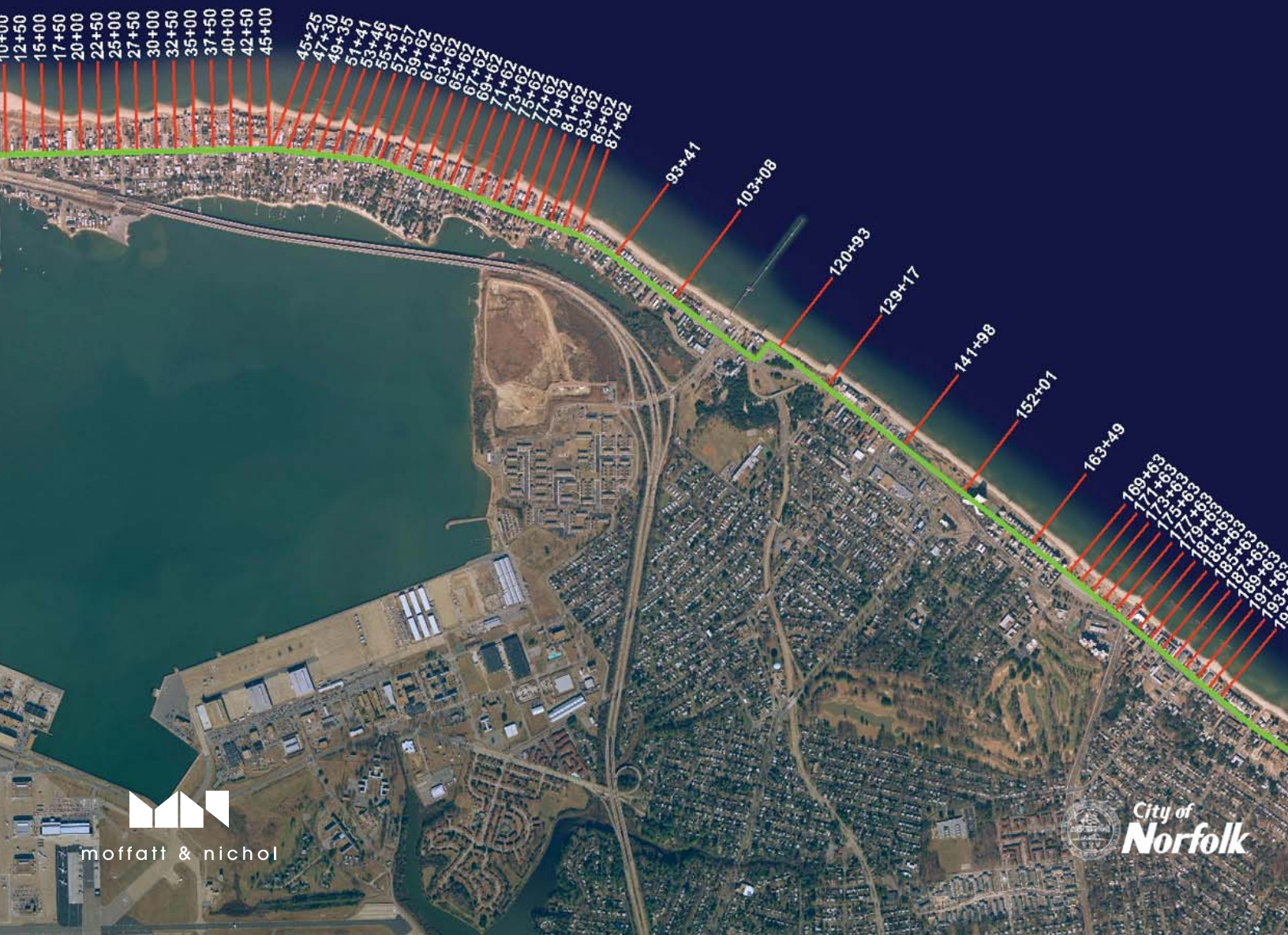
PERIODIC SURVEY EVALUATION:
OCEAN VIEW BEACH

City of Norfolk, Virginia | Spring 2021 | PN: 10390-21



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City of Norfolk

Periodic Survey Evaluation: Ocean View Beach Spring 2021

Presented to:

City of Norfolk

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1. Executive Summary

The thirty second consecutive twice-yearly survey of the Ocean View shoreline was conducted on June 1-4, 2021. The study area extends from the western end of Willoughby Spit to the western edge of Little Creek Inlet in East Ocean View. The periodic surveys are typically collected bi-annually in March/April and September/October to monitor the condition of the shoreline and the state of existing shore protection projects. The Federal coastal storm damage reduction project was constructed by Norfolk District U.S. Army Corps of Engineers (USACE) in mid-May 2017. This report documents the eighth monitoring survey following the initial adjustment period of the Federal Project, illustrating changes in the Federal Project beach and nearshore conditions approximately four years post-construction.

A baseline and transect locations were established with the first survey in September 2005 and have been used for each subsequent survey. Shoreline changes at Mean High Water (MHW) and volumetric changes above 0 feet NAVD88 and -15 feet NAVD88 are calculated at each transect. Differences in the region above 0 feet NAVD88 are indicative of changes to the dune and subaerial beach berm, while the differences above -15 feet NAVD88 indicate changes in the nearshore zone. Comparison of yearly surveys (i.e. June 2020 to June 2021) eliminates seasonal variation of profiles in volumetric change analyses. Consecutive survey comparisons (spring to spring, and fall to spring) are useful to assess the direct impact of extreme events which have occurred during the six months between surveys. This report documents the data sources, methods, and results of a periodic surveying evaluation performed to compare the June 2021 survey data with previous surveys taken in June 2020 (spring to spring comparison) and October 2020 (most recent periodic survey comparison) in the Ocean View Beach area between Willoughby Spit and Little Creek Inlet.

Comparison	Parameter	Quantity
June 2020 vs. June 2021	Average Shoreline Change Rate at MHW (+0.98 ft NAVD88)	-6.71 ft/yr
	Cumulative Volume Change Rate Above 0 ft NAVD88	27,790 cy/yr
	Cumulative Volume Change Rate Above -15 ft NAVD88	-866 cy/yr
October 2020 vs. June 2021	Average Shoreline Change at MHW (+0.98 ft NAVD88)	1.45 ft
	Cumulative Volume Change Above 0 ft NAVD88	45,501 cy
	Cumulative Volume Change Above -15 ft NAVD88	94,306 cy

The behavior in each of the shoreline reaches for the June 2020 to June 2021 and October 2020 to June 2021 periods are summarized in Table 1-1 and Table 1-2 respectively.

As illustrated in Table 1-1, the Ocean View shoreline has experienced overall retreat at MHW from June 2020 to June 2021 with a length-weighted average change rate of -6.71 ft/yr. The beach and dune above 0 feet NAVD88 gained sediment at a rate of 27,790 cy/yr from June 2020 to June 2021. The beach and dune above -15 feet NAVD88 lost sediment at a rate of -866 cy/yr from June 2020 to June 2021.

From October 2020 to June 2021, the MHW shoreline advanced on average by 1.45 feet, as shown in Table 1-2. The volumetric change over the same period showed volume gain above both 0 feet and -15 feet NAVD88 of 45,501 cy and 94,306 cy, respectively.

Table 1-1: Regional Shoreline and Volume Change Statistics (Jun. 2020 to Jun. 2021)

Region	Average Shoreline Change	Average Volume Change Rate Above 0 ft NAVD88	Cumulative Volume Change Rate Above 0 ft NAVD88	Average Volume Change Rate Above -15 ft NAVD88	Cumulative Volume Change Rate Above -15 ft NAVD88
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
Willoughby Spit (0+00 to 45+00)	-2.84	1.00	4,505	-1.47	-6,632
800 Block Breakwaters (45+25 to 87+62)	-7.53	-0.47	-2,150	0.24	1,067
West Ocean View (93+41 to 163+49)	-11.67	-0.89	-5,975	-1.11	-6,610
Central Ocean View Breakwaters (169+63 to 195+63)	-10.99	-0.03	-96	0.43	1,489
Central Ocean View (206+86 to 323+09)	-1.03	2.57	32,144	1.78	22,219
East Ocean View (329+63 to 383+58)	-12.37	-0.11	-638	-2.17	-12,400
OVERALL	Weighted Avg (ft/yr)	Weighted Avg (cy/ft/yr)	Total (cy/yr)	Weighted Avg (cy/ft/yr)	Total (cy/yr)
	-6.71	0.70	27,790	-0.07	-866

Table 1-2: Regional Shoreline and Volume Change Statistics (Oct. 2020 to Jun. 2021)

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
Willoughby Spit (0+00 to 45+00)	1.61	0.48	2,174	2.11	9,534
800 Block Breakwaters (45+25 to 87+62)	-4.13	-0.84	-3,834	-0.99	-4,481
West Ocean View (93+41 to 163+49)	0.82	0.82	6,244	2.44	18,532
Central Ocean View Breakwaters (169+63 to 195+63)	1.16	0.59	2,053	1.20	4,147
Central Ocean View (206+86 to 323+09)	5.90	2.54	31,751	3.75	46,979
East Ocean View (329+63 to 383+58)	-2.96	1.24	7,113	3.42	19,596
OVERALL	Weighted Avg (ft)	Weighted Avg (cy/ft)	Total (cy)	Weighted Avg (cy/ft)	Total (cy)
	1.45	1.19	45,501	2.46	94,306

The Federal Willoughby and Vicinity Coastal Storm Damage Reduction Project (Federal Project) was constructed in March, April and May 2017. The Federal Project placed approximately 1.2 million cubic yards material on the Ocean View Beach. Chapter 7 of this Spring 2021 monitoring survey report evaluates the performance of the Federal Project and is intended to help the City and USACE to track project conditions and effectively plan for future renourishment needs. Four reaches within the Federal project length have been identified as potentially needing renourishment to maintain the USACE Design Template level of protection:

- In the Toler Place vicinity of Willoughby Spit, from about halfway along Toler Place east to 9th View Street.

- In West Ocean View from station 93+41 (6th View Street) to station 171+63 (between Ship Watch Road and Chesapeake Boulevard).
- The shoreline within the Central Ocean View breakwaters field.
- In East Ocean View within segments of the Bay Oaks and East Ocean View breakwaters area.

The City is pursuing renourishment in these areas through beneficial use of sand material that is to be dredged from the Thimble Shoals Channel and Meeting Area 2, as part of the Norfolk Harbor Deepening Project being carried out by the Virginia Port Authority (VPA) and USACE. The design of that renourishment project is underway and permits have been applied for, with construction anticipated to occur in the fall 2021 to fall 2022 timeframe.

2. Objective

The City of Norfolk, Virginia has maintained a program of periodic surveying of the Ocean View shoreline since 2005. The periodic surveying data collection dates are shown in Table 2-1. This report documents the data sources, methods, and results of a periodic surveying evaluation performed to compare the June 2021 survey data with previous surveys taken in June 2020 (spring to spring comparison) and October 2020 (most recent periodic survey comparison) in the Ocean View Beach area between Willoughby Spit and Little Creek Inlet.

Table 2-1: Surveyors and Collection Dates

Data Collection Date	Surveyor
September 2005	McKim & Creed
March 2006	McKim & Creed
October 2006	McKim & Creed
March 2007	McKim & Creed
October 2007	McKim & Creed
March 2008	McKim & Creed
October 2008	McKim & Creed
April 2009	McKim & Creed
October 2009	Geodynamics, LLC
March 2010	Geodynamics, LLC
October 2010	Geodynamics, LLC
April 2011	Geodynamics, LLC
October 2011	Geodynamics, LLC
March 2012	Geodynamics, LLC
September 2012	Geodynamics, LLC
April 2013	Geodynamics, LLC
October 2013	Geodynamics, LLC
March 2014	Geodynamics, LLC
October 2014	Geodynamics, LLC
April 2015	Geodynamics, LLC
October 2015	Geodynamics, LLC
May 2016	Geodynamics, LLC
October 2016	Geodynamics, LLC
February 2017	USACE (Great Lakes Dredge & Dock)
May 2017	USACE (Great Lakes Dredge & Dock)
May 2017	Geodynamics, LLC
October 2017	Geodynamics, LLC
April 2018	Geodynamics, LLC
November 2018	Geodynamics, LLC
April 2019	Geodynamics, LLC
November 2019	Geodynamics, LLC
June 2020	Geodynamics, LLC
October 2020	Geodynamics, LLC
June 2021	Geodynamics, LLC

3. Data Sources

Geodynamics, LLC, conducted the most recent survey of Ocean View Beach from June 1 to June 4, 2021. The baseline and transects established for the September 2005 survey were used for the most recent survey. Figure 3-1 shows the location of the baseline, transects and the stationing applied by Geodynamics for the surveying. As shown in Figure 3-1, transects were stationed from west to east along the Ocean View shoreline. The survey data were provided in xyz and shapefile formats allowing for compatibility with multiple programs.

Geodynamics noted that typical vertical survey accuracy along the hydrographic portions of the profiles is approximately ±1 cm. This 'margin of error', if applied over the entire length of the hydrographic profiles can potentially result in significant volumetric differences, in particular on the shallow-sloped and long profiles near Willoughby Spit. Therefore, volumetric changes discussed herein are analyzed with regard to potential volumetric margins of error.

In June 2021, Chesapeake Bay Helicopters (CBH) captured LiDAR data and aerial photography of the Ocean View shoreline. CBH supplied raw LiDAR files (LAS format) and a bare-earth Digital Elevation Model (DEM) along with georeferenced aerial images of the dry beach and dune along the entire Ocean View shoreline. Geodynamics incorporated the LiDAR-derived DEM with their own surveyed data to generate two DEMs – one area above Mean High Water (MHW) and another of the area below MHW. Geodynamics also produced digital contours at the MHW elevation and at the apparent dune toe elevation. The June 2021 aerial photos with the shoreline positions from June 2021, October 2020 and June 2020 are shown in Appendix A.

Since the June 2021 photos cover a limited portion of area landward and seaward of the shoreline, a previous image provided by the City (2018) is underlain in all Appendices' map products for presentation purposes.

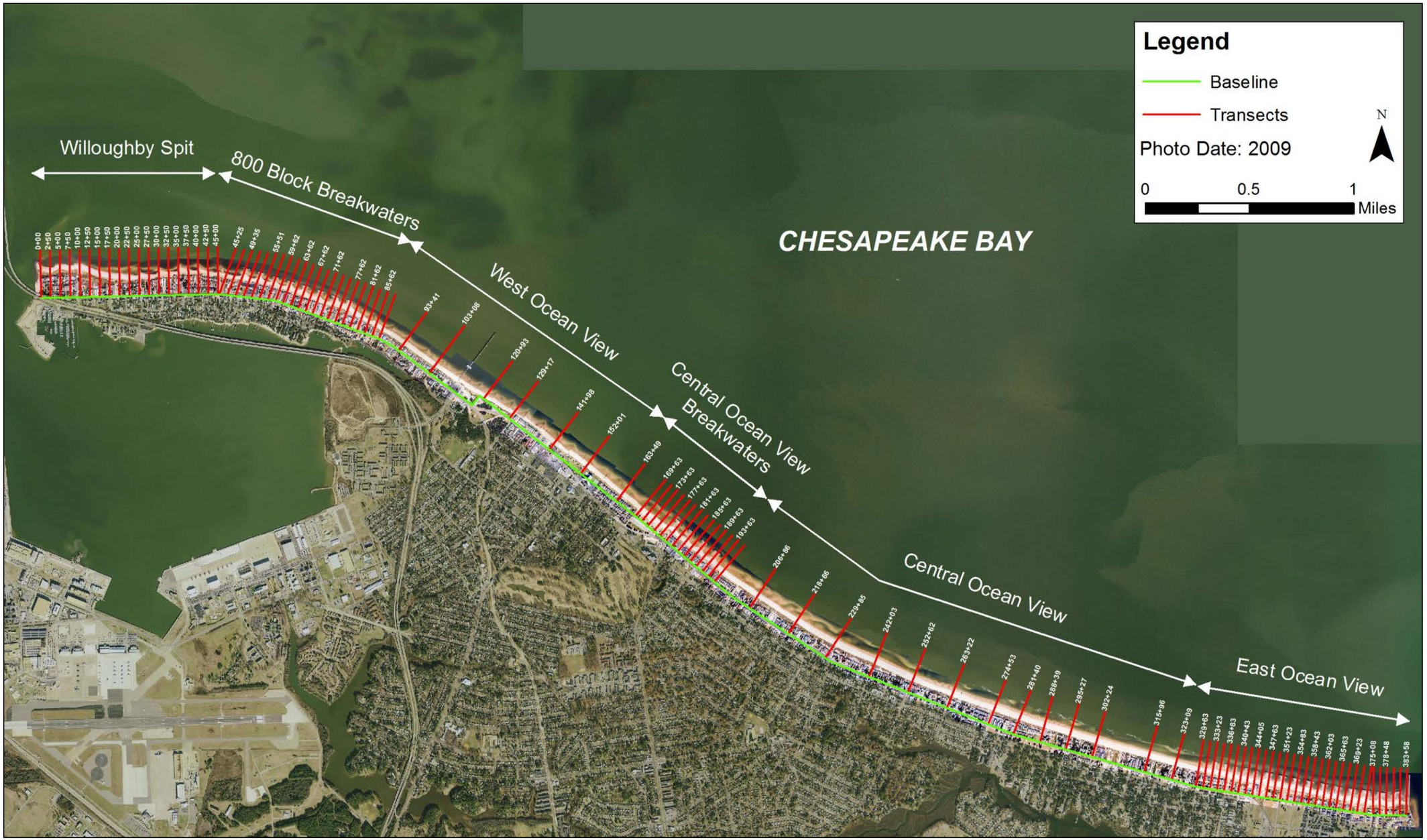

Figure 3-1: Survey Baseline and Transects

4. Methods

Survey comparisons and respective analysis were performed using a combination of Microsoft Excel, Golden Software Surfer, ESRI ArcGIS, custom-coded MATLAB routines and the USACE's Beach Morphology Analysis Package (BMAP). Surfer is a contouring and 3D surface mapping program utilized to create 3D surfaces for analysis. BMAP is a program developed by the USACE to analyze morphologic and dynamic properties of beach profiles.

The horizontal coordinate system used was Virginia South State Plane NAD 1983 (HARN), US Survey feet with a vertical datum of NAVD88. Individual profile plots showing the survey profile at each transect for each date are presented in Appendix B. From the profiles, shoreline changes and volumetric changes were then calculated at each transect for the following time periods:

1. June 2020 to June 2021 (Entire Shoreline)
2. October 2020 to June 2021 (Entire Shoreline)

First, the change in shoreline based on the survey profiles at mean high water (MHW) was calculated at each transect for each time period mentioned. MHW along Ocean View beaches is defined as +0.98 feet NAVD88 based on NOAA tidal benchmark at Sewells Point. The resulting value represents the shoreline change (feet) over the time period between surveys. The shoreline change rate (ft/yr) was then calculated by dividing by the amount of time between survey dates.

Representative volume changes were also calculated at each transect for all time periods. Volume changes were calculated for two different extents in order to better understand the processes occurring onshore and offshore of the Ocean View beach area. Calculations included volume changes above -15 feet NAVD88 and volume changes above 0 feet NAVD88. The results represent volume change per linear foot of shoreline (cy/ft) over the period of time between surveys. The volume change rate (cy/ft/yr) was then calculated by dividing by the amount of time between survey dates. In addition, the volume changes were converted to cumulative changes over the entire shoreline. This was done by applying the average end area method to the unit volume changes (cy/ft) and unit volume change rates (cy/ft/yr) computed at each transect and summing the total volume changes over the entire shoreline. The resulting value indicated the total loss or gain of material (cy) between surveys based on the applicable profile extents.

Volume changes calculated for portions of the profiles above 0 feet NAVD88 are representative of changes in the amount of material in the dune system and on the subaerial beach. These areas are highly influenced by the performance of coastal structures and the impact of storm activity. Volume changes calculated for portions of the profiles above -15 feet NAVD88 allow for the tracking of sand movement in the submerged active profile; removing profile data deeper than the -15 feet NAVD88 contour from the analysis reduces uncertainty that would be associated with hydrographic data beyond this depth.

5. Discussion of Periodic Surveying Evaluation

This section discusses differences observed between the noted surveys, overall shoreline trends, regional shoreline trends and comparison with the pre- and post-construction surveys of the Federal Project. The computed shoreline changes and volume changes at each individual transect for the time periods covered are tabulated in Appendix C.

5.1. Differences in Survey Coverage

Variation in profile positions between surveys taken as part of the ongoing program of periodic surveying of the Ocean View shoreline (June 2020, October 2020 and June 2021) were minimal in the topographic portion of the survey due to use of the same baseline and transects put in place for the initial survey in September 2005. Profile extents and alignment were virtually the same when comparing the survey data.

5.2. Key Events during the Reporting Period

Beach processes are greatly influenced by natural and engineering processes. This section describes key events that happened during the present reporting period which likely had an impact on shoreline position changes and profile volume gains and/or losses.

5.2.1. Storm Wave Events

Understanding of the wave climate immediately offshore of the Norfolk shoreline is vital for the design, monitoring, and understanding of projects along the shoreline and the behavior of the beach. The data used were collected from the City's AWAC (Acoustic Wave and Current) gage, which was deployed in 2006 directly offshore of the Norfolk Shoreline in approximately 23 feet of water. Wave data were collected throughout this survey period.

A summary of the observed conditions from the available wave data from May 2020 to April 2021 yields the following general observations:

- The average significant wave height and peak period over the measurement period was approximately 1.25 feet and 4.94 seconds.
- The largest significant wave height observed during this deployment was approximately 6.4 feet with a corresponding peak period of approximately 5.4 seconds and mean direction of 56.5 degrees (May 19, 2020).
- Waves approach from the northwest to southeast, with more than 80% approaching from 0 to 120 degrees true North.

Thirty-two events occurred during May 2020 to April 2021 for which the significant wave height reached or exceeded 3.0 feet. These events are shown in Figure 5-1 through Figure 5-37.

The overall trends remained consistent with prior measurement periods with waves during calm periods being predominantly swell traveling into the bay from the ocean and having longer wave periods and lower wave heights. Typically, the larger wave height events are driven by northerly and northeasterly

storm winds within the bay and tend to have shorter wave periods. A summary of wave statistics by month from May 2020 through April 2021 is given in Table 5-1.

