FINAL REPORT FOR 2015
ON THE CONDITION OF THE MUNICIPAL BEACHES
IN
THE CITY OF BRIGANTINE BEACH, ATLANTIC COUNTY, NEW JERSEY

View to the south from 5th Street showing Atlantic City in the distance. This photo represents conditions along Brigantine's southern shoreline following an early October 2015 northeast storm event. Beach width decreased and the beach berm was flattened from the storm waves but the dune toe remained intact at this location and through the southern section. This photo taken about 11 days following the storm event shows a ridge of sand already moving back onshore. Natural recovery was already underway with favorable weather conditions that persisted through the remainder of 2015. (Photo taken October 15, 2015)

PREPARED FOR: THE CITY OF BRIGANTINE BEACH
1417 WEST BRIGANTINE AVENUE
BRIGANTINE, NJ 08203

PREPARED BY: THE STOCKTON UNIVERSITY COASTAL RESEARCH CENTER
30 WILSON AVENUE
PORT REPUBLIC, NEW JERSEY 08241

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Annual Report for 2015 to the City of Brigantine Beach on the Condition of Municipal Ocean Beaches

Introduction:

This annual report presents the status of the beaches within the City of Brigantine Beach from October 2014 to October 2015. The report includes post-Sandy restoration efforts with a small section focused on Winter Storm Jonas. In addition a synopsis of the Absecon inlet shoreline study conducted between 2006-2014 to follow natural recovery of sand excavated by the United States Army Corps of Engineers (USACE) in 2002-2003 as part of the Absecon Inlet borrow zone inadvertently destabilized the Brigantine inlet shoreline adjacent to the borrow zone and jetty.

Prior to Hurricane Sandy, the Brigantine beaches had remained relatively stable and generally accumulated sand across the majority of the southern shoreline. The exception was at the erosional "hotspot" located from the north end of the promenade revetment through 6th Street North. The 2013 USACE post-Sandy restoration project was conducted in two phases (phase one 667,000 cubic yards (CY), January 2013, phase two 250,000 CY, July 2013) and placed a reported 917,000 cubic yards (CY) of sand on the project beaches. Following beach restoration on the federal project area and natural recovery along the southern shoreline the City's beaches were over 329,000 CY of sand above conditions prior to Sandy's landfall by the end of 2013, but the sand volume losses continued in the northern section of the City. At the south end, the beaches fully recovered and the USACE project beach template was restored. Recovery along the natural area on the north end of the island post-Sandy was much slower with significant sand volume, width and elevation deficits remaining in the dune, beach and nearshore configuration all well below pre-storm conditions.

During 2014, no additional sand was placed on the beaches in Brigantine but the beach gained 174,852 CY of sand through natural processes, all of the gain occurred from 4th Street North south to Absecon Inlet. Despite this overall gain, north of 4th Street North the engineered beach lost 197,956 CY focused along the erosional hotspot seaward of the promenade revetment near 12th Street. While to the south the beaches gained 372,808 CY of sand generating the net sand volume gain for 2014.

This accretive trend reversed in 2015 starting during the winter season with winter storms Iola and Juno in late January followed by 3 more modest to moderate northeast storms in February and March. Following a mild summer absent of tropical systems the northeast storm trend continued in fall 2015 with an early slow moving northeast event striking the coast from October 3-6, 2015. The storm generated 30-40 mph onshore winds that caused moderate beach erosion and coastal flooding.

Unfortunately, most of the sand volume gained in 2014 was lost during the first half of 2015 as a series of modest to moderate northeast storms combined to erode the Brigantine Beach shoreline over the winter. Hardest hit were the northern beaches within the erosional hotspot and along the "Feeder Beach" but the erosion continued south to 27 Street South resulting in a net loss of 327,927 CY of sand removed from October 2014 to May 2015. The early October 2015 storm caused additional erosion focused mainly at the northend, south of 4th Street north sand accumulated partially offsetting the north end losses, the net result was a loss of 162,683 CY of sand in fall 2015. By the end of 2015, the Brigantine oceanfront shoreline had a net sand volume loss of 521,495 CY of sand.

Beach Monitoring Program Methodology

The CRC established a coastal monitoring program for the City of Brigantine in June 1992, commencing research on the beaches between two major northeast events that affected the Jersey shore in October 1991 and December 1992. The program collects data from nine shoreline-perpendicular beach profile stations, initially monitored on a quarterly basis, to analyze beach changes. Starting in 2008 the program was resumed at a

survey frequency of twice annually. Beginning at a fixed reference position, a profile includes the dune system, beach, berm, nearshore and offshore to a water depth of approximately -14.0 feet (NAVD88). Table 1 lists the Brigantine sites where cross sections, photographs and field notes are presented.

Table 1:
Beach Profile Locations

- **Brig 134** - North end Green Acres undeveloped area (NJBPN #134)
- **Brig 220** - At the north end of the feeder beach, 1200 feet from road end
- **Brig 12** - 12th Street North
- **Brig 4** - 4th Street North (NJBPN #133)
- **Brig 5** - 5th Street South
- **Brig 15** - 15th Street South (NJBPN #132)
- **Brig 27** - 27th Street South
- **Brig 43** - 43rd Street South (NJBPN #131)
- **Brig 1** - 'South Beach' 600 feet north of the Absecon Inlet Jetty

Surveys Completed

The CRC completed three surveys between October 2014* and October 2015. An emergency survey was conducted in January 2016 following Winter Storm Jonas and is presented as a supplemental addition to this report.

- October 10, 2014* Survey 83
- May 14, 2015 Survey 84
- October 16, 2015 Survey 85

Note: *Site134 surveyed December 4 due to beach access issues to the State Park Natural Area.

Beach Performance

The two phases of the 2013 USACE post-Sandy restoration project combined placed 917,000 CY of sand on the engineered beach restoring the federal project beach template. When combined with past beach fills, over 3.1 million CY of sand have been placed on the beaches along the northernmost part of the developed portion of Brigantine Island. Construction of the first Federal shore protection project in the City of Brigantine Beach commenced in 2006. Since placement, the USACE engineered beach sustained several significant storm events but maintained its storm protection value to the community during Hurricanes Irene (2011) and Sandy (2012) by preventing major flooding and property damage from storm waves.

The post Sandy emergency Federal beach nourishment projects were completed in 2013, adding sand to the City's beaches. In addition natural sand recovery under generally mild storm and wave conditions that prevailed in 2014 and during the calm summer months (May 2014 to October 2014) sand gains were recorded from 5th Street South to Absecon Inlet with the exception of 27th Street South, where sand moved further offshore from the sandbar. While overall 174,852 CY of sand was added to the beaches in 2014, at the 12th Street North and 4th Street North sites near the City's promenade section and erosional "hotspot" the beaches lost sand. The rate of erosion was higher directly in front of the promenade, at the 12th Street North profile location and on the "feeder beach" net loss in this region was 190,822 CY of sand. North of the promenade, to profile location Brig-134 the beach was stable and showed an increase in sand volume through the summer 2014 season.

In 2015 a series of moderate and modest northeast storms combined to erode the Brigantine Beach oceanfront shoreline. The northern beaches within the erosional hotspot and along the "Feeder Beach" suffered the worst

erosion but sand volume losses continued south to 27 Street South resulting in a net loss of 327,927 CY of sand removed from October 2014 to May 2015. In early October 2015 a northeast storm caused additional erosion focused mainly at the northend. South of 4th Street north sand accumulated partially offsetting the north end losses, the net result was a loss of 162,683 CY of sand in fall 2015. Overall the Brigantine oceanfront shoreline lost 521,495 CY of sand during 2015. Net loss to the federal project beach from the "feeder Beach to 15th Street South was 355,283 CY of sand in 2015. The region from the "feeder beach to 5th Street North was hardest hit with a loss of 288,191 CY of sand through 2015. Since placement of sand in 2013 this region has lost 479,013 CY of sand through October 2015. The winter of 2016 has continued to erode this region during winter storm Jonas the section of beach lost an additional 48,770 CY of sand increasing the net loss since the 2013 nourishment project to 527,783 CY of sand. Current conditions at the northend have deteriorated to where the "feeder beach" is no longer providing sand to the downdrift beaches, the beach seaward of the promenade in the 12th Street North area has been severely eroded exposing the rock revetment with no dry beach at high tide. Erosion rates have accelerated to the south as exposure of the rock revetment has increased wave energy refraction when waves directly impact the hard structure resulting in beach scouring along the base of the rocks in the downdrift (south) direction. This process will continue to erode the beach and expose more of the revetment in the downdrift direction amplified during storm events.

In Table 1 below, sand volume changes are expressed in cubic yards per foot of beach (yds^3/ft), while shoreline changes are given in feet. Calculating the average volume change between adjacent profiles and multiplying by the distance separating the sites yields a net volume change expressed in cubic yards (yds^3) for the distance between the two sites. Adding the cumulative volume changes provides a net volume for the entire City of Brigantine beach over the entire length of surveyed cross section. Shoreline position changes are measured as the horizontal movement (toward the ocean (+) or toward land (-)) in the zero elevation point on each profile.

Table 2
Brigantine Shoreline and Volume Changes
October 10, 2014 to May 14, 2015

Profile	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg. Volume Change (yds^3/ft)	Distance Between (feet)	Net Volume Change (yds^3)
Brig-134	-35	-32.66			
			-27.092	3,122	-84,581
Brig-220	-8	-21.52			
			-21.594	1,860	-40,164
Brig-12	-22	-21.67			
			-15.423	1,951	-30,090
Brig-4	48	-9.18			
			-13.753	1,805	-24,823
Brig-5	2	-18.32			
			-24.620	2,729	-67,187
Brig-15	-57	-30.92			
			-25.566	3,042	-77,770
Brig-27	74	-20.22			
			-4.894	4,132	-20,220
Brig-43	-3	10.43			
			3.105	5,855	18,177
Brig-1	36	-4.22			
			-2.110	601	-1,268
Absecon Jetty					
			Total Volume Change =		**-327,927**

The table shows significant combined losses during the winter of 2014/2015 driven by several moderate winter storm events. From October 2014 to May 2015 the Brigantine oceanfront shoreline lost a combined -327,927 CY of sand. At each site the seaward beach berm was flattened and nearshore trough scoured. Northend sites suffered more significant onshore erosion with waves cutting into the beachface slope despite these losses all the developed dunes remained intact following the winter storms as the beaches absorbed most of the wave energy. Some sand was deposited on the offshore bars but additional sand was transferred offshore beyond the profile limits and longshore. Most significant losses occurred from the northend and "feeder beach" through 15th Street south. The 2015 winter sand volume loss for the City's beaches was quite large given the relatively low level of storm energy expended by any single event in New Jersey.

Table 2 below, shows the May 2015 to October 2015 sand volume changes in cubic yards per foot (yds^3/ft) of beachfront and shoreline change measured in feet for each of the City's nine profile sites. Also included is a net volume change in cubic yards for the entire project area on Brigantine Island. The total volume is calculated by averaging the volume change at adjacent profile sites, then multiplying by the distance between profile sites.

Table 3
Semi-Annual Comparison
Sand Volume and Shoreline Changes
May 14, 2015 to October 16, 2015

Profile	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg. Volume Change (yds^3/ft)	Distance Between (feet)	Net Volume Change (yds^3)
Brig-134	-1	-70.64			
			-44.833	3,122	-139,967
Brig-220	27	-19.02			

			-15.566	1,860	-28,952
Brig-12	33	-12.11			
			-17.699	1,951	-34,531
Brig-4	-117	-23.29			
			-16.544	1,805	-29,862
Brig-5	24	-9.80			
			1.029	2,729	2,807
Brig-15	12	11.86			
			10.450	3,042	31,787
Brig-27	35	9.04			
			4.714	4,132	19,476
Brig-43	-79	0.38			
			2.379	5,855	13,929
Brig-1	57	4.38			
			4.375	601	2,629
Absecon Jetty					
			Total Volume Change =		**-162,683**

From May 2015 to October 2015, the Brigantine beaches lost 162,683 CY of sand along the municipal shoreline. The natural beaches north of the feeder beach lost 139,967 CY of sand. The feeder beach lost another 28,952 CY of sand. Along the erosional "hotspot" zone that exists from the promenade to 4th Street North an additional sand volume loss of 34,531 CY occurred with an additional loss of 29,862 CY of sand between 4th Street North and 5th Street South. All the beaches south of the Federal project area gained sand totaling 70,628 CY, partially offsetting the loss of 233,312 CY which includes the large loss from the natural area. The federal project area lost 93,345 cubic yards of sand, the sand accumulation on the southend offsets 76% of this project area loss.

Annual Changes

The 2013 USACE post-Sandy restoration projects (phase one 667,000 CY, phase two 250,000 CY) placed a reported 917,000 CY of sand on the project beaches. During 2014, no additional sand was placed on the beaches in Brigantine but the beach gained 174,852 CY of sand through natural processes, all of the gain occurred from 4th Street North south to Absecon Inlet.

This accretive trend reversed over the winter of 2014/2015 and by spring 2015 the beaches net loss was 327,927 CY of sand. Summer season was dominated by calm weather patterns absent of tropical storm activity allowing some natural recovery and beach berm building to occur. Unfortunately, an early northeast event in the beginning of October caused significant erosion and removed most of this gain prior to the fall survey. As a result, the fall survey showed a net volume loss of 162,683 CY of sand from spring 2015 to fall 2015. Table 3 below shows the annual shoreline changes and sand volume changes from October 10, 2014 to October 16, 2015.

Table 4
Annual Comparison
Sand Volume and Shoreline Changes
October 10, 2014 to October 16, 2015

Profile	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg. Volume Change (yds^3/ft)	Distance Between (feet)	Net Volume Change (yds^3)
Brig-134	-8	-52.27			

			-42.548	3,122	-132,835
Brig-220	25	-32.83			
			-62.623	1,860	-116,478
Brig-12	-24	-92.42			
			-61.151	1,951	-119,305
Brig-4	-69	-29.88			
			-29.035	1,805	-52,408
Brig-5	26	-28.19			
			-24.585	2,729	-67,092
Brig-15	-44	-20.98			
			-16.242	3,042	-49,408
Brig-27	108	-11.50			
			-2.576	4,132	-10,642
Brig-43	-82	6.35			
			4.321	5,855	25,297
Brig-1	93	2.29			
			2.290	601	1,376
Absecon Jetty					
			Total Volume Change =		**-521,495**

Although the Jersey shore was not directly impacted directly by any tropical storms or major single northeast events the combination of modest to moderate storm events in the winter of 2015 and then again in early October resulted in significant erosion. From October 2014 to October 2015 the monitored oceanfront beaches lost a net 521,495 CY of sand. The vast majority of that loss occurred on the northern beaches with 368,618 CY of sand removed from 4th Street north to the Green Acres site. Twelfth Street North suffered the single largest volume loss with 92.42 yds^3/ft. of sand removed from the engineered beach seaward of the promenade revetment. Each of the profiles in this region showed significant onshore losses, flattening and reducing the beach berm elevation, cutting back the beachface slope and scouring the nearshore seafloor. There was zero to only modest deposition further offshore indicating longshore sand transfer and or cross-shore transfer well offshore beyond the profile limits. The original engineered beach area from the "feeder beach" south the 4th Street North lost 235,783 CY of sand through 2015. Remainder of the federal project beach down to 15th Street South lost an additional 119,500 CY for a net loss along the entire engineered beach of 355,283 CY of sand. Loss rates rapidly diminished south of 15th Street north with modest net gains seen at 43rd Street and near the Absecon Jetty. Net loss in this region was 33,377 CY mostly derived from the region immediately south of 15th Street South.

Individual Profile Descriptions

This section describes the changes documented at each of the beach profile locations from October 2014 to October 2015 and includes photographs and cross-sections that show the semi-annual and annual comparisons (Figures 1 – 27). For the profiles from the "feeder beach" south to Absecon Jetty a post-winter storm Jonas photo is included in the series. A separate section on Jonas is included following the annual changes for 2015.

- **Profile Brig-134: Green Acres - North end** **(Figures 1a, 1b & 1c)**

The profile line is located 4,752 feet north of the promenade at the north end of Brigantine Avenue. Located within the State Park natural area no sand has been added to the site during any of the past nourishment projects. The closest sand placement activity occurred at the "feeder beach" almost 3,500 feet south of this location. This region typically is influenced by the inlet dynamics at Brigantine Inlet to the north. Periodic episodes of sand bypassing the inlet moving south add sand to the beach in this region.

Hurricane Sandy in 2012 overwashed this natural area removing all the gains that were naturally achieved over the last 20 years since the December 1992 storm. The beach was flattened and lowered up to 5 feet in elevation. Sandy's storm surge and waves overwashed the dune system, completely removing the feature, leaving only old fence post installed after 1992 that mark its previous location. The net onshore volume change from Sandy was a loss of -39.77 yds^3/ft. of sand, removed as a wedge of sediment that extended landward of the shoreline and included the dry recreational beach and dune system.

In 2013, this site continued to erode, bringing the total volume loss since Sandy (this calculation includes the offshore changes) to -74.38 yds^3/ft. of sand. In 2014, this location began to gain sand as natural recovery began slowly following the devastating Sandy losses in 2012. Overall there was a gain of 25.19 yds^3/ft and a 9 ft shoreline advance from November 2013 to December 2014.

In 2015, the erosional trend was firmly reestablished as the site lost -52.27 yds^3/ft. of sand from the end of 2014 to October 2015. Initial losses began over the winter of 2015 and by February 2015 the beach berm had eroded leaving a flat beach configuration that persisted through fall. The dune remained intact but with little to no growth through 2015. By October 16, 2015 the nearshore seafloor was severely scoured likely the result of prolonged onshore winds at the beginning of October. The offshore bar was also flattened by October 16, 2015 while a new bar developed closer to shore partially filling the nearshore trough present in February 2015. This new deposit resides 400 feet seaward of the shoreline reducing the likely hood of rapid recovery onshore.

