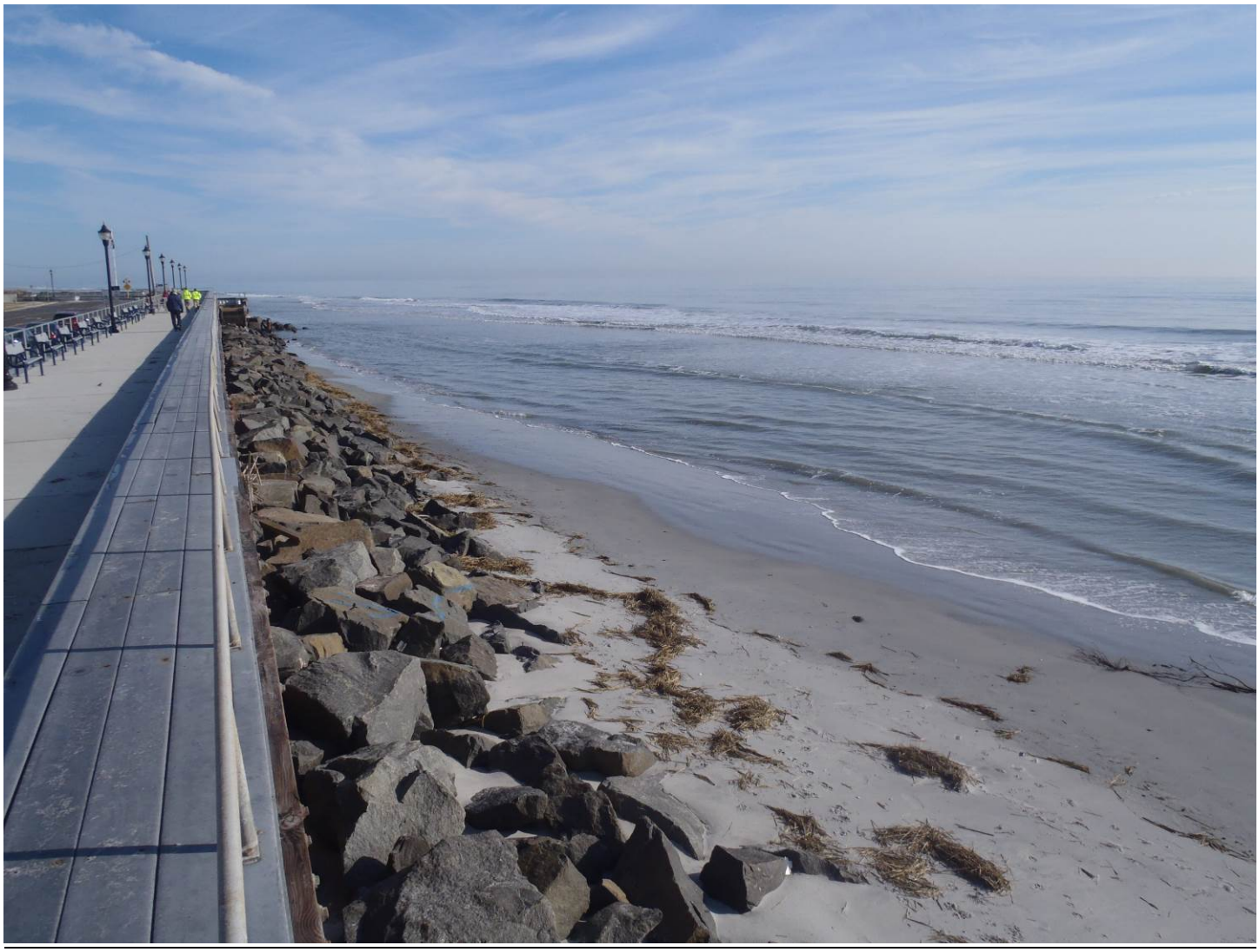
FINAL REPORT FOR 2016
ON THE CONDITION OF THE MUNICIPAL BEACHES
IN
THE CITY OF BRIGANTINE BEACH, ATLANTIC COUNTY, NEW JERSEY



View to the north from 12th Street showing the promenade, bulkhead and revetment just after Northeast Storm Jonas. The beach was eroded 4 feet vertically and the shoreline moved to the rocks at high tide. The white water offshore represents the bar created by this storm that slowly migrated landward improving the situation by summer's end.(Photo taken January 29, 2016). This oceanfront reach is the potential destination for the vast surplus of sand accumulating along the southern two miles of the Brigantine City oceanfront.

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Annual Report for 2016 to the City of Brigantine Beach on the Condition of Municipal Ocean Beaches

Introduction:

The status of the beaches within the City of Brigantine Beach from October 2015 to October 2016 is the focus of this annual report to the City. This year as in 2015 there was no survey of the Brigantine Absecon Inlet shoreline. The beach has recovered to pre-USACE project conditions following work related to the Absecon Island beach restoration project that produced concerns for shore protection along the Brigantine inlet shore.

2016 opened with a significant northeast storm January 23 and 24, 2016 named Jonas by the Weather Channel. Winds of 65 MPH raised flood levels to exceed Hurricane Sandy's flooding in Cape May County and equaled it here in Atlantic County. 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. 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 three more modest to moderate northeast storms in February and March. 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 north end, 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.

Northeast storm 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 north end 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 including Jonas to 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 15 months ending in February 2016. The single observation from the 2016 data is that the sediment transport along the Brigantine City shoreline has shown pronounced affects from southerly littoral transport to the Absecon Inlet jetty.

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 north end. 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 north end 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.

Annual & Seasonal Beach Changes:

In Table 2 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.

This annual examination shows that the Brigantine shoreline was strongly influenced by sand transport to the south due to northeast storm frequency enhancing a normal trend documented by the vast sand volume trapped north of the Brigantine Absecon Inlet jetty.

Table 2
Brigantine Shoreline and Sand Volume Changes
Fall 2015 to Fall 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-134	-22	-2.24			
			-9.496	3,122	-29,647
Brig-220	-108	-16.75			
			-5.603	1,860	-10,422
Brig-12	-111	5.55			
			-3.304	1,951	-6,446
Brig-4	-16	-12.15			
			-2.748	1,805	-4,960
Brig-5	-109	6.66			
			-6.682	2,729	-18,234
Brig-15	-38	-20.02			
			-12.614	3,042	-38,372
Brig-27	-164	-5.21			
			3.681	4,132	15,208
Brig-43	34	12.57			
			25.178	5,855	147,414
Brig-1	-16	37.79			
			37.787	601	22,710
Absecon Jetty					
			Total Volume Change =		**77,252**

Four beach profiles had shoreline retreat values over 100 feet with the largest value seen at 27th Street. These retreats were not accompanied by large sand volume losses making the northeast storm affect the dominant cause. Storms tend to flatten beaches and wash the berm landward toward the dunes or drag sand offshore generating bars in between 5 and 15 feet of water.

Looking at the sand volume changes, one sees that there are chronic losses along the northern Brigantine shoreline that shift to larger deposits at the Absecon Inlet jetty (Brig-1). Adding the individual Net Volume Changes (right column above) finds that losses reach -108,080 cubic yards at Brig-27 (27th Street South). In the 10,000-foot distance between 27th Street South and the jetty, the shoreline gains 185,332 cubic yards of sand. This yields the positive net change of 77,252 cubic yards for the year.