Table 5-1: Monthly Wave Statistics Summary

Wave Statistic	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20
Average Significant Wave Height, H_s (ft)	1.5	1.1	0.8	0.9	1.7	1.3	1.1
Average Wave Period, T_m (s)	2.6	2.4	2.4	2.4	2.9	2.9	2.8
Average Peak Wave Period, T_p (s)	4.5	4.7	5.4	5.2	5.6	5.7	5.6
Maximum Observed Significant Wave Height, H_s (ft)	6.4	5.1	2.7	3.6	5.7	4.4	3.9
Maximum Observed Wave Height, H_{max} (ft)	10.6	9.1	4.8	7.0	9.6	7.3	7.2

Wave Statistic	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21
Average Significant Wave Height, H_s (ft)	1.2	1.3	1.6	1.2	1.2
Average Wave Period, T_m (s)	2.5	2.6	2.7	2.5	2.4
Average Peak Wave Period, T_p (s)	4.9	4.6	4.5	4.2	4.4
Maximum Observed Significant Wave Height, H_s (ft)	5.2	4.9	3.8	5.6	4.2
Maximum Observed Wave Height, H_{max} (ft)	8.5	8.8	6.3	8.8	6.2

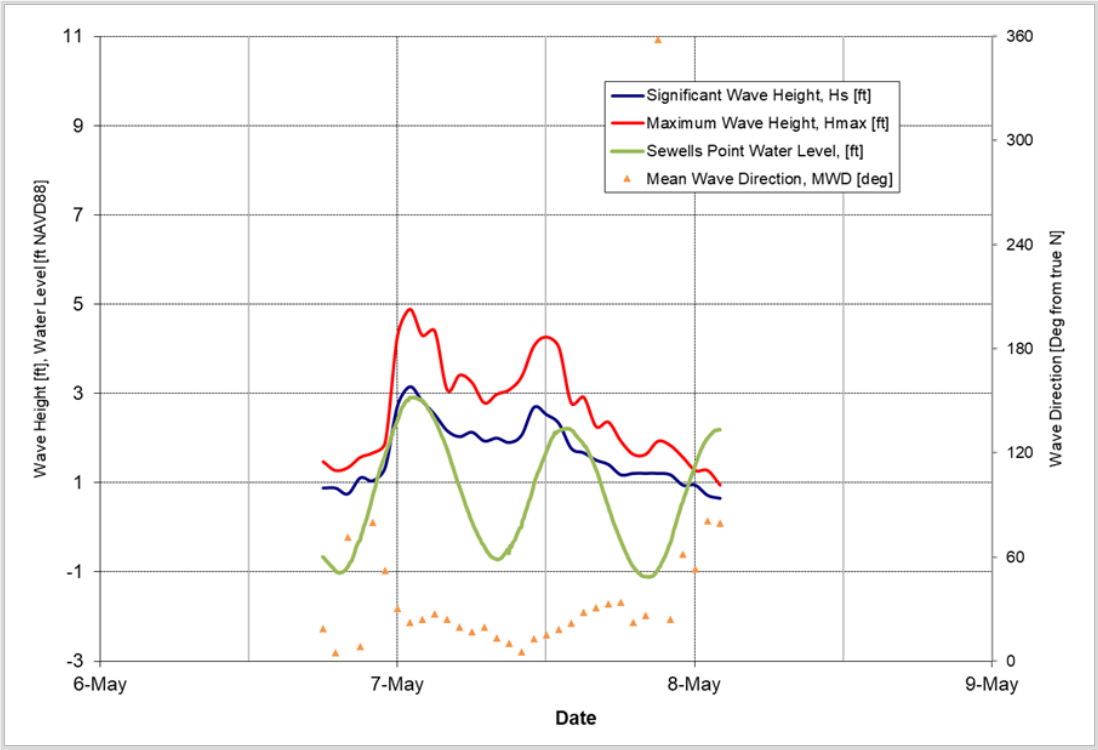

Figure 5-1: May 7, 2020 Storm

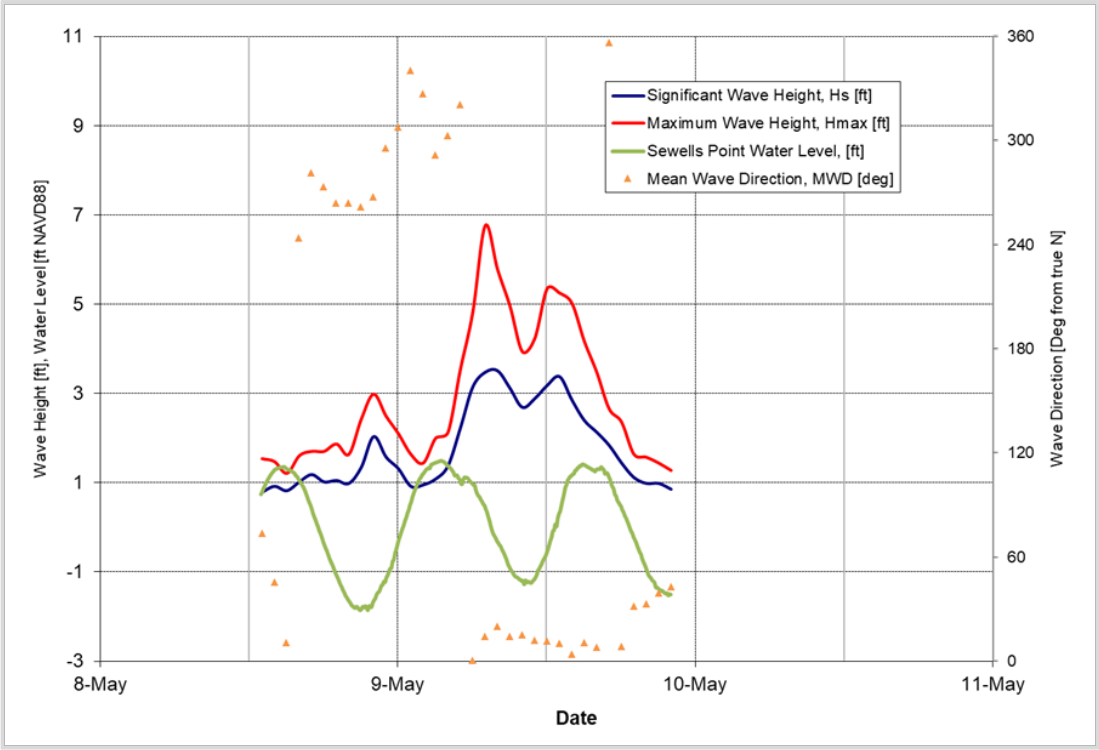

Figure 5-2: May 9, 2020 Storm

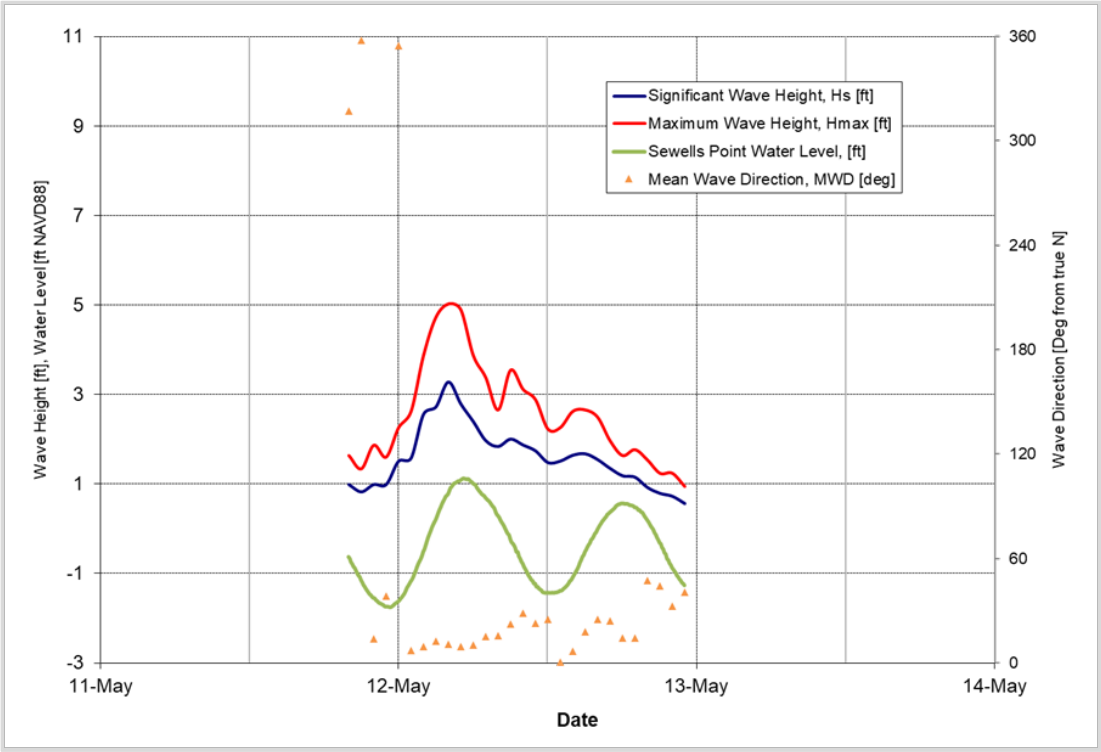

Figure 5-3: May 12, 2020 Storm

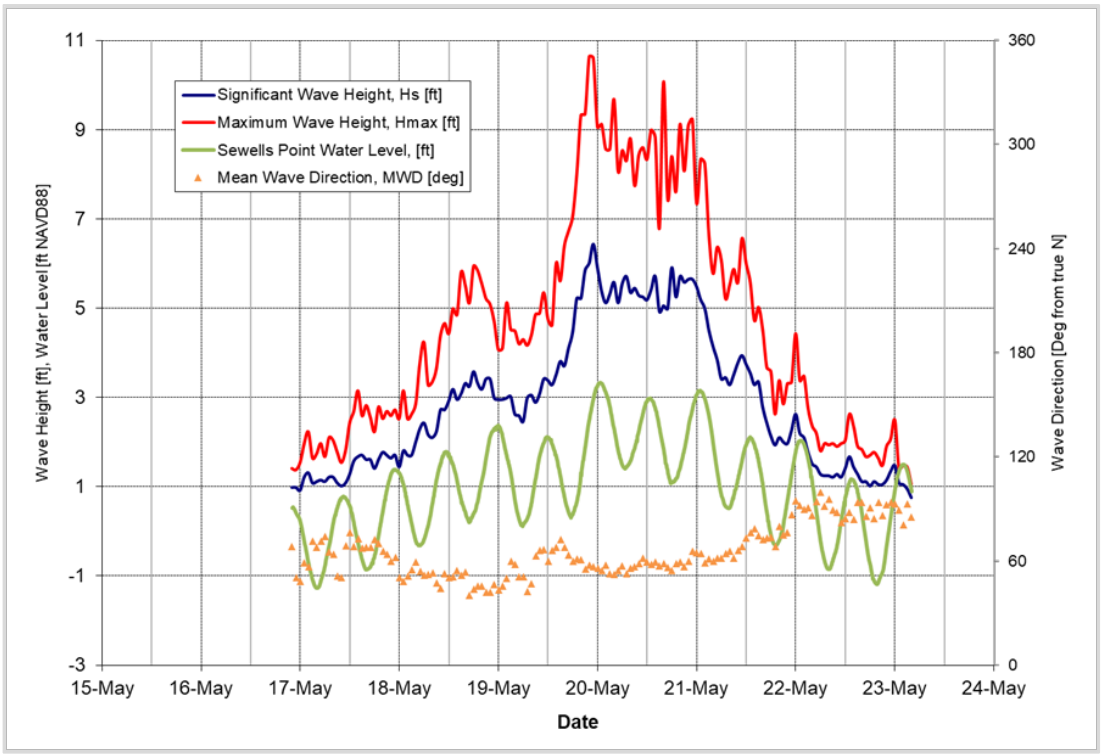

Figure 5-4: May 19, 2020 Storm

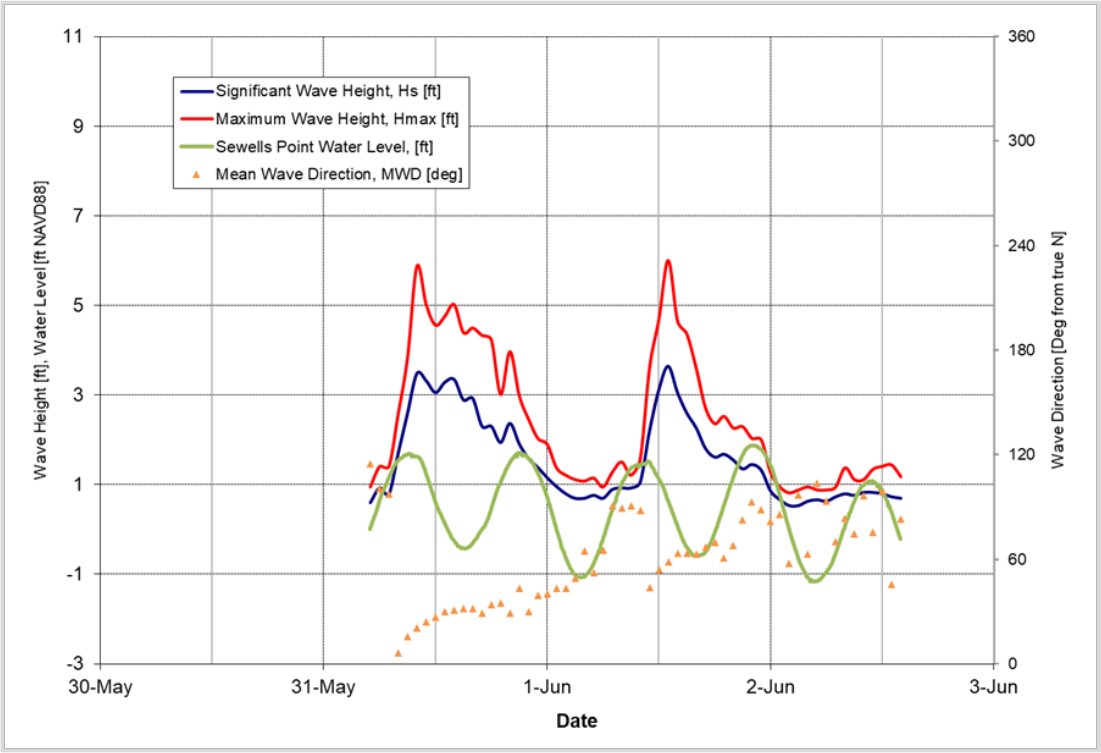

Figure 5-5: June 1, 2020 Storm

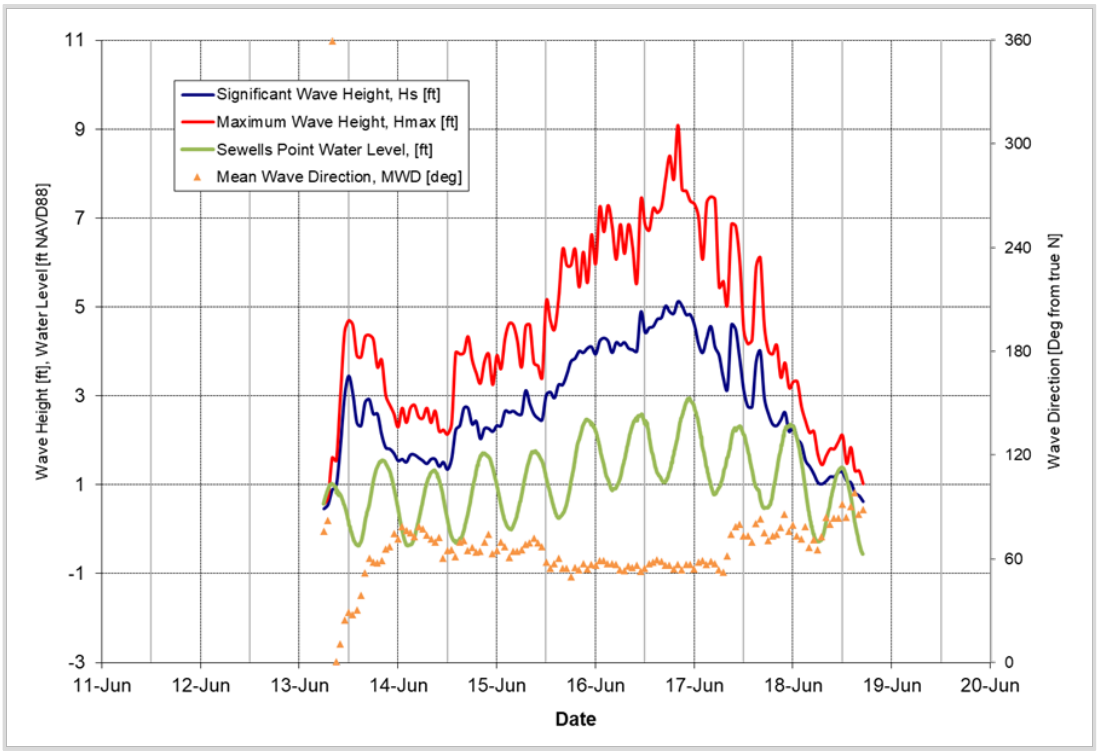

Figure 5-6: June 16, 2020 Storm

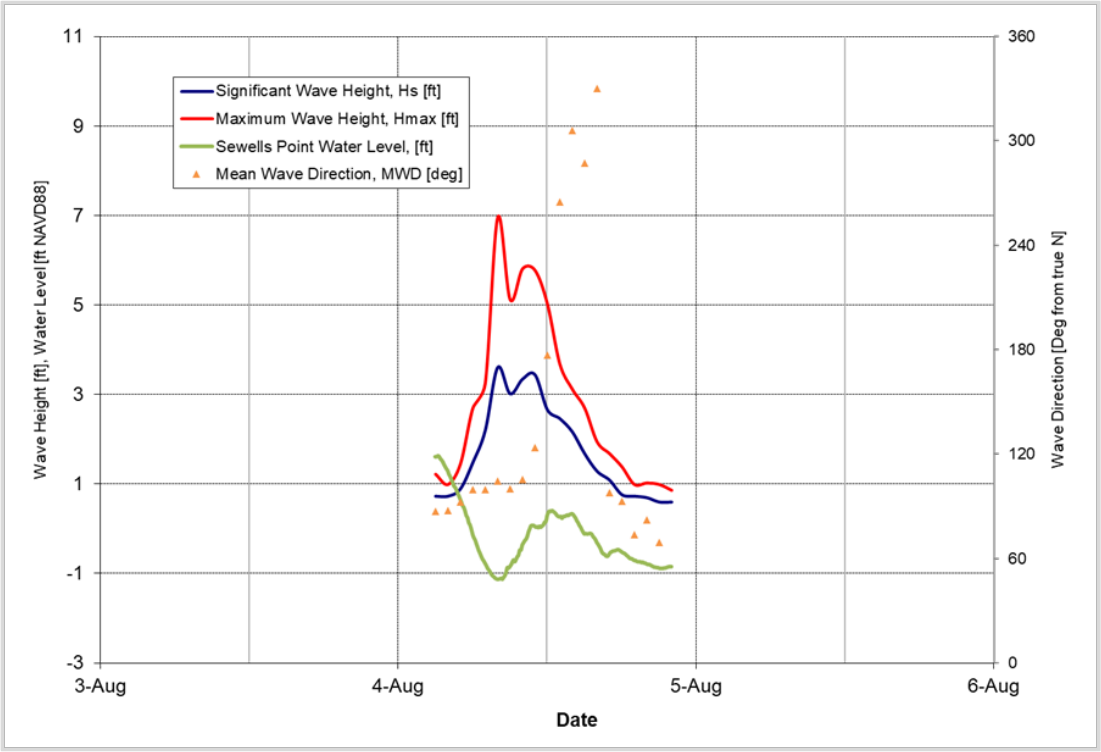

Figure 5-7: August 4, 2020 Storm

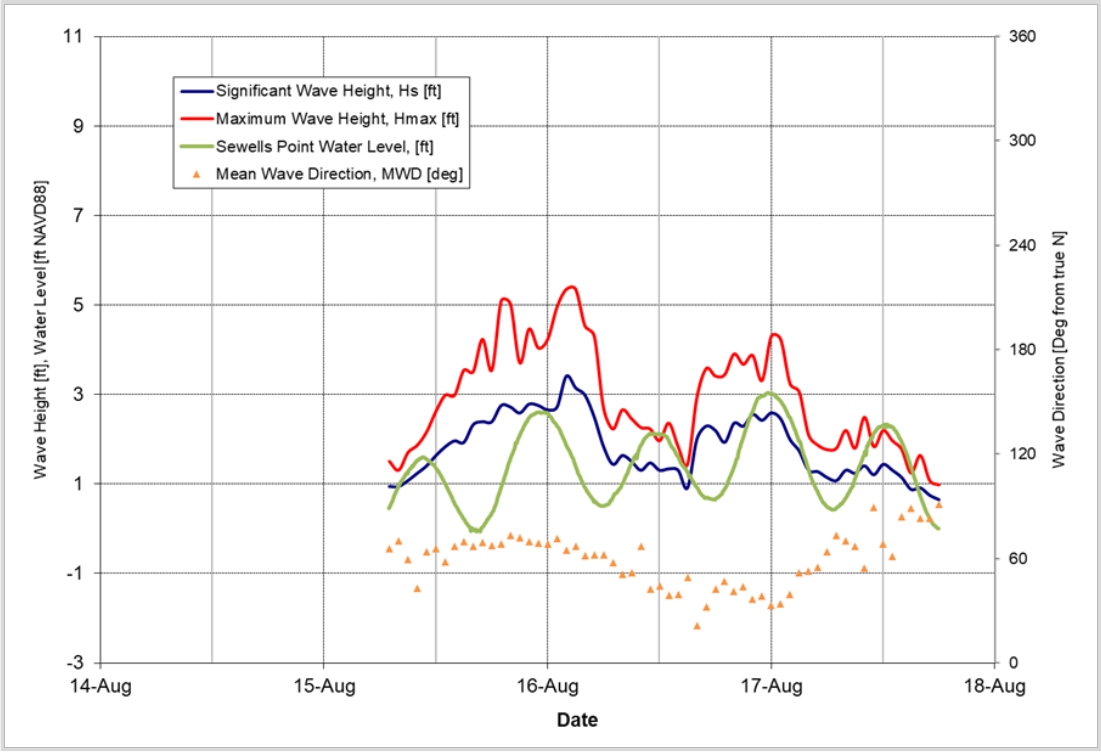

Figure 5-8: August 16, 2020 Storm

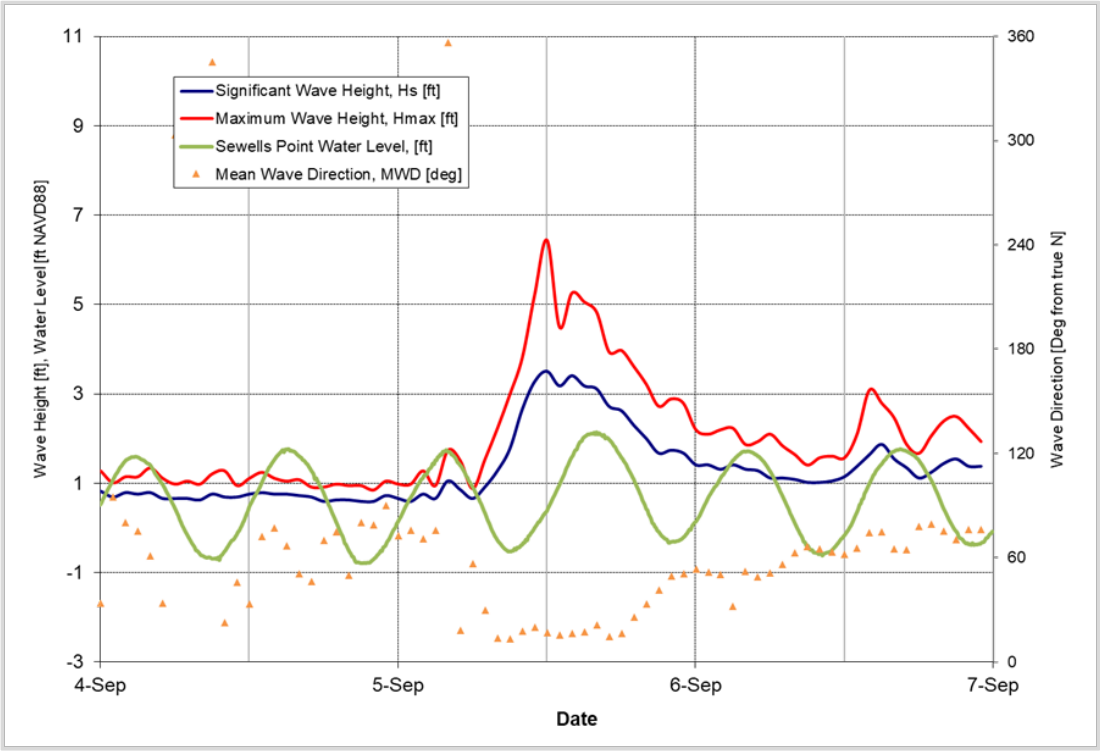

Figure 5-9: September 5, 2020 Storm

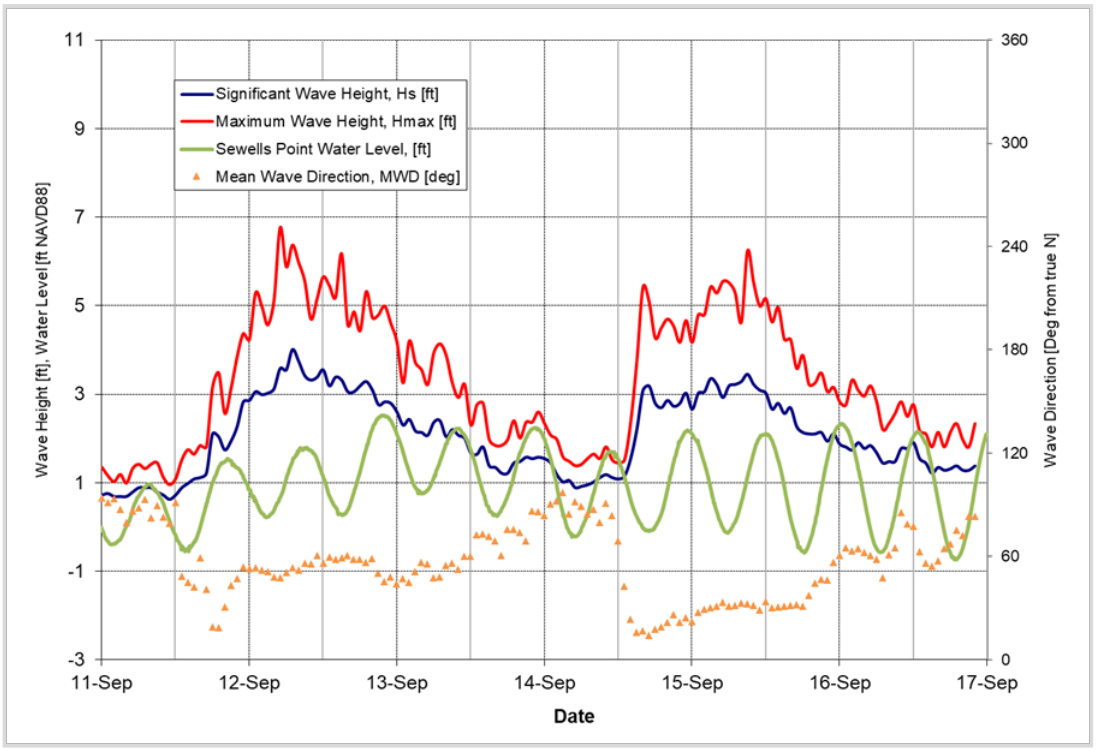

Figure 5-10: September 12, 2020 Storm

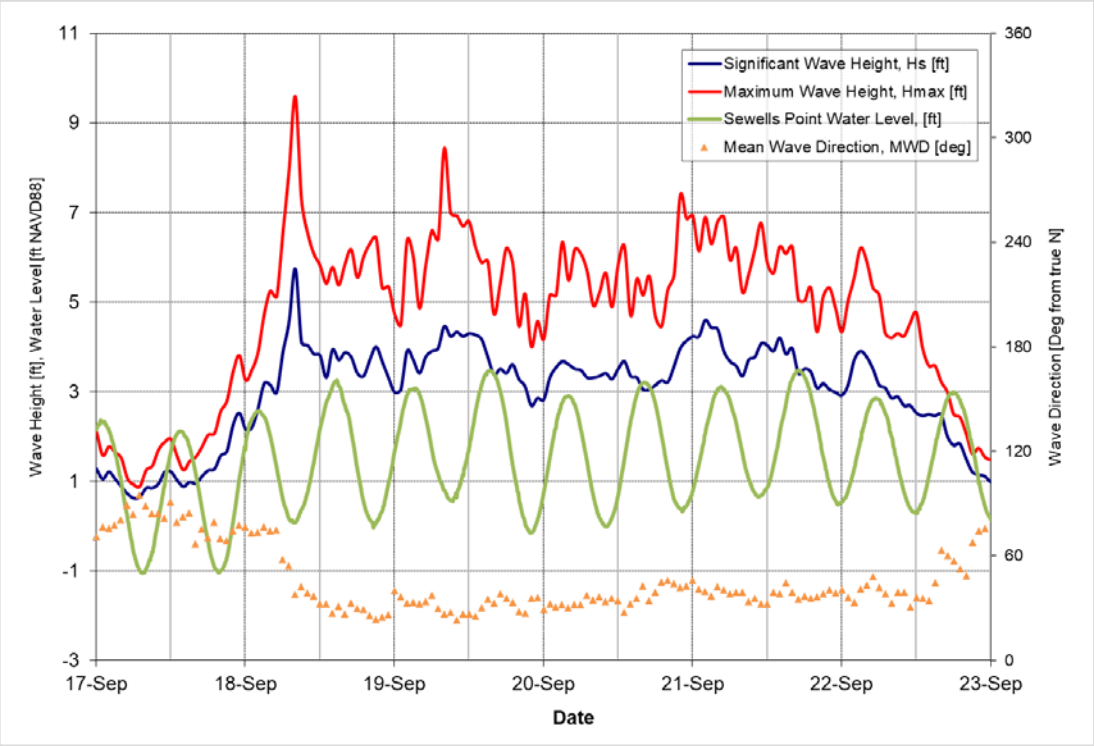

Figure 5-11: September 18, 2020 Storm

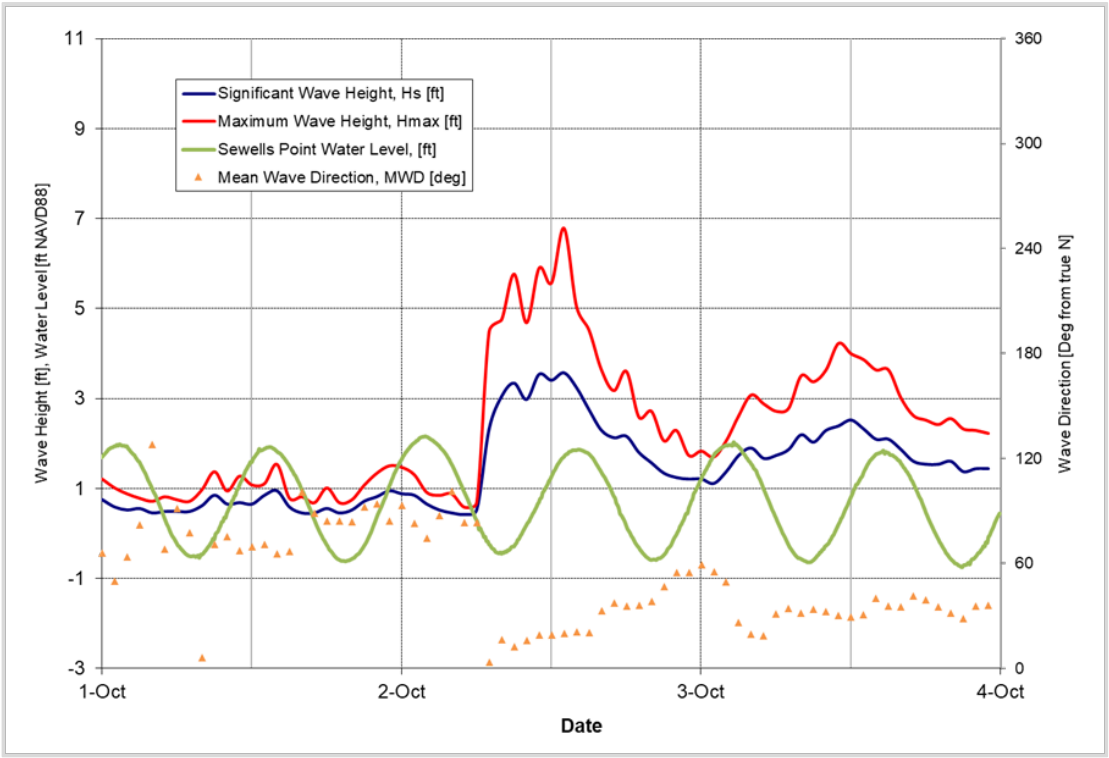

Figure 5-12: October 2, 2020 Storm

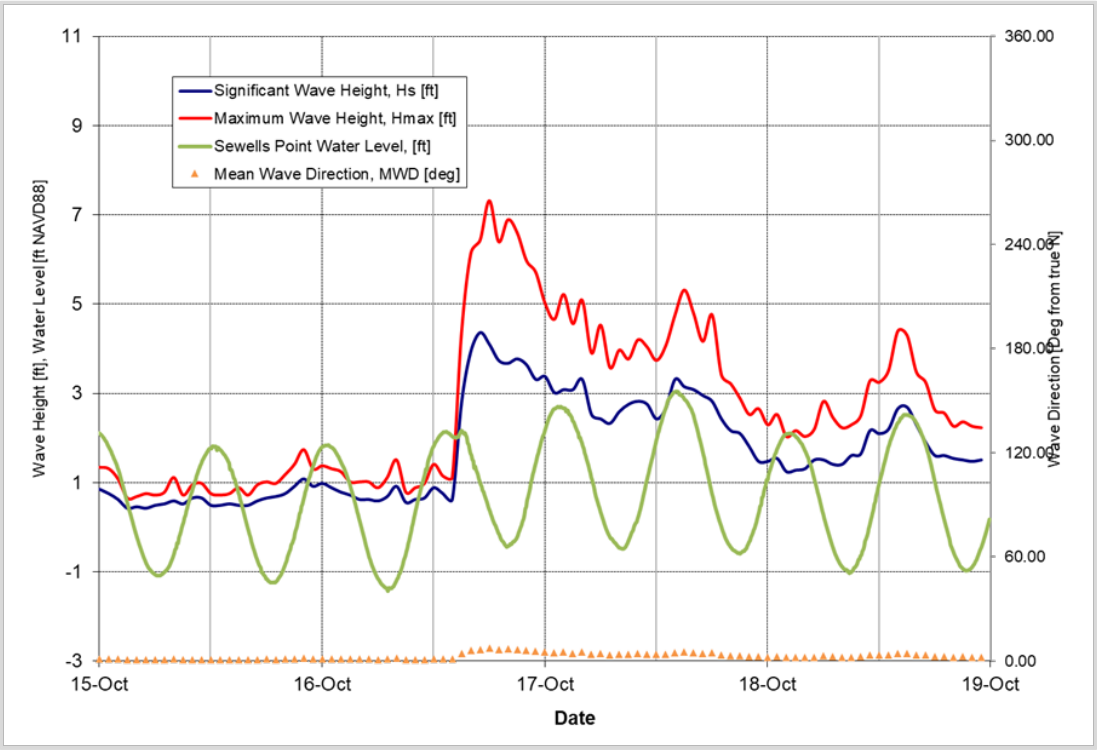

Figure 5-13: October 16, 2020 Storm

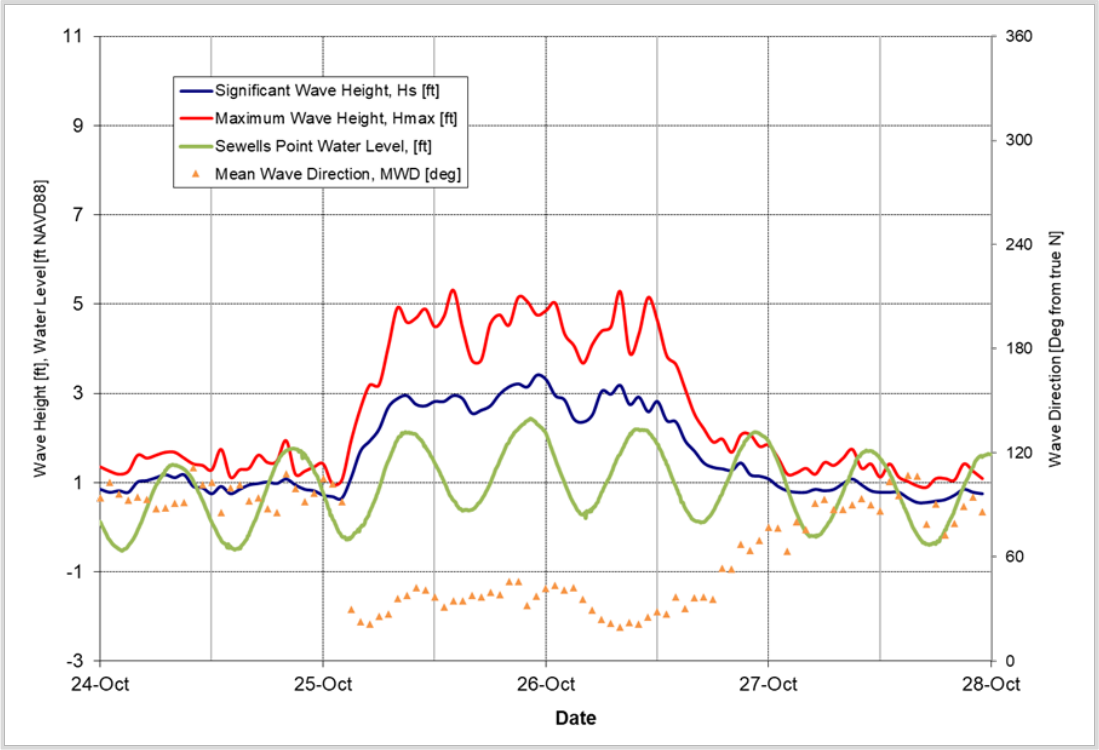

Figure 5-14: October 25, 2020 Storm

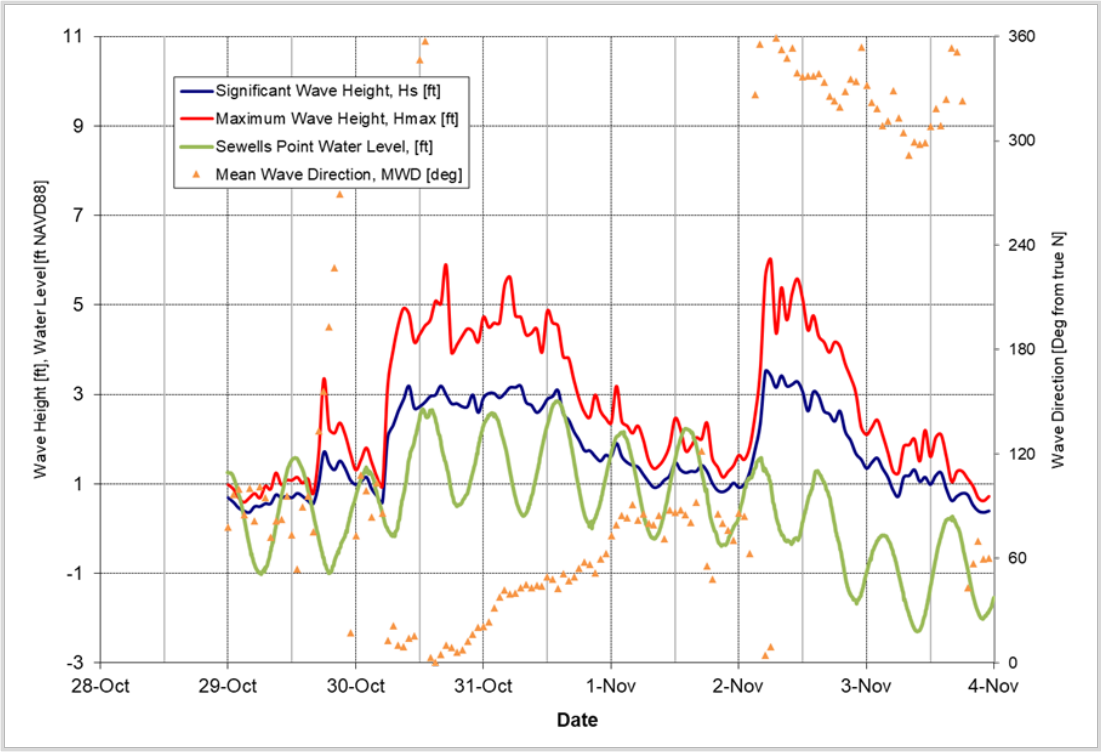

Figure 5-15: October 30, 2020 Storm

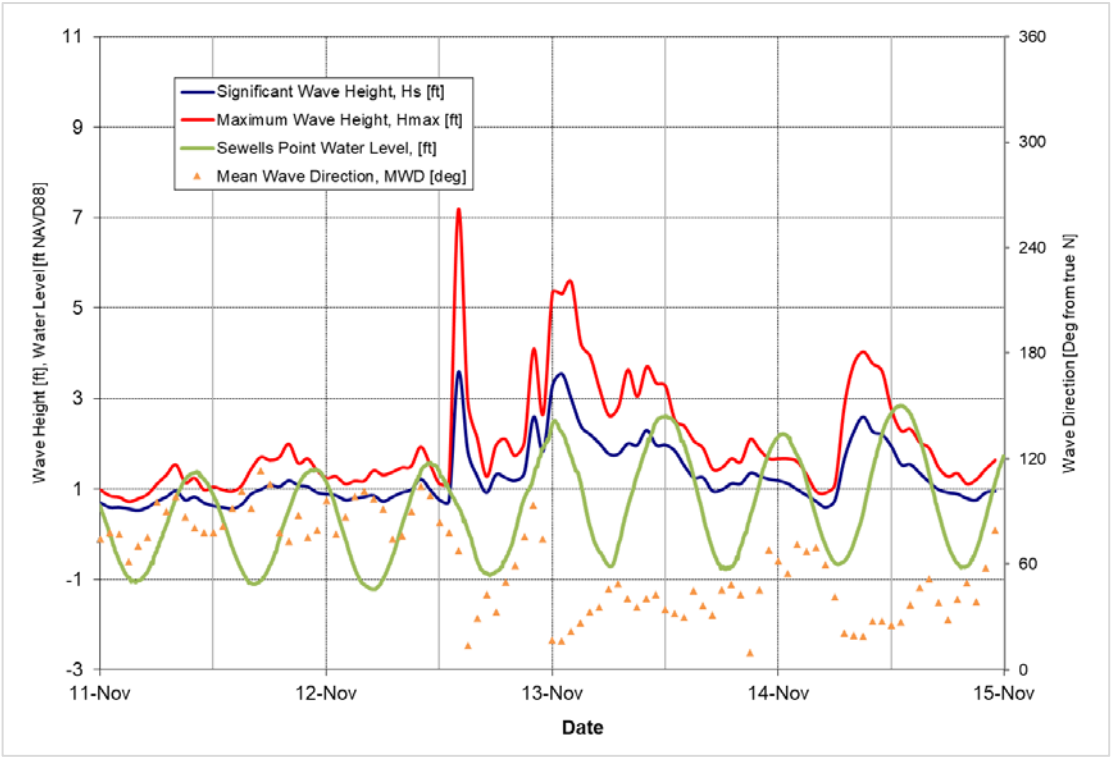

Figure 5-16: November 12, 2020 Storm

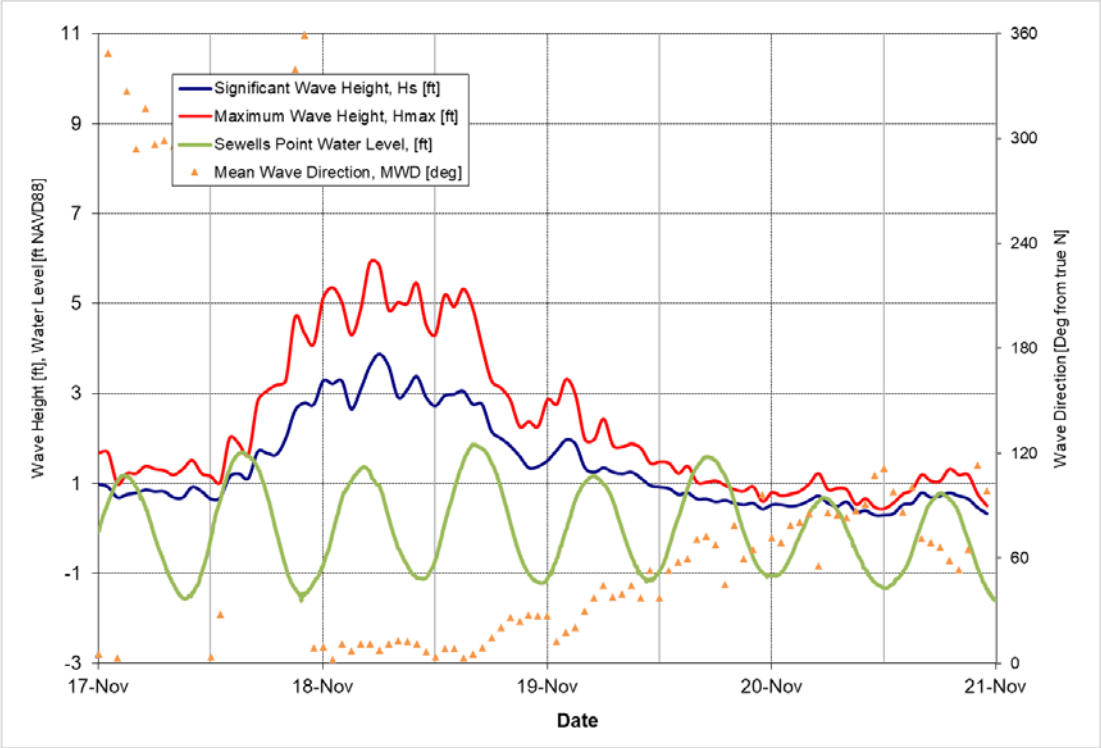

Figure 5-17: November 18, 2020 Storm

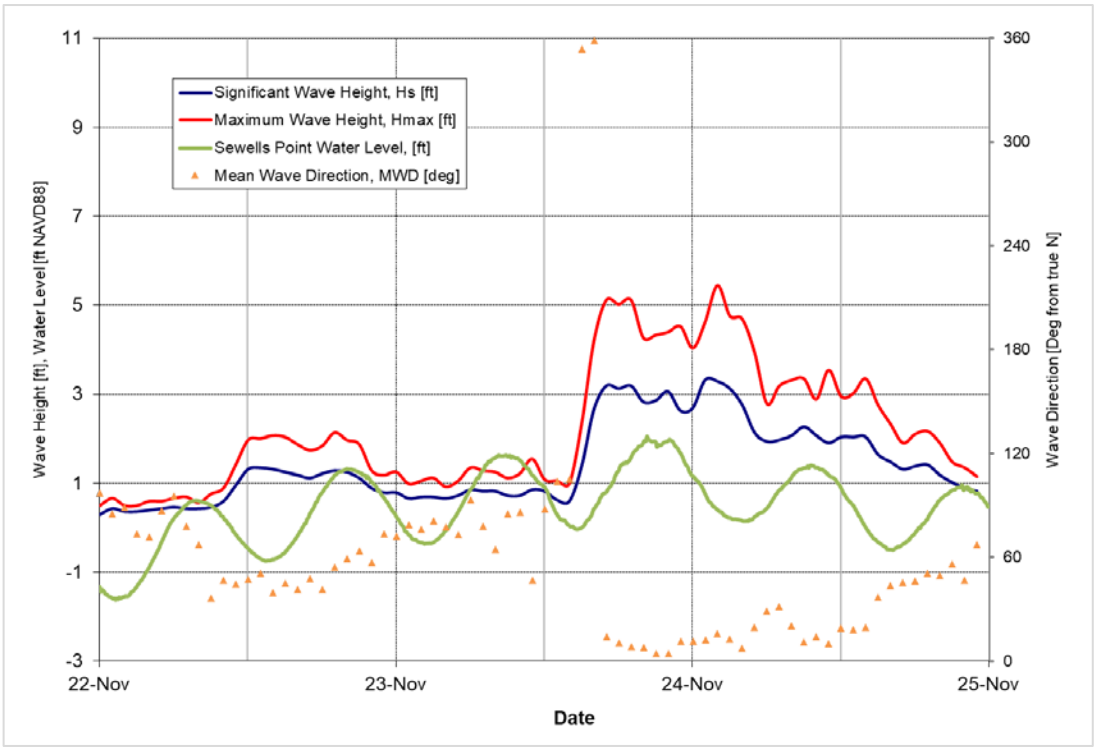

Figure 5-18: November 23, 2020 Storm

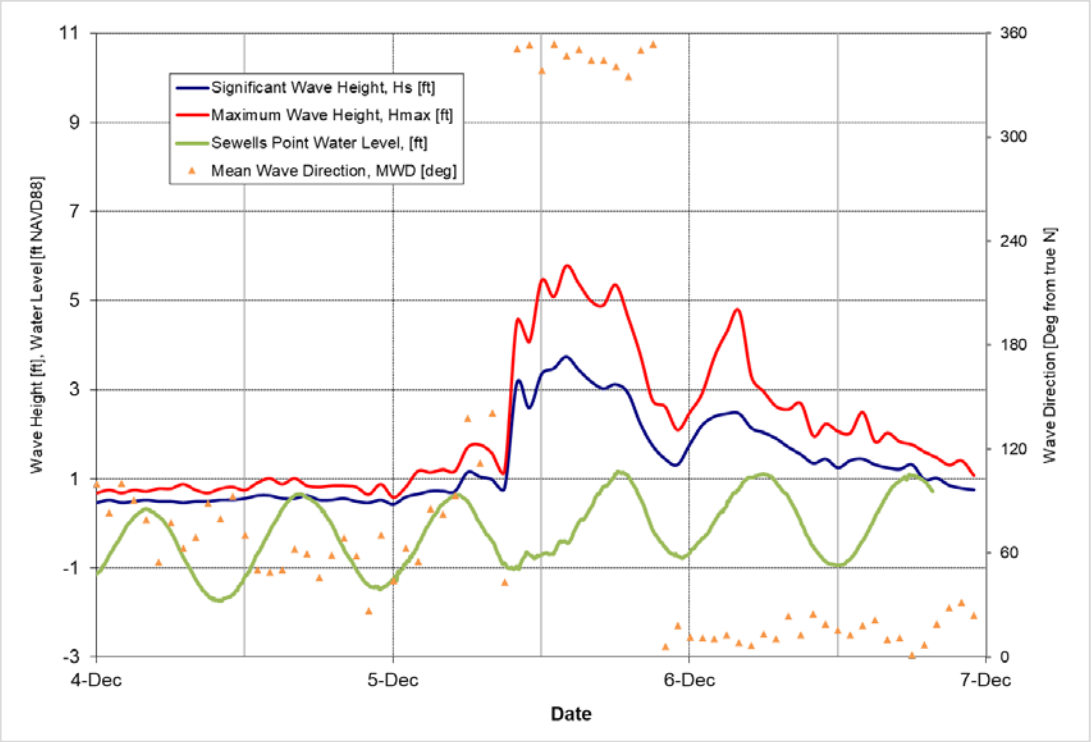

Figure 5-19: December 5, 2020 Storm

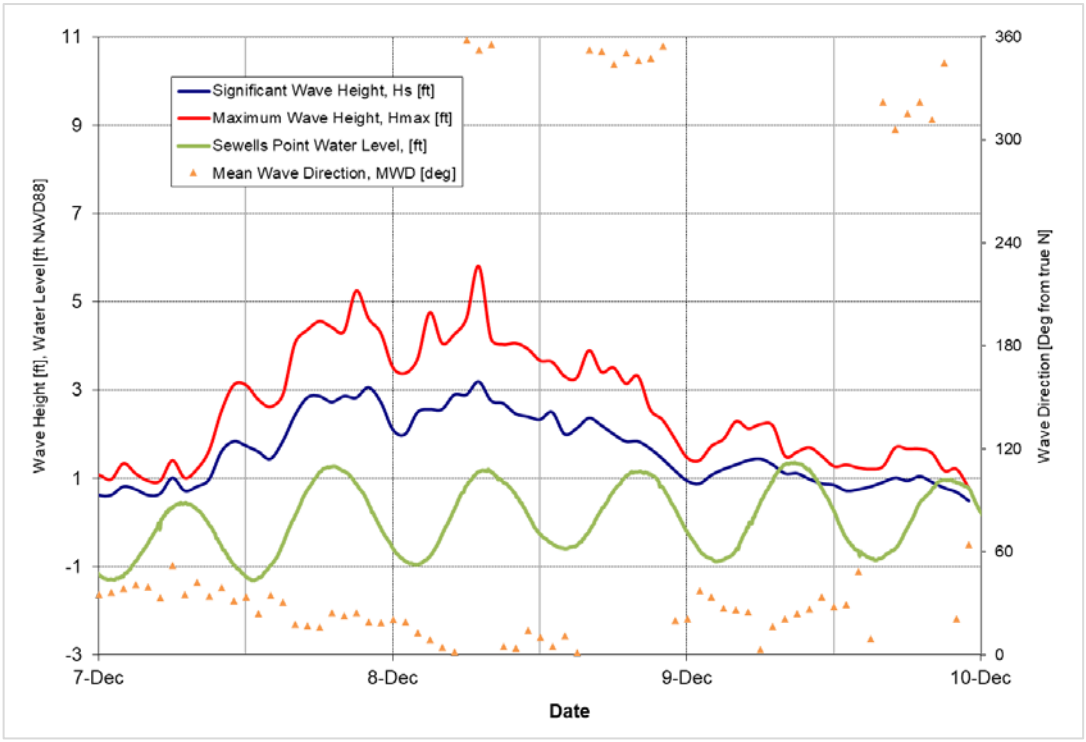

Figure 5-20: December 7, 2020 Storm

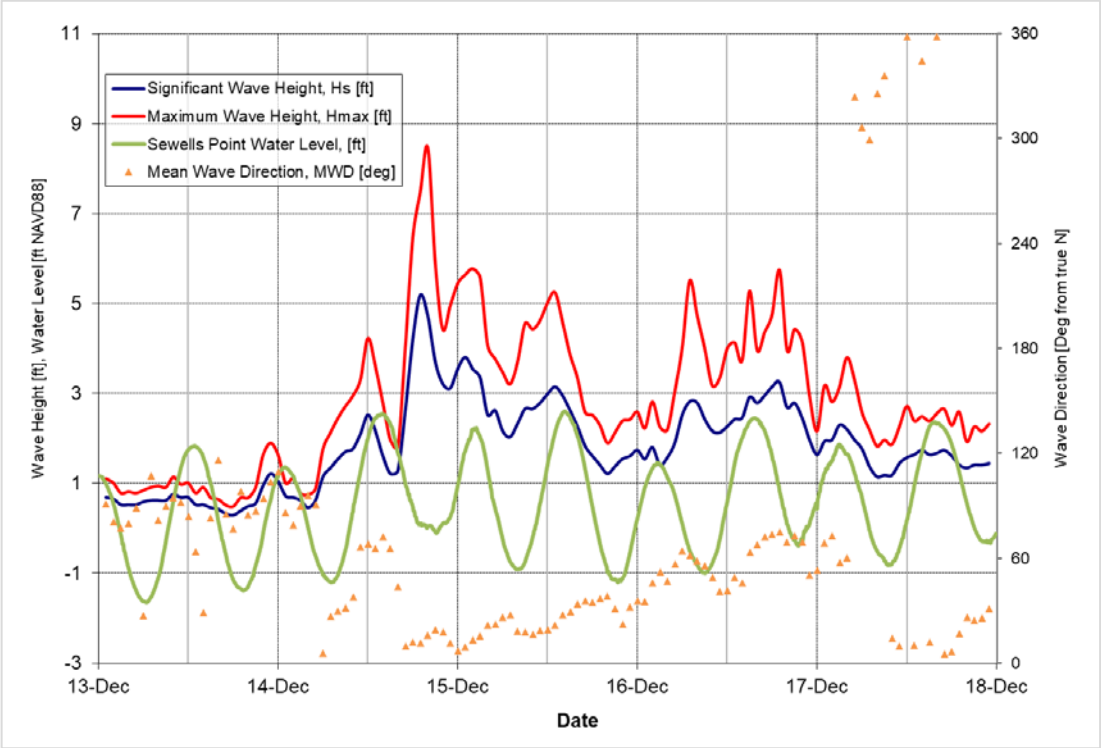

Figure 5-21: December 14, 2020 Storm

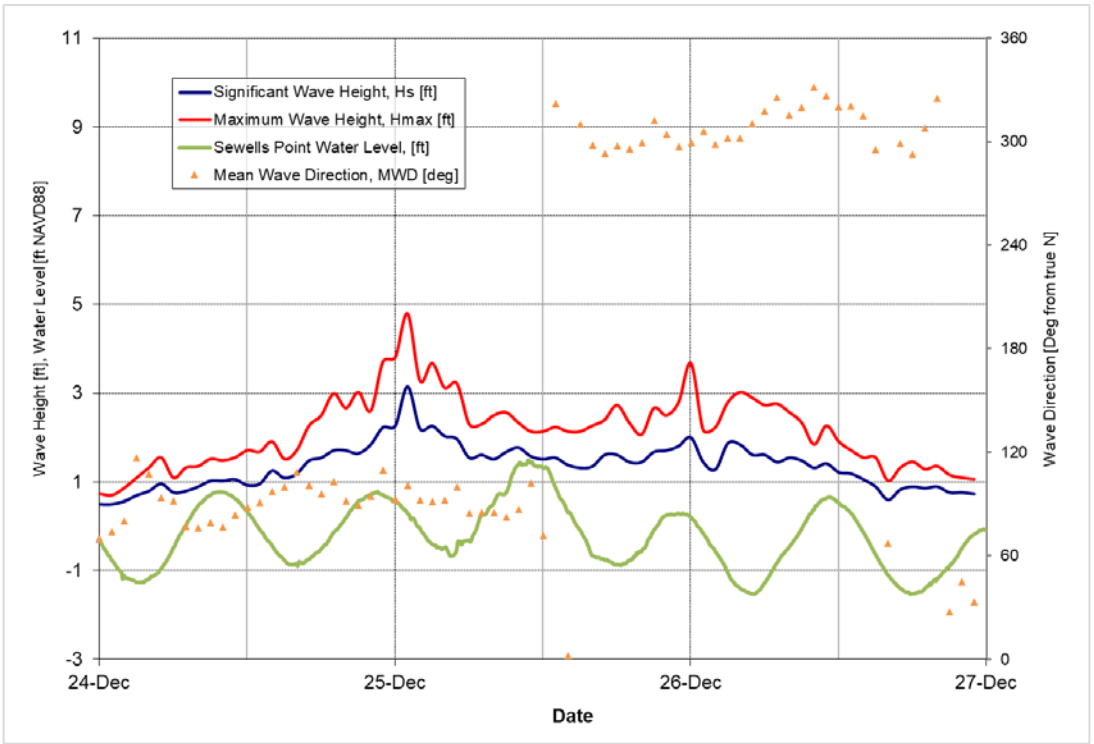

Figure 5-22: December 25, 2020 Storm

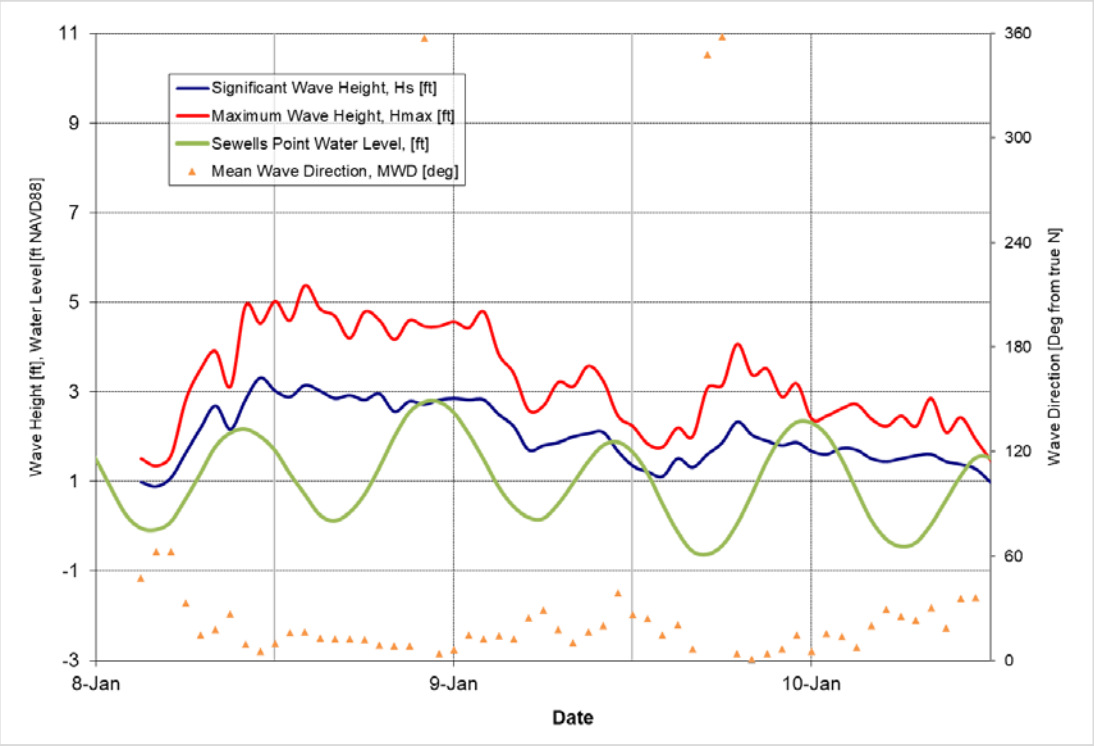

Figure 5-23: January 9, 2021 Storm

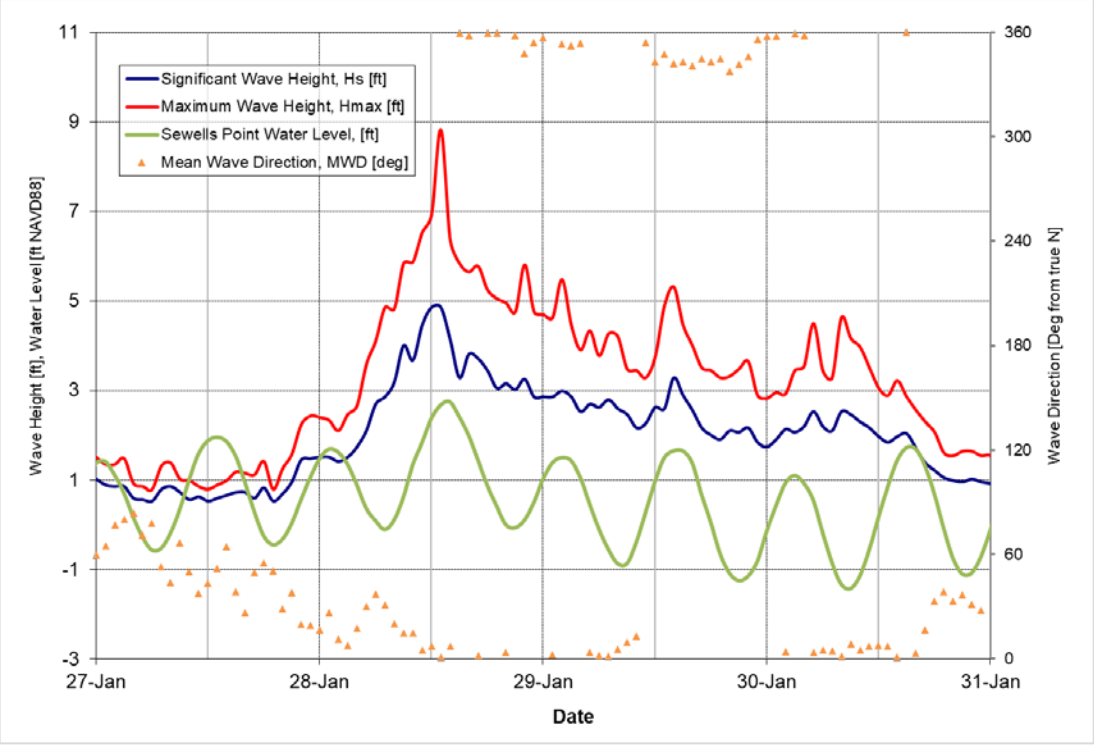

Figure 5-24: January 28, 2021 Storm

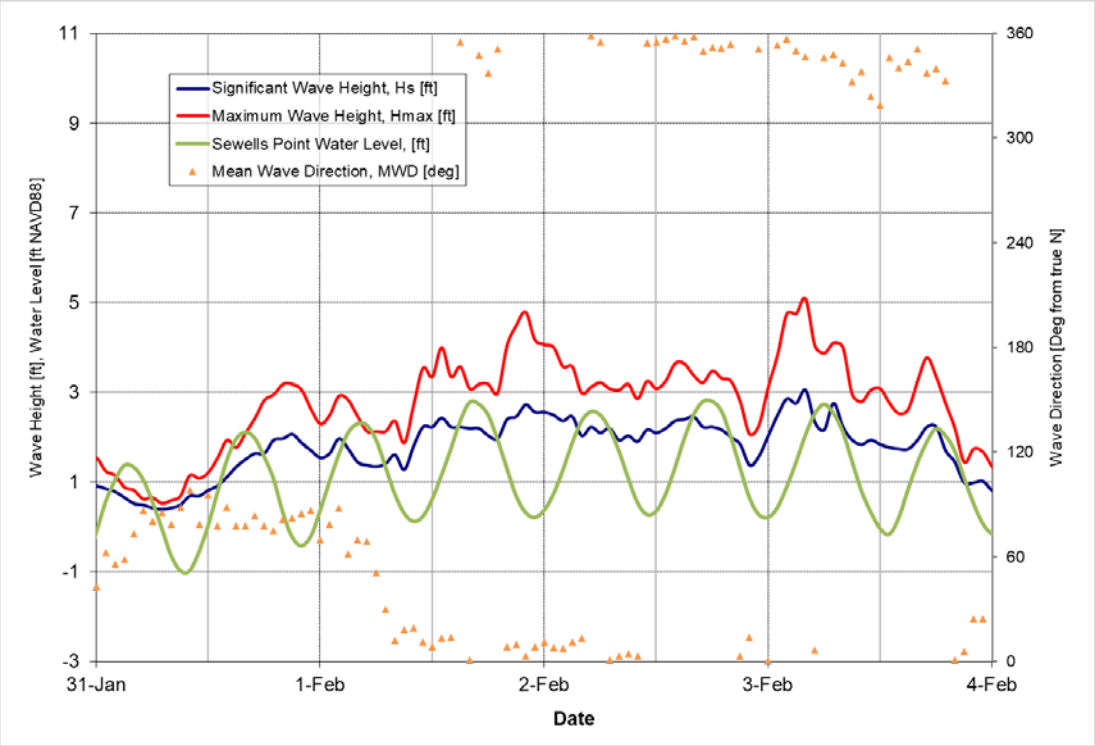

Figure 5-25: February 3, 2021 Storm

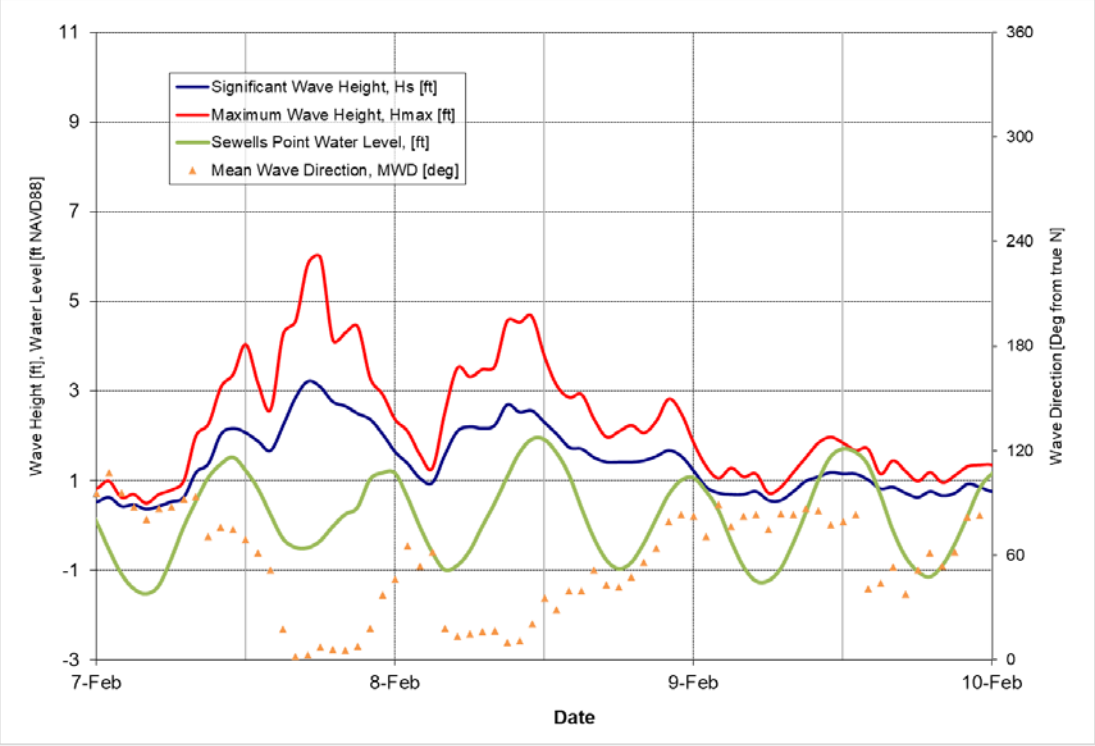

Figure 5-26: February 7, 2021 Storm

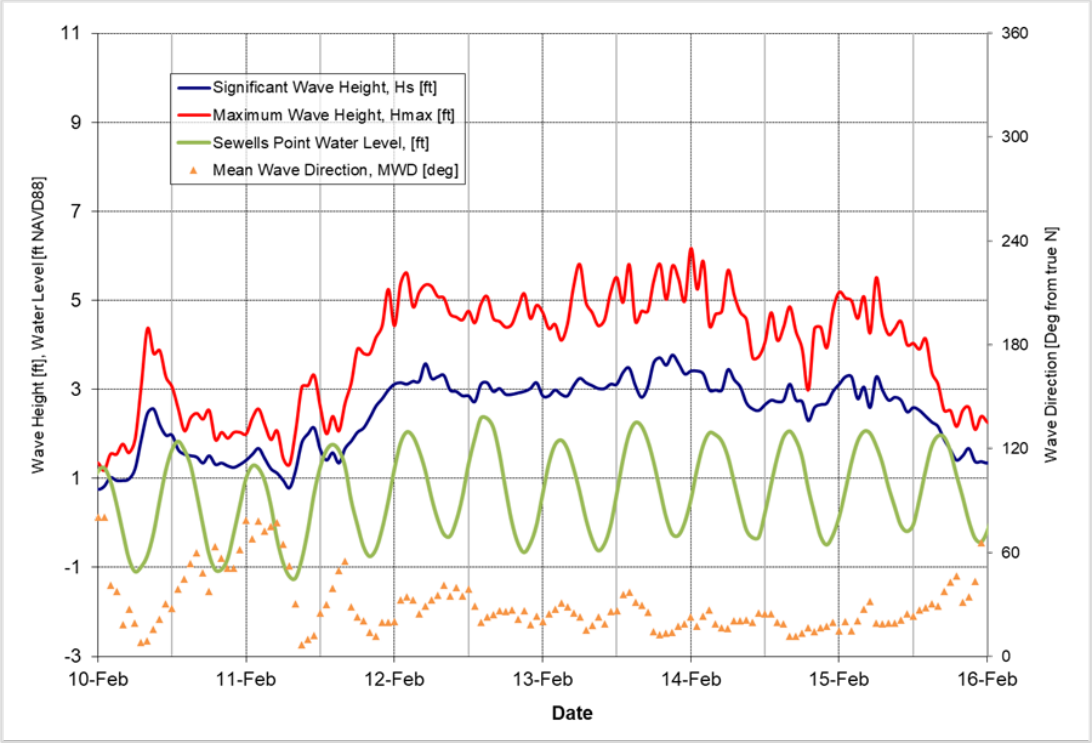

Figure 5-27: February 13, 2021 Storm

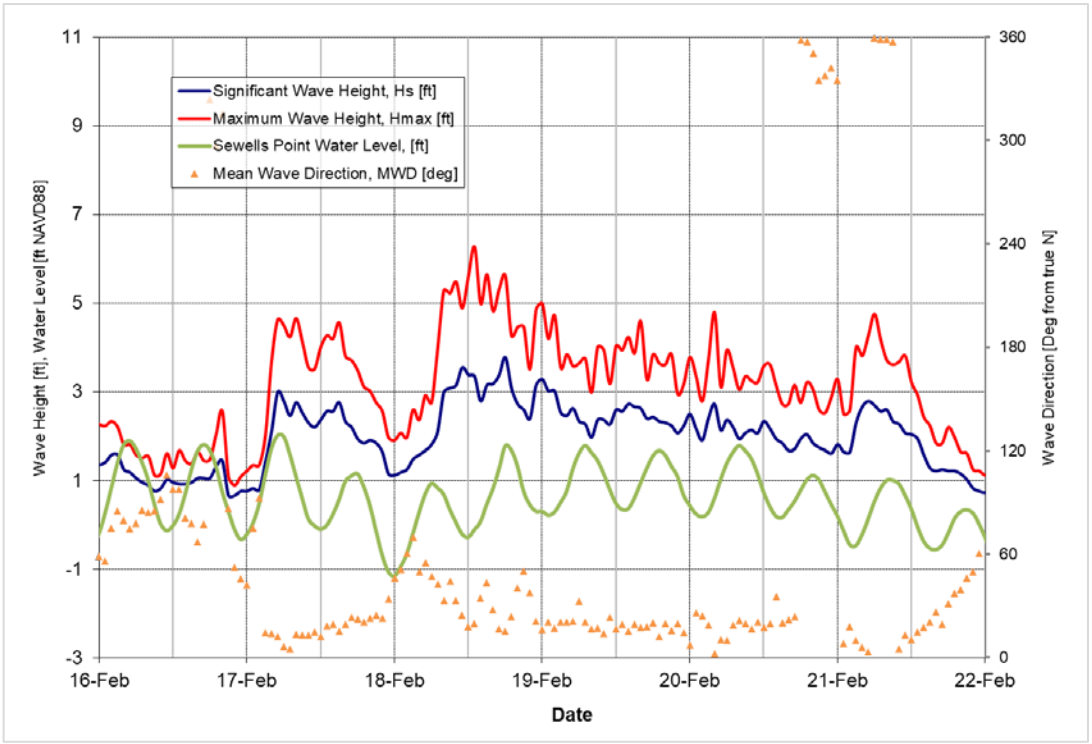