Profile Brig-134: Green Acres - North end **(Figures 1a, 1b & 1c)**

Figure 1a taken on February 27, 2015 looking north shows the dune and beach conditions had continued to naturally recover approximately 30-months following Hurricane Sandy. The post sandy dune scarp is no longer prominent.

Figure 1b taken on October 16, 2015 from the same perspective shows a slightly wider beach but the beach elevation was flattened by storm waves from the October 2015 nor'easter. The existing beach width protected the dune toe from storm waves and further erosion.

Figure 1c was taken on December 4, 2014 from the same location it was included to depict the relatively stable to slightly accretive conditions at this beach during 2015.

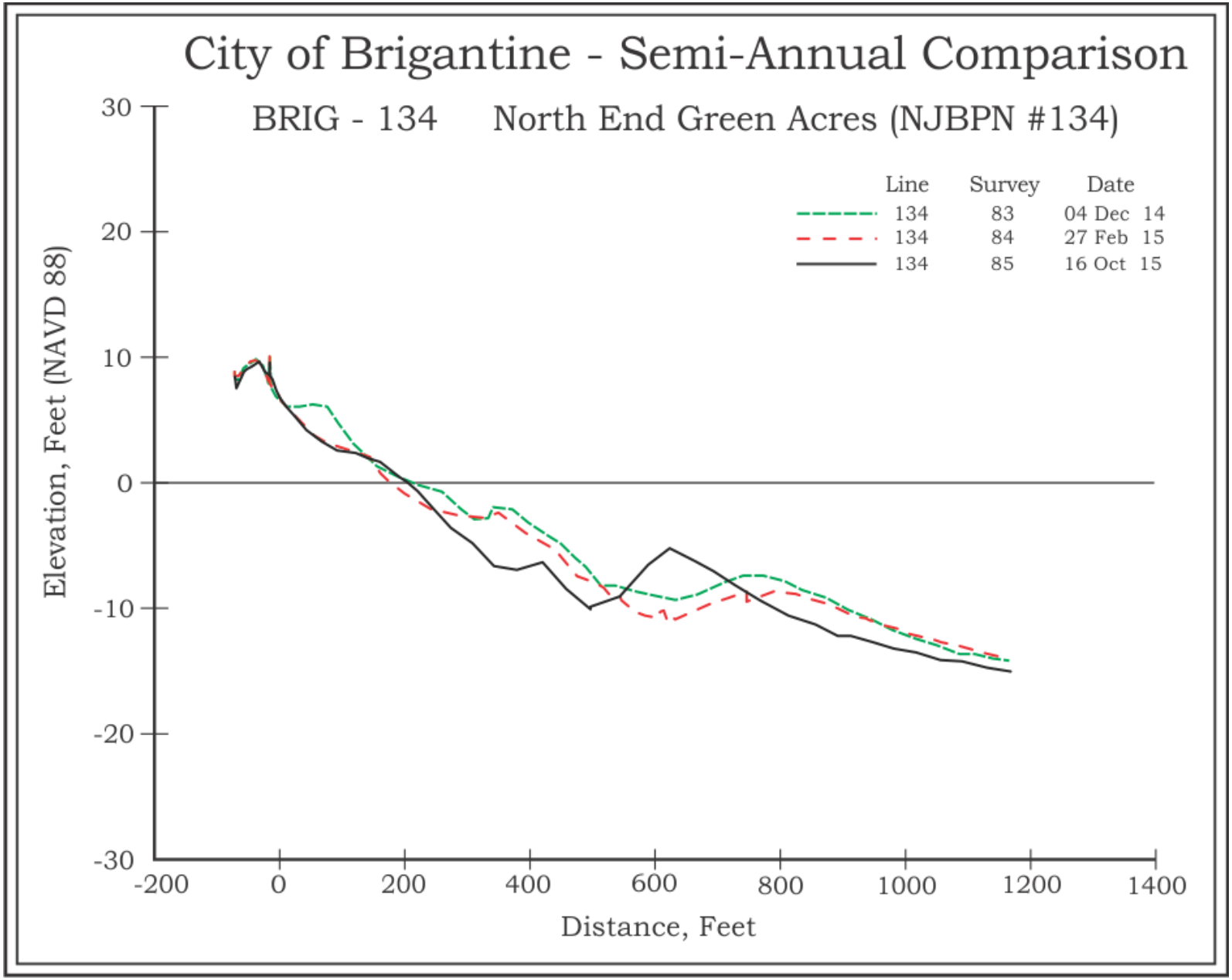

Figure 10 - The three cross sections above show the semi and annual changes in beach conditions at the Green Acres site. The beach berm eroded over the winter of 2015 along with modest scouring of the nearshore seafloor. Over the summer and fall the beach remained relatively stable while the nearshore suffered significant scouring. The offshore bar position moved landward approximately 200 feet with a loss of sand from offshore to the profile extent. A net annual loss of -52.27 yds^3/ft. of sand occurred this year.

- **Profile Brig-220: Feeder Beach - Line 00+1200 (Figures 2a, 2b & 2c)**

The site is located on the "feeder beach" portion of Brigantine's engineered beach 1200 feet north of the promenade in the natural area. Sand shed from this location provides advance nourishment to the downdrift erosional "hotspot" that is located to the south along the revetment/promenade. Identified in 1996 along with the NJDEP and the City of Brigantine, the goal for this section of beach was to provide an available sand source for recreational beaches to the south. This sand source was intended to erode and move south into the developed portion of the project area to slow erosion in front of the revetment to a more sustainable rate and extend project benefits for a longer period. This process has been documented and has performed better than expected since initial construction, provided sufficient sand volume remains in this region. Once the "feeder beach" erodes landward of the promenade the benefits diminish.

Hurricane Sandy devastated the dune system, which had largely developed naturally through aeolian processes post nourishment. The beach was flattened and lowered up to 5 feet in elevation. Sandy's storm surge and waves overwashed and breached the dune system through the lower elevation sections or eroded away the seaward dune slope back to the crest. Where the breaches occurred, sand was pushed and spread landward filling the back swale. In 2013, the USACE restoration project again placed sand at this site. The net volume gain for 2013 from both natural and project related activity was about 100 yds^3/ft of sand, when comparing to pre-Sandy conditions (October 26, 2012). Erosion continued through 2014, the net volume was -29.76 yds^3/ft of sand from fall 2013.

In 2015, the erosional trend continued with a net annual loss of -32.83yds^3/ft. of sand. Over the winter of 2015 the beach berm eroded with sand pulled to the shoreline position while the nearshore seafloor was scoured with some modest deposition further offshore near the profile limits. The net change over the winter of 2015 was a loss of 21.52 yds^3/ft. of sand. This erosional trend continued through October 16, 2015 with further loss of the beach berm and nearshore and continued development of an offshore bar 500 feet seaward of the shoreline partially offsetting the onshore and nearshore losses. From spring to fall 2015 the net volume loss was -19.02yds^3/ft. of sand.

This section of shoreline has continued to perform well as a "feeder beach" for the downdrift beaches. Despite this performance, the Army Corps project manager does not feel that federal funds should be spent on nourishing undeveloped segments of this shoreline. During the 2013 project, funding was available for a small taper north of the developed beach area and any larger deposit was to be considered a "betterment" of the project to be paid by the "local sponsors". The City of Brigantine benefited when the project specification put out to bid inadvertently contained the entire "betterment" sand volume as part of the project eliminating the City's local sponsor responsibility. This generosity by the USACE should not be expected in future projects and provisions should be made to include funding to maintain this vital source of additional sand that acts to prolong the viability of the project fronting the developed shoreline north of 4th Street North.

The original "feeder beach" was initially created to be 2,400 feet in length extending 600 feet into the NJ open space of northern Brigantine. Park officials declined to permit future activities of beach nourishment within the park boundaries, so all subsequent work extends 1,600 feet north of all oceanfront development to the City boundary with the open space lands.

Profile Brig-220: Feeder Beach - Line 00+1200 **(Figures 2a, 2b & 2c)**

Figure 2a was taken May 14, 2015 and the view is to the south. Aeolian transport has moved sand to the dune toe where the wind-blown sand has accumulated. Early colonizing plants have begun to spread across the seaward slope onto the wide beach.

Figure 2b taken October 16, 2015 shows storm waves from the early October nor'easter reached the seaward dune toe. The beach was flattened but the dune remained intact.

Figure 2c the photo above was taken January 28, 2016 following winter storm Jonas. Storm wave runup reached the seaward dune slope, reduced the beach width and further flattened the beach slope and berm elevations. In its current condition, depleted of sand, this beach no longer feeds sufficient sand to the downdrift promenade beaches to prevent exposure of the rock revetment.

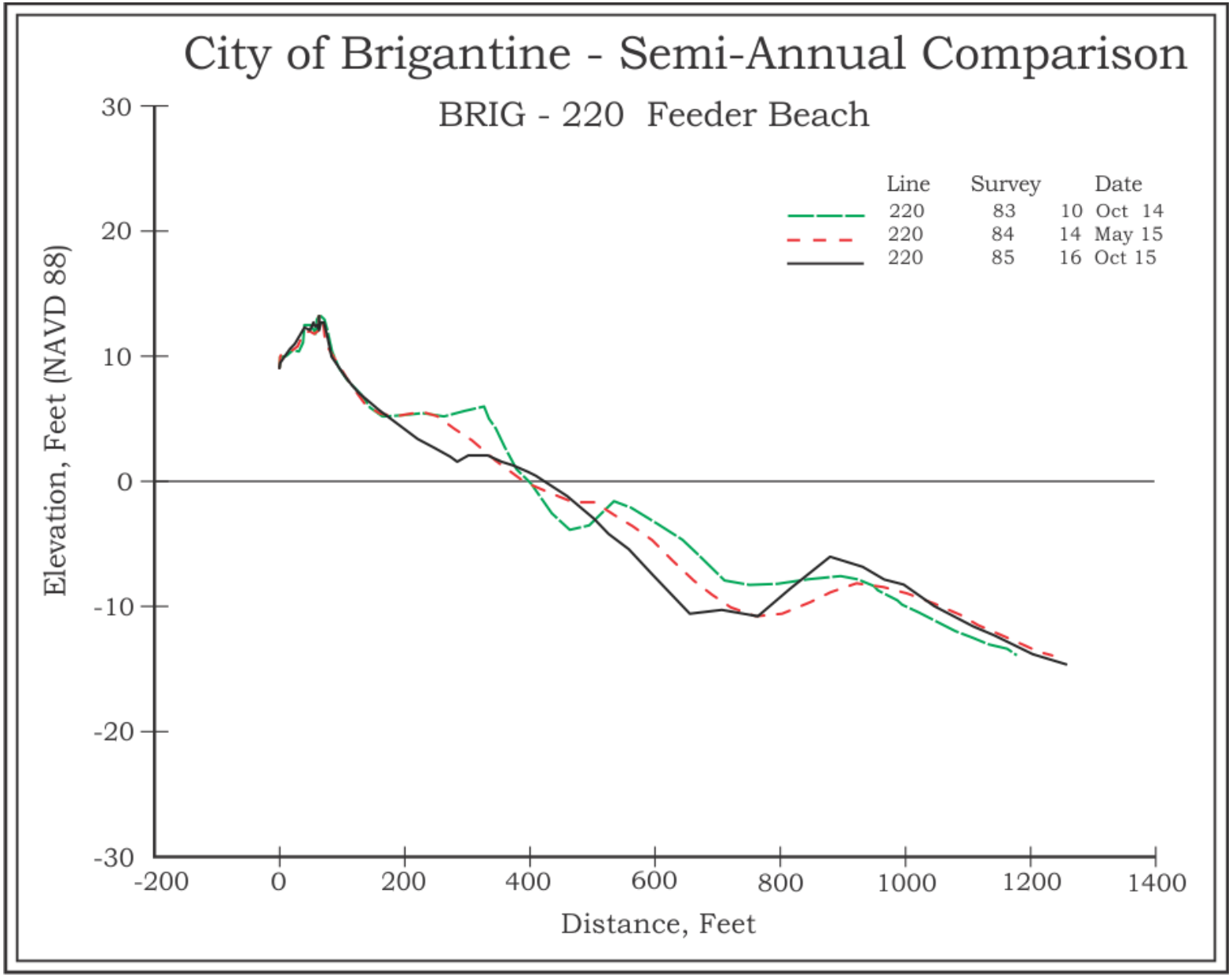

Figure 12 – The dune remained relatively stable to slightly accretive while the beach berm eroded through the year. Offshore bar development continued through 2015 while nearshore sand was lost forming a deep trough between the shoreline and offshore bar. The shoreline position change was a modest 25-foot seaward advance but with a net loss of -32.83 yds^3/ft. of sand through 2015.

- **Profile Brig-12: 12th Street North** **(Figures 3a, 3b & 3c)**

This profile site was established June 1992 along the north side of 12th Street North. The profile includes the road, promenade and bulkhead revetment structure that was completely reconstructed prior to the 1997 beach nourishment project. The Federal project placed sand here in February 2006, eventually adding 171.45 yds^3/ft. of sand to the beach. This site is within a region of chronic erosion due to the orientation of the beach and revetment that protects the north end of Brigantine Blvd. As the beach retreats to the promenade the rock revetment protection is exposed. The hard structure revetment reflects wave energy, so return flow scours the beach elevation downward rapidly. Left unchecked the erosion spreads rapidly south along the revetment towards oceanfront development near 8th Street North. The "feeder beach" was designed to alleviate this from occurring by providing advanced sand nourishment to this region in order to maintain a minimal beach seaward of the revetment and prevent exposure of the hard structure.

Hurricane Sandy eroded the beach to the revetment. With the rock revetment again exposed the storm waves over washed the promenade caused extensive property damage in the region, deposited large quantities of sand in nearby streets and scoured a deep trough at the base of the revetment. Along the seaward promenade 10 feet of sand was removed vertically by scouring affects as the wave energy reflected off the revetment rocks. In 2013, the USACE restored the damaged shoreline to the full beach template design at this site. The federal project placed 209.55 yds^3/ft. of sand while the shoreline position advanced seaward 311 feet. Over 2014, this section of shoreline rapidly eroded losing nearly 77 yds^3/ft. of sand, along with 113 feet of shoreline retreat.

Chronic erosion continued to plague this site through 2015. The site lost an additional 92.42 yds^3/ft. of sand with 24 feet of shoreline retreat. Combining the 2014 and 2015 losses account for 80% of the placed sand lost in just two years following sand placement in 2013. Losses occurred across the entire profile length. Onshore the beach berm steadily eroded while offshore the seafloor was scoured deeper nearshore and at the seaward profile limits. The loss of sand offshore reduced the likelihood of any significant onshore natural beach building processes through cross-shore sand transport. By October 2015 the beach width was reduced and the elevation flattened to a minimal configuration to support recreational activity, cover the rock revetment and provide storm protection. Winter storm Jonas in January 2016 further eroded the remaining beach exposing the rocks and bringing the mean high water line to within 20 feet of the rocks. With little or no excess sand to feed this beach remaining on the northern "feeder beach" this site will remain extremely vulnerable to beach erosion as exposure of the rocks increases wave refraction and scouring and accelerates north to south along the promenade revetment.

Profile Brig-12: 12th Street North **(Figures 3a, 3b & 3c)**

Figure 3a taken on May 14, 2015 the restored beach template remained relatively stable since completion of the 2013 USACE project. The mild 2014-2015 winter season were absent of severe storms allowing the wide beach berm to persist through to spring of 2015.

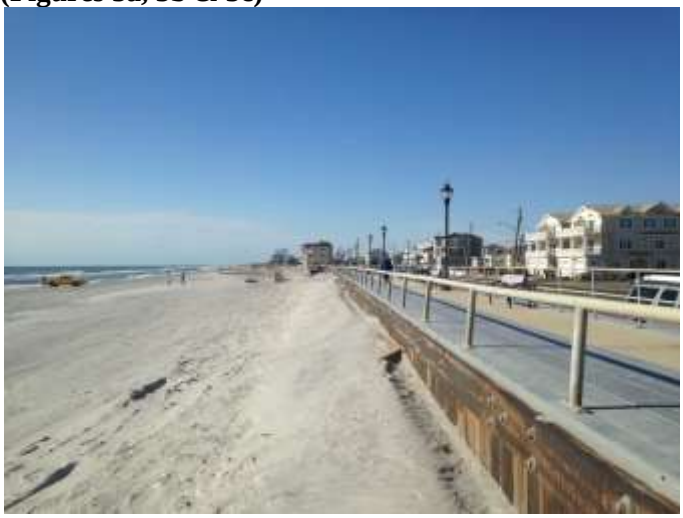

Figure 3b photo above was taken October 16, 2015 from a similar location. The wide beach berm still present in spring 2015 has been flattened by storm wave runup that nearly reached the revetment two weeks prior during the early October nor'easter.

Figure 3c taken on January 27, 2016 this photo was taken from the same location following winter storm Jonas, a severe nor'easter. Photo shows a rapid deterioration of the beach conditions since October 2015 and exposure of the rock revetment. The orientation of the natural shoreline converges with the street end revetment and promenade in this location. Once the shoreline has retreated to the rocks, erosion rates accelerate from wave refraction off the hard structure resulting in a chronic erosional hotspot.