Bottom line; sand is transported rapidly to the south by northeast storms and waves from the east, northeast moving material to the inlet jetty where it adds to the sand volume already there. This phenomenon is usually masked by regional or local profile changes, but this year the trend is crystal clear and presents a convincing argument for a program to harvest this abundance of sand at the jetty and use it to restore losses at 12th Street North with back-passing. The cost savings achieved through recycling existing sand supplies by back-passing excess supply at the jetty versus hydraulic dredging of new material from Brigantine Inlet or more costly yet, from deposits offshore, make this a worthy avenue for future sand management.

Table 3
Brigantine Shoreline and Volume Changes
May 27, 2016 to October 12, 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-134	7	-18.22			
			-3.211	3,122	-10,025
Brig-220	-28	11.80			
			8.542	1,860	15,887
Brig-12	-39	5.28			
			5.513	1,951	10,756
Brig-4	-68	5.74			
			1.805	1,805	3,258
Brig-5	-98	-2.13			
			7.218	2,729	19,697
Brig-15	-50	16.57			
			4.930	3,042	14,997
Brig-27	-140	-6.71			
			0.109	4,132	450
Brig-43	-51	6.93			
			13.631	5,855	79,810
Brig-1	-6	20.34			
			20.337	601	12,223
Absecon Jetty					
			Total Volume Change =		**147,052**

Summer seasonal shoreline retreats are not usually this large, but appear in the cross sections displayed at each individual profile site to be related to berm growth as summer waves pushed sand onto the beach building a deposit onshore combined with early storm events in September. The sand volume was more positive with 6 of 9 locations showing positive accumulations yielding a 147,029 cubic yard net gain for the summer of 2016. Recall, that this also includes Hurricane Hermine on September 7, 2016 and a three day northeast event September 28, 29 and 30, 2016 that acted to reverse the summer's sand accumulation on the beach. Yet, the lion's share of the summer gain was documented between 27th Street South and the inlet jetty (90,715 cy).

Individual Profile Descriptions

This section describes the changes documented at each of the beach profile locations from October 2015 to October 2016 and includes photographs and cross-sections that show the semi-annual and annual comparisons (Figures 1 – 27).

- **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 crossing the inlet from Little Beach and moving south adds 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. 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 reestablished as the site lost -52.27 yds^3/ft. of sand from the end of 2014 to October 2015. Since then the beach stabilized with smaller shoreline changes, but substantial sand was added offshore as a major bar by October 2016. The shoreline retreated 22 feet, but the annual change in sand volume was just -2.24 yds^3/ft.

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

Figure 1a taken on October 16, 2015 and shows a flat beach affected by storm waves from the early October 2015 northeaster. The existing beach width protected the dune toe from storm waves and further erosion.

Figure 1b taken on October 12, 2016 also followed a three day northeast event with low wind velocities, but long duration action. Again, waves did no damage to the dunes, but flattened out the beach. Waves are breaking on the large bar offshore.

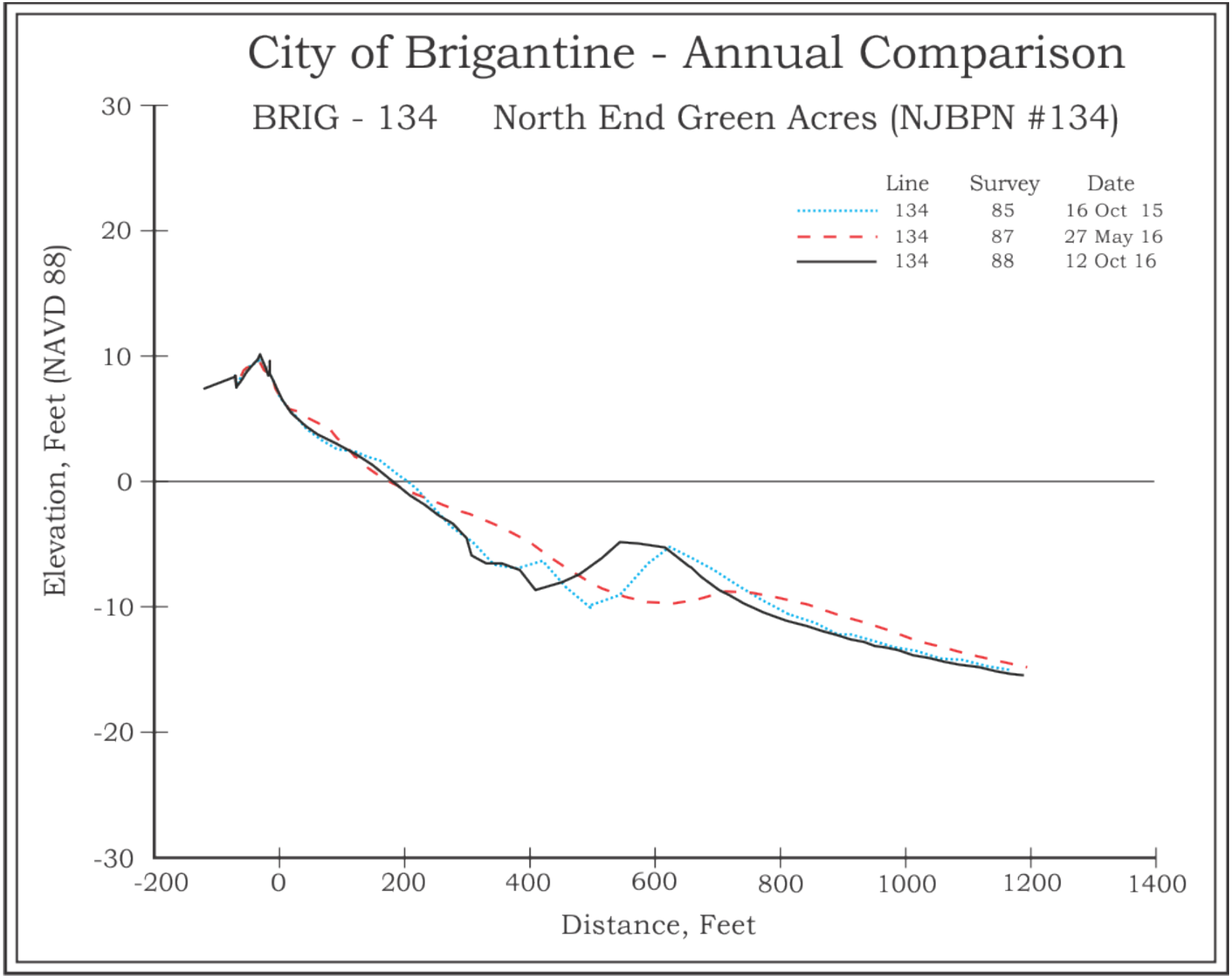

Figure 1c - The three cross sections above show that few changes took place on the beach or dune, while bar development offshore created two versions each fall with large sand volume collected in each. The most recent bar is 40 feet closer to shore than the one developed a year earlier.

