2018 Isle of Palms Restoration Project
Year 6 Monitoring Report

2024
MONITORING REPORT

Prepared for

City of Isle of Palms
Isle of Palms, South Carolina

COASTAL SCIENCE & ENGINEERING

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2018 Isle of Palms Restoration Project

Year 6 (2024) Monitoring Report

Annual Beach and Inshore Surveys

Prepared for:

City of Isle of Palms

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1.0 INTRODUCTION

This monitoring report is submitted to the City of Isle of Palms, SC (IOP) by Coastal Science & Engineering (CSE) as part of an ongoing beach monitoring effort that began in 2007 during planning for the 2008 Isle of Palms Beach Restoration Project (P/N 2007–02631–2IG) (CSE 2008). This report follows earlier monitoring reports submitted annually to the City, as well as additional reports and engineering documents related to shoal management and beach nourishment activities (P/N 2010–1041–2IG; 2016–00803 (CSE 2019). The report details the beach condition as surveyed in September 2024 and compares this condition with selected earlier dates, including the pre-2018 project condition. This is the sixth annual monitoring report following the 2018 nourishment project. Certain portions of this report detail monitoring efforts required by state and federal permit conditions for the 2018 project.

Analyses in this report include detailed beach volume change along the ~7-mile beach, which spans from Breach Inlet to Dewees Inlet. It also includes comparisons of earlier beach conditions with the present condition, calculation of annual erosion rates, and measurements of linear shoreline change. Large-scale morphologic changes occurring in Breach Inlet and Dewees Inlet are also discussed, along with the anticipated impacts of these shifting shoals on the future beach condition. Ground and aerial photographs are included to provide a visual representation of the beach condition. These images document areas with dune escarpments, show dry-beach width, and delineate areas with existing or potential damage due to erosion.

This report also discusses general information about storm events occurring in 2024 and their impact on the beach, as well as updated sea level rise information for the Isle of Palms. Observations of escarpments, vegetation, sand fences, and other beach management considerations are discussed.

2018 Nourishment Project Summary

Sponsor: The beach restoration project was funded by the City of Isle of Palms, the State of South Carolina, Wild Dunes Community Association (including individual property owners and regimes), and Wild Dunes Resort. The City of Isle of Palms served as project owner and administrator.

Engineer: Coastal Science & Engineering (CSE, Columbia, SC)

Contractor: Great Lakes Dredge & Dock Co. (Oak Brook, IL)

Permit: SC048C–OCRM USACE P/N 2016–00803

Scope: Placement of 1,676,518 cubic yards (cy) of sand in the following areas.

Reach 1 (4,400 lf)	Sta 236+00–280+00	942,320 cy	214 cy/ft
Reach 2 (4,400 lf)	Sta 280+00–324+00	734,198 cy	167 cy/ft

Const. Cost: $13,545,585.70

Nourishment Schedule

- 13 December 2017 –Mobilization of equipment and pipe
- 16 January 2018 –First pumping near Beach Club Villas
- 24 February 2018 –Completion of Reach 1
- 23 March 2018 –Completion of Reach 2
- 1 April 2018 –All equipment removed from beach and offshore zone – Project Complete

Monitoring Events

- May 2017 –Pre-Project Annual Survey
- April 2018 –Post-Project Survey
- June 2019 –Year 1 Survey
- June 2020 –Year 2 Survey
- July 2021 –Year 3 Survey
- August 2022 –Year 4 Survey
- August 2023 –Year 5 Survey
- September 2024 –Year 6 Survey

2.0 SETTING

2.1 Project Setting

The Isle of Palms is a ~7-mile-long barrier island located north of Charleston Harbor. It has a southeast-facing shoreline bounded by Breach Inlet and Sullivan's Island to the south, with Dewees Inlet and Dewees Island to the north (Figure 2.1). The northern end of the island is wider due to periodic sand additions through shoal bypass events (Kana 2002, Traynum and Kaczkowski 2015). These events result in a net accumulation of sand over several decades, which builds the updrift end of the island. The downcoast end of the island is narrower and terminates in a recurved spit at Breach Inlet. These characteristic morphologies are typical of 'drumstick' barrier islands (Hayes 1979) and occur along mixed energy coasts where both tides and waves influence shoreline evolution (Figure 2.1).

The eastern end of the island is typically more dynamic due to the influence of shoals associated with the Dewees Inlet ebb-tidal delta. Figure 2.2 shows aerial images of the east end of the island from 1944 to 1963. The photos document a large-scale shoal bypass event that impacted the shoreline encompassing the area now known as Wild Dunes. The shoal stretched for approximately two miles along the eastern end of the island. It was so large that a new ephemeral barrier beach was established over 1,000 feet (ft) seaward of the previous shoreline. This new beach ridge trapped a tidal lagoon that was flushed by a small channel and the shoal attached to the beach sometime between 1944 and 1949. By 1957, the shoal had merged with the beach, buried the lagoon, and completely attached to the main portion of the island by 1963.

The emergence of this large shoal may be a result of the merging of several shoals in the delta partially visible in the 1944 image, including two visible shoals at the northeastern tip of the island. These shoals were likely, at one point, a trailing ebb spit (see Kana 2002), and the sand from this spit merged with a shoal further west to create the large sand body that formed the lagoon. The shoal ultimately added well over 1,000,000 cubic yards (cy) of sand to the beach.

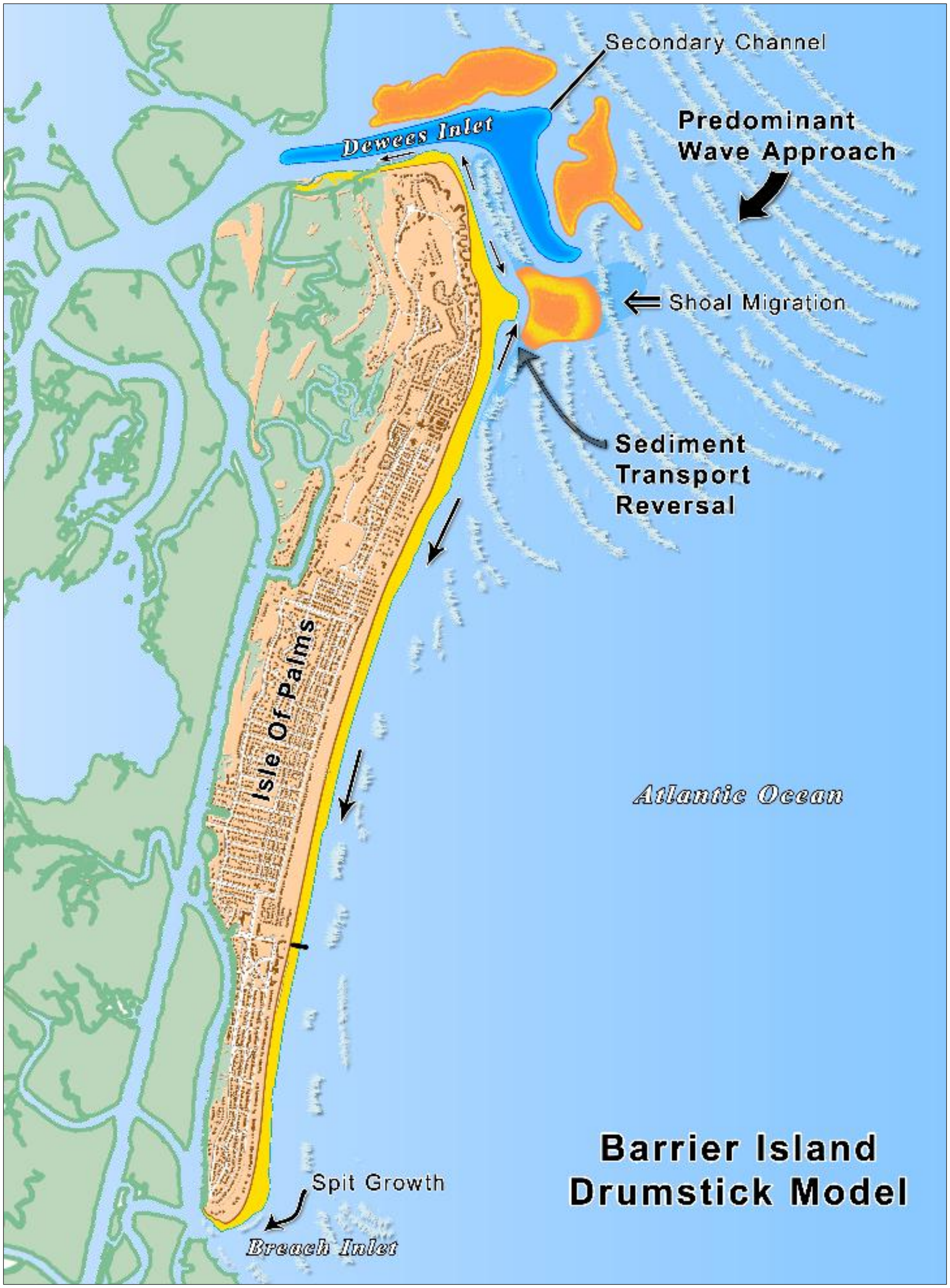

FIGURE 2.1. Schematic of the Isle of Palms showing the wider northeast end characteristic of a 'drumstick' barrier island.

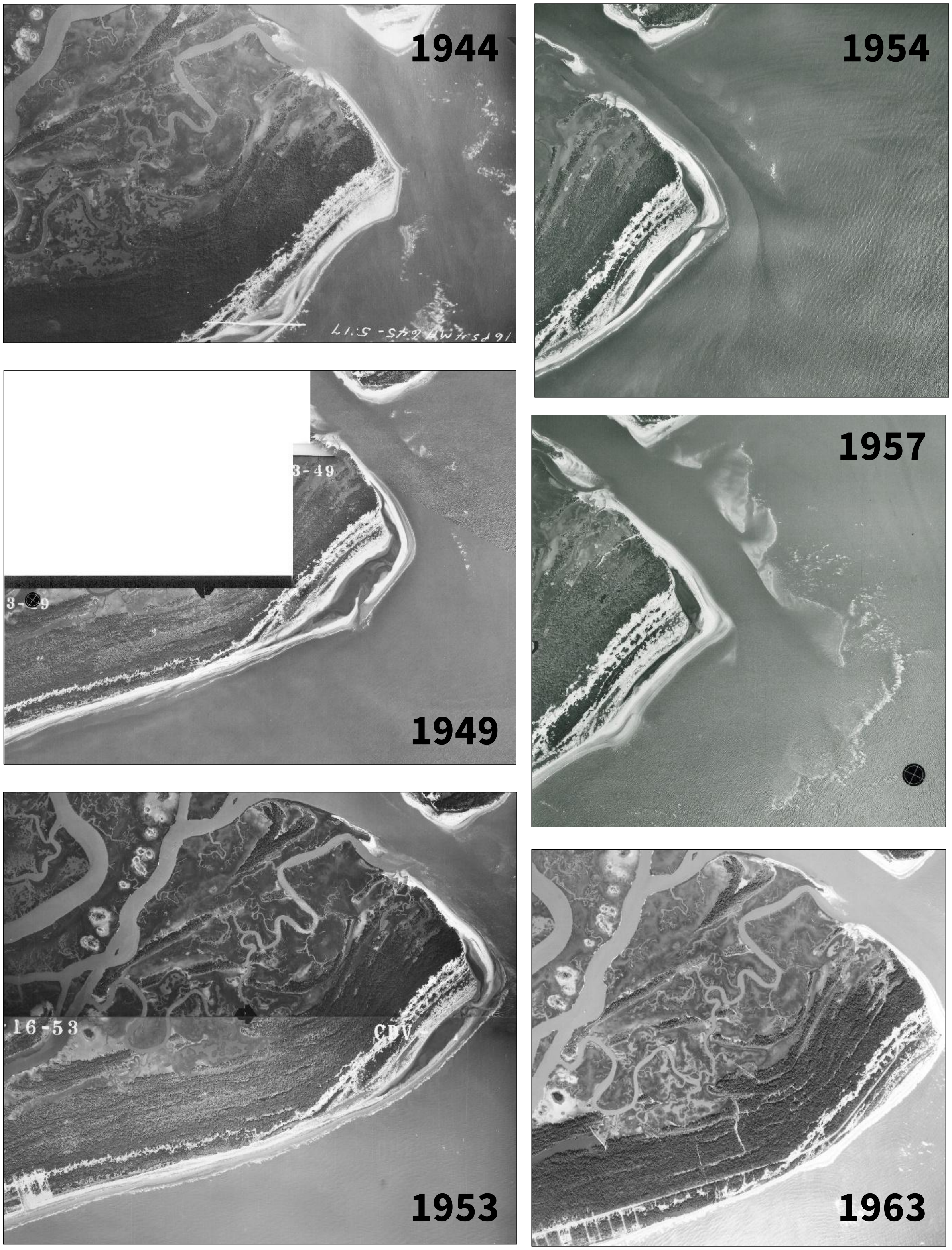

FIGURE 2.2. Historical aerials from CSE 2010 report page 56 (Figure 3.35).

Photo sequence begins (left column from top) in 1944, 1949, and 1953, then continues (right column from top) through 1954, 1957, and 1963. [Note that images are not at the same scale.]

This shoal attachment effectively built the shoreline at the northeast end of the island seaward ~500 ft between 1944 and 1963; however, much of this accreted sand eventually spread to downcoast areas. In short, the eastern end of the island (east of the present-day Beach Club Villas) was developed on sand that recently accreted to the beach and not on the stable upland area that had existed for decades like most of the remainder of the island. Much of the development built in the late 1970s and early 1980s occurred in areas that were likely wet-sand beach in the 1930s–1940s.

Following the large-scale event mentioned previously, the eastern end of the island continued to experience shoal-bypass events, though all were substantially smaller in magnitude than the 1940s–1960s event. These events generally attached along the central Wild Dunes area and are more characteristic of shoal-bypass events characterized by Kana (2002), with distinct stages of 1) emergence, 2) migration and attachment, and 3) spreading (Fig 2.3). These events have been responsible for focused erosion along various portions of the Wild Dunes area, including two events in the 1980s, another in the late 1990s, and a large event in the mid-2000s that led to the 2008 beach nourishment project.

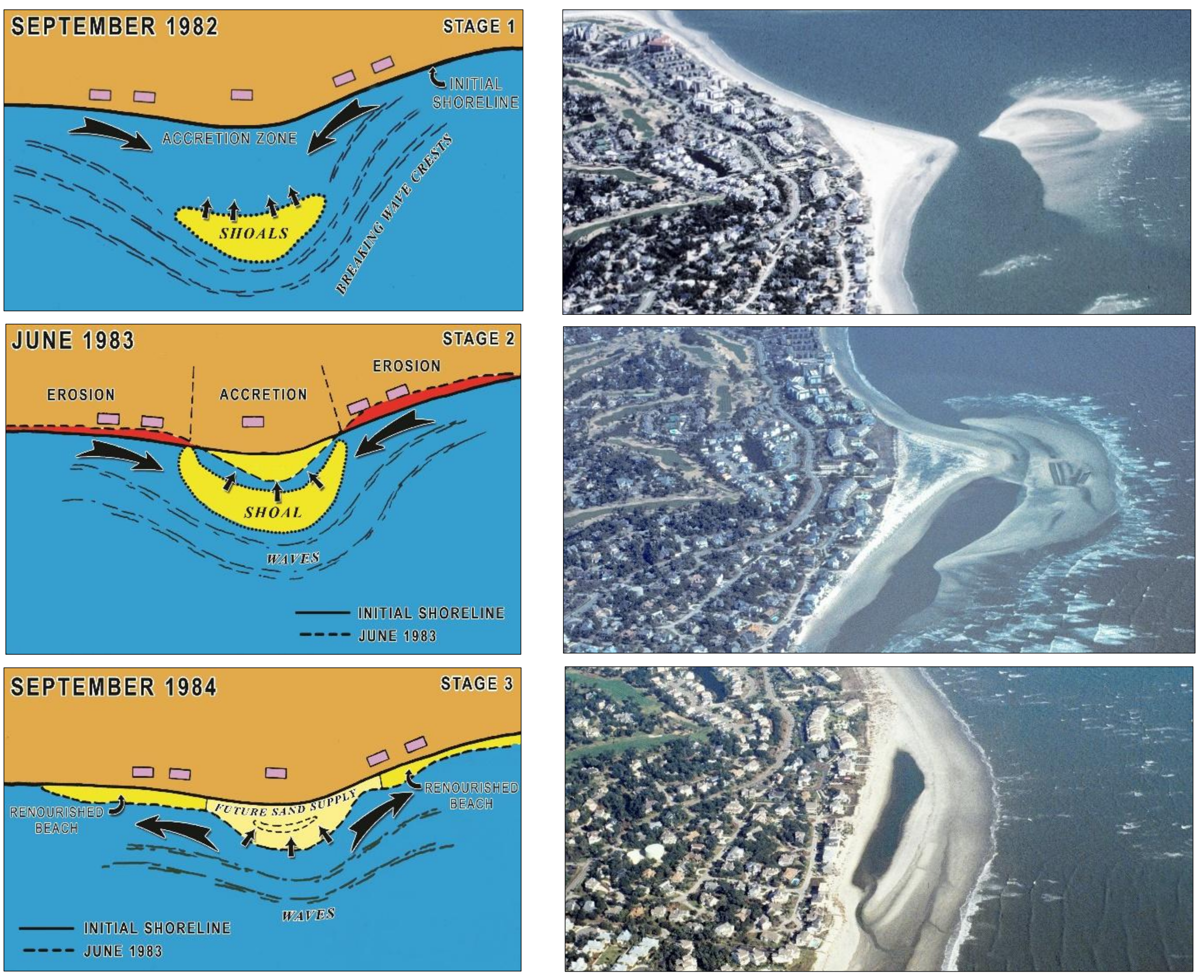

FIGURE 2.3. **[LEFT]** Schematic of the shoal-bypass cycle originally modeled from a bypass event at Isle of Palms. **[RIGHT]** A shoal-bypass event at northeastern Isle of Palms corresponding to the schematic. The upper photo shows a shoal in Stage 1 (1996). The middle image illustrates Stage 2 (1997). The bottom photo shows Stage 3 (1998).

The addition of sand from shoal bypassing at the east end of the island has contributed to relatively steady accretion along the central and western ends, resulting in a wide setback for most properties west of 58th Avenue. In the 1970s, properties along 46th Ave to 53rd Ave installed a seawall and several groins by 1984, as shown in Figure 2.4. Since 1984, the beach has accreted rapidly, and all groins and seawalls have been buried.

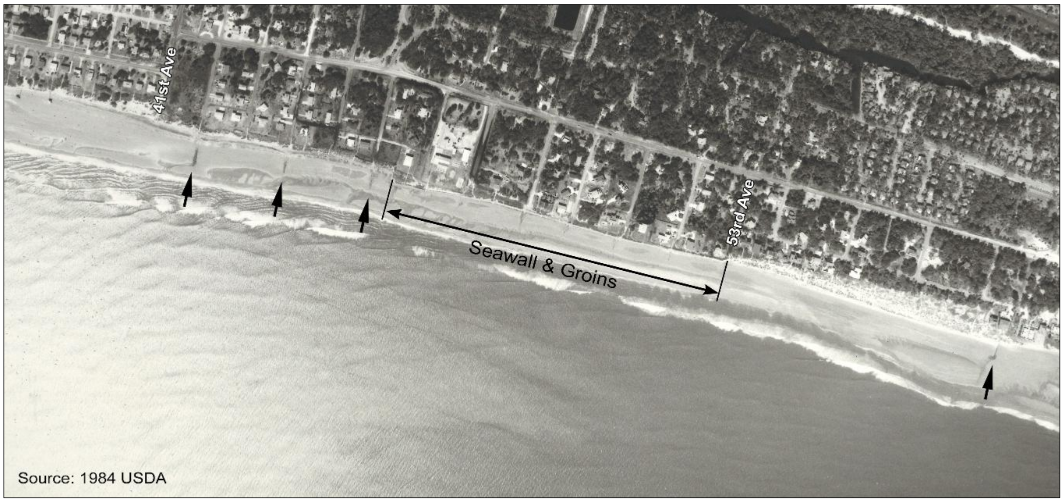

FIGURE 2.4. A seawall and groins were in place in 1984 between 46th Ave to 53rd Ave. Today, due to rapid accretion, these groins and seawalls have been buried.

2.2 Previous Projects

As mentioned in the previous section, erosion mitigation measures at Isle of Palms began in the 1970s with the construction of seawalls and groins in the area between 41st Ave and 53rd Ave. Another groin was visible in 1973 near present-day 58th Avenue. In 1981, a concrete-filled geotextile bag groin was built near the tee of the 17th hole of the Links Course to reduce the erosion threat along the Dewees Inlet shoreline. In 1983, in response to a shoal attachment event, homeowners along Seagrove and Beach Club Villas constructed a rubble mound seawall (Kana, Williams, and Stevens 1985). Sand scraping was also attempted but proved insufficient to maintain a dry-sand beach under the extreme erosion pressure. In late 1983, the first nourishment project along Isle of Palms was completed using sand dredged from the new marina at 41st Ave. Approximately 350,000 cy of sand was added to the erosional zones adjacent to the shoal as the shoal was beginning stage three of the bypass cycle. This resulted in a dramatic increase in beach width along Seagrove Villas, Beach Club Villas, and Mariners Walk, where erosion was most severe, augmenting the accretional shoal sand.

From 1984 to 2007, sand scraping from accretional areas was the only mitigation attempted to combat shoal-induced erosion. CSE and its predecessors documented scraping efforts circa 1983, 1987, and 1998 (Figure 2.3) that attempted to move sand from accreting areas to erosional arcs. From 2004–2007, sandbags were installed to protect several structures from Shipwatch to Ocean Club and prevent additional shoreline retreat (Figure 2.5).

FIGURE 2.5. To prevent additional erosion, sandbags were installed along several structures from Shipwatch to Ocean Club from 2004 to 2007.

Erosion reached such a severe condition in 2007 that there was little-to-no beach along portions of the east end of the island, even at low tide (Figure 2.6). The Wild Dunes Community Association contracted with CSE to evaluate the causes of erosion and prepare a feasibility study outlining alternatives for restoration (CSE 2007). CSE recommended nourishing the beach using sand from an offshore borrow area and began the steps to obtain a permit for the work. The City of Isle of Palms then took ownership of the project and served as the permit applicant. Permits were obtained (P/N 2007–02631–2IG), and the City contracted with Weeks Marine for a project involving the nourishment of 847,000 cy of sand over 10,200 lf (linear feet) of beach. The project extended from 200 ft north of 53rd Avenue to the 17th green of the Links Course.

FIGURE 2.6. Isle of Palms in 2007 prior to beach nourishment.

The 2008 project was completed between 15 May and 15 July 2008 (Figure 2.7). As part of the project, Weeks Marine removed all sandbags from the project area, which totaled ~9,400 bags. Homeowners removed an additional 4,680 bags from under buildings. Averaging ~25,000 cy of sand per day, the dredge *RS Weeks* pumped sand from three borrow areas 2–3 miles from the beach. The nourishment was placed in three reaches and included ~270,000 cy between 53rd Ave and Dune Crest Ln (Reach A), 552,400 cy from Mariners Walk to the 18th fairway (Reach B), and 25,000 cy from the 18th tee to the 17th fairway (Reach C). Figure 2.8 shows the layout of the 2008 project. Figure 2.9 shows a post-project aerial photo (2008) that compares to the project area before renourishment (2007).

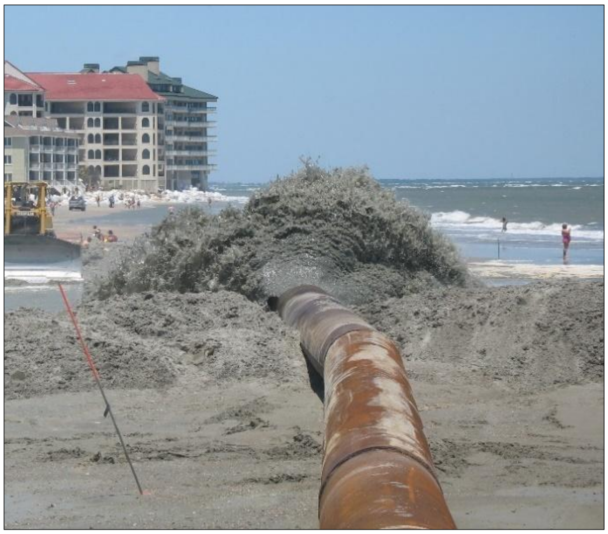

FIGURE 2.7. **[ABOVE]** 2008 beach nourishment project (completed on 15 July 2008).

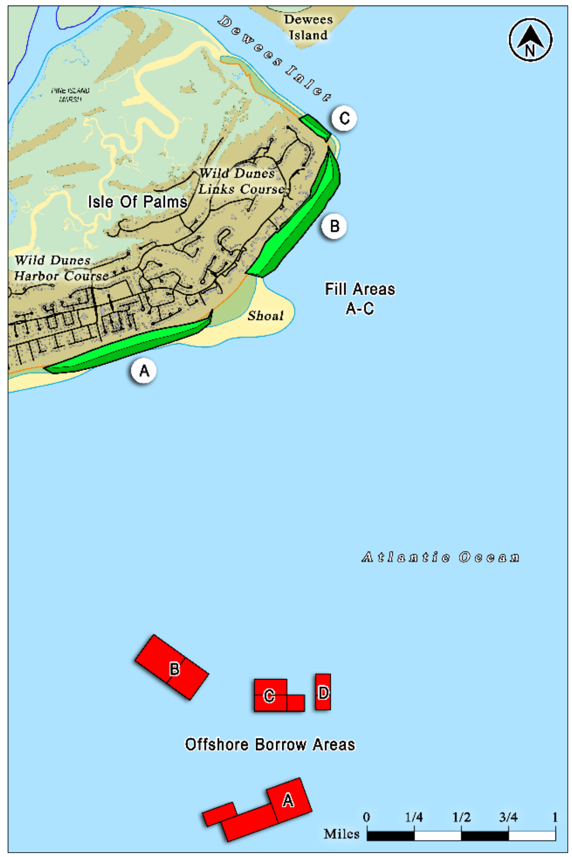

FIGURE 2.8. **[RIGHT]** 2008 nourishment project map.

FIGURE 2.9. **[LEFT]** Isle of Palms in 2007 prior to nourishment. **[RIGHT]** The project area in 2008 following nourishment.

