Delaware Annual Beach Change Report:

Ocean Coast

Prepared by:

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Abbreviations:

Cubic Feet per Linear Foot (Volume per unit Length) – cf/lf

Delaware Department of Natural Resources and Environmental Control – DNREC

Global Positioning System – GPS

Long-Range Planning – LRP

Mean Higher High Water – MHHW

Mean Higher Water – MHW

Mean Low Water – MLW

Mean Lower Low Water – MLLW

NAVD – North American Vertical Datum

NOAA – National Oceanographic and Atmospheric Agency

Real Time Kinematics – RTK

United States Army Corp of Engineers – USACE

Definitions:

MHHW – The average elevation reached by the higher of the two daily high tides over a 19-year tidal epoch. The value is computed by and available from NOAA.

MHW – The average elevation reached by all the high tides over a 19-year tidal epoch. These elevations exclude any storm surge or non-tidal residuals caused by onshore winds.

MLW – The average elevation reached by all the low tides over a 19-year tidal epoch.

MHHW – The average elevation reached by the lowers of the two daily low tides over a 19-year tidal epoch.

Dune – Natural or man-made geological feature that is shoreward of the berm and is characterized by a steep slope to the highest elevations along the beach profile.

Berm – The relatively flat portion of the beach profile directly seaward of the dune that is typically above the MHHW elevation.

Foreshore Slope – The foreshore slope is the natural slope directly seaward of the berm that is causes by tides and up rushing waves.

Intertidal Zone – The portion of the foreshore slope and nearshore that is between the MHHW and MLLW elevations.

Nearshore – For the purposes of this report, the nearshore is considered to extend from the lower portions of the intertidal zone out beyond the surf zone where waves break but onshore of most boating traffic.

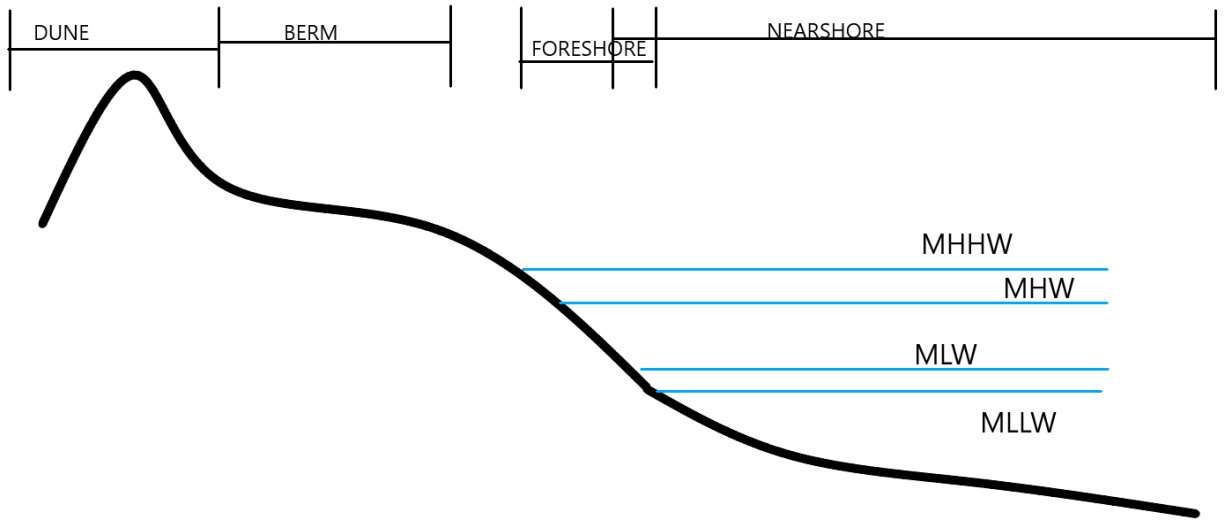


Figure 1: Beach profile definitions sketch

Introduction:

The Department of Natural Resources and Environmental Control (DNREC) envisions Delaware as a place where people embrace a commitment to the protection, enhancement, and enjoyment of the environment in their daily lives. The Shoreline and Waterway Management Section works to maintain and improve Delaware's shoreline and waterways. The Section manages the shoreline through regulation of coastal construction activities and implementation of dune and beach management practices. It also works to protect and enhance eroded beaches to enable continued recreational use of this precious resource, and to improve the state's ability to endure severe coastal storms with minimal damage to public and private property and infrastructure.

Each fall and spring, the Section's survey crew measures the beach (berm, dune, and nearshore bathymetry). Bathymetry data are collected out to about a 30-foot depth. The crew measures 41 longitudinal range profiles (LRPs) or transects along the Atlantic Coast. These locations of these transects are shown in Figure 2. Comparisons between winter and summer surveys demonstrate how beaches recover naturally after winter storms. Comparison between summer surveys from year-to-year, demonstrate long term erosion or accretion trends along Delaware Beaches. These trends are used to inform beach management strategies including beach nourishment projects.

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 2: LRP location map

The purpose of this report is to share the results of these surveys. Survey data are paired with photographs of the beach at each survey location (Appendix A) so that the public may see the changes in the beaches and dunes from season to season and from year to year. The quantities presented in the report are the average beach volumes which are defined as the area between a reference water level or contour and the crest of the primary frontal dune. (Figure 3) In this report, two volumes for each profile using different reference water levels (MHW and MLW) are documented. These volumes will be referred to as the MHW and MLW volumes, respectively. Storm tides cause erosion in the upper beach and dune, represented by the MHW volume. Some of this eroded material end up in the intertidal zone and may be captured in the MLW volume.

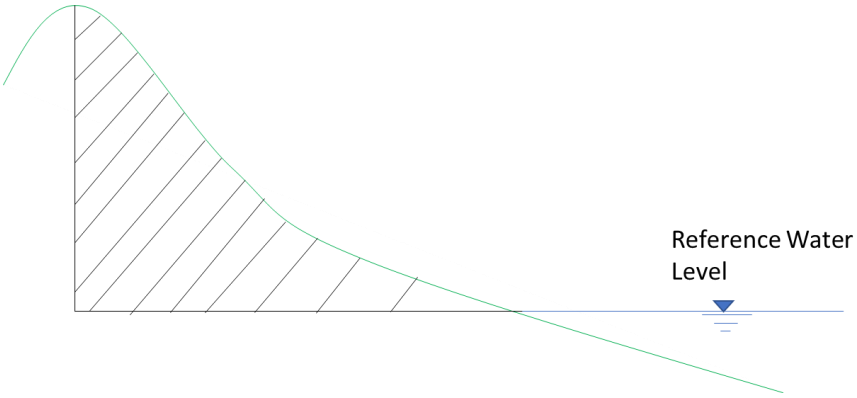


Figure 3: Sketch showing volume calculation

Geophysical setting of the Delaware Ocean Coast

For planning purposes, the ocean coast of Delaware is divided into two general sections, Ocean Coast North and Ocean Coast South by the Indian River Inlet, which falls between LRPs 54 and 55. The ocean coast extends from the point at Cape Henlopen State Park, to the north and to Fenwick Island/ the Maryland State Line to the south. Generally speaking, sand is transported along the coast from south to north along the ocean coast. The transported sand is interrupted by the jetty at the Indian River Inlet whereas sand transported along Ocean Coast North is interrupted by groynes and jetties or is ultimately deposited on Cape Henlopen. In addition to structures such as groynes and jetties, geological features such as ebb shoals may capture longshore transport.

Along the Delaware Ocean coastline, there are five sections or beaches that are regularly nourished through a funding partnership between the US Army Corp of Engineers (USACE) and DNREC. These beaches, from south to north, are Fenwick Island (LRP 66) South Bethany, Bethany (60A, 61), Dewey (47), and Rehoboth (44a-45). Though other sections of the coast are not directly nourished, it is likely that other beaches benefit from nourishment activity due to alongshore transport.

Description of Storm Impacts

Between the survey dates covered in this report, there were several storm events that coastal erosion along Delaware's Atlantic coast. Only one of these events triggered a Coastal Flood observation in NOAA's National Centers for Environmental Information (NCEI) storm event database occurring on

10/03/2022. On this date, the measured water level at the Lewes water level gage reached 3.2' MHW. Dates when water levels at the Lewes gage exceeded 2' MHW are presented in the Table 1.

Table 1: Coastal Storm Tides at the Lewes Gage

Month, Year	Water Levels (MHW, ft)	Dates	Duration	Inspection? (Y/N)
October 2021	2.8, 2.8	10/11, 10/29	5, 6	Y, Y
November 2021	2.3	11/07	7	N
January 2022	3.3, 2.5	1/03, 1/29	7, 3	N,N
April 2022	3.1	4/19	1	Y
May 2022	2.5	3/08	3	Y
September 2022	2.6	9/07	5	N
October 2022	3.2, 2.3	10/03, 10/28	7, 1	Y, N
January 2023	2	1/23	1	N
February 2023	2.2	2/28	1	N
March 2023	2	3/13	1	N

The duration of the storm in Table 1 are the number of tide cycles that the measure water level exceeds 2' MHW at high tide. Also, the Section inspects coastal lines after storm tides to assess beach and dune erosion. The decision by the Section to perform such inspection is indicative of storm events that may have caused considerable beach profile change. The last column in Table 1 indicates to which storm events the Section responded. Of the events summarized in Table 1, the Section responded to 5 of these events.

It is also noteworthy that the survey dates for different portions of the coast are not the same. Typically, all LRP lines north of the Indian River Inlet are surveyed on one day and the lines on the south side are surveyed on another. The summer survey of 2021 was collected on 10/07 and 10/14 for the south and north sides of the inlet, respectively. As such, the first storm event reported in Table 1 preceded the survey of the beaches on the north side but occurred after south side.

Fenwick Island

Fenwick Island is densely populated from the Delaware and Maryland state line to about 1 mile north of this boundary. North from this location, the coastline is sparsely populated and includes Fenwick Island State Park. There are five survey lines spaced roughly 5,000' feet apart along the section of coastline as shown in Figure 5. Within Fenwick Island, there is a federal nourishment project that aims to protect the developed portion of the shoreline.

Figure 4: LRP location map for Fenwick Island

Fenwick Island Volumes:

The average beach volumes of Fenwick Island are as shown in Table 2. Beach volumes are calculated

along 1-Dimension profiles and are reported as cubic feet per linear foot of beach length (cf/lf). The volumes for each LRP survey line in the community is presented. The volumetric change trends in Fenwick Island show erosion, season to season, from Summer 2021 to Summer 2022. The beach recovered volume from Summer 2022 to Winter 2023. This is the cause for all LRPs except LRP 67 where the beach accreted between Summer 2021 and Winter 2022 but eroded season to season from Winter 2022 to Winter 2023. By percentages, LRP 63 eroded the most from Summer 2021 to Winter 2023 while LRP 64 is the only location where the net beach change accreted between Summer 2021 to Winter 2023.

Table 2: Beach volumes for Fenwick Island

	Volume (cf/lf)									
LRP	LRP 63		LRP 64		LRP 65		LRP 66		LRP 67	
Volume Limit	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW
Summer 2021 (10/07/2021)	2945	1595	2680	1555	1970	1185	2530	1280	955	745
Summer 2022 (09/15/2022)	2675	1430	2405	1480	1810	1050	2280	1150	990	775
Winter 2022 (02/21/2022)	2605	1620	2330	1660	1755	1180	2250	1310	1095	955
Winter 2023 (03/16/2023)	2630	1525	2655	1690	1900	1120	2365	1230	855	775

A representative seasonal profile view for Fenwick Island is shown in Figure 6. For each beach, one profile view is shown in the body of the report with the remaining plots residing in Appendix B. In Summer of 2021, the berm was 2-4’ higher in elevation near the shoreline but lower in elevation closer to the dune. This accounts for the larger volume above MHW in Summer of 2021. This volume of sand appeared to by pushed landward and reshaped in subsequent seasons. The dune appears to have grown in elevation which is expected since wind blown sand is trapped by dune vegetation and the dune as not been eroded by surge and wave action.

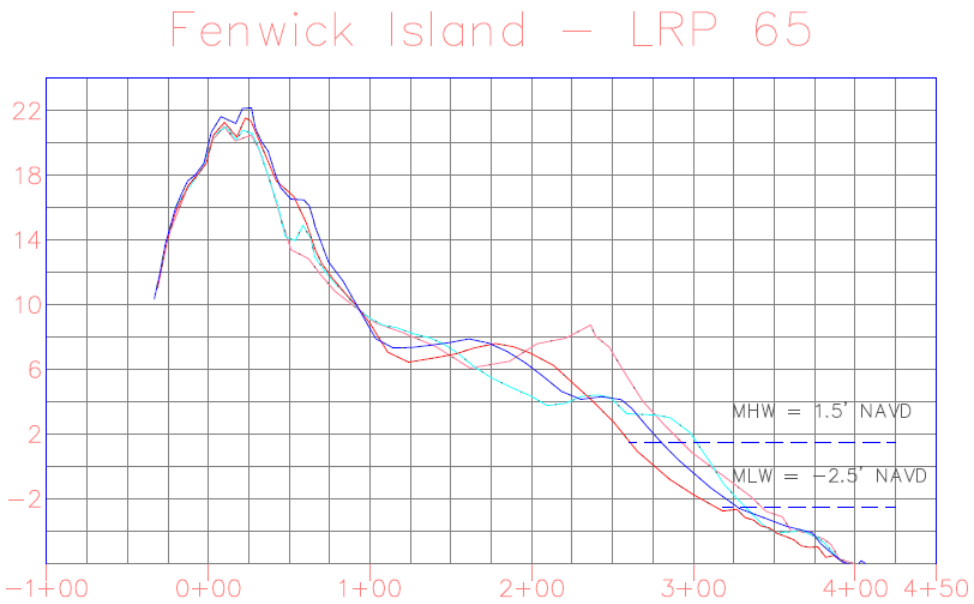


Figure 5: Representative profile in Fenwick Island. The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded one of the storm surge events that impacted Fenwick Island on 05/09/2022. Fenwick Island is nourished by the USACE in partnership with DNREC. Fenwick Island is also directly adjacent to Ocean City, Maryland which is also nourished by the USACE. Therefore, Fenwick Island tends to be sediment rich. During this storm, the surge and wave action reached the toe of the dune. A vast amount of wind blown sand was accumulated on the dunes and in the crossovers as seen in Figure 6 below.

Figure 6: Photo of Fenwick Island taken from the dune on May 5th, 2022 during the "2022 Mother's Day Storm"

South Bethany

South Bethany extends from Fenwick Island State Park roughly 4,000' north and is densely populated along the coast. South Bethany contains two survey lines separated by roughly 2,000' as shown in Figure 7.

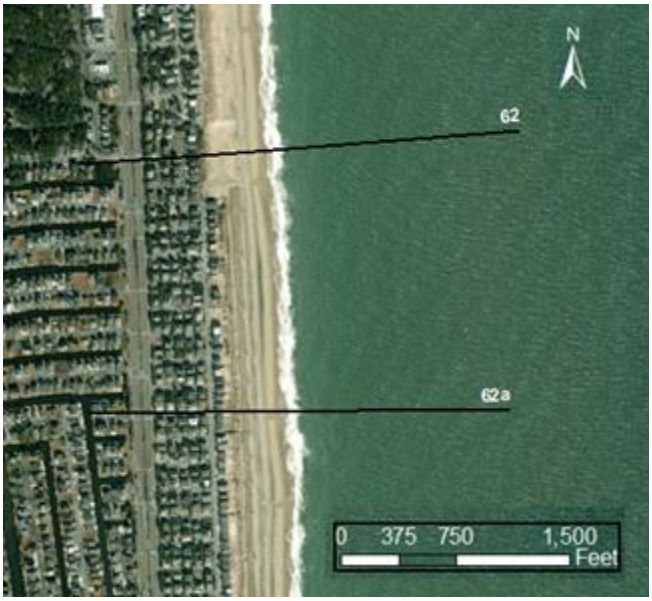


Figure 7: LRP location map for South Bethany

South Bethany Volumes:

The average beach volumes of South Bethany Beach are as shown in Table 2. Since Summer of 2021, the beach has eroded over the period covered in this report. The data at LRP 62 shows the expect seasonal trends of erosion between summer and winter with recovery between the winter and summer profiles. It is well established that beaches erode during Tropical storms and winter nor-easters while the beaches recover during calm wave condition typical of summers. It should be noted that the Summer survey would ideally occur at the end of the prolonged calm period before any impacts of tropical storm activity. Conversely, the Winter survey should occur after the last nor' easter or winter storm at the start of a prolonged calm period. The retreat of the beach during this time period is evident in the profile comparison in Figure 8.

Table 3: Average beach volumes in South Bethany

	Volume (cf/lf)			
LRP	LRP 63		LRP 64	
Volume Limit	MHW	MLW	MHW	MLW
Summer 2021 (10/07/2021)	2945	1595	2680	1555
Summer 2022 (09/15/2022)	2675	1430	2405	1480
Winter 2022 (02/21/2022)	2605	1620	2330	1660
Winter 2023 (03/16/2023)	2630	1525	2655	1690

Similar to the example profile from Fenwick Island, LRP 62 in South Bethany has a large volume of sand near the shoreline in Summer 2021 which has been pushed inland and reshapeded in the foreshore over the subsequent seasons. The storm damage to the dune that occurred on 05/09/2022, preceding the Summer 2022, is evident in the profile comparison. The dune eroded back about 35-40' leaving a 7' scarp.

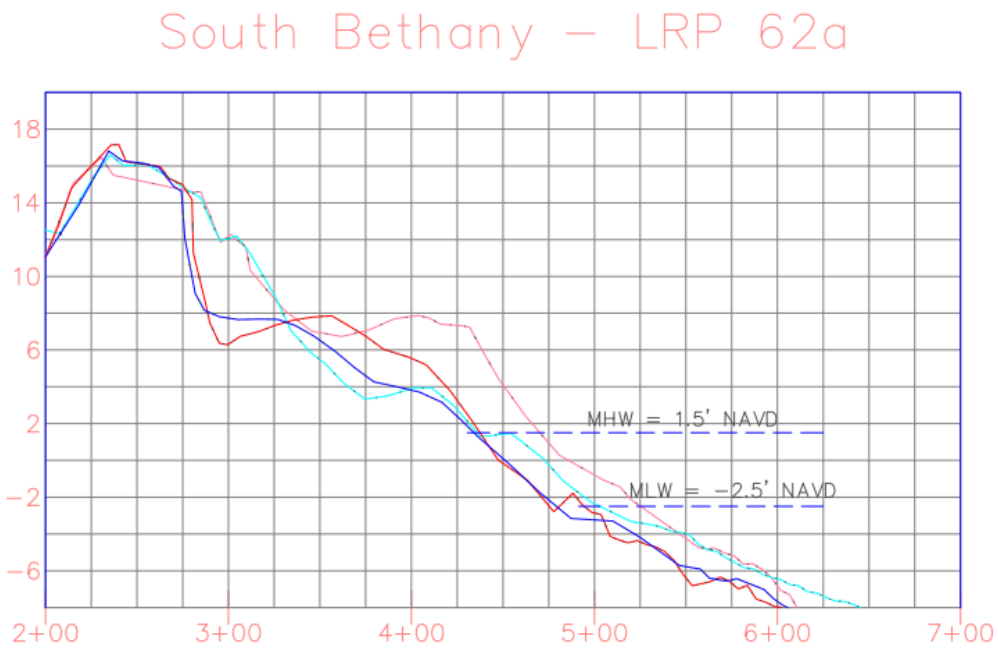


Figure 8: Representative Profile in South Bethany: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded one of the storm surge events that impacted South Bethany on 05/09/2022. During this storm, the surge and wave action the dune causing severe erosion and scarping of the dune. The scarping of the dune left the beach nearly inaccessible from the pedestrian dune crossing. The dune erosion erosion depicted in Figure 8 is also detectable in Figure 9 based on the position of the fence line relative to the eroded dune position.