- **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.

In 2015, the erosion continued with a net annual loss of -32.83yds^3/ft. of sand. The site continued to shed sand so that by October 2016 the shoreline had retreated 108 feet and the beach lost 16.75 yds^3/ft., most of it below the zero elevation datum (0.84 yds^3/ft. above the datum, and 17.59 yds^3/ft. below the zero elevation).

This section of shoreline has continued to perform well as a "feeder beach" for the downdrift beaches. By the fall of 2016 a substantial berm ridge has developed which accounts for the positive sand volume above the datum. Offshore the bar system lost elevation and generated the negative sand volume statistics. Since the US Army may not include this 1,600 feet of feeder beach as part of their responsibility, 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)

Figure 2a was taken October 16, 2015 shows storm waves from the early October northeaster reached the seaward dune toe. The beach was flattened but the dune remained intact.

Figure 2b taken October 12, 2016 from the crest of the new berm developed over the summer. This berm is very recent indicated by the water standing between it and the dune toe. There are waves breaking on the offshore bar extending south into developed Brigantine.

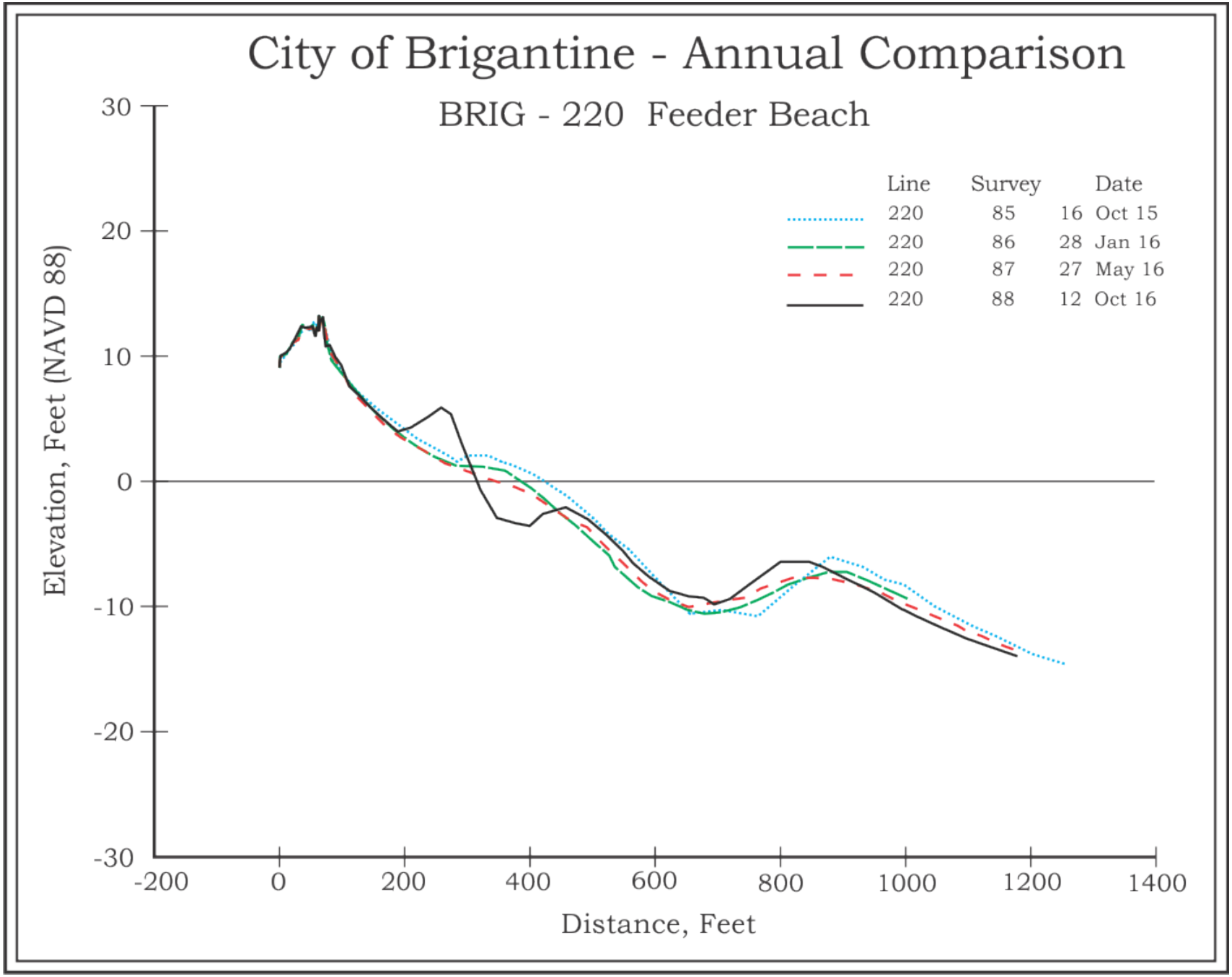

Figure 2c – The dune remained relatively stable to slightly accretive untouched by the northeast storms. The berm developed by October 12, 2016 was added to the beach relatively recently, but its offshore trough is the reason for the negative sand volume offshore.

- **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. 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. Combining the 2014 and 2015 losses account for 80% of the placed sand lost in just two years following sand placement in 2013.

In the past year the site appears to have stabilized somewhat although the shoreline at zero elevation retreated 111 feet. The sand volume decreased on the berm (-9.05 yds^3/ft.), but increased offshore (14.59 yds^3/ft.).

Beyond the net gain of 5.55 yds^3/ft., the real difference was seen in the large loss extending from the revetment wall seaward beyond the zero elevation producing a loss of 41.10 yds^3/ft. while bar development offshore captured 46.43 yds^3/ft. This is because the on-shore losses extended into water 10 feet deep before gains further seaward kicked in generating the offshore sand volume above. The zero elevation is a convenient marker for separation of gains on the beach with changes seen offshore; however, this site shows that other criteria are working as well.

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

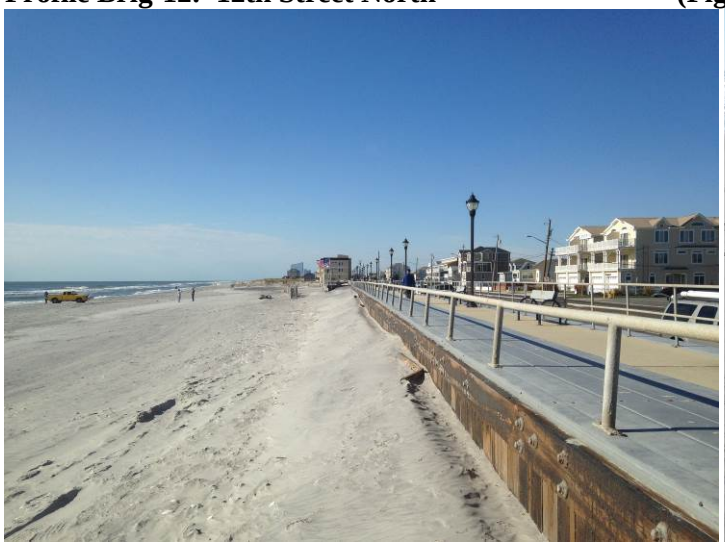

Figure 3a taken October 16, 2015 from the top of the sand against the revetment wall. The wide beach berm still present in spring 2015 has been flattened by storm wave run-up that nearly reached the revetment two weeks prior during the early October northeaster.

