Shrewsbury River Basin, Sea Bright, New Jersey
Coastal Storm Risk Management Feasibility Study
Draft Integrated Feasibility Report & Environmental Assessment

Appendix C: Economics

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Chapter 1: Introduction

An economic analysis was conducted to assist in the determination of the economic viability for Federal participation in the Shrewsbury River Basin, Sea Bright, New Jersey Coastal Storm Risk Management Feasibility Study (Shrewsbury Study, or Study). Benefits were calculated for plans that are anticipated to be the most effective with respect to local support, survivability, and flood risk management. Structural and nonstructural alternatives were screened for relative cost-effectiveness based on the level of without- and with-project damages, and preliminary estimates of benefits and costs. The result of the analysis determined that none of the structural alternatives were cost effective and the only economically viable plan is a nonstructural alternative.

1.1 Benefit Types

Many benefits can be realized from implementing flood/storm damage reduction measures, including:

- Reduced inundation damage to structures and contents
- Reduced public emergency and evacuation costs
- Reduced relocation and reoccupation of displace residents
- Reduced Federal Insurance Administration (FIA) administrative costs
- Reduced bulkhead and road damages
- Reduction in lost business revenue
- Reduction in debris cleanup

While there are many benefits, the economic analysis for the Shrewsbury River Basin study focused on evaluating the reduction in inundation damage to structures and contents. Reduction in damages to structures and contents typically produces the greatest benefits during an economic analysis, thus providing a general indication of the economic viability of the evaluated alternative.
In addition, traffic delays and public emergency and evacuation costs were reviewed in previous study efforts of Sea Bright. These damage categories were found to have negligible benefits related to any of the with-project alternatives under consideration. The analyses indicated that traffic delays caused by the closure of Route 36 by storm events in the without-project condition amount to less than $10,000 per year. While the implementation of a structural plan would reduce the risk of future storm-driven closures of Route 36 within the study area, any benefit would consequently be small because of the likelihood of Route 36 being inundated to the north and south of the study area. Similarly, public emergency and evacuation costs are likely to be unaffected because these response actions will be taken regardless.

1.2 Conditions

The methods for the economic analysis were completed in accordance with ER 1105-2-100. The screening of alternatives used an October 2015 price level and 3.125 percent discount rate for cost and benefits calculations. The base year is 2020 and the period of analysis is 50 years.

Chapter 2: Description of Study Area

The study area is located within the Borough of Sea Bright, New Jersey. The study area is the most low-lying and densely-developed area in Sea Bright and encompasses the borough's central business corridor, most residential development, and a majority of the municipal services (i.e., borough hall, police station, fire department).

The following sections delineate the study area and provide basic demographic information about the Borough of Sea Bright, Monmouth County, and the state of New Jersey.

2.1 Delineation of Study Area

The study lies between the Shrewsbury River and the Atlantic Ocean. It spans from the Shrewsbury River Bridge south to Village Road (Figure 1).

