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Isle of Palms Beach Management Planning Scenarios

BACKGROUND

Isle of Palms (IOP) is a classic "drumstick" barrier island (Hayes 1979), with a bulbous updrift end at the northeast, and a narrow recurve spit on the southwest (Figure 1). Generally, sand comes to the island via shoal bypassing at Dewees Inlet and then migrates south, maintaining a historically stable shoreline along the central portion of the island. Sand eventually accumulates along the southern spit of the island and then into the shoals of Breach Inlet. The shorelines near the inlets are highly dynamic and are classified as "unstabilized inlet erosion zones" by SCDHEC–OCRM due to the episodic fluctuations in the shorelines. Figure 2 provides a map of the monitoring stations referenced herein.

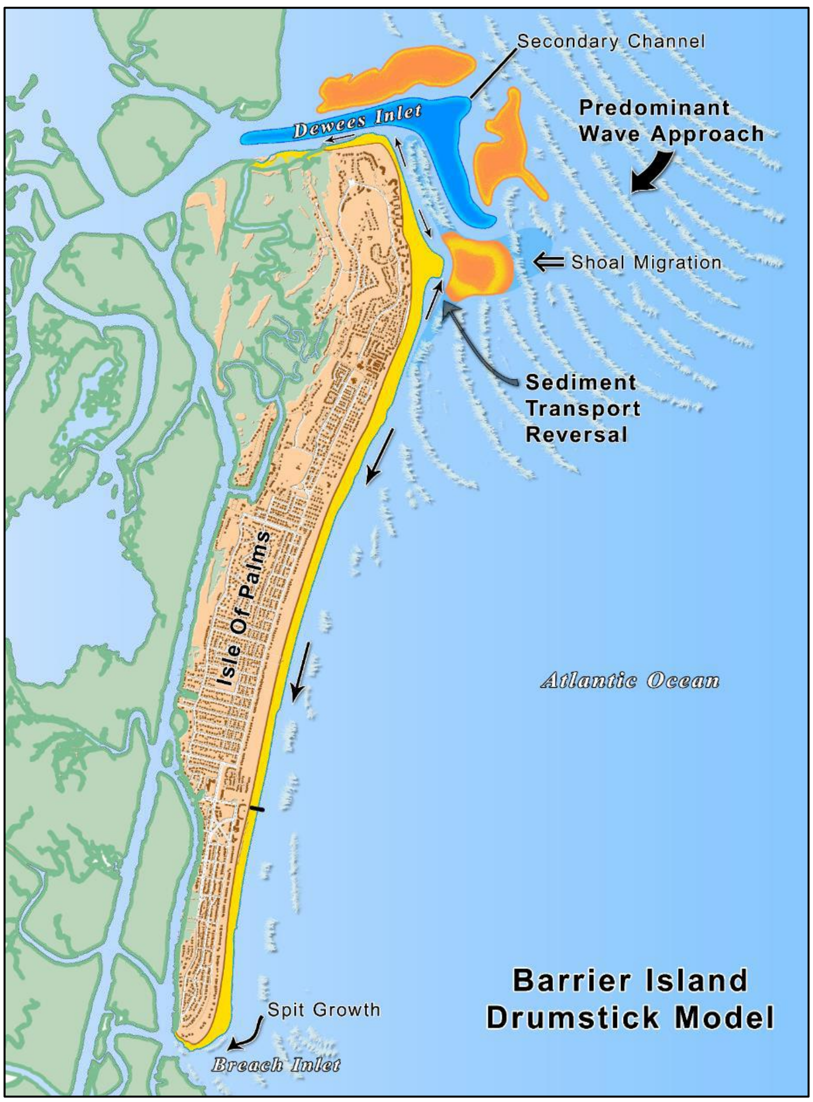

FIGURE 1. "Drumstick" barrier island model developed from Hayes (1979).

