April ____, 2021 Job No. 2015-0121

Secretary Kathleen Theoharides
Executive Office of Energy and Environmental Affairs
Attn: MEPA Office
100 Cambridge Street, Suite 900
Boston, MA 02114

Sent via email: MEPA@mass.gov

Re: **ENVIRONMENTAL NOTIFICATION FORM**
Proposed Nauset Estuary Dredging Project
Towns of Orleans & Eastham, Applicant
Orleans & Eastham, MA

Dear Secretary Theoharides,

On behalf of the Towns of Orleans and Eastham, we are hereby submitting an electronic copy of an Expanded Environmental Notification Form (EENF) for the above referenced project. Due to the current state of emergency, at this time we are refraining from sending physical copies to MEPA and the distribution list, except for the Mass. Historical Commission.

Please post this EENF Filing Notification in the next Environmental Monitor.

If you have any questions, or require any additional information, please call me at 508-495-6225 or send an email to lfields@woodsholegroup.com

Sincerely,

Leslie Fields

Leslie Fields
Coastal Geologist/Project Manager

MLF/beg

cc: Distribution List
John Kelly, Town Administrator, Town of Orleans
Jacqueline Beebe, Town Administrator, Town of Eastham
Charlie Carlson, Chair NESG

Expanded Environmental Notification Form

Nauset Estuary Dredging Project for Towns of Orleans & Eastham, MA

Photographs taken by Spencer Kennard / www.capecodphotos.com

April 2021

PREPARED FOR:
Secretary Kathleen Theoharides
Executive Office of Energy and Environmental Affairs
Attn: MEPA Office
100 Cambridge Street, Suite 900
Boston, MA 02114

PREPARED BY:
Woods Hole Group, Inc.
A CLS Company
107 Waterhouse Road
Bourne, MA 02532 USA

107 Waterhouse Road
Bourne, MA 02532
Phone: 508-540-8080
Fax: 508-540-1001
e-mail: WHGroup@whgrp.com
www.whgrp.com

Expanded Environmental Notification Form Contents:

Section N Shorebird Monitoring Reports

- 2018 Town of Orleans – Habitat Conservation Plan Annual Report
- 2019 Town of Orleans – Habitat Conservation Plan Annual Report
- 2020 Town of Orleans – Habitat Conservation Plan Annual Report

Section O Support Letters

- _____
- _____
- _____

Section P Public Notice and EENF Distribution List

Section Q Project Map & Plans

- Orleans USGS Map, identifying locus
- Plan entitled "_____", Sheets 1-___, dated _____/2021 (Currently Under Development)
- Plan entitled "Nauset Estuary Dredge Material Management Area, Orleans, MA", Sheets 1-3, dated 4/12/2021

Section A

Expanded Environmental Notification Form (EENF) & Addendum A

Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs
Massachusetts Environmental Policy Act (MEPA) Office

Environmental Notification Form

For Office Use Only

EEA#: _____

MEPA Analyst: _____

The information requested on this form must be completed in order to submit a document electronically for review under the Massachusetts Environmental Policy Act, 301 CMR 11.00.

Project Name: Nauset Estuary Dredging Project		
Street Address: Nauset Estuary & Parcels List on attached Addendum A		
Municipality: Orleans & Eastham	Watershed: Nauset Estuary	
Universal Transverse Mercator Coordinates:	Latitude: 41.826426° N Longitude: 69.946104° W	
Estimated commencement date: Fall 2023	Estimated completion date: Ongoing	
Project Type: Improvement Dredging	Status of project design: 60 %complete	
Proponent: Towns of Orleans & Eastham		
Street Address: See Addendum A		
Municipality:	State:	Zip Code:
Name of Contact Person: Leslie Fields		
Firm/Agency: Woods Hole Group, Inc.	Street Address: 107 Waterhouse Rd.	
Municipality: Bourne	State: MA	Zip Code: 02532
Phone: 508-495-6225	Fax: 508-540-1001	E-mail: lfields@woodsholegroup.com

Does this project meet or exceed a mandatory EIR threshold (see 301 CMR 11.03)?
☒Yes ☐No

If this is an Expanded Environmental Notification Form (ENF) (see 301 CMR 11.05(7)) or a Notice of Project Change (NPC), are you requesting:

a Single EIR? (see 301 CMR 11.06(8)) ☐Yes ☐No
a Special Review Procedure? (see 301CMR 11.09) ☐Yes ☐No
a Waiver of mandatory EIR? (see 301 CMR 11.11) ☐Yes ☐No
a Phase I Waiver? (see 301 CMR 11.11) ☐Yes ☐No
(Note: Greenhouse Gas Emissions analysis must be included in the Expanded ENF.)

Which MEPA review threshold(s) does the project meet or exceed (see 301 CMR 11.03)?
301 CMR 11.03 (3)(a)1.b; 11.03 (3)(b)1.a.; 11.03 (3)(b)1.c; 11.03 (3)(b)1.e.; 11.03 (3)(b)1.f; 11.03 (3)(b)3; 11.03 (3)(b)4

Which State Agency Permits will the project require?
Chapter 91 Permit, 401 Water Quality Certification, CZM Federal Consistency

Identify any financial assistance or land transfer from an Agency of the Commonwealth, including the Agency name and the amount of funding or land area in acres:
N/A

Summary of Project Size & Environmental Impacts	Existing	Change	Total
LAND			
Total site acreage	66		
New acres of land altered		23.4 (perm) 1.0 (temp)	
Acres of impervious area	0	0	0
Square feet of new bordering vegetated wetlands alteration		193 (perm) 579 (temp)	
Square feet of new other wetland alteration		41.2 (perm) 0.4 (temp)	
Acres of new non-water dependent use of tidelands or waterways		N/A	
STRUCTURES			
Gross square footage	N/A	N/A	N/A
Number of housing units	N/A	N/A	N/A
Maximum height (feet)	N/A	N/A	N/A
TRANSPORTATION			
Vehicle trips per day	N/A	N/A	N/A
Parking spaces	N/A	N/A	N/A
WASTEWATER			
Water Use (Gallons per day)	N/A	N/A	N/A
Water withdrawal (GPD)	N/A	N/A	N/A
Wastewater generation/treatment (GPD)	N/A	N/A	N/A
Length of water mains (miles)	N/A	N/A	N/A
Length of sewer mains (miles)	N/A	N/A	N/A

Has this project been filed with MEPA before?
☐ Yes (EEA #_____) ☒No

Has any project on this site been filed with MEPA before?
☐ Yes (EEA #_____) ☒No

GENERAL PROJECT INFORMATION – all proponents must fill out this section

PROJECT DESCRIPTION:

Describe the existing conditions and land uses on the project site:

Nauset Estuary is a 2,200 acre estuary located on the eastern shore of outer Cape Cod within the Towns of Orleans and Eastham. The system supports extensive salt marsh and tidal flat resources, as well as natural channels that lead to open water areas and distal ponds. Nauset barrier beach forms the eastern edge of the estuary. The barrier beach and tidal inlet to Nauset Estuary have undergone significant changes over the past 100 years. The barrier beach and tidal inlet are heavily influenced by longshore sand transport and sediment moving along the shoreline tends to be transported through the inlet into the estuary. This net movement of sediment into the estuary has resulted in significant shoaling in the estuary channels and mooring areas. The public safety of commercial and recreational boaters operating out of the Towns 13 public landings and heavily used mooring areas is at risk because of the shoaling.

Describe the proposed project and its programmatic and physical elements:

The goal of the Nauset Estuary Dredging Project is to improve navigation and public safety for commercial and recreational users of the waterway. The Project includes improvement dredging of 155,560 cy of material from 28,300 linear ft of channel. The channel extends from Town Cove to the inlet via the channel behind the barrier beach, with additional spur channels to Priscilla Rd. Landing and the entrance to Mill Pond. The channel is proposed to be 100 ft wide in areas behind Nauset barrier beach and 50 ft wide in all other channel reaches. The proposed channel depth is -5 ft MLW with 1 ft of allowable overdepth depth dredging and side slopes of 1V:3H. A dredge zone is proposed for areas of the channel that are the most dynamic, including channel reaches behind the barrier beach, eastern main channel, central main channel, and the Priscilla Rd. Landing channel. Sediment dredged from behind the barrier beach and the eastern main channel will be side cast to land under the ocean west of the dredged channel. Sediment from the Priscilla Rd. and Mill Pond channels will be dredged using a cutter suction dredge and pumped to a dewatering basin in the coastal dune located north of Nauset Public Beach. The dune will be restored and regraded to help build resiliency of the coastal dune. Sediment from the Town Cove and central main channel channels will be mechanically dredged and barged to the town landing at Goose Hummock where it will be trucked to a temporary upland stockpile area(s) for subsequent use in building coastal resiliency on other permitted projects.

The project triggers the requirement for an Environmental Impact Report (EIR) pursuant to 301 CMR 110.3 (3)(a)1.b in that it requires a state Permit and will result in alteration of more than 10 acres of wetland, other than a salt marsh or BVW. The project also requires the filing of an Environmental Notification Form (ENF) pursuant to 301 CMR 11.03 (3)(b)1.a.; 11.03 (3)(b)1.c.; 11.03 (3)(b)1.e.; 11.03 (3)(b)1.f; 11.03 (3)(b)3; and 11.03 (3)(b)4.

For further details, see Project Description in Section C and Assessment of Impacts in Section F.

NOTE: The project description should summarize both the project's direct and indirect impacts (including construction period impacts) in terms of their magnitude, geographic extent, duration and frequency, and reversibility, as applicable. It should also discuss the infrastructure requirements of the project and the capacity of the municipal and/or regional infrastructure to sustain these requirements into the future.

Describe the on-site project alternatives (and alternative off-site locations, if applicable), considered by the proponent, including at least one feasible alternative that is allowed under current zoning, and the reasons(s) that they were not selected as the preferred alternative:

A total of thirty-one (31) alternatives were developed and evaluated; 15 alternatives for the dredge channel layout (Element #1), 3 alternatives for channel width (Element #2), 9 alternatives for placement of dredged materials (Element #3), and 3 alternatives for dredge methodology (Element #4). For further details see Alternatives Considered in Section E.

NOTE*: The purpose of the alternatives analysis is to consider what effect changing the parameters and/or siting of a project, or components thereof, will have on the environment, keeping in mind that the objective of the MEPA review process is to avoid or minimize damage to the environment to the greatest extent feasible. Examples of alternative projects include alternative site locations, alternative site uses, and alternative site configurations.*

Summarize the mitigation measures proposed to offset the impacts of the preferred alternative:

Mitigation measures proposed are directed toward avoiding and minimizing impacts during and after construction, and include the following:

- **Time of year restrictions will be followed for protection of endangered species**
- **A "no dredge zone" will be established 100 ft west of the Nauset barrier beach to avoid impacts to the stability of the barrier beach**
- **Shellfish relays will be conducted prior to the start of dredging**
- **Conduct eelgrass surveys prior to dredging to ensure that dredging maintains a 50 ft setback**
- **Install and maintain erosion and sedimentation controls in construction and staging areas**
- **Restore beach and dune areas impacted by placement of dredge pipeline**
- **Plant all disturbed dune areas with beach grass**
- **Storage of all fuels and hydraulic oils off site**
- **Limits on idling of construction vehicles**
- **Implementation of a post construction monitoring and maintenance plan**

If the project is proposed to be constructed in phases, please describe each phase:

Dredging will take place as funds become available. Work in the three parts of the estuary (behind the barrier beach, Priscilla and Mill Pond channels, Town Cove and central main channel) will likely occur in separate years. Maintenance dredging may be necessary in the channel behind the barrier beach on an annual basis. All other channels are expected to require maintenance dredging every 8 to 15 years.

AREAS OF CRITICAL ENVIRONMENTAL CONCERN:

Is the project within or adjacent to an Area of Critical Environmental Concern?

☐Yes (Specify_____)

☒No

if yes, does the ACEC have an approved Resource Management Plan? ___ Yes ___ No;
If yes, describe how the project complies with this plan.

_____

Will there be stormwater runoff or discharge to the designated ACEC? ___ Yes ___ No;
If yes, describe and assess the potential impacts of such stormwater runoff/discharge to the designated ACEC.

_____

RARE SPECIES:

Does the project site include Estimated and/or Priority Habitat of State-Listed Rare Species? (see http://www.mass.gov/dfwele/dfw/nhesp/regulatory_review/priority_habitat/priority_habitat_home.htm)

☒Yes (Specify_**Estimated & Priority Habitats**_) ☐No

HISTORICAL /ARCHAEOLOGICAL RESOURCES:

Does the project site include any structure, site or district listed in the State Register of Historic Place or the inventory of Historic and Archaeological Assets of the Commonwealth?

☐Yes (Specify_____) ☒No

If yes, does the project involve any demolition or destruction of any listed or inventoried historic or archaeological resources? ☐Yes (Specify_____) ☐No

WATER RESOURCES:

Is there an Outstanding Resource Water (ORW) on or within a half-mile radius of the project site? _X_Yes ___No; if yes, identify the ORW and its location.

The project site is within the Cape Cod National Seashore ORW, in Orleans and Eastham.

(NOTE: Outstanding Resource Waters include Class A public water supplies, their tributaries, and bordering wetlands; active and inactive reservoirs approved by MassDEP; certain waters within Areas of Critical Environmental Concern, and certified vernal pools. Outstanding resource waters are listed in the Surface Water Quality Standards, 314 CMR 4.00.)

Are there any impaired water bodies on or within a half-mile radius of the project site? _X__Yes ___No; if yes, identify the water body and pollutant(s) causing the impairment:

Town Cove is listed as a Category 5 waterbody on MassDEP's 2014 Integrated List of Waters. The waterbody consists of the entire cove to Nauset Harbor, including Rachel Cove and Woods Cove, in Orleans and Eastham (area associated with Cape Cod National Seashore designated as ORW). It is listed as impaired for shellfishing due to fecal coliform from discharges from Municipal separate storm sewer systems (MS4) and waterfowl, and for fish and other aquatic life and wildlife due to estuarine bioassessments from unknown sources.

Nauset Harbor is listed as a Category 2 waterbody, which includes the waters south of an imaginary line drawn east from Woods Cove, Orleans around the southern point of Stony Island, around the southern end of the unnamed island in the harbor, to the Cape Cod National Seashore point, excluding Mill Pond, Orleans (area associated with Cape Cod National Seashore designated as ORW). It is listed as impaired for fish and other aquatic life and wildlife; however there is insufficient information as to the cause.

Is the project within a medium or high stress basin, as established by the Massachusetts Water Resources Commission? ___Yes __X_No

STORMWATER MANAGEMENT:

Generally describe the project's stormwater impacts and measures that the project will take to comply with the standards found in MassDEP's Stormwater Management Regulations:__**N/A**_____

MASSACHUSETTS CONTINGENCY PLAN:

Has the project site been, or is it currently being, regulated under M.G.L.c.21E or the Massachusetts Contingency Plan? Yes ___ No _X_ ; if yes, please describe the current status of the site (including Release Tracking Number (RTN), cleanup phase, and Response Action Outcome classification):_____

Is there an Activity and Use Limitation (AUL) on any portion of the project site? Yes ___ No _X__; if yes, describe which portion of the site and how the project will be consistent with the AUL: ____.

Are you aware of any Reportable Conditions at the property that have not yet been assigned an RTN? Yes ___ No _X__ ; if yes, please describe:_____

SOLID AND HAZARDOUS WASTE:

If the project will generate solid waste during demolition or construction, describe alternatives considered for re-use, recycling, and disposal of, e.g., asphalt, brick, concrete, gypsum, metal, wood:_**N/A**__

(NOTE: Asphalt pavement, brick, concrete and metal are banned from disposal at Massachusetts landfills and waste combustion facilities and wood is banned from disposal at Massachusetts landfills. See 310 CMR 19.017 for the complete list of banned materials.)

Will your project disturb asbestos containing materials? Yes ___ No _X__ ; if yes, please consult state asbestos requirements at http://mass.gov/MassDEP/air/asbhom01.htm

Describe anti-idling and other measures to limit emissions from construction equipment: _____
The project proponent will incorporate measures to avoid and minimize Greenhouse Gas emission during the construction period, such as limiting idling and using bio-fuels in off-road construction equipment.

DESIGNATED WILD AND SCENIC RIVER:

Is this project site located wholly or partially within a defined river corridor of a federally designated Wild and Scenic River or a state designated Scenic River? Yes ___ No X___ ;
if yes, specify name of river and designation:

If yes, does the project have the potential to impact any of the "outstandingly remarkable" resources of a federally Wild and Scenic River or the stated purpose of a state designated Scenic River? Yes ___ No ___ ; if yes, specify name of river and designation: _____;
if yes, will the project will result in any impacts to any of the designated "outstandingly remarkable" resources of the Wild and Scenic River or the stated purposes of a Scenic River.
Yes ___ No ___ ;
if yes,describe the potential impacts to one or more of the "outstandingly remarkable" resources or stated purposes and mitigation measures proposed.

ATTACHMENTS:

1. List of all attachments to this document.
2. U.S.G.S. map (good quality color copy, 8-½ x 11 inches or larger, at a scale of 1:24,000) indicating the project location and boundaries.
3.. Plan, at an appropriate scale, of existing conditions on the project site and its immediate environs, showing all known structures, roadways and parking lots, railroad rights-of-way, wetlands and water bodies, wooded areas, farmland, steep slopes, public open spaces, and major utilities.
4 Plan, at an appropriate scale, depicting environmental constraints on or adjacent to the project site such as Priority and/or Estimated Habitat of state-listed rare species, Areas of Critical Environmental Concern, Chapter 91 jurisdictional areas, Article 97 lands, wetland resource area delineations, water supply protection areas, and historic resources and/or districts.
5. Plan, at an appropriate scale, of proposed conditions upon completion of project (if construction of the project is proposed to be phased, there should be a site plan showing conditions upon the completion of each phase).
6. List of all agencies and persons to whom the proponent circulated the ENF, in accordance with 301 CMR 11.16(2).
7. List of municipal and federal permits and reviews required by the project, as applicable.

LAND SECTION – all proponents must fill out this section

I. Thresholds / Permits

A. Does the project meet or exceed any review thresholds related to **land** (see 301 CMR 11.03(1)
___ Yes _X__ No; if yes, specify each threshold:

II. Impacts and Permits

A. Describe, in acres, the current and proposed character of the project site, as follows:

	Existing	Change	Total
Footprint of buildings	_____	_____	_____
Internal roadways	_____	_____	_____
Parking and other paved areas	_____	_____	_____
Other altered areas	_____	_____	_____
Undeveloped areas	30	0	30
Total: Project Site Acreage	30	0	30

B. Has any part of the project site been in active agricultural use in the last five years?
___ Yes _X__ No; if yes, how many acres of land in agricultural use (with prime state or locally important agricultural soils) will be converted to nonagricultural use?

C. Is any part of the project site currently or proposed to be in active forestry use?
___ Yes _X__ No; if yes, please describe current and proposed forestry activities and indicate whether any part of the site is the subject of a forest management plan approved by the Department of Conservation and Recreation:

D. Does any part of the project involve conversion of land held for natural resources purposes in accordance with Article 97 of the Amendments to the Constitution of the Commonwealth to any purpose not in accordance with Article 97? ___ Yes _X__ No; if yes, describe:

E. Is any part of the project site currently subject to a conservation restriction, preservation restriction, agricultural preservation restriction or watershed preservation restriction?
**Under review** Yes___ No; if yes, does the project involve the release or modification of such restriction? ___ Yes _X__ No; if yes, describe:

Among the parcels where the work is proposed (239 Beach Road, 47 Nauset Rd, 51 Nauset Rd, or 1 Route 6A), there are no restrictions mentioned above.

Discussions are ongoing with the Cape Cod National Seashore regarding 55 Nauset Road in Orleans to determine if there are any restrictions listed above. In either case, the project does not involve the release or modification of any restrictions.

F. Does the project require approval of a new urban redevelopment project or a fundamental change in an existing urban redevelopment project under M.G.L.c.121A? ___ Yes _X__ No; if yes, describe:

G. Does the project require approval of a new urban renewal plan or a major modification of an existing urban renewal plan under M.G.L.c.121B? Yes ___ No _X__; if yes, describe:

III. Consistency

A. Identify the current municipal comprehensive land use plan
Title: **Orleans Comprehensive Plan** Date **Amended October 2006**
Title: **Town of Eastham Strategic Plan FY2020-2024** Date: **2019**

B. Describe the project's consistency with that plan with regard to:

1) economic development
2) adequacy of infrastructure
3) open space impacts
4) compatibility with adjacent land uses

1) <u>Economic Development</u> – Economic priorities of the OCP include maintaining a business community that provides diverse, year-round employment that balances the needs of business owners and consumers, as well as preserves town character. The ESP similarly notes the importance of balancing preservation of town character and protection of the natural environment with economic activity. The proposed project is consistent with the priorities outlined in the respective town plans, as the proposed improvement dredging within Nauset Estuary will preserve navigable access to public landings and mooring fields within the estuary, including to the commercial businesses in Town Cove. These businesses are frequented by both tourists and year-round residents. Maintaining access to these businesses is vital considering the Towns of Orleans and Eastham are both considerably dependent on consumer spending revenue during tourist season. In addition, the natural beauty of Nauset Estuary serves as a tourist attraction, meaning maintaining navigation within the estuary supports tourism, as well as continued use by year-round residents. Orleans and Eastham are both towns with a unique seaside character. Central to this quality is the ability to interact with the coastal environment, such as by boating. The proposed project will allow for continued recreational interaction with the natural environment, while also balancing the needs of local businesses.

2) <u>Adequacy of Infrastructure</u> – Both the Towns of Orleans and Eastham recognize the importance of adequate infrastructure to provide a high quality of life for residents. The OCP specifically notes transportation and circulation movements should be consistent with town character and that dredging projects are permitted given the project is necessary for navigation safety. The ESP also highlights improving safe travel for all users for all modes of transportation, as well as providing all members of the public access to recreation. The proposed project directly achieves these objectives by helping to maintain safe navigability within Nauset Estuary. The estuary currently experiences significant shoaling and without the proposed improvement dredging, the safety of commercial and recreational boaters navigating within the estuary is at risk. Maintaining access to the estuary is also important in order to preserve town character, as Eastham and Orleans are both coastal towns where year-round residents and tourists alike commonly utilize marine navigation ways for recreational or professional use. In addition, some residents and tourists may rely on boating to interact with the coastal environment if they experience decreased mobility on land.

3) <u>Open Space Impacts</u> – Open space objectives within the OCP include maintaining the semi-rural character of the Town and open spaces used for recreation, especially those that attract tourists and thus indirectly contribute to the local economy. Likewise, the ESP urges harmony between the natural environment and local culture, as well as protecting coastal and estuary environments. As mentioned above, the proposed project will allow for continued use of Nauset Estuary as both a working waterfront area and as a tourist attraction for recreational use. Proposed improvement dredging will adhere to time of year restrictions and other impact mitigation actions in order to minimize impacts on the environment. Through this project, recreation areas can be maintained without detrimental impacts to the environment.

4) <u>Compatibility with Adjacent Land Uses</u> – Land uses adjacent to/within the Nauset Estuary include residential, commercial, and recreational areas. One of the major goals within the OCP is to encourage preservation of downtown centers that provide living, working, or shopping opportunities for visitors and residents. Additional objectives of the OCP include preserving integrity of marine waters and maintaining navigability of estuaries used for fishing. The ESP notes the importance of protecting small town

identity and history, as well as maintaining harmony between the natural environment and town culture. The proposed project is consistent with the goals of the OCP by helping to preserve use of the Nauset Estuary as a means of accessing residential and commercial areas surrounding the estuary. The project will also allow for continued navigation within the estuary, which does provide habitat for a variety of fish and shellfish species. Impact mitigation actions have been developed during the project design to ensure the project does not result in adverse effects on the integrity of the marine waters. Thus, the proposed project balances work required for use of an estuary central to town culture as well as protecting the natural environment.

C. Identify the current Regional Policy Plan of the applicable Regional Planning Agency (RPA)
RPA: **Cape Cod Commission**

Title: **Cape Cod Regional Policy Plan** Date **February 22, 2019**

Describe the project's consistency with that plan with regard to:
1) economic development _____
2) adequacy of infrastructure _____
3) open space impacts _____

1) Economic Development - Economic development goals outlined in the CCRP include building a sustainable economy that can absorb the impacts of seasonal fluctuation in economic activity. The regional plan also emphasizes that economic development should take into account the historic harbors and cultural heritage within the region, as well as use natural assets efficiently. The proposed project will help support local business along the working waterfront that contribute to the local economy throughout the year and will ensure continued use of a historic harbor and estuary. The project will result in a substantial public benefit as the economies of Eastham and Orleans depend on water dependent uses of the Estuary. In addition, the project also represents an efficient use of the natural environment, balancing economic activity and sustainable use of natural environments. Thus, the proposed improvement dredging within Nauset Estuary is consistent with the CCRP economic development goals.

2) Adequacy of Infrastructure – The CCRP emphasizes that infrastructure should support economic activity and employment centers, have no negative impacts on natural or cultural resources, contribute to livability, and discourage low-density, sprawling development. Dredging to improve the existing navigation channel within Nauset Estuary will provide continued, safe access to the waterfront areas in Town Cove and other public landings and mooring fields. Commercial businesses in Town Cover are economic and employment centers. Maintaining access to these already existing developed areas helps to discourage any additional or sprawling development. Lastly, the project will contribute to livability and cultural resources within Orleans and Eastham, as boating is central to the way of life on Cape Cod and the cultural identities of the Towns.

3) Open Space Impacts – Open space goals described in the CCRP include providing high quality open spaces to year-round residents, as well as tourists, and to maintain or increase connectivity of open space. Improvement dredging within Nauset Estuary directly addresses these goals by allowing continued use of the estuary for recreational boating activities by maintaining a navigable channel system within the estuary, thus connecting it to other open spaces and economic activity centers.

RARE SPECIES SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **rare species or habitat** (see 301 CMR 11.03(2))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

Pre-application consultation was held with NHESP. Further consultation is expected during MEPA and subsequent regulatory reviews.

(NOTE: If you are uncertain, it is recommended that you consult with the Natural Heritage and Endangered Species Program (NHESP) prior to submitting the ENF.)

B. Does the project require any state permits related to **rare species or habitat**? ___ Yes _X_ No

C. Does the project site fall within mapped rare species habitat (Priority or Estimated Habitat?) in the current Massachusetts Natural Heritage Atlas (attach relevant page)? _X__ Yes ___ No.

D. If you answered "No" to all questions A, B and C, proceed to the **Wetlands, Waterways, and Tidelands Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Rare Species section below.

II. Impacts and Permits

A. Does the project site fall within Priority or Estimated Habitat in the current Massachusetts Natural Heritage Atlas (attach relevant page)? _X__ Yes ___ No. If yes,

1. Have you consulted with the Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program (NHESP)? _X__Yes ___No; if yes, have you received a determination as to whether the project will result in the "take" of a rare species? ___ Yes _X_ No; if yes, attach the letter of determination to this submission.

2. Will the project "take" an endangered, threatened, and/or species of special concern in accordance with M.G.L. c.131A (see also 321 CMR 10.04)? ___ Yes _X_ No; if yes, provide a summary of proposed measures to minimize and mitigate rare species impacts

3. Which rare species are known to occur within the Priority or Estimated Habitat?

Piping Plover, Least Tern, Roseate Tern, Arctic Tern, Common Tern, Red Knot, and American Oystercatcher

4. Has the site been surveyed for rare species in accordance with the Massachusetts Endangered Species Act? _X__ Yes ___ No

See Town of Orleans Habitat Conservation Plan annual reports from 2018, 2019 and 2020 in Section N.

4. If your project is within Estimated Habitat, have you filed a Notice of Intent or received an Order of Conditions for this project? ___ Yes _X (to be filed)_ No; if yes, did you send a copy of the Notice of Intent to the Natural Heritage and Endangered Species Program, in accordance with the Wetlands Protection Act regulations? ___ Yes ___ No

B. Will the project "take" an endangered, threatened, and/or species of special concern in accordance with M.G.L. c.131A (see also 321 CMR 10.04)? ___ Yes _X_ No; if yes, provide a summary of proposed measures to minimize and mitigate impacts to significant habitat:

WETLANDS, WATERWAYS, AND TIDELANDS SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **wetlands, waterways, and tidelands** (see 301 CMR 11.03(3))? _X__ Yes ___ No; if yes, specify, in quantitative terms:

11.03 (3)(a)1.b - The project will have direct/permanent impacts to 0.05 acres of coastal beach, 6.8 acres of coastal dune, 6.1 acres of barrier beach, 57.7 acres of land containing shellfish, 57.2 acres of land under the ocean, 23.4 acres of land subject to coastal storm flowage, and 64.6 acres of NHESP habitat.

11.03 (3)(b)1.a - The project will have direct/permanent impacts to 0.05 acers of coastal beach, 6.8 acres of coastal dune and 6.1 acres of barrier beach.

11.03 (3)(b)1.c - The project will have direct/permanent impacts to 43.5 acres of ORW and temporary impacts to 1.4 acres of ORW.

11.03 (3)(b)1.e – The project will place new fill in a velocity zone or regulatory floodway.

11.03 (3)(b)1.f - The project will have direct/permanent impacts to 0.05 acres of coastal beach, 57.7 acres of land containing shellfish, 57.2 acres of land under the ocean, 23.4 acers of land subject to coastal storm flowage, and 64.6 acres of NHESP habitat.

11.03 (3)(b)3 – The project includes dredging of 155,560 cubic yards of material, with possible annual maintenance dredging of 60,000 cy.

11.03 (3)(b)4 - The project includes disposal of 145,900 cubic yards of dredged material within Wetlands, Waterways, and Tidelands. An additional 9,660 cy of dredged material will be disposed of in the upland.

B. Does the project require any state permits (or a local Order of Conditions) related to **wetlands, waterways, or tidelands**? _X__ Yes ___ No; if yes, specify which permit:

Order of Conditions, 401 Water Quality Certification, Chapter 91 Permit, and Coastal Zone Management Federal Consistency Determination.

C. If you answered "No" to both questions A and B, proceed to the **Water Supply Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Wetlands, Waterways, and Tidelands Section below.

II. Wetlands Impacts and Permits

A. Does the project require a new or amended Order of Conditions under the Wetlands Protection Act (M.G.L. c.131A)? _X__ Yes ___ No; if yes, has a Notice of Intent been filed? ___ Yes _X__ No; if yes, list the date and MassDEP file number: _____; if yes, has a local Order of Conditions been issued? ___ Yes ___ No; Was the Order of Conditions appealed? ___ Yes ___ No. Will the project require a Variance from the Wetlands regulations? ___ Yes ___ No.

B. Describe any proposed permanent or temporary impacts to wetland resource areas located on the project site:

See Section F – Assessment of Impacts and Selection of Preferred Alternative.

C. Estimate the extent and type of impact that the project will have on wetland resources, and indicate whether the impacts are temporary or permanent:

Coastal Wetlands	Area (square feet) or Length (linear feet)	Temporary or Permanent Impact?
Land Under the Ocean	2,492,561 sf	permanent
Land Under the Ocean	12,033 sf	temporary
Designated Port Areas		
Coastal Beaches	2,542 sf	permanent
Coastal Beaches	25,963 sf	temporary
Coastal Dunes	296,597 sf	permanent
Coastal Dunes	19,618 sf	temporary
Barrier Beaches	263,785 sf	permanent
Barrier Beaches	19,618 sf	temporary
Coastal Banks		
Rocky Intertidal Shores		
Salt Marshes		
Land Under Salt Ponds		
Land Containing Shellfish	2,515,618 sf	permanent
Land Containing Shellfish	12,434 sf	temporary
Fish Runs		
Land Subject to Coastal Storm Flowage	1,018,562 sf	permanent
Land Subject to Coastal Storm Flowage	59,742 sf	temporary
Inland Wetlands		
Bank (lf)		
Bordering Vegetated Wetlands		
Isolated Vegetated Wetlands		
Land under Water		
Isolated Land Subject to Flooding		
Borderi ng Land Subject to Flooding		
Riverfront Area		

D. Is any part of the project:

1. proposed as a **limited project**? ___ Yes _X__ No; if yes, what is the area (in sf)?____
2. the construction or alteration of a **dam**? ___ Yes _X__ No; if yes, describe:
3. fill or structure in a **velocity zone** or **regulatory floodway**? _X__ Yes ___ No
4. dredging or disposal of dredged material? _X__ Yes ___ No; if yes, describe the volume of dredged material and the proposed disposal site:

    - **119,830 cy will be dredged using a cutter suction side cast dredge and placed in a 60-80 ft wide side cast zone west of the dredged channel behind the barrier beach**
    - **26,080 cy will be dredged using a hydraulic cutter suction dredge and pumped via pipeline to a dewatering basin/dune enhancement area north of Nauset Public Beach**
    - **9,660 cy will be mechanically dredged, offloaded at the Goose Hummock town landing and temporarily stockpiled in the upland in the Towns of Orleans and Eastham**

5. a discharge to an **Outstanding Resource Water (ORW)** or an **Area of Critical Environmental Concern (ACEC)**? _X__ Yes ___ No
6. subject to a wetlands restriction order? _X__ Yes ___ No; if yes, identify the area (in sf):

The project will occur in 1,495 sf of Tidal Flat and 8,400 sf of Barrier Beach that are subject to a wetlands restriction order.

7. located in buffer zones? ___Yes _X__No; if yes, how much (in sf) _____

E. Will the project:
1. be subject to a local wetlands ordinance or bylaw? _X__ Yes ___ No
2. alter any federally-protected wetlands not regulated under state law? ___ Yes _X__ No; if yes, what is the area (sf)?

