Pawcatuck River, Rhode Island
Coastal Storm Risk Management
Feasibility Study

APPENDIX B: ECONOMICS

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PREPARED BY:
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
NEW ENGLAND DISTRICT

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1.0 Introduction

The purpose of this appendix is to evaluate the economic feasibility of providing coastal storm damage risk reduction along the southern coast of Rhode Island, in Washington County. This appendix will provide details for major decision points along the study timeline beginning with the original study areas through the selection of the National Economic Development (NED) alternative. The analysis includes an evaluation of existing coastal storm damages, evaluation of alternatives, and calculation of coastal storm damage reduction benefits. Structural and non-structural plans were screened for cost-effectiveness based on with- and without-project damages and calculation of benefit-cost ratios. The economic analysis is consistent with Federal water resources policies and practices, including Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G, 1983) and the Corps Planning Guidance Notebook (ER-1105-2-100, 22 April 2000). Costs and benefits are evaluated at the August 2016 price level using the 2016 Federal interest rate for water resources projects of 3.125%.

2.0 Description of Original Study Areas

The original study area contained five separate locations along the coastline of southern Rhode Island extending approximately 28 miles from Misquamicut Beach in Westerly to Point Judith in Narragansett. The five original areas are shown in Figure 1 below and defined as follows:

- Area 1, furthest west, is the Misquamicut area in the town of Westerly, from Little Maschaug Pond to Winnapaug Pond Breachway.
- Area 2 is the barrier beach and property located behind it; spanning the towns of Charlestown and South Kingstown.
- Area 3 is located at Matunuck in South Kingstown and extends from Roy Carpenter's Beach to Matunuck Point.
- Area 4 is located in a small part of Narragansett known as Sand Hill Cove and is the eastern most study area indicated in Figure 1 below.
- Area 5 is the low lying area surrounding Point Judith Pond indicated by the dashed line in Figure 1. This area was added only after the vertical team advised analyzing the feasibility of a hurricane barrier across Point Judith inlet.

Damage areas were identified based on elevation data, structure density, and discussions with town and state officials regarding high damage-prone areas and history of coastal storm damages. A key component of choosing the original study areas was USACE's ability to construct projects to alleviate coastal storm damage risk while contributing to the NED objective.

Structures in the damage areas are generally single family homes in good condition. The study area is generally flat with coastal ponds and barrier beaches along the shoreline. All four towns are in the 2nd Congressional District of Rhode Island.

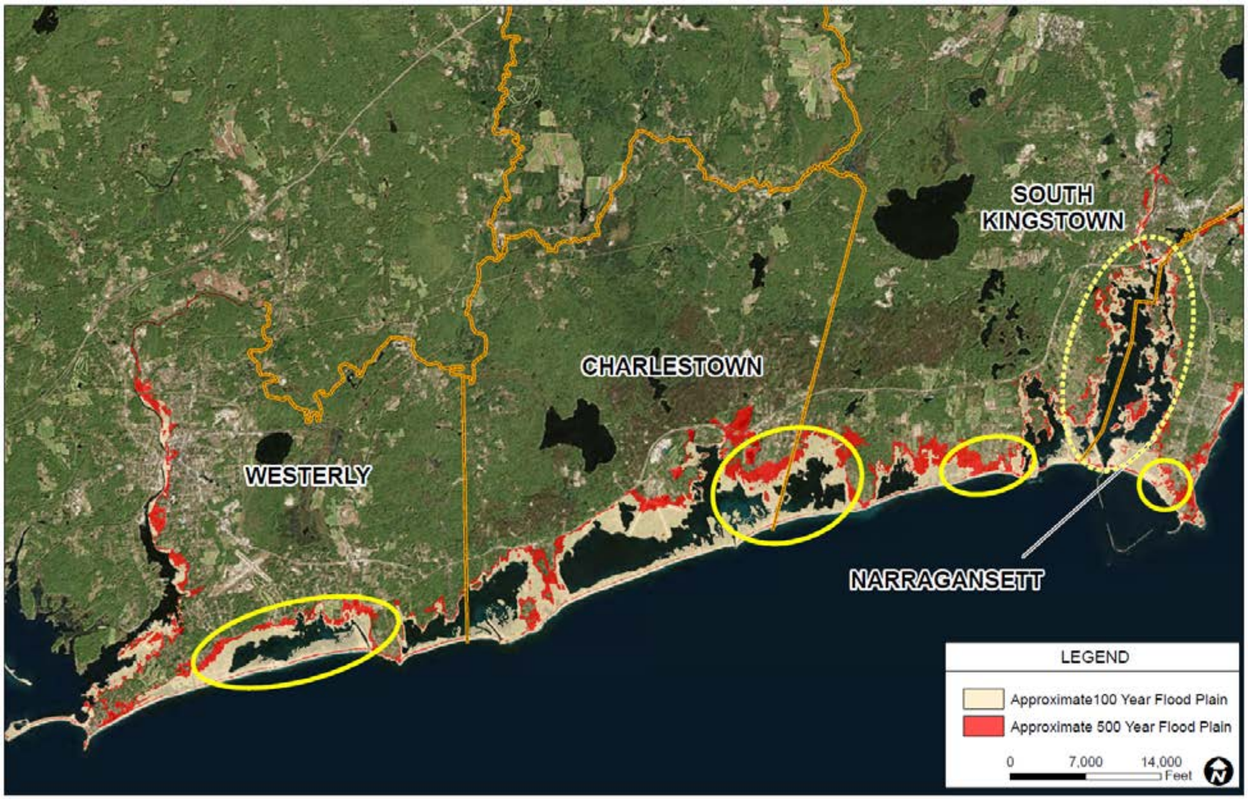

Figure 1 Original Study Areas - RI Coast

2.1 Area 1 - Westerly

The Westerly study area is located around Winnapaug Pond, including the backshore and along the Atlantic beach front. The Misquamicut area in Westerly includes residential properties located in Misquamicut, a small beach front community within the town of Westerly, and Misquamicut State Beach. Beach homes, hotels and other structures were damaged by hurricanes in 1938, 1944 and 1954. Recreational development associated with the Misquamicut State Beach includes a bathing pavilion; a structure that includes a bathhouse building, a concession building with a gift shop and offices, a lifeguard tower and shade gazebos.

These structures were damaged and much of the sand from the beach was blown into the parking lot and street during Hurricane Sandy in October 2012. Approximately 30,000 cubic yards of sand were bulldozed back onto the dunes and beach by the State. A beach sand renourishment project was completed on Misquamicut Beach by the U.S. Army Corps of Engineers in 2015 using an upland sand source. Misquamicut State Beach in Westerly is owned by Rhode Island

Department of Environmental Management and managed by the Division of Parks and Recreation. It is a major recreational resource that attracted over 268,000 visitors during the summer of 2015 (http:///www.providencejournal.com/article/20151009/NEWS/151009339). The beach provides recreational opportunities to local residents and the general public. It is also of importance to commercial establishments, since visitors to the beach spend money in nearby businesses. There are 2600 parking spots available for a fee that provides funds for the RIDEM Area Recreation and Development Fund.

2.2 Area 2 - Charlestown Beach

Charlestown Beach is also primarily residential, located between the Charlestown Breachway and the southeastern side of Trustom Pond. Trustom Pond consists of 800 undeveloped acres managed by the National Wildlife Refuge. The Charlestown barrier beach area includes shorefront as well as some backshore properties in Charlestown and South Kingstown. The area contains Charlestown Beach and Green Hill Beach.

Charlestown Beach is one of several communities along the barrier beach, most of which date from the late nineteenth century. The 1938 hurricane destroyed or damaged 185 cottages at Charlestown Beach and several people died. New buildings were demolished by Hurricane Carol in 1954, but most of the houses damaged then were rebuilt. In 2013, Hurricane Sandy severely eroded Charlestown Beach. The storm also destroyed two homes and caused major and minor damage to over 30 others, resulting in a total of $1.5 million in damage claims to the National Flood Insurance Program.

Due to lack of parking, Green Hill Beach in South Kingston is mostly utilized by local residents. In 2013 Hurricane Sandy destroyed the landmark Green Hill Beach Club, which was reopened in 2016.