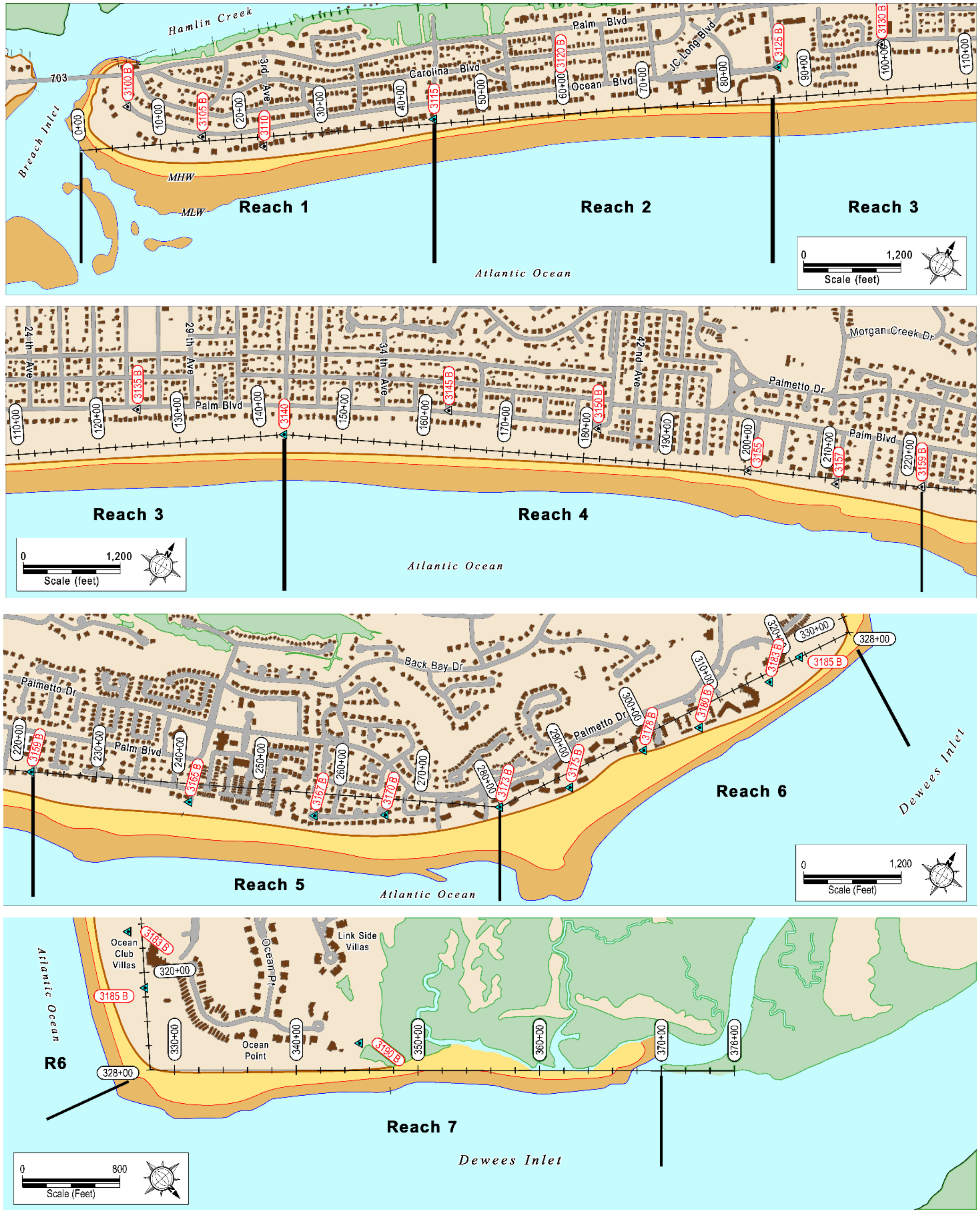

FIGURE 2. Station and reach map showing the monitoring profiles and reaches used in prior beach monitoring efforts.

Studies show that major shoal bypass events affect the eastern end of the island every ~7 years (Guadiano 1998); however, they can occur more frequently. Generally, smaller events occur on a more rapid timescale, while large events may impact the shoreline for ten years or more (ie, 1940–1950's attachment). These attachment events create localized areas of erosion and accretion that can see the shoreline change by up to 200 feet (ft) in one year. After attachment, the trend can reverse. The episodic nature of these events makes it difficult to predict shoreline trends and requires flexible solutions to deal with short-term erosion as well as long-term solutions for large-scale sand losses. While each shoal event adds sand to the system, monitoring efforts sponsored by the City of IOP show that there is a net loss of sand from the north end. This loss necessitates periodic additions of sand via offshore nourishment projects. Most of the sand added to the north end via shoals and nourishment projects shifts downcoast to maintain the remainder of the island, while the balance is eventually recycled back into Dewees Inlet to feed future shoals.

At the south end, the beach had accreted significantly in recent history despite minor fluctuations in volume from year to year and impacts from storms; however, erosion has accelerated over the past two years leaving portions of the beach critically eroded. While the condition appears to have largely stabilized in 2024, additional erosion is still a threat, and the existing beach condition is insufficient for storm protection. In CSE's opinion, the rapid erosion occurring in 2022–2023 is not likely to persist in the future. That being said, there has been a significant increase in storm activity since 2015, and sea level rise appears to be accelerating. These factors may increase the long-term erosion rate along the south end, turning the area from accretional to erosional. Until nature proves otherwise, the City should anticipate a need for projects to supplement the sand supply to the south end.

This summary of alternatives is prepared at the request of the City of Isle of Palms to outline information necessary to plan for long-term beach management along the beach. While the analysis focuses on the erosional areas at the ends of the island, the entire beach will be assessed. The summary outlines:

- Alternatives for a minimum healthy beach profile
- Determination of existing volume deficits
- Summary of recent erosion rates
- Discussion of triggers
- Cost opinion for restoration alternatives

The summary herein includes impacts of the beach restoration efforts at the east end including two large-scale nourishments, two shoal management projects, various emergency measures and a planned USACE project at the south end that is currently in the initial phase of construction.

BEACH VOLUME

The condition of the beach is determined by the volume of sand in the beach profile. This includes all sand between the reference line along the landward boundary and a point offshore where little or no measurable elevation change occurs. The landward boundary can be at the crest of the primary dune or from a point of significance, such as a structure. For developed beaches, the beach volume seaward of structures is typically the main interest. The seaward boundary is referred to as the "closure depth," and is a unique depth for every beach determined by sediment grain size, tide, and wave climate. Larger waves increase the depth of closure as the higher energy allows sand to be moved at greater depths. At Isle of Palms, the typical depth of closure is ~–13 ft NAVD (note 0 ft NAVD is approximately equal to mean sea level) (Figure 3).

Within the active beach profile, sand can shift in the cross-shore direction from varying weather conditions, with larger wave periods moving sand from the dune to underwater sandbars, and calmer weather moving sand higher in the profile. Generally, summertime weather conditions promote growth of the dry sand beach, while stormier winter conditions show narrower beaches with more gentle slopes and sandbars. Beach volumes are typically reported as cubic yards of sand per linear foot of beach (cy/ft), which is the total quantity of sand between the dunes and closure depth in every linear foot of alongshore beach. Repetitive surveys measure changes in profile volume from year to year, providing total beach volume change using the average-end-area method for quantifying sand volume between monitoring stations.