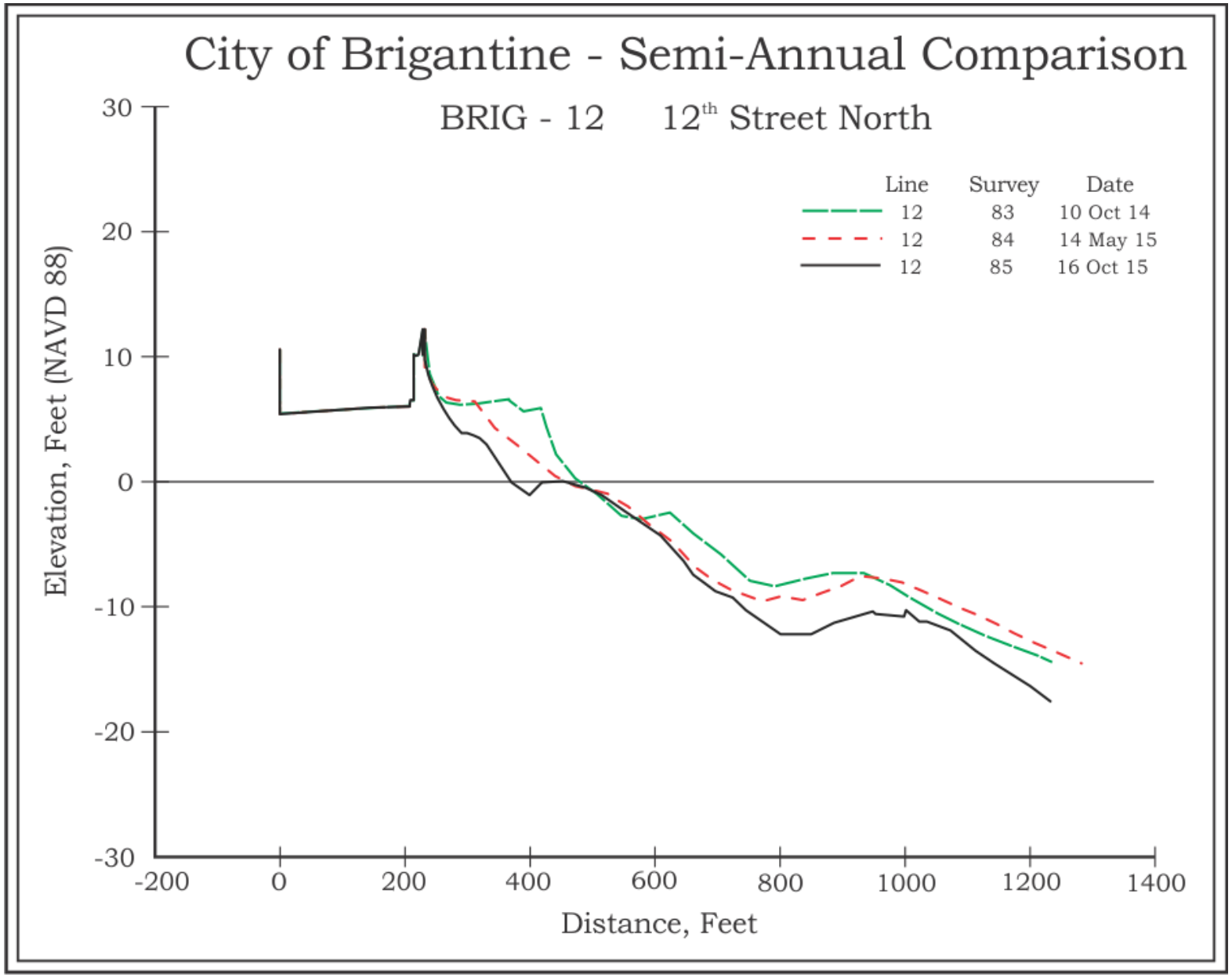

Figure 14 - The cross sections above shows a significant steady rate of sand loss across the entire profile during 2015. This known erosional "Hotspot" continued to erode and as sand on the "feeder" beach to the north diminished stability at Brig-12 deteriorated. During 2015 the shoreline position retreated 24 feet with a major net loss of 92.42yds^3/ft. of sand from this chronic erosional location.

- **Profile Brig-4: 4th Street North** **(Figures 4a, 4b & 4c)**

Brig-4 was established as part of the New Jersey Beach Profile Network in 1986, and included in the City's monitoring project in June 1992. The location is at the southern end of the original city engineered beach nourishment project area approximately 100 feet south of station 2800-00. The initial Federal project extended further south and placed 80.57 yds^3/ft. of sand at this site.

Hurricane Sandy's waves and storm surge eroded a large wedge of sand from the upper beach and seaward dune slope leaving a concaved beach slope at this site. The entire foredune feature was over washed and removed leaving a vertical scarp five feet high cut into the primary seaward dune ridge. Sufficient dune width and height remained intact here to prevent a complete over wash at this site. A few blocks north of this site the dune rapidly tapered into an exposed bulkhead near 7th Street North where over wash was extensive, causing property and infrastructure damage.

During 2013, the USACE maintenance project added nearly 75 yds^3/ft. of sand to restore the federal beach template in this region. During the second half of the year the project berm and nearshore experienced modest erosion that swept sand away from the site. The net loss was about 30 yds^3/ft. or approximately 40% of the sand placed. Changes observed over 2014 were minimal, with modest accumulations at the dune toe and seaward beach berm. This resulted in a net sand volume gain of 13.28 yds^3/foot.

In 2015, this site showed a net volume loss of -29.88 yds^3/ft. of sand as the shoreline position retreated landward 69 feet. Although the foredune ridge continued to accumulate sand and develop through 2015 the beach berm and beachface steadily eroded over 100 feet and the beach elevation was dramatically reduced. Nearshore, the seafloor was scoured developing a deep trough. Sand appears to have moved cross-shore further seaward where a large shore-parallel sand bar developed partially offsetting the nearshore and onshore losses.

The primary dune at this location is approximately 100 feet wide with a foredune ridge still developing extending the current system 150 feet seaward of the development, restoring the feature to near its pre-Sandy configuration. The beach width has steadily retreated this year making the system more vulnerable to storms. In early 2016, winter storm Jonas storm waves reached the seaward foredune slope and cut a modest scarp in the feature and further flattened the beach slope. Predominant southerly longshore transport along this section of Brigantine's shoreline moves sand eroded from the northern feeder beach and promenade area through this site. Provided sufficient sand remains within the system this site will remain more stable and resilient than the northern promenade area, however, as the sand source diminishes on the severely eroded northern beaches erosion accelerates downdrift destabilizing this shoreline. Current conditions along the northern engineered beach following Jonas show the accelerated erosion pattern has begun and is influencing conditions downdrift at 4th Street.

Profile Brig-4: 4th Street North **(Figures 4a, 4b & 4c)**

Figure 4a photo was taken looking north on May 14, 2015. This beach was fully restored to the design template two years prior. A new foredune has developed burying the installed fence, early colonizing plants have begun to propagate.

Figure 4b photo was taken looking north on October 15, 2015 following the early October storm. The beach width and elevation were reduced by the storm waves but the developing foredune remained intact.

Figure 4c taken from a similar perspective looking north on January 27, 2016 following winter storm Jonas. The developing foredune has been truncated and the beach width and elevation further reduced by the storm waves. Although considerable dune width remained to protect the properties landward the reduced beach width and elevation leaves the dune vulnerable to further storm erosion.

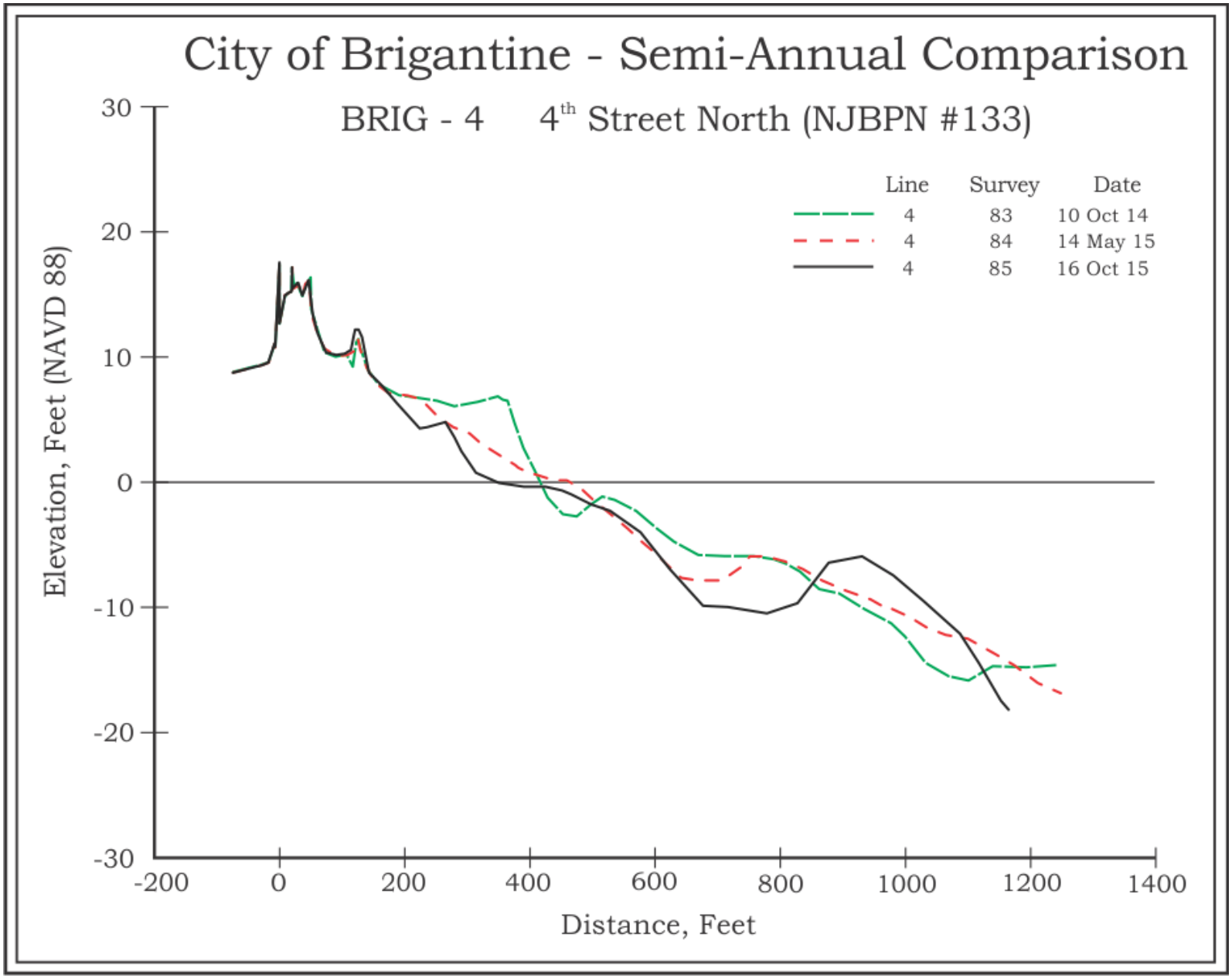

Figure 16 - The 3 cross sections above show the onshore and offshore changes at 4th Street North since October 2014. This site has not received sand since the summer of 2013. Sand has eroded onshore from the beachface to the seaward dune toe through 2015. Nearshore scouring formed a deep trough while further offshore a larger bar developed by fall 2015. The annual volume comparison shows a loss of -29.88 yds^3/ft. of sand and shoreline position retreat of -69 feet.

- **Profile Brig-5: 5th Street South** **(Figures 5a, 5b & 5c)**

This profile station was selected and established at 5th Street South in December 1998. The location is approximately midway between the end of the initial (1997) project beach at 4th Street North and the established site at 15th Street South. This site has a well-developed dune system composed of three significant ridges. The dune system is more expansive than along the northern engineered beach approximately 225 feet in width. Seaward growth through aeolian processes had added volume and width to the dunes annually until Sandy cut into the developed foredune ridge. Monitoring trends at this site over the years indicate a transitional zone exist in this region between chronic erosion to the north and accumulation on the southern beaches as sand moves south through this region on littoral currents. The initial Federal project placed a small volume of sand on this beach in 2006 and no sand was placed this far south during the 2011 USACE maintenance project.

Hurricane Sandy caused significant erosion at this location temporarily reversing the accretive trend exhibited here since the initial engineered beach project took place. The storm surge and waves flattened and lowered the beach elevation and cut into the seaward dune slope leaving an eight foot vertical scarp at the crest, 75 feet landward of the pre storm dune toe location. Despite the damage the remaining dune width and height was sufficient to prevent major over wash in this region.

No sand was placed directly on this section of shoreline during the 2013 USACE post-Sandy maintenance fill project. The project tapered into the existing beach conditions just north of this location at 3rd Street South. Moderate natural sand recovery in 2013 and spring summer beach building processes help partially restore the damage from Sandy. In 2014 the site continued to recover through natural beach building processes with sand moving onshore during the spring and summer seasons. From Nov. 2013 to Oct. 2014 this site gained a modest 7.85 yds^3/ft. of sand.

Over the winter of 2015 several modest storm events produced turbulent seas conditions that when combined caused moderate beach erosion and scoured a deep trough in the nearshore seafloor. Sand was transferred cross-shore and deposited in an offshore bar partially reducing the sand volume lost from the beach and nearshore. The net change from the spring 2015 survey was a loss of 18.32 yds^3/ft. of sand. Erosion continued into the fall driven largely by northeast conditions in early October. Waves further eroded the beachface slope flattening and lowering the beach berm elevation while wave scour deepened the nearshore trough. More sand was transferred offshore adding volume to the offshore bar and reducing the net profile loss to 9.80 yds^3/ft. of sand from May to October. The net annual change for 2015 was a loss of -28.19 yds^3/ft. of sand. Unfortunately, this sand reserve was located 500 to 600 feet from shore, separated from the beach by a 200-foot wide, 12-foot deep trough. This feature will hinder and slow cross-shore sand transfer from the offshore bar toward the beach when conditions once again favor natural beach building processes.

Profile Brig-5: 5th Street South **(Figures 5a, 5b & 5c)**

Figure 5a photo was taken looking north on May 14, 2015. Remnants of the dune scarp carved during Sandy remain partially visible in the seaward dune slope. All recovery here was natural; the 2013 USACE project ended 2 blocks north.

Figure 5b photo was taken looking north on October 15, 2014. Sand moved slightly landward into the dune toe with evidence of early colonizing plants propagation during the summer season. The early October northeaster again flattened and reduced the width of the beach berm.

Figure 5c photo was taken looking north on January 28, 2016 immediately following winter storm Jonas. You can clearly see the storm debris wrack line deposited at the seaward dune toe. Storm wave runup cut a small scarp along the seaward dune toe. The storm further reduced the beach berm width and elevation leaving the dune toe at least temporarily vulnerable to future storm waves until natural recover restores the beach conditions.

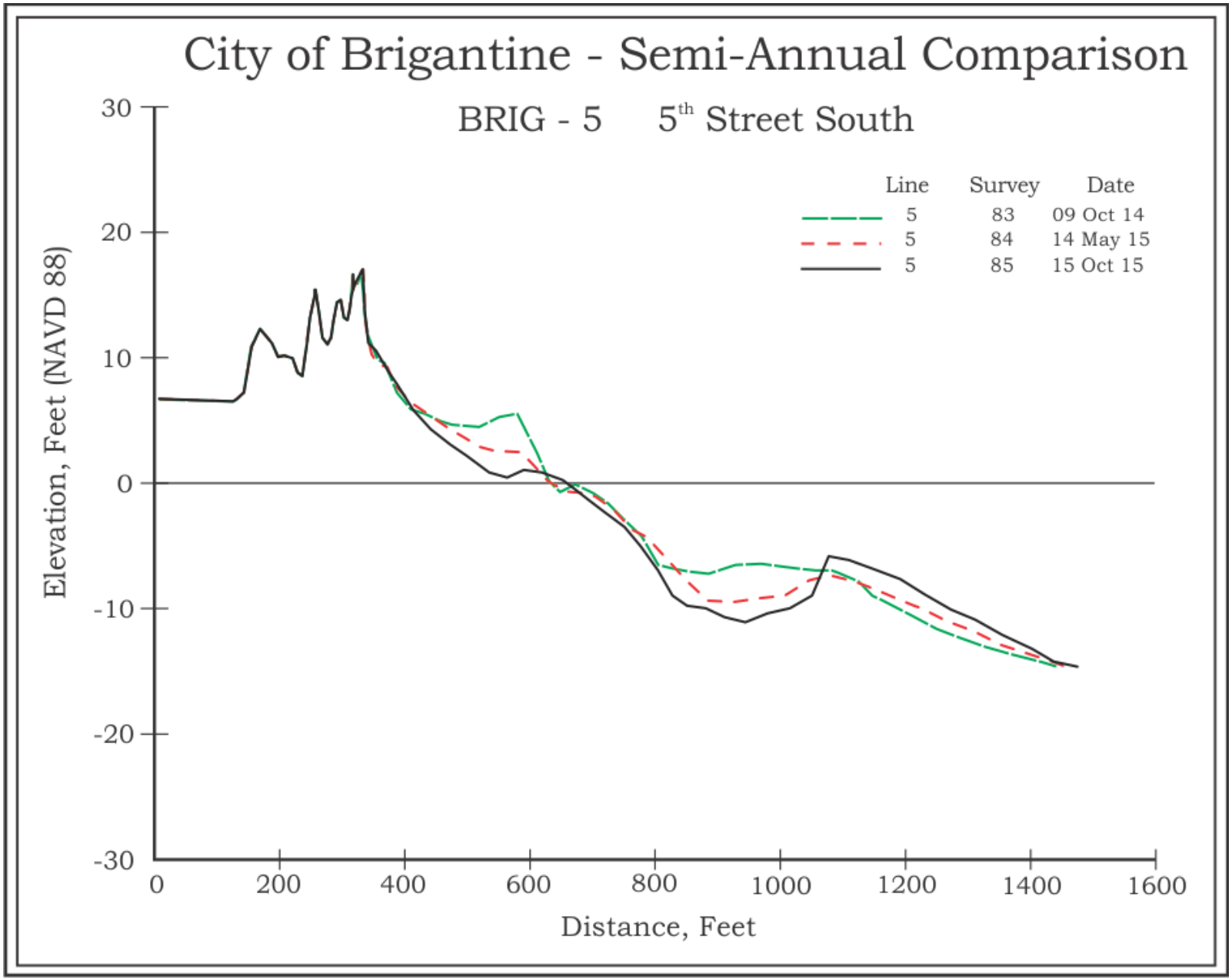

Figure 18 - The 5th Street South site since October 2014 showed a loss of sand from the beach and nearshore. Onshore the beach berm elevation was reduced over the winter of 2015 then further flattened by fall 2015. The nearshore was scoured forming a deep trough while sand was deposited further offshore forming a shore parallel bar. The annual changes for 2015 were a shoreline position advance of 26 feet while there was a net profile volume loss of -28.19 yds^3/ft. of sand.

