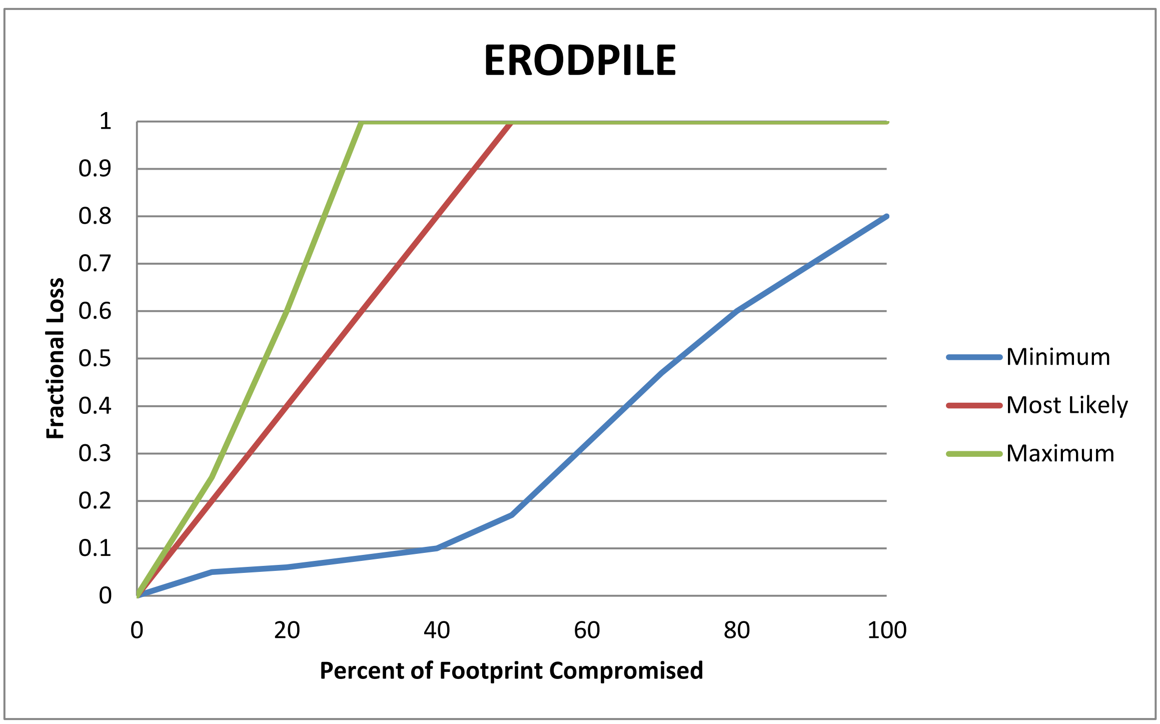


Erosion/Structure Piles

Single Family Dwelling and Walkovers

% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0

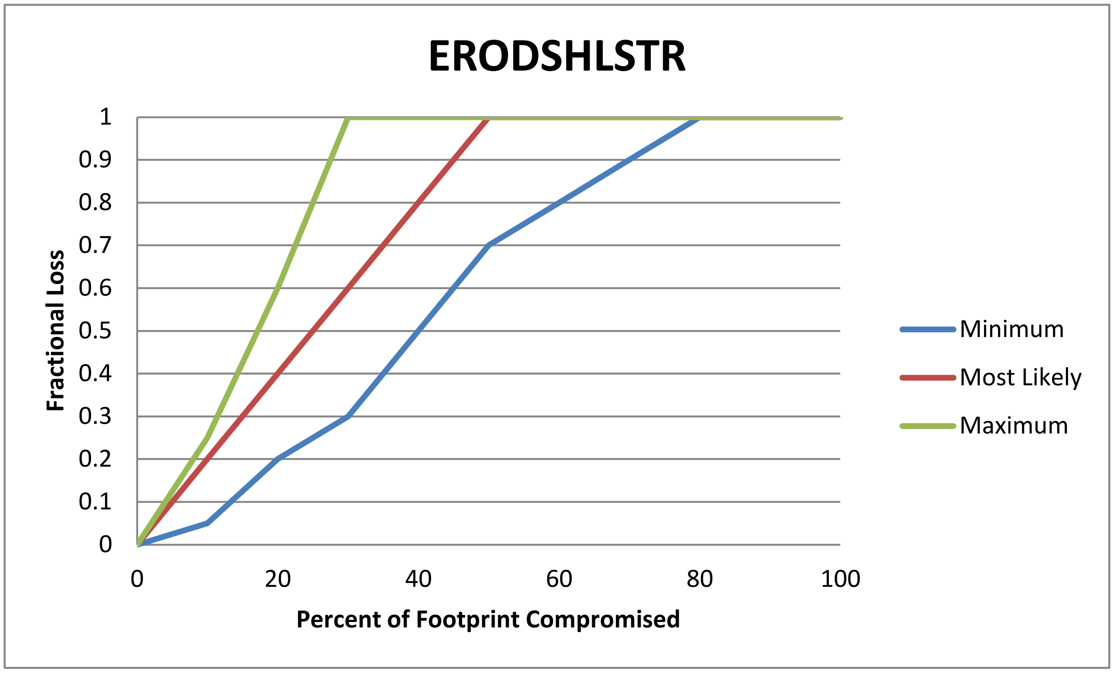
10	0.05	0.2	0.25
20	0.06	0.4	0.6
30	0.08	0.6	1
40	0.1	0.8	1
50	0.17	1	1
60	0.32	1	1
70	0.47	1	1
80	0.6	1	1
90	0.7	1	1
100	0.8	1	1



