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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

December 5, 2012

The Richard Stockton College of NJ Coastal Research Center (CRC) has initiated a post-storm survey and assessment of the New Jersey shoreline in response to severe beach erosion resulting from the impact and landfall of Hurricane Sandy. The analysis for the southern 15 survey sites starting at the Manasquan Inlet, moving north to Darlington Avenue in the Borough of Deal, NJ. The field work was completed November 12, 2012 as clean-up work continued to clear Ocean Avenue and surrounding streets of sand. This excavated material was being returned to the beach and is included in the survey cross section since it is now part of the post-Sandy beach. This initial report is focused on the impact to municipal dunes and beaches from Hurricane Sandy. The damage details have been organized specific to each municipal segment of the county shoreline starting at Manasquan Inlet and ending at the northern profile site in Deal, NJ. The coastal segment between Manasquan Inlet to Asbury Park was the section of shoreline where the New York District Army Corps of Engineers conducted its Phase II Shore Protection Project between 1999 (initial contract for Manasquan to Shark River) and 2001 (second contract for Shark River to Asbury Park). No subsequent maintenance work has been conducted in this reach. The 2011 CRC 25-year report evaluated the sand quantity remaining within this reach at the 13 sites within the project extent at between 55% and 135% of the initial placement volume. Redistribution among the various groin fields along the reach seems to have influenced the amount of sand still present.

In general terms the beach erosion was significantly worse on the north side of the storm. Southern Cape May County faired best with limited overwash, dune scarping and loss of beach elevation. Damages increased towards the region of landfall with moderate dune breaches, especially in southern Ocean City area, and damages to southern Absecon Island's oceanfront properties. Dune breaches, loss and scarping of dunes, beach width and elevation continued north into Brigantine. From the natural area of Holgate north along the remainder of the Jersey coast the intensity of breaches and overwash and erosion of the dunes, beaches and damage to oceanfront property increased dramatically. Since this part of the Monmouth County shoreline is developed on a coastal plain bluff of far greater geologic age with no barrier beaches and divided by small rivers that have become freshwater lakes due to sand (and development) closing the "estuary" to tidal flow, the damage due to coastal flooding was dominated by the quantity of wave run-up that crossed the beach and dune system before flowing inland among the structures. Each of the "estuary" lakes was breached badly and flooded with salt water. At each one crews were both pumping out the flood waters and excavating at the drainage weir to find the exit pipeline to the ocean to allow normal freshwater discharge again. Prior to development, a major storm like Sandy would flood these lakes with salt water and the combination of freshwater run-

off and the storm surge flood would rip open the bay-mouth barrier beach allowing a brief period of tidal exchange after the storm until the normal wave action re-built the bay-mouth barrier again. Historically data supports this contention occurring as late as 1922 when Manasquan Inlet closed to tidal flow and remained closed until the ACOE built the pair of inlet jetties in 1931. In between the "estuary" lakes the storm surge overwhelmed the beach/dune system in most places destroying the boardwalk or promenade transporting huge volumes of sand landward by as much as two blocks from Ocean Avenue (the shore-parallel roadway). The sites at Allenhurst/Loch Arbor and southern Deal are included to show the contrast between the nourished project beaches and the armored and non-nourished shoreline north of Asbury Park.

Beach/Dune Damage Assessment by Municipal Island Segment:

To measure the erosion, pre-existing New Jersey Beach Profile Network (NJBPN) monitoring sites were used to provide an accurate comparison and assessment of storm-related shoreline and beach volume changes. Using the data from the fall 2012 NJBPN survey, completed in Monmouth County by October 4, 2012, provides a good baseline for damages that occurred during the hurricane. Data collected at the 15 oceanfront beach profile locations was completed November 12, 2012 using RTK GPS and extended from the reference location, across the dunes, beach and into the surf to wader depth. Swimming was not done to increase the speed of data collection. By the 12th, it was clear that sand recovery was well under way as a berm had been deposited on the erosional surface generated by Sandy with a substantial offshore bar present in water less than 5 feet deep offshore. However, massive amounts of sand had been transported inland and were being returned to the beach. This was especially bad in Manasquan, Spring Lake, and southern Ocean Grove.

Profile Locations: The following sites were surveyed during September and October 2012 and post-Sandy on November 12, 2012 (Figure 1). *Below is a map showing the location of each profile.

NJBPN 256	Pompano Ave.	Manasquan	**NJBPN 163**	5th Ave.	Belmar
NJBPN 157	Riddle Way	Manasquan	**NJBPN 164**	Sylvania Ave.	Avon-by-the Sea
NJBPN 158	Trenton Ave.	Sea Girt	**NJBPN 165**	McCabe Ave.	Bradley Beach
NJBPN 159	New York Ave.	Sea Girt	**NJBPN 166**	Ocean Pathway	Ocean Grove
NJBPN 160	Salam Ave.	Spring Lake	**NJBPN 167**	3rd Ave.	Asbury Park
NJBPN 161	Brighton Ave.	Spring Lake	**NJBPN 267**	7th Ave.	Asbury Park
NJBPN 162	18th Ave.	Belmar	**NJBPN 168**	Corlies Ave.	Allenhurst
			NJBPN 169	Darlington Ave.	Deal

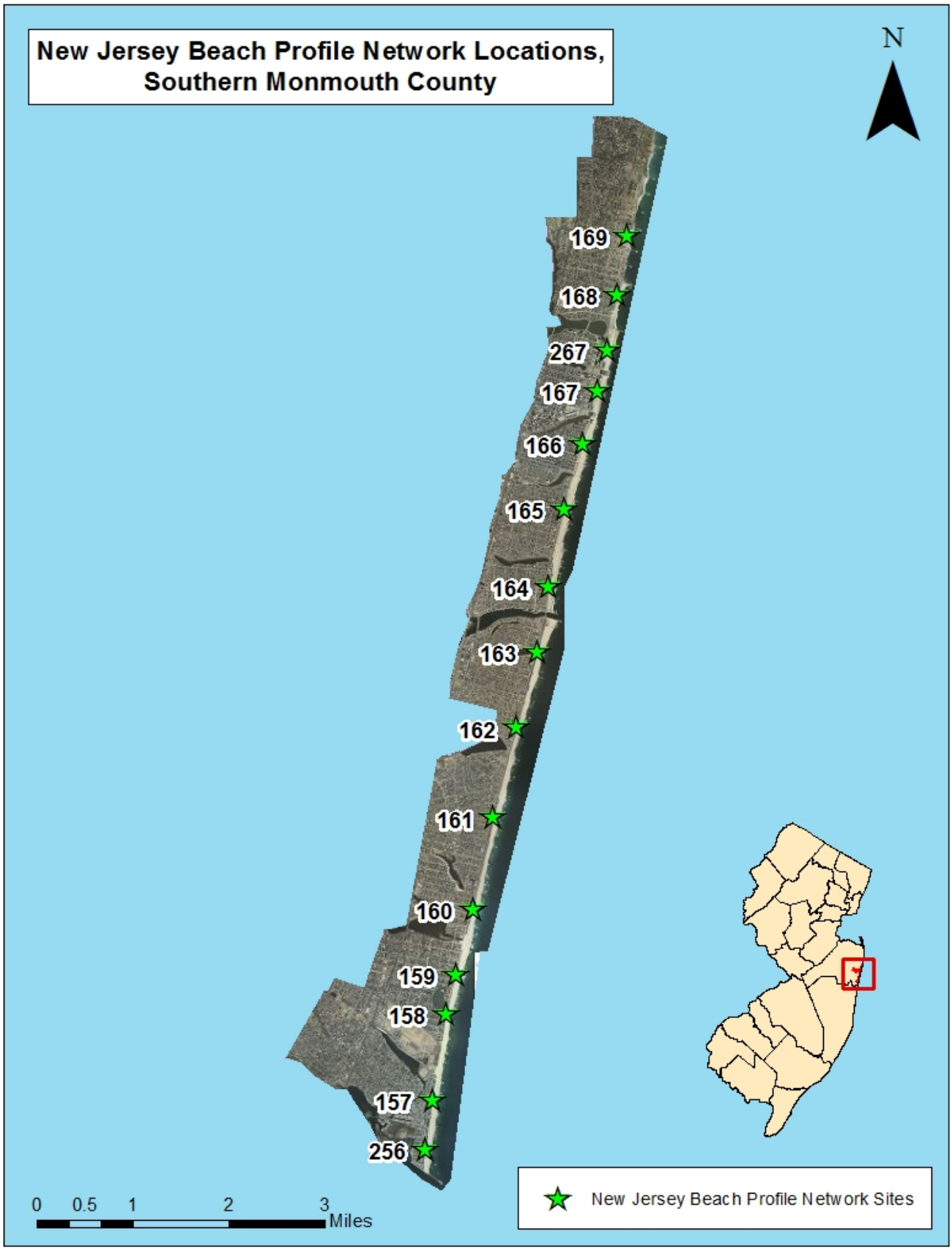


Figure 1. NJBPN Profile Locations, between Manasquan Inlet and Deal, Monmouth County, New Jersey

Manasquan Borough;

Manasquan is located at the southern limit of the NY District's massive Monmouth County beach restoration project and positioned just north of the Manasquan Inlet. Developed at the turn of the 20th Century, many small homes populate the former primary dune between the ocean and First Avenue. Prior to the ACOE project, the Borough had established a small dune system seaward of the paved promenade that is in front of the oceanfront homes This was primarily in response to the December 1992 northeast storm that last damaged the community. Litigation over the dune height, width and access pathways limited the enthusiasm for enlarging the dune's footprint in spite of the Borough's winning the litigation. Sandy broke through the dune line and passed over the promenade into the initial row of homes. Since there are frequently more than one dwelling between the promenade and First Avenue, a great deal of moderate damage was done as water, sand and debris were forced between the narrow passages between buildings. Vast amounts of sand and debris clogged First Avenue such that the oceanfront area was still closed to the public and barely passable on November 12th. There was a substantial offshore bar and a new recovery berm in the process of building. The sand was very coarse and contained abundant pebbles originally derived from bluff erosion over the centuries. There are two cross sections in Manasquan. No promenade remained at Pompano Avenue with tiny remnant dunes present at Riddle Way. A ridge of excavated sand had been built along the alignment of the promenade at the south end of the Borough Beach.