Figure 9: Storm tide and wave erosion during the Mother's Day storm in 2022.

Bethany Beach

Bethany Beach extends from Middlesex Beach to a series of private beaches that separate Bethany Beach and State-owned beaches. Bethany Beach contains five lines along the densely populated coast as shown in Figure 9. LRP 59 to 61 are spaced roughly 1000’ – 1500’ apart whereas LRP 58 is roughly 1 mile north of LRP 59 and is within a private community.

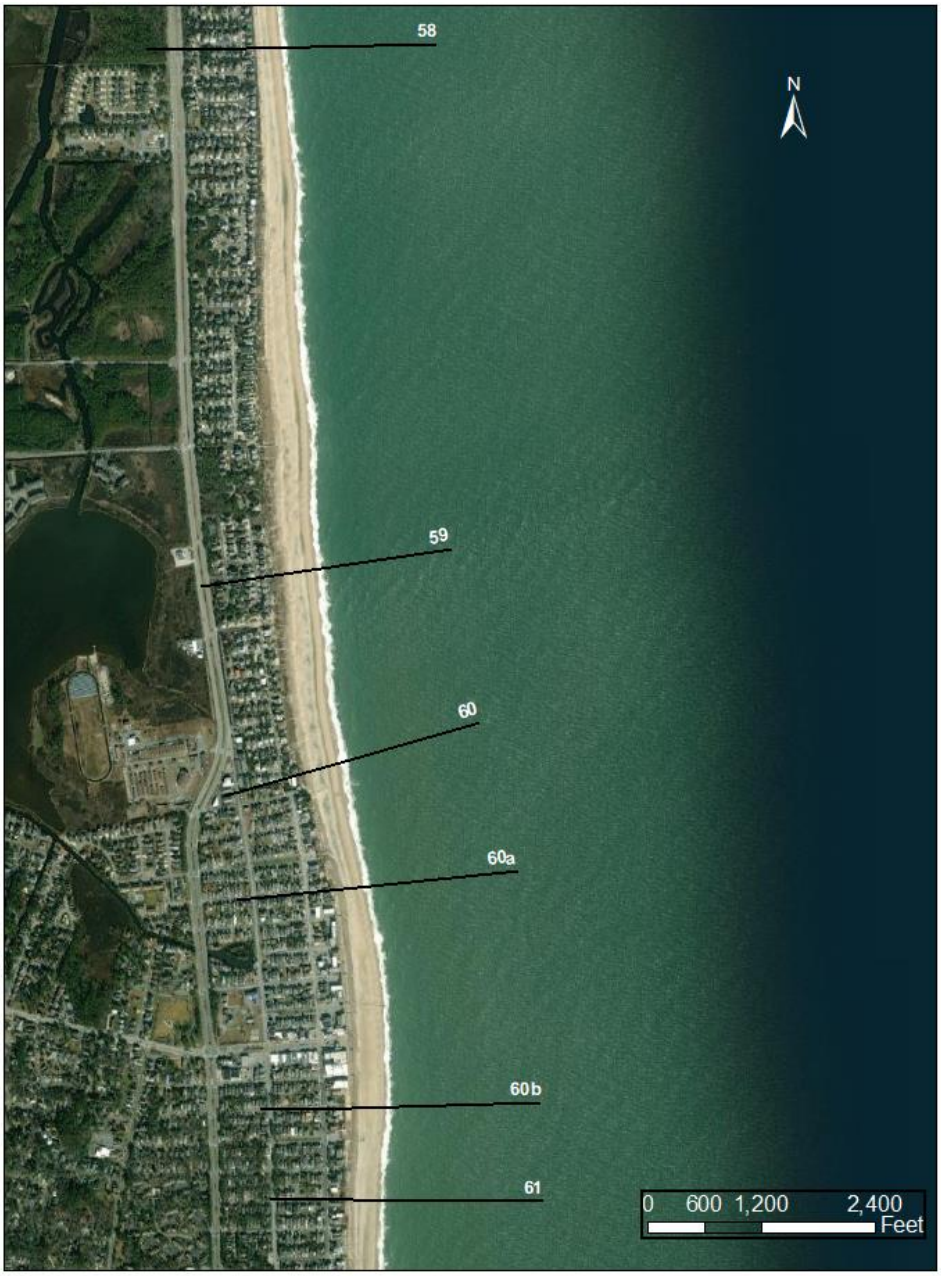


Figure 10: LRP location map for Bethany Beach

Bethany Beach Volumes:

Since the Summer 2021 season, the beach within the Town of Bethany Beach has accreted. The beach was most voluminous in Summer 2021 but was substantially eroded over the course of autumn 2021. During the Summer of 2021, a large mound of sand accreted on the berm in Bethany. This growth and subsequent erosion accounts for the large volume in that season and the lesser volume in the following Winter.

Table 4: Average beach volumes in the Town of Bethany Beach

	Volume (cf/lf)							
LRP	LRP 58		LRP 59		LRP 60		LRP 60a	
Volume Limit	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW
Summer 2021 (10/07/2021)	1315	950	2690	1450	2935	1685	1570	1070
Summer 2022 (09/15/2022)	1300	930	2730	1400	2845	1535	1100	830
Winter 2022 (02/21/2022)	1150	935	2515	1450	2820	1630	920	1000
Winter 2023 (03/16/2023)	1280	920	2620	1405	2840	1505	1240	790

Volume (cf/lf)			
LRP 60b		LRP 61	
MHW	MLW	MHW	MLW
1315	950	2690	1450
1300	930	2730	1400
1150	935	2515	1450
1280	920	2620	1405

The changes in the beach profile is evident in the profile comparison at LRP 60 as shown in Figure 10. In the profile comparison, there is noticeable variability in the berm and foreshore part of the profile. Surprising, the impacts of the 05/09/2023 storm is not clear in the profile plot.

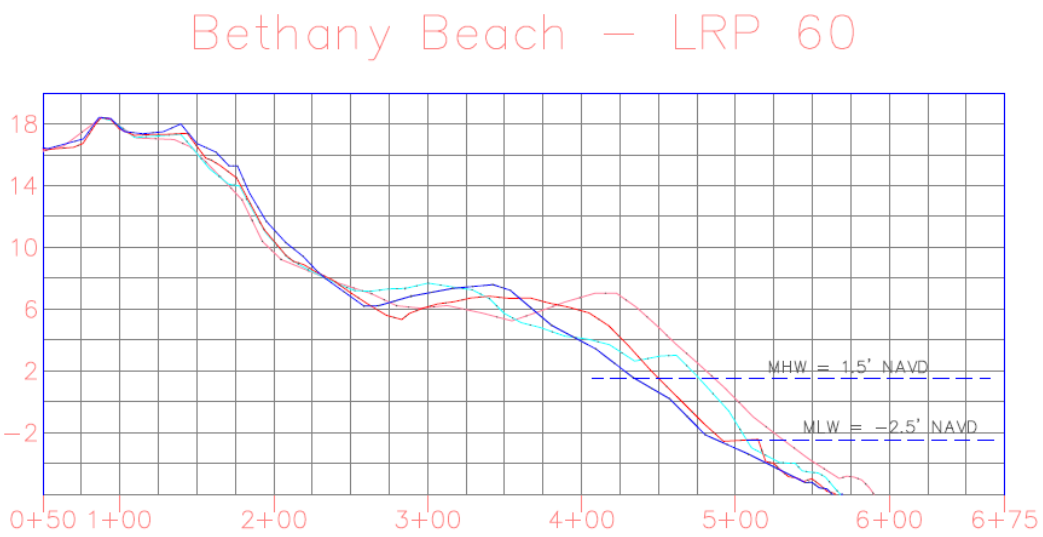


Figure 11: Bethany Beach: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded one of the storm surge events that impacted Bethany on 05/09/2022. During this storm, the surge and wave action the dune causing some erosion and scarping of the dune. The scarping of the dune left moderately scarped. The beach access was moderately impacted in some sections of the coast.

Figure 12: Storm tide and wave conditions in Bethany Beach during the Mother's Day Storm of 2022

Oceanview

North of Bethany is Oceanview which contains a series of private communities including Sussex Shores and Ocean Village. There is only one survey line in this section of beach which is densely populated with private communities at the location shown in Figure 11. This is the northernmost developed shoreline community south of the Indian River Inlet.

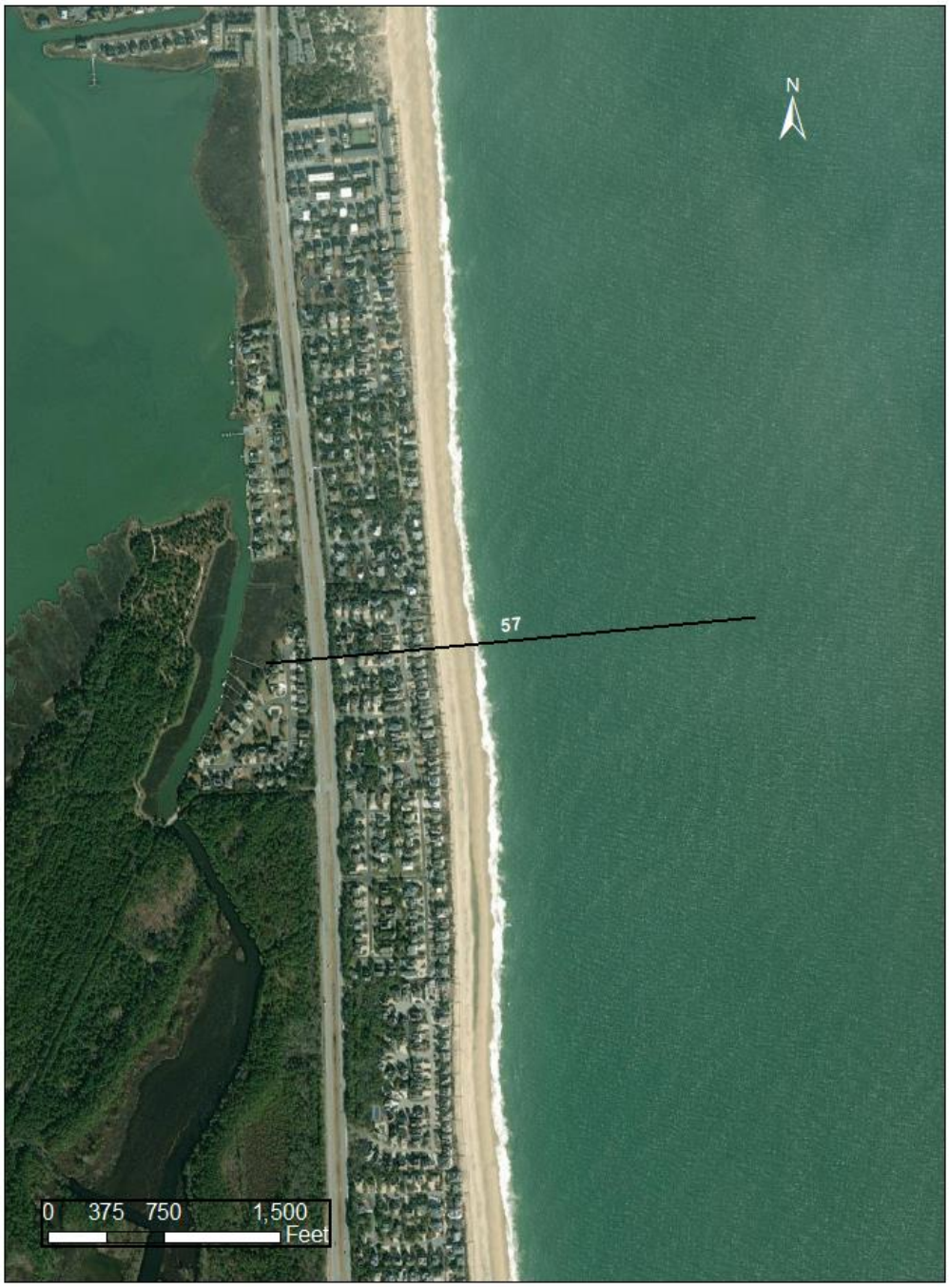


Figure 13: LRP location in Oceanview

Oceanview Volumes:

The profile volumes in Oceanview exhibits the theoretical seasonable variability with erosion during winter and recovery over the summer. Overall, the beach volumes are stable or potential accretional since the Winter 2023 profile contains more volume than in 2022.

Table 5: Average beach volumes in Oceanview

	Volume (cf/lf)	
LRP	LRP 58	
Volume Limit	MHW	MLW
Summer 2021 (10/07/2021)	1315	950
Summer 2022 (09/15/2022)	1300	930
Winter 2022 (02/21/2022)	1150	935
Winter 2023 (03/16/2023)	1280	920

The beach profiles in Oceanview are shown in Figure 14. The substantial erosion from Summer 2021 to Winter 2022 is evident. The subsequent recover of the profile and much less substantial erosion in Winter 2023 is also observable.

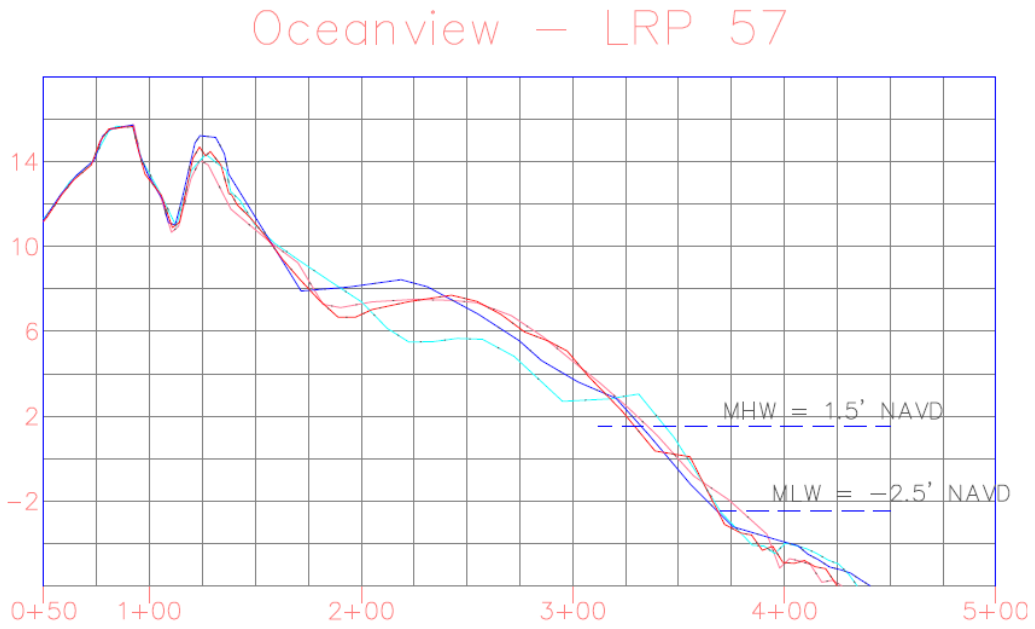


Figure 14: Oceanview: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

South Seashore State Parks

The Delaware Seashore State Park south of the Indian River Inlet which consists of 3R's and Southside Indian River day beach has two survey lines. LRP 55 is directly adjacent to the jetty and LRP 56 is about half a mile south of the inlet and runs through the LRP 3R's parking lot as shown in the Figure 15.

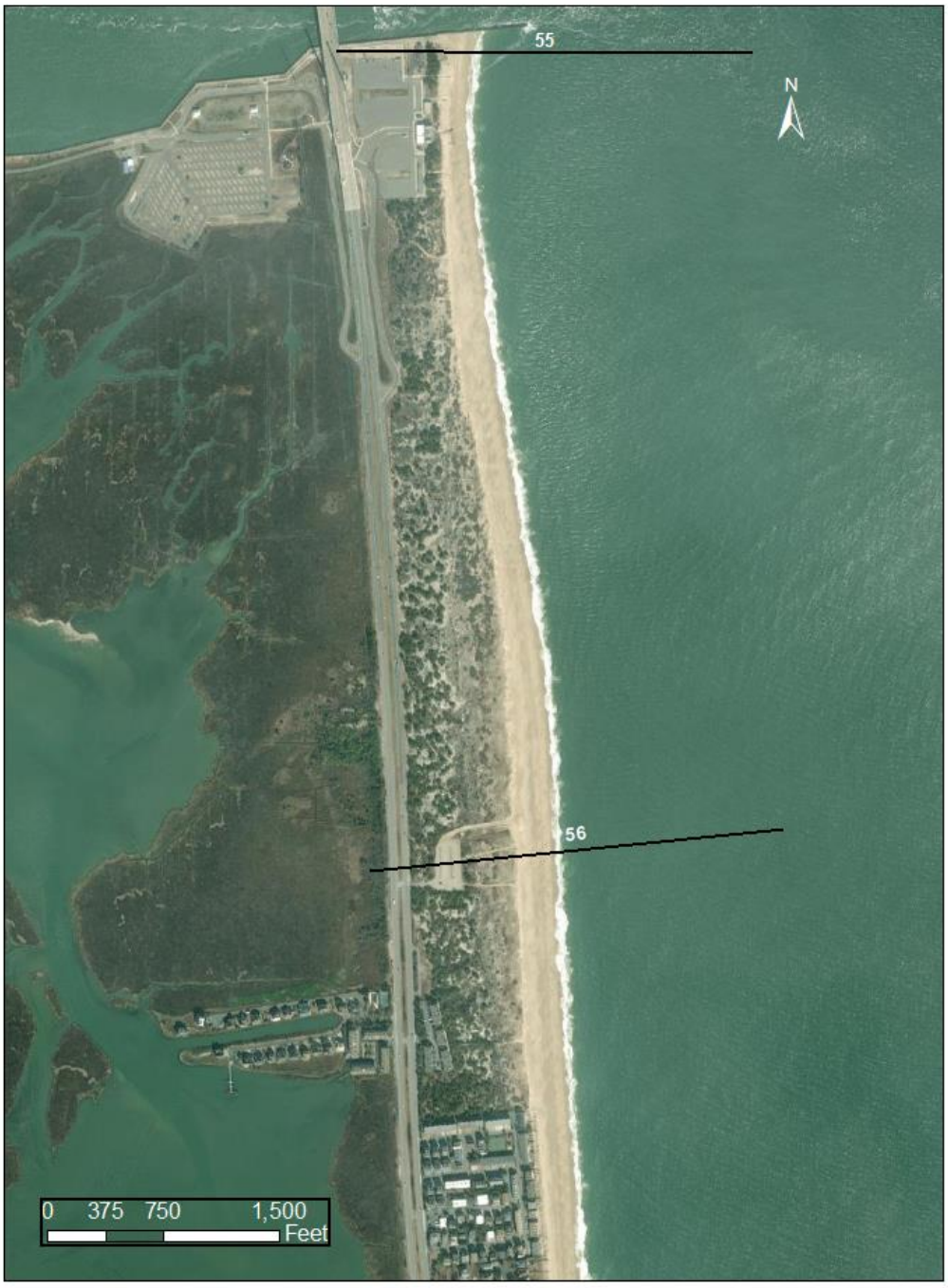


Figure 15: LRP location in Southside Indian River Inlet

South Seashore State Parks Volumes:

Since the Summer of 2021, the beaches at Southside Indian River Inlet and 3R's state beaches has substantially eroded near the jetty. At LRP 56, the beach volumes indicate the beach is stable.

