FINAL REPORT FOR 2021
ON THE CONDITION OF THE MUNICIPAL OCEANFRONT BEACHES
BATHYMETRY OF TOWNSENDS INLET
THE BOROUGH OF AVALON, CAPE MAY COUNTY, NEW JERSEY

View of the Avalon oceanfront May 13, 2021 showing the extent of the 2021 sand back-passing operation underway to add additional sand from the 32nd to 38th Street region. The sand was extracted from the intertidal zone, stockpiled on the berm then loaded into trucks that drove to the placement area between 12th and 17th Streets. 56,000 cubic yards of sand were moved. PHOTO by Ted Kingston.

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ANNUAL REPORT FOR 2021 - TO THE BOROUGH OF AVALON
ON THE
CONDITION OF THE MUNICIPAL BEACHES & BATHYMETRY OF TOWNSENDS INLET

Introduction:

The 2021 annual report provides the results and analyses from the fall 2020 to fall 2021 survey datasets from the 40 years of oceanfront surveys for Avalon. This report continues looking at changes seen since the 2019 US Army Corps of Engineers-sponsored beach restoration. Additionally, the 2021 spring effort to add sand to the engineered beach zone was fortuitously captured by the CRC pilot on May 13th in action. It was the seventh year of evaluation of conditions in the ebb-tidal shoals of Townsends Inlet. The entire inlet area was surveyed this December between 91st Street in Sea Isle City and 12th Street in Avalon two years after the US Army Corps maintenance during the fall of 2019.

Recent Fill Projects:

2013:	Post-Hurricane Sandy restoration;	USACE with 336,359 cubic yards.
2015:	Avalon restored the engineered beach;	740,000 cubic yards.
2016:	Avalon undertook a back-pass operation;	50,000 cubic yards.
2017:	USACE Maintenance of Avalon & Stone Harbor;	USACE with 944,000 cubic yards.
2018:	Avalon undertook a back-pass operation;	53,000 cubic yards.
2019:	USACE Maintenance of Avalon;	USACE with 571,351 cubic yards.
2021	Avalon's back-pass operation	56,000 cubic yards

TOTAL SAND VOLUME MOVED TO THE ENGINEERED BEACH SINCE 2013: 2,750,710 cu. yds.

Monitoring Program:

The CRC monitored the ten oceanfront cross sections four times in 2021 once each season. These surveying activities continue a monitoring program that started in 1981 with surveys between 9th and 28th Streets. 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 that started in 1987 with a local/state sponsored project. These data focus on project performance evaluation. Each topographic beach profile starts at a fixed reference position landward of the dune. The 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 156 December 11, 2020; 4th Quarter
- Survey 157 March 12, 2021; 1st Quarter
- Survey 158 June 1, 2021; 2nd Quarter
- Survey 159 September 14, 2021; 3rd Quarter
- Survey 160 December 3, 2021; 4th Quarter

Winter Storm Impacts:

The 2020-2021 winter months started with two northeast storms in late December which were subsequent to the December 2020 beach survey. The worst event occurred February 1 and 2, 2021 with moderate storm surge and wave activity. The impacts show in the March survey for the first quarter of 2021. By the time of the June survey all northeast storms had run their course with the last one occurring on the final weekend in May. Tropical systems had considerably more impact inland in New Jersey this August than on the oceanfront with

Hurricane Ida spawning both heavy rains and tornados inland as it tracked across the state into New England. The fall months saw several mild northeast storms with little measurable impact individually.

Quarterly Beach Changes in 2021:

Oceanfront beaches were surveyed quarterly to depict both seasonal and annual changes, erosional and recovery rates and to assist in storm damage assessments and project performance assessments. Table 1 below shows the individual profile site trends for sand volume changes quarter by quarter during 2021.

Table 1
2021 Oceanfront Beach Profile
Quarterly Sand Volume Changes at Each Survey Line Location

Profile Number	Winter 12/20 - 3/21 (yds^3/ft)	Spring 3/21 - 6/21 (yds^3/ft)	Summer 6/21 - 9/21 (yds^3/ft)	Fall 9/21 - 12/21 (yds^3/ft)
8th Street Jetty				
AV-9	198.52	11.18	-16.99	-52.71
AV-12	-58.90	37.81	-2.64	-32.07
AV-17	-35.11	-6.17	-2.09	-6.97
AV-23	-5.57	-13.05	-1.13	1.82
AV-28	-29.56	-4.13	3.83	3.69
AV-35	5.79	-19.55	10.05	-6.34
AV-44	-24.64	13.91	22.66	-8.93
AV-58	-8.78	-1.26	13.69	4.92
AV-70	-31.61	10.02	15.77	-10.83
AV-78	-3.82	2.96	-5.71	-5.89
Quarterly Volume Change (yds^3) =	**-189,487**	**44,735**	**163,372**	**-151,161**

The winter season recorded the highest volume of sand loss in spite of a large gain at 9th Street in the offshore region as inlet material deposited beyond 1,300 feet from the reference location behind the dunes. The spring season saw minor gains with the deposition at 12th Street the direct result of sand back-passing from 35th Street which recorded a modest sand volume loss. That loss was recovered during the summer season as the southern sites all gained sand save for 78th Street. During the fall season losses resumed reaching just over 150,000 cubic yards. For the year the Avalon oceanfront beaches lost 132,541 cubic yards if the large addition offshore at 9th Street is factored in. If only the normal offshore distance is used for 9th Street the loss volume rises to 202,791 cubic yards of sand. This is due to the sudden appearance of a large deposit of sand at the 8th Street jetty tip,

extending both further seaward and to the immediate south of the jetty including the transect line for the 9th Street profile extended further offshore.

Table 2 below shows the fourth quarter changes at each profile location where sand eroded from the engineered beach shoreline but deposited in almost equal volumes south of 28th Street. 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
2021 Oceanfront Beach Profiles
Fourth Quarter Sand Volume Change Sept. to Dec. 2021

Profile Number	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg.Volume Change (yds^3/ft)	Cell Distance (yds^3/ft)	Net Volume Change (yds^3/ft)	Cumulative Volume (yds^3/ft)
8th Street Jetty						
			-52.714	500	-26,357	-26,357
AV-9	-52.8	-52.71				
			-42.390	840	-35,608	-61,965
AV-12	-43.6	-32.07				
			-19.516	1400	-27,322	-89,287
AV-17	17.1	-6.97				
			-2.571	1680	-4,319	-93,606
AV-23	7.0	1.82				
			2.758	1400	3,861	-89,746
AV-28	18.9	3.69				
			-1.322	2025	-2,677	-92,423
AV-35	33.0	-6.34				
			-7.631	2510	-19,153	-111,575
AV-44	18.9	-8.93				
			-2.003	3925	-7,862	-119,437
AV-58	2.0	4.92				
			-2.956	3360	-9,932	-129,369
AV-70	-20.4	-10.83				
			-8.361	2240	-18,729	-148,098
AV-78	-7.9	-5.89				
			-5.890	520	-3,063	-151,161
Volume Change for the Entire Beach Between the Jetty & 78th St. =					**-151,161**	**(yds^3)**

The fourth quarter beach changes were negative at the very north end of the oceanfront as well as 4 of 7 sites south of 23rd Street to yield the -151,161 cubic yards of sand. The back-passing effort ended the year at 12th Street with the site breaking even after the sand was placed. Visual inspection on December 13, 2021 to survey Townsend's Inlet found that the sand fencing immediately in front of the 12th Street rocks were at the edge of current erosion limits on the berm. None of the down-beach losses were significant, but with the large distances between sites involved, the total sand loss ramped up considerably.

The third table below contains the direct annual comparison of survey 156 done during December 2020 with survey 160 completed in December 2021. This provides the annual assessment for 2021 beach changes.

Table 3
Annual Beach Changes
December 2020 to December 2021

Profile Number	Shoreline Change (feet)	Volume Change (yds^3/ft)	Avg.Volume Change (yds^3/ft)	Cell Distance (yds^3/ft)	Net Volume Change (yds^3/ft)	Cumulative Volume (yds^3/ft)
8th Street Jetty						
			8.476	500	4,238	4,238
AV-9	-40.0	8.48				
			-23.701	840	-19,908	-15,670
AV-12	-82.7	-55.88				
			-52.576	1400	-73,606	-89,276
AV-17	-51.9	-49.27				
			-33.286	1680	-55,920	-145,197
AV-23	9.6	-17.30				
			-19.980	1400	-27,971	-173,168
AV-28	-10.1	-22.66				
			-16.713	2025	-33,843	-207,011
AV-35	4.3	-10.76				
			-2.735	2510	-6,864	-213,874
AV-44	49.1	5.30				
			9.349	3925	36,693	-177,181
AV-58	-6.6	13.40				
			0.289	3360	969	-176,212
AV-70	-11.3	-12.83				
			-10.137	2240	-22,706	-198,918
AV-78	1.5	-7.45				
			-7.448	520	-3,873	-202,791
Annual Volume Change for Oceanfront Beaches =					**-202,791**	**cu. yds.**

The annual sand volume change amounted to -202,791 cubic yards dominated by the losses to the 2019 US Army Corps maintenance work between 12th and south to 17th Streets accounting for 129,526 cubic yards with over 80 feet of shoreline retreat at 12th Street. From the 23rd Street site south the situation moderated with lower loss rates finally ending with positive results at 44th Street. These next two sites saw positive sand volumes that reversed again with minor losses at the southern two sites.

Going back to Table 1 on page 2, the 198.52 $yds^3/ft.$ value at 9th Street for the first quarter of 2021 in sand volume added counts this major deposit of sand around the 8th Street jetty discovered during the 2020 Townsends Inlet survey. That large a value, all deposited well seaward of the bathing area, acts in the quarterly summary to greatly reduce the total "annual loss" to 132,541 cubic yards. The normal 9th St. transect length surveyed in Dec. 2020 compared to a similar transect length in Dec. 2021 generates a far smaller gain of 8.48 $yds^3/ft.$ creating the more realistic loss (in terms of beach area actually in use) of -202,791 cubic yards.

Individual Site Review:

Each of the ten survey stations is illustrated with photographs and the individual cross sections to document 2021 changes to the beach.