III. Waterways and Tidelands Impacts and Permits

A. Does the project site contain waterways or tidelands (including filled former tidelands) that are subject to the Waterways Act, M.G.L.c.91? _X_ Yes ___ No; if yes, is there a current Chapter 91 License or Permit affecting the project site? ___ Yes _X__ No; if yes, list the date and license or permit number and provide a copy of the historic map used to determine extent of filled tidelands:

B. Does the project require a new or modified license or permit under M.G.L.c.91? _X__ Yes ___ No; if yes, how many acres of the project site subject to M.G.L.c.91 will be for non-water-dependent use? Current _**0**__ Change _**0**__ Total _**0**__
If yes, how many square feet of solid fill or pile-supported structures (in sf)? **N/A**

C. For non-water-dependent use projects, indicate the following: **N/A**
Area of filled tidelands on the site:_____
Area of filled tidelands covered by buildings:_____
For portions of site on filled tidelands, list ground floor uses and area of each use:
_____
Does the project include new non-water-dependent uses located over flowed tidelands? Yes ___ No ___
Height of building on filled tidelands_____

Also show the following on a site plan: Mean High Water, Mean Low Water, Water-dependent Use Zone, location of uses within buildings on tidelands, and interior and exterior areas and facilities dedicated for public use, and historic high and historic low water marks.

D. Is the project located on landlocked tidelands? ___ Yes _X_ No; if yes, describe the project's impact on the public's right to access, use and enjoy jurisdictional tidelands and describe measures the project will implement to avoid, minimize or mitigate any adverse impact:

E. Is the project located in an area where low groundwater levels have been identified by a municipality or by a state or federal agency as a threat to building foundations? ___Yes _X_ No; if yes, describe the project's impact on groundwater levels and describe measures the project will implement to avoid, minimize or mitigate any adverse impact:

F. Is the project non-water-dependent **and** located on landlocked tidelands **or** waterways or tidelands subject to the Waterways Act **and** subject to a mandatory EIR? ___ Yes _X_ No; *(NOTE: If yes, then the project will be subject to Public Benefit Review and Determination.)*

G. Does the project include dredging? __**X**_ Yes ___ No; if yes, answer the following questions:
What type of dredging? Improvement _**X**__ Maintenance _____
What is the proposed dredge volume, in cubic yards (cys) **_155,560 cy** _____
What is the proposed dredge footprint:
28,300_length (ft) 100 to 50 width (ft)_-5 ft MLW (-5.5 ft NAVD88)_depth (ft);

Will dredging impact the following resource areas?

Intertidal Yes_**X**_ No__; if yes, _**2,542**__ sq ft
Outstanding Resource Waters Yes_**X**_ No__; if yes, **1,895,272** sq ft
Other resource area (i.e. shellfish beds, eel grass beds) Yes_**X**_ No__; if yes **1,793,700** sq ft
If yes to any of the above, have you evaluated appropriate and practicable steps to: 1) avoidance; 2) if avoidance is not possible, minimization; 3) if either avoidance or minimize is not possible, mitigation?

See Section I – Avoidance, Minimization & Mitigation Measures

If no to any of the above, what information or documentation was used to support this determination?

Provide a comprehensive analysis of practicable alternatives for improvement dredging in accordance with 314 CMR 9.07(1)(b). Physical and chemical data of the sediment shall be included in the comprehensive analysis.

See Section E - Alternatives Considered

Sediment Characterization

Existing gradation analysis results? _X_Yes ___No: if yes, provide results.

See Section M for Grain Size Data.

Existing chemical results for parameters listed in 314 CMR 9.07(2)(b)6? _X_Yes ____No; if yes, provide results.

See Section M for Chemistry Data.

Do you have sufficient information to evaluate feasibility of the following management options for dredged sediment? If yes, check the appropriate option.

Beach Nourishment _**X**__
Unconfined Ocean Disposal ___
Confined Disposal:
Confined Aquatic Disposal (CAD) ___
Confined Disposal Facility (CDF) ___
Landfill Reuse in accordance with COMM-97-001 _**X**__
Shoreline Placement _**X**__
Upland Material Reuse__**X**__
In-State landfill disposal__**X**__
Out-of-state landfill disposal ____
(NOTE: This information is required for a 401 Water Quality Certification.)

IV. Consistency:

A. Does the project have effects on the coastal resources or uses, and/or is the project located within the Coastal Zone? _X__ Yes ___ No; if yes, describe these effects and the projects consistency with the policies of the Office of Coastal Zone Management:

See Section K - Review of CZM Policies

B. Is the project located within an area subject to a Municipal Harbor Plan? _X__ Yes ___ No; if yes, identify the Municipal Harbor Plan and describe the project's consistency with that plan:

Town of Eastham Harbor & Waterways Management Plan (TEHWMP)
February 2020

The TEHWMP is consistent with the OCP, ESP, and the CCC local and regional plans, emphasizing the main objective of maintaining and improving existing infrastructure, access points, and natural resources. Specific economic goals include use of opportunities to increase the cultural and economic benefits of being a coastal town, while maintaining town character. Specifically, the TEHWMP highlights potential interest in additional commercial development within Eastham, including a shellfish wholesaler and distributor, marine supply store, and eco-tourism. In terms of infrastructure, the TEHWMP aims to enhance coastal infrastructure that supports commercial and recreational waterway uses.

The proposed improvement dredging within Nauset Estuary is consistent with the TEHWMP given the prosed project ensures continued use of the Nauset Estuary and adjacent developed areas for both economic and recreational activities central to town culture and identity. The TEHWMP promotes the use of dredging to maintain safe channel navigation, although special consideration needs to be given to impacts on the barrier beach, use of dredged material, and longevity of the project given the dynamic environment. During project design, a number of impact mitigation actions were developed to minimize any adverse impacts on the existing environment, including the barrier beach. The TEHWMP also mentions potential future development of a dredging management plan for waterways, which will likely have to address periodic maintenance dredging within Nauset Estuary, given the dynamic environment.

WATER SUPPLY SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **water supply** (see 301 CMR 11.03(4))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **water supply**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Wastewater Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Water Supply Section below.

II. Impacts and Permits

A. Describe, in gallons per day (gpd), the volume and source of water use for existing and proposed activities at the project site:

	Existing	Change	Total
Municipal or regional water supply	_____	_____	_____
Withdrawal from groundwater	_____	_____	_____
Withdrawal from surface water	_____	_____	_____
Interbasin transfer	_____	_____	_____

(NOTE: Interbasin Transfer approval will be required if the basin and community where the proposed water supply source is located is different from the basin and community where the wastewater from the source will be discharged.)

B. If the source is a municipal or regional supply, has the municipality or region indicated that there is adequate capacity in the system to accommodate the project? ___ Yes ___ No

C. If the project involves a new or expanded withdrawal from a groundwater or surface water source, has a pumping test been conducted? ___ Yes ___ No; if yes, attach a map of the drilling sites and a summary of the alternatives considered and the results. _____

D. What is the currently permitted withdrawal at the proposed water supply source (in gallons per day)? _____Will the project require an increase in that withdrawal? ___Yes ___No; if yes, then how much of an increase (gpd)? _____

E. Does the project site currently contain a water supply well, a drinking water treatment facility, water main, or other water supply facility, or will the project involve construction of a new facility? ___ Yes ___No. If yes, describe existing and proposed water supply facilities at the project site:

	Permitted Flow	Existing Avg Daily Flow	Project Flow	Total
Capacity of water supply well(s) (gpd)	_____	_____	_____	_____
Capacity of water treatment plant (gpd)	_____	_____	_____	_____

F. If the project involves a new interbasin transfer of water, which basins are involved, what is the direction of the transfer, and is the interbasin transfer existing or proposed?

G. Does the project involve:

1. new water service by the Massachusetts Water Resources Authority or other agency of the Commonwealth to a municipality or water district? ___ Yes ___ No
2. a Watershed Protection Act variance? ___ Yes ___ No; if yes, how many acres of alteration?
3. a non-bridged stream crossing 1,000 or less feet upstream of a public surface drinking

water supply for purpose of forest harvesting activities? ___ Yes ___ No

III. Consistency

Describe the project's consistency with water conservation plans or other plans to enhance water resources, quality, facilities and services:

WASTEWATER SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **wastewater** (see 301 CMR 11.03(5))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **wastewater**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Transportation -- Traffic Generation Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Wastewater Section below.

II. Impacts and Permits

A. Describe the volume (in gallons per day) and type of disposal of wastewater generation for existing and proposed activities at the project site (calculate according to 310 CMR 15.00 for septic systems or 314 CMR 7.00 for sewer systems):

	Existing	Change	Total
Discharge of sanitary wastewater	_____	_____	_____
Discharge of industrial wastewater	_____	_____	_____
TOTAL	_____	_____	_____

	Existing	Change	Total
Discharge to groundwater	_____	_____	_____
Discharge to outstanding resource water	_____	_____	_____
Discharge to surface water	_____	_____	_____
Discharge to municipal or regional wastewater facility	_____	_____	_____
TOTAL	_____	_____	_____

B. Is the existing collection system at or near its capacity? ___ Yes ___ No; if yes, then describe the measures to be undertaken to accommodate the project's wastewater flows:

C. Is the existing wastewater disposal facility at or near its permitted capacity? ___ Yes___ No; if yes, then describe the measures to be undertaken to accommodate the project's wastewater flows:

D. Does the project site currently contain a wastewater treatment facility, sewer main, or other wastewater disposal facility, or will the project involve construction of a new facility? ___ Yes ___ No; if yes, describe as follows:

	Permitted	Existing Avg Daily Flow	Project Flow	Total
Wastewater treatment plant capacity (in gallons per day)	_____	_____	_____	_____

E. If the project requires an interbasin transfer of wastewater, which basins are involved, what is the direction of the transfer, and is the interbasin transfer existing or new?

(NOTE: Interbasin Transfer approval may be needed if the basin and community where wastewater will be discharged is different from the basin and community where the source of water supply is located.)

F. Does the project involve new sewer service by the Massachusetts Water Resources Authority (MWRA) or other Agency of the Commonwealth to a municipality or sewer district? ___ Yes ___ No

G. Is there an existing facility, or is a new facility proposed at the project site for the storage, treatment, processing, combustion or disposal of sewage sludge, sludge ash, grit, screenings, wastewater reuse (gray water) or other sewage residual materials? ___ Yes ___ No; if yes, what is the capacity (tons per day):

	Existing	Change	Total
Storage	_____	_____	_____
Treatment	_____	_____	_____
Processing	_____	_____	_____
Combustion	_____	_____	_____
Disposal	_____	_____	_____

H. Describe the water conservation measures to be undertaken by the project, and other wastewater mitigation, such as infiltration and inflow removal.

III. Consistency

A. Describe measures that the proponent will take to comply with applicable state, regional, and local plans and policies related to wastewater management:

B. If the project requires a sewer extension permit, is that extension included in a comprehensive wastewater management plan? ___ Yes ___ No; if yes, indicate the EEA number for the plan and whether the project site is within a sewer service area recommended or approved in that plan:

TRANSPORTATION SECTION (TRAFFIC GENERATION)

I. Thresholds / Permit

A. Will the project meet or exceed any review thresholds related to **traffic generation** (see 301 CMR 11.03(6))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **state-controlled roadways**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Roadways and Other Transportation Facilities Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Traffic Generation Section below.

II. Traffic Impacts and Permits

A. Describe existing and proposed vehicular traffic generated by activities at the project site:

	Existing	Change	Total
Number of parking spaces	_____	_____	_____
Number of vehicle trips per day	_____	_____	_____
ITE Land Use Code(s):	_____	_____	_____

B. What is the estimated average daily traffic on roadways serving the site?

Roadway	Existing	Change	Total
1. _____	_____	_____	_____
2. _____	_____	_____	_____
3. _____	_____	_____	_____

C. If applicable, describe proposed mitigation measures on state-controlled roadways that the project proponent will implement:

D. How will the project implement and/or promote the use of transit, pedestrian and bicycle facilities and services to provide access to and from the project site?

C. Is there a Transportation Management Association (TMA) that provides transportation demand management (TDM) services in the area of the project site? ____ Yes ____ No; if yes, describe if and how will the project will participate in the TMA:

D. Will the project use (or occur in the immediate vicinity of) water, rail, or air transportation facilities? ____ Yes ____ No; if yes, generally describe:

E. If the project will penetrate approach airspace of a nearby airport, has the proponent filed a Massachusetts Aeronautics Commission Airspace Review Form (780 CMR 111.7) and a Notice of Proposed Construction or Alteration with the Federal Aviation Administration (FAA) (CFR Title 14 Part 77.13, forms 7460-1 and 7460-2)?

III. Consistency

Describe measures that the proponent will take to comply with municipal, regional, state, and federal plans and policies related to traffic, transit, pedestrian and bicycle transportation facilities and services:

TRANSPORTATION SECTION (ROADWAYS AND OTHER TRANSPORTATION FACILITIES)

I. Thresholds

A. Will the project meet or exceed any review thresholds related to **roadways or other transportation facilities** (see 301 CMR 11.03(6))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **roadways or other transportation facilities**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Energy Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Roadways Section below.

II. Transportation Facility Impacts

A. Describe existing and proposed transportation facilities in the immediate vicinity of the project site:

B. Will the project involve any

1. Alteration of bank or terrain (in linear feet)? _____
2. Cutting of living public shade trees (number)? _____
3. Elimination of stone wall (in linear feet)? _____

III. Consistency -- Describe the project's consistency with other federal, state, regional, and local plans and policies related to traffic, transit, pedestrian and bicycle transportation facilities and services, including consistency with the applicable regional transportation plan and the Transportation Improvements Plan (TIP), the State Bicycle Plan, and the State Pedestrian Plan:

ENERGY SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **energy** (see 301 CMR 11.03(7))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **energy**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Air Quality Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Energy Section below.

II. Impacts and Permits

A. Describe existing and proposed energy generation and transmission facilities at the project site:

	Existing	Change	Total
Capacity of electric generating facility (megawatts)	_____	_____	_____
Length of fuel line (in miles)	_____	_____	_____
Length of transmission lines (in miles)	_____	_____	_____
Capacity of transmission lines (in kilovolts)	_____	_____	_____

B. If the project involves construction or expansion of an electric generating facility, what are:

1. the facility's current and proposed fuel source(s)?
2. the facility's current and proposed cooling source(s)?

C. If the project involves construction of an electrical transmission line, will it be located on a new, unused, or abandoned right of way? ___Yes ___No; if yes, please describe:

D. Describe the project's other impacts on energy facilities and services:

III. Consistency

Describe the project's consistency with state, municipal, regional, and federal plans and policies for enhancing energy facilities and services:

AIR QUALITY SECTION

I. Thresholds

A. Will the project meet or exceed any review thresholds related to **air quality** (see 301 CMR 11.03(8))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **air quality**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Solid and Hazardous Waste Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Air Quality Section below.

II. Impacts and Permits

A. Does the project involve construction or modification of a major stationary source (see 310 CMR 7.00, Appendix A)? ___ Yes ___ No; if yes, describe existing and proposed emissions (in tons per day) of:

	Existing	Change	Total
Particulate matter	_____	_____	_____
Carbon monoxide	_____	_____	_____
Sulfur dioxide	_____	_____	_____
Volatile organic compounds	_____	_____	_____
Oxides of nitrogen	_____	_____	_____
Lead	_____	_____	_____
Any hazardous air pollutant	_____	_____	_____
Carbon dioxide	_____	_____	_____

B. Describe the project's other impacts on air resources and air quality, including noise impacts:

III. Consistency

A. Describe the project's consistency with the State Implementation Plan:

B. Describe measures that the proponent will take to comply with other federal, state, regional, and local plans and policies related to air resources and air quality:

SOLID AND HAZARDOUS WASTE SECTION

I. Thresholds / Permits

A. Will the project meet or exceed any review thresholds related to **solid or hazardous waste** (see 301 CMR 11.03(9))? ___ Yes _X__ No; if yes, specify, in quantitative terms:

B. Does the project require any state permits related to **solid and hazardous waste**? ___ Yes _X__ No; if yes, specify which permit:

C. If you answered "No" to both questions A and B, proceed to the **Historical and Archaeological Resources Section**. If you answered "Yes" to either question A or question B, fill out the remainder of the Solid and Hazardous Waste Section below.

II. Impacts and Permits

A. Is there any current or proposed facility at the project site for the storage, treatment, processing, combustion or disposal of solid waste? ___ Yes ___ No; if yes, what is the volume (in tons per day) of the capacity:

	Existing	Change	Total
Storage	_____	_____	_____
Treatment, processing	_____	_____	_____
Combustion	_____	_____	_____
Disposal	_____	_____	_____

B. Is there any current or proposed facility at the project site for the storage, recycling, treatment or disposal of hazardous waste? ___ Yes ___ No; if yes, what is the volume (in tons or gallons per day) of the capacity:

	Existing	Change	Total
Storage	_____	_____	_____
Recycling	_____	_____	_____
Treatment	_____	_____	_____
Disposal	_____	_____	_____

C. If the project will generate solid waste (for example, during demolition or construction), describe alternatives considered for re-use, recycling, and disposal:

D. If the project involves demolition, do any buildings to be demolished contain asbestos? ___ Yes ___ No

E. Describe the project's other solid and hazardous waste impacts (including indirect impacts):

III. Consistency

Describe measures that the proponent will take to comply with the State Solid Waste Master Plan:

HISTORICAL AND ARCHAEOLOGICAL RESOURCES SECTION

I. Thresholds / Impacts

A. Have you consulted with the Massachusetts Historical Commission? ___ Yes _X__ No; if yes, attach correspondence. For project sites involving lands under water, have you consulted with the Massachusetts Board of Underwater Archaeological Resources? ____Yes __X__ No; if yes, attach correspondence

B. Is any part of the project site a historic structure, or a structure within a historic district, in either case listed in the State Register of Historic Places or the Inventory of Historic and Archaeological Assets of the Commonwealth? ___ Yes _X__ No; if yes, does the project involve the demolition of all or any exterior part of such historic structure? ___ Yes ___ No; if yes, please describe:

The house at 51 Nauset Road is listed as a historic structure in the State Register of Historic Places, however the portion of the property included in the proposed project site is along the shoreline where the dredge pipeline will be placed and nowhere near the house.

C. Is any part of the project site an archaeological site listed in the State Register of Historic Places or the Inventory of Historic and Archaeological Assets of the Commonwealth? ___ Yes _X__ No; if yes, does the project involve the destruction of all or any part of such archaeological site? ___ Yes ___ No; if yes, please describe:

D. If you answered "No" to all parts of both questions A, B and C, proceed to the **Attachments and Certifications** Sections. If you answered "Yes" to any part of either question A or question B, fill out the remainder of the Historical and Archaeological Resources Section below.

II. Impacts

Describe and assess the project's impacts, direct and indirect, on listed or inventoried historical and archaeological resources:

III. Consistency

Describe measures that the proponent will take to comply with federal, state, regional, and local plans and policies related to preserving historical and archaeological resources:

CERTIFICATIONS:

1. The Public Notice of Environmental Review has been/will be published in the following newspapers in accordance with 301 CMR 11.15(1):

   (Name) Cape Cod Times (Date) ???

2. This form has been circulated to Agencies and Persons in accordance with 301 CMR 11.16(2).

Signatures:

Date	Signature of Responsible Officer or Proponent	Date	Signature of person preparing EENF (if different from above)
	John Kelly		Leslie Fields
	Name (print or type)		Name (print or type)
	Town of Orleans		Woods Hole Group, Inc.
	Firm/Agency		Firm/Agency
	19 School Road		107 Waterhouse Road
	Street		Street
	Orleans, MA 02653		Bourne, MA 02532
	Municipality/State/Zip		Municipality/State/Zip
	508-240-3770 Ext 2415		508-495-6225
	Phone		Phone

CERTIFICATIONS:

1. The Public Notice of Environmental Review has been/will be published in the following newspapers in accordance with 301 CMR 11.15(1):

   (Name) Cape Cod Times (Date) ???

2. This form has been circulated to Agencies and Persons in accordance with 301 CMR 11.16(2).

Signatures:

Date	Signature of Responsible Officer or Proponent	Date	Signature of person preparing EENF (if different from above)
	Jaqueline Beebe		Leslie Fields
	Name (print or type)		Name (print or type)
	Town of Eastham		Woods Hole Group, Inc.
	Firm/Agency		Firm/Agency
	2500 State Highway		107 Waterhouse Road
	Street		Street
	Eastham, MA 02642		Bourne, MA 02532
	Municipality/State/Zip		Municipality/State/Zip
	508-240-5900		508-495-6225
	Phone		Phone

A. ADDENDUM A - Proponent & Parcel Owner Information

Proponents:

John Kelly, Town Administrator
Town of Orleans
19 School Road
Orleans, MA 02653
Phone Number: 508-240-3700, Ext 2415

Jacqueline Beebe, Town Administrator
Town of Eastham
2500 State Highway
Eastham, MA 02642
Phone Number: 508-240-5900

Parcels Included in Project:

239 Beach Road (Nauset Beach), Orleans, Map 14 Parcel 11:

Town of Orleans
19 School Road
Orleans, MA 02653

Deed Reference: Book 1170 Page 127

55 Nauset Road, Orleans, Map 22 Parcel 76:

United States of America
Cape Cod National Seashore
99 Marconi Road
Wellfleet, MA 02667

Deed Reference: Book 1523 Page 750

47 Nauset Road, Orleans, Map 22 Parcel 71:

Kristine & Barton Graf Jr, Trustees
47 Nauset Road Realty Trust
3 Abbott Road
Lexington, MA 02420

Deed Reference: Book 29927 Page 28

51 Nauset Road, Orleans, Map 22 Parcel 72:

51 Nauset LLC
c/o John McCormack
404 Riverside Dr, Apt. 3N
New York, NY 10025

Deed Reference: Book 29010 Page 104

1 Route 6A (Jeremiash's Gutter/Boat Ramp), Orleans, Map 18 Parcel 48:

Town of Orleans
19 School Road
Orleans, MA 02653

Deed Reference: Not Available

Section B

Summary

B. SUMMARY

The Nauset Estuary Dredging Project (Project) is located within the Towns of Orleans and Eastham. A portion of the Project is also located within the Cape Cod National Seashore (Figure B-1). At 2,200 acres in size, Nauset Estuary is one of the largest estuarine systems on Cape Cod. The estuary is protected from the Atlantic Ocean by Nauset barrier beach, which stretches north from Nauset Heights for more than 2 miles. Tidal waters between the Atlantic Ocean and the estuary are exchanged through a dynamic tidal inlet that is both narrow and shallow. Inside the estuary the system contains large areas of salt marsh with a series of natural channels that lead to open water areas and distal ponds. Ponds in the southern end of the system include Town Cove, Mill Pond, Roberts Cove, Woods Cove and Rachel Cove. Ponds and water bodies at the northern end of Nauset Estuary include Nauset Bay, Salt Pond and Salt Pond Bay.

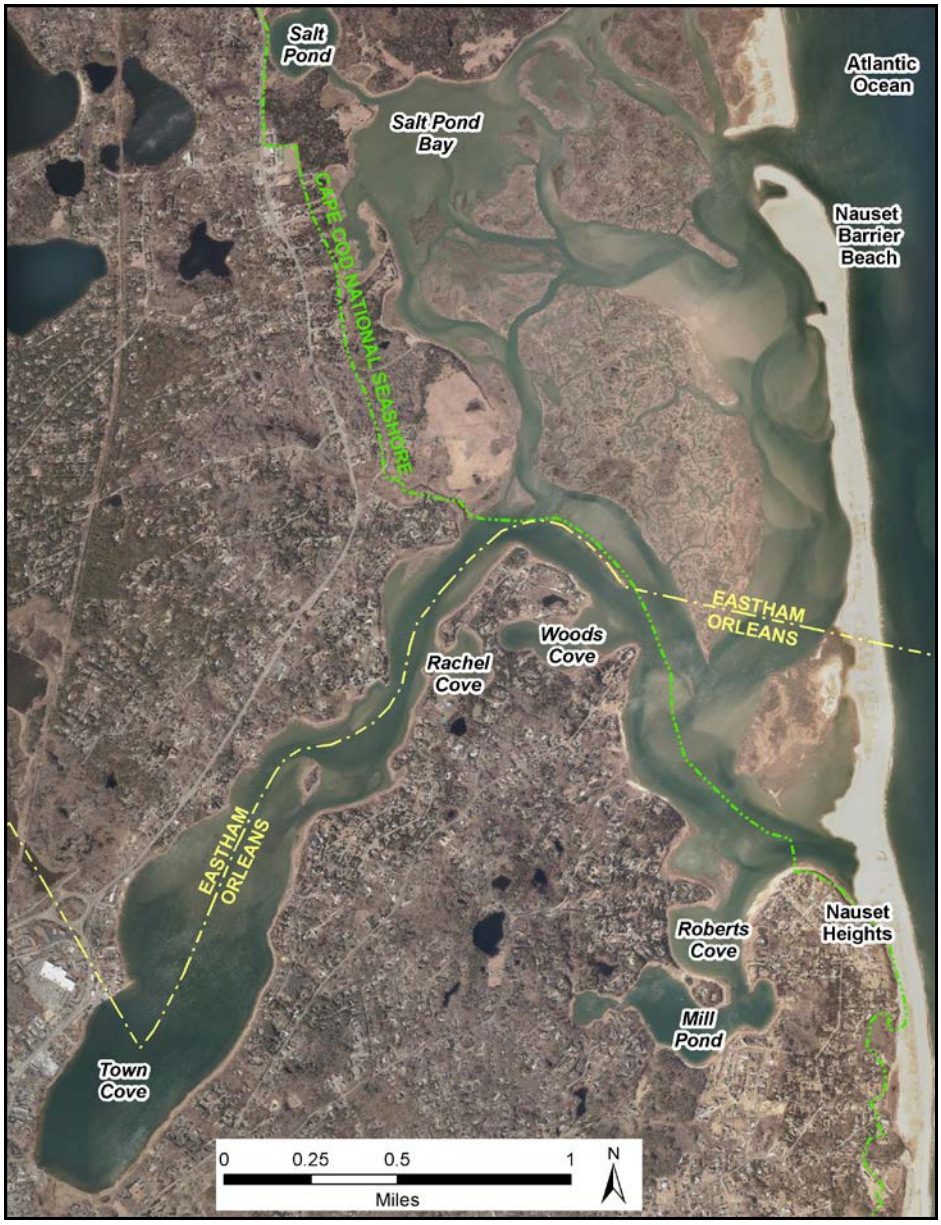

Figure B-1. Project area map showing primary features of the Nauset Estuary system.

Nauset barrier beach and the inlet leading to the estuary are dynamic features of the system that have undergone significant changes over the past 100 years. Since the 1950s the barrier beach and inlet have experienced several periods of northerly growth, punctuated by inlet breaching to the south. The most recent period of northerly migration started in the mid-1990s. Since this time the inlet has migrated north approximately 1.2 miles to its present location, which represents the most northerly location since early record keeping. The barrier beach and inlet are heavily influenced by longshore sand transport and the hydrodynamics of the estuary are such that sediment moving along the ocean facing beaches tends to be transported into the estuary through the inlet. This net movement of sediment into the estuary has resulted in significant shoaling within the estuary channels and mooring areas.

The problem has advanced to the point where many commercial fishing vessels can no longer operate from town landings within the estuary, and instead operate from exposed moorings in the center of the navigation channel south of the inlet. Traditionally, commercial fishing vessels could only pass through Nauset inlet for 2-3 hours before and after high tide. The evolution of shoaling within the navigation channel has further restricted that window, forcing members of the commercial fleet to moor their boats and stage their equipment closer to the inlet itself, at great risk and at great personal expense. The Nauset Estuary Dredging Project is being proposed to address these issues by providing improvements to navigation and public safety for both commercial and recreational uses of the estuary.

During development of the project and selection of the preferred alternative, a number of project Elements were considered. These include the following:

- Element #1: Dredge channel layout
- Element #2: Dredge channel width
- Element #3: Placement areas for dredged material
- Element #4: Dredge methodology

The preferred alternative represents a combination of these project Elements as illustrated in Figure B-2 and described below.

Element #1: Dredge Channel Layout - The preferred channel layout extends approximately 4 miles from the inlet to Town Cove via the channel Behind the Barrier Beach. The Town Cove area supports public facilities at Goose Hummock, Cove Road, Collins Landing, and Asa's Landing, as well as private facilities at the Orleans Yacht Club and the Goose Hummock Shop. A spur channel that provides access to Snow Shore and Priscilla Road Landings is also included in the preferred channel layout, as well as a channel leading to the entrance of Mill Pond. In addition to the channel reaches proposed for dredging, the preferred alternative also includes a dredge zone for channel areas between the inlet and Stoney Island and for the Priscilla Rd. spur channel. The dredge zone allows for adaptive management of the channel anywhere within the zone at the time of construction, to minimize the area and volume of dredging while still maintaining the navigation channel.

Figure B-2. **Nauset Estuary Dredging project showing the preferred alternatives for channel layout, channel width and dredged material placement sites.**

Element #2: Dredge Channel Width – The preferred alternative for channel width is 100 ft wide in the channel reach Behind the Barrier Beach and 50 ft wide in all other channel areas. The channel is proposed to be dredged to -5 ft MLW (-5.5 ft NAVD) with 1 ft of possible overdepth dredging. Channel side slopes are proposed at 1V:3H.

Element #3: **Placement Areas for Dredged Material –** Because of the size of the proposed dredge area, a variety of placement options are included in the preferred alternative depending on where the dredging is taking place. Dredged material from the Town Cove and the Central Main Channel areas will be stockpiled in the upland within the Towns of Orleans or Eastham and beneficially reused at a later date for other permitted resiliency projects. Sand removed from the channel Behind the Barrier Beach and the Eastern Main Channel will be sidecast approximately 60 to 80 ft from the edges of the dredged channel. Material from the Priscilla Rd. and Mill Pond spur channels will be beneficially reused to enhance the coastal dunes north of Nauset Public Beach.

Element #4: **Dredge Methodology** – Because of the size of the proposed dredge area and the location of the preferred placement sites, it is not possible to use one dredging methodology. As such the preferred alternatives for dredge methodology are sidecast dredging for the channel area Behind the Barrier Beach and the Eastern Main Channel, hydraulic cutter suction pipeline dredge for the Priscilla Rd. and Mill Pond spur channels, and mechanical dredging for the Town Cove and Central Main Channel areas. Using the preferred channel layout, width, and depth, it is estimated that 119,830 cy will be sidecast dredged, 26,080 cy will be dredged using a hydraulic cutter suction pipeline dredge, and 9,660 cy will be mechanically dredged.

The Project is located within the Towns of Orleans and Eastham, and portions of the Project are also located within the Cape Cod National Seashore (CCNS). Dredge pipeline access for the dune enhancement north of Nauset Public Beach is proposed on properties owned by the US Govt., the Town of Orleans, and two (2) private properties in the Nauset Heights area. The Towns have been in consultation with the CCNS since the early stages of the Project and it is expected that the formal National Environmental Policy Act (NEPA) review process will start during the third or fourth quarter of 2021. At this time the Towns will be seeking guidance from the CCNS on the level of NEPA review required for the project.

The Nauset Estuary Dredging Project will require the following local, state, and Federal permits:

- Executive Office of Energy and Environmental Affairs: Certificate from the Secretary of Energy and Environmental Affairs on the Expanded Environmental Notification Form
- Executive Office of Energy and Environmental Affairs: Certificate from the Secretary of Energy and Environmental Affairs on Draft and Final Environmental Impact Reports
- Orleans Conservation Commission: Order of Conditions
- Eastham Conservation Commission: Order of Conditions
- MassWildlife Natural Heritage & Endangered Species Program: Massachusetts Endangered Species Act Determinations for Orleans and Eastham
- Massachusetts Department of Environmental Protection/Wetlands & Waterways: 401 Water Quality Certification

- Massachusetts Department of Environmental Protection/Waterways Division: Chapter 91 Permit
- Massachusetts Coastal Zone Management: Federal Consistency Determination
- U.S. Army Corps of Engineers: Individual Permit
- National Park Service: National Environmental Policy Act Review (CE, EA, or EIS)

This Expanded Environmental Notification Form (EENF) is the first application filed for the project which will initiate environmental review. All other applications will be submitted once the Massachusetts Environmental Policy Act (MEPA) review process is complete. The project will not require a land transfer. The Project has not received a Permit, Financial Assistance or Land Transfer, although it is likely that grant opportunities will be sought for construction funding.

A total of thirty-one (31) alternatives were evaluated between all four (4) of the project Elements as summarized below. A detailed description of the alternatives considered is provided in Section E.

Element #1: **Dredge Channel Layout** – (15 alternatives)

Alternative 1-1	No dredge scenario
Alternative 1-2A through 1-2G	Channel access between the inlet and town landings via the channel Behind the Barrier Beach
Alternative 1-3	Channel access between the inlet and the inner estuary via the channel Behind the Barrier Beach
Alternative 1-4A & 1-4B:	Chanel access between the inlet and town landings via Cable Creek
Alternative 1-5A through 1-5D	Channel access between town landings and the back side of the barrier beach

Element #2: **Dredge Channel Width** – (3 alternatives)

Alternative 2-1	100 & 80 ft channel widths
Alternative 2-2	50 ft channel widths
Alternative 2-3	100 & 50 ft channel widths

Element #3: **Placement Areas for Dredged Material** - (10 alternatives)

Alternative 3-1	Beach nourishment on Nauset barrier beach
Alternative 3-2	Beach nourishment at Nauset Public Beach
Alternative 3-3	Dune restoration on Nauset barrier beach
Alternative 3-4A	Dune enhancement at Nauset Public Beach
Alternative 3-4B	Dune enhancement north of Nauset Public Beach
Alternative 3-5	Land Under the Ocean adjacent to dredged channel
Alternative 3-6	Subaqueous placement in the terminal ponds
Alternative 3-7	Salt marsh restoration
Alternative 3-8	Beach nourishment on Nauset Estuary shorelines
Alternative 3-9	Upland stockpile/beneficial reuse

Element #4: **Dredge Methodology** – (3 alternatives)

Alternative 4-1	Hydraulic cutter suction pipeline dredge
Alternative 4-2	Sidecast dredge
Alternative 4-3	Mechanical dredge

Environmental impacts and benefits associated with each alternative were evaluated and are discussed in Section F. Findings from the assessment of impacts were used to select a suite of preferred alternatives that achieve the goals of the Project and avoid and/or minimize adverse environmental impacts. Table B-1 provides a summary of preferred alternatives for the Nauset Estuary Dredging Project with associated resource area impacts. Resource area impacts are classified as temporary or permanent, depending on whether the work is within the pipeline corridor or areas of construction access (temporary) or within the direct footprint of the Project (permanent). Impacts to wetland resources have been minimized to the extent possible while still achieving the Project goal of improving navigation and public safety within Nauset Estuary.