Table 6: Average beach volume in the southern Seashore State Parks

	Volume (cf/lf)			
LRP	LRP 55		LRP 56	
Volume Limit	MHW	MLW	MHW	MLW
Summer 2021 (10/07/2021)	925	890	1970	1160
Summer 2022 (09/15/2022)	730	765	1930	1160
Winter 2022 (02/21/2022)	655	800	1755	1140
Winter 2023 (03/16/2023)	420	670	1960	1160

The profile comparison shown in Figure 16 shows that the berm eroded substantially between Summer 2021 and Winter 2022. The beach recovered prior to the Summer 2022 survey and experience little change observable in the Winter 2023 profile.

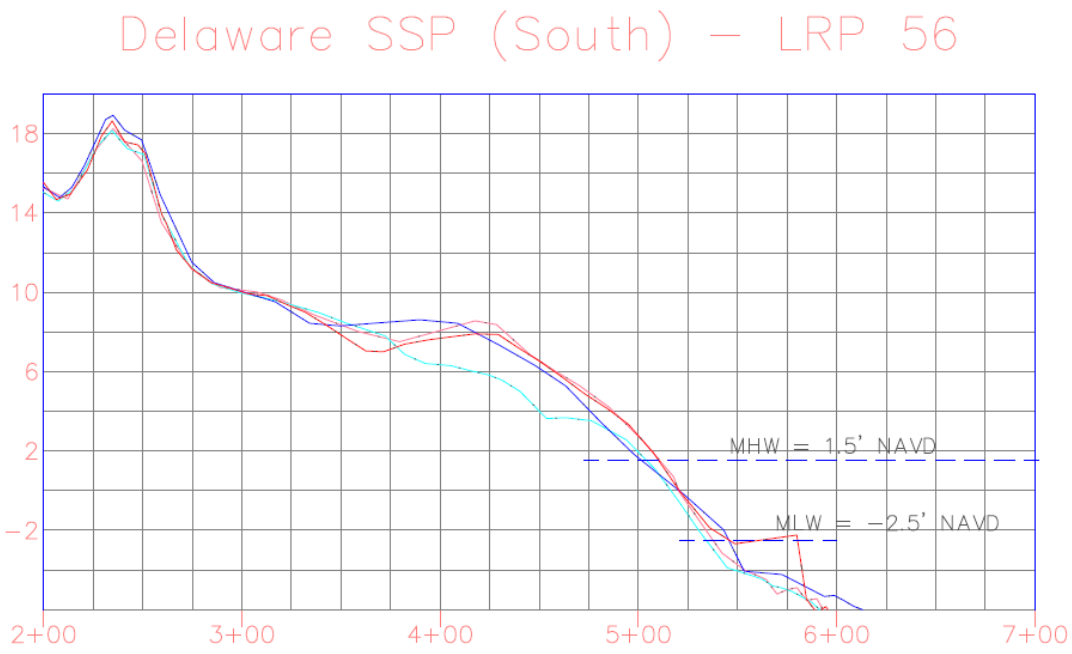


Figure 16: DSSP South: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

North Seashore State Parks

Northside of Indian River Inlet contains nearly five miles of state-owned beaches from Tower Road at the north end to the inlet at the south end. Within this five-mile stretch, there are seven survey lines that are evenly spaced, save for the two that are closet to the inlet as shown in Figure 17.

Figure 17: LRP location map in northshores of Delaware Seashore State Parks

North Seashore State Parks Volumes:

Since Summer 2021, the beach accreted in most locations. The growth directly near the inlet is likely due to the truck haul of material from upland sources. Further north from these locations, the beach tends to accrete with sand bars that fuse with the shoreline.

Table 7: Average beach volumes in northern Delaware Seashore State Parks.

	Volume (cf/lf)							
LRP	LRP 48		LRP 49		LRP 50		LRP 51	
Volume Limit	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW
Summer 2021 (10/14/2021)	2500	1410	1220	1060	2365	1370	2410	1450
Summer 2022 (09/19/2022)	2750	1335	1400	950	2480	1250	2610	1370
Winter 2022 (02/21/2022)	2675	1425	1270	1020	2530	1370	2475	1465
Winter 2023 (03/07/2023)	2685	1370	1300	1000	2370	1315	2560	1420

Volume (cf/lf)					
LRP 52		LRP 53		LRP 54	
MHW	MLW	MHW	MLW	MHW	MLW
1420	960	450	480	465	480
1315	840	575	430	270	285
1520	970	570	665	595	760
1280	915	650	700	530	670

The seasonal profiles near the inlet are shown in Figure 18. This beach is typically erosional without the maintenance via bypassing and backpassing. Since 2020, the State has used heavy equipment to backpass or scrape material from accretional beaches to maintain the shoreline represented by LRP 53. This method was employed since the bypass facility has been out of service while the diesel motors are being replaced with electric ones. When the beach is too narrow, backpassing is not possible. Since Summer of 2021, sand has been truck hauled from inland sources to rebuild the beach at this section of the beach for backpassing to resume.

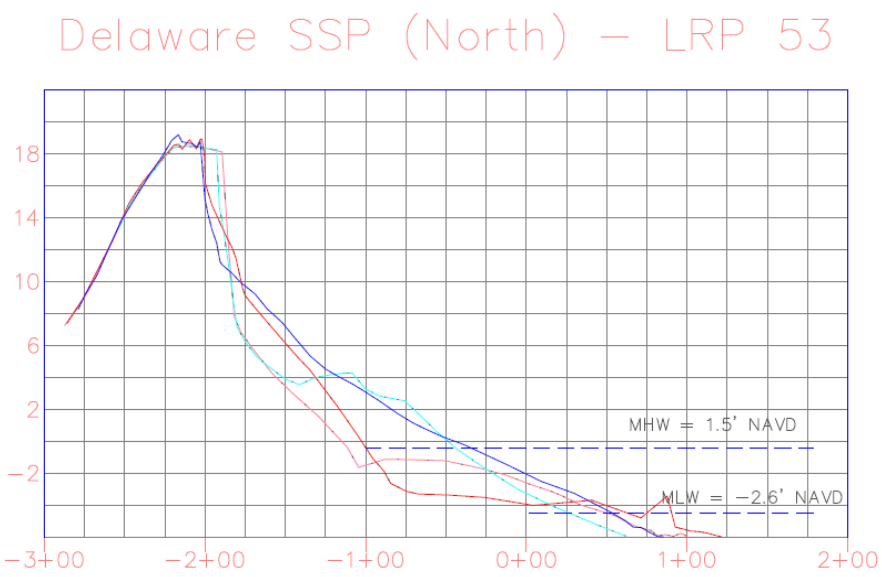


Figure 18: DSSP North (near Indian River Inlet): The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The seasonal profiles in the central section of North Seashore State Parks are shown in Figure 19. The changes in the berm geometry appears to be balanced by the variability in the intertidal and foreshore zones.

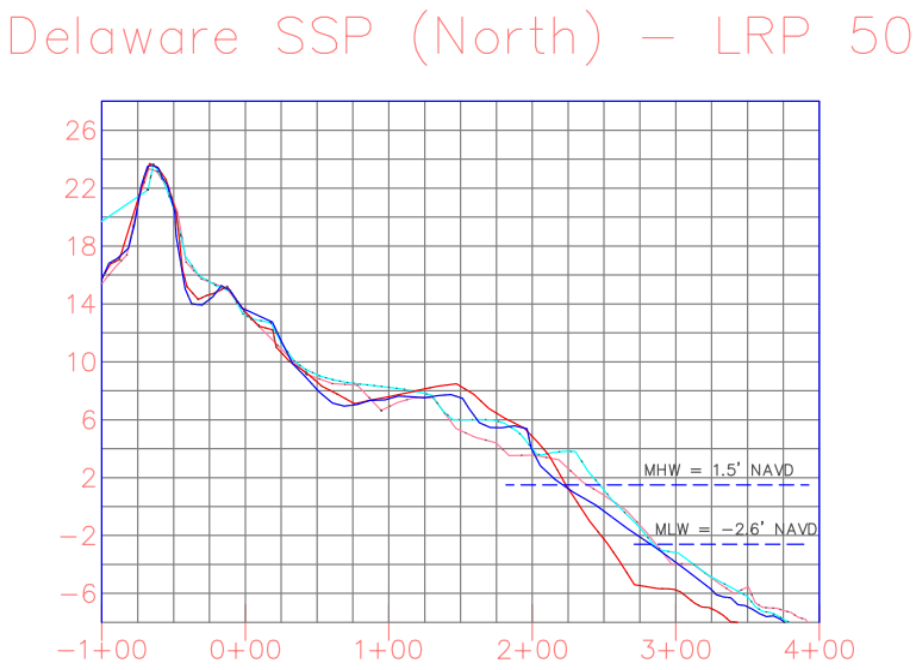


Figure 19: DSSP North: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MHW and the lower line being MLW.

On 10/10/2021 the section observed the beach during a coastal storm. The storm cause extensive dune and beach erosion. The picture in Figure 20, shows elevated water level, wave setup, and uprush at Northside Indian River Inlet beach.

Figure 20: Storm surge and waves at Northside Indian River Inlet on 10/10/2021

Dewey Beach

North of Indian River, Dewey Beach extends roughly 7,500' northward to Silver Lake Shores, which separates Dewey and Rehoboth Beaches. Dewey is densely populated and consists of only one survey line located near the southern town limit. Silver Lake Shores also includes one survey line as shown in Figure 21.

Figure 21: LRP location in Dewey Beach

Dewey Beach Volumes:

Between Summer 2021 and 2022, the volume of Dewey Beach increased but lost all the gains from Summer 2022 to Winter 2023. It is unexpected that the beach volume grew between Winter and Summer 2022 owing to the Mother's Day storm that appeared to cause substantial erosion. It is possible that the beach did, in fact, experience extensive erosion and the eroded material wash back up the beach during the calm summer conditions.

Table 8: Average beach volumes in Dewey Beach

	Volume (cf/lf)	
LRP	LRP 55	
Volume Limit	MHW	MLW
Summer 2021 (10/07/2021)	1220	990
Summer 2022 (09/15/2022)	1360	950
Winter 2022 (02/21/2022)	1235	995
Winter 2023 (03/16/2023)	1200	970

The seasonal profiles in Dewey Beach are shown in Figure 22. The changes in the berm geometry appears to be balanced by the variability in the intertidal and foreshore zones. Though the volume analysis masqueraded the erosion experience during the Mother's Day storm, the evidence of the storm appears to be present in the profile comparison. The dip in elevation at the toe of the dune, where the berm begins, in the Summer 2022 profile is likely relic erosion experienced during the storm. The berm, on the other hand, recovered and grew in the summer months.

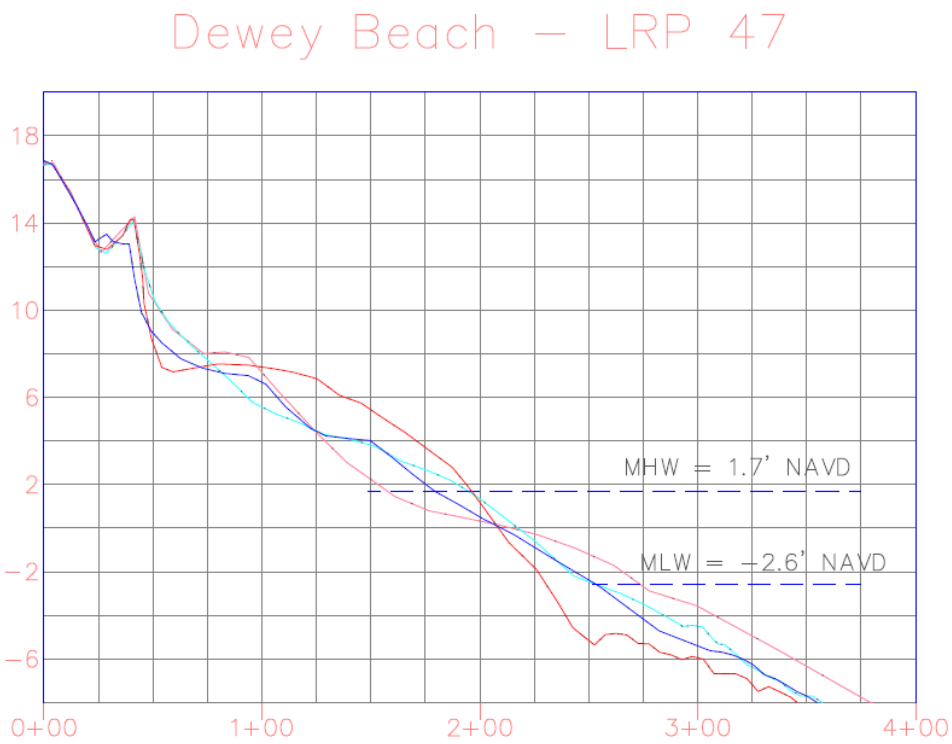


Figure 22: Dewey Beach: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded one of the storm surge events that impacted Dewey on 05/09/2022. During this storm, the surge and wave action the dune causing some erosion and scarping of the dune. The scarping of the dune left moderately scarped in southern part of the beach. Beach access was not impacted. In the center and northern part of the beach, the storm tide barely reached or stopped short of the dune.

Rehoboth Beach

North of Silver Lake Shores is the town of Rehoboth Beach, which is approximately 8,500' long. Rehoboth is densely populated and includes four profiles as shown in Figure 19. Directly north of Rehoboth Beach is Henlopen Acres.

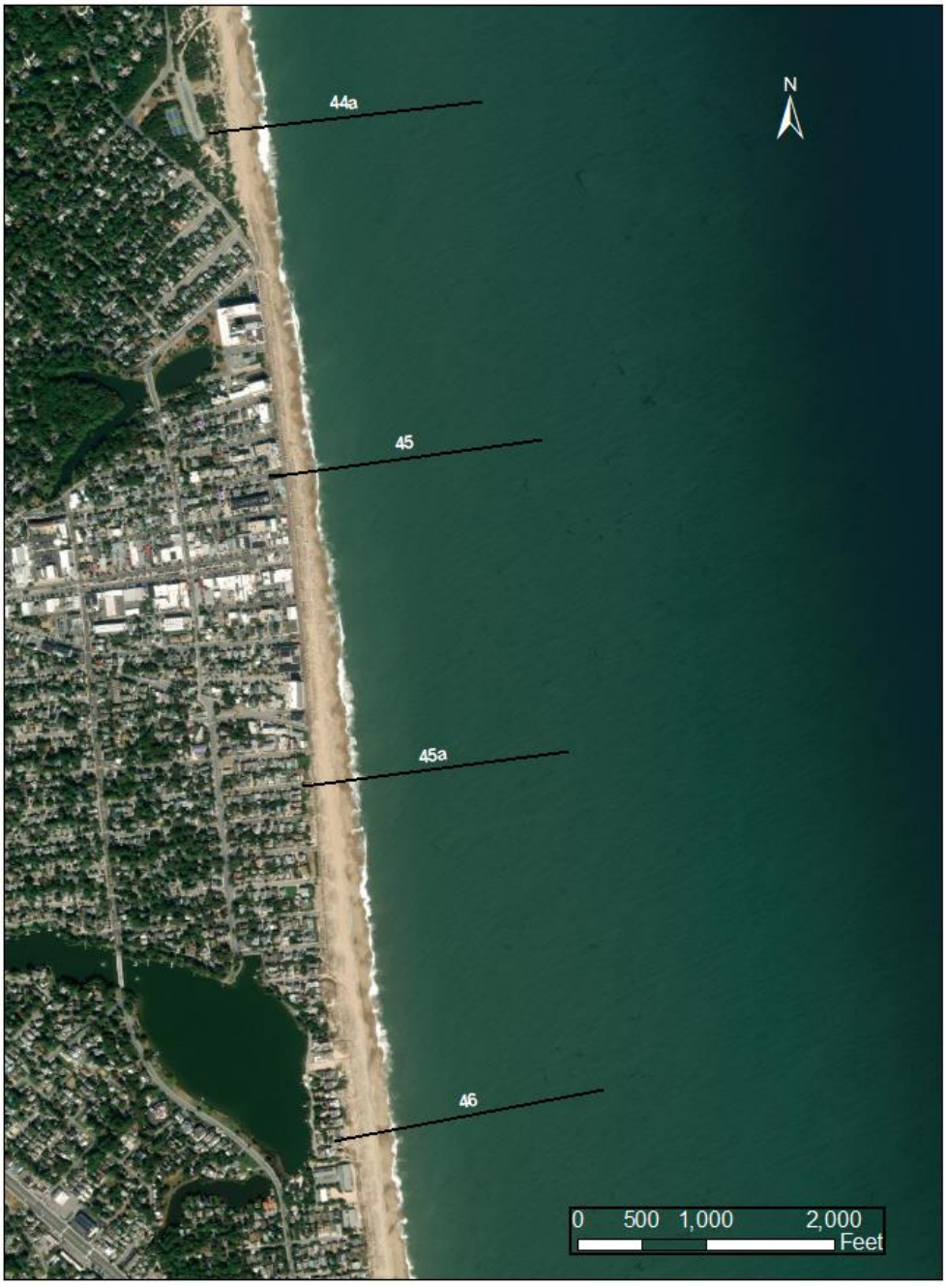


Figure 23: LRP location map in Rehoboth Beach

Rehoboth Beach Volumes:

Since the Summer of 2021, there has been substantial beach change from season to season. In the center portion of the shoreline, there was net beach accretion, whereas net erosion was observed at LRP 45 and 47.

Table 9: Average beach volumes in Rehoboth Beach.

	Volume (cf/lf)							
LRP	LRP 45		LRP 45a		LRP 46		LRP 47	
Volume Limit	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW
Summer 2021 (10/14/2021)	545	835	1580	1210	1475	1130	1220	990
Summer 2022 (09/19/2022)	655	800	1730	1120	1690	1110	1360	950
Winter 2022 (02/21/2022)	620	825	1550	1185	1535	1150	1235	995
Winter 2023 (03/07/2023)	490	785	1580	1150	1600	1180	1200	970

The seasonal profiles in Rehoboth Beach are shown in Figure 24. The large variability in the beach profile from season to season can be seen. The berm in Summer 2022 was the largest but the foreshore slope is steeper. Also, there is a dip in elevation near the toe of the dune, which is likely the eroded conditions owing to the Mother's Day Storm.