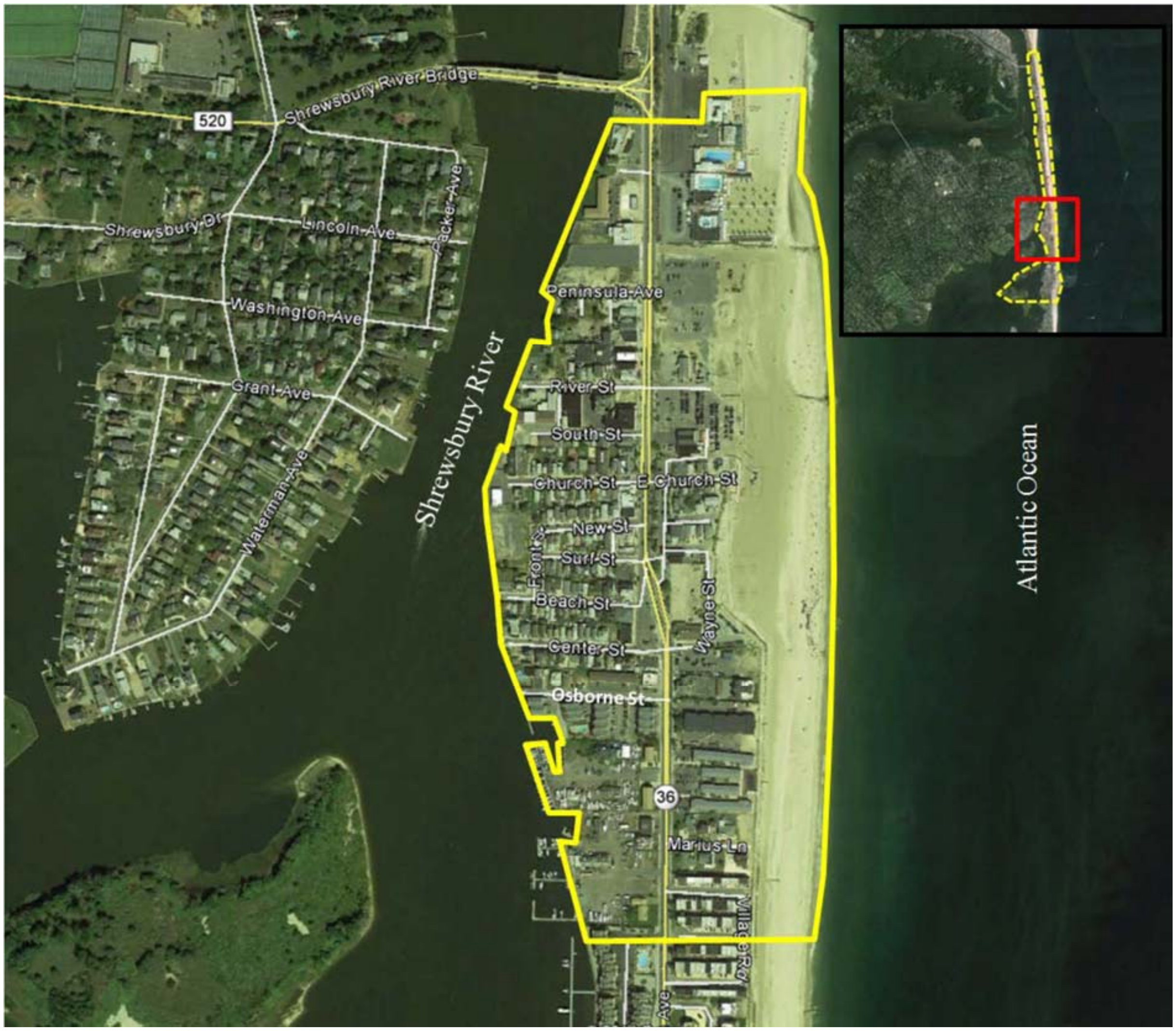

Figure 1: Study area.

2.2 Population

According to the year 2010 U.S. Census, the population of Sea Bright was 1,412 persons. The median age of the population in Sea Bright is 46.7 years. Between 2000 and 2010, the population of Sea Bright decreased by 22.3 percent. Tables C-1 and C-2 summarize the population data.

Table C-1: Population of New Jersey, Monmouth County, and Sea Bright (U.S. Census, 2010).

Area Name	2000 Census	2010 Census	Percentage
New Jersey	8,414,350	8,791,894	4.5%
Monmouth County	615,301	630,380	2.5%
Sea Bright	1,818	1,412	-22.3%

Table C-2: Population and household statistics of New Jersey, Monmouth County, and Sea Bright (U.S. Census, 2010).

Category	Sea Bright		Monmouth County		New Jersey	
	Total	%	Total	%	Total	%
Population	1,412		630,380		8,791,894	
Male	729	51.6%	306,654	48.6%	4,279,600	48.7%
Female	683	48.4%	323,726	51.4%	4,512,294	51.3%
Under 5 years	55	3.9%	34,755	5.5%	541,020	6.2%
18 years and over	1,252	88.7%	480,081	76.2%	6,726,680	76.5%
65 years and over	205	14.5%	86,691	13.8%	1,185,993	13.5%
Median Age	46.7		41.3		37.4	

2.3 Employment and Income

Results from the U.S. Census' American Community Survey (ACS) were used to estimate employment statistics. The ACS 2009-2013 data indicates that there are 1,218 (85.7 percent) residents of Sea Bright who are of working age (16 years or older) and 921 (64.8 percent) are in the civilian labor force. Tables C-3 and 4 provide a breakdown of employment statistics.

Table C-3: Employment data (ACS, 2009-2013).

Category	Sea Bright	Monmouth County	New Jersey
Population	1,424	629,735	8,832,406
16 years or over	1,218	501,783	7,080,181
In Civilian Labor Force	921	335,366	4,688,186
Employed	834	305,222	4,235,089
Unemployed	87	30,144	453,097
Unemployment	9.4%	9.0%	9.7%

Table C-4: Employed civilian population (ACS, 2009-2013).

Industry	Sea Bright		Monmouth County		New Jersey	
	Total	Percent	Total	Percent	Total	Percent
Agriculture, forestry, fishing and hunting, and mining	17	2.0%	1,359	0.4%	14,692	0.4%
Construction	68	8.2%	19,547	6.4%	233,339	5.6%
Manufacturing	58	7.0%	18,786	6.2%	369,927	8.8%
Wholesale trade	8	1.0%	10,412	3.4%	147,576	3.5%
Retail trade	41	4.9%	35,181	11.5%	469,108	11.2%
Transportation and warehousing, and utilities	36	4.3%	15,513	5.1%	236,692	5.6%
Information	21	2.5%	10,936	3.6%	123,121	2.9%
Finance, insurance, real estate, and rental and leasing	141	16.9%	31,717	10.4%	368,865	8.8%
Professional, scientific, management, administrative, and waste management services	143	17.1%	38,703	12.7%	529,294	12.6%
Educational, health and social services	137	16.4%	70,109	23.0%	981,817	23.4%
Arts, entertainment, recreation, accommodation and food services	79	9.5%	26,526	8.7%	344,102	8.2%
Other services (except public administration)	39	4.7%	12,193	4.0%	189,508	4.5%
Public administration	46	5.5%	14,240	5%	189,442	4.5%
Total	834	100%	305,222	100%	4,197,483	100%

According to the ACS 2009-2013 data, the median household income in Sea Bright is $82,821 and a per capita income of $70,174. Approximately 3.7 percent of families and 5.5 percent of the population live below the poverty level (Table C-5). The total number of housing units in Sea Bright is 1,142. According to the Census Bureau, the median value of all owner occupied units is $449,200.