Sea Girt Borough;

Sea Girt is divided into two parts, each with a profile site. The southern site at Trenton Avenue typifies the coastal bluff with major homes and a wide, reasonably high dune landward of the boardwalk that protected the bluff face from erosion and kept the overwash out of the street ends. Some overwash had occurred at Trenton Avenue, but was well on its way to clean-up. The boardwalk had been damaged at Trenton Avenue, but otherwise survived. A dune had grown seaward of the boardwalk since the ACOE project, but it had been eroded away.

The northern half is represented by the New York Avenue site where a shore-parallel Ocean Avenue allows vehicle access to the boardwalk and beach for public access. Homes exist across Ocean Avenue. Here there were no dunes, Sandy's waves washed over the beach, across the boardwalk and down the streets a block inland. Tidal flooding also entered by way of Wreck Pond, the second "estuary" lake north of Manasquan Inlet. Crews were at work trying to clear a vast sand deposit from the tidal weir gate and were pumping flood water out of Wreck Pond. This "estuary" still retains a small aspect of the old, natural bay-mouth barrier inlets once common to Monmouth County. That aspect had clearly been utilized by the Hurricane Sandy forces.

Spring Lake;

Two cross sections located in Spring Lake showed that the dune, developed decades ago landward of the boardwalk, was also insufficient to protect the town landward of it. Storm wave up-rush went under the boardwalk, hit the dunes, was force upward and lifted the entire Spring Lake boardwalk off excellent concrete supports and eventually deposited most of it in Ocean Avenue. Hurricane Irene had previously damage some of the structure the August previously in 2011, and the walk had recently been re-surfaced with composite decking. The CRC observed that the steel tie-down pieces had rusted to nearly nothing since 1944 (?) and as a result meant that the entire boardwalk deck assembly was held in place essentially by gravity. Large quantities of sand had been transported onto Ocean Avenue and down many side streets. Large scale damage to homes was not evident; however flooding by the water level was evident. The "estuary" lake (Lake Como) between Spring Lake and Belmar was likewise being both pumped out and excavated to locate and clear the drainage weir to the ocean.

Belmar;

Belmar has two survey sites, one at 18th Avenue and the second at 5th Avenue near Shark River Inlet. The Belmar beach has a boardwalk between it and Ocean Avenue that suffered damage but was still largely present. Sand was in Ocean Avenue and was partially cleared. Belmar would push up a sand ridge in the late fall to act as a minor storm barrier, but it is not known if that had been accomplished prior to Sandy. The beach width had been reduced, but berm growth was underway with offshore bars present at all locations along this reach. Shark River Inlet separates Belmar from Avon-by-the-Sea and was a major source of storm surge flooding to low-lying parts of all communities surrounding this estuary. This was clearly in evidence by the rows of debris piled along the streets, observed in some detail since both highway drawbridges were up and out of service requiring the crew to detour to Highway 35 inland.

Avon-by-the-Sea;

Avon has one site located at Sylvania Avenue where damage to the boardwalk was extensive extending to the structures adjacent to the boardwalk. Sand occupied Ocean Avenue with evidence of wave damage to businesses on the far side of the roadway. Avon had a "landscaped" dune that did little to protect the infrastructure, so once the waves crossed the beach, there was little to prevent them from dissipating their energy on the infrastructure. The same offshore bar and recovery berm was present on the beach here as everywhere else.

Bradley Beach;

The McCabe Avenue site had some damage, but fared better than most locations. The dunes did survive in places and kept the worst of wave impacts out of the City. Storm surge flooding did occur with damage to some structures and boardwalk sections. Sand was being hauled back to the beach which was recovering with a berm and bar close to the shoreline.

Ocean Grove;

The southern half of Ocean Grove was still in the process of having Ocean Avenue cleared of a thick sand deposit with the material being hauled back to the beach. The boardwalk was broken up and the dune system was gone. To the north of Main Street, things improved with remnant dunes in place, little sand in the street and an intact boardwalk. At Ocean Pathway the dune remained as did the large, open, but roofed over seating area seaward of the boardwalk. The dune remained with the instrument monument about 1.5 feet from the scarp.

Asbury Park;

The Federal project beach in Asbury Park had no dune, but the sand was ramped up to the elevation of the boardwalk. As a consequence, at both survey sites there was minor decking damage, some railings destroyed and the majority of the wave energy passed over the boardwalk into Ocean Avenue. Sand was in front of business establishments on the landward side of the boardwalk with flow at each street end. Sand was being hauled to the 7th Avenue site where sieving equipment was separating debris from the sand prior to it being returned to the beach. Sand recovery from offshore was also well underway.

Allenhurst – Loch Arbor;

The site #168 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 we 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 further 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 Arbor 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 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, I have 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.

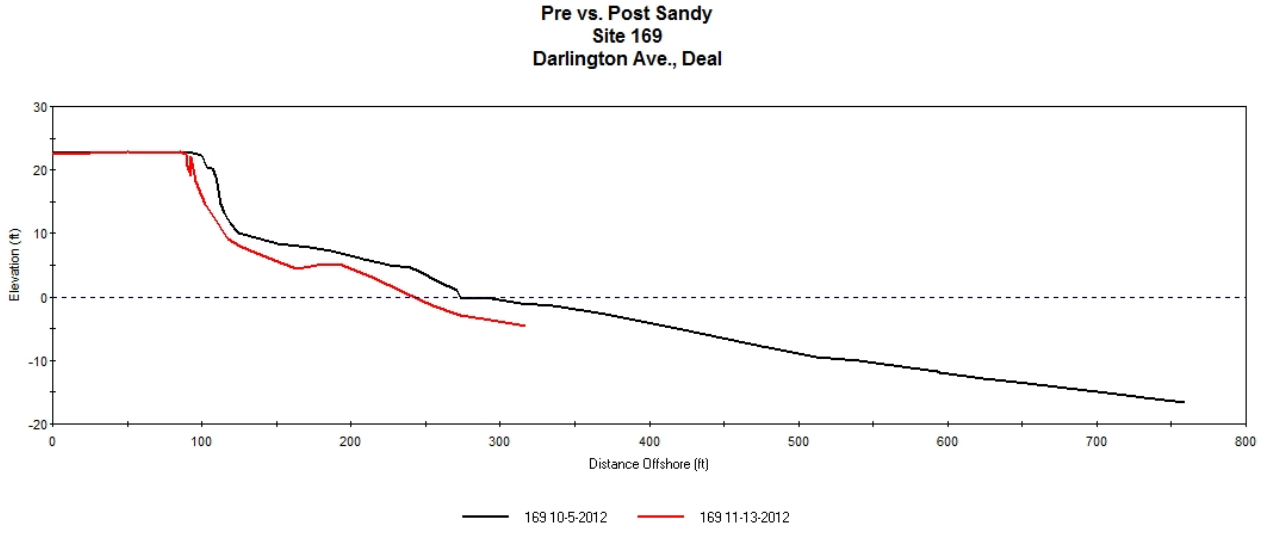
Individual Site Descriptions:

Each location was surveyed following Hurricane Sandy on November 12 and 13, 2012. The profile line was covered using RTK-GPS with data points on the dune, beach and shallow offshore regions. In all cases, the very visible offshore bar could not be reached due to water depth and wave action. The sand loss figures apply to the dune/beach system only and do not account for a percentage of sand dragged offshore by Sandy's waves, to return later in time. This recovery process was clearly already underway. A berm and small bars had already attached to the shoreline above low tide.

NJBPN 169 – Darlington Avenue, Deal

The photographs above were taken on October 5, 2012 (left) and November 13, 2012 (right).

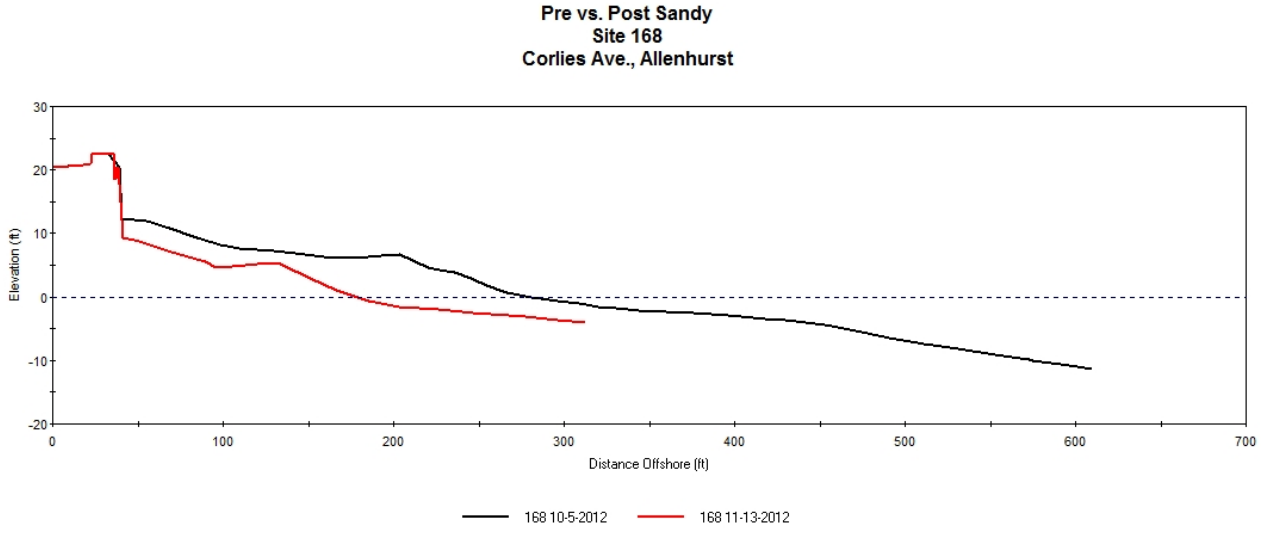
Figure 2. The following figure shows the unexpected retreat in the uplands bluff in Monmouth County. Darlington Ave. was picked because a small sand beach was contained between two larger groins and a view of the bluff sediments had been historically visible. During the storm the beach was submerged and waves obviously broke directly on the various types and quality of "bluff armor". Very little man-made work survived along this shoreline segment. This was the most extensive view of the natural bluff sand, gravel and silt ever seen in the past 50 years. The retreat in the bluff location was partly the removal of waste concrete debris dumped over the edge at the street end and erosion into the uplands sediments. To the north of the profile line about 25 feet of bluff retreat occurred after the timber bulkhead had been destroyed.