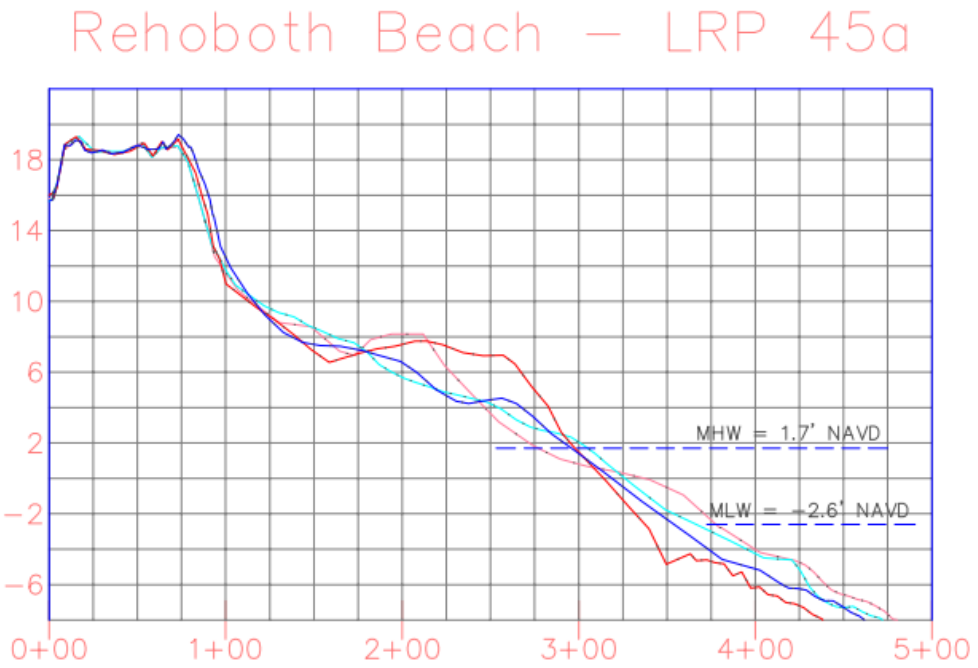


Figure 24: Rehoboth Beach: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded to three storm events that impacted Rehoboth on October 3rd and 9th of 2022 and 2021, respectively, in addition to the Mother's Day Storm. During this storm, the surge and wave action the dune causing some erosion and scarping of the dune. The scarping of the dune left moderately scarped in southern part of the beach. Beach access was not impacted. In the center and northern part of the beach, the storm tide barely reached or stopped short of the dune.

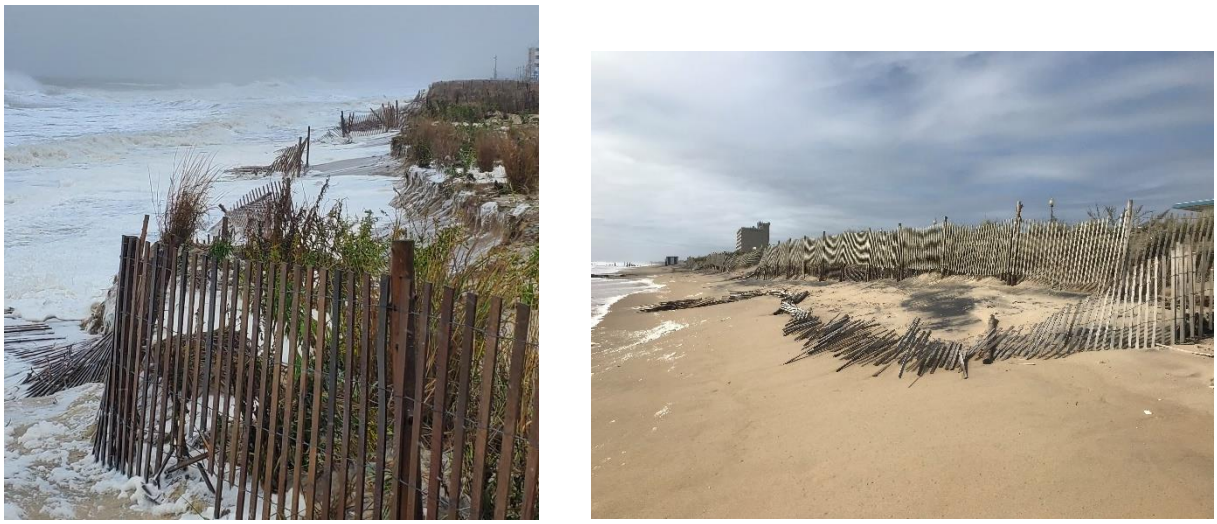


Figure 25: Picture of storm surge and beach damage in Rehoboth Beach during October of 2021 (left) and May of 2022 (right)

Gordons Pond

North of Henlopen Acres, which contains one profile line, is North Shores and Gordon Pond State Beach. This section of coast includes three profile lines.

Figure 26: LRP location in Gordon's Pond State Beach

Gordon's Pond Volumes:

Since Summer 2021, the beach volumes in Gordon's Pond grew. Comparing the summer volumes, there was substantial accretion such that there was overall net accretion after fall and winter storms.

Table 10: Average beach volumes along Gordons Pond State Beach

	Volume (cf/lf)					
LRP	LRP 43		LRP 43a		LRP 43b	
Volume Limit	MHW	MLW	MHW	MLW	MHW	MLW
Summer 2021 (10/14/2021)	300	635	1585	1355	970	1025
Summer 2022 (09/19/2022)	660	720	1890	1370	1180	990
Winter 2022 (02/21/2022)	300	740	1615	1420	1020	1060
Winter 2023 (03/07/2023)	485	780	1675	1415	990	1040

The seasonal profiles in Gordons Pond are shown in Figure 27. The large variability in the beach profile from season to season can be seen. The berm in Summer 2022 was the largest but the foreshore slope is steeper.

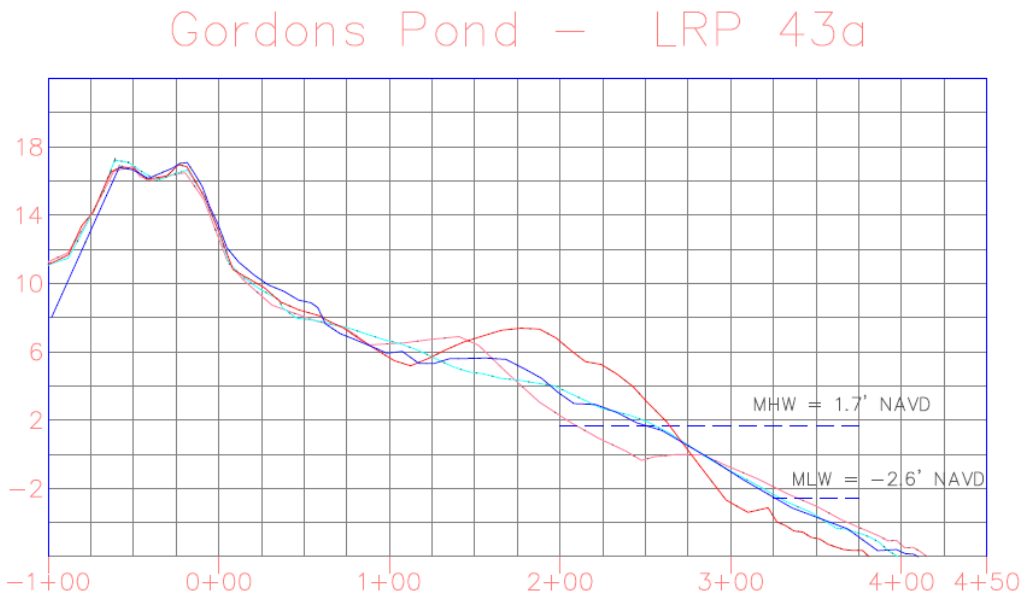


Figure 27: Gordons Pond: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded to one of the storm events that impacted Gordons Pond on October 3th of 2022. During the storm, the surge and wave action did not reach the dunes. In fact, the image in Figure 28 demonstrated a foredune growing shoreward of the fence dune limit. This depicts some of the

accretion observed in the reported volumes.

Cape Henlopen – Herring Point

Cape Henlopen State Park is the northernmost section of beach along Delaware's ocean coast. Herring Point is at the southern end of the park and is characterized by the large naval jetty. There are five LRP lines in Herring Point as shown in Figure 28.

Figure 28: LRP location map in Cape Henlopen State Park at Herring Point

Along most of Herring Point, the beach demonstrates the theoretical seasonal variability. Comparing summer volumes, the beach at Herring Point is stable. From Summer 2022 to Winter 2023, some profiles experienced erosion while others accreted.

Table 11: Average beach volumes at Herring Point in Cape Henlopen State Park

	Volume (cf/lf)									
LRP	LRP 41		LRP HP1		LRP HP6		LRP HP10		LRP 42	
Volume Limit	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW	MHW	MLW
Summer 2021 (10/14/2021)	615	780	1005	920	1250	1040	1305	955	1780	1200
Summer 2022 (09/19/2022)	800	725	1050	920	1310	1090	1375	945	2010	1180
Winter 2022 (02/21/2022)	695	820	905	870	1070	1015	1425	1180	1820	1185
Winter 2023 (03/07/2023)	450	810	900	820	1165	1025	1475	1190	1720	1175

The seasonal profiles in Herring Point are shown in Figure 27. The large variability in the beach profile from season to season can be seen. Most of the profile change occurs from the berm and intertidal zone. The dune and nearshore are fairly stable. The berm is lowest during Winter 2022.

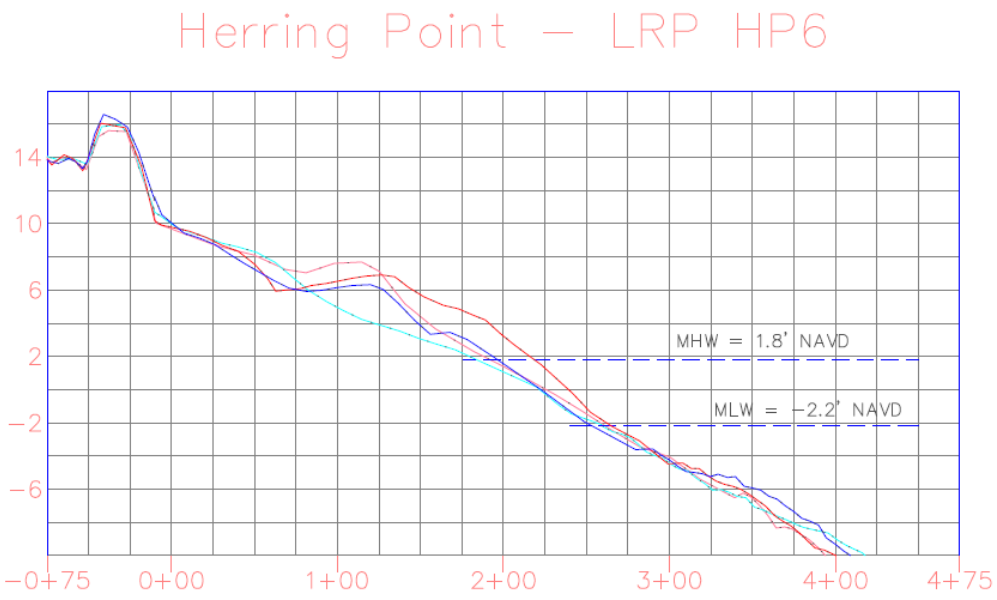


Figure 29: Herring Point: The plots are as follows: Summer 2021 (pink); Summer 2022 (red); Winter 2022 (cyan); Winter 2023 (blue). The dashed blue lines represent the tide levels with the higher line being MHW and the lower line being MLW.

The Section's crew responded to one of the storm events that impacted Herring Point on October 12th of 2021. During the storm, the surge and wave action did not reach the dunes. The appearance of the vegetation shows strong onshore winds. This suggest sand may have been blown into the dune, trapped

by the vegetation, leading to growth in the dune.

Figure 30: Herring Point during a storm event on 10/12/2021. Winds likely blew sand into the dunes leading to dune growth.

Cape Henlopen

The main day-use area is north of Herring Point in Cape Henlopen State Park. This portion of the park contains four survey lines; the two northernmost lines on the spit are sometimes inaccessible due to closures for piping plover nesting.

Figure 31: LRP location in the northern portion of Cape Henlopen State Park

Cape Henlopen Volumes:

The average beach volumes of the northern section of Cape Henlopen are as shown in Table 12. The volumes indicate that there is little change from Summer 2021 to Winter 2022 but a large amount of accretion from Winter 2022 to Summer 2022. Some of the accreted volume was eroded over the fall and winter months preceding Winter 2023.

Table 12: Average beach volumes in the main day-use area of Cape Henlopen State Park

	Volume (cf/lf)			
LRP	LRP 43		LRP 43a	
Volume Limit	MHW	MLW	MHW	MLW
Summer 2021 (10/14/2021)	300	635	1585	1355
Summer 2022 (09/19/2022)	660	720	1890	1370
Winter 2022 (02/21/2022)	300	740	1615	1420
Winter 2023 (03/07/2023)	485	780	1675	1415

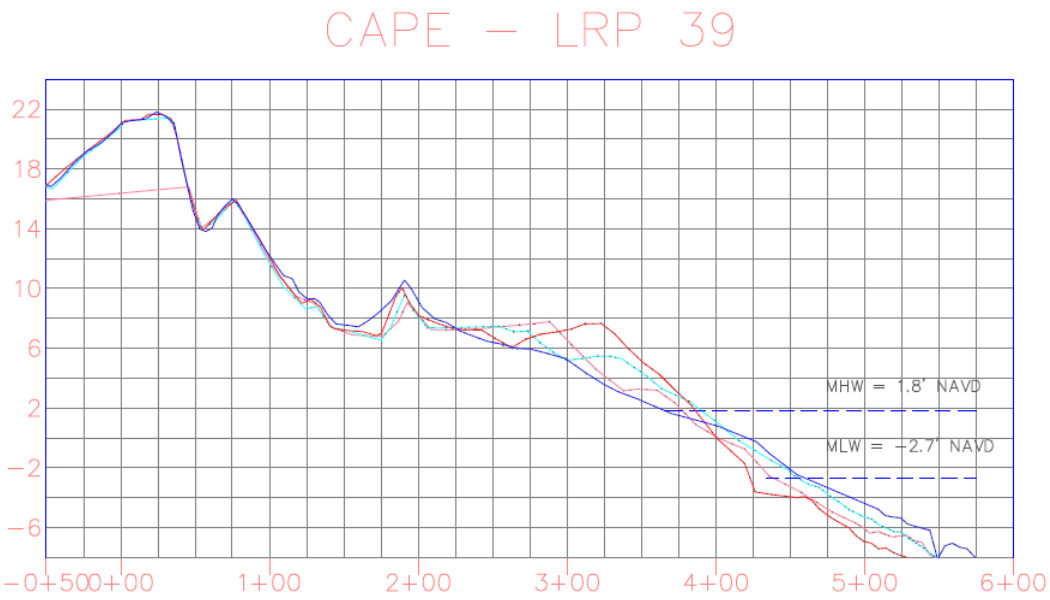
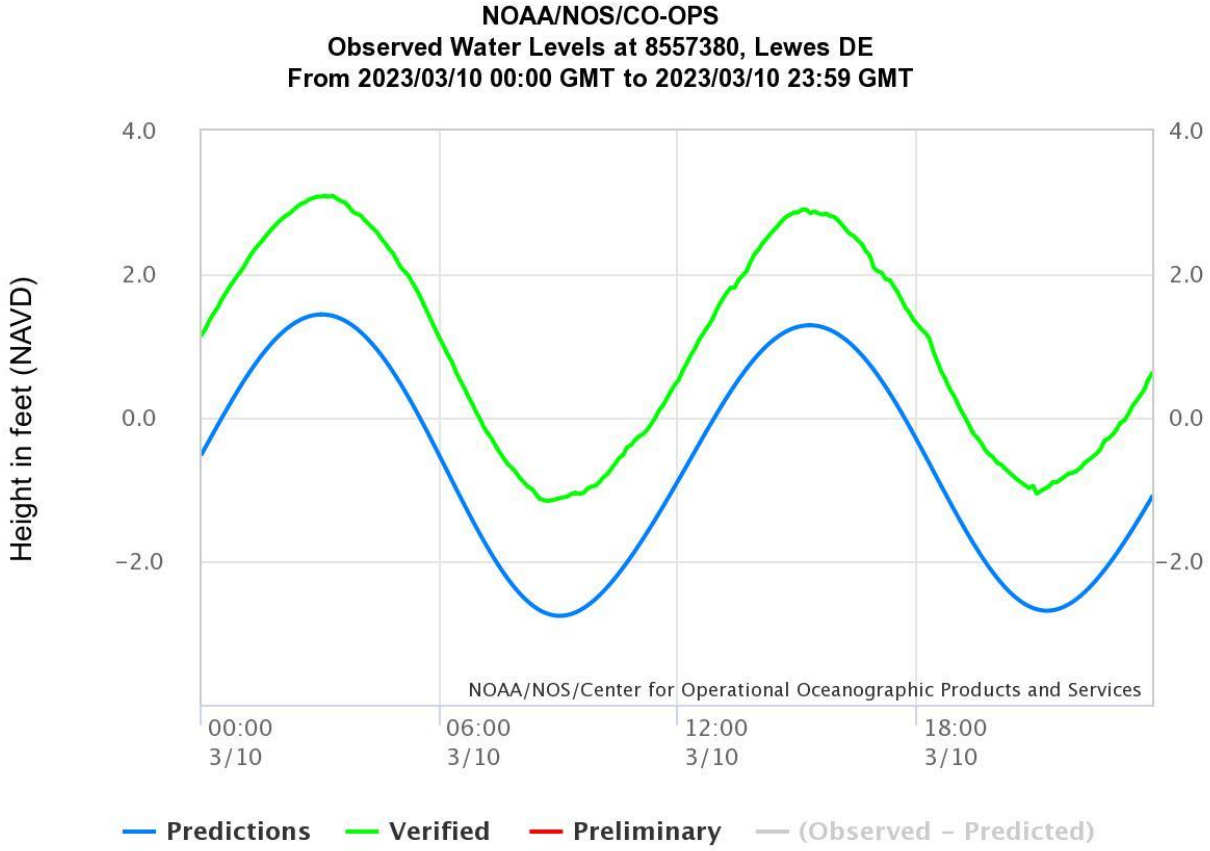


Figure 32: Cape Henlopen: The plots are as follows: Summer 2020 (dashed red); Summer 2021 (solid red); Winter 2021 (dashed cyan); Winter 2022 (dashed dark grey). The blue lines represent the tide levels with the higher line being MHHW and the lower line being MLLW

The section did not inspect this northern part of the Cape Henlopen for storm damage at any time during the period covered by this report.

Appendix A – Drone Imagery

Beaches north of the Indian River Inlet were flown on 03/10/2023. During the flight there was a storm surge of about 1.5'. The measured water level during this date is shown in green whereas the predicted tides are in blue. Refer to this water level time series when assessing the photos to understand the tidal conditions at the time of flight.