2.3 Area 3 – Matunuck Beach

The Matunuck area is in South Kingstown and includes the area from Roy Carpenter’s Beach to Matunuck Point. It is considered one of the most densely settled summer communities along the entire Rhode Island shore. At Matunuck Beach, there are several hotels and cottages to accommodate visitors. In 2013, Hurricane Sandy eroded as much as 50 feet of beach. Some cottages at Roy Carpenter’s Beach were destroyed when the sand underneath them was swept away

In total, South Kingstown contains over ten miles of beaches. Although no homes were destroyed by Hurricane Sandy, at least a dozen homes sustained major damage resulting in $3.5 million in claims to the National Flood Insurance Program.

2.4 Area 4 - Sand Hill Cove

Area 4 is a small Narragansett community located to the west of Point Judith. It includes some commercial development, encompassing the area located south of Spruce Ave between Wheeler Beach and Sand Hill Cove near Stanton Ave.

One housing unit was destroyed in Narragansett during Hurricane Sandy and six units suffered major damage. Following the storm, property owners in the town submitted claims to the National Flood Insurance Program totaling over $4 million.

2.5 Area 5 – Point Judith

Area 5 in South Kingstown is nearly all residential, located around on the shoreline of Point Judith Pond or Great Island in the middle of Point Judith Harbor. Galilee, a fishing village located in Narragansett, is a working harbor that remains home to the largest fishing fleet in Rhode Island with commercial fisherman and lobstermen as well as deep sea fish cruises.

3.0 Socioeconomics

3.1 Demographics and Housing

Based on the 2010 census, the four towns in the study area had a total population of 77,121 and contained 40,150 housing units. Other than South Kingstown, the towns in the study area showed slight population declines from 2000 to 2010, but all are projected to show slight increases in population through 2040, according to state projections. Actual and projected population for the towns in the study area and the state are shown below. South Kingstown is the largest town in the study area, followed by Westerly. The actual population of all four towns increases in the summer months, with the influx of tourists, boaters, and beach goers.

Table 1 Actual & Projected Population

	2000	2010	% change 2000-2010	Projected 2020	Projected 2030	Projected 2040
Westerly	22,966	22,787	-0.8%	22,876	23,417	23,466
Charlestown	7,859	7,827	-0.4%	8,316	8,912	9,329
South Kingstown	27,921	30,639	9.7%	32,756	35,556	37,684
Narragansett	16,321	15,868	-2.8%	15,998	16,376	16,411
Total	75,067	77,121	2.7%	79,946	84,261	86,890
Rhode Island	1,048,319	1,052,567	0.4%	1,049,177	1,070,677	1,070,104

Sources: 2000 and 2010 - US Census Bureau
Projections - Rhode Island Statewide Planning Program, Technical Paper 162, Rhode Island Population Projections

Additional demographic data and housing data are shown in the table below. The population in the study area towns is primarily white, with other races generally making up less than ten percent of the population. South Kingston and Westerly contain the most housing units in the study area, with 13,218 and 12,320 housing units respectively, of which 18 percent and 15 percent area seasonal or recreational housing units. This is in contrast to the state as a whole, where only 4% of housing units are seasonal or recreational.

Table 2 Demographics and Housing Units

	Westerly	Charlestown	South Kingston	Narragansett	Rhode Island
AGE					
Median age (years)	44.3	47	35.7	40.4	39.4
18 years and over	79.0%	80.8%	82.3%	85.7%	78.7%
21 years and over	76.2%	77.6%	64.8%	77.3%	73.3%
62 years and over	22.5%	22.9%	17.1%	21.0%	17.7%
65 years and over	18.6%	17.7%	13.7%	16.7%	14.4%
RACE					
White (alone)	91.4%	93.9%	89.3%	94.6%	75.1%
Black or African American	0.9%	0.4%	2.0%	0.8%	5.2%
American Indian and Alaska Native	0.6%	1.8%	1.1%	0.7%	0.4%
Asian	2.5%	0.7%	2.6%	0.8%	3.1%
Native Hawaiian and Other Pacific Islander	0.0%	0.0%	0.0%	0.0%	0.0%
Hispanic or Latino (of any race)	2.9%	1.6%	2.8%	1.7%	13.3%
Some Other Race/Two or more races	1.8%	1.6%	2.1%	1.4%	2.9%
HOUSING					
Total Housing units	12,320	5,142	13,218	9,470	462,930
Seasonal, recreational or occasional	1,890	1,648	2,318	2,314	17,077
% seasonal	15%	32%	18%	24%	4%

Source: US Census Bureau, 2010 Census, http://factfinder.census.gov

3.2 Economy and Unemployment

Major employment sectors in the four study area towns include Retail Trade; Arts, entertainment, recreation, accommodations and food service; and Public administration (government). After high unemployment rates in Rhode Island during the economic crisis of 2008 – 2009, many parts of Rhode Island had high unemployment rates of 10% to 12%. However, in recent years the economic recovery has taken hold and the June 2016 unemployment rate in all four towns was below 6%.

Westerly is primarily a town of small employers with strong economic base and a significant history of textile manufacturing and finishing and printing. Of Rhode Island‘s top 100 employers, there are two with headquarters in Westerly: the Westerly Hospital and The Washington Trust Company. Westerly‘s economic base includes many other businesses that cater to the seasonal tourist industries, ranging from bed and breakfast establishments, and other inns and hotels. The Westerly population increases during the summer months due to the presence of seasonal residents and the daily visitors to Westerly‘s beaches.

Charlestown is a small town containing primarily residential development including many seasonal homes. Summer residents and tourists are attracted to the coastal resources and rural character of Charlestown, including several beaches and Ninigret Pond, a large aquatic resource which attracts many boaters. South Kingstown is the largest town in the study area. The largest employer in South Kingstown is the University of Rhode Island. Narragansett is a small town but contains the state's largest fishing port, Point Judith, in the Galilee section of the town. Point Judith often ranks in the top 25 ports in the nation in terms of both pounds landed and dollar value. Landings in 2015 totaled 57 million pounds with a value of $50 million. Narragansett also includes several major beaches, including Narragansett Town Beach, Scarborough State Beach, and Roger Wheeler State Beach. Summary data regarding the unemployment rate, size of labor force, median household income, and employment by industry for each town in the study area are shown in the table below.

Table 3 Employment Data

INCOME & EMPLOYMENT	Westerly	Charlestown	South Kingstown	Narragansett	Rhode Island
Unemployment rate (June 2016)	5.9%	4.8%	5.2%	3.6%	5.1%
Labor Force	11,348	4,100	16,742	9,234	557,539
Median household income (dollars)	$ 62,381	$ 68,904	$ 72,021	$ 65,842	$ 56,423
Employment by Industry					
Agriculture, forestry, fishing and hunting, and mining	not disclosed	not disclosed	83	30	953
Construction	291	166	348	133	17,011
Manufacturing	513	not disclosed	574	89	41,150
Wholesale trade	74	19	659	107	16,922
Retail trade	1,897	135	1,279	651	48,053
Transportation and warehousing, and utilities	62	not disclosed	154	108	10,883
Information	123	20	157	8	8,609
Finance and insurance, and real estate and rental and leasing	329	78	484	188	30,662
management, and administrative and waste management services	276	117	413	211	63,576
Educational services, and health care and social assistance	1,967	138	314	491	99,247
Arts, entertainment, and recreation, and accommodation and food services	2,132	not disclosed	225	1421	56,224
Other services, except public administration	not disclosed	not disclosed	705	205	17,702
Public administration	1,066	213	3,773	989	58,983

4.0 Storm History

A history of storm events that have impacted coastal Rhode Island, including both nor'easters and other storms, is shown Table 4 below.