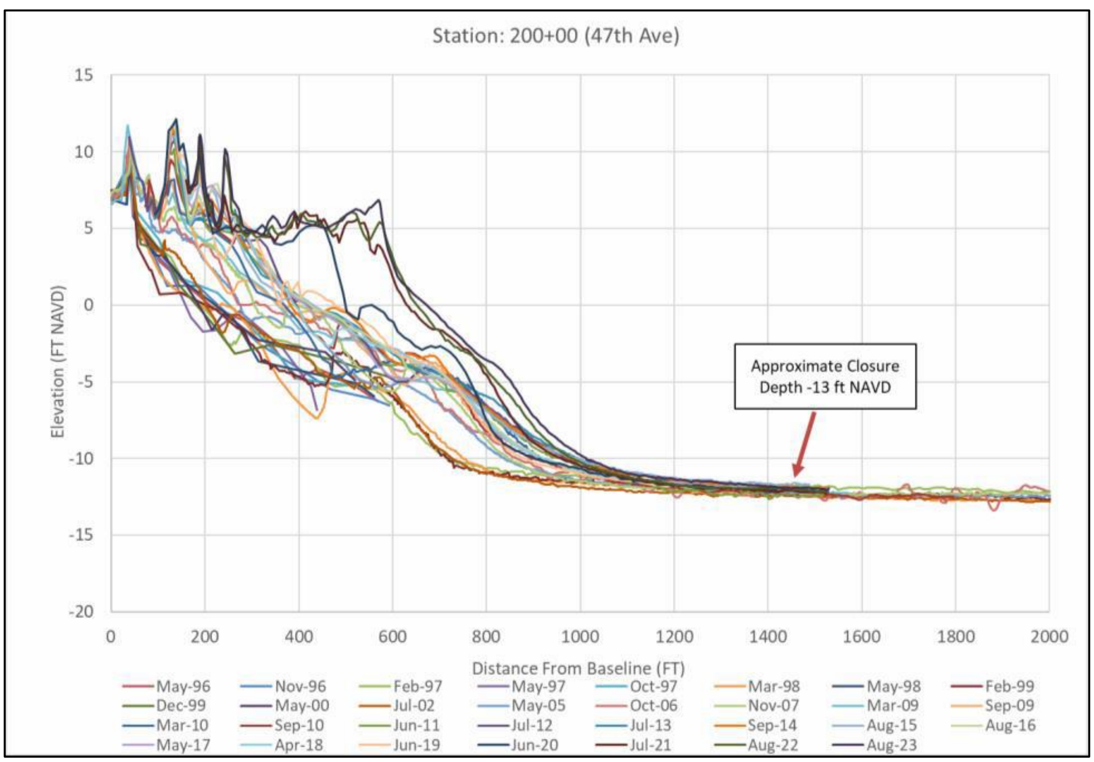

FIGURE 3. Example of "Closure Depth" at Isle of Palms. Repetitive surveys eventually overlap near –13 ft NAVD, which is considered the limit of measurable profile change.

Cross-shore movement of sand within a profile can occur without any net change in beach volume. Sand also moves alongshore due to currents and waves approaching the beach at an angle. This can result in net gains or losses of sand to a given area, resulting in accretion or erosion. Sediments arriving from adjacent sections of a shoreline often control whether a beach is gaining or losing sand, and changes to the sediment supply can create temporary or long-term changes in erosion rates. There are other mechanisms for changing beach volumes, including shoal bypassing, inlet dynamics, nourishment, and storms. When considering short and long-term changes to the beach volume, each of these factors need to be considered to determine the principal cause of erosion and identify appropriate alternatives for restoration.

Figure 4 shows a schematic of beach volumes for various beach conditions along the Isle of Palms in 2023. The profiles show the shape of the beach seaward of the structure line (0 ft on the x-axis). The beach conditions at the various locations represent areas that are eroded (Beachwood East), have a minimum healthy beach profile (9th Ave), and have an excess quantity of sand (Citadel House). The profile at Beachwood presently holds about 340 cy of sand per linear foot and is in a highly eroded condition. Note the volume would be even lower except for additional sand in the lower profile from an approaching shoal. The profile at 9th Ave holds ~380 cy/ft of sand, which is sufficient to hold a modest dune field and dry sand beach at this location. This volume can be considered the minimal healthy beach volume at this location. The profile at Citadel House holds over 700 cy/ft of sand, which is a surplus resulting from sand spreading from the nourishment projects and shoal attachments in Wild Dunes.

Comparison of beach profile volumes aids in beach management planning by providing quantitative erosion rates, determining the required volume to maintain a healthy beach profile, and providing forecasts of beach conditions. The minimum healthy beach volume is a measure of the required sand volume to maintain a healthy beach profile that includes a dune capable of withstanding a significant storm event and a dry sand beach that can accommodate seasonal weather changes without impacting the dune. This volume is site-specific based on beach slope, dune size, and closure depth. Regional closure depths are typically similar, but can be impacted by inlets and shoals, as these features alter the beach slope and wave climate reaching the beach.

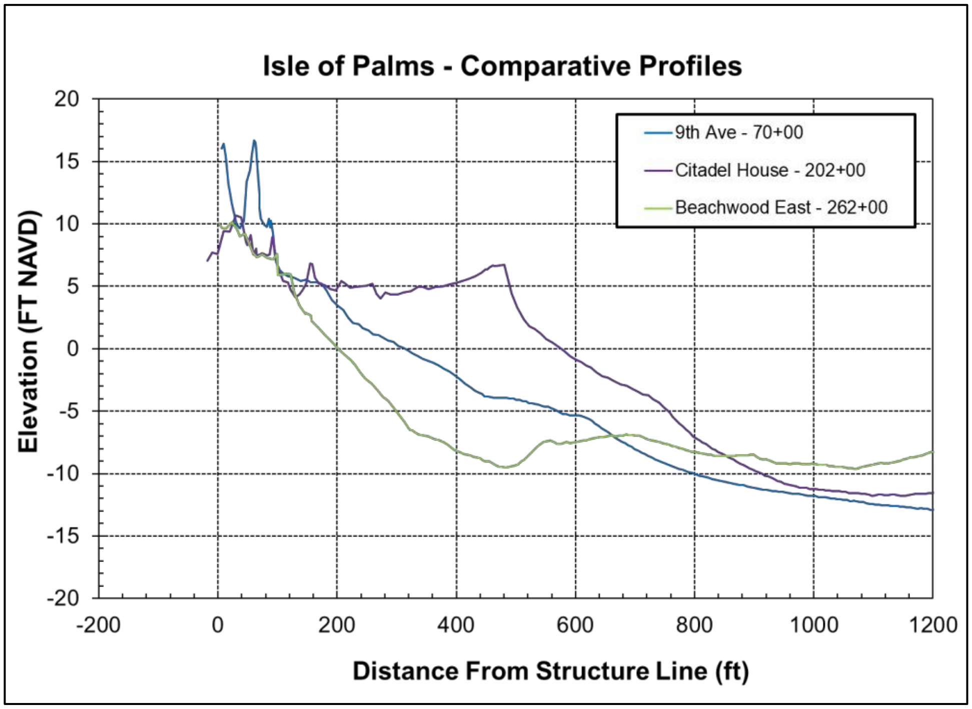

FIGURE 4. Comparative profiles along Isle of Palms showing eroded, healthy, and surplus sand volume conditions.

At Isle of Palms, the minimal healthy beach volume for the areas away from inlets is ~380–400 cy/ft when measured from the structure line to a depth of −13 ft NAVD. This value is based on the equilibrium shape of the beach, dune volume, and historical conditions.