- **Profile Brig-15: 15th Street South** **(Figures 6a, 6b & 6c)**

At 15th Street South, the dune is absent as the near continuous dune system along the developed shoreline is interrupted by the Legacy Vacation Resort (old Brigantine Hotel, built in 1929). Instead shore protection for the seaward properties is limited in this two block section between 14th and 15th Street South to the aging exposed wooden bulkhead. North of 14th Street South and south of 15th Street South the bulkhead is buried below a well-developed dune system that provides significant storm protection for seaward properties. This site is located at a nodule point for the City beaches both from a geographical location and sand deposition and erosion perspective. No sand has been placed here directly during previous beach nourishment efforts as natural sand accumulation has been sufficient to maintain a wide recreational beach.

North and south of this profile the dune was severely scarped during Hurricane Sandy but sufficient width and height remained intact to prevent major over wash and property damage. In contrast the absence of a dune between 14th and 15th Street allowed the storm surge and waves to over wash the bulkhead pushing a wedge of sand inland. Sand was pushed landward burying the bulkhead position and street end with up to three feet of sand. Storm wave over wash carried sand and flood waters down 14th and 15th Streets onto Ocean Avenue.

Post Sandy recovery has been limited here to natural processes as no sand was placed in this region during the 2013 federal maintenance project. By the end of 2013, the site remained about 13 yds^3/ft. of sand below the pre-Sandy volume although the shoreline position remained relatively stable despite the reduction in elevation and width of the beach berm. Through 2014, natural recovery continued with 76 feet of shoreline advance and a net sand volume gain of 25.24 yds^3/ft. concentrated in the both the seaward berm and beachface slope.

The winter of 2014-2015 produced several strong northeast storms generating heavy surf that eroded the shoreline, flattened the beach berm and scoured the nearshore seafloor. Sand was scoured from the upper beach and along the wooden bulkhead, further offshore there was limited bar development. Net loss over the winter was -30.92 yds^3/ft. and 57 feet of shoreline retreat. Following the early fall storm event in October 2015 the beachface slope was further reduced in elevation and flattened while the nearshore trough deepened. Sand was deposited closer to shore forming a small ridge while offshore a pronounced bar developed. Net result was a modest gain of 11.86 yds^3/ft. of sand from May 2015 to October 2015 mostly accumulating offshore. This modest gain partially offset the winter losses reducing the net annual loss to -20.98 yds^3/ft. of sand and 44 feet of shoreline position retreat. Three years following Sandy this site had nearly recovered all the lost sand through natural processes, this year's erosion returned the site to a modest net negative post Sandy volume of approximately -8 yds^3/ft. of sand.

Profile Brig-15: 15th Street South **(Figures 6a, 6b & 6c)**

Figure 6a photo was taken looking north on May 13, 2015 heading into summer season. The beach berm is well-defined at this location as natural spring summer beach building processes are well underway.

Figure 6b taken on October 15, 2015 after the October northeaster. The berm has been lowered and pushed seaward with a shallow runnel and ridge pictured here at low tide.

Figure 6c photo was taken looking north on January 29, 2016 following Jonas. Beach width and elevation have been further reduced but a sufficient wide beach berm remains to provide shore protection for the dune in the vent of future storm events.

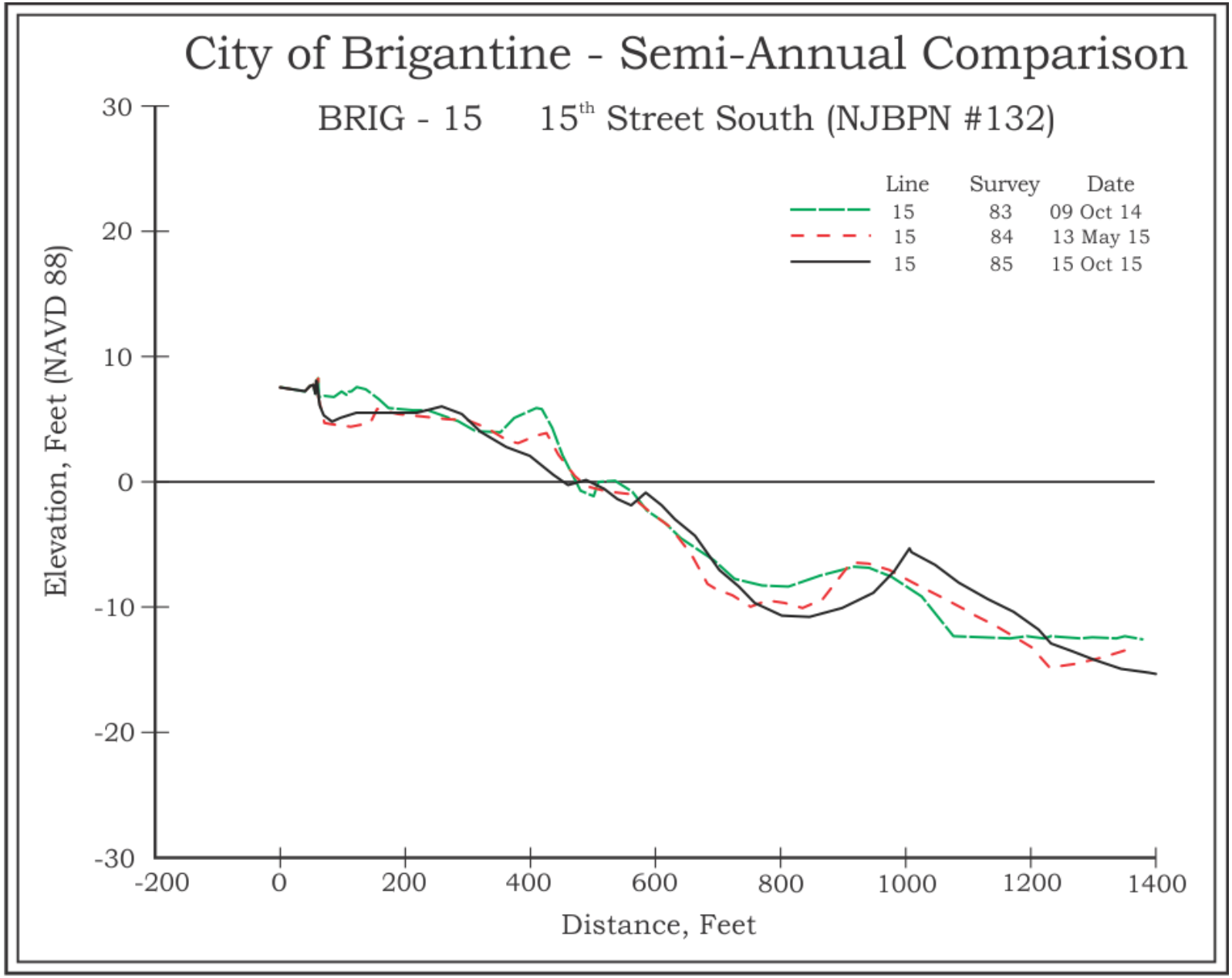

Figure 20 - At 15th Street South the 2015 erosional trend continued to dominate. Over the winter of 2015 the beach eroded losing sand from the revetment to the beach berm crest. There was some modest recovery on the upper beach over the summer of 2015 but by fall 2015 the beachface slope was flattened a trough was scoured nearshore, offshore sand was deposited forming a larger bar approximately 100 feet seaward of its previous location. The annual change for 2015 was 44 feet of retreat in the shoreline position with a net volume loss of -20.98 yds^3/ft. of sand.

- **Profile Brig-27: 27th Street South** **(Figures 7a, 7b & 7c)**

This site was established in 1992 for the city's beach monitoring program. The location was selected to fill a void between two preexisting NJBPN sites, located at 15th Street South and 43rd Street south. In contrast to 15th Street South, Brig-27 has a well-established dune system nearly 375 feet wide supported with a 300-foot wide beach. Multiple dune ridges provide significant storm protection against storm wave damage to the oceanfront properties. Extension of the Absecon Inlet jetty has created a region of backfill that continues to extend north past this site. The jetty will continue to trap sand moving south transported by longshore currents towards the inlet providing a source of sand to feed this dune system and continue seaward expansion of the beach for the foreseeable future.

In contrast to 15th Street South the wide beaches and well developed dune system provided significant protection for ocean front property and infrastructure during Hurricane Sandy, preventing over wash and major damage. The wide beach berm absorbed most of the storm surge and wave energy reducing and flattening the feature but preventing over wash of the dune system with little or no scarp cut into the seaward slope in this region. This site demonstrated the value of a wide, high beach berm and well developed dune system for providing storm protection for oceanfront property and infrastructure.

In 2013, natural beach recovery started driven by southerly longshore transport of sand along Brigantine's shoreline. Initial recovery was modest and the shoreline position remained 73 feet landward of the pre-Sandy position and about 20 yds^3/ft. of sand below the pre-Sandy volume. Through 2014 there were only minor changes in volume and shoreline position as early gains were offset by mid-year losses.

The first half of 2015 was dominated by the winter storm events, the beach berm elevation was reduced and a deep nearshore trough scoured between 200 to 300 feet from the shoreline position. A moderate net volume loss of 20.22 yds^3/ft. of sand occurred as a result of these changes. The dune and upper beach remained stable to slightly accretive while sand was dragged from the beach berm to the lower beachface slope extending the shoreline 74 feet seaward. Additional sand was deposited further offshore initiating development of a new shore parallel bar. Beach configuration changes in the second half of the year were dominated by the early October strong northeast wind event. Storm waves cut into the beachface slope further reducing the berm elevation and pulling some sand lower on the beachface slope. This resulted in a net seaward expansion of the shoreline position by 35 feet. The nearshore trough scouring continued and sand was transferred offshore further developing the offshore bar. For the second half of 2015 a modest net volume gain of 9.04 yds^3/ft. of sand indicates a longshore component to the sand transfer in addition to the cross-shore transport noted above. The net annual changes to the 27th Street beach are a shoreline position advance of 108 feet despite a lowering of the seaward beach berm, and modest net volume loss of 11.50 yds^3/ft. of sand mostly derived from the beachface and seaward berm. Despite these changes the upper 250 feet of upper recreational beach remained stable to slightly accretive and continued to support modest growth along the seaward dune slope.

Profile Brig-27: 27th Street South **(Figures 7a, 7b & 7c)**

Figure 7a photo was taken looking south on May 13, 2015. Two years following Sandy natural aeolian accumulation of sand along the seaward dune slope fully restored and enhanced the seaward slope and toe. Grasses have colonized to the seaward toe.

Figure 7b photo was taken looking south on October 15, 2015. The wide beach berm absorbed the full impact of the early October 2015 northeast storm event, first of a series in this El Nino season. There's no wrack line or indication wave run up reached anywhere near the seaward dune toe during the storm.

Figure 7c taken January 29, 2016, again looking south from the same location following winter storm Jonas. The thick debris wrack line is evidence that wave storm run up reached the seaward dune toe during Jonas. However, the wider beach berm did absorb most of the wave energy preventing any significant erosion along the dune toe in this region. The beach berm is slightly narrower following the storm but still wide enough to provide significant storm protection during future events.

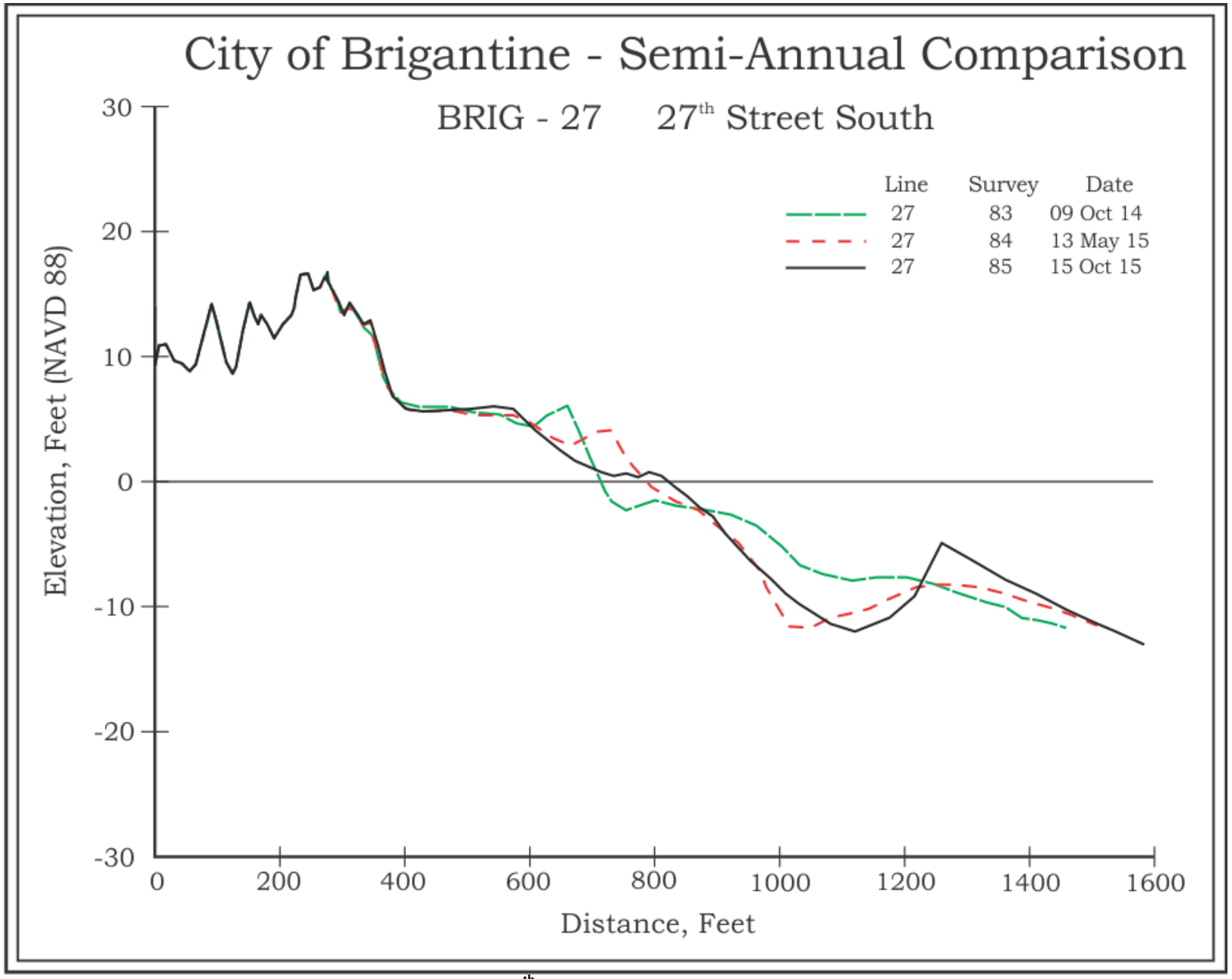

Figure 22 - The three cross sections above show the changes at 27th Street South from October 2014 to October 2015. As seen at the northern sites the beachface and beach berm crest again eroded through 2015. Nearshore a deep scour trough was cut and offshore a larger bar developed, partially offsetting onshore losses. The annual change for 2015 was a net volume loss of -11.50 yds^3/ft. of sand but sand pulled from the upper beachface to the lower beachface advanced the shoreline position 108 feet despite a retreat in the recreational beach berm width.

- **Profile Brig-43: 43rd Street South** **(Figures 8a, 8b & 8c)**

This site was established in 1986 as part of the New Jersey Beach Profile Network and was incorporated in the City's monitoring project in June 1992. The profile is located in an area dominated by the sand retention characteristics of the Absecon Inlet jetty. Sand retention benefits extend from the Absecon Inlet jetty to about 15th Street South. In 1986 the end of the street was the start of the beach with little dune growth. The present shoreline here is almost a half mile seaward of the shoreline position before the inlet jetty was built in 1944. The dune system occupies over 800 feet of width between the development and the seaward toe of the dune. The current recreation beach berm extends over 600 feet seaward of the dune toe.

In this region Hurricane Sandy's storm surge and wave energy were absorbed over the wide recreational beach that protected the primary dune system from erosion. The small foredune was flattened and swept away but protected the primary dune from direct wave impact. At many beach locations in New Jersey Sandy caused significant property damage, but here the massive beach and dune system protected the oceanfront property and infrastructure from damage. The net loss in shoreline position (zero datum) was just 10 feet with about 24 yds^3/ft. of sand removed from over 1200 feet seaward of the street end.

