FINAL REPORT FOR 2015
ON THE CONDITION OF THE MUNICIPAL OCEANFRONT BEACHES
THE BOROUGH OF AVALON, CAPE MAY COUNTY, NEW JERSEY

Photo above was taken two days after a January 2016 northeast storm named Jonas. Its impact on the north end of the Avalon shoreline is visible with exposed rocks at 11th Street. Waves overtopped the jetty scouring the beach along the south margin. The water reached the dune toe other places, but fortunately did little serious damage. (photo by Ted Kingston for the CRC).

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ANNUAL REPORT FOR 2015 - TO THE BOROUGH OF AVALON
ON THE
CONDITION OF THE MUNICIPAL BEACHES

Introduction:

Avalon continues to have both the finest beaches and dunes anywhere along the Mid-Atlantic coast and a zone of serious erosion needing nearly constant attention. The segment between 31st Street and 56th Street is a 100 acre tract one just would never expect to see still in existence along the highly developed NJ shoreline, yet the dunes and beach represent the finest ecological examples of a mature maritime coastal forest to be found anywhere. It is the site of 6-7 massive homes located at 50-foot elevations proximal to Dune Drive, with over 1,000 feet of magnificent dunes extending to a 300-foot wide dry beach and accretional shoreline.

In contrast the segment from 8th Avenue south to 25th Street needs attention because wave-generated sand transport has consistently moved large volumes of sand south into the high dune zone and to a large extent offshore requiring repetitive beach nourishment projects, extensions to the inlet jetty, and the construction of a timber bulkhead and rock toe revetment between 8th Street and 17th Street all since 1962.

Seven-Mile Island is one of the more stable NJ barrier islands, but Townsends Inlet has taken its toll on the northernmost part of the island. Northeast exposure is the greatest, other than that of North Wildwood because the offset across the inlet makes the local slogan literally true "Cooler by a Mile". This offset in the two shorelines means that the northeast storm winds and waves can directly pound the Avalon shoreline at Townsends Inlet, making stability a seaming illusion.

During 2015 Avalon undertook its own restoration of the 2013 USACE (US Army Corps of Engineers) emergency maintenance due to impacts from Hurricanes Irene and Sandy when a reported 336,359 cubic yards (CY) of sand was placed on the engineered beach. The 2013 project was eligible for Flood Control and Coastal Emergency funds under Public Law 84-99 and in response to P.L. 113-2 Disaster Relief Appropriations Act. Unfortunately, winter storm Saturn and a series of smaller storms impacted the Jersey coast soon after the USACE project was completed and quickly began to erode the project beach berm.

By fall 2013 the northern engineered beach had severely eroded and most of the sand placed by the USACE was removed. In response the Borough conducted a 2014 backpassing project which transferred 50,097 cubic yards of sand from the northern borrow zone between 31st and 38th Streets to a section of the engineered beach. The erosional trend continued prompting Avalon to contract with Great Lakes Dredge and Dock and between June and July of 2015 they placed 740,000 cubic yards of Townsends Inlet sand between 9th and 23rd Streets to restore the federal design profile at the north end of the Borough.

A quick summary of Sand Back-passing Projects:

In 2006, a pilot project moved 58,000 CY of sand from the beaches between 31st and 68th Streets back to the northern zone of erosion. Mount Construction Corp. commenced sand hauling for a second project in February 6, 2012 completed March 5, 2012 with 63,956 CY of sand moved to the erosional shoreline between 12th and 21st Streets.

The third back-passing project commenced in late February 2014 and was scheduled to be completed prior to the shorebird nesting season in early spring. To ensure the construction activity did not interfere with potential arriving shorebirds in the mid-island natural area / exclusion zone only the northern borrow zone was utilized for this project. Earthworks Construction moved 50,097 CY of sand within a 6 week window based upon sand volumes recorded for the 1,544 truckloads of sand excavated from the borrow zone and hauled to the engineered beach. This summery is included because the Borough is considering this action once again.

Monitoring Program:

The CRC monitored the ten oceanfront cross sections four times in 2015 on a seasonal timeline. These surveying activities continue a monitoring program dating back to 1981. The five northern sites are located within the engineered beach project area while the southern five sites cover the accretional region including the natural exclusion area and sand back-passing borrow zones. Monitoring provides details on natural sediment movement along the Borough's Atlantic shoreline and surveying has continued through multiple beach restoration projects starting in 1987 with a local/state sponsored project that gathers data for project performance evaluation. Each topographic beach profile starts at a fixed reference position landward of the dune. The repetitive surveys for each profile include changes to the dune, beach and nearshore.
The following is a list of quarterly studies included in this report and the dates of the surveys:

- Survey 129 December 15 & 16, 2014
- Survey 130 March 31 & April 1, 2015; 1st Quarter
- Survey 131 June 11 & 12, 2015; 2nd Quarter
- Survey 132 Special post fill; June 11 & July 15, 2015; north 5 sites only.
- Survey 133 October 9 & 10, 2015; 3rd Quarter
- Survey 134 December 21 & 22, 2015; 4th Quarter

Oceanfront Beaches:

Following the initial state/local beach restoration project in 1987 regular beach maintenance has been required to maintain the north end engineered beach from the 8th Street Jetty south to 26th Street. Initially responsibility for maintenance was solely on the State and Borough of Avalon with the municipality conducting several projects independently to keep up with the erosion and storm event damages.

The USACE authorized construction of the Seven Mile Island project that included both the north end of Avalon and Stone Harbor as a federal project. A cost share ratio of 65% federal to 35% local was established for the project that included future federal maintenance projects. With the state paying 75% of the local match the Borough was responsible for 25% of the cost per project cycle. The USACE restored the ocean beaches starting in 2002, with the Borough and State providing additional sand hydraulically pumped onto the beach in 2006 and 2008 between federal nourishment cycles. Trucks were used under contract to haul in quarry sand in 2007 and 2009 to restore recreational access between 10th and 17th Streets. Trucks were utilized again in 2010 to restore the dune in the 4-block section between 17th and 21st Streets followed by the 643,000 CY of sand pumped in June of 2010 onto the engineered beach. In 2011, a federal maintenance beach replenishment project placed 450,000 CY of sand on the northern beaches. Following Hurricane Sandy the USACE conducted an emergency maintenance project in early 2013 to restore the engineered beach design template with placement of 336,359 CY of sand. The most recent major project was conducted by Avalon with 740,000 cubic yards of sand placed by July 2015.

A sand back-passing program was implemented as a pilot project in 2006 to recycle 58,000 CY of sand hauled to the northern shoreline using sand obtained from the steadily accreting shoreline between 31st and 70th Streets. This was repeated again in 2012 under US Army Corps authorization when 63,956 CY of sand were hauled from the same source beaches to the zone between 12th and 21st Streets. A third sand back-passing project followed hurricane Sandy and severe winter storm erosion in 2013. In March of 2014 this most recent project began hauling 50,097 CY of sand to the erosional northend beaches from southern accreting beaches north of the natural area exclusion zone to 31st Street. Planning is underway to augment winter 2015-2016 beach losses with sand transferred north from the mid-Island borrow zones using the backpassing technology.

Oceanfront beaches were surveyed quarterly to depict both seasonal and annual changes and to assist in performance assessments of each project focused on erosional and recovery rates. During the Great Lakes project, each of the five engineered beach cross sections (9th to 28th Streets) were surveyed prior to sand

placement and as the work was completed to show sand volumes placed. The subsequent observations show trends in both shoreline position and volume that occurred later in the summer into the fall of 2015. There were no east coast hurricanes in 2015 that created any problems, with the first northeast storm occurring in October as a multi-day event with low wind velocities, but having substantial beach impacts. The next two months were very mild as the warmest December on record unfolded. Winter started seriously in January 2016 ushering in a northeast storm named Jonas followed two weeks later with a second smaller event. A special survey of Jonas damage is also included in this report. Table 1 below shows the trends in sand volume by quarter.

Table 1
2015 Oceanfront Beach Profile
Quarterly Sand Volume Changes

Profile Number	Winter 12/14 - 3/15 (yds^3/ft)	Spring 3/15 - 6/15 (yds^3/ft)	Summer 6/15 - 10/15 (yds^3/ft)	Fall 10/15 - 12/15 (yds^3/ft)
8th Street Jetty				
AV-9	-8.86	-18.60	72.12	-21.80
AV-12	-20.62	-10.88	143.78	-29.69
AV-17	-16.12	-11.25	96.90	-12.12
AV-23	-3.41	-3.84	53.74	-5.85
AV-28	-11.06	-2.58	28.70	10.89
AV-35	8.87	2.83	11.92	8.67
AV-44	-4.92	8.93	-18.68	23.58
AV-58	4.86	6.00	-13.57	3.39
AV-70	9.37	-0.05	-25.75	16.32
AV-78	3.21	0.98	-33.10	12.09
Quarterly Volume Change (yds^3) =	**-27,000**	**1,517**	**316,621**	**113,330**

The net seasonal total sand volume change along the Avalon oceanfront shoreline during 2015 was a substantial gain of 404,468 CY. Over the winter the Avalon beaches lost 27,000 CY of sand. This minor erosional trend reversed as a very small pre-fill sand accumulation into the summer. Over the summer Great Lakes pumped 740,000 cubic yards building a wide beach which remained stable during the calmer summer wave climate. The first northeast storm in early October removed sand from the beaches south of 11th Street, but in relatively minor quantities, 537,577 CY or 73% of the project sand remained in place.

Table 2 below shows the fourth quarter changes at each profile location following the fall 2015 seasonal changes. Shoreline position changes (zero datum NAVD88) are measured in feet. Profile volume changes were averaged with adjacent sites to calculate an average volume change then multiplied by the distance between sites to determine a net cell volume change in cubic yards. Summation of each cell volume change provides the total change in sand volume for the Avalon oceanfront beaches during the fourth quarter.

Table 2
2015 Oceanfront Beach Profile
Fourth Quarter Sand Volume Change

Profile Number	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg.Volume Change (yds^3/ft)	Cell Distance (feet)	Net Volume Change (yds^3)	
8th Street Jetty						
			-21.799	500	-10,900	-10,900
AV-9	-34	-21.80				
			-25.742	840	-21,623	-32,523
AV-12	-15	-29.69				
			-20.902	1400	-29,262	-61,785
AV-17	54	-12.12				
			-8.986	1680	-15,096	-76,881
AV-23	-20	-5.85				
			2.519	1400	3,527	-73,354
AV-28	-15	10.89				
			10.891	2025	22,054	-51,300
AV-35	-77	8.67				
			16.124	2510	40,470	-10,830
AV-44	-28	23.58				
			13.485	3925	52,929	42,099
AV-58	2	3.39				
			9.858	3360	33,123	75,222
AV-70	0	16.32				
			14.206	2240	31,821	107,043
AV-78	-14	12.09				
			12.090	520	6,287	113,330
Total Volume Change for Oceanfront Beaches in cubic yards =					113,330	

Table 2 above shows the fourth quarter changes from fall 2015. Erosion along the engineered beach was concentrated at the 3-day northeast episode between October 4 to 7, 2015 where a steady 25 to 30MPH wind built a moderate wave set. From the 8th Street jetty through 23rd Street the shoreline lost 73,354 CY of sand. This was offset by a gain of just over 186,684 CY of sand on the southern beaches. The net change was a gain of 113,330 CY of sand from October 7, 2015 to December 18, 2015 along the Avalon oceanfront beaches.