Erosion/Structure Shallow Foundation

Single Family Dwelling and Walkovers

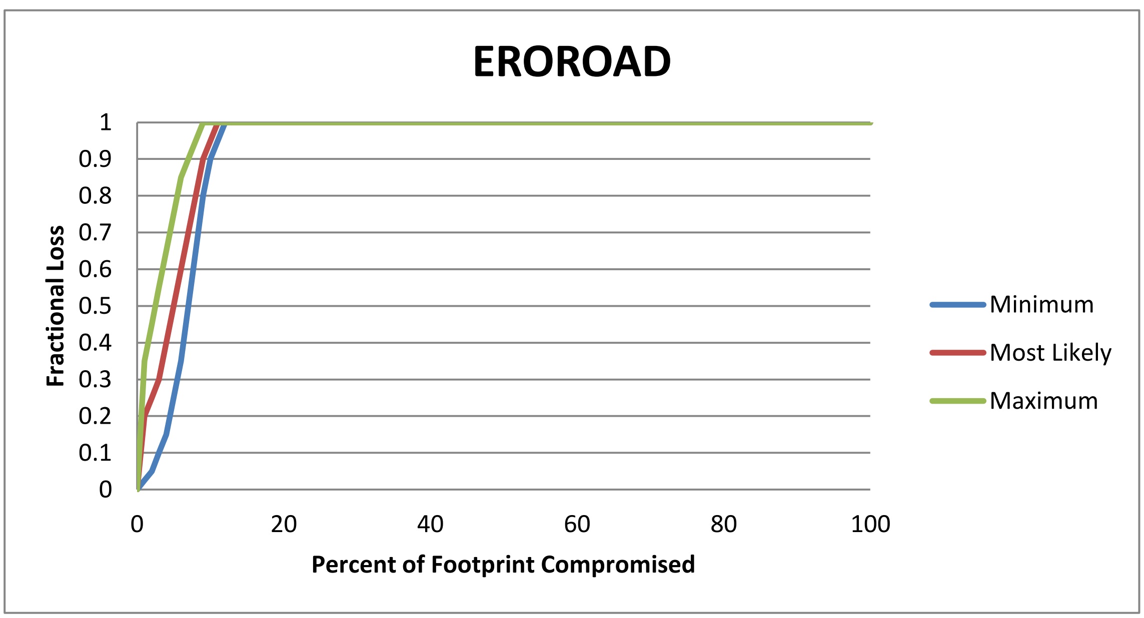
% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0
10	0.05	0.2	0.25
20	0.2	0.4	0.6
30	0.3	0.6	1
40	0.5	0.8	1
50	0.7	1	1
60	0.8	1	1
70	0.9	1	1
80	1	1	1
90	1	1	1
100	1	1	1



Erosion/ Structure Road

% of Footprint Compromised	Minimum	Most Likely	Maximum
0	0	0	0
1	0.025	0.2	0.35
2	0.05	0.25	0.45

3	0.1	0.3	0.55
4	0.15	0.4	0.65
5	0.25	0.5	0.75
6	0.35	0.6	0.85
7	0.5	0.7	0.9
8	0.65	0.8	0.95
9	0.8	0.9	1
10	0.9	0.95	1
11	0.95	1	1
12	1	1	1
100	1	1	1