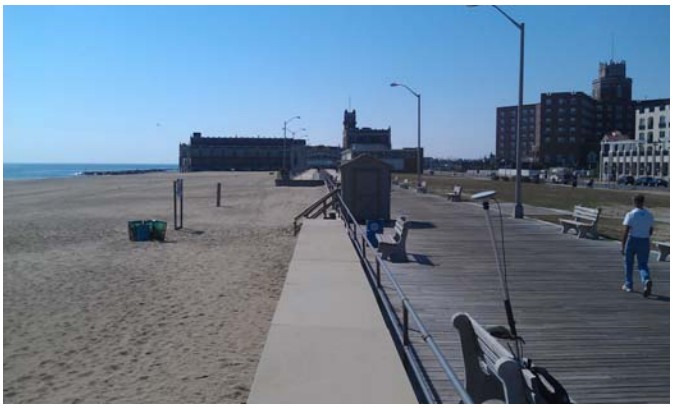
NJBPN 168 – Corlies Avenue, Allenhurst

The photographs above were taken on October 5, 2012 (left) and November 13, 2012 (right).

Figure 3. This site stands in for Loch Arbor's 2-block shoreline as well. Here an old concrete wall protects the sedimentary bluff. Age and decay has had an effect, but waves clearly broke over the top of the wall with sufficient force to dislodge about 50 feet of the boardwalk (right photograph in front of the white truck) and negatively impact the landscaping across the street. Note that nothing remains of the white cabaña complex at the north end of the Allenhurst beach. In Loch Arbor the dune and public beach were completely over-washed with 3-4 feet of sand in the streets and waterfront home yards. Flooding of the homes was considerable as was salt water flowed into Deal Lake just to the south.

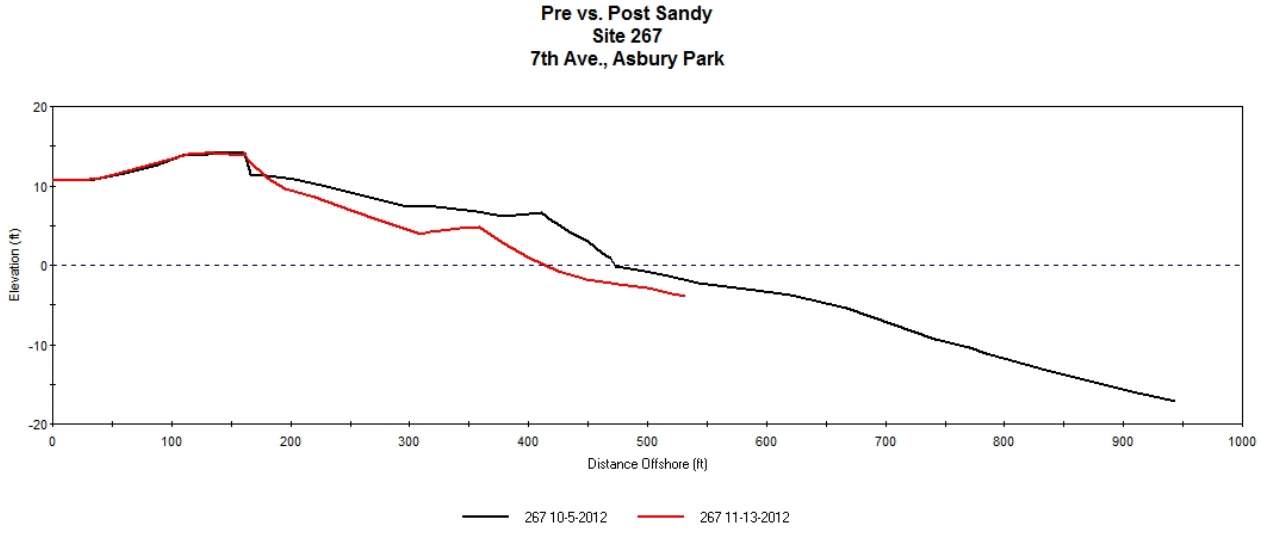


NJBPN 267 – 7th Avenue, Asbury Park



The photographs above were taken on October 5, 2012 (left) and November 13, 2012 (right).

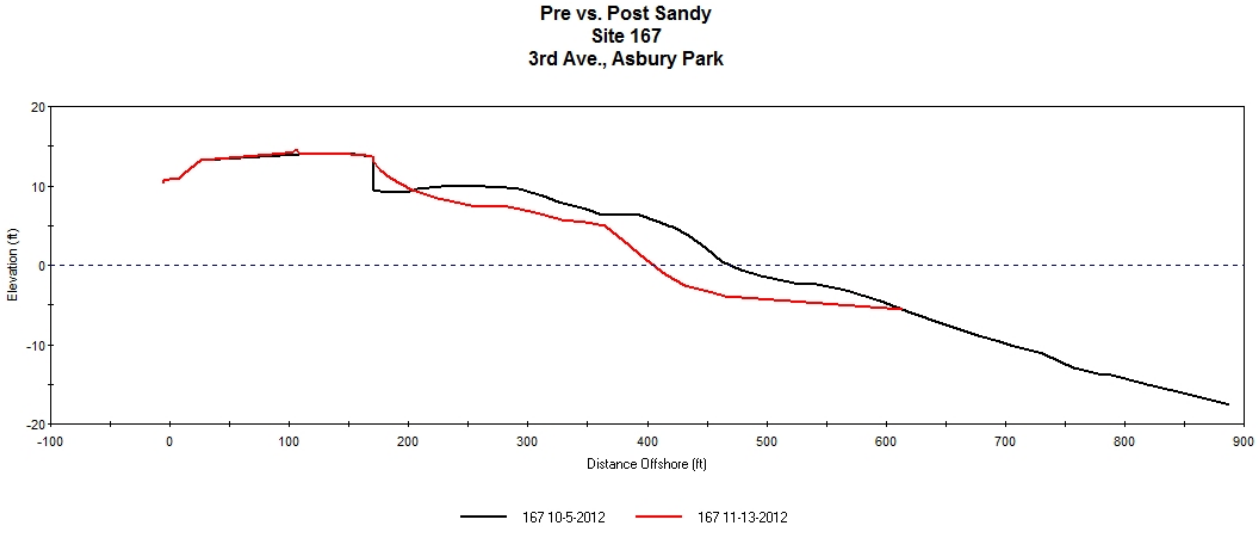
Figure 4. Hurricane Sandy stripped sand from the beach, pushed the berm landward with sand washed up to the boardwalk as a ramp allowing the waves to pass over the structure inland. The smaller structures showing on the left photograph are missing after sandy, but the boardwalk had minor damage as waves forced sand under and upward raising decking in an irregular pattern. The City was sorting sand from debris at 7th Ave. and placing sand to fill voids scoured into the surface landward of the boardwalk. Sand was being carted back to the beach as well.



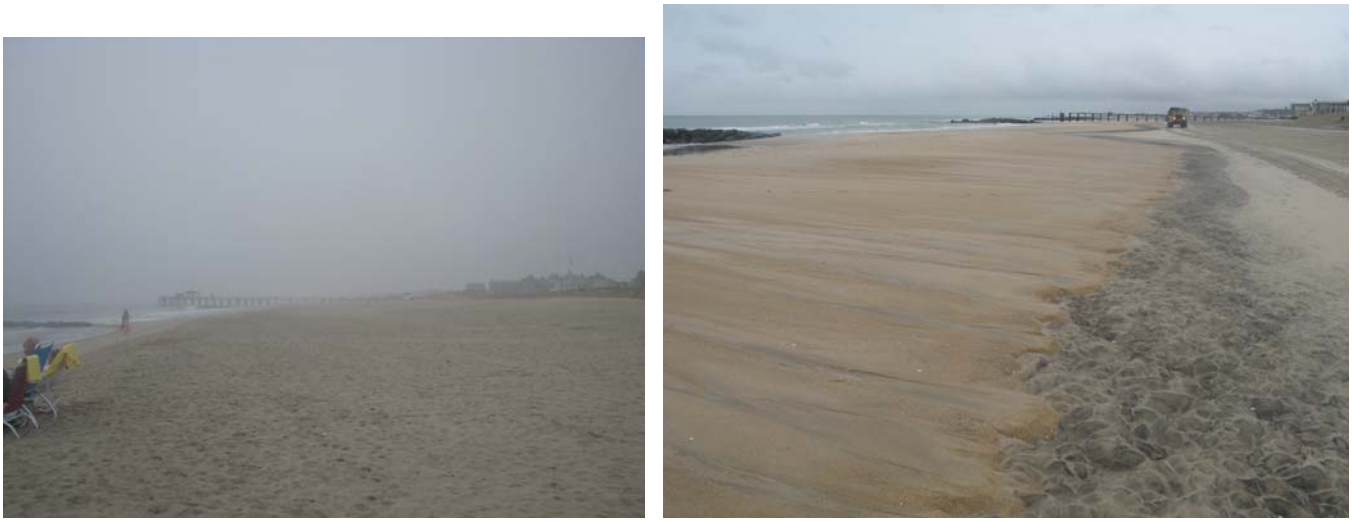
NJBPN 167 – 3rd Avenue, Asbury Park

The photographs above were taken on October 5, 2012 (left) and November 13, 2012 (right).