Table 3 below shows the annual volume change for 2015. Individual profile shoreline position changes (zero datum) are presented in feet while the profile sand volume change is expressed in cubic yards per foot. A net cell volume was calculated by averaging the adjacent profile volume changes multiplied by the cell distance. A cumulative sand volume change for the Borough's oceanfront beaches was derived by the summation of the net cell volume changes.

Table 3
Oceanfront Beach Profile
2015 Annual Sand Volume Change

Profile Number	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg.Volume Change (yds^3/ft)	Cell Distance (feet)	Net Volume Change (yds^3)	
8th Street Jetty						
			20.135	500	10,068	10,068
AV-9	72	20.14				
			51.288	840	43,082	53,149
AV-12	129	82.44				
			71.603	1400	100,244	153,394
AV-17	161	60.77				
			50.665	1680	85,117	238,511
AV-23	31	40.57				
			33.627	1400	47,078	285,589
AV-28	-35	26.69				
			26.689	2025	54,045	339,634
AV-35	-49	32.01				
			20.206	2510	50,717	390,351
AV-44	-24	8.40				
			10.022	3925	39,334	429,685
AV-58	-1	11.64				
			9.505	3360	31,937	461,622
AV-70	-17	7.37				
			-4.574	2240	-10,246	451,376
AV-78	-57	-16.52				
			-16.519	520	-8,590	442,786
Total Volume Change for Oceanfront Beaches in cubic yards =					442,786	

A direct comparison between surveys conducted in December 2014 with those in December 2015 show an annual gain of 442,786 CY of sand derived largely from the July sand placement effort. This contrasts with the loss of 122,783 CY of sand from the Avalon oceanfront beaches last year. Sand from the fill did move in quantity onto the 35th Street profile adding 32 cubic yards of sand per foot of shoreline. No indication that impacts were evident further south than 35th Street.

Table 4 below follows the shoreline and sand volume changes across the Avalon engineered oceanfront beaches since completion of the 2015 Great Lakes Avalon maintenance project. The table compares survey data collected at the five quarterly sites within the engineered beach on June 2015 immediately prior to project construction to July 2015, immediately following completion.

Table 4
Avalon Post-Nourishment
Sand Volume and Shoreline Changes - June 2015 – July 2015

Profile Number	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg.Volume Change (yds^3/ft)	Cell Distance (feet)	Net Volume Change (yds^3)	
8th Street Jetty						
			159.218	500	79,609	79,609
AV-9	299	159.22				
			184.171	840	154,703	234,312
AV-12	374	209.12				
			172.126	1400	240,976	475,288
AV-17	231	135.13				
			129.243	1680	217,127	692,415
AV-23	216	123.36				
			58.756	1400	82,258	774,673
AV-28	-36	-5.85				
Total Volume Change for Oceanfront Beaches in cubic yards =					774,673	

As of December 2014 the engineered beach had lost 100% of the 2013 USACE project fill volume of 336,359 CY of sand plus an additional loss of 383,685 CY of sand for a total loss of 720,044 CY of sand eroded from the engineered beaches in just 22 months. This loss was entirely replaced at Borough expense. This number above is 34,000 cubic yards larger than the Great Lakes pay volume, because the CRC carried the computation to 28th Street as an average for the taper that did not extend all the way to 28th Street.

Table 5
Northeast Storm Jonas Beach Impact – January 24, 2016

Profile Number	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg.Volume Change (yds^3/ft)	Cell Distance (feet)	Net Volume Change (yds^3)	
8th Street Jetty						
			7.173	500	3,587	3,587
AV-9	-9	7.17				
			-12.437	840	-10,447	-6,860
AV-12	-90	-32.05				
			-25.306	1400	-35,428	-42,288
AV-17	-62	-18.57				
			-12.221	1680	-20,530	-62,818
AV-23	-8	-5.88				
			-9.264	1400	-12,969	-75,787
AV-28	-31	-12.65				
Total Volume Change for Oceanfront Beaches in cubic yards =					-75,787	

Following the early October northeast storm, conditions were very calm until January 24, 2016 when northeast storm Jonas occurred during a spring tide. Flooding and wave damage was considerable throughout Cape May

and Atlantic Counties. Rated as approximately a 10-year storm, Jonas eroded beaches flat and reached the dune toe with varying amounts of scarping depending on existing beach widths. The CRC conducted an emergency survey to document the impact for Emergency Management purposes should there be a disaster declaration. Table 5 results below showing the storm losses observed. The loss amounted to 75,787 cubic yards concentrated between 12th and 17th Streets tapering rapidly at 23rd Street.

Avalon's north end is susceptible to erosion even during modest and moderate storm events due to its orientation to the northeast and prevailing southerly longshore currents that moves sand rapidly away from the engineered beaches. The USACE recently began construction of a massive nourishment project for southern Ocean City and all of Ludlam Island. This project will introduce approximately 4 million cubic yards of offshore sand into the nearshore littoral system. Introduction of this sand never previously present on any historical beach into the system will dramatically alter the rate of sediment entering Townsends Inlet potentially restoring natural sand bypassing rates to Avalon. Of the approximately 3.2 million cubic yards destined to be deposited on Ludlam Island, NJ coastal processes guarantee that about half will make its way south to Townsends Inlet within two years' time. This process is being followed and the first iteration of the inlet review appears in its own chapter in this report.

Individual Site Review:

This section describes the changes documented at each of the cross section locations. In general for 2015, winter losses were overshadowed by the Borough project to restore serious losses seen following the USACE project in 2013. The Borough completed a sand back-passing project in March 2014 harvesting sand from a borrow zone defined between 31st Street and approximately 38th Street then transferring the sand to the erosional shoreline north of 18th Street. Loss rates declined until January 2016 following onset of winter northeast storms.

AV-9 - Ninth Street

After Sandy the USACE restored their design template at 9th Street, however a March 2013 northeast storm had a significant impact on this and other site profiles. The first two quarterly surveys (#130 and #131) show a beach that sloped right up to the seaward dune toe with a continuous slope gradient from the beach offshore to 12-14 feet of water. The July 2015 survey (#132) followed beach restoration by Avalon with the addition of 159.22 yds^3/ft. in new sand.

Subsequently, surveys in October and December show considerable loss in berm width moving the zero elevation position back landward by 212 feet. The sand volume removed amounted to 122.46 yds^3/ft. 13.5 yds^3/ft. of that total was deposited offshore about 1,100 feet from the dune reference position. The total quantity deposited further seaward than 1,100 feet is probably significant because the October cross section runs out beyond 1,400 feet at elevations considerably higher than the July 15, 2015 survey's ending point and slope gradient. The apparent wedge of material indicated as deposited well offshore since July is at least half the volume removed from the berm.

1a. June 8, 2015

1b. July 15, 2015

1c. January 26, 2016

Photographs 1a to 1c. 9th Street view to the south.

Photograph 1a shows the beach and seaward dune slope just prior to the July fill. The dry beach is very narrow with waves able to erode into the accumulation of sand along the seaward dune toe fence.

View 1b immediately follows the 740,000 cy sand fill and demonstrates the visual effect of the material showing in the cross section below for July 15, 2015.

View 1c after the worst northeast storm since Sandy (Jonas on January 24th) the storm waves reached to the dune fencing and the loss to the berm width shown on the cross sections becomes apparent.

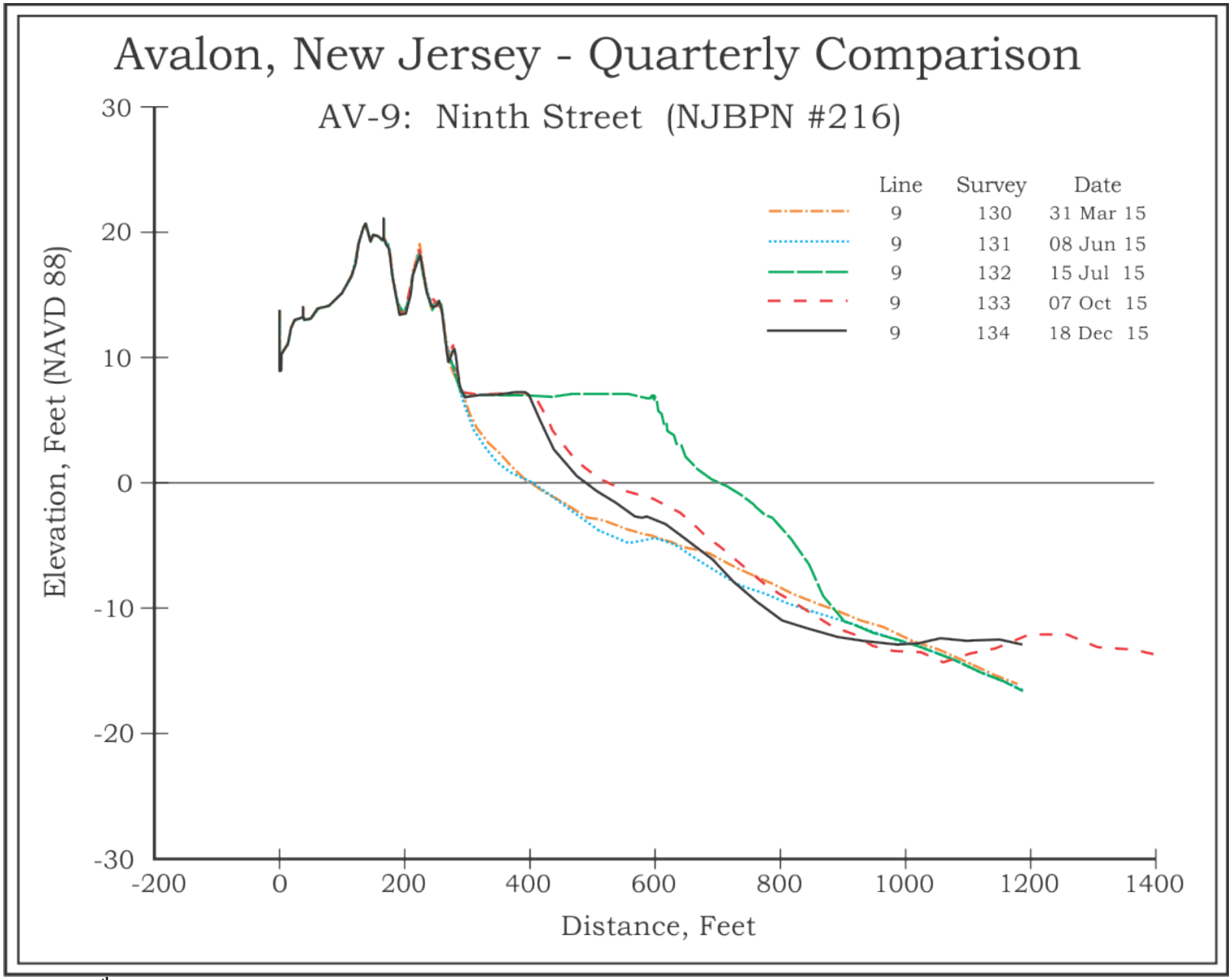

Figure 1. At 9th Street the four quarterly surveys combined with the July 2015 post fill survey demonstrate the existing conditions 2 years after the 2013 federal project and the rapid rate of sand volume lost both offshore and to the south along the beach. Over 150 cubic yards of sand per foot were added and 2/3's of that volume was redistributed offshore and south by mid-December.