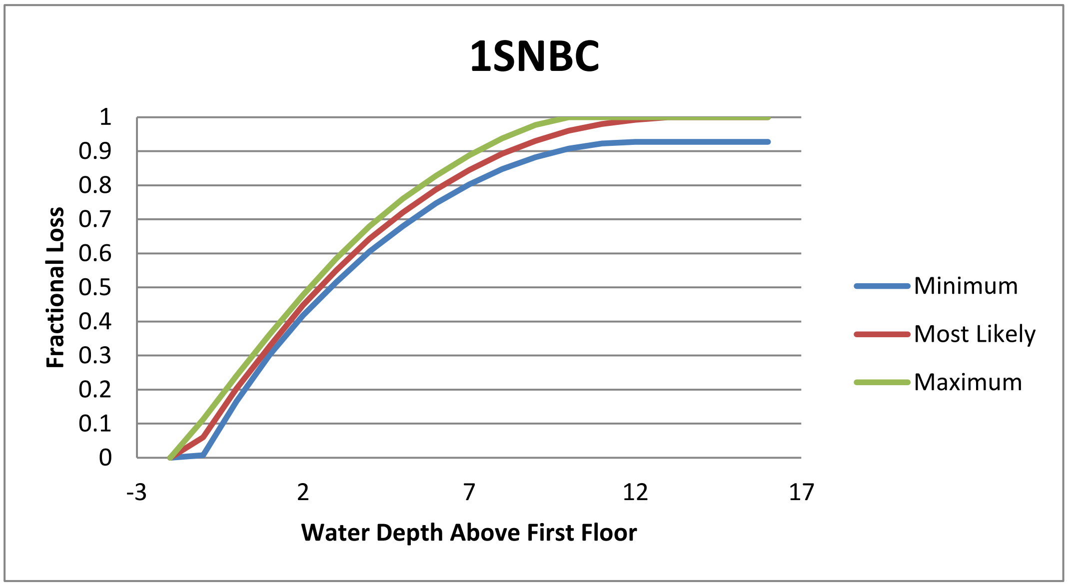


Inundation/Contents All Foundations

Multi-family and Single Family Dwellings

Water Depth Above 1st Floor	Minimum	Most Likely	Maximum
-2	0	0	0
-1	0.0075	0.06	0.1125
0	0.165	0.2025	0.24
1	0.3025	0.3275	0.3625
2	0.4175	0.4475	0.4775
3	0.515	0.55	0.585
4	0.605	0.6425	0.68
5	0.68	0.72	0.76
6	0.7475	0.7875	0.8275
7	0.8025	0.845	0.8875
8	0.8475	0.8925	0.9375
9	0.8825	0.93	0.9775
10	0.9075	0.96	1
11	0.9225	0.98	1
12	0.9275	0.9925	1
13	0.9275	1	1
14	0.9275	1	1

15	0.9275	1	1
16	0.9275	1	1

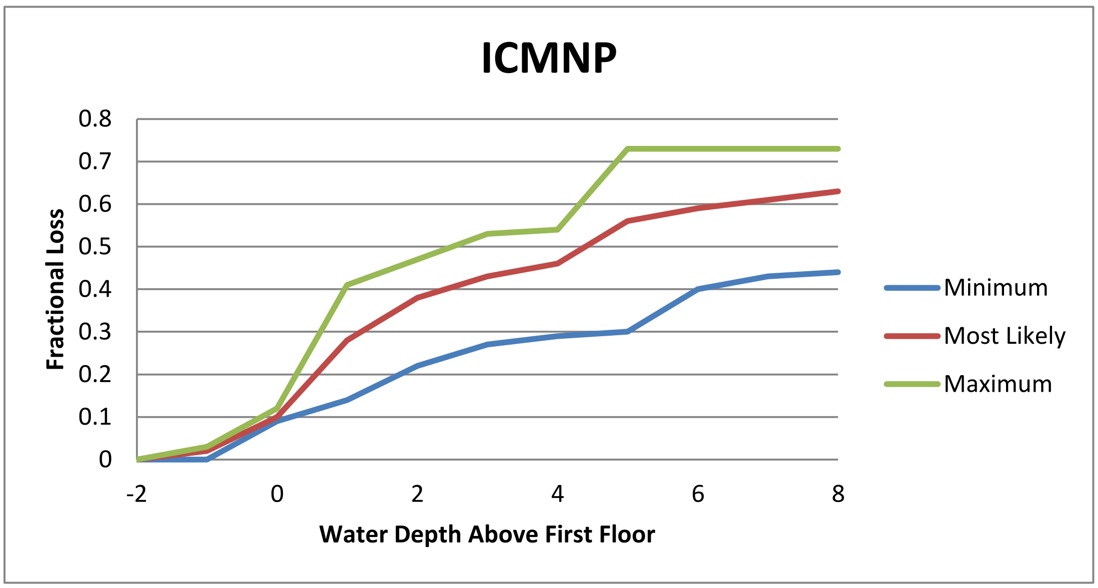


Inundations/Structure Shallow Foundation/Masonry

Single Family Dwelling

Water Depth Above 1st Floor	Minimum	Most Likely	Maximum
-2	0	0	0
-1	0	0.02	0.03
0	0.09	0.1	0.12
1	0.14	0.28	0.41
2	0.22	0.38	0.47

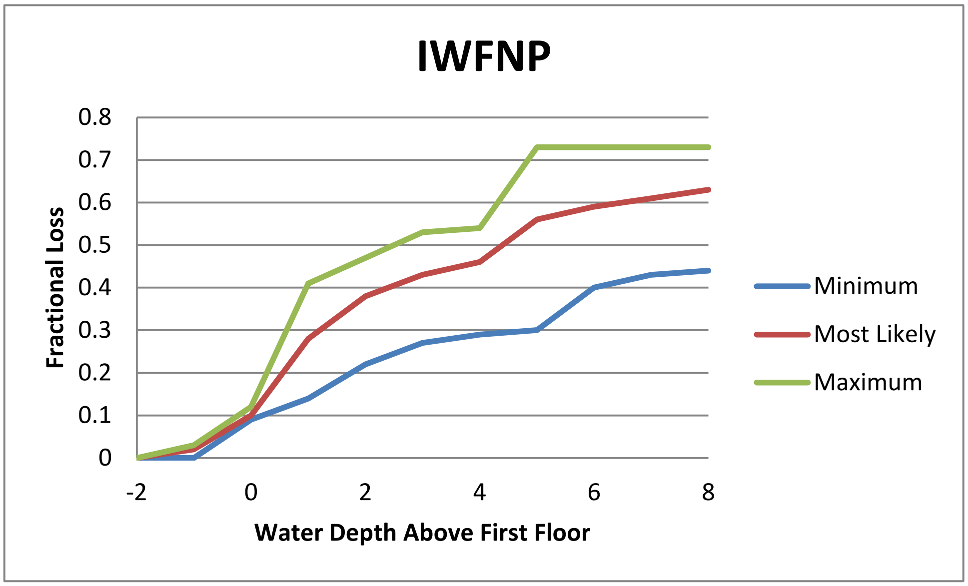
3	0.27	0.43	0.53
4	0.29	0.46	0.54
5	0.3	0.56	0.73
6	0.4	0.59	0.73
7	0.43	0.61	0.73
8	0.44	0.63	0.73