Following the 2008 project, CSE monitored the beach at least annually to document beach volume changes and project performance. Two shoal-bypass events occurred in 2009 and 2010, and another larger event began to emerge offshore in 2010. In anticipation of the need for potential remediation (and after observation of an erosional hotspot forming near the Ocean Club/Seascape area), the City sought a permit to manipulate the accretional shoal area, expedite attachment, and move sand to the erosional hotspots. An initial project was completed in 2012 that transferred ~80,000 cy of sand from the central portion of Wild Dunes to the east end near the Ocean Club. A larger project was completed in late 2014 through early 2015, which moved ~280,000 cy from two accretional areas (an attaching shoal centered near Beach Club Villas and from 53rd to 56th Avenues) to the beach fronting Beachwood East (~70,000 cy) and the area fronting Seascape/Ocean Club/18th hole (~210,000 cy). The project sought to transfer as much sand as possible from the shoal to the beach (Figure 2.10).

FIGURE 2.10. January 2015 aerial image of the 2014–2015 shoal management project showing equipment transferring sand from an attaching shoal to the eroded beach.

2.3 2018 Project

From 2015 to 2018, the beach along the eastern end of the island continued to respond to a shoal attachment event. Erosional hotpots were present along Beachwood East and near the 18th hole of the Links Course. In 2016, the City opted to pursue a permit for another large-scale renourishment project. CSE was retained to provide engineering services necessary to complete a permit application package with associated reports and documents. The project design called for the addition of 1,676,000 cy of sand along the eastern end of the island, with maximum fill densities of over 300 cubic yards per foot (cy/ft). The design fill would add over 600 ft of dry-sand beach in the largest fill areas.

Engineering for the project began with analyses to determine the volume of sand required to restore the beach to a desired condition. CSE initially prepared a fill plan based on the beach condition in 2015, when a recent shoal attachment created a bulge in the shoreline near the center of the project area. Following hurricane impacts in 2015, 2016, and 2017, as well as erosion of the attached shoal, CSE modified the fill template to account for erosion occurring in the center of the project area and substantial accretion at the eastern end. The final fill plan is listed in Table 2.1 and shown graphically in Figure 2.11. The data reflect the final design prior to a change order issued during the project that placed additional sand along the center of the project area. The fill density averaged 161.5 cy/ft over the length of the project area, with a maximum fill volume of ~325 cy/ft. The nourishment volume decreased along the center of the project area, with a minimum of 50 cy/ft added.

The fill template ranged in width based on the final design, reaching as much as 600 ft in the highest density areas. The berm width decreased along the central portion of the project area, as the pre-project beach was wider than adjacent areas. At either end of the project, the berm width tapered to the existing dune line (Figs 2.11 and 2.12).

Construction began on 16 January 2018 and was completed by 23 March 2018. Table 2.2 shows the design and actual fill volumes determined by TI Coastal, the independent surveyor retained by Great Lakes Dredge and Dock Company, the nourishment contractor. The 'Design Volume' column represents the volume of sand above the before dredge (BD) condition and below the design template. Note that this volume is less than the final contract amount due to accretion between the pre-project design surveys and TI Coastal's BD survey. The 'Fill Volume' column represents the total amount of sand placed on the beach. The rows highlighted in yellow represent the area repumped following the Hurricane *Irma* change order. In total, 1,725,942 cy of sand was added to the project area. Of that total, 974,374 cy were pumped west of Station 280+00 (Property Owners Beach House), and 751,568 cy were placed east of Station 280+00. The 49,424 cy of sand placed above the pay quantity of 1,676,518 cy was not paid.

TABLE 2.1. The modified fill schedule designed to account for variable erosion and beach widths along the project area, as well as substantial accretion at the eastern end of the island.

Station	Pre-Project Unit Volume (cy/ft)	Fill Vol (cy/ft)	Design Fill Vol (cy/ft)	Post-Project Unit Volume (cy/ft)
230	321.6	**0.0**	321.6	351.6
232	338.9	**0.0**	338.9	379.0
234	298.4	**0.0**	298.4	349.0
236	262.7	**0.0**	262.7	329.7
238	258.3	**26.4**	284.8	358.5
240	272.2	**59.0**	331.2	399.6
242	255.7	**73.9**	329.6	415.9
244	295.9	**170.8**	466.7	499.0
246	283.7	**233.3**	517.0	526.5
248	289.5	**277.7**	567.2	562.6
250	306.2	**296.6**	602.8	587.9
252	283.8	**307.5**	591.2	554.5
254	267.2	**315.2**	582.4	539.7
256	228.9	**320.6**	549.6	524.7
258	251.7	**325.8**	577.6	544.6
260	275.5	**314.6**	590.2	547.9
262	306.5	**298.2**	604.7	563.4
264	333.8	**260.0**	593.8	595.7
266	382.5	**240.0**	622.5	620.5
268	376.4	**210.0**	586.4	543.5
270	359.2	**150.0**	509.2	549.8
272	372.9	**120.0**	492.9	537.1
274	355.6	**90.0**	445.6	515.2
276	442.8	**75.0**	517.8	576.2
278	426.6	**60.0**	486.6	587.3
280	534.3	**60.0**	594.3	771.4
282	436.3	**60.0**	496.3	652.7
284	450.9	**50.0**	500.9	746.0
286	520.6	**50.0**	570.6	760.5
288	456.4	**50.0**	506.4	705.7
290	444.9	**60.0**	504.9	657.8
292	479.3	**60.0**	539.3	672.8
294	526.0	**80.0**	606.0	686.2
296	511.1	**110.0**	621.1	655.5
298	498.4	**130.0**	628.4	634.5
300	487.0	**160.0**	647.0	630.9
302	472.4	**190.0**	662.4	622.6
304	436.9	**225.0**	661.9	597.7
306	442.7	**250.0**	692.7	614.1
308	392.2	**250.0**	642.2	571.3
310	376.4	**250.0**	626.4	560.2
312	361.0	**225.0**	586.0	546.5
314	320.2	**180.0**	500.2	488.9
316	415.6	**140.0**	555.6	560.5
318	427.6	**90.0**	517.6	529.7
320	449.0	**30.0**	479.0	526.7
322	449.8	**20.0**	469.8	495.5
324	418.4	**0.0**	418.4	450.9
326	415.0	**0.0**	415.0	434.3
328	420.0	**0.0**	420.0	451.0

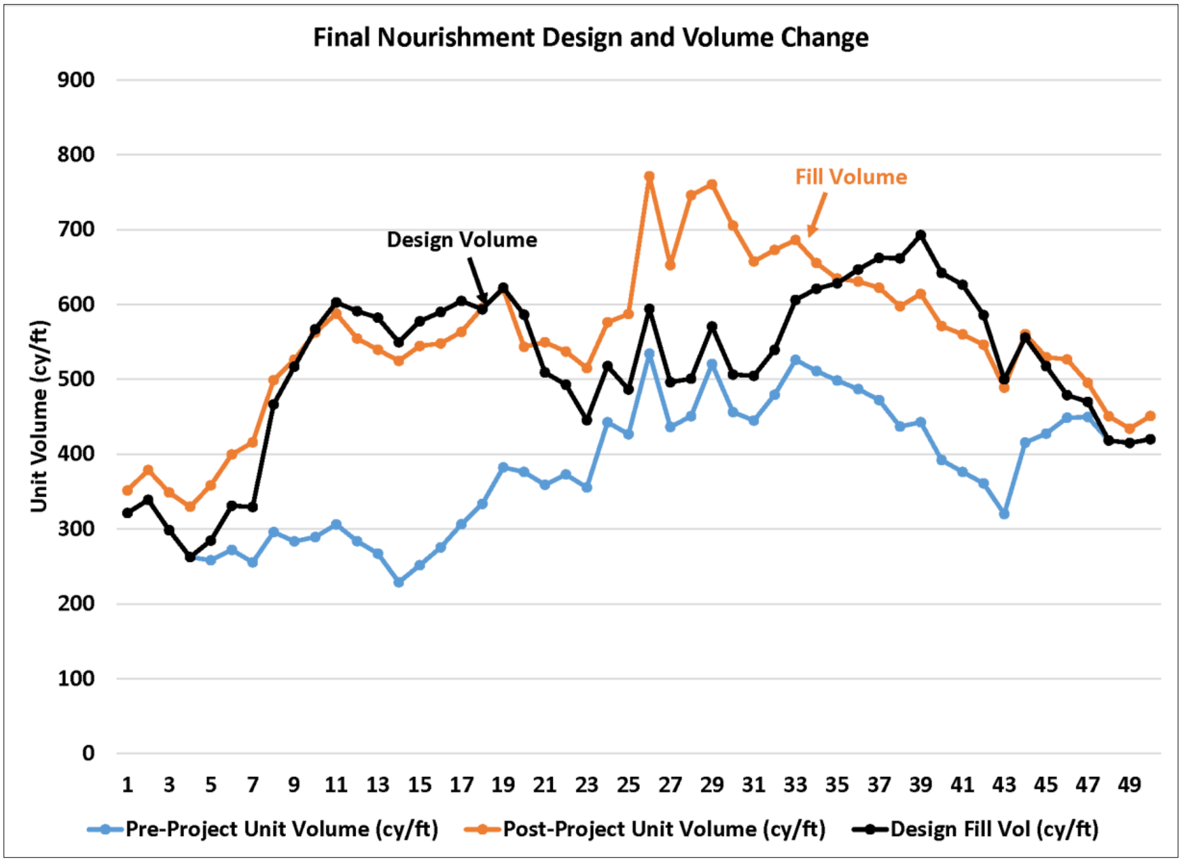

FIGURE 2.11. A graphic representation of the 2018 final fill template (shown in TABLE 2.2).

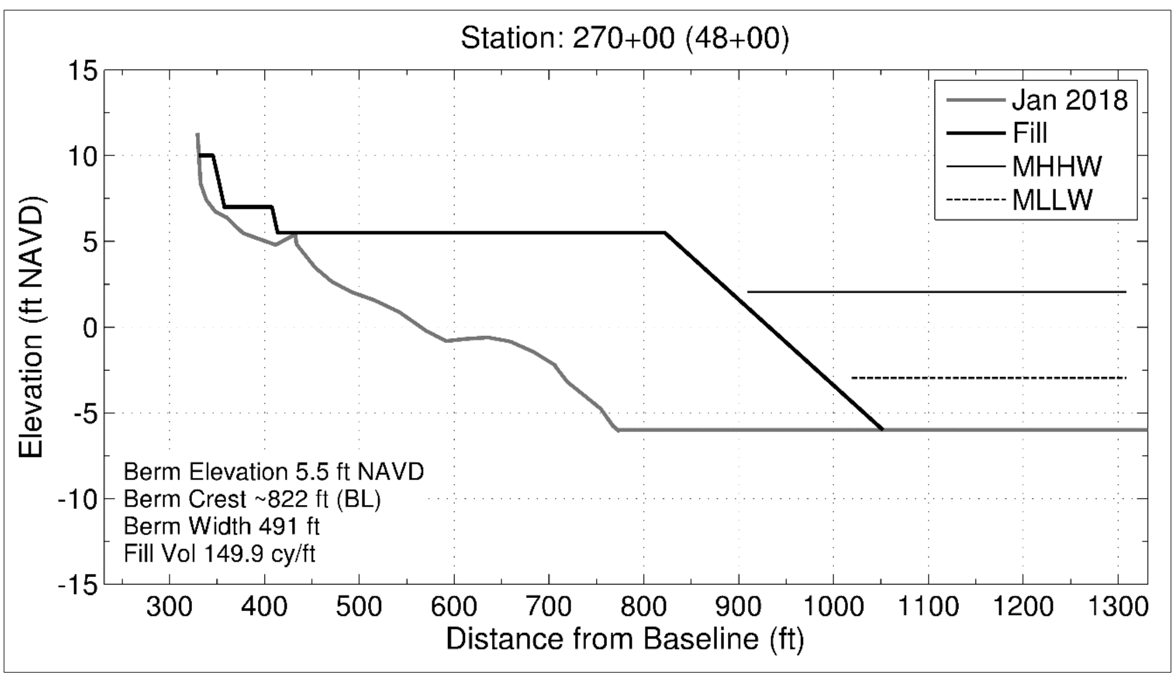

FIGURE 2.12. The 2018 design fill profile incorporated a dune, storm berm, wide fill berm, and sloping section.

TABLE 2.2. Design and actual fill volumes determined by TI Coastal.

Station	Design Volume (cy)	Fill Volume (cy)	Station	Design Volume (cy)	Fill Volume (cy)
236+00	0		289+00	11,105	11,132
237+00	804	884	290+00	11,049	11,207
238+00	2,205	3,896	291+00	11,063	11,254
239+00	3,170	5,926	292+00	11,125	11,402
240+00	4,061	8,310	293+00	11,333	11,170
241+00	6,061	11,356	294+00	11,347	10,909
242+00	9,107	13,518	295+00	11,327	11,444
243+00	12,503	15,683	296+00	11,308	11,948
244+00	16,387	18,628	297+00	11,631	11,995
245+00	19,920	21,625	298+00	12,201	12,333
246+00	22,899	24,474	299+00	12,236	12,523
247+00	25,585	27,183	300+00	12,241	13,075
248+00	27,455	28,754	301+00	12,913	13,281
249+00	28,789	28,239	302+00	13,948	14,104
250+00	30,167	31,479	303+00	15,069	15,477
251+00	31,181	32,451	304+00	16,027	16,373
252+00	31,470	33,976	305+00	16,586	16,906
253+00	31,426	32,359	306+00	17,129	17,478
254+00	32,042	32,369	307+00	17,448	18,473
255+00	32,443	30,318	308+00	17,536	18,527
256+00	33,719	34,416	309+00	17,610	18,244
257+00	34,963	35,931	310+00	17,555	18,307
258+00	33,841	34,875	311+00	17,757	18,698
259+00	32,952	33,558	312+00	17,687	18,582
260+00	32,567	32,868	313+00	17,120	17,922
261+00	31,827	32,428	314+00	16,452	16,991
262+00	30,985	32,027	315+00	15,600	16,329
263+00	29,682	30,800	316+00	13,887	14,910
264+00	27,782	28,388	317+00	11,634	12,404
265+00	26,261	26,810	318+00	9,514	10,179
266+00	25,145	25,880	319+00	7,189	8,952
267+00	23,634	24,314	320+00	5,076	8,638
268+00	22,321	22,946	321+00	3,256	7,093
269+00	21,015	22,001	322+00	1,831	4,643
270+00	18,789	19,955	323+00	1,030	2,780
271+00	16,199	17,330	324+00	631	1,609
272+00	13,753	14,883	279+00	0	0
273+00	11,886	12,419	279+80	1,782	1,812
274+00	10,815	11,146	279+90.404	12,904	14,394
275+00	10,220	10,461	280+00	14,782	16,133
276+00	10,142	10,235	281+00	12,116	12,366
277+00	10,368	10,381	282+00	12,265	12,707
278+00	10,533	10,394	283+00	12,658	13,602
279+00	10,860	10,903	284+00	12,539	13,338
279+80	8,977	9,312	285+00	12,243	12,875
279+90.404	8,459	9,138	286+00	12,229	12,552
280+00	8,460	9,147	287+00	12,153	12,283
281+00	11,040	11,720	288+00	11,948	12,239
282+00	11,006	11,551	289+00	12,056	12,328
283+00	11,091	11,565	290+00	12,171	12,270
284+00	11,120	11,190	291+00	11,992	11,919
285+00	10,931	10,094	292+00	10,418	10,852
286+00	10,903	10,901	293+00	6,838	8,118
287+00	11,171	11,319	294+00	3,503	4,813
288+00	11,218	11,336	**Total**	**1,635,358**	**1,725,942**

3.0 METHODS

Monitoring efforts for the present report were performed in September 2024. Sand volume changes in the active beach zone were evaluated by obtaining topographic and bathymetric data along shore-perpendicular transects at established locations along the beach (herein referred to as the baseline) (Fig 3.1). The present baseline spans from the center of the Breach Inlet Bridge (Station 0+00) and continues to Cedar Creek spit at the northeastern end of the island (Station 376+00). Stationing relates to the distance along the shore with the number before the "+" symbol representing 100 feet (ft). Therefore, Station 36+00 is 3,600 ft from Station 0+00. The baseline is generally set landward of the active beach to allow for future erosion/accretion.

Topographic data were collected via RTK-GPS (Trimble™ R10 GNSS), which provides position and elevation measurements at centimeter accuracy. Beach profiles were obtained by collecting data at low tide along the dunes, berm, and active beach to low-tide wading depth. Overwater work was then performed at high tide to overlap the land-based work (Fig 3.2) and was collected with RTK-GPS coupled with an Odom CV100™ precision echosounder mounted on CSE's survey vessel, the *RV Southern Echo*.

Profiles were collected from the most landward accessible point in the dune system to a minimum of 1,500 ft from the baseline. Profiles along the northeast end of the island extended up to 6,000 ft offshore to encompass the shoals associated with Dewees Inlet. Alongshore spacing of the profiles ranged from 200 ft to 1,000 ft, with the more closely spaced profiles north of 53rd Avenue and along Breach Inlet. Comparative profiles from CSE's monitoring efforts are shown in Appendix A. The complexity of areas impacted by inlets requires a more detailed analysis (closer profile spacing) to fully incorporate volume changes associated with shoal-bypassing events and inlet migration.

To better understand regional sand volume changes, seven reaches were defined along the Isle of Palms. Combining several profiles into a reach makes it easier to identify overall sediment gains and losses over large portions of the beach. In the project area, the reaches differ from those used during construction to encompass areas where no work was performed.

FIGURE 3.1. Baseline map of Isle of Palms showing the reference line used to establish monitoring profiles. Stationing increases to the north from Breach Inlet.

FIGURE 3.2.

Surveying beach profiles involves collection of land-based data at low-tide and hydrographic data collection overlapping the land-based work.

The reaches used for monitoring purposes are shown in Figure 3.3 and are defined as follows:

Reach 1	0+00 to OCRM 3115	Breach Inlet to 6th Avenue
Reach 2	OCRM 3115 to OCRM 3125	6th Avenue to Sea Cabins Pier
Reach 3	OCRM 3125 to OCRM 3140	Sea Cabins Pier to 31st Avenue
Reach 4	OCRM 3140 to 222+00	31st Avenue to 53rd Avenue
Reach 5	222+00 to 280+00	53rd Avenue to Wild Dunes Property Owners Beach House
Reach 6	280+00 to 328+00	Wild Dunes Property Owners Beach House to Dewees Inlet
Reach 7	330+00 to 370+00	Dewees Inlet Shoreline

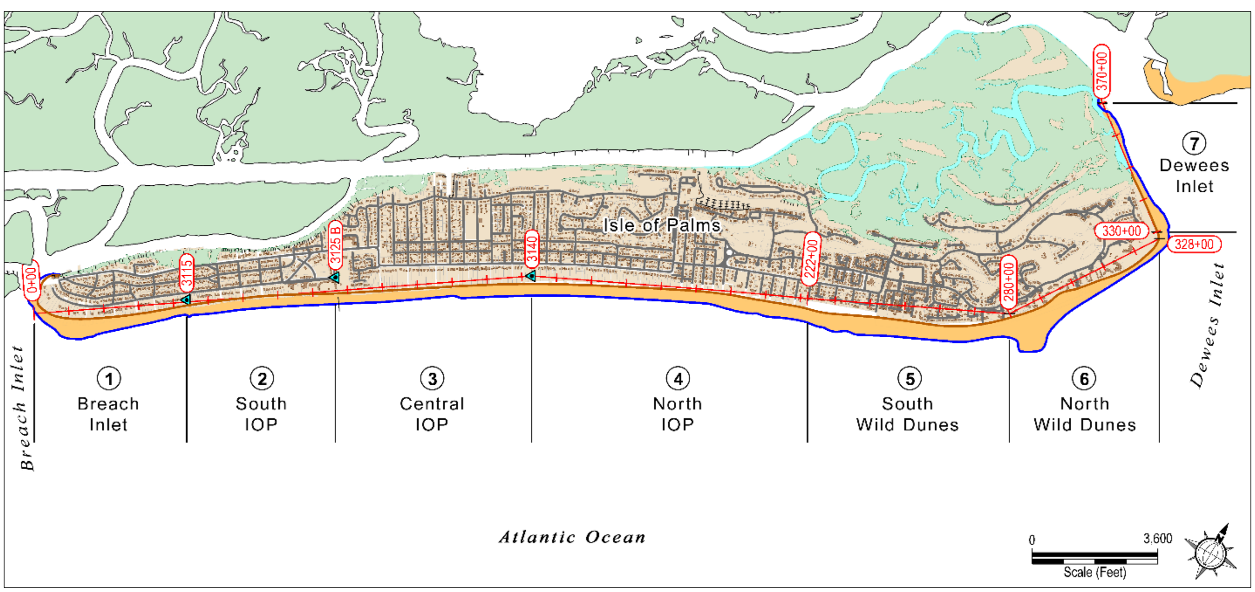

FIGURE 3.3. Reach limits used in the present monitoring report.

To determine changes in beach volume along Isle of Palms, beach profile data were entered into CSE's in-house custom software, Beach Profile Analysis System (BPAS), which converts 2D profile data in x–z (distance–elevation) format to 3D volumes. The software provides a quantitative and objective way of determining ideal minimum beach profiles and how the sand volume per unit length of shoreline compares with the desired condition. It also provides an accurate method of comparing historical profiles—as the volume method measures sand volumes in the active beach zone rather than extrapolating volumes based on single-contour shoreline position (ie – from aerial photography). Unit-volume calculations can distinguish the quantity of sediment in the dunes, on the dry beach, in the intertidal zone to wading depth, and in the remaining area offshore to the approximate limit of profile change (closure depth).

Figure 3.4 depicts the profile volume concept. The reference boundaries are site-specific but, ideally, encompass the entire zone over which sand moves each year. Sand volume was calculated between the primary dune and between −10 ft and −18 ft NAVD. The lower calculation limit was site-specific, as profiles in the center of the island and along Dewees Inlet generally have deeper closure depths than areas in the unstable inlet/shoal zones. Comparative volumes and volume changes were computed using standard procedures (average-end-area method, in which the average of the area under the profiles computed at the ends of each cell is multiplied by the length of the cell to determine the cell's sand volume). Certain adjustments were made to account for changes in the baseline direction and for volumes at the turn in the baseline at Dewees Inlet.

For the present report, several adjustments were made to the calculation limits for profiles showing significant erosion in recent years. The erosion has resulted in the active beach moving landward into areas not previously included in volume measures. Profile volumes for all previous surveys were recomputed using these new limits to provide accurate comparisons. This results in report volumes for a given year being slightly different than volumes reported in earlier reports.

Sand volumes for offshore areas were calculated from digital terrain models (DTMs) produced by MATLAB® and GlobalMapper®. DTMs are digital 3D representations of the topography and bathymetry of an area and are useful for calculating changes in contour positions and sediment volumes. Position data were entered into the software as x–y–z coordinates and were processed to provide cross-section profiles and volumes. DTMs are compared with earlier collections to determine changes in shoal positions and volumes.

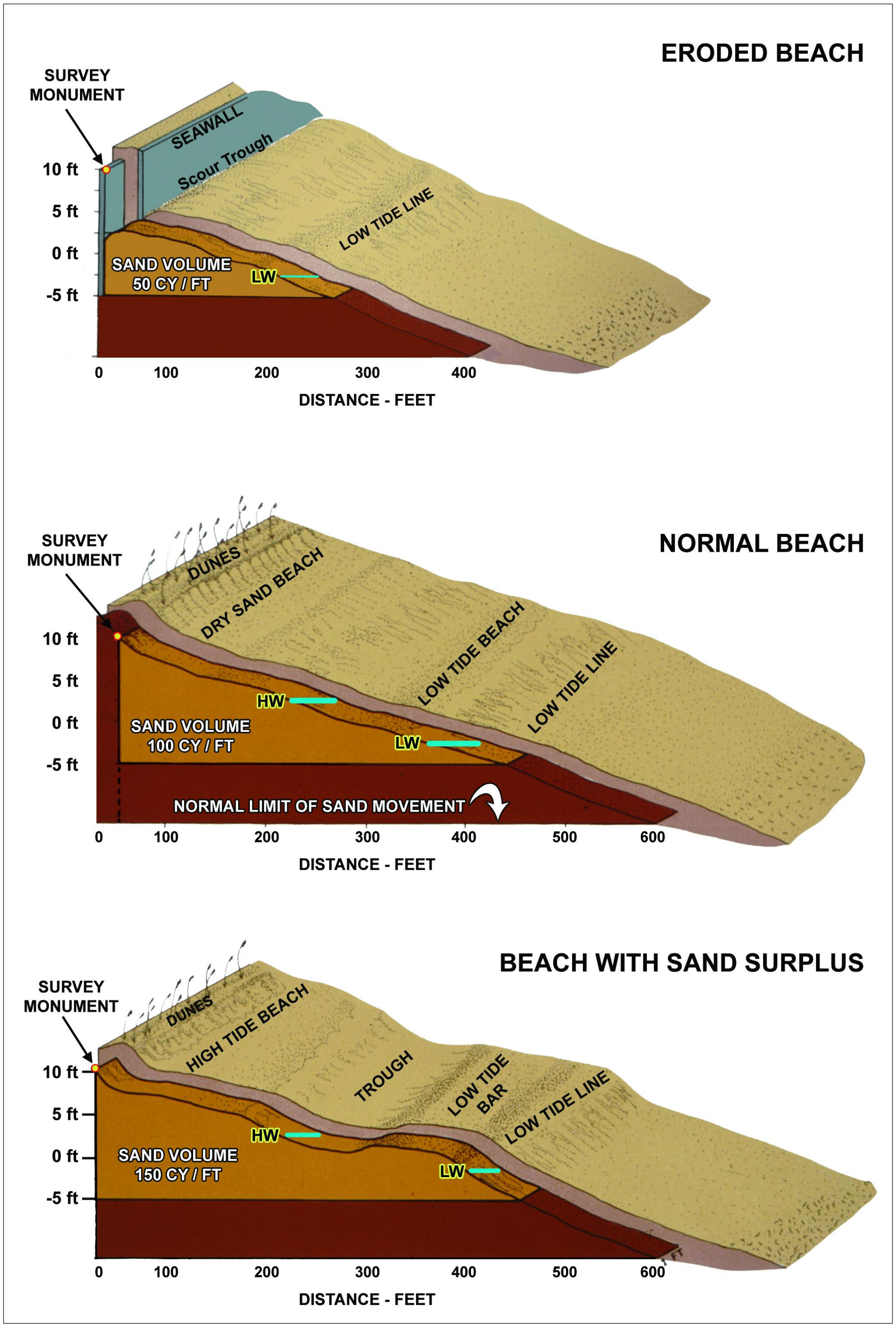

FIGURE 3.4. Illustration of the profile volume concept.

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4.0 RESULTS

Results of the beach monitoring effort presented in the following sections focus on changes occurring since the 2018 project but also address the condition relative to earlier periods, such as the pre-2008 project condition. CSE attempts to simplify the discussion of beach changes by focusing on larger reaches or areas rather than change measured at a single profile.