AV-12 - Twelfth Street

The past two years saw the entire 2013 USACE project's sand deposition disappear exposing the rocks and leaving a wet beach to the toe of the rocks. The Borough undertook additional restoration in July 2015 adding 209.12 yds^3/ft. in new sand to this site. The July cross section illustrates the berm configuration immediately following sand placement. Erosion since the project has taken 95.59 yds^3/ft. of sand, accompanied by 159 feet of shoreline retreat. Half the sand is gone and not deposited offshore as the five cross sections illustrate. All end at the same elevation in 15 feet of water 1,300 feet seaward of the reference location. Storms in January 2016 did not seriously impact this beach, leaving most of the remaining sand in place as of mid-February 2016.

The sand lost must have been transported south toward the middle of the island. The process involves residence time offshore between 17th and 31st Streets before a fraction makes its appearance on the beach near 35th Street.

2a. June 11, 2015

2c. January 26, 2016

2b. June 15, 2015

Photographs 2a to 2c. 12th Street Views to the south.

Photograph 2a shows the 12th Street entrance just prior to the Avalon beach restoration where the rocks were exposed, the sand wet to the rocks, a condition that had existed since the previous winter.

View 2b taken just after the July project was complete looking southeast from the dune crest across the new beach entrance ramp onto the wide berm present following the fill.

View 2c was taken January 26th following the NE storm Jonas. The access pathway was cut into a scarp near the location of the revetment rocks, but the beach was still high and wide enough to not have them exposed to wave action. The dune scarp diminished rapidly in both directions from 12th Street.

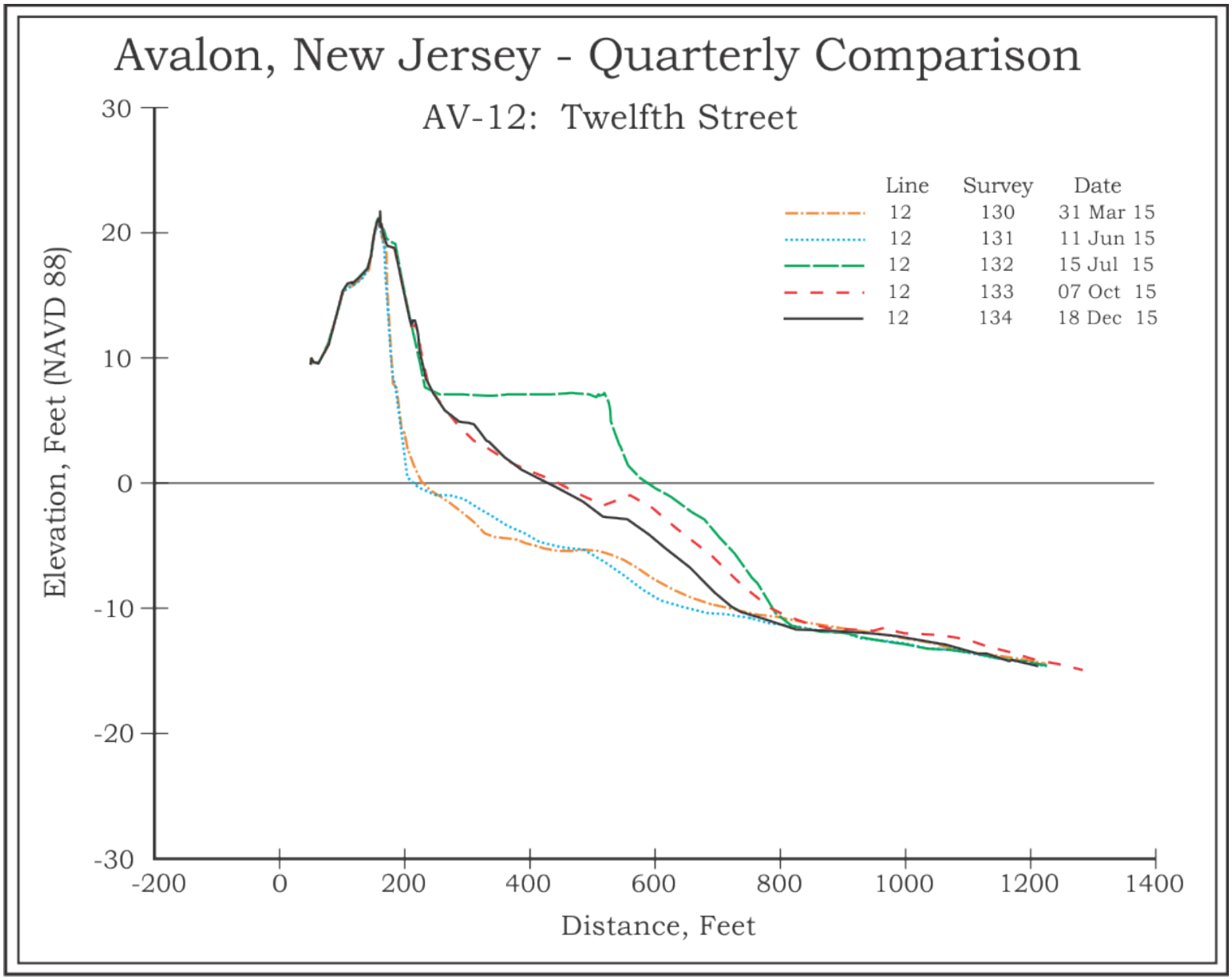

Figure 2. The first two quarters of 2015 show the eroded state of the site with the rock revetment exposed and a steep dune scarp from the dune crest dropping straight down to the rocks. By July the berm was in place with added beachfill advancing the shoreline 374 feet between the June and July surveys. Since then the shoreline has retreated 159 feet while the sand volume declined by 95.59 yds^3/ft.

AV-17 - Seventeenth Street

The profile is located at the southern terminus of a rock revetment which continues north to 8th Street. No rock exposure occurred during the erosional phase that ended with the July sand placement. The project added 125.13 yds^3/ft. with a 231-foot shoreline advance. The beach fill and the two subsequent survey cross sections all remained relatively constant offshore without much change. The beach flattened out with a loss of 46.75 yds^3/ft. as the shoreline retreated 71 feet. Note that all five profiles merge at the same elevation offshore a 950-foot distance from the reference position.

3a. June 8, 2015

3c. January 26, 2016

3b. July 15, 2015

Photographs 3a to 3c. 17th Street, view to the south.

Photograph 3a shows the narrow dry beach at 17th Street just prior to the Avalon beach maintenance project. The dunes were still unaffected by the sand loss, but the need for maintenance was real.

View 3b following the beach fill in July, the width of the berm and the scale of the deposit is apparent in this view. The cross section below shows the vertical plane as the flat berm surface.

View 3c shows the impact of NE storm Jonas where the storm waves reached the dune toe and cut a small scarp into the accumulated wind deposit there. The berm is much narrower with a flatter beachface, but still provides a considerable buffer at this moment.

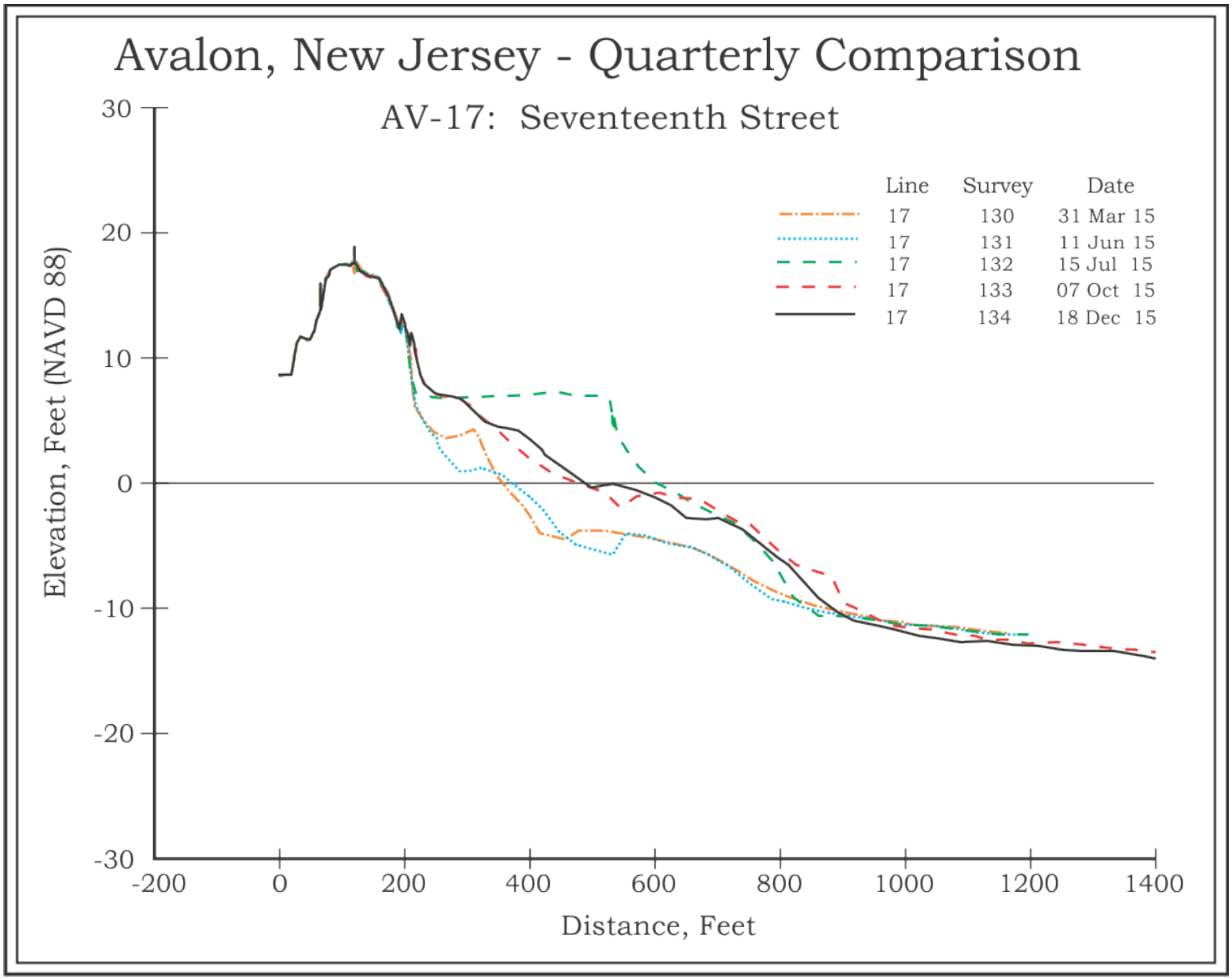

Figure 3. The five surveys document the retreat following the 2013 USACE project and the recovery produced by the 2015 Avalon Borough maintenance effort. The shoreline advanced 231 feet as the new berm was deposited. The subsequent adjustments reduced the sand volume by 46.75 yds^3/ft. along with a 71-foot retreat in the shoreline.

AV-23 - Twenty Third Street

The 23rd Street cross section is located seaward of the Avalon boardwalk near the southern end of the engineered beach and federal project. Sand loss had taken the beach back to the dune toe and produced a scarp in the foredunes. Sand placement in July 2015 created an extensive berm as 123.36 yds^3/ft. in new sand was added. The shoreline advanced 216 feet in the process.