Table C-5: Income data (ACS, 2009-2013).

Category	Sea Bright	Monmouth County	New Jersey
Per Capita Income	$70,174	$42,749	$36,027
Median Household Income	$82,821	$84,526	$71,629
Families Below Poverty Line	3.7%	5.1%	7.9%
Individuals Below Poverty Line	5.5%	7.0%	10.4%
Medium Value of Owner Occupied Housing Unit	$449,200	$389,900	$327,100

Chapter 3: Description of the Problem

Coastal storms such as nor'easters, tropical storms, and hurricanes have long impacted the New Jersey coast. These storms produce wind and wave-driven surges that cause extensive flooding and erosion within the study area. The shoreline composition has been greatly altered with time.

3.1 Storm History

Sea Bright has a history of being impacted by coastal storms. The most recent storms that have impacted the study area include:

The Perfect Storm, October – November, 1991. The nor'easter was absorbed Hurricane Grace and ultimately evolved back into a small unnamed hurricane late in its life cycle. The storm lashed the east coast of the United States with high waves and coastal flooding before turning to the southwest and weakening. In Sea Bright waves washed over a seawall, forcing 200 people to evacuate. Further inland, the Hudson, Passaic, and Hackensack rivers experienced tidal flooding.

Hurricane Isabel, September 8, 2003. Hurricane Isabel produced slightly above normal tides and rough surf along the Jersey shore, killing one surfer off of Wildwood Crest. The combination of gusty winds and the heavy surf produced moderate beach erosion along much of the coastline, primarily to beaches facing southeastward. Most coastal areas of Monmouth County reported eroded beaches by up to 4 feet (1.2 m), with Union Beach losing about 5,000 sq. feet (465 sq. m) of sand.

Hurricane Irene, August 14, 2011. Hurricane Irene was a long-lived Cape Verde-type Atlantic hurricane during the 2011 Atlantic hurricane season. The storm formed near Cape Verde on August 4 and crossed the Atlantic, turning northward around Bermuda before being absorbed by an extratropical storm while situated southeast of Newfoundland. The storm caused beach erosion and flooding in Monmouth County, notably in Sea Bright.

Hurricane Sandy, October 30, 2012. Hurricane Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season, and the second-costliest hurricane in United States history. While it was a Category 2 storm off the coast of the Northeastern United States, the storm became the largest Atlantic hurricane on record (as measured by diameter, with winds spanning 1,100 miles (1,800 km)).

3.2 Impacts to Sea Bright

While the risk of flooding in Sea Bright directly from ocean storm surges is reduced by a previously constructed oceanfront sea wall, downtown Sea Bright remains vulnerable to flooding from the Shrewsbury River even during normal weather conditions. A series of low bulkheads, which are irregular in design and maintenance, provide little risk reduction to downtown from the Shrewsbury River. High water from the Shrewsbury River backs up storm sewers during spring tides and floods streets in the center of town. Monthly flooding damages automobiles parked in the street. The study area has been repeatedly flooded by hurricanes and nor'easters. During storms, surge overtops the low-lying bulkheads that line the Shrewsbury shoreline in Sea Bright town center, flooding streets and a significant number of homes that have not been elevated. Residents of this area of Sea Bright experience flood-related reduction in their incomes when they are unable to get to work due to flood waters, the most severe of which occur during winter months. Hurricane Sandy devastated Sea Bright, with storm surge inundating the Borough from both the Shrewsbury River and Atlantic Ocean. Sea Bright was totally inundated, during which storm surge overtopped or breached the Shrewsbury River bulkheads, seawalls fronting the Atlantic Ocean, and beaches.

Chapter 4: Without-Project Conditions

The without-project conditions were evaluated to provide a better understanding of the existing conditions of the study area and what is anticipated through the period of analysis.

4.1 Existing Condition

Sea Bright is comprised primarily of a mix of residences and commercial businesses. The commercial businesses community is based on catering to beach tourism. Because of the reliance on beach tourism, access to the beach and visible and easy access to their businesses is critical. While Sea Bright has been able to capitalize on its proximity to beaches, its location has also made it vulnerable to flooding from both the ocean and the Shrewsbury River.

Within the study area there are 238 structures, of which 234 (approximately 98%) lie within the 1 percent annual chance of exceedance ("100-year") floodplain. Many structures within the study area neighborhoods have been repeatedly flooded, including many of the low-lying roadways. This flooding and associated movement of sand and debris inhibits access to and from most of the community during and after emergencies. Within the study area the typical base flood elevation in the study area is +7 to + 9 feet NAVD88.