However, individual profiles are useful in visualizing how the shape of the beach changes over time, how shoals migrate onshore, and how the beach's condition is in front of specific properties or features. Volume change is first reported for the entire island, followed by localized changes in reaches 1–7.

4.1 Island-wide Changes

The Isle of Palms lost ~43,200 cy of beach sand from August 2023 to September 2024. Erosion was the most severe along Wild Dunes and Reach 2 (Fig 4.1). Within Wild Dunes, there were variations in volume change due to the onshore migration of a shoal from the Dewees Island system. Accretion downcoast of the project area (south of 53rd Ave) continued as in prior years. Across the entire island, the beach contains ~456,700 cy more sand than the 2017 pre-nourishment condition and ~211,000 cy more sand than in 2009 (Figure 4.3).

Tables 4.1 and 4.2 provide beach volume data for selected dates from 2008 through 2024 for each project reach and profile. Table 4.2 provides unit volumes for each line, with the 2018 project area highlighted.

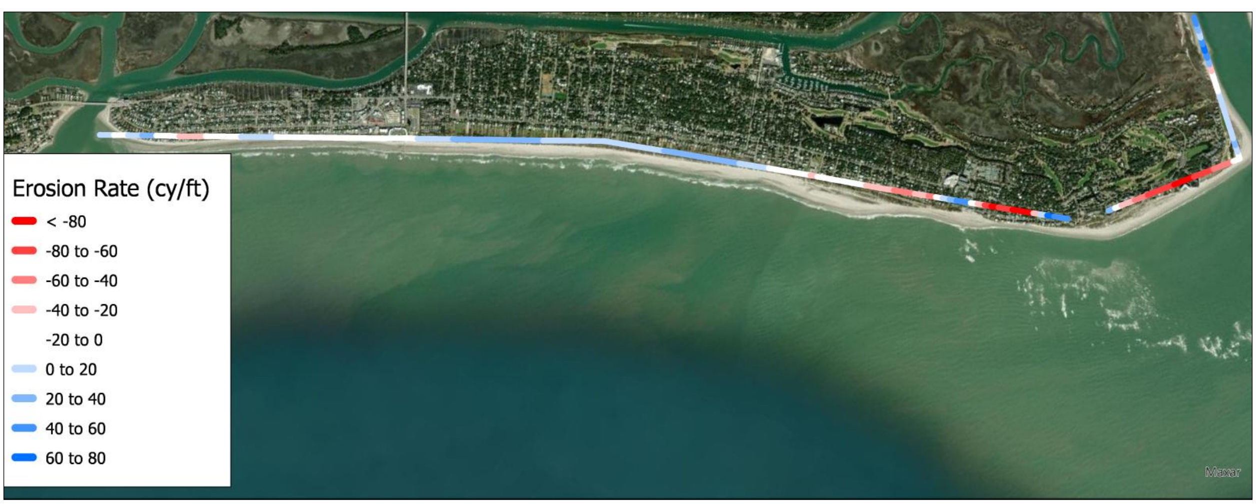


FIGURE 4.1. Line map showing variations in erosion and accretion patterns over Isle of Palms from August 2023 to September 2024. The shoal attachment zone along the eastern third of the island was the most dynamic over the last year. The central portion of the island exhibited a slightly positive beach volume change, while the Breach Inlet portion of the island lost sand at a more moderate pace than has been observed since 2021.

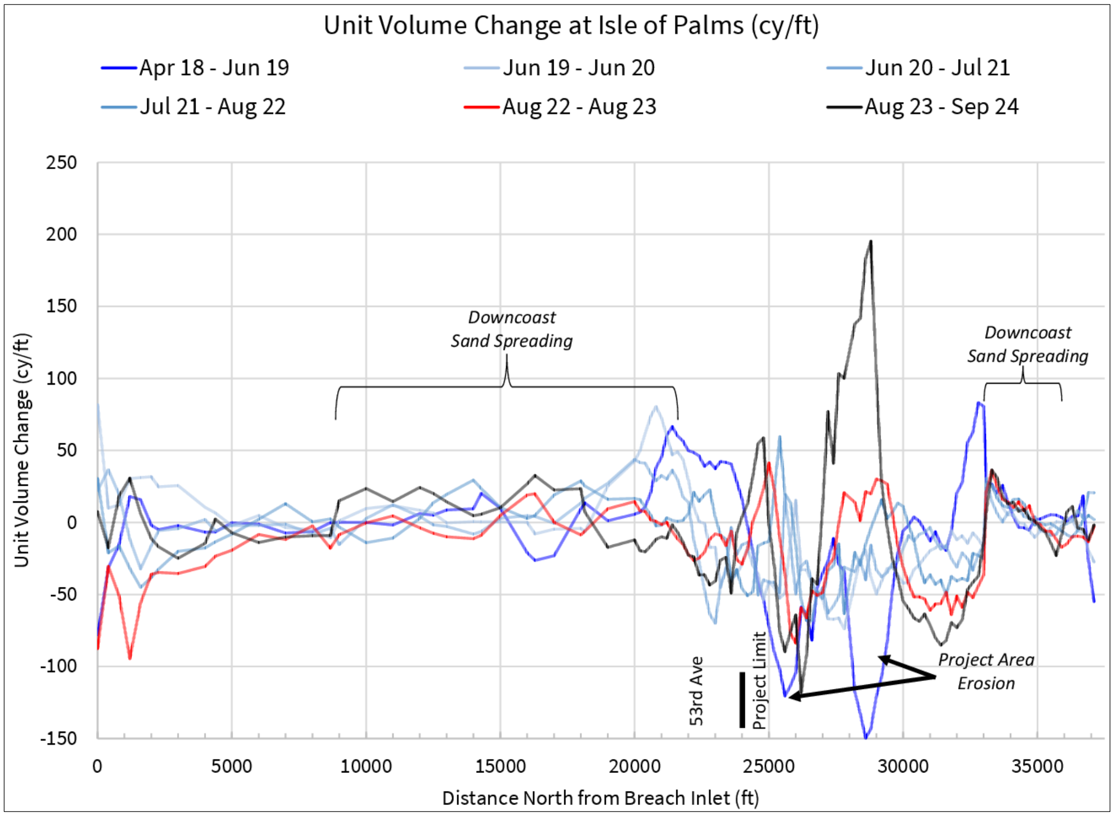


FIGURE 4.2. Beach unit volume change between each monitoring event at Isle of Palms. The X axis represents distance from Breach Inlet. This graph highlights the erosion occurring in the project area and accumulation of spreading sand adjacent to the project area.

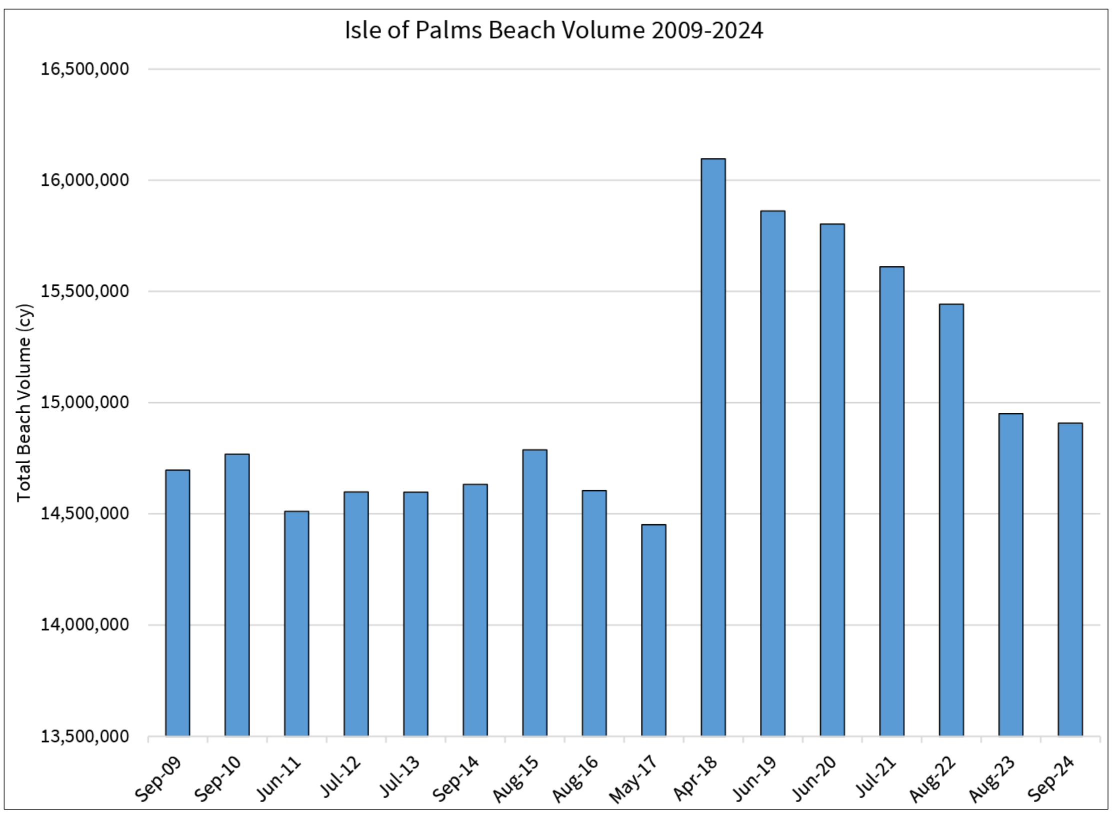


FIGURE 4.3. Total beach volume at Isle of Palms from 2009 to 2024. Effects of the 2018 project are seen in the rapid increase in the April 2018 island-wide beach volume.

TABLE 4.1. Beach volume data for selected dates since 2008 by reach.

Total Volume (cy)																			
	Length (ft)	Mar-08	Jul-08	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Aug-15	Aug-16	May-17	Apr-18	Jun-19	Jun-20	Jul-21	Aug-22	Aug-23	Sep-24
Reach 1	4,390			1,940,588	1,993,636	1,942,143	1,881,244	1,816,322	1,881,462	1,872,947	1,775,416	1,757,549	1,791,525	1,759,618	1,863,247	1,860,783	1,759,825	1,563,792	1,537,015
Reach 2	4,280			1,459,694	1,482,997	1,415,263	1,531,348	1,552,061	1,528,779	1,494,240	1,517,129	1,493,822	1,502,877	1,486,790	1,480,475	1,465,678	1,471,542	1,420,557	1,380,803
Reach 3	5,620			1,810,569	1,876,440	1,828,257	1,896,808	1,967,693	1,970,583	2,007,460	2,016,198	2,012,752	2,019,758	2,040,749	2,071,086	2,069,438	2,088,619	2,061,784	2,151,189
Reach 4	7,910			2,596,737	2,631,739	2,651,113	2,803,737	2,921,254	2,934,335	3,002,074	2,980,044	2,987,522	3,032,547	3,106,339	3,257,028	3,389,472	3,491,323	3,513,668	3,541,936
Reach 5	6,000	2,549,937	2,861,693	2,786,313	2,745,765	2,661,727	2,512,657	2,406,324	2,362,329	2,293,119	2,129,726	2,063,023	2,972,774	2,796,544	2,577,463	2,361,302	2,241,714	2,126,890	2,082,396
Reach 6	4,900	1,693,074	2,315,187	2,323,458	2,239,921	2,182,964	2,119,653	2,053,612	2,048,008	2,206,134	2,267,962	2,249,140	2,919,450	2,796,471	2,676,289	2,570,853	2,476,388	2,342,601	2,277,455
Reach 7	4,000	1,734,455	1,747,799	1,779,401	1,796,965	1,829,702	1,852,674	1,879,955	1,906,471	1,911,566	1,918,296	1,887,345	1,857,506	1,875,343	1,876,662	1,893,570	1,912,700	1,921,766	1,937,029
Reaches 5-6	10,900	4,243,011	5,176,880	5,109,772	4,985,687	4,844,691	4,632,311	4,459,936	4,410,336	4,499,253	4,397,688	4,312,163	5,892,224	5,593,015	5,253,751	4,932,155	4,718,102	4,469,491	4,359,850
Total Island Volume	37,100			14,696,761	14,767,463	14,511,169	14,598,121	14,597,222	14,631,967	14,787,541	14,604,770	14,451,155	16,096,437	15,861,854	15,802,249	15,611,096	15,442,112	14,951,057	14,907,824
Unit Volume (cy/ft)																			
	Length (ft)	Mar-08	Jul-08	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Aug-15	Aug-16	May-17	Apr-18	Jun-19	Jun-20	Jul-21	Aug-22	Aug-23	Sep-24
Reach 1	4,390			442.0	454.1	442.4	428.5	413.7	428.6	426.6	404.4	400.4	408.1	400.8	424.4	423.9	400.9	356.2	350.1
Reach 2	4,280			341.1	346.5	330.7	357.8	362.6	357.2	349.1	354.5	349.0	351.1	347.4	345.9	342.4	343.8	331.9	322.6
Reach 3	5,620			322.2	333.9	325.3	337.5	350.1	350.6	357.2	358.8	358.1	359.4	363.1	368.5	368.2	371.6	366.9	382.8
Reach 4	7,910			328.3	332.7	335.2	354.5	369.3	371.0	379.5	376.7	377.7	383.4	392.7	411.8	428.5	441.4	444.2	447.8
Reach 5	6,000	425.0	476.9	464.4	457.6	443.6	418.8	401.1	393.7	382.2	355.0	343.8	495.5	466.1	429.6	393.6	373.6	354.5	347.1
Reach 6	4,900	345.5	472.5	474.2	457.1	445.5	432.6	419.1	418.0	450.2	462.8	459.0	595.8	570.7	546.2	524.7	505.4	478.1	464.8
Reach 7	4,000	433.6	436.9	444.9	449.2	457.4	463.2	470.0	476.6	477.9	479.6	471.8	464.4	468.8	469.2	473.4	478.2	480.4	484.3
Reaches 1-7	37,100			396.1	398.0	391.1	393.5	393.5	394.4	398.6	393.7	389.5	433.9	427.5	425.9	420.8	416.2	403.0	401.8
Profile Volume Change Since Last Survey (cy)																			
	Length (ft)	Mar-08	Jul-08	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Aug-15	Aug-16	May-17	Apr-18	Jun-19	Jun-20	Jul-21	Aug-22	Aug-23	Sep-24
Reach 1	4,390				53,048	-51,492	-60,899	-64,922	65,140	-8,515	-97,531	-17,867	33,975	-31,907	103,629	-2,463	-100,958	-196,033	-26,777
Reach 2	4,280				23,303	-67,734	116,085	20,713	-23,282	-34,539	22,888	-23,306	9,054	-16,086	-6,315	-14,797	5,864	-50,985	-39,754
Reach 3	5,620				65,871	-48,183	68,550	70,886	2,889	36,877	8,738	-3,446	7,007	20,990	30,337	-1,647	19,181	-26,835	89,405
Reach 4	7,910				35,002	19,374	152,624	117,518	13,081	67,739	-22,030	7,478	45,025	73,792	150,689	132,444	101,852	22,344	28,268
Reach 5	6,000	-79,389.26	311,755.42	-75,379.47	-40,548	-84,038	-149,070	-106,333	-43,996	-69,210	-163,393	-66,703	909,751	-176,230	-219,081	-216,160	-119,588	-114,824	-44,495
Reach 6	4,900	9,437.24	622,112.95	8,271.32	-83,537	-56,958	-63,310	-66,042	-5,604	158,126	61,828	-18,821	670,309	-122,978	-120,183	-105,436	-94,465	-133,787	-65,146
Reach 7	4,000	48,342.72	13,344.27	31,601.55	17,565	32,736	22,972	27,282	26,516	5,095	6,729	-30,950	-29,839	17,837	1,319	16,908	19,130	9,066	15,264
Reaches 1-7	37,100				70,703	-256,294	86,951	-898	34,744	155,574	-182,770	-153,616	1,645,283	-234,583	-59,605	-191,152	-168,985	-491,054	-43,234
Unit Volume Change Since Last Survey (cy/ft)																			
	Length (ft)	Mar-08	Jul-08	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Aug-15	Aug-16	May-17	Apr-18	Jun-19	Jun-20	Jul-21	Aug-22	Aug-23	Sep-24
Reach 1	4,390				12.1	-11.7	-13.9	-14.8	14.8	-1.9	-22.2	-4.1	7.7	-7.3	23.6	-0.6	-23.0	-44.7	-6.1
Reach 2	4,280				5.4	-15.8	27.1	4.8	-5.4	-8.1	5.3	-5.4	2.1	-3.8	-1.5	-3.5	1.4	-11.9	-9.3
Reach 3	5,620				11.7	-8.6	12.2	12.6	0.5	6.6	1.6	-0.6	1.2	3.7	5.4	-0.3	3.4	-4.8	15.9
Reach 4	7,910				4.4	2.4	19.3	14.9	1.7	8.6	-2.8	0.9	5.7	9.3	19.1	16.7	12.9	2.8	3.6
Reach 5	6,000	-13.2	52.0	-12.6	-6.8	-14.0	-24.8	-17.7	-7.3	-11.5	-27.2	-11.1	151.6	-29.4	-36.5	-36.0	-19.9	-19.1	-7.4
Reach 6	4,900	1.9	127.0	1.7	-17.0	-11.6	-12.9	-13.5	-1.1	32.3	12.6	-3.8	136.8	-25.1	-24.5	-21.5	-19.3	-27.3	-13.3
Reach 7	4,000	12.1	3.3	7.9	4.4	8.2	5.7	6.8	6.6	1.3	1.7	-7.7	-7.5	4.5	0.3	4.2	4.8	2.3	3.8
Reaches 1-7	37,100				1.9	-6.9	2.3	0.0	0.9	4.2	-4.9	-4.1	44.3	-6.3	-1.6	-5.2	-4.6	-13.2	-1.2

TABLE 4.2a. Beach volume data for selected dates since 2008 for each project reach and each monitoring profile.

	Station	Distance to Next	Mar-08	Jul-08	Sep-09	Sep-10	Jul-12	Sep-14	May-17	Apr-18	Jun-19	Jun-20	Jul-21	Aug-22	Aug-23	Sep-24	Apr 18 - Jun 19	Jun 19 - Jun 20	Jun 20 - Jul 21	Jul 21 - Aug 22	Aug 22 - Aug 23	Aug 23- Sep 24	Sep 09 - Sep 24	Apr 18 - Sep 24
Reach 1	0	400			207.4	278.7	290.5	254.8	278.5	266.3	188.3	270.1	292.1	322.5	235.0	242.6	-78.0	81.8	22.0	30.4	-87.5	7.5	35.2	-35.9
	4	400			424.6	458.6	412.0	393.2	409.8	425.1	393.6	403.6	440.2	419.0	388.6	371.1	-31.4	9.9	36.6	-21.1	-30.4	-17.5	-53.4	-38.7
	8	400			461.3	449.6	423.2	436.9	411.7	424.9	409.5	421.8	441.1	424.8	373.9	392.3	-15.4	12.3	19.3	-16.2	-50.9	18.4	-69.0	-19.4
	12	400			614.6	610.8	543.2	582.7	527.7	514.8	532.7	563.1	551.5	519.6	425.0	455.8	17.9	30.4	-11.7	-31.9	-94.6	30.8	-158.8	-71.9
	16	400			573.6	567.0	485.1	541.3	484.3	480.4	496.1	527.3	495.1	450.1	394.2	400.3	15.7	31.2	-32.2	-45.0	-55.9	6.1	-173.3	-84.0
	20	270			491.4	492.0	437.0	458.8	402.8	418.6	416.7	448.5	432.3	394.1	358.1	346.8	-1.9	31.8	-16.1	-38.2	-36.0	-11.3	-144.7	-56.1
	3110	730			442.1	454.4	422.9	418.7	384.9	398.8	393.8	418.5	412.9	380.4	345.7	328.8	-5.0	24.7	-5.7	-32.5	-34.7	-16.9	-113.3	-56.1
	30	1000			402.3	425.9	422.8	408.9	374.5	388.5	386.3	411.9	407.6	387.5	352.1	327.3	-2.2	25.6	-4.3	-20.1	-35.4	-24.9	-75.0	-47.2
	40	390			380.7	390.1	401.1	375.9	359.7	367.1	360.4	370.9	372.9	355.3	324.7	310.1	-6.8	10.5	2.1	-17.7	-30.6	-14.5	-70.5	-49.6
Reach 2	3115	610			365.1	369.2	386.8	363.4	344.1	355.6	349.0	355.6	349.7	336.3	312.9	315.3	-6.6	6.5	-5.8	-13.4	-23.4	2.4	-49.9	-28.8
	50	1000			369.2	379.7	382.2	360.1	359.1	357.1	357.0	354.7	352.7	344.5	325.2	318.1	-0.2	-2.2	-2.1	-8.1	-19.3	-7.1	-51.1	-41.0
	60	1000			342.2	347.7	360.2	353.7	352.6	343.4	342.2	346.9	344.8	347.0	338.6	324.7	-1.2	4.8	-2.1	2.2	-8.4	-13.9	-17.6	-28.0
	70	1000			342.7	340.9	358.9	364.9	354.5	358.7	351.3	347.8	346.6	359.7	347.8	337.7	-7.4	-3.5	-1.2	13.1	-11.9	-10.1	-5.0	-16.8
	80	670			300.5	310.0	318.7	336.0	321.0	330.1	323.7	318.6	310.6	311.1	308.7	299.5	-6.4	-5.1	-8.1	0.5	-2.4	-9.2	-1.0	-21.5
Reach 3	3125	330			344.2	350.1	359.6	384.7	372.1	385.9	385.8	375.1	371.0	373.5	355.5	346.4	-0.1	-10.6	-4.1	2.4	-17.9	-9.1	2.2	-25.7
	90	1000			306.6	316.1	330.5	350.8	342.9	345.8	346.0	347.2	331.8	328.6	320.0	335.1	0.2	1.2	-15.4	-3.2	-8.6	15.1	28.6	-7.7
	100	1000			325.1	344.3	339.6	363.7	365.1	362.7	362.8	372.5	375.3	361.2	361.0	384.5	0.1	9.7	2.8	-14.1	-0.3	23.5	59.4	19.4
	110	1000			306.8	316.5	321.6	332.3	343.2	338.6	336.8	348.6	360.9	350.0	354.6	369.1	-1.8	11.8	12.3	-10.8	4.5	14.5	62.2	25.8
	120	500			333.4	346.4	358.9	358.5	374.5	375.3	381.4	389.9	394.1	396.9	393.3	417.6	6.1	8.5	4.2	2.7	-3.6	24.3	84.2	43.1
	3135	500			351.4	355.8	360.9	364.6	377.2	389.0	394.1	400.7	399.0	412.6	405.2	425.4	5.1	6.5	-1.6	13.6	-7.4	20.2	74.0	48.2
	130	1000			322.3	329.3	328.4	335.5	352.7	356.9	365.4	365.2	362.4	381.8	371.8	386.1	8.6	-0.3	-2.7	19.4	-10.0	14.3	63.8	33.4
	140	290			314.5	330.6	328.5	346.1	353.7	354.5	364.0	364.5	356.5	385.9	374.6	379.2	9.5	0.6	-8.0	29.4	-11.2	4.6	64.7	25.5
Reach 4	3140	710			329.1	342.7	335.8	357.4	364.7	362.3	382.5	383.0	376.6	400.1	391.1	396.9	20.2	0.5	-6.4	23.5	-9.0	5.8	67.9	32.3
	150	1000			299.5	309.7	313.0	337.9	346.6	350.6	360.5	361.0	363.9	374.3	379.1	389.4	9.9	0.4	2.9	10.4	4.8	10.3	89.9	42.7
	160	290			284.6	283.1	305.0	328.2	347.2	377.0	356.1	356.2	360.8	363.5	382.5	409.2	-21.0	0.1	4.6	2.7	19.0	26.8	124.6	62.0
	3145	710			299.1	285.0	321.9	345.3	367.9	399.3	373.0	365.0	369.2	374.1	393.9	426.5	-26.3	-8.0	4.2	4.9	19.9	32.6	127.5	58.6
	170	1000			291.8	293.4	317.0	339.3	366.0	388.0	364.8	360.1	359.6	378.6	378.7	401.2	-23.2	-4.7	-0.6	19.0	0.1	22.5	109.4	35.3
	180	150			318.2	336.2	354.6	375.4	407.6	395.6	404.9	400.8	414.3	443.1	434.4	457.9	9.3	-4.0	13.5	28.7	-8.7	23.5	139.7	50.3
	3150	850			332.5	274.4	317.7	393.6	413.5	406.2	419.8	413.3	430.1	455.4	449.3	456.6	13.6	-6.5	16.9	25.3	-6.1	7.3	124.1	43.1
	190	1000			318.7	336.5	370.6	366.8	378.1	372.3	373.5	398.7	426.0	442.1	451.5	434.2	1.2	25.3	27.3	16.1	9.4	-17.3	115.5	56.1
	200	200			341.7	362.5	383.1	388.9	373.7	375.8	381.5	424.1	467.9	484.5	499.0	486.8	5.6	42.6	43.8	16.7	14.5	-12.2	145.1	113.1
	202	200		320.6	365.1	377.3	391.4	396.9	389.0	386.4	393.6	443.4	484.9	500.7	508.7	489.0	7.2	49.8	41.6	15.8	8.0	-19.7	123.9	100.0
	204	200		339.9	386.0	396.1	405.7	410.8	393.4	400.3	411.3	473.3	514.5	525.0	532.6	512.2	11.0	62.0	41.1	10.5	7.6	-20.4	126.1	118.8
	206	200		327.6	375.3	383.6	392.3	400.6	388.9	389.1	409.9	483.6	517.4	522.4	524.2	508.0	20.8	73.7	33.8	5.0	1.8	-16.2	132.7	119.1
	208	200		328.8	367.4	381.7	400.8	406.1	393.4	386.5	424.6	505.0	534.0	531.6	532.4	520.6	38.1	80.4	29.0	-2.4	0.8	-11.8	153.2	127.3
	210	200		354.1	394.3	407.9	421.1	438.8	415.9	413.6	458.9	531.4	564.1	562.2	560.7	550.7	45.3	72.5	32.7	-1.9	-1.5	-10.0	156.4	134.8
	212	200		333.8	374.0	386.7	411.1	411.7	389.5	385.2	445.4	505.6	535.5	538.8	539.0	528.0	60.2	60.2	29.9	3.3	0.2	-11.0	154.0	138.5
	214	200		326.9	380.8	381.8	410.3	391.2	382.2	388.6	455.1	502.1	538.5	539.9	533.6	532.0	66.5	47.0	36.3	1.5	-6.3	-1.7	151.2	149.8
	216	200		327.4	376.4	377.2	406.5	394.4	387.2	391.5	451.7	500.8	530.7	531.4	520.0	513.3	60.2	49.1	29.9	0.7	-11.4	-6.7	137.0	126.2
	218	200		349.3	387.7	393.6	417.6	419.3	406.5	409.2	465.7	509.4	527.1	528.6	513.4	499.7	56.5	43.7	17.7	1.5	-15.2	-13.7	112.0	93.2
	220	200		342.5	382.1	388.1	416.4	430.0	403.1	412.5	462.4	492.2	506.3	512.3	490.3	467.6	49.9	29.8	14.1	6.0	-22.0	-22.7	85.5	64.4
Reach 5	222	200	302.4	310.3	343.8	352.6	382.3	388.2	360.2	366.0	414.6	425.4	412.9	433.7	407.4	383.5	48.6	10.7	-12.5	20.8	-26.4	-23.8	39.8	23.3
	224	200	323.2	335.2	375.3	373.5	411.2	409.6	379.8	382.1	428.3	429.1	402.4	416.9	392.1	355.7	46.3	0.8	-26.7	14.6	-24.8	-36.5	-19.6	-24.1
	226	200	303.2	310.8	372.4	362.8	386.4	383.6	345.7	342.3	381.3	380.5	333.5	352.7	332.1	295.8	39.0	-0.7	-47.0	19.2	-20.6	-36.3	-76.5	-49.9
	228	200	328.1	357.6	405.3	383.2	396.4	392.6	340.4	343.0	384.9	367.7	304.0	326.7	314.9	271.5	41.9	-17.2	-63.7	22.7	-11.8	-43.4	-133.8	-68.9
	230	200	370.4	422.4	438.2	414.5	399.9	406.1	349.9	354.8	392.1	374.7	304.8	308.6	300.7	260.0	37.3	-17.3	-69.9	3.8	-7.9	-40.7	-178.2	-89.9
	232	200	400.4	436.9	450.8	452.3	445.8	427.0	366.8	379.0	421.3	376.2	332.4	323.6	314.6	288.4	42.3	-45.1	-43.7	-8.8	-9.0	-26.2	-162.4	-78.3
	234	200	342.6	417.1	424.5	416.4	398.4	378.7	318.6	348.6	390.4	359.1	325.7	314.0	297.9	273.8	41.7	-31.3	-33.5	-11.7	-16.1	-24.2	-150.7	-44.9
	236	200	307.8	388.7	394.2	391.4	378.3	345.9	285.5	329.7	370.2	330.7	327.2	286.1	280.1	231.1	40.5	-39.6	-3.5	-41.1	-6.1	-49.0	-163.1	-54.5
	238	200	299.2	389.0	394.0	392.4	374.4	343.8	286.3	358.5	386.9	351.0	328.6	296.0	270.3	263.0	28.4	-35.9	-22.3	-32.7	-25.7	-7.2	-131.0	-23.3
	240	200	306.6	400.9	409.1	407.0	392.5	355.4	300.4	399.6	416.0	386.8	371.3	325.4	296.4	300.2	16.4	-29.2	-15.5	-45.9	-29.1	3.8	-109.0	-0.2
	242	200	292.4	385.7	395.9	394.8	372.4	336.6	282.2	415.9	413.2	396.1	382.1	331.3	312.7	325.6	-2.7	-17.2	-13.9	-50.9	-18.6	12.9	-70.3	43.4
	244	200	339.5	433.3	449.4	441.5	419.2	383.5	318.7	499.0	479.7	449.9	430.3	382.2	382.8	414.4	-19.3	-29.8	-19.5	-48.1	0.6	31.6	-35.1	95.7
	246	200	355.9	444.8	442.2	439.1	413.0	386.1	315.9	526.5	484.5	448.8	398.5	382.2	392.7	447.5	-42.0	-35.7	-50.4	-16.3	10.5	54.8	5.3	131.6
	248	200	387.0	469.0	461.8	451.5	421.9	420.6	316.6	562.6	508.9	455.4	415.6	401.2	424.7	483.4	-53.7	-53.5	-39.8	-14.3	23.5	58.7	21.5	166.8
	250	200	391.8	484.0	461.6	465.2	420.7	436.8	318.5	587.9	515.6	474.6	433.1	419.9	461.2	459.5	-72.3	-41.0	-41.5	-13.3	41.3	-1.7	-2.1	140.9
	252	200	365.7	458.7	431.4	418.2	389.7	369.1	268.3	554.5	464.7	419.5	377.9	399.1	422.3	392.5	-89.8	-45.2	-41.6	21.2	23.2	-29.8	-38.9	124.1
	254	200	346.4	447.1	415.3	390.2	372.1	326.8	243.9	539.7	437.8	385.2	336.4	396.0	385.2	309.4	-101.9	-52.6	-48.9	59.6	-10.8	-75.9	-106.0	65.4

