APPENDIX A

Draft Engineering Appendix

US Army Corps
of Engineers
New York District

New Jersey
Department of
Environmental
Protection

Sandy Hook to Barnegat Inlet,

Beach Erosion Control Project,

Section I- Sea Bright to Ocean Township:

Elberon to Loch Arbour Reach

Hurricane Sandy Limited Reevaluation Report

APPENDIX A: ENGINEERING

December 2013

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1.1 Project Area

The Sea Bright to Manasquan Beach Erosion Control Project is divided into two sections on the Atlantic Coast of New Jersey, covering 21 miles of coastline. Section I includes the area from Sea Bright to Ocean Township, while Section II includes the area from Asbury Park to Manasquan.

The project was originally separated into six construction reaches, five of which are approximately three miles long, with the sixth (Belmar to Manasquan), being approximately six miles long. A total of 18 miles of project have been constructed, within the 21 mile long project area. Three miles of shoreline from South Long Branch (Elberon) through Ocean Township (just north of the Deal Lake outfall) have never been constructed.

1.2 Authorized Project Description

The project was designed to provide beach erosion control (or storm damage reduction) to the highly populated communities and infrastructure located along this area of the New Jersey shoreline. Storm damage reduction is provided by a 100 ft wide beach berm at elevation +10 ft MLW (+7.3 ft NAVD), with a width from the project baseline of 100 ft. A two foot berm cap, 80 ft wide from the baseline, was designed at elevation +12 ft MLW (+9.3 ft NAVD) to prevent frequent overtopping of the berm from wave runup. Notching existing stone groins and construction of outfall structures and outfall extensions were also activities included as part of the original construction contracts.

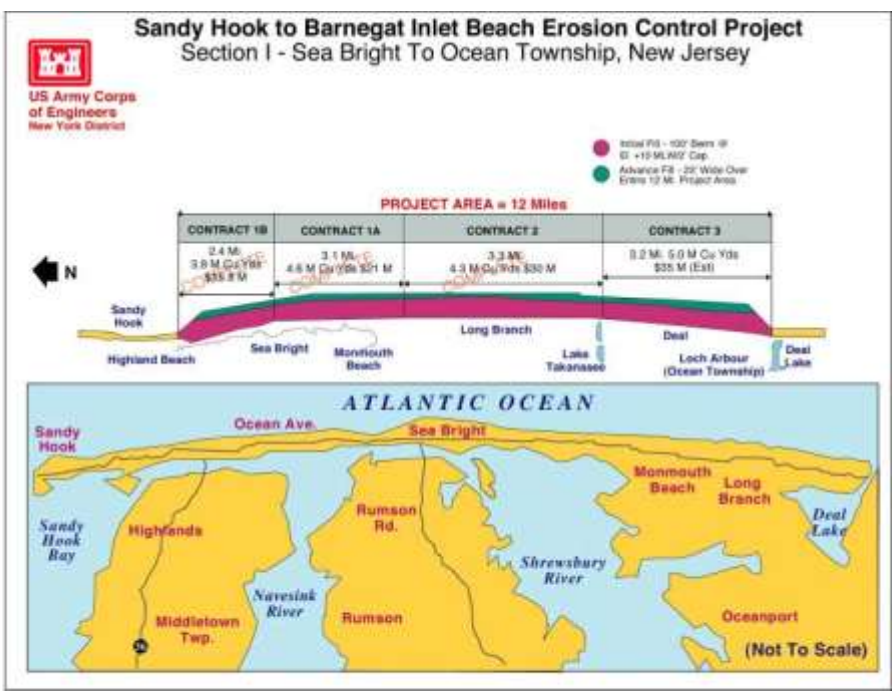

Figure 1: Contract Map - Section I - Sea Bright to Ocean Township, NJ

2. Project Area Conditions since 1989

As Reported in the 2011 New Jersey Beach Profile Network Annual Report: Covering 25 Years of New Jersey Coastal Research, Coastal Research Center (CRC), The Richard Stockton College of New Jersey:

"Monmouth County received the benefit of the largest, most expensive and most comprehensive beach nourishment project ever in the United States beginning in 1994. Completed by the New York District Army Corps of Engineers (ACOE) for $210,000,000, this project continued in three phases until the year 2000. In all, 21 miles of the county shoreline were restored with a 100-foot wider berm and a dune system built in all locations where practical (a total of 6.1 million cubic yards of sand). The only gaps in the entire project where no sand was placed on the beaches were in the communities of Loch Arbour, Allenhurst, Deal and Elberon. This fact divides the restored shoreline into two filled segments: one from the Sandy Hook National Seashore south to the Long Branch/Elberon boundary; then no fill to the Asbury Park boundary; and the second segment from Asbury Park to the Manasquan Inlet.

Loss from the southern Monmouth County fill section that moved to the north has benefited Loch Arbour and the Borough of Allenhurst as sand slowly moved north around the northern Asbury Park groin into the short shoreline cell containing these two municipalities. An extensive groin complex built at the Allenhurst – Deal boundary prevents sand movement into the Borough of Deal. Likewise, 13 years of observations have shown that little sand has moved south into Elberon or Deal from Long Branch (Pullman Ave., Roosevelt Ave., and Darlington Ave. monitoring sites). The groins and shoreline armor stone remain the line of storm defense for this shoreline segment."

3. Post-Hurricane Sandy Coastal Existing Conditions

3.1 Elberon to Loch Arbour

As reported in the Beach-Dune Performance Assessment of New Jersey Beach Profile Network (NJBPN) Sites at Between Manasquan Inlet and Allenhurst, New Jersey Related to FEMA DR-JI 4086 Declared for Hurricane Sandy, dated December 5, 2012 and the Beach-Dune Performance Assessment of New Jersey Beach Profile Network (NJBPN) Sites Between Deal and Sea Bright, New Jersey, Related to FEMA DR-NJ 4086 Declared for Hurricane Sandy Coastal Research Center, dated 12 December 2012, both the Coastal Research Center at the Richard Stockton College of New Jersey:

"The major observation was that Hurricane Sandy's waves were dramatically higher upon breaking in this portion of the coastline than they were farther south, especially south of the center of rotation for the storm. Damage seen in Deal and Elberon demanded that waves exceeded 30 feet in NAVD 88 elevation levels on breaking on the bluff. The Pullman Avenue monitoring site saw two homes with foundation elevations at +28 feet destroyed and a third of the lot transformed into empty space where the land once stood. The Lake Tackanassee monitoring site was obliterated and the entire Long Branch boardwalk on the top of the bluff was destroyed.

Allenhurst – Loch Arbour:

The monitoring site at Allenhurst sits on top of an ancient concrete wall that drops vertically to the sand beach. There is a wooden walk elevated above the road just landward of the concrete wall. It was at this site that the CRC came to realize the power of Hurricane Sandy's wave forces. The boardwalk is 20 feet above sea level, behind a vertical concrete wall located about 100 feet from the low tide line on the beach. About 50 feet of the boardwalk was stripped from the supports and shifted toward the roadway with ample evidence that waves had moved across the lawns of the major houses farther landward. A well-clipped hedge was pushed over landward with debris threaded through it and the grass landward was dying from salt water with loads of small debris all over it. Down below, the beach was present, ramped up to the wall's base. Two massive slabs of concrete had settled downward and slightly outward at the base indicating that failure was threatened during the height of the storm. There was a recovery berm and offshore bar along the entire segment between the Deal boundary groin and the Deal Lake flume. Loch Arbour is only a two-block shoreline with half public beach and half in private ownership. There has been a long history of storm waves washing through the private beach club into Deal Lake. This clearly had occurred as the road across the "estuary" lake bay mouth barrier was still closed. Deal Lake is the largest of the now-closed stream estuaries along the Monmouth County Shoreline. It has been mapped as open to the tide flow as late as 1880, but closed by 1889. There was no paved road across the bay mouth sand bar until after 1920 according to the earliest aerial photography. There is a sizable weir and boxed flume carrying freshwater seaward to drain the lake. This was still functioning though sand had spilled into the lake at the seaward end. No Federal Project sand was deposited along this short segment, but over the past 13 years material has escaped by the large terminal groin in Asbury Park enhancing this small reach.