AV-9 - Ninth Street

The US Army Corps returned to Townsend's Inlet in the fall of 2019 and placed 144.46 yds^3/ft. of inlet sand on the 9th Street beach producing a 263-foot shoreline advance. The deposition of Townsends Inlet shoal sand around and south of the jetty tip appeared in the first quarterly survey of 9th Street in 2021 triggered by the 2020 inlet boat surveys which include data obtained further offshore than the normal beach transects extend. In March 2021, the field crew extended the normal transect to cover that area done with the vessel in December and found that the sand was still present. Subsequent surveys show a decrease in surface elevation and the December 2021 inlet boat work shows that the deposit extends further seaward than it did in 2020. This sand has not made any significant move toward the oceanfront shoreline. Comparison between the 2020 and the 2021 Townsend's Inlet bathymetry in proximity to the tip of the 8th Street jetty (Figures 23 and 24) shows that the deposit seen in 2020 has shifted south to an alignment of its maximum width with the extension of 10th Street instead of being aligned with the jetty if it were extended further seaward. This deposit of material remains well offshore but has moved south along the oceanfront by several hundred feet.

1a. June 3, 2020

1b. December 11, 2020

1c. December 3, 2021

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

View 1a. was taken in June following addition of new fencing. Some beach retreat had occurred, but the site remains in good condition.

View 1b. This view from December 2020 and shows the remaining expanse added to the beach width by the USACE maintenance effort. Wind transport was actively burying the new fence line.

View 1c. The beach width remains acceptable and wind transport continues to bury the newest fencing placed after the 2019 maintenance.

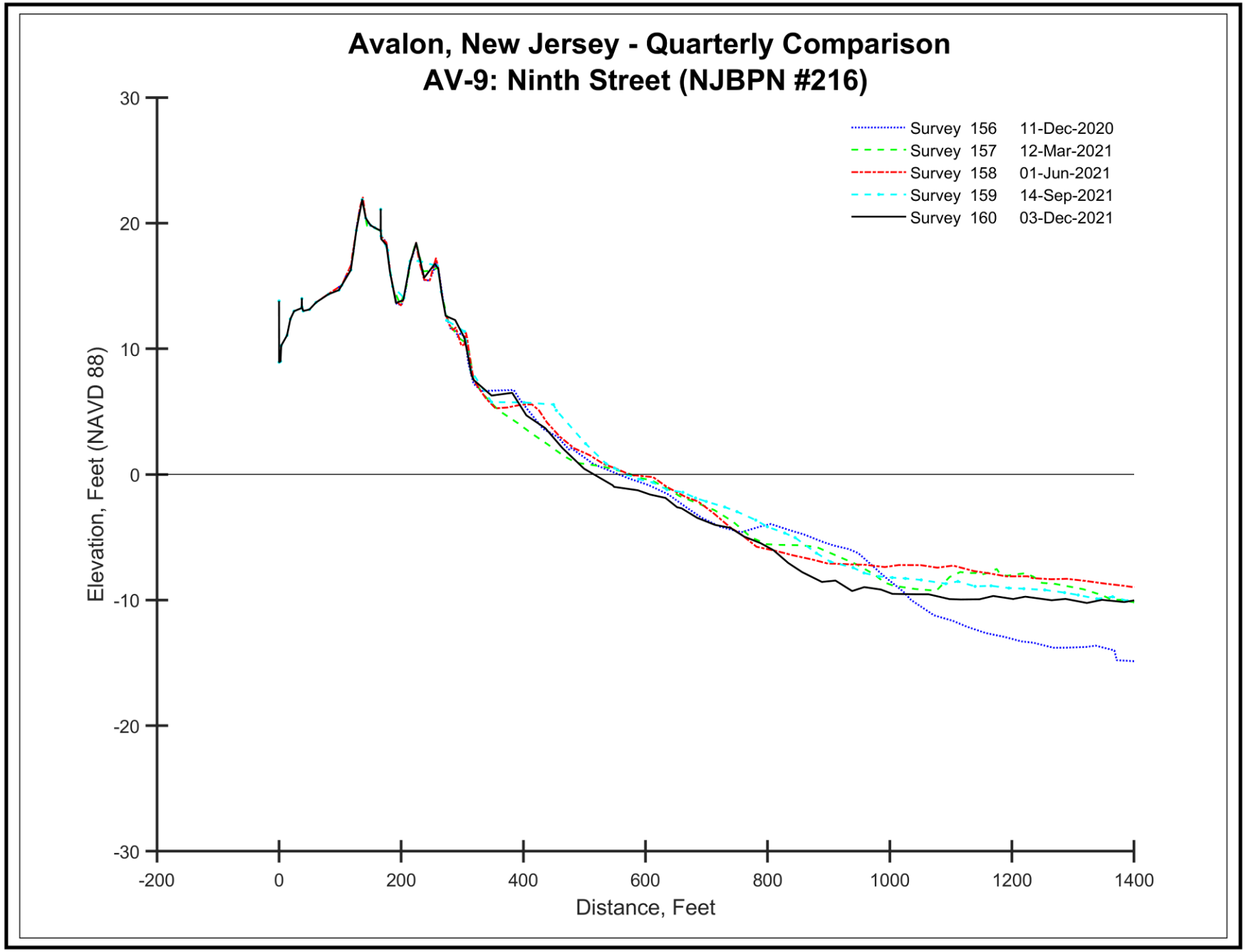

Figure 2. The 9th Street site maintained its beach width with a somewhat narrower berm since September 2021, but not as narrow as it was in March 2021. Sand volume deposited offshore as of June 2021 declined in elevation but remains well above the Dec. 2020 elevations. Direct movement onto the beach remains an open question.

AV-12 - Twelfth Street

Unlike the 9th Street site, the beach from 11th to 17th Street is not sheltered by the Townsends Inlet jetty and is directly impacted by northeast storms. This impact is combined with a general lack of sand sources to resupply the beachfront after loss events occur. Sediment bypassing the inlet from Sea Isle City appears to be an illusion since none has appeared over the past three decades in any quantity unless it was directly pumped during sand placement projects.

The 2019 project placed 218.46 yds^3/ft. in new sand adding 347 feet to the beach width. The largest sand volume was placed here among the three sites in our study that received material in 2019. The largest losses were seen at this site as well (-220.5 feet of shoreline retreat combined with sand volume losses of 164.3 yds^3/ft. during 2020). Therefore, 63.5% of the beach width added in 2019 and 75.2% of the added sand volume eroded from this location and moved south along the shoreline. The 2021 beach back-pass operation placed 56,000 cubic yards of sand from the 35th Street beach area enhancing the 12th Street location as of the June survey by 37.81 yds^3/ft. During the summer very minor loss occurred, but by December an equivalent quantity to the volume added by trucking had been removed from this transect. But, for the year 2021, this location remains at the December 2020 sand volume condition.

Figure 3a. May 13, 2021 aerial view of the Avalon back-passing depositional zone between 12th and 15th Streets where the truck loads are dropped off and then graded into the desired beach template. Erosion continues its work between 11th and 17th Streets so beach utility depends on regular episodes of sand addition to keep the resource functional as both storm protection and a recreational space.

Figure 3b. December 3, 2021 view to the south from the dune crest at 12th Street. The extent of this beach including the intertidal zone is due to the back-pass project completed last May. The rocks remain buried in the dune's seaward slope with the dense vegetation defining the landward crest of the revetment rock wall and bulkhead.

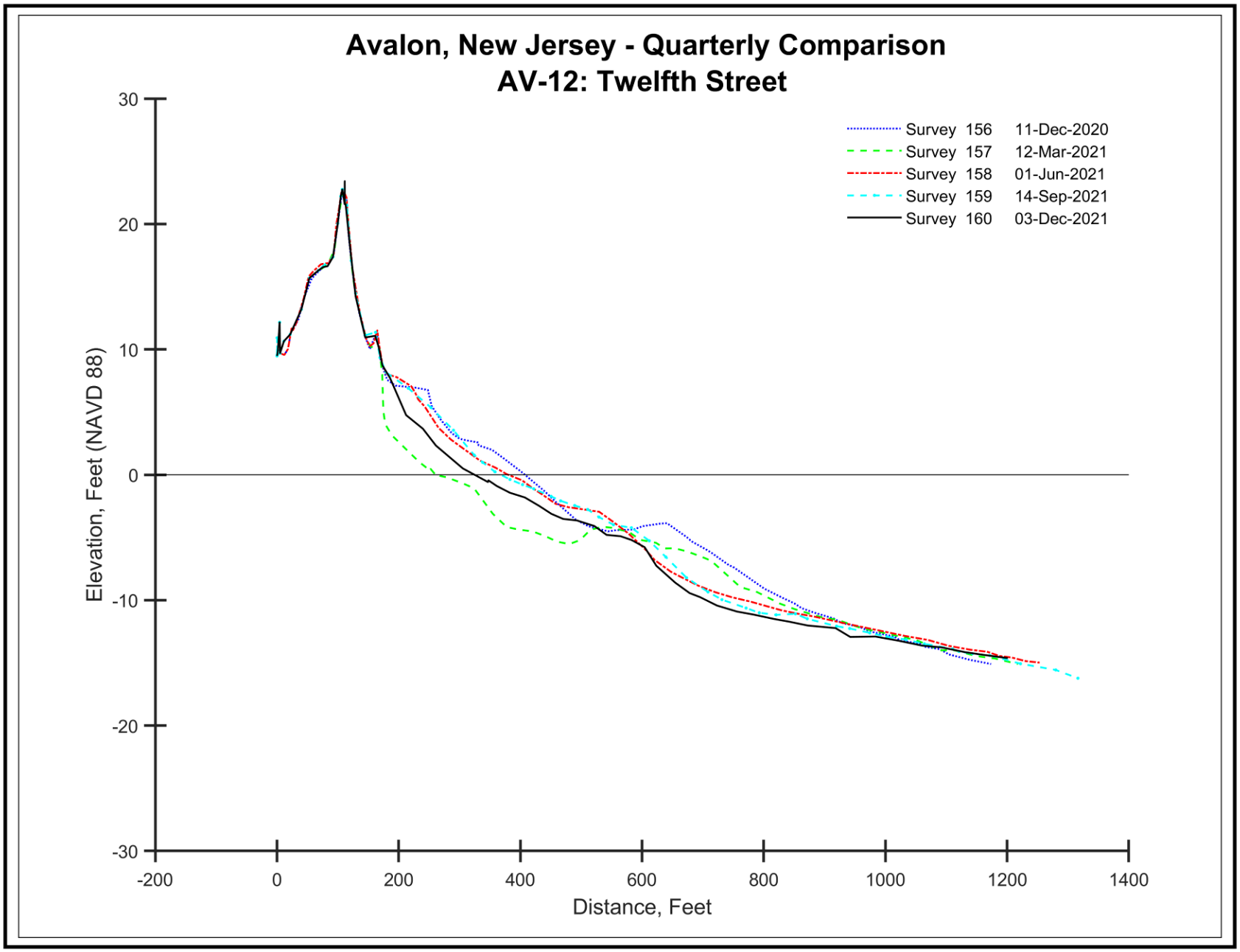

Figure 4. Storm-generated retreat occurred between Dec. 2020 (two late Dec. storms) and March 2021 (Feb 1 & 2, 2021). Sand placement during the spring of 2021 shows in the June, September and with a somewhat lower elevation as of December 2021, but above elevations seen in March 2021. Sand offshore as of Dec. 2020 may have contributed to material on the beach presently.