TABLE 4.2b. Beach volume data for selected dates since 2008 for each project reach and each monitoring profile.

	Station	Distance to Next	Mar-08	Jul-08	Sep-09	Sep-10	Jul-12	Sep-14	May-17	Apr-18	Jun-19	Jun-20	Jul-21	Aug-22	Aug-23	Sep-24	Apr 18 - Jun 19	Jun 19 - Jun 20	Jun 20 - Jul 21	Jul 21 - Aug 22	Aug 22 - Aug 23	Aug 23- Sep 24	Sep 09 - Sep 24	Apr18 - Sep 24
Reach 5 (Continued)	256	200	351.5	450.2	409.2	373.2	381.1	291.4	226.4	524.7	404.2	355.1	374.4	394.4	359.1	269.3	-120.5	-49.1	19.3	20.0	-35.3	-89.8	-139.8	42.9
	258	200	390.9	484.6	439.0	399.7	421.4	321.9	250.1	544.6	431.3	419.4	404.5	418.2	341.4	265.6	-113.4	-11.9	-14.9	13.8	-76.9	-75.8	-173.4	15.5
	260	200	432.0	502.2	454.9	414.9	415.9	308.6	264.4	547.9	443.5	458.9	409.2	393.9	310.2	246.0	-104.4	15.4	-49.7	-15.4	-83.7	-64.2	-208.9	-18.4
	262	200	464.2	529.3	481.3	457.9	417.1	293.5	288.8	563.4	504.8	472.0	441.7	387.9	328.5	210.5	-58.7	-32.8	-30.3	-53.8	-59.3	-118.0	-270.7	-78.3
	264	200	525.0	575.4	527.2	504.4	444.6	349.6	328.6	595.7	532.2	499.3	472.6	404.5	338.1	245.9	-63.5	-33.0	-26.7	-68.1	-66.4	-92.2	-281.3	-82.7
	266	200	538.0	599.6	542.4	521.8	459.8	377.5	347.8	620.5	538.8	496.9	455.7	387.5	340.0	300.9	-81.7	-41.9	-41.2	-68.2	-47.5	-39.2	-241.6	-47.0
	268	200	521.0	566.2	493.3	478.2	438.2	366.3	353.1	543.5	498.2	448.1	397.1	349.2	298.6	255.7	-45.2	-50.1	-51.1	-47.9	-50.6	-42.9	-237.6	-97.4
	270	200	550.5	582.7	506.1	501.4	400.2	412.7	417.0	550.1	514.9	461.6	416.2	363.4	314.8	325.9	-35.1	-53.3	-45.4	-52.8	-48.5	11.1	-180.1	-91.1
	272	200	555.0	569.4	501.9	503.4	416.0	416.2	388.2	537.1	510.1	443.3	380.4	346.9	316.4	393.4	-27.0	-66.8	-62.9	-33.5	-30.5	77.0	-108.5	5.2
	274	200	518.1	526.2	463.0	490.7	402.0	398.1	387.0	509.0	497.9	430.8	372.7	342.7	317.9	359.0	-11.1	-67.2	-58.0	-30.0	-24.8	41.1	-104.0	-28.0
	276	200	622.6	619.9	559.9	594.1	492.4	527.9	472.1	576.2	547.2	481.0	429.6	414.7	413.7	517.1	-28.9	-66.3	-51.4	-14.9	-1.0	103.3	-42.9	44.9
	278	400	642.3	593.3	550.1	616.4	475.2	524.2	492.7	585.4	551.8	477.9	446.8	383.6	404.1	504.2	-33.6	-73.9	-31.1	-63.3	20.6	100.1	-45.9	11.5
Reach 6	280	200	706.1	676.2	834.8	794.7	578.3	665.6	634.8	766.3	648.6	606.3	572.0	551.2	565.1	703.0	-117.7	-42.3	-34.3	-20.8	13.9	137.8	-131.9	68.1
	282	200	631.7	568.1	753.6	683.5	480.2	556.7	516.6	652.7	520.2	495.4	469.5	439.8	441.1	582.6	-132.5	-24.8	-25.9	-29.6	1.3	141.5	-171.0	66.0
	284	200	676.3	671.0	827.1	737.7	575.3	672.3	608.4	757.8	608.2	588.8	548.9	533.8	555.1	738.2	-149.6	-19.4	-39.9	-15.1	21.3	183.1	-89.0	129.7
	286	200	651.2	666.9	773.9	709.0	590.8	700.8	633.9	760.5	617.3	579.6	563.8	559.9	579.8	775.1	-143.2	-37.7	-15.8	-3.9	19.9	195.4	1.3	141.2
	288	200	487.2	577.8	608.1	599.8	536.5	608.0	546.1	705.7	585.0	535.2	502.2	508.4	538.5	640.0	-120.7	-49.8	-32.9	6.1	30.2	101.5	32.0	93.9
	290	200	382.0	486.4	521.6	524.9	498.9	573.6	506.7	657.8	550.8	510.0	472.3	488.1	517.1	544.0	-107.0	-40.7	-37.7	15.8	29.0	26.9	22.4	37.2
	292	200	377.4	486.6	522.2	511.3	538.4	608.3	534.8	672.8	589.4	557.3	522.7	525.5	552.1	549.0	-83.3	-32.1	-34.7	2.8	26.7	-3.1	26.9	14.3
	294	200	385.8	514.9	535.1	527.6	571.9	585.9	576.9	686.2	639.5	608.4	579.9	586.9	593.1	567.4	-46.7	-31.1	-28.5	7.1	6.1	-25.6	32.3	-9.4
	296	200	356.5	496.5	498.1	495.8	539.7	518.2	538.3	655.5	634.1	597.8	571.3	584.7	568.4	529.8	-21.4	-36.3	-26.5	13.4	-16.3	-38.6	31.7	-8.6
	298	200	320.0	483.9	471.5	467.6	490.9	446.3	512.2	634.5	628.7	586.6	568.4	579.5	548.3	493.7	-5.8	-42.1	-18.2	11.1	-31.2	-54.6	22.2	-18.5
	300	200	308.2	483.5	463.2	457.4	491.4	433.8	499.1	630.9	629.0	587.4	578.3	576.4	533.7	473.7	-1.9	-41.5	-9.1	-1.9	-42.7	-60.0	10.5	-25.4
	302	200	279.5	474.9	441.9	436.7	463.0	405.7	478.6	622.6	626.4	593.5	580.6	568.6	516.8	450.5	3.8	-32.9	-12.9	-12.0	-51.7	-66.4	8.6	-28.1
	304	200	259.8	451.5	408.2	399.8	429.3	355.4	430.9	597.7	598.5	569.2	561.0	530.5	478.8	410.2	0.8	-29.4	-8.2	-30.5	-51.7	-68.6	2.0	-20.7
	306	200	270.1	460.1	404.9	400.2	421.7	364.6	428.1	614.1	608.7	584.3	577.4	535.6	482.4	418.8	-5.4	-24.4	-6.9	-41.8	-53.2	-63.5	14.0	-9.3
	308	200	246.1	428.0	371.1	346.3	366.0	287.4	372.1	571.3	558.4	538.8	535.5	499.2	438.2	366.9	-12.9	-19.6	-3.3	-36.3	-61.0	-71.3	-4.2	-5.2
	310	200	252.2	412.0	339.8	333.4	336.9	247.0	351.3	560.2	553.7	536.0	523.4	480.3	423.6	343.6	-6.5	-17.7	-12.6	-43.1	-56.6	-80.1	3.8	-7.7
	312	200	232.0	398.1	334.0	310.3	322.9	235.8	331.7	546.5	531.1	516.2	497.6	457.6	401.2	316.1	-15.4	-14.9	-18.6	-40.0	-56.4	-85.1	-18.0	-15.7
	314	200	192.1	349.8	272.6	274.0	279.6	208.0	286.2	488.9	469.4	451.8	435.7	385.4	336.9	255.0	-19.5	-17.7	-16.0	-50.4	-48.5	-81.9	-17.7	-31.2
	316	200	261.7	432.8	375.2	371.6	348.4	286.4	380.7	560.5	554.6	548.9	523.7	486.3	422.3	352.8	-5.9	-5.8	-25.1	-37.4	-64.0	-69.5	-22.4	-27.9
	318	200	246.7	428.2	370.0	358.9	355.4	275.1	393.3	529.7	550.2	538.2	507.1	466.4	415.2	342.1	20.5	-12.1	-31.1	-40.7	-51.1	-73.1	-27.9	-51.2
	320	200	261.3	440.4	388.4	375.6	361.3	297.4	416.2	526.7	554.2	544.9	523.9	485.0	426.0	358.3	27.6	-9.3	-21.1	-38.9	-59.1	-67.7	-30.2	-57.9
	322	200	267.0	435.2	387.1	379.2	334.4	297.3	416.2	495.5	551.2	536.6	511.2	470.8	422.4	375.8	55.6	-14.5	-25.4	-40.4	-48.4	-46.6	-11.3	-40.4
	324	200	246.4	407.1	387.3	370.1	316.7	291.6	394.0	450.9	513.4	506.3	473.0	451.5	399.2	357.7	62.5	-7.2	-33.3	-21.5	-52.3	-41.5	-29.6	-36.3
	326	200	248.7	365.9	383.9	369.7	325.7	323.2	398.5	434.3	517.5	506.0	483.9	461.1	417.0	379.7	83.2	-11.6	-22.0	-22.8	-44.1	-37.3	-4.1	-18.7
	328	100	303.2	354.4	401.2	388.6	344.2	344.3	415.3	451.0	531.6	514.1	498.3	473.3	436.9	423.3	80.7	-17.6	-15.7	-25.0	-36.4	-13.6	22.1	8.0
Reach 7	330	200	180.0	209.7	240.4	281.7	302.3	280.4	263.7	250.3	278.6	302.1	332.8	360.6	382.1	389.2	28.3	23.5	30.7	27.8	21.5	7.1	148.8	125.5
	332	200	507.1	560.5	574.5	619.8	650.7	685.0	665.3	630.3	656.8	681.9	696.6	722.6	758.7	795.1	26.5	25.1	14.6	26.0	36.1	36.4	220.6	129.8
	334	200	473.1	528.3	548.0	573.4	611.3	652.3	633.1	605.6	626.0	648.9	655.3	672.1	697.1	728.3	20.4	22.9	6.3	16.8	25.1	31.1	180.3	95.2
	336	200	459.8	519.2	516.9	524.7	567.2	612.2	609.7	584.2	609.9	620.4	620.6	632.4	648.5	666.6	25.8	10.4	0.3	11.7	16.1	18.1	149.7	56.9
	338	200	444.2	500.0	467.9	467.4	504.7	551.0	563.4	546.9	561.2	566.5	573.2	583.5	597.7	610.5	14.3	5.2	6.7	10.4	14.2	12.8	142.6	47.2
	340	200	438.0	495.3	448.3	441.8	472.8	514.8	521.5	509.3	513.6	519.2	527.6	543.6	553.9	567.9	4.4	5.6	8.4	15.9	10.3	14.0	119.6	46.3
	342	200	481.5	505.0	481.8	470.4	506.3	530.0	530.3	521.2	517.8	517.6	527.2	543.4	557.7	565.4	-3.5	-0.2	9.7	16.2	14.3	7.7	83.6	35.1
	344	200	444.6	456.2	444.4	431.6	459.1	479.0	473.7	462.9	459.3	458.3	462.5	475.3	483.5	492.5	-3.6	-0.9	4.1	12.8	8.2	9.1	48.1	18.8
	346	200	437.6	438.2	433.4	421.3	440.1	454.6	448.2	443.1	437.6	431.9	434.7	437.4	449.2	451.8	-5.5	-5.8	2.8	2.7	11.7	2.6	18.4	3.6
	348	200	380.9	378.1	378.0	364.8	376.9	384.5	393.9	388.8	391.1	380.7	384.7	383.0	383.2	384.4	2.2	-10.3	4.0	-1.8	0.3	1.1	6.3	-9.5
	350	200	429.8	430.5	426.0	424.2	432.6	446.1	453.7	453.3	455.6	449.5	444.6	444.4	443.1	439.4	2.3	-6.0	-4.9	-0.2	-1.3	-3.7	13.4	-14.4
	352	200	422.4	423.1	414.2	417.6	421.9	437.4	442.1	444.9	449.0	442.2	436.1	434.3	428.2	421.3	4.1	-6.8	-6.1	-1.8	-6.1	-6.9	7.1	-20.8
	354	200	436.8	438.7	430.2	437.0	445.0	453.9	448.7	450.9	456.2	452.5	443.4	442.7	436.5	422.1	5.3	-3.7	-9.0	-0.7	-6.2	-14.4	-8.1	-26.6
	356	200	447.7	447.2	438.3	444.1	453.3	454.9	443.1	443.0	448.1	448.6	440.4	437.1	425.3	402.3	5.1	0.5	-8.2	-3.3	-11.7	-23.0	-36.0	-40.7
	358	200	413.8	411.0	399.5	412.2	422.4	402.8	384.9	384.2	387.7	387.8	385.4	379.6	362.3	353.5	3.5	0.1	-2.3	-5.8	-17.2	-8.9	-46.0	-31.5
	360	200	405.8	402.9	391.3	402.3	413.2	380.7	359.6	360.5	361.5	364.7	363.8	355.1	340.3	347.6	0.9	3.3	-0.9	-8.7	-14.8	7.4	-43.7	-12.0
	362	200	394.5	392.3	386.8	400.4	402.3	360.4	339.0	340.4	344.5	346.1	347.4	337.1	327.3	338.4	4.2	1.6	1.2	-10.2	-9.9	11.1	-48.4	-0.6
	364	200	352.4	352.7	356.0	362.2	337.8	311.6	297.8	296.3	300.8	294.9	303.3	297.8	288.4	284.3	4.6	-5.9	8.4	-5.5	-9.5	-4.0	-71.6	-13.5
	366	200	413.5	410.9	412.8	402.6	405.0	408.5	397.7	379.3	397.7	390.7	393.8	395.1	385.0	380.3	18.4	-7.0	3.1	1.3	-10.1	-4.7	-32.5	-17.4
	368	200	538.8	544.3	538.9	534.6	538.0	566.5	575.5	584.1	557.1	537.6	558.4	563.3	550.0	537.9	-27.0	-19.5	20.8	4.9	-13.3	-12.1	-1.0	-37.6
	370	0	520.1	0.0	579.5	583.1	503.3	611.5	647.1	666.6	611.7	584.3	604.9	606.8	604.0	602.2	-54.9	-27.4	20.6	2.0	-2.8	-1.8	22.6	-44.9

4.2 Project Area Reaches

The 2018 nourishment project placed sand along most of reaches 5 and 6 at the eastern end of the island. Reach 7 is included in this section as a portion of it was nourished in the 2008 project.

4.2.1 Reach 7

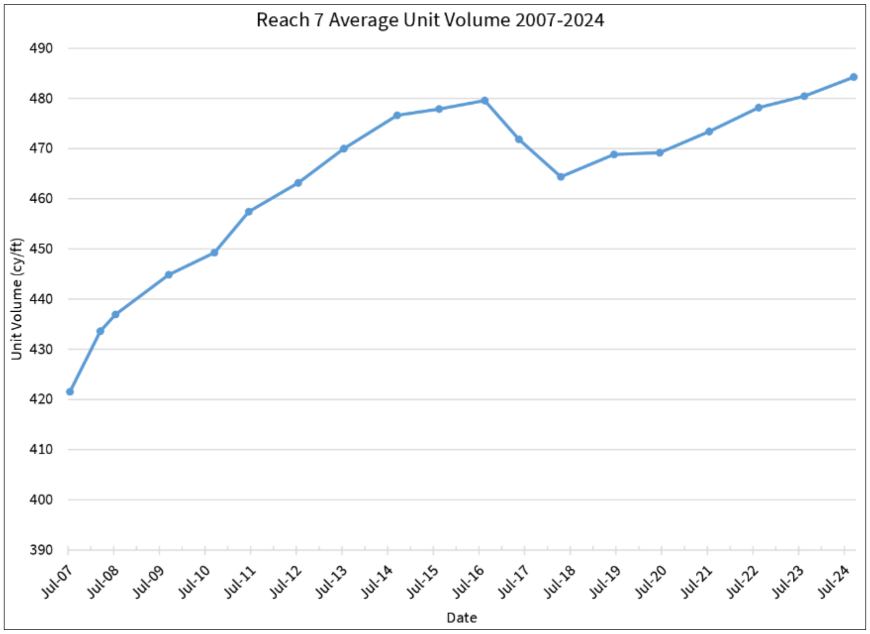
Reach 7 encompasses the beach between lines 330 and 370 that span the shoreline fronting the Dewees Inlet channel (Figure 4.4). The inlet shoals shelter this portion of beach from the largest open-water waves, so the profile generally features a narrow, dry sand berm and a steep beach face. The steep beach face reduces the total profile volume needed for a stable profile compared to oceanfront areas. The seaward end of the reach was included in the 2008 nourishment project and has traditionally exhibited relative stability in beach volumes.

FIGURE 4.4. Baseline stationing along Reach 7 encompassing the length of beach between lines 330 and 370.

Except for an erosional period from 2017 to 2018 and one in 2023, Reach 7 has remained stable or accretional since 2008 (Fig 4.5). From August 2023 to September 2024, the reach gained ~15,000 cy (3.8 cy/ft). Within the reach, the volume change pattern has remained consistent over the past several years, with stable gains along the seaward end of the reach, while the inland portion of the reach is variable. The stable gains are due to sand moving north from nourishment and shoal attachments in Reach 6, while the variability along the inland profiles is due to irregularities in sand loss into the inlet and marsh.

Since 2018, there has been an erosional 'wave' moving north and west (inland) along Reach 7. The highest losses along individual profiles have shifted from Station 340 between 2018 and 2019 north and west to Station 360 between 2023 and 2024. Fortunately, these profiles are located along an undeveloped portion of the beach well within Dewees Inlet, such that any minor to moderate chronic erosion – like that observed in the last ~6 years – does not represent a significant threat to life or property.

Accretion at the seaward end of the reach has led to an increase of over 260 ft of berm width since 2008, including over 150 ft of seaward advance in the high water line since 2018 at Station 334. All stations seaward of the 17th tee (groin) show at least 10 cy/ft more sand than the most eroded condition since 2008 (Fig 4.5). Ground photos from the reach show that the berm is transitioning into a healthy dune field, with no visible escarpments and reduced areas of dry sand as vegetation cover increases. Photos from further inland also show a healthy dry-sand beach with vegetation-covered dunes well landward of the typical high tide line (Fig 4.6).



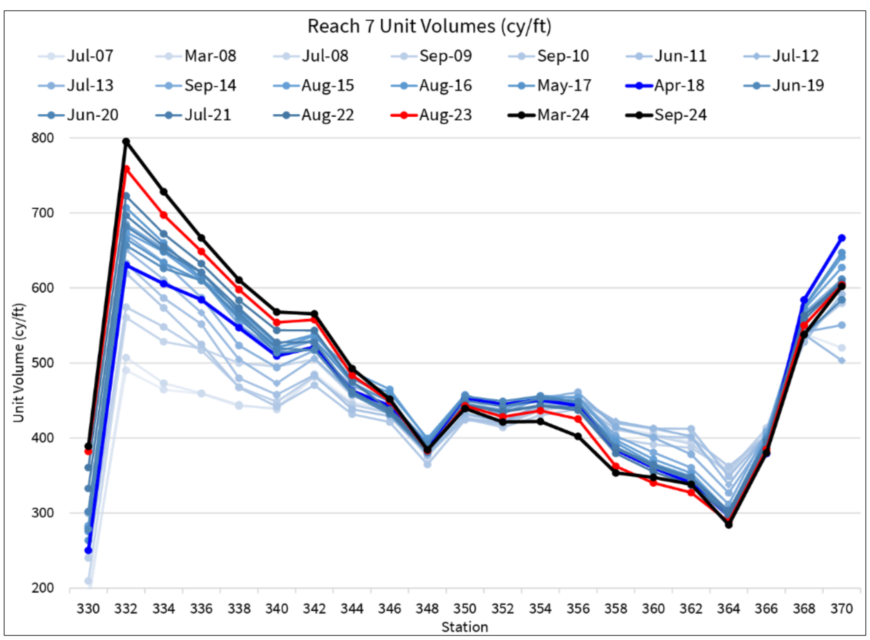
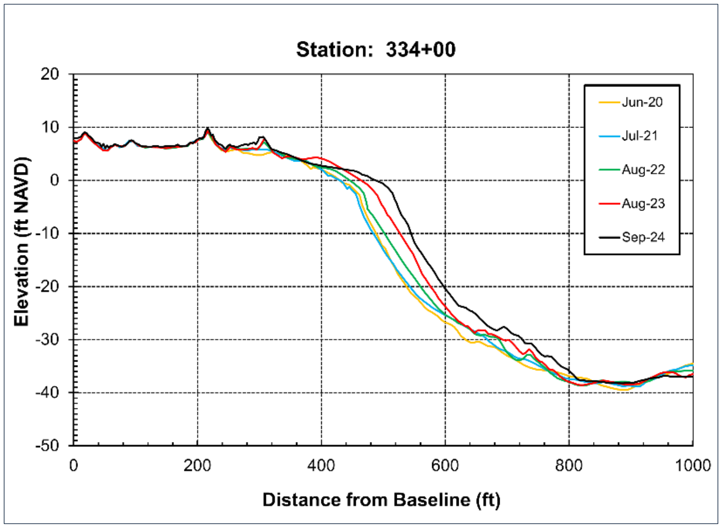


FIGURE 4.5. **[UPPER]** Average beach volume in Reach 7 since 2007. **[LOWER]** Profile unit volumes for each monitoring line in Reach 7.



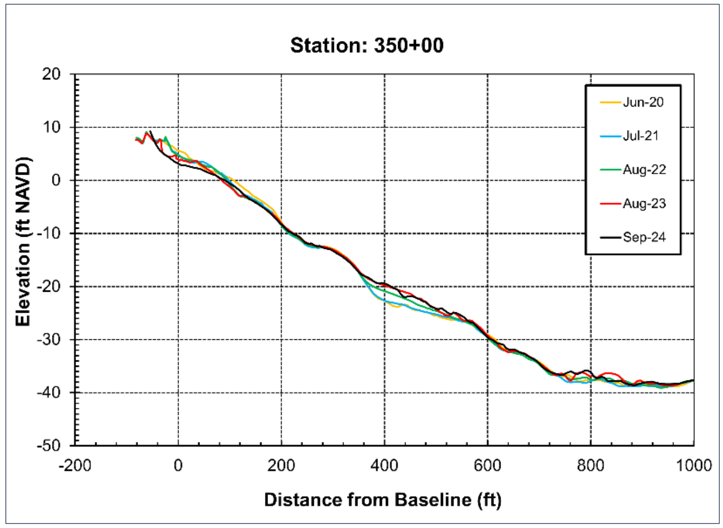


FIGURE 4.6.
[UPPER] Beach profiles from Reach 7.