Figure 5-28: February 18, 2021 Storm

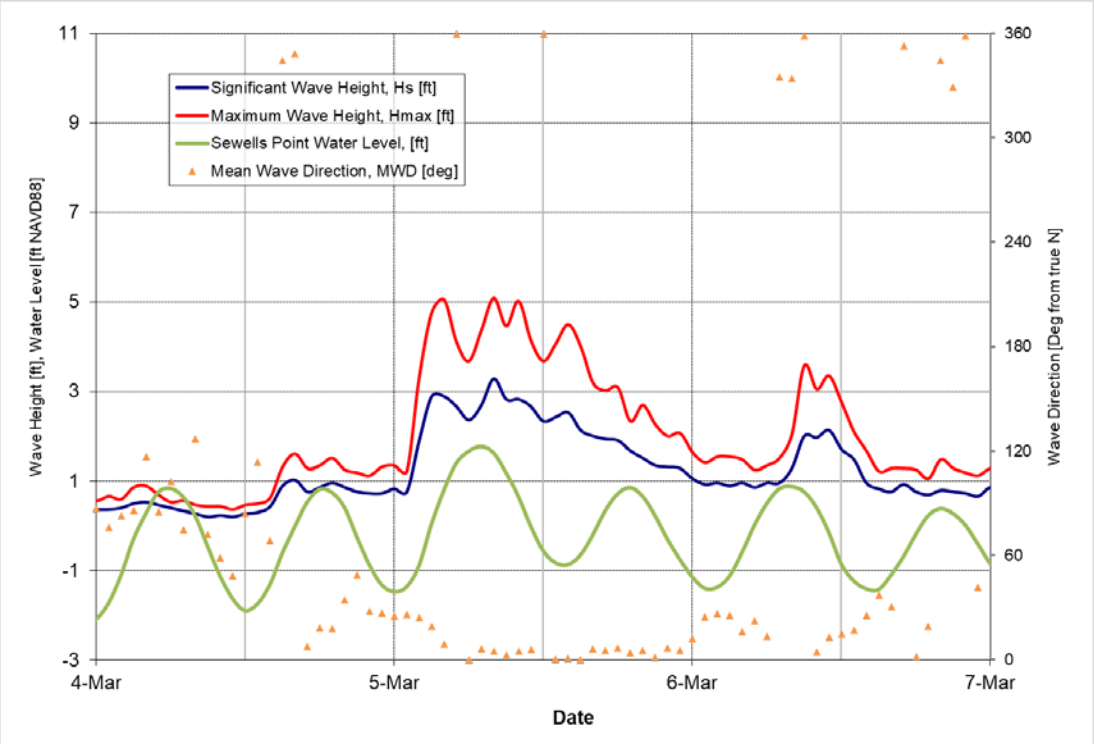

Figure 5-29: March 5, 2021 Storm

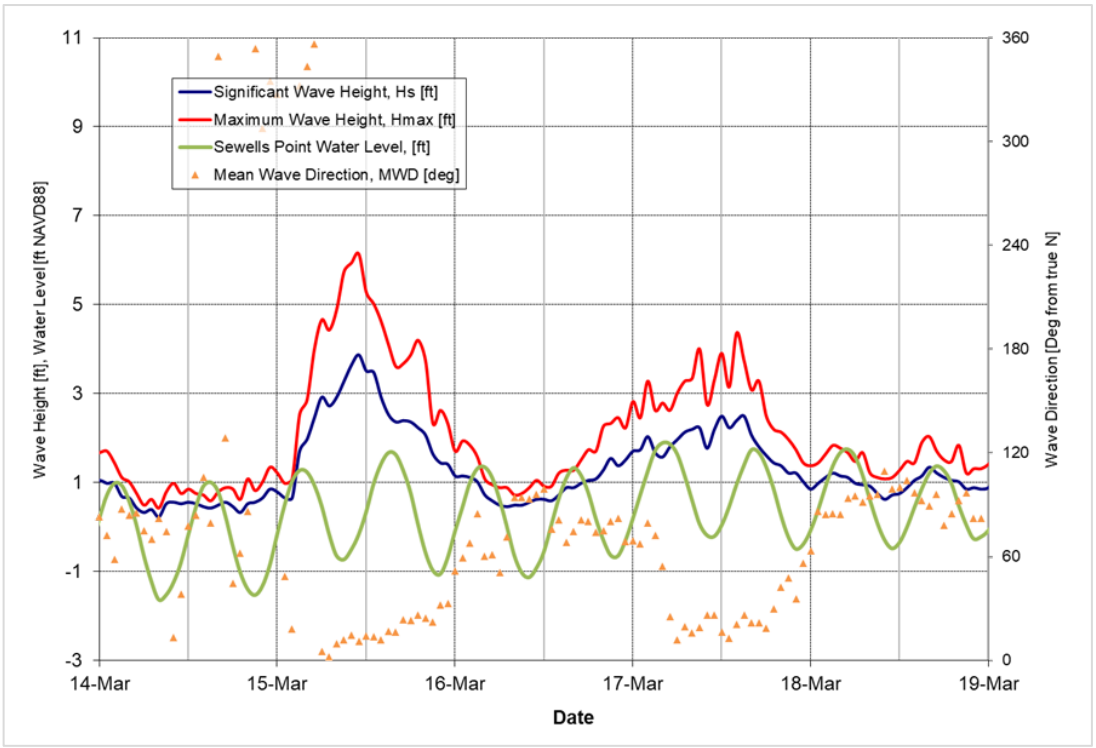

Figure 5-30: March 15, 2021 Storm

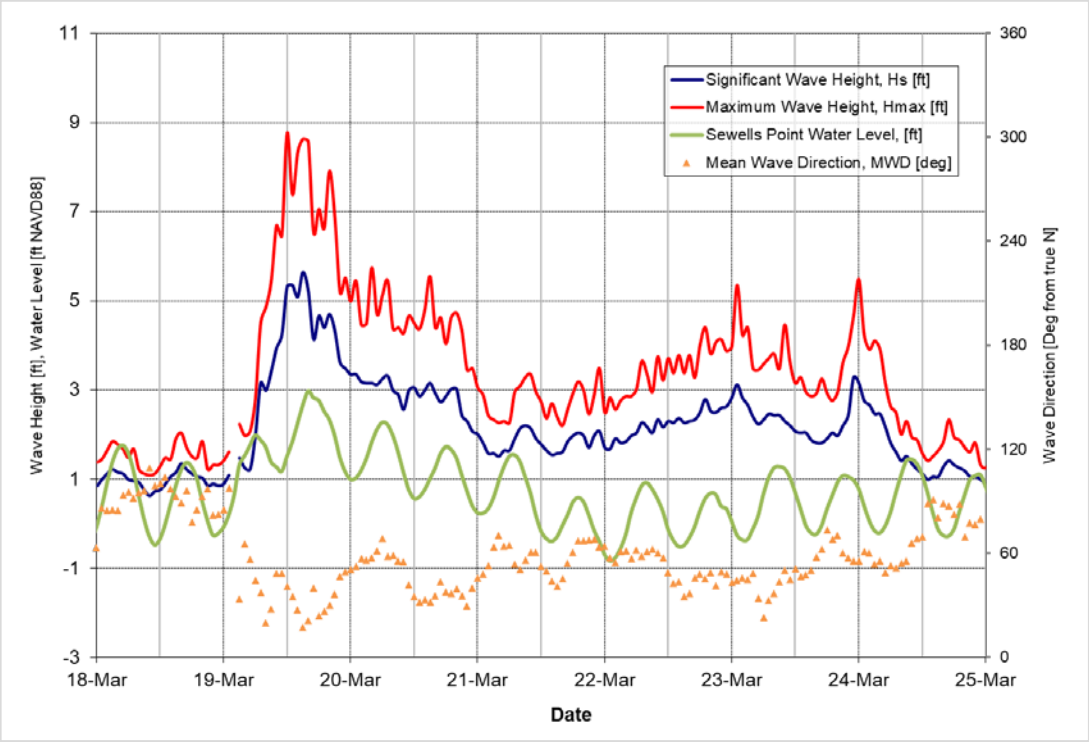

Figure 5-31: March 19, 2021 Storm

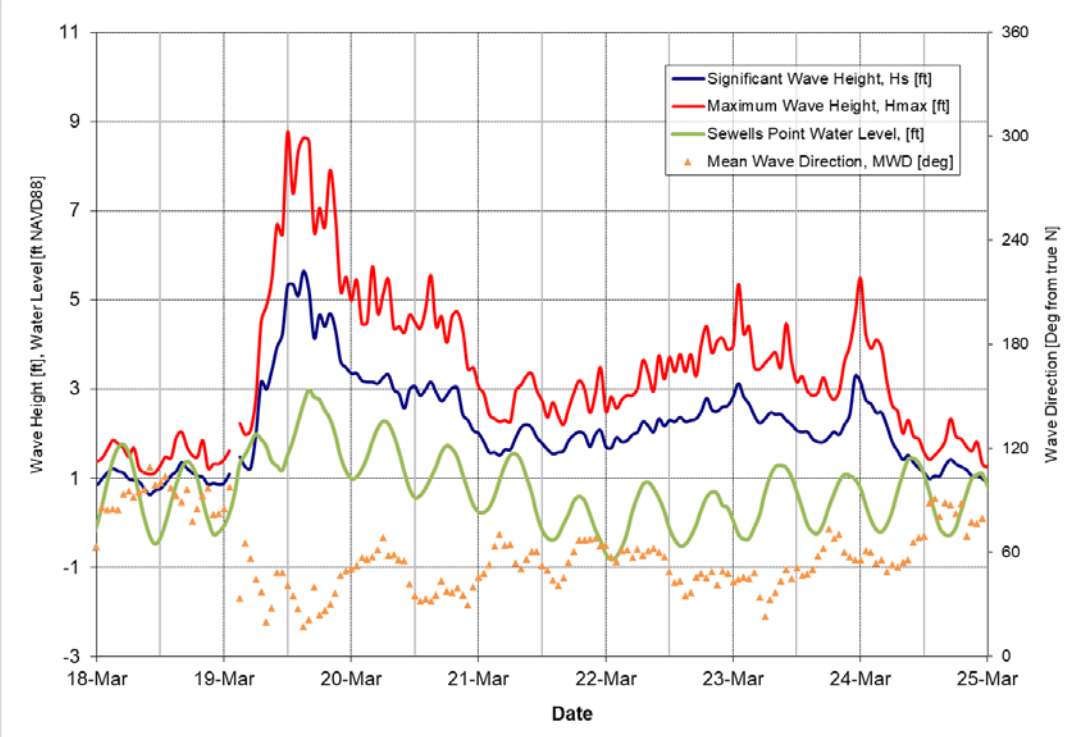

Figure 5-32: March 19, 2021 Storm

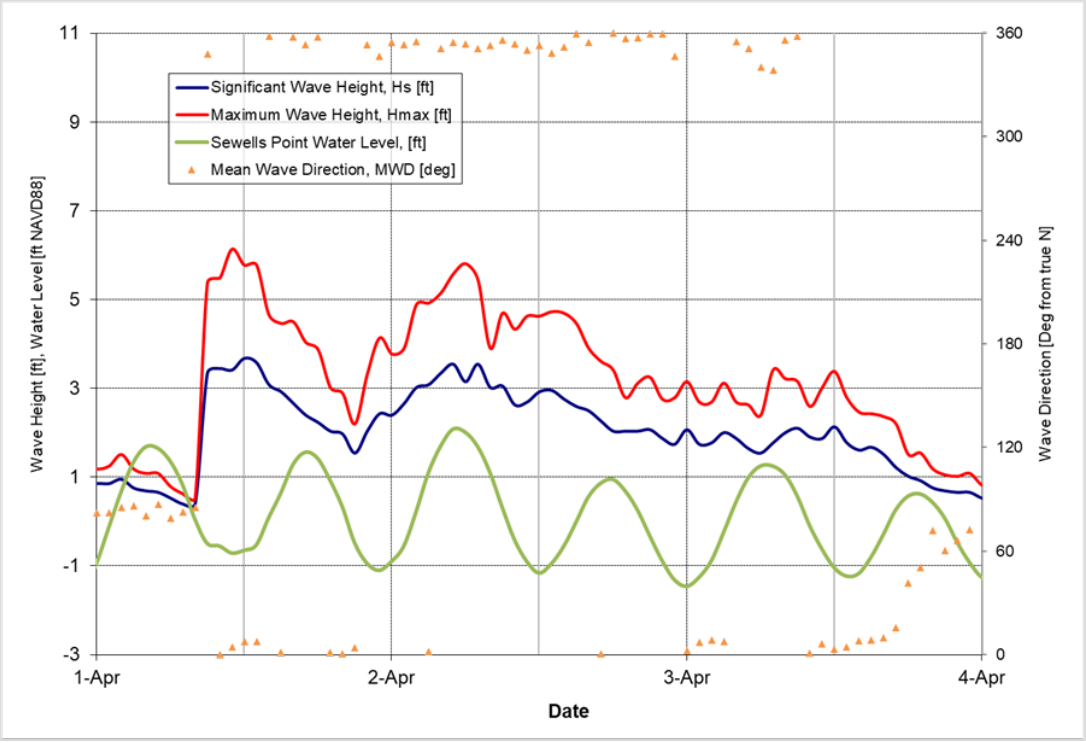

Figure 5-33: April 1, 2021 Storm

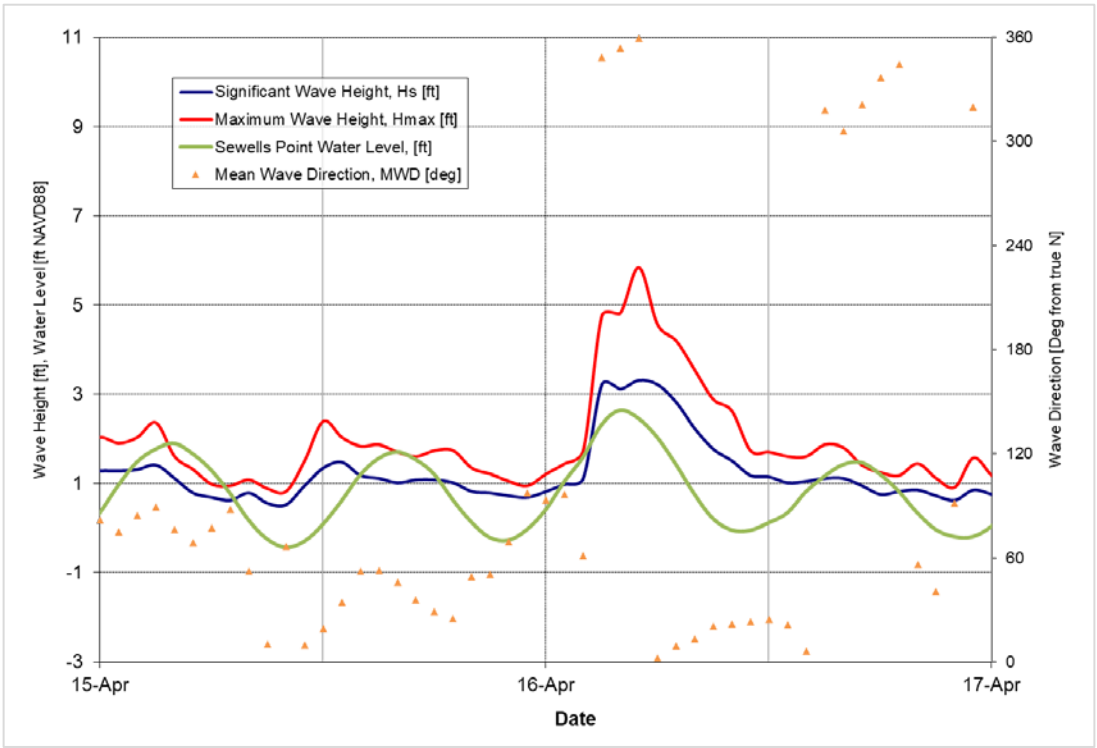

Figure 5-34: April 16, 2021 Storm

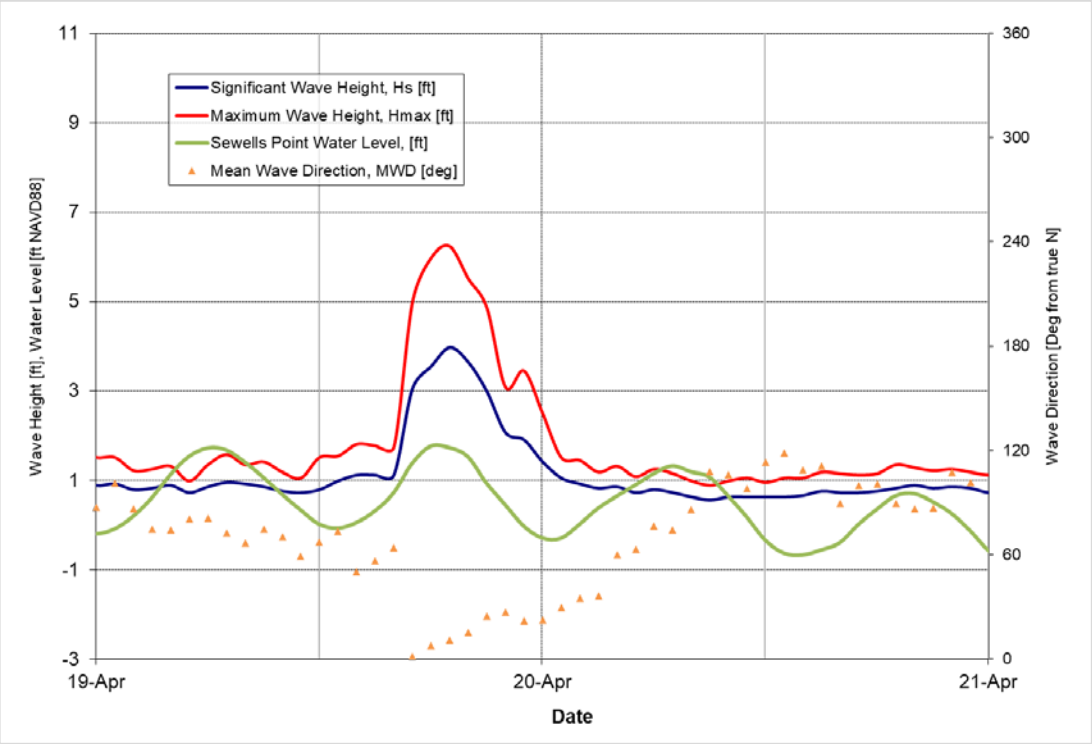

Figure 5-35: April 19, 2021 Storm

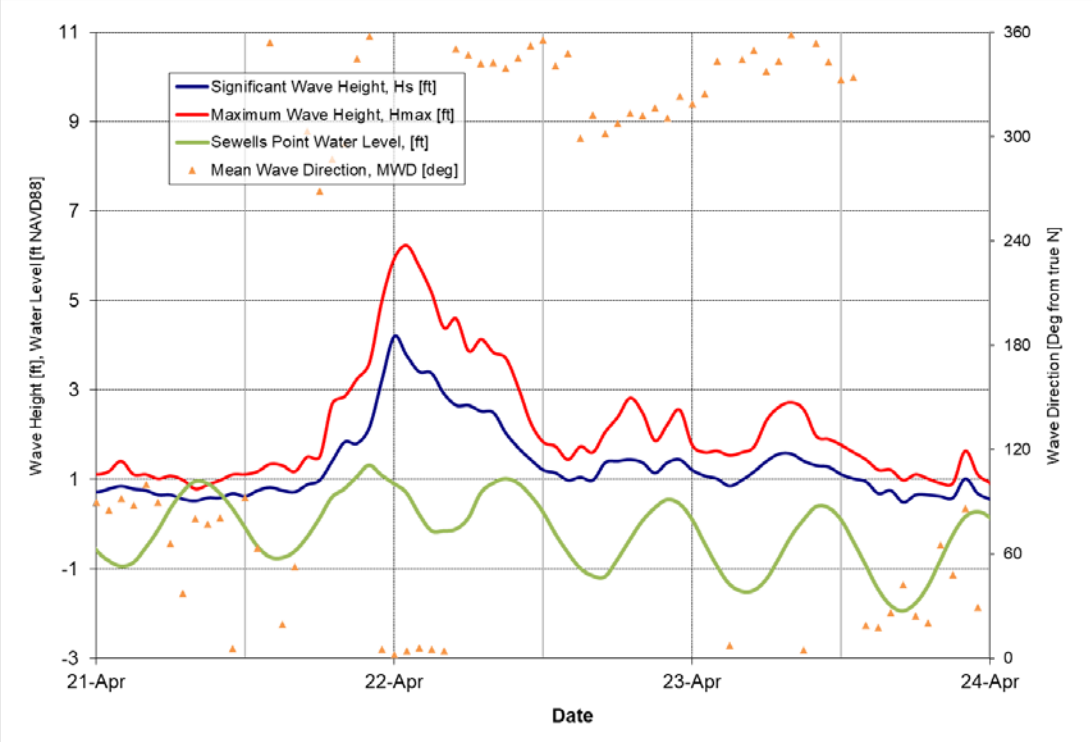

Figure 5-36: April 22, 2021 Storm

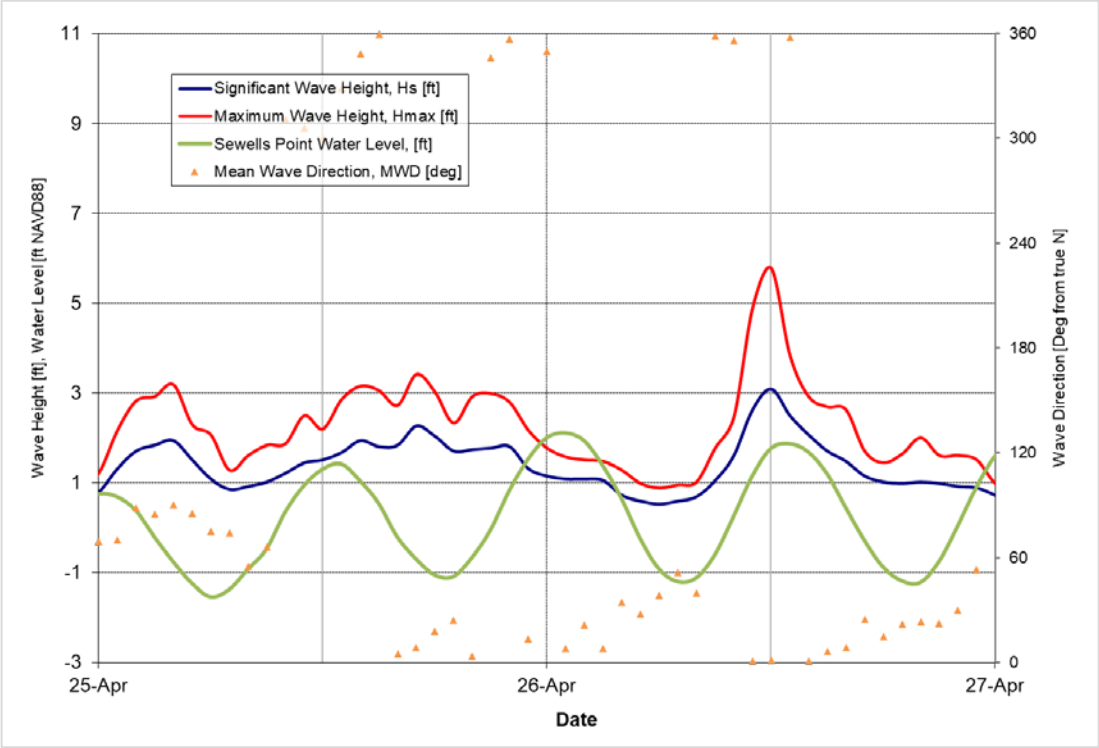

Figure 5-37: April 26, 2021 Storm

5.2.2. Engineering Activities

The Toler Place breakwater modification project near 11th View Street was constructed between March 2020 and July 2020.

5.3. General Shoreline Trends

Key statistics were calculated to describe the shoreline and volume change trends over the entire shoreline as well as for each region of the shoreline as defined in Figure 3-1. The computed statistics include average shoreline change, average volume change, and cumulative volume change (e.g. total volume of material lost or gained along a section of shoreline). A summary of the resulting statistics for the June 2020 to June 2021 comparison are presented in Table 5-2. A summary of the resulting statistics for the October 2020 to June 2021 comparison are presented in Table 5-3.

As illustrated in Table 5-2, the Ocean View shoreline has experienced overall retreat at MHW during June 2020 to June 2021 with a length-weighted average change rate of -6.71 ft/yr. The beach and dune above 0 feet NAVD88 gained sediment at a rate of 27,790 cy/yr from June 2020 to June 2021. The beach and dune above -15 feet NAVD88 lost sediment at a rate of -866 cy/yr from June 2020 to June 2021.

From October 2020 to June 2021, the MHW shoreline gained an average shoreline change of 1.45 feet, as shown in Table 5-3. The volumetric change over the same period showed a gain of 45,501 cy above 0 feet NAVD88, and a gain of 94,306 cy above -15 feet NAVD88, respectively.

The overall trends and the behavior of the system are better understood by looking at patterns of change on a reach-by-reach basis, as discussed in more detail in the following section.

Table 5-2: Regional Shoreline and Volume Change Statistics (Jun. 2020 to Jun. 2021)

Region	Average Shoreline Change	Average Volume Change Rate Above 0 ft NAVD88	Cumulative Volume Change Rate Above 0 ft NAVD88	Average Volume Change Rate Above -15 ft NAVD88	Cumulative Volume Change Rate Above -15 ft NAVD88
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
Willoughby Spit (0+00 to 45+00)	-2.84	1.00	4,505	-1.47	-6,632
800 Block Breakwaters (45+25 to 87+62)	-7.53	-0.47	-2,150	0.24	1,067
West Ocean View (93+41 to 163+49)	-11.67	-0.89	-5,975	-1.11	-6,610
Central Ocean View Breakwaters (169+63 to 195+63)	-10.99	-0.03	-96	0.43	1,489