Figure 5. A similar impact occurred at 3rd Avenue where sand, stripped from the beach was ramped up to the boardwalk allowing the waves to pass over the structure without destroying it. The small building to the left side of the left photograph was gone, but boardwalk damage was limited to raised sections of decking. Wave flooding had clearly impacted boardwalk businesses however. The miniature golf course between the boardwalk and Ocean Avenue had an abundance of new sand trap hazards for potential players after Sandy.

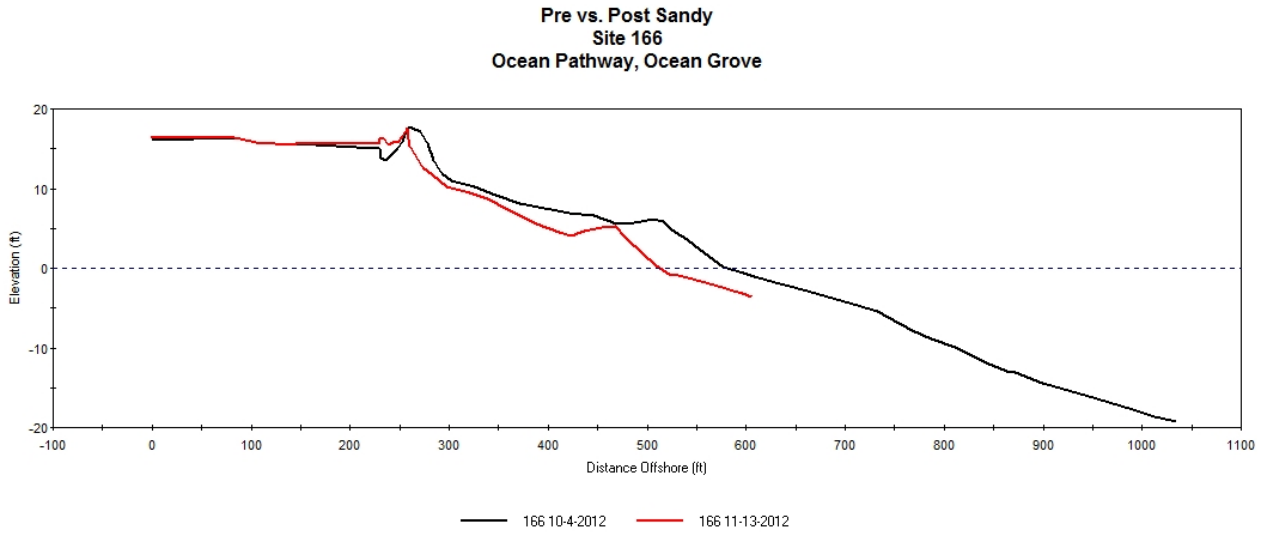


NJBPN 166 – Ocean Pathway, Ocean Grove



The photographs above were taken on October 4, 2012 (left) and November 13, 2012 (right).

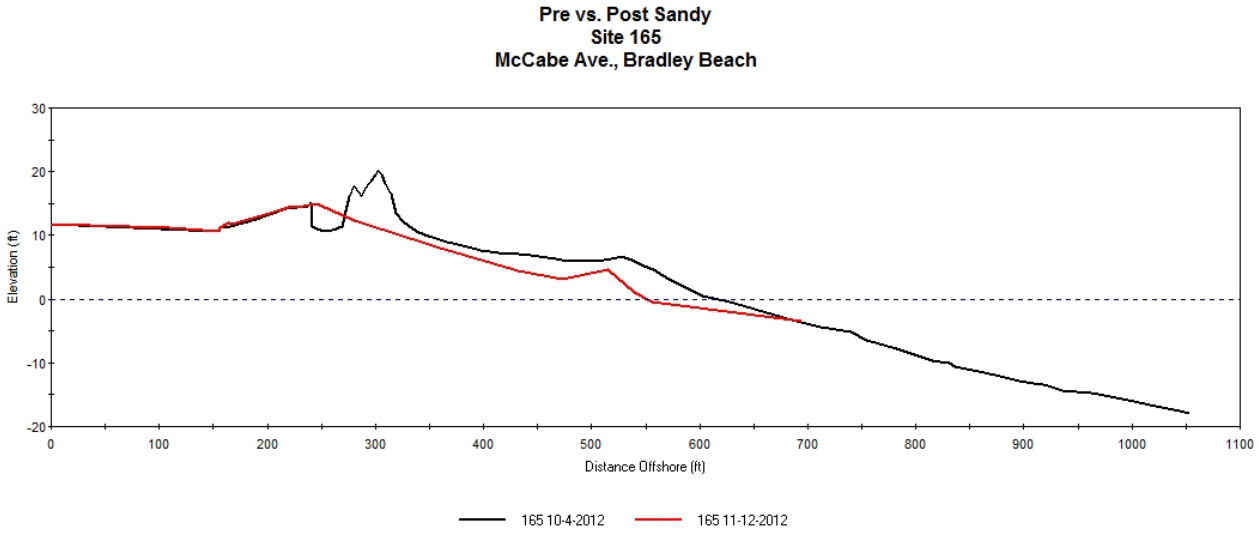
Figure 6. The dunes along the northern Ocean Grove shoreline survived as partial sections, example below, but were removed south of Main Street. Sand was being excavated from Ocean Avenue and carted back to the beach (vehicle in right photo above). The post-Sandy photograph illustrates the recovery as of November 13th as a coarse, yellow-colored sand was building back onto the beachface as bars were developing offshore.



NJBPN 165 – McCabe Avenue, Bradley Beach

The photographs above were taken on October 4, 2012 (left) and November 12, 2012 (right).

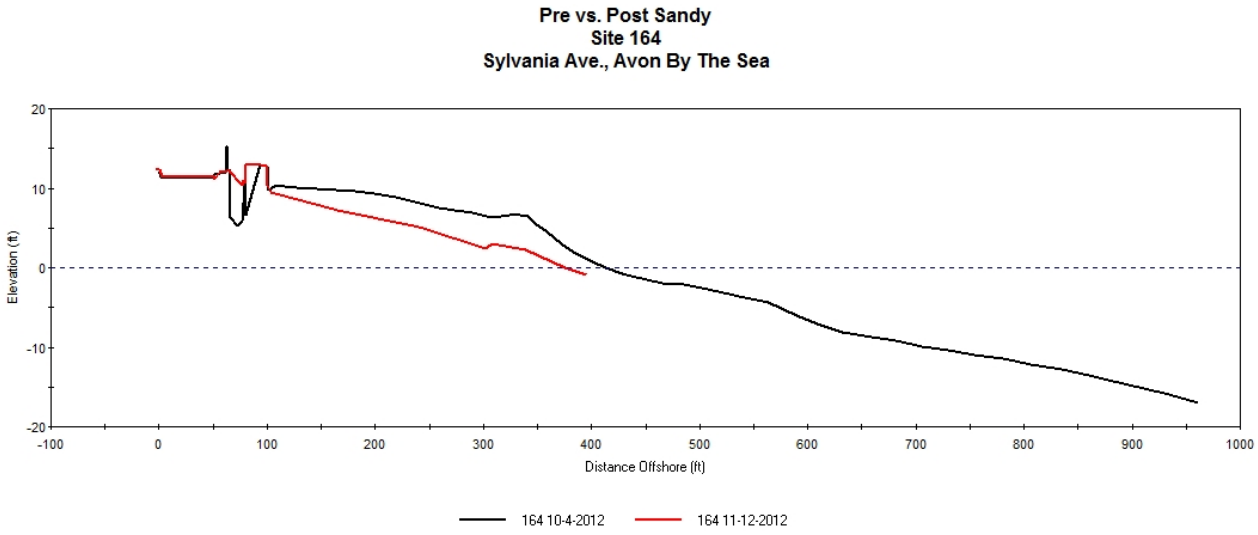
Figure 7. Dune damage was extensive, but the result produced a reduction in the damages landward. The promenade was impacted, but not destroyed and abundant sand was still present in Ocean Avenue. The swale between the dune system and the promenade was filled with sand and the volume lost was significant from the beach. Berm recovery was underway at all these Monmouth County Sites.