Figure 3b photo above was taken October 12, 2016 showing the significant loss over the past year. Rocks exposed and a hundred-foot narrower beach is present with a generous deposit seen offshore where waves are breaking.

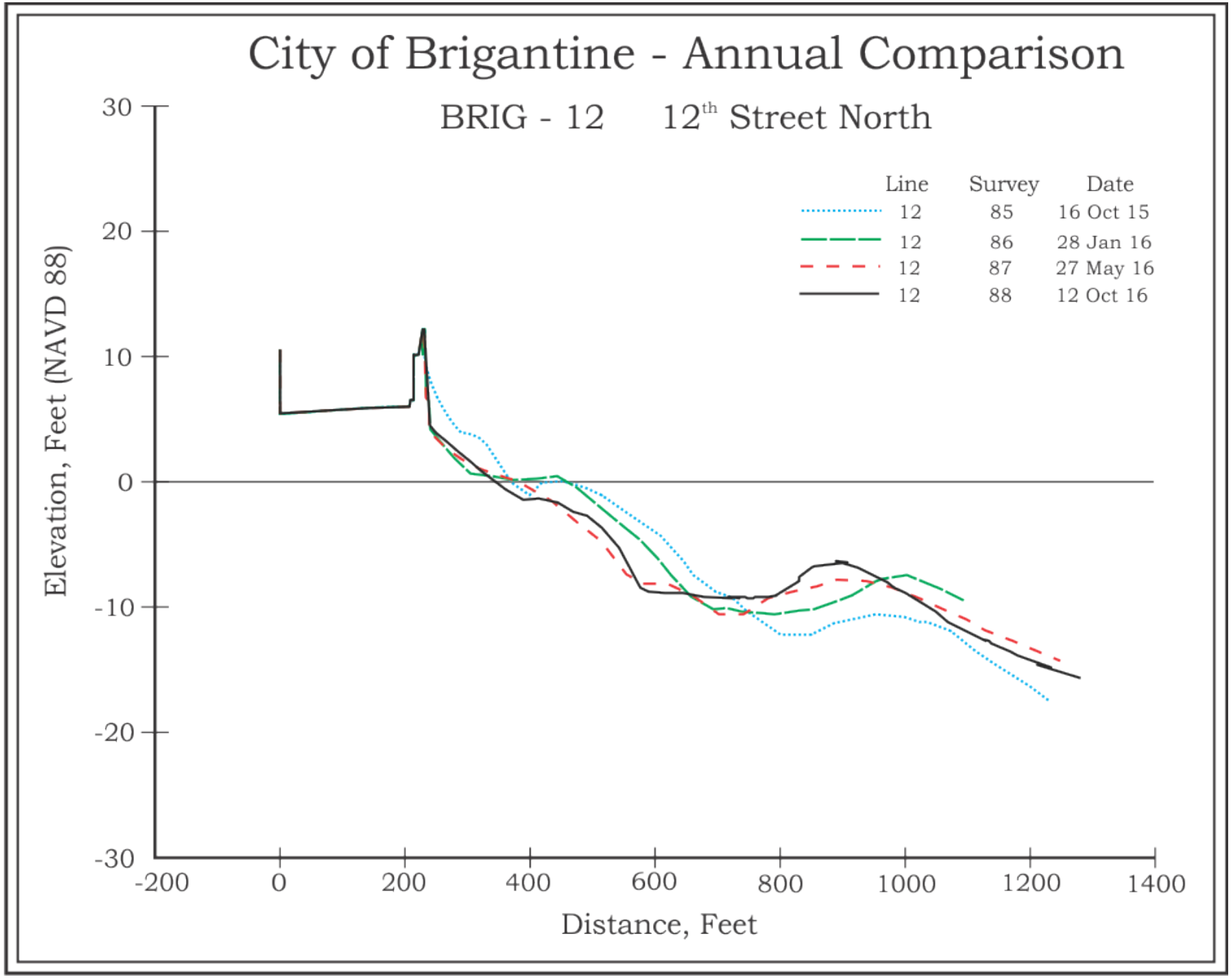

Figure 3c - The cross sections depict a beach loosing sand especially above the zero elevation. Jonas was particularly effective in stripping the beach at the revetment and producing significant shoreline retreat. The beach continued to retreat in May and less so by October. Hermine and a 3-day northeaster impacted the sand supply between May and October 2016. Offshore a very large bar accumulated between October 2015 and October 2016. This feature produced the near balance in sand volume for the year.

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

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.

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.

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. Winter storm Jonas storm waves reached the seaward foredune slope and cut a modest scarp in the feature and further flattened the beach slope.

Over the summer and into the early fall, modest shoreline retreat reduced the beach width by 16 feet while the berm developed (-0.12 yds^3/ft.) adding to the dune and beach while offshore the bar diminished in size generating a loss of 12.03 yds^3/ft. The net loss of 12.15 yds^3/ft. was relatively modest.

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

Figure 4a 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 4b photo was taken looking north on October 12, 2016 following Hurricane Hermine and a late September 3-day northeast event. The resulting bar deposit and flat beach are evident.