Since then retreat was extremely rapid, achieving near total removal by October 7, 2015. The additional change by December was positive on the beach and neutral offshore as bar crests and troughs filled in or leveled off. The July to December change was a loss of 75.65 yds^3/ft. and a 192-foot shoreline retreat. Most of the remaining sand is to be found below the elevation of low tide. The beach width is but 24 feet wider than it was prior to the July beach fill.

The five profiles merge to one elevation 1,000 feet seaward of the reference line which strongly implies that there is little seaward transport taking place into water over 15 feet deep. This sand loss is most likely moving south toward the 35th Street region.

4a. June 11, 2015

4b. July 15, 2015

4c. January 26, 2016

Photographs 4a to 4c. 23rd Street, views to the north.

Photograph 4a shows the dune erosion present a month prior to the beach maintenance effort. The pipeline is exposed to the dune and the beach is fairly narrow.

View 4b was taken immediately following sand placement. The equipment area is still fenced off up the beach. The storm pipeline is buried to the outfall in new sand.

View 4c as of NE storm Jonas the beach width and elevation was severely reduced. Even the December 18th survey before Jonas shows nearly total loss of the berm width and the photograph clearly shows the storm pipeline exposed to the dune toe once again. The erosion focus at 23rd Street is relatively new and perhaps a consequence of the specific wave directions in the two northeasters that occurred between July and this photo.

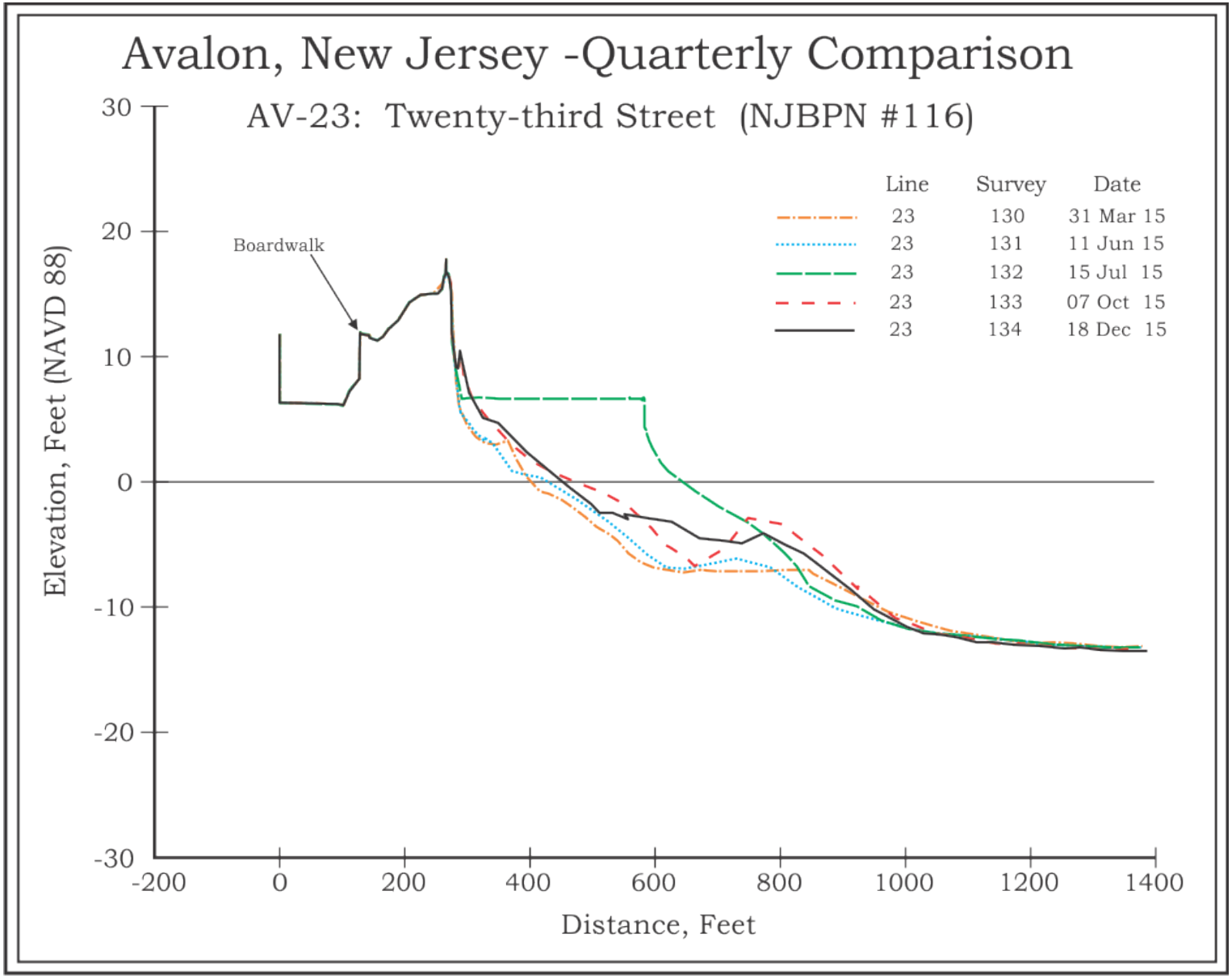

Figure 4. The five surveys really show the speed at which sand moves away from the locality where beach maintenance places it. The berm built in July 2015 had eroded within 24 feet of the June location by October 7th. Of the sand placed 75.65 yds^3/ft. moved south or remained in the immediate offshore region as a bar.

AV-28 - Twenty Eighth Street

The 28th Street location is situated along the barrier island where the shoreline curves slightly to the west altering the angle or approach for northeast waves, which results in a lower impact from the erosion that plagues the beaches to the north. This site also benefits from predominant longshore current transport of sand south from the north end erosional beaches. Although included in the federal project scope this beach is typically located near the taper end of the USACE maintenance projects. The 2015 Avalon beach maintenance did not directly place any sand on this location either. The two early surveys prior to the fill were relatively stable. The July survey fell directly among those two surveys indicating little change.

The post-fill surveys seem to provide the evidence that sand moves south offshore, creeping back up slope as an offshore bar that appears at the 800-foot distance in October and grows substantially larger by mid-December 2015. The berm accumulates a decent profile by December as well due to cross shore transport of the sand extracted from further north.

The site gained 46.66 yds^3/ft. between July and December accompanied by a 42-foot shoreline advance seaward. The magnitude of the sand volume increase indicates influx from the beaches to the north.

5a. June 11, 2015

5b. July 15, 2015

5c. January, 26, 2015

Photographs 5a to 5c. 28th Street, views to the south.

Photograph 5a was taken just prior to the beach maintenance. The beach and dune system were adequate for normal activities and minor storm events.

View 5b show the 28th Street beach following the July beach fill project. No sand was added this far south, but subsequently, evidence points to sand migrating here largely in the offshore portion of the profile.

View 5c is a view 2 days after NE storm Jonas that took a bite out of the dune toe slope and flattened the berm beyond that shown in the December 18, 2015 profile below. Material lost was transported south and offshore.

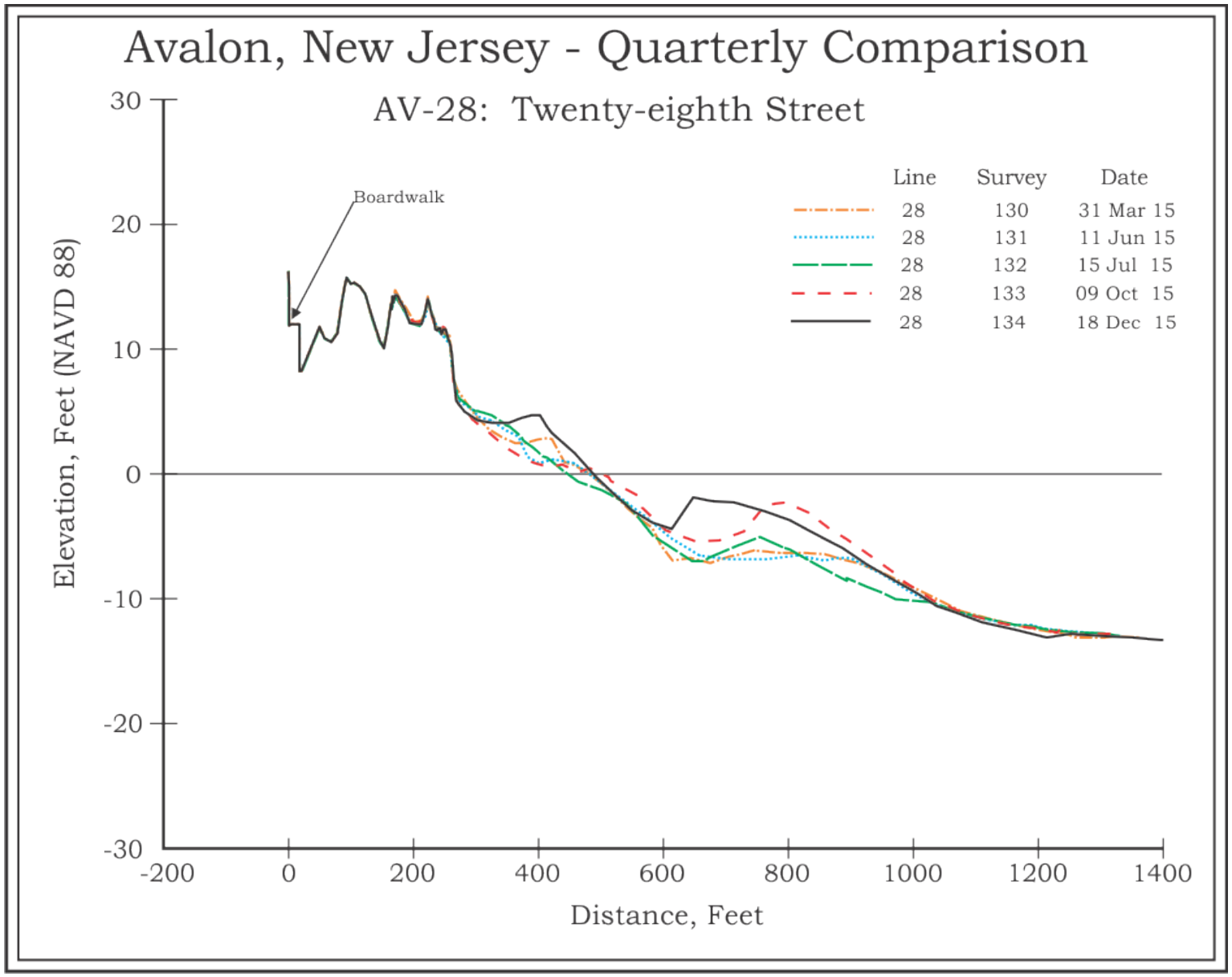

Figure 5. Positioned south of the vast majority of maintenance fill efforts, this site gains sand as those to the north lose material. The creation of the substantial offshore bar and the berm came at the expense of the sites between 9th and 23rd Streets. Bar growth indicates that the accumulation occurs via littoral transport after the beach erodes and sand moves offshore.