In 2013 sand moved back onshore with conditions favorable for natural beach building processes. The upper beach elevation a year later was higher than prior to Sandy although the overall beach berm width and crest elevation was not fully recovered one year later. In 2014, sand collection at this site persisted, as gains were observed across most of this profile. All features were fully restored to pre-Sandy conditions. The foredune area was reestablished, and continues to develop. This site recovered in 2 year through natural processes linked with the Absecon Inlet jetty sand retention and dominate southerly littoral drift along the developed City shoreline. In 2014 the shoreline advanced 149 feet with a sand volume gain of 44.97 yds^3/ft. focused mainly in the beach berm and slope.

Through 2015 sand continued to accumulate on the seaward dune slope and upper recreational beach. Winter storm waves and the early fall storm in October combined to erode the beachface slope and seaward berm ridge. Sand was transferred to the shallow nearshore and further offshore near the profile limits. In between deposition areas a nearshore trough developed throughout 2015. Overall this site showed a modest net sand volume gain of 6.35 yds^3/ft. during 2015 despite an 82-foot retreat in the shoreline position. Again in most location along the jersey shore 82 feet of shoreline retreat would be cause for serious alarm for property owners and public infrastructure but here it's negligible and unnoticeable to the causal beach patron. It is expected that this loss will be recovered through continued natural processes and the sand retention nature of the Absecon Inlet jetty.

Profile Brig-43: 43rd Street South **(Figures 8a, 8b & 8c)**

Figure 8a photo was taken looking north on May 13, 2015. The berm is extremely wide at this location and supports continued aeolian expansion of the dune onto the upper beach.

Figure 8b photo was taken looking north on October 15, 2016. The new foredune ridge was colonized by grasses and there is evidence of development of a new foredune seaward of the current toe position but no storm damage.

Figures 8c this picture was taken on January 29, 2016 following winter storm Jonas. There is wrack debris and the darker sand is evidence storm wave runup reached the seaward dune toe and caused berm top ponding around the dune hummocks that developed in 2015. There is no visual evidence that Jonas caused any significant beach erosion to the nearly 600-foot wide recreational beach berm.

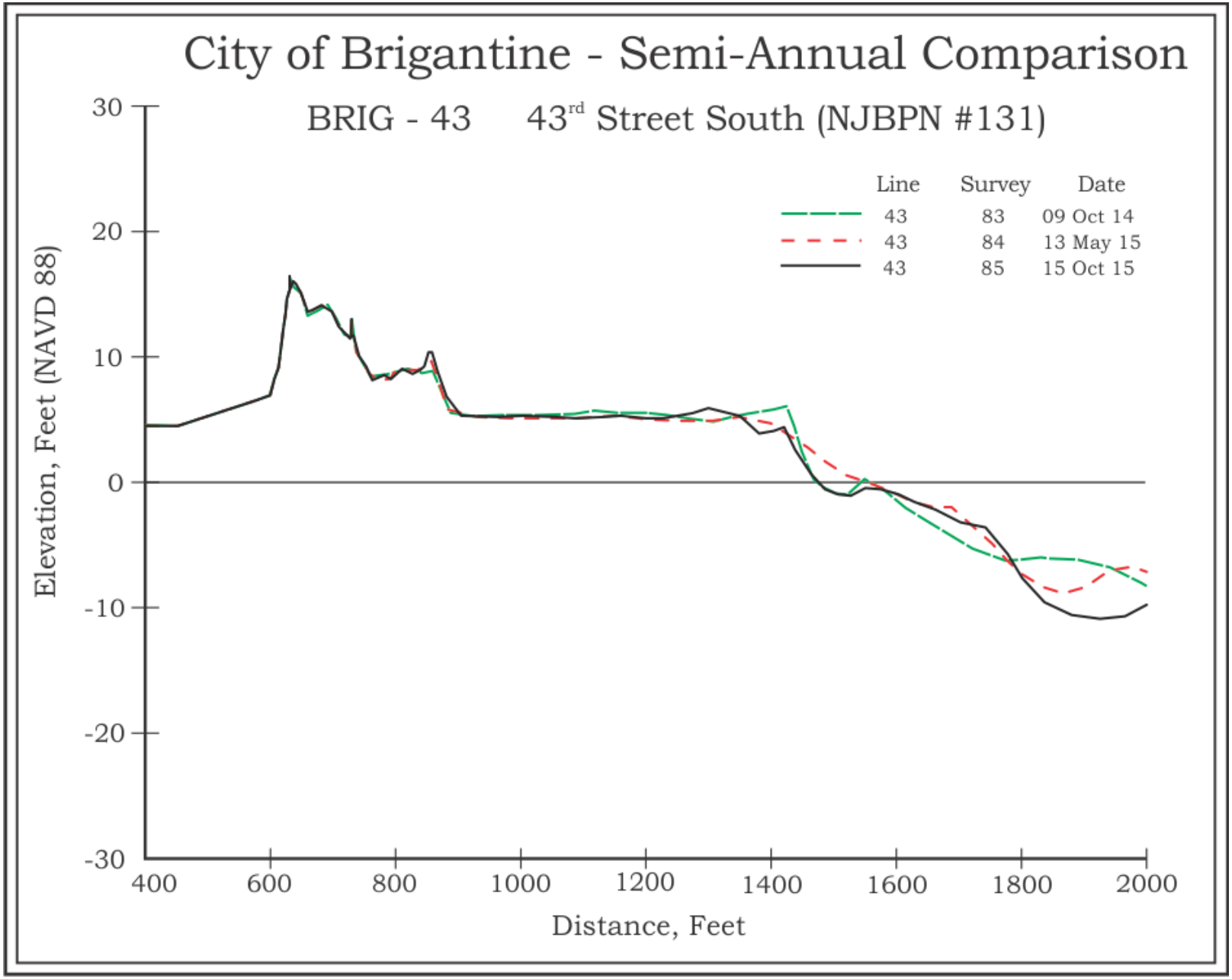

Figure 24 – This site has demonstrated significant and sustainable sand accumulation resulting in massive growth of the dune and beach width since monitoring began here 3 decades ago. The three cross sections above show a steady but modest accumulation of sand on the seaward dune slope and new developing foredune crest. In contrast to the northern locations the 43rd Street recreational beach berm width remained relatively stable. Wave scour at the shoreline position cut a shallow trough that resulted in a shoreline position retreat of 82 feet over 2015. The net volume gain was 6.35 yds^3/ft. of additional sand.

- **Profile Brig-1: South Beach** **(Figure 9a, 9b & 9c)**

This site is located just 600 feet from the jetty, established to determine if sand is retained, eroded and or bypasses the structure. After years of observation around this structure including the inlet shoreline sand is moves around the Absecon jetty in cycles of retention, erosion then bypassing of the jetty. The current jetty configuration and length has essentially reached its capacity to retain new sand moving into the system. Once the beach width has expanded seaward to near the seaward end of the jetty and is exposed to storm erosion the sand moves offshore to the ebb shoal system or onto the inlet shoreline inside the jetty. This process has prevented the primary dune in this location from continuing to expand seaward beyond its present location and has left it vulnerable to scarping on the seaward slope during larger storm events. Current dune configuration at this site extends over 1000 feet seaward of the development with approximately 300 feet of additional dry beach width.

Hurricane Sandy in 2012 caused extensive beach and dune erosion at this location cutting a vertical scarp nearly 12 feet high at the primary dune crest. Over 40 feet of dune width at the seaward dune toe was lost as storm waves flattened the berm and removed the majority of the dry recreational beach.

In 2013, the beach elevation and width recovered naturally with formation of a new berm ridge along the shoreline and accumulation of aeolian sand on the upper beach. Aeolian sand accumulated naturally along the seaward toe of the dune scarp cut by Sandy. Sand accumulation continued in 2014, mainly concentrated to the beachface slope the profile volume gained of 13.53 yds^3/ft. of sand. The two year sand accumulation trend following Sandy's severe erosion indicates the natural cycle of sand retention by the Absecon Inlet Jetty had resumed.

The first half of 2015 there was modest erosion on the beachface slope flattening the seaward berm crest and scouring the nearshore at the shoreline position. Sand was transferred cross-shore to the offshore bar and pushed higher onto the beach berm. Net result was a modest sand volume loss of -4.22 yds^3/ft. of sand from October 2014 to May 2015. Over the spring and summer months sand moved into the system both on the nearshore and offshore bar. By the fall survey sand had pushed higher up the beachface slope reforming a seaward beach berm while a deep nearshore trough developed following the October northeast event. Sand eroded from the trough was transferred to the offshore bar further developing that feature. Net gain from May 2015 to October 2015 was a modest 4.38 yds^3/ft of sand as the nearshore scouring was offset by an influx of sand. Sand accumulation along the lower beachface slope extended the shoreline position 57 feet seaward. For the year the dune remained relatively stable to slightly accretive while the site gained another 2.29 yds^3/ft. of sand and the shoreline position advanced seaward 93 feet.

Profile Brig-1: South Beach **(Figure 9a, 9b & 9c)**

Figure 9a photo was taken looking south on May 13, 2015. The beach width had expanded sand recovered naturally at this site through late 2014 into 2015. Note the position of the Absecon Lighthouse in the distance.

Figure 9b photo from October 15, 2015 after the first in a series of El Nino year northeast storm events. The wide beach protected the dune system from erosion with little net impact to the beach configuration

Figure 9c was taken January 29, 2016 after Jonas looking south towards Atlantic City in background. The beach remains in nearly the same configuration following Jonas with no evidence of the storm waves impacting the seaward dune toe in this location.

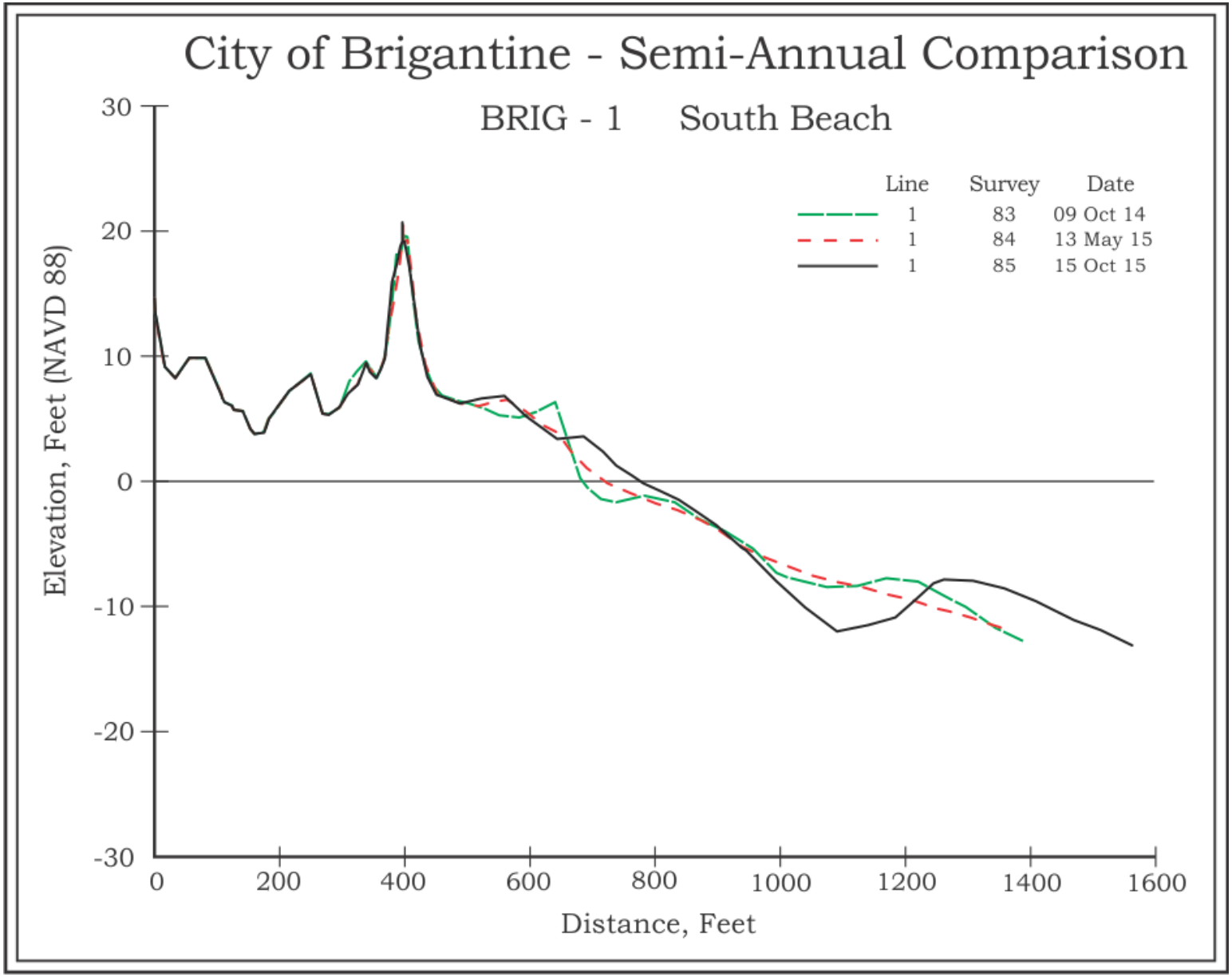

Figure 26 - The three cross sections above show the activity at the South Beach site in 2015. The dune system remained relatively stable although the primary frontal dune ridge remains extremely narrow. This location gained sand steadily over the course of 2014 into 2015. On the upper beach berm sand accumulated and additional sand continued to push onshore advancing the shoreline position seaward. By fall 2015 a large bar and trough system had developed. The net annual volume change (October 2014-October 2015) shows that the shoreline advanced 93 feet seaward while 2.29 yds^3/ft. of sand was added across the site from the dune toe to the offshore bar. More sand was deposited near and beyond the profile limits not included in this analysis total.

Summary:

Sandy's impact in 2012 caused major beach and dune erosion along the City's north end from Roosevelt Blvd. north. Damages and severe erosion suffered during Sandy prompted an emergency maintenance fill project by the USACE in 2013. This project was authorized to restore the federal project beach to the original design template. The project was completed in two stages in early winter and late spring (phase one 667,000 cubic yards (CY), January 2013, phase two 250,000 CY, July 2013) and placed a reported 917,000 CY of sand on the federal project beach. Overall the Brigantine shoreline was relatively stable to slightly accretive in 2014 although the northend project beaches from the "feeder beach" through 4th Street North lost 190,822 CY of sand.

In 2015 an erosional trend developed over the winter months with a series of five modest to moderate northeast storm events that began in January and continued through March 2015. None of these individual events was considered severe in intensity but the frequency and duration of the events combined caused significant beach erosion. As a result from October 2014 to May 2015 the oceanfront beaches lost a net 327,927 CY of sand while the federal project area lost 162,264 CY of sand. With the frequency of events occurring every few weeks there was insufficient time for natural recovery to move sand onshore and reestablish a protective beach berm. This was especially evident on the northend project beaches. Following a relatively mild summer season absent of tropical systems impacting the Jersey shore a northeaster struck in early October lasting several days. This storm resulted in an additional loss of 162,683 CY of sand removed from the oceanfront beaches and 93,345 CY of sand lost from the federal project area. The net change for 2015 from the Brigantine Beach oceanfront shoreline was a loss of 521,495 CY of sand with 355,283 CY of sand lost from the federal project beach.

In early 2016 winter storm Jonas struck the Jersey shore. Brigantine Beach shoreline net loss was 76,005 CY during Jonas with -48,770 CY lost from the northend beaches. The beaches from 43rd Street south lost -56,706 CY this was partially offset by a gain of 29,470 CY of sand in the mid-section of the developed shoreline. The combined net storm loss from winter storm Jonas and from 2015 brings the net loss over the last 15 months to 597,500 CY of sand. This disturbing 15 month erosional trend indicates over 65% of the sand volume placed by the USACE in 2013 was lost from the Brigantine shoreline.

Sand backpassing remains an attractive option to reduce the frequency of required expensive beach nourishment projects on the northend beaches. It is evident from decades of monitoring that sand harvesting from the southern beaches is a sustainable option. The southern beaches have steadily accumulated sand over the 30 years of monitoring at a rate that exceeds the sand harvesting volume requirements needed to extend the interval between cost restrictive hydraulic dredge sand nourishment projects on the engineered beach. Over the past decade sand backpassing projects have been implemented as sustainable programs in several Cape May County communities. The Borough of Avalon has successfully completed three projects while the Wildwoods have completed two projects. Both Avalon and the Wildwoods are currently undertaking sand backpassing projects in 2016.

These relatively small scale projects completed by these communities have demonstrated the relatively low cost per yard delivered to the erosion zone, sustainability of carefully selected borrow zones for harvesting and the relative ease of permit acquisition. In Brigantine's case, the City is the owner of the entire beach, both source area and deposition zone. As a result, an annual program could be established that utilizes efforts by public works, requiring a loader, three trucks and a grader/bulldozer could accomplish a significant maintenance effort entirely in-house or by any number of local contractors.

Sand backpassing is an attractive, affordable and sustainable method of beach maintenance augmentation to repetitive large scale hydraulic nourishment. The USACE has undertaking extensive studies on the feasibility of large scale sand backpassing in the Wildwoods as the solution for the Wildwoods section of the NJ coast. In this region the southern Wildwood communities are accumulating sand at a rate that causes significant difficulties maintaining the storm outfall pipes while North Wildwood suffers from chronic erosion issues. The

idea is to harvest sand from the areas of accumulation and backpass the sand to the areas of chronic erosion from which the sand originated.

The City of Brigantine Beach by recycling sand back into the system through a regular sand back passing program could significantly extend the northern beaches in the chronic erosional zone. By maintaining these beaches near the design configuration provides maximum storm protection for the next storm event rather than allowing them to deteriorate between events. Intervals of hydraulic nourishment would be required following severe storm events to restore the beach design template. Sand backpassing should not be considered an alternative for restoring the depleted beach template but as an augmentation used to maintain the design template and prolong the need for frequent large scale nourishment.