[MIDDLE] Aerial photo of Reach 7 collected September 2024.

[LOWER] Ground photos from Station 334 **[LEFT]** and Station 346 **[RIGHT]** in September 2024.

4.2.2 Reach 6

Reach 6 encompasses ~4,900 linear feet of beach between the Wild Dunes Property Owners Beach House (Station 280) and the 18th hole of the Links Course (Station 328+00) (Figure 4.7). This area is along the 'corner' of the shoreline between Dewees Inlet and the open ocean and is where shoals attach as part of cyclical bypass events from the inlet. Depending on the location and magnitude of the bypass, the shoreline can move hundreds of feet landward or seaward over the course of just a few months (Kana et al 1985, Gaudiano 1998).

FIGURE 4.7. Baseline stationing along Reach 6 encompassing ~4,900 lf of beach between Wild Dunes Property Owners Beach House and the 18th hole of the Links Course.

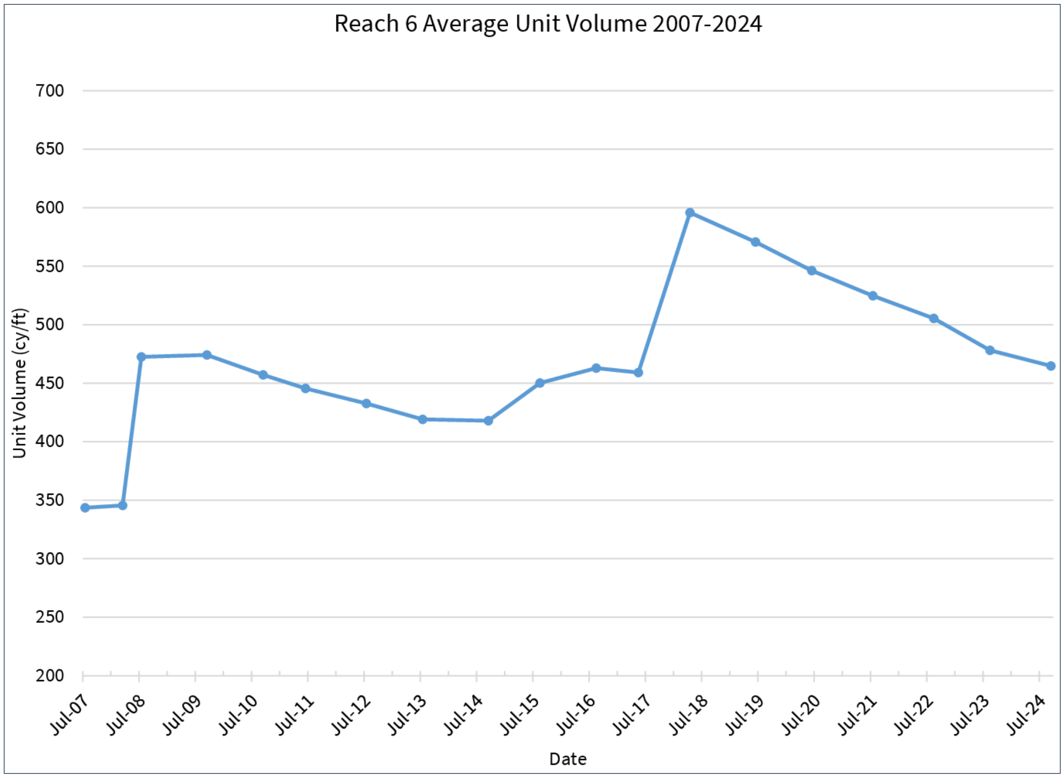
Reach 6 experiences regular shoal attachment (bypass) cycles. The time elapsed between these events varies due to variations in the magnitude and speed of an individual shoal; however, since the 1940s, these events have tended to occur within a decade of one another. Due to the dynamics of these shoal bypass events (see Fig 2.3), Reach 6 often experiences dramatic erosion and accretion simultaneously. As a shoal approaches, volumes increase in the immediate vicinity of the attachment area between the shoal and beach. Wave refraction around the shoal concentrates erosion on either side, often just a few hundred feet up or down the coast. As the shoal attaches to the beach, sand spreads laterally and fills in the erosional arcs cut on either side of the attachment zone.

Since the 2008 project, CSE surveys have identified multiple attachment events along Reach 6. These events have led to variable rates of erosion and accretion along every profile in the reach. To that point, although Reach 6 has lost ~46,000 cy (–9.4 cy/ft) since the 2008 project, it has gained ~28,300 cy (5.8 cy/ft) since the 2018 project (Fig 4.8 upper). Not including the 2018 nourishment volume, the reach has lost sand in most surveys but tends to regain much of the lost volume over the course of the periodic bypass events. While these shoals deliver significant sand volumes to the reach relatively quickly, they have not been sufficient to fully counteract long-term erosion. Over the past 20 years, shoal attachments have not been able to compensate for the persistent erosion observed in the area.

Reach 6 lost 65,150 cy (13.3 cy/ft) of sand from August 2023 to September 2024. This is the lowest loss recorded since May 2017, before the 2018 project. Since completing the 2018 project, Reach 6 has lost ~642,000 cy (131.0 cy/ft). This represents more than 95% of the nourishment volume added in 2018; however, several profiles along the western end of the reach have documented significant volume increases over the post-project period. Stations 280–292 show an average gain of 78.6 cy/ft compared to the pre-project condition, whereas Stations 294–328 show an average loss of 22.5 cy/ft of sand compared to pre-nourishment conditions.

A significant amount of the volume increases measured along the western end of the reach are due to an ongoing shoal bypass event between Mariner's Walk and Dunecrest Lane. For instance, up until the August 2022 survey, Stations 280–292 (mentioned above) actually lost 53.5 cy/ft from 2018 to 2024 (largely due to sand spreading from the 2015–2016 shoal attachment). Compare the offset in unit volumes measured along individual profiles from west to east, and from April 2018 to August 2023 to September 2024 (Fig 4.8 lower). The greatest volume losses from 2018 to 2023 were among the westernmost profiles in Reach 6. These same profiles have recorded the greatest volume increases (>100 cy/ft) from 2023 to 2024.

Aerial and ground photos of the reach taken in September 2024 document the recent variability in beach and dune volumes (Figs 4.9 and 4.10). Whereas the western portion of the reach contains relatively healthy and continuous vegetation along the upper dry-sand beach and dunes, cover along the eastern portions of the reach is sparse to nonexistent. Around the Ocean Club, there is little-to-no dry-sand beach protecting structures.



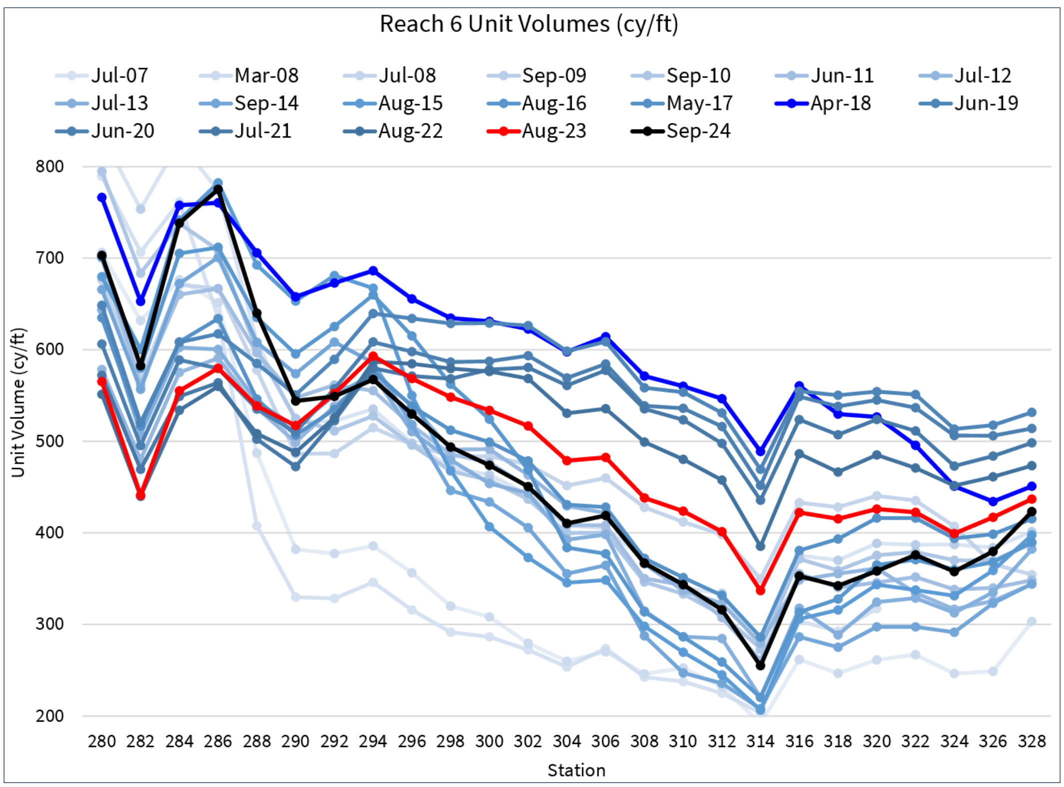
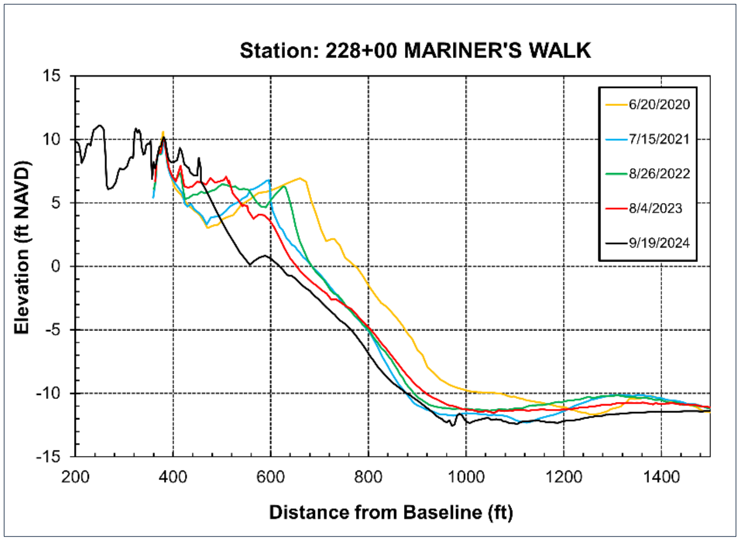


FIGURE 4.8. [UPPER] Average beach volume in Reach 6 since 2007. [LOWER] Profile unit volumes for each monitoring line in Reach 6.



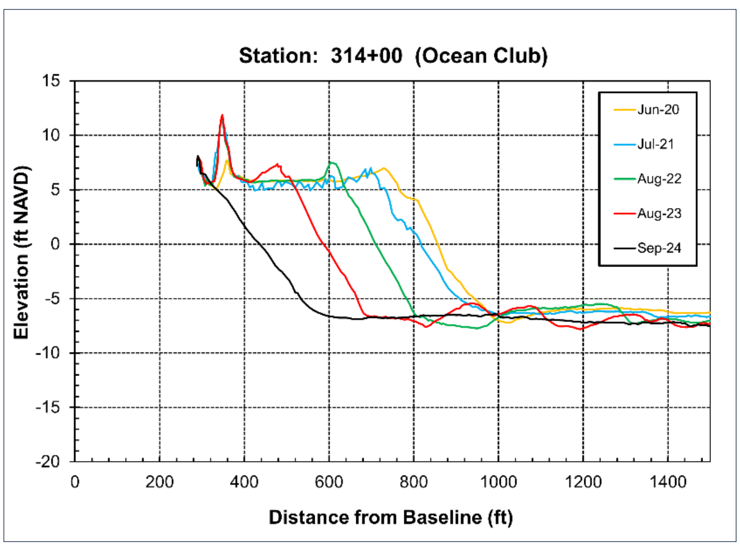


FIGURE 4.9. [LEFT] Reach 6 profiles. The rapid erosion in this area is suspected to be a continuation of the higher erosion trend observed prior to the 2018 project. **[RIGHT]** Aerial photos collected in September 2024.

FIGURE 4.10. Ground photos from Station 284 **[UPPER]** and Station 316 **[LOWER]** in September 2024.

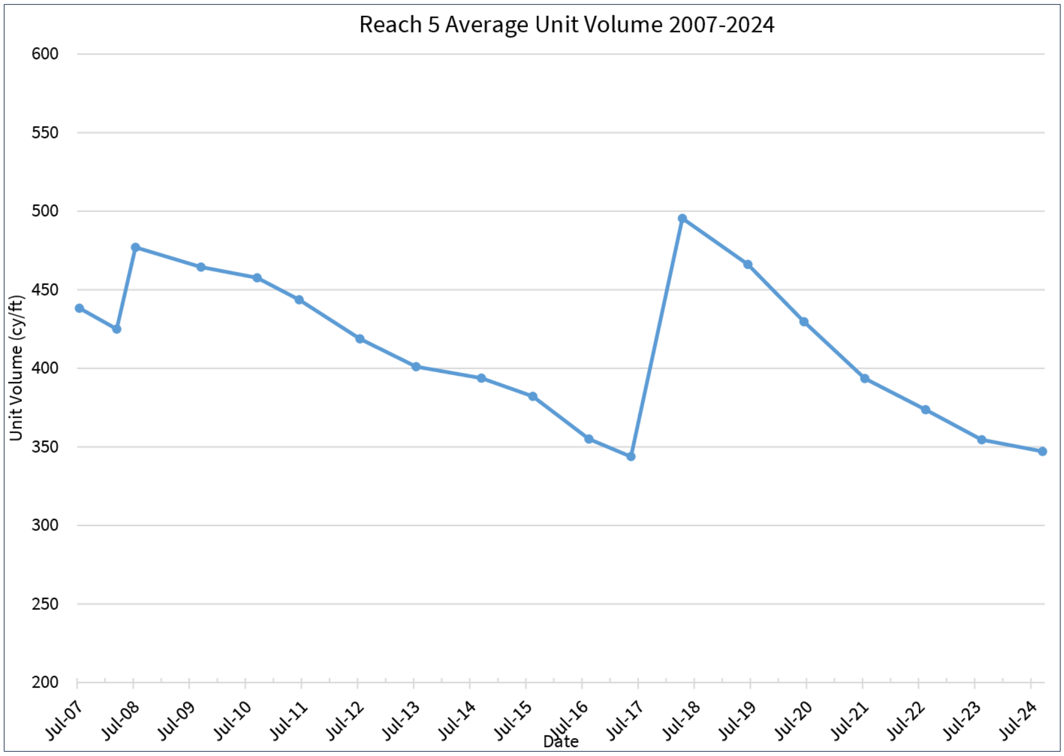
4.2.3 Reach 5

Reach 5 includes ~5,800 lf of beach between 53rd Avenue and the Wild Dunes Property Owners Beach House (Stations 222–280 – Figure 4.11). The central and eastern portions of Reach 5 are strongly influenced by shoal-bypass events, much like Reach 6. An important difference between Reaches 5 and 6, however, is that because the shoals tend to attach along Reach 6, Reach 5 tends to experience the waves of erosion and accretion during and after shoal bypass events: while Reach 6 has experienced accretion as well as erosion over the years, Reach 5 tends to exhibit more erosion over the long term.

FIGURE 4.11. Baseline stationing along Reach 5 which spans ~5,800 lf of beach between 53rd Avenue and Wild Dunes Property Owners Beach House.

Although the 2008 nourishment project added ~318,000 cy of sand to the reach, an erosional wave moved from east to west across Reach 5 from 2009 through 2016. Shoal bypassing brought volume increases to the eastern portions of the reach between 2013 and 2014, but these were quickly negated by the damage associated with Hurricane *Matthew*. Following the 2018 project, which brought volume increases of ~909,000 cy of sand (151.6 cy/ft), Reach 5 has lost ~890,400 cy (148.4 cy/ft) — effectively the entire project volume (Figure 4.12). As of September 2024, the reach contains less than 5% of the 2018 project volume. However, it's important to note that these losses are not evenly distributed. Areas near the Grand Pavilion and the eastern portion of the reach continue to exhibit a healthy beach profile.

Losses measured since the 2018 project have been particularly high along Beachwood East, especially across approximately 1,000 ft of shoreline. Such changes in beach conditions along isolated areas are known as ‘hot spots’ and can be driven by variations in nearshore bathymetry (Kraus and Galgano 2001). As shoals move ashore on the east end of Reach 5 and at the Wild Dunes Grand Pavilion, the gap along Beachwood allows higher waves to pass through. This leads to concentrated wave energy along relatively short lengths of beach. Based on anecdotal observations of the ongoing shoal bypass event along Reaches 5 and 6, it is probable that such a change in wave energy along the Reach has driven the recent dramatic erosion along Beachwood East.



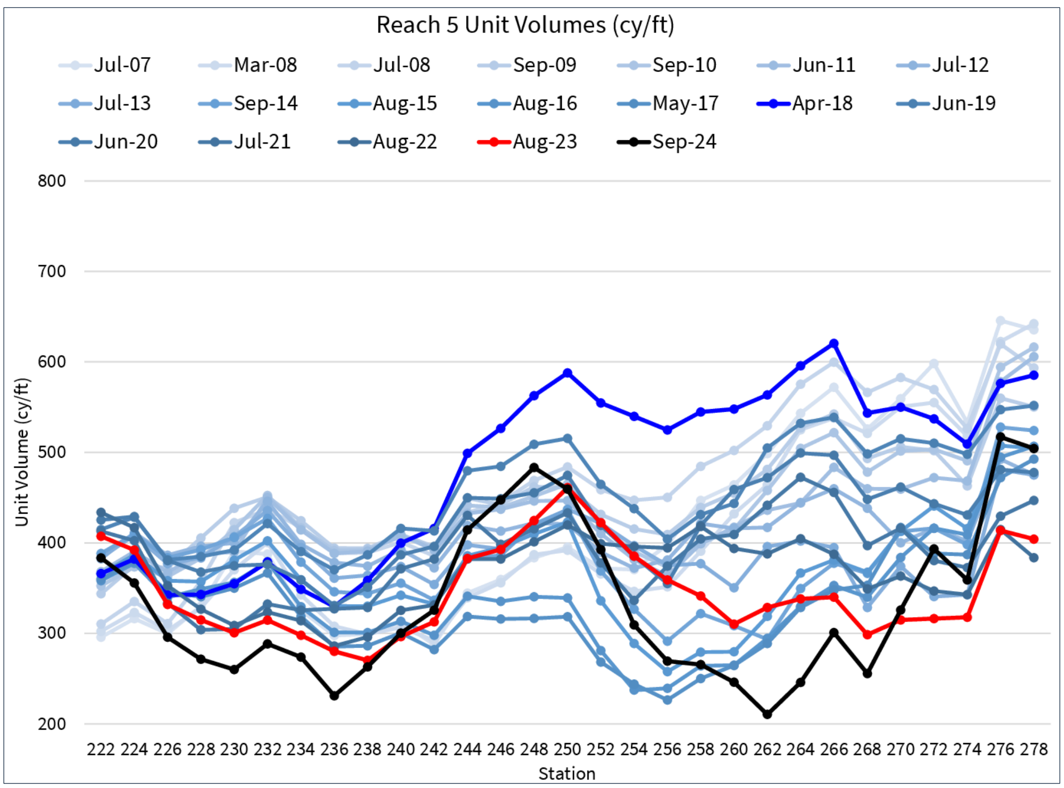


FIGURE 4.12. [UPPER] Average beach volume in Reach 5 since 2007. [LOWER] Profile unit volumes for each monitoring line in Reach 5.

Reach 5 lost ~44,500 cy (–7.4 cy/ft) from August 2023 to September 2024. This is among the lowest levels of erosion documented along the reach since the 2008 project. That said, some profiles along Beachwood East exhibited losses up to 100 cy/ft or more from 2023 to 2024. These losses were offset by volume increases of 100 cy/ft along the eastern portion of the reach, where shoal sand is nearing attachment and is now included in beach volume calculations.

The variability in erosion and accretion rates along Reach 5 is worth mentioning here, as it underlines the range of beach conditions and volume changes along relatively small lengths of beach due to shoal bypass events. Within the reach, changes from 2023 to 2024 along individual profiles ranged from –118.0 cy/ft to +103.3 cy/ft.

Accretion was measured between Stations 240 and 248 as well as Stations 270 and 278; both of these areas are located along shoal attachment points, and the accretion along these reaches mostly occurred along the underwater zone but has helped maintain a healthy dry-sand beach (Figs 4.13 and 4.14). From Stations 250 to 268, wave refraction across low points in the shoal has concentrated erosion and triggered higher-than-normal losses along Beachwood East.

4.2.4 Summary of East End Changes

Overall, the 2018 project area reaches (5 and 6) have lost ~1,532,400 cy (–140.6 cy/ft) of sand from April 2018 to September 2024. This value equates to an annual loss of 23 cy/ft per year and represents nearly ~100% of the nourishment quantity. Historical erosion rates along the eastern end of the island are variable but generally fall between 5–10 cy/ft per year (CSE 2007). The higher erosion rates are likely due to a combination of shoal configuration and storm timing from 2016 through 2024, but could also be impacted by rising sea levels (discussed in Section 5). CSE has observed higher than typical erosion rates along several beaches in the Charleston area over the same period.

While the magnitude of the erosion is high, beach conditions along much of the Wild Dunes area remain similar to or better than before the 2018 project. Erosion has occurred along the central portion of Wild Dunes, and much of the shoreline along Reaches 5 and 6 retains at least 100 ft more beach width than the 2017 condition (Fig 4.15). Notable exceptions to this trend are near the 59th Avenue access, Beachwood East, and Ocean Club. As the ongoing shoal bypass event continues and sand begins spreading laterally, some of the recent losses along these areas should begin to reverse, and some accretion – albeit temporary – is anticipated.

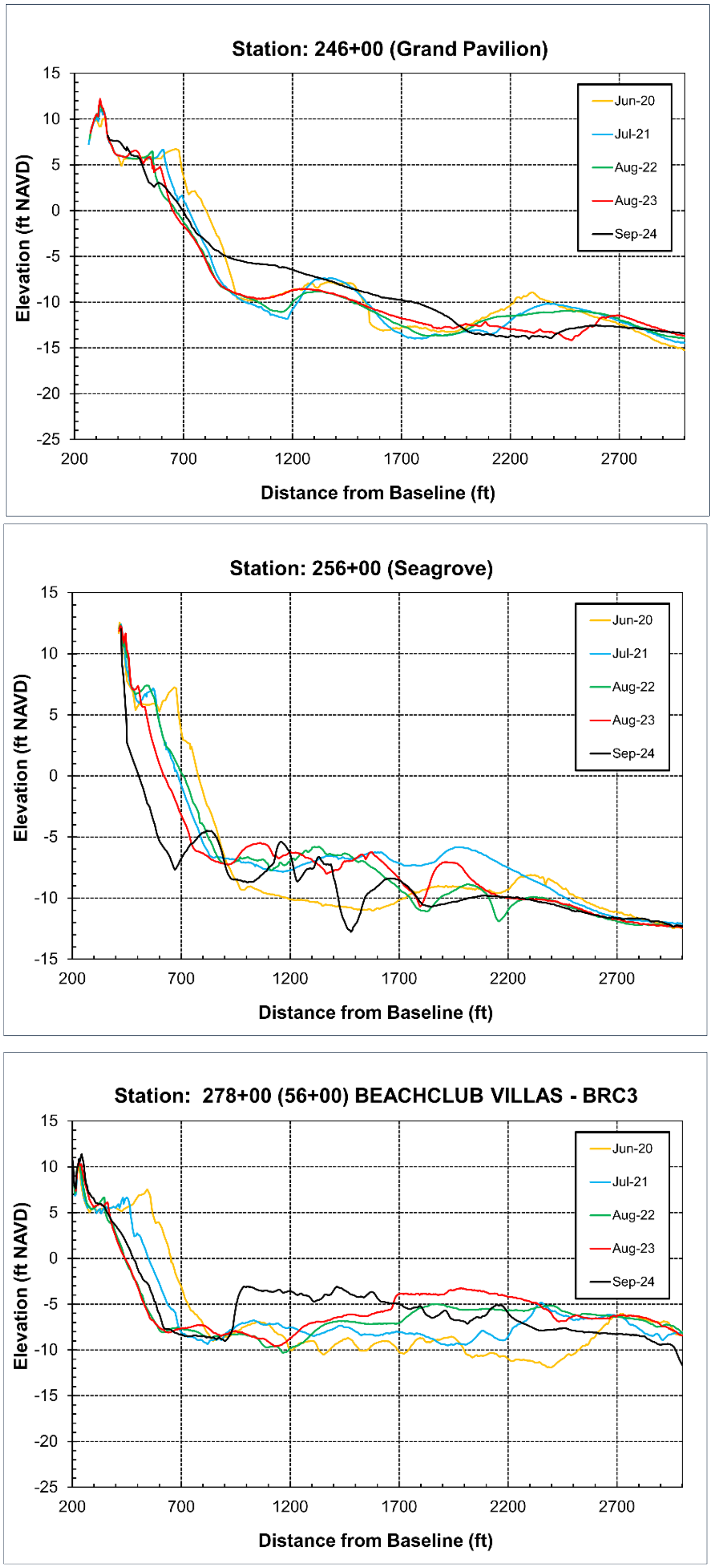


FIGURE 4.13. Reach 5 profiles.

FIGURE 4.14. Ground photos of Reach 6 in September 2024 showing Station 236 **[UPPER LEFT]**, Station 244 **[UPPER RIGHT]**, Station 252 **[MIDDLE LEFT]**, and Station 272 **[MIDDLE RIGHT]**. Aerial photos from September 2024 are shown in the bottom two photos.