Southern Deal:

Deal is divided from Allenhurst by a massive boxed pair of groins that retain all sand on the Allenhurst beach, letting none past to the north. The Darlington Avenue monitoring site is about a mile north into Deal and was picked because there was a pocket beach centered at Darlington Avenue extending several blocks in either direction. The sediment bluff, once exposed 25 years ago had been armored by individual property owners over time with timber bulkhead "seawalls". The beach varied little over time. The wave forces over-matched the newer timber structures smashing them to rubble and exposing an erosional scarp in the bluff sediments. In 50 years, the CRC has never observed so much of the Cretaceous sediments that comprise the Monmouth County uplands exposed to view. The retreat at the top of the bluff was about 25 feet of loss to the oceanfront property owners in a very irregular pattern. Those who chose to build a beach cabana at or near the sand at the base of the bluff lost it to splintered wood. One was concrete and suffered the same fate because the storm undermined its foundation. Old structural relicts, never seen earlier were exposed on the lower beach with a bar offshore where the sand had been carried and deposited. With the erosion noted in the bluff, this little beach likely gained sand volume the time-honored way by storm erosion of the bluff sediments.

Roosevelt Avenue, Deal:

The Roosevelt Avenue monitoring site is located north of the Deal sewage pumping station built in 1906 at the base of the sedimentary bluff. It is essentially a three-story building with just the top story presented at the end of Roosevelt Avenue. South of this street is a series of private homes built on the bluff with a decent sand beach seaward of the dune-mantled bluff edge. Phillips Avenue is the location of a public bathing complex that was totally destroyed by the loss of the Phillips Avenue fishing pier built decades ago over the rock groin at the end of Phillips

Avenue. North of Roosevelt Avenue there is essentially no dry beach between closely-spaced groins. This monitoring site has a 26-year history of a wet beach against the rocks. Occasional offshore bars have migrated to the shoreline yielding a temporary dry beach less than 25 feet in width. Hurricane Sandy's waves over-topped the rock wall and scoured deeply into the soil, fill debris (bricks etc.) and bluff sediments. Water poured landward flooding both Roosevelt and Ocean Avenues to 3-foot depths as seen in debris lines on nearby properties. The tile roof was torn off the seaward side of the sewer plant pumping station and all three floors of the facility were filled with seawater. Deal's $650,000 investment in rehabilitation of the facility last year was in ruins.

Pullman Avenue, Elberon:
The single monitoring site located in Elberon at Pullman Avenue demonstrated the susceptibility of even the high bluff located here (28 feet NAVD88) to major erosion from the storm surge and waves generated by Hurricane Sandy. Homes built at the bluff edge were destroyed by waves with about a third of each lot's width inland gone. The rock revetment and timber wall account for about 40% of the bluff height and were unaffected. Apparently waves broke on the revetment with crests at least 35 feet high because both homes were smashed in on the seaward side. This was not from wave spray on impact with the fortifications. The end of Pullman Avenue was eroded landward by about 50 feet.

Lake Takanassee, Long Branch:
This monitoring site is positioned just south of a series of major condominium complexes between West End Avenue and Lake Takanasee. This is the northernmost "estuary lake" along the Monmouth County shoreline and, like the others has a fresh water drainage system buried under a bay-mouth barrier. There is no bluff here, so the storm waves simply rolled over everything in their path to the lake where Ocean Avenue crosses it on a bridge structure. An historic life-saving station converted to a bathing complex was utterly destroyed. All traces of the beach survey monitoring site established two years ago were gone, so the site was navigated to using the GPS coordinates for the reference monuments. The beach profile ran up-grade to a point where the slope reversed downgrade seaward into the water. An offshore bar was present as well. Multiple individuals with metal detectors were busy finding coins long buried by sand now washed landward toward the lake. The abundance of metal artifacts was such that this author picked up two 25¢ coins on the beach surface while doing the post-storm survey. The sand loss was extensive and the structural damage was total."

3.2 Flood Control and Coastal Emergency Work on other Sections

In response to Hurricane Sandy, a series of repairs on the previously constructed reaches of the project were undertaken as funded by PL 84-99 and PL 113-2. Each of the originally constructed reaches is being repaired to its original design condition, including repairs of any outfalls that sustained storm damages. The repairs are ongoing and should be complete in May 2014. Each repair contract follows the delineations in the initial construction of the project (Sea Bright and Monmouth Beach; Long Branch; Asbury Park to Avon-by-the-Sea; Belmar to Manasquan). Below is a brief description of the schedule and scope of each of the repair contracts:

- Sea Bright and Monmouth Beach: 2,175,000 cubic yards of beach fill placement and repairs of two outfalls in Monmouth Beach; repairs conducted between July and December 2013
- Long Branch: 3,300,000 cubic yards of beach fill placement and repairs of four outfalls; conducted between September 2013 and April 2014

- Asbury Park to Avon-by-the-Sea: 1,200,000 cubic yards of beach fill placement, conducted between November 2013 and May 2014
- Belmar to Manasquan: 1,500,000 cubic yards of beach fill placement, conducted between August 2013 and January 2014.

4.0 Future Rates of Sea Level Rise

4.1 Guidance

The Department of the Army Engineering Circular EC-1165-2-212 (October 2011) requires that future sea level rise (SLR) projections must be incorporated into the planning, engineering design, construction and operation of all civil works projects. The project team should evaluate structural and non-structural components of the proposed alternatives in consideration of the "low," "intermediate" and "high" potential rates of future SLR for both "with" and "without project" conditions. This range of potential rates of SLR is based on findings by the National Research Council (NRC, 1987) and the Intergovernmental Panel for Climate Change (IPCC, 2007).

4.2 Components of Sea Level Rise

SLR considers the effects of (1) the *eustatic,* or global, average of the annual increase in water surface elevation due to the global warming trend, and (2) the "regional" rate of vertical land movement (VLM) that can result from localized geological processes, including the shifting of tectonic plates, the rebounding of the Earth's crust in locations previously covered by glaciers, the compaction of sedimentary strata and the withdrawal of subsurface fluids.

Elberon to Loch Arbour, New Jersey is located in an area that experiences positive land subsistence due to geological processes; therefore, the net relative sea level rise at this project location is greater than the eustatic SLR. Said differently, when land in Elberon to Loch Arbour subsides as water surface elevation increases, the net local SLR is greater in Elberon to Loch Arbour than at a location experiencing an increase in water surface elevation only.

4.2.1 Rates of Sea Level Rise

When calculating the intermediate and high rates of sea level rise, the local rate of VLM must first be determined. An example calculation for Sandy Hook is provided in Section 2.3.1, Determining Local VLM.

4.2.2 Historic Rate of Sea Level Rise

The historic rate of future sea-level rise is determined directly from gauge data gathered in the vicinity of the project area. The nearest NOAA tide gauges from which tide data can be evaluated include: The Battery and Montauk Point gauges in New York, and the Sandy Hook gauge in New Jersey. Of these three locations, tide conditions at Sandy Hook (NOAA Station #8531680) best represent the conditions experienced in Elberon to Loch Arbour. A 75-year record (1932 to 2006) of tide data gathered at Sandy Hook, NJ indicates a mean sea level trend (eustatic SLR + the local rate of VLM) of <u>+3.9 mm/year</u>.