AV-35 - Thirty Fifth Street

No beach restoration sand has ever been deposited on this site. The beach has accreted sand ever since 1987 when beach nourishment occurred for the first time. The primary dunes mark the old shoreline position in 1987.

The first three surveys in 2015 are relatively similar with the October profile showing a sizable offshore bar that appears at the 1,400 to 1,600-foot distance. The sand is likely derived from the July fill providing a new slug of material. The bar grew larger by mid-December and advanced toward the shoreline. In addition, sand accumulated as a significant berm as lower beach sand was moved up slope to create it.

The annual sand volume change was a 32.01 yds^3/ft. gain, but with a 49-foot shoreline retreat produced by berm growth and beachface steepening. The vast majority of the new material was added at or below the zero elevation datum.

6a. April 1, 2015

6b. December 20, 2015

6c. January 27, 2016

Photographs 6a to 6c. 35th Street, views to the north.

Photograph 6a shows the conditions at the end of the first quarter of 2015. The dune toe has accumulated sand nearly to the top of another row of fencing.

View 6b photo taken in December 2015 shows deposition around a new row of fence as the process of dune growth continues. Work is in progress on the fishing pier.

View 6c was taken as a survey was done on the northern borrow area reserved for sand backpass operations. This view was taken 3 days after NE storm Jonas and is the southernmost post-storm picture in the set of surveys. The wave run-up reached the proximity of the dune toe, but did no harm. The beach berm is flat and a large bar system had developed offshore.

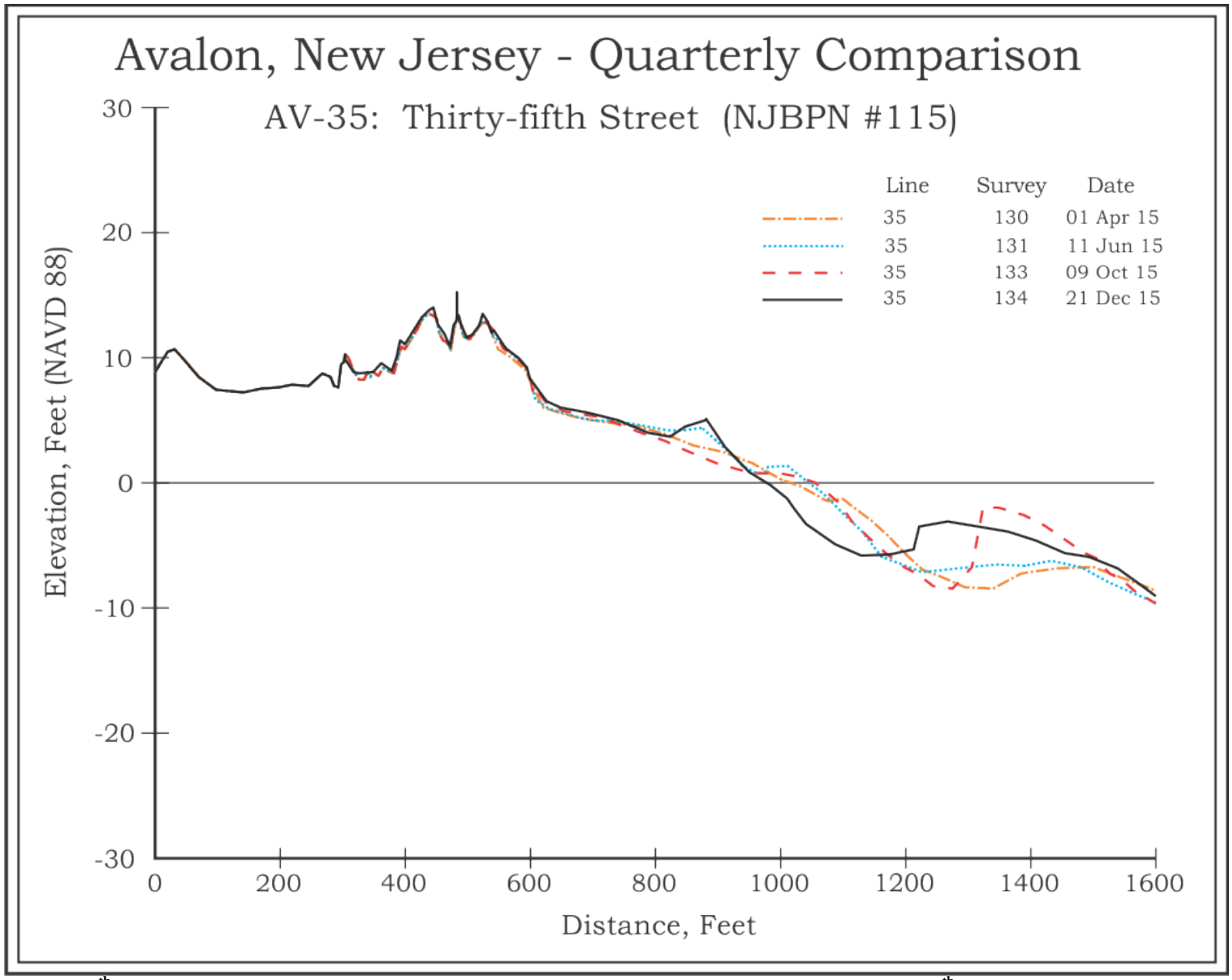

Figure 6. 35th Street is the northernmost dune park profile which starts at the end of the paved street, but 35th Street only extends a third the way from Dune Drive to the beach. The primary dune grows larger each year with the seaward most segment rising to reach parity with the landward peak in 2015. Sand added offshore likely had its origin in the July 2015 beach fill excavated since placement and transported offshore to generate the bar system that appears by October and advances landward as of December.

AV-44 - Forty Fourth Street

Located in the Avalon "High Dune Area" comprised of over 100 acres of premier coastal dunes along the New Jersey shoreline, this site has gained sand over the last two decades of monitoring. The location has a 1,000-foot wide zone of dunes between the 50-foot elevation primary dune along Dune Drive that is populated by multiple ridges of lower elevation because they accumulated and expanded quickly over many decades as the beach accreted seaward. The site also is within the natural exclusion zone primarily established to preserve habitat for endangered and threatened shorebirds. Despite the abundance of available sand accumulating in this region annually no sand has been harvested from this region during the Borough's multiple sand back-passing programs.

The primary dune has been superseded by the growth of a foredune ridge at the edge of the grass. This dune area has multiple gaps yet without vegetation making it ideal habitat for the piping plover and least tern during the summer.

Dynamic bar development added sand to the offshore region here after the June survey. The annual changes were small and confined to sand added to the beach (+8.40 yds^3/ft.). Offshore bar trough deepening and landward migration resulted in a net increase of 0.044 yds^3/ft., essentially zero. Variations in sand position amounted to 15 to 24 yds^3/ft. along the submerged parts of the profile.

7a. April 1, 2015

7b. December 21, 2015

7c. December 16, 2014

Photographs 7a to 7c. 44th Street, views to the north & south.

Photograph 7a is a view northeast across the foredune area with the wide dry beach reserved each summer for piping plover nesting. The rapid dune growth is not enhanced with fences, so the gaps in grass colonies allow good habitat for the birds.

View 7b is the same view in December showing grass growth with sand deposits in new locations as the seasons came and went.

View 7c is a view to the south in December 2015 showing the access pathway leading back to Dune Drive.

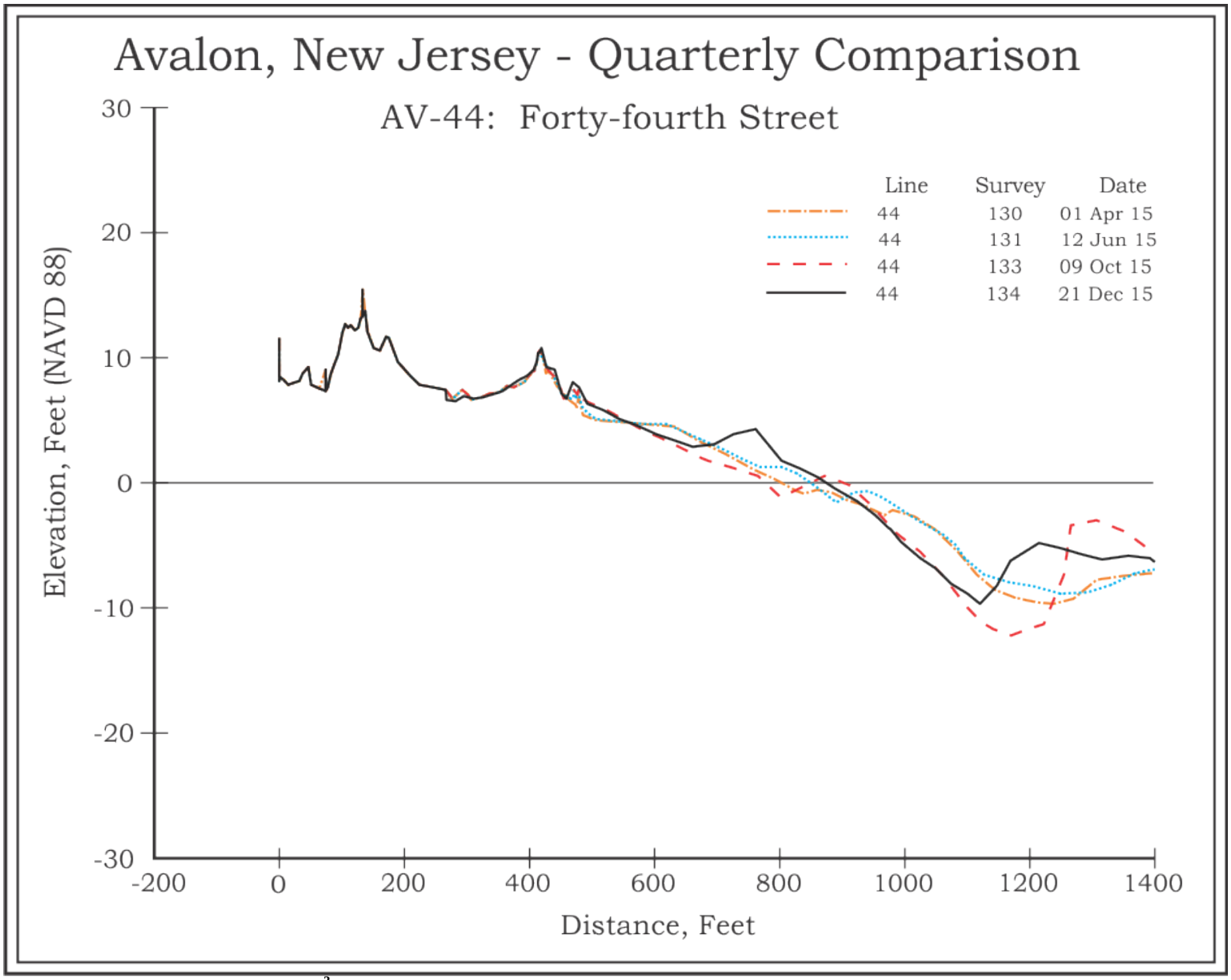

Figure 7. The beach gained 8.40 yds^3/ft., while little change occurred offshore over the past 12 months of surveys. The berm in December reflects the mild early winter where temperatures reached into the 70's.