Inundation/Structure/Shallow Foundation/Wood

Single Family Dwelling

Water Depth Above 1st Floor	Minimum	Most Likely	Maximum
-2	0	0	0
-1	0	0.02	0.03
0	0.09	0.1	0.12
1	0.14	0.28	0.41
2	0.22	0.38	0.47
3	0.27	0.43	0.53
4	0.29	0.46	0.54
5	0.3	0.56	0.73
6	0.4	0.59	0.73
7	0.43	0.61	0.73
8	0.44	0.63	0.73

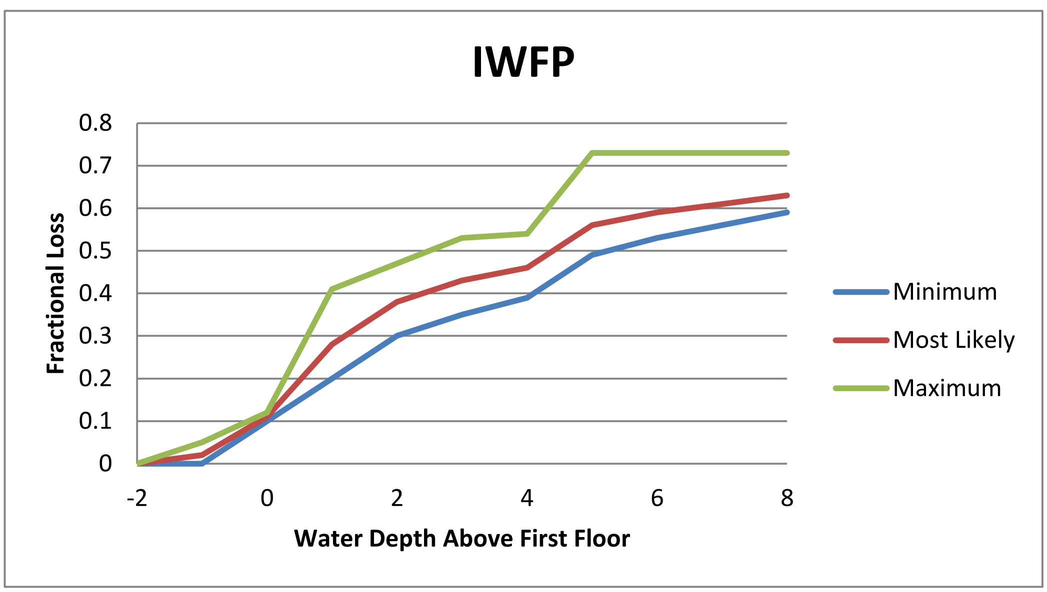


Inundation/Structure All Piles

Single Family and Multi-Family Dwelling

Water Depth Above 1st Floor	Minimum	Most Likely	Maximum
-2	0	0	0

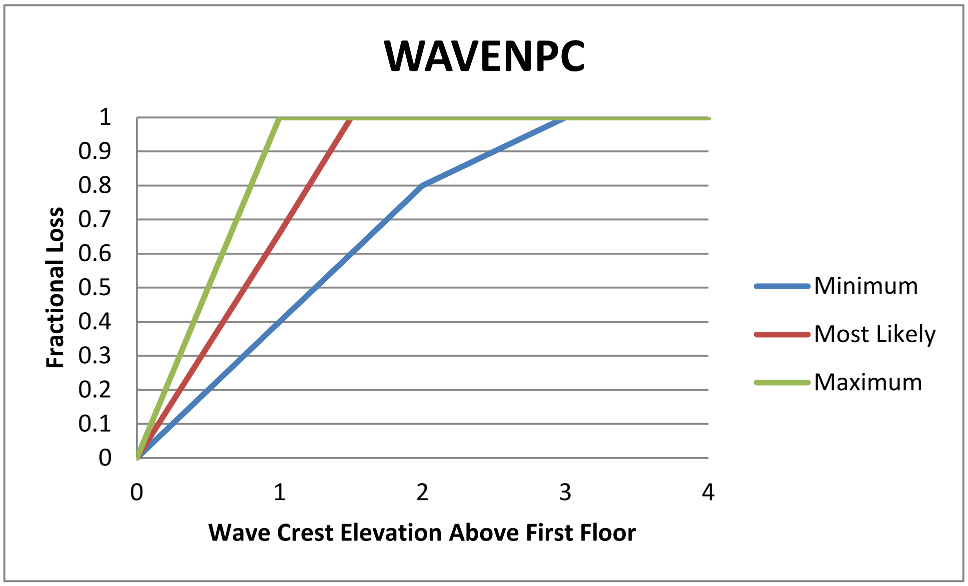
-1	0	0.02	0.05
0	0.1	0.11	0.12
1	0.2	0.28	0.41
2	0.3	0.38	0.47
3	0.35	0.43	0.53
4	0.39	0.46	0.54
5	0.49	0.56	0.73
6	0.53	0.59	0.73
7	0.56	0.61	0.73
8	0.59	0.63	0.73