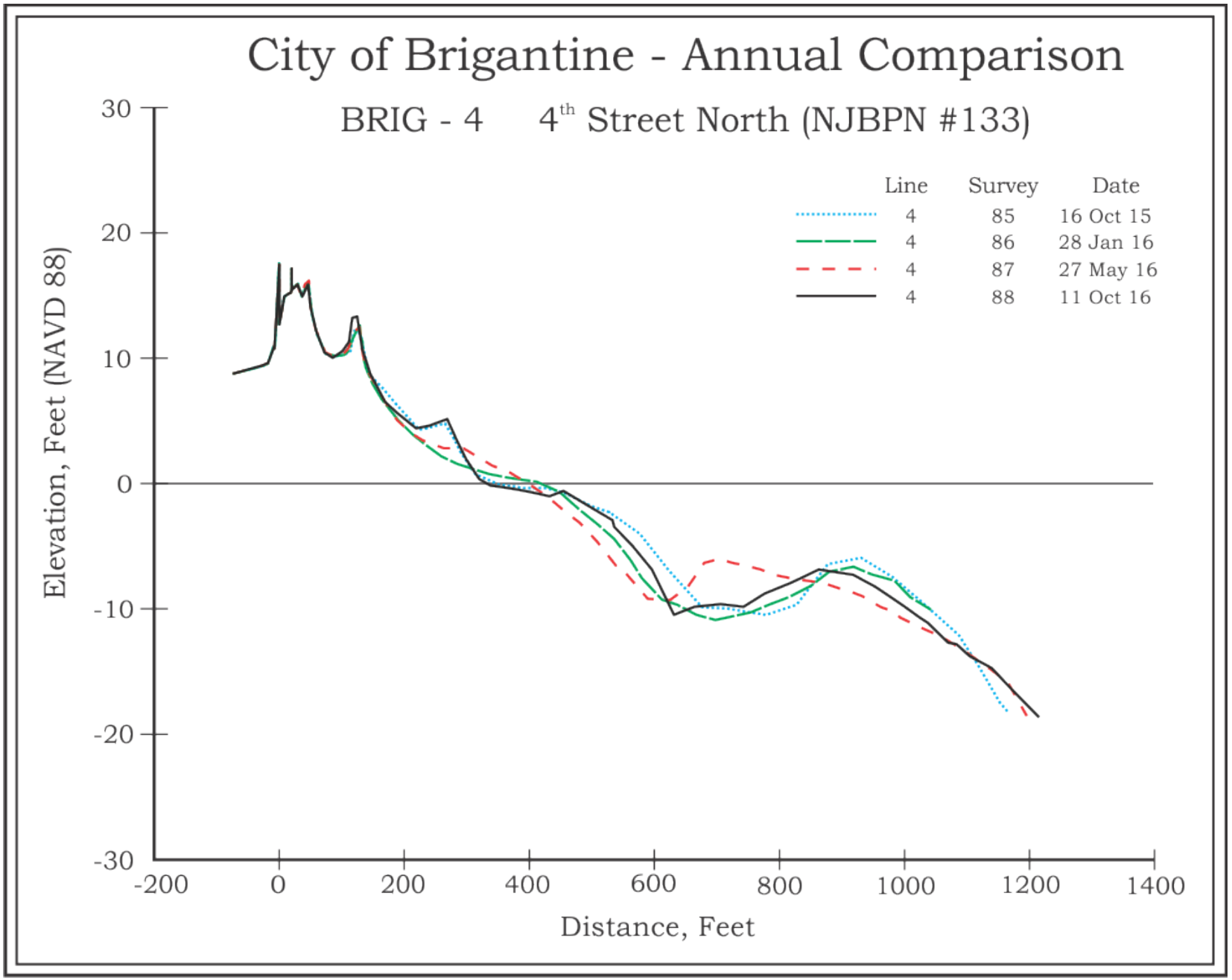

Figure 4c - The site was relatively stable with losses confined to the offshore bar changes. Sand deposited on the beach following the summer in near identical patterns in 2015 and 2016. Jonas flattened the beach, but post-storm deposition brought back the berm and added to the fore dune as wind transported sand inland.

- **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. 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.

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. The net annual change for 2015 was a loss of -28.19 yds^3/ft. of sand.

During 2016, the shoreline retreated 109 feet, but the sand volume was surprisingly stable gaining 3.28 yds^3/ft. above the datum and 3.38 yds^3/ft. below the datum (6.66 yds^3/ft. net gain). The retreat in the shoreline appears to be related to the chance position of the 2015 nearshore bar and beachface entirely above the zero datum while the same feature present in October 2016 was located so that the beachface dipped below the zero datum leaving the nearshore bar below zero. This translates into an apparent 109-foot shoreline retreat that while accurate, should produce no cause for alarm.

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

Figure 5a photo was taken looking north October 15, 2015. Sand moved slightly landward into the dune toe with evidence of early colonizing plants propagation during the summer season.

Figure 5b photo was taken looking north on the beach near the swash on October 11, 2016. The beach was flat due to the late September northeast storm.

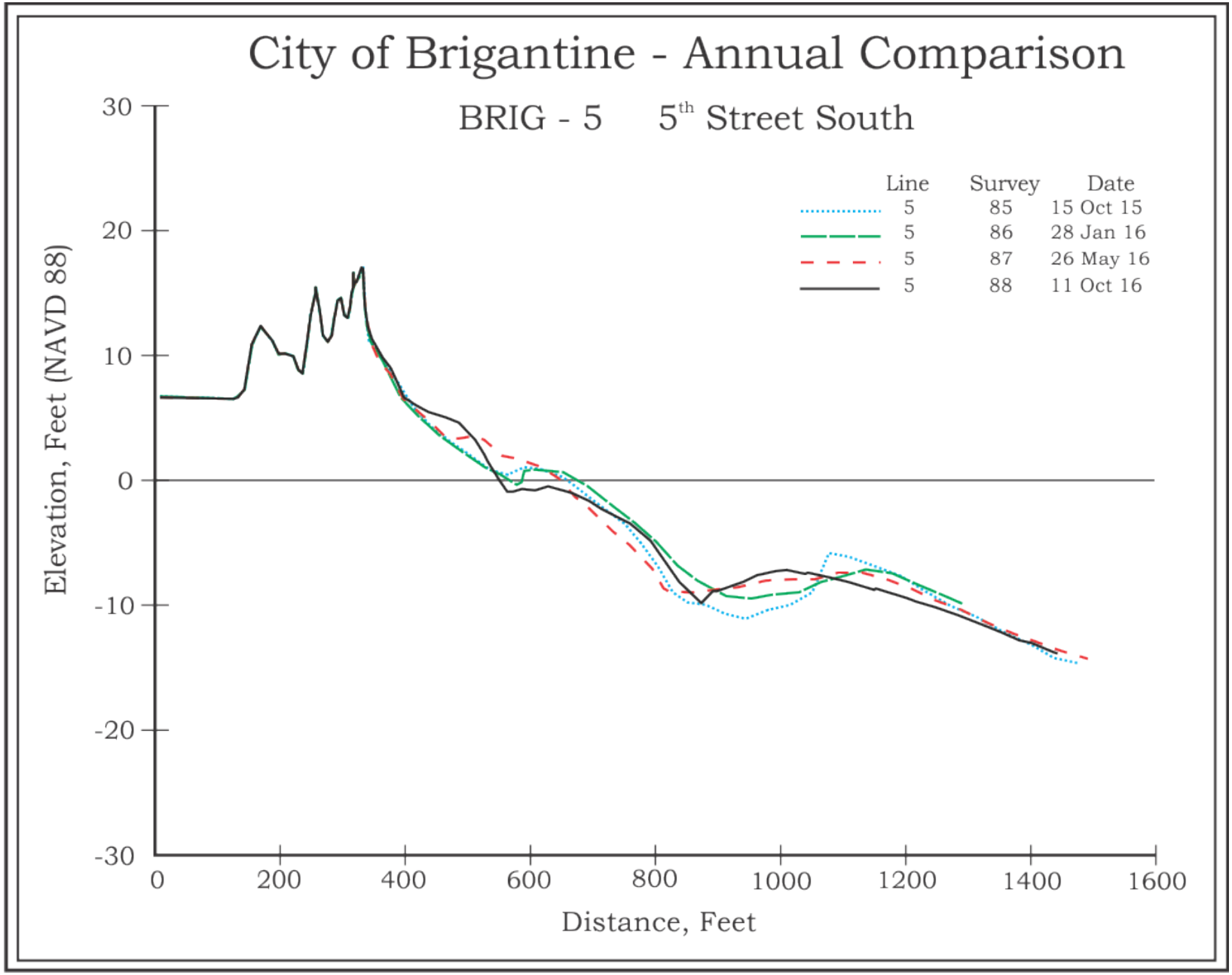

Figure 5c - The 5th Street South site showed a berm deposited by October 2016 as sand moved landward from the May 2016 location. The 108-foot shoreline retreat is more a result of position for the berm and its immediate seaward terrace just below the zero elevation than any other reason. The October 2015 feature is similar, but positioned 1.5 feet higher in elevation.