Central Ocean View (206+86 to 323+09)	-1.03	2.57	32,144	1.78	22,219
East Ocean View (329+63 to 383+58)	-12.37	-0.11	-638	-2.17	-12,400
OVERALL	Weighted Avg (ft/yr)	Weighted Avg (cy/ft/yr)	Total (cy/yr)	Weighted Avg (cy/ft/yr)	Total (cy/yr)
	-6.71	0.70	27,790	-0.07	-866

Table 5-3: Regional Shoreline and Volume Change Statistics (Oct. 2020 to Jun. 2021)

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
Willoughby Spit (0+00 to 45+00)	1.61	0.48	2,174	2.11	9,534
800 Block Breakwaters (45+25 to 87+62)	-4.13	-0.84	-3,834	-0.99	-4,481
West Ocean View (93+41 to 163+49)	0.82	0.82	6,244	2.44	18,532
Central Ocean View Breakwaters (169+63 to 195+63)	1.16	0.59	2,053	1.20	4,147
Central Ocean View (206+86 to 323+09)	5.90	2.54	31,751	3.75	46,979
East Ocean View (329+63 to 383+58)	-2.96	1.24	7,113	3.42	19,596
OVERALL	Weighted Avg (ft)	Weighted Avg (cy/ft)	Total (cy)	Weighted Avg (cy/ft)	Total (cy)
	1.45	1.19	45,501	2.46	94,306

5.4. Regional Shoreline Trends

Regional shoreline trends are discussed below for the defined regions between Willoughby Spit and Little Creek Inlet (see Figure 3-1). A summary of the information in Table 5-2 and Table 5-3 has been created for each region of study.

Figure 5-38 through Figure 5-41, following the discussion of regional shoreline trends, present the shoreline and volume change at each transect within the defined regions.

5.4.1. Willoughby Spit

The western end of the Willoughby Spit region has, on average since regular monitoring started in 2005, been a relatively stable and accreting region. However, over the past year between monitoring surveys, the western end of the spit between stations 0+00 and 20+00 generally lost sand volume above the -15 feet NAVD88 contour.

The eastern end of this region contained an erosional hot spot that was studied in 2010, and that study recommended improvements to manage erosion rates. Prior to December 2012, coastal structures in this region included two offshore breakwaters, a rock terminal groin, and several timber groins. Construction of the Willoughby Spit Shoreline Improvement Project was completed by December 2013, and it included sand nourishment, the removal of the existing timber groin field, relocation of a prior existing breakwater in the 800 Block breakwater field, and addition of seven new detached breakwaters connecting the 800 Block breakwaters with the two prior existing Willoughby Spit breakwaters. Modifications to the 2013 breakwater field were constructed between March and July 2020, such that the effects of the modifications were captured in the October 2020 to June 2021 reporting period. A summary of average shoreline and volume change rates for the Willoughby Spit region between June 2020 and June 2021 and between October 2020 and June 2021 are presented in Table 5-4.

Table 5-4: Average Shoreline and Volume Change Rates for Willoughby Spit

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
June 2020 vs. June 2021 Comparison					
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