The project will adhere to the following measures to avoid, minimize and mitigate for environmental impacts during and following construction.

- Time of year restrictions as determined by the regulatory agencies will be followed for all work to protect and *avoid* direct impacts to endangered species and to *avoid* redistribution of red tide cysts during dredging and subsequent management of the dredged materials. This will result in a work window during the late fall and winter months that will *avoid* impacts to endangered and threatened nesting shorebirds, fisheries resources, and red tide cyst distributions. The exact time of year restriction will be refined based on agency input.
- Establish a "no dredge zone" within 100 ft of the west side of Nauset barrier beach to *avoid* impacting the stability of the barrier beach.
- Conduct shellfish relays prior to the start of dredging under the supervision and direction of the Orleans and Eastham Natural Resources Managers to *avoid* adverse impacts to those resources. Important areas for this action include an area of bay scallops in the Priscilla reach, areas of blue mussels, soft shell clams and surf clams behind the barrier beach and areas of quahogs in Town Cove and Priscilla; these correspond with areas of high-density shellfish populations as determined by the September 16 and 17, 2019 shellfish surveys.
- Hold a pre-construction on-site meeting with selected contractors, project engineers and representatives from the Towns of Orleans and Eastham to ensure appropriate actions will be taken to *avoid* and *minimize* impacts to the surrounding resources.
- Submit pre- and post-dredge bathymetric surveys to the regulatory agencies. Utilize pre-dredge survey data to delineate the most efficient and effective location to dredge the channel within the permitted dredge zone, thereby *minimizing* impacts.
- Conduct pre-dredge eelgrass surveys (between July and September) to ensure that the project meets the minimum setback of 50 ft between all dredging and eelgrass resources. Make adjustments to the location of the dredge channel within the dredge zone as needed to *avoid* impacts to eelgrass.

- Install and maintain erosion and sedimentation controls in all construction and staging areas. This will include areas around Callanan's Pass and the Goose Hummock public landing.
- *Mitigate* impacts to the coastal resource areas by restoring all beach and dune areas impacted by the dredge pipeline to pre-existing grades.
- Revegetate all disturbed dune areas with Cape American beach grass (*Ammophila breviligulata*) planted 18 inches on center.
- Store all fuels, hydraulic oil, etc. in a locked storage trailer or remove them off site on a daily basis.
- No excessive idling of construction vehicles will occur.
- No machinery or vehicles will be stored on the coastal beach or coastal dunes overnight, and during periods of high-water levels all equipment will be moved to the construction access.
- Implementation of a post construction monitoring and maintenance plan (Section J).

Table B-1. Summary of Preferred Alternatives with Associated Resource Area Impacts and Other Selection Criteria.

	Project Element Areas of Impact (acres)				
	Elements #1 and #2: Dredge Channel Layout and Dredge Channel Width (1-2B w/ 2-3)		Elements #3 and #4: Placement Areas for Dredged Material and Dredge Methodologies		
Resource Area	Alternative 1-2B: Channel access between inlet and Town Cove with spur channels to Priscilla Rd Landing and Mill Pond **WITH** Alternative 2-3: 100 ft wide channel Behind the Barrier Beach and 50 ft wide channels for all other dredge areas	Dredge Zone	Alternative 3-4B: Dune enhancement north of Nauset Public Beach	Alternative 3-5: Sidecast Adjacent to Dredged Channel	Alternative 3-9: Upland Stockpile/Beneficial Reuse
Coastal Beach	-	-	0.60 (temp)	-	-
Intertidal Zone	0.1 (perm)	8.4	-	-	-
Coastal Dune	-	-	6.8 (perm) 0.45 (temp)	-	-
Barrier Beach	-	-	6.1 (perm) 1.0 (temp)	-	-
Land Containing Shellfish	41.2 (perm)	181.5	0.3 (temp)	16.6 (perm)	-
Land Under the Ocean	41.0 (perm)	164.7	0.3 (temp)	16.2 (perm)	-
Land Subject to Coastal Storm Flowage	41.2 (perm)	181.5	6.8 (perm) 0.17 (temp)	16.6 (perm)	0.03 (temp)
NHESP Habitat	41.2 (perm)	181.5	6.8 (perm) 0.17 (temp)	16.6 (perm)	-
Outstanding Resource Waters	20.1 (perm)	128.8	6.8 (perm) 0.17 (temp)	16.6 (perm)	-

Section C

Project Description

C. PROJECT DESCRIPTION

The Nauset Estuary Dredging Project (Project) is located on the eastern shore of outer Cape Cod within the Towns of Orleans and Eastham. A portion of the Project is also located within the Cape Cod National Seashore (Figure C-1). Nauset Estuary is one of the largest estuarine systems on Cape Cod. The estuary system supports extensive salt marsh and tidal flat resources, as well as natural channels that lead to open water areas and distal ponds. Nauset barrier beach forms the eastern edge of the estuary and serves to protect the estuarine environment from waters of the Atlantic Ocean.

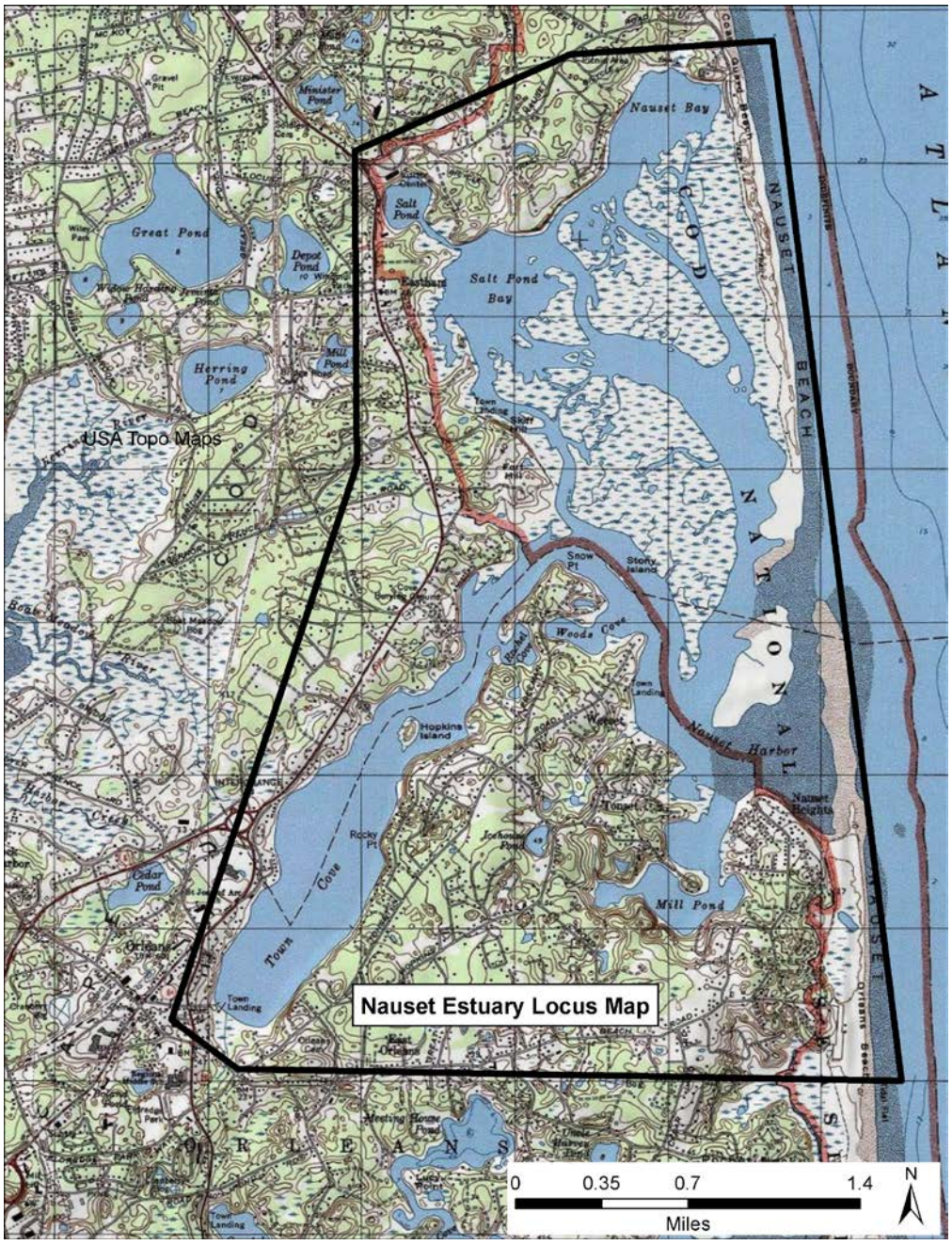

Figure C-1. USGS topographic map showing the area of the Nauset Estuary.

1.0 Project Need

Nauset Estuary has a long history of maritime use, starting with settlers around 4,000 BC and extending through the period of French explorers and English settlers, to the present-day commercial and recreational users. Today, the primary users of Nauset Estuary are commercial fishermen and recreational boaters. To support these users, the Towns of Orleans and Eastham maintain a total of thirteen (13) town landings. They also provide moorings for commercial and recreational boaters at twenty (20) different locations throughout the estuary, serving a total of 411 boaters (Figure C-2). On the commercial side, facilities at Goose Hummock Marina and Nauset Marine provide a wide range of services for commercial and recreational users of the estuary, including mooring and boat rentals, sales of fuel, boats, and equipment, and marine repair services. These local businesses support the local economies of Orleans and Eastham by drawing tourists and employing seasonal and year-round staff.

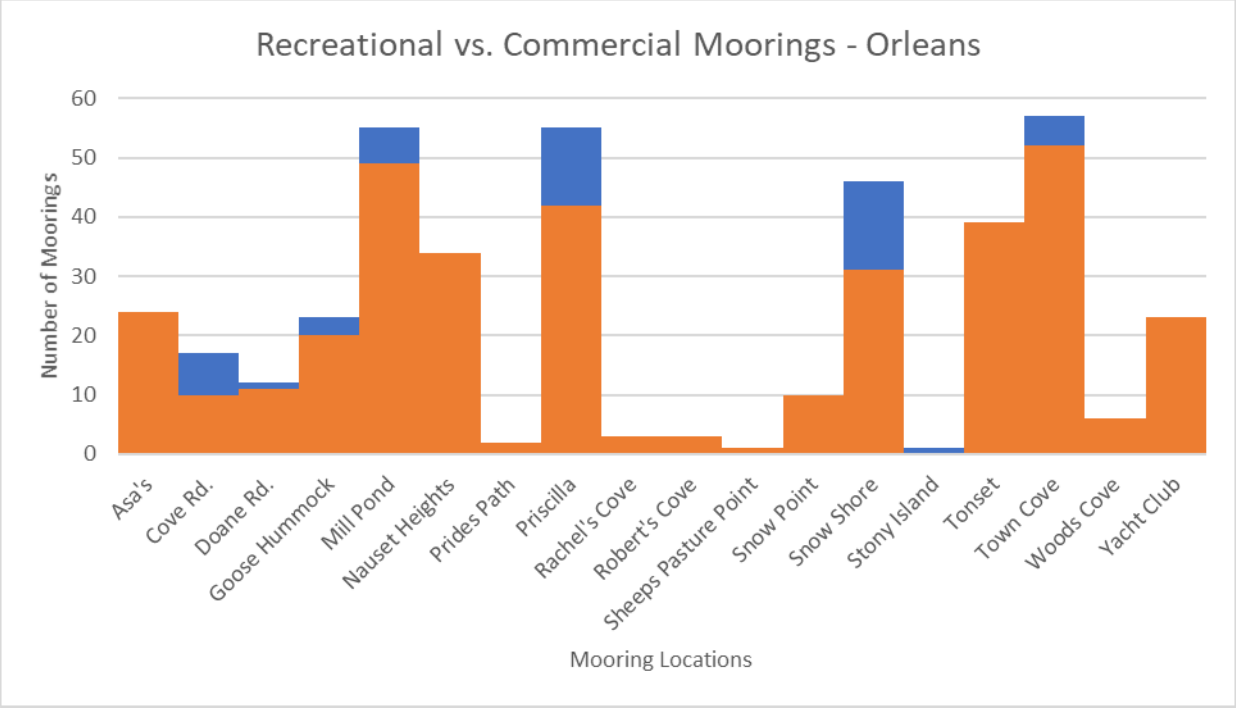

Figure C-2. Recreational (orange) and commercial (blue) moorings in Nauset Estuary based on data from 2016.

The commercial fishing community operating out of Nauset Estuary is comprised of lobstermen, fin fishermen, and shell fishermen. Between 2010 and 2015 there were an average of 19 lobster, 53 finfish, and 173 shellfish commercial permit holders operating within Nauset Estuary. During this period a total of 1,626,500 lbs of lobster, 325,440 lbs. of finfish, and 1,298,980 lbs. of shellfish were landed with an approximate value of $3.5 million (Figure C-3). Starting around 2012, the number of permits issued for lobster and finfishing began to decline because of the difficulties associated with navigating between the inlet and the town landings and moorings. Lobstermen and fin fishermen generally operate larger, deeper draft boats than shell fishermen, and rely heavily on safe and navigable conditions to reach Nauset Inlet and fishing grounds located offshore. The decline in number of permits issued is likely related to the decrease in landings since 2013 shown in Figure C-3.

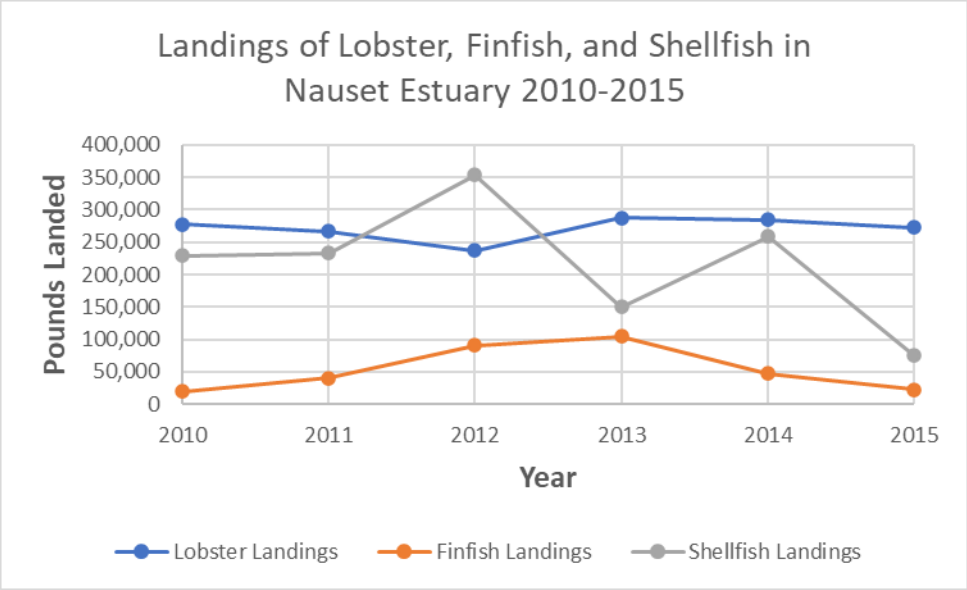

Figure C-3. Total landings of lobster, finfish and shellfish by Nauset Estuary watermen between 2010 and 2015.

Historically, commercial fishing vessels moored in the upper estuary and could leave port 2.5-3.0 hours prior to low tide, navigate the channel to Nauset inlet, and have enough clearance to cross the shoals to the fishing grounds. Increased shoaling now requires the fleet to leave 4.0-4.5 hours before low tide to ensure there is enough water for their vessels to clear the shoals that have accumulated in the navigation channel. This shoaling has added 1.5-2.0 hours to the beginning of each fishing trip, requiring boats to leave earlier to ensure there is enough water left within the estuary for safe passage. Starting in 2013 the commercial fleet started a practice of mooring their boats in the navigation channel just south of the inlet to reduce the time and distance required to travel between the town landings and the inlet. This requires the fishermen to load all necessary gear and crew into a work skiff to shuttle between the town landings and the moored work boats. The near inlet mooring area is exposed to swift currents and coastal storms, requiring heavier tackle with increased risk of damage to the vessels.

Nauset Estuary is also a popular year-round destination for recreational kayakers, paddleboarders, and boaters. In recent years there has been a dramatic increase in recreational boat traffic. Historically, Orleans residents accessed Nauset barrier beach via off road vehicle access pathways; however recent restrictions on access to the barrier beach have motivated many recreational users to launch or moor privately owned boats to access the beach via Nauset Estuary. This change in the way recreational users access the beach has caused recreational boat traffic within the estuary to increase, emphasizing the need for a safe and navigable channel.

As shoaling in the estuary has advanced, the navigation channels have narrowed substantially, causing problems for both commercial fishermen and recreational boaters. Depending on the tide, commercial fishing vessels occupy much of the navigation channel while underway. During the summer months, when there is heavy recreational boat and kayak traffic within the

channel, this poses a significant public safety risk as smaller boats may not have room to move out of the path of an oncoming vessel. The combination of advancing shoals, narrow channel width, and inexperience on the part of many recreational mariners has set the stage for conflict between user groups. Emergency response vessels operated by the Towns of Orleans and Eastham operate out of Town Cove. For emergencies behind the barrier beach or near the inlet, response times are reduced during periods of low tide when the response vessels are required slow down to navigate the narrow and shoaled channels to avoid grounding.

The Towns of Orleans and Eastham are proposing the Nauset Estuary Dredging Project to improve navigation and public safety for commercial and recreational users of the waterway. Dredging is needed to restore navigation and safe passage in channels that have become increasingly narrower and shallower due to ongoing shoaling. The project will help lobster, fin fish and shellfish permit holders, as well as commercial businesses in both towns. Recreational boaters and emergency first responders will also benefit from the project. These stakeholder groups combined, provide significant contributions to the local economies. In the words of one of the local business owners, "This is a matter of the economic life and death of the town and the people that live here and the people that work here."

Letters of support for the Project from the Towns of Orleans and Eastham are provided in Section O.

2.0 Proposed Project

The Nauset Estuary Dredging Project includes improvement dredging of 155,560 cy of material from 28,300 linear ft of channel (Figure C-4). The proposed channel extends from Town Cove to the inlet via the channel Behind the Barrier Beach, with additional spur channels to Priscilla Rd. Landing and the entrance to Mill Pond (channel layout alternative 1-2B). The channel is proposed to be 100 ft wide in areas behind Nauset barrier beach and 50 ft wide in all other channel reaches (channel width alternative 3-2). The proposed channel depth is -5 ft MLW (-5.5 ft NAVD88) with 1 ft of allowable overdepth depth dredging and side slopes of 1V:3H. A dredge zone is proposed for areas of the channel that are the most dynamic, including channel reaches Behind the Barrier Beach, Eastern Main Channel, Central Main Channel, and the Priscilla Rd. Landing channel. The dredge zone allows for adaptive management of the channel anywhere within the zone at the time of construction, to minimize the area and volume of dredging while still maintaining the navigation channel. The channel design will improve access to thirteen (13) town landings in the estuary and 411 commercial and recreational moorings. The channel will also increase access to commercial businesses located in Town Cove.

Proposed dredged material placement locations and dredge methods vary according to channel reach as described below.

- The Town Cove and Central Main Channel reaches will be dredged mechanically (dredge method alternative 4-3), dewatered in barges, and then offloaded at the Goose Hummock town landing (placement area alternative 3-9; Figure C-5). The material will then be stockpiled in upland areas of the Towns of Orleans or Eastham and beneficially reused at a later date for other permitted resiliency projects. This section of the project

will require the dredging of 9,660 cy of material, comprised of 0.2% gravel, 96.0% sand, and 3.8% fines passing the #200 sieve. It is estimated that maintenance dredging in the Town Cove and central main channel reaches will be required every 10 to 15 years.

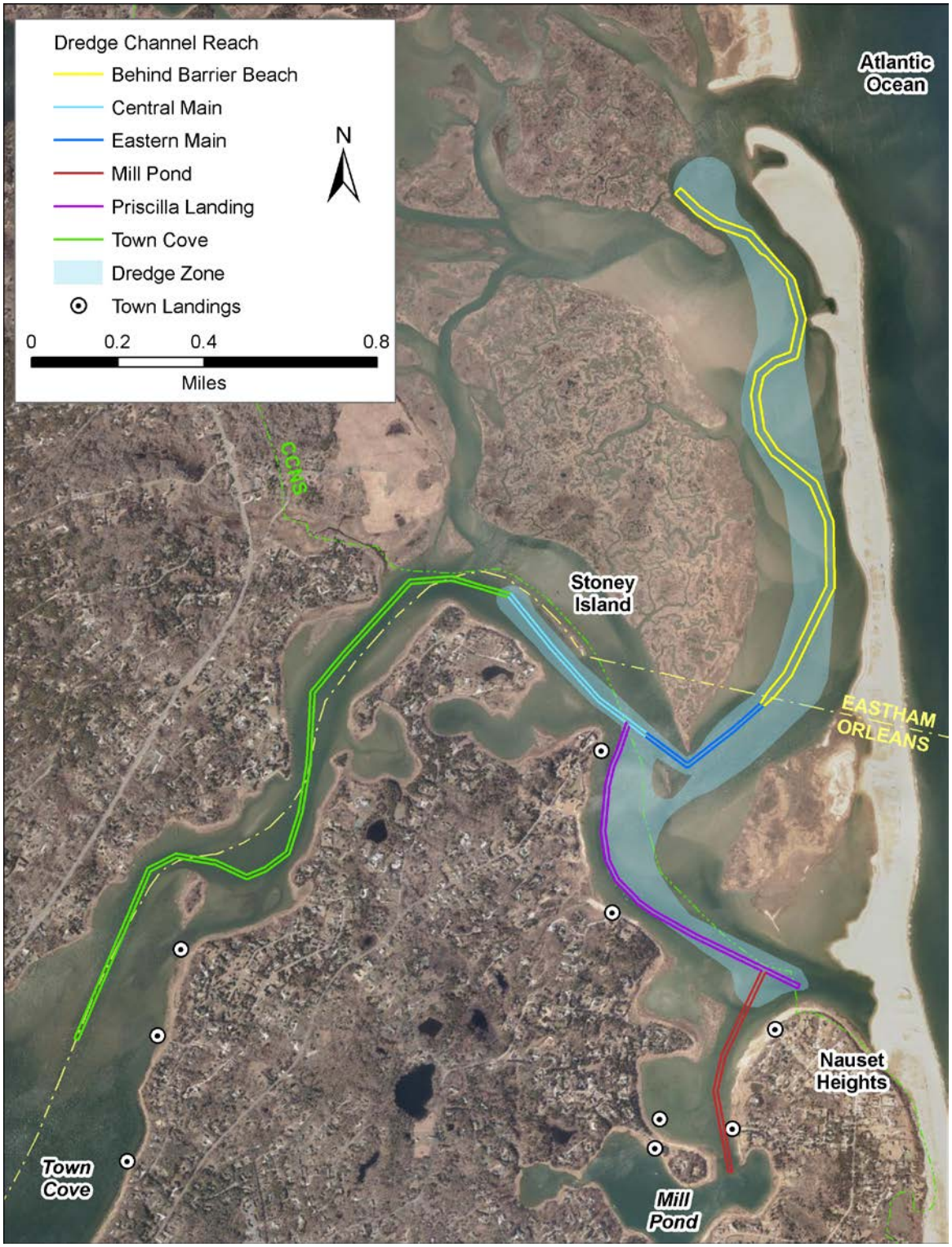

Figure C-4. Nauset Estuary Dredging project showing the preferred alternatives for channel layout, channel width and location of the dredge zone.

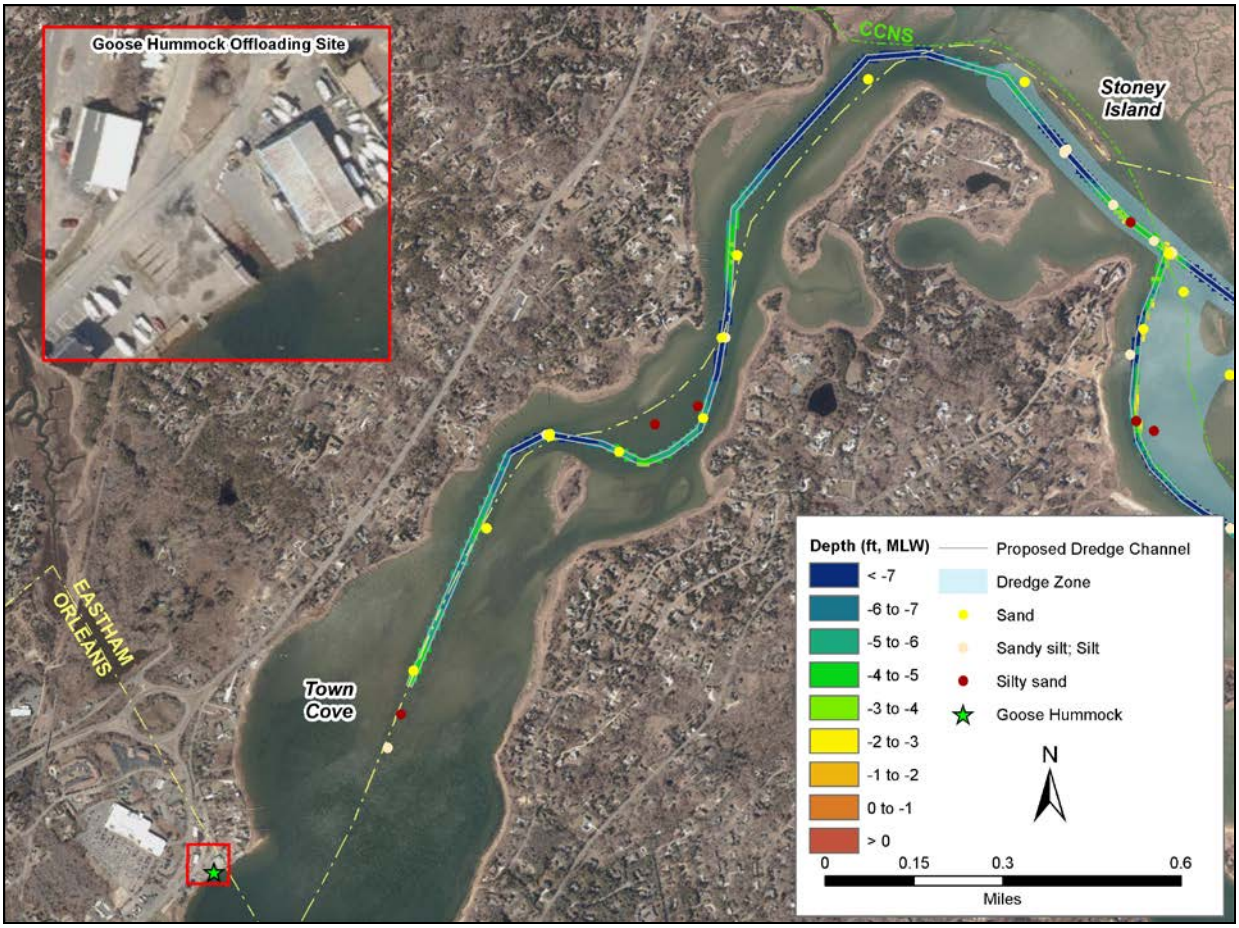

Figure C-5. Proposed dredge channels in Town Cove and the Central Main Channel reaches showing the proposed materials offloading site at Goose Hummock Town Landing.

- Channel reaches behind Nauset Barrier Beach and in the Eastern Main Channel will be dredged using a hydraulic cutter suction sidecast dredge (dredge method alternative 4-2). The material will be sidecast to land under the ocean resources approximately 60 to 80 ft from the edges of the dredged channel (placement area alternative 3-5; Figure C-6). This section of the project will require the dredging of 119,830 cy of material, comprised of 2.0% gravel, 96.6% sand, and 1.4% fines passing the #200 sieve. Given the dynamic nature of this channel area, it is anticipated that maintenance dredging of key shoal areas may be required on an annual basis.

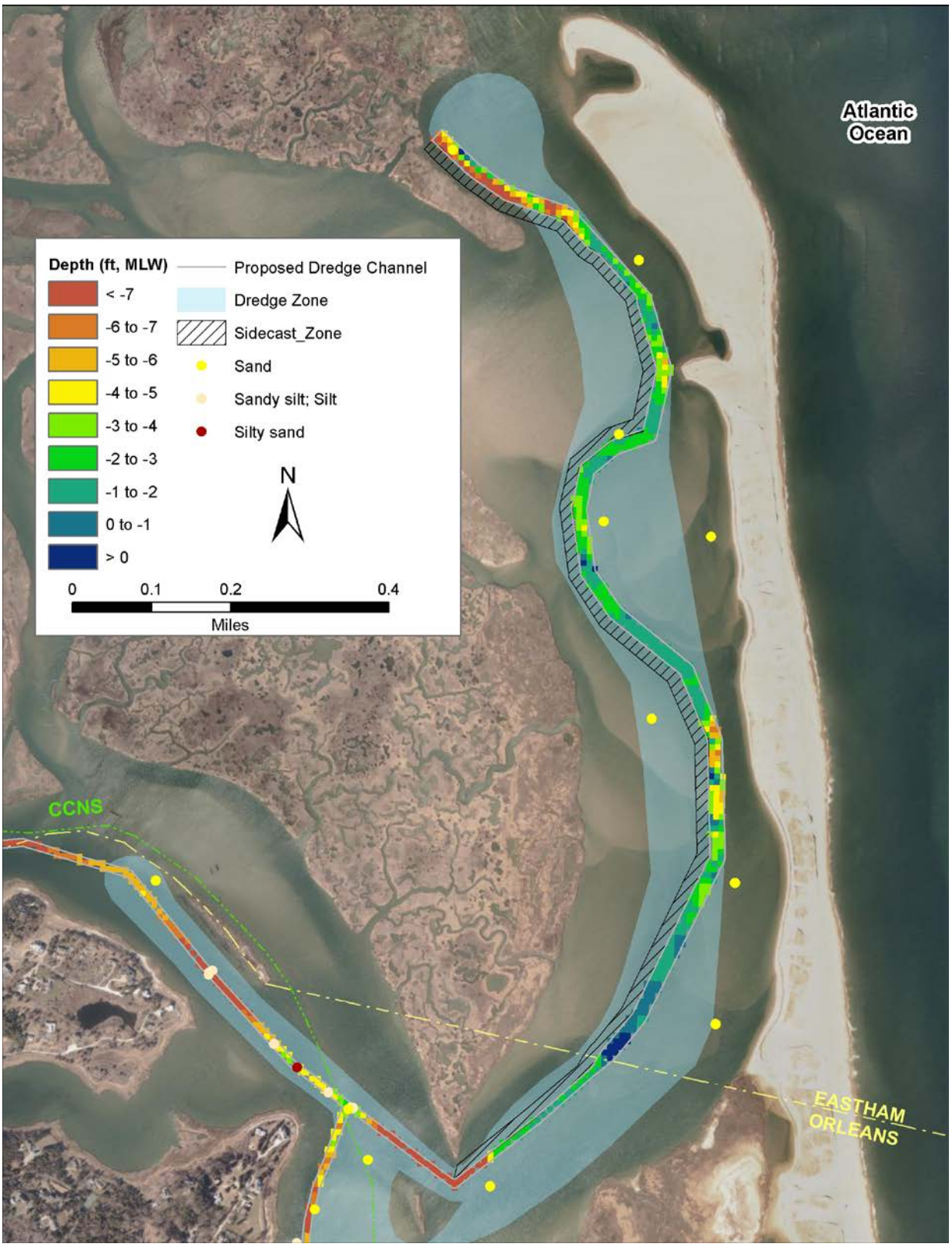

Figure C-6. **Proposed dredge channel reaches for areas Behind Nauset Barrier Beach and the Eastern Main Channel showing the proposed sidecast placement areas.**

- The Priscilla Rd. and Mill pond spur channels will be dredged using a hydraulic cutter suction pipeline dredge (dredge method alternative 4-1). The material will be pumped to a dewatering basin constructed in the dunes north of Nauset Public Beach (placement area alternative 3-4B; Figure C-7). This section of the project will require the dredging of 26,080 cy of material, comprised of 0.7% gravel, 83.3% sand, and 16.0% fines passing the #200 sieve.

  The bottom of the basin will be excavated to an elevation of 3.3 ft NAVD88 over an area of 2.4 acres. Sand excavated from the dunes to create the dewatering basin will be used to build containment berms around the north, south and west sides of the basin. The berms will be built to elevation 17 ft NAVD88 with a crest width of 35 to 40 ft and side slopes of 1V:3H. The existing dune with a crest elevation of 20 ft NAVD88 will form the eastern side of the basin. With the berms included, the basin footprint will cover 6.8 acres. Approximately 22,000 cy of dune material, not needed for berm construction, will be temporarily removed to the northern end of the dune and the Nauset Beach parking lot.

  The pipeline between the dredge and the dewatering basin will extend across one of the overwash features in the barrier beach just north of Nauset Heights. From this point the pipeline will follow along the toe of the coastal dune south to Callanan's Pass where it will cross to the landward side of the dune and follow an existing path to the dewatering basin just north of the Nauset Public Beach parking lot. The total length of pipeline over the beach and dune resources is estimated to be 3,185 linear feet. The pipeline will be located on properties owned by the US Govt., the Town of Orleans, and two (2) private properties in the Nauset Heights area (Figure C-7). Two booster pumps will be needed to pump the material from the dredge to the dewatering basin. One pump will be located on a barge anchored offshore of Priscilla Rd. landing and the second pump will be located at the base of the dunes near Callanan's Pass.