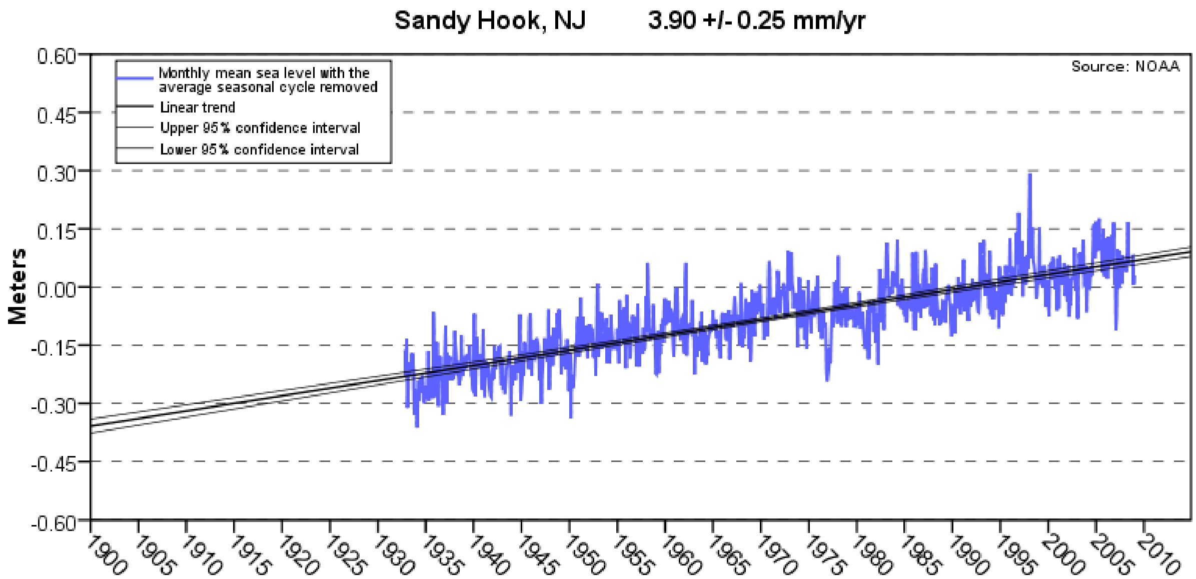

Figure 2: Mean Sea Level Trend at Sandy Hook, NJ (NOAA Station # 8531680)

4.2.3 Intermediate Rate of Sea Level Rise

The intermediate rate of local mean SLR is estimated by considering the modified NRC projections and adding the appropriate value to the local rate of vertical land movement. The intermediate rate of local sea level rise is based on the modified NRC Curve I since its value is comparable to that of the IPCC projection.

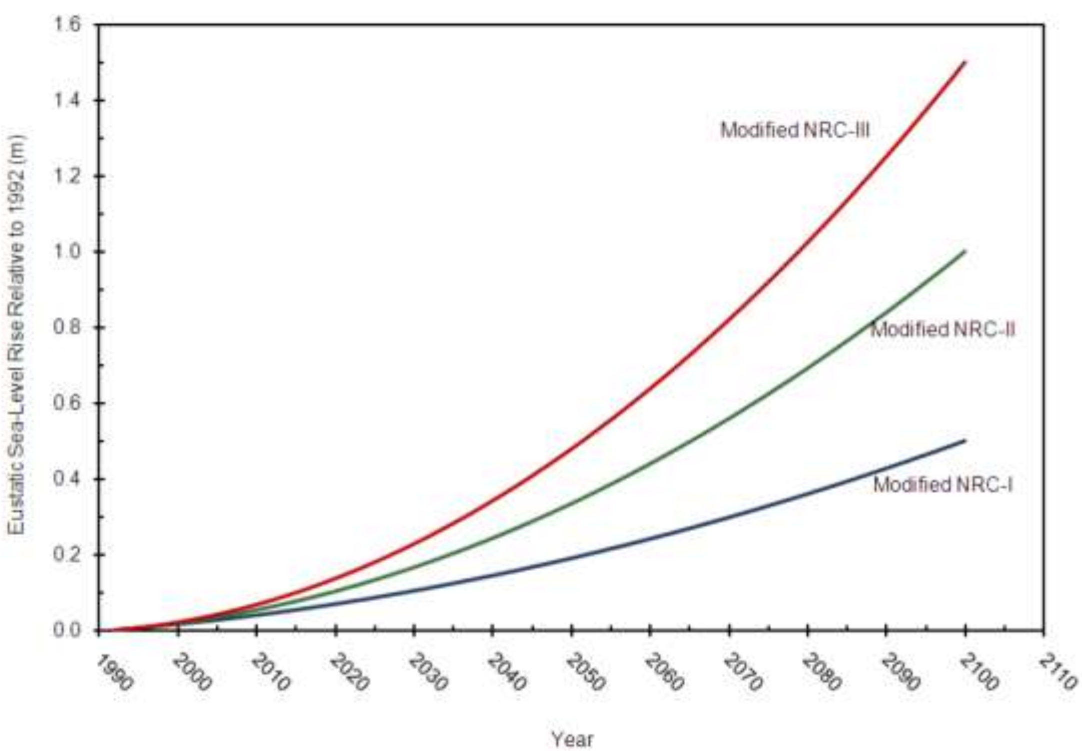

Figure 3: Modified NRC curves for predicting future rates of eustatic SLR.

NRC Curve I is based on the general equation $E(t) = 0.0017t + bt^2$,
where the constant 0.0017 = the IPCC 2007 annual rate of eustatic SLR in meters;

t = time in years (relative to the year 1986 when the curves were developed) and;

$b = 2.71E^{-5}$

4.2.4 High Rate of SLR

The high rate of local mean SLR is estimated by determining the modified NRC Curve III value and adding it to the local rate of vertical land movement. This high rate scenario exceeds the 2001 and 2007 IPCC projections and considers the potential rapid loss of ice from Antarctica and Greenland.

NRC Curve III is also based on the general equation $E(t) = 0.0017t + \mathrm{b}t^2$; however, the constant b changes to $b = 1.13E^{-4}$.

For both the intermediate and high rates of SLR, the NRC curves accelerate upward over time beginning in the year 1992 when the curves were developed; therefore, it is necessary to estimate SLR for a particular time horizon relative to 1992.

4.2.5 Determining Local VLM

The local rate of VLM, which is considered to be constant through time, is determined by subtracting the NRC/IPCC eustatic SLR value (1.7 mm/yr) from the local mean sea level trend. Recall from Section 2.1 above that the two components figuring into the local mean sea level include the eustatic SLR value and the local rate of VLM. The mean rate of SLR at the Sandy Hook station is +3.9 mm/year (7.7 inches in 50 years).

The local rate of VLM at Sandy Hook is calculated from the relationship:
$VLM_{Sandy\ Hook}$ = [local rate of SLR] – [eustatic rate of SLR], or
$VLM_{Sandy\ Hook}$ = 3.9 mm/yr – 1.7 mm/yr = 2.2 mm/yr (0.087 in/yr)

At Sandy Hook, the local rate of VLM accounts for a total of 4.35 inches (0.087 in/yr x 50 yrs) at a 50-year time horizon.

This local rate of VLM is added back into the sea level rise computations after the eustatic portion has been determined from NRC curves I and III.