Willoughby Spit (0+00 to 45+00)	-2.84	1.00	4,505	-1.47	-6,632
October 2020 vs. June 2021 Comparison					
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
Willoughby Spit (0+00 to 45+00)	1.61	0.48	2,174	2.11	9,534

On average, this region gained volume in the beach and dune above 0 feet NAVD88 over the seasonal comparison (October 2020 - June 2021) and in the yearly comparison (June 2020 - June 2021). This region gained volume in the subaerial beach and in the submerged profile above -15 feet NAVD88 over the seasonal comparison (October 2020 - June 2021), while it lost volume over the yearly comparison (June 2020 - June 2021). For the yearly comparison, the MHW shoreline receded at a rate of -2.84 ft/yr while gaining volume above 0 feet at a rate of 4,505 cy/yr and lost volume above -15

feet NAVD88 at a rate of -6,632 cy/yr, respectively. The seasonal comparison showed advancement of the MHW shoreline of 1.61 feet on average and a cumulative sediment gain of 2,174 cy above 0 feet and a gain of 9,534 cy above -15 feet NAVD88, respectively. The breakwaters that were part of the 2013 shoreline improvement project that connected to the previously existing 800 Block breakwaters have provided stability to the majority of the Willoughby Spit reach as shown in Figure 5-38 and Figure 5-41. To further stabilize the shoreline from approximately 11th View Street to 12th View Street along Toler Place, the construction of the Toler Place breakwater modification project near 11th View street began in March 2020 and was completed in July 2020. Comparison of survey data from October 2020 and June 2021 indicates a minor seaward progression of the MHW shoreline directly behind the newly constructed breakwater, with shoreline retreat further west along Toler Place. This region gained volume in the beach and dune above 0 feet NAVD88 over the seasonal comparison (October 2020 - June 2021) and lost volume over yearly comparison (June 2020 - June 2021).

5.4.2. 800 Block Breakwaters

The 800 Block Breakwaters region (Sta 45+25 to Sta 87+62) is characterized by a field of eight breakwaters. The easternmost breakwater was relocated in February 2006 along with removal of a pre-existing groin spur and toe extension. This relocated breakwater was placed further offshore to mitigate an excessive salient / tombolo formation, caused by the prior structural configuration that had impaired natural sediment transport to the west. In conjunction with the 2013 Willoughby Spit shoreline improvement project, the second easternmost breakwater in the 800 Block set was also relocated further offshore to enhance natural sediment transport in the region. A summary of average shoreline and volume change rates for the 800 Block Breakwaters region between June 2020 and June 2021 and between October 2020 and June 2021 are presented in Table 5-5.

Table 5-5: Average Shoreline and Volume Change Rates for 800 Block Breakwaters

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