AV-17 - Seventeenth Street

The profile is located at the southern terminus of a rock revetment which extends to here from 8th Street. The annual sand volume loss during 2020 declined from 164.3 yds^3/ft. at 12th Street to 73.2 yds^3/ft. at 17th Street. Shoreline retreat was cut from 220 feet to 89 feet at this location. The 2019 federal work added 118.1 yds^3/ft. to this site so the loss rate was 62% of the sand quantity placed. As of December 2021, further erosion took a 35.11 yds^3/ft. slice out of the beach berm due to the winter northeasters as of March 2021. Subsequently the site's loses on the beach were minimal and the entire transect lost 6.17 yds^3/ft. in June 2.09 yds^3/ft. by September and 6.97 yds^3/ft. by December 2021. Sand from the May 2021 back-pass operation likely was of benefit to this site since it was placed on the beach.

5a. May 30, 2020

5c. December 3, 2021

5b. December 11, 2020

Photographs 5a to 5c. 17th Street, view to the south.

View 5a. By May 30th the grass had advanced into the ridge between the fences. The beach remained in decent condition as the new dune ridge continued to grow.

View 5b. This view shows the beach width reduced somewhat, but still an effective barrier to dune erosion as of the end of 2020.

View 5c. As of December 3, 2021, the beach slope was flatter with a small, lower elevation berm built in the absence of storm activity to that date.

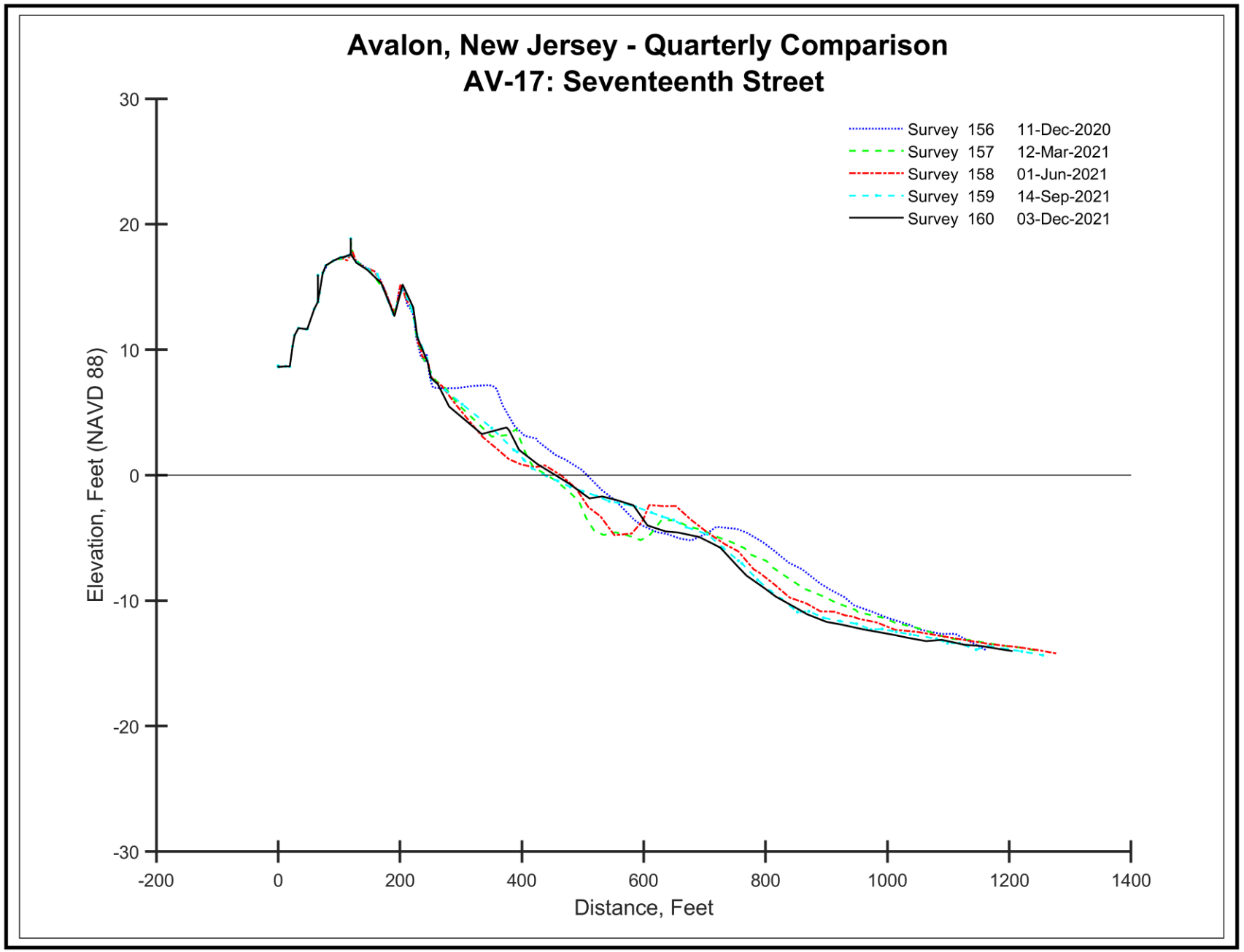

Figure 6. The Dec. 2020 berm eroded due to the spring 2021 storms (see Figure 4). Sand did accumulate by Sept. 2021 in modest volumes. The December 2021 cross section shows a small berm at a lower beach elevation and some material in the nearby offshore region.

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.

The 2019 USACE project did not place sand at this site. Sand lost last year further north appeared as a deposit starting with this location. During 2021 the site only shed 5.57 yds^3/ft. due to winter storm damage and continued the year with a 13.05 yds^3/ft. loss as of June 2021. The summer months produced a small loss of 1.13 yds^3/ft. which was followed by an equally small gain of 1.83 yds^3/ft. as of December 2021. The December 2021 beach elevation was at the highest continuous elevation among the four site surveys for the year.

7a. September 18, 2020

7b. December 11, 2020

7c. December 3, 2021

Photographs 7a to 7c. 23rd Street, views to the north.

View 7a. By September 2020 the beach was somewhat wider as sand was transferred to the site from further north. Little additional fence burial occurred.

View 7b. By December 2020 the beach showed added wind deposition on the dune slope with added material at the stormwater pipeline in the distance.

View 7c. The December 2021 view shows a beach width at similar values with a small added sand volume on the dune slope due to wind deposition.

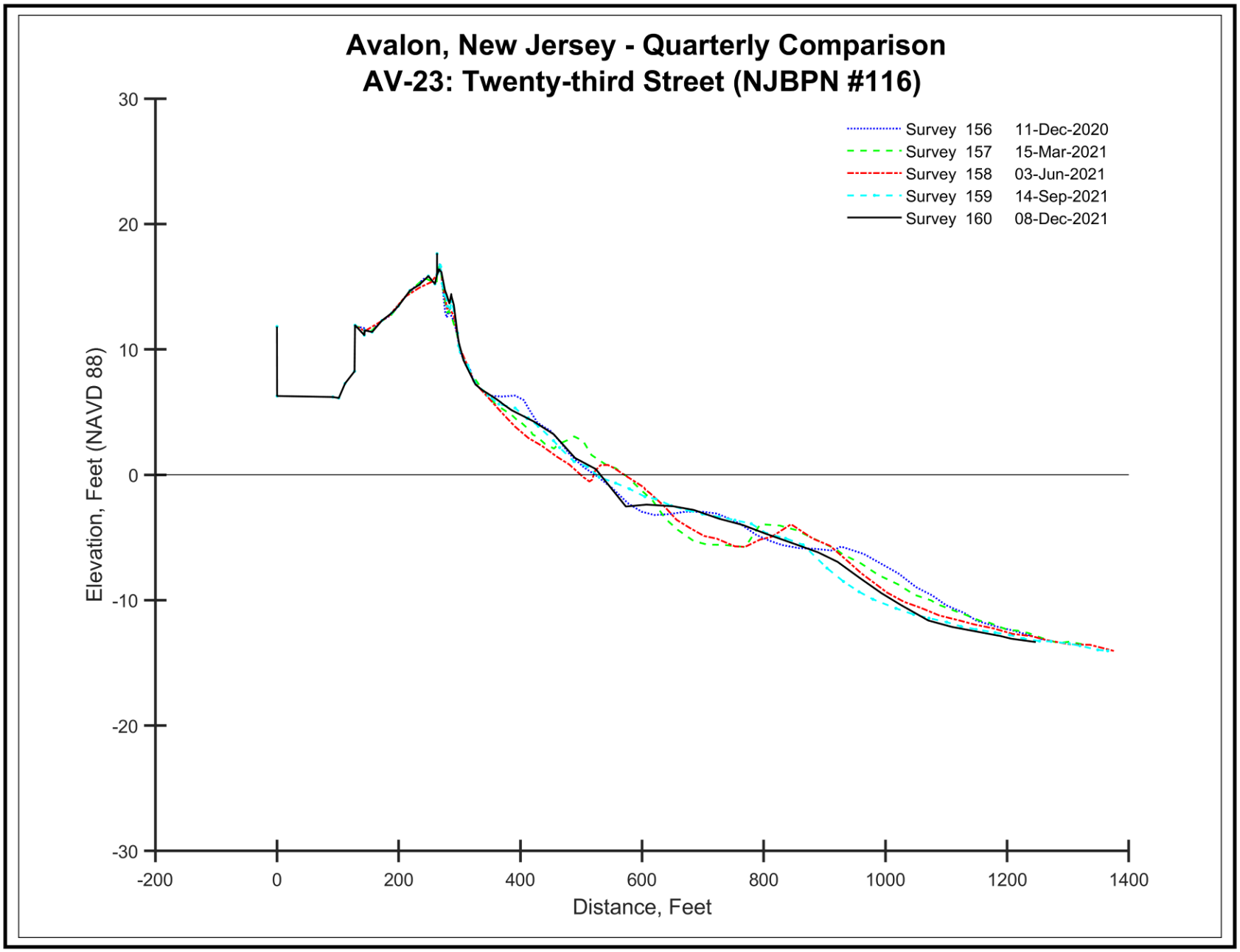

Figure 8. The 23rd Street site performed better following the June 2021 survey with sand added to the beachface slope by December 2021.