AV-58 - Fifty Eighth Street

This site lies at the southern margin of the Avalon high dune area and natural area exclusion zone. Development from 58th Street south extends east of Dune Drive along numbered streets toward the beach. The 58th Street site has shown a long term accretional trend over the monitoring history. The surveys extend over 1,600 feet seaward of the reference location and cover a range in bar development that is quite extensive. The old and highest segment of the primary dune has been added to at the seaward side widening it by nearly 150 feet.

During 2015 the site added 11.95 yds^3/ft. above the datum, lost 0.31 yds^3/ft. below the datum with a shoreline position change of -1.4 feet. The dry beach is over 250 feet wide at this location.

8a. April 1, 2015

8b. December 21, 2015

8c. December 21, 2015

Photographs 8a to 8c. 58th Street, views to the north along the seaward dune toe and mid-beach.

Photograph 8a illustrates the broad expanse of the dry beach that extends seaward from the edge of the dune grass early in the season when sand accretion is more common.

View 8b is a view looking north in December across the wide, dry beach with the accretional dune toe in the distance.

View 8c shows the December 2015 beach mid-way between the dunes and the high tide line at 58th Street.

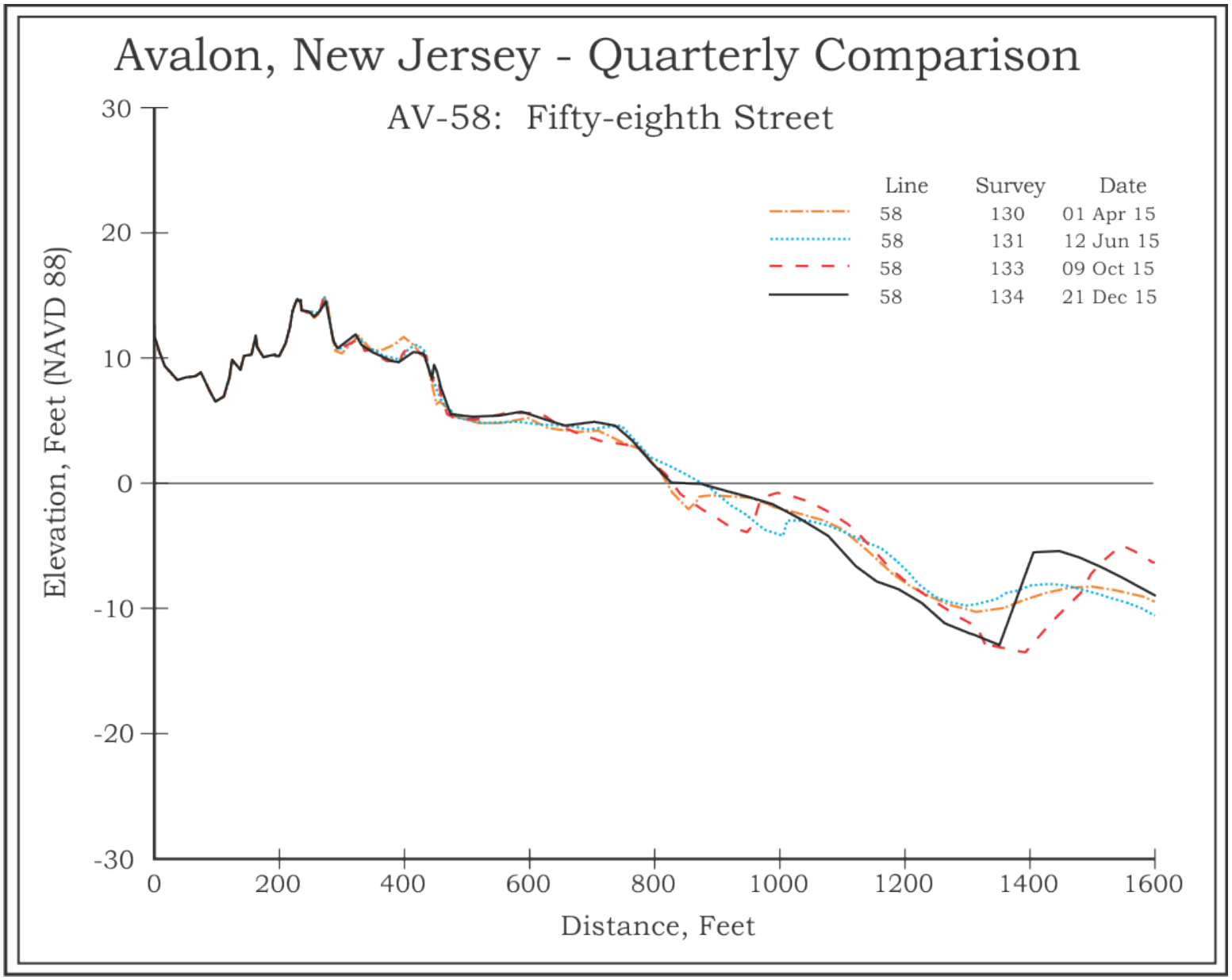

Figure 8. 20 Years of accretion has generated a significant dune, a 250-foot wide beach and a massive bar system offshore. This is the start of an even larger, more distant bar set extending south into Stone Harbor.

AV-70 - Seventieth Street

The 70th Street dune cross section is 250 feet wide with a crest elevation of 16 feet NAVD88 seaward of the development. This current dune configuration expanded seaward since 1998 by aeolian processes derived from sand on the wide dry recreational beach area. Repeated fencing installation over the past 18 years has driven the seaward expansion of the dune. The wider beaches in this region not only support continued dune growth but have been used as a southern borrow zone in previous sand backpassing project, no sand was harvested from this location during the 2014 project.

Located just outside the limits where the Stone Harbor section of the 2003 Seven-Mile Island Shore Protection Project commenced to add sand, the location is very stable.

The changes were continued addition to the dune, a well developed berm and a very sizable growth in the sand found in the offshore bar system.

The beach gained 15.55 yds^3/ft. while the offshore lost 8.17 yds^3/ft. and the shoreline retreated 17 feet during 2015. The deep trough in the bar system is the region generating the sand volume loss offshore. The trough excavated 38.79 yds^3/ft. between the 908 and the 1,372-foot location.

9a. April 1, 2015

9b. December 21, 2015

9c. December 21, 2015

Photographs 9a to 9c. 70th Street, views to the north & south.

Photograph 9a shows the dune toe and beach conditions at the beginning of April 2015. The new fence has already started to accumulate sand

View 9b shows a near identical view with the new fence all but buried following the passage of the rest of 2015.

View 9c shows the view to the south along the same fencing placed earlier in the year.

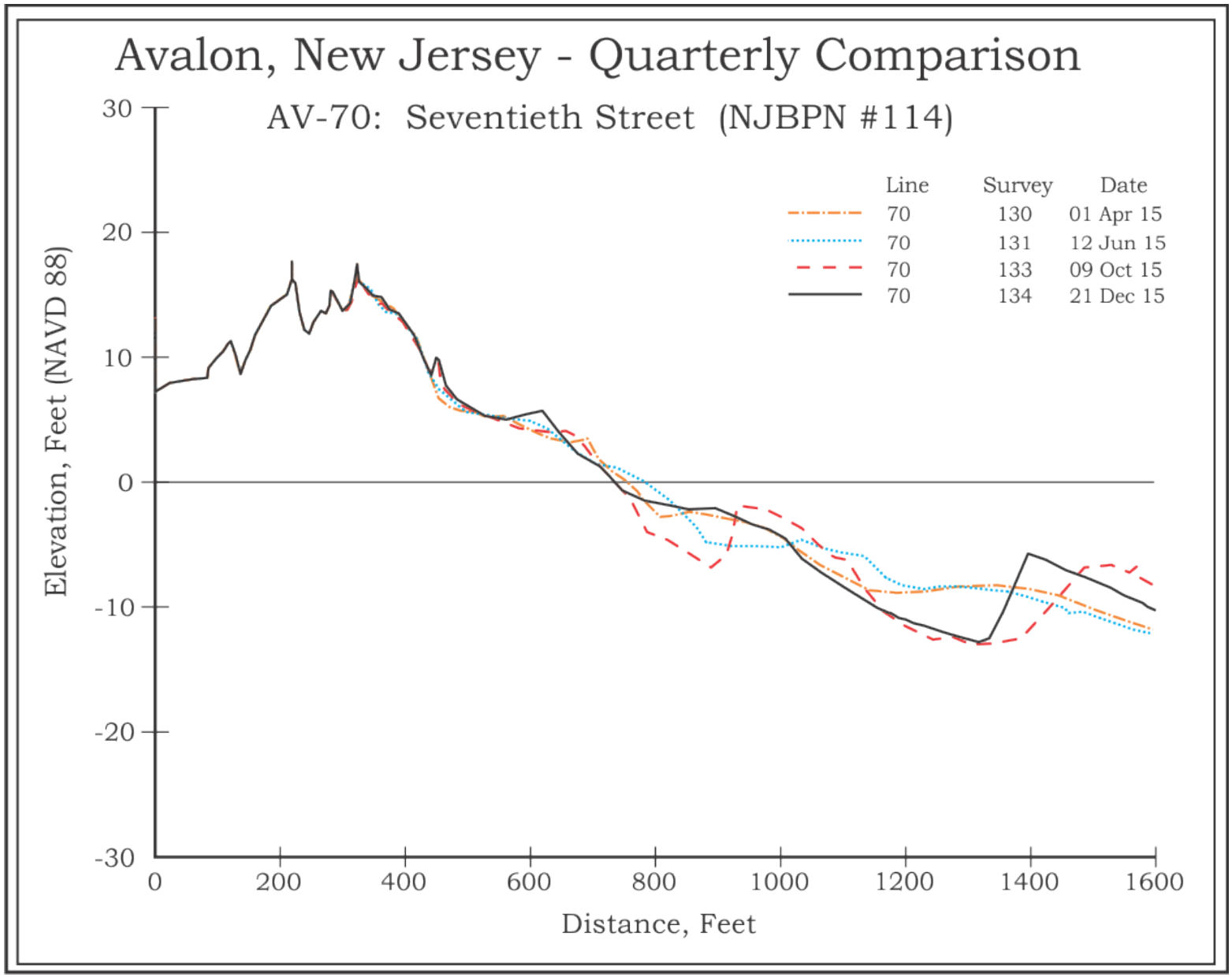

Figure 9. The old primary dune lies landward of a new crest that equals the original elevation years later. There is a small foredune developing at the toe of the new crest. Sand was arranged into a large offshore bar with a deep trough that appeared by October and advanced marginally landward by mid-December 2015.

AV-78 - Seventy Eighth Street

This site is located just two blocks from the boundary with Stone Harbor in front of the Avalon hotel district. The dune is 170 feet wide and rises to an elevation of 18 feet. This site has periodically received sand as part of the federal project for southern Avalon and Stone Harbor. As a result of the commercial development's encroachment on the landward dune slope the dune system and beach are slightly narrower than the sites to the north.

However, this dune also has developed a second crest seaward of the original. The two early cross sections show no pronounced offshore bar, while the second pair demonstrate how dramatic this shift can be. The annual change was a 5.31 yds^3/ft. gain in beach sand volume, but a -16.52 loss offshore attributable to the deep trough (-49.03 yds^3/ft. between 852 and 1,188 feet offshore from the reference location). The naturally excavated sand from the new trough moved onto the beach to build the berm and further offshore building the bar crest elevation.