  The dredged material will be pumped as a slurry of water and sediment to the dewatering basin. Sediment in suspension in the slurry will settle to the bottom of the dewatering basin near the end of the discharge pipe and the water will drain out to the ocean via a drainpipe installed under the existing dunes.

  Once the dredging is complete and the sediments have dewatered, grades across the dewatering basin will be restored to their pre-existing conditions using material from the temporary berms and the excess material stored at the northern end of the dune and the Nauset Beach parking lot. A portion of the western berm will be regraded to form a secondary dune with a crest elevation of 17 ft NAVD88 and crest width of approximately 10 ft. The dredged sediment and secondary dune added to this area of the site will help to build resiliency to the coastal dune against future impacts of sea level rise and wave-induced erosion. The project will result in an excess of 12,000 cy of dune sand, originally excavated to form the dewatering basin and temporarily stored at

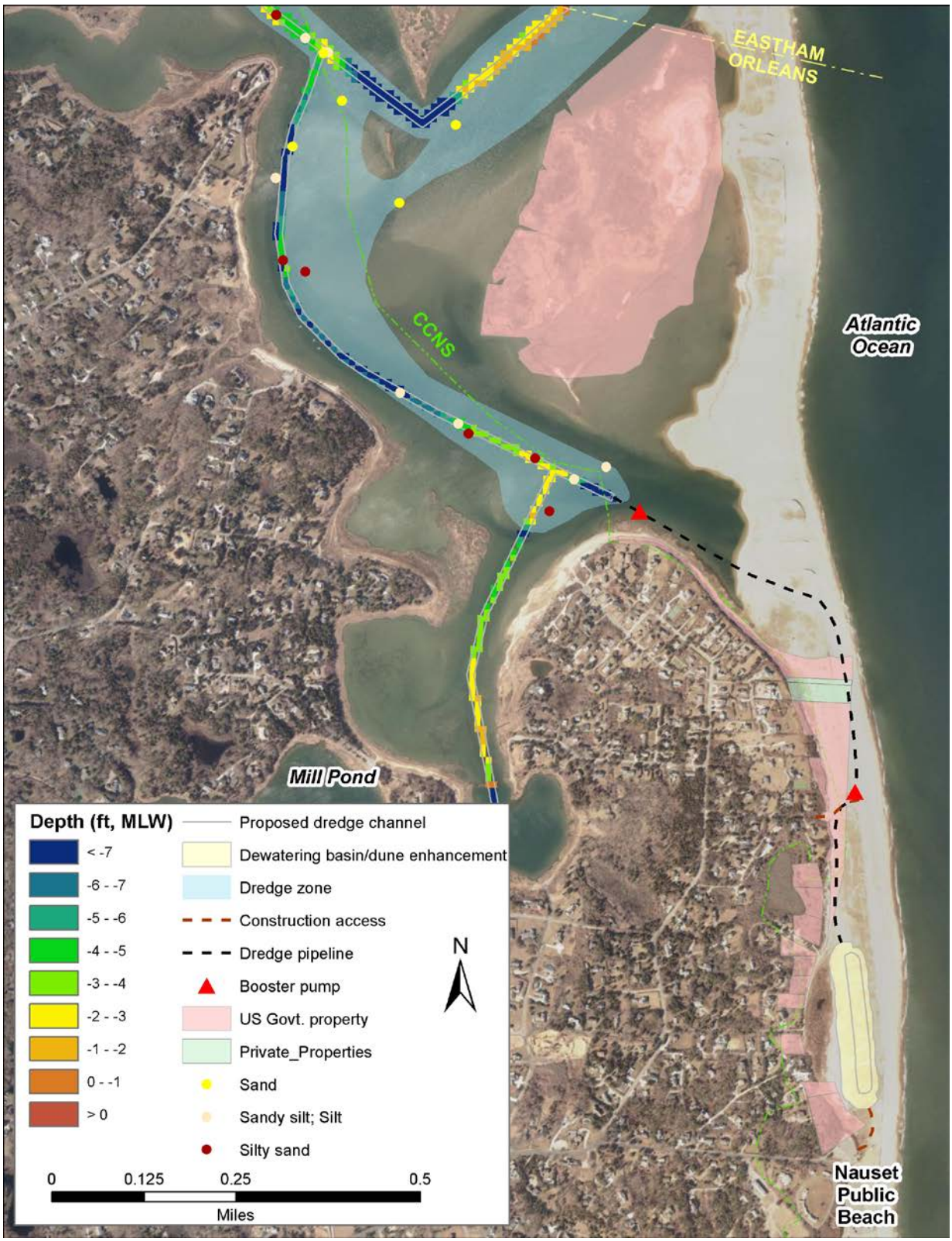

Figure C-7. **Proposed dredge channels in Priscilla Rd. and Mill Pond reaches showing the proposed dewatering basin and dune enhancement area north of Nauset Public Beach as well as the pipeline and construction access routes.**

the north end of the Nauset Beach parking lot. Depending on needs at the public beach, the excess sand will either be used for the currently permitted dune enhancement as part of the Town's phased retreat from Nauset Public Beach or taken offsite for beneficial reuse at other permitted resiliency projects.

It is estimated that maintenance dredging in the Priscilla Rd. and Mill Pond channel reaches may be required every 8 to 10 years. Depending on the condition of Nauset Public Beach and the surrounding dunes at the time maintenance dredging is needed, it may be advantageous to relocate the dewatering basin to a different location where added resiliency is needed.

Additional details on construction methods for each channel reach and placement location are provided in Section G. Engineering plans for the Project are included in Section Q.

Section D

Existing Environment

D. EXISTING ENVIRONMENT

1.0 Existing Environment

1.1 Geomorphology

The history of geomorphologic change along Nauset barrier beach shows two distinctly different periods of spit growth and inlet migration. Historical charts and early aerial photos from 1779 to 1946 show the inlet to be located just north of Nauset Heights, at the southeastern edge of the estuary (Figure D-1; Aubrey and Speer, 1984). Over this approximate 170-yr period Nauset Spit extended in a southerly direction from Coast Guard Beach and the inlet held a relatively stable location against the bluffs at Nauset Heights. Scientific literature suggests that the southward extending spit was formed by a pattern of net southerly sediment transport along the Outer Cape between Wellfleet and Monomoy (Pinet, 2011; Berman, 2011; Aubrey and Speer, 1984; Leatherman, 1979).

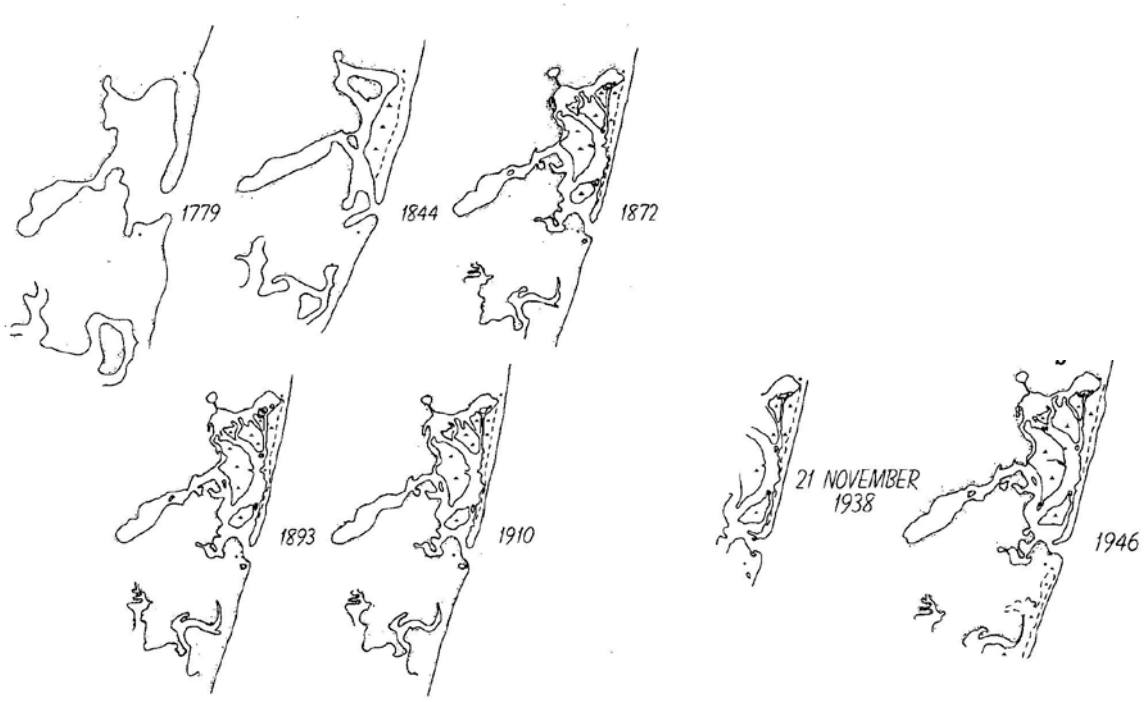

Figure D-1. Shoreline data from 1779 to 1946 showing long-term stability of Nauset Inlet at Nauset Heights (Aubrey and Speer, 1984).

Since this time, inlet activity has been distinctly more active, showing periods of spit growth from Nauset Heights and northerly inlet migration punctuated by inlet breaching to the south. Starting in the 1950s a spit began to grow in a northerly direction from Nauset Heights, causing the inlet to migrate north. A series of storms in the late 1950s and early 1960s re-established the inlet to its southernmost position adjacent to Nauset Heights. A second cycle of northerly spit growth and inlet migration began in 1965 and lasted approximately 25 years until 1990 (Figure D-2). Over

this period, the inlet migrated north approximately 1.3 miles as the spit extending from Coast Guard Beach shortened.

In the early 1990s a storm caused a breach of the barrier near the north end of Tern Island and the system supported two inlets for a period of 2 to 4 years (Figure D-2). Sometime after 1996 the northern inlet closed, and the system began another cycle of northerly inlet migration. Since 1996 the inlet has migrated north approximately 1.2 miles. The present location of the inlet represents the most northerly location since early record keeping in 1779.

These changes in the patterns of spit growth and inlet migration at Nauset Estuary have led scientists to hypothesize that there has been a change in the net direction of sediment transport along this stretch of coastline (Borelli, et al., 2019; Giese and Adams, 2007). Prior to the 1950s the net direction of transport along Nauset Spit was to the south, and since this time the net direction of transport has been to the north. With this change in transport direction, it is also likely that the net annual volume of sediment moving along Nauset Spit has been reduced (Borelli, et al., 2019). When the spit was fed by a southerly transport, large stretches of high coastal bluff from Wellfleet and Eastham were available as a sediment source; however, with a net northerly transport the lower lying barrier beaches to the south supply less material to the system.

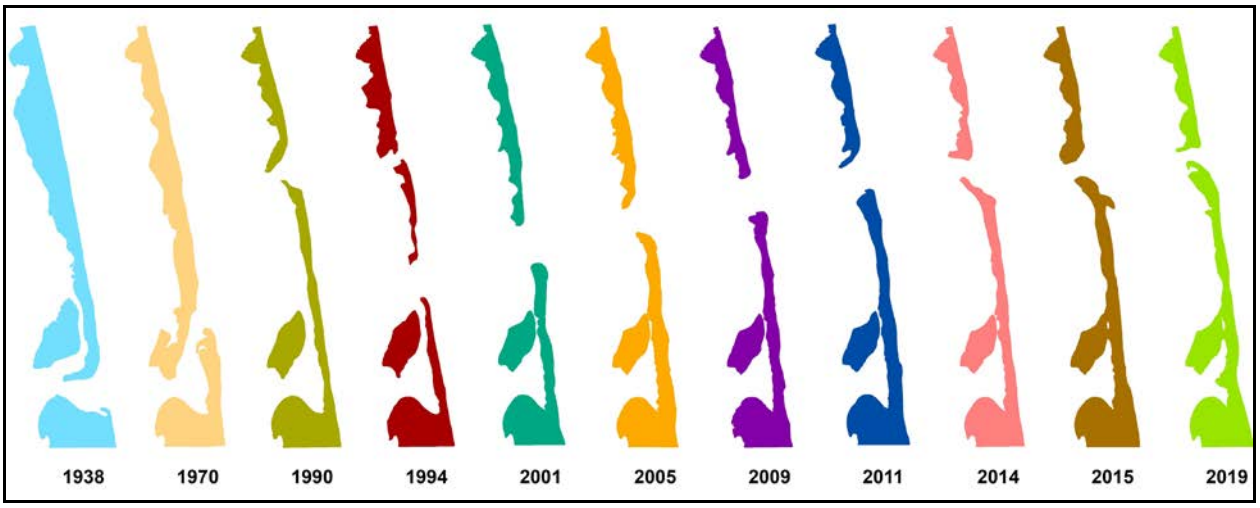

Figure D-2. History of spit growth and inlet migration from 1938 to 2019.

Changes in the width and elevation of Nauset Spit during the past 20 years were evaluated using a combination of aerial photographs and LiDAR data. The goal of the evaluation was to determine if the barrier beach has been migrating landward into the estuary in response to sea level rise and storm overwash, and to determine if the width and/or elevation of the barrier has been decreasing. Barrier beaches are dynamic features that migrate landward in response to sea level rise and storm events. Increased water levels and large storm waves typically remove sand from the ocean facing beaches and deposit it on the bay side beaches in the form of overwash fans. In systems with a limited sediment supply, this natural barrier beach roll over process is often impeded as the overall width and elevation of the barrier decreases over time.

Figure D-3 illustrates the process of landward (easterly) migration at Nauset Spit during the 18-year period between 2001 and 2019. Over the long-term (right panel) areas of erosion are shown along the ocean facing shoreline north and south of Tern Island. While a large area of accretion occurs on the west side of the barrier north of Nauset Heights in the form of an overwash fan, significant accretion or landward migration is not shown along the rest of the barrier beach. In some areas this is due to tidal currents in the main Nauset Estuary channel that sweep along the back side of the barrier beach, preventing accumulation of sediment.

Figure D-3. Landward migration of Nauset Spit from 2001 to 2019.

Changes in the width of Nauset Spit from 2014 to 2019 are shown in Figure D-4. Width increases between 50 and 400 ft are shown between Tern Island and Nauset Heights where storms created a large overwash fan along the west side of the barrier beach. The barrier increased in width in this area despite erosion along the ocean facing shoreline. South of the overwash fan erosion on the ocean side of the barrier resulted in an average 40 ft decrease in width over a 700 ft long stretch of shoreline. North of Tern Island erosion along 700 ft of the back side of the barrier caused an average reduction in width of 34 ft. At the northern end of the spit, significant narrowing and widening of the barrier were the result of dynamics associated with movement at the tip of the spit. Areas of the barrier north and south of Tern Island with decreasing width are potential weak spots where future breaches may occur.

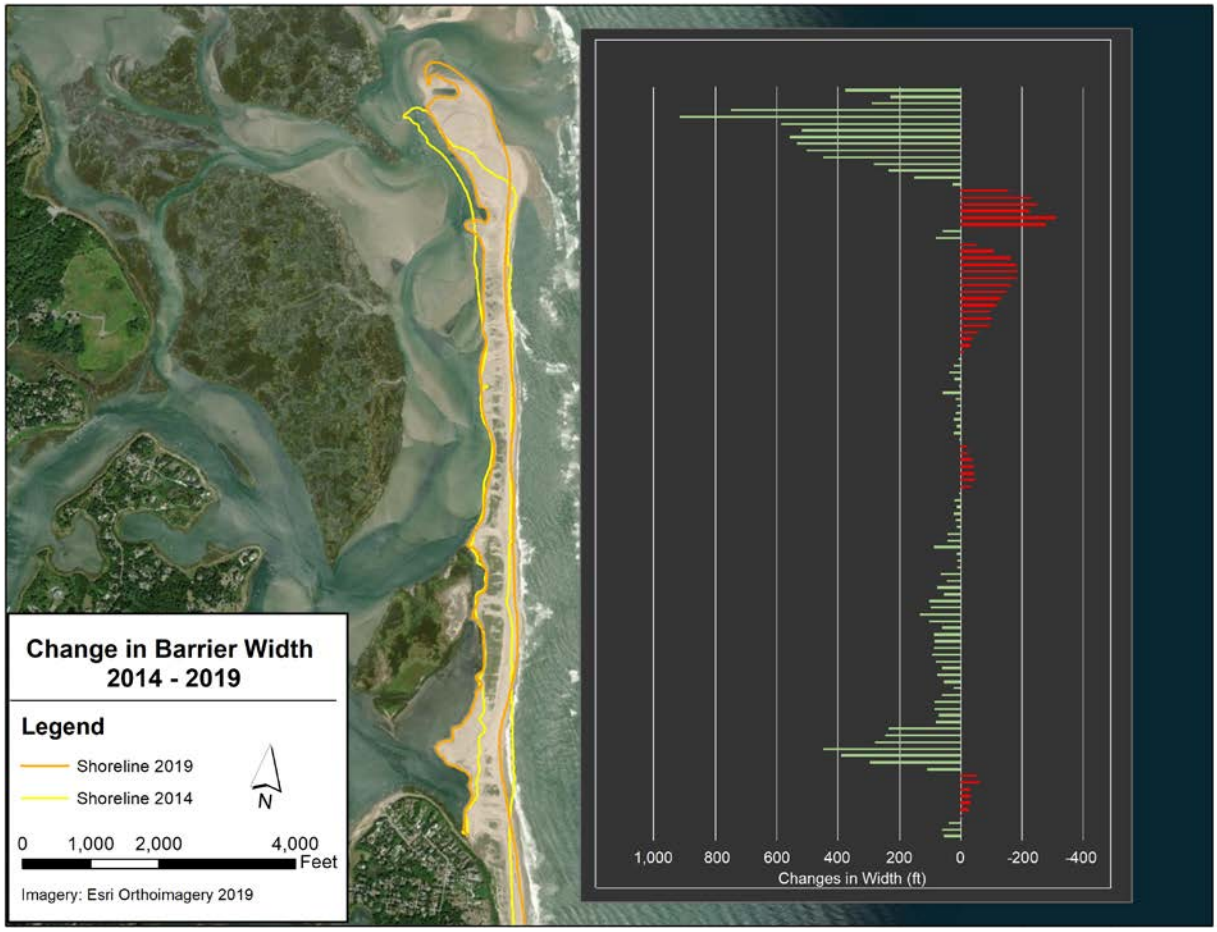

Figure D-4. Changes in the width of Nauset Spit from 2014 to 2019.

Changes in elevation of Nauset Spit from 2000 to 2018 based on LiDAR data are shown in Figure D-5. Red and orange colors indicate a reduction in elevation and green colors indicate an increase in elevation. Over the long-term (right panel) these data show a loss of elevation along the eastern side of the barrier caused by erosion/retreat of the shoreline. In most places the central core of the barrier shows an increase in elevation as wind-blown sediment was trapped to build dunes. The primary overwash areas also showed an increase in elevation despite being heavily impacted during storm events. Changes in elevation at the northern half of the spit for the 2000 to 2018 time period (right panel) were heavily influenced by growth of the spit to the north as well as the dynamics at the tip of the barrier beach.

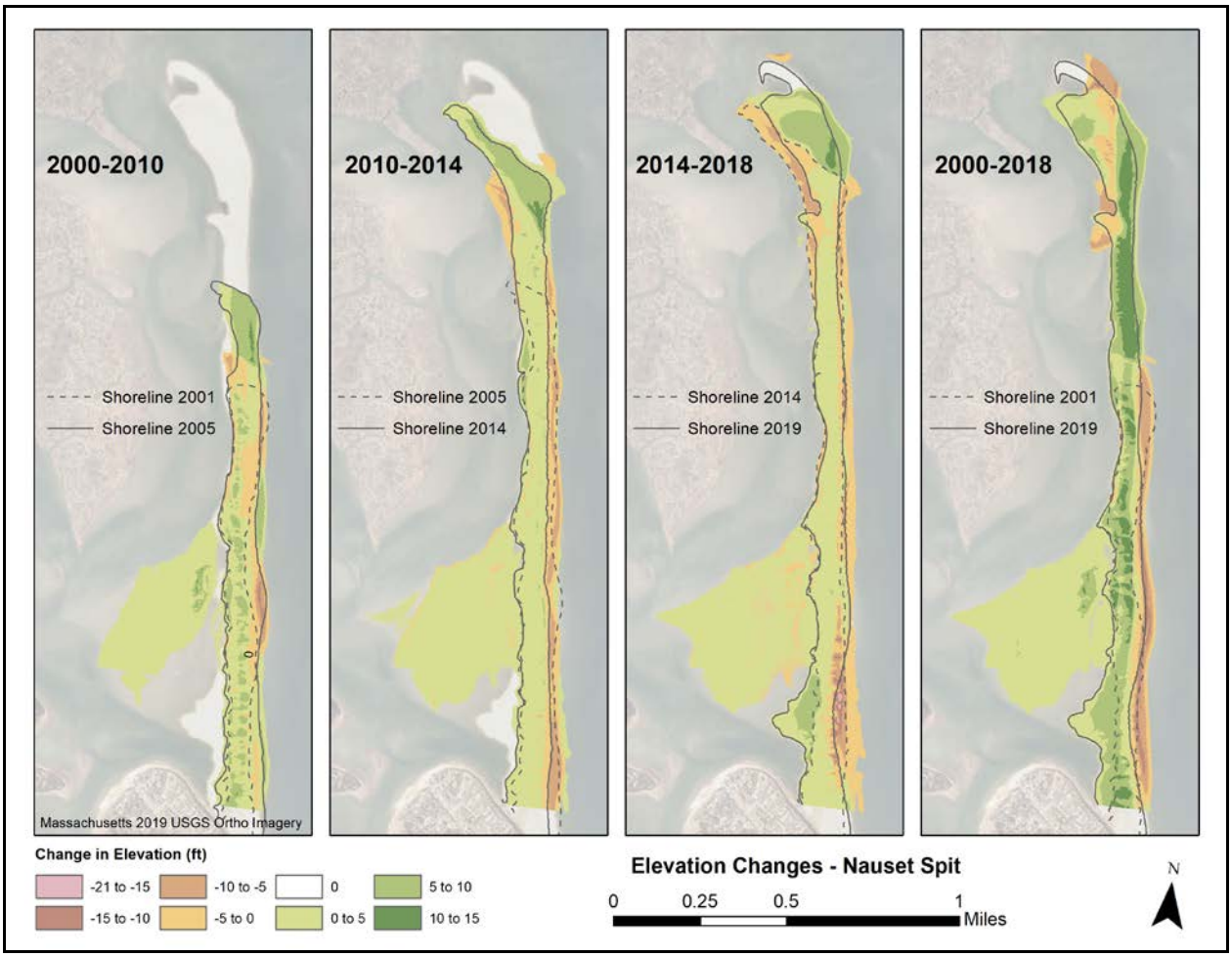

Figure D-5. Changes in elevation of Nauset Spit from 2000 to 2018.

1.2 Shoreline Change

Long- and short-term shoreline change data compiled by Massachusetts Coastal Zone Management (CZM) and the US Geological Survey (USGS) for the Nauset Spit area are shown in Figure D-6 (Himmelstoss, et al., 2019; Thieler, et al., 2013). Shoreline positions derived from a combination of historical maps, aerial photography and topographic LiDAR data were used to compute long- and short-term rates of change at equally spaced intervals along the shoreline. In dynamic areas like Nauset Spit, inlet migration and spit growth/shortening influence the shoreline change data, and care must be taken when interpreting the data for signs of future change. In areas south Nauset Heights where barrier beach dynamics are not a factor, the long- and short-term data show erosion, with a trend towards increasing rates of erosion over the last 44 years (short-term) in the Pochet and Nauset Heights areas (Figure D-6). Higher rates of erosion shown further to the north are related to the location of the inlet in an area that previously contained the barrier spit that extended south from Coast Guard Beach. In general, the data shown in Figure D-3 on short-term landward migration of the barrier spit correspond well the short-term shoreline change data (right panel Figure D-6) from CZM and USGS.

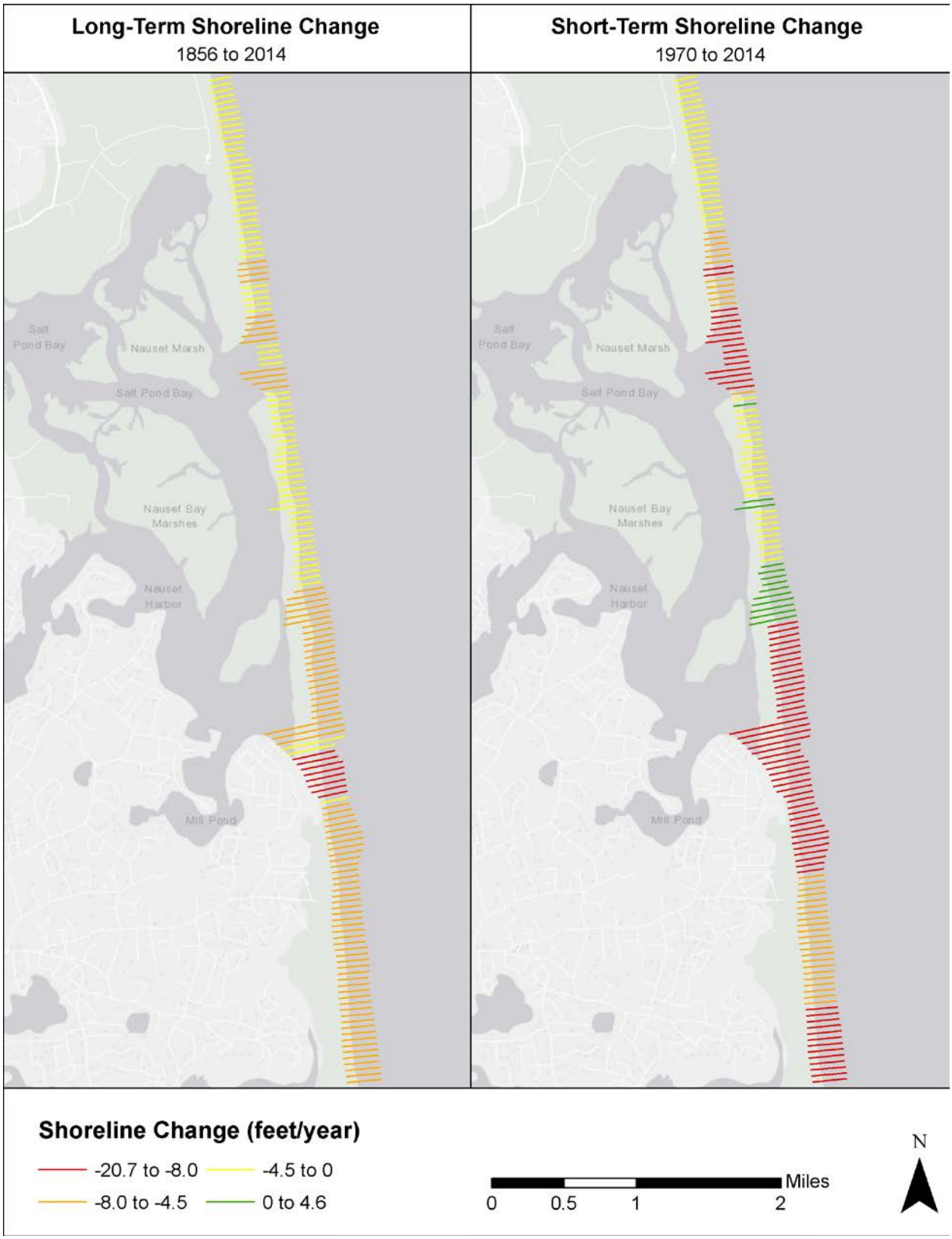

Figure D-6. Long- and short-term shoreline change data for Nauset Beach from USGS and CZM (Himmelstoss, et al., 2019; Thieler, et al., 2013).

1.3 Water Levels

Water level data within Nauset Estuary have been collected by various organizations over the past 17 years. Even though the water levels were collected at different stages of barrier beach and inlet migration, the data show similar trends. The Massachusetts Estuaries Project (MEP, 2012) collected water level data in the fall of 2001 at four (4) locations around the estuary and one (1) location offshore of Coast Guard Beach. Tidal elevations over a 24-hr period from the MEP deployment are shown in Figure D-7. The data show a clear attenuation of the tidal signal between the ocean and Nauset Estuary, with reductions in tidal amplitude and phase delays.

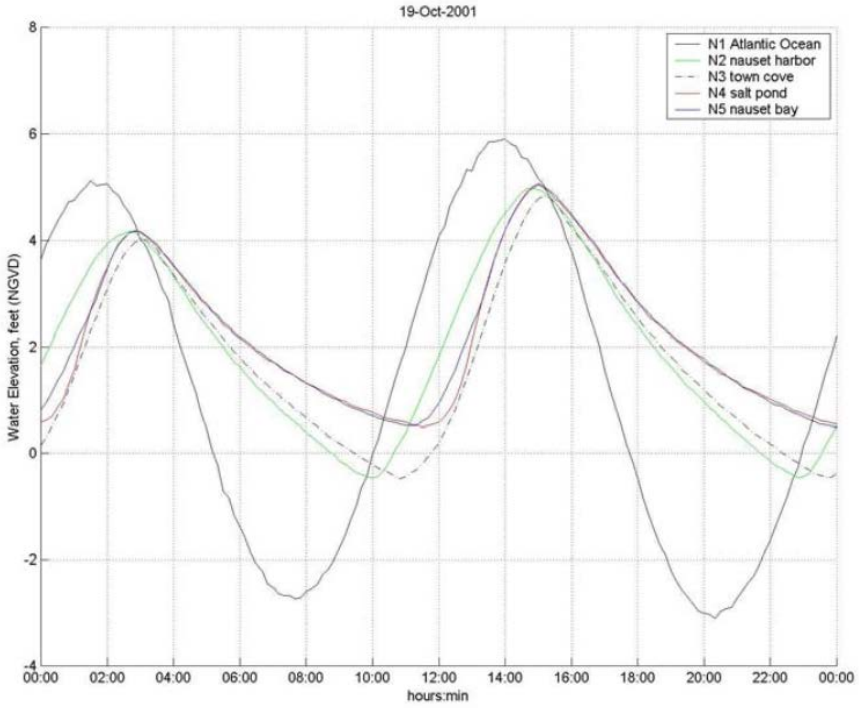

Figure D-7. Attenuation in tidal signal measured by MEP in 2001 (MEP, 2012).

The Center for Coastal Studies (CCS) collected water level data in Town Cove between April 2016 and December 2018 (Legare et al., 2018). Additional data were collected at three (3) secondary sites located inside Salt Pond, Upper Nauset (near entrance to Salt Pond) and Lower Nauset (near Snow Shore Landing) during the summer of 2016. The data were used to compute monthly tidal statistics for Mean High Water (MHW), Mean Sea Level (MSL) and Mean Low Water (MLW) (Table D-1). The Nauset Estuary data were compared with water levels in Boston Harbor collected during the same time period to show attenuation of the tidal amplitudes at all locations and phase shifts at the Salt Pond and Upper Nauset locations.

Table D-1. Tidal Datums Computed for Nauset Estuary by CCS

Tidal Datum	Town Cove June 2016	Lower Nauset June 2016	Town Cove July 2016	Upper Nauset July 2016	Salt Pond July 2016
MHW (ft, NAVD88)	2.82	2.89	2.79	2.89	2.82
MSL (ft, NAVD88)	1.02	1.21	0.98	1.12	1.02
MLW (ft, NAVD88)	-0.30	-0.10	-0.33	-0.36	-0.46

Most recently, Woods Hole Group measured water levels for a 30-day period in the fall of 2018 at two (2) sites; one near the mouth of Salt Pond in the northern end of the estuary, and a second at the end of Cove Rd. (Figure D-8). The data were collected using a Sea-Bird Scientific MicroCat 37SM CTD. Elevations of the sensors were surveyed at deployment and recovery and used to correct the raw pressure measurements collected by the gages to elevations relative to the NAVD 88 datum.

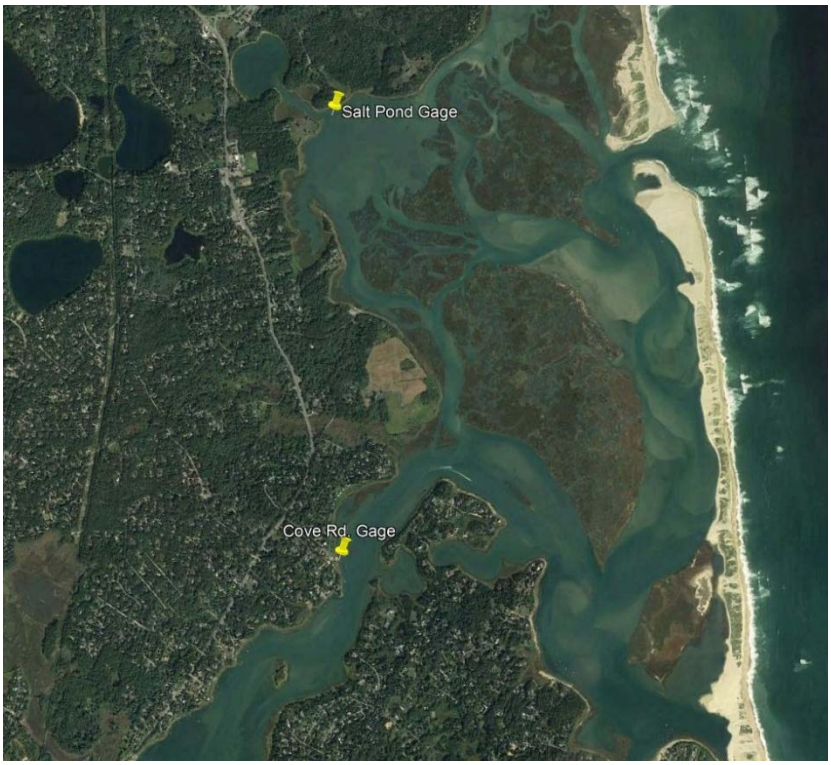

Figure D-8. Woods Hole Group tide gages deployed during the fall of 2018.