AV-28 - Twenty Eighth Street

The 28th Street location has usually been the nodal point between chronic erosion and regular sand deposition in Avalon. No sand was directly added in 2019 as a result of the Army Corps project maintenance. This has been true over the past number of maintenance efforts because material was not needed directly at this site.

During 2020 the 28th Street location gained sand as material moved south from the region to the north. For 2021 winter storm losses were considerable at 29.56 yds^3/ft. as of the March survey. By June the site lost an additional 4.13 yds^3/ft. in sand volume, but that was followed with a 3.83 yds^3/ft. gain as of September and 3.69 yds^3/ft. increase as of December 2021. The beach berm was present in December, not quite as pronounced as it had been a year earlier.

9a. September 18, 2020

9b. December 11, 2020

9c. September 14, 2021

Photographs 9a to 9c. 28th Street, views to the north.

View 9a shows the 28th Street beach following the summer 2020 season as the beach width improved in width due to sand deposition derived from northern beach sites.

View 9b shows the beach with wind deposition along the seaward dune slope and a generally higher beach elevation.

View 9c was taken a year later than 9a and demonstrates continued vegetation improvement and a stable beachfront.

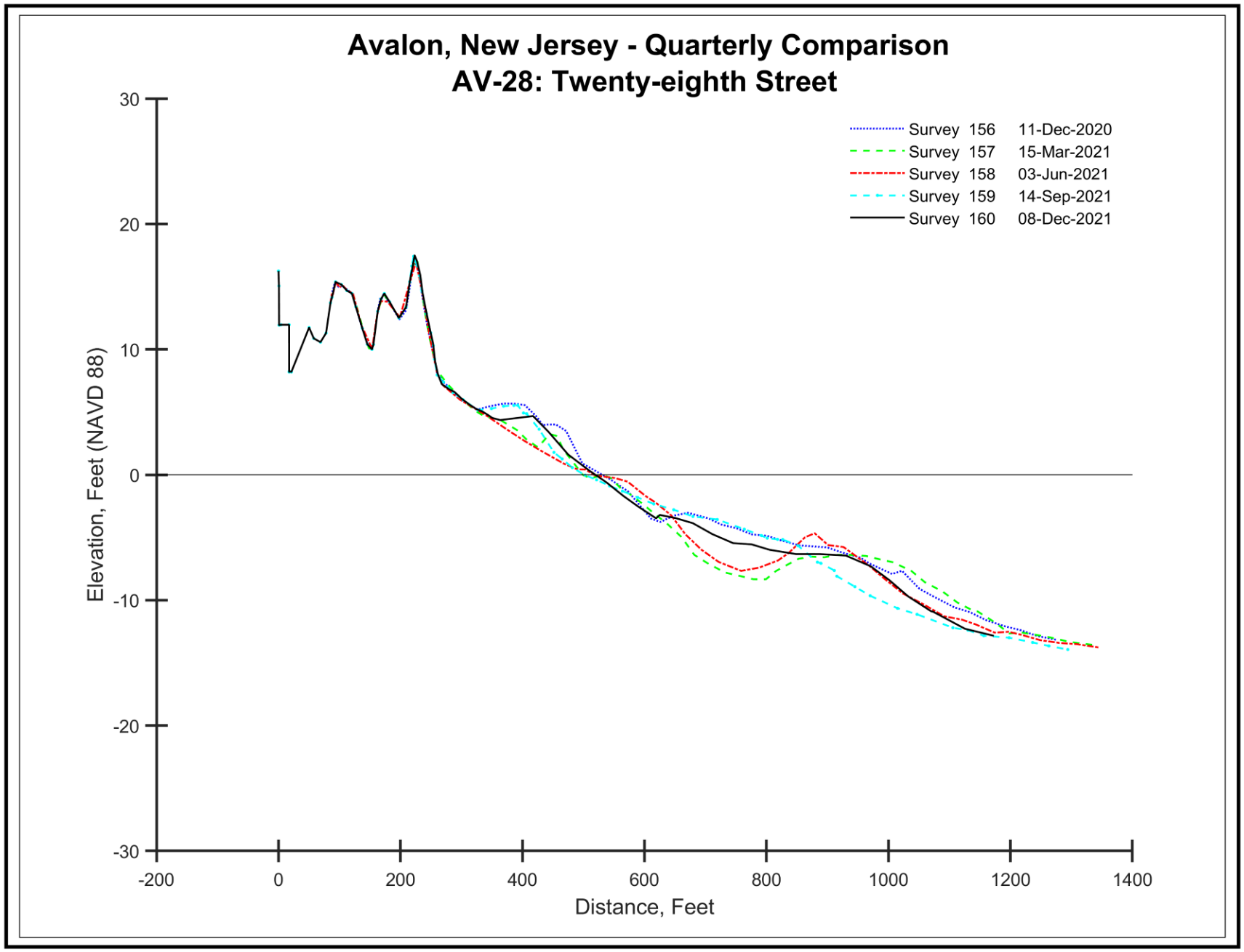

Figure 10. No sand has been placed at 28th Street directly in many years. The site benefits from littoral transport south from upstream beaches. Berm development was present in three of five surveys with sand deposited offshore in the bar trough as of December 2021.

AV-35 - Thirty Fifth Street

Sand has been deposited at 35th Street for decades and more recently has been used as a sand source to augment the erosional beaches in the 12th to 15th Street area. The "borrowing" area is the lower beachface and any nearby bars that are exposed at low tide where harvesting of sand occurs.

During 2021 the winter storms provided 5.79 yds^3/ft. in new sand offshore followed by a 19.55 yds^3/ft. sand volume loss as of June 2021 due to sand harvesting for 14th Street area. The photograph immediately below documents that activity as it was on-going. Subsequently by September 10.05 yds^3/ft. in sand volume was deposited at 35th Street with 6.34 yds^3/ft. eroded from the site as of December 2021.

Using the March, June, Sept. and Dec. 2021 surveys on the beachface slope at 35th Street, the net change in sand volume present was a plus 2.886 yds^3/ft. added between the 650-foot and 1,100-foot distances from the reference position on the intertidal beachface slope into the ocean. This interval represents the back-pass sand harvesting zone on the beach. The back-pass operation took 9.028 yds^3/ft. as of the June survey, followed by the accumulation in the same zone of 9.928 yds^3/ft. as of the Sept. 2021 survey and another 2.042 yds^3/ft. as of the Dec. 2021 survey deposited on the same 450 feet of width. This verification of sand recovery in the borrow zone authorized for Avalon back-pass operations provides confidence that sand hauled back to 12th Street and vicinity always makes its way back to the source beach within a short time. Sand is continuously in route south along the Avalon oceanfront shoreline and regularly adds to the quantity found at 35th Street.

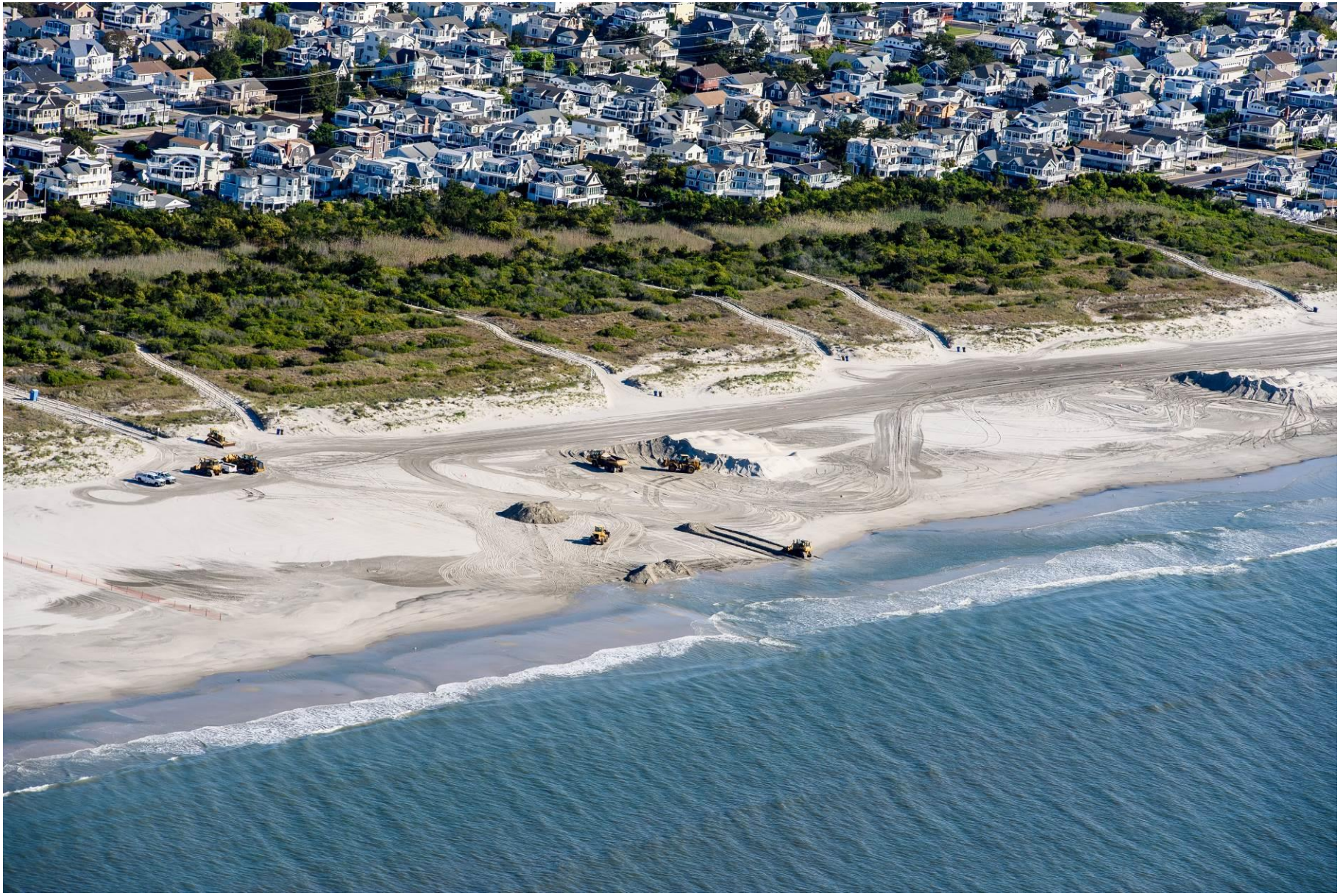

Figure 11. May 13, 2021 aerial view of sand harvesting between 35th and 38th Streets on the Avalon oceanfront. The bulldozer is pushing sand up from the intertidal zone derived from the small ridges of material migrating onto the dry beach. The stockpiled material is loaded into trucks and hauled on the beach to the depositional zone between 12th and 17th Streets. This view also illustrates the extensive dune system present at this site along with a wide dry beach that has accumulated sand over the past 35 years of study at this location specifically. To the left side of the photo is an orange fence defining the USF&WS exclusion zone for sand harvesting.