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

At 15th Street South, the dune 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 due to southerly littoral transport 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.

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.

A modest gain during 2015 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, 2015 erosion returned the site to a modest net negative post Sandy volume of approximately -8 yds^3/ft. of sand.

In 2016 there was a strong disconnect between the deposition of 11.36 yds^3/ft. above the zero datum while 31.38 yds^3/ft. eroded below the zero datum. The shoreline retreated 38 feet with a net loss in total sand volume (-20.02 yds^3/ft.). The berm was well developed and storm wave erosion in September left a wide, shallow terrace offshore, creating an extensive shoreline retreat.

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

Figure 6a photo was 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 6b taken October 11, 2016 also following a late September 3-day northeast event. Waves did not reach the dune toe and the beach remains wide and well developed.

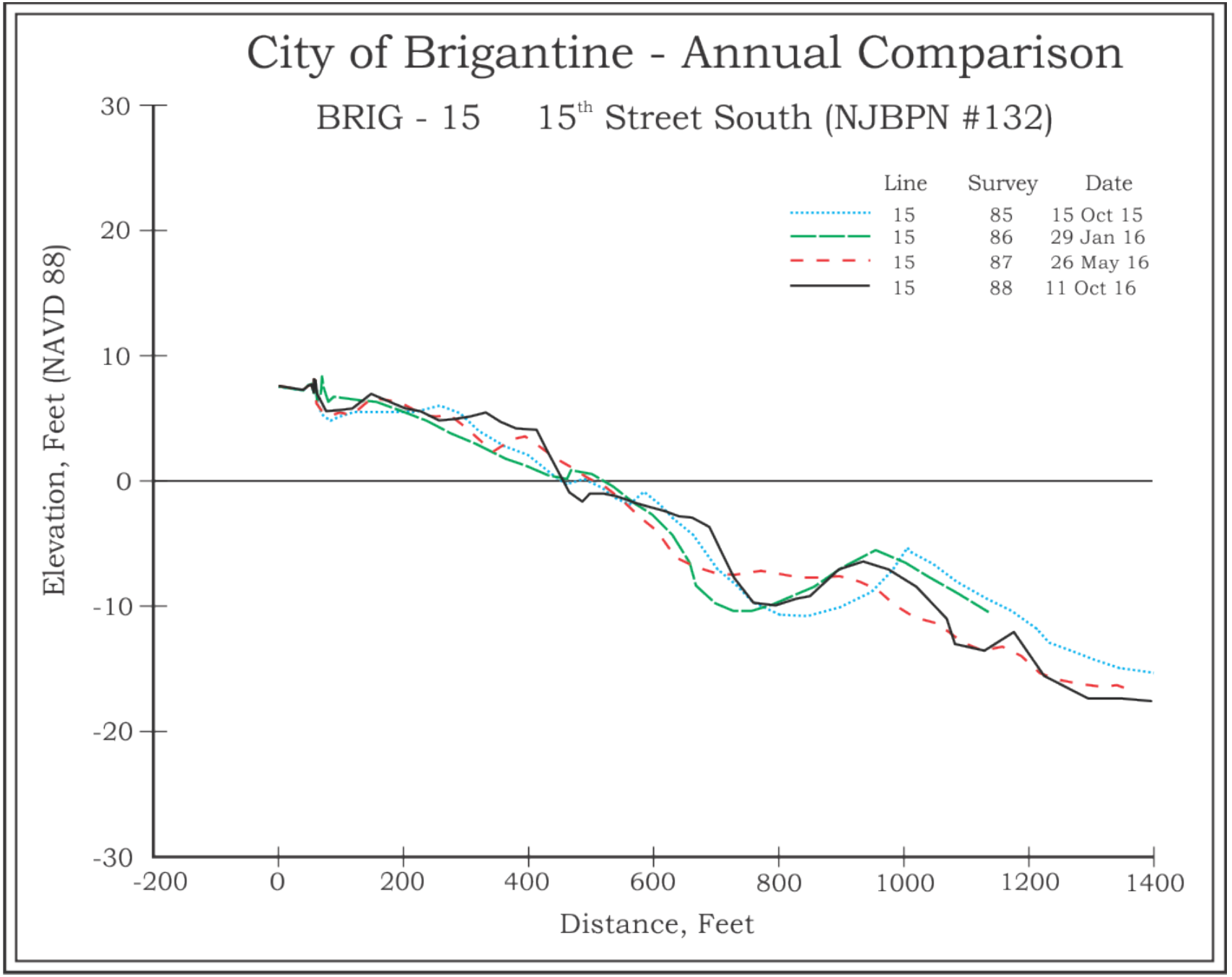

Figure 6c - At 15th Street South sand was added to the beach as a wide berm with proximal bars just offshore nearly attached to the beach by October 11, 2016. Two additional bars existed offshore, but at lower elevations than present in 2015, generating the sand volume loss documented.

- **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 pre-existing 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. 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 growth 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 oceanfront property and infrastructure during Hurricane Sandy. The wide beach absorbed the storm surge and wave energy reducing and flattening the feature but preventing over wash of the dune system with little 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, the 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 net annual changes during 2015 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.

In 2016, the site saw 164 feet of shoreline retreat as a wide, low gradient beach in October 2015 became a steep berm slope with the nearby offshore positioned just below the zero elevation position. The sand volume changes were small (-2.52 yds^3/ft. above the datum, and -2.69 yds^3/ft. below the zero datum). The sand loss does not confirm the idea that this beach lost substantially in spite of the largest shoreline retreat seen this year.

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

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 dune.

Figure 7b. October 11, 2016 shows that the dune continued to accumulate sand filling in around the lifeguard shack at 27th Street. The wide beach and great dune system protect all built infrastructure behind it.