Table 4 FEMA Disaster and Emergency Declarations, RI

Disaster Number	Date	Incident Description	Declaration Type
4212	04/03/2015	Severe Winter Storm	Major Disaster
4107	3/22/2013	Severe Winter Storm	Major Disaster
4089	11/3/2012	Hurricane Sandy	Major Disaster
3355	10/29/2012	Hurricane Sandy	Emergency
4027	9/3/2011	Tropical Storm Irene	Major Disaster
3334	8/27/2011	Hurricane Irene	Emergency
3311	3/30/2010	Severe Storms and Flooding	Emergency
1894	3/29/2010	Severe Storms and Flooding	Major Disaster
1704	5/25/2007	Severe Storms and Flooding	Major Disaster
3255	9/19/2005	Hurricane Katrina Evacuation	Emergency
3203	2/17/2005	Snow	Emergency

3182	3/27/2003	Snowstorm	Emergency
1091	1/24/1996	Blizzard	Major Disaster
3102	3/16/1993	Blizzard	Emergency
913	8/26/1991	Hurricane Bob	Major Disaster
748	10/15/1985	Hurricane Gloria	Major Disaster
548	2/16/1978	Snow, Ice	Major Disaster
3058	2/7/1978	Blizzards and Snowstorms	Emergency
39	8/20/1955	Hurricane Diane, Flood	Major Disaster
23	9/2/1954	Hurricane Carol	Major Disaster

2.0 http://www.fema.gov/disasters/grid/state-tribal-government/34

4.1 History of Nor'Easters

A nor'easter (also called northeaster) is a cyclonic storm that moves along the east coast of North America with continuously strong northeasterly winds blowing in from the ocean. These winter weather events are known for producing heavy snow, rain, and oversized waves that often cause beach erosion and structural damage. This type of storm is a primary concern for Rhode Island residents not only because of the damage potential, but because there is a frequent rate of recurrence. Nor'easters have an average frequency of 1 or 2 per year, with a storm surge equal to or greater than two feet. The comparison of hurricanes to nor'easters reveals that the duration of high surge and winds in a hurricane is 6 to 12 hours while a nor'easter's duration can be from 12 hours to 3 days. (RIEMA, 2011)

The blizzard of 1978 remains the worst winter storm on record for Rhode Island. It was a slow moving nor'easter accompanied by astronomically high tides that caused serious coastal flooding, beach erosion, broken seawalls and massive property damages. Although not all damages were in the coastal areas, the state suffered 26 fatalities and damages in excess of $15 Million. (Strauss, 2003)

The Halloween Storm of 1991 was another strong extended nor'easter that caused flooding in tidal areas and over wash of the dunes along the southern coast during times of high tide. This in turn caused flooding in Westerly that damaged many businesses and flooded approximately one third of the residential area (Westerly, 2010).

Additional nor'easters include the 2003 President's Day Storm, the 2005 Blizzard, and the March 2010 Nor'easter that caused significant coastal flooding, including road and bridge washouts, flooded homes and businesses, damaged utilities and major disruptions to utility services.

4.2 History of Major Hurricanes

Five hurricanes of category 3 or greater, occurring in 1635, 1638, 1815, 1869, and 1938, have made landfall on the New England coast since European settlement. (Jeffrey P. Donnelly, 2001) Based on National Weather Service records, Rhode Island has experienced approximately 30 hurricanes throughout recorded history with 14 occurring in the 20th century. (RIEMA, 2011)

The most notable storm to hit Rhode Island was the hurricane of September 21, 1938 which brought major devastation to the State, with 262 deaths and damage estimated at $100 million. (RIEMA, 2011) Another major hurricane occurred on September 14, 1944; no lives were lost, but property damage was over $2 million. The coastal area from Westerly to Little Compton experienced the heaviest damage.

Ten years later, Hurricane Carol hit Rhode Island resulting in 19 deaths and $200 million in property damage (RIEMA, 2011). Hurricane Carol arrived on August 31, 1954 shortly after high tide. Even though the storm arrived after high tide, resulting in a lower storm tide, Narragansett Bay received storm surge greater than 14 feet in the upper reaches of the bay. In the capitol city of Providence, the surge was recorded at 14.4 feet, surpassing that of the 1938 Hurricane (NOAA). Entire coastal communities were nearly wiped out from Westerly to Narragansett. (RIEMA, 2011).

The next major storm to warrant a FEMA Major Disaster Declaration was Hurricane Diane in August 1955 which caused $5 Million in property damages when its 6-foot tidal surge hit Rhode Island. (RIEMA, 2011)

Hurricane Gloria, which was downgraded to a tropical storm over New England, caused two fatalities in Rhode Island and damages close to $20 Million when it struck on September 27, 1985. Fortunately, the storm arrived at low tide and reported surges were less than 5 feet in Rhode Island. (Grammatico, 2002)

On August 19, 1991, the eye of Hurricane Bob passed over Block Island and made landfall over Newport. Hurricane Bob caused a storm surge of 5 to 8 feet along the Rhode Island shore with approximate property damages of $115 million. (NOAA Coastal Services Center, 1999) Extensive beach erosion occurred from Westerly, eastward. Some south facing beach locations on Martha's Vineyard and Nantucket islands lost up to 50 feet of beach to erosion (NOAA).

Hurricane Irene made landfall on the RI coast during morning high tide on August 28, 2011, bringing storm surge values recorded at 2 to 4.8 feet with storm tides of 4.5 to 8.2 feet (NAVD88). (NOAA-US Dept. Commerce) The storm surge into Narragansett Bay caused some coastal damage, although Providence, at the head of the bay, was spared downtown flooding in part due to its hurricane barrier. (Wikipedia)

Hurricane/Post-tropical Cyclone Sandy was a late-season storm that came ashore in the U.S. near Brigantine, New Jersey on October 29 with 80 mph sustained winds and record storm tide heights. Its impact was felt along the entire East Coast of the United States from Florida northward to Maine; causing historic devastation and substantial loss of life.

4.3 Recent Storm Damages

The arrival of Hurricane Sandy on October 29, 2012 was preceded by Coastal Flood Warnings and mandatory evacuations in Rhode Island for coastal towns, low lying areas and mobile homes. Major evacuations from Rhode Island towns along Narragansett Bay and the Southern Atlantic Coast included Bristol, Charlestown, Fall River Middletown, Narragansett, South Kingston, Tiverton and Westerly.

The storm surge of Hurricane Sandy destroyed houses and businesses, damaged pilings and deck supports, blew out walls on lower levels, and moved significant amounts of sand and debris into homes, businesses, streets, and adjacent coastal ponds. Propane gas tanks were dislodged from houses, septic systems were damaged and underground septic tanks were exposed, creating potential hazardous material exposure. The National Guard was called out to restrict entry to the community of Misquamicut (located in the town of Westerly) due to the devastation.

The Westerly Sun newspaper reported that “houses were ripped from their stilts and deposited in the streets while other structures appeared precariously perched over the ocean.” In some areas, roads were either flooded or covered in three feet of sand.

More than $39.4 million in support from four federal disaster relief programs is helping Rhode Island recover from Hurricane Sandy’s effects. FEMA’s website reports the National Flood Insurance Program (NFIP) has paid more than $31.1 million for more than 1,000 claims. In addition to NFIP claims, Federal aid also included more than $5.3 million in Public Assistance (PA) grants for state and local agencies and private nonprofits, and more than $423,000 in Individual Assistance grants paid directly to eligible individuals and families to meet basic needs for housing and cover other essential disaster-related expenses. The U.S. Small Business Administration has provided approximately $2.6 million in low-interest disaster recovery loans to Rhode Island homeowners, renters and business owners of all sizes. (FEMA, 2013)

FEMA’s PA program has approved more than 260 projects to reimburse local and state agencies in Rhode Island for 75 percent of eligible Sandy-related costs that include emergency response, debris removal, and repair or replacement of facilities or infrastructure. (FEMA, 2013) The US Department of Housing and Urban Development allocated $3.24 million in Community Development Block Grant Disaster Recovery funding to support projects that address the impacts of Hurricane Sandy in Rhode Island. (RIHCD, 2013)

Figure 2 below shows the coastal areas at risk of flooding during Category 2 and category 4 Hurricanes.