Unfortunately, the current beach conditions within the federal engineered beach project area have deteriorated to a level that requires large scale restoration efforts to restore the design beach template before any sand backpassing maintenance program could be implemented. The series of storm events through 2015 combined with the El Nino series of storms that have occurred during the winter of 2016 have left the northend beaches in a severely degraded condition. The most heavily impacted region is from the "feeder beach" south towards 4th Street North where the project beach berm has been eroded exposing the rock revetment along the promenade. Currently this region has lost an estimated 550,000 CY of sand since placement in 2013, when combining the losses recorded from 2014 and 2015. Additional sand has been eroded from the engineered beach during the El Nino winter of 2016, the review of winter storm Jonas below shows an additional 49,000 CY of sand was eroded from this region during that single storm event in January.

Impact of Winter Storm Jonas

Winter storm Jonas struck the New Jersey coast starting on January 22 through January 24, 2016. The storm arrived at a time where astronomical tides enhanced the impact of the storm surge resulting in record flooding throughout many locations in New Jersey. In addition to the flooding wind speeds were sustained at over 50 mph with gust reached over 70 mph recorded. The extremely strong northeast winds generated turbulent sea conditions and storm waves on top of the surge. Wind direction, speed, duration and length of wind fetch over the water created extreme conditions along the Jersey shore for 24-36 hours with strong onshore flow and waves battering the coast. Southern New Jersey was especially hit hard by the storm surge flooding and waves leading to significant damage in many coastal communities. In addition to property and infrastructure damage the beaches and dunes along the coastal towns suffered significant erosion.

Brigantines dune system remained intact with only minor wave runup reaching the seaward dune toe. The beaches absorbed most of the wave energy causing beach berm erosion and flattening the beach face slope. Sand was transferred cross-shore reducing the net sand volume losses, longshore transfer of sand added offshore resulted in small net gains at several locations including 12th Street North, 5th Street South and 27th Street South. Hardest hit beaches were the northend engineered beaches in the chronic erosional zone seaward of the promenade revetment through 4th Street North. The site at 5th Street South remained relatively stable while at 15th Street South the berm and beachface were flattened and sand pushed landward to the timber street end bulkhead. Along the southern shoreline beach erosion was modest and limited to the beachface slope and berm.

Table 4 below shows the October 15, 2015 to January 29, 2016 sand volume changes in cubic yards per foot (yds^3/ft) of beachfront and shoreline change measured in feet for each of the City's eight profile sites along the developed shoreline. Included is a net volume change in cubic yards for the Brigantine developed shoreline. The total volume attributed to Jonas is calculated by averaging the volume change at adjacent profile sites, then multiplying by the distance between profile sites.

Table 5:
Post-Jonas Comparison
Sand Volume and Shoreline Changes
October 16, 2015 to January 29, 2016

Profile	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg. Volume Change (yds^3/ft)	Distance Between (feet)	Net Volume Change (yds^3)
Brig-220	-37	-24.17			
			-10.110	1,860	-18,804
Brig-12	4	3.95			
			-10.050	1,951	-19,607
Brig-4	70	-24.05			
			-5.739	1,805	-10,359
Brig-5	16	12.57			
			4.101	2,729	11,190
Brig-15	26	-4.37			
			5.254	3,042	15,983
Brig-27	-5	14.88			
			0.556	4,132	2,297
Brig-43	110	-13.76			
			-9.208	5,855	-53,910
Brig-1	-17	-4.652			
			-4.652	601	-2,796
Absecon Jetty					
				Total Volume Change =	**-76,005**

Table 4 above shows the sand volume loss from Jonas was moderate compared to previous storm events. A net loss of 76,005 cubic yards occurred along the Brigantine shoreline during Jonas with 48,770 cubic yards lost from the northend beaches. Surprisingly the beaches from 43rd Street south lost 56,706 cubic yards partially offset by a gain of 29,470 cubic yards of sand in the mid-section of the developed shoreline. The net storm loss from Jonas was relatively modest but when combined with the net loss of 521,495 cubic yards of sand from 2015 brings the net loss over the last 15 months of 597,500 cubic yards of sand. This is a disturbing erosional trend that shows over 65% of the sand volume placed by the USACE in 2013 was lost from the Brigantine shoreline in the last 15 months.

Post-Jonas Individual Profiles: (Figures 27-34)

- **Profile Brig-220: Feeder Beach - Line 00+1200**

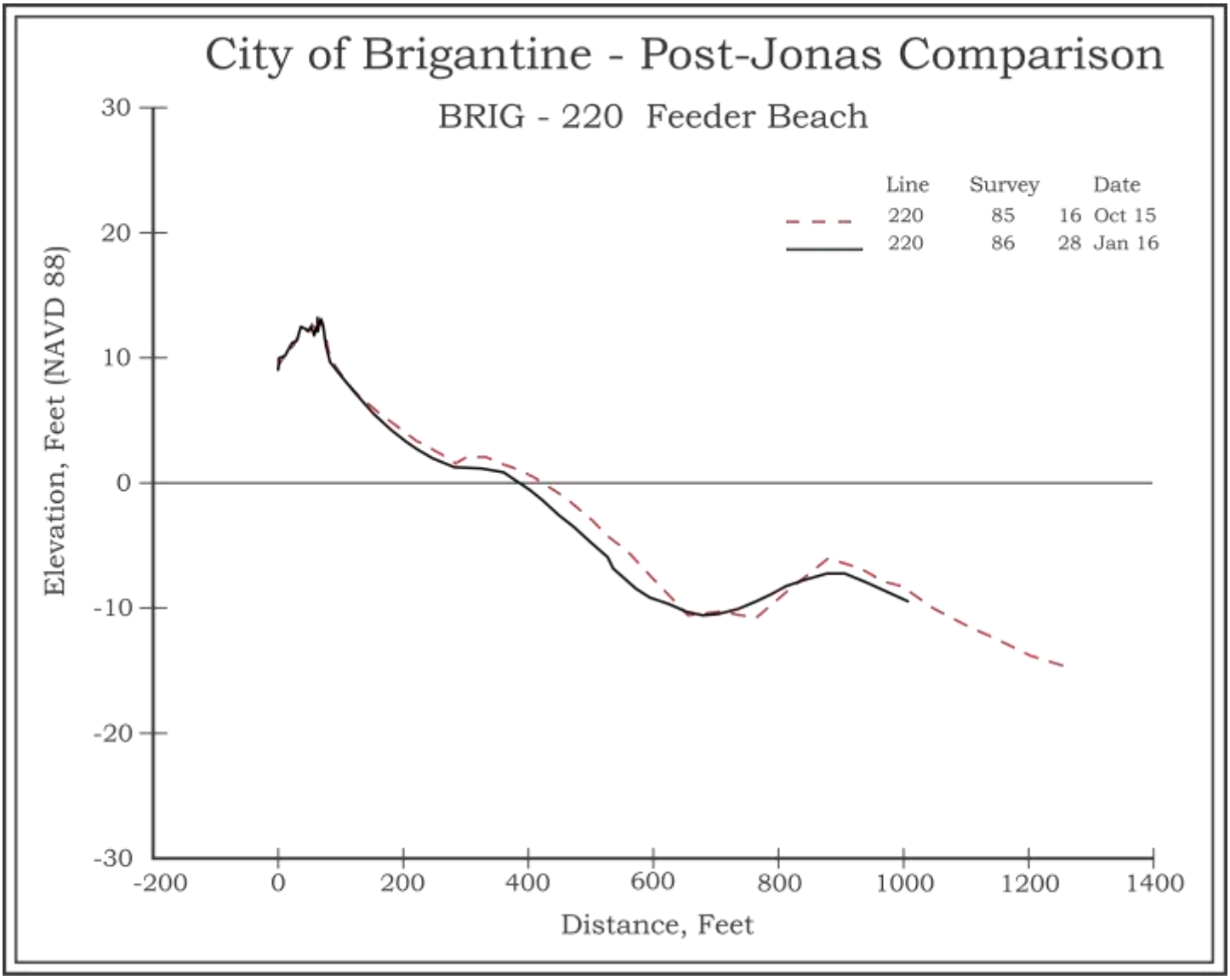

Figure 27 – By the end of 2015 the "feeder beach" configuration had been flattened by the early October 2015 northeast event. The wide recreational beach berm following the 2013 nourishment was completely eroded through 2015 and the sand volume that fed the downdrift beaches was depleted. Winter storm Jonas further eroded the beachface and nearshore, no cross-shore transfer of sand was evident resulting in a net loss to the site. Shoreline position at this location retreated landward 37 feet with a loss of -24.17 yds^3/ft. of sand. The dune system remained intact as the remaining beach absorbed most of the storm surge and wave energy. Jonas has further reduced this regions capability to supply sufficient sand to stabilize downdrift beaches in the chronic erosion area. A major influx of sand and or nourishment will be needed for this region to continue to act as a "feeder beach".

- **Profile Brig-12: 12th Street North**

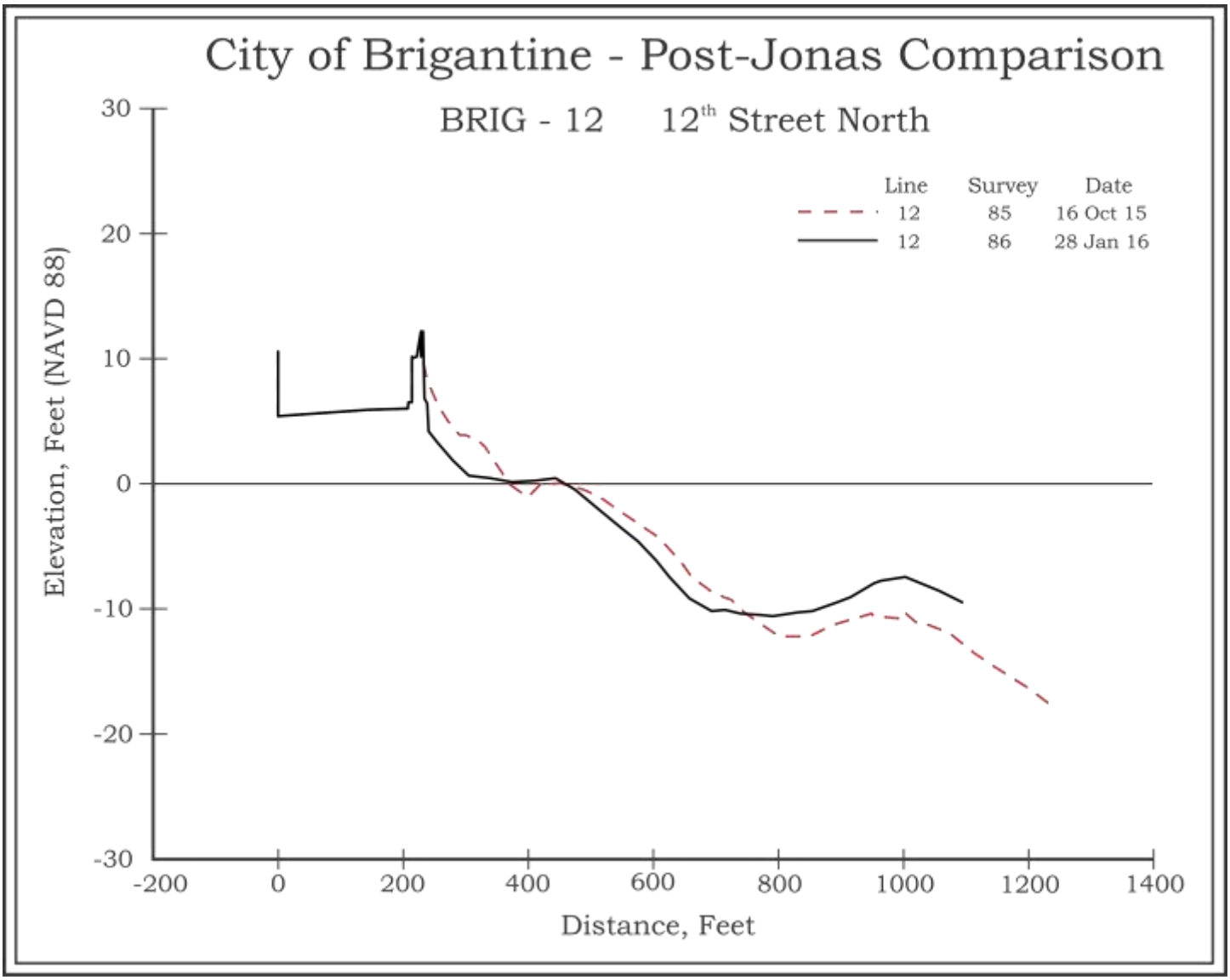

Figure 28 – Throughout 2015 this chronic erosional beach had rapidly lost sand and by the end of 2015 the sand volume had decreased by a massive 92.42 yds^3/ft. of sand. This onshore and offshore sand loss diminished the beach width and elevation increasing the regions storm vulnerability. Jonas storm surge and waves removed the remaining beach berm cutting the beach landward to the revetment. Refracted wave energy during the storm scoured the remaining beach exposing the rocks along the promenade. Onshore the site lost another 12.22 yds^3/ft. of sand. A storm wave also scoured the nearshore slope removing an additional 14.08 yds3/ft. of sand but unlike the beach to the north sand was transferred offshore at this location forming a shore parallel bar with. The offshore deposition of 28 yds^3/ft. of sand offset the onshore and nearshore losses resulting in a minor net gain of 3.95 yds^3/ft. of sand at this site despite these onshore and nearshore erosion. The minor net gain indicates a modest influx of sand was still moving south from the "feeder beach" to this region during Jonas. However, with both the "feeder beach" and chronic erosion regions now depleted of sand it is extremely likely that accelerated erosion along the promenade revetment will increase the erosion rate towards the south along the remaining engineered beach. Efforts to nourish this region should be made to reduce the impact to the downdrift beaches.

- **Profile Brig-4: 4th Street North**

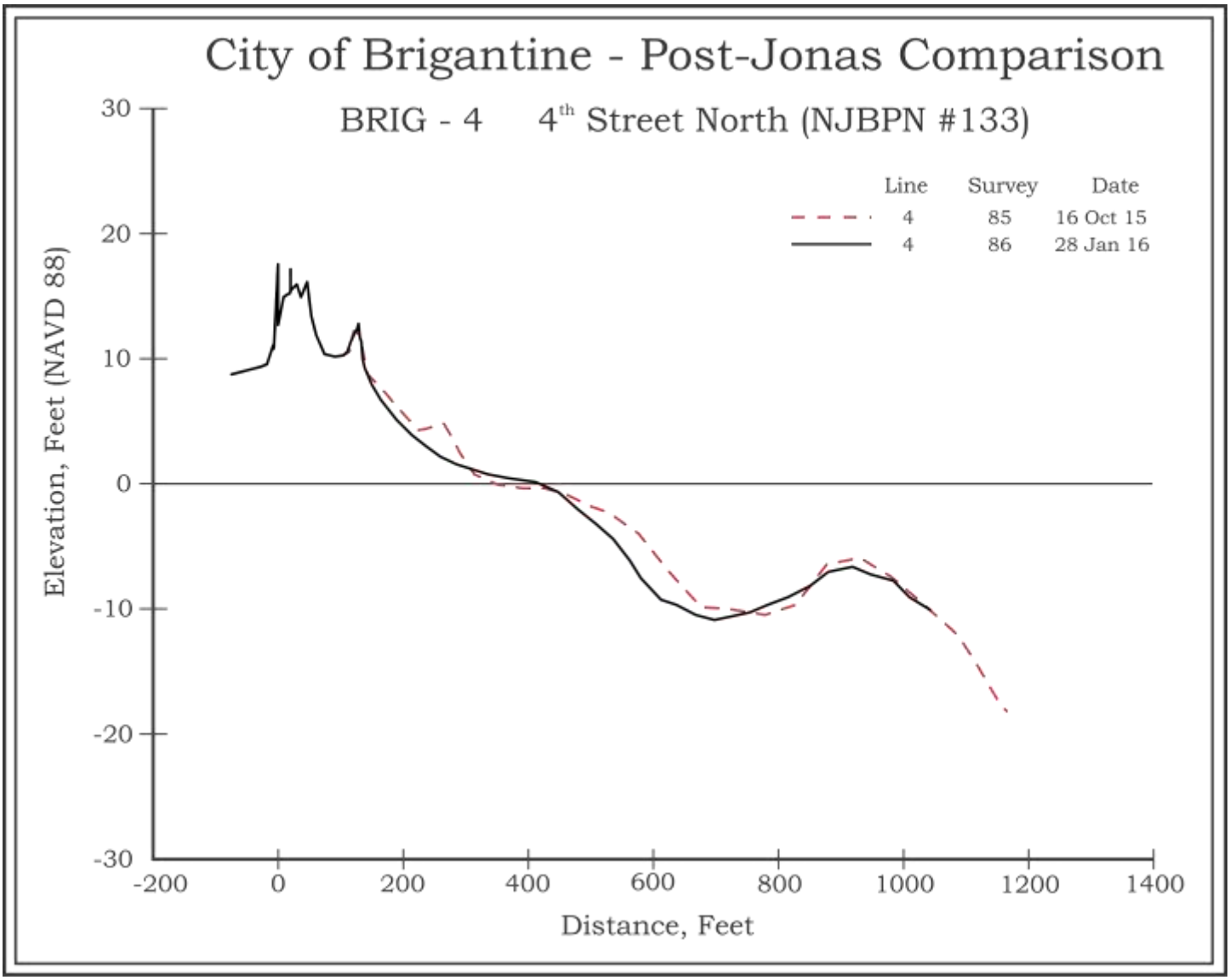

Figure 29 – Although loss rates at 4th Street North were not as extreme as at 12th Street North this site did experience significant erosion throughout 2015 with a net loss of -29.88 yds^3/ft. The beach berm width and elevation had been reduced following the October 2015 event leaving a modest beach berm to protect the dune system from winter storm events. Jonas's storm surge and waves flattened the remaining berm and wave run up reached the toe of the developing foredune. Wave energy scoured the nearshore slope but there was little to no cross-shore transfer of sand evident at this location. As a result the net loss from Jonas was -24.05 yds^3/ft. of sand. Although the dune system escaped erosion during Jonas the beach configuration leaves the foredune feature vulnerable to future events. With the feeder beaches to the north in a depleted condition the influx of sand to naturally restore this section of shoreline this spring will likely be derived from further erosion of the beaches seaward of the promenade as erosion progresses south along the rock revetment. In the absence of nourishment this sites dune system will likely remain susceptable in 2016 to future storm impacts.