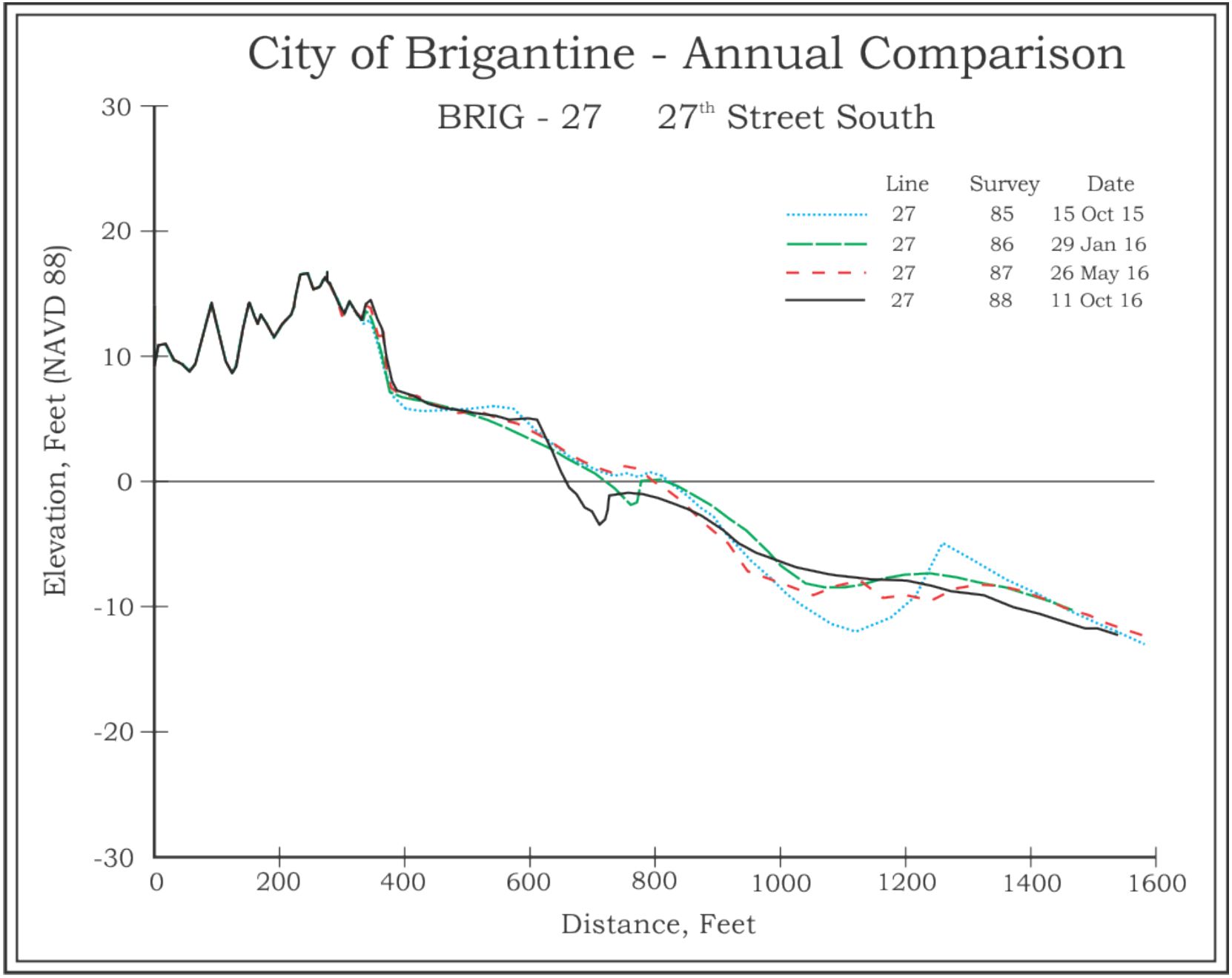

Figure 7c - The shore did change at the zero elevation position with a steep beachface leading to a nearshore bar about to weld onto the beach in October 2016. The beach width was affected by the contrast between the gentler slope and bar a year earlier. The distal offshore bar was quite flat by the end of 2016.

- **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.

In 2013, sand moved back onshore with conditions favorable for natural beach building processes. All features were fully restored to pre-Sandy conditions. 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.

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. This past year the beach and dune continued to gain sand (12.29 yds^3/ft.) with a 34-foot shoreline advance. Minor change offshore added minimal material so the net gain was 12.57 yds^3/ft.

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

Figure 8a 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.

Figure 8b photo was taken looking north on October 10, 2016 10 days after a 3-day northeast storm. Water flooded about half the beach width, but did no real damage.

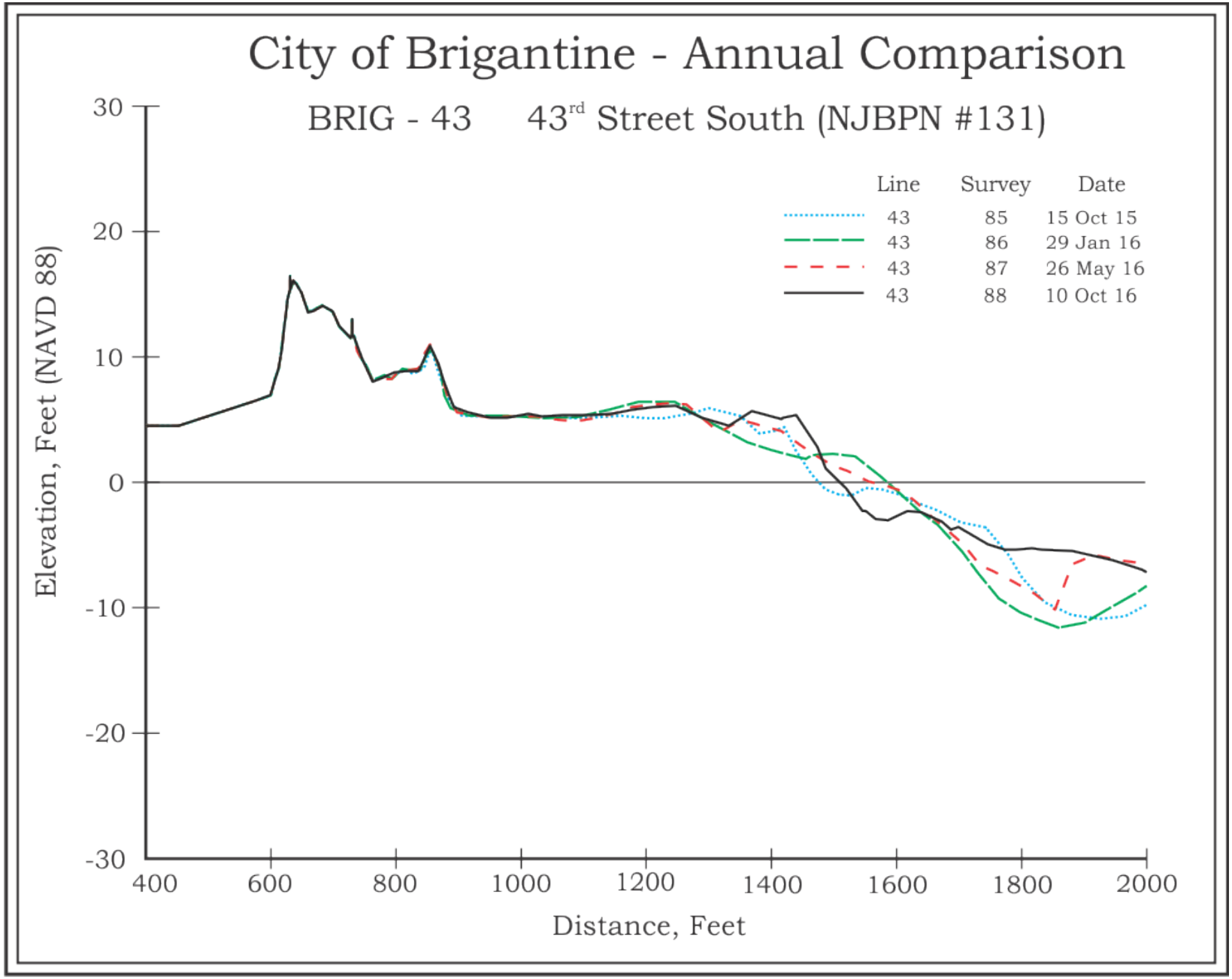

Figure 8c – This site has tripled its width over the 30-year monitoring history with the development of a wide berm in 2016 following the northeast storm Jonas in January 2016. The upper beach/dune area remained unchanged while sand added to or left the nearshore and distal parts of the profile offshore. The huge trough scoured by Jonas, filled in by October with sand arriving from up the beach and from further seaward (May profile).