4.2 Future Conditions

Sea Bright will continue to be subject to coastal storm flooding from the Shrewsbury River. It will continue to experience road flooding during spring tides and structural damages during storms as water from the Shrewsbury River comes through and over bulkheads. It is expected that storms will continue to occur in the future, causing damage in Sea Bright. Tidal inundation is expected to increase gradually over time, in direct relation to the anticipated rise in relative sea level. Based upon long-term trends measured at Sandy Hook, a 0.014-foot per year increase anticipated, resulting in a 0.7-foot increase over the 50-year period of analysis.

It is anticipated that the existing residential and nonresidential structures will remain, however some changes may occur as structures are rehabilitated and/or elevated. Significant new development is not anticipated within the study area. Any new development that does occur is anticipated to meet or exceed local floodplain ordinances. Therefore, future development is not anticipated to significantly increase flood/storm damages in the study area.

Chapter 5: Extent and Scope of Alternatives

The study area requires an effective storm risk management program that would provide adequate levels of risk management against flooding and storm-driven waves. 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:

- Nonstructural Alternatives
- Floodwalls (Bulkheads)
- Levees
- Road Raising
- Beach and Dune Fill
- Offshore Breakwaters and Flood Barriers
- Pumps
- Ringwalls

Consideration was given to all feasible structural and nonstructural measures. Sound engineering judgment was utilized in selecting the structural components for each alternative. Existing topography, wetlands, structures, roadways, and drainage patterns were some of the constraints that had to be accommodated in the design process.

The focused array of alternative plans includes the following:

- Nonstructural Alternatives
- No Action Alternative
- Floodwall Alternatives
- Storm Surge Barrier Alternative

5.1 Nonstructural Alternatives

The nonstructural alternatives consist of implementing one or more of the following measures:

- Wet floodproofing
- Dry floodproofing
- Elevation
- Rebuilding
- Acquisition
- Evacuation Plans
- Floodplain development zoning changes/enforcement

Different nonstructural scenarios were developed, each affecting an incrementally greater number of structures. The scenarios were formulated by grouping structures with different main floor elevations (MFE). The groupings were comprised of structures with a MFE less than or equal to the water surface elevations (WSELs) for the 10, 4, and 1 percent annual chance of exceedance flood events (10-year, 25-year, and 100-year flood events, respectively). The nonstructural alternatives are:

- Nonstructural Alternative 1: structures with a MFE less than or equal +4.5 feet NAVD88 (the 10 percent flood water surface elevation)
- Nonstructural Alternative 2: structures with a MFE less than or equal to +6.0 feet NAVD88 (the 4 percent flood water surface elevation)
- Nonstructural Alternative 3: structures with a MFE less than or equal to +8.2 feet NAVD88 (the one percent flood water surface elevation)

An algorithm was used to help the PDT choose the most appropriate treatment for each structure. It has been used for many other USACE feasibility studies with nonstructural components, most recently in the CENAN for the Leonardo, NJ feasibility study. The algorithm identified two nonstructural measures as the most appropriate for the study area: elevations and ringwalls. Table C-6 provides a breakdown by structure type (residential and commercial/nonresidential) for each of the nonstructural alternatives.

Table C-6: Structure types included in nonstructural alternatives.

Alternative	Elevation		Ringwall*		Total # Structures
	Residential	Commercial/ Nonresidential	Residential	Commercial/ Nonresidential	
Structures at/below 10 percent WSEL (+4.5 feet NAVD88)**	1	0	1	7	9
Structures at/below 4 percent WSEL (+6.0 feet NAVD88)	33	0	2	30	66
Structures at/below 1 percent WSEL (+8.2 feet NAVD88)	66	3	5	38	112

* maximum number of structures behind ringwalls, as explained in detail later in this section
** WSEL = water surface elevation

To identify the most efficient and cost effective nonstructural plan, structure elevations and ringwalls were considered separately. For the initial array, nonstructural plans that included only structure elevations were used for comparison and screening of the initial array of alternatives. Ringwalls that were economically justified on their own, or incrementally justified, were added to the plan later in the planning process. Table C-7 shows alternatives were used for initial screening.

Table C-7: Nonstructural alternatives.

Nonstructural Alternatives	Description	Features
Alternative NS 1 Structures at/below 10 percent WSEL** (+4.5 feet NAVD88)	Elevations only for structures with a MFE at or below the 10 percent WSEL of +4.5 feet NAVD88	1 structure elevation
Alternative NS 2 Structures at/below 4 percent WSEL (+6.0 feet NAVD88)	Elevations only for structures with a MFE at or below the 4 percent WSEL of +6.0 feet NAVD88	34 structure elevations*
Alternative NS 3 Structures at/below 1 percent WSEL (+8.2 feet NAVD88)	Elevations only for structures with a MFE at or below the 1 percent WSEL +8.2 feet NAVD88	69 structure elevations

* one structure that was originally included within a ringwall is included in this plan
** WSEL = water surface elevation

5.2 Floodwall Alternatives

The floodwall alternatives would reduce risk to the most vulnerable and frequently flooded parts of the downtown area. The alignment would span from the Shrewsbury River Bridge to just south of Osborne Place, about a half mile. It would tie into relatively high Ocean Avenue to the east. Various floodwall crest elevations were considered (Table C-8). The crest elevations of the tieback components are controlled by the need to prevent induced flooding and by site conditions at the southern end of the study area, where the raised road dimensions are restricted by the topography, the proximity of existing structures, and drainage issues.