June 2020 vs. June 2021 Comparison					
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
800 Block Breakwaters (45+25 to 87+62)	-7.53	-0.47	-2,150	0.24	1,067
October 2020 vs. June 2021 Comparison					
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
800 Block Breakwaters (45+25 to 87+62)	-4.13	-0.84	-3,834	-0.99	-4,481

The 800 Block region lost volume over the seasonal comparison (October 2020 - June 2021) and gained volume over the yearly comparison (June 2020 - June 2021). Over the past year, there has been retreat of the MHW shoreline of -7.53 ft/yr as well as an overall volume loss above 0 feet NAVD88 of -2,150 cy/yr and overall volume gain above -15 ft NAVD88 of 1,067 cy/yr, respectively. The seasonal comparison showed there was retreat of the MHW shoreline of -4.13 feet with a loss of sediment volume above 0 feet NAVD88 and a loss of sediment volume above -15 feet NAVD88 of -3,834 cy and -4,481 cy, respectively.

5.4.3. West Ocean View

The West Ocean View area (Sta 93+41 to Sta 163+49), between the 800 Block and Central Ocean View breakwaters, was characterized prior to 2013 by a series of timber groins. The 2013 West Ocean View Shoreline Improvement Project included the removal of all timber groins located between the Ocean View Fishing Pier and Station 141+98, the reconstruction of a rock groin at station 129+17, and 73,600 cy of sand nourishment placed in front of Sarah Constant Beach Park. A summary of average shoreline and volume change rates for the West Ocean View region between June 2020 and June 2021 and between October 2020 and June 2021 are presented in Table 5-6.

Table 5-6: Average Shoreline and Volume Change Rates for West Ocean View

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
June 2020 vs. June 2021 Comparison					
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
West Ocean View (93+41 to 163+49)	-11.67	-0.89	-5,975	-1.11	-6,610
October 2020 vs. June 2021 Comparison					
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
West Ocean View (93+41 to 163+49)	0.82	0.82	6,244	2.44	18,532

This region lost sand volume and beach width over the yearly comparison (June 2020 - June 2021) with retreat of the MHW shoreline at a rate of -11.67 ft/yr, a volume loss above 0 feet NAVD88 of -5,975 cy/yr and a volume loss above -15 feet NAVD88 of -6,610 cy/yr, respectively. The seasonal comparison (October 2020 - June 2021) showed advancement of the MHW shoreline of 0.82 feet, a gain of material above 0 feet NAVD88 of 6,244 cy and a gain of material above -15 feet NAVD88 of 18,532 cy.

5.4.4. Central Ocean View Breakwaters

The Central Ocean View Breakwaters region covers the four offshore breakwaters at Central Ocean View and approximately 800 feet westward (Sta 169+63 to Sta 195+63). A summary of average shoreline and volume change rates for the Central Ocean View Breakwaters region between June 2020 and June 2021 and between October 2020 and June 2021 are presented in Table 5-7.