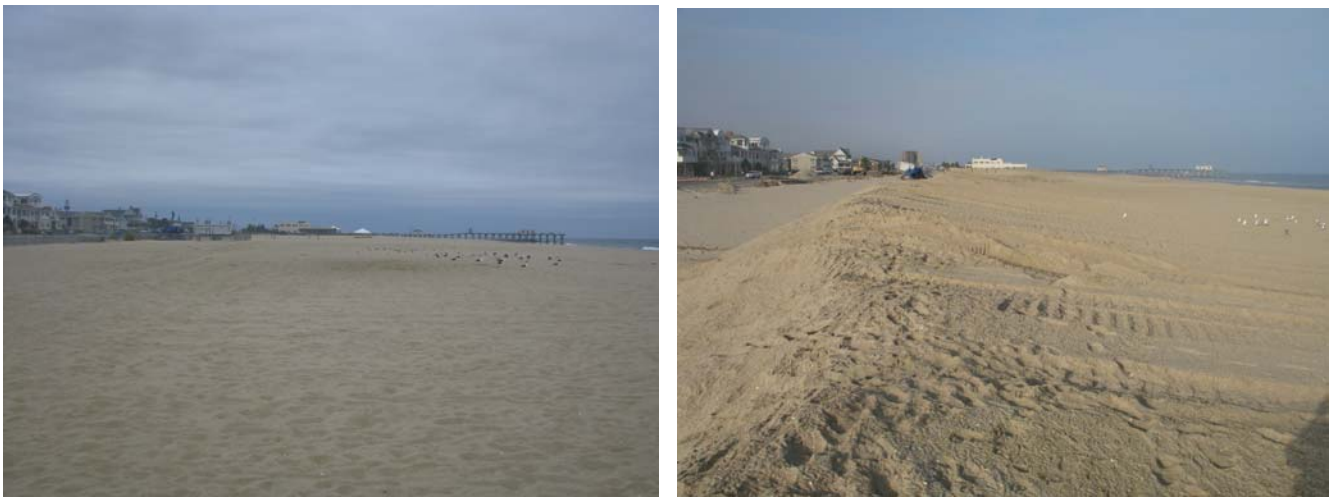
NJBPN 164 – Sylvania Avenue, Avon-by-the Sea

The photographs above were taken on October 4, 2012 (left) and November 12, 2012 (right).

Figure 8. The beach had been totally submerged and sand was washed inland well beyond Ocean Avenue. The swale between Ocean Avenue and the boardwalk was filled in. Damage to the building just north of the profile line was extensive. The small lakes were also impacted with sand burying the drainage system as well as raising lake level with salt water. Efforts were underway to excavate the drainage and lower lake level.

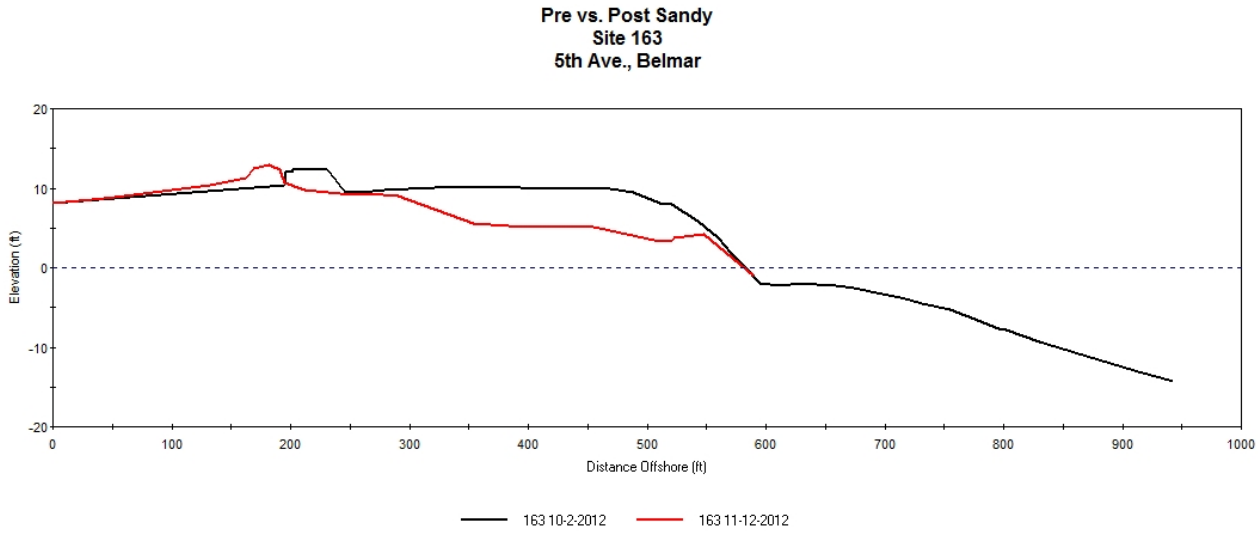


NJBPN 163 – 5th Avenue, Belmar

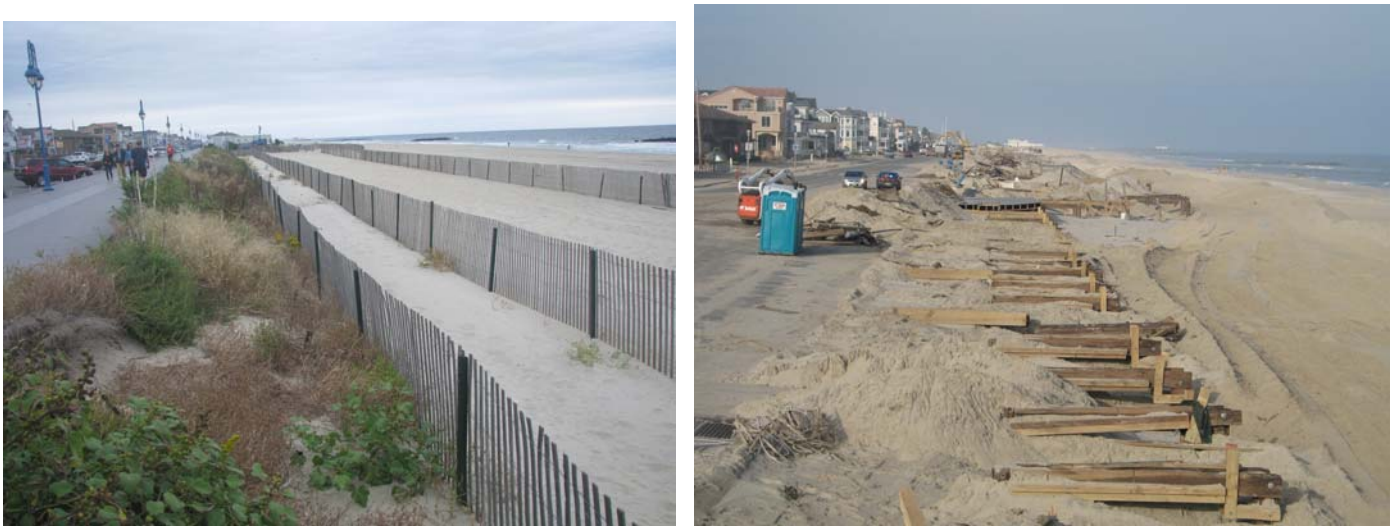


The photographs above were taken on October 2, 2012 (left) and November 12, 2012 (right).

Figure 9. Fifth Avenue had no dune, but had a wide, dry beach that was submerged by the storm surge. Sand was carried landward onto Ocean Avenue accompanied by extensive flooding. A mound of sand had been transported back to the beach and was deposited landward of the mound pushed up by early in October (black line).