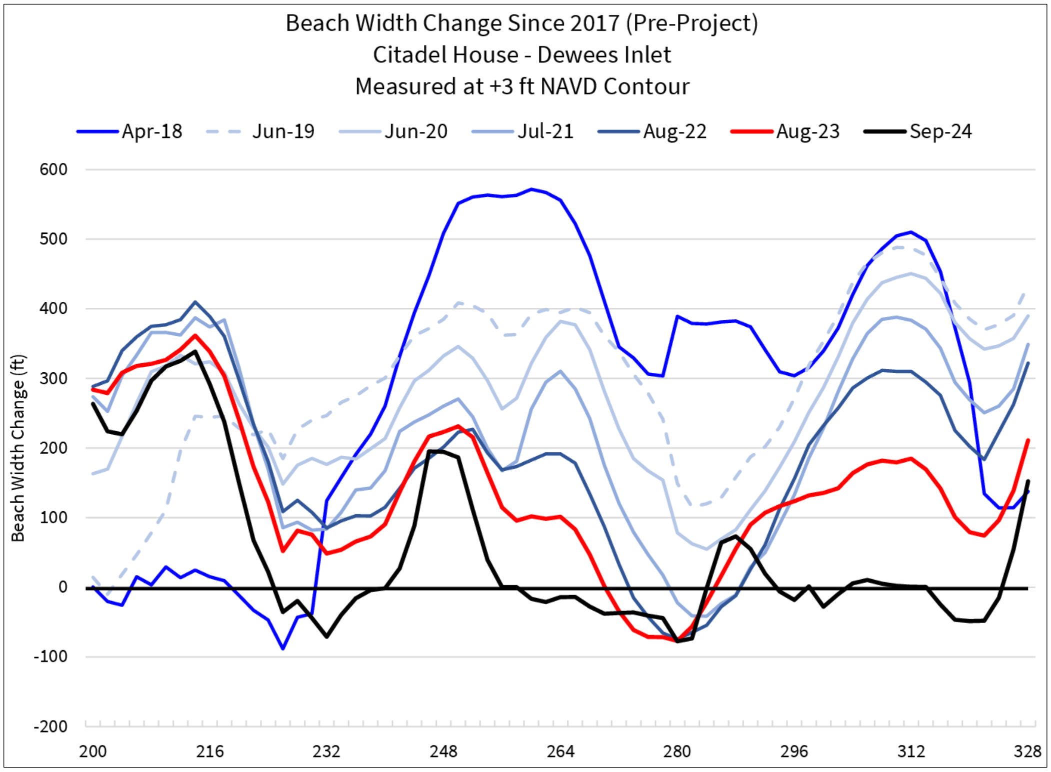


FIGURE 4.15a. Beach width changes along the area spanning the Citadel House to the 18th hole of the Links Course. Note the greater losses around Stations 230 (55th Ave) and 270–280 (Beachwood). Also, note the extensive accretion present south of the 2018 project area (left side of the image from Stations 200–230).

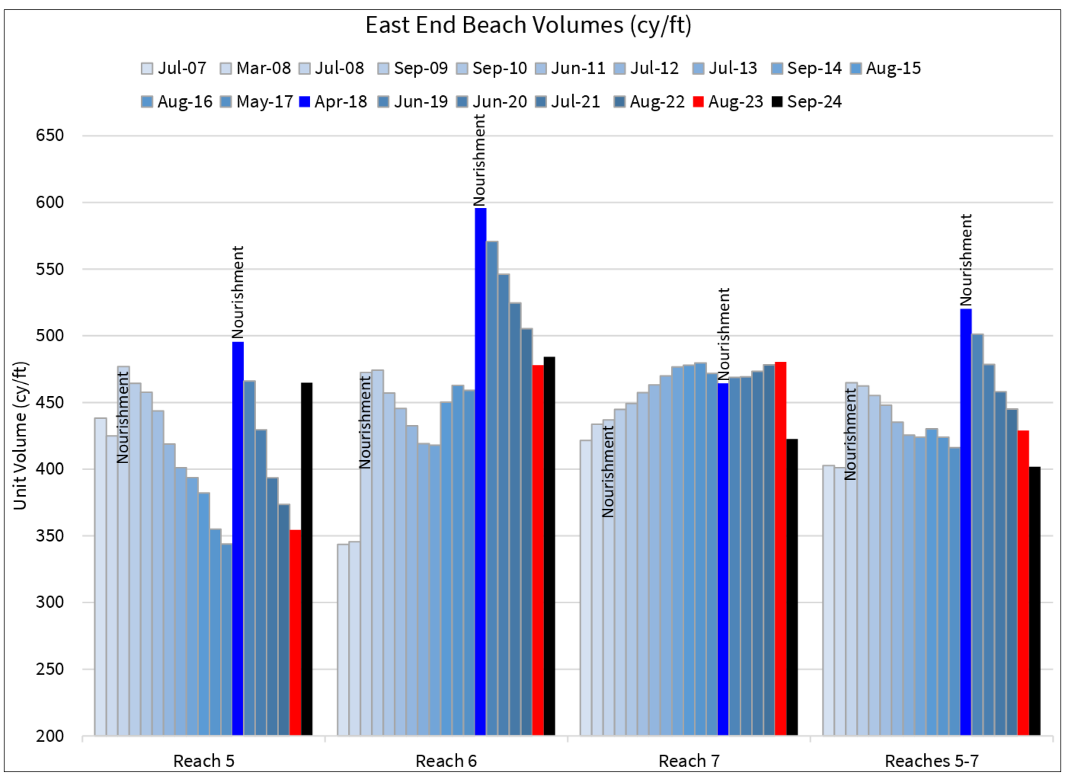


FIGURE 4.15b. The beach volume history of the eastern end of the island since 2007, with dates following nourishment indicated.

Figure 4.16 provides the beach volume history of the eastern end of the island since 2007, with dates following nourishment indicated. The overall erosional trend is evident along Reaches 5 and 6 between nourishment projects, each of which restores sand volumes to maintain a dry beach and protective dune. Sand lost from Reaches 5 and 6 either moves south to provide sediment to the rest of Isle of Palms, or recycles to Dewees Inlet, which will eventually form a shoal and recycle back to the beach (as is currently happening).

Annualized erosion rates from 2018 through 2024 are 150% higher than those observed in the preceding decade (see Fig 4.16). It is likely this increased erosion is due to the relatively high number of impactful storms (both tropical and non-tropical) the Charleston area has experienced since 2016, as well as increased water levels due to ongoing sea level rise. CSE has observed similar increases in year-to-year erosion rates along several beaches across South Carolina and is closely tracking these changes as they affect the projected lifetimes of nourishment projects and related funding cycles in local communities.

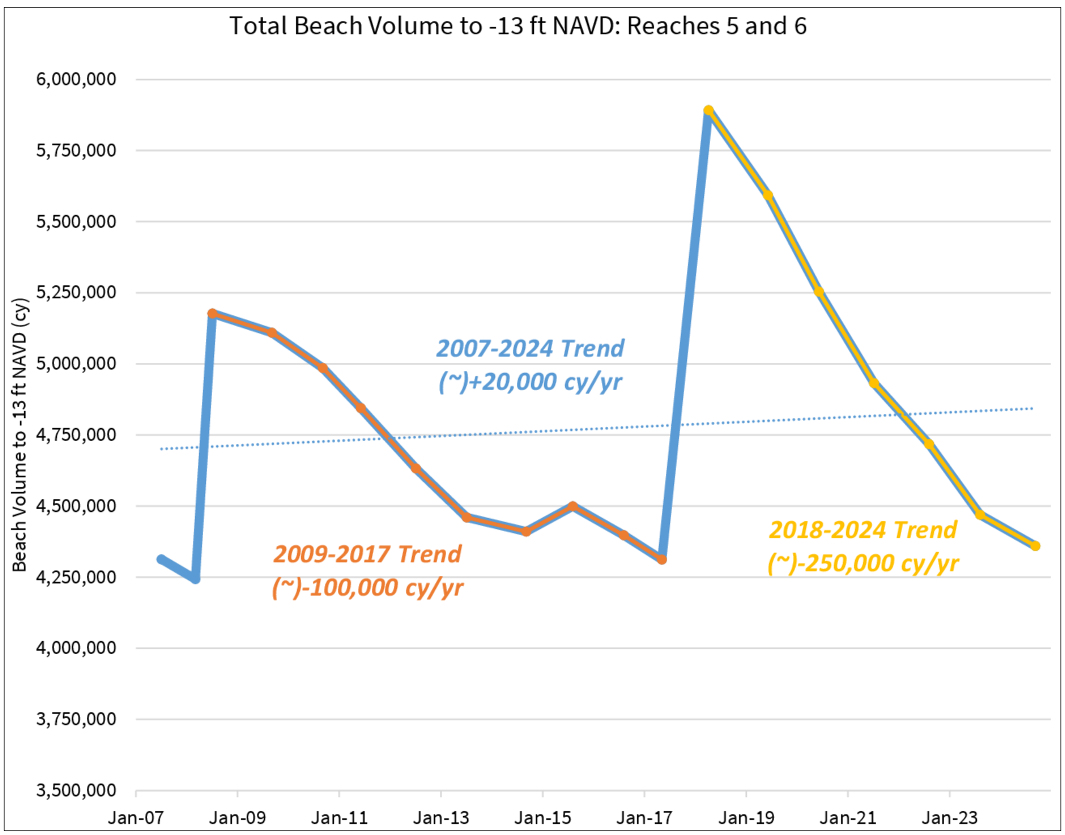


FIGURE 4.16. Total beach volume history of the eastern end of the island since 2007. The graph illustrates the overall erosional trend along reaches 5 and 6 between nourishment projects.

4.2.5 Reach 4

Reach 4 includes the length of beach between 31st and 53rd Avenues (Stations OCRM 3140 to CSE 222+00 – Fig 4.17 and Fig 4.18). This reach is ~7,910 ft long and immediately downdrift of the 2008 and 2018 project area. It is also outside Dewees Inlet's direct influence and maintains a more typical and consistent beach profile shape. By being positioned downdrift of the nourishment area, it receives nourishment sand spreading from the placement area as well as spreading shoal sand. The reach has gained sand every year since 2009 except for 2016, the year after Hurricane *Matthew* impacted the Isle of Palms.

FIGURE 4.17. Baseline stationing along Reach 4 spanning the length of beach between 31st Ave and 53rd Ave.

The reach receives sand eroded from the island's east end, particularly reaches 5 and 6, with that sand originating from shoal bypass events or nourishment. A significant influx of sand has been observed along the reach since the 2018 project, with an accretional wave propagating south. The leading edge of the spreading sand is visible as a span of high accretion relative to adjacent areas. Over time, the magnitude of the accretion wave decreases as sand spreads at uneven rates. The peak in accretion along individual profiles reached ~70 to 80 cy/ft between Stations 214 and 208 (in 2019 and 2020, respectively), but has subsided to ~20 to 30 cy/ft between Stations 180 and 150 (in 2023 and 2024, respectively). Accretion has led to the creation of a new dune ridge and wide dry-sand beach along the reach (Fig 4.19).

Reach 4 gained ~28,300 cy (3.6 cy/ft) of sand from August 2023 to September 2024. As of September 2024, the reach contains nearly 945,200 cy more sand than the 2009 condition, including a net gain of 509,400 cy since 2017. While the reach still trends accretional since 2017, Stations 190 to 220 all experienced moderate losses over the past year. This trend extends into the southern part of Reach 5 and is likely due to the downcoast spreading of sand from the highly accretional area following the 2018 project. The erosion in this area is partially the result of an upstream pause in sediment supply as sand from the east is now moving behind the shoal instead of continuing south, thereby interrupting the sediment transport. Some of the erosion may also be influenced by the small shoal attachment near the Grand Pavilion.

FIGURE 4.18. September 2024 aerial photo of Reach 4 (53rd Avenue is at the middle of the image). By being positioned downdrift of the nourishment area, Reach 4 receives nourishment sand spreading from the placement area as well as spreading shoal sand. This reach has gained sand every year since 2009 except 2016. As the vegetated dunes expand, sheltered locations (such as low-lying areas behind protective dune ridges) will gradually transform into a shrub habitat with larger areas of wax myrtle replacing dune grasses. The 2008 dune line is shown by the red arrow.

Reach 4 has gained 945,200 cy (+119.5 cy/ft) since 2009 and 554,400 cy (+70.1 cy/ft) since 2017. Individual profiles show the dune width has increased by at least 50 ft along the reach, and the dry-sand beach by at least another 50 ft. Along the northern end of the reach, the beach is over 250 ft wider than the 2009 condition, with unit volume gains of over 155 cy/ft. This level of accretion is of similar magnitude to many large beach nourishment projects conducted along coastal communities in South Carolina and is equivalent to a $10–15 million nourishment investment. The dune has grown ~3–5 ft in elevation and offers substantially more storm protection than the 2009 condition.

While some continued accretion might occur in the near term, it is anticipated that the rate will be lower than prior years. With the current phase of shoal bypassing and a reduction in the accretional area, CSE expects to see some erosion of Reach 4 in the next 1–2 years. **Combined with Reach 3, there is a net gain of 1,185,000 cy of sand along the downcoast areas of Isle of Palms (Sea Cabins Pier to 53rd Ave), which is a direct benefit of the 2008 and 2018 nourishment projects.**

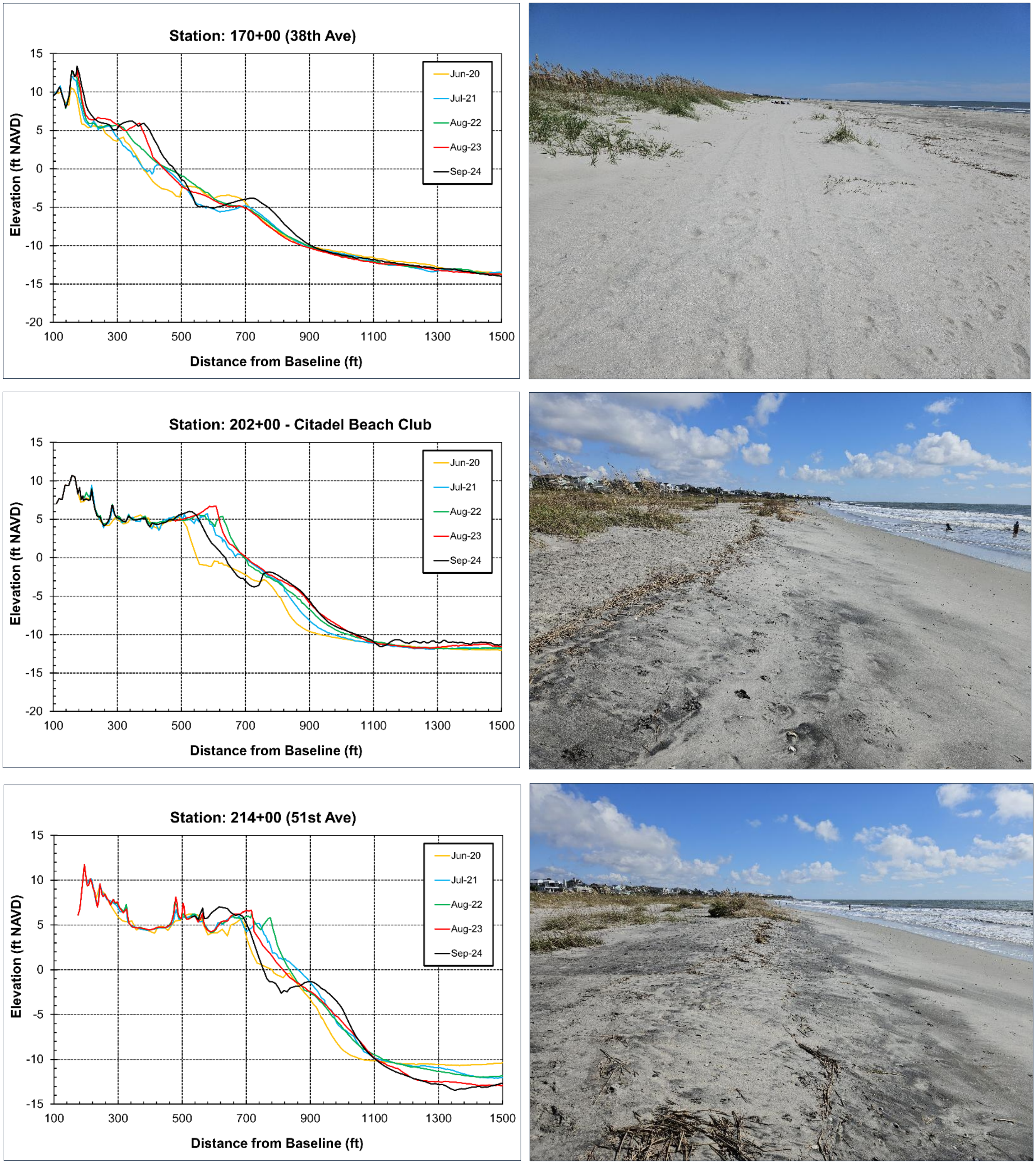


FIGURE 4.19. **[LEFT]** Profiles along Reach 4 show accretion has led to gains of over 300 ft of dry sand width and formation of new dune ridges. **[RIGHT]** Ground photos from Station 170 **[UPPER]**, Station 202 **[MIDDLE],** and Station 214 **[LOWER]** in September 2024.

4.2.6 Reach 3

Reach 3 extends from the Sea Cabins Pier to 31st Avenue (OCRM monuments 3125 to 3140 – Fig 4.20 and Fig 4.21). Like Reach 4, the long-term trend in this area is stable to accretional. Dwellings in the reach are well set back from the beach, generally between 400 ft and 500 ft, except at the western end where Sand Dune Lane and the county park are set back ~150 ft. The reach has shown periods of erosion and accretion since CSE began island-wide monitoring in 2009. This is typical for stable to moderately accretional beaches as variations in wave conditions from year to year and temporary changes in sediment supply lead to minor fluctuations in yearly volume change.

FIGURE 4.20. Baseline stationing along Reach 3 spanning the length of beach from the Sea Cabins Pier to 31st Ave.

FIGURE 4.21. Aerial photo of Reach 3 in September 2024 (24th Ave in the foreground). The long-term trend for Reach 3 is stable to accretional. Dwellings in the reach are generally set back from the beach between 400 ft and 500 ft.

From August 2023 to September 2024, Reach 3 gained 89,400 cy (15.9 cy/ft). The northern end of the reach gained volume from August 2023 to September 2024, with average increases of ~16 cy/ft between Stations 120 and 140. Station 3125 had the only recorded loss in the reach at –9.1 cy/ft.

Overall, the reach has gained ~138,400 cy since 2017 and ~340,600 cy since 2009. This is equivalent to an average annual accretion rate of 1.8 cy/ft/yr since 2017 and 4.3 cy/ft/yr since 2009. Profile plots from the reach (Figure 4.22) show that the dune continues to increase in width as it recovers from the series of hurricanes impacting the area from 2015 to 2022.

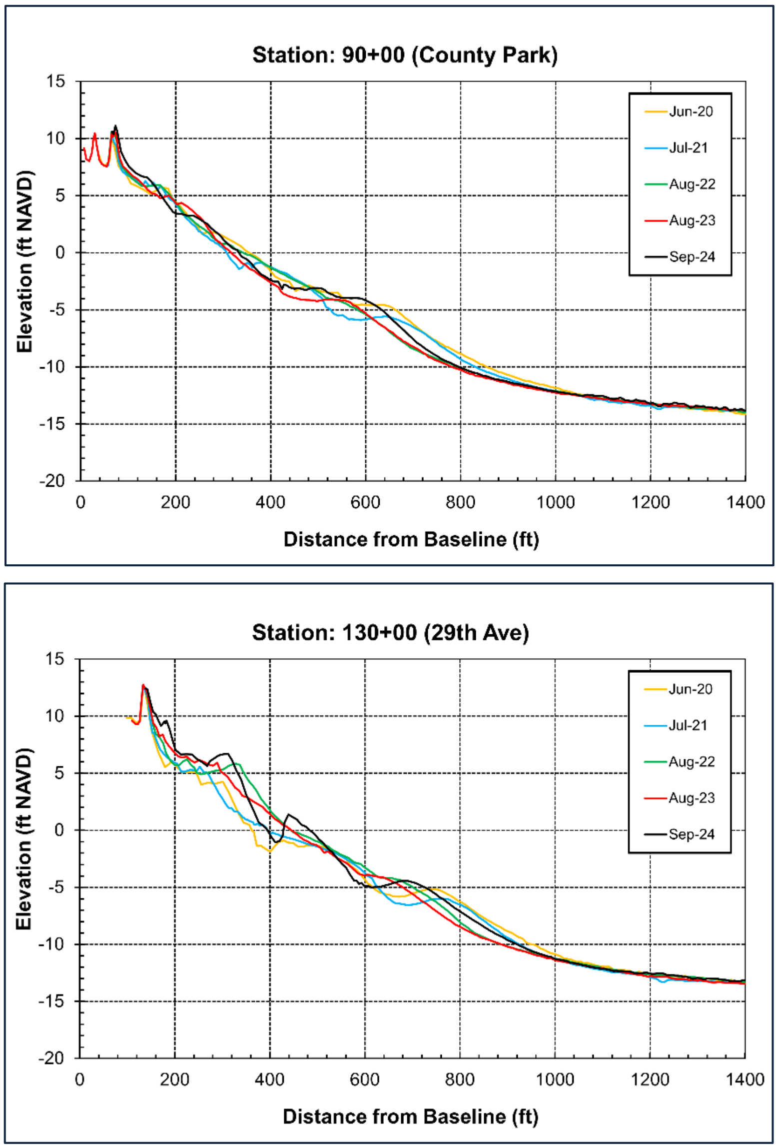


FIGURE 4.22. Example profiles from Reach 3. At Station 90+00, there was a net loss of volume due to movement of the underwater sandbar. The dry beach remained stable over the past year.

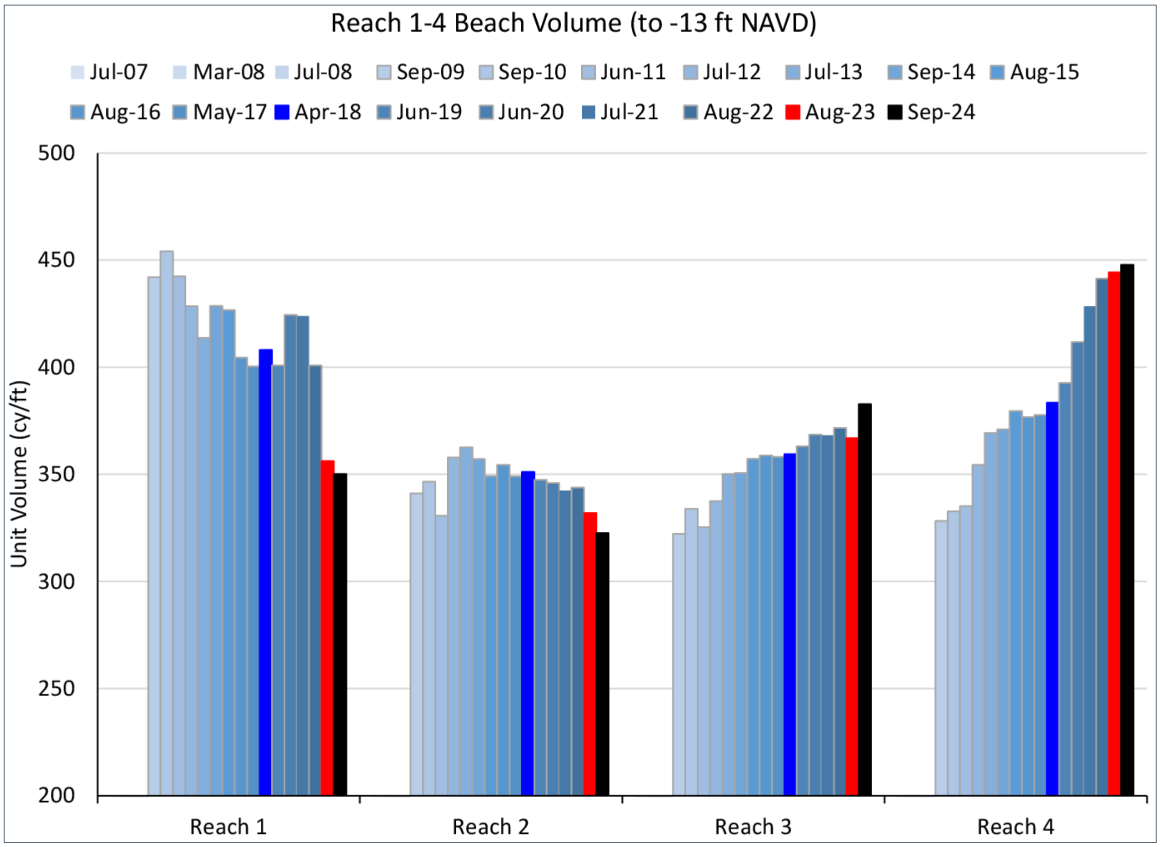


FIGURE 4.23. Reaches 3 and 4 have steadily gained sand since 2007, while Reaches 1 and 2 have experienced more erosion over the last 2–3 years relative to the long-term trends. This recent shift towards erosion in Reaches 1 and 2 is related to the dynamics of Breach Inlet and is addressed later in the report.

4.2.7 Reach 2

Reach 2 spans 4,280 ft between 6th Avenue and the Sea Cabins Pier (OCRM monuments 3115–2125 – Fig 4.24 and Fig 4.25). It includes the oceanfront commercial area at the eastern end of the reach. Reach 2 shows an erosion/accretion pattern like Reach 3, with intermittent periods of accretion and erosion and a long-term trend towards accretion. Since monitoring began in 2009, Reach 2 has been the most stable reach, with lower magnitude volume changes than all other reaches.

FIGURE 4.24. Baseline stationing along Reach 2 spanning between 6th Avenue and the Sea Cabins Pier.

Year-to-year changes in unit volumes along Reach 2 (Figure 4.23) highlight general trends of accretion and erosion over the past decade. Volume increases and/or relative stability tended to dominate from 2007 through the August 2016 survey. From August 2016 through April 2018, changes varied between relatively minor accretion and erosion. However, from 2018 through 2024, erosion has set in and has gradually increased such that the losses observed from August 2022 to August 2023 and August 2023 through September 2024 have both (individually) represented the greatest year-to-year erosion in over a decade. Between August 2023 and September 2024, the Reach lost 39,750 cy (–9.3 cy/yr).

These relatively minor but consistent changes between accretion and erosion imply Reach 2 is sensitive to yearly changes in weather patterns impacting short-term sediment supply. This is a contrast to the changes from large-scale inlet dynamics that tend to overwhelm volume changes closer to Breach and Dewees Inlets. The trend also suggests the sand wave moving west from the project area remains upcoast from Reach 2, with no discernable volume contribution.

Photos and profiles show the healthier condition of the eastern end of the reach (south of the pier) compared to the western end (Fig 4.25). The dune created in 2017 after Hurricane *Irma*, which was constructed by scraping sand from the intertidal beach to accelerate recovery, initially provided some protection. However, despite its initial stability, the dune has now completely eroded. While the northern portion of the reach still exhibits stability, no trace of the *Irma* dune remains as of September 2024.