Data from the gages were used to determine tidal datum elevations with respect to NAVD88 for mean higher high water (MHHW), MHW, mean tide level (MTL), MLW, and mean lower low water (MLLW). Results of the tidal datum calculations for each gage are summarized in Table D-2. The data show a slightly greater tide range of 3.49 feet at the Salt Pond gage as compared to a range of 3.29 feet at the Cove Road gage. The elevations of MLLW and MLW are nearly equal at the two locations, while the MHW and MHHW datums are greater at the Salt Pond gage, thus leading to the increase in tide range.

Table D-2. Tidal Datums Computed for Nauset Estuary by Woods Hole Group Using Data Collected in the Fall of 2018.

Datum	Cove Rd. Elev. (ft, NAVD88)	Salt Pond Elev. (ft, NAVD88)
MHHW	2.73	2.94
MHW	2.43	2.65
MTL	0.97	1.08
MLW	-0.49	-0.49
MLLW	-0.56	-0.55

Water level data from the closest NOAA gages at Boston Harbor and Chatham (Aunt Lydia's Cove) for the same Fall 2018 time period are shown in comparison with the Nauset Estuary data in Figure D-9. The data show significant attenuation of the Nauset Estuary tidal signal over both nearby NOAA recording stations. The tidal range decreases by 5.1 ft between Boston and the Chatham Fish Pier, and by 1.7 ft between the Chatham Fish Pier and the Cove Rd. site.

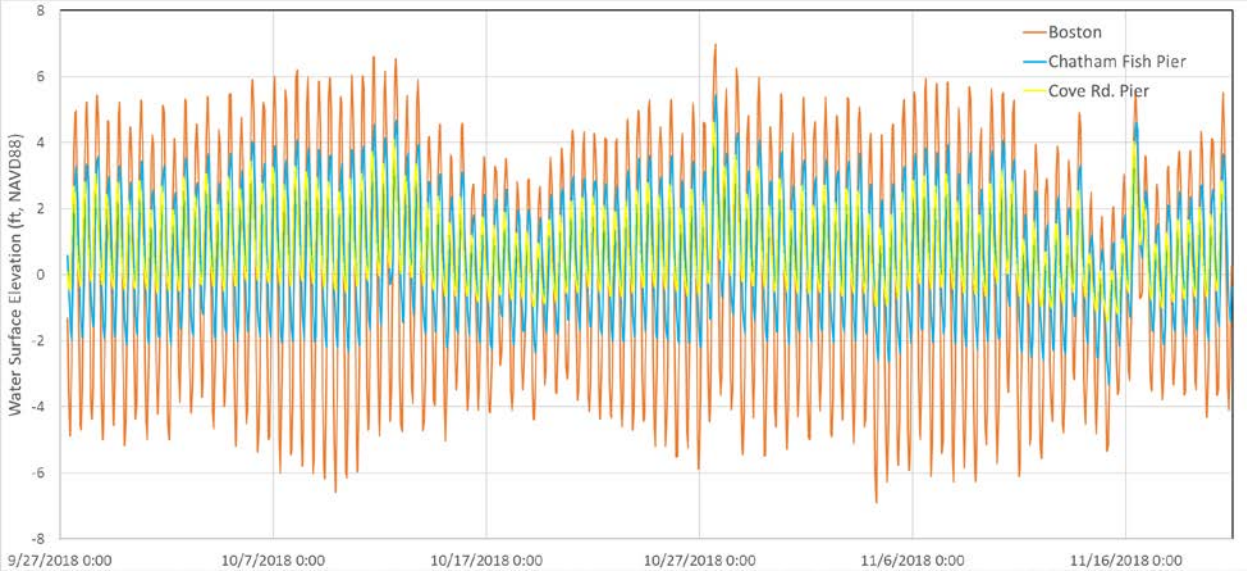

Figure D-9. Water level elevations at Nauset Estuary compared to water levels measured at NOAA gages in Boston and Chatham.

Water level data from all three (3) sources show tidal attenuation between the ocean and Nauset Estuary. Over time they also show that the tidal amplitude has decreased as the channel has lengthened due to northerly inlet migration and the friction increased. The data also show that the elevation of high water is skewed above MTL in relation to the elevation of low water, indicating that the estuary does not drain efficiently during the falling tide. Tidal datums derived from the 2018 Woods Hole Group data were used to adjust bathymetric survey data to the common datum of MLW.

1.4 Bathymetry

Three separate surveys have been conducted in Nauset Estuary to document water depths and shoal locations. The first survey was performed in November of 2015 and included the main channel between Town Cove and the inlet, as well as the spur channel to Priscilla Landing. A second survey was performed in October 2018 to update the dynamic areas of the channel

behind the barrier beach. The third survey was performed in November 2018 to evaluate potential channel locations in the Town of Eastham including the Hemenway Spur which connects the main channel to the Town Landing at Hemenway, and the Cable Creek channel which connects the Town Landing with the inlet (Figure D-10).

The bathymetric surveys were performed using an Odom Hydrotrac 200 kHz single-beam echosounder integrated with a Trimble RTK GPS to allow for real-time tide corrections. Post-processing of the 2018 data included removal of bad data, smoothing of the 6-second sounding measurements, and comparison of RTK tidal corrections with tidal records collected at the Cove Rd. and Salt Pond tide gages. To allow for simple comparison to channel design and navigational goals, the soundings were converted to the MLW tidal datum. The MLW datum determined from the 2018 tidal record was used to correct both the 2018 and 2015 bathymetric survey data.

Soundings plotted in yellow and red on Figure D-10 highlight channel areas that are shallower than the -5 ft MLLW channel design. Overall, depths in the survey area range from -31 to 1.1 MLW. The shallowest areas of the channel are located at the northern and southern ends of the Hemenway spur, along with a number of isolated shoals in the main channel behind the barrier beach.

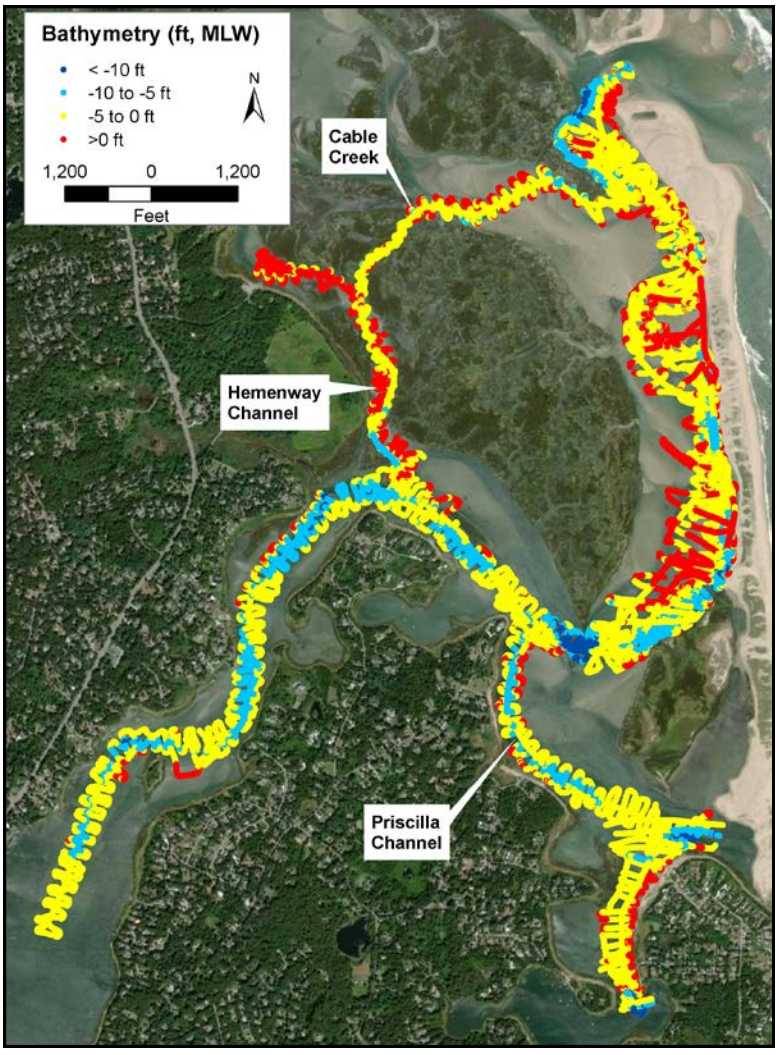

Figure D-10. Bathymetry of Nauset Estuary measured November 2015, October 2018, November 2018 and February 2021. Elevations shown relative to MLW.

The main channel in Nauset Estuary that runs behind the barrier beach is the most dynamic part of the system and is subject to shoaling from inlet processes, barrier formation, and storm generated overwash. However, channel areas further inside the estuary are subject to shoaling as well. A qualitative assessment of channel shoaling was conducted using historical aerial photos from 1972 to 2015. Areas of major shoaling were identified on the photos, digitized within a geographic information system (GIS), and then compared over time. The resulting maps shown in Figure D-11 provide a reasonable approximation of areas within the estuary that have experienced shoaling.

The data show significant variability in channel shoaling immediately west of the barrier beach, caused by inlet and barrier migration and storm overwash processes. Patterns of shoaling are also evident further inside the estuary where the geometry of the estuary changes from narrow constricted channels to a wider, more open configuration. This is consistent with typical flow dynamics where sediment moving with the higher velocity currents in the narrower channels, drops out of suspension when the current velocities decrease in the wider parts of the estuary.

In general, the historical shoal locations correspond with current patterns of shoaling identified in the 2015 and 2018 bathymetric surveys, and also with problematic navigation areas identified by the Towns of Orleans and Eastham.

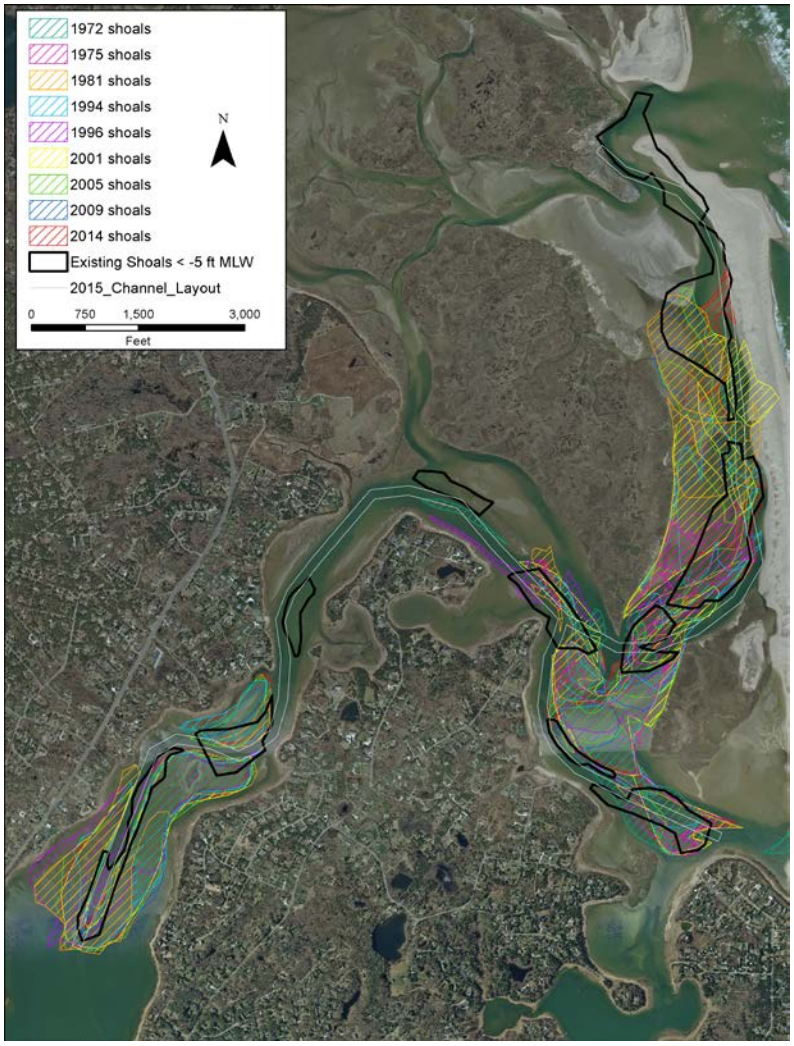

Figure D-11. Patterns of historical shoaling in Nauset Estuary compared with current shoal locations identified from the 2015 and 2018 bathymetric surveys.

1.5 Hydrodynamics

The hydrodynamics of Nauset Estuary have been evaluated as part of two separate studies. In 2016 a hydrodynamic model previously developed for Nauset Estuary was used to assess the current hydrodynamic conditions, as well as potential changes that would result from the dredging project (Woods Hole Group, 2016). This study used the Finite Volume Coastal Ocean Model (FVCOM) (Chen et al., 2003) with an unstructured grid and node spacing ranging from less than 10 meters in the estuary to 4 km on the open boundary (Figure D-12). High-resolution bathymetry was used for the model from LiDAR-derived topographic maps of Cape Cod National Seashore from the U.S. Geological Survey (USGS) (Brock et al. 2007). Bathymetry in subtidal regions too deep for LiDAR penetration was based on previous acoustic surveys and observations by investigators from the USGS (Cross et al. 2006). The model was previously

calibrated and validated against observations of water level, salinity, temperature, and velocity from moored sensors at multiple locations around the estuary (Ralston et al. 2015).

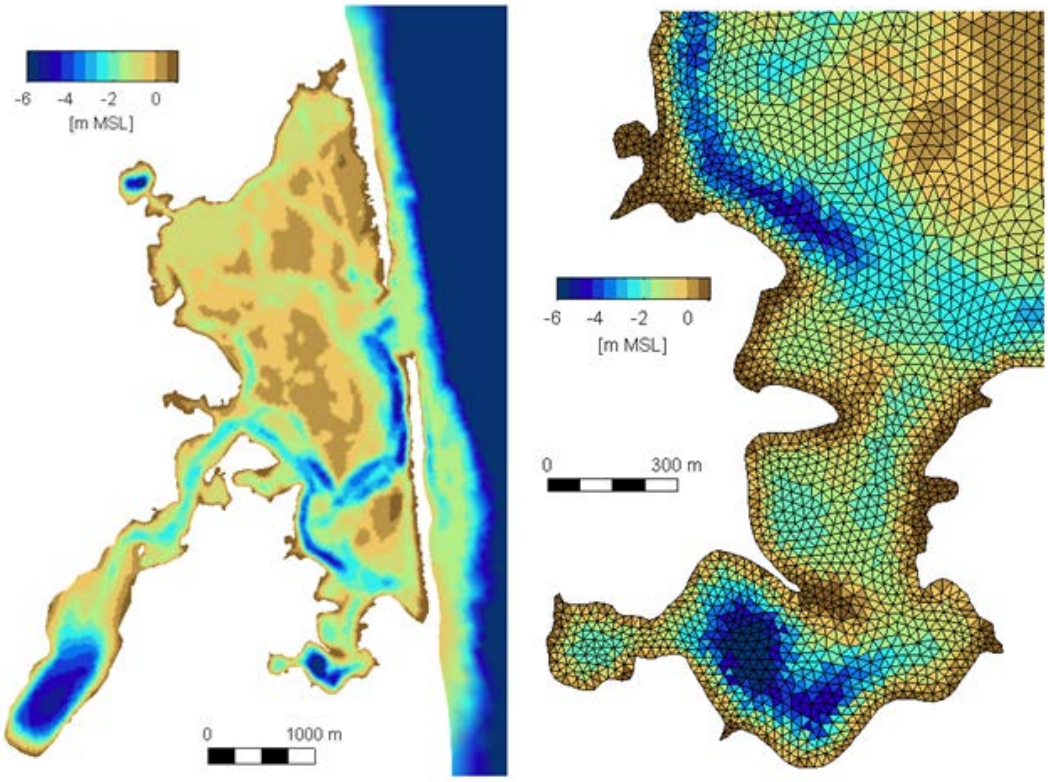

Figure D-12. Model bathymetry, with a zoom on the unstructured grid configuration in the vicinity of Mill Pond. Model open boundaries (not shown) extend north, south, and offshore from the inlet approximately 1.5 miles in each direction.

For the 2016 study the model grid bathymetry was updated based on the November 2015 bathymetric survey of the planned dredge project (Figure D-10). Note that the location of the inlet at the time of the 2016 study was approximately 660 ft north of the previous model grid, which was based on the inlet position in 2007. For the 2016 study, no attempt was made to change the model grid to reflect the more northerly inlet location because the model was being used in a diagnostic sense to evaluate relative changes in flow patterns between the no dredge and dredge condition. The 2016 modeling showed that Nauset Estuary is a flood dominated inlet, meaning that peak incoming flood currents are stronger than peak outgoing ebb currents. Flood dominated systems tend to be sediment sinks, as more material is transported into the estuary during the flood tide, than can be exported on the ebb tide.

The MEP 2012 study of Nauset Estuary used the RMA-2 finite element hydrodynamic model to evaluate the tidal circulation and flushing characteristics of the system (Howes, et al., 2012). Tidal flushing describes the exchange of water between sub-embayments in Nauset Estuary and the ocean. Flushing rate, or residence time, relates to the average time it takes for a parcel of water to migrate from the various sub-embayments to the inlet (system residence time), or from one sub-embayment to another (local residence time). The MEP uses residence times as a

first order evaluation of estuarine water quality. In general, lower residence times correspond to higher water quality.

The MEP model grid for Nauset Estuary was developed using aerial photography from 1994 and bathymetric survey data collected in support of the MEP modeling. As such, the MEP model evaluation represents a time when the inlet was approximately 4,000 ft south of the current location. The modeled results therefore likely represent lower system residence times over present-day conditions, since the longer channel behind the barrier beach, with greater frictional effects, will cause a decrease in tidal flushing with higher residence times. Despite differences between modeled and present-day conditions, the MEP study provides valuable information on local residence times in the distal ponds at Town Cove, Mill Pond and Salt Pond. Table D-3 summarizes residence times for Nauset Estuary from the MEP 2012 study. Model results indicate that Salt Pond has the longest residence time, followed by Mill Pond.

Table D-3. Nauset Estuary Residence Times from MEP Study (MEP, 2012).

Embayment	System Residence Time (days)	Local Residence Time (days)
Nauset System	1.2	1.2
Town Cove	4.4	1.7
Salt Pond	197.1	3.9
Mill Pond	27.0	1.8

1.6 Ecology

The 2012 MEP study used water quality data collected by the Towns of Orleans and Eastham at sixteen (16) stations throughout Nauset Estuary, in combination with key habitat parameters (infauna and eelgrass) and sediment characteristics, to draw conclusions about the ecological health of the estuary. The assessment noted healthy salt marsh habitat in areas closest to the barrier beach, but significant impairments in the distal ponds (Salt Pond, Town Cove and Mill Pond). The impairments included low dissolved oxygen, high phytoplankton biomass, macroalgal mats, eelgrass loss over time, and impaired benthic animal communities. Since completion of the MEP study, continued water quality monitoring has been performed. Noted changes in some of the water quality parameters are still being studied by the MEP to determine the causes of the measured changes.

1.7 Sediments

Sediment characteristics and distributions throughout Nauset Estuary were evaluated to determine the quality of sediment required for dredging and the feasibility of different placement alternatives. Four (4) different phases of sediment sampling were conducted as follows:

- Phase 1: Confirmatory grab sampling was performed at six (6) locations throughout the estuary in 2015 as part of the Feasibility Study (Figure D-13). The purpose of the confirmatory sampling was to gather information to identify targeted areas for subsequent vibracore sampling, with specific emphasis on identifying boundaries between sandy and fine-grained sediments. A Van Veen grab sampler was used to collect samples from the upper 6-12 inches of the sea floor on November 30, 2015.

Sediment characterizations were performed by a trained sedimentologist based on visual and textural observations.

- Phase 2: The Phase 2 sampling included collection of sediment cores at six (6) locations in the estuary (Figure D-13). The coring was conducted on December 10, 2015 using a shallow draft pontoon boat equipped with an A-frame, winch, anchoring spuds, and a vibracore unit. The coring was conducted to a depth of -6.0 ft MLW and the cores ranged in length from 2.7 to 6.6 ft. The cores were collected in clear polycarbonate liners and transported to the Woods Hole Group office where they were split, photographed, described, and sub-sampled. Visual observations of changes in sediment characteristics, grain size and texture were used as the basis for sub-sampling. In cases where the cores were homogenous, a vertical composite sample was obtained for laboratory analysis. In cases where changes in sediment characteristics were observed, vertical composite samples were obtained for each layer. All samples were shipped to GeoTesting Express, Inc. for grain size analyses.

Results from the Phase 1 and Phase 2 sampling are summarized in Table D-4. The data indicate that sediments within the main channel are mostly sand and silty sand. Grab samples taken most proximally to Town Cove and Priscilla Rd. landing contained slightly finer grained silty sand or silt (Samples 15 and 9 respectively). Laboratory analyses of the cores taken closest to these grab samples (Cores N-1 and N-6) showed a thin surface layer (0.2 to 0.6 ft thick) containing in excess of 30% fines, underlain by 3.0 ft of medium to fine-grained sand. Sediment core logs and laboratory grain size data are provided in Section M.

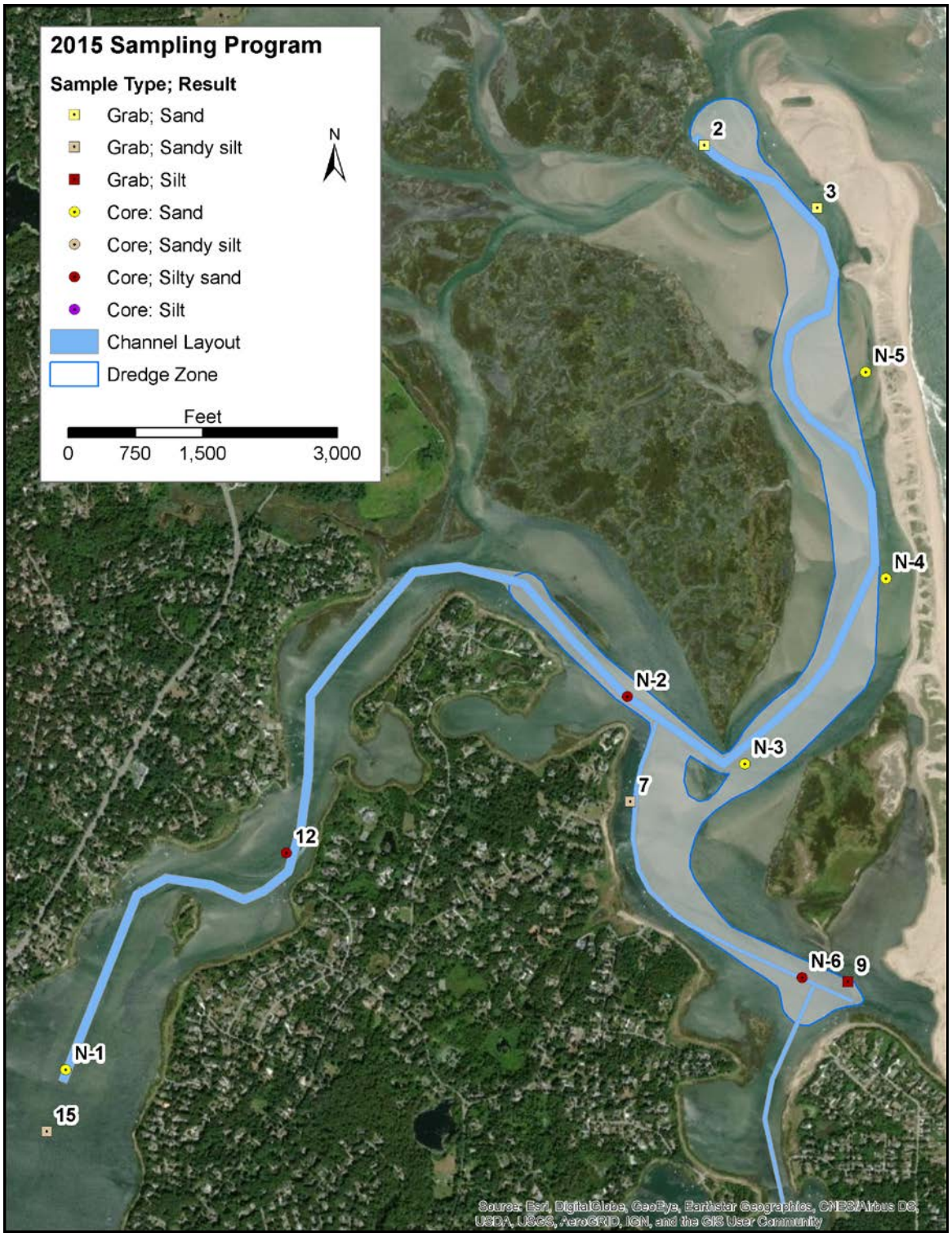

Figure D-13. Grab and sediment core locations sampled during Phase 1 and Phase 2 in 2015.

Table D-4. Sediment Grain Size Characteristics from Phase 1 and Phase 2 Sampling.

Sample ID	Sample Type	Sediment Type (Q – qualitative; D_{50})	% Gravel	% Sand	% Silt/Clay
2	Grab	Sand (Q)	NA		
3	Grab	Sand (Q)			
9	Grab	Silt (Q)			
7	Grab	Sandy silt (Q)			
12	Grab	Silty sand (Q)			
15	Grab	Sandy silt (Q)			
N-1 (0.0.2)	Core	Medium sand (D_{50} 0.25 mm)	0.1	69.5	30.4
N-1 (0.2-2.3)	Core	Medium sand (D_{50} 0.38 mm)	0	96.8	3.2
N-2 (0-2.6)	Core	Medium sand (D_{50} 0.40 mm)	0	86.7	13.3
N-3 (0-1.8)	Core	Coarse sand (D_{50} 0.60 mm)	0.4	98.3	1.3
N-4 (0-3.3)	Core	Coarse sand (D_{50} 0.55 mm)	4.5	94.2	1.3
N-5 (0-4.5)	Core	Coarse sand (D_{50} 0.57 mm)	1.9	97.3	0.8
N-5 (4.5-4.8)	Core	Coarse sand (D_{50} 0.59 mm)	15.0	74.9	10.1
N-6 (0.2-0.6)	Core	Medium sand (D_{50} 0.20 mm)	0	55.3	44.7
N-6 (0.9-3.2)	Core	Medium sand (D_{50} 0.41 mm)	0.2	98.2	1.6

Phases 3 and 4 of the sampling program were guided by a Sampling and Analysis (SAP) plan that was prepared by Woods Hole Group and approved by the Massachusetts Department of Environmental Protection (DEP) and the US Army Corps of Engineers (USACE) in the summer of 2017. See Section L for copies of the SAP and approvals by the DEP and USACE.

- Phase 3: The Phase 3 sampling included collection of sixteen (16) sediment cores at key locations throughout the estuary (Figure D-14). The sampling locations were chosen to best represent the proposed dredge zone, with special attention paid to areas of finer-grained sediments (Town Cove and Pricilla Rd. spur) and areas where the bathymetry data indicated significant dredging will be needed to alleviate shoaling. The coring was conducted on October 3, 2017 using a push corer operated from a shallow draft boat. The coring was conducted to a depth of -6.0 ft MLW and the cores ranged in length from 2.0 to 5.9 ft. The cores were collected in clear polycarbonate liners and transported to the Woods Hole Group office where they were split, photographed, and described. One half of each of the split cores was homogenized (composited) and retained for laboratory analysis. All samples were sent to GeoTesting Express for grain size analysis.

- Phase 4: The Phase 4 sampling included collection of eight (8) sediment cores at locations previously determined to contain fine-grained material (Figure D-14). The purpose of the sampling was to collect cores for analysis of sediment chemistry needed to inform the evaluation of alternatives for placement of the dredged material. The coring was conducted on July 29, 2019 using a shallow draft pontoon boat equipped with an A-frame, winch, anchoring spuds, and a vibracore unit. The coring was conducted to a depth of -6.0 ft MLW and the cores ranged in length from 2.5 to 3.4 ft. The cores were collected in clear polycarbonate liners and split, photographed,

described, and sub-sampled on site. Sub-samples were collected to capture changes in sediment stratification. Areas of homogeneity within cores and among adjacent cores were composited into a single sample as follows:

- ✓ Cores HOPN1 and HOPN2 – upper 0.4 ft from each core composited for analysis of grain size and sediment chemistry (Sample ID: HOPN1+2)
- ✓ Core HOPN1 – upper 0.4 ft sampled for analysis of VOCs (Sample ID: HOPN1)
- ✓ Cores STON1 and STON2 – upper 0.3-0.5 ft from each core composited for analysis of grain size and sediment chemistry (Sample ID: STON1+2)
- ✓ Core STON2 – bottom portion from each core composited for analysis of grain size (Sample ID: STON1+2B)
- ✓ Core PRISC-1 – upper 0.4 ft sampled for analysis of grain size (Sample ID: PRISC-1)
- ✓ Core PRISC-2 – upper 0.4 ft sampled for analysis of grain size, sediment chemistry and VOCs (Sample ID: PRISC-2)
- ✓ Core PRISC-2 – bottom portion of core composited for analysis of grain size
- ✓ Cores PRISC-3 and PRISC-4 – upper 1.2 to 1.3 ft from each core composited for analysis of grain size and sediment chemistry

All samples were sent to Alpha Analytical for analyses of grain size, total organic carbon, VOCs, PAHs, PCBs, EPHs, and metals.

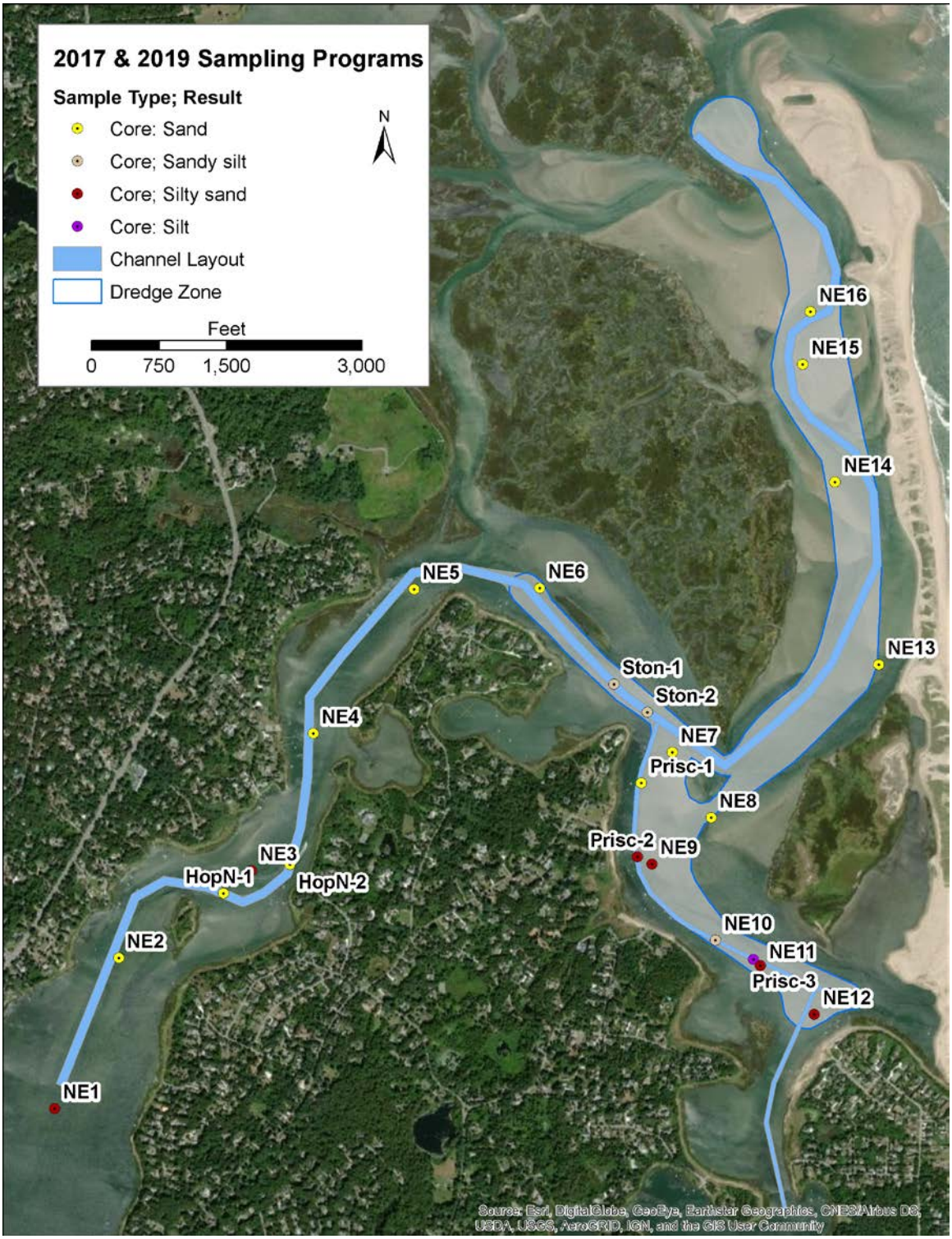

Figure D-14. Sediment core locations sampled during Phase 3 and Phase 4 in 2017 and 2019.

Results from the Phase 3 and Phase 4 sampling are summarized in Tables D-5 and D-6, and Figure D-15 provides a map of sediment characteristics based on all Phases of sampling. The data indicate that sediments within the main channel between Town Cove and the inlet are mostly sand, with silt and clay percentages less than 10%. The only exception occurs east of

Stony Island near the opening to Woods Cove where the sediments are silty sands, with silt and clay percentages greater than 10%. The channel to Priscilla Rd. landing also contains silty sands with silt and clay percentages greater than 10%. These finer-grained sediments occur in the upper 0.5 to 1.2 ft thick surface layer and are underlain by medium to fine-grained sand. Sediment core logs and laboratory grain size data are provided in Section M.

The spur channel between Priscilla Rd. landing and Mill Pond was added to the project footprint in the Fall 2020. Consequently, sediment samples have not yet been collected in this area. Plans are underway to obtain these samples in the Spring of 2021.

Table D-5. Sediment Grain Size Characteristics from Phase 3 and Phase 4 Sampling.

Sample ID	Sediment Type (D_{50})	% Gravel	% Sand	% Silt/Clay
NE-1	fine sand (D_{50} 0.12 mm)	1.3	66.7	32.0
NE-2	medium sand (D_{50} 0.33 mm)	0.2	93.1	6.7
NE-3	medium sand (D_{50} 0.38 mm)	0.1	82.1	17.8
NE-4	medium sand (D_{50} 0.36 mm)	0.2	98.5	1.3
NE-5	medium sand (D_{50} 0.36 mm)	0.5	98.6	0.9
NE-6	medium sand (D_{50} 0.42 mm)	0	98.1	1.9
NE-7	medium sand (D_{50} 0.32 mm)	0	97.4	2.6
NE-8	coarse sand (D_{50} 0.52 mm)	0.1	98.9	1.0
NE-9A	medium sand (D_{50} 0.28 mm)	0.1	82.1	17.8
NE-10A	medium sand (D_{50} 0.27 mm)	1.0	55.0	44.0
NE-11	coarse sand (D_{50} 0.62 mm)	2.4	76.7	20.9
NE-12	medium sand (D_{50} 0.46 mm)	0.9	86.7	12.4
NE-13	medium sand (D_{50} 0.41 mm)	0.5	95.8	3.7
NE-14	medium sand (D_{50} 0.49 mm)	2.3	96.7	1.0
NE-15	coarse sand (D_{50} 0.58 mm)	2.2	97.1	0.7
NE-16	coarse sand (D_{50} 0.59 mm)	1.3	98.0	0.7
HOPN1+2	medium sand (D_{50} 0.25 mm)	0.3	90.8	8.9
STON1+2	medium sand (D_{50} 0.28 mm)	0.5	77.1	22.4
STON1+2B	medium sand (D_{50} 0.31 mm)	1.0	86.5	12.5
PRISC-1	medium sand (D_{50} 0.41 mm)	0	87.2	12.8
PRISC-2	medium sand (D_{50} 0.31 mm)	0	84.5	15.5
PRISC-2B	medium sand (D_{50} 0.29 mm)	0.3	83.2	16.5
PRISC-3+4	medium sand (D_{50} 0.27 mm)	2.7	51.7	46.5

Table D-6. Sediment Chemistry from Phase 4 Sampling.

		HOPN1	HOPN1+2	STON1+2	STON1+2B	PRISC-1	PRISC-2	PRISC-2B	PRISC3+4	Disposal Option Thresholds				
	Lab ID	L1933910-01	L1933910-02	L1933910-03	L1933910-04	L1933910-05	L1933910-06	L1933910-07	L1933910-08					
	Date	07/29/19	07/29/19	07/29/19	07/29/19	07/29/19	07/29/19	07/29/19	07/29/19					
Physical Parameters	Units									**Upland Placement 310 CMR 40.0975 (MCP S-1 & GW-1)**	**Disposal at Unlined Landfill (Policy # COMM 97-001 & COMM 94-007)**	**Disposal at Lined Landfill (Policy # COMM 97-001 & COMM 94-007)**	**NOAA ERL**	**NOAA ERM**
% Gravel	%	-	0.30	0.50	1.0	ND	ND	0.30	2.7	-	-	-	-	-
% Sand	%	-	90.8	77.1	86.5	87.2	84.5	83.2	51.7	-	-	-	-	-
% Fines (clay & silt)	%	-	8.9	22.4	12.5	12.8	15.5	16.5	45.6	-	-	-	-	-
% Total Organic Carbon	%	-	0.216	0.602	-	-	-	-	0.918	-	-	-	-	-
% Solids	%	-	84.0	77.2	-	-	82.1	-	61.3	-	-	-	-	-
VOC (USEPA Method 5035 Low)														
Vinyl chloride	mg/kg	ND	-	-	-	-	ND	-	-	0.9	-	-	-	-
Bromomethane	mg/kg	ND	-	-	-	-	ND	-	-	0.5	-	-	-	-
Acetone	mg/kg	0.071	-	-	-	-	0.083	-	-	6	-	-	-	-
Methyl tert-butyl ether (MTBE)	mg/kg	ND	-	-	-	-	ND	-	-	0.1	-	-	-	-
trans- 1,2-Dichloroethene	mg/kg	ND	-	-	-	-	ND	-	-	1	-	-	-	-
1,1-Dichloroethane	mg/kg	ND	-	-	-	-	ND	-	-	0.4	-	-	-	-
Cis-1,2-Dichloroethene	mg/kg	ND	-	-	-	-	ND	-	-	0.2	-	-	-	-
Chloroform	mg/kg	ND	-	-	-	-	ND	-	-	0.4	-	-	-	-
1,1,1-Trichloroethane	mg/kg	ND	-	-	-	-	ND	-	-	30	-	-	-	-
Carbon tetrachloride	mg/kg	ND	-	-	-	-	ND	-	-	10	-	-	-	-
Benzene	mg/kg	ND	-	-	-	-	ND	-	-	2	-	-	-	-
1,2-Dichloroethane	mg/kg	ND	-	-	-	-	ND	-	-	0.01	-	-	-	-
1,2-Dichloropropane	mg/kg	ND	-	-	-	-	ND	-	-	0.1	-	-	-	-
Bromodichloromethane	mg/kg	ND	-	-	-	-	ND	-	-	0.1	-	-	-	-
Toluene	mg/kg	ND	-	-	-	-	ND	-	-	30	-	-	-	-
trans- 1,3-Dichloropropene	mg/kg	ND	-	-	-	-	ND	-	-	0.01	-	-	-	-
1,1,2-Trichloroethane	mg/kg	ND	-	-	-	-	ND	-	-	0.1	-	-	-	-
Dibromochloromethane	mg/kg	ND	-	-	-	-	ND	-	-	0.005	-	-	-	-
Chlorobenzene	mg/kg	ND	-	-	-	-	ND	-	-	1	-	-	-	-
Ethylbenezene	mg/kg	ND	-	-	-	-	ND	-	-	40	-	-	-	-
Xylene (mixed isomers)	mg/kg	ND	-	-	-	-	ND	-	-	400	-	-	-	-
Styrene	mg/kg	ND	-	-	-	-	ND	-	-	3	-	-	-	-
Bromoform	mg/kg	ND	-	-	-	-	ND	-	-	0.1	-	-	-	-
1,1,2,2-Tetrachloroethane	mg/kg	ND	-	-	-	-	ND	-	-	0.005	-	-	-	-

PAH/PCB Congeners by GC/MS														
Napthalene	mg/kg	-	ND	ND	-	-	-	-	ND	4	Total SVOCs = 100	Total SVOCs = 100	0.16	2.10
Acenaphthylene	mg/kg	-	ND	ND	-	-	-	-	ND	1			0.04	0.64
Acenaphthene	mg/kg	-	ND	ND	-	-	-	-	ND	4			0.02	0.5
Fluorene	mg/kg	-	ND	ND	-	-	-	-	ND	1,000			0.02	0.54
Phenanthrene	mg/kg	-	ND	0.00493	-	-	-	-	0.01420	10			0.24	1.50
Anthracene	mg/kg	-	ND	ND	-	-	-	-	ND	1,000			0.85	1.10
Fluoranthene	mg/kg	-	ND	0.00966	-	-	-	-	0.02860	1,000			0.60	5.10
Pyrene	mg/kg	-	ND	0.00889	-	-	-	-	0.02590	1.000			0.67	2.60
Benzo(a)anthracene	mg/kg	-	ND	0.00371	-	-	-	-	0.01070	7			0.26	1.60
Chrysene	mg/kg	-	ND	0.00481	-	-	-	-	0.01450	70			0.38	2.80
Benzo(b)fluoranthene	mg/kg	-	ND	0.00530	-	-	-	-	0.01910	7			-	-
Benzo(k)fluoranthene	mg/kg	-	ND	0.00429	-	-	-	-	0.01280	70			-	-
Benzo(a)pyrene	mg/kg	-	ND	0.00440	-	-	-	-	0.01310	2			0.43	0.763
Indeno(1,2,3-cd)pyrene	mg/kg	-	ND	0.00418	-	-	-	-	0.01180	7			-	-
Dibenzo(a,h)anthracene	mg/kg	-	ND	ND	-	-	-	-	ND	0.7			0.06	0.26
Benzo(g,h,i)perylene	mg/kg	-	ND	0.00421	-	-	-	-	0.01210	1,000			-	-
Cl2-BZ#8	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl3-BZ#18	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl3-BZ#28	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl4-BZ#44	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl4-BZ#49	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl4-BZ#52	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl4-BZ#66	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl5-BZ#87	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl5-BZ#101	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl5-BZ#105	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl5-BZ#118	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl6-BZ#128	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl6-BZ3138	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl6-BZ#153	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl7-BZ#170	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl7-BZ#180	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl7-BZ#183	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl7-BZ#184	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl7-BZ#187	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl8-BZ#195	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl9-BZ#206	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Cl10-BZ#209	mg/kg	-	ND	ND	-	-	-	-	ND	-	-	-	-	-
Total PCBs	mg/kg	-	ND	ND	-	-	-	-	ND	1	<2	<2	0.023	0.180

EPH (USEPA Method 3546)														
C9-C18 Aliphatics	mg/kg	-	ND	ND	-	-	-	-	ND	1,000	-	-	-	-
C19-C36 Aliphatics	mg/kg	-	ND	ND	-	-	-	-	ND	3,000	-	-	-	-
C11-C22 Aromatics	mg/kg	-	ND	ND	-	-	-	-	ND	1,000	-	-	-	-
C11-C22 Aromatics, Adjusted	mg/kg	-	ND	ND	-	-	-	-	ND					
Metals														
Arsenic	mg/kg	-	1.6700	3.5400	-	-	-	-	5.8400	20	40	40	8.2	70
Cadmium	mg/kg	-	0.0700	0.0770	-	-	-	-	0.2430	70	30	80	1.2	9.6
Chromium	mg/kg	-	3.5300	9.0000	-	-	-	-	19.0000	100	1,000	1,000	81	370
Copper	mg/kg	-	1.6500	4.4100	-	-	-	-	10.9000	-	-	-	34	270
Lead	mg/kg	-	1.8000	4.7900	-	-	-	-	11.4000	200	1,000	2,000	47	218
Mercury	mg/kg	-	0.0060	0.0110	-	-	-	-	0.0230	20	10	10	0.15	0.71
Nickel	mg/kg	-	2.1800	5.3100	-	-	-	-	11.8000	600	-	-	20.9	51.6
Zinc	mg/kg	-	7.3700	17.0000	-	-	-	-	38.3000	1,000	-	-	150	410

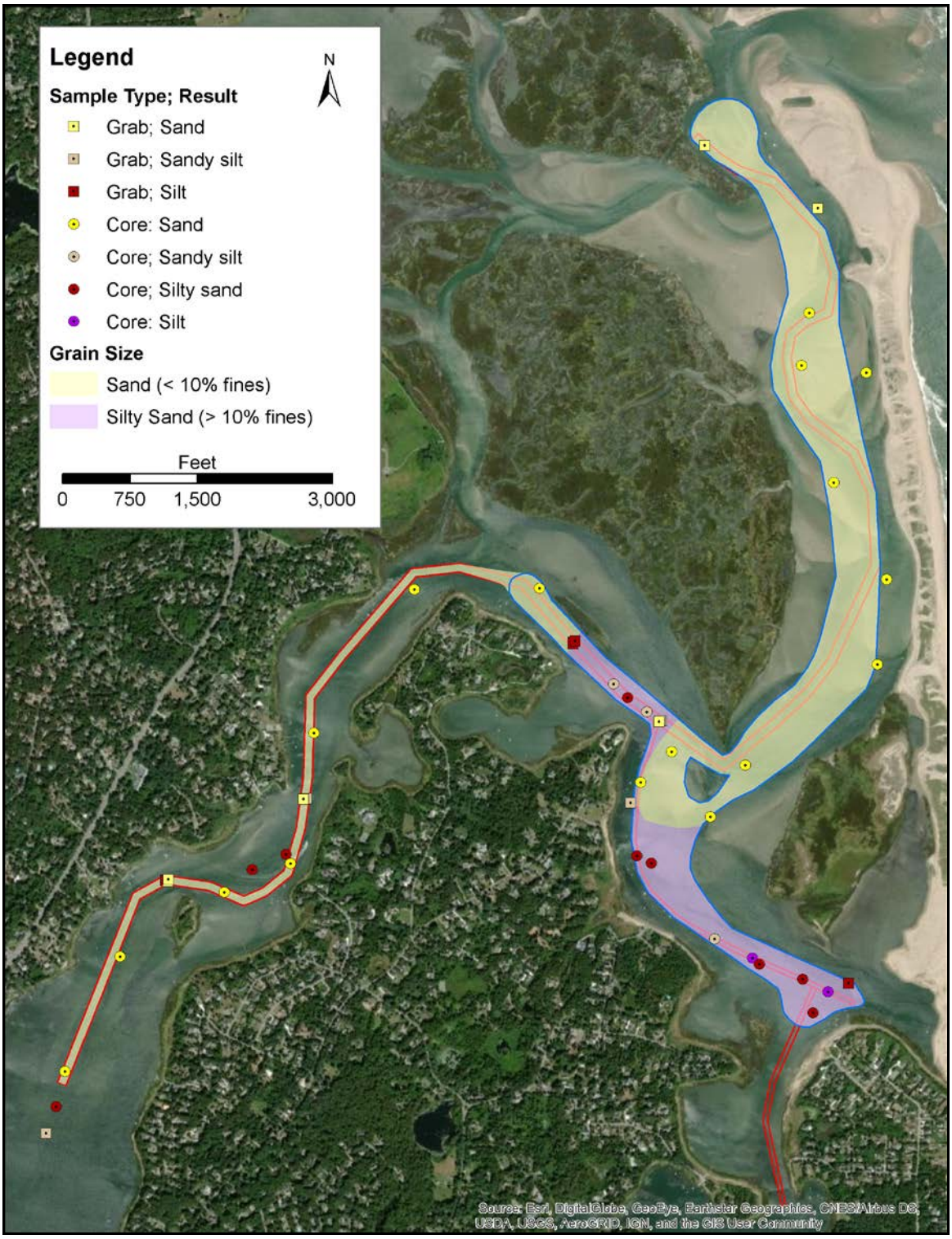

Figure D-15. Sediment locations sampled during Phases 1, 2, 3 and 4 showing predominant sediment characteristics.

1.8 Red Tide

There are two types of *Alexandrium* blooms in the New England region, both caused by the species *A. fundyense* (hereafter referred to simply as *Alexandrium*). One occurs along the open

coast of the Gulf of Maine from the Bay of Fundy to Massachusetts and outer Cape Cod, and on rare occasions, this distribution stretches to the islands of Nantucket and Martha's Vineyard and occasionally, to Rhode Island (i.e., Anderson et al., 2005a; Anderson et al., 2005b; Borkman et al. 2014). Blooms in the coastal region of the Gulf of Maine can stretch over hundreds of miles and last for several months.

The second type of *Alexandrium* bloom in the region is much smaller in scale and is representative of the blooms that occur in the Nauset Estuary system. *Alexandrium* blooms occur, but those episodes are sporadic and highly independent of each other or of the large-scale coastal blooms described above. Instead, isolated and localized blooms occur in those areas, with very tight linkage in time and space to cyst populations in bottom sediments of the areas where toxicity occurs. These locations can be viewed as self-seeding "point sources", in that *Alexandrium* populations originate within the embayments or estuaries, with no input of cells from coastal waters, and they deposit cysts after those blooms, to "seed" future blooms. These "localized" or "point source" blooms have been well studied by D. M. Anderson and colleagues (e.g., Anderson et al. 1983; Anderson and Stolzenbach 1985; Crespo et al. 2011; Ralston et al. 2013, 2015; Brosnahan et al. 2014).

The distribution of the *Alexandrium* blooms within Nauset Estuary is not uniform. It has been well established that the hot spots of toxicity occur at the three distal end points of the system - namely Salt Pond, Town Cove, and Mill Pond (collectively termed salt ponds hereafter). Although the central marsh does occasionally show dangerous levels of toxicity, the highest and earliest levels are always recorded within these salt ponds, with the toxicity in the central marsh delivered there from the localized blooms. In all cases, the salt ponds have deeper central portions (kettle holes), with water exchange with the central marsh limited by shallow, restricted inlet channels. Figure D-16 shows the distribution of cysts in Nauset Estuary in 2008, 2009, and 2011. Figure D-17 shows a time series of *Alexandrium* cell abundance between March and May 2009. Clearly, there is a strong linkage between the location of the cyst accumulations and the origins of the Nauset blooms, with cells first appearing in Mill Pond, then Town Cove and Salt Pond, with low abundances observed in the central marsh, and no connectivity between the three salt ponds.

Another important feature of the *Alexandrium* bloom dynamics is that the cysts in bottom sediments do not just sit at the surface of those sediments. Bioturbation (i.e., mixing by worms and other bottom-dwelling animals) as well as physical mixing from storms and currents can bury the cysts. It is common to find more cysts a few centimeters below the surface than there are at the surface, as shown in a core profile taken in Roberts Cove, immediately adjacent to Mill Pond (Figure D-18). However, dinoflagellate cysts require oxygen for germination (Anderson et al. 1987), and typically

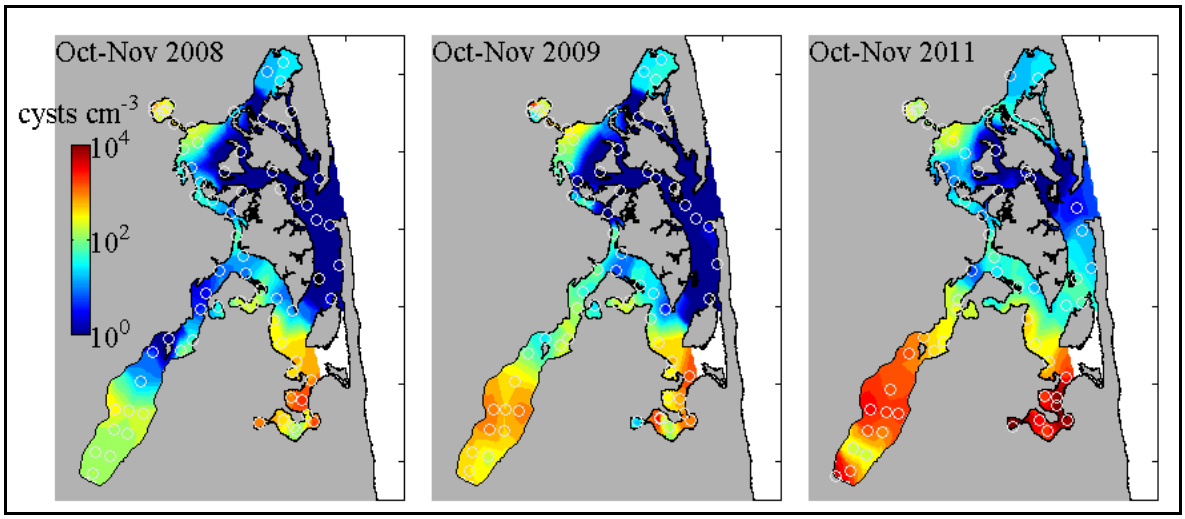

Figure D-16. Contour maps of Nauset Estuary mean *A. fundyense* cyst concentrations (cysts/cm3) in: (left) 2008, (center) 2009, and (right) 2011. Gray circles indicate sample sites (From Ralston et al., 2015).

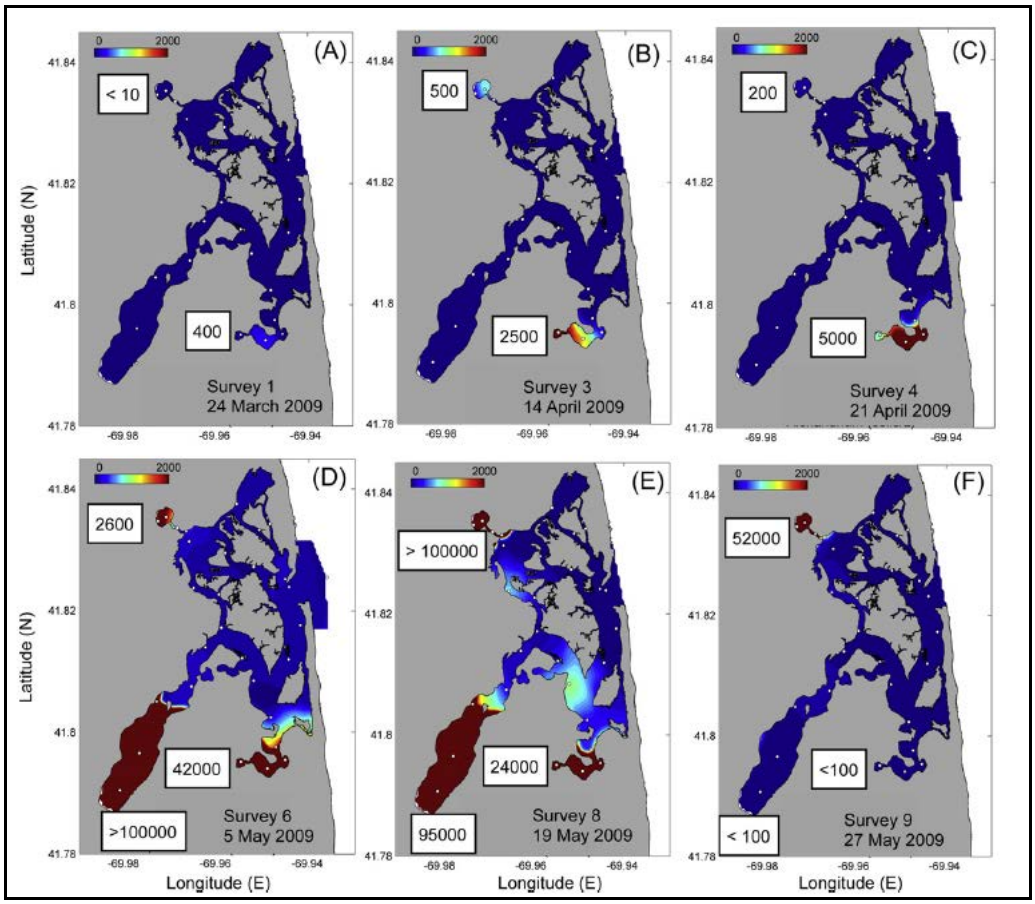

Figure D-17. Distribution of Nauset Estuary *A. fundyense* cells (cells L-1) between March 24 and May 27, 2009. Maximum number of cells for Mill Pond, Town Cove and Salt Pond indicated in the white squares. White dots indicate sample sites (From Crespo et al., 2011).

oxygen is only found in the top centimeter or less of bottom sediments. This means that cysts that are buried below that layer typically do not germinate and participate in the bloom formation in the spring. Instead, they remain dormant and either eventually die, or are mixed to the sediment surface or the water column by storms, bioturbation, or other disturbances. One important conclusion from Figure D-18 and from many other cyst profiles in sediment cores is that in Nauset Estuary, *Alexandrium* cysts are quite low in abundance below 10 cm (D. M. Anderson, unpub. data).

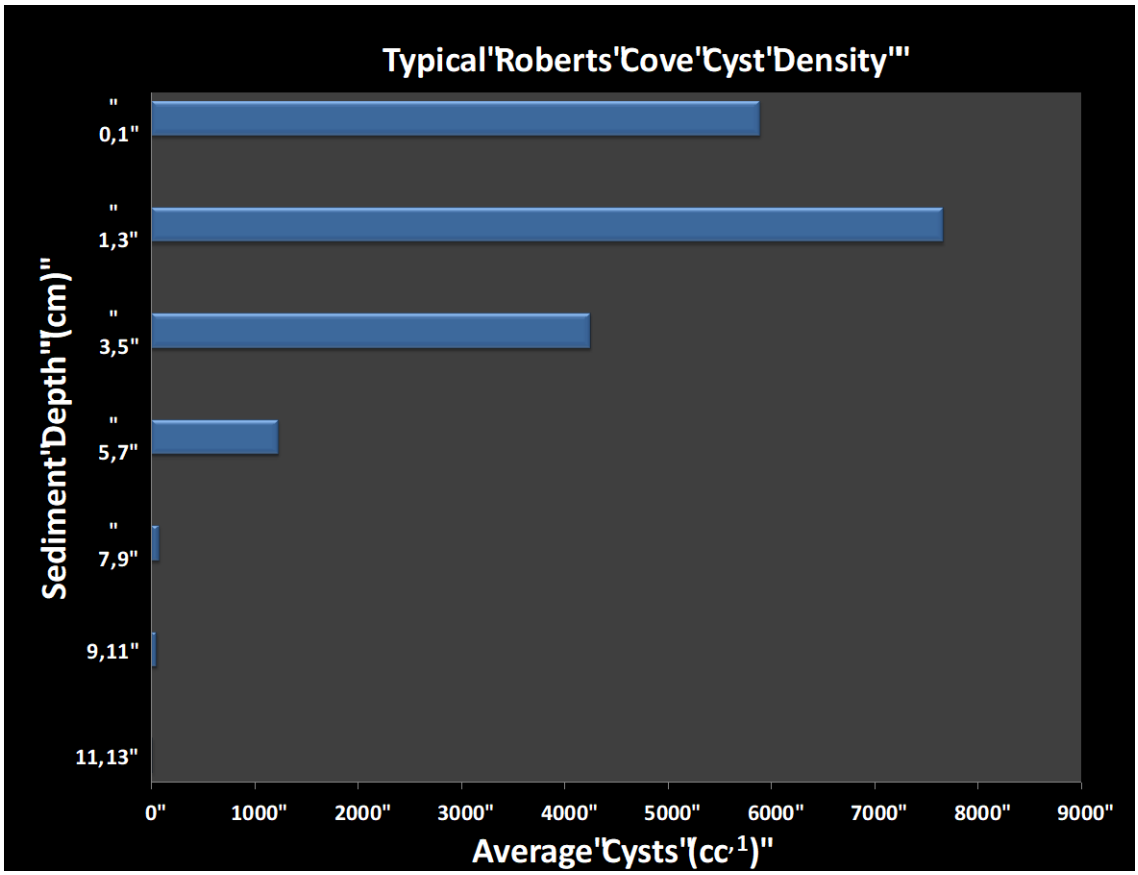

Figure D-18. Vertical profile of *Alexandrium* cyst abundance (cysts/cm3) from Roberts Cove in the Nauset Estuary.

To evaluate current red tide conditions in Nauset Estuary, sediment cores were collected at 10 sites on December 10, 2015 for analysis of red tide cysts (Figure D-19). The sample locations were planned to coincide with previous red tide cyst analyses conducted by others. A push-core sampling device equipped with a 2 5/8 inch inner diameter clear polycarbonate barrel was used to collect the cores. To ensure sufficient retrieval depth, the cores were pushed to a penetration depth of 1.5 feet. Cyst concentrations ranged from 0 (central marsh sites) to values as high as 2,446 cysts/cm3 in the top cm of sediment near Mill Pond and Roberts Cove. Other high values were also in the areas closest to the mouths of the salt ponds. Concentrations in the 1-10 cm fraction were generally much lower than the surface counts at each station, except at station F near Roberts Cove, where 2,941 cysts/cm3 was measured.

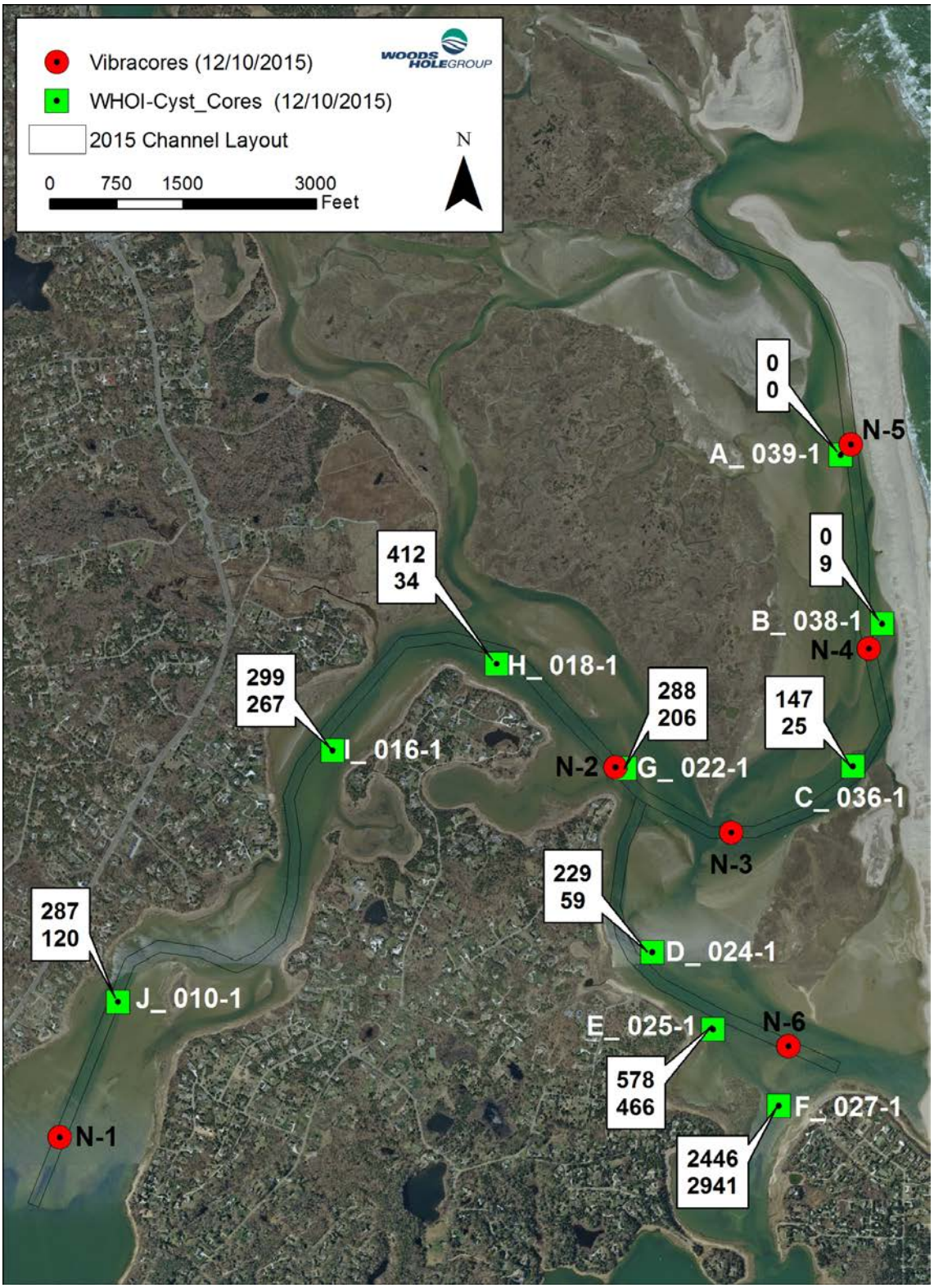

Figure D-19. **Map showing cyst coring locations and cyst counts sampled in Dec. 2015. White boxes near each station show the *Alexandrium* cyst abundances (cysts/cm3) in the top cm (top line) and 1-10 cm layer (bottom line).**

These 2015 cyst samples were collected and analyzed to allow comparisons between the limited number of samples collected now, and those collected in more extensive, marsh-wide system surveys in 2008, 2009 (Crespo et al., 2011) and 2011 (Ralston et al. 2015). Figure D-20 compares cyst abundance at sampling sites from 2008, 2009, 2011, and 2015. It is immediately apparent that the general distribution of *Alexandrium* cysts in the area to be dredged has not changed over these years, and it is also clear that cyst abundance has a similar range to that measured in other years. This is an important observation, and the main justification for taking the samples, as it demonstrates that cyst abundance and distribution within the estuary are generally similar among years. Since it will take a number of years to permit the dredging program, there is confidence that these measurements, and those in the recent past, are a realistic representation of the situation at the time the dredging will eventually occur.