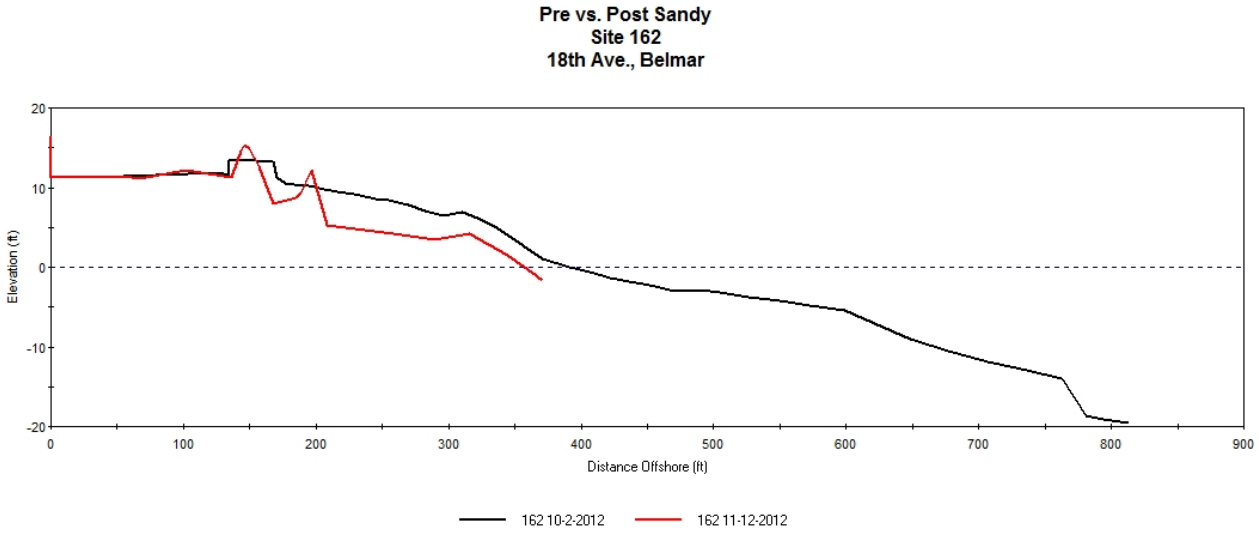


NJBPN 162 – 18th Avenue, Belmar

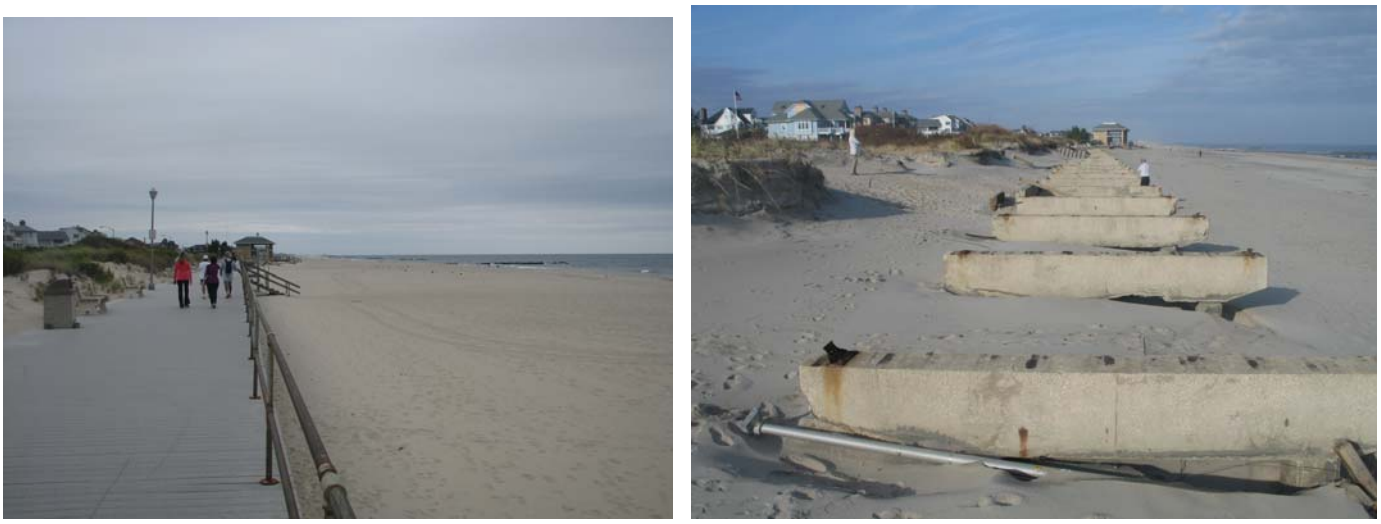


The photographs above were taken on October 2, 2012 (left) and November 12, 2012 (right).

Figure 10. The southern Belmar shoreline was completely overrun by the force of Hurricane Sandy. Lake Como segment was closed to traffic because multiple pumping pipelines were in place moving lake water back to the sea. Excavators were digging to clear the normal drainage system as well. Nothing but the supports remained from the boardwalk, with the small dune and all the fencing swept away. Even the lamp standards were taken away. Mounds of sand had been carted back to the beach.

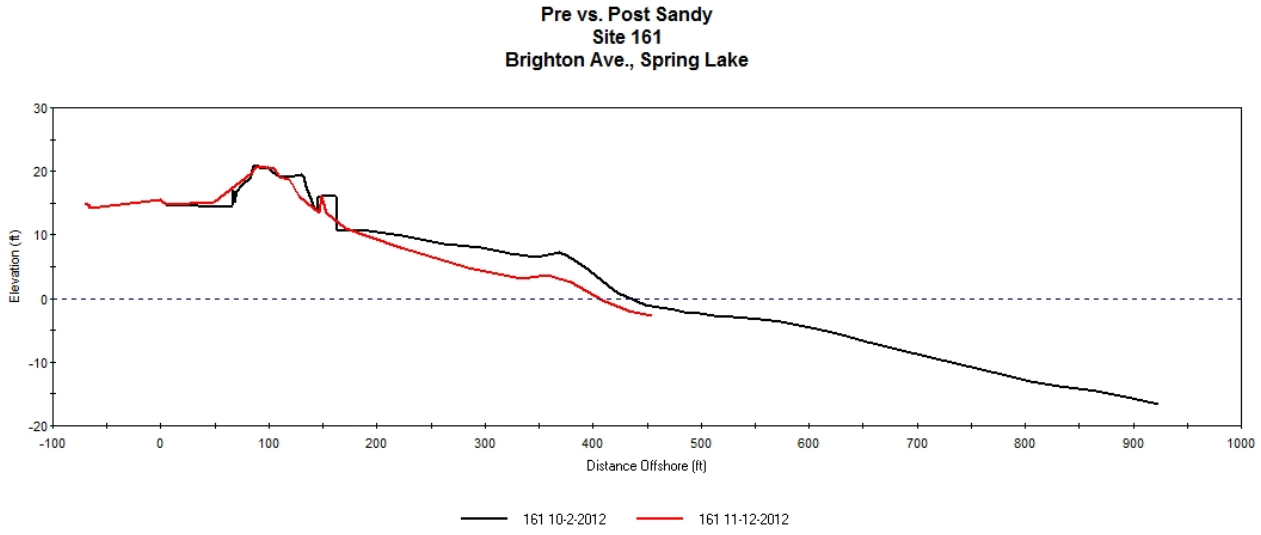


NJBPN 161 – Brighton Avenue, Spring Lake



The photographs above were taken on October 2, 2012 (left) and November 12, 2012 (right).

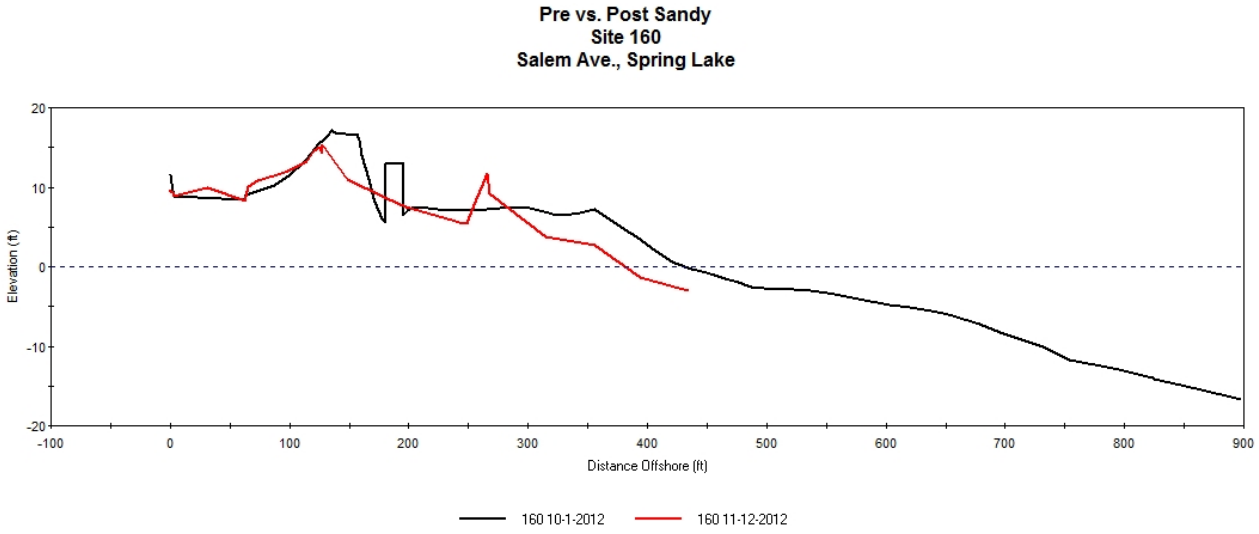
Figure 11. Spring Lake lost the entire boardwalk deck. Extensive damage occurred at the ocean-side bathing buildings with most of the dunes breached frequently and some segments removed entirely. Since the boardwalk had been seaward of the dunes for over 60 years, the waves impacting the dunes acted to lift the boardwalk deck sections from the concrete supports. The fact that the steel deck retainers (extreme left and right on the top of the concrete supports) were rusted away by decades of neglect did not help matters in terms of boardwalk survival.



NJBPN 160 – Salem Avenue, Spring Lake

The photographs above were taken on October1, 2012 (left) and November 12, 2012 (right).

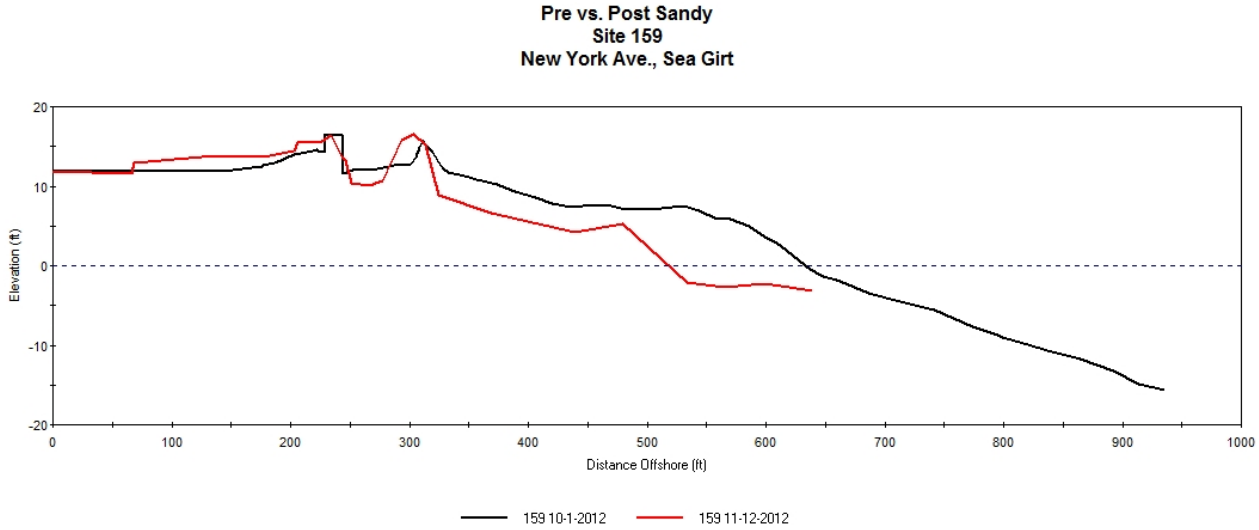
Figure 12. Serious dune erosion allowed waves to move sand into Ocean Avenue and strip the boardwalk deck from the supports. A ridge of sand was had been carted back to the beach as the feature showing on the beach on the November 12th survey line. Sand loss was extensive on the berm.



NJBPN 159 – New York Avenue, Sea Girt

The photographs above were taken on October 1, 2012 (left) and November 12, 2012 (right).

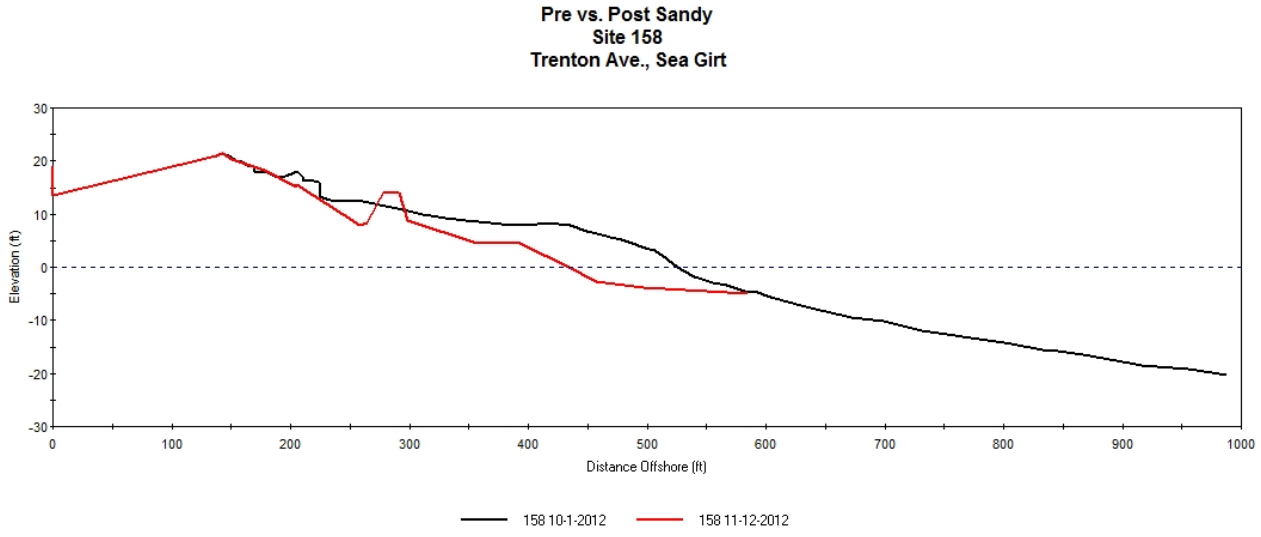
Figure 13. The damage along the northern Sea Girt shoreline impacted the infrastructure more intensely than further south. The boardwalk was damaged and washed over completely. Sand was being carted back the beach as a sizable ridge. The berm was reduced in both width and elevation in dramatic fashion. The sand was still present along New York Avenue west of Ocean Avenue. Wreck Pond was an active site with excavators attempting to clear sand from around the normal drainage weir system and pump the salt water inflow out to sea. Wreck Pond has been the most active "estuary lake" in terms of the sea opening it to tidal flow during storms.



NJBPN 158 – Trenton Avenue, Sea Girt

The photographs above were taken on October 1, 2012 (left) and November 12, 2012 (right).

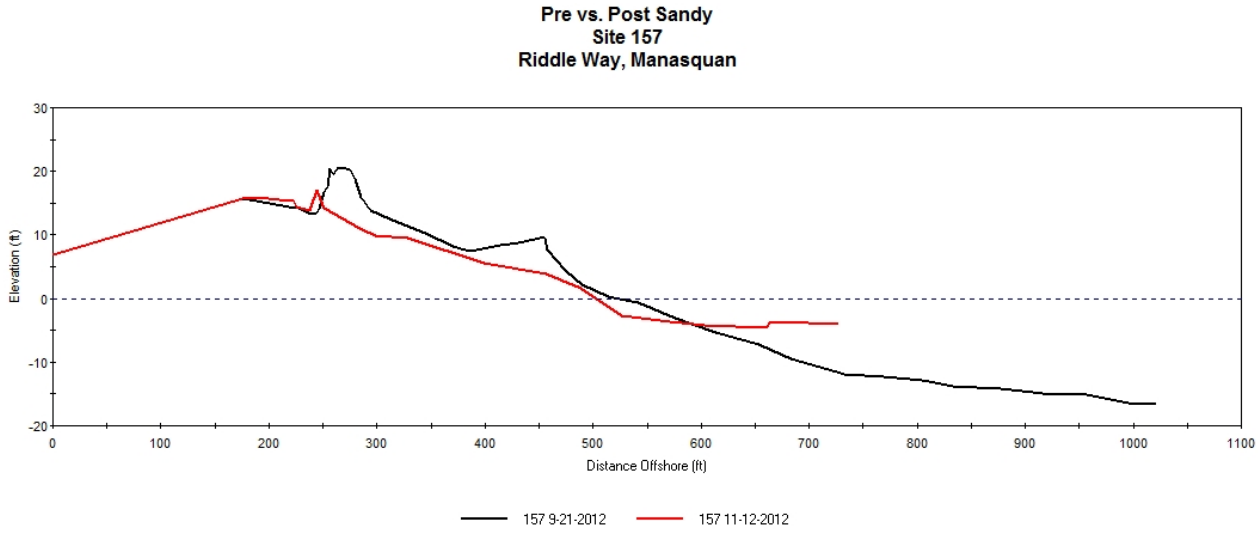
Figure 14. At Trenton Avenue the beach was reduced in elevation and width, with sand from the street end carted back to the beach as the ridge showing in the right-hand photograph. Since Ocean Avenue does not continue south to this location, the beach to the north suffered dune loss, but no waves reached the homes because both the dune was extensive following the 2000 Federal Project (developing naturally over the past 12 years) and the homes sit on top of the Monmouth County bluff.



NJBPN 157 – Riddle Way, Spring Lake

The photographs above were taken on September 21, 2012 (left) and November 12, 2012 (right).

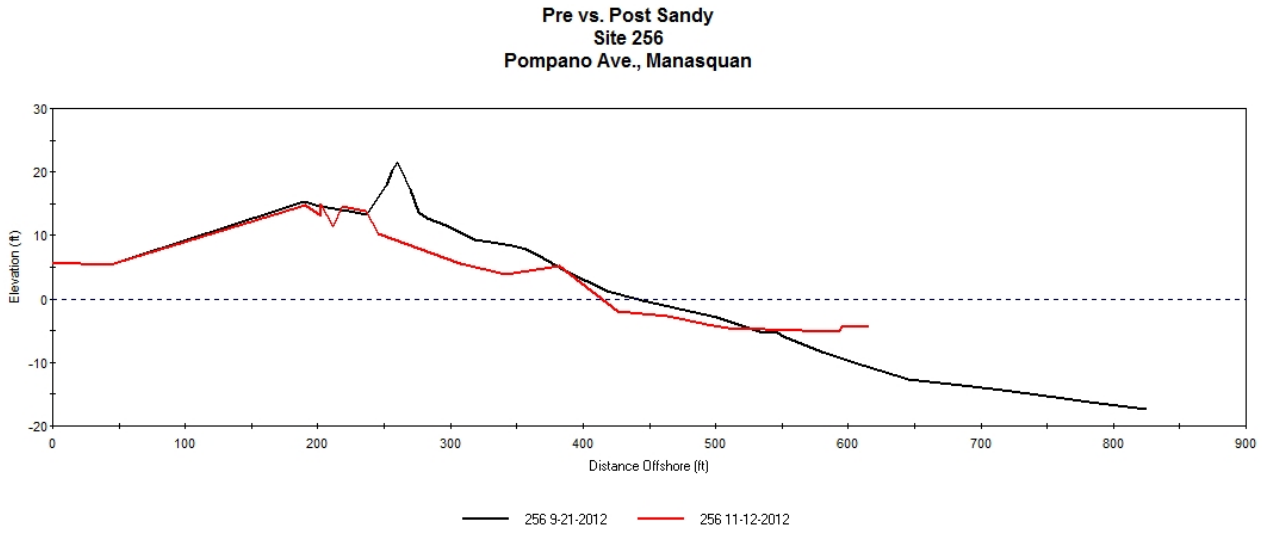
Figure 15. Both Manasquan sites were heavily damaged with massive wave flooding and sand transport among the homes and into First Avenue. The promenade survived at Riddle Way, but the dune was removed and washed landward. The public access up from First Avenue to the beach at Riddle Way had been a giant white water flume discharging into Manasquan's beach front development. Work was proceeding to move sand back to the beach as seen in the piles showing on the right photograph.



NJBPN 256 – Pompano Avenue, Manasquan

The photographs above were taken on September 21, 2012 (left) and November 12, 2012 (right).

Figure 16. Damage was worse further south at Pompano Avenue a few hundred feet from the Manasquan Inlet jetty. The promenade was removed, as were the dunes and all the material missing below the black line below had been transported through the homes into First Avenue in the Borough. Sand was dragged offshore as well since the post-Sandy cross section extends seaward at shallow depths beyond that surveyed September 21, 2012. Multiple homes had been "red-stickered" with "unfit for habitation" tags with some clearly off their foundations.