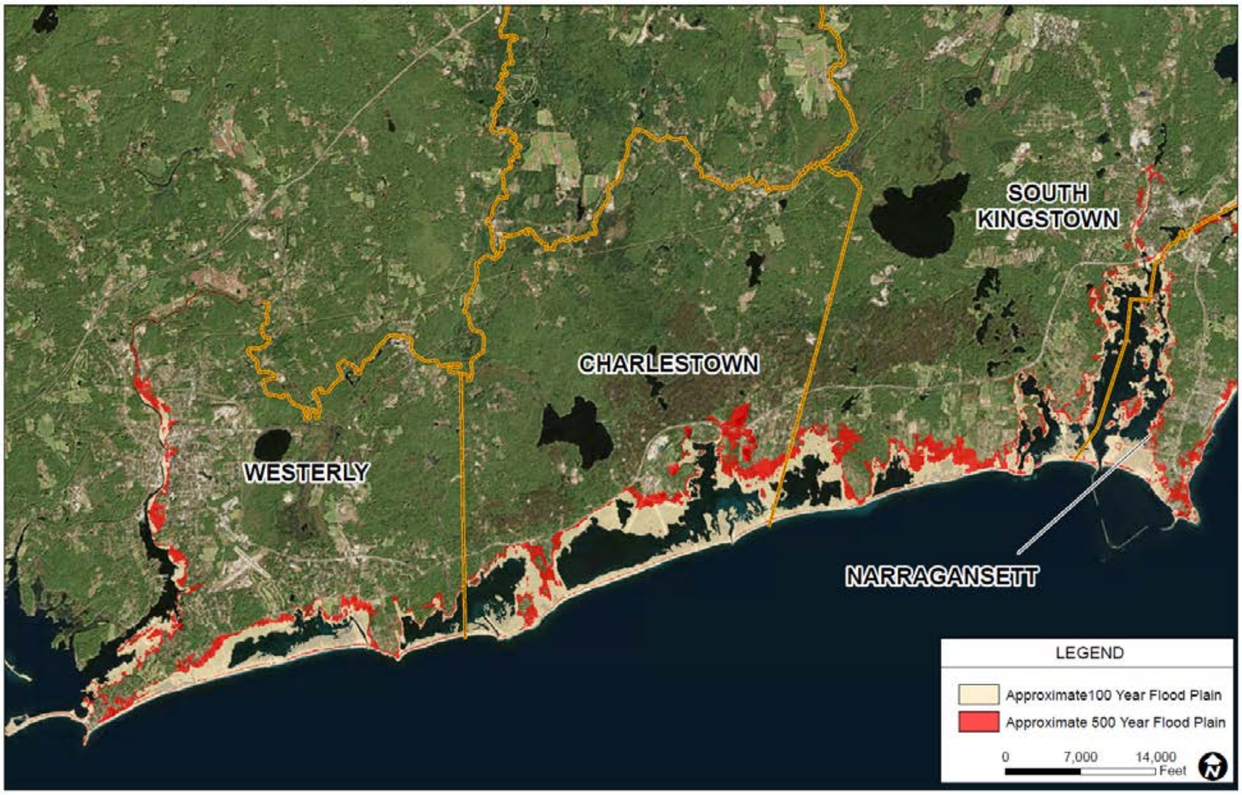

Figure 2 Category 2 and Category 4 Inundation Areas

In Narragansett, the storm surge from Hurricane Sandy caused shoreline erosion and damage to buildings, roads and a section of the seawall. One home was totally destroyed and 6 other residences had major damage. Several low-income housing authority units and four town-owned single family residences were also damaged. NFIP claims for Sandy damage for the entire town were in excess of $4.1 million. (RIHCD, 2013) The Coast Guard House Restaurant, a historic landmark overlooking the ocean, was severely damaged. A low-lying segment of Col. John Gardner Road in the Bonnet Shores neighborhood was significantly damaged, and a section of approximately 1,000 feet was undermined and washed away. (RIHCD, 2013) A section of sidewalk from State Pier No. 5 to the town beach was also damaged and 200 feet of seawall was overturned. The state was awarded $3.0 million by the US Department of Transportation quick release emergency relief funds to address the damages. (RIDOT, 2012)

In South Kingstown, Hurricane Sandy destroyed a recreational facility in the basement of the Green Hill Beach Club, but the elevated portion of the clubhouse remained. The building finally collapsed after consecutive days of large post-storm surf that took out the last remaining support pilings. The club had been built 51 years ago and had served 225 families. (SRIN, 2013)

Structures damaged or lost included the South Kingstown Town Beach pavilion, a local tavern, and three of the historic Browning Cottages, which were built over 100 years ago. The on-going erosion and storm threat also prompted the South Kingstown Zoning Board to permit the relocation of 28 first and second row cottages at Roy Carpenter's Beach on Cards Pond Road.

In Charlestown, Hurricane Sandy altered the shoreline, damaged and destroyed buildings and infrastructure, spread debris, and caused utility interruptions. Damage to the Charlestown breach-way, the inlet to Ninigret Pond, resulted from the pounding of storm waves against the east side of the inlet channel. A number of rocks lining the channel were pushed into the channel causing parts of the bank to be nearly underwater at high tide, and the stone embankment was no longer safe to walk on. Charlestown and the State of RI are also applying for federal aid to repair the inlet.

In Westerly, damages from Hurricane Sandy were especially severe in the Misquamicut Beach area, in the vicinity of Atlantic Avenue. FEMA has reported multiple repetitive loss properties in Westerly; properties that have had two or more claims exceeding $1,000 over a ten year period.

5.0 Existing Conditions

Under existing conditions, coastal Rhode Island is subject to significant risk from coastal storms as described in the preceding paragraphs. Damages include destruction of buildings, erosion, flooding, and loss of structures, as well as damages to roads and utilities. Homeowners and businesses make individual efforts to repair damages after each coastal storm.

6.0 Future Without-Project Condition

The future without project condition serves as the base condition to use as a comparison for all other alternatives. In the absence of a Federal project, homeowners and businesses will continue individual efforts to repair damages after coastal storms, using emergency funding or personal resources when available. In the event a residential or commercial structure sustains damage equal to or greater than 50% of its depreciated replacement cost, it is assumed that the structure will be elevated in accordance with NFIP and local rules. The future without project condition within the period of analysis (2020-2070) is identified as continued damages to coastal floodplain structures and property from future storm events.

No future growth or development in the study area was projected for this analysis, therefore structure inventory and values were kept the same as those under existing conditions. Much of the coastal floodplain in the study area is already developed, and there are limited opportunities for new expansion. There are a few vacant parcels spread throughout the study reach, most of which are behind the barriers and strictly regulated in terms of development and the ability to withstand coastal storms.

7.0 Economic Analysis Methods

A Federal project is considered economically justified if the benefits of the project equal or exceed the costs. The economic benefits of a coastal storm damage reduction project are measured by the degree to which the project reduces expected annual storm damages. Damages in the without- and future with-project conditions were calculated using two different certified USACE modelling tools; Beach-*fx* and the USACE flood damage analysis tool, HEC-FDA (Hydrologic Engineering Center - Flood Damage Analysis). A summary of the models used and their key components is provided in the following sections.

7.1 Beach-*fx*

The USACE Beach-*fx* software was used to model conditions in the original Westerly study area. Beach-fx was developed by the USACE Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi. The model links the predictive capability of coastal shoreline evolution modeling with damage elements in the project area. Damage elements for the Westerly area include infrastructure information, structure and content damage functions, and economic valuations used to estimate the costs and total damages under various shore protection alternatives.

Coastal modeling to provide the storm response data base for Beach-*fx* was performed using SBEACH software (Storm-induced BEAch CHange Model). This model simulates cross-shore beach, berm, and dune erosion produced by storm waves and water levels. The storm suite used for the study area was developed from The North Atlantic Coast Comprehensive Study (NACCS) information. The NACCS modeling efforts included the latest atmospheric, wave, and storm surge modeling and external statistical analysis techniques. (See Appendix C, Coastal Engineering) Once the storm suite is configured and integrated with the damage elements, hurricane and storm damages at existing and future years are computed. Beach-fx is an event-driven life-cycle model that estimates the present worth of accumulated damages and associated costs over the 50-year period of analysis based on a number of factors including storm probabilities, tidal cycle, tidal phase and beach morphology.

7.2 HEC-FDA

The USACE flood damage analysis tool, HEC-FDA, was used to model all inundation damages in the following four scenarios:

- 2020 Without Project

- 2070 Without Project with Sea Level Rise
- 2020 With-Project
- 2070 With-Project with Sea Level Rise

Alternatives were evaluated based on the FY16 discount rate of 3.125 percent and a period of analysis of 50 years. Damages under future with- and without-project conditions were estimated based on an inventory of structures in the 100-yr FEMA floodplain, depreciated structure replacement costs and content values, and the use of appropriate stage-damage functions. The combination of stage-frequency relationships with stage-damage relationships was used to determine damage-frequency relationships. The Pawcatuck risk management plans are evaluated based on the probabilistic analysis of integrated hydrologic engineering and economic data provided by HEC-FDA.