Figure 5 shows the historical beach volume envelope for the Isle of Palms (not including the Dewees Inlet shoreline). The plot shows the maximum and minimum beach volumes measured since 2008, as well as the current volume and average volume between 2008 and 2023/2024. The plot shows the beach volume seaward of the structure line, which results in areas with greater setbacks having higher volumes, and structures that protrude beyond adjacent properties having lower volumes. This means that the volumes may not necessarily reflect erosion trends, but do show relative levels of dune protection across the island. In addition, it's important to note that the localized erosion patterns are highly dynamic near the inlets, and areas that are relatively healthy now may quickly change due to shoal-induced erosion.

The figure includes a line showing the minimum healthy beach volume across the island. At Breach Inlet, the value is higher due to the constant presence of sand in the shallow underwater profile from the northern shoal of Breach Inlet. This increases the total sand volume in the profile measured to −13 ft NAVD. The minimum profile volume decreases at the northern tip of the island, as the sheltering effects of the Dewees Inlet delta create a steeper beach slope, reducing the volume necessary to maintain a healthy profile. Away from the inlets, the minimum healthy profile is ~380 cy/ft.

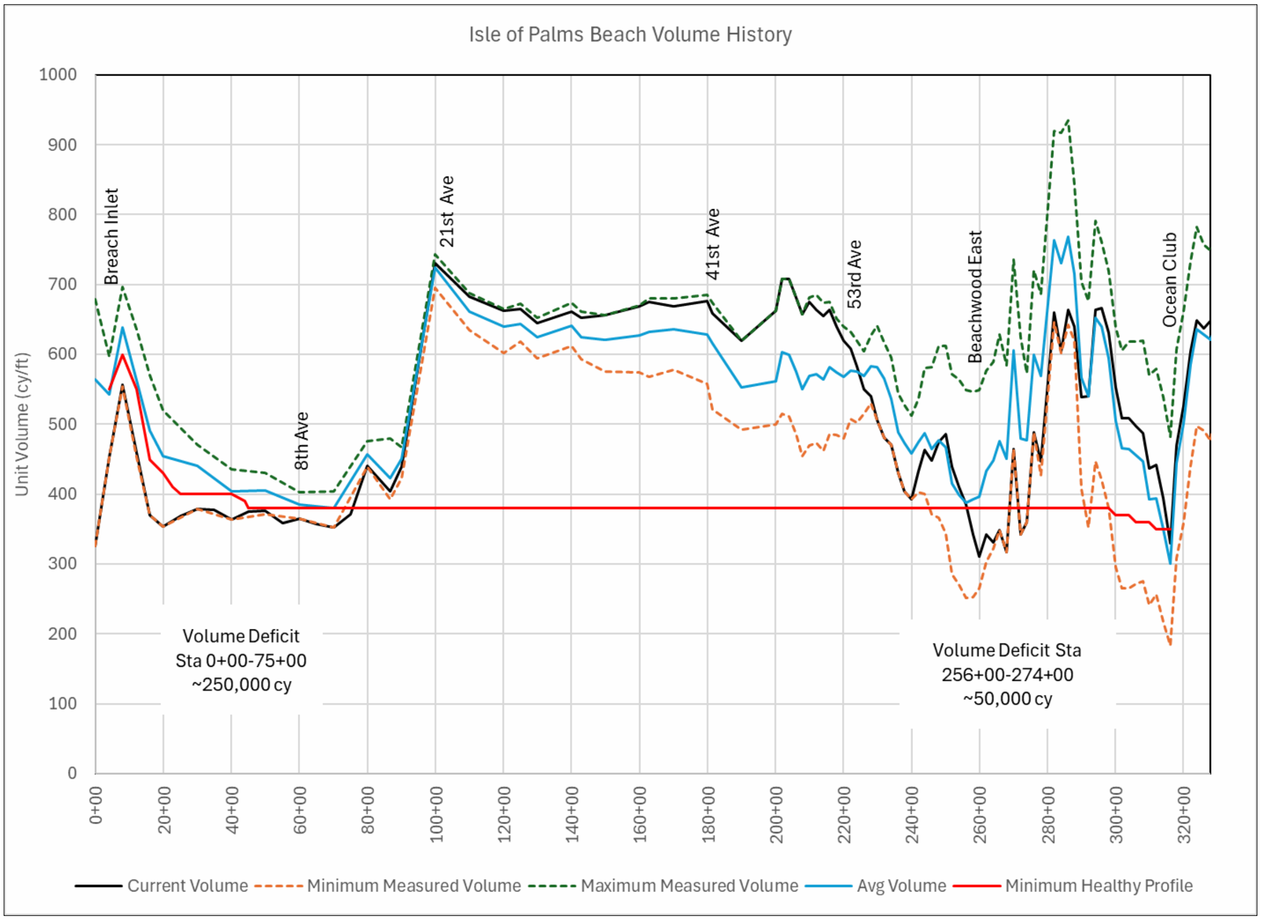

FIGURE 5. Volume summary for Isle of Palms 2009–2024. Note where the current condition (black line) is near the most eroded (orange line) or the healthiest (green line). The red line shows a site-specific minimum healthy beach volume.

The graph shows that the current beach condition is near the minimum measured volume south of the county park. The volume is near the maximum measured volume from the county park to 53rd Ave, and varies north of 53rd Ave as a result of shoal processes. Presently, ~7,500 linear feet (lf) of beach between Breach Inlet and 9th Ave is at or below the minimum ideal volume, as well as ~1,600 lf around Seagrove and Beachwood East in Wild Dunes. The station fronting the Ocean Club building is also just below the threshold volume.

Within the southern erosional area, there is a total sand deficit of ~250,000 cy to reach the minimum healthy condition at all stations. Along the northern erosional area, the current deficit is ~51,000 cy. These volumes would be required to bring the affected beach areas to the minimum healthy volume (this is commonly referred to as the "deficit volume" or "base volume"). Additional volume is required to account for future erosion over the design life of a project to protect this minimally healthy beach. This additional volume is generally referred to as "advance fill." A beach nourishment project volume is the sum of the deficit volume and advance fill volume.

Figure 6 shows unit volumes for monitoring stations along the southern end of IOP since 2015. The bars show the beach volume for each year at each station, and the variability in erosion and accretion trends is apparent through 2021. Beginning in 2022, an erosional event was beginning, decreasing beach volumes at stations south of 50+00. The erosion accelerated from 2022–2023, leaving stations 8+00–50+00 (Breach Inlet to 6th Ave) below the healthy beach condition. Additional erosion was present in many stations as of March 2024.