Wave/Contents/Shallow Foundation

Single Family Dwelling

Wave Crest Elevation Above 1st Floor	Minimum	Most Likely	Maximum
0	0	0	0
0.5	0.2	0.33	0.5
1	0.4	0.66	1
1.5	0.6	1	1
2	0.8	1	1
2.5	0.9	1	1
3	1	1	1
3.5	1	1	1
4	1	1	1

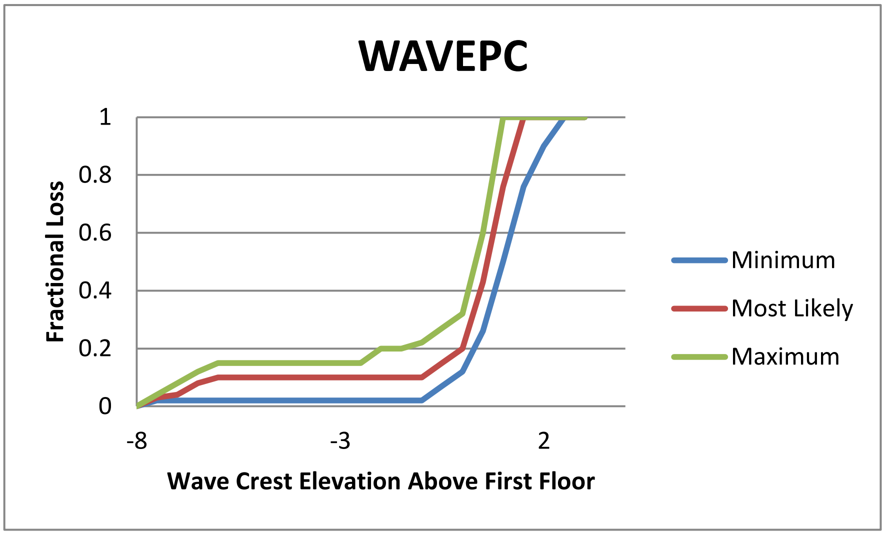


Wave/Contents Pile Foundation

Single Family Dwelling, Multi-family Dwelling and Walkovers

Wave Crest Elevation Above 1st Floor	Minimum	Most Likely	Maximum

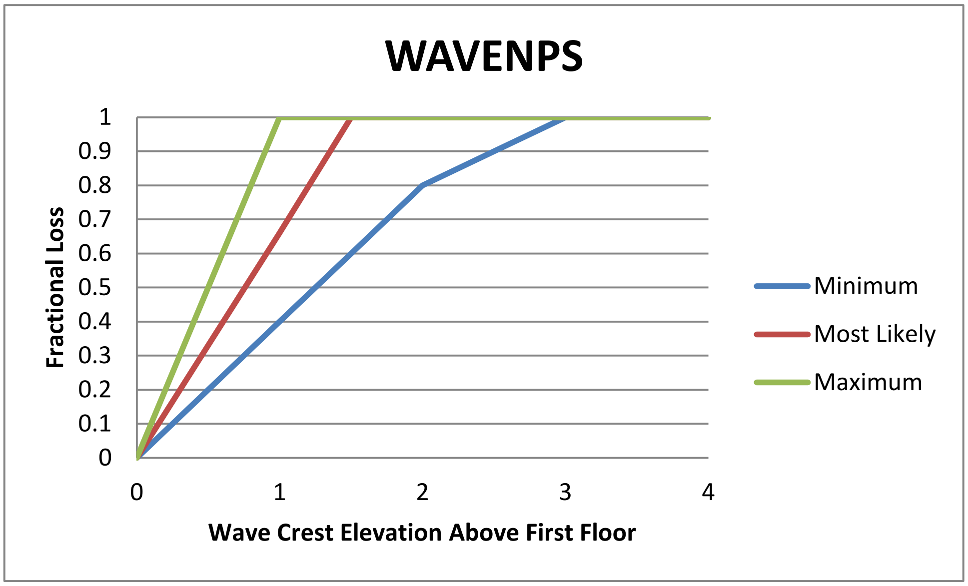
-8	0	0	0
-7.5	0.02	0.03	0.04
-7	0.02	0.04	0.08
-6.5	0.02	0.08	0.12
-6	0.02	0.1	0.15
-5.5	0.02	0.1	0.15
-5	0.02	0.1	0.15
-4.5	0.02	0.1	0.15
-4	0.02	0.1	0.15
-3.5	0.02	0.1	0.15
-3	0.02	0.1	0.15
-2.5	0.02	0.1	0.15
-2	0.02	0.1	0.2
-1.5	0.02	0.1	0.2
-1	0.02	0.1	0.22
-0.5	0.07	0.15	0.27
0	0.12	0.2	0.32
0.5	0.26	0.43	0.6
1	0.5	0.76	1
1.5	0.76	1	1
2	0.9	1	1
2.5	1	1	1
3	1	1	1