10a. April 1, 2015

10c. December 21, 2015

10b. December 21, 2015

Photographs 10a to 10c. 78th Street, views to the south & north.

Photograph 10a shows the dune and beach from near the instrument set-up position. The beach width is partially due to the 2003 federal project and partly all natural accretion.

View 10b shows December view from the dune toe slope to the south with the dry beach extending into Stone Harbor.

View 10c was taken on the same day looking north along the dune toe showing the view back into Avalon.

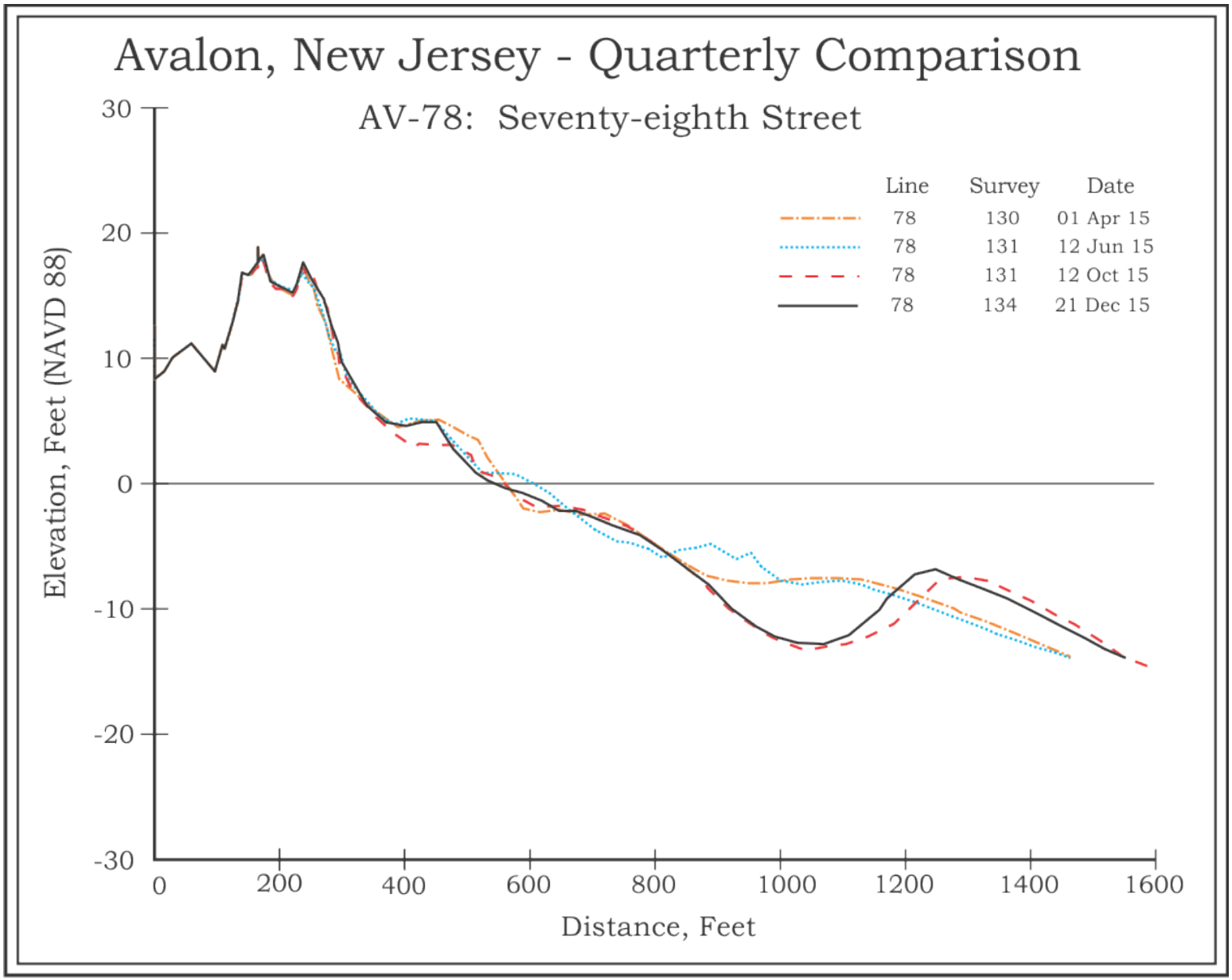

Figure 10. The double crested berm is a product of the wider beach and added sand since 2003. The site oscillates between a gentle offshore gradient without substantial bar systems and the later in the year pair of deep trough and high crest offshore bars shown above.

SUMMARY OF AVALON'S OCEANFRONT BEACHES:

The major event incorporated into 2015 was the Avalon Borough completing a 740,000 cubic yard beach restoration between 9th and 23rd Streets tapering to zero around 25th Street. The 2013 federal maintenance was decimated by late 2014 with the rocks between 11th and 12th Streets again exposed and the beach unable to prevent each high tide's waves from reflecting off them. Great Lakes Dredge and Dock Inc. performed the 2015 work deriving sand from the Townsend's Inlet borrow zone. The CRC did a special post-project survey of the 5 northern quarterly sites on July 15, 2015 and used the second quarter survey in June to provide a sand deposit summary. The 4th Quarter survey was compared to the July survey to gage the 6-month loss rate. In addition, an end of year survey was conducted using the 200-foot spaced engineered beach station lines to determine the project performance in 2015.

The most severe loss was at 23rd Street in terms of percentage of the fill removed, but the largest volume came from 12th Street where half the 216 yds^3/ft. was moved away. Prior to Jonas in January 2016 the beaches looked pretty good with no rocks showing, or scarps in the dunes.

The fall storms started with an odd, long-duration northeaster that started October 4th and lasted until October 6th with winds about 25 MPH average. This did manage to build 6-foot seas and generate strong southward transport of sand.

After the event the conditions calmed down, temperatures remained mild, reaching 70 degrees in December. No winter storms appeared until January 24, 2016 and was serious enough to be named Jonas. Rated a 10-year storm, tidal flooding raised the water levels so waves reached to the dunes and cut scarps in many places. Avalon's beaches faired far better than those in Stone Harbor where at the south end of the island the dune was eroded back into 15-foot high scarps. No overwash occurred, but water invaded among the lower foredunes in the 35th to 44th Street sites.

Two weeks later another northeast event took place, also within a spring tidal cycle, and extended the attack on beaches. These results were documented in Table 4 showing 75,787 cubic yards of additional sand from the project beaches. If the subsequent evaluation across Cape May and Atlantic Counties generates sufficient damages, there may be a limited disaster declaration for these events and perhaps subsequent work effort to restore the scarps for the coming season.

Townsend's Inlet Bathymetric Survey:

This year's work included a first-ever survey of the entire ebb-tidal shoal system of Townsend's Inlet from the southern segment of Sea Isle City to about 9th Street in Avalon back to the inlet bridge. The reasoning is related to long standing theory that the original placement of the approved inlet borrow zone used repetitively since 1987 for sand to maintain Avalon's and Sea Isle City's beaches (since 1978) at a thousand foot distance from the revetment rocks in Avalon was counterproductive to allowing inlet bypassing to transfer sand from the Sea Isle City side of the inlet shoals to the Avalon shoreline.

During 2015 the USACE introduced 3.4 million cubic yards of sand onto Ludlam Island's oceanfront completing this section of the NJ Shore Protection program. The sand was mined from ancient deposits over two miles offshore and never previously deposited on the modern NJ beaches. This infusion of new material will be winnowed and moved by the northeast storm events to eventually start to appear as vast bar deposits within the Townsend's Inlet ebb-tidal shoal system.

To better define this process and to cover implications this deposition may have on supplying at long last new sand supplies to the Avalon beaches north of 28th Street, the Borough approved the CRC survey shown below as a Digital Elevation Model for the inlet as of November 2015. The data was collected using Hypack

software, RTK-GPS and an Echo-Trac digital depth sounder combined on the RV Osprey, a 24-foot research vessel. This initial survey was fortuitously scheduled for a day when there were essentially no waves at sea. The operation was able to cover the entire ebb shoal system even into water of under 3-foot depths at high tide. The survey lines start at the dune and cross the beach into the water using traditional land surveying methods, where the vessel continues to cover the ocean floor to depths of 30 feet offshore. The ebb-tidal flow deposits sand into the ocean outside the inlet where the waves then mold the material into the typical spoon-shape with the main channel located somewhere within the shoals. In the Townsend's Inlet case, the main channel lies medially with the lion's share of the shoal sand to the northeast of the channel closer to Sea Isle City. This situation has been true for several decades since beach nourishment has been using the inlet as the sand source. Dredging the material from a zone starting over 1,000 feet northeast of the Avalon shoreline has maintained this location since 1978.

Older aerial photographs document main ebb-tidal channels pressed tight against the Avalon inlet shoreline, a fact previously responsible for the erosional loss of Avalon Streets numbered lower than 7th Avenue. The severe erosion in 1962 drove the urgency to construct the rock jetty and revetment along the inlet shoreline afterward to stop this progressive erosion.

Sand shows as exposed over wide areas in the ebb-tidal zone in these older photographs. These deposits have slowly disappeared due to excavation for beach restoration in both municipalities since 1978. With the introduction of the new Ludlam Island-wide offshore sand supply in 2015, the long shore transport of this sand should restore large ebb-tidal shoal deposits that will, hopefully, duplicate the pre-1978 situation.

Figure 11. 1971 aerial photograph of Townsend's Inlet after construction of the 8th Ave. jetty, the rock revetment and 3 short finger groins in the inlet. The main channel lies next to the revetment with vast shoals exposed at low tide immediately northeast of the channel. Note that the seaward parts of the shoal wrap around the inlet mouth and contributed large slugs of sand to the beach lying between the jetty and 17th Street in Avalon. At this time there was a 465-foot wide vegetated dune system seaward of the end of 17th Street before reaching the dry, high tide beach. Flood tidal currents and storm wave action moved sand over the jetty into the inlet where the ebb-tidal currents carried it back out to the shoals for eventual return to the north end beach. A stable cycle of sediment was in place.