Cape Henlopen

LRP39: (09:45)

LRP40: (09:55)

Cape Henlopen – Herring Point

LRP HP10: (10:20)

Gordon's Pond

LRP 43: (10:35)

LRP 44: (10:45)

Rehoboth Beach

LRP 44A: (10:45)

LRP 44B: (10:38)

LRP 45: (10:55)

LRP 45A: (11:00)

LRP 46: (11:05)

North Seashore State Parks

LRP 48: (11:20)

LRP 49: (11:25)

LRP51 (11:40)

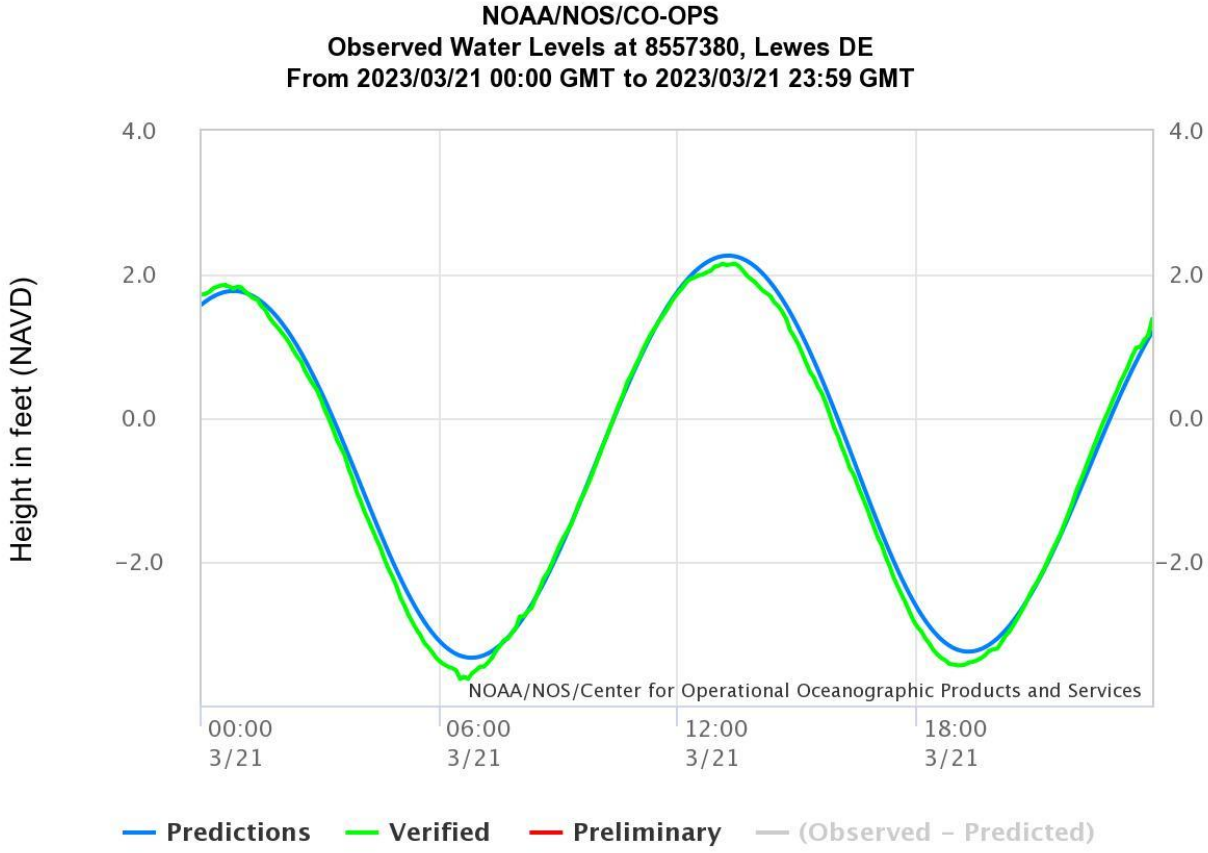


:

LRP52 (11:50)

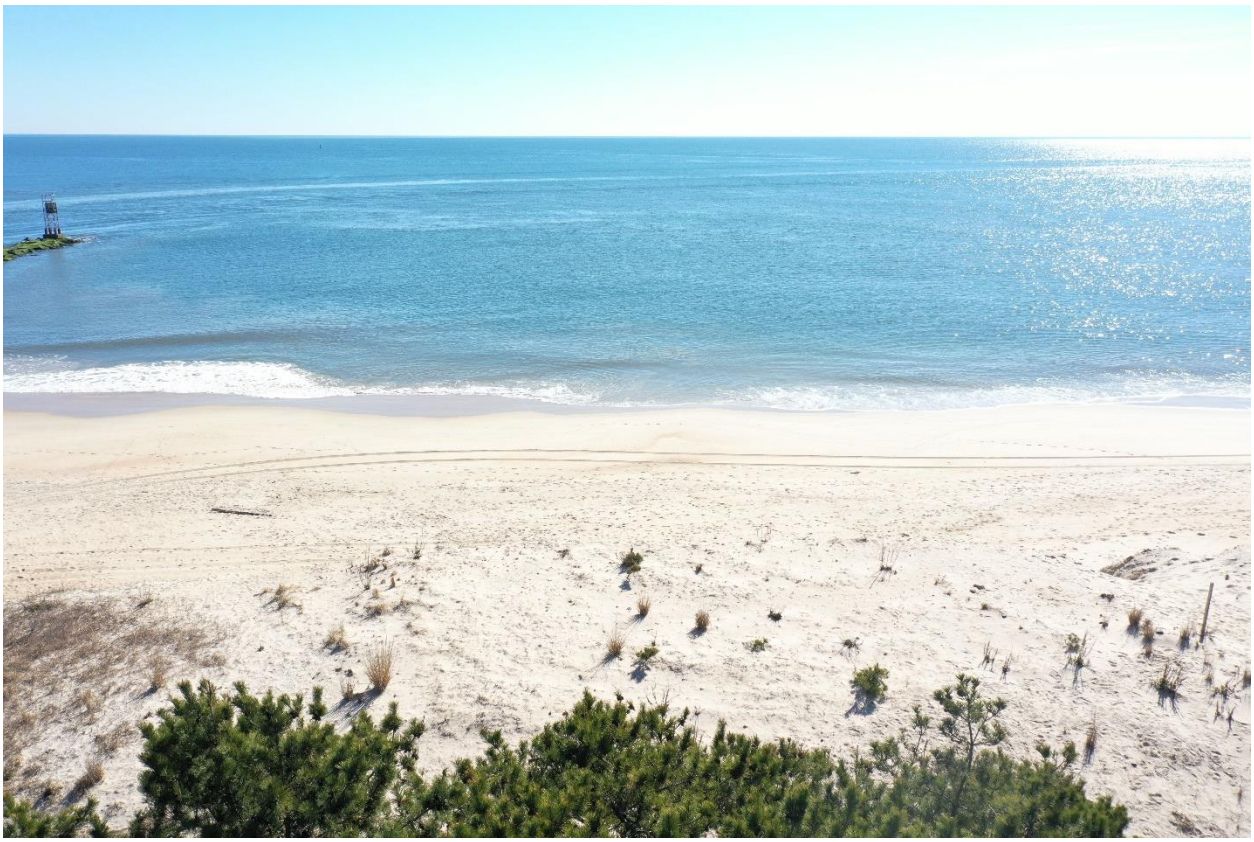
Near Inlet: (11:55)

Beaches south of the Indian River Inlet were flown on 03/21/2023. During the flight there was little to no non-tidal residual. The measured water level during this date is shown in green whereas the predicted tides are in blue. Refer to this water level time series when assessing the photos to understand the tidal conditions at the time of flight.



South Seashore State Parks

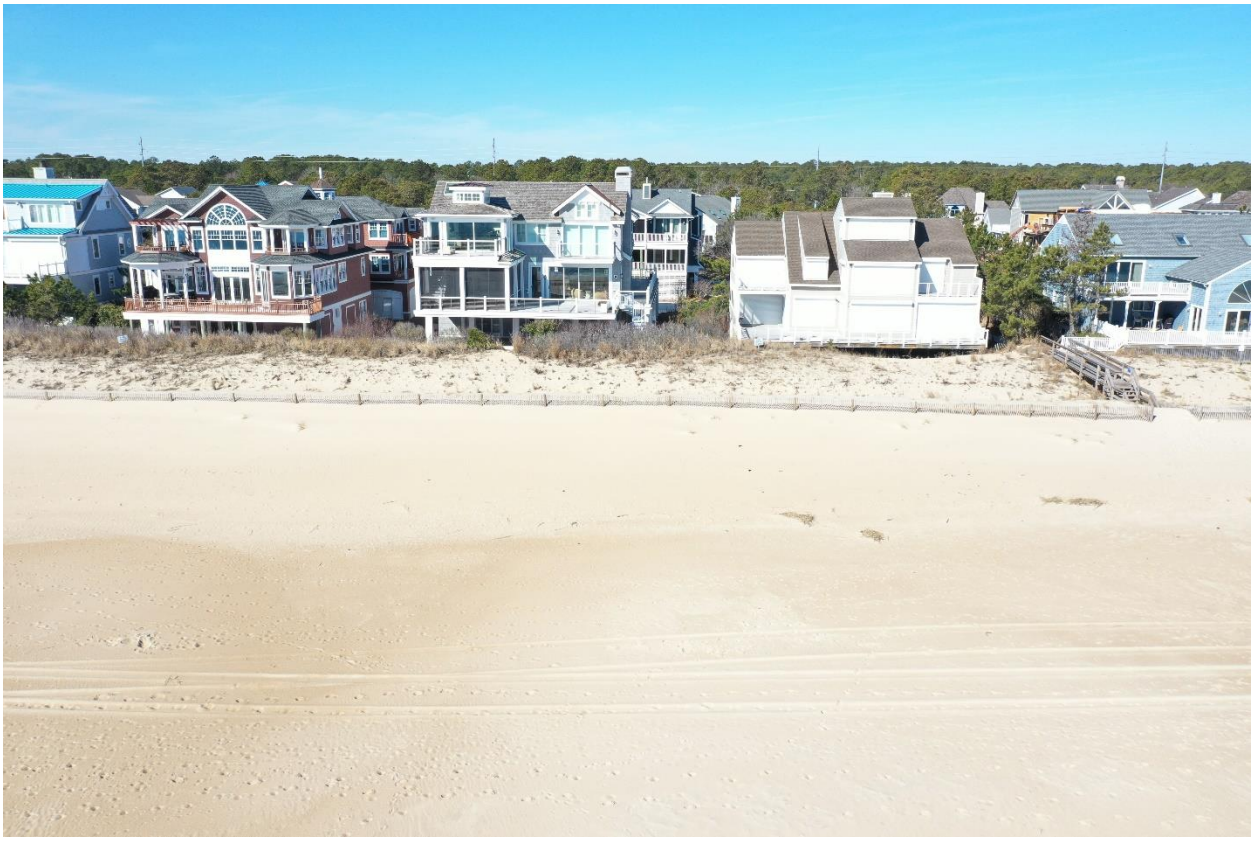
LRP55: (10:42)



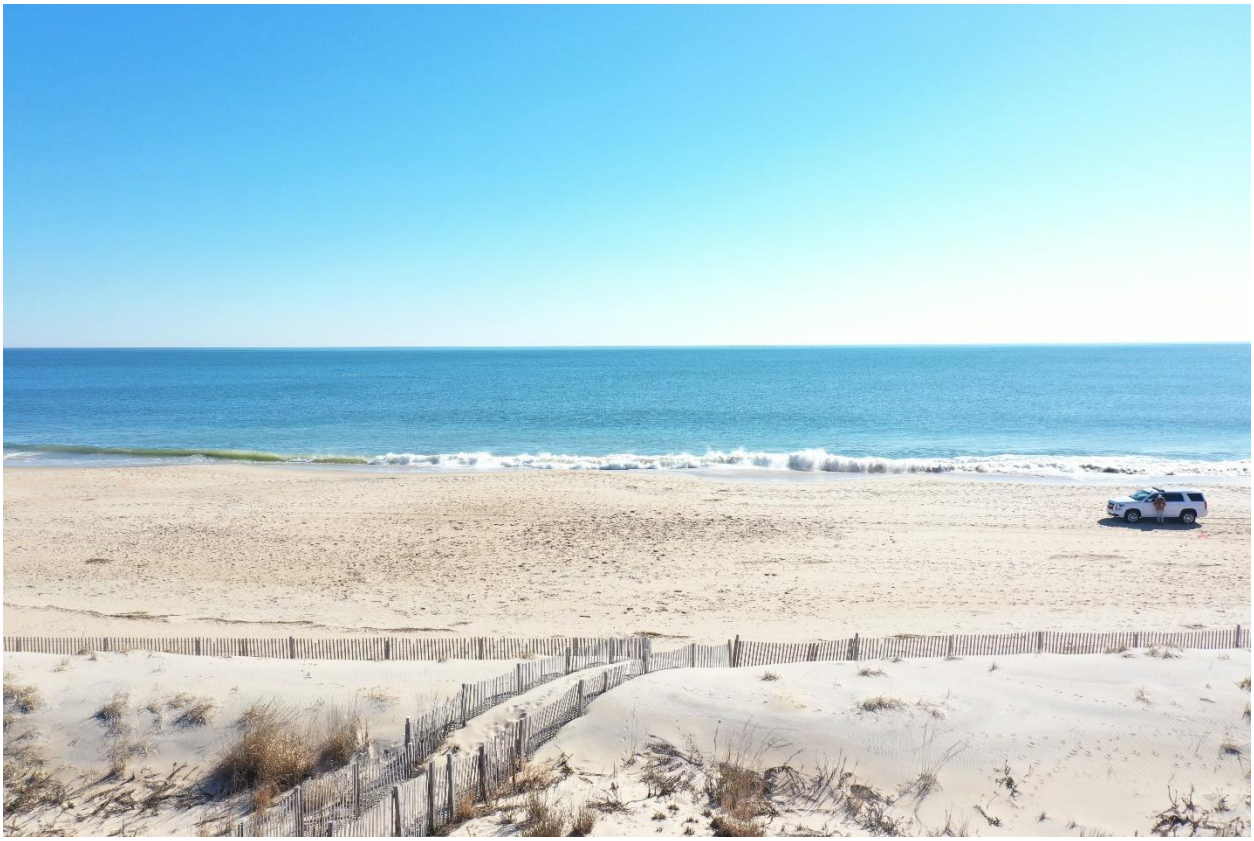
LRP 56: (10:28)

Bethany Beach

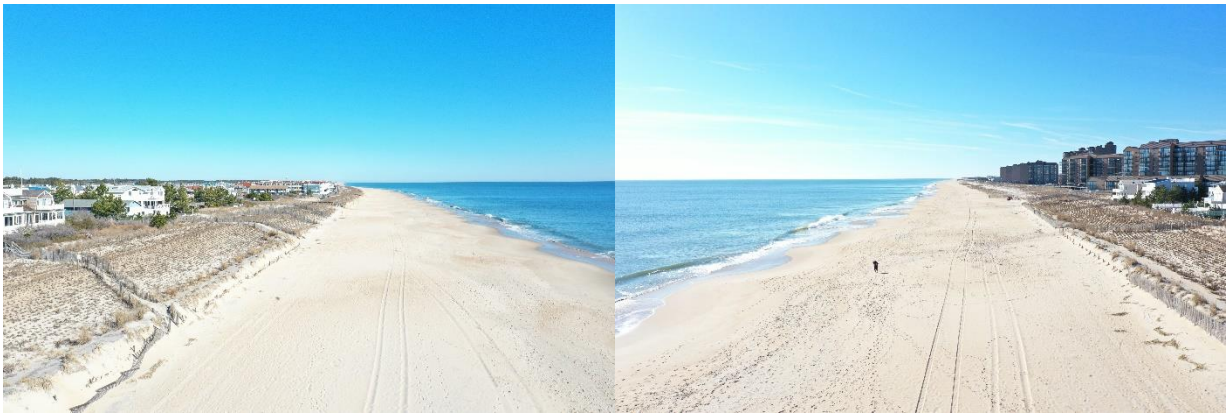
LRP 58: (10:17)

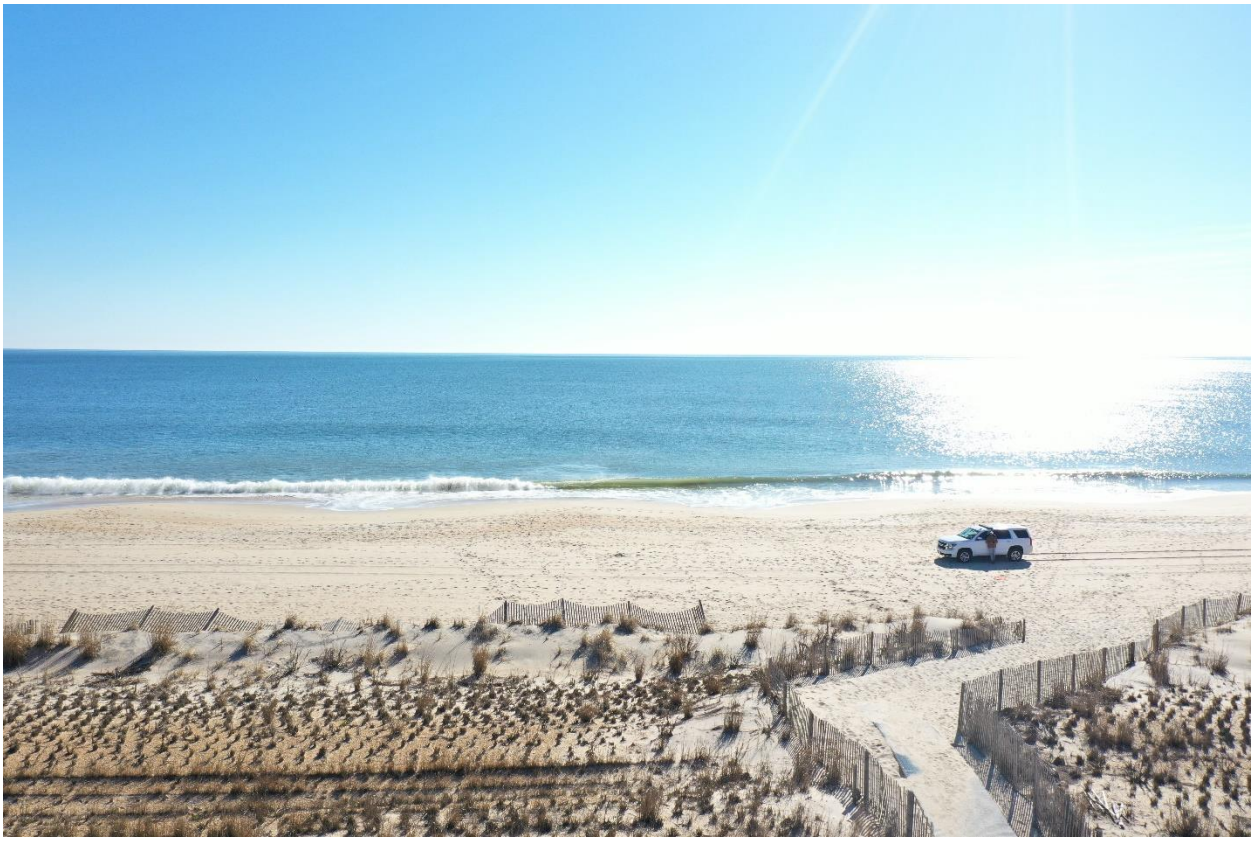


LRP 60: (10:08)