- **Profile Brig-5: 5th Street South**

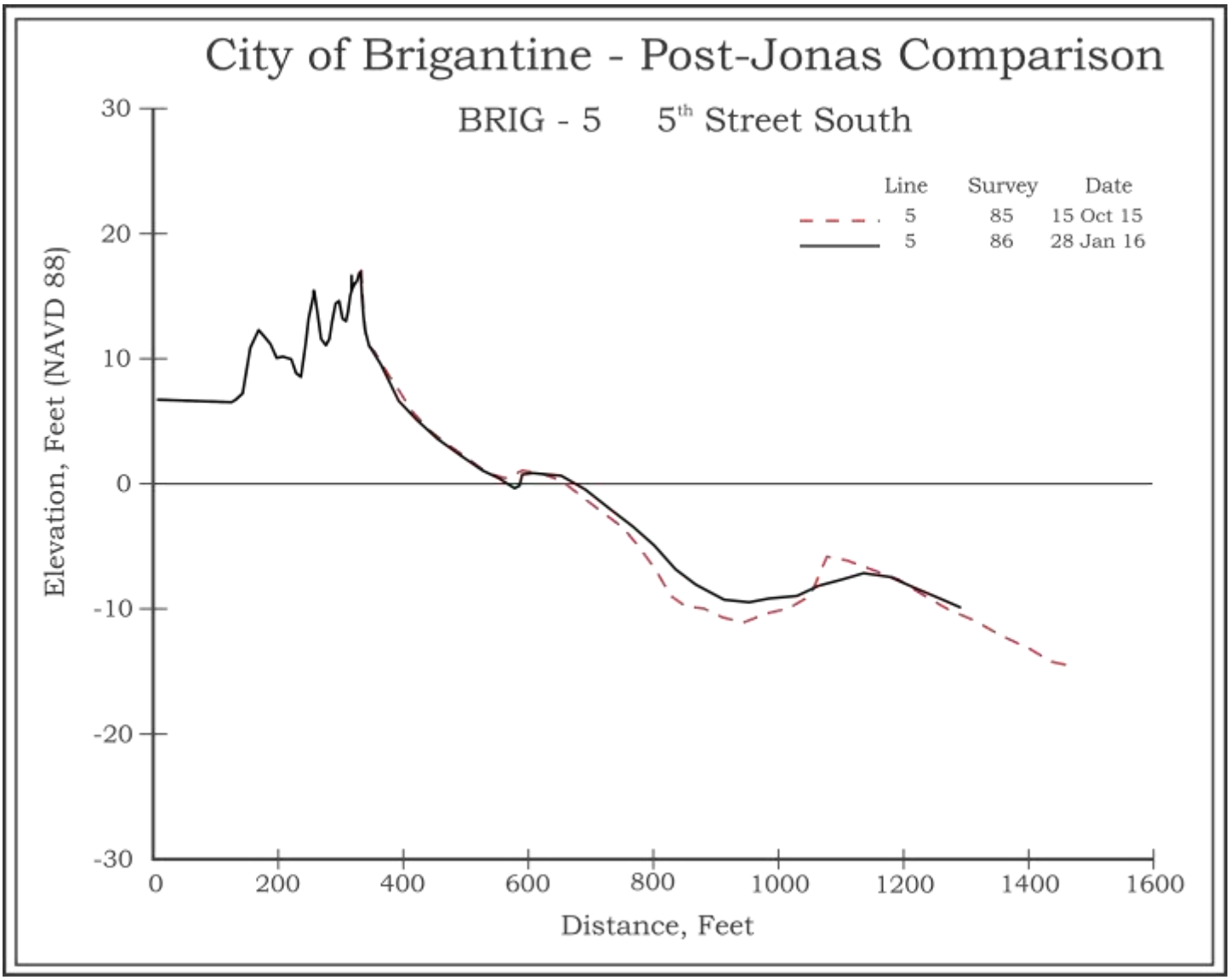

Figure 30 – Fifth Street North had also suffered significant beach erosion during 2015. The beachface and berm were flattened, reduced in elevation and width by winter storms and the October 2015 event. By the end of 2015 the site had seen a net loss of -28.19 yds^3/ft. of sand. Winter storm Jonas had only a minor impact on the beach configuration at 5th Street. The storm surge and wave energy was absorbed by the remaining beach preventing wave run up from reaching the seaward dune toe. Sand accumulated along the nearshore slope likely transferred via longshore currents from the northern erosional shoreline. The net sand volume change was a gain of 12.57 yds^3/ft. of sand following Jonas. This accumulation of sand was positioned close enough to the shoreline to provide a source of sand for natural beach building should favorable conditions prevail.

- **Profile Brig-15: 15th Street South**

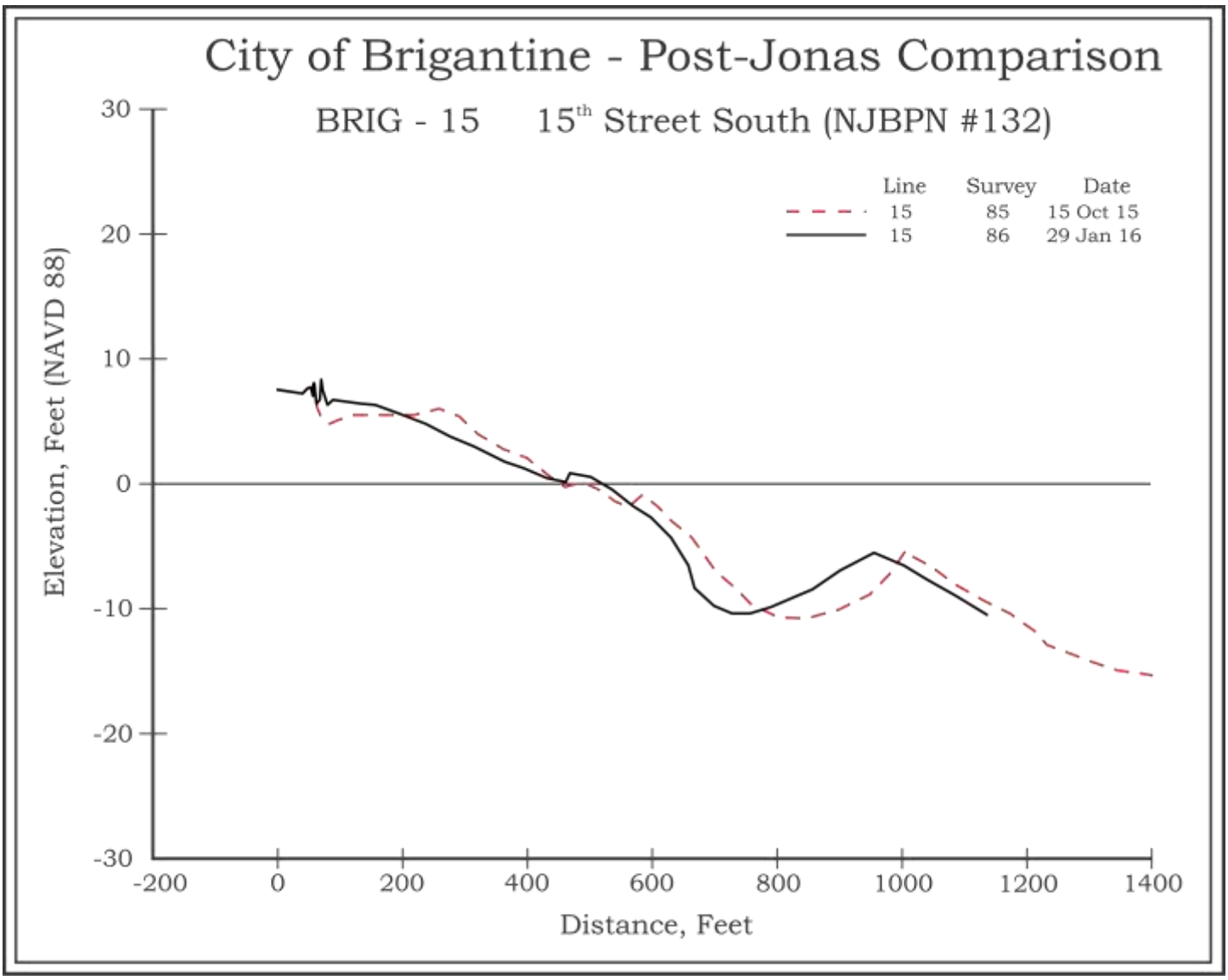

Figure 31- Following the early October 2015 northeast event the beach was flattened as the beachface slope was pushed landward. During 2015, the site at 15th Street South had lost -20.98 yds^3/ft. of sand with 44 feet of landward retreat in the shoreline position. Jonas's storm surge and wave energy further flattened the berm and pushed the beachface slope further landward. Sand was pushed higher onto the beach accumulating along the street end revetment. The nearshore slope was scoured but some sand accumulated offshore moving the shore parallel bar positon landward approximately 100 feet. Sand accumulation offshore and along the street end bulkhead reduced the net volume loss to -4.37 yds^3/ft. The net onshore change in volume was -2.81 yds^3/ft. of sand as material moved landward and seaward, offshore changes were minor -1.56 yds^3/ft. of sand with material carried cross-shore in a seaward direction.

- **Profile Brig-27: 27th Street South**

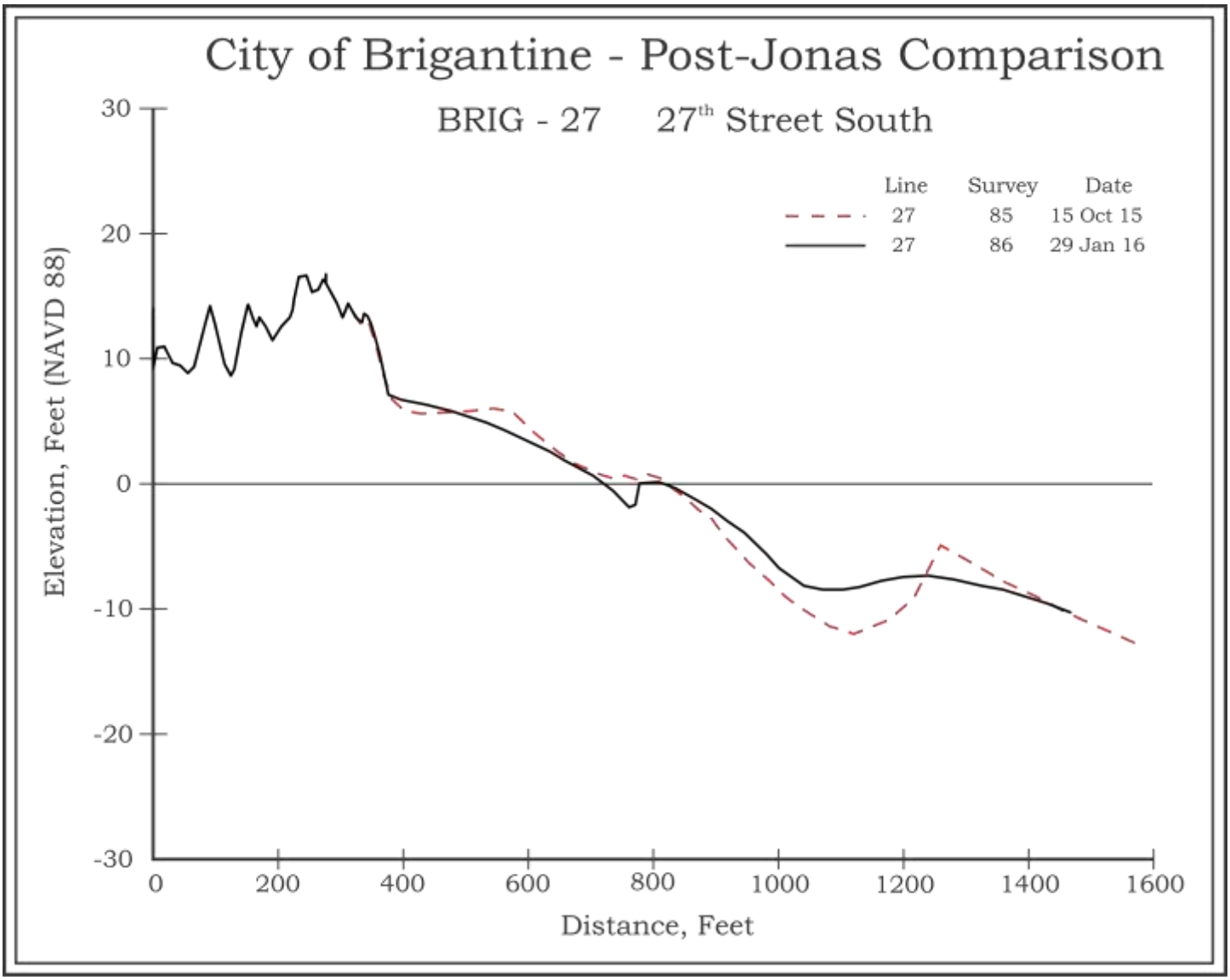

Figure 32 - The 27th Street South site demonstrated a more resilient nature through 2015 with more modest changes to the beach and nearshore. Net sand volume losses here for 2015 was -11.50 yds^3/ft. of sand while the shoreline position advanced seaward 108 feet. This site typically falls within the accretive transition zone between erosion towards the north and accumulation along the southern shoreline driven by predominant longshore currents. Following Jonas this site showed a net gain of 14.88 yds^3/ft. of sand. The beachface slope was flattened, the berm elevation reduced with modest scouring at the shoreline position. Wave runup moved sand landward to the seaward dune toe but the seaward dune slope remained stable. A significant wedge of sand accumulated along the nearshore slope seaward through the trough. This sand appears to largely have been transferred to this site through longshore currents resulting in the net gain following Jonas. Natural recovery and expansion of this beach will likely continue as sand feeds into this region from north to south.

- **Profile Brig-43: 43rd Street South**

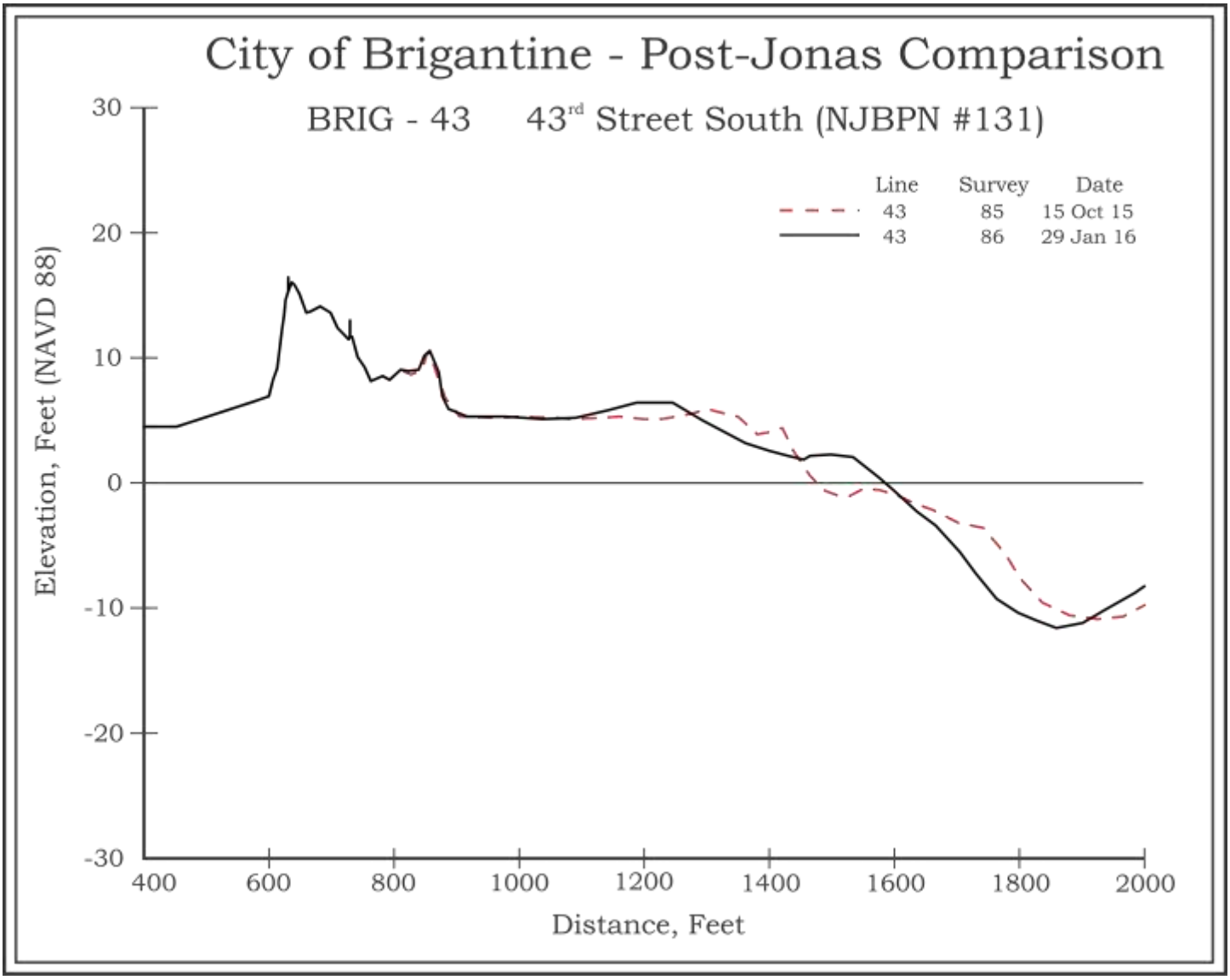

Figure 33 - Thirty years of monitoring at 43rd Street has shown this region to be remarkably resilient able to sustain near continuous growth in beach and dune width. There is currently over 1500 feet of beach and dune width between the shoreline and development. This site has sustained growth while the northend has suffered chronic erosion. The impact of storm events is marginalized by the nearly 700 feet of beach width that absorbs storm surge and wave energy even during Sandy there was only modest erosion of the seaward dune slope. In contrast to the northern beaches 43rd Street continued to gain sand adding 6.35 yds^3/ft. of sand to the beach during 2015, reversing the erosional trend seen from 27th Street north. Jonas storm surge and wave energy was absorbed on the beachface and beach berm. Sand was pushed landward elevating the beach berm and cross-shore to the lower beachface slope. The sand added to the lower beachface slope extended the shoreline position seaward 110 feet. Nearshore scouring removed sand from the nearshore slope with evidence of some limited seaward cross-shore movement. Following Jonas this site showed a net loss of -13.76 yds^3/ft. of sand indicating a predominant longshore component to sand movement during the storm event. With this sites remarkable history of sand accumulation it is very likely that this site will quickly recover from these recent storm losses through natural processes.