7.3 Structure Inventory

The structure inventory is valued at the 2015 depreciated replacement cost according to the Computer Assisted Mass Appraisal (CAMA) system provided by Vision Government Solutions. This system provides costs per square foot for varying types and grades of construction and then allows the assessor to make decisions for each property as to what type and quality a structure is, and how much depreciation the structure has. As an example if the assessor deems a house to be of "Custom" design and very good quality, but appears to have depreciated approximately ten years, CAMA system applies the cost per square foot for a Custom style home, then subtracts a percentage for depreciation. The vertical team agreed early in the project that this was an acceptable structure valuation given the large number of properties analyzed.

The structure inventory was compiled using geospatial data available from the state of Rhode Island. All processing was done with ArcGIS 10.1 using RI State Plane NAD83 feet as the horizontal projection and NAVD88 feet as the vertical datum.

The parcel data was originally in the format of a polygon shapefile, which was converted to points as centroids within each parcel polygon. The centroids were adjusted to correspond to the low openings on each structure, and a ground elevation was determined using the 'Extract by Value' tool on the FEMA 2011 LiDAR raster grid.

Each structure was viewed individually in either the assessor database, Google Earth or online real estate sites to determine the type of construction, type of foundation and the first floor elevation relative to the ground elevation. Select areas were visited for a windshield survey to verify the accuracy of the online assessment. A small sample of structures were also visited by a USACE survey team so surveyed first floor elevations could be compared to the online assessments. The results of the survey showed a variance less than 0.5 feet between the visual assessment and surveyed values of first floor elevations for homes in the backshore. Shorefront homes showed a variance less than 2.0 feet. These homes were reviewed again to obtain more accurate elevations.

7.4 Water Surface Profile

The 2014 FEMA Flood Insurance Study (most recent available) and associated mapping for Washington County Rhode Island was used to develop stage-frequency data for the analyses. Index stations correspond to coastal areas designated as FEMA AE and VE high risk zones where FEMA has provided detailed analysis of depths and base flood elevations. FEMA AE zones are areas with a 1% annual chance of flooding. FEMA VE zones are areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. Table 5 below lists the Index stations used in HEC-FDA and the corresponding FEMA hazard zones with base flood elevations (BFE).

Table 5 Index Stations

Flood Zone with BFE	HEC-FDA Index Station
AE11	25
AE12	30
AE13	40
AE14	50
VE14	60
VE15	70
VE16	80
VE17	90

The water surface elevation (WSEL) data and corresponding HEC-FDA water surface profiles for the 2020 base year, without sea level change (SLC) are presented below in Table 6 and Figure 3.

To account for SLC, the mean sea level trend at New London, CT was selected to represent the project site because it was the closest long term gauge to the project location. The USACE coastal engineer calculated intermediate and high rates of relative sea level change at 0.017 and 0.047 feet per year respectively. This equates to an approximate increase of 0.37 feet for the low SLC and 2.33 feet for the high rate over a 50 year period. An increase of 0.37 feet, based on the low rate of SLC, was added to the WSELs for 2070 future conditions.

Table 6 Water Surface Elevations

AEP	0.5	0.1	0.04	0.02	0.0133	0.01	0.004	0.002
Index Station	2	10	25	50	75	100	250	500
25	5.0	5.0	6.5	8.5	10	11	13	14
30	5.0	6.0	7.5	9.5	11	12	14	15
40	5.0	7.0	8.5	10.5	12	13	15	16
50	5.0	8.0	9.5	11.5	13	14	16	17
60	7.0	8.0	10	12	13.3	14	16	18
70	7.0	9.0	11	13	14.3	15	17	19
80	7.0	9.0	12	14	15.3	16	18	20
90	8.0	10.0	13	14.5	16	17	19	21

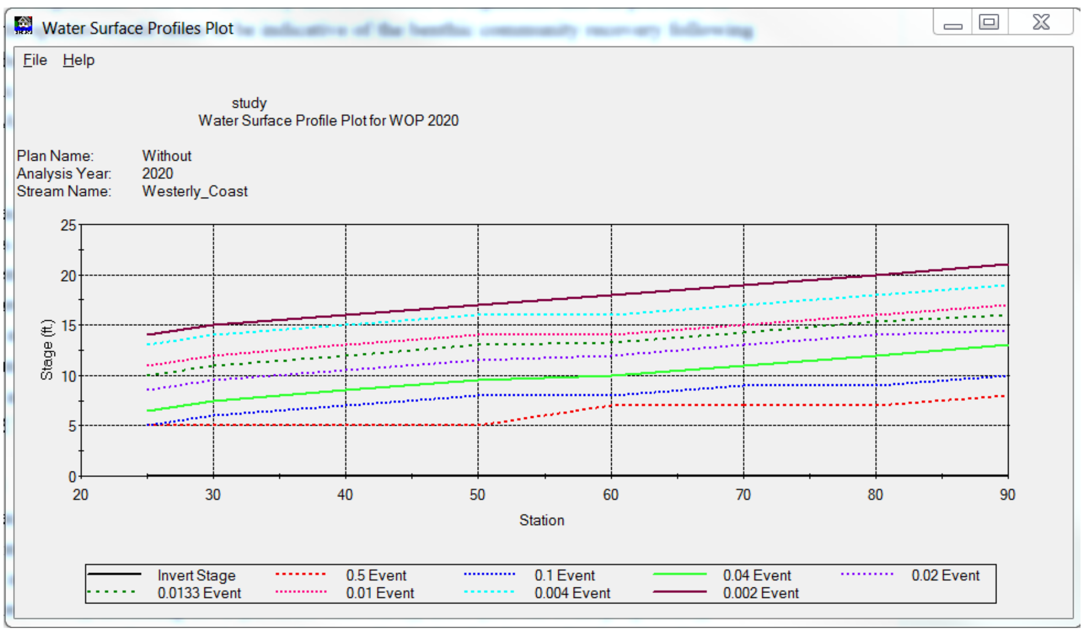

Figure 3 HEC-FDA Water Surface Profile Year 2020

7.5 Damage Functions

Depth-damage relationships developed for the North Atlantic Coastal Comprehensive study were used for all structures in the inventory. These depth-damage functions estimate the likely degree of damage to structure and contents at each elevation of flooding relative to the first floor, expressed as a percentage of structure and content value, based on actual damages experienced during Hurricane Sandy in the northeast.

8.0 Evaluation of Alternatives

The Feasibility Study plan formulation considered a range of structural and nonstructural measures to reduce the risk of storm damage in the study areas. Coastal storm risk management measures were developed to address problems and to capitalize upon opportunities described in the main report. They were derived from a variety of sources including prior studies, the public scoping process, and the Project delivery Team (PDT). The following measures were considered:

- Storm Surge Barrier
- Beach Restoration and Dunes
- Breakwaters and Groins with Beach Restoration
- Shoreline Protection
- Levees, berms and floodwalls
- Nonstructural Measures

Through an iterative planning process, potential coastal storm risk management measures were identified, evaluated, and compared. Net benefits and benefit-to-cost ratios (BCR) were reviewed to determine the viability of each alternative based on an economic justification.

Initial screening of alternatives indicated that detailed study of structural (sheet pile flood walls and tide gates), soft structural (beach fill/nourishment), and nonstructural (elevation and buyout of properties) should be conducted in Westerly due to the higher density development in the area.

Beaches, cobble berms and dike alternatives evaluated in Charlestown, South Kingstown, and the Sand Hill Cove area of Narragansett were not economically justified due to the high cost of renourishment and smaller study areas containing lower structure values. A hurricane Barrier was evaluated for the Point Judith area of Narragansett, but the high cost of construction and possible impacts to the existing federal navigation channel did not lead to a positive BCR. Non-structural alternatives made sense for evaluation in the towns of Charlestown, South Kingstown, and Narragansett.

The array of initial alternatives evaluated and the benefit-to-cost ratios are presented in Table 7 below. The east flood wall and tide gate alternatives in Westerly resulted in positive BCRs but did not maximize NED benefits when compared to non-structural measures.

Westerly alternatives were modeled by the USACE Engineering Research and Development Center in Vicksburg, MI. A detailed description of the Beach-*fx* results can be found in the Coastal Engineering analysis located in Appendix C. Details of preliminary project designs can be found in the Civil Engineering Appendix; Appendix D.