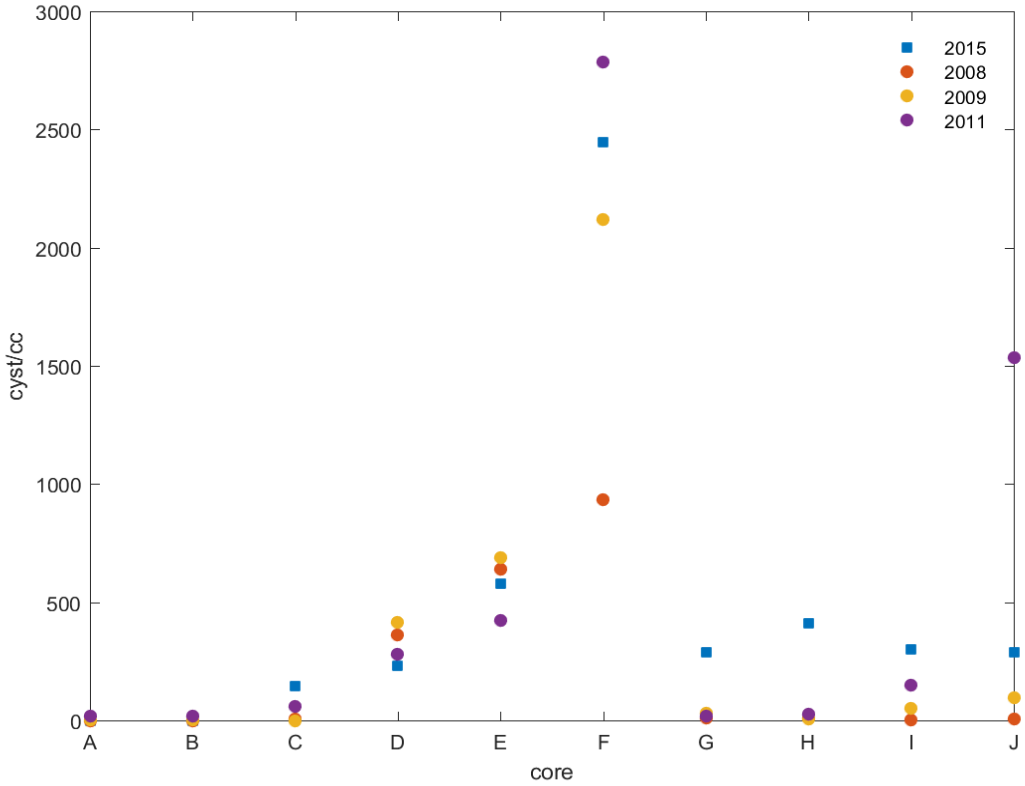

Figure D-20. Comparison of cyst abundance at the 2015 core locations with data from previous cyst surveys in 2008, 2009, and 2011.

1.9 Sea Level Rise

Moving into the 21st century and beyond, it is likely that other long-term processes such as sea level rise will affect the Nauset Estuary system. The morphology of the barrier beach will likely be impacted as the sediment supply, currents, waves, winds, water levels and tidal range are influenced by climate change. While it is not possible to quantify the impacts of sea level rise on future dredging needs in Nauset Estuary, it is important to recognize the potential for change, and to design a dredging program that is flexible enough to maintain navigable waterways into the future.

1.10 Regulated Environmental Resource Areas

The proposed project area includes a number of wetland resource areas including land under the ocean, coastal beach/tidal flats, coastal dune, barrier beach, coastal bank, rocky intertidal shore, salt marsh, land containing shellfish, Natural Heritage Estimated Habitats of Rare Wildlife, land subject to coastal storm flowage, bordering vegetated wetland, and outstanding resource waters (Figure D-21). Each of these resource areas is described below.

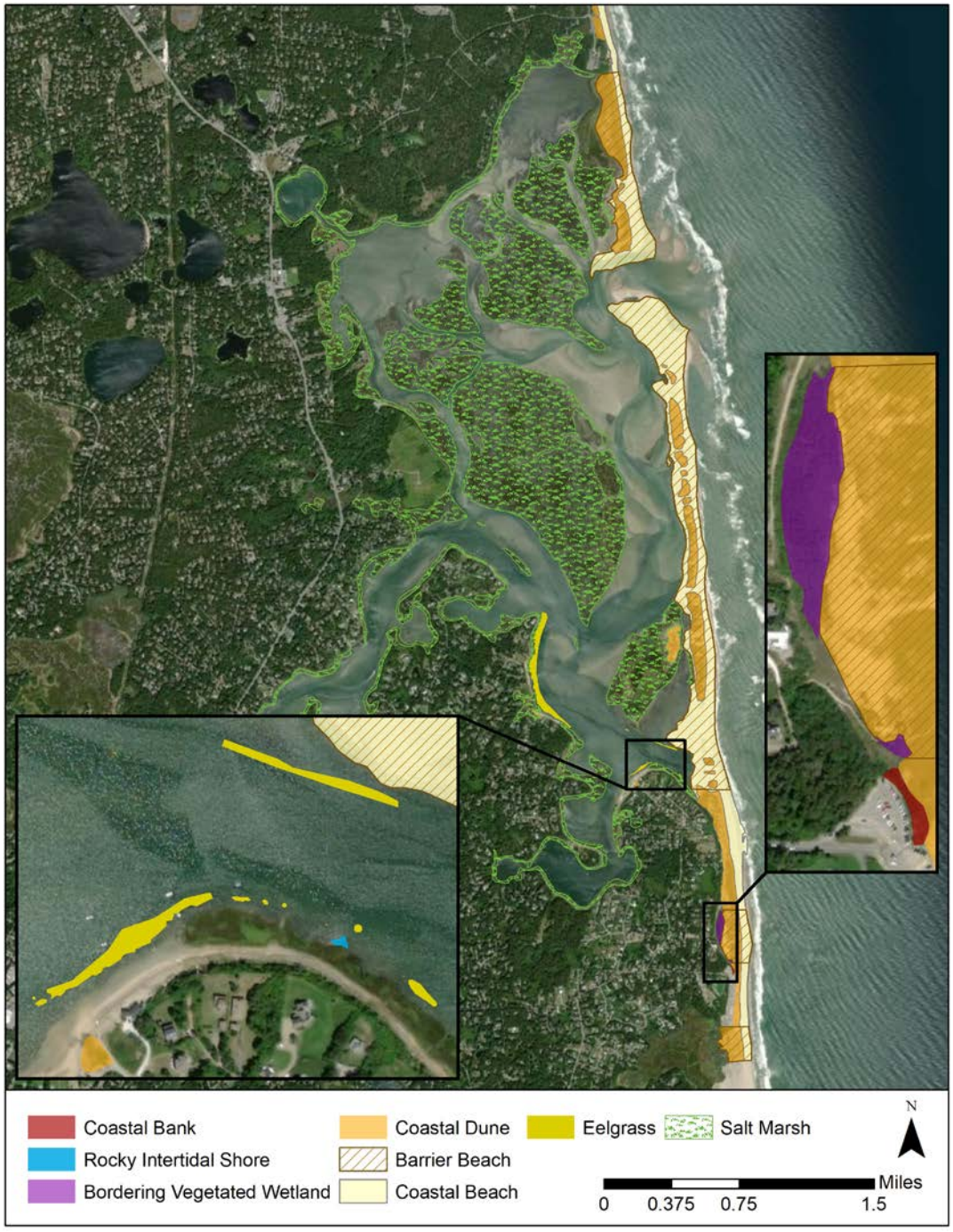

Figure D-21. Regulated environmental resource areas around the project area.

1.10.1 Land Under the Ocean 310 CMR 10.25

The project area contains a significant portion of land under the ocean. Within this resource area are mapped eelgrass habitat areas (Figure D-22). Eelgrass surveys were conducted on September 18 and October 4, 2017 to map the extent of eelgrass within the project area. Eelgrass was present in both smaller patches and larger meadows, ranging in size from 13 square feet to 316,815 square feet. The largest meadow of eelgrass is located along the western shoreline of the Priscilla spur channel, followed by two patches north of Priscilla Rd. landing. A number of small and isolated patches were also identified in the same area north and northeast of Priscilla Rd. landing. In total, eelgrass covers approximately 358,155 square feet. Overall, eelgrass was present in high densities in both nearshore and offshore areas (Figure D-23). Rocky intertidal shore was also found in close proximity to some of the eelgrass habitat near Priscilla Rd. landing.

Eelgrass beds provide valuable ecosystem benefits to the Nauset Estuary including serving as a nursery and habitat for marine fisheries, in addition to supporting additional waterfowl and invertebrate species. Eelgrass beds also provide sediment and shoreline stabilization, sequester carbon, and improve water quality.

Figure D-22. Eelgrass resource areas along the Priscilla spur channel in Nauset Estuary.

Figure D-23. Underwater photo of eelgrass taken during October 2017 boat-based survey (left) and eelgrass meadow near Tonset landing taken during September 2017 land-based survey (right).

1.10.2 Coastal Beach 310 CMR 10.27

The proposed project area contains coastal beach resources along Nauset barrier beach and along the shorelines within Nauset Estuary (Figure D-24 and Figure D-25). The coastal beach is shaped by a dynamic environment influenced by waves, currents, tides and available sediment supply. The coastal beach resource area also contains tidal flats, which are interspersed with salt marsh habitat and waterways resources.

The coastal beach provides recreational resources as well as storm protection for residential areas, businesses, and harbors surrounding and within the estuary. The coastal beach also protects westerly resource areas including an extensive salt marsh system.

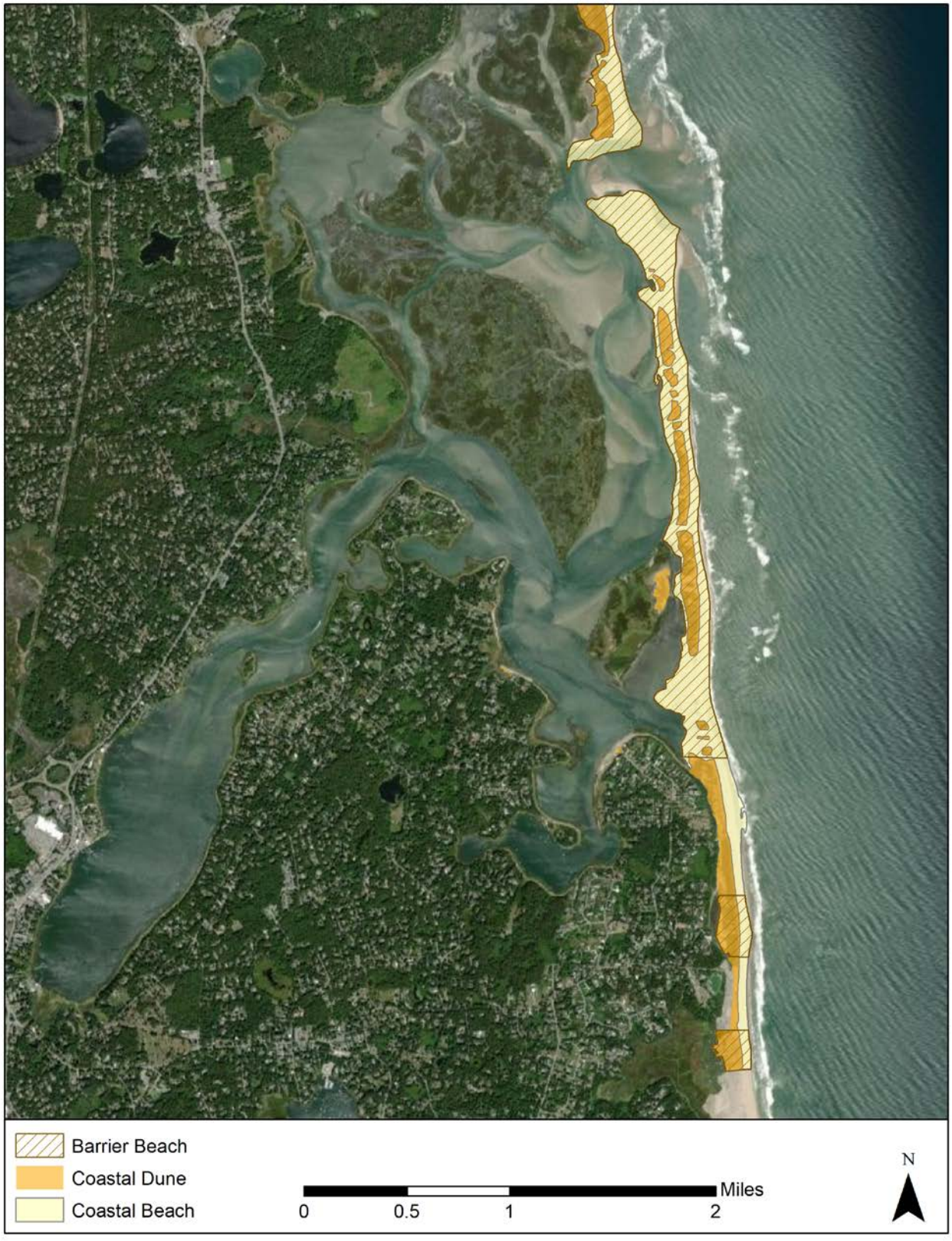

Figure D-24. Coastal beach, coastal dune, and barrier beach resource areas along Nauset barrier beach.

Figure D-25. Coastal beach along the west (top) and east (right) side of Nauset barrier beach. Tidal flat interspersed with salt marsh east of Tern Island (bottom).

1.10.3 Coastal Dunes 310 CMR 10.28

The coastal dune at the project site runs along the center of Nauset barrier beach for approximately 3.8 miles (Figure D-24). Similar to the coastal beach resource area, the coastal dune is also part of the greater barrier beach system and provides both storm damage protection and flood control. The dune ranges in width from 150 feet at the Nauset Public Beach parking lot, to approximately 670 feet near the northern end of Nauset Heights. The costal dune is primarily vegetated with American beach grass (Ammophila breviligulata), beach plum (Prunus maritima), and Rosa rugosa (Figure D-26). Portions of the coastal dune have experienced overwash during nor'easters (Figure D-26).

The Town of Orleans conducted a dune enhancement project at Nauset Public Beach during the winter of 2018-2019. Approximately 27,000 cubic yards of sand were trucked to the site and used to enhance the landward (western) edge of the coastal dune for protection of the public beach resource and infrastructure.

Figure D-26. Coastal dune resources on Nauset barrier beach (right) and north of Nauset Public beach (right). Overwash through coastal dune near Nauset Heights (bottom).

1.10.4 Barrier Beach 310 CMR 10.29

The project site is located within a state designated Barrier Beach (Figure D-27), as determined by the Massachusetts Barrier Beach Inventory Project. In 1982, the Massachusetts Office of Coastal Zone Management (CZM) completed a comprehensive effort to identify and delineate 681 barrier beaches in Massachusetts. Since the time of the CZM inventory, the inlet to Nauset Estuary has migrated north and the shape of the barrier beach has changed. The configuration of the existing barrier beach is depicted in Figure D-24.

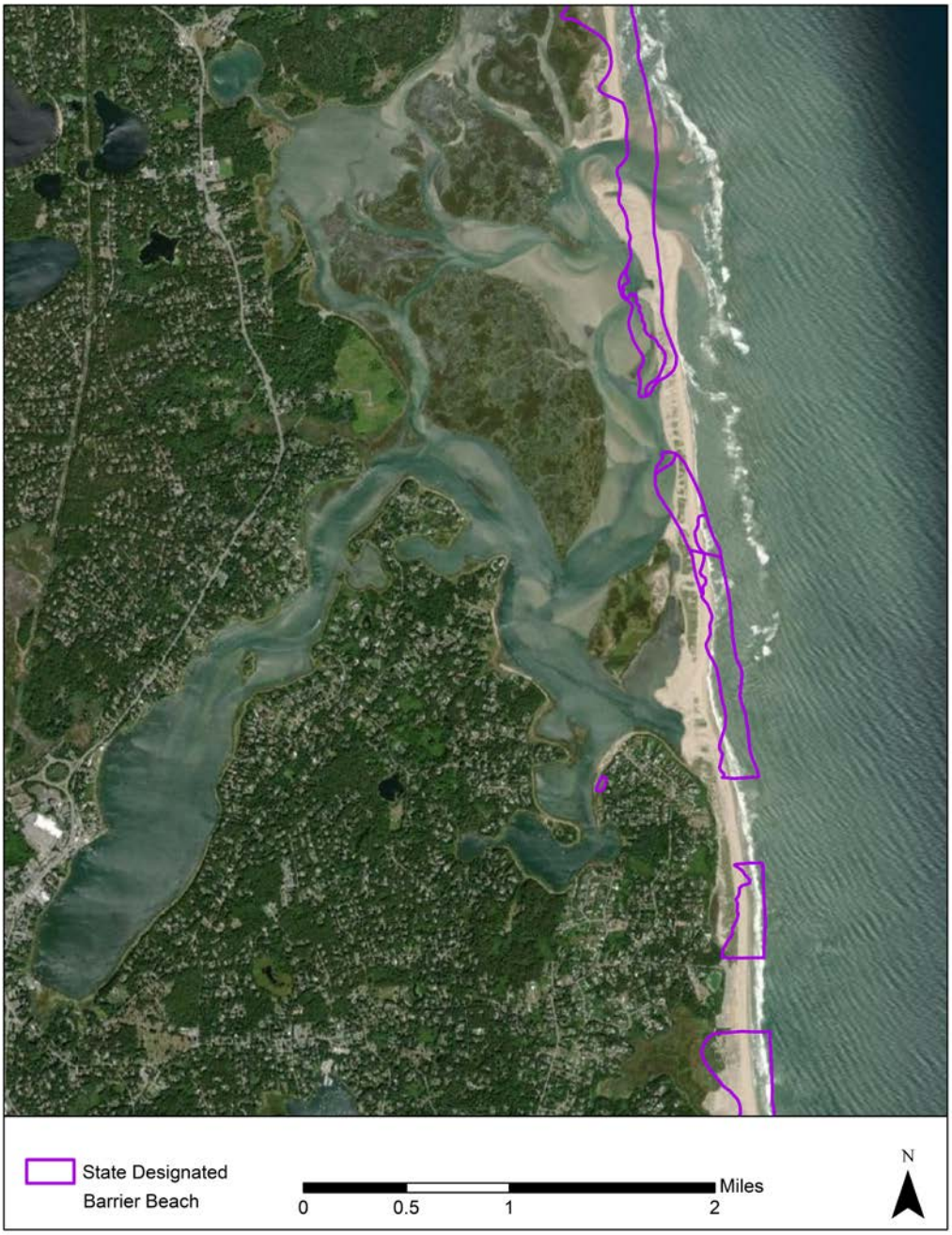

Figure D-27. State Designated Barrier Beach within the project site.

1.10.5 Coastal Bank 310 CMR 10.30

There is a relatively small area (9,280 square feet) of coastal bank within the project area, located adjacent to the northern end of the Nauset Public Beach parking lot (Figure D-28). The coastal bank is vegetated with beach plum (*Prunus maritima*) and Bittersweet (*Celastrus orbiculatus*) (Figure D-29). This resource area provides a buffer between the barrier beach system and upland areas from storm damage and flooding. The coastal bank does not serve as a sediment source to the costal beach or coastal dune.

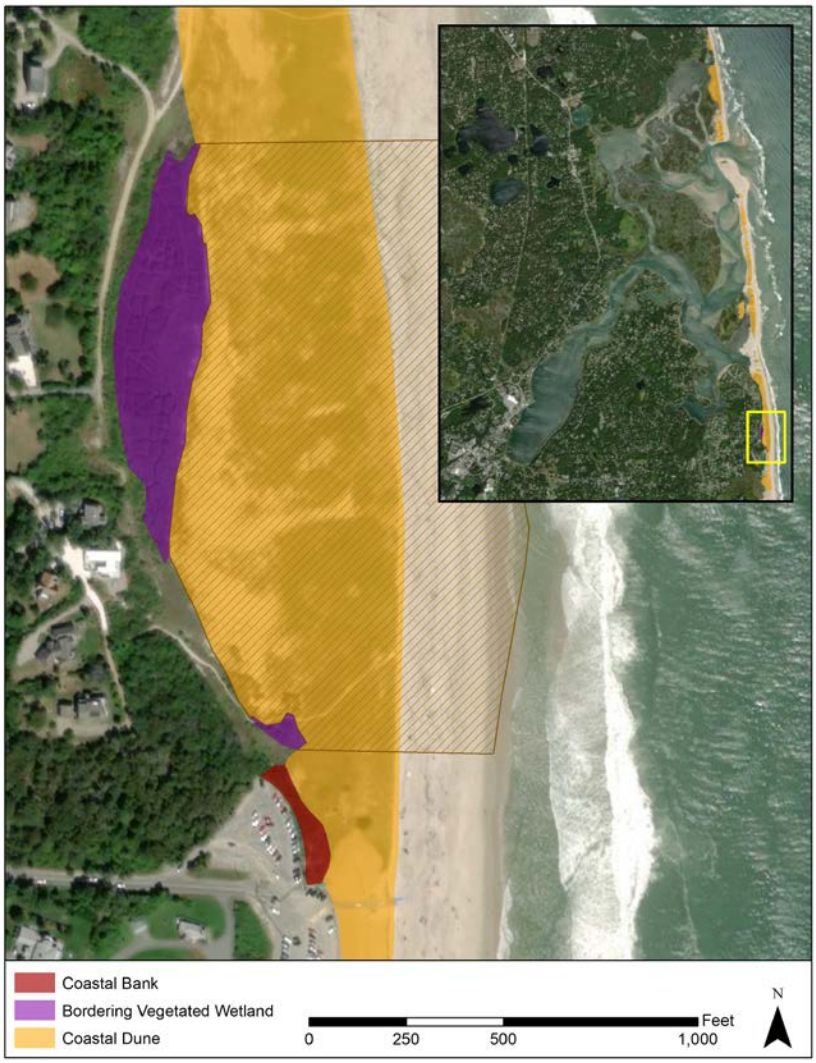

Figure D-28. Coastal bank resource area within the project site.

Figure D-29. Coastal dune and vegetated coastal bank at north end of Nauset Public Beach.

1.10.6 Rocky Intertidal Shores 310 CMR 10.31

During field surveys of the project area, one area of rocky intertidal shore was delineated along the western shore of the Priscilla spur channel (Figure D-22). The resource area is 1,047 square feet and is comprised of a mix of boulders and cobble with attached barnacles (Figure D-30).

Figure D-30. Rocky intertidal shore along the western shore of Priscilla spur channel.

1.10.7 Salt Marsh 310 CMR 10.32

Nauset Estuary contains an extensive salt marsh system fringing the shorelines of Nauset Bay, Salt Pond, Town Cove, Woods Cove, Orleans Cove, and Mill Pond, in addition to salt marsh habitat areas covering small islands within the estuary (Figure D-31). Salt marsh was mapped using data available from Massachusetts Department of Environmental Protection (MassDEP) and field surveys conducted by Woods Hole Group (WHG). The salt marsh is characterized by areas of fringing marsh interspersed with boulders, as well as by larger meadows (Figure D-32). Dominant vegetation with the marsh includes smooth cordgrass (*Spartina alterniflora*) and salt meadow cordgrass (*Spartina patens*). Other resource areas interspersed with the salt marsh include water bodies and waterways resources.

Figure D-31. Salt marsh resource area within the project site.

Figure D-32. Salt marsh habitat areas within Nauset Estuary.

1.10.8 Land Containing Shellfish 310 CMR 10.34

A comprehensive shellfish survey was conducted within the project area on September 16-17, 2019. The purpose of the survey was to document shellfish resources that may be impacted by the proposed dredging and to compare survey data to shellfish suitability areas delineated by Massachusetts Division of Marine Fisheries (DMF). As shown in Figure D-33, DMF considers the project area within Nauset Estuary to be significant to the protection of marine fisheries and to contain suitable habitat for bay scallop (*A. irradians*), blue mussel (*M. edulis*), quahog (*M. mercenaria*), razor clam (*E. directus*), and soft-shelled clam (*M. Arenaria*).

The shellfish survey protocol was developed in direct consultation with the Massachusetts DMF Habitat Program. To thoroughly sample the project area, a total of (105) 2-acre hex-bins were established throughout the project area. Among the full set of 105 hex-bins, a subset of (35) 2-acre hex-bins were selected for sampling. The selection process was guided by two primary factors; (i) desire to get full coverage of the project area, and (ii) desire to sample in areas near existing aquaculture operations and shellfish harvest areas. The distribution of hex-bins selected for sampling is shown in Figure D-34. Within each of the selected hex-bins, two discrete sampling locations were identified using a random point generator, for a grand total of 70 sample locations within the project area.

Once the survey bounds were established, Woods Hole Group Coastal Scientists navigated to each sampling point to conduct the survey. At each point, an underwater camera was used to capture images of the sea floor. Shellfish sampling was then conducted using a bull rake lined with 0.25-inch oyster mesh operated from either the research vessel, or from the water adjacent the vessel. The survey team raked each location for 4 minutes, sampling approximately 4 cubic feet of sediment. Once each sample had been washed and sorted, the number, species, and length of all live shellfish were noted (Figure D-35). Raking start and end locations for each sampling point were recorded using a handheld Garmin 78sc handheld chart plotter.

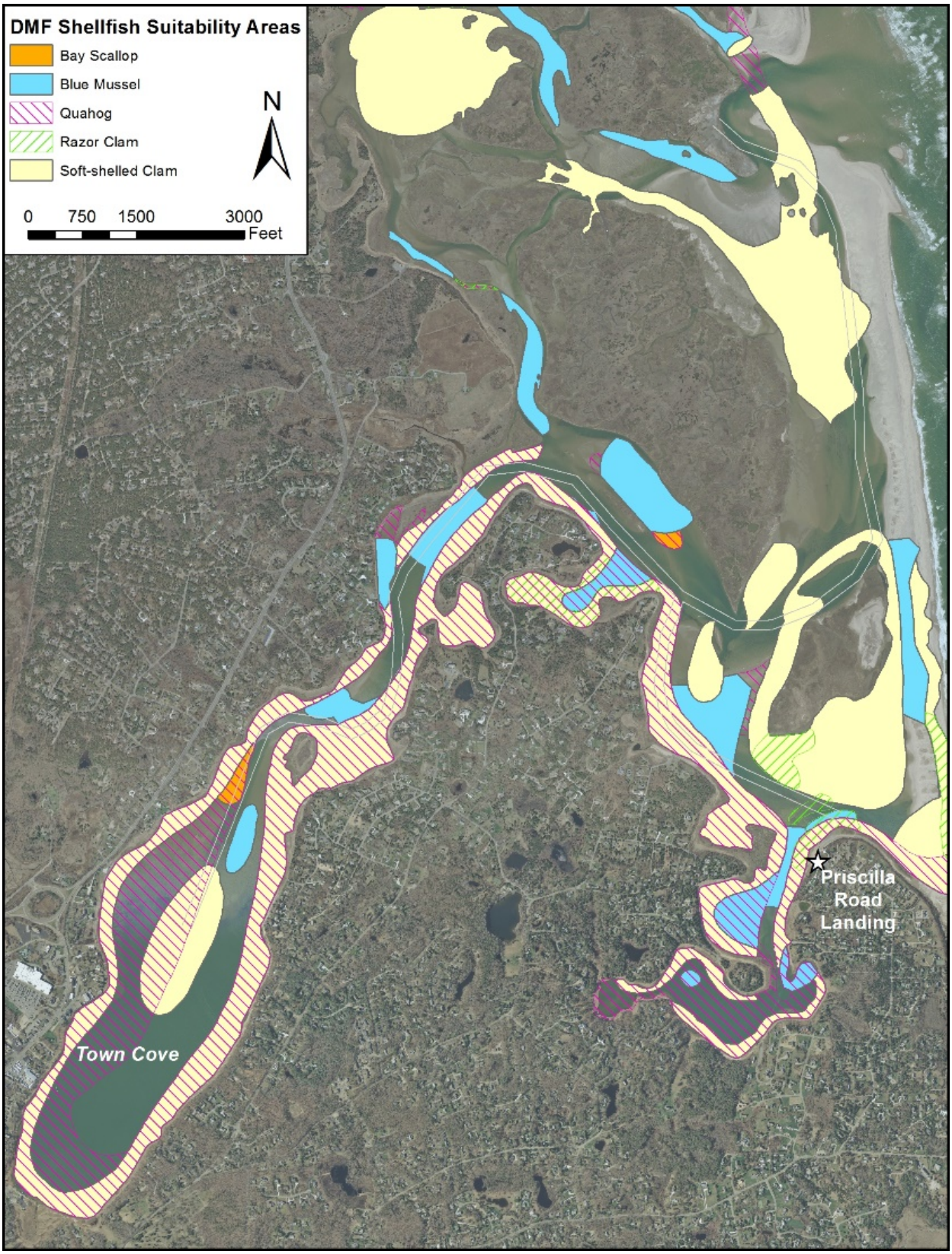

Figure D-33. Massachusetts Division of Marine Fisheries Shellfish Suitability Areas within Nauset Estuary, spanning the Towns of Orleans and Eastham, Massachusetts.

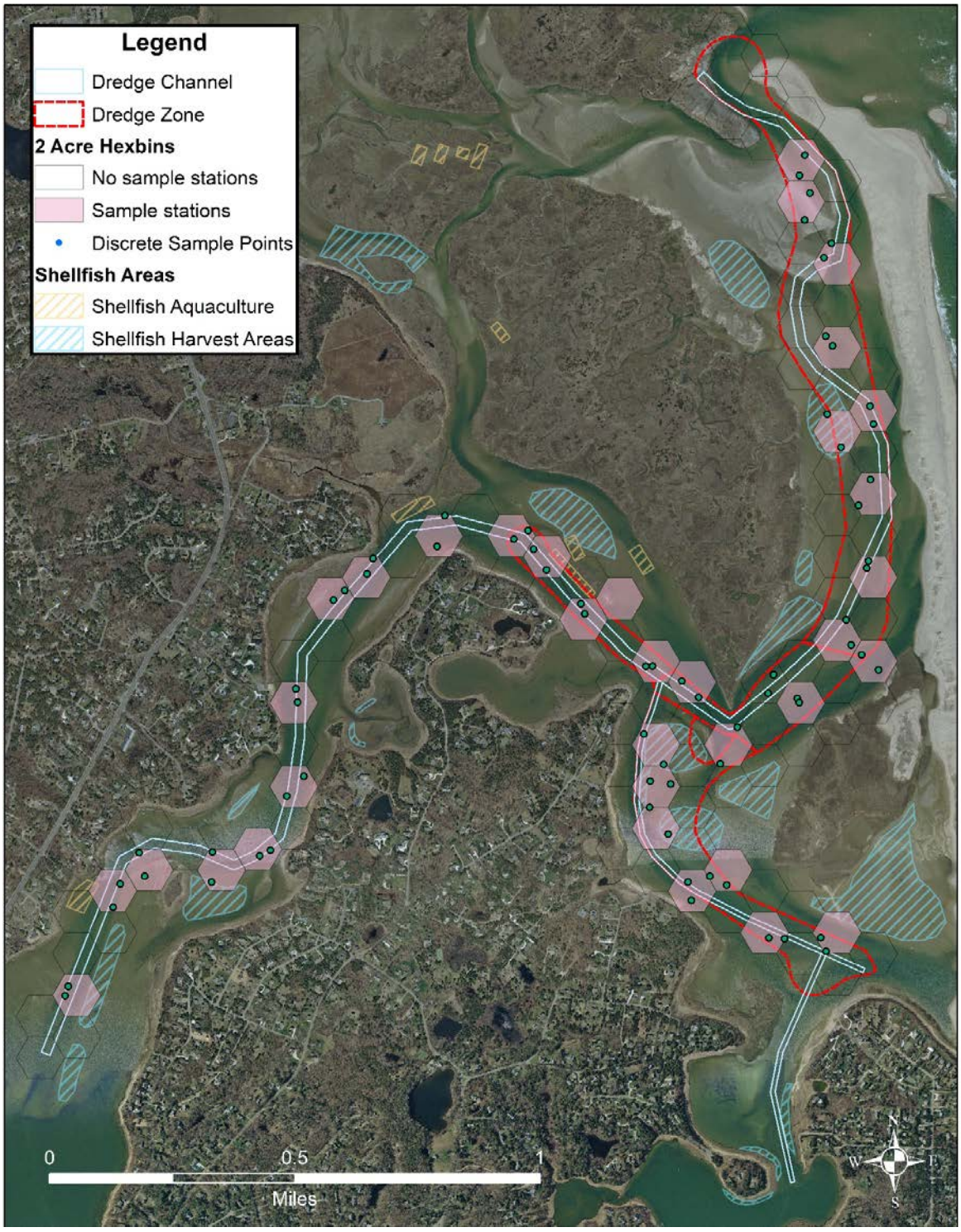

Figure D-34. Hex-bin and discrete sampling point locations within the project area.

D-35. Samples were sorted and live shellfish recorded.

Results of the shellfish survey indicated the presence of bay scallop (*A. irradians*), blue mussel (*M. edulis*), quahog (*M. mercenaria*), soft-shelled clam (*M. Arenaria*), and surf clam (*S. solidissima*) within the project area (Figures D-36 through D-41). A summary of shellfish density for the entire estuary is provided in Table D-7, and for individual channel reaches in Table D-8.

Table D-7. Individual shellfish and overall densities observed during Nauset Estuary shellfish survey conducted September 16–17, 2019.

Species	Individuals Observed	Net Density / ft^3*
Bay Scallop	4	0.01
Blue Mussel	24	0.08
Soft-Shelled Clam	2	0.01
Surf Clam	31	0.11
Quahog	269	0.96

*All density calculations assumed a total of 4 ft^3 of sediment sampled over the 4-minute sampling time at each sampling location, for a total sample volume of 280 ft^3 across 70 sampling points. The total number of each species of shellfish observed in the project area were then divided by the total sample volume, generating an approximate density of shellfish per ft^3 of sediment sampled (i.e., 4 bay scallops/280 ft^3 = 0.01 bay scallops/ ft^3).

Table D-8. Individual shellfish and overall densities for each channel reach observed during Nauset Estuary shellfish survey conducted September 16–17, 2019.