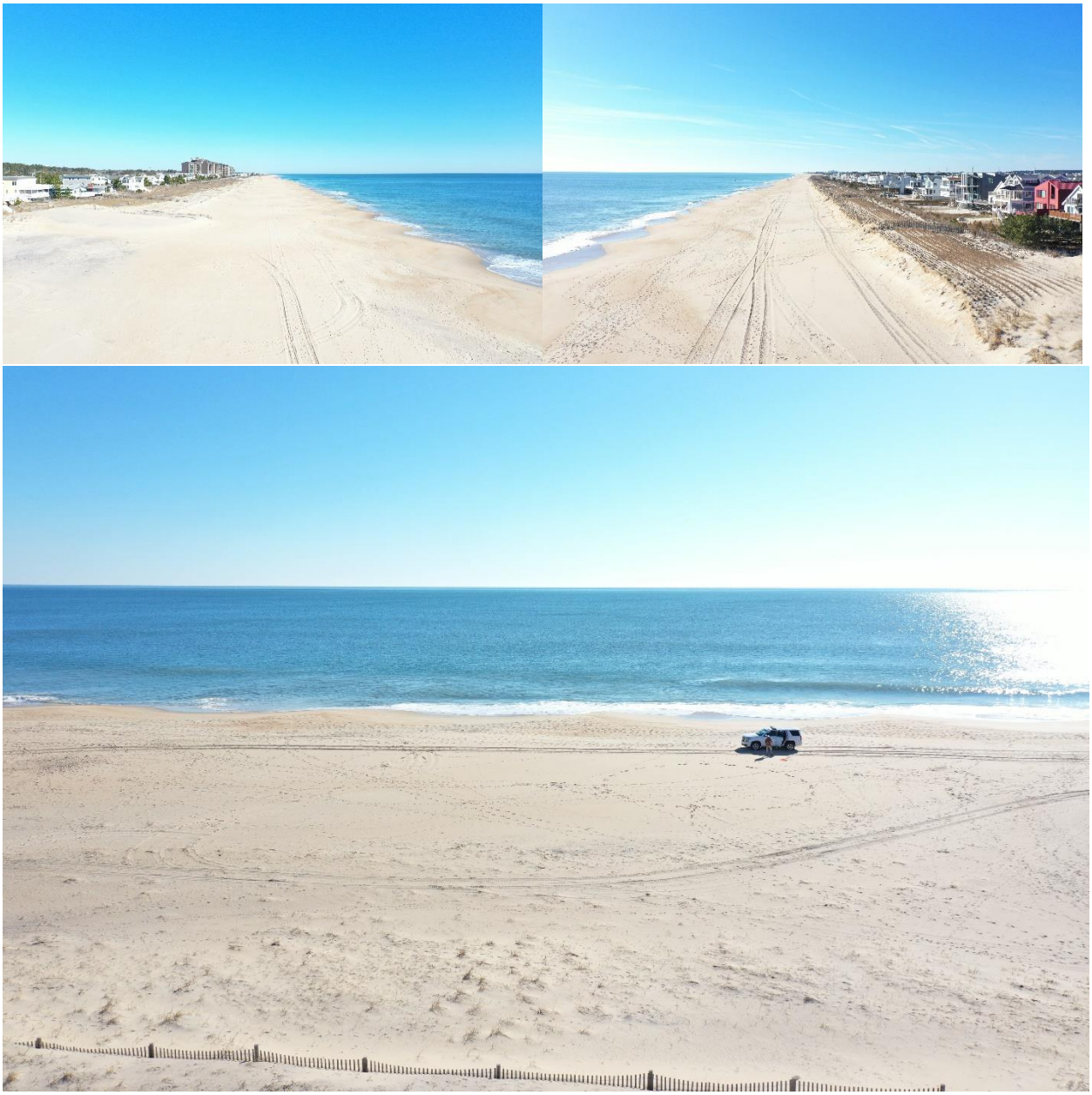
LRP 61: (9:58)





South Bethany

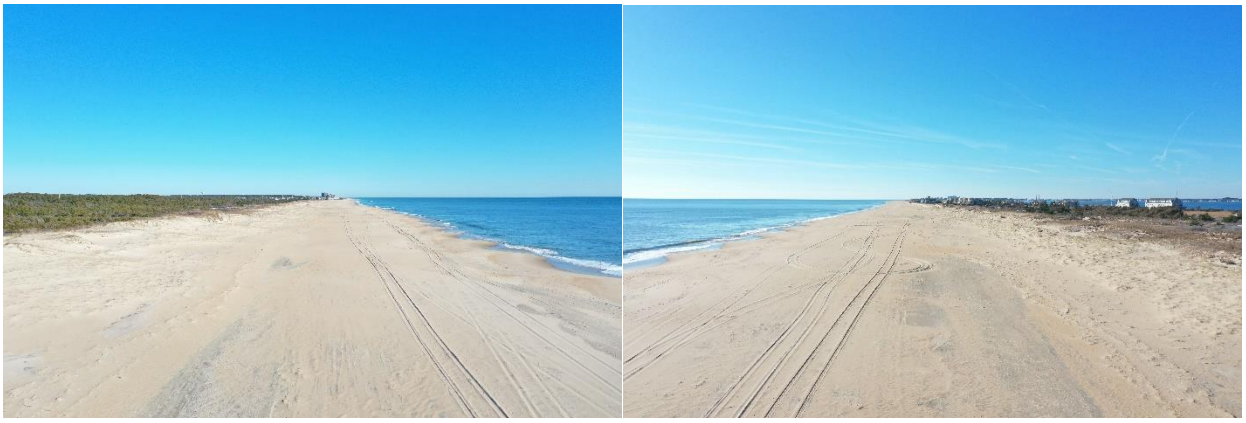
LRP 62: (09:51)



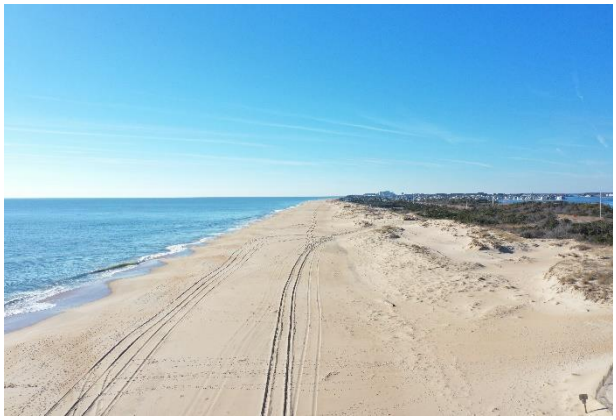
Fenwick Island

LRP 63: (09:38)

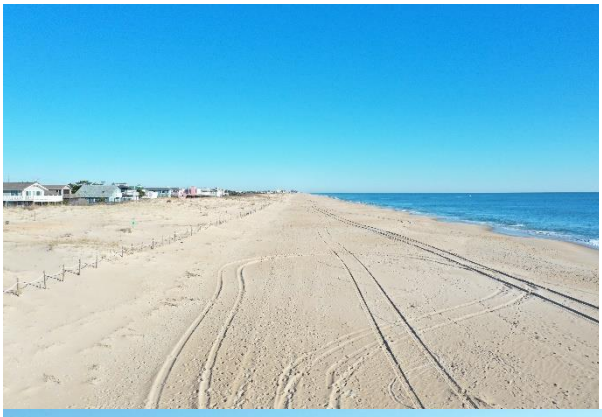
LRP 64: (09:32)



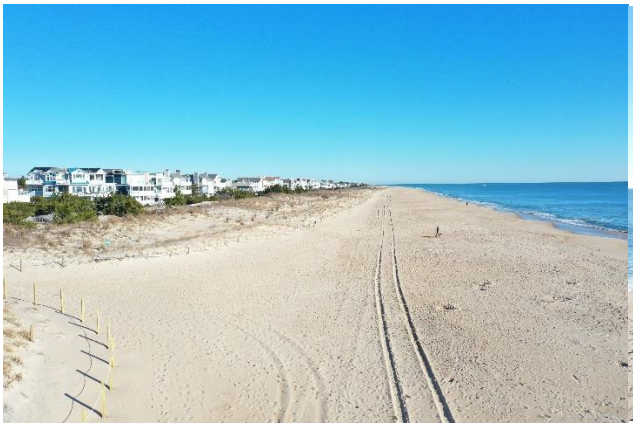
LRP65: (09:25)



LRP66: (09:18)

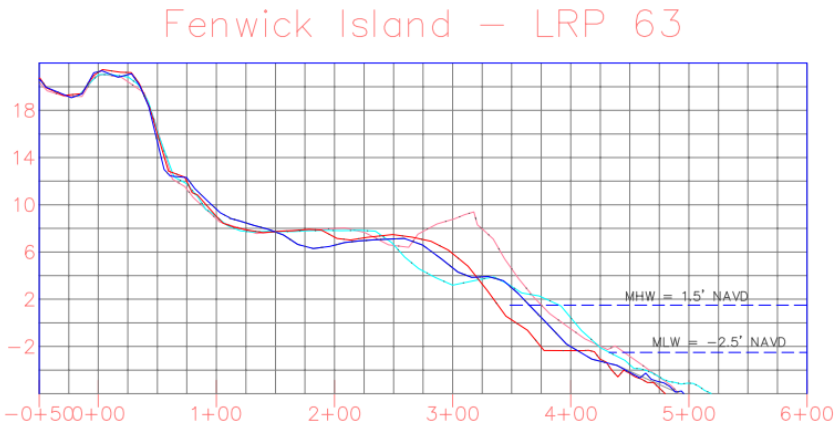


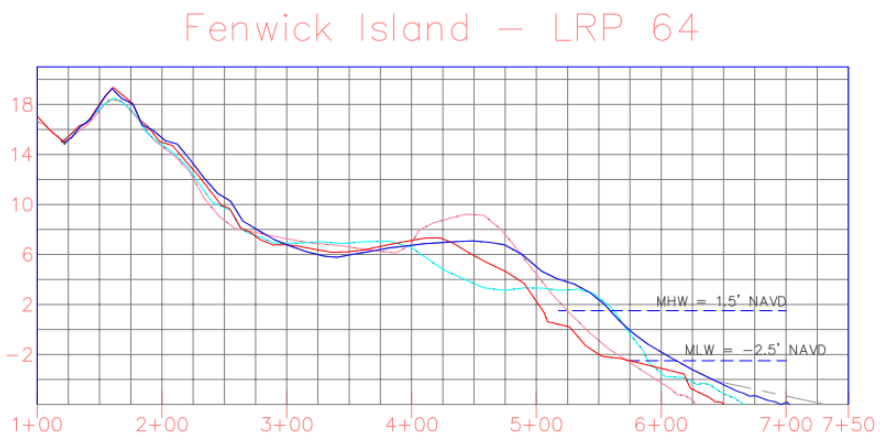
LRP67: (09:11)

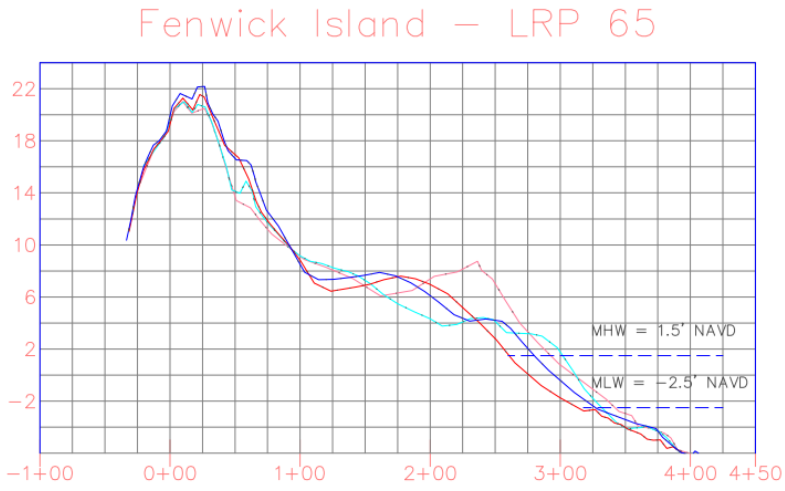


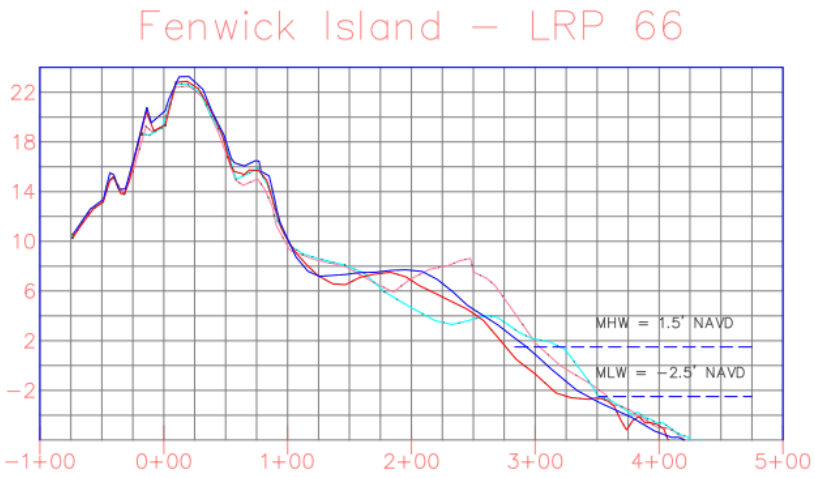
Appendix B:

Fenwick Island:








Fenwick Island – LRP 66
22
18
14
10
6
2
−2
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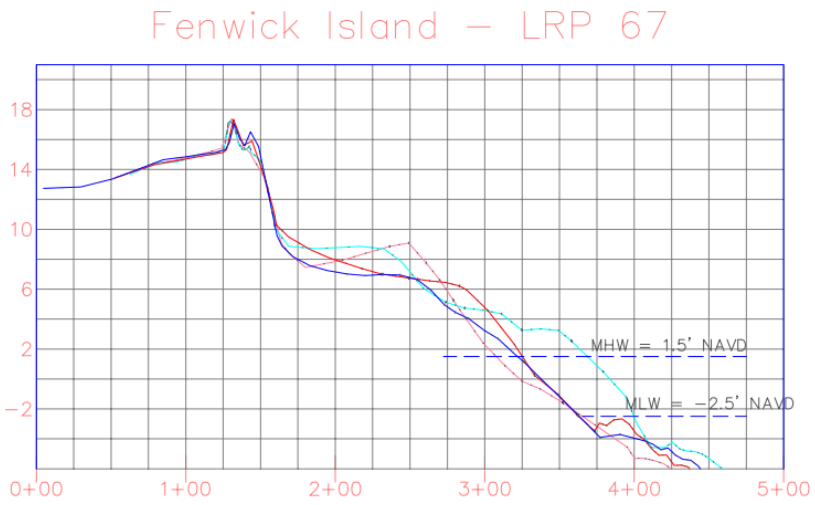
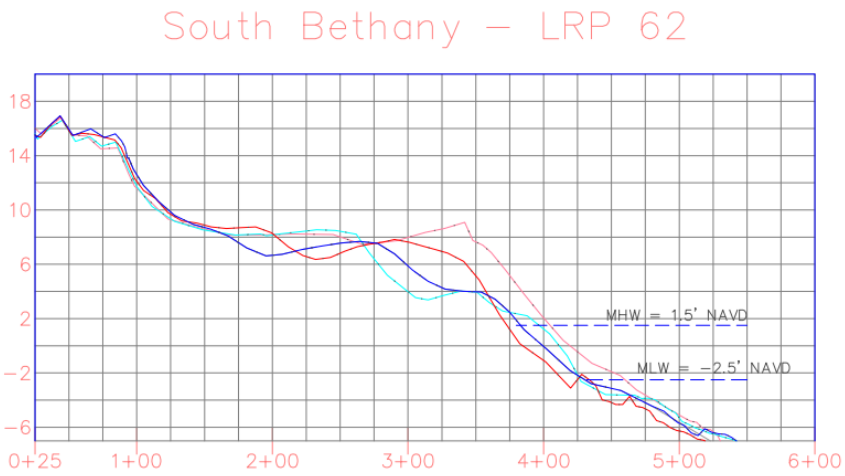
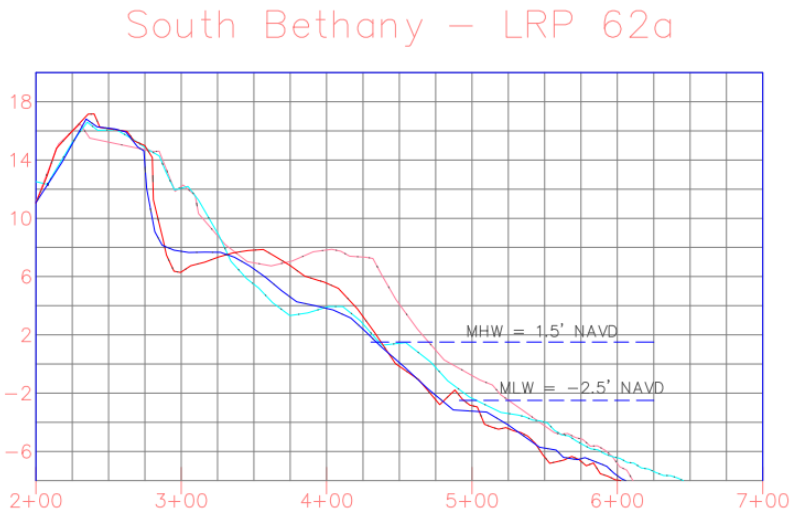
MLW = −2.5' NAVD
−1+00
0+00
1+00
2+00
3+00
4+00
5+00

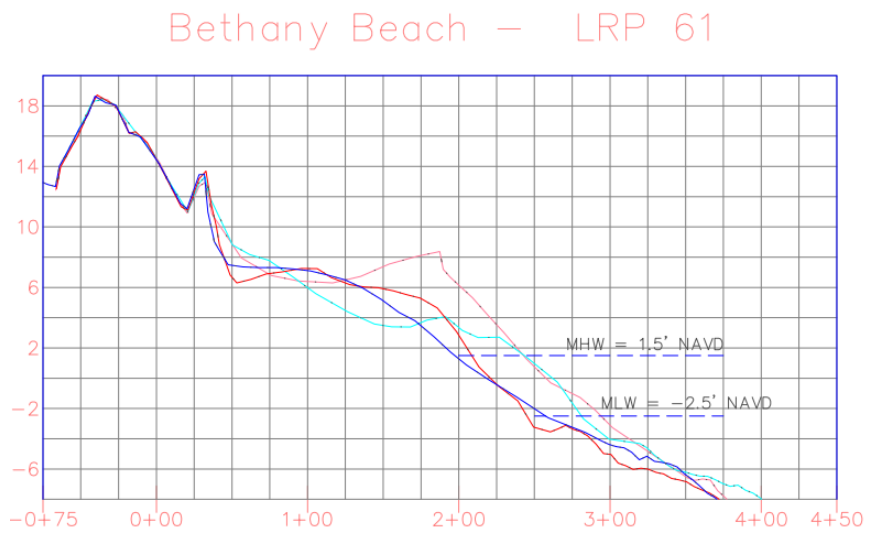

Fenwick Island – LRP 67
18
14
10
6
2
−2
MHW = 1.5' NAVD
MLW = −2.5' NAVD
0+00
1+00
2+00
3+00
4+00
5+00