Table C-8: Floodwall dimensions considered.

Alternative	Floodwall Crest Elevation (+ft NAVD88)	Tieback Crest Elevation (+ft NAVD88)	Annual Chance of Exceedance (based on still water level)
Alternative F1	7.0	5.3	2%
Alternative F2	8.5	6.0	1%
Alternative F3	9.5	7.0	0.5%
Alternative F4	11.5	10.0	0.3%

5.3 Storm Surge Barrier Alternative

The storm surge barrier alternative would provide a comprehensive solution to flooding in the Shrewsbury River Basin by reducing the risk of storm surge coming from the Shrewsbury River. It would include an offshore breakwater extending across Sandy Hook Bay at the mouth of the Shrewsbury River. The structure would likely tie into raised ground or a raised road. Closure gates would be constructed to allow for navigation on the Shrewsbury River.

The total breakwater alignment is approximately 4,500 feet, crossing a broad shoal area on the Sandy Hook side. At the location of the existing navigation channel approximately 500 feet from the state bulkhead, a 200-foot wide navigation sector gate would be installed to allow for a 100-foot clear opening for navigation transit when the gate is in the open position. Prior to potential major storm events, the sector gate would be closed during a period of lower tide, sealing the inner basin, providing additional runoff storage leeward of the barrier.

Mean bay-bottom elevation along the breakwater alignment is roughly –4 feet NAVD88 or less, except across the navigation channel where it is approximately –19 to –21 feet NAVD88. The crest of the breakwater would be set at elevation +12.4 feet NAVD88. The crest elevation was selected to limit the effect of storm waves, reduce overtopping damage to the leeward side of the breakwater, and avoid water buildup from overtopping wave effects. There is insufficient storage leeward of the breakwater to store storm water runoff buildup to below elevation +5 feet NAVD88 with the sector gate closed, therefore a pump station would be required. Based on gross approximations, a 4,000 cfs pump station would be necessary to prevent residual damages from the closed gate.

Preliminary cost estimates indicated that because of the high cost of the Storm Surge Barrier Alternative, it would not be economically justified. Therefore, the Storm Surge Barrier Alternative was not evaluated in detail for the economic analysis.

Chapter 6: Economic Analysis Method

The economic analysis evaluated flood/storm related damages to structures and contents. The method and approach for the economic analysis are described in the following sections.

6.1 Structure Inventory

A database of residential and nonresidential structures in the study area was compiled to assist in calculating flood damages. The structure inventory data was generated by a survey of the structures in the study area and was mostly obtained through a “windshield survey” of the area in combination with a full elevation survey of ground and main floor elevations for each vulnerable structure. Various data were gathered and physical characteristics assessed during the structure inventory survey, including:

- Structure ID #
- Map Number
- Type of structure
- Use of structure
- Size
- Number of Stories
- Basement Type
- Number of Garage Openings
- Exterior Construction
- Quality of Construction
- Current Condition
- Ground Elevation
- Main Floor Elevation
- Location of Low Openings
- Assigned Reach
- Notes/Description (as required)

Each structure (or distinct use type where multiple usages occur within a single building) was assigned a unique structure identification number following the identification of all structures for inventory using Geographic Information Systems (GIS) mapping. GIS has also been used to determine the footprint size and hence main floor area for each structure. Sizes have been adjusted as necessary, according to observations in the field, to account for the presence of decks, attached garages, and other ancillary structures adjoined to the main construction.

The original structure inventory was performed in 2006[1], but it has been updated periodically to account for changes in the study area. The most recent update was conducted in the summer of 2015. The 2015 update consisted of field observation of the structures in the study area and additional internet research to verify the occupancy type of nonresidential structures. The 2015 update recorded changes that have occurred since Hurricane Sandy damaged the area in 2012, which include the demolition or elevation of some structures. Photos taken of the structures in 2015 were compared to the information in the structure inventory database and updates where made where appropriate.

6.2 Structure Values

The replacement value for each structure was estimated based on the characteristics of the structure and RSMeans Square Foot Costs data. The characteristics of each structure were compared to similar structure types listed in RSMeans. The estimated dollar-per-square-foot values were multiplied by the structure size to estimate the replacement value. The resulting estimates were reviewed to ensure that the structure values were reasonable.

[1] Refer to the *Shrewsbury River Basin, New Jersey, Flood Control and Ecosystem Restoration Study, Interim Economics Submission for the Borough of Sea Bright* (July 2010) for details of the original structure inventory.

The depreciated replacement value of each structure was estimated based on the replacement value of the structure and the condition of the structure. The depreciation was based on a general factor related to the condition (Table C-9). The replacement value was multiplied by the depreciation factor to estimate the depreciated replacement value of the structure.

Table C-9: Depreciation factor.