Aerial photos (Fig 4.26) of the reach show a crescent-shaped beach extending south of the pier. The shoreline morphology and the variable erosion patterns observed in this area should be closely monitored, as building setbacks are generally less than along Reaches 3–4. Should an erosional period persist, or a major storm impact the area, structures along Front Beach or the southern end of the Isle of Palms could become threatened. At a minimum, additional erosion along the south end of the reach will reduce the dry beach width, limiting recreational area. From 2011 to 2022, the reach was essentially stable, gaining a total of only 11,460 cy. The last two years experienced an unprecedented acceleration in erosion, resulting in a volume loss of approximately 90,740 cy. This represents a substantial increase from historical erosion rates. The Reach is showing a two-year average annual erosion rate of ~45,000 cy/yr. This equates to 360,000 cy over an 8-year period if erosion continues at this pace. This magnitude of loss would require mitigation via nourishment. Given the observed increase in erosion rates, CSE recommends that this area be included in future permit applications for nourishment.

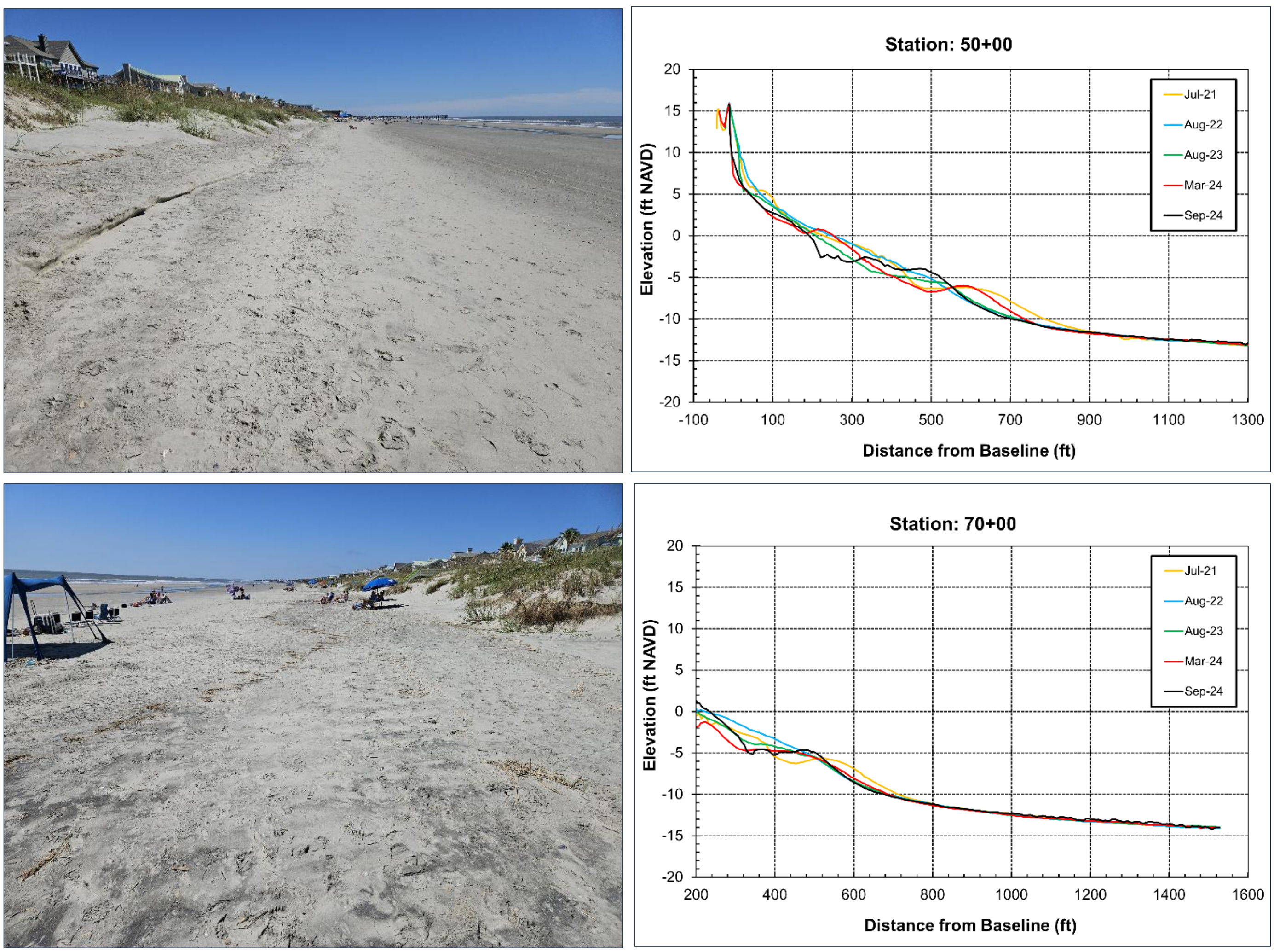


FIGURE 4.25. September 2024 photos of Reach 2. **[UPPER LEFT]** View north from Station 50. **[LOWER LEFT]** View west from Station 70. The photos show a healthy beach with dry sand seaward of the dune. Profiles show that the dune remains more landward than the 2012 condition; however, it has been fairly stable since 2017.

FIGURE 4.26. Aerial view of Reach 2 in September 2024. Since monitoring began in 2009, Reach 2 has been the most stable reach, typically showing lower magnitudes of volume change compared to the other reaches along Isle of Palms. The arc in the shoreline west of the pier indicates that the pier may act to trap sand, which may impact Reach 2 in certain wave conditions.

4.2.8 Reach 1 – Breach Inlet

Reach 1 encompasses the beach between Breach Inlet and 6th Avenue (Fig 4.27) and is classified as an unstabilized inlet erosion zone due to the dynamic nature of the shoals associated with the inlet delta. The long-term trend in the reach is accretion, evidenced by a new row of houses built seaward from the original 'beachfront' row in the 1980s. Sand supply originates from shoal-bypass events at Dewees Inlet and longshore sand transport from north to south over the length of the Isle of Palms. Excess sand is deposited along the southern spit of the island and in the Breach Inlet ebb-tidal delta. The shoals of Breach Inlet form a prominence in the shoreline, which backs sand up along the oceanfront much like a terminal groin traps sand. Changes in this area are related to bars from the inlet delta migrating onto the beach or marginal flood channels moving landward or seaward. Such natural processes lead to rapid changes in the beach volume compared to the central Isle of Palms reaches.

FIGURE 4.27. Baseline stationing along Reach 1 which encompasses the beach between Breach Inlet and 6th Avenue.

Due to its proximity to Breach Inlet, Reach 1 experiences variable periods of erosion and accretion, with the long-term trend showing erosion since 2009 (Fig 4.29). Over the past year, the beach was less erosional than the 2021–2023 period, losing roughly 27,000 cy (6.1cy/ft). This was the least erosional period measured since July 2021. Volume loss was greatest near Station 30+00 and Station 3110; however, sand loss was not as significant and widespread for the reach as it was in 2022.

The beach condition has continued to fluctuate over the past year, with some recovery of the dry-sand beach. However, sandbags remain in place along the 100–300 blocks, indicating ongoing erosion concerns. As of September 2024, erosional waves were still impacting the reach, and ridge-and-runnel systems were visibly influencing the dry-sand beach conditions. While some sections have seen improvements, persistent erosion remains a challenge across the area. Photos of the 2024 condition are shown in Figure 4.28.

The Breach Inlet reach has been dynamic since 2009 and needs to be closely monitored moving forward. The USACE is performing a beneficial use project to aid in the navigation of the Intracoastal

Waterway and will place a planned 500,000 cy of sand along Reaches 1 and 2. The City is planning on supplementing this project by shifting material placed by the USACE into the dune areas eroded over the past two years. Once complete, the project will have added more sand than has been lost in the reaches since monitoring began in 2009. CSE recommends the City also consider including Reach 1 in future large-scale renourishment projects.

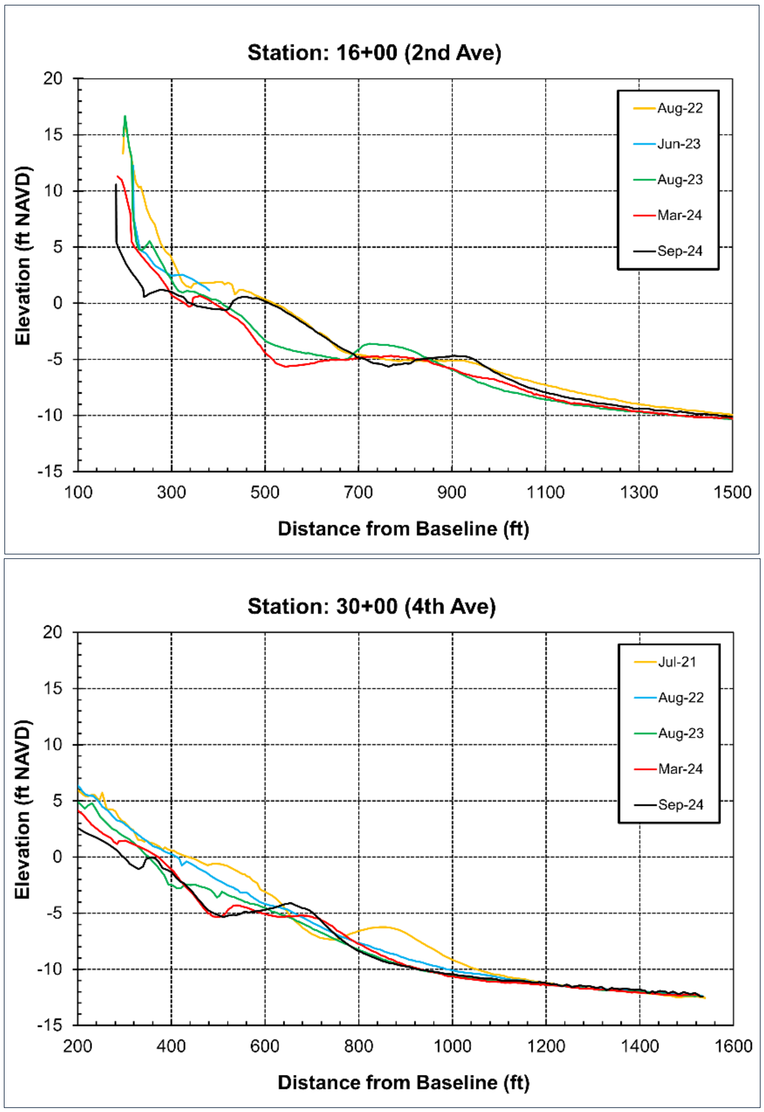


FIGURE 4.28. [LEFT] Profile plots for Reach 1 showing significant loss of the dune area over the past two years. **[TOP RIGHT]** September 2024 aerial photo of Reach 1. **[MIDDLE RIGHT]** Ground photo of Station 12 looking south. **[BOTTOM RIGHT]** Ground photo of Station 30 looking south.

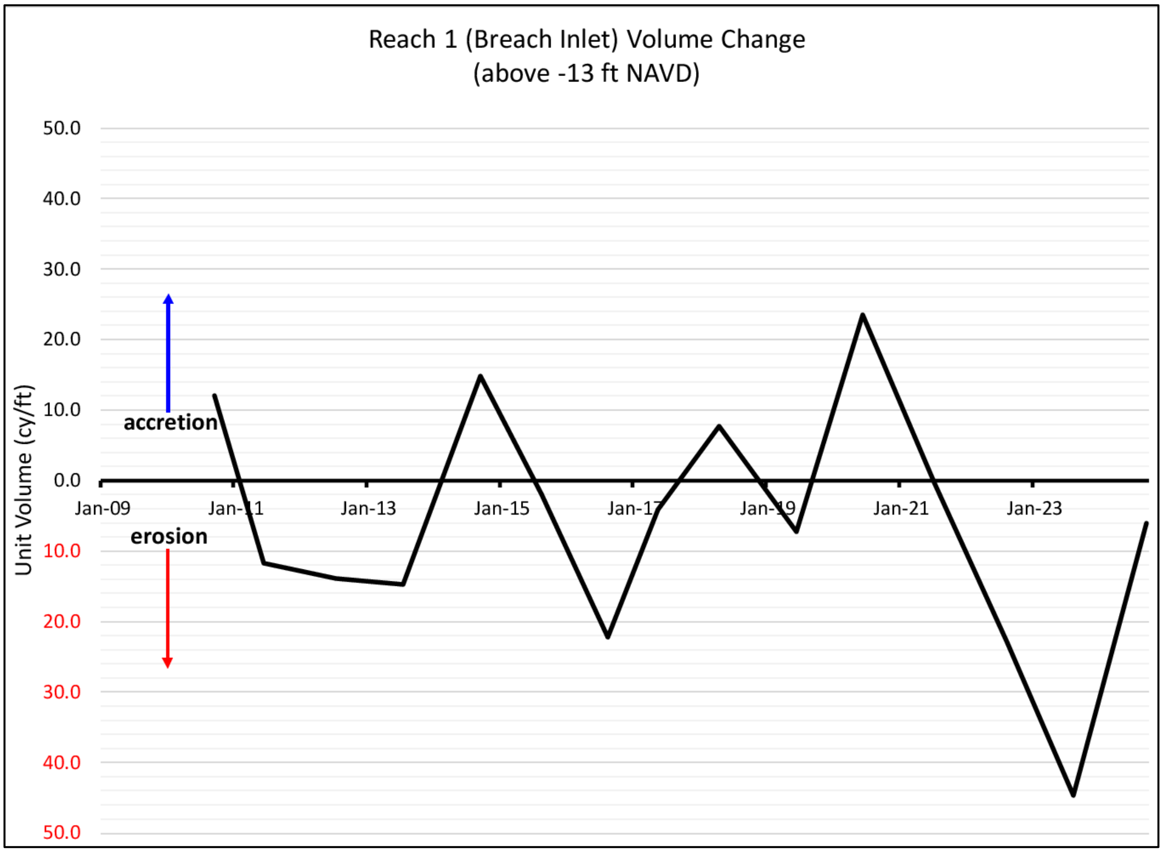


FIGURE 4.29. Volume changes along Reach 1 are highly cyclical and alternate between periods of moderate erosion and accretion. This is a common dynamic equilibrium around relatively small inlets like Breach Inlet, which tend to experience shoal bypass events at a greater frequency – but generally lower magnitude – than the larger inlet systems like Dewees Inlet at the east end. As the underwater bars and channels of Breach Inlet shift back and forth from the Isle of Palms to Sullivan's side of the system, there are likewise changes in shoreface steepness, wave energy, and beach volumes on either side of the inlet. This is a natural feature of systems like Breach Inlet, and has been well documented in other mixed energy settings around the world (Beck and Wang 2019, Nienhuis and Ashton 2016, Gaudiano and Kana 2001, FitzGerald 2000).

CSE obtained bathymetric data spanning most of the Breach Inlet channel and created a digital terrain model of the data (Figure 4.30). The model shows a well-defined primary channel bordering Sullivan's Island, and a ~5,000-ft long submerged spit running south and west off the Isle of Palms shoreline. In recent years, particularly between 2020 and 2022, secondary channels developed running across the submerged spit. It is likely the development of these channels impacted beach volumes along the Isle of Palms side of Breach Inlet and played a role in the excessive erosion rates observed from 2021 through 2023. These observations indicate Breach Inlet experienced a shoal bypass event over that 2-year period (see FitzGerald et al 2000), which by 2024 had displaced the -5 ft contour off Sullivan's Island and deflected the main channel seaward. No new secondary channels have developed since that bypass event, and erosion rates along the Isle of Palms side of Breach Inlet have returned closer to the long-term averages.

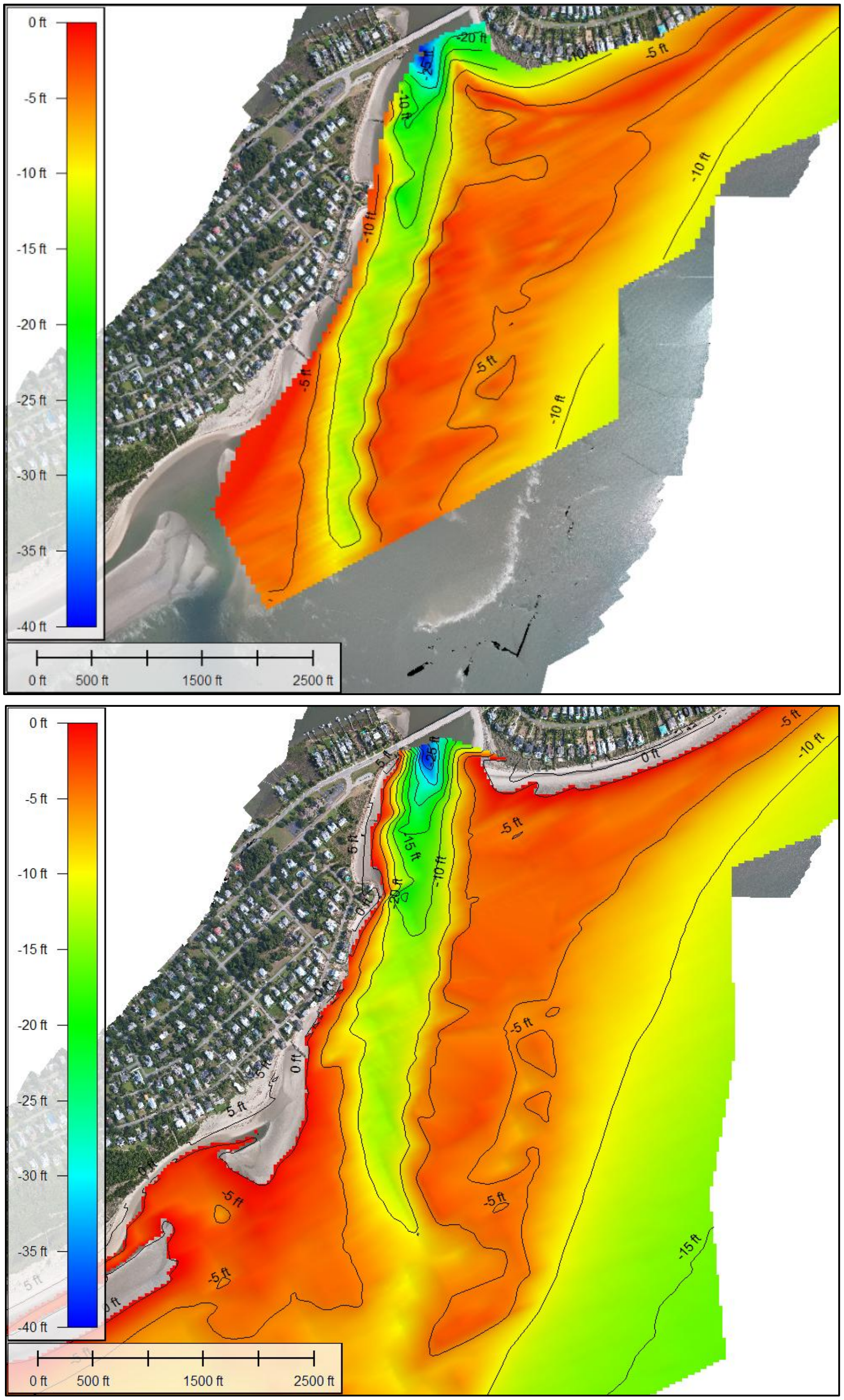


FIGURE 4.30. A pair of digital terrain models spanning the majority of Breach Inlet collected in 2023 (upper) and 2024 (lower). The most notable trend over the last year is the continued migration of the primary inlet channel (up against the Sullivan's side of the inlet) towards Sullivan's Island. The submerged spit running south and west from the Isle of Palms side of the channel remains a swash platform at elevations from –3 to –5 ft NAVD.

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5.0 COASTAL RESILIENCY UPDATE

5.1 Weather and Climate Conditions, August 2023 to September 2024

CSE gathered weather and climate data from outside sources (all NOAA-supported) to evaluate observed changes to the beach with respect to environmental conditions. Wind and wave data reported here cover the time period from August 2023 to September 2024 (the same as the survey data presented herein). Wind data are compared to historical data covering the period from 1945 to 2024 (Fig 5.1). Real-time and historical hourly wind data from across the United States are aggregated by the Midwestern Regional Climate Center (MRCC), a cooperative program between offices of the National Oceanic and Atmospheric Administration (NOAA) and Purdue University (MRCC 2025, http://mrcc.purdue.edu/). The closest operational station is located at Charleston International Airport (FAA Identifier – CHS) in North Charleston, ~20 miles northwest of Isle of Palms.

The average wind speed and direction* was 14.6 miles per hour (mph) from ~172° (approximately south, Fig 5.1). The peak observed wind speed was a gust to 73.1 mph from ~22° (approximately north) on 30 September 2022 during the passage of Hurricane *Ian*. According to data from MRCC-NOAA, wind data over the study period were similar to the long-term trends. The proportion of winds from the southeast (90°–180°) and southwest (180°–270°) quadrants represent ~50.0 percent of the total from 1945 to 2024; between August 2023 to September 2024, these have represented ~47.0 percent of the total incoming winds. Northerly winds were consistent with long-term trends, as well.

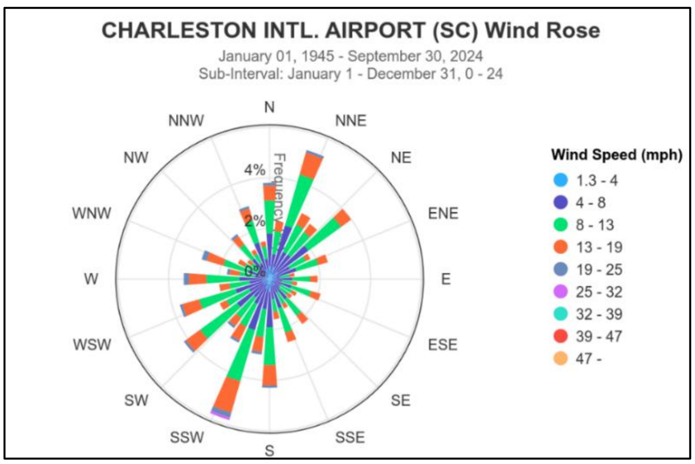
Wave data are recorded by the National Data Buoy Center (NDBC) Station 41004 ('Edisto'), 41 nautical miles (nm) southeast of Charleston (SC) (NOAA 2025, http://www.ndbc.noaa.gov/station_page.php?station=41004). The average wave height at Station 41004 from August 2023 to September 2024 was ~4.4 ft, with an average dominant wave period of ~7.6 seconds. The maximum observed wave height was ~27.2 ft on 17 December 2023 during the passage of a nor'easter. The average wave direction was ~166° (approximately southeast).

From January 2010 to September 2024, Station 41004 experienced similar wave conditions compared to recent years. Data from Station 41004 have been collected nearly continuously since January 2010, and in the period from then until September 2024, wave height exceeded 10 ft ~184 times per year and 15 ft ~24 times per year. Between August 2023 to September 2024, wave height exceeded 10 ft an average of ~537 times per year and exceeded 15 ft ~74 times per year.

Atmospheric pressure dropped below 1000 millibars (mb) ~71 times per year from 2010 to 2024 and detected ~349 times below 1000 mb from August 2023 to September 2024 (Fig 5.2). Most of this was observed between the months of November and March 2023.

Most Category 1 hurricanes have a central pressure of ~980–990 mb, and many nor'easter-type storms will feature central pressures below 1000 mb. On 17 December 2023, a nor'easter bearing a pressure of 989 millibars traveled up the South Carolina coast with near hurricane-force winds (max wind speeds detected at 69.8 mph). Additionally, pressure dropped below 1000 millibars two times in January and April, and once during hurricane season. Tropical Strom Debby impacted the South Carolina region from 7 August to 11 August 2024, bringing pressure as low as 996 mb and wave heights nearing 8 feet. As depicted in Figure 5.3, the South Carolina coast near Isle of Palms experienced a rather rough winter with numerous low-pressure systems.

Similarly, wave height is an easy parameter for the relative intensity of storm events. However, atmospheric pressure and wave height are imperfect measures because these are simply proxies for the physical processes that result in beach erosion (eg – a more energetic surf zone with alongshore transport in a particular direction occurring in phase with high tide).



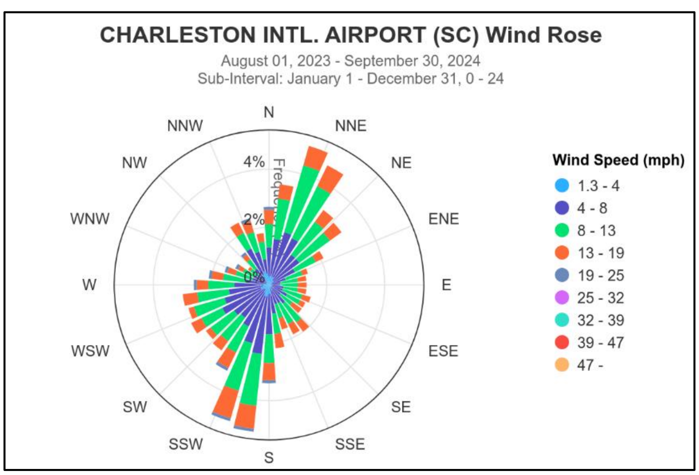


FIGURE 5.1. Wind roses showing the direction and magnitude of winds measured at Charleston International Airport from January 1945 to September 2024 **[UPPER]** and from August 2023 to September 2024 **[LOWER]**.

* *Herein, wind and wave direction is either given in degrees north or in terms of the direction from which it propagates.*

** *The direction from which waves propagate toward NDBC Station 41004.*

The work of erosion is fundamentally a sand transport problem. An increase in erosion indicates more sand is being transported away from a location than being transported to replace lost volume. Sand transport increases exponentially with current velocity and wave energy increases by the square of the wave height. So, in tidal channels, a doubling of velocity will result in an eight-fold increase in net transport, while a doubling of wave heights produces a four-fold increase in erosive force. This helps explain why even minor storms can do significant damage along the coast. A four-foot wave impacting a structure or the foredune will be much more impactful than a normal two-foot wave.

Engineers and scientists use measurements of wave properties like height, wavelength, and speed to estimate the magnitude of energy exerted by a wave striking the beach. The estimate is expressed as 'wave power' in kilowatts per meter of crest length (kW/m). Because sand can migrate either way along a beach, wave power must be adjusted so that waves resulting in southerly transport (ie – north to south) and northerly transport (ie – south to north) can be differentiated. To accomplish this, wave power can be calculated so that northerly transport is measured above zero (positive) while southerly transport is measured below zero (negative). Wave power at Station 41004 is presented in Figure 5.3 with wave height. The larger-magnitude wave power values from September to March represent the passage of cyclonic storms during the fall and winter. In the spring and summer, lower-magnitude positive values tend to dominate.