Table 7 Alternative Screening

Study Area/ Alternative	Annual Costs	Annual Benefits	Net Benefits	BCR
Westerly				
FW-West	191,308	39,575	(151,733)	0.21
FW-East	370,476	377,373	6,897	1.02
FW-West and East	582,951	416,948	(166,003)	0.72
Tide Gate	562,738	659,311	96,573	1.17
Tide Gate & FW-West	779,731	698,887	(80,844)	0.90
Non-Structural-Acquisition	911,340	1,498,260	586,920	1.64
Non-Structural-Elevations	**199,860**	**1,445,080**	**1,245,220**	**7.23**
Charlestown - Charlestown Beach				
Beach 11,000 Feet	1,463,000	259,115	(1,203,885.00)	0.18
Beach 28,000 Feet	3,724,000	2,554,950	(1,169,050)	0.69
Non-Structural-Acquisition	2,288,120	2,395,220	107,100	1.05
Non-Structural-Elevations	**483,700**	**2,343,430**	**1,859,730**	**4.84**
South Kingstown - Matunuck Beach				
Beach and Cobble Berm	1,171,500	293,100	878,400	0.25
Non-Structural-Acquisition	855,990	1,077,800	221,810	1.26
Non-Structural-Elevations	**194,790**	**1,059,370**	**864,580**	**5.44**
Point Judith				
Hurricane Barrier	6,126,557	4,089,000	(2,037,557)	0.67
Non-Structural-Acquisition	3,352,570	8,254,120	4,901,550	2.46
Non-Structural-Elevations	**1,064,570**	**8,148,900**	**7,084,330**	**7.65**
Sand Hill Cove				
6000 FT Dike and 2000 FTBeach	914,000	393,000	(521,000)	0.43
Non-Structural-Acquisition	216,880	107,490	(109,390)	0.50
Non-Structural-Elevations	**49,010**	**91,480**	**42,470**	**1.87**

9.0 Tentatively Selected Plan

Based on the results of the initial analysis and interim project review, the PDT proceeded with the non-structural solution as the Tentatively Selected Plan because large-scale structural alternatives did not warrant Federal interest. The study areas were expanded to include all structures in the 100-year FEMA coastal floodplain, instead of just the original areas that held potential for structural solutions.

The Tentatively Selected Plan consists of elevating the first floors of 341 structures in the four study area communities. The first floors will be elevated to a height corresponding to the FEMA designated Base Flood Elevation (BFE), ranging from +11' North Atlantic Vertical Datum of 1988 (NAVD88) to +17' NAVD88, plus 1' in accordance with state building code. Properties eligible for elevation, by town, are as follows:

- Westerly: Elevate 45 Structures
- Charlestown: Elevate 44 Structures
- South Kingstown: Elevate 172 Structures
- Narragansett: Elevate 80 Structures

10.0 Evaluation of the Tentatively Selected Plan

The non-structural with-project analysis was based on changing first floor elevations (FFE) in individual structures. A flowchart outlining the process of determining eligibility for the non-structural solution is provided in Figure 4 below. The FFE of every structure in the inventory was compared to the FEMA Base Flood Elevation (BFE). If the first floor elevation was below the BFE (Test 1), it was changed in the HEC-FDA model inventory to equal the BFE plus 1 foot plus 0.37 feet for sea level change.

The non-structural analysis used the structure Detail Output (SDO) files generated by HEC-FDA to determine Annual Equivalent Damages (AED) for each individual structure in the four without- and with-project scenarios listed in section 7.2 above. The SDO output presents structure damages by storm frequency, or annual exceedance probability. This damage-frequency curve was integrated to find average damages for each individual structure in the 2020 base year, and 50 years out in 2070. Average AED were derived using an average annual equivalent factor of 0.3866 based on a constant growth rate over the 50-year period of analysis and the FY16 Federal discount rate of 3.125 percent.

The benefits of elevating the first floor of individual structures are calculated by subtracting the AED in the with-project condition from the AED in the without project condition. The benefit amount was divided by the FY16 capital recovery factor to determine the cost each structure's benefits could support (Test 2).

All structures whose benefits could support the minimum elevation cost were individually reviewed again to assign a more precise elevation cost based on the structure size and construction type. After the costs were finalized, the benefit-to-cost ratio (BCR) was calculated to determine which structures were eligible to have the first floor elevated. A BCR of 0.9 or higher was considered appropriate to determine final eligibility due to uncertainty in model parameters (Test 3).

10.1 Cost Data

Elevation costs for six different structure types were estimated for both the AE and VE flood zones (see Table 8 below). The costs presented for the TSP were developed using the USACE Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII). The MII cost estimate used RS Means, MII Cost Libraries, and vendor quotations. The project contingencies were developed through the Abbreviated Risk Analysis (ARA) tool provided by the USACE Cost Center of Expertise. Detailed cost information is provided in Appendix E.

Table 8 Elevation Costs

SAMPLE ELEVATION COSTS					
A ZONE STRUCTURES	Base Cost	Contingency	Subtotal	PED & S/A	TOTAL
Simple ranch	$79,995	25.85%	$100,674	20%	$120,808
Complicated raised ranch	$136,086	25.85%	$171,264	20%	$205,517
Complicated 2 story with slab	$154,410	25.85%	$194,325	20%	$233,190
Complicated 2 story with basement	$128,444	25.85%	$161,647	20%	$193,976
Complicated 1 story ranch with basement	$93,069	25.85%	$117,127	20%	$140,553
Simple 2 story	$92,635	25.85%	$116,581	20%	$139,897
Average	*$114,107*		*$143,603*		*$172,324*
V ZONE STRUCTURES	Base Cost	Contingency	Subtotal	PED & S/A	TOTAL
Simple ranch	$115,822	25.85%	$145,762	20%	$174,914
Complicated raised ranch	$171,913	25.85%	$216,353	20%	$259,623
Complicated 2 story with slab	$190,238	25.85%	$239,415	20%	$287,297
Complicated 2 story with basement	$164,272	25.85%	$206,736	20%	$248,084
Complicated 1 story ranch with basement	$128,896	25.85%	$162,216	20%	$194,659
Simple 2 story	$128,462	25.85%	$161,669	20%	$194,003
Average	*$149,934*		*$188,692*		*$226,430*