Condition	Factor
New	1.00
Excellent	0.94
Good	0.85
Average	0.72
Fair	0.55
Poor	0.36
Dilapidated	0.20

6.3 Water Surface Elevations

Two WSEL models were developed to represent flooding related to the alternatives. An "exterior" conditions model was developed to represent general flooding conditions from the Shrewsbury River. The exterior conditions were used to evaluate damages for the No Action Alternative, the nonstructural alternatives, and when flooding would exceed the design level of the structural alternatives.

An "interior" conditions model was developed to represent flooding inside the line of protection of the floodwall alternatives. The interior conditions accounted for local rainfall runoff and wave action that would overtop a floodwall and result in flooding within the protected area.

Tidal inundation is expected to increase gradually over time in direct relation to the anticipated rise in relative sea level. Based on long-term trends measured at Sandy Hook, a 0.014 foot (ft) per year increase is anticipated, resulting in a 0.7 ft increase in WSEL over the 50-year period of analysis. To account for sea level rise, 0.7 ft was added to the WSELs of the exterior conditions for the future conditions.

Because of recent breach and dune restoration activities, storm surge and wave action from the ocean side of Sea Bright were not evaluated. The beach and dune restoration activities were assumed to provide appropriate storm risk management as to not influence the economic analysis of flooding from the Shrewsbury River.

6.4 Depth-Damage Functions

All structures in the study area were assigned a depth-damage function (DDF) that represents structure and content damage as a percent of the structure's depreciated replacement value and depth of inundation. Residential structures were assigned generic DDFs based on EGM 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements, and EGM 01-03, Generic Depth-Damage Relationships for Residential Structures without Basements. Per the memoranda, content value was set to equal the depreciated replacement value of the structure.

Nonresidential structures in the study area were assigned DDFs based on data developed during the Passaic River Basin Study (PRB). The PRB DDFs were originally developed in 1982 as part of the Passaic River Basin Feasibility Study in northern New Jersey. The functions were later updated in 1995. For the PRB DDFs, content value was set to equal the depreciated replacement value of the structure. The PRB functions were considered applicable due to the broadly similar nature of the building stock in the study area and the Passaic River Basin, their proximity (the two areas are approximately 25 miles apart), and the relatively small size of the inventory did not warrant the development of project-specific DDFs.

The DDFs also included functions that captured “Other” damages. Other damages generally include landscaping, vehicles, storage sheds, garage, clean up, and extra housing costs. Other damages were also calculated as a percentage of structure value.

6.5 Damage Estimation

The flood damage calculations were performed using the Hydrologic Engineering Center’s Flood Damage Analysis (HEC-FDA) software, version 1.4. The WSELs, DDFs, and structure data were imported into HEC-FDA. HEC-FDA took into consideration the change in WSEL from sea level rise and a discount rate of 3.125 percent to estimate the equivalent annual damages (EAD) for each alternative. For the No Action Alternative and the nonstructural alternatives, the exterior WSEL model was used to estimate the EAD.

For the structural alternatives, two HEC-FDA models were developed – one model estimated the EAD based on the WSELs from the exterior model and the other to account for interior flooding. For the exterior conditions HEC-FDA model, the tie-off elevations for the structural alternatives were set at a stage of 6 ft (NAVD), which is the low point of line of protection. The analysis of exterior and interior stages indicated that they would meet or cross each other above elevation 6 ft. Based on Shrewsbury Project Performance with target stage 6 ft tie-off elevation for interior drainage, residual damage was set to correspond with the median annual exceedance probability of 0.0403 (24.8 years). The respective tie-off stages have been derived for the structural alternatives individually based on data provided in Final Interior WSEL by USACE. The EAD from each model were added together to estimate the total with-project damages for each structural alternative.

HEC-FDA adds Monte Carlo simulation capabilities and incorporates uncertainty associated with key inputs to compute the EAD. The following areas of uncertainty were incorporated into the HEC-FDA model:

- stage-frequency for each flood event
- first floor elevation
- depreciated structure and contents value
- DDFs

Chapter 7: Evaluation of Alternatives

The alternatives were evaluated based on their costs and benefits to determine the economic viability of each alternative. The alternatives were evaluated based on a 3.125 percent discount rate and a period of analysis of 50 years (2020 – 2070).

7.1 Costs of Alternatives

The initial construction costs and the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs of each alternative were estimated using MCASES II and/or engineering judgement. Table C-10 summarizes the initial construction costs and OMRR&R.

Table C-10: Alternative costs.