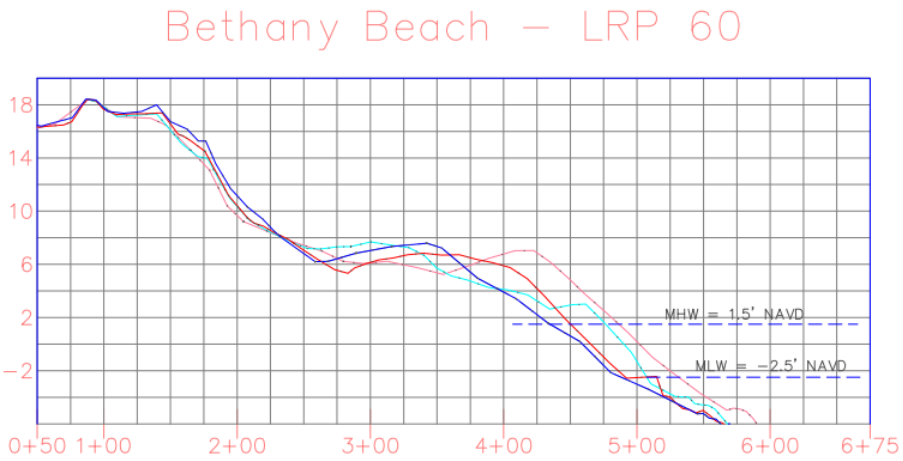
South Bethany Beach:

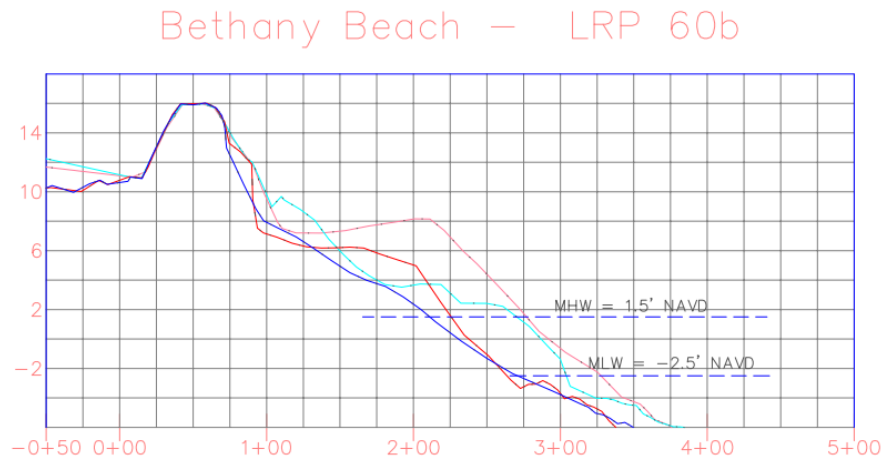




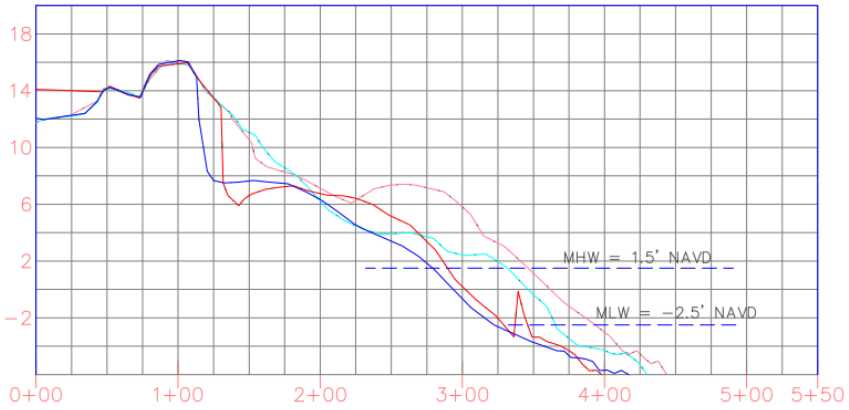
Bethany Beach:



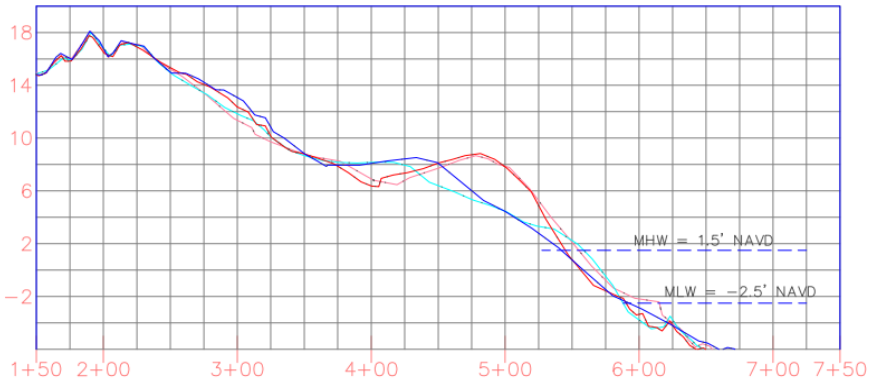




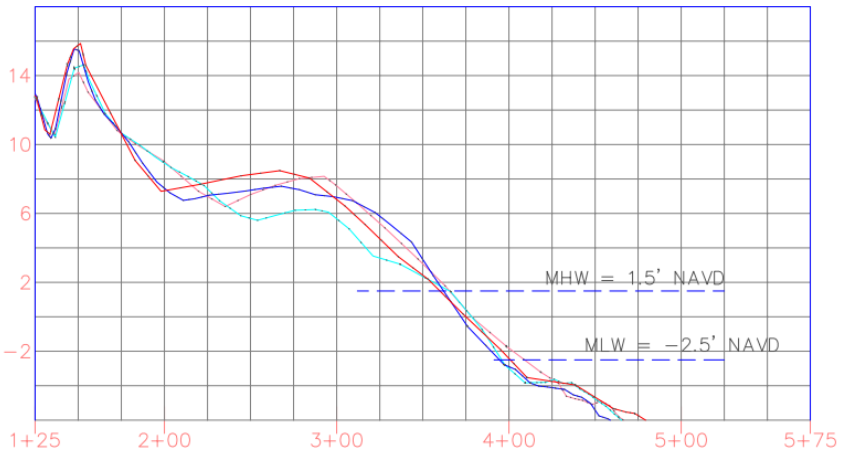
Bethany Beach – LRP 60a



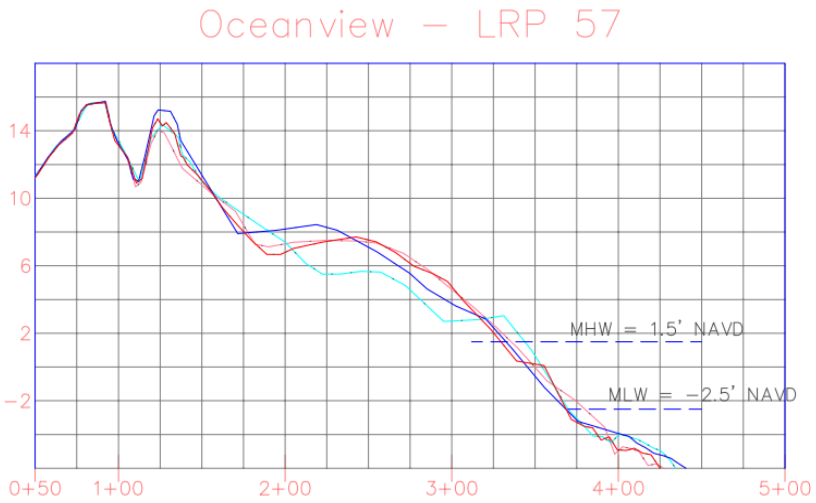
Bethany Beach – LRP 59



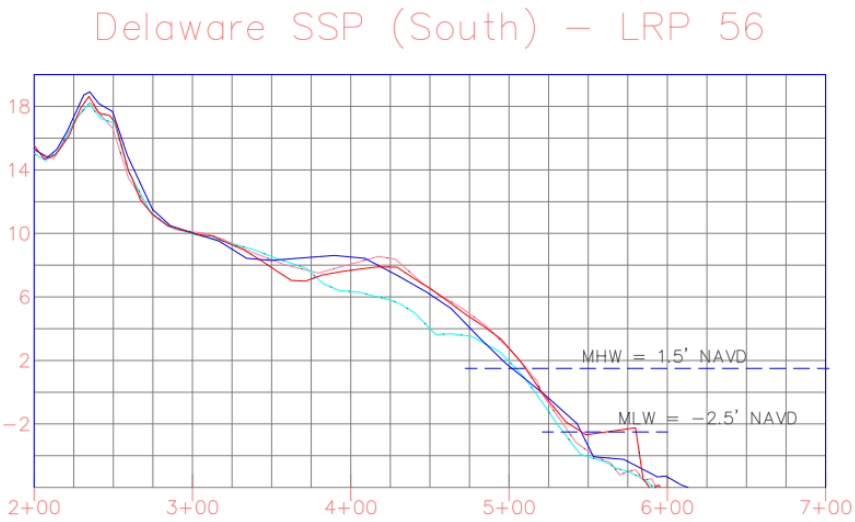
Bethany Beach – LRP 58

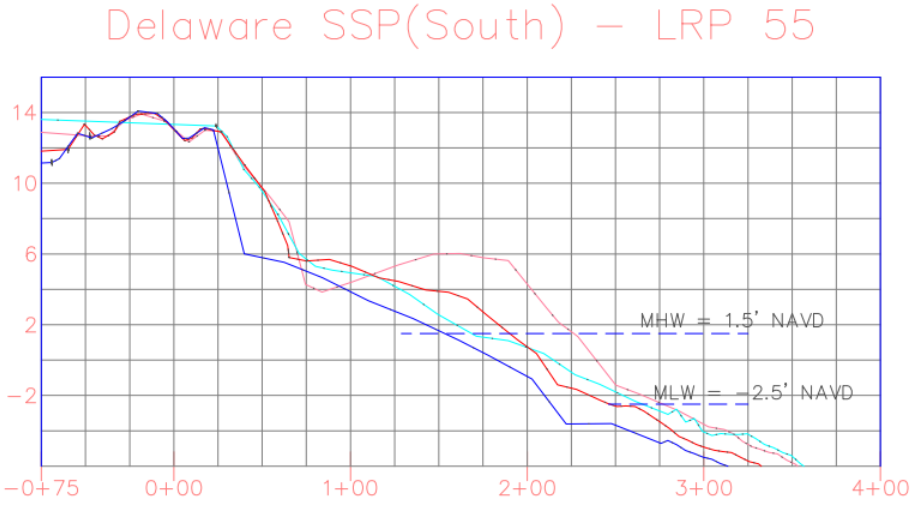


Oceanview

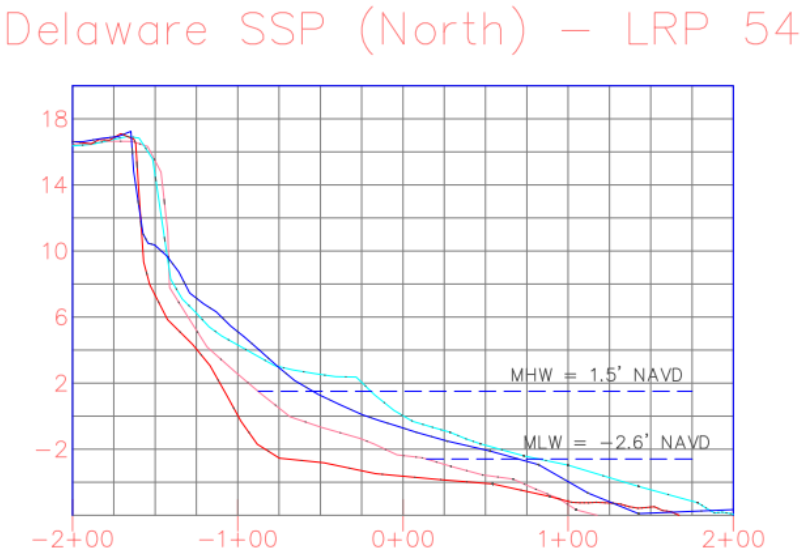

Oceanview – LRP 57
14
10
6
2
−2
MHW = 1.5' NAVD
MLW = −2.5' NAVD
0+50
1+00
2+00
3+00
4+00
5+00

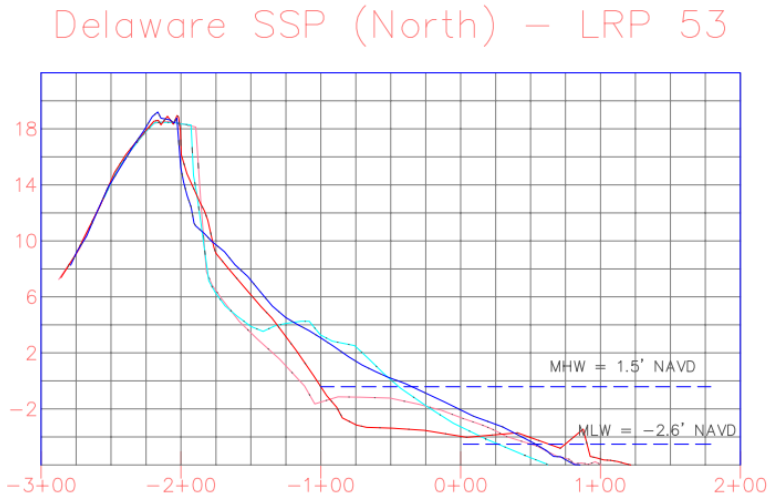
DSSP South:


Delaware SSP (South) – LRP 56
18
14
10
6
2
−2
MHW = 1.5' NAVD
MLW = −2.5' NAVD
2+00
3+00
4+00
5+00
6+00
7+00

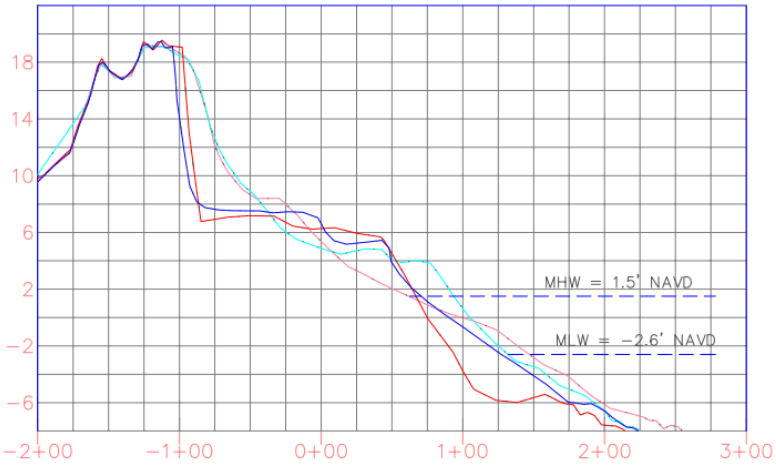

Delaware SSP(South) – LRP 55
14
10
6
2
−2
MHW = 1.5' NAVD
MLW = −2.5' NAVD
−0+75
0+00
1+00
2+00
3+00
4+00

DSSP North:

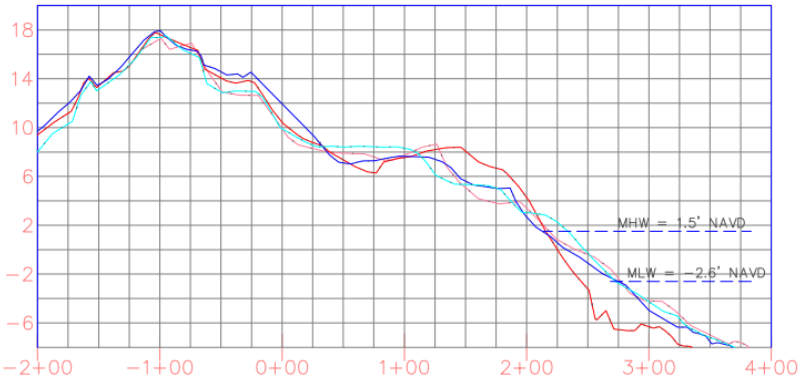

Delaware SSP (North) – LRP 54
18
14
10
6
2
−2
MHW = 1.5' NAVD
MLW = −2.6' NAVD
−2+00
−1+00
0+00
1+00
2+00


Delaware SSP (North) – LRP 53
18
14
10
6
2
−2
MHW = 1.5' NAVD
MLW = −2.6' NAVD
−3+00
−2+00
−1+00
0+00
1+00
2+00