Table 5-7: Average Shoreline and Volume Change Rates for Central Ocean View Breakwaters

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
June 2020 vs. June 2021 Comparison					
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
Central Ocean View Breakwaters (169+63 to 195+63)	-10.99	-0.03	-96	0.43	1,489
October 2020 vs. June 2021 Comparison					
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
Central Ocean View Breakwaters (169+63 to 195+63)	1.16	0.59	2,053	1.20	4,147

This region experienced volume gain above -15 feet NAVD88 over the yearly comparison (June 2020 – June 2021), and volume gain over the seasonal comparison (October 2020 - June 2021) above 0 and -15 feet NAVD88. The yearly comparison showed retreat of the MHW shoreline at an average rate of -10.99 ft/yr and an overall volume gain above -15 feet NAVD88 at a rate of 1,489 cy/yr, respectively. The seasonal comparison indicated advancement of the MHW shoreline at an average rate of 1.16 ft and a gain of material above 0 feet NAVD88 and -15 feet NAVD88 of 2,053 cy and 4,147 cy, respectively.

5.4.5. Central Ocean View

Central Ocean View (Sta 206+86 to Sta 323+09) is historically a stable region with slight accretion despite the absence of engineering interventions (e.g. beach fill or structures). A summary of average shoreline and volume change rates for the Central Ocean View region between June 2020 and June 2021 and between October 2020 and June 2021 are presented in Table 5-8.

Table 5-8: Average Shoreline and Volume Change Rates for Central Ocean View

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
June 2020 vs. June 2021 Comparison					
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
Central Ocean View (206+86 to 323+09)	-1.03	2.57	32,144	1.78	22,219
October 2020 vs. June 2021 Comparison					
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
Central Ocean View (206+86 to 323+09)	5.90	2.54	31,751	3.75	46,979

As shown in Table 5-8, the yearly comparison (June 2020 – June 2021) for the Central Ocean View region showed volume gain above 0 feet NAVD88 of 32,144 cy/yr and volume gain above -15 feet NAVD88 of 22,219 cy/yr. The seasonal comparison (October 2020 - June 2021) indicated volume gain above 0 feet NAVD88 and above -15 feet NAVD88 of 31,751 cy and 46,979 cy, respectively. The average yearly shoreline loss rate was -1.03 ft/yr an average gain of 5.90 ft occurring over the reach during the current survey period.

5.4.6. East Ocean View

The East Ocean View region (Sta 329+63 to Sta 383+58) is characterized by 15 breakwaters of which the 5 westernmost were built in August 2009. In March 2009, prior to the breakwater construction, a beach renourishment project added approximately 196,000 cy of material to the beach. Table 5-9 summarizes average shoreline and volume change rates for the East Ocean View region between June 2020 and June 2021 and between October 2020 and June 2021.

Table 5-9: Average Shoreline and Volume Change Rates for East Ocean View

Region	Average Shoreline Change	Average Volume Change Above 0 ft NAVD88	Cumulative Volume Change Above 0 ft NAVD88	Average Volume Change Above -15 ft NAVD88	Cumulative Volume Change Above -15 ft NAVD88
June 2020 vs. June 2021 Comparison					
	(ft/yr)	(cy/ft/yr)	(cy/yr)	(cy/ft/yr)	(cy/yr)
East Ocean View (329+63 to 383+58)	-12.37	-0.11	-638	-2.17	-12,400
October 2020 vs. June 2021 Comparison					
	(ft)	(cy/ft)	(cy)	(cy/ft)	(cy)
East Ocean View (329+63 to 383+58)	-2.96	1.24	7,113	3.42	19,596

This region is normally characterized by a consistent annual erosional pattern due to sediment movement along the shoreline from east to west with no external sand source due to the terminal groin at Little Creek Inlet. East Ocean View experienced volume loss over the yearly (June 2020 – June 2021) comparison, but the reach experienced volume gain over the seasonal (October 2020 - June 2021) comparison. The yearly comparison showed an overall retreat of the MHW shoreline at a rate of -12.37 ft/yr and an overall volume loss above 0 feet NAVD88 and -15 feet NAVD88 at a rate of -638 cy/yr and -12,400 cy/yr respectively. The seasonal comparison showed a MHW shoreline retreat of -2.96 feet, and gain of material above 0 feet NAVD88 of 7,113 cy and gain of sediment above -15 feet NAVD88 of 19,596 cy.

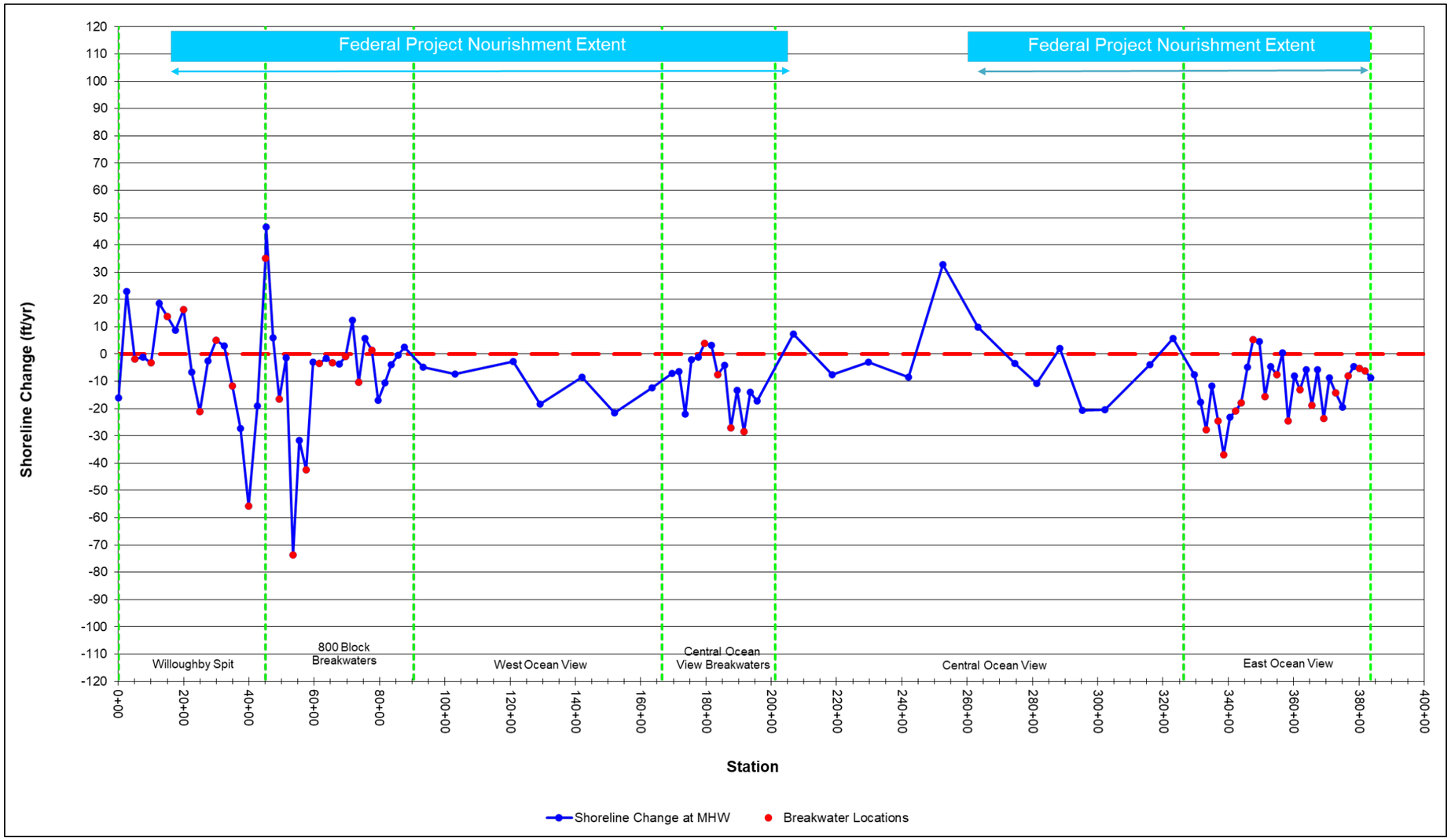

Figure 5-38: Shoreline Change Rate (ft/yr) at Mean High Water (+0.98 ft NAVD88) for June 2020 to June 2021 (Note: Positive = Accretion, Negative = Erosion)

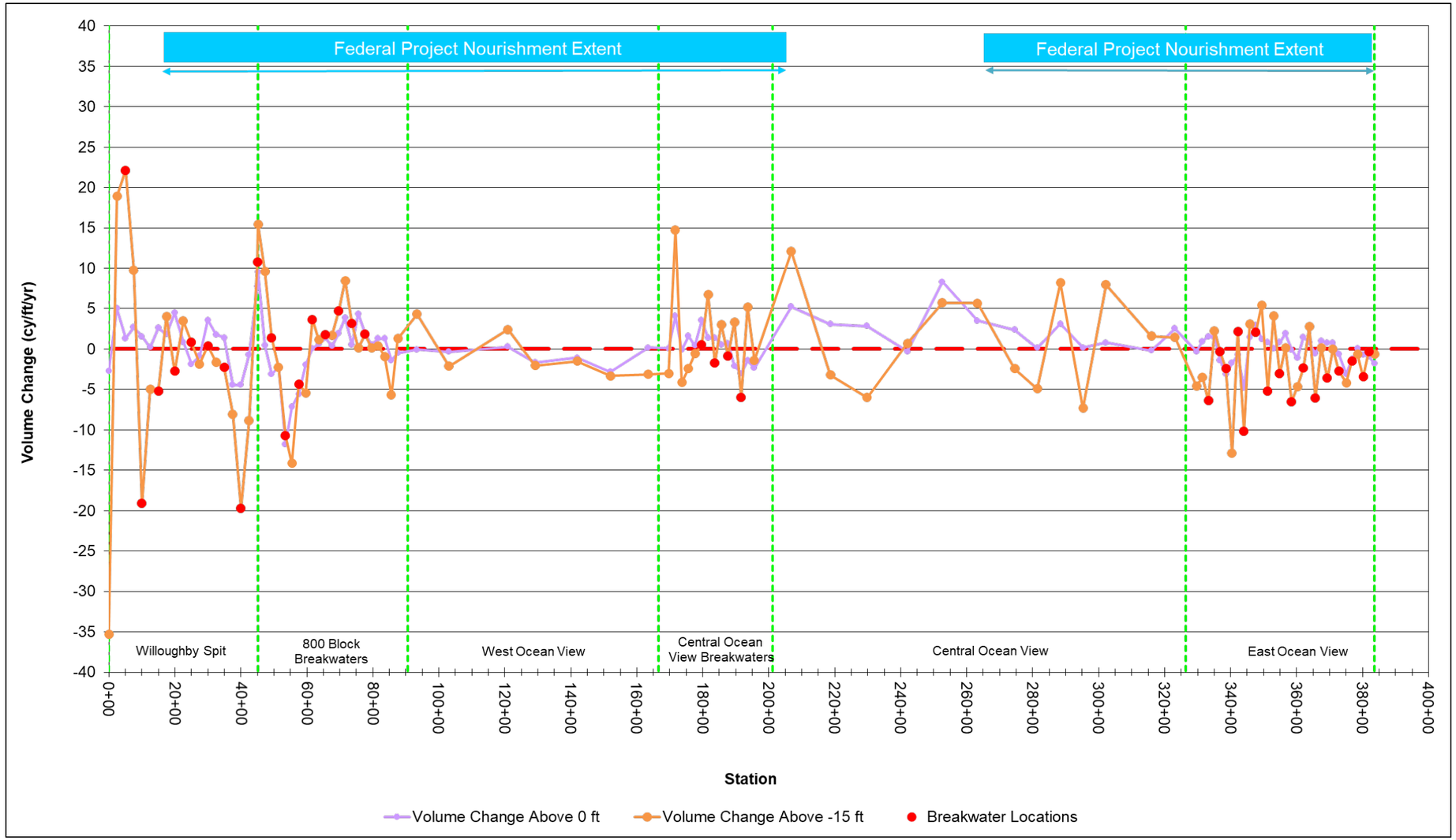

Figure 5-39: Volume Change Rate Above 0 ft NAVD88 and -15 ft NAVD88 (cy/ft/yr) for June 2020 to June 2021 (Note: Positive = Accretion, Negative = Erosion)

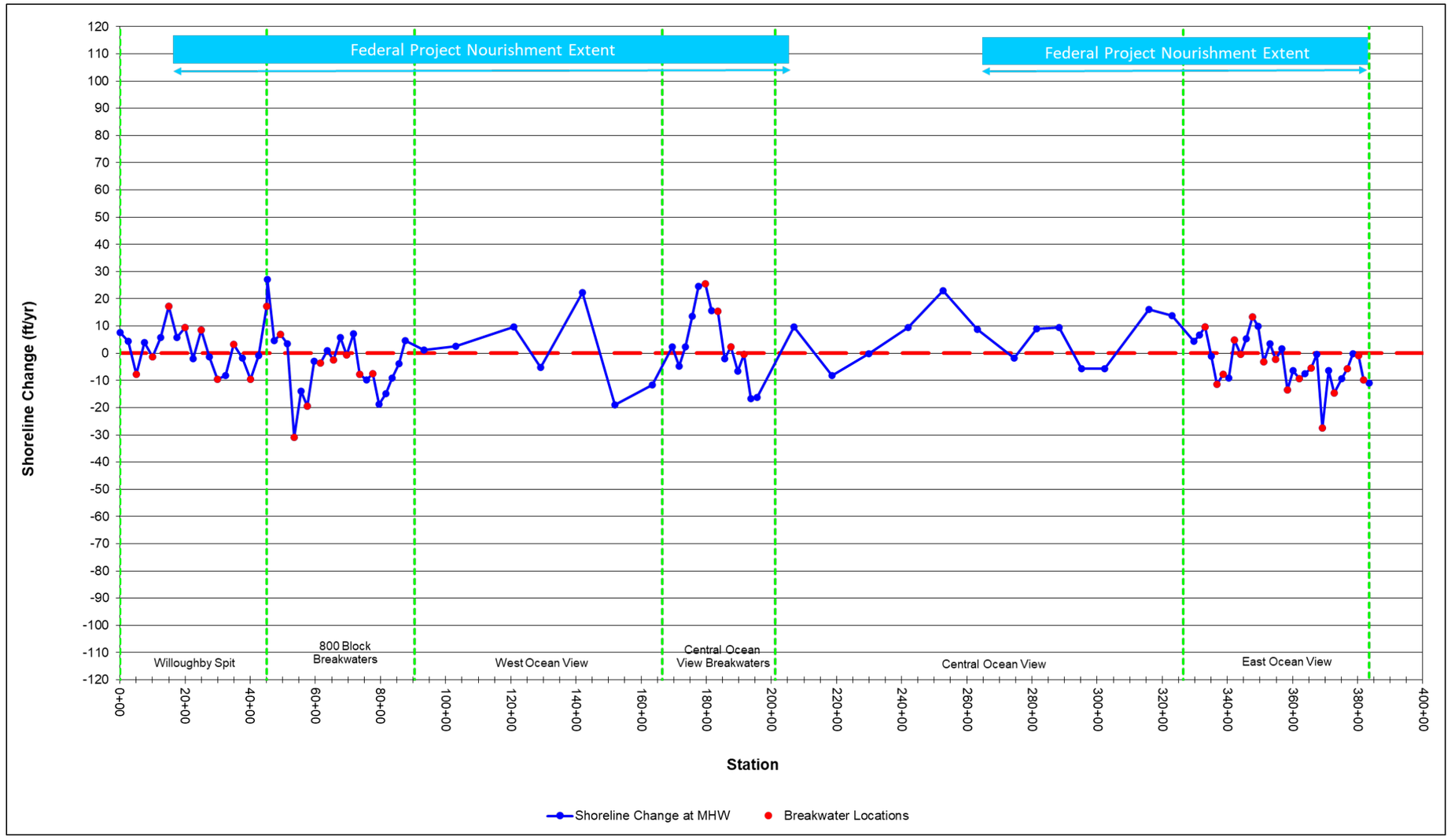

Figure 5-40: Shoreline Change (ft) at Mean High Water (+0.98 ft NAVD88) for October 2020 to June 2021 (Note: Positive = Accretion, Negative = Erosion)

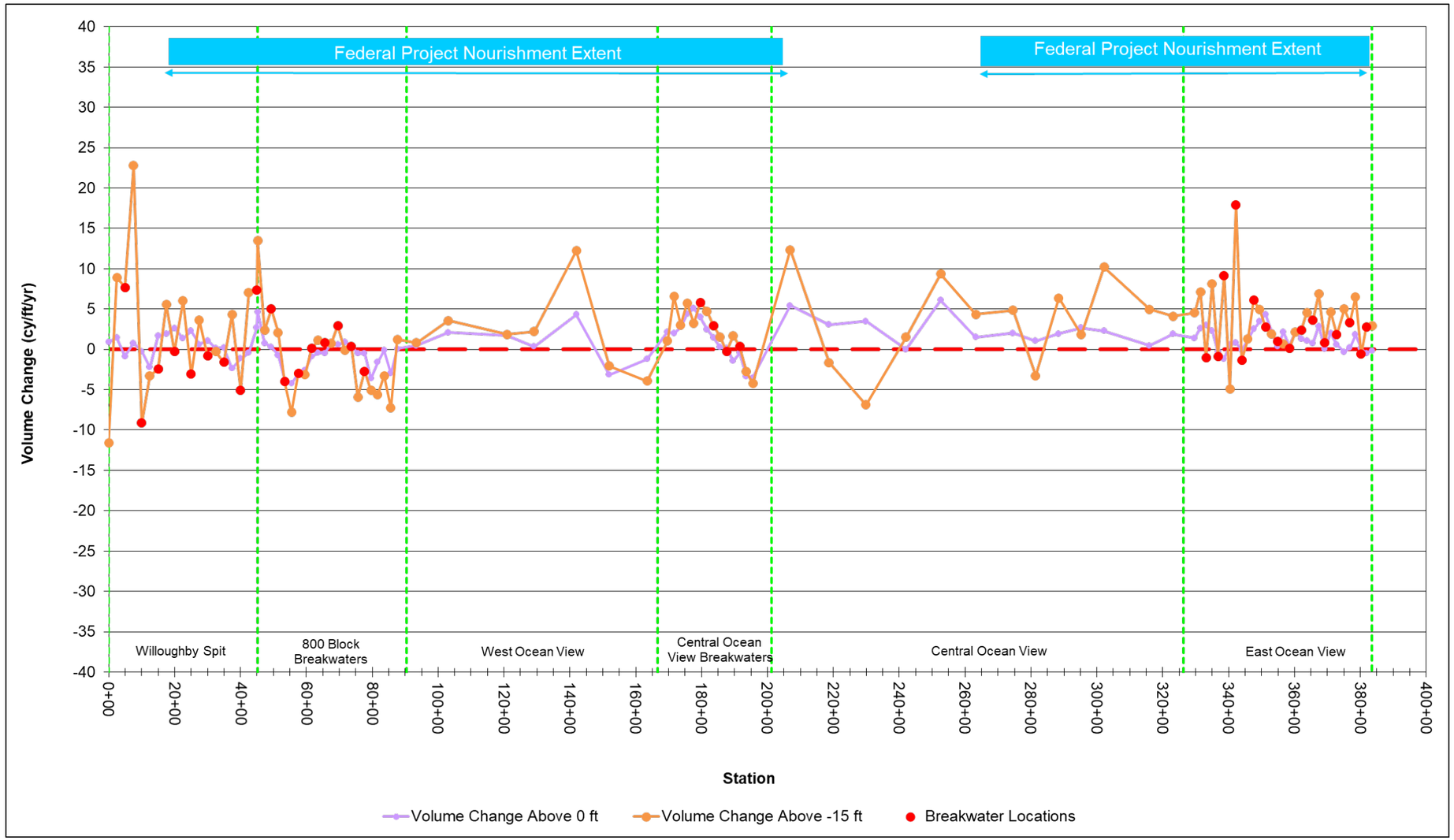

Figure 5-41: Volume Change above 0 ft NAVD88 and -15 ft NAVD88 (cy/ft) for October 2020 to June 2021 (Note: Positive = Accretion, Negative = Erosion)

6. Bed Elevations Immediately West of the Willoughby Spit Terminal Groin

Bed elevations immediately west of Willoughby Spit terminal groin were captured in the June 2021 survey of the Ocean View shoreline. The text of this chapter of the report is identical to the information presented in the Fall 2018 monitoring report.

The 2012 design and subsequent construction of the Willoughby Spit Shoreline Improvement projects included elevation of the crest of the terminal groin, along with excavation of sand from the area immediately west of the terminal groin. The excavated sand was used as beach fill borrow material in other reaches of the project to pre-fill the newly constructed Willoughby Spit breakwaters field.

Prior to the 2012 project, a resident had expressed concerns to the City about sand accretion at their pier and boat dock adjacent to the terminal groin. The crest of the terminal groin was raised, and the sand between the groin and the pier was excavated, in order to mitigate some of the potential for sand to migrate over the groin and into the vicinity of the pier.

Two surveys in April 2018 and June 2021 as shown in Figure 6-1 were used to evaluate the depths near the pier. The left and right panels of Figure 6-1 show the April 2018 and June 2021 survey point depths, respectively, between the terminal groin and the pier and the relatively deeper waters near the Hampton Roads Bridge Tunnel. In both surveys, depths near the pier were deeper than -4.0 feet NAVD88, which is approximately 2.5 feet deeper than local Mean Low Water (MLW). Bed elevations were consistently at or deeper than this elevation from the pier to the deeper water at the end of the spit.

In addition, no significant change in bed elevation was seen between the April 2018 and June 2021 survey data. Thus, the surveys indicate that the depths between the terminal groin and the pier were relatively stable between April 2018 and June 2021.

Figure 6-1: Spring 2018 and Spring 2021 Survey Depths West of the Willoughby Spit Terminal Groin

7. Federal Coastal Storm Damage Reduction Project

7.1. Initial Construction of the Federal Project

The initial nourishment of the Federal Willoughby and Vicinity Coastal Storm Damage Reduction Project (Federal Project) was constructed in March, April and May 2017. The Federal Project placed approximately 1.2 million cubic yards of sand from the Thimble Shoals Auxiliary Channel along most of the Ocean View shoreline. An exception is that the Federal Project did not place sand between Warwick Avenue (station 206+86) and 1st Bay Street (station 274+53). The Spring 2017 survey (done in late May 2017 after all of the Federal Project beach fill had been placed) captured the project's beach and nearshore condition very soon after construction was completed. The volume gains from October 2016 to May 2017 associated with Federal Project construction, and the initial readjustment of the Federal project post-construction, were discussed in the prior reports for Fall 2017 and Spring 2017 monitoring periods.