Alternative	Implementation Cost	Average Annual Implementation Cost	OMRR&R*	Total Average Annual Cost
Alternative F1	$12,596,000	$501,000	$212,000	$713,000
Alternative F2	$13,089,000	$521,000	$219,000	$740,000
Alternative F3	$13,164,000	$524,000	$223,000	$747,000
Alternative F4	$14,669,000	$584,000	$243,000	$827,000
Alternative NS 1A (w/ringwalls)	$9,913,000	$394,000	$14,000	$408,000
Alternative NS 1B (w/o ringwalls)	$283,000	$11,000	$0	$11,000
Alternative NS 2A (w/ringwalls)	$44,162,000	$1,757,000	$45,000	$1,802,000
Alternative NS 2B (w/o ringwalls)	$7,891,000	$314,000	$0	$314,000
Alternative NS 3A (w/ringwalls)	$73,993,000	$2,944,000	$74,000	$3,018,000
Alternative NS 3B (w/o ringwalls)	$14,641,000	$583,000	$0	$583,000
Ringwall 1	$5,660,000	$225,000	$7,000	$232,000
Ringwall 2	$2,840,000	$113,000	$3,000	$116,000
Ringwall 3	$3,856,000	$153,000	$5,000	$158,000
Ringwall 4	$5,981,000	$238,000	$6,000	$244,000
Ringwall 5	$1,843,000	$73,000	$6,000	$79,000
Ringwall 6	$2,026,000	$81,000	$2,000	$83,000
Ringwall 8	$2,927,000	$116,000	$4,000	$120,000
Ringwall 9	$2,880,000	$115,000	$3,000	$118,000
Ringwall 10	$1,958,000	$78,000	$2,000	$80,000
Ringwall 11	$3,702,000	$147,000	$4,000	$152,000
Ringwall 18	$2,599,000	$103,000	$3,000	$106,000

* Note: The removable ringwall alternatives have OMRR&R costs associated with deployment prior to an event and removal following an event.

7.2 Benefits of Alternatives

The benefits of the with-project alternatives are the reduction in damages in relation to the No Action Alternative. The results of the HEC-FDA models were used to estimate the damages for each alternative and the benefits of the with-project alternatives. Table C-11 presents the EAD (i.e., residual flood damages) for each alternative[2].

[2] Damages from interior drainage issues for ringwalls have not been evaluated, but any damage is anticipated to be negligible.

Table C-11: Equivalent annual damages for alternatives.

Alternative	EAD (exterior model)	EAD (interior model)	Total EAD
No Action	$1,533,000		$1,533,000
Alternative F1	$888,000	$166,000	$1,054,000
Alternative F2	$888,000	$137,000	$1,025,000
Alternative F3	$888,000	$83,000	$971,000
Alternative F4	$888,000	$58,000	$946,000
Alternative NS 1A (w/ringwalls)	$1,257,000		$1,257,000
Alternative NS 1B(w/o ringwalls)	$1,526,000		$1,526,000
Alternative NS 2A (w/ringwalls)	$481,000		$481,000
Alternative NS 2B (w/o ringwalls)	$1,138,000		$1,138,000
Alternative NS 3A(w/ringwalls)	$230,000		$230,000
Alternative NS 3B (w/o ringwalls)	$949,000		$949,000
Ringwall 1	$1,360,000		$1,360,000
Ringwall 2	$1,485,000		$1,485,000
Ringwall 3	$1,493,000		$1,493,000
Ringwall 4	$1,460,000		$1,460,000
Ringwall 5	$1,501,000		$1,501,000
Ringwall 6	$1,522,000		$1,522,000
Ringwall 8	$1,474,000		$1,474,000
Ringwall 9	$1,504,000		$1,504,000
Ringwall 10	$1,411,000		$1,411,000
Ringwall 11	$1,473,000		$1,473,000
Ringwall 18	$1,523,000		$1,523,000

Table C-12 presents the benefits for each with-project alternative, which is the reduction in the EAD from the No Action Alternative.

Table C-12: Annual benefits of with-project alternatives.

Alternative	Annual Benefits
Alternative F1	$479,000
Alternative F2	$508,000
Alternative F3	$562,000
Alternative F4	$587,000
Alternative NS 1A (w/ringwalls)	$276,000
Alternative NS 1B (w/o ringwalls)	$7,000
Alternative NS 2A(w/ringwalls)	$1,052,000
Alternative NS 2B (w/o ringwalls)	$395,000
Alternative NS 3A (w/ringwalls)	$1,303,000
Alternative NS 3B (w/o ringwalls)	$583,000
Ringwall 1	$172,000
Ringwall 2	$48,000
Ringwall 3	$40,000
Ringwall 4	$73,000
Ringwall 5	$32,000
Ringwall 6	$11,000
Ringwall 8	$59,000
Ringwall 9	$29,000
Ringwall 10	$122,000
Ringwall 11	$60,000
Ringwall 18	$10,000

7.3 Results of Evaluation

The project costs and benefits were evaluated for each alternative for an initial screening analysis. Costs and benefits were further refined later in the planning process. The net benefits and benefit-to-cost ratio (BCR) were reviewed to determine which alternative are economically justified (Table C-13).

Table C-13: Results of analysis of with-project alternatives.