- **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 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. 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 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. 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.

During 2016, sand packed into this site adding 12.32 yds^3/ft. above the datum and 25.47 yds^3/ft. below the datum with a 16-foot shoreline retreat. This year saw a clear transport of sand from the beaches north of 27th Street south depositing it in ever higher volumes (37.79 yds^3/ft.) toward the jetty.

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

Figure 9a photo was taken looking south 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.

Figure 9b photo taken May 25, 2016 near the water's edge shows the beach width adjacent to the Absecon Inlet jetty.

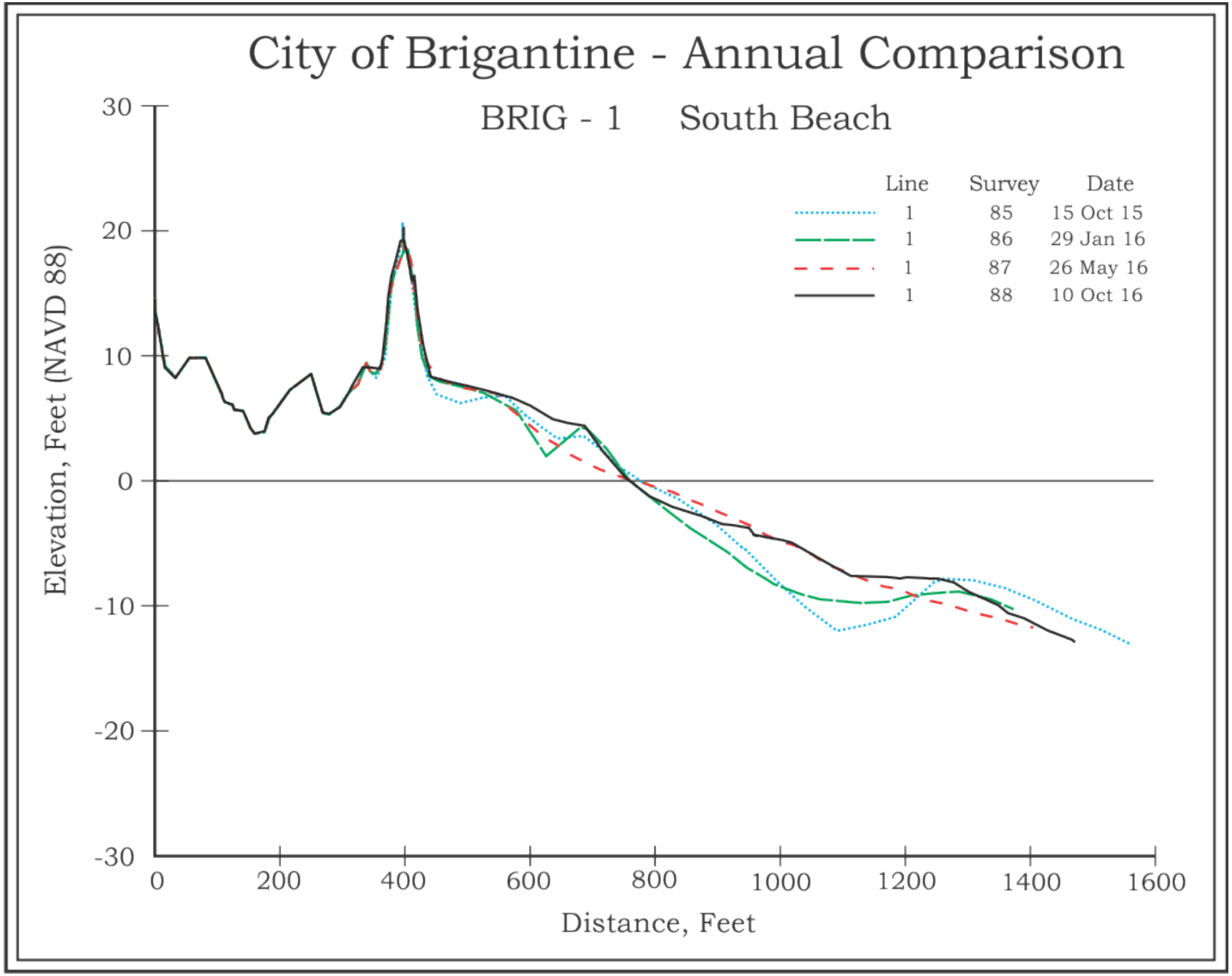

Figure 9c – The sand deposited on the beach raised the elevation considerably across the entire berm, filling in all the earlier irregular areas between the dune toe and the berm crest. Offshore the elevation decreased as well as the bar trough from Jonas filled in with sand from up the beach.

Summary:

In early 2016 winter storm Jonas struck the Jersey shore. Brigantine Beach shoreline's net loss was 76,005 CY during Jonas with -48,770 CY lost from the north end 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.

In 2016 the net gain was 77,252 cubic yards, but that number fails to show the dramatic loss between Brigantine Inlet and 27th Street South where the loss was 108,080 cubic yards with the beach south of 27th Street South gaining 185,332 cubic yards to offset the sand volume loss to the north. This process has built a super-wide beach between 15th Street South and the jetty, which entraps over 6 million cubic yards of sand, all within 500 feet of the water's edge. The built infrastructure lies between 800 and 1,000 feet further landward.

Sand back-passing remains an attractive option to reduce the frequency of required expensive beach nourishment projects on the north end 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 back-passing projects have been implemented as sustainable programs in several Cape May County communities. The Borough of Avalon has successfully completed four projects while the Wildwoods have completed three projects.

Sand back-passing 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 back-passing 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 back-pass the sand to the areas of chronic erosion from which the sand originated.

Between February and May of 2016 the City of North Wildwood moved 171,000 cubic yards of sand from Wildwood beaches (storm water outfall zones) to the erosional area of the municipal shoreline at a cost of $5.75/cubic yard. Nine trucks were used for a single work shift, five days per week. All truck driving was done on the beach at the wet/dry line for the day.

This type of project now has multiple examples completed in New Jersey since 2006; therefore there are experienced contractors available with a growing fleet of suitable vehicles to execute a similar project in Brigantine. The CRC feels that permitting issues should be relatively minor since there could be multiple borrow regions on the beach, limited wildlife impact, no ownership issues, no impediments to a direct, beachfront haul route, and limited citizen objections. Perhaps it is time to discuss this option with the Philadelphia District's project manager, the NJ State Division of Coastal Engineering to see if it could be a cost effective way to extend the service life of the expensive hydraulic beach nourishment projects.

Absecon Inlet Jetty Study:

The City opted not to authorize the continuation of this study in 2015 and 2016.