- **Profile Brig-1: South Beach**

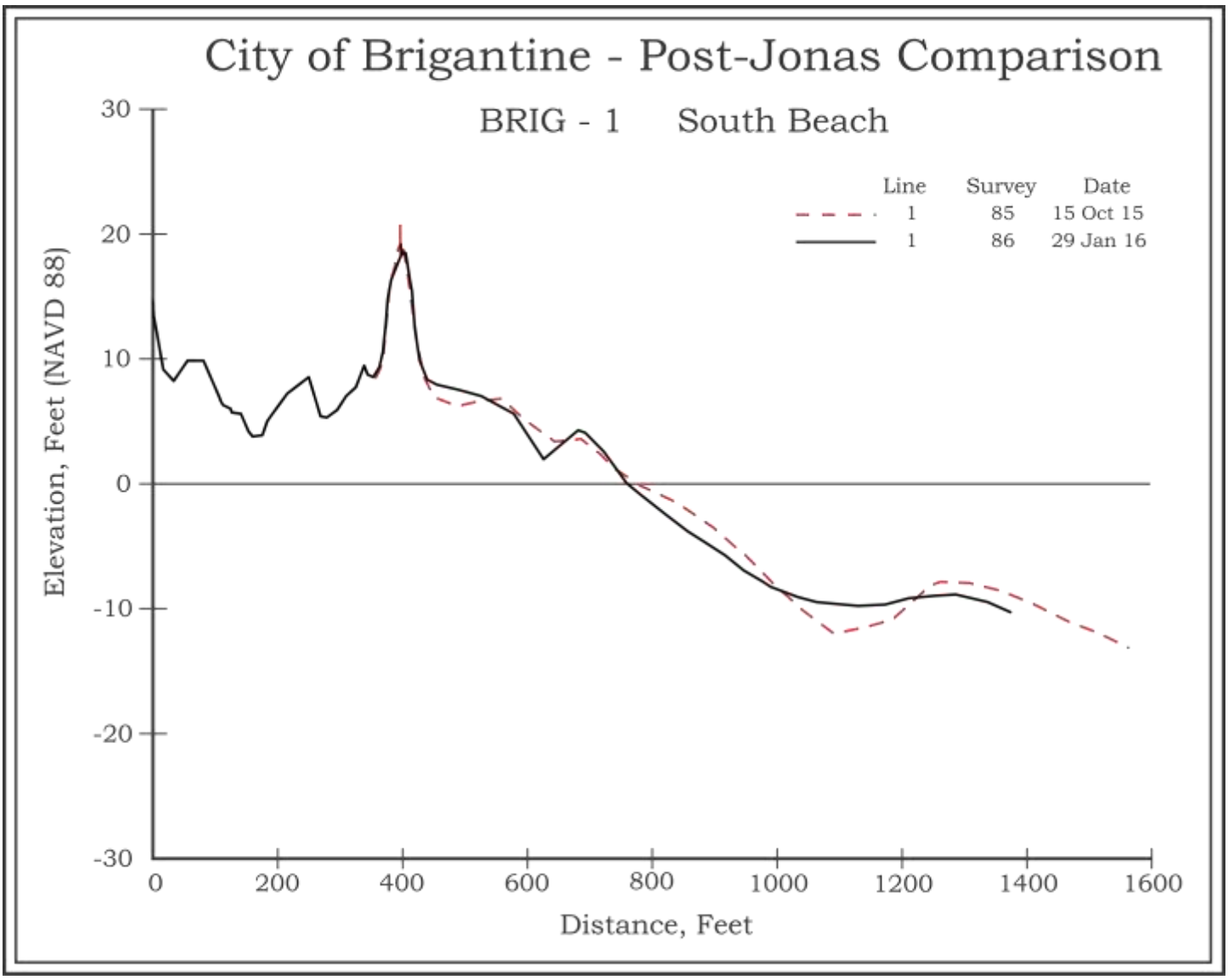

Figure 34- The south beach site at the Absecon Jetty was relatively stable through 2015 showing a minor volume gain of 2.29 yds^3/ft. of sand while the shoreline position moved seaward 93 feet. There was a 100 foot-wide elevated recreational beach berm seaward of the dune toe following the October 2015 northeast event that provided storm protection for the dune system. Winter storm Jonas scoured a second lower tier berm into the beachface slope and pushed sand landward to the seaward toe of the dune. No wave scarping occurred at the dune toe indicating most of the storm wave energy was absorbed by the beachface and berm. Nearshore scouring occurred on the slope with sand transferred seaward and re-deposited in the deep trough, the offshore bar elevation was reduced. The resulting net change following Jonas was a minor volume loss of -4.65 yds^3/ft. of sand while the shoreline position retreated 17 feet landward. These storm losses are modest and will likely be naturally recovered as sand continues to move into this region from further north and seas return to conditions favorable for natural beach building processes to continue. Storm events like Jonas do help bypass sand from this oceanfront beach to the inlet shoreline. This processes has led to natural recovery of the Brigantine side of the Absecon Inlet shoreline following excavation of nearly 600,000 cubic yards of sand from the inlet borrow zone by the USACE in 2002-2003.

Absecon Inlet Jetty Study:

The City opted not to authorize the continuation of this study in 2015. Attached below is a synopsis of the 2014 final survey for review.

Following excavation of 600,000 cubic yards of sand from the Absecon Inlet borrow zone, partially adjacent to the Brigantine inlet shoreline, concerns arose as to the stability of the inlet shoreline. The City of Brigantine requested the Coastal Research Center (CRC) complete regular assessments of the Brigantine inlet and oceanfront shoreline around the Absecon Jetty to track changes. In 2014 the CRC completed the last beach erosion assessment at the Absecon Inlet Jetty under the 2014 contract with the City of Brigantine. Results indicated the inlet shoreline was returning to its pre-excavation configuration although full recovery had not been achieved.

On August 21th, 2014 the CRC survey crew conducted a complete survey of the Brigantine shoreline adjacent to Absecon Inlet. The survey data were analyzed in ArcGIS software to generate a digital elevation model (DEM) of the area. Shoreline migration rates from 2013 to 2014 and from 1995 to 2014 are shown within the study area. This task was not authorized for 2015 to update migration rates and shoreline changes.

Inlet Study Summary:

Examination of the changes since 2006 show a pattern of sand deposition derived from the oceanfront beach restoring some of the former extent of sand accumulation on the inlet shoreline side of the jetty. The federal Absecon Island shore protection project took over 600,000 cubic yards of material in 2002-03 leaving a large excavation that was filled by eroding the shoreline-associated sand very rapidly. Following urgent discussions with the USACE project managers, it was decided to cease using the borrow area located 400 feet south of the north jetty within the inlet allowing the situation to recover as new sand moved from the Brigantine oceanfront beach into the inlet to replace the loss. By 2014 this process has partially restored the inlet shoreline present in 2002 but there is a long way to go before full recovery is achieved through natural processes. It is recommended the inlet beaches continue to be surveyed annually to verify the ongoing shoreline trends and processes continue unabated by natural or human influences.

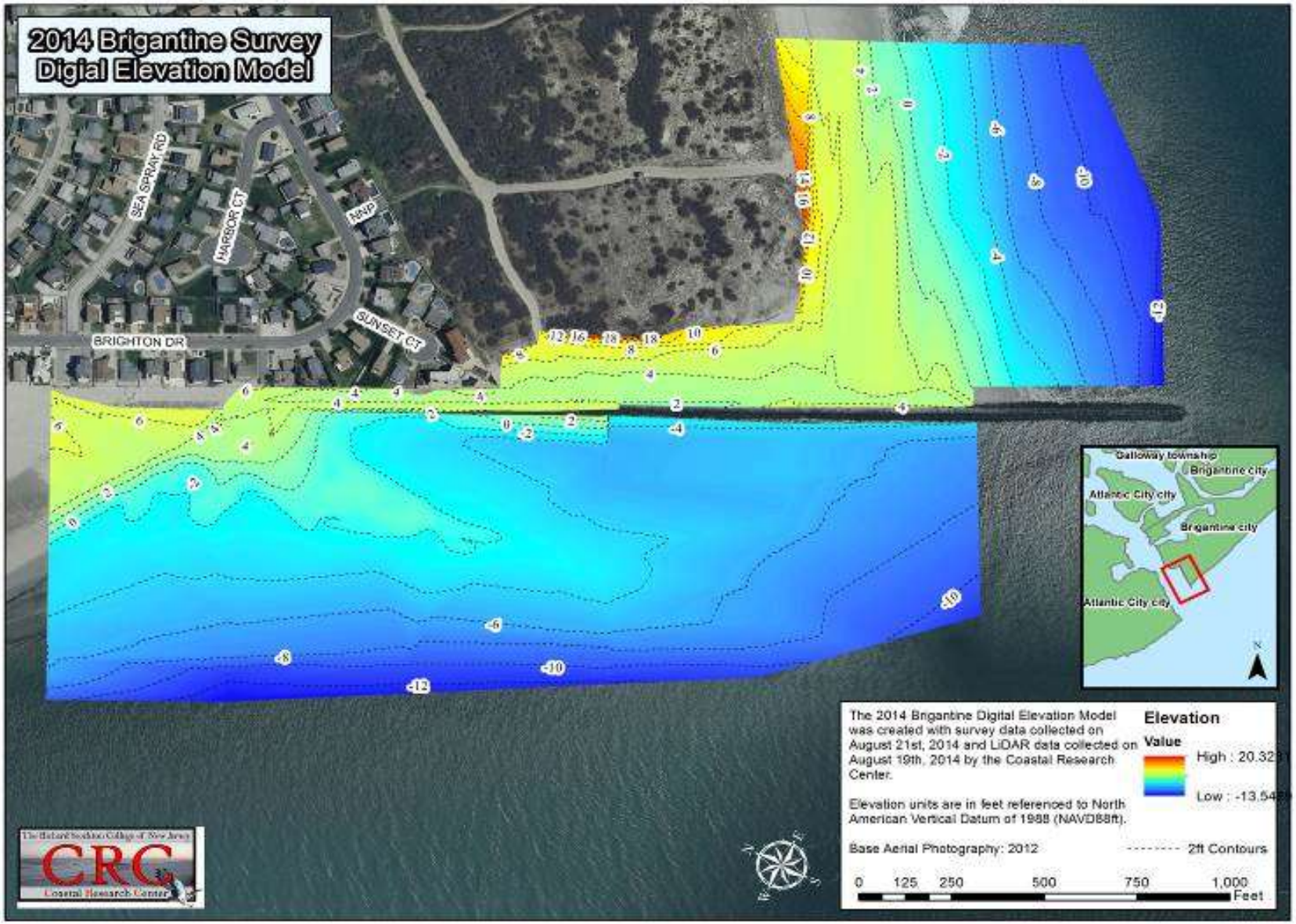

Figure 35 - Cooler blue colors represent lower elevations, and warmer yellow and red colors represent higher elevations. Contour intervals are at 2-foot intervals. Elevation units are in NAVD88. Much of the inlet beach surveyed is low lying and not much higher than 4 feet NAVD88. The ocean facing beach has a moderately sized beachface, backed by a large primary dune, giving way to a gradual downward slope.

Figure 36 - Shoreline migration of Brigantine's beaches in the vicinity of Absecon Inlet where analyzed between 2013 and 2014. Shoreline positions are overlain on 2012 aerial photography. The average shoreline position advanced at both the inlet and ocean facing beaches over this study period.

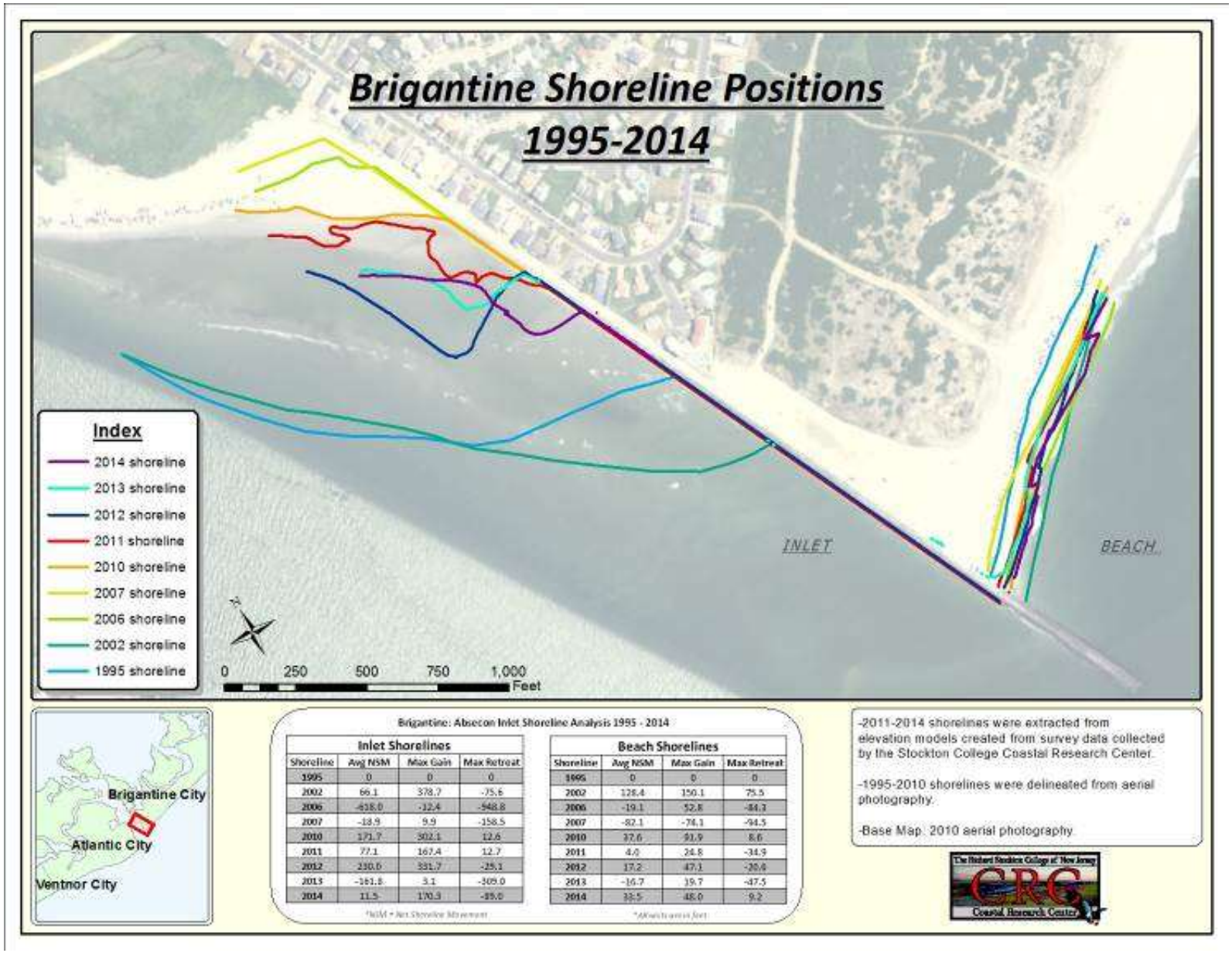

Figure 37 - Shoreline migration of Brigantine's beaches in the vicinity of Absecon Inlet where analyzed between 1995 and 2014. The pre-ACOE dredging shoreline of 1995 to 2002 reflects a maximum extent of sand on the inlet side of the jetty. By 2006 concerns for erosion flanking the western end of the jetty brought focus onto the problem. Since no further sand was extracted from the inlet borrow zone, the problem has moderated somewhat as oceanfront sand has moved around the jetty.