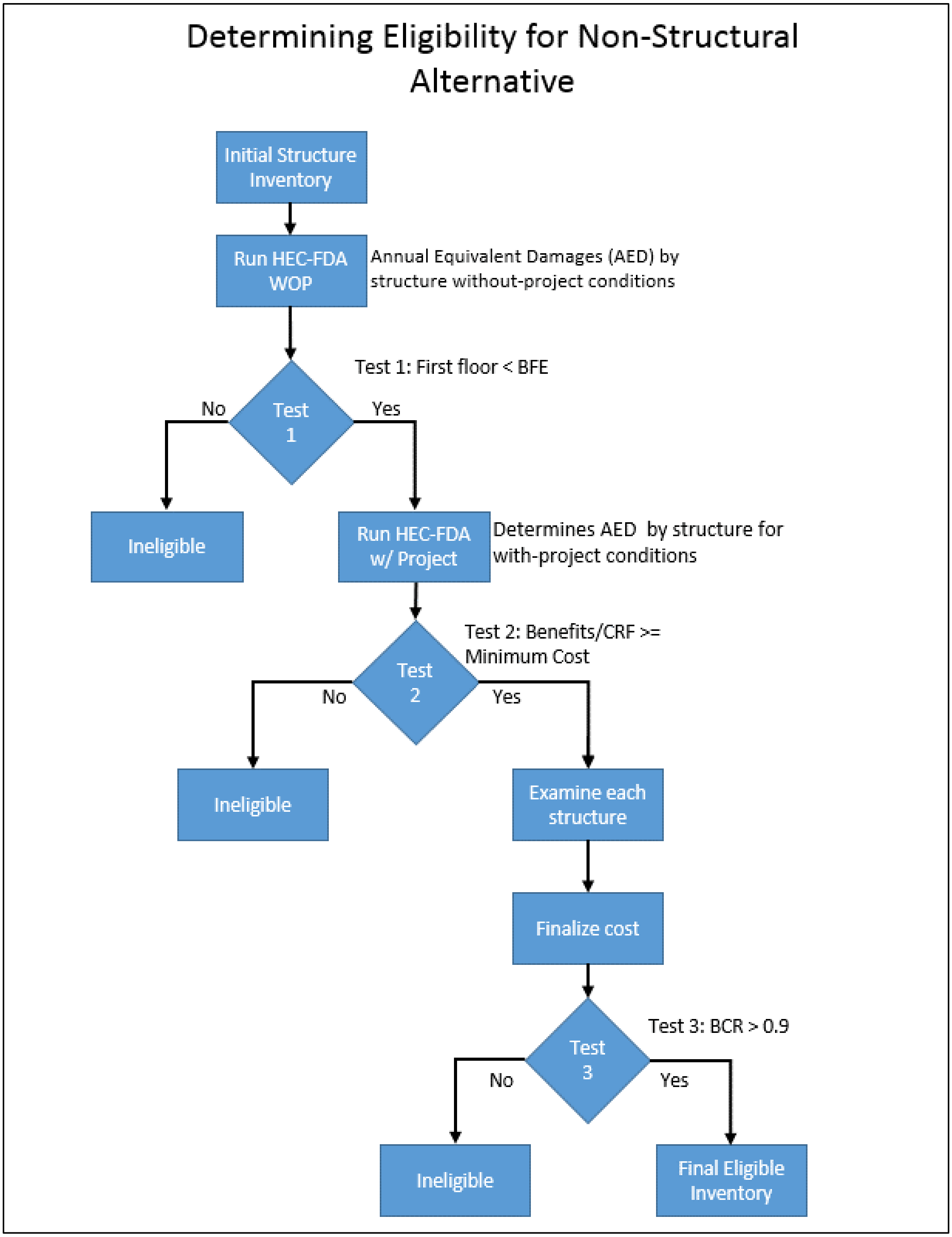

Figure 4 Flowchart of Non-Structural Eligibility Process

10.2 Westerly

A total of 871 structures were evaluated for inundation damages in the town of Westerly, including 25 commercial structures valued at $15.4 million (3 %) and 846 residential structures valued at $280.4 million (97 %). The estimated total value of structures and contents amounts to $221.9 million. A summary of the structure inventory by structure type is presented in Table 9 below.

Table 9 Westerly Structure Inventory

Structure Type	Description	# of Structures	Structure Value ($000)	Content Value ($000)	Total Value ($000)
NACCS 2 NP	Hotels	3	5,380	2,690	8,070
NACCS 3 NP	Warehouses	12	1,139	570	1,709
NACCS 3 P	Restaurants	10	1,165	583	1,748
NACCS 5A	Single-Story/ No basement	283	20,372	10,186	30,557
NACCS 5B	Two-Story/ No Basement	172	39,660	19,830	59,490
NACCS 6A	Single Story/ With Basement	187	21,210	10,605	31,814
NACCS 6B	Two Story/ With Basement	177	47,537	23,768	71,305
NACCS 7A	Residential on Open Piles	2	378	189	567
NACCS 7B	Residential on Enclosed Piles	25	11,068	5,534	16,602
Total		**871**	**147,909**	**73,955**	**221,862**

Of the 871 structures analyzed, a total of 305 structures had no benefits; indicating their first floor elevations were already above the base flood elevation and they did not experience any change in storm damages from the without-project condition to the with-project condition. The remaining 566 structures generated average annual equivalent benefits ranging from approximately $50 to $173,430.

Dividing the average annual equivalent benefits by the FY16 capital recovery factor of 0.3979 determines the project cost that each individual structure can support. The costs for elevating a structure range from $120,808 to $287,297, as described in Section 10.1 above. An initial screening identified 73 structures generating benefits greater than the minimum cost of elevating the first floor. These structures were further reviewed to assign the correct elevation cost based on the size, style and foundation type of the house.

The elevation cost was annualized and compared to the average annual benefits to determine a preliminary benefit to cost ratio. A total of 45 structures generated enough benefits to support the cost of elevating the first floor with a BCR greater than 0.9. Using a BCR of 0.9 or higher was considered appropriate to determine final eligibility due to uncertainty in model parameters such as first floor and water surface elevations, stage-damage functions, and elevation costs. Table 10 below presents the average annual costs and benefits of elevating the first floor for 45 structures in Westerly.

Table 10 Westerly Benefit-Cost Analysis

Annualized Cost Calculation	**Westerly**
Number of Structures Elevated	**45**
Construction Cost	7,657,520
Real Estate	458,000
Total First Cost	8,115,520
IDC	656,047
Total Investment Cost	8,771,567
Capital Recovery Factor at 3.125% (CRF) =	0.03979
Average Annual Cost	349,047
Annualized Benefit Calculation	
Equivalent Annual Damages - Without Project	833,414
Equivalent Annual Damages - With Project (Residual)	8,490
Average Annual Benefits (Rounded)	824,900
Total Annual Net Benefits	475,900
Benefit to Cost Ratio	**2.36**

10.3 Charlestown

A total of 869 structures were evaluated for inundation damages in the town of Charlestown, including 3 commercial structures and 864 residential structures. The estimated total value of structures and contents amounts to $269.2 million. A summary of the structure inventory by structure type is presented in Table 11 below.

Table 11 Charlestown Structure Inventory

Structure Type	Description	# of Structures	Structure Value ($000)	Content Value ($000)	Total Value ($000)
NACCS 3 NP	Warehouses	3	107	53	160
NACCS 5A	Single-Story/ No basement	126	11,435	5,718	17,153
NACCS 5B	Two-Story/ No Basement	133	34,041	17,021	51,062
NACCS 6A	Single Story/ With Basement	177	23,698	11,849	35,547
NACCS 6B	Two Story/ With Basement	289	81,176	40,588	121,765
NACCS 7A	Residential on Open Piles	66	9,513	4,757	14,270
NACCS 7B	Residential on Enclosed Piles	75	19,531	9,766	29,297
Total		**869**	**179,503**	**89,751**	**269,254**

Of the 869 structures analyzed, a total of 583 structures had no benefits; indicating their first floor elevations were already above the base flood elevation and they did not experience storm damages. The remaining 286 structures generated values ranging from less than $53 to $98,876 for average annual equivalent benefits. A total of 44 structures generated enough benefits to support the cost of elevating the first floor with a BCR greater than 0.9. Table 12 below presents the average annual costs and benefits of elevating the first floor for these structures in Charlestown.

Table 12 Charlestown Benefit-Cost Analysis

Annualized Cost Calculation	**Charlestown**
Number of Structures Elevated	**44**
Construction Cost	6,952,016
Real Estate	447,800
Total First Cost	7,399,816
IDC	598,190
Total Investment Cost	7,998,006
Capital Recovery Factor at 3.125% (CRF) =	0.03979
Average Annual Cost	318,264
Annualized Benefit Calculation	
Equivalent Annual Damages - Without Project	743,904
Equivalent Annual Damages - With Project (Residual)	11,907
Average Annual Benefits (Rounded)	732,000
Total Annual Net Benefits	413,700
Benefit to Cost Ratio	**2.30**

10.3 South Kingstown

A total of 1101 structures were evaluated for inundation damages in the town of South Kingston, including 11 commercial structures valued at $4.3 million (2.4 %) and 1090 residential structures valued at $172.7 million (97.6 %). The estimated total value of structures and contents amounts to $177 million. A summary of the structure inventory by structure type is presented in Table 13 below.

Table 13 South Kingstown Structure Inventory

Structure Type	Description	# of Structures	Structure Value ($000)	Content Value ($000)	Total Value ($000)
NACCS 1A-3	Apartments/ Three-story/No Basement	8	2,566	1,283	3,849
NACCS 2 NP	Hotels	4	1,377	689	2,066

NACCS 3 NP	Warehouses	2	355	178	533
NACCS 3 P	Restaurants	5	1,139	570	1,709
NACCS 5A	Single-Story/ No basement	608	30,125	15,067	45,192
NACCS 5B	Two-Story/ No Basement	87	16,951	8,478	25,429
NACCS 6A	Single Story/ With Basement	102	11,648	5,827	17,475
NACCS 6B	Two Story/ With Basement	149	30,116	15,062	45,177
NACCS 7A	Residential on Open Piles	98	17,163	8,585	25,747
NACCS 7B	Residential on Enclosed Piles	38	6,604	3,303	9,908
Total		**1101**	**118,045**	**59,041**	**177,085**

Of the 1101 structures analyzed, a total of 213 structures had no benefits; indicating their first floor elevations were already above the base flood elevation and they did not experience storm damages. The remaining 888 structures generated values ranging from less than $1 to $289,607 for average annual equivalent benefits.