The data in Figure 6 are useful in trying to predict future volume change where erosional patterns are generally consistent. It is more difficult to predict when a beach may reach the minimum healthy volume when erosion patterns vary, as in the case of the south end of IOP. Volumes fluctuate up and down from year to year before falling off dramatically in 2023. Figure 7 shows a similar graphic from beach monitoring at Edisto Beach, SC. Here, the areas represented by Reaches 1–4 are the main project area and show relatively consistent erosion trends since the last nourishment was constructed in 2017. This makes forecasting future beach conditions easier, as annual losses can be projected with more confidence.

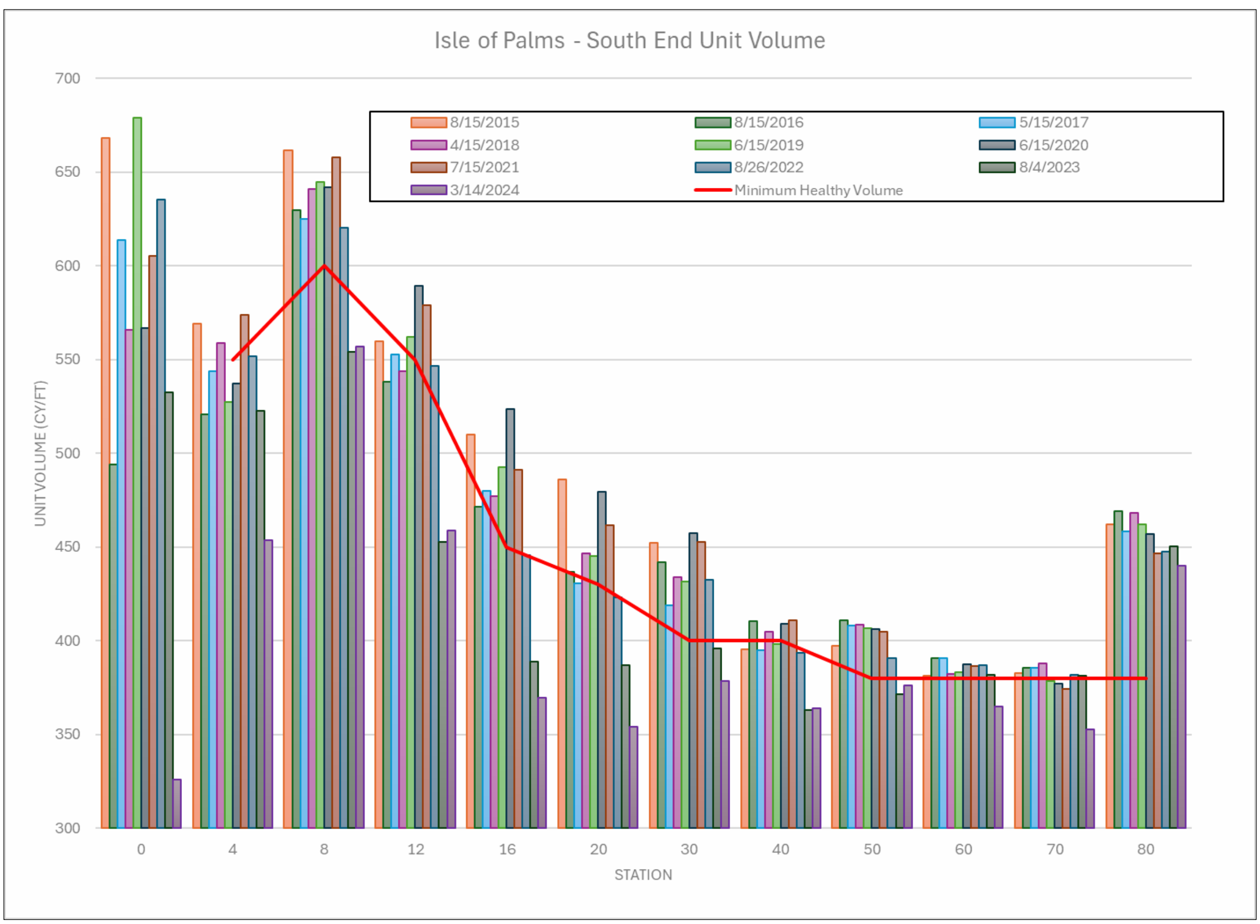

FIGURE 6. Beach Unit Volumes for the southern area of Isle of Palms. The local minimum healthy beach condition is shown in red. Note the dynamic trend south (left) of station 50 due to effects of Breach Inlet. Volume trends become more consistent away from the inlet (Stations 50–80).