The most powerful waves from August 2023 to September 2024 exhibited ~9.1 kW/m of wave power in southerly and 8.8 kW/m in northerly directions, with southerly waves occurring more frequently (Fig 5.3). However, the average power of a northerly-directed wave from August 2023 to September 2024 was 1.4 kW/m, while the average southerly-directed wave power was –0.6 kW/m. Calculating the average of all wave power indicates a more stable shoreline over the same period.

These results indicate that most waves at Isle of Palms approach from the south, but the strongest waves approach from the north. Since 2010, a similar pattern has been observed wherein approximately three to four times more total energy is expended moving waves in a northerly direction compared to a southerly direction. However, individual southerly-directed waves are roughly twice as powerful. This result corroborates long-term observations along the Isle of Palms documenting southerly-directed drift. It is important to note that Station 41004 is several dozen miles off the coast with slightly different exposure to northerly winds. Thus, the net total wave power exhibited at Station 41004 may be somewhat different from the inshore zone off of Isle of Palms, but the general trends in long-term wave climate should be similar.

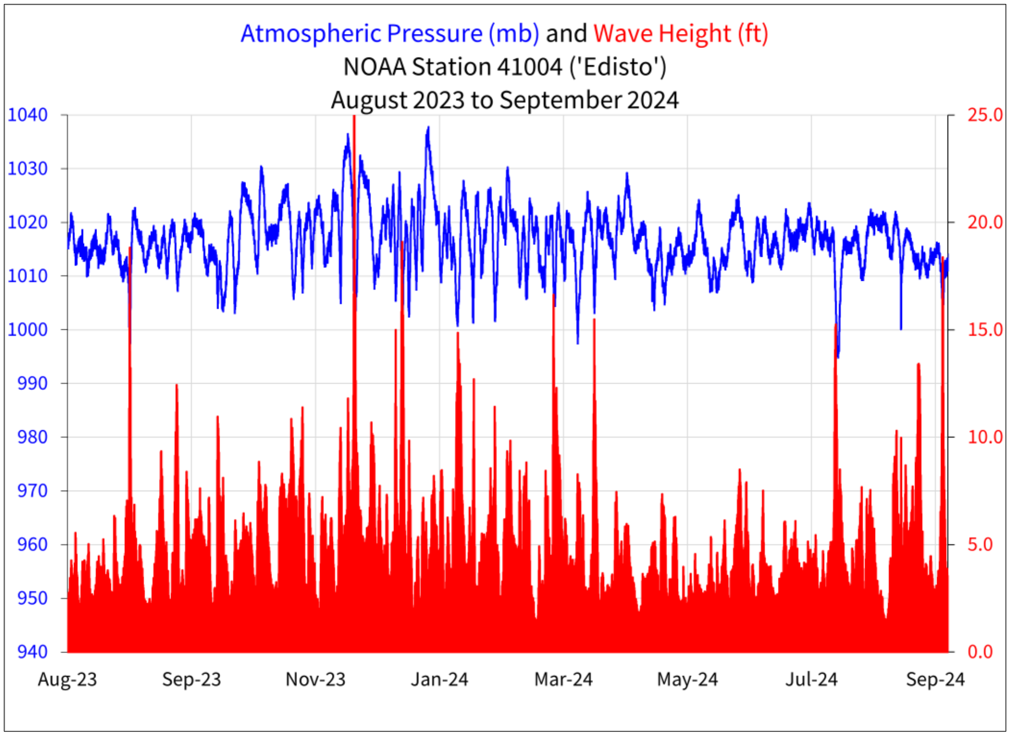


FIGURE 5.2. Atmospheric pressure and wave height at NDBC 41004 from August 2023 to September 2024. Wave heights exceeded 10 ft multiple times during the study period –and atmospheric pressure did go below 1000 mb during a few low-pressure systems occurring during the winter, spring, and summer months. These two parameters indicate conditions have been rough over the past year.

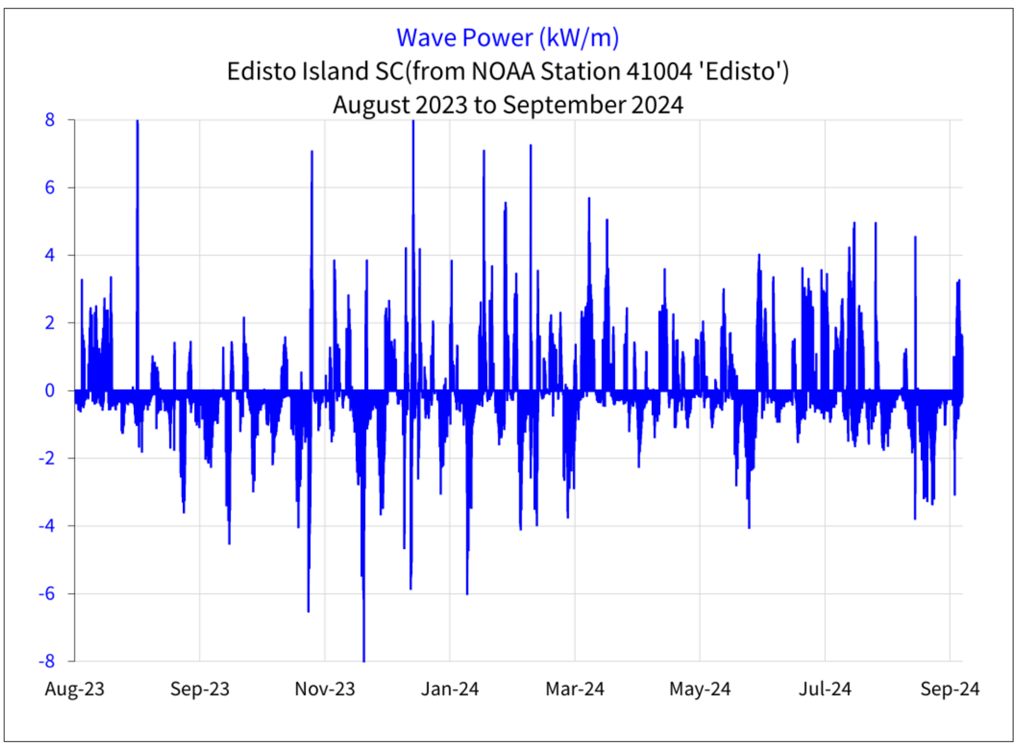


FIGURE 5.3. Wave power (in kW/m) and wave height (in m) for NDBC 41008 from August 2023 to September 2024. Wave power is a useful parameter for determining the relative magnitude and direction of wave energy in an alongshore direction along a beach. Positive values indicate waves move from south to north (ie – northerly transport), while negative values indicate a predominance of north-to-south (ie – southerly) transport.

5.2 Flood Vulnerability

Regional projections of average sea level rise (SLR) within the Southeast US range from ~1 ft to ~10 ft (Sweet et al 2022). These projections are based on modeled values of future emissions, shifts in ocean circulation, vertical movements in the Earth's crust, and changes to Earth's gravitational field and rotation. They range from 'Low' (~1 ft by 2100) to 'Extreme' (~10 ft by 2100), with a 'High' scenario at 8 ft and three 'Intermediate' values averaging ~4 ft (Fig 5.4; NOAA 2021).

For reference, the highest astronomical tide (aka 'King Tide') expected at Isle of Palms would bring water levels ~3 ft above mean sea level (MSL). So, the water levels observed during those King Tide events represent the higher range of projected MSL by ~2060 and the lower-intermediate projected MSL by ~2100 (Fig 5.4).

Relative to 1995–2014 conditions, the likely global mean sea level rise by 2100 is ~1 to 2 ft under the *lowest* emissions scenario. This scenario calls for warming to be held at or below 1.5 °C by 2100 compared to 1900 and for 'net-zero' CO_2 emissions by 2100. 'Net-zero' emissions represent the condition in which removals of atmospheric carbon exceed emissions. The 'intermediate' scenarios are approximately in line with the upper (eg – higher-emitting) end of reduced emissions and project ~3 ft of SLR by 2100, while the 'very high' scenario assumes no policy changes and project ~5 to 6 ft of SLR by 2100.

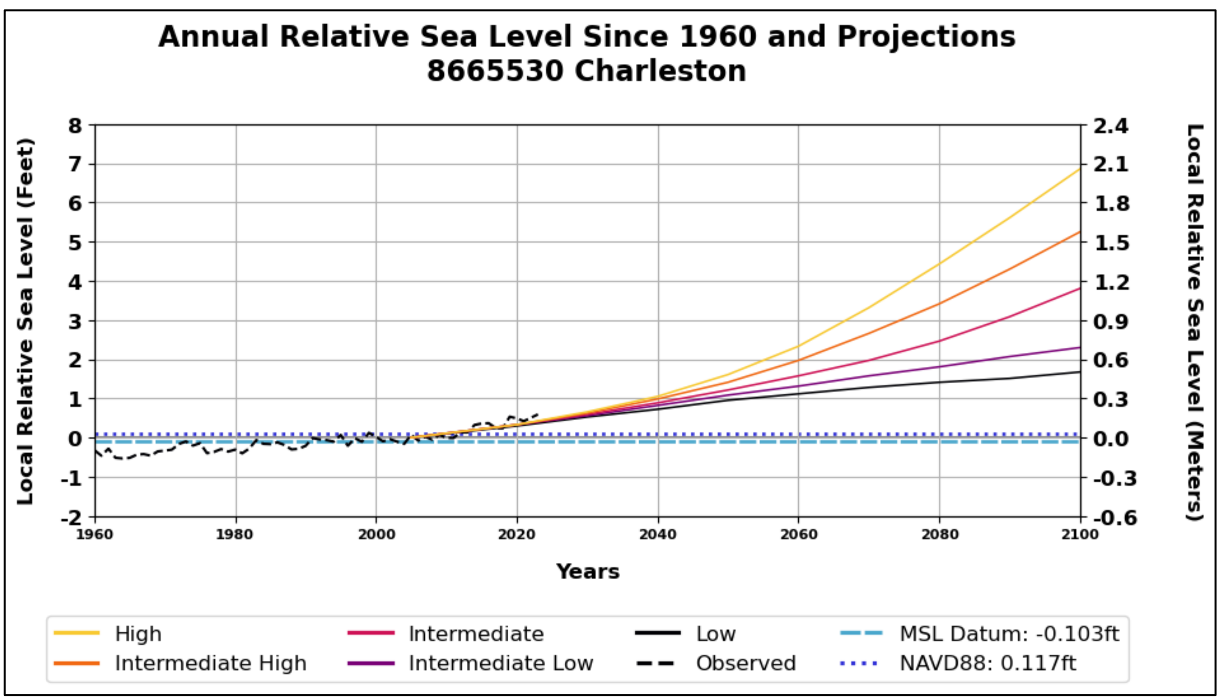


FIGURE 5.4. Projected MSL values under an 'Intermediate' emissions scenario average ~2 ft by 2060, and ~4 ft by 2100 at Charleston Harbor. These projections are global-scale predictions of future water levels (based largely on emissions) adapted to the Lowcountry by accounting for regional and localized changes in ocean circulation, vertical movement in the ground surface, and other factors.

Keep in mind that any rise in *mean* sea level in the future is accompanied by a corresponding rise in mean high tide. So, in simple terms, today's high tide level would become a future mean tide level, and a future normal high tide level could be the equivalent of the storm tides the Isle of Palms experienced during hurricanes *Matthew* or *Dorian*.

Coastal communities are becoming more aware of the subtle differences in these impacts as they begin to feel pressure from sunny-day 'nuisance' floods (see Sweet et al 2018, Sweet et al 2020, Sweet et al 2022). Such floods will tend to impact low-lying sheltered shorelines, such as causeways over the marsh or creek-front backyards. Just a small increase in sea level can quickly overtop a road that is barely above normal spring tide levels. On the other hand, locations on the open ocean generally do not experience nuisance floods the same way. This is because dunes just inland from the beach lie at higher elevations than the mainland-facing 'back side' of barrier islands, where the shoreline transitions more gradually into marsh and creek habitats.

NOAA provides a 'Sea Level Rise Viewer' (SLRV; see https://coast.noaa.gov/digitalcoast/tools/slr.html) to help people identify local variations in flood impacts under different SLR scenarios. This tool allows users to specify water levels and generate inundation maps showing MSL and depth in previously dry areas. The NOAA viewer is a handy tool to see which SLR scenarios begin to impact a particular property.

Figure 5.5a,b shows a range of SLR scenarios between 1 ft and 4 ft above mean higher high water (MHHW). MHHW is presently 2.62 ft above 0 ft NAVD at the Charleston Harbor entrance. So, ~2 feet of SLR would bring MSL up to present-day MHHW and likewise move MHHW upwards. These visualizations do not distinguish between MSL and MHWW; however, they indicate the water level at 1, 2, 3, and 4 ft above MHHW. This means the maps show where the highest astronomical tide would flood under these scenarios. It is apparent that with increasing SLR, flooding will be more impactful along the backside of the island.

At present, all properties on the island remain above MHHW. Under a SLR scenario of 1 ft (Fig 5.5), some of the marsh edge along the Intracoastal Waterway, Waterway Island, and the landward side of Wild Dunes would be inundated. The road could be threatened by nuisance flooding more frequently than at present. This is particularly true for the portions of Waterway Boulevard near holes 6 through 8 of the Harbor Course. This scenario is equivalent to projected MHHW in ~2040 under an 'Intermediate' scenario (see Fig 5.4). A 2-ft increase in MHHW would lead to further marsh creep and periodic inundation of holes 6 through 10 of the Harbor Course (Fig 5.5). Marsh edges behind the Harris Teeter and around Marsh Island Lane and Merritt Boulevard would continue to move inland and upward, and these areas would likely see increased nuisance flooding. According to NOAA projections under an 'Intermediate' scenario, this increase would occur by ~2070 (see Fig 5.4). Kiawah Island has begun strategic planning to address the impacts of this SLR rate and magnitude (see Town of Kiawah Island 2018).

The SLRV indicates that the most significant changes could occur when MHHW increases from 2 ft to >3 ft above present (Fig 5.5). Many properties would be permanently inundated, particularly along Waterway Boulevard, between 2nd and 6th Ave, behind the Harris Teeter, and along Back Bay Drive in Wild Dunes. With 3 ft of SLR, Palm Boulevard near Hunley Bridge will become permanently inundated. At 4 ft of SLR, a large portion of the neighborhood bound by 32nd Ave, Hartnett Boulevard, and 41st Ave would be inundated.

SLR of 3 ft and 4 ft on the oceanfront could trigger a mixture of impacts. If sufficient sand volumes are maintained along the oceanfront, the first one or two rows of beachfront homes would likely remain high and dry even with a 4-ft rise in MHHW. This is because most oceanfront properties are elevated higher than back-barrier buildings to accommodate surge and wave runup. Keep in mind that such properties may be safe from normal conditions, but will still be exposed to higher water levels in storms. Houses presently elevated to the 100-yr flood level standard will become more vulnerable to lower return-period storm surges – perhaps as frequently as a 30-yr interval – under the likely SLR scenarios in the next 80 years (see Marsooli et al 2019).

A 3-ft increase in MHHW is possible under the 'Intermediate' scenario by ~2090 (see Fig 5.4), whereas a 4-ft SLR under the same scenario is not expected until after 2100. Folly Beach plans to adapt to SLR of 3 ft by ~2060 (see SC Sea Grant 2017). Extensive research is being conducted worldwide to improve future sea-level predictions and ramifications for individual locations. A key finding of the August 2021 IPCC* report is that regardless of any level of reduction in atmospheric CO_2, sea levels will rise through 2100 by at least 2 to 3 ft.

* *IPCC – the Intergovernmental Panel on Climate Change was formed by the United Nations to provide regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. The panel currently has 195 members worldwide, with dozens of additional scientists contributing to each report.*

FIGURE 5.5a,b. Sea level inundation models around the Isle of Palms generated using data from NOAA (https://coast.noaa.gov/digitalcoast/tools/slr.html). Shades of yellow, orange, red, and maroon are used to signify SLR of 1, 2, 3, and 4 ft above present-day MHHW.

5.3 Coastal Resilience in the 21st Century

NOAA's Ocean Service defines coastal resiliency as the "ability of a community to 'bounce back' after hazardous events…rather than simply react to impacts" (NOAA 2021). NOAA recommendations for effectively preparing for hazardous situations, and improving coastal resiliency, include being "informed and prepared" for the impacts of SLR as a community.

As mentioned above, many communities around the nation, the world, and a handful of communities in South Carolina, have begun strategic planning initiatives to address the impacts of projected SLR. The impacts of SLR are diverse and extensive, and conditions vary significantly from one community to another. Individualized plans developed at a community level help prepare for these impacts using a variety of tools and adaptation strategies.

Other communities in South Carolina have categorized potential adaptation strategies according to their role and utility in mitigating impacts from future SLR. These include water infrastructure management, uplands management and/or conservation, transportation adaptation, and education/communication. The order of mitigation and adaptation strategies should be timed according to the vulnerability and capabilities of the community in question. Shorter-term goals (eg – 1 to 3 years) are focused on generating plans and recommendations based on a detailed inventory of the vulnerability of upland properties at a parcel scale. Medium- and long-term goals (eg – 3 to 5+ years) include implementing recommendations.

SLRV data indicate flooding along Waterway Boulevard and portions of Wild Dunes will present issues for the entire island by mid-century under 'Intermediate' SLR scenarios. Mitigation and adaptation strategies for that particular vulnerability should target improving drainage following rain events and elevating the road surface above future MHHW. On a longer timescale ('Intermediate' scenarios as projected by the end of the century), developed properties between Hartnett Boulevard and the Harbor Course, as well as near the Exchange Club, will be vulnerable to persistent flooding even during calm weather conditions.

The City should consider sponsoring a Climate Change and SLR adaptation plan similar to those developed by Folly Beach and Kiawah Island to improve its coastal resiliency. Adaptation plans are not unlike the Beachfront Management Plans prepared by many communities, although due to the broad array of SLR impacts, they can represent a more interdisciplinary effort. These plans contain recommendations and identify time horizons for specific priorities and goals. More importantly, they inform a community of the hazards presented by SLR and how to prepare adequately before those hazards negatively impact the community.

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6.0 SUMMARY & RECOMMENDATIONS

This report describes beach condition changes occurring at Isle of Palms from 2023 to 2024. Overall, the island lost ~43,200 cy (1.2 cy/ft) of sand from August 2023 to September 2024. Within the 2018 project area, the island lost ~109,600 cy (10.1 cy/ft) over the past year and has lost ~1.53 million cy since project completion. This represents more than 95% of the 2018 project volume. Since project completion, the project area has seen higher erosion rates compared to the previous post-project monitoring period (2009–2017). From 2009 to 2017, annual losses in Reaches 5 and 6 measured ~100,000 cy/yr, while from 2018 through 2024, they measured ~250,000 cy/yr.

There are several dynamics that would drive a multi-year increase in erosion rates, as have been observed. First and foremost is the relatively high frequency of moderate-strength storm impacts over the same period. More than a dozen named tropical cyclones, un-named tropical cyclones, and non-tropical nor'easter-type storms have impacted the Isle of Palms since Hurricane *Matthew* in 2016. The short windows of relatively quiet conditions between these storms hamper post-storm recovery in the beach and dune system, which increases the vulnerability to erosional losses during subsequent storm events (Houser and Hamilton 2008).

Second, an ongoing shoal bypass event in Reaches 5 and 6 has resulted in rapid, localized erosion around Beachwood East and Ocean Club due to wave refraction around the approaching shoal. Changes in the shoals of Breach Inlet, along with storm impacts, have also triggered nearly 330,000 cy of erosion between 2021 and 2024.

Third, sea level rise has accelerated around the Charleston area since 2010 such that year-to-year water level increases from 2010 through 2024 are an order of magnitude higher than those observed from 2000 through 2010. While the increase in water levels does not necessarily trigger beach erosion on its own, increased water levels coincident with a series of storm impacts – noted above – allow storm waves to erode higher on the profile and do more damage than under a scenario with lower water levels.

With the ongoing shoal bypass event at Dewees Inlet, reduced dune volumes at Breach Inlet, and ever-increasing flood hazards due to sea level rise, the City certainly has a number of active concerns with regard to beach (and coastal) planning. CSE recommends the City continue its current efforts to pursue various restoration efforts, including short-, mid-, and long-term plans. This includes continued maintenance of emergency protective measures, pursuit of a shoal-management permit and project, and expedited implementation of a long-term nourishment project. The USACE beneficial use project at the south end (if completed to design) will restore all of the sand volume lost over the past three years and should serve as sufficient protection for that area over the next 5–10 years. CSE expects the shoal at the east end to attach this year, which will provide sufficient sand to restore some of the eroded areas. It is unlikely that the shoal alone will provide sufficient sand to offset all of the losses since 2018, and offshore nourishment will likely be needed in the next few years. The City has committed to increasing the frequency of beach monitoring, which will aid in determining rates of recovery and in planning for future nourishment.

REFERENCES & BIBLIOGRAPHY

CSE. 2007. Shoreline assessment and long-range plan for beach restoration along the northeast erosion zone, Isle of Palms, South Carolina. Feasibility Report for Wild Dunes Community Association, Isle of Palms, SC. Coastal Science & Engineering (CSE), Columbia, SC, 76 pp.

CSE. 2008. Isle of Palms beach restoration project. Final Report for City of Isle of Palms, South Carolina. Coastal Science & Engineering (CSE), Columbia, SC, 46 pp + appendices.

CSE. 2009. Beach restoration project (2008), Isle of Palms, South Carolina. Year 1 Monitoring Report, City of Isle of Palms, SC. CSE, Columbia, SC, 107 pp + appendices.

CSE. 2010. Beach restoration project (2008), Isle of Palms, South Carolina. Interim Year 2 (May 2010) Monitoring Report, City of Isle of Palms, SC. CSE, Columbia, SC, 24 pp + appendices.

CSE. 2011a. Beach restoration project (2008), Isle of Palms, South Carolina. Year 2 (March 2011)—Beach Monitoring Report, City of Isle of Palms, SC. CSE, Columbia, SC, 93 pp + appendices.

CSE. 2011b. Beach restoration project (2008), Isle of Palms, South Carolina. Year 3 (November 2011)—Beach Monitoring Report, City of Isle of Palms, SC; CSE, Columbia, SC, 95 pp + appendices.

CSE. 2012. Beach restoration project (2008), Isle of Palms, South Carolina. Year 4 (November 2012)—Beach Monitoring Report, City of Isle of Palms, SC; CSE, Columbia, SC, 83 pp + appendices.

CSE. 2013. Beach restoration project (2008), Isle of Palms, South Carolina. Beach Monitoring Report – Year 5 (December 2013), City of Isle of Palms, SC; CSE, Columbia, SC, 89 pp + appendices.

CSE. 2015. Beach restoration project (2008), Isle of Palms, South Carolina. Year 6 (April 2015)—Beach Monitoring Report, City of Isle of Palms, SC; CSE, Columbia, SC, 85 pp + appendices.

CSE. 2016 (June). Annual beach and inshore surveys: 2008 Isle of Palms restoration project. Year 7 (2015) monitoring report for Isle of Palms, SC. CSE, Columbia, SC, 69 pp + appendices (2447YR1).

CSE. 2019 (April). City of Isle Palms 2018 Beach Restoration Project. Final report for the city of Isle of Palms, SC. CSE, Columbia (SC), 57 pp + appendices.

CSE. 2020 (July). City of Isle Palms 2018 Beach Restoration Project. Year 1 (July 2020) —Beach Monitoring Report, City of Isle of Palms, SC. CSE, Columbia (SC), 63 pp + appendix.

FitzGerald DM, NC Kraus, and EB Hands. 2000. Natural Mechanisms of Sediment Bypassing at Tidal Inlets.

Gaudiano, DJ. 1998. Shoal bypassing in South Carolina inlets: geomorphic variables and empirical predictions for nine inlets. Tech Rept, Dept Geological Sciences, Univ South Carolina, Columbia, 182 pp.

Hayes, MO. 1979. Barrier island morphology as a function of tidal and wave regime. In S Leatherman (ed), *Barrier Islands*, Academic Press, New York, NY, pp 1-26.

Houser, C, S Hamilton. 2009. Sensitivity of post-hurricane beach and dune recovery to event frequency. Earth Surf. Proc. and Landforms 34, 613-628.

Kana, TW. 2002. Barrier island formation via channel avulsion and shoal bypassing. In Proc 28th Intl Conf Coastal Engineering (Cardiff), pp 3438–3448.

Kana, TW, ML Williams, and FD Stevens. 1985. Managing shoreline changes in the presence of nearshore shoal migration and attachment. In Proc Coastal Zone '85, Vol 1, ASCE, New York, NY, pp 1277-1294.

Kraus, NC, and FA Galgano. 2001. Beach Erosional Hot Spots: Types, Causes, and Solutions (Coastal Hydraulics Engineering Technical Note No. ERDC/CHL CHETN-II-44).

Marsooli, R, N Lin, K Emanuel, et al. 2019. Climate change exacerbates hurricane flood hazards along US Atlantic and Gulf Coasts in spatially varying patterns. Nat Commun 10, 3785. https://doi.org/10.1038/s41467-019-11755-z

National Oceanic and Atmospheric Administration (NOAA). 2021. Tides and Currents. https://tidesandcurrents.noaa.gov/

South Carolina Sea Grant. 2017. City of Folly Beach, South Carolina, Sea Level Rise Adaptation Report. SC Sea Grant Consortium Product #SCSGC-T-17-04.

Sweet, W, G Dusek, D Marcy, G Carbin, and J Marra. 2018. 2018 State of U.S. High Tide Flooding with a 2019 Outlook (NOAA Technical Report No. NOS CO-OPS 090).

Sweet, WV, G Dusek, G Carbin, JJ Marra, D Marcy, and S Simon. 2020. 2019 State of US High Tide Flooding With a 2020 Outlook. NOAA Tech. Rep. NOS CO-OPS., Vol. 92. Silver Spring, MD: National Oceanic and Atmospheric Administration, 17.

Sweet, W., et al. 2022, Global and regional sea level rise scenarios for the United States: Updated mean projections and extreme water level probabilities along United States coastlines, NOAA Tech. Rep. NOS 01, Natl. Ocean Serv., NOAA, Silver Spring, MD, 111 pp.

Town of Kiawah Island. 2018. Flood Mitigation and Sea Level Rise Adaptation for Kiawah Island SC. Kiawah Island, SC. 123 pp.

Traynum, SB, and H Kaczkowski. 2015. Evolution of a large-scale shoal-bypass event at Isle of Palms, SC – Implications for local beach management and shoreline predictions. Proc. Coastal Sediments, 14 pp.

USFWS. 2017. Biological opinion for Isle of Palms, Charleston County, SC. US Department of Interior, US Fish & Wildlife Service, FWS Log No 04ES1000–2017–F–0157, Charleston, SC, 67 pp.