4.3 Projected Water Surface Elevation Increases

The Elberon to Loch Arbour project design water level stages were developed as of 1996. Using the year 1996 as the base year from which future sea level elevations are estimated, Table 1 shows the projected increase in water surface elevation for the historic, intermediate and high rates of future sea level rise at Elberon to Loch Arbour, New Jersey to the year 2100.

For example, in the year 2030, it is anticipated that the water surface elevation in Elberon to Loch Arbour, NJ could increase by 0.44 feet under the historic rate future sea level rise scenario; by 0.56 ft under the intermediate scenario and by 0.96 ft under the high scenario. Water surface elevations at the end of the 50-year project life in year 2065 (assuming completion of construction in 2015) could increase by 0.88 feet under the historic rate future sea level rise scenario; by 1.36 ft under the intermediate scenario and by 2.85 ft under the high scenario.

Table 1: Increase in predicted water surface elevations at Elberon to Loch Arbour, NJ under the historic, intermediate and high rates of future sea level rise (from base year 1996)

Year	Years from base year	Historic (ft)	Intermediate (ft)	High (ft)
1996	0	0.00	0.00	0.00
2000	4	0.05	0.06	0.07
2005	9	0.12	0.13	0.17
2010	14	0.18	0.21	0.29
2015	19	0.24	0.29	0.43
2018	22	0.28	0.34	0.53
2020	24	0.31	0.38	0.59
2025	29	0.37	0.47	0.77
2030	34	0.44	0.56	0.96
2035	39	0.50	0.66	1.18
2040	44	0.56	0.77	1.41
2045	49	0.63	0.88	1.66
2050	54	0.69	0.99	1.93
2055	59	0.75	1.11	2.22
2060	64	0.82	1.23	2.53
2065	69	0.88	1.36	2.85
2068	72	0.92	1.43	3.06
2070	74	0.95	1.49	3.20
2075	79	1.01	1.62	3.56
2080	84	1.07	1.76	3.94
2085	89	1.14	1.91	4.34
2090	94	1.20	2.06	4.76
2095	99	1.27	2.21	5.19
2100	104	1.33	2.37	5.65

4.4 Adaptation of the Flood Risk Management Component of the Recommended Plan for Increased Sea Levels

The Elberon to Loch Arbour Shore Protection Component design consists of a sand berm cross section, which is adaptable to changes in sea level. Adaptations to the protective section would include increase in berm elevation to compensate for increasing still water levels. Regular renourishment operations are part of the Recommended Plan. Each renourishment cycle provides an opportunity to recalculate storm impacts to the design section and to modify the section to account for deeper water and larger waves. The berm design can be modified to adapt to other potential impacts from climate change including changes to storm frequency and intensity.

Outfall extensions within the project area will be designed for 30 year economic life and will take into account the intermediate projections of sea level rise, for design of invert elevations.

5. Project Area Design

5.1 Beachfill Design and Quantities

Design: The design template (authorized cross section) for this reach of the project consists of a 100 ft wide beach berm at elevation +10 ft MLW (+7.3 ft NAVD), with a width from the project baseline of 100 ft. A two foot berm cap, 80 ft wide from the baseline, was designed at elevation +12 ft MLW (+9.3 ft NAVD) to prevent frequent overtopping of the berm from wave runup. The offshore slope of the design template is 1 on 10 from el. +9.3' NAVD 88 to el. -2.7' NAVD 88 and 1 on 35 from el. -2.7' NAVD 88 to depth of closure. Figure A9 from the General Design Memorandum is included below as Figure A1 to illustrate this concept, and the design template from Euclid Avenue in Loch Arbour (STA 628+00) is included at Figure A2 to show how the design template compares to existing conditions:

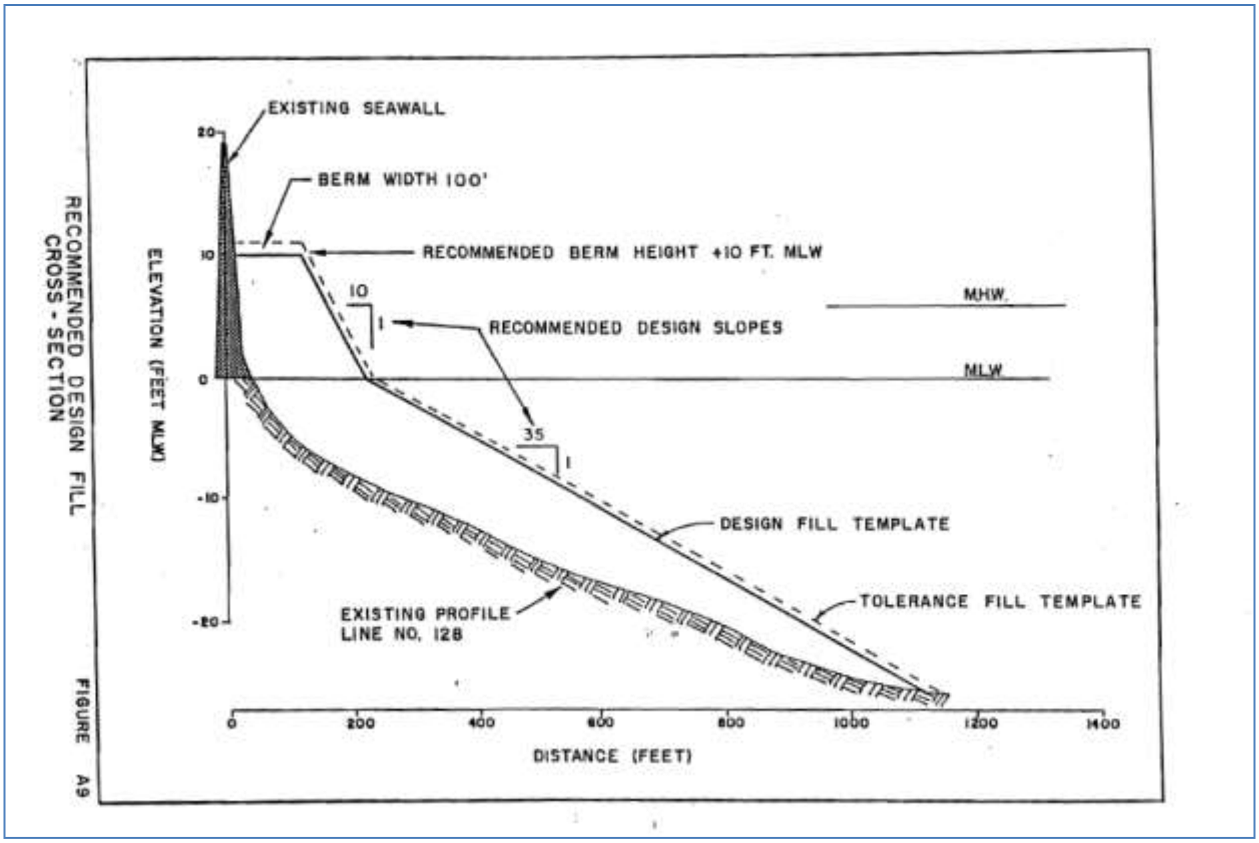

Figure 4: Design Template (reproduced from General Design Memorandum)