A total of 172 structures generated enough benefits to support the cost of elevating the first floor with a BCR greater than 0.9. Table 14 below presents the average annual costs and benefits of elevating the first floor for these structures in South Kingstown.

Table 14 South Kingstown Benefit-Cost Analysis

Annualized Cost Calculation	**South Kingstown**
Number of Structures Elevated	**172**
Construction Cost	27,290,007
Real Estate	1,750,700
Total First Cost	29,040,707
IDC	2,347,609
Total Investment Cost	31,388,316
Capital Recovery Factor at 3.125% (CRF) =	0.03979
Average Annual Cost	1,249,034
Annualized Benefit Calculation	
Equivalent Annual Damages - Without Project	4,519,717
Equivalent Annual Damages - With Project (Residual)	27,426
Average Annual Benefits (Rounded)	4,492,300
Total Annual Net Benefits	3,243,300
Benefit to Cost Ratio	**3.60**

10.4 Narragansett

A total of 863 structures were evaluated for inundation damages in the town of Narragansett, including 30 commercial structures valued at $17.15 million (7.8%) and 833 residential structures valued at $202.3 million (92.2%). The estimated total value of structures and contents amounts to $219.5 million. A summary of the structure inventory by structure type is presented in Table 15 below.

Table 15 Narragansett Structure Inventory

Structure Type	**Description**	**# of Structures**	**Structure Value ($000)**	**Content Value ($000)**	**Total Value ($000)**
NACCS 2 P	Offices	10	4,805	2,403	7,208
NACCS 3 NP	Warehouses	10	4,352	2,176	6,527
NACCS 3 P	Restaurants	10	2,274	1,138	3,412

NACCS 5A	Single-Story/ No basement	302	25,415	12,713	38,128
NACCS 5B	Two-Story/ No Basement	169	31,361	15,684	47,045
NACCS 6A	Single Story/ With Basement	174	29,607	14,809	44,416
NACCS 6B	Two Story/ With Basement	188	48,509	24,259	72,768
Total		**863**	**146,323**	**73,181**	**219,504**

A total of 432 structures had no benefits; indicating their first floor elevations were already above the base flood elevation and they did not experience storm damages. The remaining 431 structures generated values ranging from less than $2 to $557,103 for average annual equivalent benefits.

A total of 80 structures generated enough benefits to support the cost of elevating the first floor with a BCR greater than 0.9. Table 16 below presents the average annual costs and benefits of elevating the first floor for these structures in Narragansett.

Table 16 Narragansett Benefit-Cost Analysis

Annualized Cost Calculation	Narragansett
Number of Structures Elevated	**80**
Construction Cost	12,082,654
Real Estate	814,300
Total First Cost	12,896,954
IDC	1,042,571
Total Investment Cost	13,939,525
Capital Recovery Factor at 3.125% (CRF) =	0.03979
Average Annual Cost	554,695
Annualized Benefit Calculation	
Equivalent Annual Damages - Without Project	1,495,425
Equivalent Annual Damages - With Project (Residual)	15,632
Average Annual Benefits (Rounded)	1,479,800
Total Annual Net Benefits	925,100
Benefit to Cost Ratio	**2.67**

11.0 Summary of Tentatively Selected Plan

The TSP contributes to National Economic Development by reducing the risk of coastal storm damages. A summary of Results for the Tentatively Selected Plan is presented in Table 17 below.

Table 17 TSP Summary Results

Annualized Cost Calculation	**Totals**
Number of Structures Elevated	**341**
Construction Cost	53,982,197
Real Estate	3,470,800
Total First Cost	57,453,000
IDC	4,644,000
Total Investment Cost	62,097,000
Capital Recovery Factor at 3.125% (CRF) =	0.03979
Average Annual Cost	2,471,040
Annualized Benefit Calculation	
Equivalent Annual Damages - Without Project	7,592,461
Equivalent Annual Damages - With Project (Residual)	63,455
Average Annual Benefits (Rounded)	7,529,000
Total Annual Net Benefits	5,058,000
Benefit to Cost Ratio	**3.05**

12.0 Risk and Uncertainty

Risk and uncertainty was factored into the economic analysis through the use of statistical risk based models. Beach-fx, was used in the study to formulate and evaluate the structural alternatives in Westerly. The non-structural evaluations for all four study area communities were conducted using HEC-FDA, which is a probability based model.

After completing the non-structural analysis on an individual structure-by-structure basis, HEC-FDA was used to run an aggregated inventory of only those structures eligible for the non-structural solution of elevating the first floor. The results of the HEC-FDA aggregate modeling runs were $540,300 or 7.18% lower than the results generated through the Structure Detail Output files for the individual structure analysis. Table 18 below shows the difference in benefits generated between the two methods of analysis. Table 19 below shows model results from the HEC-FDA Risk and Uncertainty, indicating that the average annual benefits of $7.5 million are within the range of expected results over the 50-year period of analysis.

Table 18 Difference in Benefits: Individual v. Aggregate

Town Name	# of Struct	BENEFITS		Difference in Benefits		Avg Diff/Struct	COSTS	Difference in BCRs	
		Individual	Aggregate	($)	(%)	($)	($)	Individual	Aggregate
Westerly	**45**	824,900	766,800	58,200	7.06	1,300	349,000	2.36	2.20
Charlestown	**44**	732,000	700,900	31,100	4.25	700	318,300	2.30	2.20
South Kingston	**172**	4,492,200	4,200,100	292,100	6.50	1,700	1,249,000	3.60	3.36
Narragansett	**80**	1,479,800	1,320,800	159,000	10.74	2,000	554,700	2.67	2.38
Total	**341**	7,528,900	6,988,600	540,300	7.18	1,600	2,471,000	3.05	2.83

Table 19 Risk & Uncertainty - 50 Year Period of Analysis

Town Name	EQUIVALENT ANNUAL DAMAGE				PROBABILITY DAMAGE REDUCED EXCEEDS INDICATED VALUES		
	Total With Project		Damage Reduced		0.75	0.50	0.25
	Base	*Elevate*	*Base*	*Elevate*	*Elevate*	*Elevate*	*Elevate*
Westerly	783,900	17,100	-	766,800	678,700	769,900	856,100
Charlestown	725,200	24,300	-	700,900	601,400	706,900	806,400
South Kingston	4,255,600	55,400	-	4,200,100	3,959,000	4,217,700	4,458,600
Narragansett	1,368,200	47,500	-	1,320,800	1,120,100	1,345,800	1,531,500
Total	7,132,900	144,300		6,988,600	6,359,200	7,040,300	7,652,600

13.0 Sensitivity Analysis

Sensitivity runs were conducted for the non-structural analysis to capture the effect of "intermediate" (0.84' over 50 years) and "high" (2.33' over 50 years) sea level change over the 50-year period of analysis. Increased water surface elevations will increase the number of houses whose damages support the cost of elevating the first floor above the BFE. Intermediate SLC will increase the number of eligible structures by 30 while high SLC will add 130 eligible structures, as shown in Table 20 below.

Table 20 Impact of SLC on Number of Eligible Structures

Town	LOW	INTERMEDIATE		HIGH	
Westerly	45	53	18%	61	36%
Charlestown	44	55	25%	73	66%
Narragansett	80	85	6%	107	34%
South Kingstown	172	178	3%	230	34%
TOTAL	**341**	**371**	**9%**	**471**	**38%**

14.0 Regional Economic Development

USACE guidance requires that study alternatives be evaluated under all accounts the National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE) and Environmental Quality (EQ). NED effects have been addressed above. RED effects would be the impact of project spending, either direct or induced, on the local economy. It is expected that with increased Federal spending on home elevation, income and employment would show some modest temporary increase. The reduction in coastal storm damages will also help to maintain the current residential population and associated tax base.

Improving overall resiliency of the study area in response to coastal storms is the primary effect on the OSE account. Please see the Integrated Project Report for discussion of the EQ account.

15.0 Conclusion

The tentatively selected plan is to elevate the first floor of 341 structures located in the southern Rhode Island coastal towns of Westerly, Charlestown, Narragansett and South Kingstown. This non-structural alternative generates a benefit-to-cost ratio of 3.05 and maximizes NED benefits.

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