7.2. Shoreline and Beach Berm Contour Changes Relative to the May 2017 Post-Construction Condition of the Federal Project

7.2.1. Shoreline Change

The most recent June 2021 periodic survey documents the continued evolution of the Federal Project through background erosion / accretion due to coastal processes from May 2017 through June 2021. Figure 7-1 shows the position of the Mean Higher High Water (MHHW) contour line extracted from the profile surveys from the following months:

- October 2016, approximately six months pre-construction;
- May 2017, post-construction;
- October 2017, approximately five months post-construction;
- April 2018, 11 months post-construction;
- November 2018, 18 months post-construction;
- April 2019, 23 months post-construction;
- November 2019, 29 months post-construction;
- June 2020, 36 months post-construction; and
- October 2020, 40 months post-construction
- June 2021, 47 months post-construction

The movement of the shoreline is consistent with the shoreline changes tabulated by Ocean View region earlier in this report (Table 1-2). The chart in Figure 7-1 shows shoreline position rather than shoreline change rate as a means of illustrating the beach planform remaining in the project relative to its construction design. The chart illustrates that the MHHW contour changed less in both the six months from October 2020 and June 2021 and over the year from June 2020 to June 2021, compared to the changes observed in the first year post-construction (May 2017 to April 2018). This is consistent with typical expectations of a beach nourishment project's evolution.

The median shoreline change rate from June 2020 to June 2021 among the 106 transects (without any length-weighting) was approximately -6 ft/yr, with 78% of transects having negative change rates with an average rate of -13 ft/yr. Over the more recent six months from October 2020 to June 2021, the median shoreline change rate was 0 ft/yr with 54% of transects having negative change rates with an average rate of -8 ft/yr. Thus, the survey data indicate that the shoreline changed more slowly during the Fall 2020 to Spring 2021 period than it did over the past year as a whole.

7.2.2. Berm Contour Change

The Federal Project authorized beach template is not defined by the shoreline position, but by the beach width (seaward of the dune toe) at or above a beach berm elevation of +3.5 feet NAVD88. Figure 7-2 shows the position of the most bayward +3.5 ft NAVD88 elevation contour (representing the authorized Federal beach berm elevation) as extracted from the October 2016, May 2017, October 2017, April 2018, November 2018, April 2019, November 2019, June 2020, October 2020 and June 2021 surveys. The median berm contour change post-construction of the Federal project, through June 2021, is approximately -48 feet, with 60% of the stations exhibiting change between +40 feet and -70 feet.

The breakwater at 11th View Street was modified and a new breakwater added between this one and the 800 Block breakwaters, with construction taking place between March 2020 and July 2020. The beginnings of sand accretion in the lee of these breakwaters was observed during a site visit in June 2020. The survey data captured in June 2021 indicates a seaward progression of the MHW shoreline directly behind the newly constructed breakwater at stations 45+00 and 45+25 from October 2020 to June 2021. The western part of the Toler Place area (stations 37+50 to 42+50) lost volume in the beach and dune above 0 feet NAVD88 over both the seasonal comparison (October 2020 – June 2021) and yearly comparison (June 2020 – June 2021). However, the seasonal erosion was reduced compared to the yearly erosion. The eastern part of Toler Place area (45+00 to 47+30) gained volume in the beach and dune above 0 feet NAVD88 over both the seasonal comparison and yearly comparison indicating that this section of shoreline is gradually recovering.

The map plots in Appendix E shows areas of elevation change between the dates indicated in the map legends. Elevation gains (accretion) are shown in green shades, and elevation losses (erosion) are shown in yellow to red shades. The maps were prepared by subtracting elevations in each grid cell within survey Digital Elevation Models (DEMs) between survey dates October 2020 to June 2021.

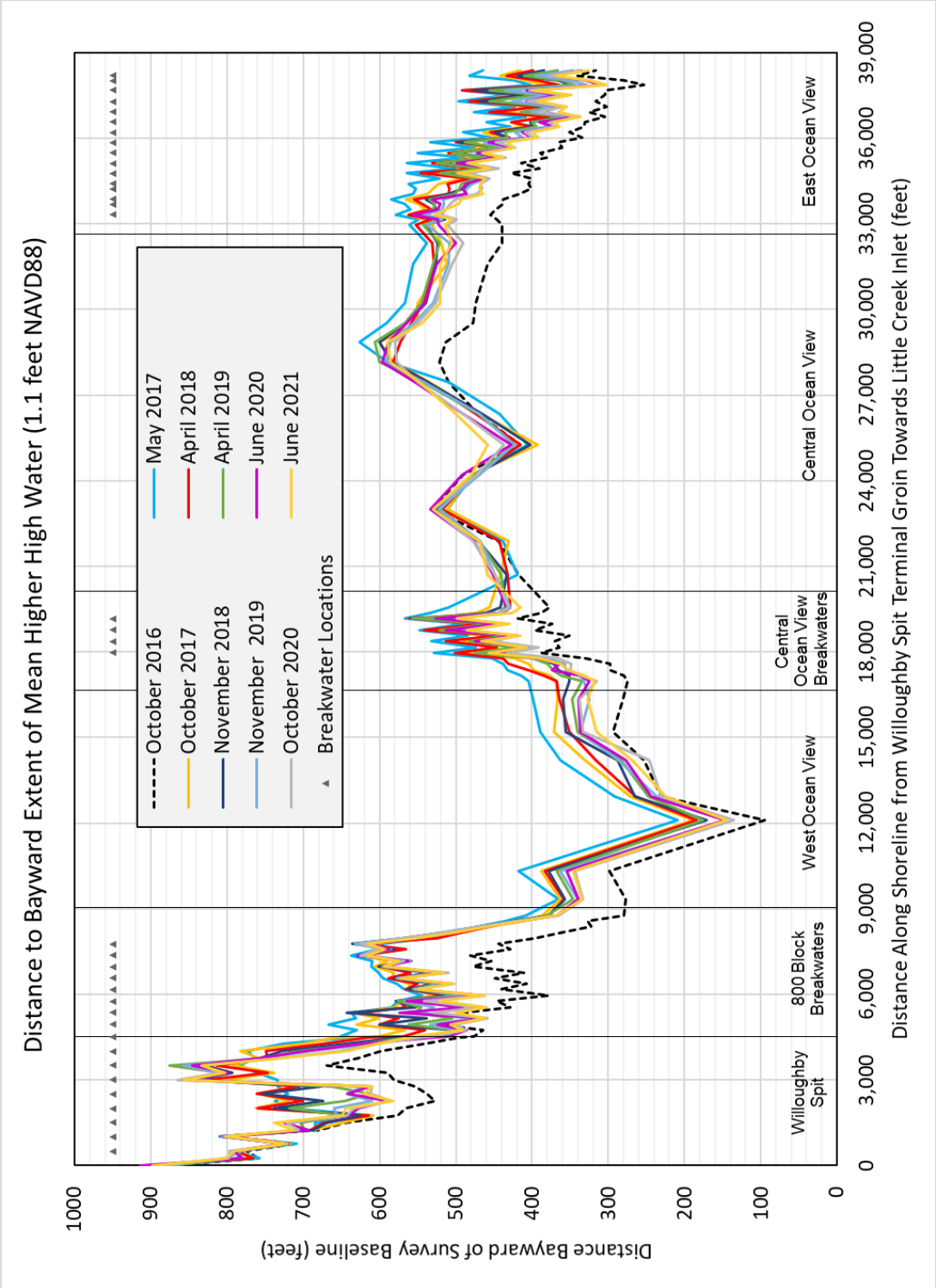

Figure 7-1: Position of the Mean Higher High Water (+1.1 ft NAVD88) Contour Relative to Pre- and Post-Construction of the Federal Project

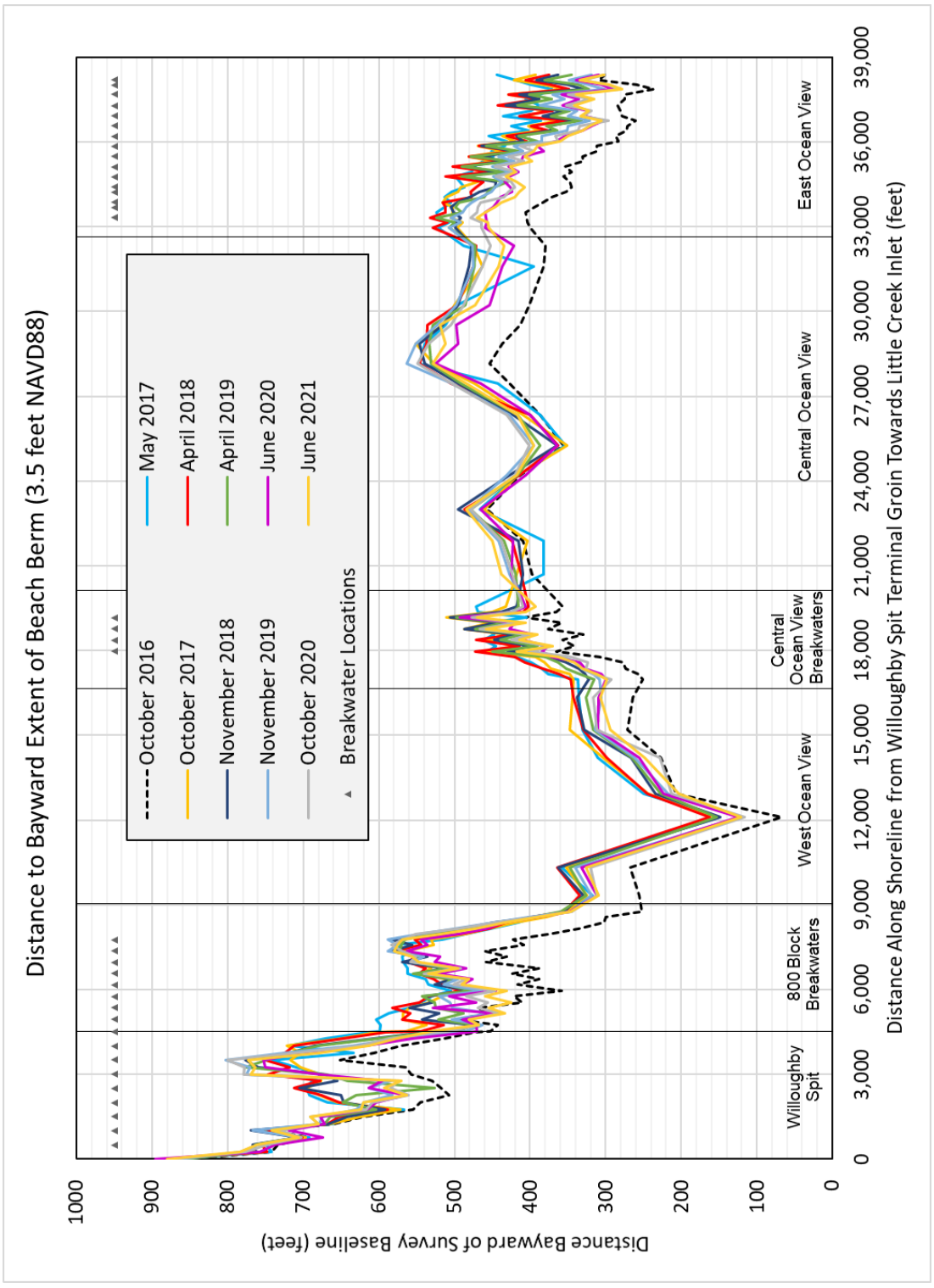

Figure 7-2: Position of the Bayward Extent of the +3.5 ft NAVD88 Beach Berm Contour Relative to Pre- and Post-Construction of the Federal Project

7.3. Federal Project Status Relative to a Renourishment Threshold

The USACE Federal Project design studies established a threshold criteria for renourishment of the Federal Project. The published documents presently available relative to the Federal Project do not define a particular shoreline or beach berm position in physical space that represents such a threshold condition. Instead, the threshold is discussed in the Federal Project's authorizing documents state that [renourishment] would occur when the berm has eroded to a width of 30 feet, which is half of the authorized beach berm width of 60 feet at an elevation of +3.5 feet NAVD88.

For survey stations that are within the limits of the Federal Project's initial construction, the Appendix B survey comparison profiles include a representation of the authorized USACE Design Template (dashed black line), indicating the beach fill outline to achieve a berm width of 60 feet fronting the October 2016 pre-Federal Project monitoring survey data. A USACE Nourishment Threshold is also shown, indicating a berm and slope position 30 feet landward of the authorized 60 ft wide berm. The template outlines provide a way to visually assess the current status of the beach berm with respect to the authorized design and nourishment criteria.

For example, at station 37+50, on page 16 of Appendix B, the survey profiles indicate that the berm edge is approximately 14 feet bayward of the USACE Design Template and that the berm elevation is approximately 1.0 foot higher than the USACE berm template's elevation. Between October 2020 and June 2021, the shoreline at this station slightly retreated and the berm width narrowed while the upland beach eroded. However, the bayward edge of the berm still remains bayward of the nourishment threshold. Slightly further east at station 47+30, the June 2021 profile shows that the beach has retreated landward of both the USACE Design Template and the Nourishment Threshold, indicating a need for renourishment at this station and the adjacent area.

It is difficult to find a single statistic that conveys the status of the beach morphology and berm width at each transect station in a graphical or tabular form. Instead, it is recommended that City and USACE staff review the profiles in Appendix B to track the progression of the Federal Project toward an eventual nourishment need. To assist with this review, the map panels in Appendix F and Table 7-1 below summarize characteristics of the June 2021 survey profiles with respect to the USACE Design Template and the Nourishment Threshold. The map panels in Appendix F also show color shading representing the beach and nearshore elevation change from immediately post-construction of the Federal Project (May 2017) to June 2021.

Table 7-1: Beach Berm Status Relative to the Federal Project Design Template and Nourishment Threshold

Transect Stations	Location Description	Status of the Beach Based on June 2021 Survey Profiles
0+00 to 17+50	Terminal groin to 14th View Street	Outside the limits of initial Federal Project construction.
20+00 to 37+50	14th View Street to east of 12th View Street, midway along Toler Place	Beach berm edge between 22+50 and 27+50 has retreated landward to the USACE Design Template. Other transects remain significantly bayward of the USACE Design Template. At a few transects, in breakwater gaps, the lower berm slope is near the Nourishment Threshold.
40+00 to 55+51	Midway along Toler Place to the 800 Block Breakwaters	The berm edge and lower contours of the beach slope retreated landward of the Design Template. At stations 47+30 through 51+41, the beach is moderately to significantly landward of the Nourishment Threshold, indicating the need for renourishment in this reach. At stations 45+00 and 45+25 where the new Breakwater was constructed in March through July 2020, some beach recovery occurred between the October 2020 survey and the June 2021 survey.
57+57 to 87+62	800 Block Breakwaters and eastward adjacent area	Berm edge remains bayward of the Design Template, except station 57+57. In several locations, lower contours of the beach slope reached the Nourishment Threshold.
93+41 to 120+93	Vicinity of the Ocean View Fishing Pier	Berm edge reached the Design Template, while the lower contours of the beach slope are landward of the Nourishment Threshold, indicating the need for renourishment in this reach.
129+17 to 152+01	Ocean View Beach Park and adjacent westward area; bulkhead and revetment present at the back of the beach	At all transects the berm edge is landward of the Nourishment Threshold, with the lower beach slope also having retreated landward of the Nourishment Threshold, indicating the need for renourishment in this reach.
163+49 to 181+63	From Ocean View Beach Park to west end of the Central Ocean View Breakwaters	Berm edge retreated landward of the Design Template, while the lower contours of the beach slope have retreated landward of the Nourishment Threshold, indicating that nourishment would be beneficial in this reach.
183+63 to 195+63	Central Ocean View Breakwaters and adjacent eastward reach to Atlans Street	The berm edge is at or slightly bayward of the Design Template. Reasonable variations in profile observed between stations at breakwaters vs. stations in gaps between breakwaters where in presence of breakwaters the lower beach slope is bayward of the Nourishment Template.
206+86 to 263+22	Central Ocean View between Warwick Avenue and Inlet Road	Outside the limits of initial Federal Project construction. Beach profiles show stable behavior over the past year.

Transect Stations	Location Description	Status of the Beach Based on June 2021 Survey Profiles
274+53 to 331+43	1st Bay Street to west end of the Bay Oaks Breakwaters	Berm edge remains at or bayward of the Design Template.
333+23 to 383+58	Bay Oaks Breakwaters and East Ocean View Breakwaters to near Little Creek Inlet	The berm edge is at or slightly bayward of the Design Template. Reasonable variations in profile observed between stations at breakwaters vs. stations in gaps between breakwaters. In the breakwater gaps, the lower beach slope either close to or reached the Nourishment Template, indicating that nourishment would be beneficial in this reach.
381+88 to 383+58	Adjacent to Little Creek Inlet west jetty	Profile has retreat to or landward of the Nourishment Template, indicating the need for renourishment in this reach.

From this evaluation, it is summarized that four reaches of the Ocean View shoreline are approaching or have crossed the Nourishment Threshold and would benefit from renourishment. All of the proposed placement areas would be within the template of the Federal beach nourishment project. The four potential renourishment reaches are:

- The Toler Place vicinity, from about halfway along Toler Place east to 10th View Street. Nourishment in this reach would prefill the area within the breakwater construction that was completed in July 2020. The reach is approximately 1,500 feet long.
- From station 93+41 (6th View Street) to station 171+63 (between Ship Watch Rd and Chesapeake Blvd), the June 2020 profile has retreated back landward of the USACE Design Template, and is close to or landward of the USACE Nourishment Threshold template. The reach is approximately 7,800 feet long.
- The shoreline in the Central Ocean View breakwaters eroded significantly after the May 2017 USACE project construction, but the profile has been fairly stable over the last year and is still significantly bayward of the Fall 2016 pre-nourishment shoreline. If sand becomes available, refilling this breakwater field may have benefit. The length would be approximately 2,000 feet.
- Some segments of the Bay Oaks and East Ocean View breakwaters area are getting close to the USACE Design Template, with some nearing the Nourishment Threshold. The reach closest to the USACE nourishment threshold starts at about 24th Bay or 25th Bay and goes eastward to the inlet covering approximately 2,400 feet of shoreline length.

8. Summary

Comprehensive periodic surveying of the entire Ocean View shoreline began with an initial survey in September 2005. The most recent survey was completed in June 2021. The beach and bathymetric surveys performed by Geodynamics utilized baseline and transect positions established in September 2005 which are used for all periodic surveys. For this periodic evaluation, the June 2021 survey was compared with both the prior year and prior six months' surveys (June 2021 compared to June 2020 and October 2020, respectively). The surveys were used to compute shoreline change at MHW and volume change above 0 feet NAVD88 and above -15 feet NAVD88.

Key statistics were computed for defined regions along Ocean View and the entire shoreline for the time period between the June 2020 and June 2021 surveys and between the October 2020 and June 2021 surveys.

Comparison	Parameter	Quantity
June 2020 vs. June 2021	Average Shoreline Change Rate at MHW (+0.98 ft NAVD88)	-6.71 ft/yr
	Cumulative Volume Change Rate Above 0 ft NAVD88	27,790 cy/yr
	Cumulative Volume Change Rate Above -15 ft NAVD88	-866 cy/yr
October 2020 vs. June 2021	Average Shoreline Change at MHW (+0.98 ft NAVD88)	1.45 ft
	Cumulative Volume Change Above 0 ft NAVD88	45,501 cy
	Cumulative Volume Change Above -15 ft NAVD88	94,306 cy

The average shoreline change rate for the entire shoreline at MHW between the June 2020 and June 2021 surveys was -6.71 ft/yr shoreline retreat, and the cumulative volume changes above 0 feet NAVD88 and -15 feet NAVD88 were approximately 27,790 cy/yr and -866 cy/yr, respectively.

The average shoreline change for the entire shoreline at MHW between the October 2020 and June 2021 surveys was 1.45 ft, and the cumulative volume changes above 0 feet NAVD88 and -15 feet NAVD88 were approximately 45,501 cy and 94,306 cy, respectively.

Areas of greater shoreline retreat (compared to average rates along Ocean View as a whole) include: between 11th View Street and the 800 Block Breakwaters; adjacent to the west and east ends of the Central Ocean View Breakwaters; and west of the Bay Oaks Breakwaters in East Ocean View.

Shoreline change rates varied widely on a transect by transect basis. Since construction of the Federal project, the median shoreline change among the 106 transects (without any length-weighting) has been approximately -48 feet, with 85% of transects having change between +65 and -105 feet. Over the past six months 85% of transects having change between +25 and -15 feet.

Four reaches within the Federal project length have been identified as potentially needing renourishment to maintain the USACE Design Template level of protection:

- In the Toler Place vicinity of Willoughby Spit, from about halfway along Toler Place east to 10th View Street.
- In West Ocean View from station 93+41 (6th View Street) to station 171+63 (between Ship Watch Rd and Chesapeake Blvd).
- The shoreline within the Central Ocean View breakwaters field.

- In East Ocean View within segments of the Bay Oaks and East Ocean View breakwaters area.

This is the thirty-second periodic survey report completed to date, and the thirty-second evaluation of a consistent survey period utilizing beach and bathymetric surveys. As noted, there are inevitable margins of error associated with the survey data that may reduce the accuracy of volumetric change analyses. Therefore, it is essential to thoroughly review the beach and bathymetric profiles using various analytical techniques and general engineering judgment to assure that results are not falsely interpreted. Comparison of surveys taken at the same season of the year (i.e. June 2020 to June 2021) mitigates seasonal variation of profiles in volumetric change analyses. Consecutive spring-fall or fall-fall survey comparisons are useful to assess the direct impact of extreme events which may occur during the approximate six month period between surveys.

Future periodic survey evaluations will continue to track changes in and the condition of the Federal Project, to assist the City to manage these beaches and coordinate with USACE regarding Federal Project maintenance.