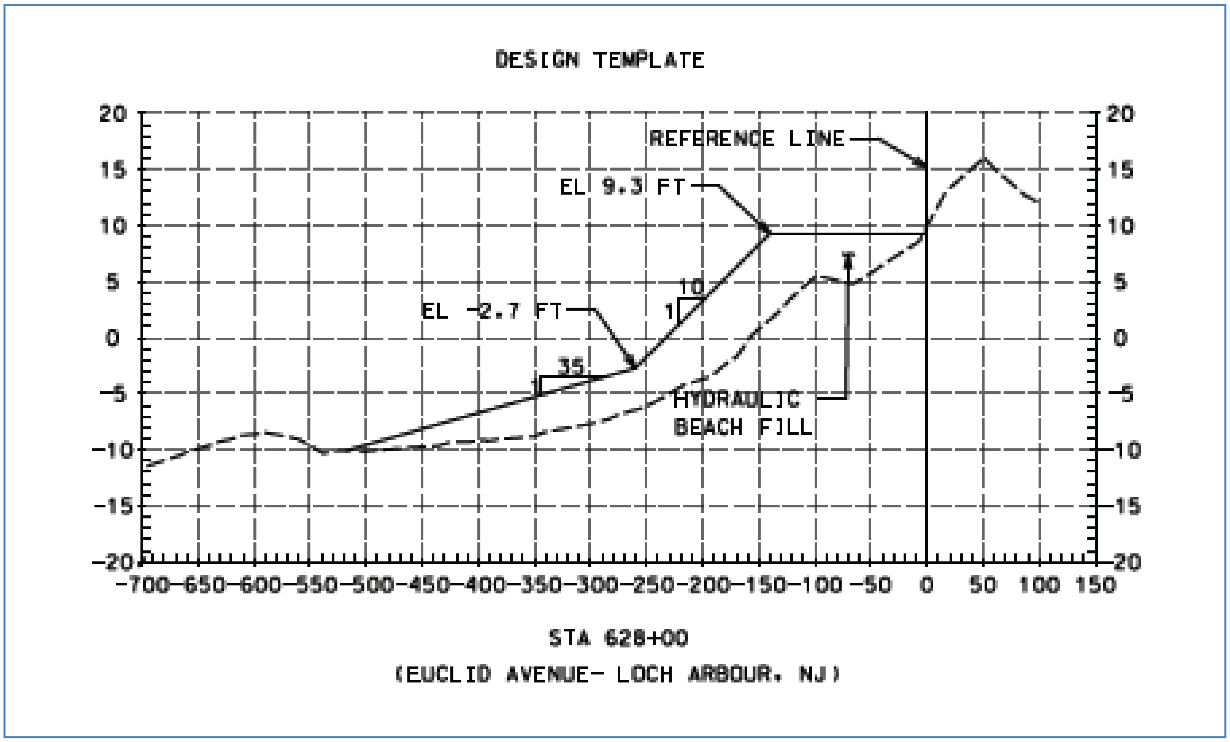

Figure 5: Design Template at STA 628+00 (Euclid Avenue, Loch Arbour, NJ)

Existing (post- Hurricane Sandy) Conditions: In order to develop accurate cost estimates for the project reach, existing conditions were reviewed through a series of site observations, information provided by project area municipalities and the non-Federal sponsor, and beach profile surveys. Site observations were conducted in July and August 2013. Information was provided by municipalities in July-October 2013. Beach profile surveys were taken in March and April 2013.

Site Observations: Site observation visits were conducted in July and August 2013. The purpose of the site visits, with respect to beach fill placement, was to review the conditions of the project reference line, specifically the structural conditions of walls, bulkheads, and revetments that were expected to form the landward limit of beach fill placement and to determine the landward slope of the beach berm in areas without bulkheads or revetments. Any significant landward retreat of the walls, bulkheads, or revetments would increase the amount of fill required for the landward slope to existing ground. The site observations showed little to no damage to the reference line area in Loch Arbour and Allenhurst, moderate damage to the reference line area in Deal (all of which had been repaired or was under repair), and significant damage to the reference line area in Elberon (City of Long Branch), much of which had not been repaired and was not under repair at the time of site observation visits.

Loch Arbour and Allenhurst: Site observation visit of Loch Arbour and Allenhurst was conducted on 25 July 2013. As seen in Figures A3 and A4, the seawalls that form the project reference line were in good condition and should be able to support beach fill placement to the reference line.

Figure 6: Loch Arbour, NJ

Figure 7: Allenhurst, NJ

Deal: Site observation visit for Deal was conducted on 25 July 2013. Moderate damage to the reference line area was observed, and review of time lapse aerial imagery showed damage to the reference line area that occurred during Hurricane Sandy and had been repaired by the time of the site visit. All existing damage was under repair at the time of the survey.

Figure 8: Neptune Ave. Deal, NJ

Elberon: Site observation visits of Elberon (City of Long Branch) were conducted on 25 July and 6 September 2013. Observations of the reference line area range from good to marginal. The reference line area was marginal in the northern portion Elberon, where wave action from Hurricane Sandy had overtopped the existing wooden bulkhead (which serves as the reference line itself), causing scour and loss of sand. At Pullman Ave., the embankment behind the bulkhead has eroded to the point where first line structures cannot be occupied. At Plaza Court in Elberon, at least one structure is being relocated landward of its original position. Coordination with the City of Long Branch in ongoing with respect to the Corps' concerns about placing beach fill against the bulkhead in its current condition. Small amounts of sand will need to be placed landward of the bulkhead line in areas where the bulkhead has been destroyed or where scouring has occurred to the point where the bulkhead tie backs and dead man have been exposed.

Figure 9: Pullman Ave., Elberon, NJ facing north (note elevation of grade landward of bulkhead)

Figure 10: Pullman Ave., Elberon, NJ facing south (note loss of sand landward of bulkhead)

Beach Profile Surveys: Beach profile surveys of the project area were conducted in March and April 2013. A total of 41 survey profiles were taken for the project area (20 short range profiles and 21 long range profiles).

Figure 11: Long Range Profile Locations

Figure 12: Long Range Profile Locations

Survey data from these profiles was imported into InRoads (Bentley software) and then triangulated to develop a three dimensional surface of the existing conditions. A three dimensional surface was also created for the "design" template that included an advance nourishment width of 40', and using the project reference line as the horizontal alignment. The landward slope of the design fill template was adjusted along the length of the project area to account for existing backshore conditions, and a 1 foot tolerance (to account for constructability concerns) was applied to the template. The triangle volume function of InRoads was then used to determine the cut and fill volumes between the "design" template surface and the "existing conditions" surface. InRoads reports a "cut", "fill", and "net" volume difference. Since no reshaping of the existing beach is authorized in order to achieve the design template, only the "fill" volume difference is reported.

The required construction quantity for initial construction for the project area is 4,450,000 cubic yards. An additional survey will be completed for final design, which will include additional short range profiles in the southern portion of the project area.

Borrow Area: Four distinct borrow areas were located within the larger Seabright and Seabright '88 footprint. The total volume available within all five areas is 6.4 mcy. This computation discounts side slope volumes. The assumption was made that 33% of the material found will be deemed unsuitable by the dredger, i.e., a total of 9.6mcy was delineated, of which 6.4 will be found usable. This factor of 33% is to account for the paucity of data available The maximum number of existing Vibracore locations per borrow area is three and the minimum is none. The material varies in grain size from fine sand (0.17mm median grain size) to coarse gravel (~32mm). The material is expected to contain negligible amounts of silt and/or clay. In a couple of instances the lithologic layers will contain 100% gravel, but on average not more than 25% of the material per area is expected to consist of gravel. Figure A10 shows the borrow area delineations and volume computations.