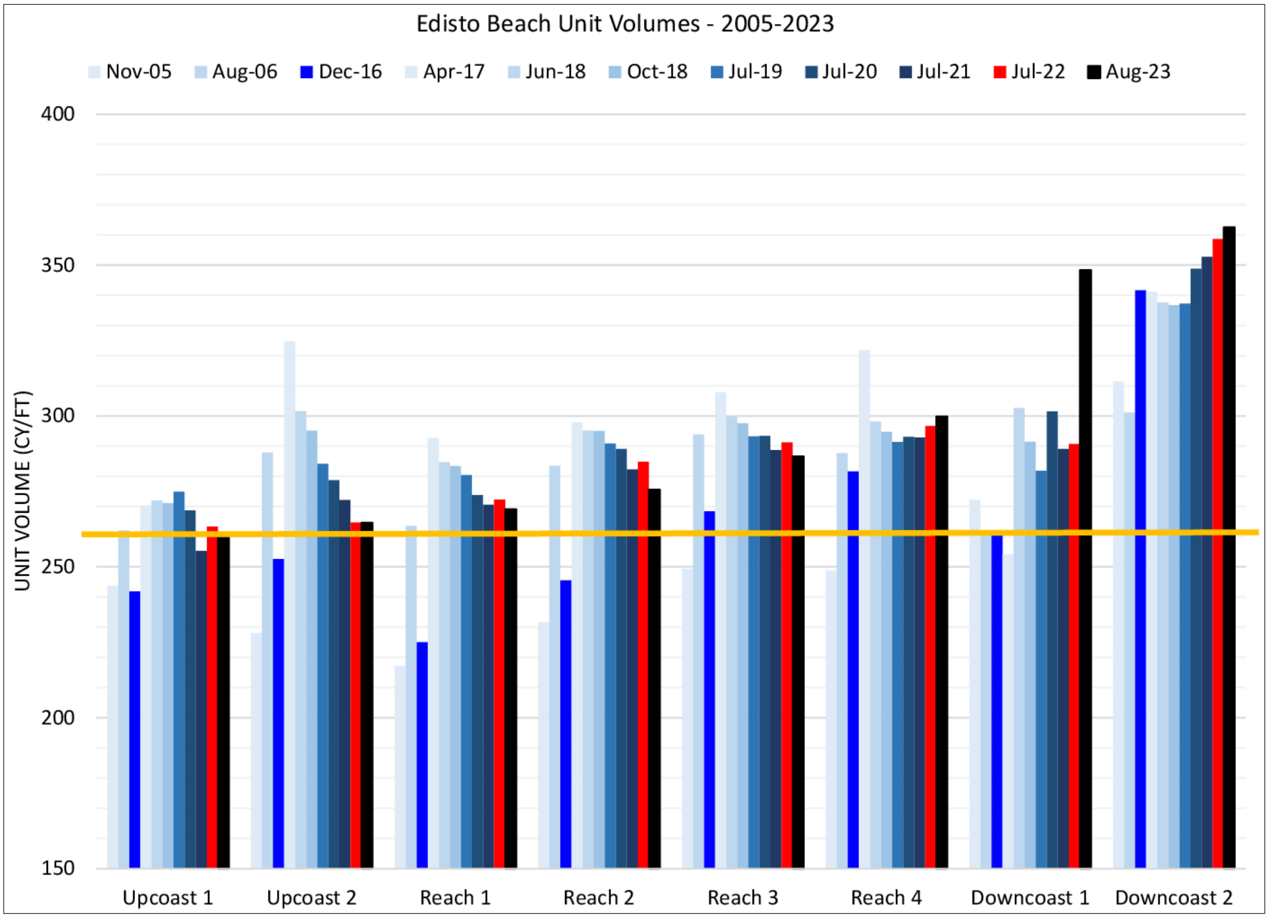

FIGURE 7. Beach Unit Volumes along Edisto Beach. Here, Reaches Upcoast 2 - Reach 3 represent the shoreline away from inlets and erosional trends are fairly consistent and predictable.

Figure 8 shows beach volumes combined into monitoring reaches used in prior reports to the City. The plot includes the minimum healthy beach volume for each reach. Assessing beach volumes by reach simplifies volume trends by eliminating highly localized spatial and temporal changes, but can mask erosional hotspots if the reaches include areas of varying beach condition. For example, Reach 5 includes healthy sections of beach north of 53rd Ave, as well as eroded sections near Beachwood East. The total volume may indicate a healthy beach, but areas within the reach may have less volume. The plot shows that Reach 1 is well under the minimum healthy volume, and Reach 2 is trending towards the minimum volume from 2018 to 2023, with a substantial decrease observed from August 2023 to March 2024, bringing the volume to below the minimum healthy condition. Along the center portions of the island (Reaches 3 and 4), the volumes have trended up since 2007, with only a few instances of annual decreases observed. At reaches 5 and 6 (north of 53rd Ave), the beach volumes decrease rapidly, then increase with nourishment (2008 and 2018). Note the volume increase from 2014 to 2016 in Reach 6 resulting from a large shoal attachment. For these reaches, a review of individual station volumes provides a better assessment of volume deficits.

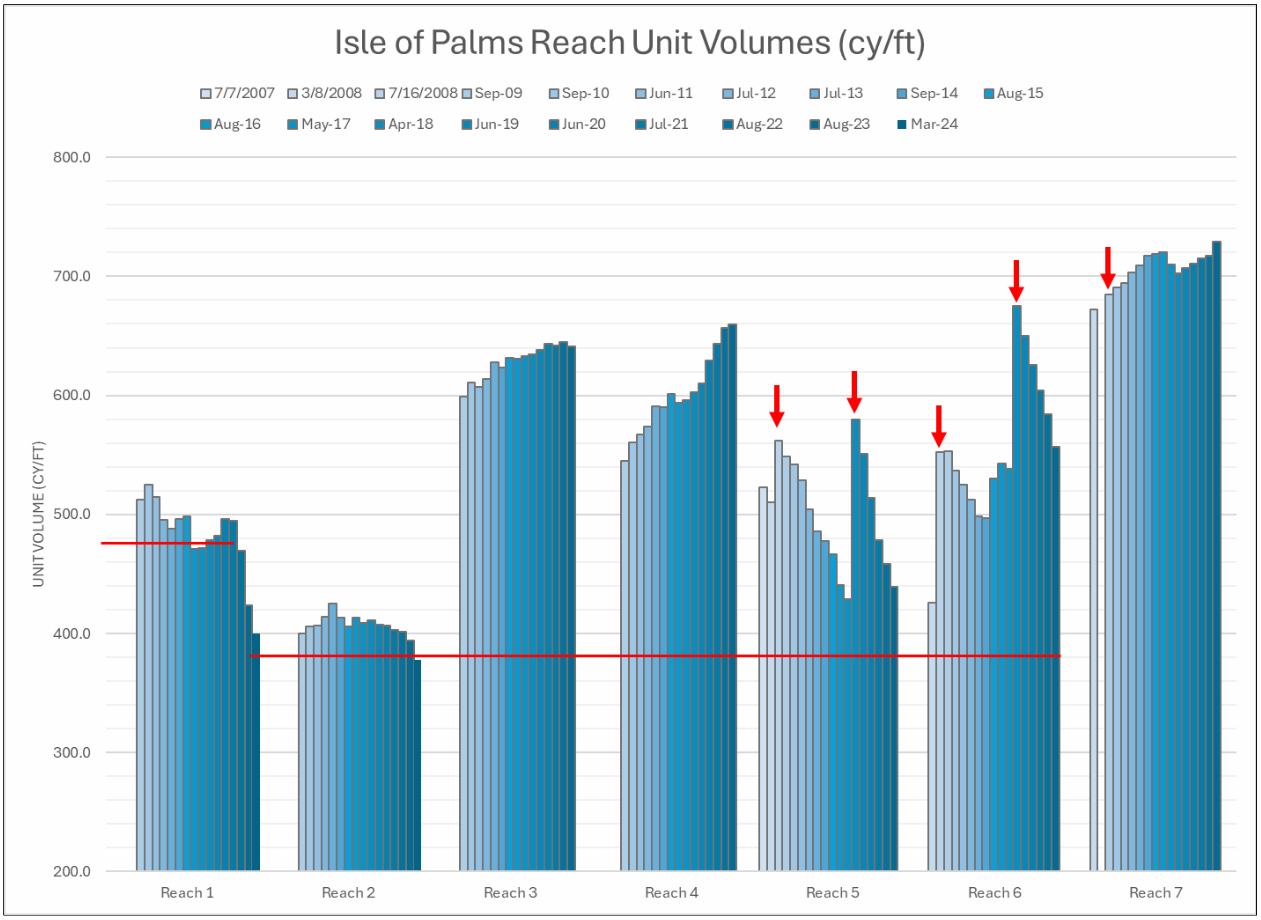

FIGURE 8. Reach Unit Volumes at Isle of Palms. Minimum healthy beach volumes are shown in the red line.

Table 1 shows erosion measures for the south end of Isle of Palms, covering the time period from 2018–2024. As mentioned previously, erosion has accelerated over the past two years, which has significantly increased erosion rates compared to historical averages. Collectively, the area south of station 80+00 has lost an average of 68,000 cy each year since 2018. This compares to a loss of 13,500 cy per year between 2009 and 2018. Should this level of erosion persist, artificial nourishment of 680,000 cy every ten years would be required to maintain the shoreline position. CSE believes the recent rates will return closer to the historical average, but with additional sea-level rise, there is a probability that future rates will be greater than the 2009–2018 rate.

At the north end, erosion has averaged ~250,000 cy per year since nourishment in 2018. This has been a very high rate of loss; however, much of the volume loss is attributable to the loss of shoal sand as well as nourishment, and much of the 2018 project area remains in good condition. A new shoal is nearing attachment, which will reduce erosion rates over the next two years. A better indication of long-term changes that include periodic shoal attachments can be estimated by comparing losses occurring from 2008–2017. This period represents the post-2008 nourishment to the pre-2018 condition and includes erosion of project sand and attachment of multiple shoal events. Over that time, reaches 5–6 lost a total of 865,000 cy of sand, or ~98,000 cy per year. This is a more realistic long-term erosion rate for the north end; however, the variability and dependence on shoals cannot be understated.

Presently, the area between the northern end of the Grand Pavilion and Dunecrest Lane has lower volumes than the minimum healthy beach volume. The City is pursuing a shoal-management permit to mitigate erosion in this area.

TABLE 1. Volume change measures for the south end of Isle of Palms.

Station	Deficit Vol (cy/ft)	Erosion Rate 2018-2023/24 (cy/ft per year)	Annual Losses (cy/yr)	Total Deficit Vol (cy)	10-yr erosion volume (cy)
3100					
3105					
0					
4	−96.3	−17.78	−6,398	−27,860	63,976
8	−43	−14.21	−5,708	−26,820	57,082
12	−91.1	−14.33	−6,492	−34,280	64,923
16	−80.3	−18.13	−6,749	−31,260	67,491
20	−76	−15.61	−6,153	−26,875	61,535
25	−31.5	−9.00	−4,582	−13,225	45,819
30	−21.4	−9.33	−4,332	−10,825	43,319
35	−21.9	−8.00	−3,732	−14,500	37,321
40	−36.1	−6.93	−3,607	−10,375	36,071
45	−5.4	−7.50	−3,248	−2,325	32,480
50	−3.9	−5.49	−2,373	−6,225	23,730
55	−21	−4.00	−1,735	−9,050	17,351
60	−15.2	−2.94	−1,735	−9,600	17,351
65	−23.2	−4.00	−2,483	−12,650	24,828
70	−27.4	−5.93	−2,733	−9,200	27,328
75	−9.4	−5.00	−2,450	−2,350	24,498
80		−4.80	−1,608	0	16,077
Total			**−67,993**	**−247,420**	**679,927**

NOURISHMENT REQUIREMENTS

Beach monitoring efforts show that the total sand quantity along the Isle of Palms increased by 854,000 cy between 2008 (pre-nourishment) and 2023. This includes the placement of ~900,000 cy in 2008 and 1.6 million cy in 2018. Without these two projects, the volume change along IOP would be a net loss of ~1.7 million cy. Reaches 3, 4, (Sea Cabins Pier to 53rd Ave), and 6 and 7 (north of WD Property Owners Beach House) currently have more sand than the pre-2008 condition, while reaches 1–2 (south of Sea Cabins Pier) show a net loss of ~736,000 cy and Reach 5 (53rd Ave to Property Owners Beach House) has lost 424,000 cy.

The values above show that localized erosion trends within certain areas of the Isle of Palms can be distinct from total island changes. While the north end is more dynamic, with periods of erosion and accretion and high spatial variability within the reaches, the south end has had high erosion rates over the past two years. Despite the gains in the upcoast areas, insufficient sand has moved south from the central part of the island to compensate for losses to Breach Inlet.

To keep pace with erosion rates observed since 2018, the City will need to supplement an average of ~68,000 cy of sand per year along the south end, and ~100,000 cy of sand per year at the north end. Over a 10-year period, these loss rates translate into 680,000 and 1,000,000 cy projects, assuming there is a minimal healthy beach volume at the start of the project. Any deficit volume would be added to these values to bring all sections of the beach up to the same condition at project completion.

CSE recommends the City plan for nourishment projects at 8–10 year intervals based on current erosional trends, the performance of prior projects, and a general desire to limit the number of mobilizations and construction impacts. The City can establish triggers to aid in decision-making on when to move forward with a project; however, CSE recommends that any trigger allow for flexibility to accommodate the unique beach condition at the time, stage of shoal attachments, dredger availability, and storm impacts. Example triggers could be when a certain length of beach is projected to reach the minimum healthy beach condition within the next 12–24 months, a project would be considered. This could include separate triggers to aid in determining whether to move forward with a shoal management project, or a large-scale project at the north end.

A shoal project could be triggered by a smaller length of affected beach (on the order of 1,500–2,000 ft), with a caveat that the beach and shoal conditions meet permit conditions for buffers. A large-scale project could be triggered by a larger length of beach reaching a set volume above the minimum healthy profile. One example would be if 5,000 ft of beach at the east end averaged less than 430 cy/ft (50 cy/ft above minimum), then a large-scale project could be pursued (again, with a caveat that the specific conditions at the time would need to be considered).