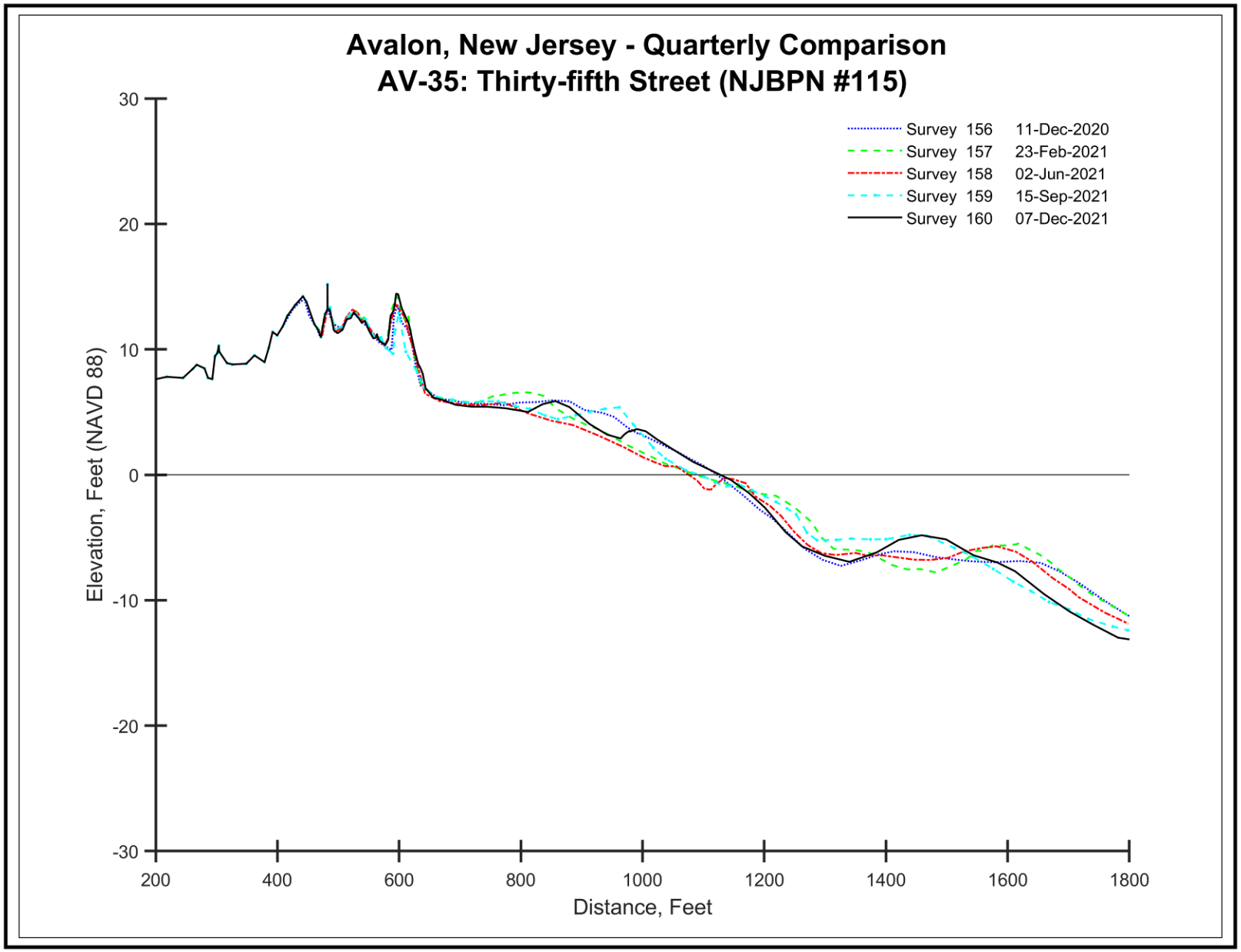

Figure 12. 35th Street location was used again as sand source for the back-pass operation. The June 2021 survey shows the most beachface reduction with dramatic recovery of the berm in Sept and again in December 2021. From Feb 23rd to June 2nd sand loss on the beachface was 9.084 yds^3/ft. followed between June 2nd and Sept. 15th with a 9.928 yds^3/ft. recovery in the same zone on the beachface where sand was harvested. By Dec. 2021 another 2.042 yds^3/ft. were added as two more small ridges advanced up the beachface.

AV-44 - Forty Fourth Street

This site is located within an exclusion zone in the Avalon "High Dune Area" established by the NJ Endangered Species Program to govern how and where Avalon could harvest beach sand for back pass operations. Their goal was to create a habitat not under repetitive excavation that could impact beach surface food sources for piping plover chicks hatching in the spring of the year. Therefore, as a result, no sand has been harvested from this survey site during the Borough's multiple sand back-passing programs.

The 2021 data indicate that the site lost 24.64 yds^3/ft. due to winter storms as shown in the March 2021 survey. By June 2021 13.91 yds^3/ft. had reappeared on the beach and offshore followed by another 22.66 yds^3/ft. as of the September 2021 survey. The fall of 2021 produced 8.93 yds^3/ft. in sand volume loss by the end of the year. This location gained more sediment during 2021.

13a. June 4, 2020

13b. September 23, 2020

13c. December 7, 2021

Photographs 13a to 13c. 44th Street, views to the south.

View 13a is the same view in June showing grass growth and wind deposition in the dunes.

View 13b is the September 2020 view to the south showing the dunes and beach where debris has been deposited near the dune toe recently.

View 13c represents the December 2021 view to the south along the foredune crest location including the upper beach. Comparing the June 2020 view with this picture demonstrates the added wind deposition at the post and rail fence.

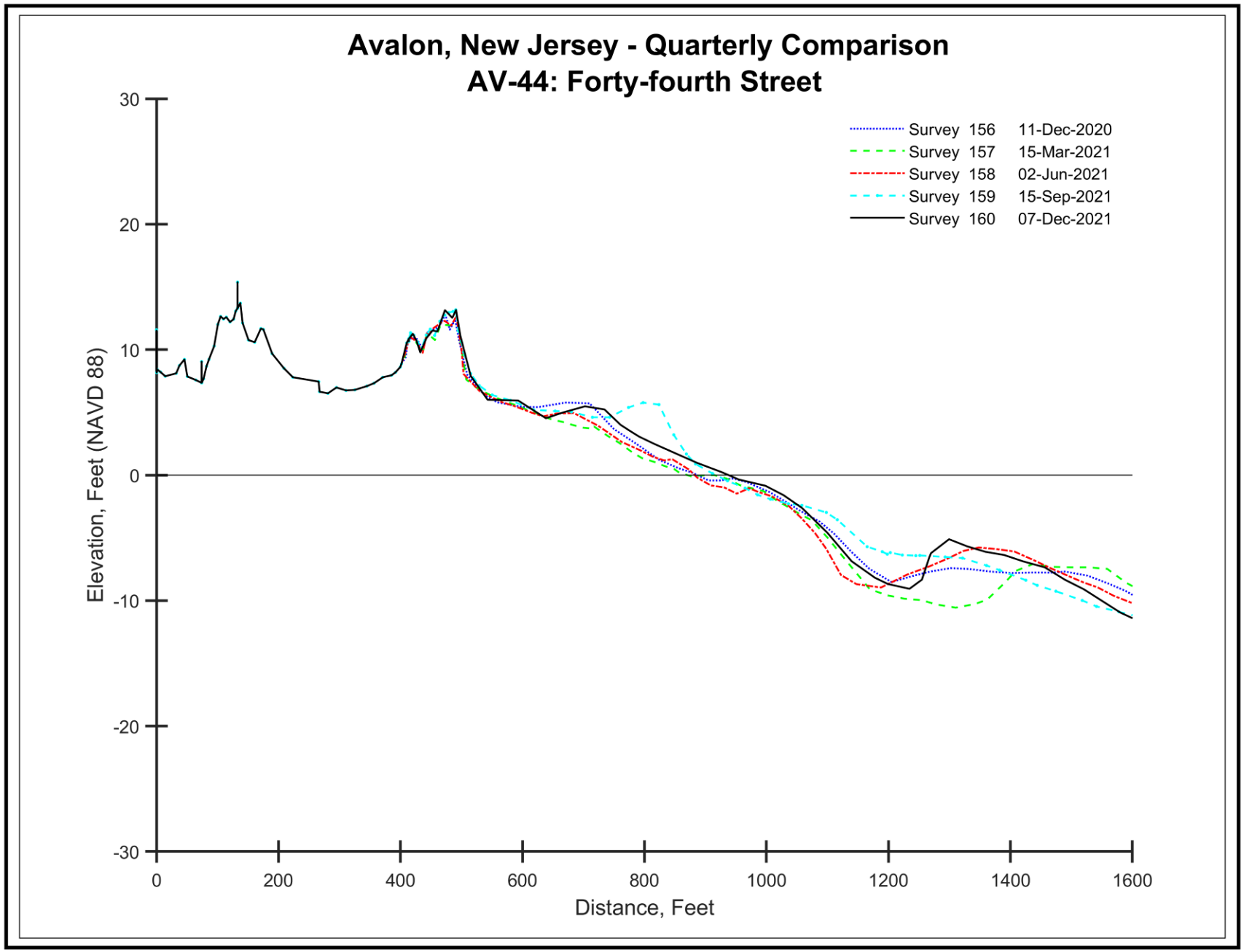

Figure 14. A large berm developed by Sept. 2021 that was flattened and pushed landward as of December 2021. The offshore bar elevation and trough depth varied considerably, but the position remained relatively constant. This site did gain sand volume over 2021.

AV-58 - Fifty Eighth Street

The 58th Street site has been depositional at the dune and beach over the years. No sand has been harvested from the southern back-pass borrow zone in the past five cycles because sufficient material was available within the northern zone centered at 35th Street.

During 2020 this site gained sand in three of four quarterly surveys, only seeing erosion during the March to May interval (-16.23 yds^3/ft.). The annual net change was a gain of 6.69 yds^3/ft. and a 68-foot shoreline advance. In 2021 storm erosion during the winter took 8.78 yds^3/ft. which was followed by a minor 1.26 yds^3/ft. additional loss as of June 2021. The next two surveys saw deposition with 13.69 yds^3/ft. added by September and 4.92 yds^3/ft. added as of December 2021. Little material was deposited landward of the berm crest on the beach while the berm itself maintained a variety of elevations and positions.

15a. June 4, 2020

15b. December 11, 2020

15c. December 6, 2021

Photographs 15a to 15c. 58th Street, views to the south along the seaward dune toe.

View 15a. This June view shows the impact of beach raking at the dune toe with the debris removed from the beach.

View 15b. The December 2020 view shows sand accumulation in the dunes at the site.

View 15c. By December 6, 2021 fog obscures the view, but sand has materialized across the upper dry beach and into the dunes.

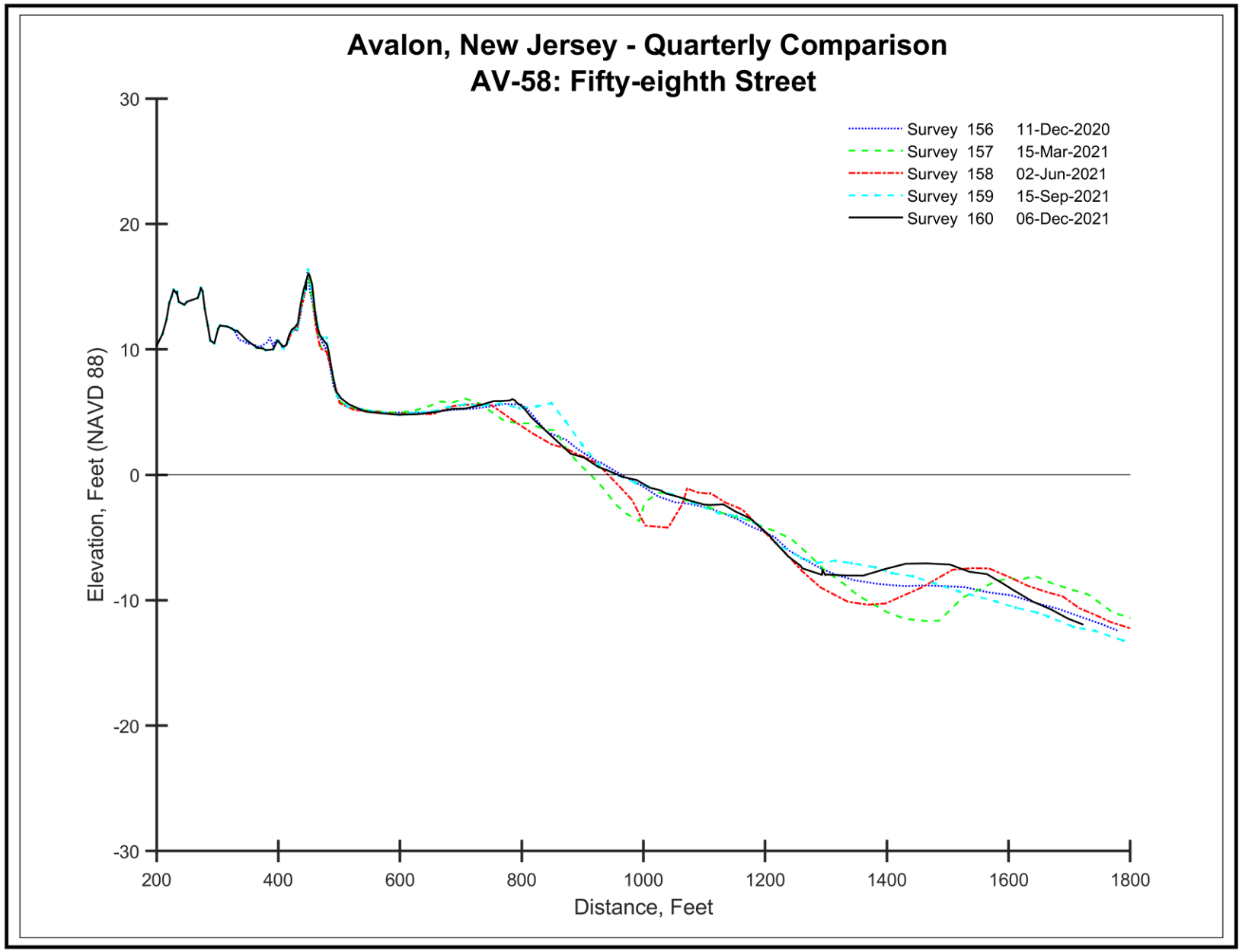

Figure 16. The upper beach and dune system changed relatively little over 2021. The beachface slope shifted with each incidence of bar migration onto the beach. Offshore the configuration changed frequently generating most of the offshore sand volume changes.

AV-70 - Seventieth Street

The 70th Street dune has increased its mass over time as sand deposited in the seaward ridge raising its elevation and extending it inland up the main dune's seaward slope. The resulting dune array is a consolidation of multiple small foredune ridges developed at fencing that have amalgamated into one large feature at this site. This process continued through 2021.

The winter 2021 storms took 31.61 yds^3/ft. from the site, but spring accretion restored 10.02 yds^3/ft. by June 2021. Subsequently, the summer produced an additional deposition of 15.77 yds^3/ft. with 10.83 yds^3/ft. removed by December 2021 largely from the changes in the offshore bar configuration.

17a. September 23, 2020

17b. December 11, 2020

17c. December 7, 2021

Photographs 17a to 17c. 70th Street, views to the south along the dune toe.

View 17a is a view along the dune toe showing the expanse of dry beach and the foredune seaward slope.

View 17b. This view from north of the access pathway shows the dunes and dry beach with some sand pushed up along the pathway.

View 17c. The December 2021 view is to the south along the seaward dune toe and across the dry beach width.

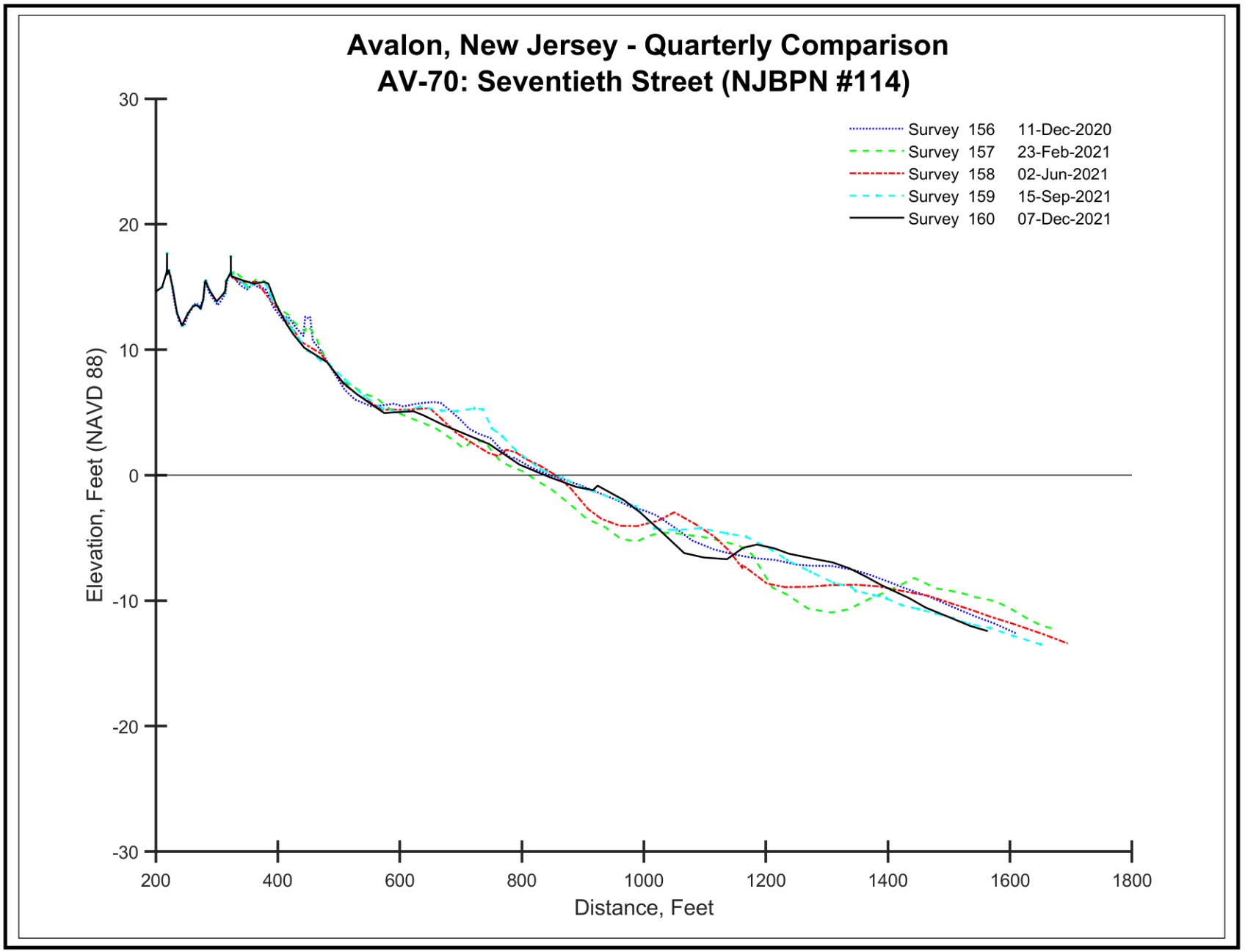

Figure 18. The 70th Street beach and dune changed little over the past year. The beach berm accumulated and eroded flat twice related to storm events (the Feb. 23rd survey followed the worst northeaster of the year and the Dec. 2021 survey followed several mild fall storms). Offshore the bar configuration was in a constant state of change in both position and elevation.

AV-78 - Seventy Eighth Street;

This site is located 520 feet from the boundary with Stone Harbor and is within the placement taper established for the Stone Harbor federal nourishment project. Since Stone Harbor declined to participate in the 2019 maintenance effort because of the issues surrounding the use of Hereford Inlet ebb-tidal delta deposits using federal funds (CBRS controversy not yet settled among those involved), no major additions were seen at this site during 2020 or 2021.

The 2021 surveys found a modest loss of 3.82 yds^3/ft. related to the winter storm activity that was followed by an addition of sand in June (2.96 yds^3/ft.). The subsequent two surveys produced small net losses of 5.71 yds^3/ft. as of September and -5.89 yds^3/ft. by December 2021. Most of the changes occurred in the offshore bar system as material moved around between the crest and trough of the bars.

19a. June 5, 2020

19b. December 11, 2020

19c. December 7, 2021

Photographs 19a to 19c. 78th Street, views to the north.

View 19a. The spring view shows grass growth in full swing as the season gets going.

View 19b. This view along the foredune area shows continued stability at the site with added sand across the seaward dune slope.

View 19c. Out on the dry beach, wave run-up reached over half way to the dunes on this day when high tide was at 5.8 feet on a new moon.

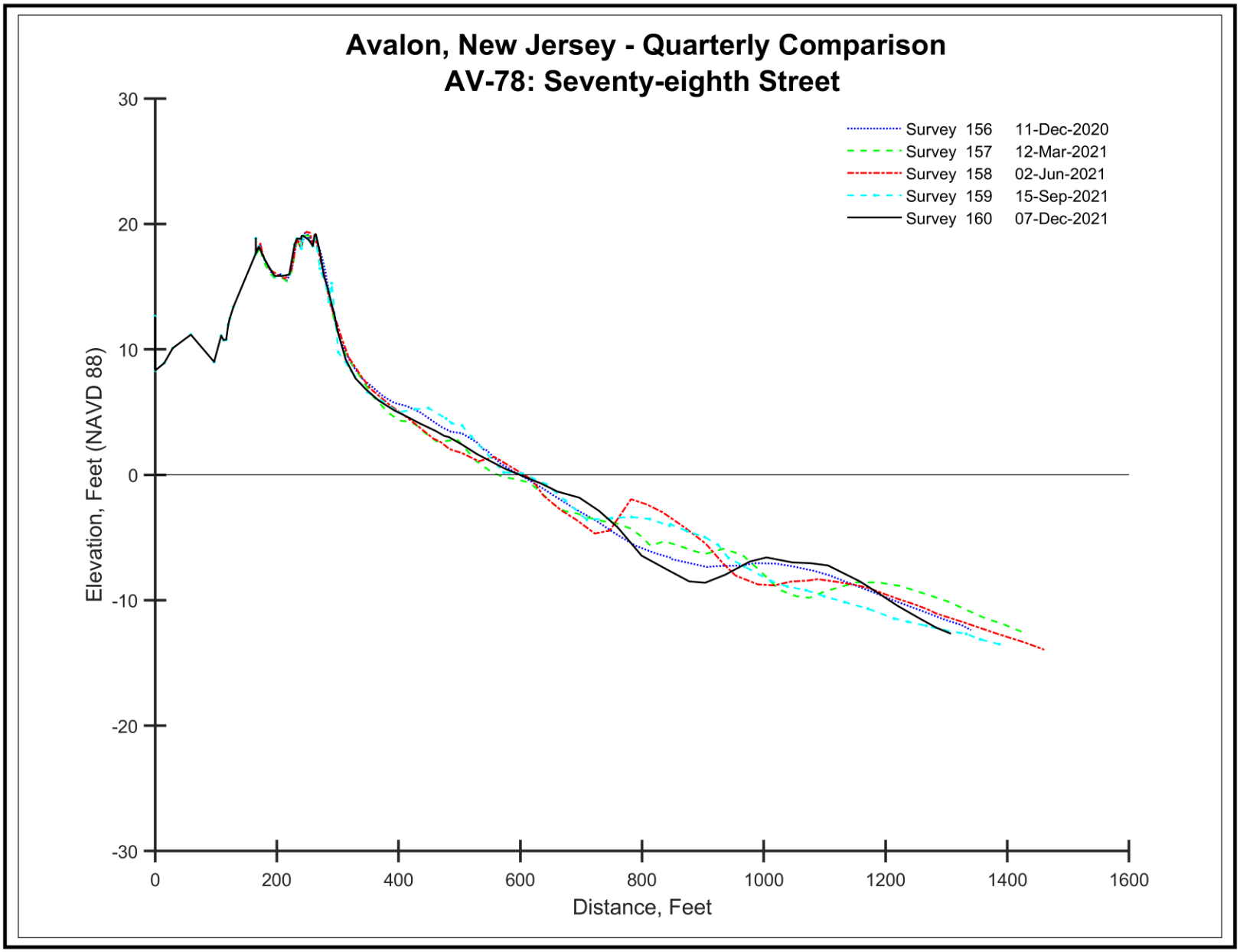

Figure 20. Beach and dune changes were minimal during 2021. The offshore bar presented the largest amount of sand poised to move onto the beach in June 2021. By December 2021 the bar reformed further seaward with new material.

Summary of Avalon's Oceanfront Beaches:

In the fall of 2019, the USACE added 564,264 cubic yards of sand between the jetty and a point south of 17th Street to restore early erosion and to augment the 940,000 cubic yards added during their 2017 effort.

No additional sand was added to the northern beaches during 2020 as a result of the USACE work in 2019. By May of 2021 the Borough moved 56,000 cubic yards of beach sand deposited in the vicinity of 35th Street back to an area centered on 14th Street and contoured it to match the existing beach template. The effort was made necessary because of a moderate intensity, two-day northeast storm on February 1 and 2, 2021 that resulted in it being the worst storm event of the winter season. Two earlier events in later December 2020 also had a negative impact on the northern engineered shoreline and these storms occurred after the final 2020 beach survey December 11, 2020. Therefore, the March 12, 2021 first quarter survey documented the major portion of all storm damage to the municipal beaches and showed a loss across the Borough oceanfront of 189,487 cubic yards that was partially offset by the inclusion of 198.52 yds^3/ft. discovered to have been deposited well offshore at the 9th Street profile cross section as a result of Townsend's Inlet sand redistribution. The June second quarter survey did document the sand placement at the 12th Street site as a sand volume increase of 37.81 yds^3/ft. Using that fill rate per foot of oceanfront, the 56,000 cubic yards would represent 1,481 feet of oceanfront filled. The actual sand volume was placed between the 9th and 17th Street locations and was shown to be still doing beneficial work in the vicinity as of December 3, 2021.

The entire Avalon oceanfront beach lost between 135,000 and 150,000 cubic yards of sand either further offshore or transferred south into Stone Harbor carried by the dominant southerly littoral wave-generated currents. Northeast events are the driving force behind these currents and the sand is largely moved on the offshore bar systems found along these beaches. The northernmost Stone Harbor beaches did show sand volume increases in 2021 without any added material from beach nourishment maintenance efforts. This indicates a sand source derived from littoral transport from Avalon.

A final word about the sand back-passing efforts the Borough orchestrates:

1. The northern borrow zone beach authorized by the reviewing agencies supplied 56,000 cy according to the truck trip tickets
2. The June survey readily documented both the added material trucked north to the 12th Street locality (+37.81 yds^3/ft.) and showed the deficit produced on the 450-foot wide segment of the 35th Street intertidal beachface used to supply that sand (-9.028 yds^3/ft.).
3. Subsequent surveys in September and December 2021 at 35th Street show direct recovery of more than the entire sand volume excavated and moved north (page 21, 35th Street discussion).
4. For decades of survey studies, the 35th Street beach has been gaining sand supplies, and advancing the shoreline seaward as material eroded from the northern beaches is carried south along the mid-section of the Avalon oceanfront.

Townsend's Inlet Bathymetric Survey:

December 7, 2021 the CRC surveyed the ebb-tidal area and adjacent beaches to conduct a complete Townsend's Inlet survey. That information was compared to the December 2020 inlet survey completed last year. The two surveys follow the 2019 excavation of sand from the borrow zone for the Avalon beachfront.

The sand observed to deposit seaward of the 8th Street inlet jetty and extending south far enough to intersect the 9th Street profile transect line offshore had shifted further south to include the area encompassed by 10th Street extended seaward. The general water depths continued to show a decrease in depth of between 5 and 6 feet where new material had accumulated.

The 2019 excavation sand volume was 569,210 cubic yards from the USACE authorized borrow zone. The contractor got paid for 571,351 cubic yards of sand. The latest survey of the inlet focused on the authorized borrow zone shows that over the past year 422,600 cubic yards of sand were added to the borrow zone footprint and that the entire ebb-tidal region of Townsend's Inlet had gained 755,894 cubic yards of sand. The zone of breaking waves was medially positioned along the northeast main tidal channel margin with shallow areas toward the northeast and closer to the Sea Isle City beach. A navigable pathway still persists close to the Sea Isle beaches, past the 93rd Street jetty and angled offshore along the Sea Isle beachfront. Last year the comparison showed that the borrow area had recovered the entire sand volume that the USACE excavated in 2019 and posted a modest gain of 12,930 cubic yards of sand above the quantity taken for the Avalon maintenance beachfill.

November 2020 to December 2021 CRC Survey of Townsends Inlet;

A digital elevation map (DEM) was prepared showing the ocean beach shorelines adjacent to Townsends Inlet on both the Sea Isle City and Avalon sides of the inlet. The land crew stopped their survey at approximately 1,000 feet from the high tide line on the beach. The CRC survey vessel took over the collection of bathymetric data out to water depths of -30.0 feet offshore beyond the area where tidal flow deposits what is called the ebb-tidal delta for Townsend's Inlet. The survey extends landward to the Townsend's Inlet bridge to Sea Isle City and covers the inlet from the Ludlam Island to the Seven-Mile Island shoreline.

The December 7, 2021 survey of Townsend's Inlet was compared to that done November 5, 2020 under relatively similar conditions in the ocean. The November 2020 survey benefited from absolutely calm wave conditions allowing 100% coverage. In 2021 swell breaking on the shallowest areas prevented coverage at the shallowest spot on the shoal that extends seaward parallel with the main channel on the Sea Isle City side of the inlet. Differences appear to be:

1. The greatest depths in the main tidal channel are a little closer to the Avalon inlet shoreline
2. The deepest spot remains directly under the Townsend's Inlet drawbridge (~60 feet, not centered on the draw-span however).
3. The northeastern main tidal channel margin lies along the southwesterly margin of the USACE authorized borrow area in the inlet shoals. Fully half the borrow zone area is currently less than -6.0 feet NAVD1988. The seaward half is shallower (-14 to -16 feet versus -18 to -20 feet in 2020).
4. The shallow Sea Isle City side shoal attached to the oceanfront beach is larger in area and with larger shallow zones (about -3.5 to -4.0 feet NAVD 1988) (the larger 2021 breaker zone).
5. The 2020 Avalon inlet jetty tip sand deposit (at -10 feet) noted last year does extend further seaward in 2021 and has shifted further south almost aligned with 10th Street extended. In 2020 the apex of the deposit was located between 8th and 9th Streets extended offshore.

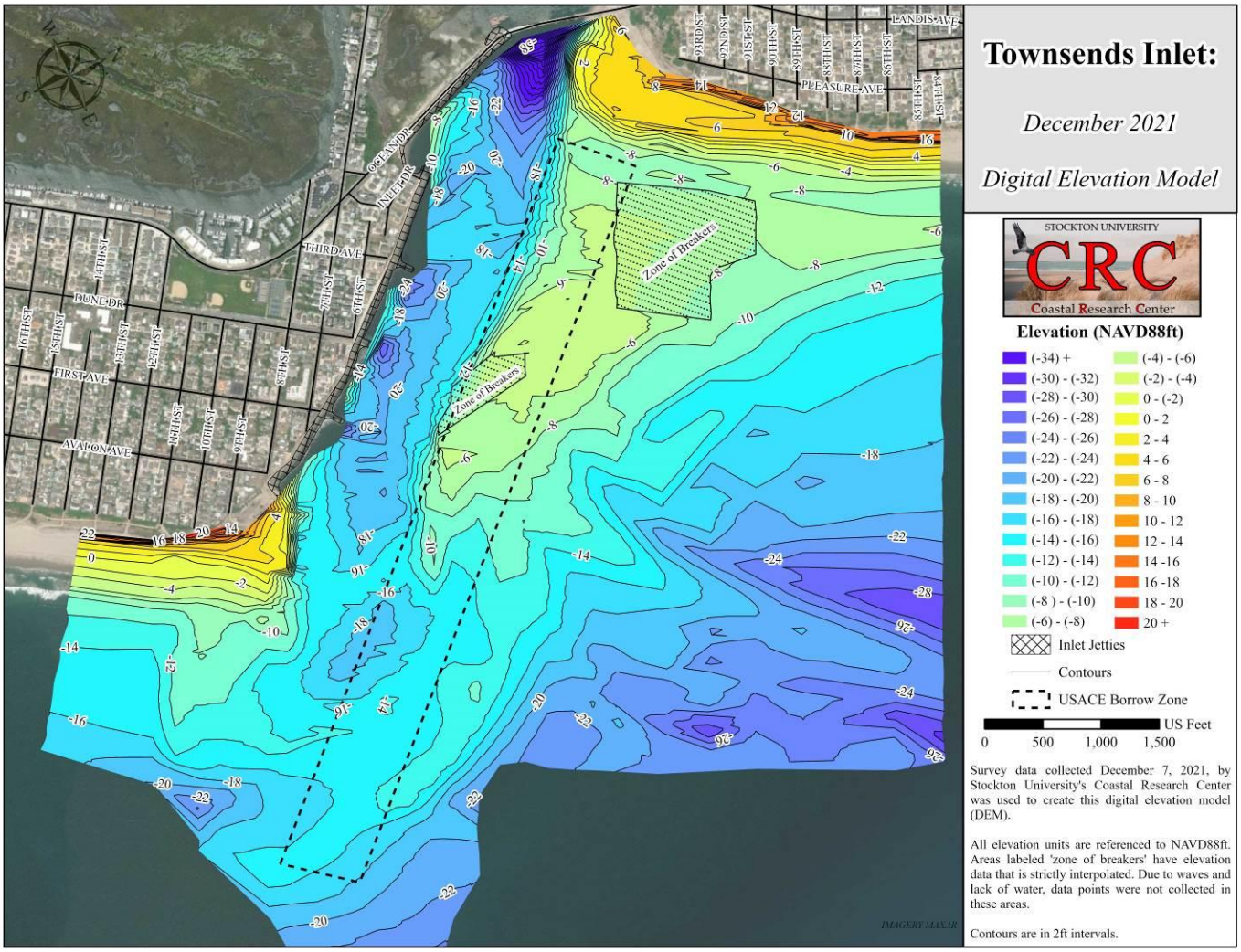

Figure 21 displays the inlet-adjacent beaches and the borrow zone and the immediate vicinity in Townsends Inlet. The zones of breakers indicate the shallowest parts of the sand deposition around the main channel.

The 2021 combined bathymetric and topographic data was compared to similar November 2020 information obtained last year by the CRC as part of this inlet monitoring effort.

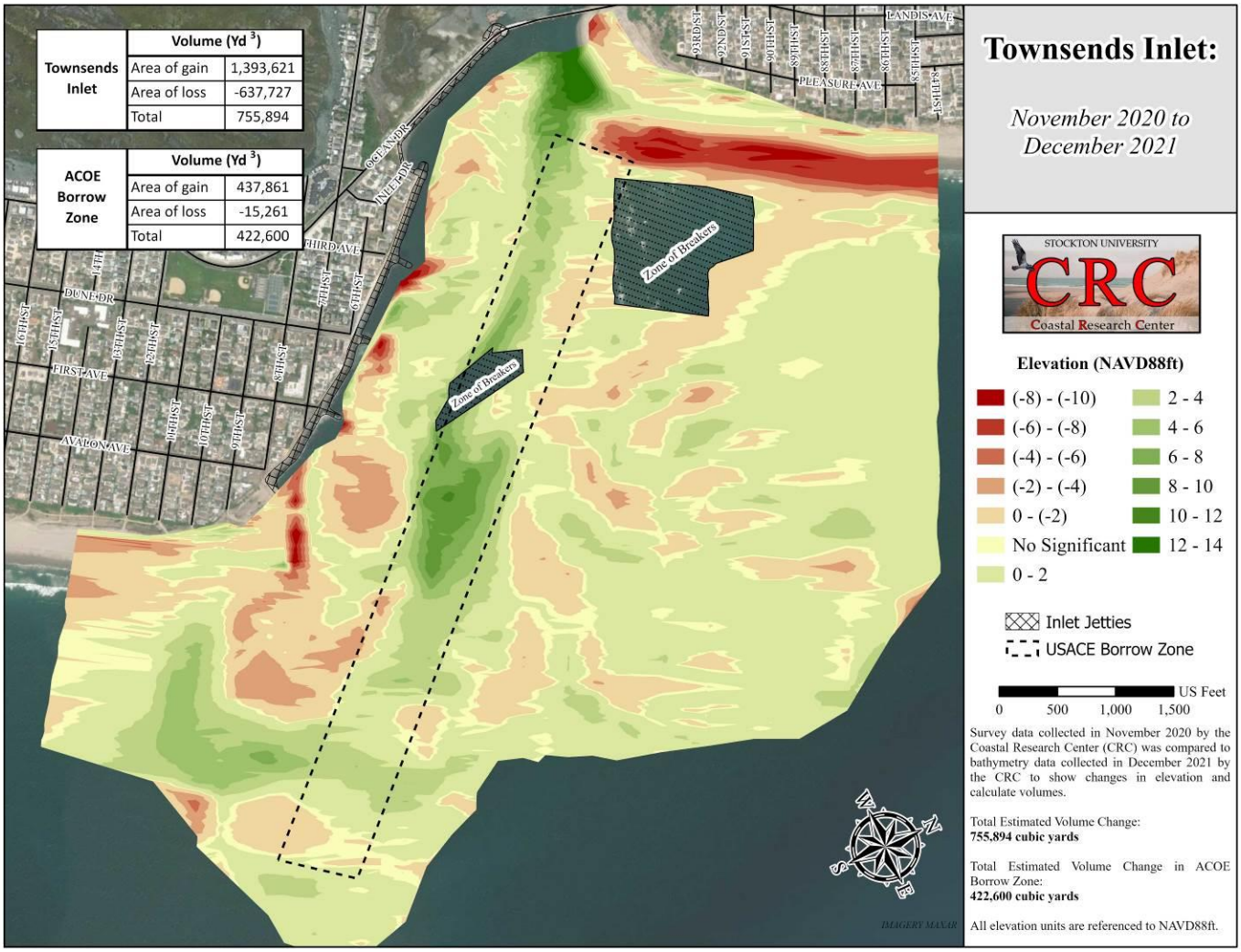

Figure 22. Digital elevation model for the comparison between November 2020 and December 2021 showing changes in bottom elevations across the area. Clearly heavy sand accumulation has occurred within the authorized Townsend's Inlet borrow zone footprint with up to 10 feet of new material vertically in the central part of the borrow area. Deeper areas lie along the Avalon revetment shoreline and extend offshore from the 8th Street jetty. A lobe of sand up to 6 feet thick deposited seaward of the 8th Street jetty and extends south to include 10th Street if it were extended seaward.

Townsend's Inlet Conclusions:

The Townsend's Inlet sand supply remains dependent on losses from Sea Isle City. The USACE derived the Sea Isle beach sand from offshore which is a net benefit to the current NJ beach environment, but the supply transferred to the inlet is a function of northeast storm frequency and intensity. There was one modestly intense northeast storm early in February 2021 with no coastal hurricanes passing NJ offshore this past year. Hurricane Ida had an inland track with abundant rainfall, tornados, and flooding but little in the way of coastal damage. Sand deposited substantially along the northeast main tide channel margin from the Sea Isle City beachfront out to points equal to the extent of the 8th Street Avalon inlet jetty.

The 2019 maintenance effort, focused solely on Avalon's beach maintenance needs, did not severely impact either the sand volume available or the geomorphic arrangement of the shallow shoal areas vital to inlet stability in the zone where sand accumulates as the "ebb-tidal delta" deposit. Sand observed to deposit offshore from the 9th Street survey site continued to shift south, reaching a place equal to the location of 10th Street extended seaward. A generous sand supply is available within the USACE borrow area for use in Avalon when the next maintenance effort is required.