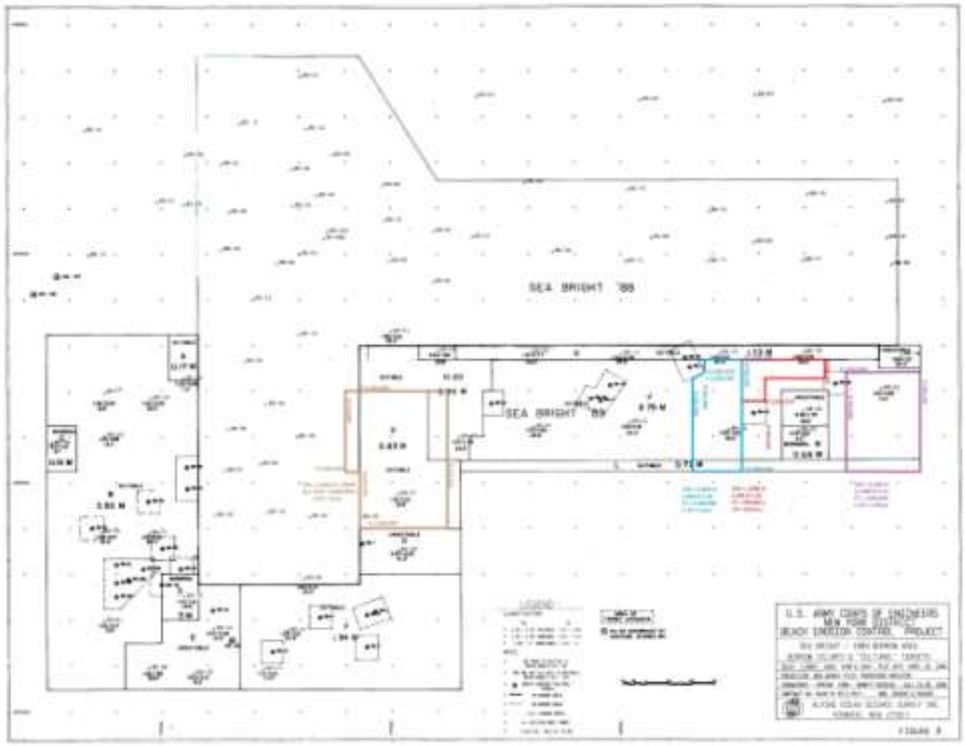

Figure 13: Borrow Area

5.2 Groin Modifications

As stated in the General Design Memorandum, the selected plan will bury many of the existing groins. Within the Loch Arbour to Elberon reach of the project area, six (6) groins will extend further than 150' seaward of the design cross section MLW. These groins are given special attention, as their length and condition makes it likely that significant impoundment will occur on the updrift side of the groin, leading to a sand starved condition of the downdrift side of the groin. The length of these groins with respect to their spacing from the downdrift groins exceeds current design guidance, which can cause filleting updrift of the groin and scouring downdrift of the groin. This situation goes against the stated purpose of the project: a stable beach of uniform width along the length of the project.

The most effective method to address the groins' impact on sediment transport is complete removal of the portions of the groin seaward of the design template. This solution would be cost prohibitive and typically lacks public support, so it was not proposed in the GDM. As was executed elsewhere in the project area (Long Branch, Belmar, Spring Lake, Asbury Park, Bradley Beach, Avon-by-the-Sea), "groin notching" (removal of the top layer of armor stone in a 100' section) will be pursued. A total of 28 groin notches have been previously completed in the project area from Sea Bright to Long Branch and from Asbury Park to Manasquan. The groin notch will create something similar to a weir section and will allow sediment to pass through the groin cross section and prevent impoundment. The notch will extend approximately 100' seaward of the design mean low water shoreline. The final location of the notch will account for the advance nourishment width. The stone that is removed from the groins will be reused at a location determined by the State of New Jersey.

Notch Design and Construction-

Design: Each groin notch will be designed to be 100' wide along the length of the groin, and will have a bottom slope of 1 on 35, the same slope as the offshore profile of the design beach fill in the Loch Arbour to Elberon reach. Side slopes of 1V to 3H will be constructed at the landward and seaward edge of the existing groin to tie the notch into the existing groin. Stone will be excavated and sorted for reuse in construction of the notch. Once stone is excavated to create the slope, a 2' layer of bedding stone will be placed to create a base layer, with armor stone then replaced to create the top layer. (Bocamazo, et al. 2003)

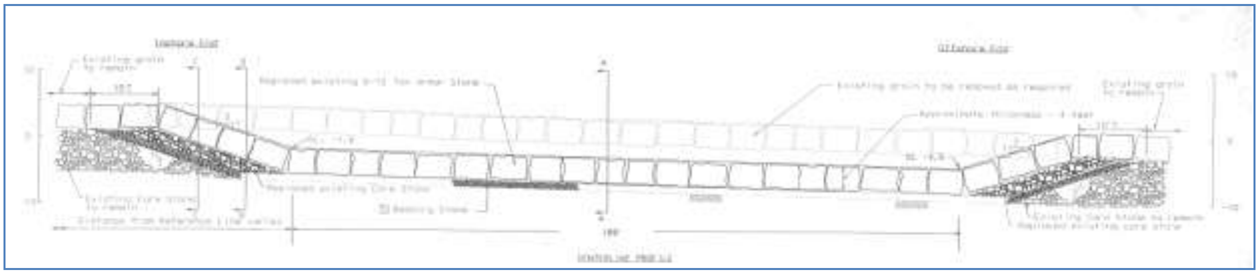

Figure 14: Typical Groin Notching Details

The following elements will also be incorporated into the design:

-The groin notches will be placed sufficiently landward so that it is located within the swash zone under all but extreme wave conditions (Rankin, Bruno, Herrington, 2004)

- only the upper layer of armor stone will be removed within the notch area and the remaining structure profile within the notch will follow the natural slope of the adjacent beach. This will leave the lower portion to remain as a guard against vertical scour. (Rankin, Bruno, Herrington, 2004)

- Construction specifications will be written such that groin notching will not take place until after beach fill placement.

Construction: In previous iterations of notching construction, working within the surf zone has proven to be challenging. Expected equipment for construction of each notch includes:

- Two excavators with hydraulic thumbs and 4 yard buckets
- Dump truck for stone removal
- Dozers for stone movement
- Light plants to support 24 hour operation
- Pumps to dewater excavated holes

A containment zone will have to be created so that the work can occur in a no wave environment. The zone will be created 40 ft north and south of the groin using the stone that can't be reused in the notch, with a steel plate placed seaward of the stone for stability.

Quantities: The following quantities of excavation and bedding construction are expected for this project-

Groin	Excavation Quantity (CY)	Bedding Layer Quantity (CY)
92	1,179	505
94	1,128	575
95	961	344
97	1,123	508
99	2,089	649
101	1,640	556

Table 2: Groin Modification Quantities

Existing Conditions:
Visual surveys of the groins slated for notching were conducted on 25 July 2013. Five of the six groins were observed to be in good condition, with one groin (Roseld Avenue, Deal) observed to have some degradation in the middle portion of the groin. 25 July 2013 conditions are shown in the below photographs.

Figure 15: Structure 92- Whitehall Street, Deal- Site of Groin Notch #1.

Figure 16: Structure 94- Phillips Avenue, Deal- Site of Groin Notch #2

Figure 17: Structure 95- Deal Casino, Deal- Site of Groin Notch #3

Figure 18: Structure 97- Roseld Avenue, Deal- Site of Groin Notch #4 (note degraded conditions in middle)

Figure 19: Structure 99- Marine Place, Deal- Site of Groin Notch #5; note significant fillet on south (updrift) side of groin

Figure 20: Structure 101-Cedar Avenue, Allenhurst- Site of Groin Notch #6

Topographic surveys of the groins slated for notching were completed in July/ August 1996. These surveys were combined with visual observations to determine the quantities of stone to be removed for purposes of cost estimating within this report. Updated surveys will be completed to support final quantity development during the plans and specifications phase of the project.