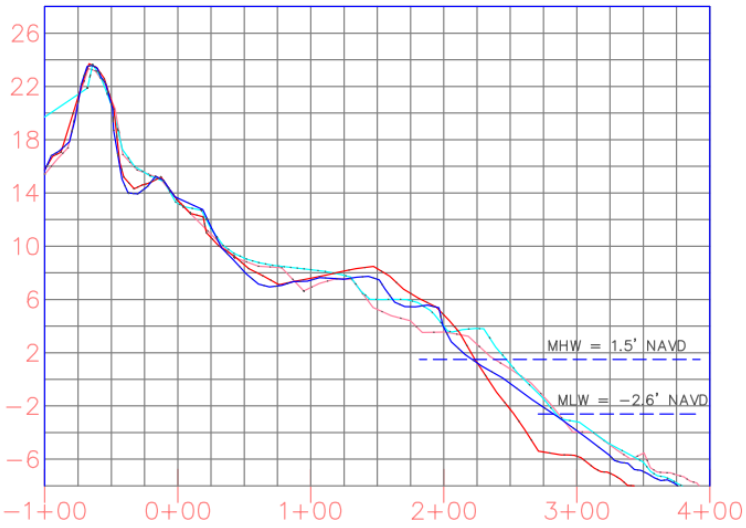
Delaware SSP (North) – LRP 52



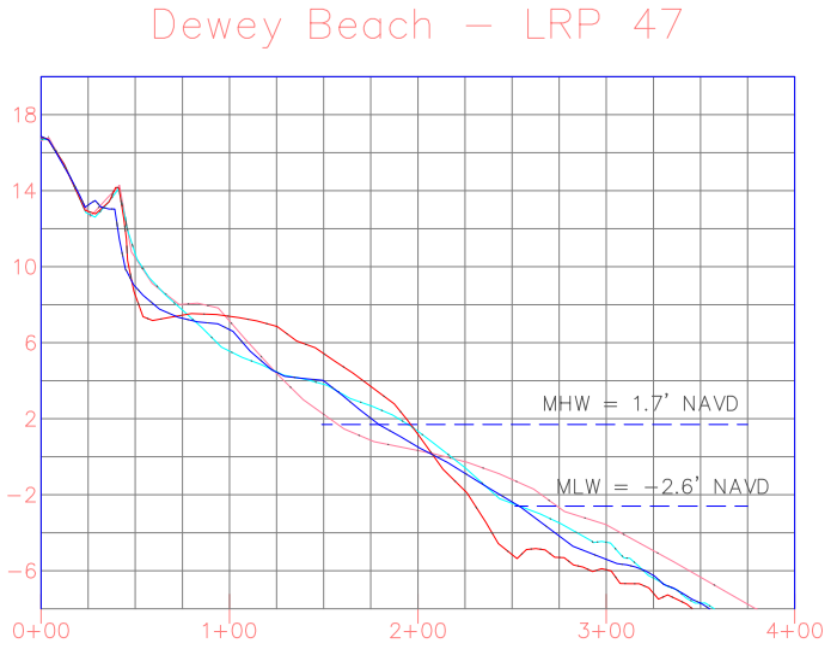
Delaware SSP (North) – LRP 51



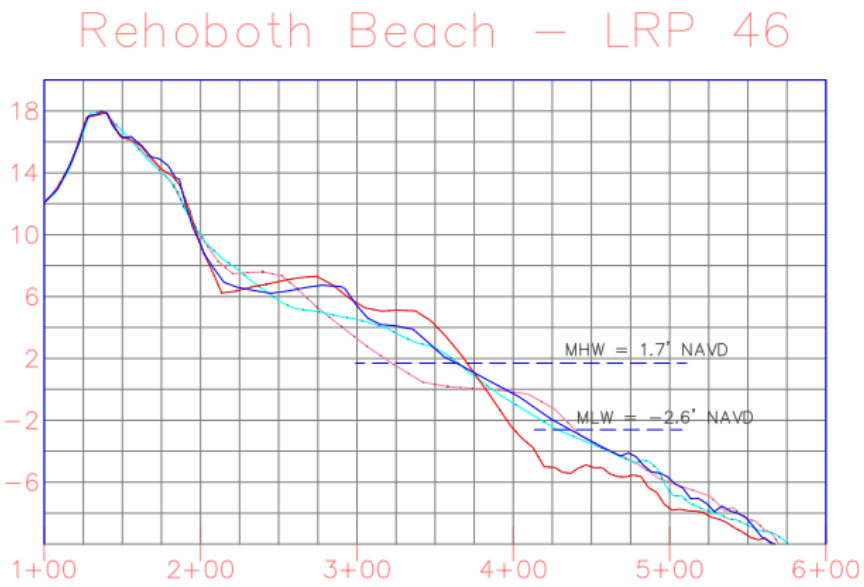
Delaware SSP (North) – LRP 50

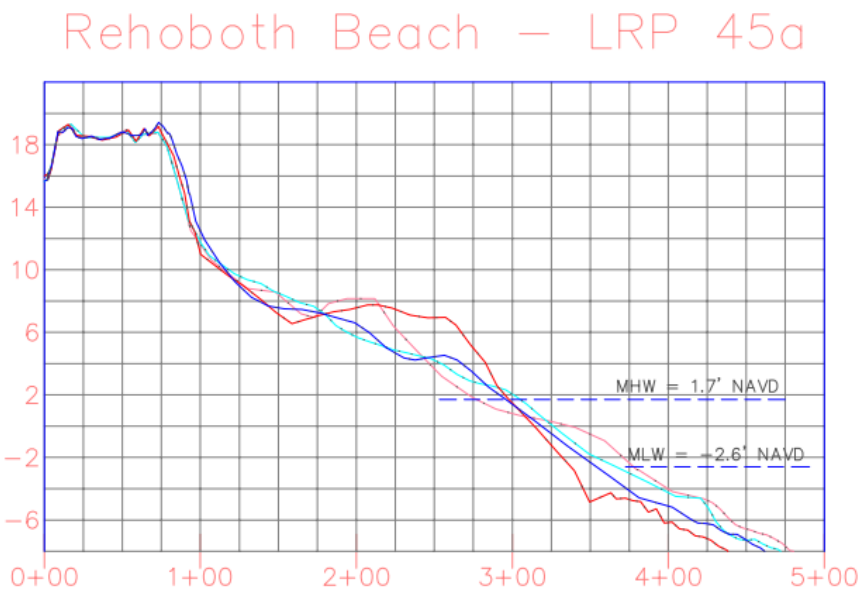


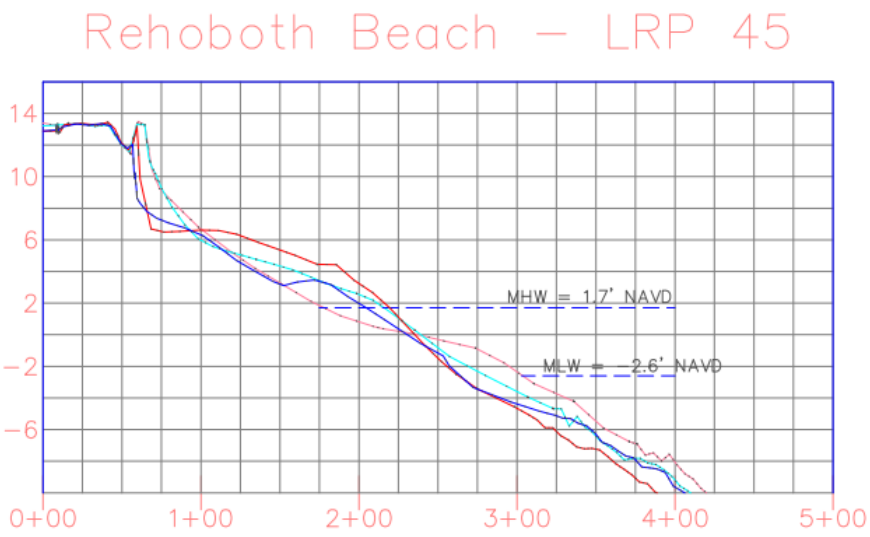
Dewey:

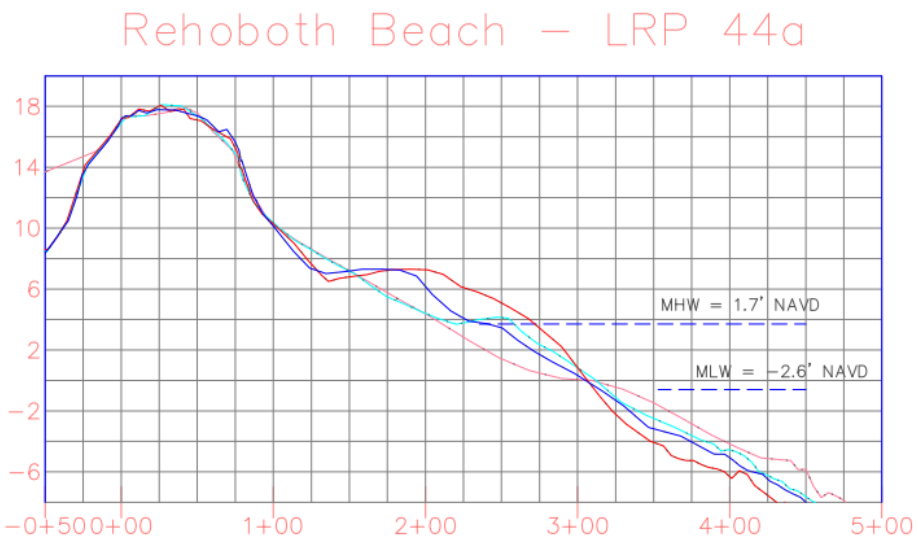


Rehoboth:

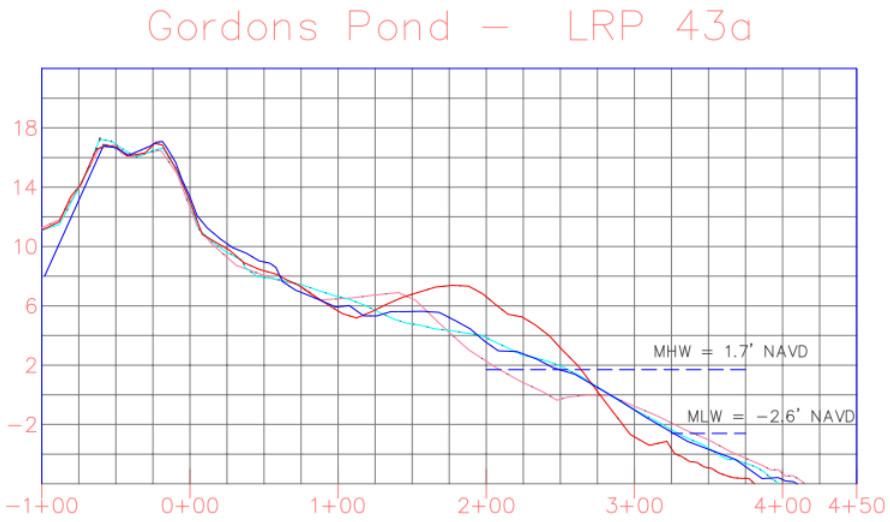


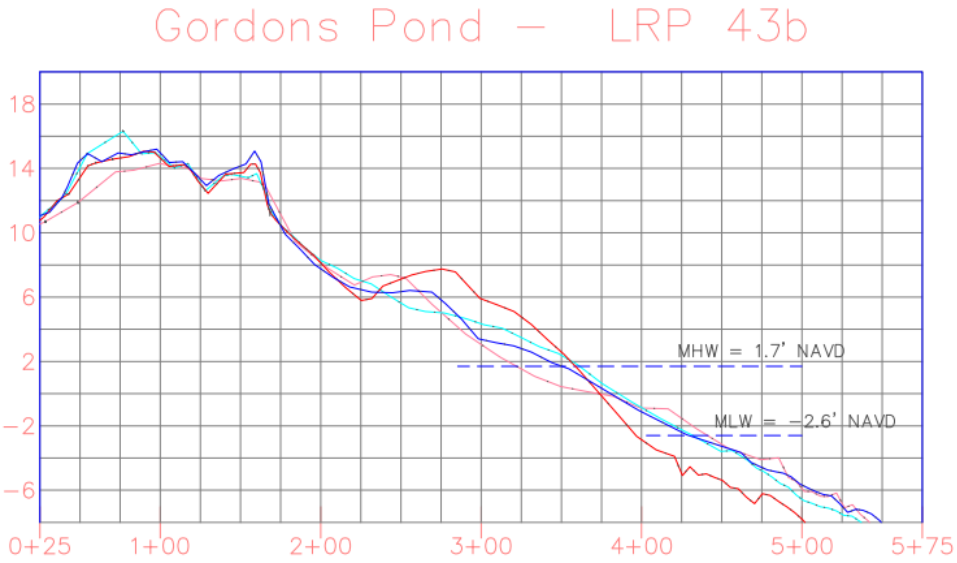

Rehoboth Beach – LRP 45a
18
14
10
6
2
−2
−6
MHW = 1.7' NAVD
MLW = −2.6' NAVD
0+00
1+00
2+00
3+00
4+00
5+00

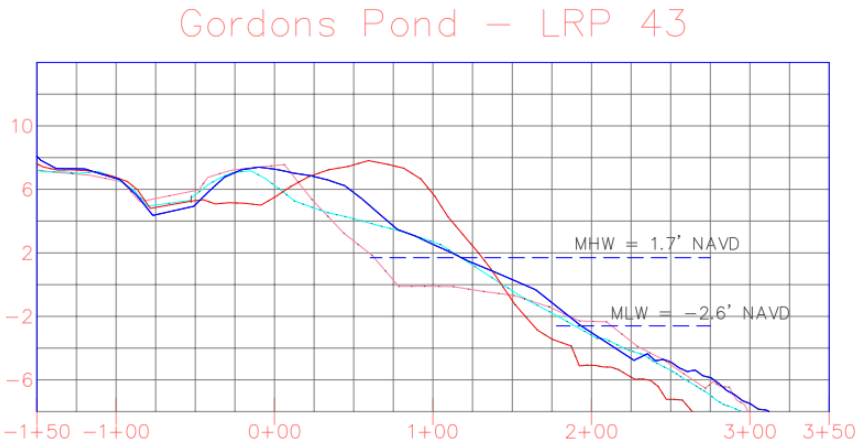

Rehoboth Beach – LRP 45
14
10
6
2
−2
−6
MHW = 1.7' NAVD
MLW = −2.6' NAVD
0+00
1+00
2+00
3+00
4+00
5+00


Rehoboth Beach – LRP 44a
18
14
10
6
2
−2
−6
MHW = 1.7' NAVD
MLW = −2.6' NAVD
−0+50
0+00
1+00
2+00
3+00
4+00
5+00

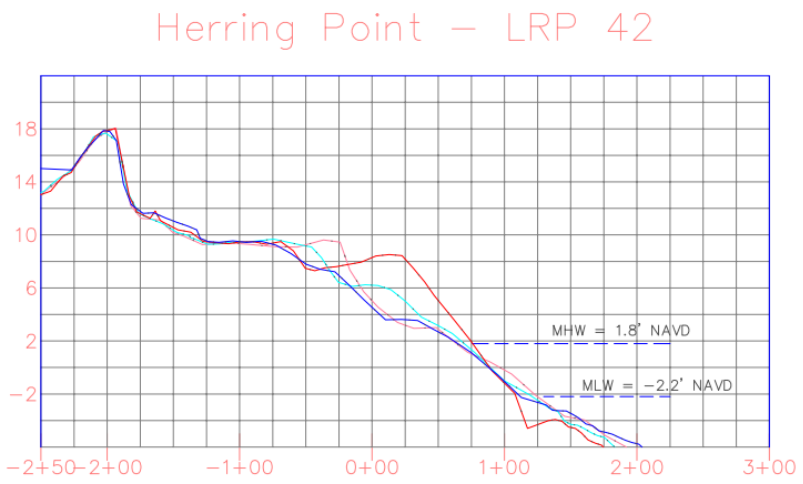
Gordons Pond:

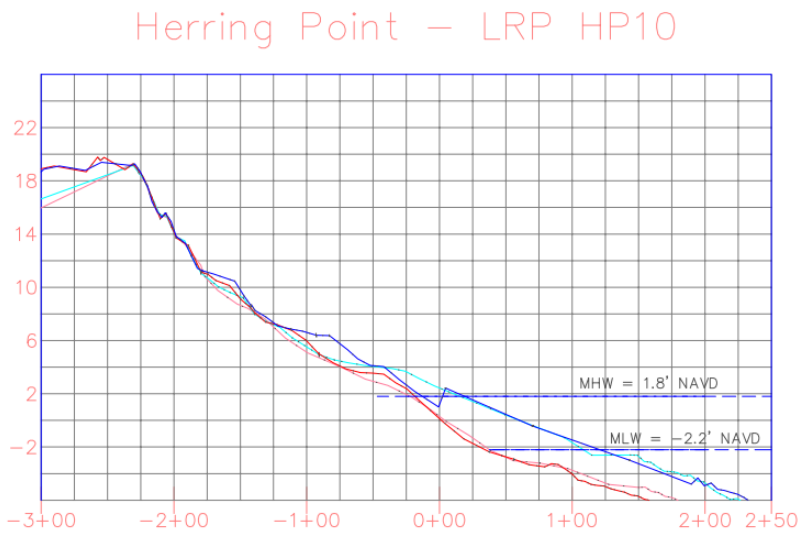


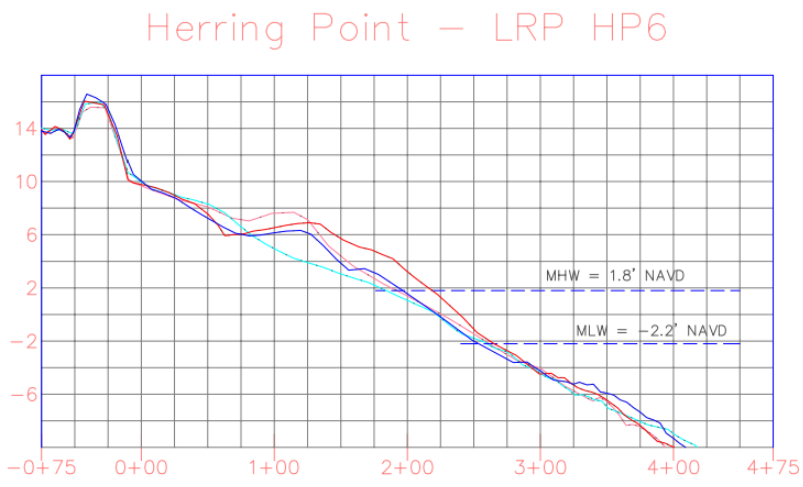


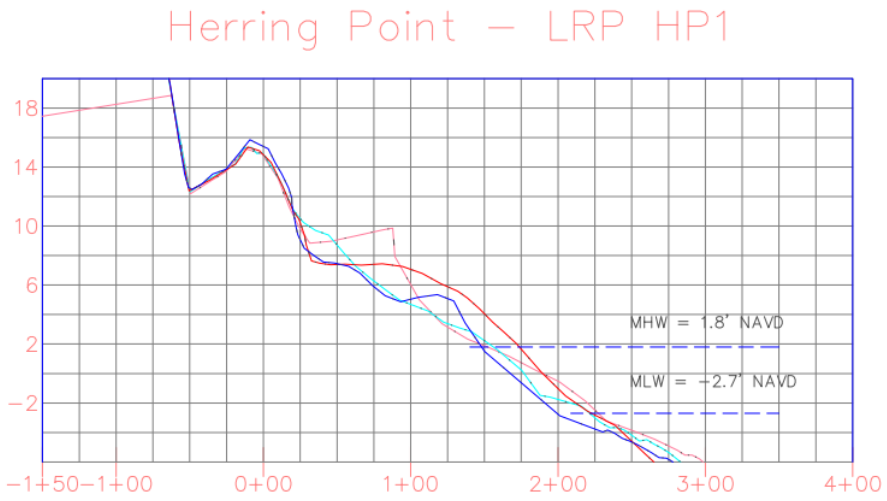


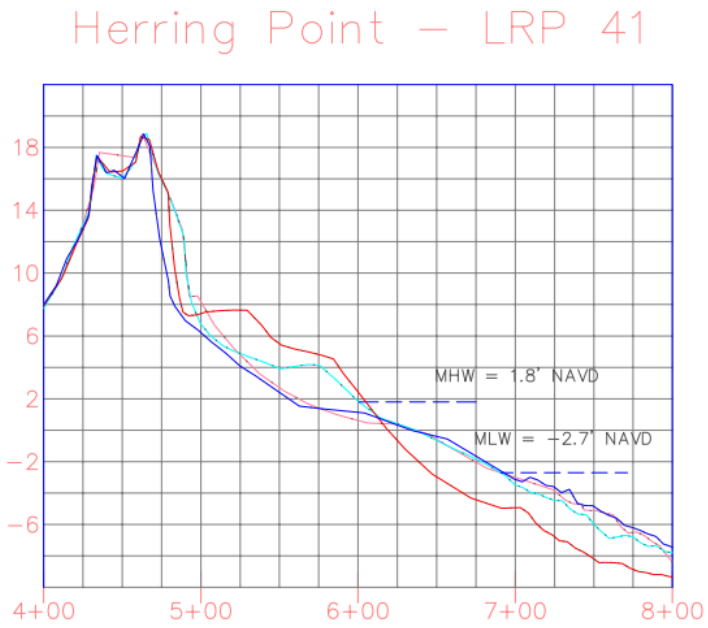
Herring Point:








Herring Point – LRP HP1
18
14
10
6
2
−2
MHW = 1.8' NAVD
MLW = −2.7' NAVD
−1+50
−1+00
0+00
1+00
2+00
3+00
4+00


Herring Point – LRP 41
18
14
10
6
2
−2
−6
MHW = 1.8' NAVD
MLW = −2.7' NAVD
4+00
5+00
6+00
7+00
8+00

Cape Henlopen: