Attachment 18:

Revised Mid-Currituck Bridge Submerged Aquatic Vegetation Mitigation Plan, July 24, 2024 (Final Revised)

Revised Mid-Currituck Bridge

Submerged Aquatic Vegetation Monitoring Plan to Determine Mitigation

July 2024

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Mid-Currituck Bridge

Submerged Aquatic Vegetation Monitoring Plan to Determine Mitigation

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Background

A new bridge from the mainland to Corolla on the Outer Banks in Currituck County, North Carolina is proposed for construction by the North Carolina Department of Transportation (NCDOT). Construction of the new Mid-Currituck Bridge will impact submerged aquatic vegetation (SAV) resources that exist within the proposed bridge footprint (Selected Alternative, NCDOT) (**Figure 1**). Since the original SAV Monitoring and Mitigation plan was approved in 2020, there has been an increase in the amount of SAV growing in the project area. This revised plan is updated with the most recent SAV data. The exact acreage of SAV that will require mitigation due to permanent and/or temporary impacts is unknown at this time. This document describes some proposed options for mitigating potential impacts to SAV (e.g., bridge piling, temporary construction bridge and shading).

SAV in Currituck Sound have been studied for several decades (Davis and Brinson, 1990; Luczkovich, 2010; CZR, 2011) and status and distribution have been examined since the early 1980s (Davis and Carey, 1981; Davis and Brinson, 1983; Carter and Rybicki, 1994). Surveys performed by Elizabeth City State University (2003) and the Albemarle-Pamlico National Estuary Program (2006 and 2012) have shown an increase in total SAV acreage throughout Currituck Sound from 2003 to 2012 (Corbett et al., 2018) (**Figure 2**). Other studies by Nelson and Hartis (2014) and USACE (2007 and 2010) address the status of SAV in Currituck Sound. Another study by (Atkins 2013) collected some additional habitat information as part of an effort to identify potential mitigation sites. Additionally, the Submerged Aquatic Vegetation Evaluation in Currituck Sound (SAVE Currituck) Study, funded by NCDOT and conducted by the East Carolina University (ECU) Coastal Studies Institute and research partners developed a comprehensive understanding of the dominant drivers of SAV distribution in the oligohaline waters of Currituck Sound, by collecting and synthesizing bathymetry, wind, wave, sediment, and SAV percent cover data (**Figures 2, 3, 4**). (Corbet, 2018). These environmental data, particularly those provided in the recent SAV Currituck Study, including the advanced wave energy modeling, extend the initial analysis done by Atkins (2013) to a more comprehensive spatial extent and provide updated knowledge to inform mitigation opportunities associated with the Mid-Currituck Bridge construction.

The distribution of SAV habitat falling specifically within the Mid-Currituck Bridge alignment has also recently been examined by review of previous data along with recently collected side-scan imaging sonar data collected from May and September 2023 (RK&K, 2023) (**Figures 5a, 5b, 5c, 6a, 6b, 6c**). The proposed bridge landing area on the east end (Corolla, on the Outer Banks) has SAV habitat forming nearly continuous cover from the shoreline westward into the Sound, (**Figures 5a**, **5b)**. Proceeding west towards the mainland, the bridge alignment crosses an area of deeper water where SAV is absent (**Figures 5b,5c,6b,6c**). At the western landing site on the mainland in Currituck County (**Figures 5c**, **6c**), no SAV was observed in surveys prior to 2022, although small SAV patches along the shoreline have been observed in previous years, indicating a spatially and temporally variable SAV resource in this area.

Beginning in May of 2022 SAV cover increased in the project area, including larger areas of SAV occurring near the western landing site where little to no SAV had been seen in recent years.

SAV in the project area occupied 24.01 acres in May 2022 and 54.59 acres in September 2022, 58.31 acres in May 2023 and 53.49 acres in September 2023 (**Table 1**).

Until the September 2022 survey, water depths ranging from -6 to -11 MLLW feet were not occupied with SAV (**Figure 6b**). During the September 2022, and both 2023 surveys, SAV was observed in water depths of -7.3 feet, not accounting for daily wind or tide variations. Deeper open waters (> -7.4 feet) were assessed, and no SAV was located. Water clarity was measured with a Secchi disk and ranged from 1.0m to 1.2m across the study area in May and 0.4m to 1m in September 2023 (RK&K 2023).

From 2015 to May 2021, SAV coverage has remained relatively constant throughout the study area; however, since the September 2021 survey, a steady increase in SAV coverage has been observed (**Table 1**). This is likely due to a combination of favorable weather and climate conditions contributing to less turbidity in the Sound, promoting SAV growth which in turn contributes to less turbidity (**Table 2**).

A total of seven SAV taxa have been identified in Currituck Sound from the SAVE Currituck Study (Corbett et al., 2018). Taxa consist of one species of a euryhaline seagrass (*Ruppia maritima*), four species of freshwater aquatic plants (*Myriophyllum spicatum*, *Najas guadalupensis*, *Potamogeton perfoliatus*, and *Vallisneria americana*), and two freshwater algae taxa (both of the genus *Chara*). It is important to note that one of the SAV species is invasive, the Eurasian watermilfoil (*Myriophyllum spicatum*). This species has been observed frequently throughout the study area close to shore.

Table 1. Submerged Aquatic Vegetation (SAV) coverage by year for R-2576 (Mid-Currituck Sound Bridge).

YEAR	***SAV COVERAGE (acres)***
2015	14.90
2016	14.78
2017	13.17
May 2018	15.59
September 2018	17.26
May 2019	13.59
September 2019	14.32
May 2020	12.57
September 2020	14.06
May 2021	14.22
September 2021	18.50*
May 2022	24.01
September 2022	54.59
May 2023	58.31
September 2023	53.46**

*September 2021 SAV coverage was corrected from 28.60ac. to 18.50ac.

**Tropical Storm Ophelia landfall occurred on September 21, 2023. This storm event may have impact SAV in the area.

Table 2. Secchi Depths per Year of Surveys

Year	***Secchi Depth Across Study Ares (meters)***
October 2018	0.4m-0.6m
2019	0.3m-0.5m
2020	0.3m-0.75m
2022	0.6m -1.1m
2023	0.4m-1.2m

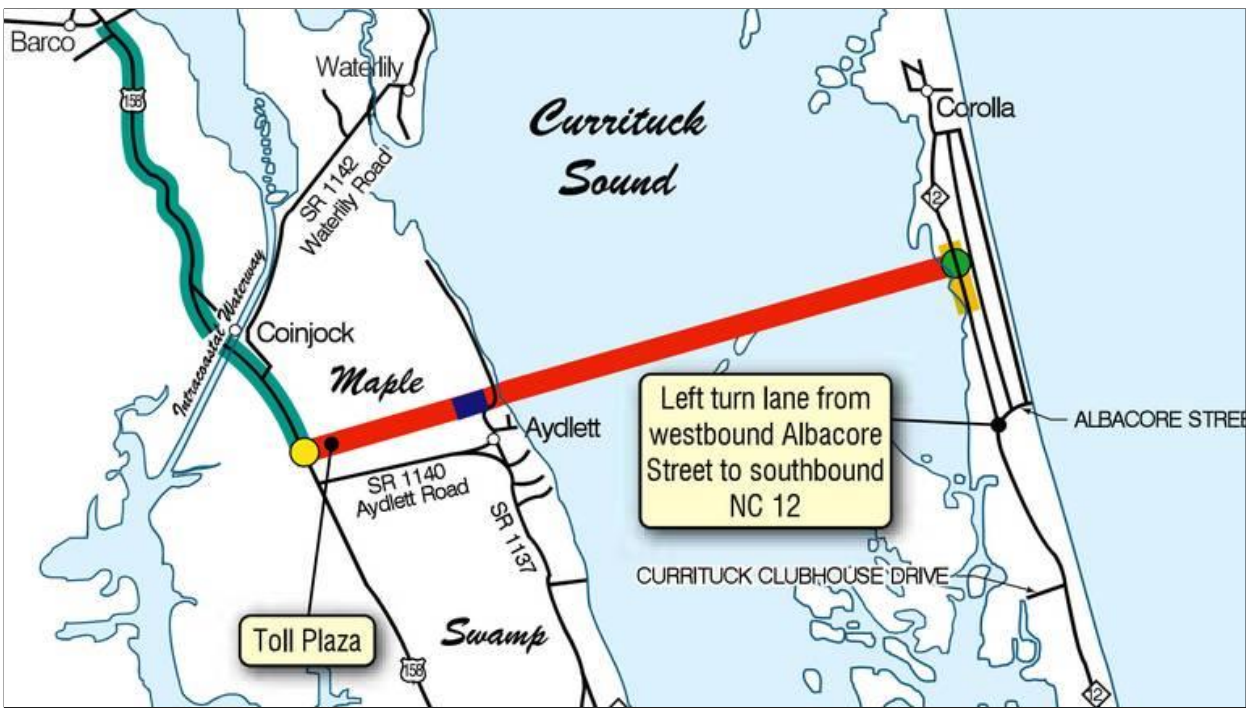


Figure 1. NCDOT Selected Alternative, alignment for the Mid-Currituck Bridge.

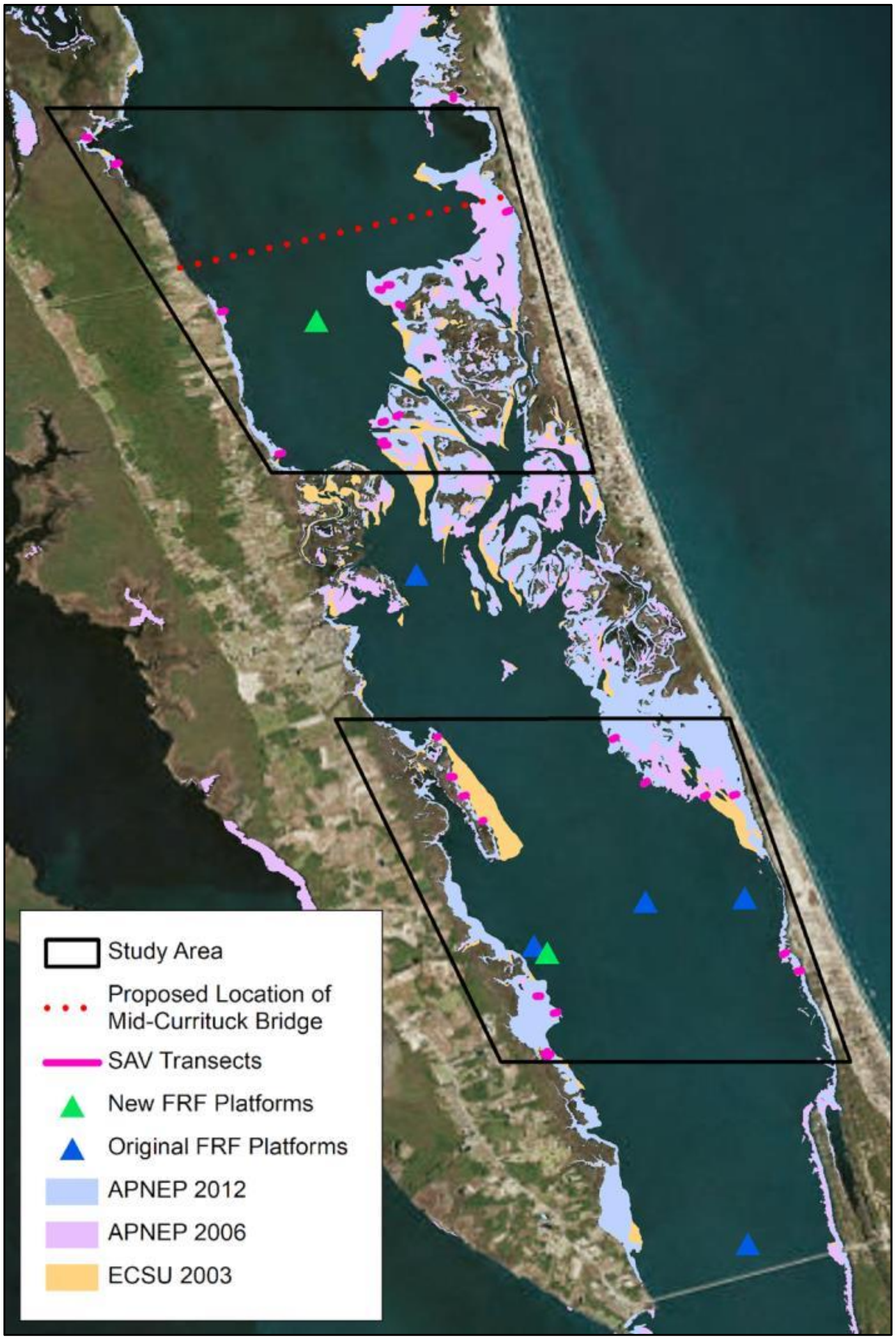


Figure 2. Previous SAV distribution data in Currituck Sound in 2003 from Elizabeth City State University (ECSU) and in 2006 and 2012 from the Albemarle-Pamlico National Estuary Program (APNEP) for the NCDOT-funded SAVE Currituck Study. Water quality data is also being collected for the SAVE Currituck Study by the USACE Field Research Facility (FRF). Map provided by D.R. Corbett, ECU.

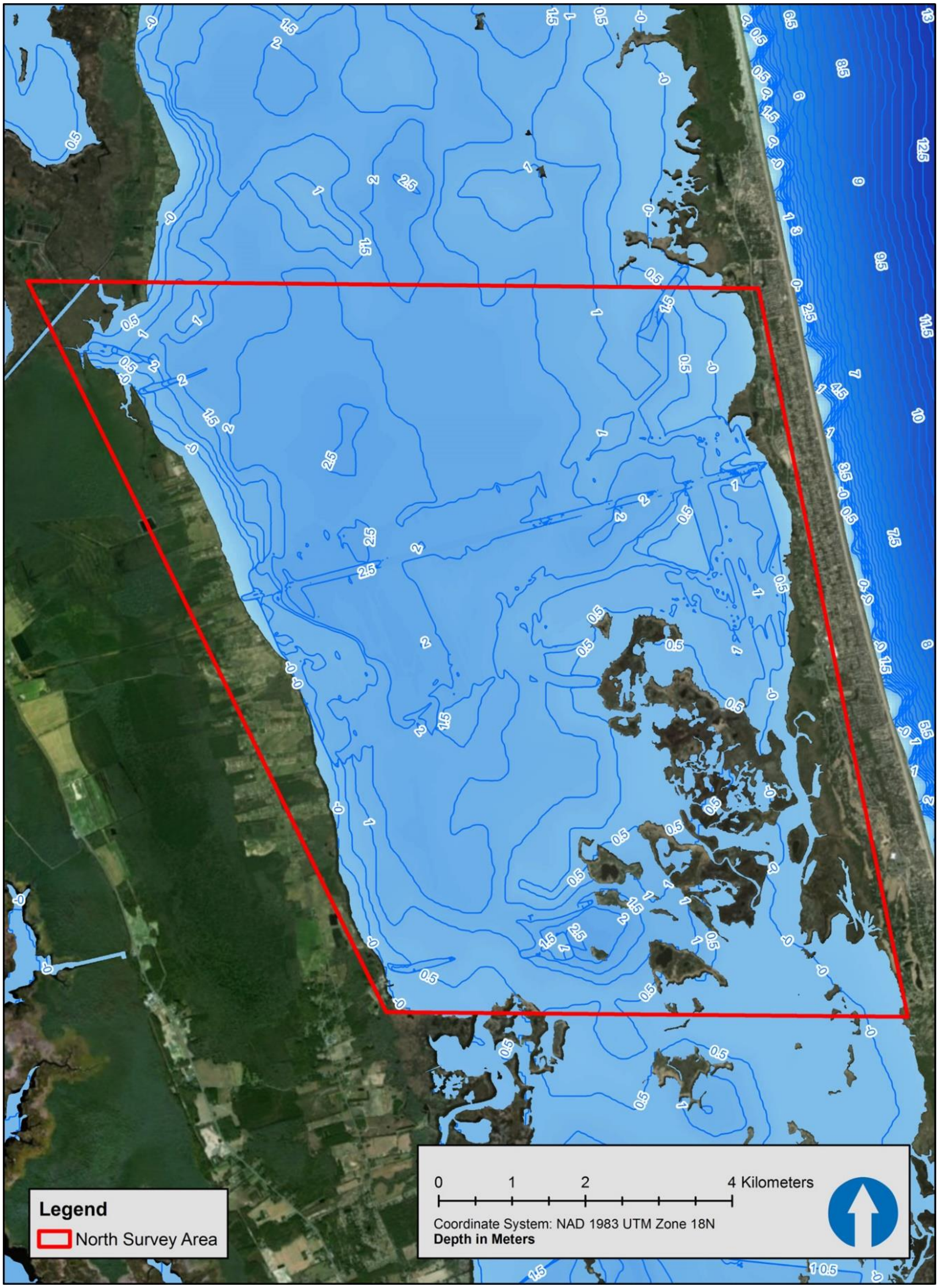


Figure 3. Comprehensive bathymetry data for Currituck Sound compiled for the NCDOT-funded SAVE Currituck Study. Map provided by CSA Ocean Sciences Inc., 2018.

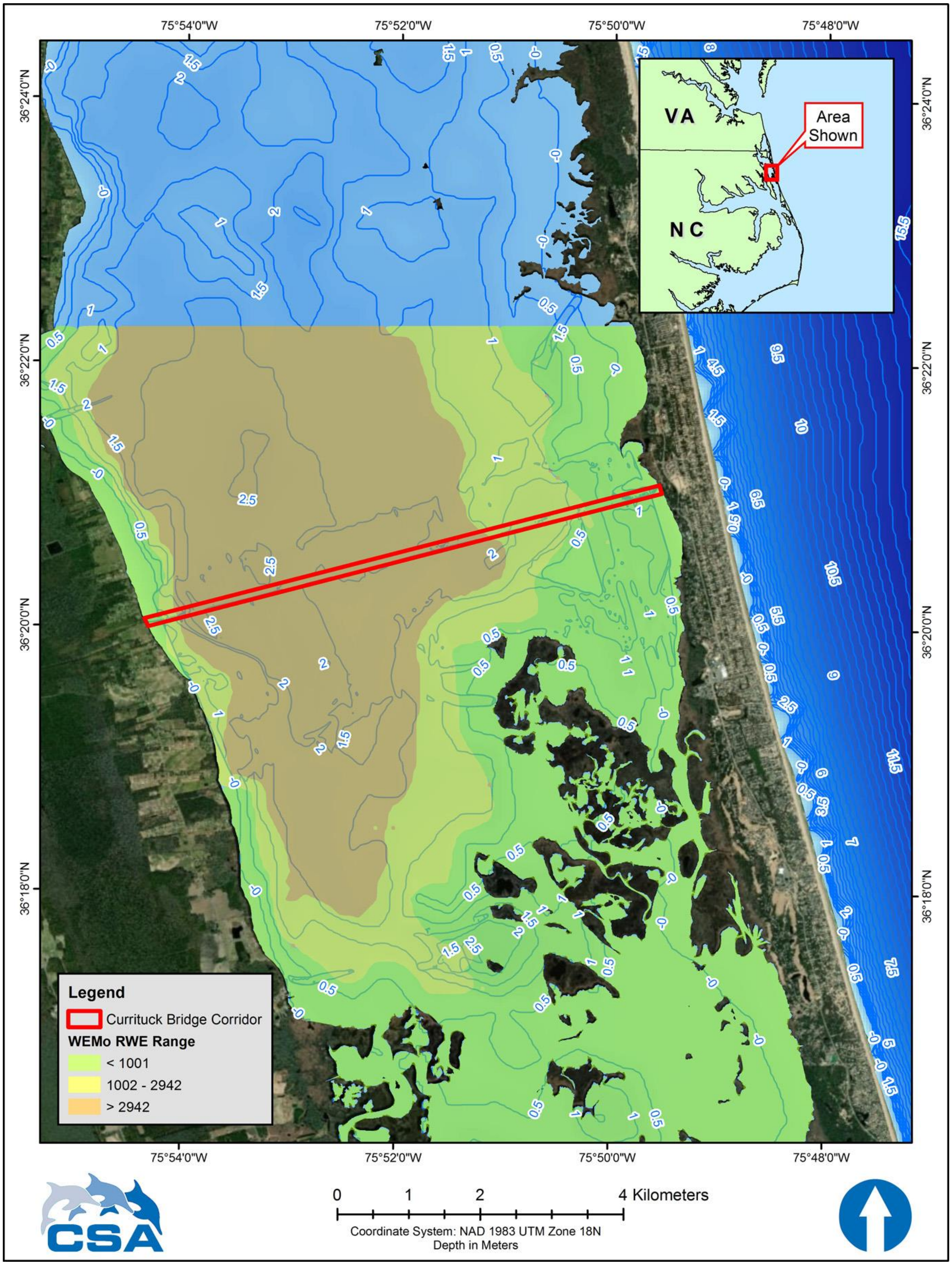


Figure 4. Results from the Wave Exposure Model (WEMo) analysis in Currituck Sound for the NCDOT-funded SAVE Currituck Study showing representative wave energy (RWE) zones. Map provided by CSA Ocean Sciences Inc., 2018.

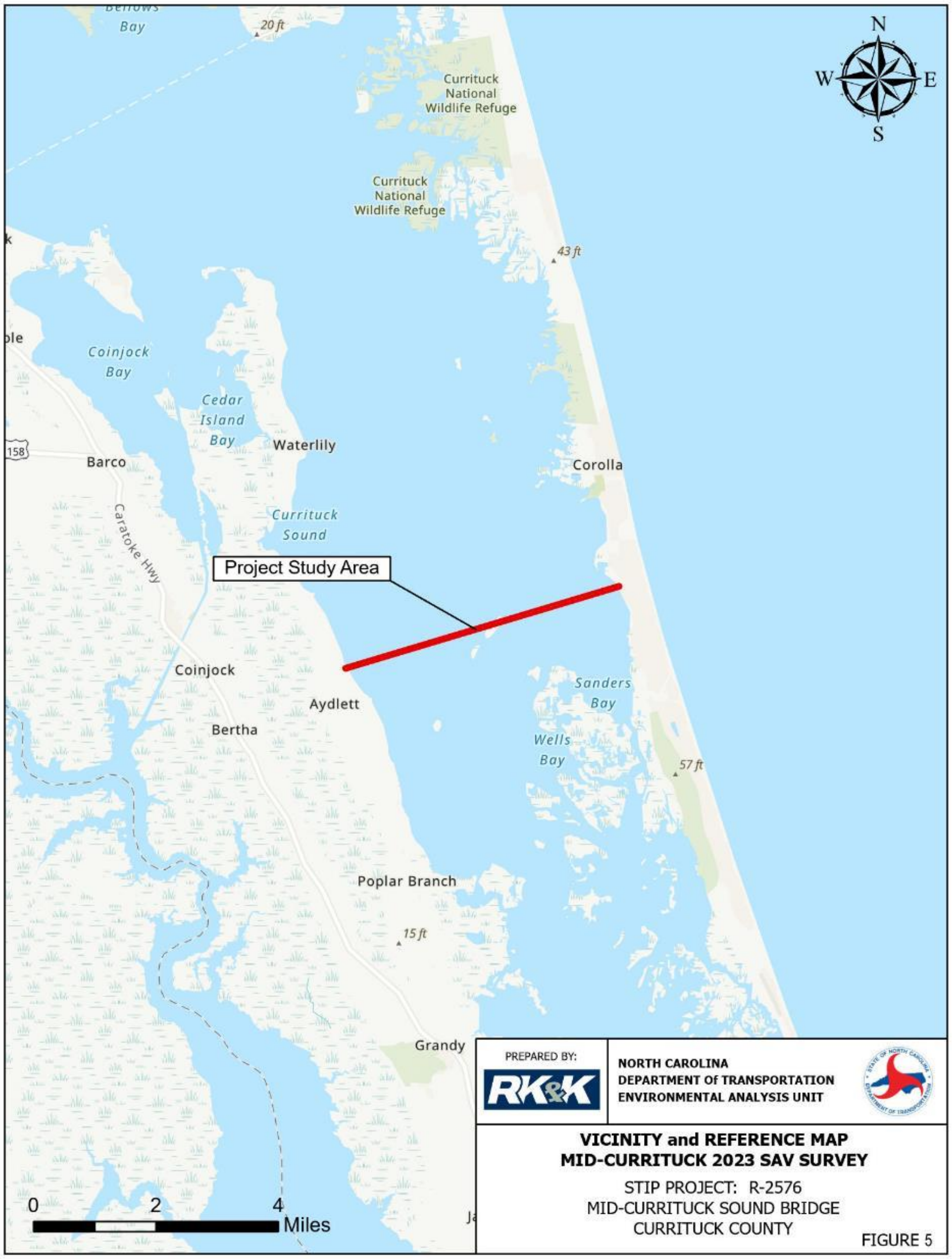


Figure 5. Study area reference for figures 5a-6c.

Figure 5a. East end of the proposed Mid-Currituck Bridge alignment showing SAV cover in May and October 2023.

Scale: 1 in. : 300 ft.

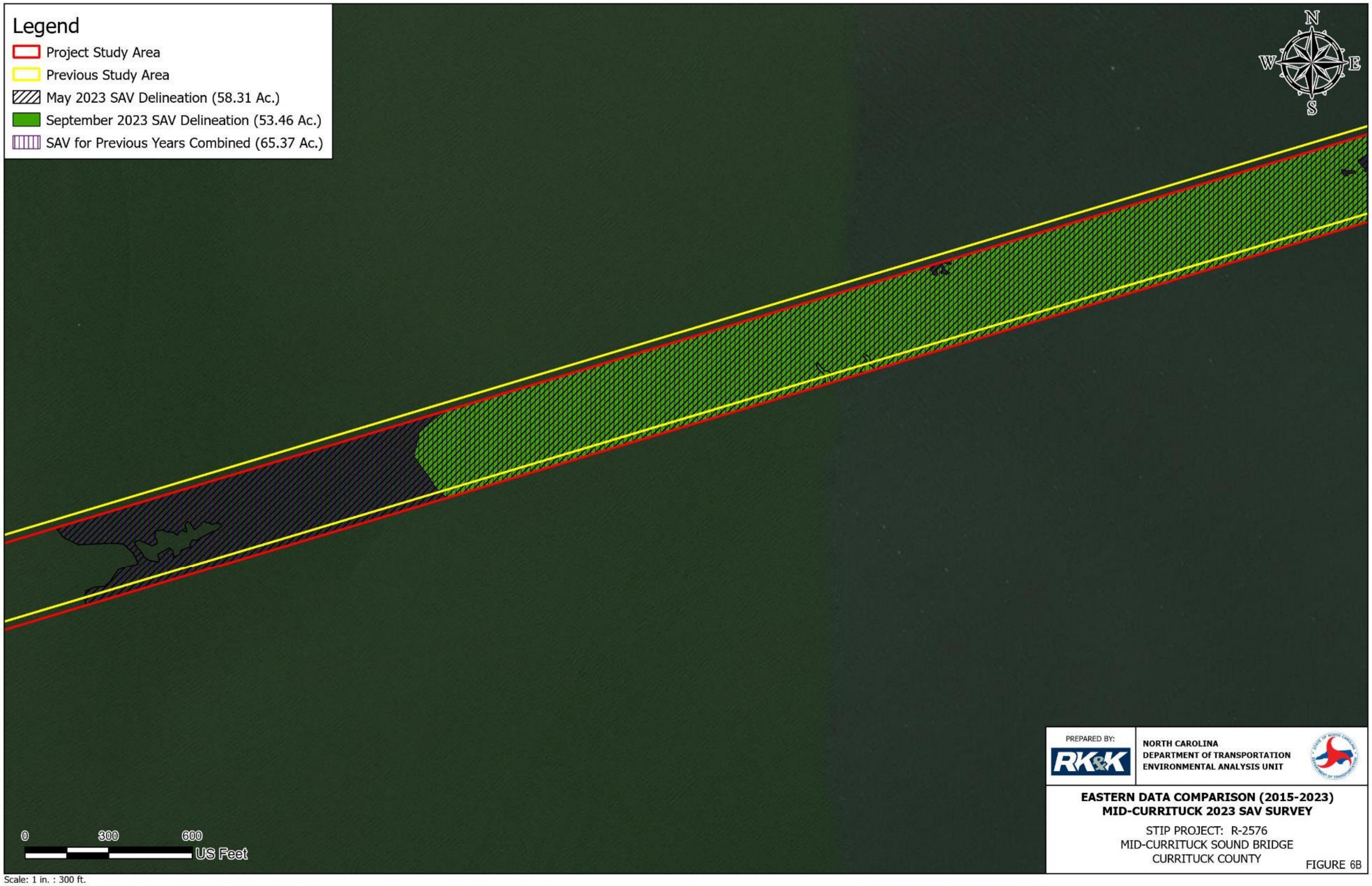
Figure 5b. Middle of the proposed Mid-Currituck Bridge alignment showing SAV cover in May and October 2023.

Scale: 1 in. : 150 ft.

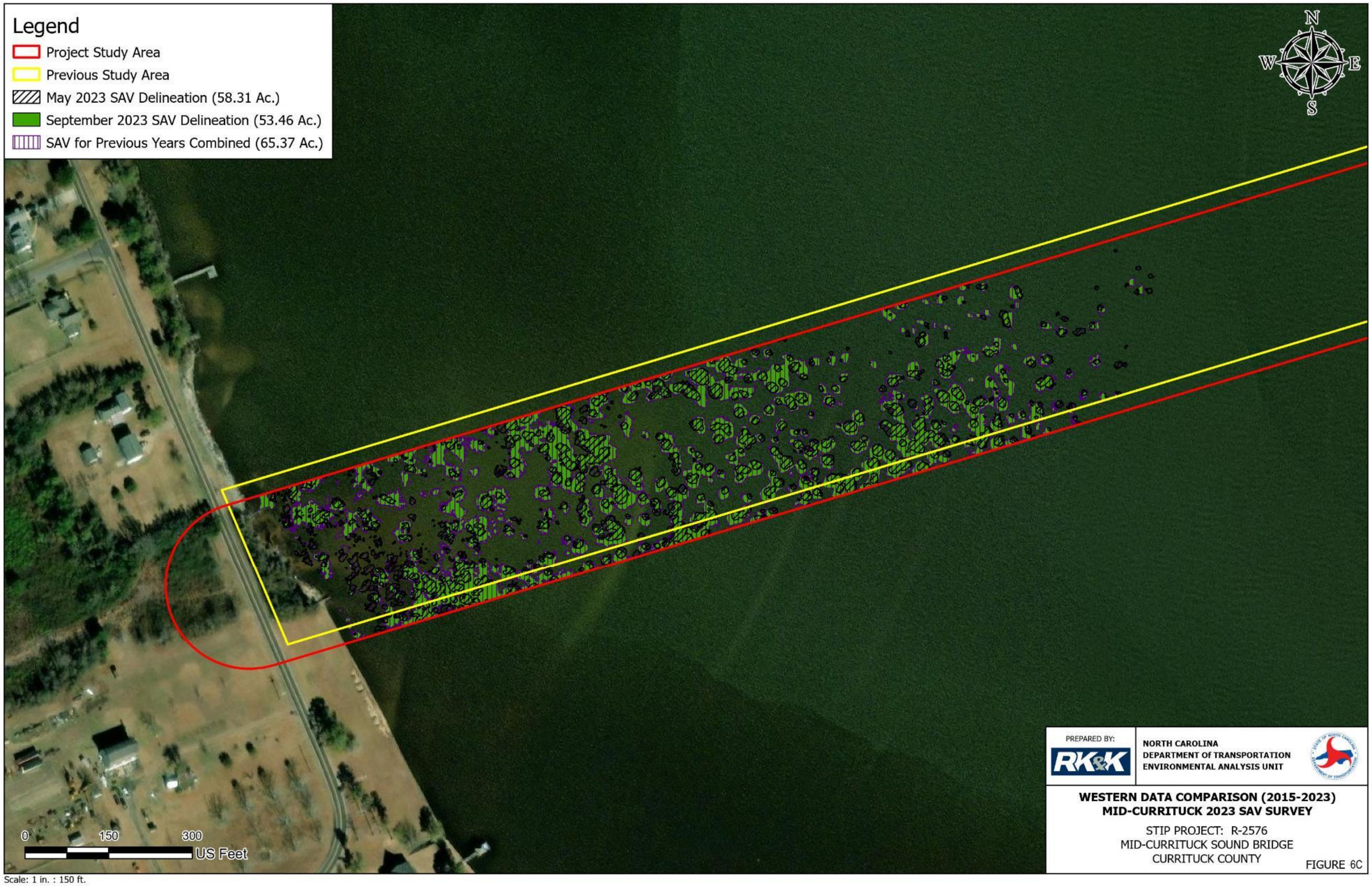
Figure 5c. Mainland (west) end of the proposed Mid-Currituck Bridge alignment showing SAV cover in May and October 2023.

Scale: 1 in. : 300 ft.

6a. East end of the proposed Mid-Currituck Bridge alignment showing submerged aquatic vegetation (SAV) cover in 2023 and previous years.



6b. Middle of the proposed Mid-Currituck Bridge alignment showing submerged aquatic vegetation (SAV) cover in 2023 and previous years.



6c. West end of the proposed Mid-Currituck Bridge alignment showing submerged aquatic vegetation (SAV) cover in 2023 and previous years.

Impacts Summary

Beginning in 2015, SAV surveys have been conducted by NCDOT in the project area, which extends 150 feet on either side of the proposed bridge centerline for a total of 300 feet. While we realize there is historical SAV data from Currituck Sound, the data that exists is not specific to the bridge alignment. The data collected by ECU in 2010 was specific to the alignment, however, the SAV data was estimated/predicted based on random ground truthing of sonar transect data. Only the sonar data, that NCDOT began collecting in the alignment area in 2015, can be used as baseline data for the purposes of the mitigation monitoring plan.

SAV coverage from NCDOT surveys has ranged from 13.17 acres in 2017 to 58.31 acres in 2023. The survey area extended for a total of a 300 feet wide area to account for any possible temporary construction bridge impacts. Given the Selected Alternative (**Figure 1**) and using the data collected by NCDOT beginning in 2015, the proposed bridge structure will permanently impact up to 0.064 acres of existing SAV beds within the permanent bridge piling footprint. Total baseline seagrass coverage in the proposed bridge footprint that may be impacted by shading is 8.94 acres. Based on the Shading Tool Model run on the 2023 data, the highest potential impact from all shading zones of the permanent bridge is 22.45 acres. However, based on shading data currently being collected at the new Rodanthe Bridge, it is unlikely that all 22.45 acres of SAV coverage will lose function due to shading of the bridge.

Table 3. Impacts Summary

Type of Impact	***Acres Affected***
Permanent bridge piles	0.064
Potential shading from permanent bridge deck dripline (includes permanent bridge piles acreage)	8.94
Highest estimate of potential shading zones (0%-100%) from permanent bridge shadow (includes dripline)	22.45*
Temporary bridge piles	0.112
Potential shading from temporary bridge deck (includes temporary bridge piles acreage)	0.889

*From October 2023 shading tool model run (Table 5).

In surveys prior to 2023, no SAV had been found to grow in water more than 3 feet deep. Beginning in 2022 water clarity conditions in the Sound improved and grass was observed growing at a depth of 7.3ft. in both 2022 and 2023.

The final amount of seagrass coverage that will require mitigation will be determined by the results of this approved monitoring to determine mitigation plan. Previous data collected by APNEP in 2012-2013 will also be considered at this time.

Shading Tool Prediction

To better understand the shading influence of transportation structures on SAV, an interactive shading tool was developed. This modeling tool allows users to input the structural geometry (e.g., height, width) over an open water structure to derive a geographically and temporally accurate projection of shading produced by that structure. The amount of light reduced by shading and the percentage of time that a given area of habitat is shaded along with ambient water column attenuation may then be related to any changes in SAV abundance (e.g., biomass, cover).

The tool utilizes the solar angle for a given geographic location, day of the year, and time of day to cast a shadow from a selected structure on the surrounding environment. The shading tool was applied to the Selected Alternative for the proposed Mid-Currituck Bridge structure at two different times of year, June, and October, to account for seasonal differences in solar angle and extent of SAV habitat. Results from the shading tool for the eastern and western shores of the bridge corridor are displayed in **Figures 7a**-**7d** and show various gradations of shading (percent time in shade) within the corridor footprint. The shading tool bins the percent time in shade into five strata: 0 to 20%, 20 to 40%, 40 to 60%, 60 to 80%, and 80 to 100%.

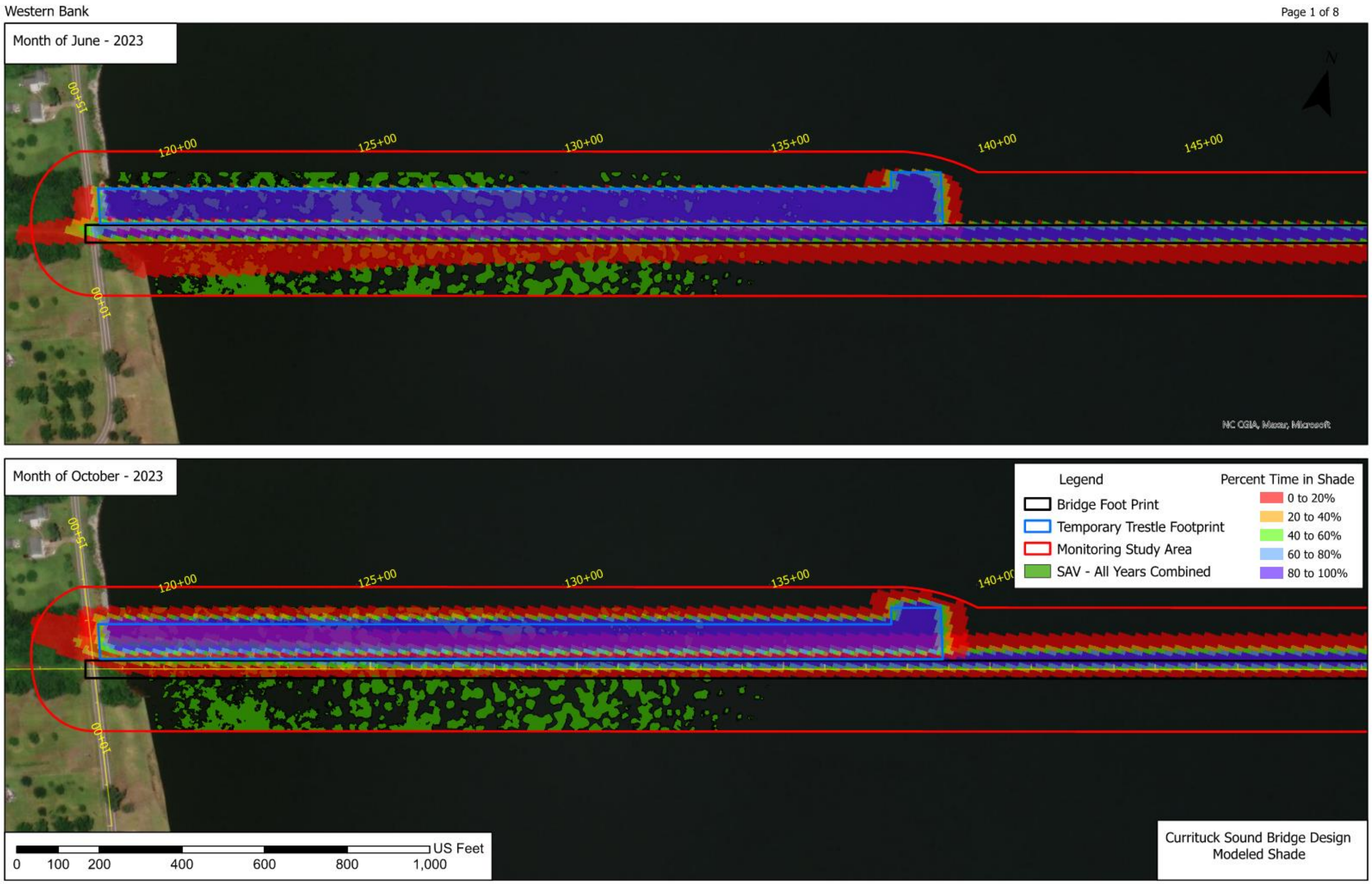


Figure 7a. West end of the proposed Mid-Currituck Bridge alignment showing SAV cover, and various gradations of shading predicted by the shading tool for the months of June and October 2023. *Please zoom in on electronic version to better view legend.*

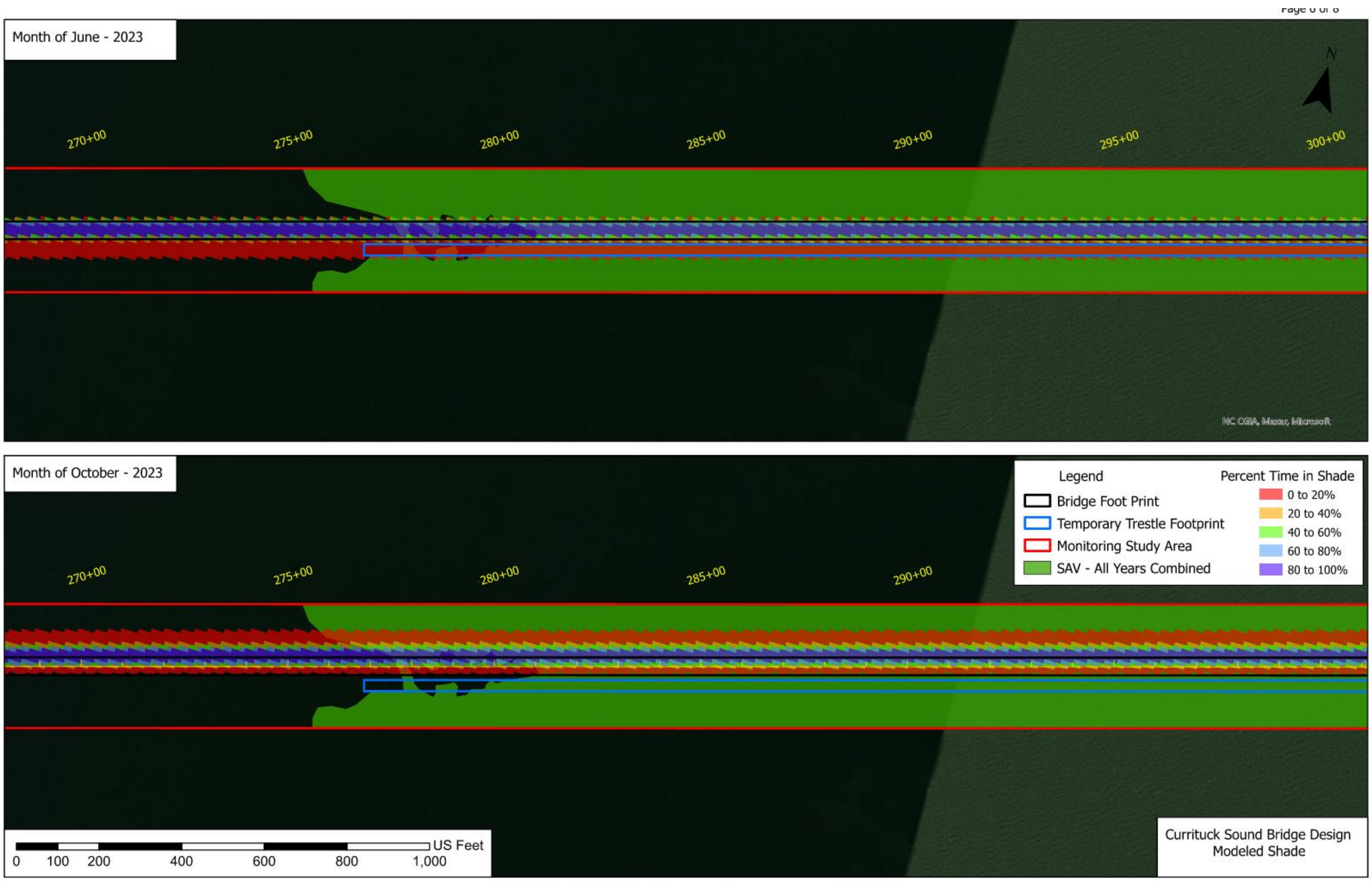


Figure 7b. Toward middle of the proposed Mid-Currituck Bridge alignment showing SAV cover, and various gradations of shading predicted by the shading tool for June and October 2023. *Please zoom in on electronic version to better view legend.*

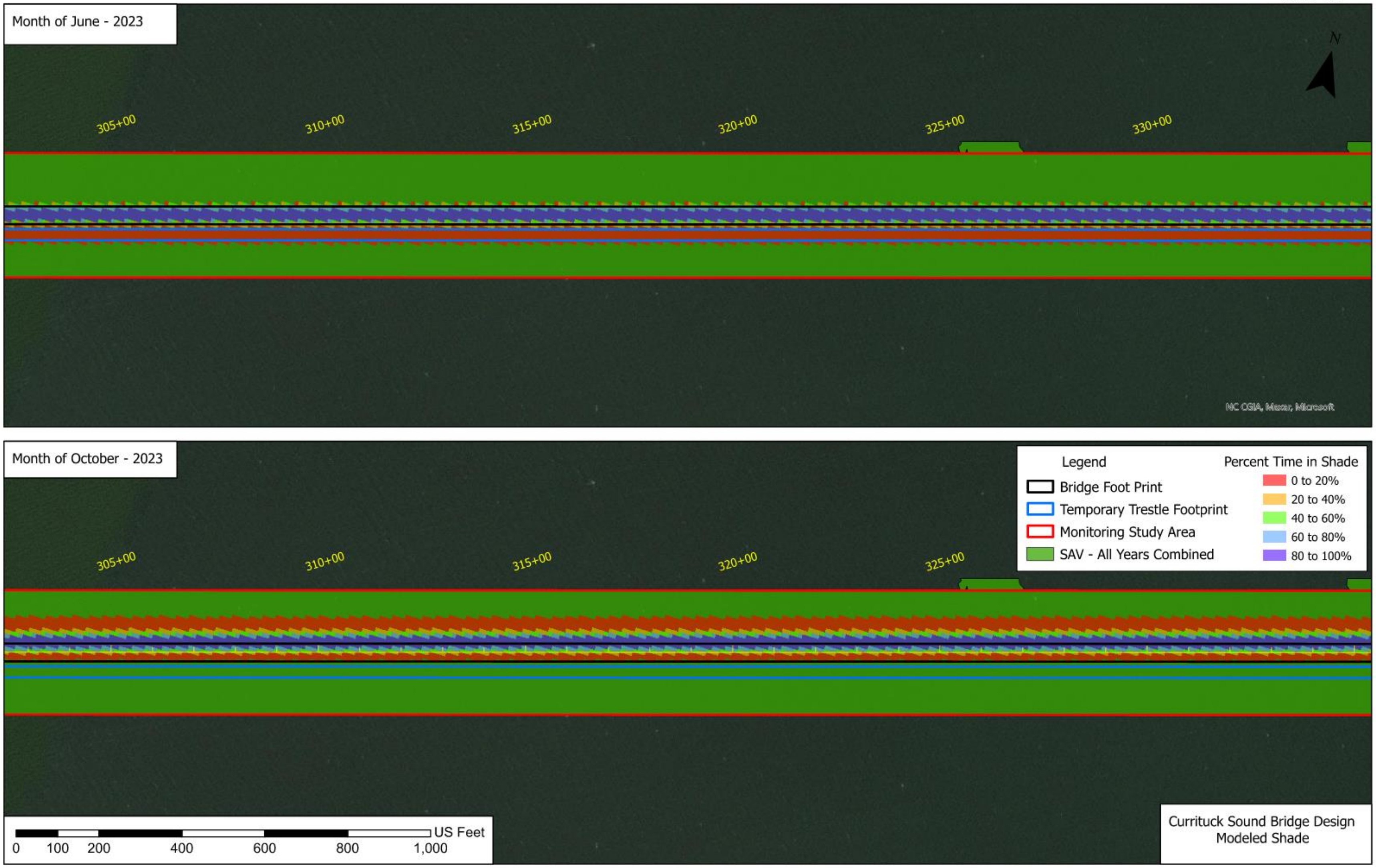


Figure 7c. Middle (east) of the proposed Mid-Currituck Bridge alignment showing SAV cover, and various gradations of shading predicted by the shading tool for June and October 2023. *Please zoom in on electronic version to better view legend.*

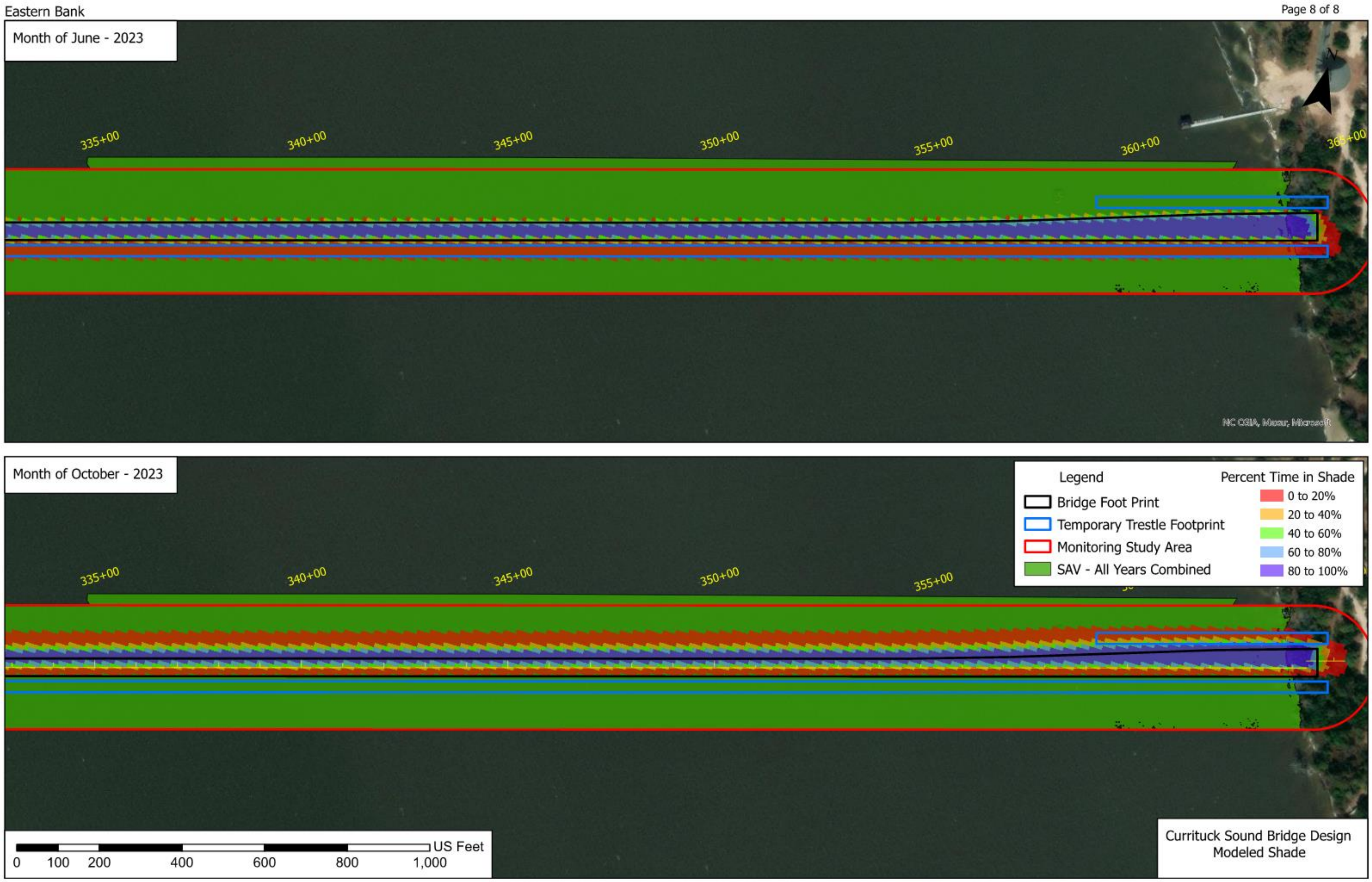


Figure 7d. East end of the proposed Mid-Currituck Bridge alignment showing SAV cover, and various gradations of shading predicted by the shading tool for June and October 2023. *Please zoom in on electronic version to better view legend.*

Estimations of acreage of SAV within the alignment corridor affected by varying percent time in shade was calculated by the shading tool for the alignment in June (**Table 4**) and October 2023 (**Table 5**). Results from the shading tool will be verified with field-based monitoring, which will include photosynthetic active radiation (PAR) measurements at the water's surface and SAV abundance and density estimations for each of the five shading strata.

Table 4. Estimations of SAV acreage affected by various gradations of shading predicted by the shading tool for the month of ***June 2023*** within the east and west end of the Mid-Currituck Bridge alignment.

Percent Time in Shade	***West end (acres)***	***Eastern end (acres)***	***Total SAV***
0-20%	0.77	8.11	8.88
20-40%	0.15	2.17	2.32
40-60%	0.09	1.41	1.5
60-80%	0.15	2.08	2.23
80-100%	0.23	5.7	5.93
Total	**1.39**	**19.74**	**20.86**

Table 5. Estimations of SAV acreage affected by various gradations of shading predicted by the shading tool for the month of ***October 2023*** within the east and west end of the Mid-Currituck Bridge alignment.

Percent Time in Shade	***West end (acres)***	***Eastern end (acres)***	***Total SAV***
0-20%	0.57	9.27	9.84
20-40%	0.14	2.39	2.53
40-60%	0.10	1.70	1.80
60-80%	0.18	2.41	2.59
80-100%	0.27	5.42	5.69
Total	**1.26**	**21.19**	**22.45**

Proposed Monitoring/Mitigation Plan

Mitigation for impacts to SAV (e.g., bridge piling, temporary construction trestles, and shading) will be performed if warranted, to the extent necessary as determined from pre- and post-construction SAV monitoring surveys in comparison to local reference baseline. Unlike marine SAV communities, the SAV communities in Currituck Sound appear to be more spatially and temporally dynamic. This inherent variability will ultimately influence overall mitigation levels and monitoring strategy in order to discriminate natural variability from potential bridge impacts. Recent studies of Currituck Sound overall supported by NCDOT and directed surveys of the bridge corridor provide a useful pre-construction portrait of the SAV resources and their inherent variability in the area.

The NCDOT will monitor temporary construction impacts and shading impacts from the permanent bridge and the temporary construction trestles during construction and for at least five years post construction. Any shading impacts to SAV that are determined by NCDOT and the appropriate agencies to be permanent impacts shall be mitigated using the best science available at the end of the five-year post construction monitoring period.

Monitoring

The project area consists of the impact area which includes the permanent bridge footprint, the shading impact area for the proposed bridge and all temporary trestle impact areas. All areas previously within the 300ft wide project area outside of the impact area will be considered reference. The original 300ft wide area is now increased on the west terminus due to changes in the trestle location. Monitoring methodology of these areas will not change (Figure 8).

Bridge construction is estimated at 4.5 years. Thus, the temporary impacts and potential shading impact monitoring plan will be conducted in two phases for at least nine monitoring years (MY). Phase 1 – Will occur during bridge construction for at least 4 years (MY1 – MY4). Phase 2 – will occur post-construction and will monitor the entire study area for at least five years (MY5 -MY9).

Baseline data will be collected during the growing season within the study area and reference area to include SAV presence/absence, present cover, and species composition and distribution.

Monitoring of the temporary and potential shading impacts will begin as soon as portions of the bridge are completed and will occur throughout the entire study area and consist of the following metrics:

- Verify biannual SAV delineation
- Seagrass species percent cover and composition/distribution via random sampling
- Monitoring of the shadow produced by the structure, targeting areas where the shadow passes through seagrass cover
- Measurement of PAR reaching the water surface at fixed grids
- Comparison of pre and post construction data sets
- Temporary impact areas will be monitored for recovery including number of growing seasons for grass to return, if temporarily impacted.

This plan may be adjusted as necessary by NCDOT and the appropriate agencies to address construction schedule and methods. An annual report will be submitted, as well as a final report at the end of the monitoring period. Annual field meetings may be scheduled as needed.

Figure 8a-e. SAV Monitoring Area Indicating Reference and Impact Zones

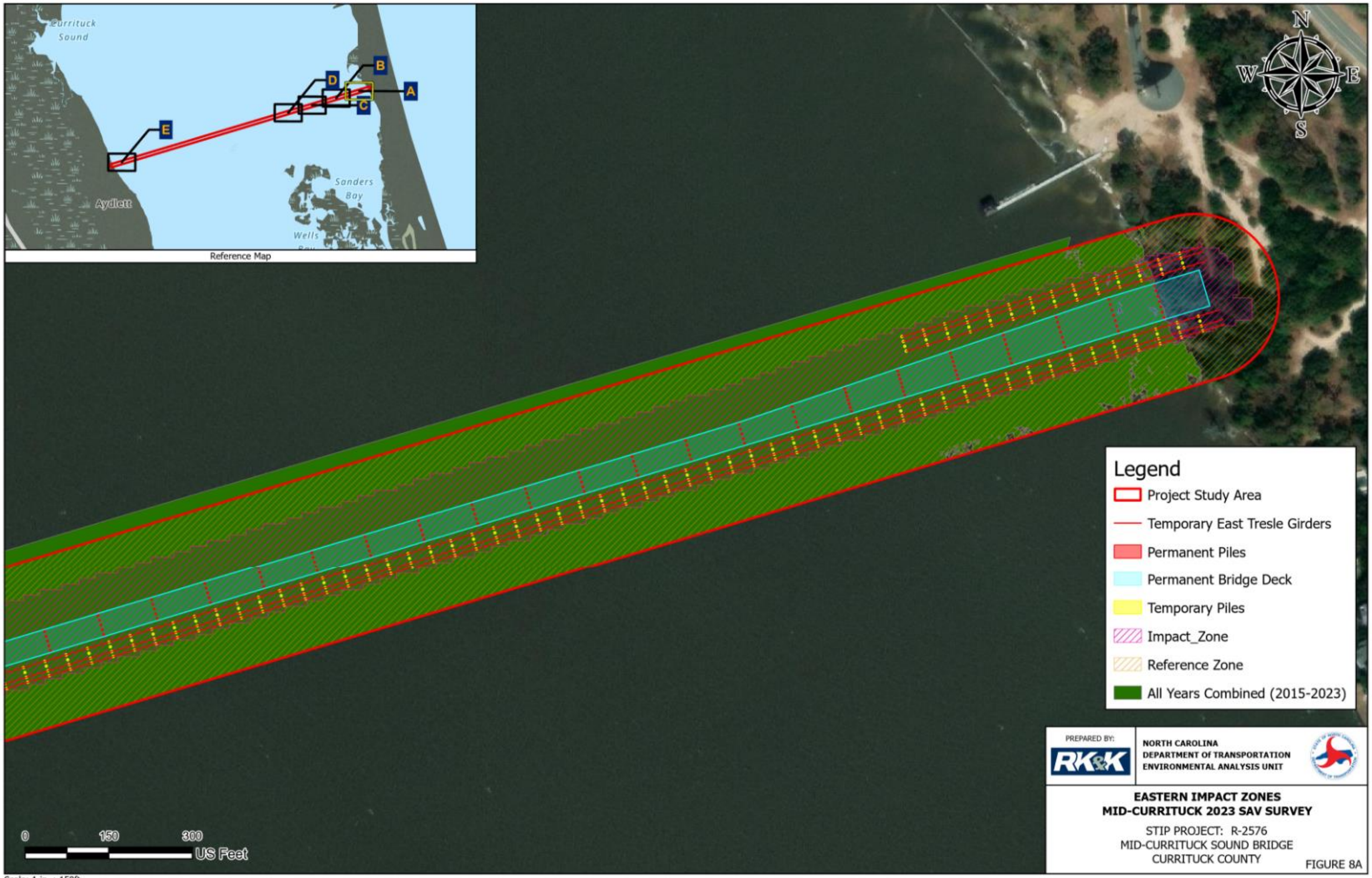


Figure 8a. East side SAV monitoring area indicating reference and impact zones.

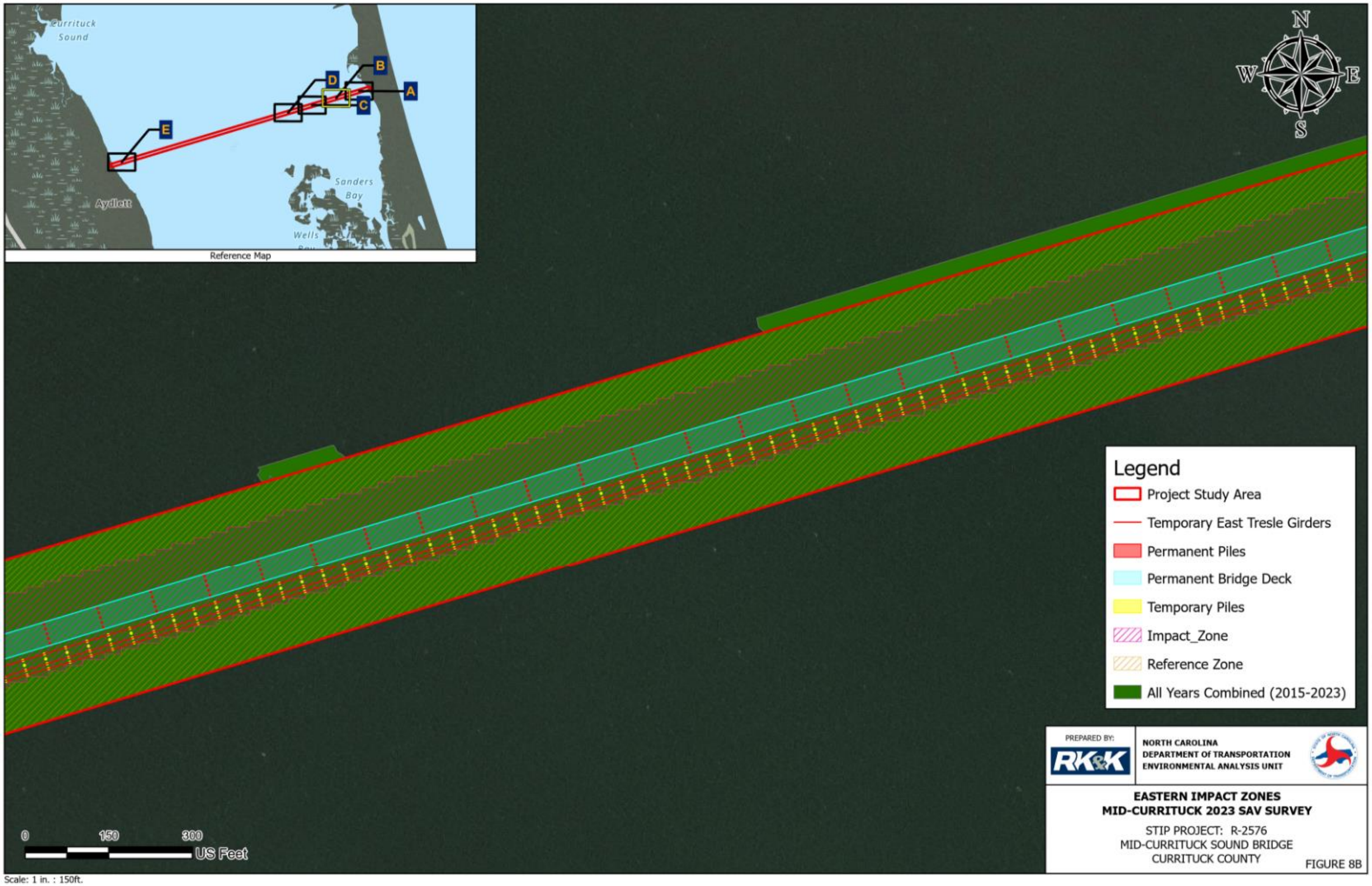


Figure 8b. Toward middle SAV monitoring area indicating reference and impact zones.

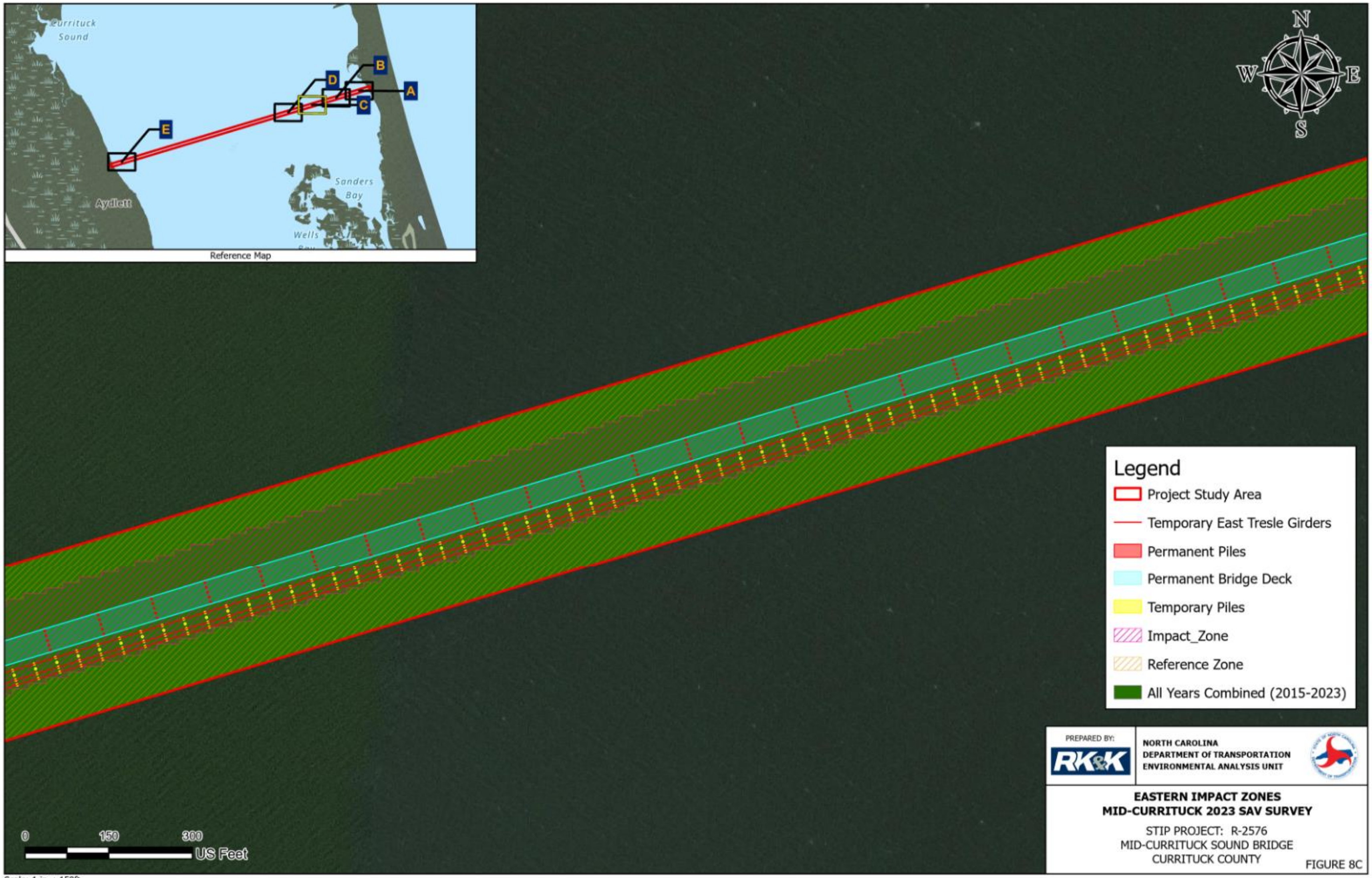


Figure 8c. Middle, farther west, SAV monitoring area indicating reference and impact zones.

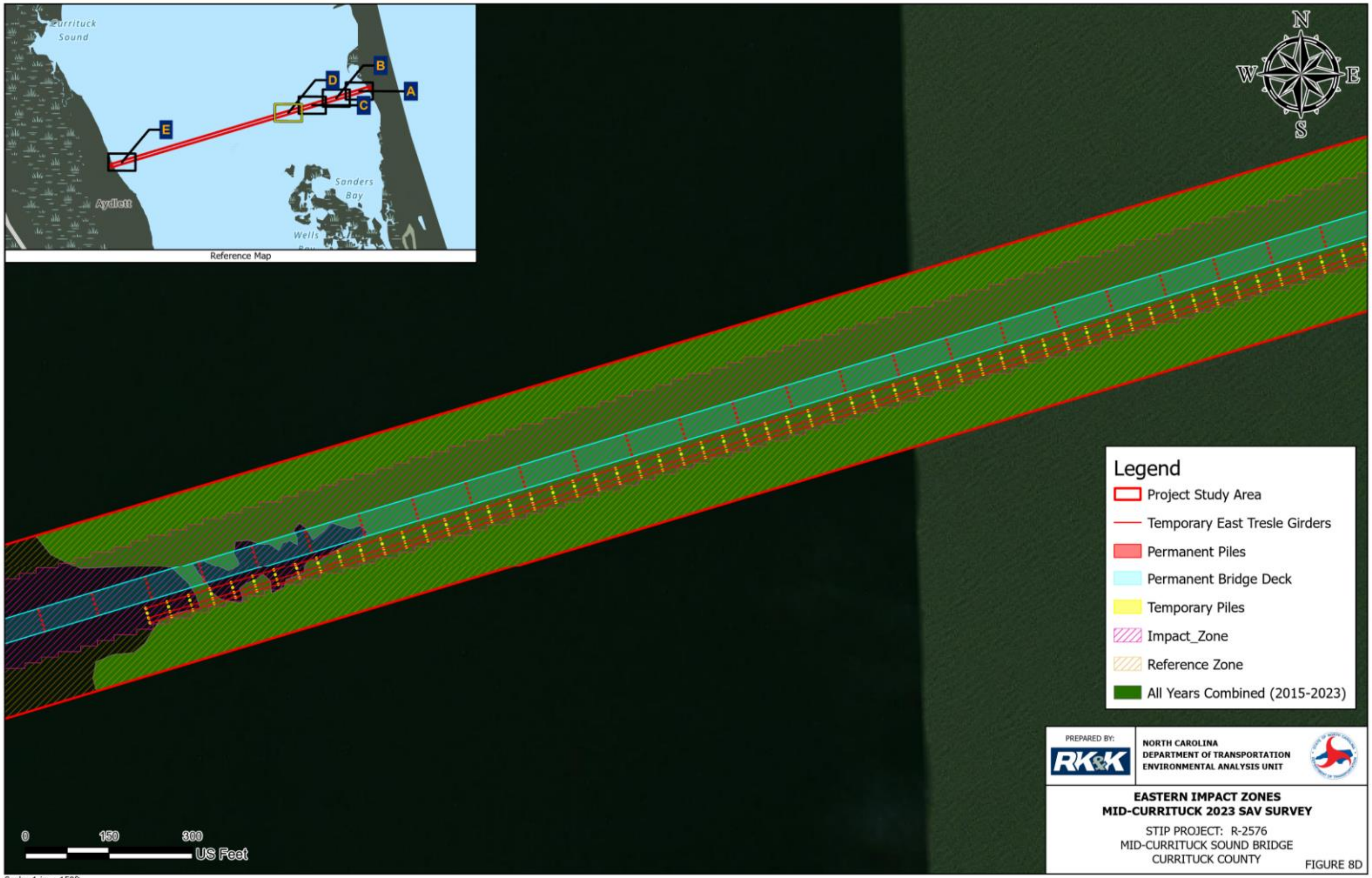


Figure 8d. Western end of middle, SAV monitoring area indicating reference and impact zones.

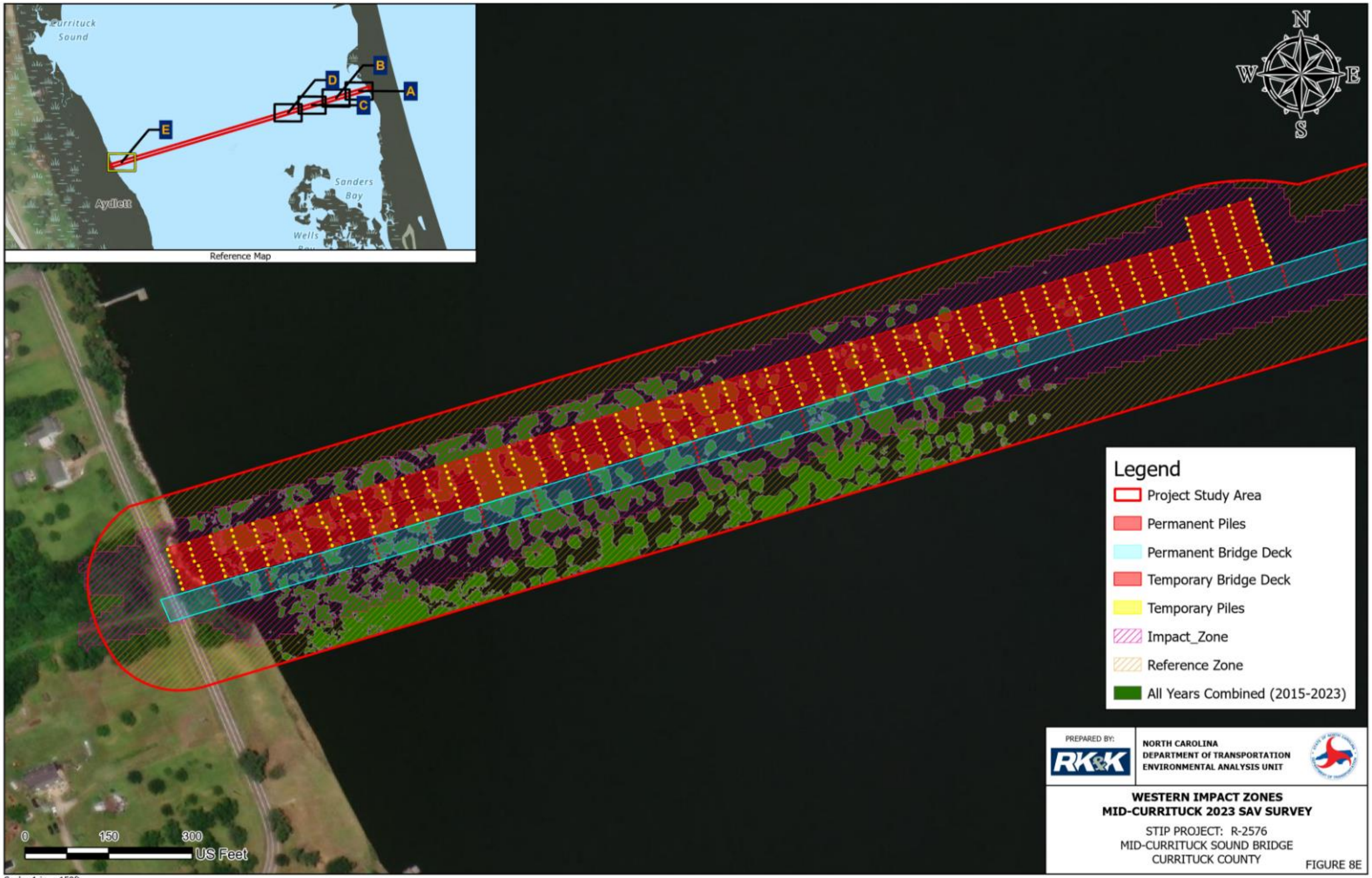


Figure 8e. West side SAV monitoring area indicating reference and impact zones.

Potential Mitigation Options

The mitigation ideas suggested for consideration in this plan include both in-kind and out-of-kind mitigation. It is understood that in-kind options would be mitigated at a ratio of at least 1:1 and any out-of-kind options chosen could be mitigated at a higher ratio. These ideas are suggestions of mitigation options based on current knowledge.

The final scale of any selected mitigation option will be determined in coordination with NCDOT and the agencies following review of results of a multiple year post construction monitoring effort and any project related research. This flexibility in selecting options after monitoring could allow for the use of multiple mitigation options to address impacts to the various functions of SAV (e.g. fisheries functions vs. waterfowl).

Several mitigation options have been developed and are designated as either at, or offshore from, the shoreline. In the first two options living shoreline alternatives are proposed, one at the shore and the other offshore. The transition in choice from at or offshore forms of living shoreline alternatives is generally governed by exposure of the site to wave energy. Living shorelines placed at the shoreline provide stabilization through the addition of natural structural materials to absorb wave energy, reducing erosion of the shoreline, thereby reducing sediment input to the Sound, and restoring shoreline marsh areas. However, protection located at the shoreline itself is limited to the mid-range of wave energy conditions. Very low wave energy environments without shoreline erosion may not require living shoreline amendments whereas highly exposed shorelines can have wave energy that may exceed the structural limits of the typically, less structurally robust shoreline protection methods. When higher wave energy is experienced at a shoreline, inclusion of a structure located offshore of the shoreline may be appropriate (Miller et al. 2015). However, offshore structures may also be complimented by living shoreline amendments at the shoreline itself (Fear and Bendell 2011). The cut-off for when at the shoreline vs. off the shoreline mitigative alternatives should be employed in North Carolina is not yet quantitatively determined (Miller et al. 2015) and represents a potential information gap.

One of the focal areas of the SAVE Currituck Study has been the potential influence of wave exposure on SAV using a WEMo (Malhotra and Fonseca 2010). In that study, wave height and energy maps of Currituck Sound, including that of the bridge alignment that have already been developed and provide a source of guidance in mitigation site selection. However, those wave height and energy maps are developed using mean sea level bathymetry. Wind-driven shifts in water levels are a regular feature of Currituck Sound and the Pamlico Sound in general (Mark Fonseca, pers. obs.). A wind event that generated high wave energy superimposed over a generally elevated water level would allow for comparatively unimpeded transmission of wave energy to the shoreline. Thus, the wave height and energy maps available should be treated as a nominal condition and, though a substantial improvement over the fetch estimations provided previously (Atkins 2013), are not necessarily fully representative of wave energy that could reach a shoreline under all water level conditions. However, the WEMo program offers the ability to uniformly raise or lower the water level across a given bathymetric data layer, allowing simulation of changes in wave energy distribution as the result of fluctuations in water level, although this was not part of the SAVE Currituck Study.

A third option included for consideration is to utilize the WEMo results from the SAVE Currituck Study to expand on the initial analysis provided by Atkins (2013) to determine if wavebreak structures could be used to enhance or restore SAV habitat around the marsh island areas. In this mitigation scenario the modification of wave energy in SAV or marsh habitat to cause a shift to more unit area cover of SAV or marsh with less temporal variability (vís a vís the Bonner Bridge wavebreak structure; CSA 2018 and living shoreline concepts for North Carolina marshes in general [e.g., Broome et al., 1992, Currin et al., 2010]). Finally, an alternative for reclaiming excavated seafloor to SAV habitat is considered. This alternative is patterned after options regularly utilized in other southeastern states as a seagrass mitigation alternative.

In coordination with the regulatory agencies, finalization of any option or combination of options will be further informed and determined by subsequent surveys of physical conditions and SAV distribution at the mitigation site. Wave exposure on SAV using the noted wave height and energy maps of the Currituck, including that of the bridge alignment will be consulted along with any subsequently generated survey data to inform the most appropriate alternative for a given site. Additional options may be added for consideration in the future. Finalization of any option or combination of options will also be subject to a review of potential impacts that may be incurred to other coastal resources such as public trust usage and shallow bottom habitat by implementation of the mitigation option. The final option or options may require additional regulatory review and approval, which could include notification to adjacent riparian landowners, public notice, etc. The ability to permit any mitigation option in this plan has not yet been determined.

ONSHORE ALTERNATIVES

Option 1: Living shorelines at bridge landings for erosion control and marsh enhancement - Out of Kind

Description: Various materials including sand, rock, fabricated concrete, fence, coconut fiber logs, marsh plants and/or other SAV, can be utilized for living shorelines placed at the shoreline itself. Reduced wave energy along the shoreline as a result of this wave interception provided by living shoreline materials also reduces shoreline erosion, facilitates sediment accretion and marsh growth, adding to the stability of the shoreline. Additionally, living shorelines provide ecological services by providing habitat, predation refuges and nursery areas for aquatic animals and plants, in addition to improving water quality through enhanced nutrient and sediment reduction (Gittman et al., 2016; National Oceanic and Atmospheric Administration [NOAA] Habitat Blueprint, no date; North Carolina Department of Environmental Quality [NCDEQ], no date). Estuarine shoreline erosion of swamp forests and marshes on the western side of Currituck Sound as well as back-barrier island shoreline erosion of marshes on the eastern side of the sound has been a critical issue for several decades (Benner et al., 1982; Riggs, 2001) and is of concern for NCDOT at landing sites of the proposed Mid-Currituck Bridge (T. Stanton, 2019, pers. comm., NCDOT).

Methodology: Living shorelines could be installed at the shoreline along selected portions of the shoreline on either side of the bridge landing sites or at appropriate locations as determined by the NCDOT and the appropriate agencies where erosion of existing riparian vegetation is observed, and wave energy is moderate. Construction of living shorelines could require specialized machinery to effectively place heavier material such as rock, coconut fiber logs, or sandbags along the edge of the shoreline or several meters from the shoreline underwater, to create a sill feature (**Figure 9**). A comprehensive synthesis report evaluating 27 marsh sill projects in eastern North Carolina found them to be effective at combating shoreline erosion (Fear and Bendell, 2011). Native species of marsh grasses (*Spartina* spp.) could be obtained from local plant nurseries and planted along the shoreline or in the intertidal area between the sill and emergent marsh along shore.

However, this option would only be appropriate for non-high wave energy areas. According to the Currituck WEMo data (**Figure 4**), wave energy is in the low category along the shoreline at both landing sites (<1001 joules/meter^2); however on the western side there is a gradient to high wave energy within approximately 0.5 km from shore (again, recalling that the WEMo model data represent nominal water level conditions; slight elevation of water levels could allow substantially increased wave transmission to the shoreline) and therefore living shorelines at the shoreline itself could be less appropriate at the western versus the eastern landing site.

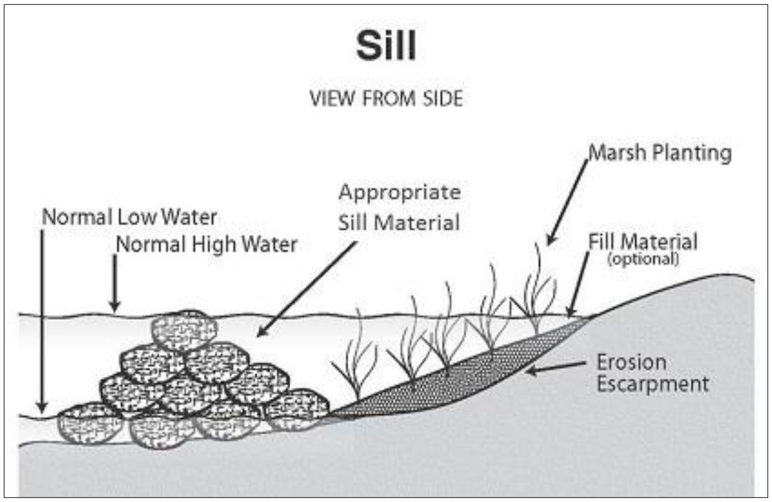


Figure 9. Schematic of a living shoreline that includes a sill feature. Drawing by NCDEQ, no date.

OFFSITE AND OFFSHORE ALTERNATIVES

Option 2: Offshore wavebreaks near landing sites for erosion control and marsh enhancement - Out of Kind

Description: In higher wave energy areas, wavebreaks located offshore of the shoreline could be more effective at reducing wave energy to protect the actual shoreline. These structures could also facilitate shoreward sediment accretion, adding to expansion and stabilization of the shorelines versus other alternatives such as living shorelines at the shoreline itself (NOAA, no date). Engineering considerations including material, shape, location, size, seafloor slope, and water depth of the wavebreaks would be informed by physical data including wind and wave energy forecasts as well as local bathymetry and sediment characteristics. Verification of the suitability of areas just offshore landing sites to receive wavebreaks would require detailed physical surveys; however, existing WEMo results and sediment data from the SAVE Currituck Study would be consulted initially to help inform suitability of this option at any selected site.

Methodology: Wavebreaks could be constructed of modular artificial reef units or rock material, or other suitable substrate. Design and planning of wavebreaks would be performed by professional engineers, while construction would be performed by a local contractor with engineering oversight. Heavy equipment such as excavators and barges would likely be utilized during construction. Native marsh plantings (*Spartina* spp.) could be added following construction to vegetate the shoreline shoreward of the wavebreak, depending on the shoreline morphology and presence of suitable substrate.

Option 3: Modification of SAV landscape on eastern end of bridge corridor via offshore wavebreaks - In Kind

Description: The eastern side of Currituck Sound supports extensive SAV beds (**Figure 2**). However, the distribution and density of SAV has been spatially and temporally dynamic, likely due to the life history of these plant communities and aperiodic extreme wind events and waves. Consistent with the approach used at the Bonner Bridge wavebreak project, here it is proposed to enhance natural SAV distribution and cause a shift to enhance SAV recruitment for a more extensive and permanent cover (decrease patchiness and variability in cover over time) thereby providing a net increase in SAV cover.

Methodology: SAV colonization or expansion from nearby existing beds would be facilitated by use of stone sills or modular fabricated units (e.g., Bonner Bridge wavebreak structures) to create wavebreaks arranged in a chevron pattern normal to the direction(s) of the predominant wave energy in areas adjacent to SAV beds but on unvegetated seafloor. Structures would be high enough to provide wind wave (and any vessel wake) reduction based on the tidal frame at the site. The length of each wavebreak would be determined based on the acreage of SAV required for mitigation based on experience generalized from CSA (2018) regarding the amount of SAV generated per linear foot of wavebreak.

Option 4: Filling of dredge holes near existing SAV habitat – In Kind

Description: If anthropogenically created holes or depressions in the seafloor exist (a result of dredging, dock removal, or other activities) near extant SAV habitat in Currituck Sound, these holes would be filled and brought to the grade of the surrounding, natural seafloor. Water depth, and thus light penetration is likely a strong factor influencing SAV distribution in Currituck Sound. SAV distribution data collected to date for the SAVE Currituck Study found 99% of all SAV surveyed to date to occur in water depths less than 1.9 m, and 80% in water depths less than 1 m (Corbett et al., 2018). Therefore, if suitable mitigation sites of this nature exist, areas deeper than 1.9 m could be filled and brought to grade of the surrounding seafloor providing habitat for natural colonization from existing, surrounding SAV beds, thus providing new SAV acreage. For example, there exists an area south of the eastern terminus of the proposed bridge alignment, where the marsh is eroding toward NC 12, that would be an appropriate candidate to assess for this mitigation option.

Methodology: Bathymetric data (SAVE Currituck Study) and local knowledge (e.g., NCDENR, ECU, USACE) for Currituck Sound would be consulted to investigate potential sites with man-made depressions in the seafloor with water depths greater than 1.9 m that also occur near extant SAV habitat. If depressions of this nature exist, after permitting they would be filled with suitable fill and brought to grade. Depending on the size of the site, fill could be provided using techniques perfected in restoration of vessel groundings elsewhere. Deep depressions could require mechanical placement of fill. For shallower depressions in shallow water, biodegradable sandbags would be delivered to the site via barge and placed using machinery or a combination of wading and snorkeling depending on the size and water depth of the site. Sand would be sourced from upland locations and biodegradable bags and/or tubes would be filled with sand while on land. Sediment elevation of the filled area would be confirmed for consistency with adjacent seafloor standard survey methods.

Option 5: Restoration or enhancement of SAV habitat and/or erosion reduction around marsh islands - -Combination of Out of Kind and In Kind - NCDOT PREFERRED OPTION

Description: Building off the concept in the Atkins (2013) report, locations in Currituck Sound where shoreline erosion has resulted in marsh and/or SAV loss would be targeted for erosion control intervention and potentially SAV and/or marsh plantings as a mitigation strategy.

Methodology: The WEMo model data from the SAVE Currituck Study would be used to stratify shoreline and SAV habitats into areas of high, medium, and low wave energy based on the frequency distribution of the model raster file. This model would be re-run at other overall water depths to account for storm conditions that could deliver wave energy to new areas. Additionally, shoreline and SAV change analysis using historical aerial imagery and the annual collection of new data during the pre/post construction monitoring period would be performed for the high wave energy strata from the wave modeling. For shorelines, the method would follow that of Cowart et. al. (2010) who developed a process using North Carolina marsh shorelines. SAV change could be more difficult to ascertain given the issues involved with using remote imagery to detect SAV in Currituck Sound, but this would be attempted. The areas found to have the highest shoreline and/or SAV loss would be considered for application of mitigation measures as described in Options 1 through 3.

The NCDOT also requests that any NCDOT funded research specific to informing mitigation for SAV in Currituck Sound be considered as part of any mitigation required for this project. A specific percentage of research allowed for mitigation would be decided by coordination with the NCDOT, Turnpike and the appropriate agencies.

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