5.3 DRAINAGE OUTFALL EXTENSIONS

5.3.1 EXISTING CONDITIONS

Site Inspections, consultations with municipal engineers, review of previous design documents (General Design Memorandum and draft construction plans from Spring 2000) and a survey have shown that there are 39 outfalls within the Loch Arbour to Elberon shoreline. These outfalls range in size from 4” PVC outfalls that appear to drain only a single property, to 72” diameter outfalls (at Lake Takanasee in Long Branch and Poplar Brook in Deal). All drainage outfalls in the project shoreline are listed in Table 1. The existing outfalls are either steel, concrete, ductile iron pipe, PVC, Vitreous Clay Pipe, or HDPE. In the case of Poplar Brook, the existing outfall is a meandering stream that flows across the beach from Ocean Avenue.

5.3.2 REQUIRED MODIFICATIONS

The proposed project will require modifications to several of the outfalls to ensure the outfalls remain operational and that there is no damage to the newly constructed beach. Per the General Design Memorandum, the selected modification was to extend outfalls where required by drainage and safety requirements, take no action where drainage and safety could be maintained without taking further action, and to pursue alternative solutions (such as cutting back existing outfalls to achieve a higher invert elevation or installing a dry well) where cost effective. The following evaluation method was applied to the existing outfalls to determine the appropriate action:

5.3.2.1 No Action Evaluation: those outfalls that were 30" or less in diameter and that had an invert elevation of +10.3' NAVD or greater will have no action taken. The elevation of these outfalls ensures that impounding will not lead to upland flooding, and the small diameter of the outfall will not lead to dangerously eroded conditions of the constructed beach. No Action will be applied to Township of Ocean Sewerage Authority outfall or the Roosevelt Ave. sanitary sewer outfall (both in Deal), as these sanitary sewer outfalls empty 1500'-2000' offshore, so there is no concern of impoundment.

5.3.2.2 Extension Evaluation: several outfalls with a diameter greater than 30", or with an elevation lower than +10.3' NAVD will be extended as part of this project. The invert elevations lower than +10.3' NAVD will lead to impoundment of the outfall by the constructed beach, which can lead to upland flooding. Several outfalls, such as outfall #36 at Phillips Ave. in Deal, already suffer from impoundment under existing conditions. Erosion caused by outfalls greater than 30" in diameter can form trenches in the constructed beach. This can result in a dangerous condition. (GDM)

5.3.2.3 Alternative Solution Evaluation: not all outfalls in the project shoreline fall in to the "No Action" category or "Extension" category. Several outfalls cannot have "no action" taken without negative effects on the upland tributary areas, but extending these outfalls is not the best solution, due to high initial construction costs and high maintenance costs. In these cases, a case specific solution has been recommended, such as replacing the final section of pipe so that the invert elevation rises above +10.3' NAVD, cutting back existing exposed outfall pipe so that the new invert elevation rises above +10.3' NAVD, or pursuing a local retention system.

5.3.3 OUTFALL MODIFICATION DESIGN

Outfall extensions for pipes 30" diameter or less will be supported using timber crib structures. An example of this structure is shown in Figure 21. Outfall extensions for pipes greater than 30" diameter will be supported using a composite cribbing structure such as that previously constructed in the Long Branch area of the project shoreline. This solution was chosen because it can support the increased size of the pipes without taking a up a significantly larger area. The composite outfall structures in Long Branch have performed well over the life of the project and sustained little to no damage during Hurricane Sandy. An example of the composite outfall structure is shown in Figure 22. The retention system basis of design is shown in Figure 23. These bases of design were used to develop outfall modification costs. A list of all outfalls in the project area and actions to be taken is included in Table 3.

5.3.3.1 Extension Length: in accordance with the selected plan from the General Design Memorandum and the construction completed in rest of the Sea Bright to Manasquan area, the outfalls will be extended to the edge of the construction template. Length of each extension was determined by plotting the existing outfall opening and assuming a slope of 2.5% to the edge of the construction template.

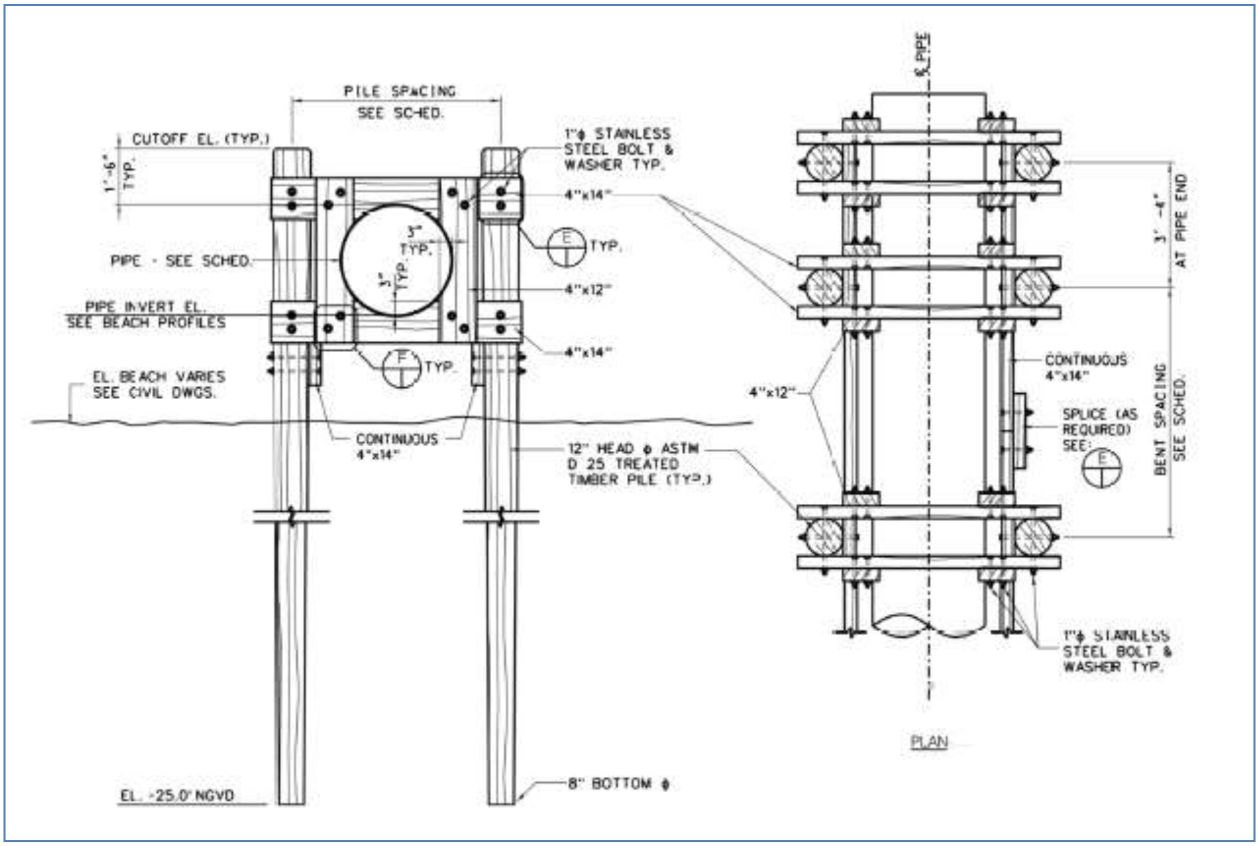

Figure 21: Timber Outfall Structure

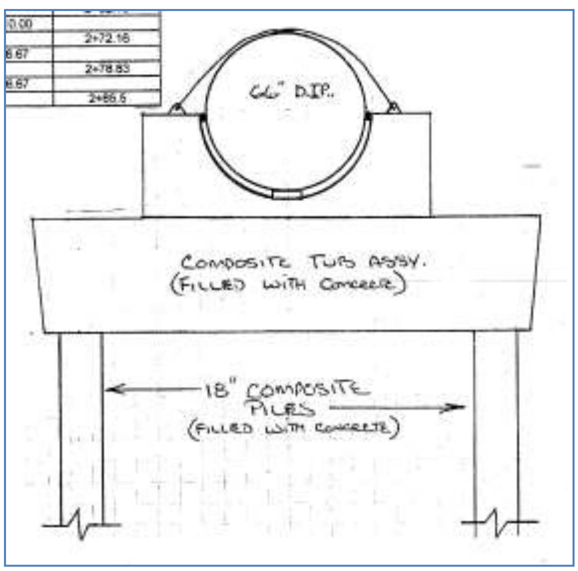

Figure 22: Composite Outfall Structure

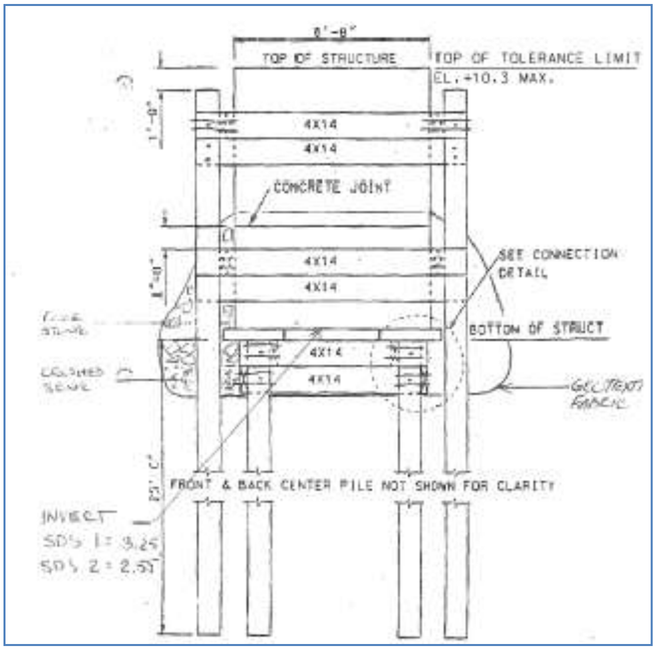

Figure 23: Example of retention structure (currently in use at Cooper Ave. and Seaview Ave. in Long Branch, NJ)

6. Resiliency, Sustainability, Consistency with the North Atlantic Coast Comprehensive Study (NACCS), and Risk

6.1 Resiliency, Sustainability and Consistency with the North Atlantic Coast Comprehensive Study

6.1.1 This section has been prepared to address how the recommended alternative contributes to resiliency of affected coastal communities; how the recommended alternative affects the sustainability of environmental conditions in the affected area; and how the recommended alternative will be consistent with the findings and recommendations of the NACCS.

6.1.2 Resiliency is defined in the USACE-NOAA Infrastructures Systems Rebuilding Principles White Paper (USACE-NOAA 2013) as “the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies”. The recommended plan for Elberon to Loch Arbour includes sand placement to increase the height and width of the berm. Engineered beaches, such as part of the recommended plan for Elberon to Loch Arbour, are designed, constructed, and periodically renourished specifically to reduce the risk of economic losses arising from coastal storms. Natural recovery of a beach berm after a storm may occur over a period that ranges from days to months. Engineered beaches are sacrificial by nature, however, they provide coastal storm risk management that contributes significantly to the resilience of the community in which the project is located. If a project is exceeded, there would be varying risks based on the severity of the storm. Storm impacts could include lowereing of berm height, increased height of wave run up, farther landward wave run up and more inundation. However, these potential impacts with the designed project in place would provide greater coastal storm risk management than current without project conditions. Even if the project is exceeded, with an engineered beach project in place, fewer homes, businesses, and public infrastructure elements are damaged and destroyed, and fewer lives are disrupted or lost. Transportation and critical health and public safety assets return to full function after a storm more quickly. All of these considerations lessen the duration and reduce the costs of the recovery period, and make the community more resilient than it would have been without the project in place.

6.1.3 Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity); without interruption or diminution. The recommended plan for Elberon to Loch Arbour includes groin modifications for uniformity in beach berm conditions by reducing detrimental sand impoundment and downdrift sand losses, in addition to sand placement. Those features reduce sand losses to the berm, reduce the frequency of renourishment and channel filling and therefore increase overall sustainability of the project. Periodic beachfill renourishment is included in the HSRR project in recognition of local prevailing storm and long term erosion forces and shoreline response. The estimated periodic beachfill renourishment frequency and volume quantity are specifically designed to ensure project sustainability for a range of coastal event risk over the 50 year evaluation period.

6.1.4 As previously described, the proposed features for construction in the Elberon to Loch Arbour community represent a resilient and sustainable solution.

6.1.5. In assessing consistency with the NACCS, it is acknowledged that the Study's results are not yet available, but that there are overriding principles which have been established for the NACCS that can be addressed for consistency. These principles recognize that preferred plans are those that provide coastal storm risk management with the use of sand features, which are readily adaptable, and could be modified or terminated based upon findings of the NACCS. NACCS acknowledges that hard structures may be necessary, and can be implemented if based upon current, state-of-the-art science and planning. The NACCS also emphasizes the need for integrated land-use planning, recognizing the need for local adoption of Flood Plain Management Regulations, based upon current understanding of risks.

6.1.6 The proposed features at Elberon to Loch Arbour are consistent with these principles of the NACCS. The overall coastal storm risk management is to be provided with a berm system that could be readily adapted. These designs have been developed and analyzed using state of the science and planning. The recommended design has also accounted for sea level rise.

6.1.7. With respect to integrated land management, the community landward and surrounded by this project is heavily developed, which limits the focus of land management to rebuilding activities as opposed to as opposed to regulating new development. There are existing land use regulations that are in effect within the project area, including FEMA Floodplain Regulations and the New Jersey State Coastal Areas Facilities Act (CAFRA) Regulations which effectively address rebuilding in the project area. The project is not designed to alter the existing floodplain regulations and is not expected to have an impact on potential future development in this area.

6.2 Risk

6.2.1 This HSLRR demonstrates that the recommended plan, sand placement only, reduces flood and coastal storm risks and contributes to improved capacity to manage such risks. There were impacts to the shoreline in the project area as a result of Hurricane Sandy. These changes, as described previously, however, do not change the risk assessment or economic justification of the project. The recommended plan will remain economically justified for the 50 year authorized period of federal participation even with structures removed from the damage pool in response to post Hurricane Sandy analysis.

REFERENCES:

Rankin, K.L.; Bruno, M.S., and Herrington, T.O. 2003. Nearshore Currents and Sediment Transport Measured at Notched Groins. Journal of Coastal Research, SI (33), 237-254, West Palm Beach, Florida.

Bocamazo, L.M.; Donohue, K.A.; Williams, B., and Awad, G. 2003. Groin Notching in Spring Lake, N.J. Coastal Structures 2003, ASCE-COPRI, Reston, Virginia.

Richard Stockton Coastal Research Center, 2012. 2011 New Jersey Beach Profile Network Annual Report: Covering 25 Years of New Jersey Coastal Research. Port Republic, New Jersey.

Richard Stockton Coastal Research Center, 2012. Beach-Dune Performance Assessment of New Jersey Beach Profile Network Sites Between Deal and Sea Bright, New Jersey Related to FEMA DR-NJ 4086 for Hurricane Sandy. Pomona, New Jersey.