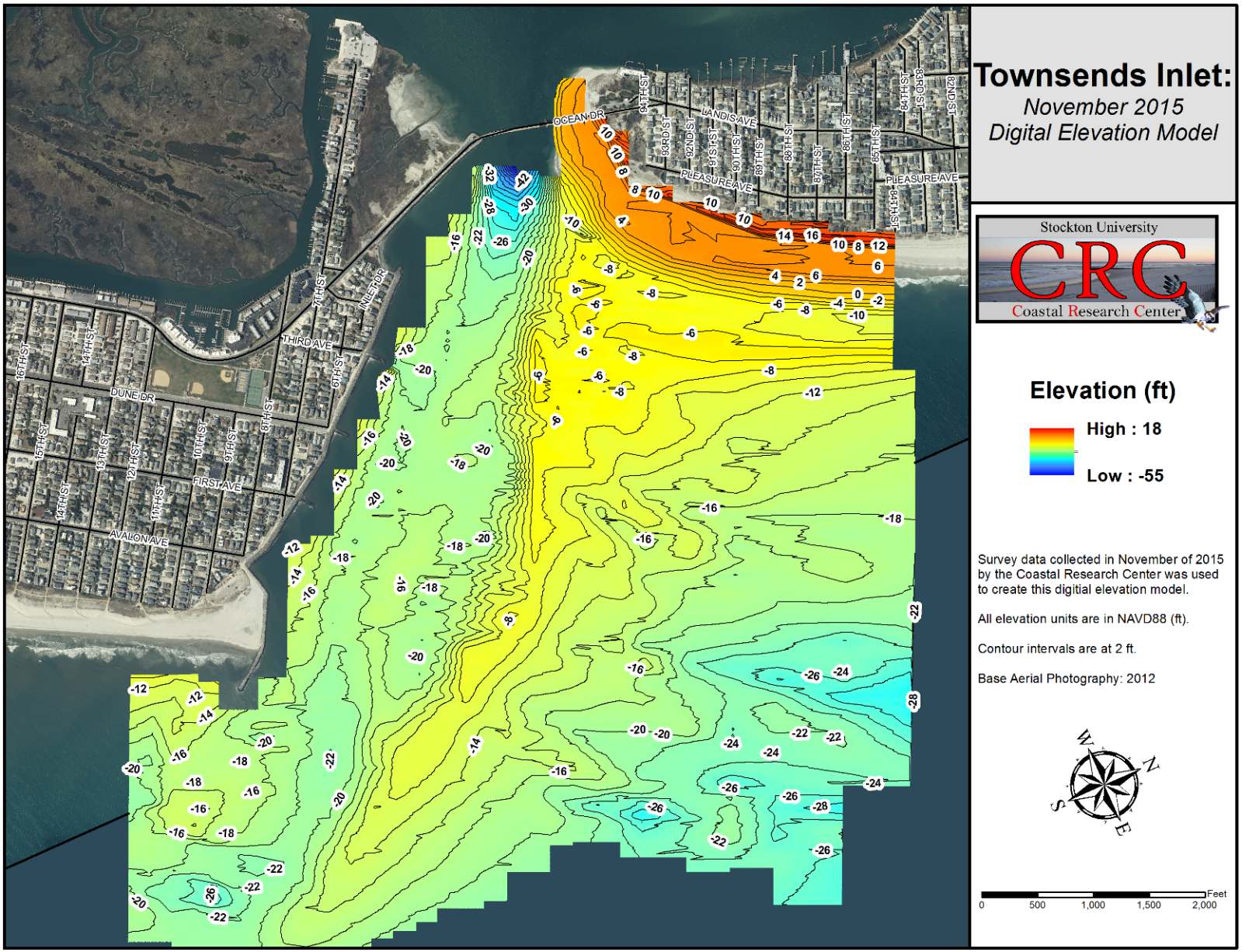

Figure 12. November 2015 survey of Townsend's Inlet, Cape May County, NJ showing the beach in Sea Isle City with the shoal system attached to the nearshore region and extending seaward along the main ebb-tidal channel of the inlet. The deep scour under the inlet bridge does not extend far out the inlet channel where average depths range between -18 and -20 feet in elevation. The elevation on the top of the shoal extending seaward is -4 feet at the nearshore region gradually getting deeper very gradually over a 3,000-foot distance toward the southeast. In the 1970's the sand was exposed in this region, closer to the Avalon inlet shoreline as well. It is anticipated that the 3.4 million cubic yards of sand added to Ludlam Island will reconstitute this shoal system to its pre-dredging for beach fill status.

Above is the November 2015 survey of the inlet done as the initial survey prior to any of the Ludlam Island beach nourishment material reaching the ebb tidal shoals. Each year, a repeat of this survey will be compared to show changes and where sand is being distributed by the tides and waves within the shoal system. Presently, the shoals are not exposed at low tide, but covered with about 2 feet of water at a minimum. During moderate surf conditions, white breakers surround the area making access difficult to impossible as the breaking waves are doing their jobs in moving sand into the shape seen. The tidal currents act to distribute sand along the axis of the feature and when the flood tide is running with big waves breaking the entire shoal is shifted southwest toward Avalon.

Ebb-tidal currents and waves act to allow sand to extend the feature seaward along its axis to a point where waning currents allow just the waves to mold the shoal around the inlet opening and set the stage to by-pass a large volume of sand to Avalon when and if a breach occurs somewhere back along the northeast axis toward the Sea Isle City beach. The main channel shifts to the new breach and this allows the detached section, however big, to be redistributed toward the Avalon shoreline. This is how inlet sand by-passing occurs.

The 2015 Post-Avalon Beachfill Assessment:

The CRC staff used the US Army Corps of Engineers project cross sections within the project to survey the Borough's project completed in mid-July 2015 to compare the post-construction data with data collected in November 2015. The CRC utilized RTK-GPS combined with a total station transit and swimmers to survey each of the lines to water about 10 feet in depth, where the CRC survey vessel continued the lines seaward to approximately 20-foot depths offshore. The boat data was collected in conjunction with the Townsend's Inlet survey under ideal wave conditions. The ground crew finished within a week of the offshore surveys.

As the individual site cross sections at 9th, 12th, 17th, 23rd, and 28th Streets have already demonstrated, there was substantial loss to the berm built by the project. The early October northeast storm, while not very intense, was of long duration and acted to move large volumes of sand south along the beach. The deep red colors on the digital elevation model below (figure 13) focus on the lost berm sand totaling 412,858 cubic yards. The green zone offshore starting at 15th Street and continuing south, growing wider to the limit of the survey contained 48,879 cubic yards clearly derived from the fill volume. The surveys end without covering 88% of the lost volume. Jonas continued this sand movement adding ever greater volumes to the middle of Seven-Mile-Island.

Given the costs associated with bringing in a hydraulic dredge, setting up the distribution pipeline and staffing the project, it truly is difficult to accept the federal and state regulatory agencies refusing to allow recovery of the lost resources from the beaches between 31st and 70th Streets in spite of repetitive documentation of steady state accretion along the segment. Three pilot projects have demonstrated that sand volumes extracted are 2 of 3 times replaced within the borrow zone entirely before the project wraps up with the after-project beach profiling.

A program where in the absence of the endangered species, the beachface could be mined at a 5 to 10 cubic yards of material per foot of shoreline across the 10,000 feet of accretional area (35th to 70th Streets) could produce enough sand to maintain the 9th to 28th Street beach to reduce the need for the dredge to as little as once a decade. This appears to be a pipedream, given Avalon's multiple efforts to convince those responsible for the endangered species program that there would be no deleterious impact from such a program on any of the bird species or loss of habitat suitable for the next season's nesting.

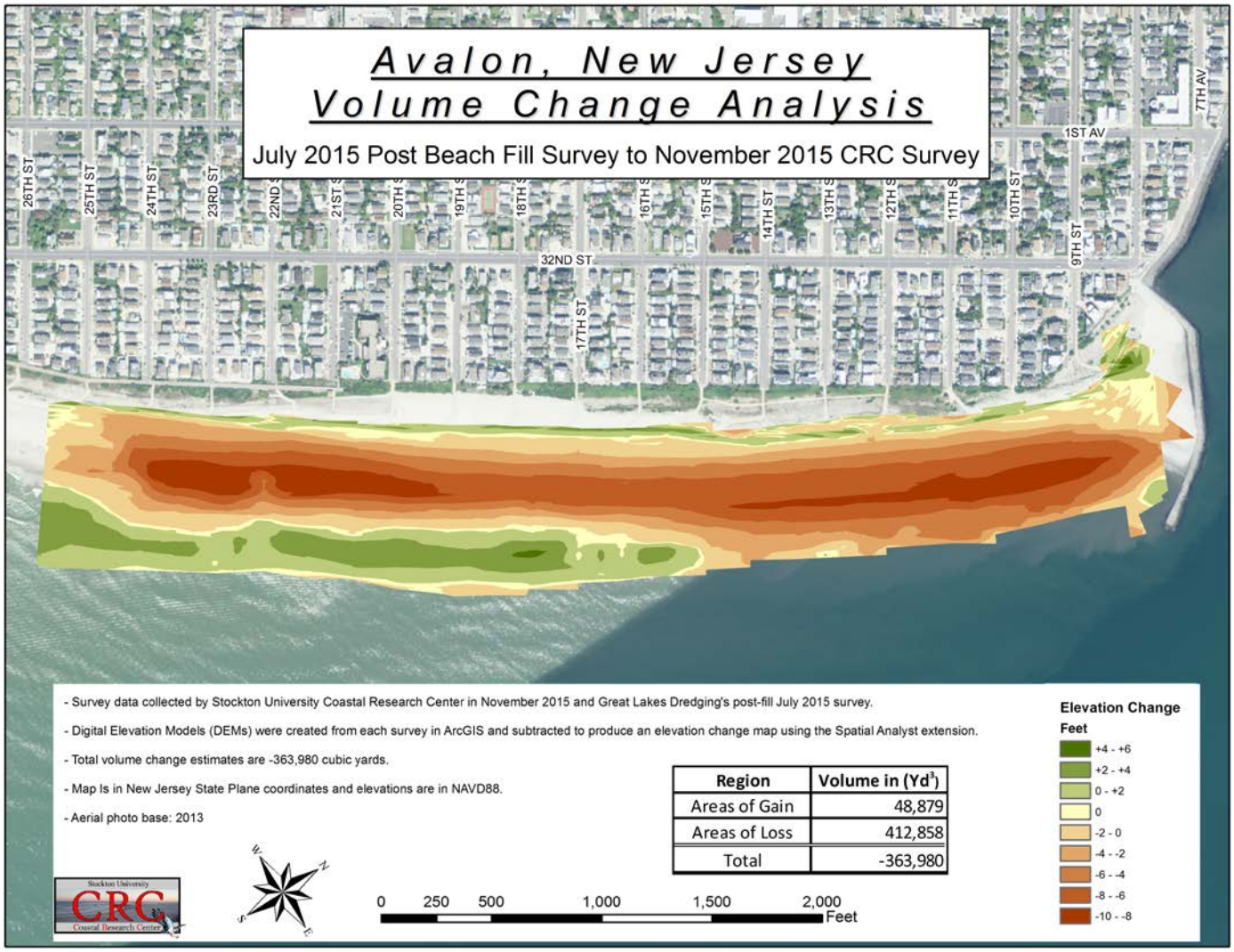

Figure 13. Digital elevation comparison between the immediate post-construction of the 2015 beach nourishment project in Avalon with similar site data taken in November 2015. The loss rate was substantial driven by the initial 3-4 day northeast storm in early October 2015 and likely enhanced by northeast storm Jonas January 24, 2016. Berm loss was not associated with any offshore gain from the 8th Street jetty, south to 15th Street. An offshore bar commenced at 15th Street and grew wider and higher to the south indicating that sand cut from the berm has been deposited offshore AND south along the Avalon oceanfront.

Conclusions:

The Borough of Avalon expended millions of dollars on a major sand replenishment effort in 2015 that has survived into 2016 at about 60% of the original placed volume. The worst beach is 23rd Street where nearly all the added sand is gone. The beach is still sufficient for use and protection, but the deposit has moved south to be distributed between 35th and 70th Streets inexorably adding to their sand budgets.

Work proceeds to consider a sand back-passing effort to repair the storm damage shown from two early 2016 northeasters and be ready for the coming summer season.

The Ludlam Island project is complete and the initial inlet survey shows where the sand supply is available and what its configuration is and gives a hint of where sand might be added to assist in supplying new material to Avalon without their needing to fund a dredge to pump it to the Borough.