Summary & Conclusions

Manasquan Inlet to Darlington Ave. Deal Post-Sandy Site Volume Changes

Site Location and Number		Site Sand Volume Change (cu yds/ft)	Dune Failure (Y or N)	Date of Recent Beach Fill
Manasquan	256	-31.37	Y	1997
Manasquan	157	-27.46	Y	1997
Sea Girt	158	-40.92	N	1997
Sea Girt	159	-39.08	No Dune	1997
Spring Lake	160	-20.76	Y-partial	1997
Spring Lake	161	-25.70	Y-partial	1997
Belmar	162	-23.13	No Dune	1999
Belmar	163	-39.52	No Dune	1999
Avon By the Sea	164	-27.67	No Dune	1999
Bradley Beach	165	-30.89	Y-partial	1999
Ocean Grove	166	-23.55	Y-partial	1999
Asbury Park	167	-22.42	No Dune	1999
Asbury Park	267	-30.18	No Dune	1999
Allenhurst	168	-32.30	No Dune	Never
Deal	169	-20.86	No Dune	Never

Figure 17 shows a table of sand loss volumes per foot of shoreline at each of the Southern Monmouth County sites. No beach nourishment was done at the two northern sites because Allenhurst/Loch Arbor and Deal declined to participate in the project. The ownership issues were the major stumbling block. Since the shoreline reach from Asbury Park to Manasquan is an area where extensive businesses are concentrated, focused on coastal tourism and the day-trip population is far larger than many barrier island communities, a system of extensive and consistently-sized dunes were never part of the Federal Shore Protection project. Asbury Park, Belmar, Avon had no dunes. The remaining towns cultivated dunes derived from natural accretion around sand fencing installed following the Federal project. These dunes were only partially successful in preventing wave over-topping and extensive storm surge flooding of the community. Spring Lake had a set of dunes between Ocean Avenue and the boardwalk for decades prior to the Federal project. However, little was ever done to enhance either their height and conditions did not allow making them wider. A significant recommendation would be to re-assess the view on creating a wide, double ridge of sand to provide a higher level of storm protection for expensive and obviously very vulnerable boardwalk and associated commercial/municipal establishments. The double ridge idea would allow the crest elevation to be lower to allow ocean views from the boardwalk, but still act to impede waves from reaching the boardwalk or inland infrastructure.

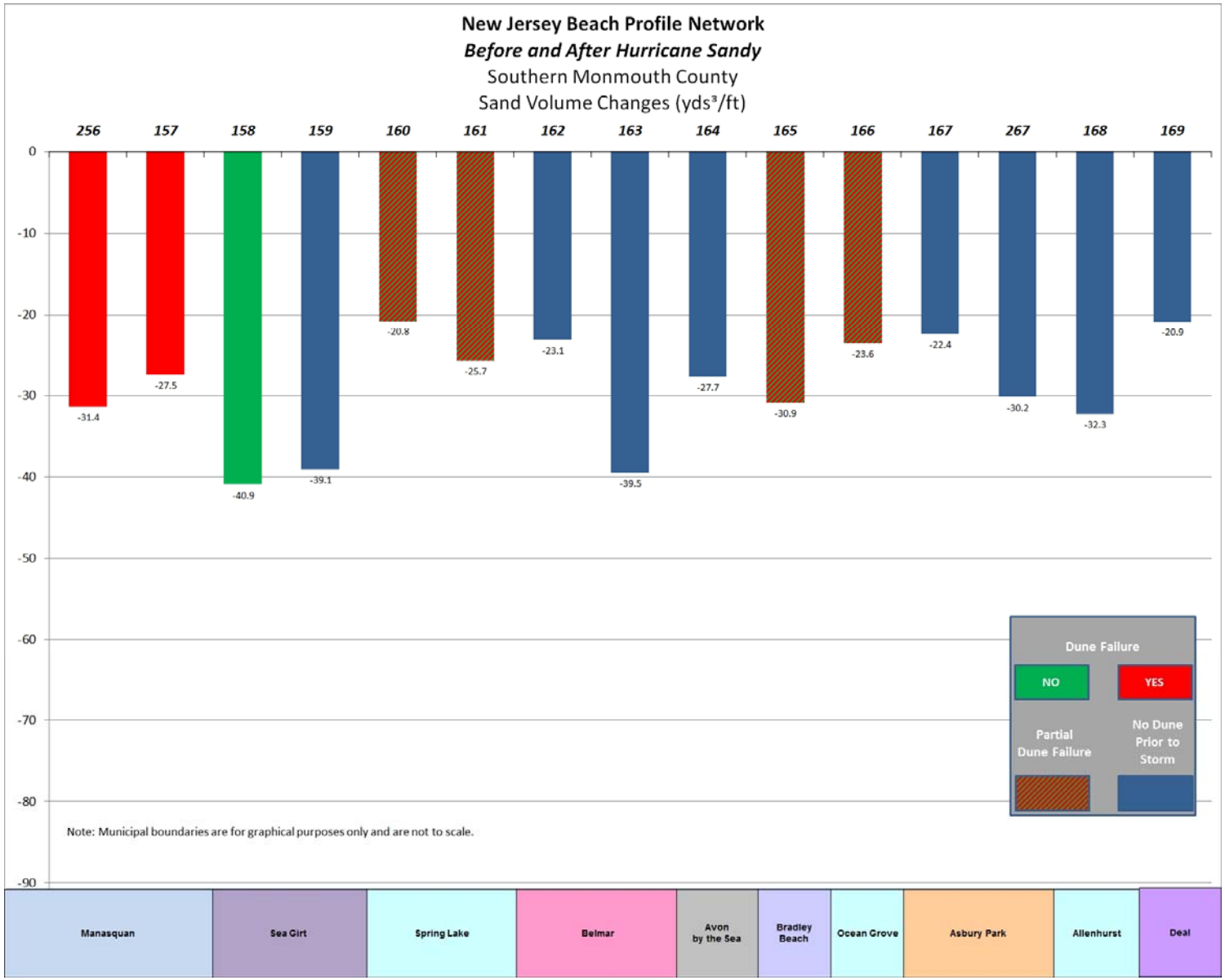


Figure 18. This graphic shows the sand volume loss figures for each of the communities within the developed sections of the southern Monmouth County Atlantic shoreline. The Federal shore protection project covered all but site numbers 169 and 168 in Allenhurst and Deal. All sites experienced berm erosion and dune loss or removal if dunes were present. The "no dune" condition applied to six sites (northern Sea Girt, Belmar, Avon and Asbury Park). No dune exists at either the Deal or Allenhurst sites. The former is a beach against the bluff and the latter has a beach against a concrete wall.

Southern Monmouth County Post Sandy Volume Changes

MUNICIPALITY	NJBPN Site#	Shoreline Change in the Zero Elev. Position since 1997 or 1999	Vol Change cu yds per ft	Average of Sand Loss Between Adjacent Sites (cy/ft)	Dune Failure	Recent Beach Fill	Distance Between Sites (FEET)	Vol Change - Cubic Yards Between Profiles (South to North)	Cumulative Volume Change - Cubic Yards (South to North)
Manasquan	256	-55.4	-31.37	To Jetty	Y	1997	1,230	-38,585	-38,585
Manasquan	157	-60.9	-27.46	-29.42	Y	1997	2,764	-81,313	-119,898
Sea Girt	158	-136.5	-40.92	-34.19	N	1997	4,790	-163,763	-283,661
Sea Girt	159	-63.7	-39.08	-40.00	No Dune	1997	2,246	-89,850	-373,511
Spring Lake	160	-6.5	-20.76	-29.92	Y-partial	1997	3,711	-111,038	-484,548
Spring Lake	161	47.6	-25.70	-23.23	Y-partial	1997	5,139	-119,376	-603,925
Belmar	162	-65.2	-23.13	-24.42	No Dune	1999	5,122	-125,056	-728,981
Belmar	163	46.3	-39.52	-31.33	No Dune	1999	4,318	-135,275	-864,256
Avon By the Sea	164	-90.2	-27.67	-33.60	No Dune	1999	3,607	-121,177	-985,433
Bradley Beach	165	-87.2	-30.89	-29.28	Y-partial	1999	4,363	-127,736	-1,113,169
Ocean Grove	166	-169.0	-23.55	-27.22	Y-partial	1999	3,789	-103,127	-1,216,296
Asbury Park	167	-93.1	-22.42	-22.99	No Dune	1999	3,005	-69,072	-1,285,368
Asbury Park	267	-46.8	-30.18	-26.30	No Dune	1999	2,282	-60,006	-1,345,374
Allenhurst	168	no project	-32.30	-31.24	No Dune	Never	3,104	-96,958	-1,442,332
Deal	169	no project	-20.86	-26.58	No Dune	Never	3,337	-88,710	-1,531,042

Figure 19. This table provides a summary of all the individual site sand volume losses from the dune and beach to the limit of the post-Sandy survey. The shoreline change data is the distance in feet that the zero elevation position has moved landward since the Federal project was completed (1997 or 1999). This coastal segment contains the southern phase of the NY District Corps of Engineers massive Monmouth County Shore Protection Project with the exception of the Allenhurst and Deal sites (#168 & 169) where no sand was ever placed. The totals for sand loss is derived by adding the two adjacent site losses and dividing by two, then multiplying by the distance in feet between the two sites. This is known in the dredging industry as “closed-end averaging” to obtain dredged volume along a channel. It is acknowledged that sand resources reside seaward of the short post-storm surveys in the form of growing offshore sand bars, but the need for speed dictated that taking additional time to survey to 15-16 feet of water offshore would not add significantly to the losses seen within the beach/dune system. It is also acknowledged that the large distances between sites limits the precision of the sand loss total volume for restoration purposes, but it gives a decent approximation. The longer surveys will be completed in due course however. A percentage of the sand carried offshore by Sandy will move back toward the beach over time in the absence of future storms. All sand lost from the dunes will require human intervention to replace, groom and re-vegetate in order to have the protection in place quickly. A natural dune system developing from scratch would require 15 to 20 years to re-establish close to what was lost.