Wave/Structure/Shallow Foundation

Single Family Dwelling

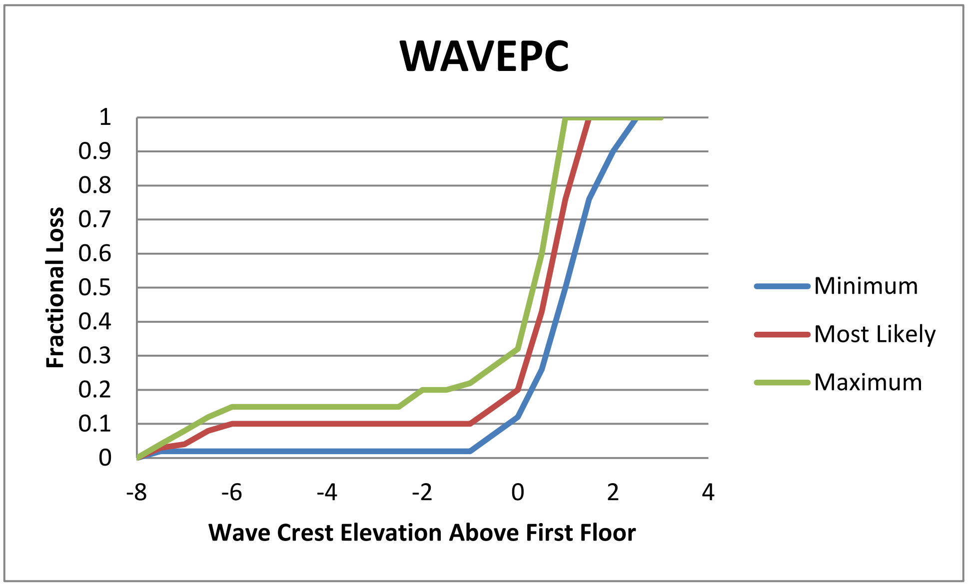
Wave Crest Elevation Above 1st Floor	Minimum	Most Likely	Maximum
0	0	0	0
0.5	0.2	0.33	0.5
1	0.4	0.66	1
1.5	0.6	1	1
2	0.8	1	1
2.5	0.9	1	1
3	1	1	1
3.5	1	1	1
4	1	1	1



Wave/Contents/Pile Foundation

Single Family Dwelling, Multi-Family Dwelling and Walkovers

Wave Crest Elevation Above 1st Floor	Minimum	Most Likely	Maximum
-8	0	0	0
-7.5	0.02	0.03	0.04
-7	0.02	0.04	0.08
-6.5	0.02	0.08	0.12
-6	0.02	0.1	0.15
-5.5	0.02	0.1	0.15
-5	0.02	0.1	0.15
-4.5	0.02	0.1	0.15
-4	0.02	0.1	0.15
-3.5	0.02	0.1	0.15
-3	0.02	0.1	0.15
-2.5	0.02	0.1	0.15
-2	0.02	0.1	0.2
-1.5	0.02	0.1	0.2
-1	0.02	0.1	0.22
-0.5	0.07	0.15	0.27
0	0.12	0.2	0.32
0.5	0.26	0.43	0.6
1	0.5	0.76	1
1.5	0.76	1	1
2	0.9	1	1
2.5	1	1	1
3	1	1	1


WAVEPC
Fractional Loss
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-8
-6
-4
-2
0
2
4
Wave Crest Elevation Above First Floor
Minimum
Most Likely
Maximum

Attachment 2

Edisto Beach

Recreation Benefits Analysis:

Table of Contents

Introduction:

The purpose of this section is to estimate National Economic Development (NED) recreation benefits that will accrue as a result of implementing the tentatively selected coastal storm damage reduction plan on Edisto Beach. It is noted that the tentatively selected plan is not formulated for recreation benefits. They are considered incidental to the primary project purpose of storm damage reduction. NED benefits are economic benefits which accrue to the nation as a whole. They should not be confused with regional economic benefits which include localized impacts that are primarily transfers from a national perspective. All benefit values are stated in constant FY13 dollars. A project life of 50 years and a federal discount rate of 3.75 percent are used in the analysis.

Currently, there are no private beaches in the project area, they are all for public use. Edisto Beach provides parking for the general public. At some access points there are parking lots that provide for up to 150 cars. The other access points have parking along the streets that are permitted by the town. The State of South Carolina recognizes that in order participate in beach nourishment projects public access is a must and therefore protects and promotes public access to the state's beaches. Parking is a reasonable walking distance to the beach.

Evaluation Procedure:

The evaluation procedure used for this report is the Unit Day Value method (UDV). This method relies on expert or informed opinion and judgment to estimate the average willingness to pay of recreational users. Unit Day Value (UDV) method was selected as the evaluation procedure because there are no specialized recreational activities for the area and the annual visits expected do not exceed 750,000.

Location:

The Town of Edisto Beach (the Town) and Edisto Beach State Park are part of Edisto Island located in South Carolina. The Town of Edisto Beach occupies the central and southern portions of the island and is generally separated from Edisto Beach State Park by State Highway 174. Its beachfront extends approximately 4.5 miles between Highway 174 and the South Edisto River/St. Helena Sound. The town has been developed as a permanent and seasonal residential area with limited commercial development. Edisto Beach State Park occupies approximately 1,255 acres of the island and is structured around a dense live oak and maritime forest. It offers ocean and marsh side camping sites, as well as cabins, picnic areas, and nature and hiking trails.