Alternative	Costs	Benefits	Net Benefits	BCR
Alternative F1	$713,000	$479,000	-$234,000	0.7
Alternative F2	$740,000	$508,000	-$232,000	0.7
Alternative F3	$747,000	$562,000	-$185,000	0.8
Alternative F4	$827,000	$587,000	-$241,000	0.7
Alternative NS 1A (w/ringwalls)	$408,000	$276,000	-$132,000	0.7
Alternative NS 1B(w/o ringwalls)	$11,000	$7,000	-$4,600	0.6
Alternative NS 2A (w/ringwalls)	$1,802,000	$1,052,000	-$751,000	0.6
Alternative NS 2B (w/o ringwalls)	$314,000	$395,000	$81,000	1.3
Alternative NS 3A (w/ringwalls)	$3,018,000	$1,303,000	-$1,715,000	0.4
Alternative NS 3B (w/o ringwalls)	$583,000	$583,000	$1,000	1.0
Ringwall 1	$232,000	$172,000	-$60,000	0.7
Ringwall 2	$116,000	$48,000	-$68,000	0.4
Ringwall 3	$158,000	$40,000	-$118,000	0.3
Ringwall 4	$244,000	$73,000	-$172,000	0.3
Ringwall 5	$79,000	$32,000	-$47,000	0.4
Ringwall 6	$83,000	$11,000	-$72,000	0.1
Ringwall 8	$120,000	$59,000	-$61,000	0.5
Ringwall 9	$118,000	$29,000	-$89,000	0.2
Ringwall 10	$80,000	$122,000	$42,000	1.5
Ringwall 11	$152,000	$60,000	-$92,000	0.4
Ringwall 18	$106,000	$10,000	-$96,000	0.1

Based on the results of the analysis, most large- and small-scale structural and widespread nonstructural alternatives do not appear to warrant Federal interest. This initial screening showed that of the alternatives, Alternative NS 2 is the plan that maximizes net benefits. Ringwalls were individually considered in a last-added analysis to reduce residual risk. Many different ringwall designs were considered. Of the ringwalls in Alternative NS 2, one ringwall had positive annual net benefits of $42,000. Ringwall #10 is located around two attached structures, and would be up to 7 feet tall. The ringwall was added to Alternative NS 2.

When evaluating the alternatives, the analysis only considered reduction in damage to residential and commercial structures and their contents. Damages to structures and contents are generally the largest benefit category of a flood damage reduction study. The other benefit categories identified in Chapter 1 were not evaluated, but as discussed, these damage categories are not anticipated to be significant for the study area. Therefore, it is believed that the majority of the benefits were captured. While additional analysis may help to refine the results, it would most likely not change the outcome of the analysis.

Chapter 8: Tentatively Selected Plan

The benefits of implementing the alternatives represent flood damages avoided by the project. Benefits were calculated as the difference in damages before and after project implementation. Benefits were then amortized over a 50-year period (2020 through 2069) to identify equivalent annual benefits using October 2015 price levels and a discount rate of 3.125 percent.

8.1 Selection of the Tentatively Selected Plan

Based on the evaluation of the structural and nonstructural alternatives (Table C-13), the Alternative NS 2B w/o ringwalls had the greatest net benefits. In addition, the Ringwall 10 alternative also had positive net benefits and the benefits were incremental to Alternative NS 2B. Therefore, the Tentatively Selected Plan (TSP) is comprised of both the Alternative NS 2B and the Ringwall 10 alternatives. Based on additional information, the TSP was revised to remove three structures from consideration. As a result, the TSP includes the elevation of 34 structures and the use of a deployable ringwall around 2 adjacent structures.

8.2 Evaluation of the Tentatively Selected Plan

A more detailed cost estimate of the TSP was completed using MCASES II. The fully funded project cost is $12,109,000 and is cost shared: 65 percent federally funded and 35 percent non-federal. These costs include the initial first cost of $11,140,687 (Table C-14) for construction, including lands and damages, design, supervision and associated administration costs. In addition, the escalation to midpoint of construction is included. This midpoint was determined assuming a start date of March 2019. In addition, annual OMRR&R costs are anticipated to be approximately $2,000.

Table C-14: Construction Cost of the Tentatively Selected Plan

Description	Total Cost
11 Floodwalls	$1,214,416
19 Buildings, Grounds, and Utilities	$7,603,174
Construction Estimate Totals	**$8,817,590**
01 Lands and Damages	$529,080
30 Planning, Engineering, and Design	$1,184,408
31 Construction Management	$609,609
Total First Cost	**$11,140,687**

The economic evaluation of the TSP was refined to account for the construction schedule. The following assumptions were made:

- Half of the implementation costs would be expended in 2019 and half in 2020
- Based on the completion of the ringwall in 2019, OMRR&R would begin in 2020

The benefits for the TSP were estimated in HEC-FDA for the elevations of the individual structures and the deployable ringwall. Table C-15 presents the results of the evaluation of the TSP.

Table C-15: Results of the tentatively selected plan.

Average Annual Cost	Annual OMRR&R	Total Annual Cost	Equivalent Annual Benefits	Net Benefits	Benefit-Cost Ratio	Interest During Construction
$450,000	$2,000	$452,000	$466,000	$14,000	1.0	$174,073

8.3 Risk and Uncertainty

While risk and uncertainty were incorporated in the HEC-FDA model, a more detailed analysis of the risk and uncertainty associated with various confidence intervals of net benefits and BCRs will be completed during optimization.

8.4 Regional Economic Development

Since the scope of this project is small, construction activities will have minimal impacts to regional economic development.

The reduction in flood/storm damages will help the region by assisting to maintain the current residential population and associated tax base. However, the TSP offers little protection to commercial businesses in the study area. These businesses will continue to incur flood/storm related damages as estimated under the No Action Alternative.