The pending USACE project will add ~500,000 cy of sand to the southern end of IOP, restoring the deficit volume and providing an additional ~4 years' worth of erosion at recent rates. CSE is optimistic that this project will restore a dry sand beach to all areas south of the pier and allow for future dune growth following the City's supplemental efforts in connection with the USACE project. For cost projections, CSE assumes that the USACE project will accomplish restoring the existing deficit volume at the south end.

Nourishment costs are driven by several factors, summarized below:

1) Mobilization – Mobilization of an ocean-certified dredge can range from $3–5 million or more depending on the amount of pipe required (distance to borrow area and length of shore pipe), dredge proximity, fleet availability, season, and local factors such as equipment access
2) Efficiency of borrow area – closer borrow areas with deeper available cuts, high-quality sand, and efficient layout can reduce costs. Reduced uncertainties about sediment quality and weather allow for better confidence and lower costs
3) Fill density – Larger fill volumes are typically more efficient to construct on the beach
4) Season – Typically, the summer season provides better weather conditions and more fleet availability; however, sea turtle concerns may impact permitting
5) Contract requirements – Insurance, wage, tolerances, or other requirements placed on contractors may increase costs

At Isle of Palms, prior nourishment projects have generally been bid at lower unit volumes compared to other projects in the state. For example, the unit cost for the 2018 project was $6.15 per cy, along with mobilization of ~$3.5 million. Comparable projects at nearby areas have cost $11–12 per cy (Pawleys Island 2020, Edisto Beach 2017, DeBordieu Beach 2022). For planning purposes, and with considerations for inflation and higher construction prices over the past few years, CSE anticipates unit pumping costs for the next five years at IOP to be $10–12 per cy with mobilization of $4–5 million.

CSE recommends the City pursue a plan that allows for concurrent nourishment of the north and south ends (if necessary) to greatly reduce mobilization costs compared to separate projects. A joint project would require the dredge equipment to shift from one end of the island to the other, and would likely require a separate borrow area for the south end; however, these types of shifts are common to offshore dredging projects and would not result in a significant increase in mobilization costs. Constructing the projects separately would require full mobilization costs for each project.

Table 2 provides a 30-year example of a nourishment scenario, assuming the erosion losses discussed above. It includes a 3% inflation factor for mobilization and sand placement. CSE would recommend a contingency volume to account for storm events or higher-than-normal erosional periods to modify any particular project. In addition, should a major storm impact the beach, FEMA may reimburse the City to replace losses caused by the storm. For a combined project, CSE estimates that an initial project for both ends of the island would cost ~22 million dollars. Future project costs are shown assuming the 3% inflation.

TABLE 2. Example cost scenario for joint offshore projects at the north and south end over a 30-year period. A 3% inflation factor is assumed.

	Unit Cost	Volume (cy)	Total Cost - Year	Year 10	Year 20	Year 30
Mobilization	$ 5,000,000.00		$ 5,000,000.00	$ 6,719,581.90	$ 9,030,556.17	$ 12,136,312.36
North End Placement	$ 10.00	1,000,000	$ 10,000,000.00	$ 13,439,163.79	$ 18,061,112.35	$ 24,272,624.71
South End Placement	$ 10.00	680,000	$ 6,800,000.00	$ 9,138,631.38	$ 12,281,556.40	$ 16,505,384.80
Total Project		1,680,000	$ 21,800,000.00	$ 29,297,377.07	$ 39,373,224.92	$ 52,914,321.87

Funding plans should consider potential partnerships with the state, as all the south end, and a portion of the north end would qualify for state beach nourishment assistance, if available. Note that presently, there are little remaining funds in the state's beach nourishment fund. Additionally, private funding from the Wild Dunes community may be available for cost-sharing of work completed within Wild Dunes.

Nourishment via offshore dredge with placement at both ends of the island provides the most cost-effective, large-scale alternative for long-term beach management. These projects allow for predictable planning schedules, costs, and outcomes (with the caveat that periodic maintenance shoal projects may be required at the east end). The only other alternative for large-scale nourishment (>400,000 cy) at the south end is a project that would dredge sand from the shoals of Breach Inlet. This project could have lower pumping costs due to a shorter pump distance; however, it would still require high mobilization costs for an "ocean-certified" dredge. While altering the inlet could alleviate some of the present morphologic conditions that are drawing sand off the south end, there may be unintended consequences of large-scale alterations of the inlet to both Isle of Palms and Sullivan's Island. Also, after permitting and funding are secured, natural changes in the inlet system may create conditions where relocating a channel is not as effective as if it were constructed today.

There may be several opportunities for modest-scale projects via beneficial use projects from the Intracoastal Waterway and/or adjacent creeks, especially at the south end. The USACE intends to place sand directly from the waterway in future years if the upcoming project proves successful and the material is beach-compatible. This may add several hundred thousand yards of sand whenever the waterway is dredged. If federal funds are not available, the City can partner with the USACE to sponsor a project for the benefit of IOP. A modest-scale waterway project may cost $3–6 million, with the high range due to variable volume scenarios. The upcoming USACE project will be constructed for just under $10 million, but involves a larger volume than typical waterway dredging and involves clearing deposition basins and the double handling of material. More typical waterway dredging projects would cost less.

Should the erosion rate along the south end return to historical trends, it's likely that the beach can be maintained with infrequent smaller-scale projects. Future monitoring will be critical for determining the necessary mitigation plan. Ultimately, analysis of the unit cost for the different alternatives should be considered. Due to economies of scale, and mobilization being required for offshore projects at the east end, nourishment via offshore dredging likely has similar or lower unit cost as smaller-scale beneficial use projects (if not paid for by the USACE).

CSE recommends that the City seek permits well in advance of potential construction windows to allow for as much flexibility as possible. Permits can take 12–18 months to receive after submission of all necessary documentation. Engineering and sand searches may take 6–12 months prior to submission of an application. Initial planning for an offshore dredging permit should start 3–4 years after the last project is completed so that a permit is issued in year 5 or 6. With a 5-year life, the permit would allow for construction to occur anytime between years ~6 and 11, which allows for flexibility to account for unexpected changes in erosion trends, storm impacts, shoal attachments, and contractor availability.

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