The park had approximately 312,640 recorded visitors in 2012. Its beachfront extends approximately 1.5 miles between Jeremy Inlet and Highway 174.

Competing Resources:

Edisto Beach provides a variety of recreational activities including sunbathing, swimming, beachcombing, walking/jogging, cycling, fishing, surfing, sand sculpting, beach games and has become increasingly popular for weddings, parties and receptions. The Town has 4.67 miles of bike/walking trails integrated throughout the town that provide recreational activities for the public. Competing resources are other beaches such as Isle of Palms, Hilton Head, Sullivan Beach, Kiawah Island and Folly Beach. However, Edisto Beach is one of the few remaining un-commercialized, family-oriented beaches on the coast of South Carolina.

Benefit Evaluation:

In order to determine the recreation benefits of the tentatively selected plan an economic value must be placed on the recreation experience at the Edisto Beaches. By applying a unit day value to estimated use, an approximation is obtained that will be used to estimate project recreation benefits. For this analysis, general unit day values (UDV) are used to determine the economic value of recreation at Edisto Beach. UDV are administratively determined values which represent the NED recreation values for typical types of recreation. Guidance for their use is provided by Engineering Regulation 1105-2-100.

Current Visitation:

In 2012, the Town of Edisto Beach area had approximately 371,000 beach visitors. Traffic counts combined with estimated rentals determine expected visitors per year. This estimate is based on data provided by the Town of Edisto Beach. Visitation is generally constrained by availability of beach area only during peak days and is not limited at other times of the year. The peak recreation season is Memorial Day through Labor Day. Recreational visitation reaches a peak four times a year. These times are Spring Break, Memorial Day, Independence Day and Labor Day. Table 1 shows annual visitation from 2009 to 2012.

Table 25: Edisto Beach Annual Visitation

Year	Visitation
2009	245,000
2010	297,500
2011	350,000
2012	371,000

Parking and Access:

Public parking along the right of way in the Town of Edisto's streets is permitted by the Town. There are 113 on street parking spaces. There are 24 public access points that provide an additional 214 parking spaces. There are two private parking areas that provide additional parking; Pavilion Pier and the facility at the Wyndham Resort. The State Park also provides some parking for those visitors who park at the State Park and recreate on the Edisto Beaches outside of the park limits due capacity constraints at the park. Edisto Beach has 206 off-street parking spaces with an additional 113 on street parking spaces, these totals 319 designated parking spaces. Some of the remaining beach capacity could be used by the public dropping visitors off without parking, and residence and vacationers of Edisto Beach.

There are a total of 38 public access points, excluding the State Park, in Edisto Beach that lie along Palmetto Boulevard, Point Street and Yacht Club Road. Each access is marked with a highly reflective blue sign and numbered 1 thought 38 for notification of where the accesses are located. The average width of each access is 50 feet with an average distance between each access point of 400ft. Maintenance is performed on an annual basis at each access point by volunteer groups and town personnel. There is a private access area that serves Wyndham Resorts, but the right of way leading to the facility is owned by the Town. This facility is accessible to the public and contains a drop off area for a tram shuttle, concessions, showers, restrooms, handicap access, among other amenities.

According to ER1105-2-100, reasonable access is access approximately every one-half mile or less. Each access point is identified with "Beach Access" signs. The 38 access points are exclusive of the State Park. Provisions of reasonable public access rights of ways are present in

Edisto Beach. The following table shows the beach access location and facilities at each location.

Table 26: Edisto Beach Parking and Access

	PARKING & ACCESS								
Location	Feet Between Access Points	Sign Number	Pedestrian Only	Boardwalk	Walkover	Off-Street Parking	On-Street Parking	Handicapped Access	Signage
Coral St	842	1					x		x
Fenwick St	807	1a	x				x		x
Mary St	829	2	x				x		x
Whaley St	791	3	x				x		x
Matilda St	797	4	x				x		x
Cupid St	787	5	x				x		x
Atlantic St	802	6	x				x		x
Portia St	797	7	x				x		x
Dawhoo St	300	8				6	x		x
Cheehaw St	288	9				11	x		x
Osceola St	290	10				8	x		x
Byrd St	300	11	x				x		x
Nancy St	302	12				5	x		x
Thistle St	317	13				11	x	x	x
Chancellor St	300	14	x				x		x
Dorothy St	300	15	x				x		x
Marianne St	284	16				10	x	x	x
Lybrand St	300	17		x	x	10	x	x	x
Catherine St	300	18	x	x			x		x
Mitchell St	303	19			x	15	x	x	x
Baynard St	300	20	x		x	2	x	x	x
Edings St	300	21		x	x	7	x	x	x
Jenkins St	300	22				4	x	x	x
Seabrook St	300	23				10	x	x	x
Murray St	300	24				10	x	x	x
Holmes St	308	25				10	x	x	x
Loring St	300	26				10	x	x	x
Laroche St	300	27				10	x	x	x
Neptune St	907	28	x				x	x	x
Billow St	300	29	x	x			x		x

	PARKING & ACCESS								
Location	Feet Between Access Points	Sign Number	Pedestrian Only	Boardwalk	Walkover	Off-Street Parking	On-Street Parking	Handicapped Access	Signage
White Cap St	350	30				9	x	x	x
Edisto St.	387	31				6	x	x	x
Mikell St.	599	32		x		2	x	x	x
Townsend St.	1249	33	x				x		x
Louise St.	600	34	x	x			x		x
Ebb Tide St.	1425	35		x	x	4	x	x	x
Yacht Club Rd.	865	36	x	x			x		x
Yacht Club Rd.		37		x		2	x		x

Beach Area and Capacity:

Beach area acts as a constraint on the number of visitors that will visit the Edisto Beaches during peak days. To measure the beach capacity of the existing condition, the existing condition beach profile was used to calculate the total area that can be used for recreation. The total length of the project in which beach visitors can recreation on the existing berm is 27,128 feet. The length is then multiplied by the berm width of the given reach to determine the total area of that reach. The total area of all reaches in which recreation occurs for the Without project condition is 944,965 square ft. It is assumed that each visitor will require 100 square feet of beach each day. In the Without project condition, Edisto Beach parking areas are capable of supporting 9,450 users per day. In the With Project condition, the total beach area is 956,371and the beach is capable of supporting 9,565 visitors per day. Assuming an average of 4 persons per automobile and a turnover rate of 1.5 cars per parking space per day because some visitors spend only part of the day at the beach, the 319 parking spaces will support visitation of about 1,914. Besides the parking spaces and spill over from the State Park, Edisto Beach has the potential to receive many more visitors. The entire Town of Edisto has the capability of walking to the beach. The structures are located such that the distance for a walk to the beach on the island is a half mile or less. There are about 2,400 residences in walking distance to the beach.

Without and With Project Values:

The UDV are determined using a point system that takes into account the following factors: recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental (esthetics) quality. A good deal of judgment is required in the assessment of point values. A group of five planning professionals and experts of the study area made independent judgments of the UDV values which were averaged. The differences in the values were applied to the estimated visitation. The difference in the Without and With project values of recreation determine the NED recreation benefits. The source of the value of recreation is obtained from the Economic Guidance Memorandum, 13-03, Unit Day Values for Recreation for Fiscal Year 2013.

Point System:

Recreation Experience. Under the Without project condition, Edisto beaches have several general recreation activities including swimming, boating, picnicking, crabbing, shrimping, kayaking and sunbathing, providing a recreation experience equivalent to 16 points out of 30. In the With project condition, it is assumed the beach area will provide for a better recreation experience due to the beach area being increased and the project being maintained to a certain template and received a rating of 28.

Availability of Opportunity. Availability of opportunity is considered high because there are not similar beaches within 30 minutes to one hour driving time. Edisto Beach is rare because it remains one of the few family-oriented, gently developed beaches in South Carolina. Because there are not a large number of competing recreation opportunities, this category was 16 points out of 18 in the Without project condition and 18 points in the With project condition.

Carrying Capacity. The carrying capacity of the facilities is considered adequate to conduct recreation during peak demand days, although facilities can certainly be strained at those times. The carrying capacity is the same in the Without and With project condition and a rating of 13 out of 14 was given to both conditions.

Accessibility. The project is considered very accessible, with high quality roads to the site and 38 access points within the site. This equates to 13 points out of a total of 18 both for the With and Without project conditions since the conditions will not change.

Environment. A rating of 4 out of a total of 20 points was awarded because the current aesthetic value is of average quality. Under the With project condition, it was felt that the additional beach width would result in an increase in esthetic value during peak days. It is expected the aesthetic quality of the beach will be enhanced as a result of the project and will not degrade over time due to erosion as would occur in some areas in the Without project condition and a With project condition value of 15 is applied.

The UDV point totals convert to a recreation value of $9.02 in the Without project condition and the $10.57 in the With project condition per Economics Guidance Memorandum, 13-03, Unit Day Values for Recreation, Fiscal Year 2013. The difference in the Without and With project conditions general recreation values is $1.55. The dollar values for UDV scores of 62 and 85 were obtained by interpolating between 60 and 70 in the Without project condition and 80 and 90 in the With project condition. Table 3 shows the UDV for Edisto Beach.

Table 27: UDV for Edisto Beach

Criteria	W/O Project Points	W/ Project Points
Recreation Experience	16	28
Availability of Opportunity	16	18
Carrying Capacity	13	13
Accessibility	13	13
Environment (Esthetics)	4	15
Total Points	62	85
General Recreation Value	$9.02	$10.57

Because Edisto Beach is already a public beach, there will be no new visitation based on the beach becoming accessible to the general public due to a Federal project. It is assumed that the 2012 visitation is indicative of future visitation given that the Edisto Island beach front is almost fully developed and generally there is no more room for parking areas. However, it is recognized that visitation could be much higher than reported due to the homes and vacation rentals being in walking distance from the beach and spill over from the State Park. Applying the unit day values of $9.02 in the Without project condition of 62 total points and $10.57 for the With project condition of 85 points results in annual recreation benefits of approximately $573,200. Table 4 shows the benefit to cost ratio analysis with recreation benefits.

Table 28: Summary of Benefits and Cost

Average Annual CSDR Benefits	$ 2,482,600
Average Annual Recreation Benefits	$ 573,200
Total Average Annual Benefits	$ 3,055,800
Total Average Annual Cost	$ 1,804,900
Benefit-to-Cost Ratio	1.7
Net Benefits	$ 1,250,860