Channel	Behind Barrier	Eastern Main Channel	Priscilla	Central Main Channel	Town Cove
# Samples	19	8	15	8	20
Bay Scallop					
Individuals Observed	0	0	14	7	7
Density/ft^3	0	0	0.23	0.22	0.09
Blue Mussel					
Individuals Observed	23	0	0	7	0
Density/ft^3	0.30	0	0	0.22	0
Soft-Shelled Clam					
Individuals Observed	14	0	0	0	0
Density/ft^3	0.18	0	0	0	0
Surf Clam					
Individuals Observed	190	7	0	0	14
Density/ft^3	2.5	0.22	0	0	0.18
Quahog					
Individuals Observed	0	108	521	129	1059
Density/ft^3	0	3.38	8.68	4.03	13.24

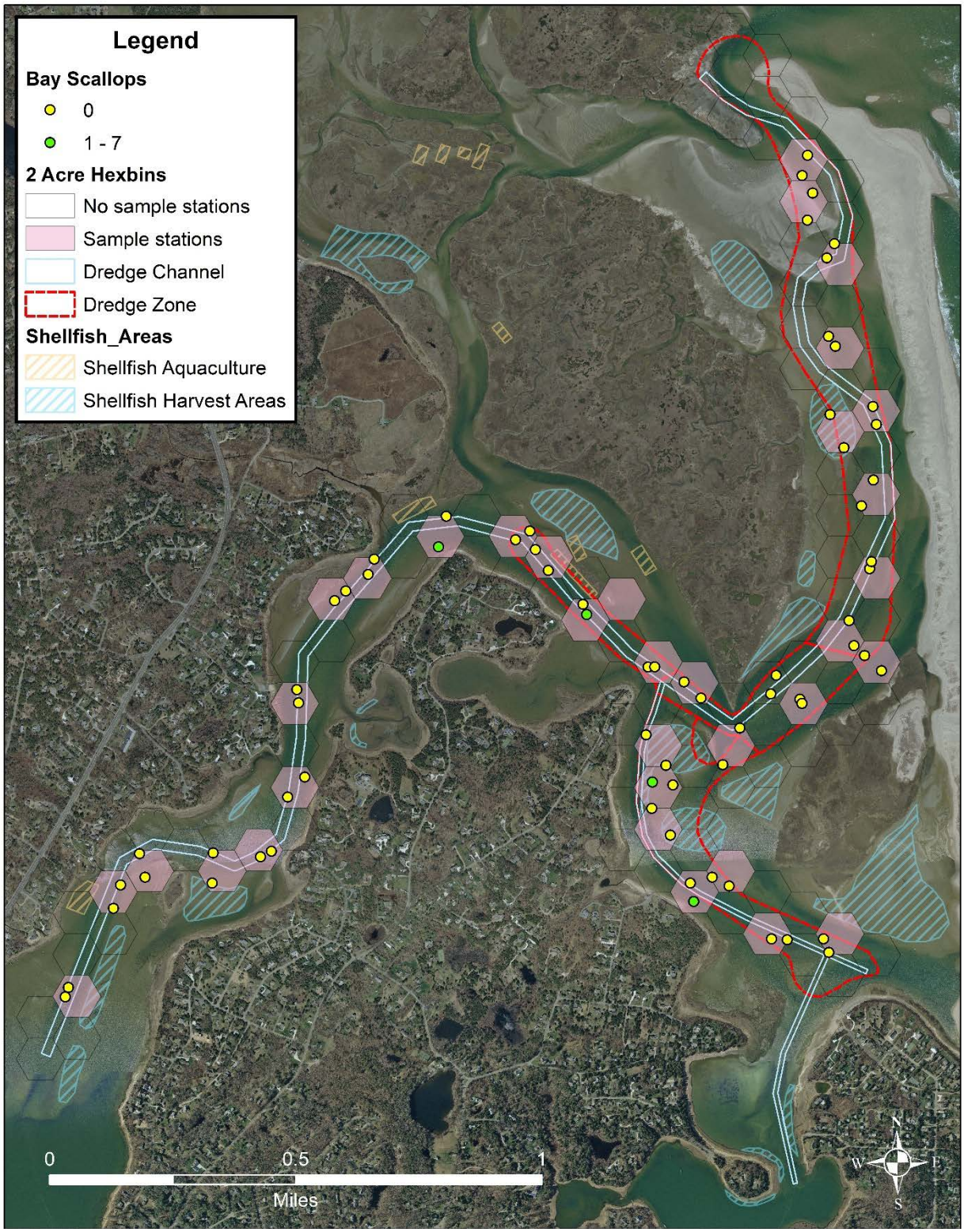

Figure D-36. Observed bay scallop distribution during Nauset Estuary shellfish survey conducted September 16–17, 2019.

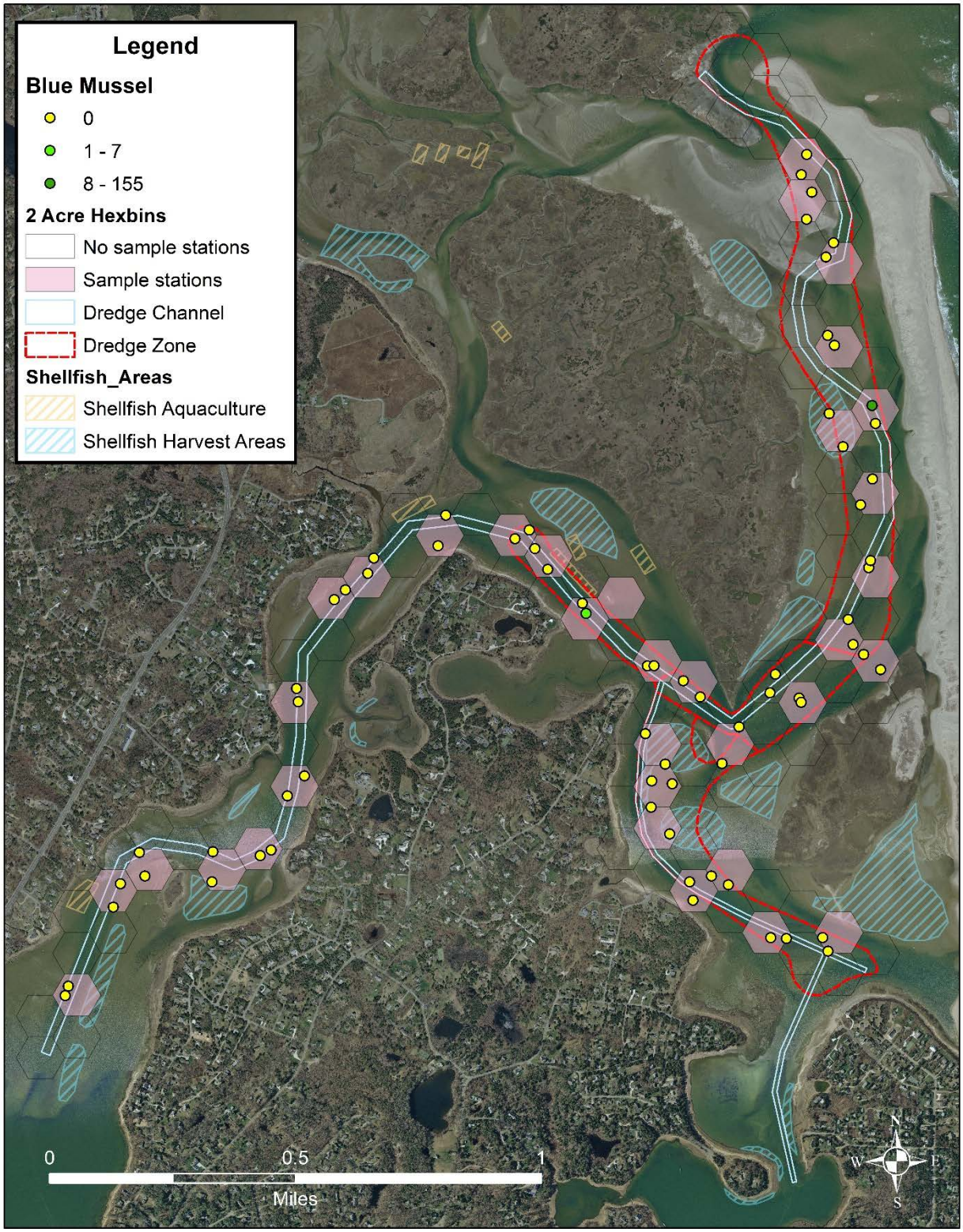

Figure D-37. Observed blue mussel distribution during Nauset Estuary shellfish survey conducted September 16–17, 2019.

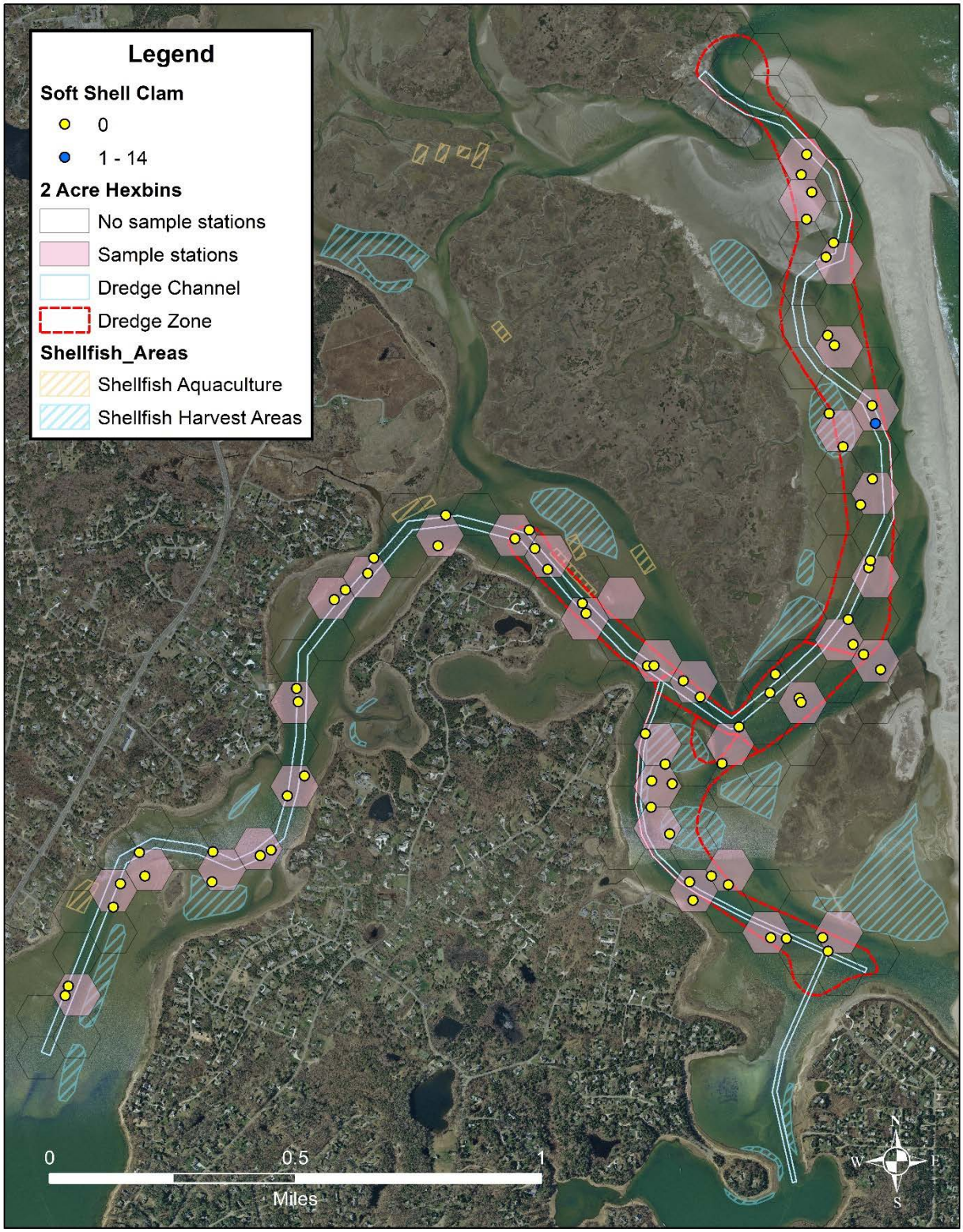

Figure D-38. Observed soft-shelled clam distribution during Nauset Estuary shellfish survey conducted September 16–17, 2019.

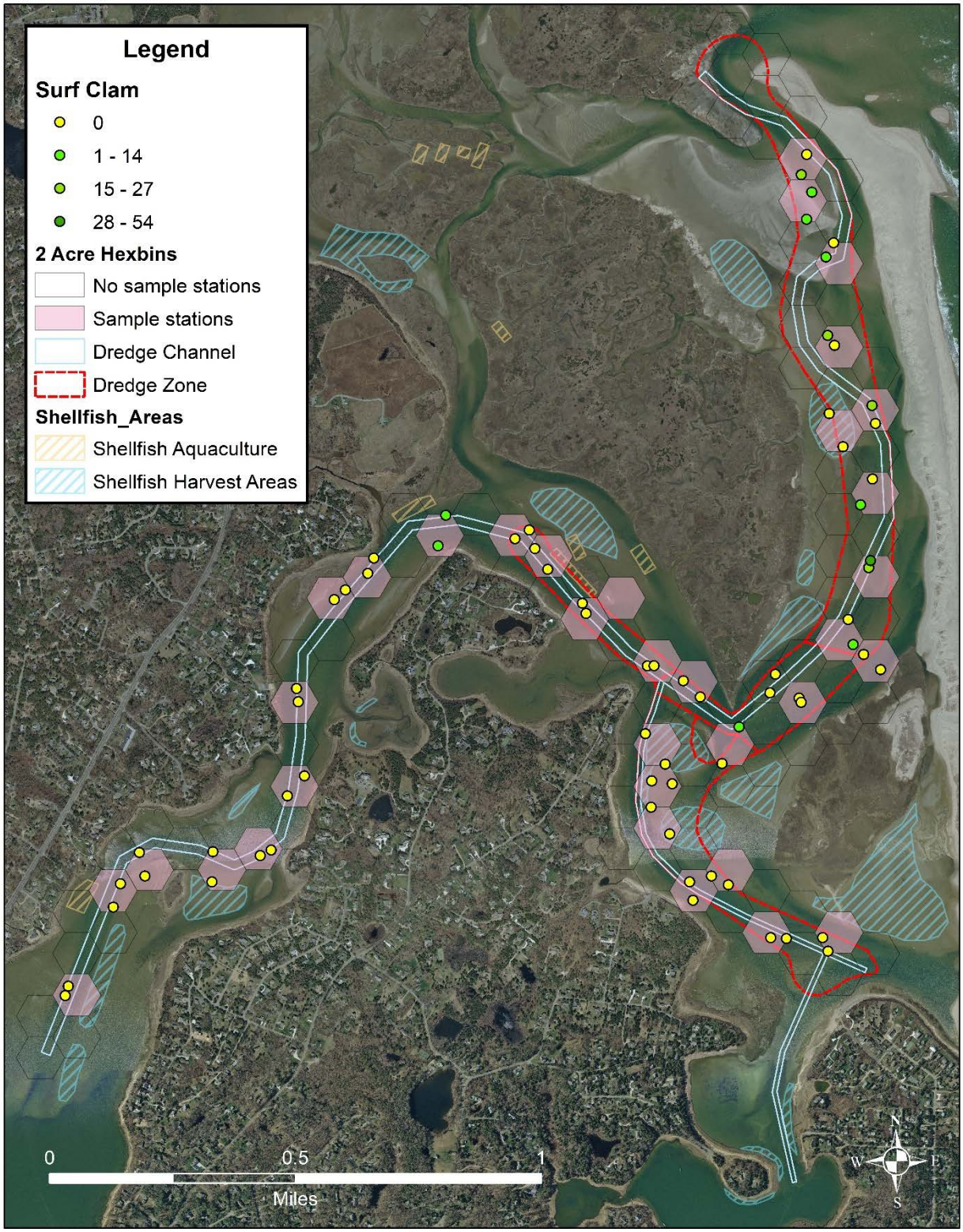

Figure D-39. Observed surf clam distribution during Nauset Estuary shellfish survey conducted September 16–17, 2019.

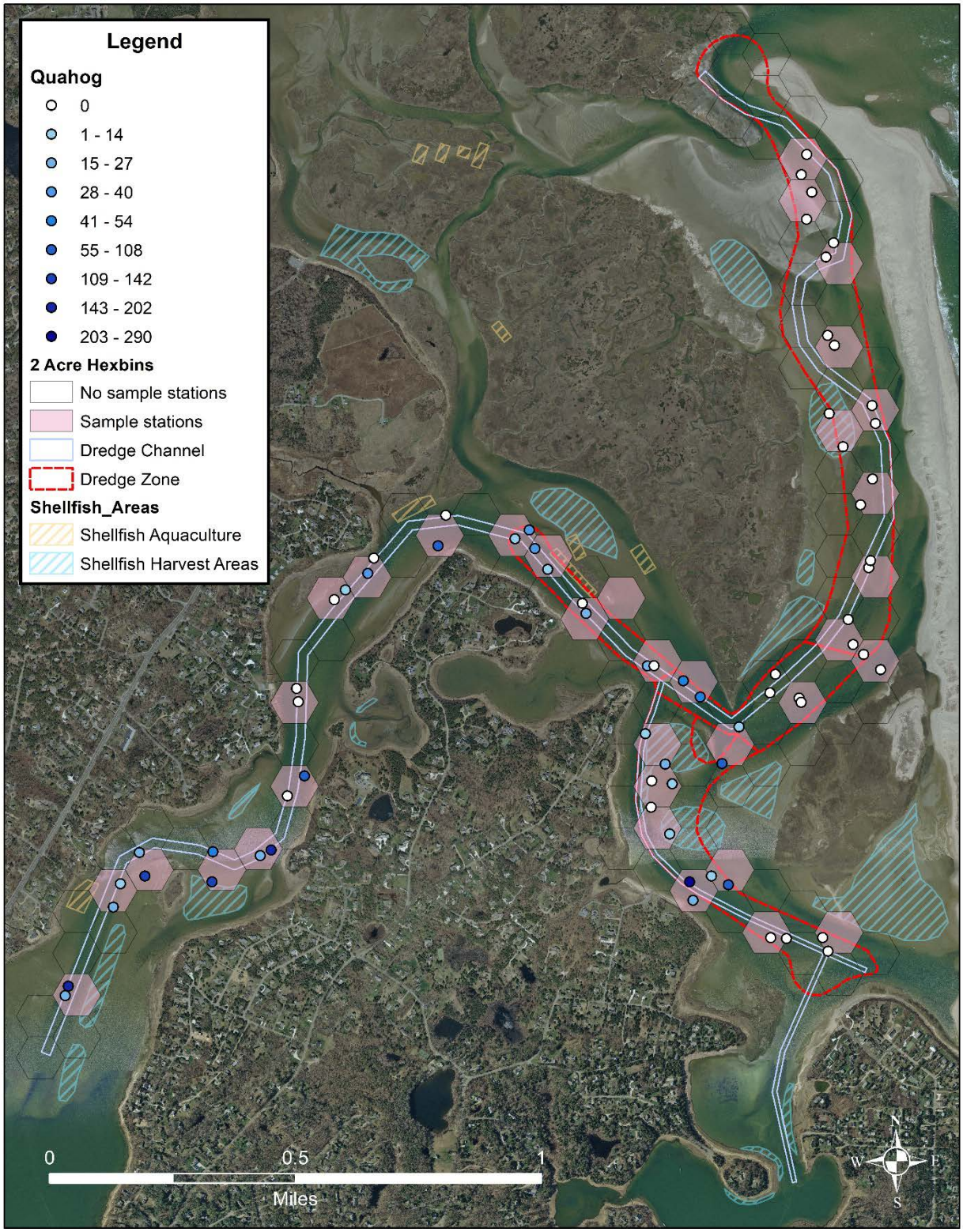

Figure D-40. Observed quahog distribution during Nauset Estuary shellfish survey conducted September 16–17, 2019.

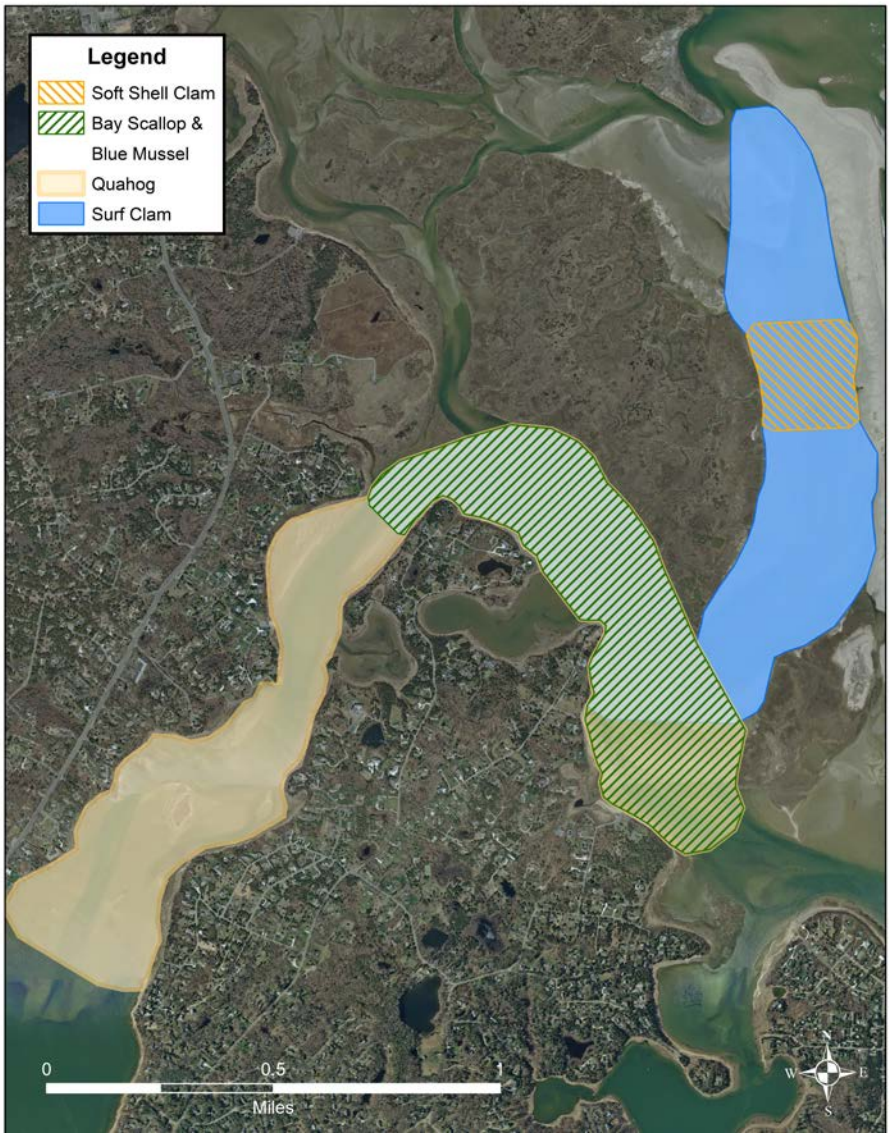

Figure D-41. Summary of observed shellfish species distribution during Nauset Estuary shellfish survey conducted September 16–17, 2019.

Variability exists in the biological resources defined by 310 CMR 10.34 (Land Containing Shellfish) within Nauset Estuary. Despite this variability, the estuary contains important areas for bay scallops in the Priscilla Rd. spur channel, areas for blue mussels, soft shell clams and surf clams behind the barrier beach, and areas for quahogs in the Town Cove and Priscilla Rd. channel reaches.

1.10.9 Estimated Habitats of Rare Wildlife 310 CMR 10.37

According to the Massachusetts Natural Heritage & Endangered Species Program (NHESP), Division of Fisheries & Wildlife, the site of the proposed project is located within Priority and Estimated Habitats for Rare Species (Figure D-42). The Town of Orleans Natural Resources Department monitors the site for three (3) species of protected shorebirds (Table D-9). These species are protected under the Massachusetts Endangered Species Act (MESA) and its

implementing regulations (321 CMR 10.00), as well as the Wetlands Protection Act and its implementing regulations (310 CMR 10.00). Habitat Conservation Plan annual reports prepared by the Town of Orleans for Nauset Beach for the years 2018 through 2020 are provided in Section N.

Table D-9. State and Federally Listed Shorebird Species at the Project Site.

Species	State Status	Federal Status
Piping plover (*Charadrius melodus*)	Threatened	Threatened
Least tern (*Sterna antillarum*)	Special concern	--
Roseate tern (*Sterna dougallii*)	Endangered	Endangered

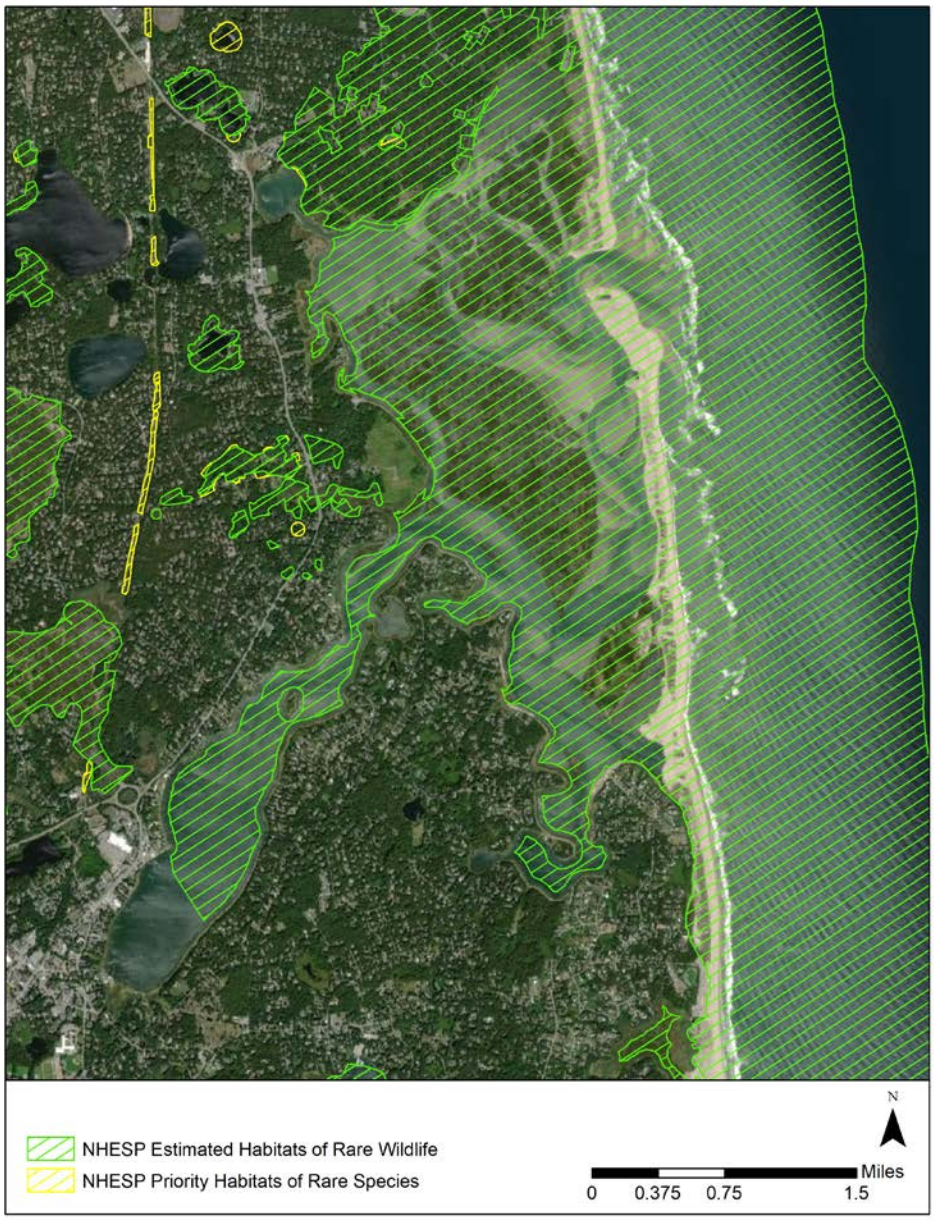

Figure D-42. National Heritage & Endangered Species Program (NHESP) estimated and priority habitats (14th Edition of the Natural Heritage Atlas).

1.10.10 Land Subject to Coastal Storm Flowage 310 CMR 10.00

Land subject to coastal storm flowage is land subject to any inundation caused by coastal storms up to and including that caused by the 100-year storm, surge of record, or storm of record, whichever is greater, and includes both V zones (velocity zones or areas of wave action), and A zones (the extent of the quantifiable 100-year coastal floodplain). Figure D-43 shows that the project area is mapped on the FEMA Flood Insurance Rate Map (FIRM) as Zones AE (elevation 10 through 14) and VE (elevation 12 through 15). As such, all areas of the project site within FEMA's AE and VE Zones are classified as land subject to coastal storm flowage, and all of the proposed work will occur within the land subject to coastal storm flowage resource area.

Figure D-43. Nauset Estuary effective FEMA flood zones and land subject to coastal storm flowage resources.

1.10.12 Bordering Vegetated Wetland 310 CMR 10.55

There are two isolated areas of bordering vegetated wetland within the project area (Figure D-28). The first is 85,192 square feet and located approximately 500 ft north of the Nauset Public Beach parking lot along the east side of Inlet Road. A second smaller BVW is located immediately north of the parking lot and adjacent coastal bank resource area. The smaller BVW is 3,254 square feet. Both areas border the costal dune resource area and are densely vegetated with Phragmites (Figure D-44).

Figure D-44. Bordering vegetated wetland near Aspinet and Inlet Roads.

1.10.11 Outstanding Resource Waters 314 CMR 4.04(3)

Portions of the project area are located within the Cape Cod National Seashore (CCNS) (Figure D-45). According to 314 CMR 4.04(3) under the Massachusetts Surface Water Quality Standards, certain waters and their tributaries, as well as wetlands and other waters are to be protected and maintained. These waters are classified by the DEP based on their socio-economic, recreational, ecological and/or aesthetic values. Table 26 of 310 CMR 4.06 lists the waters in and adjacent (within 1,000 ft seaward of mean low water) to the CCNS as Class SA outstanding resource waters. As such, all portions of the Project area within the CCNS are considered outstanding resource waters.

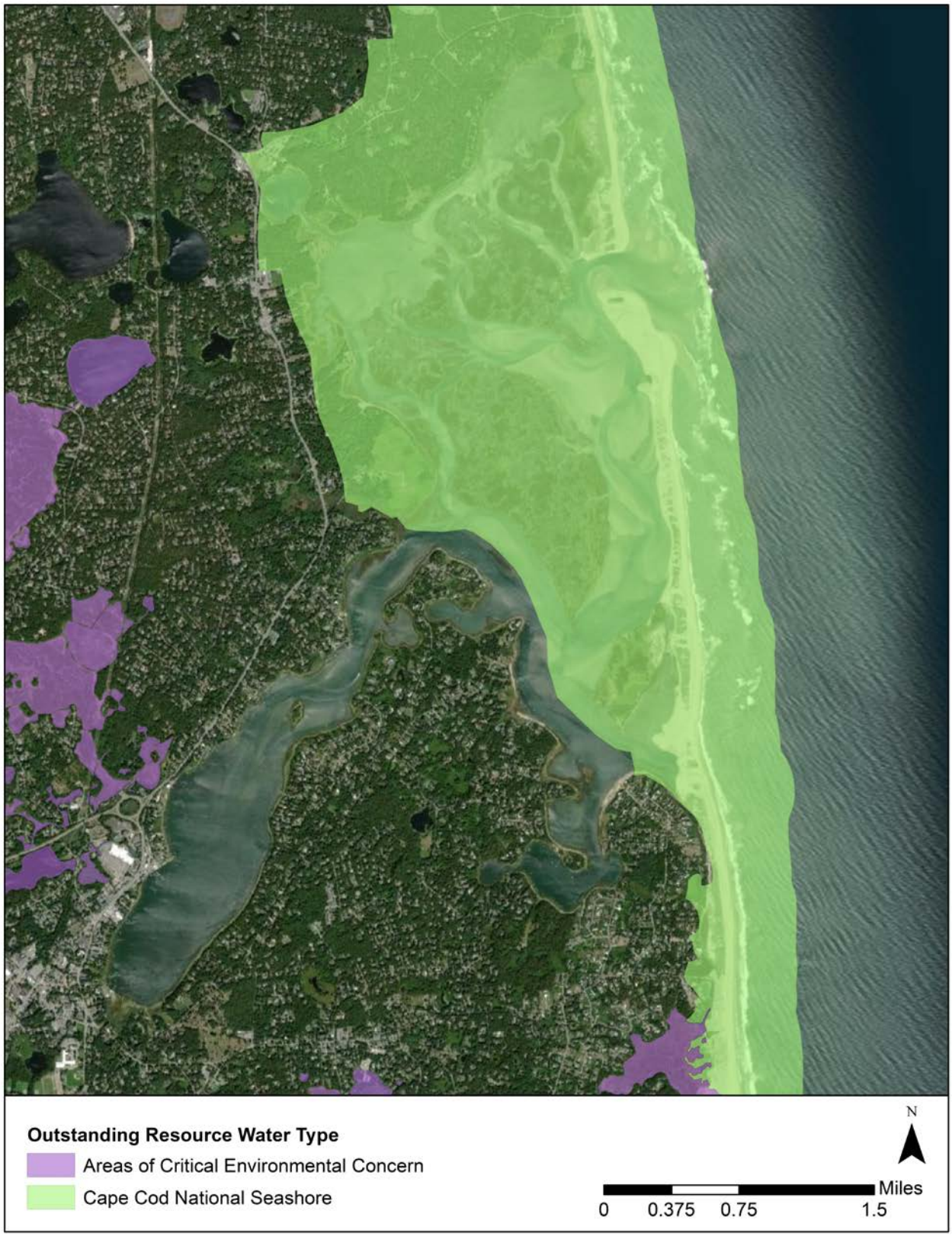

Figure D-45. Areas of the Nauset Estuary within the Cape Cod National Seashore and outstanding resource waters.

1.10.12 Essential Fish Habitat

NOAA's Essential Fish Habitat (EFH) mapper shows species with designated EFH in the Project area (Table D-10). There are also Habitat Areas of Particular Concern (HAPC) for juvenile Cod in the Project area.

Table D-10. Species with Designated Essential Fish Habitat in the Project area.

New England Management Council Species		
Atlantic Wolffish	Haddock	Winter Flounder
Little Skate	Ocean Pout	Atlantic Herring
Atlantic Cod	Pollock	Red Hake
Silver Hake	Yellowtail Flounder	Monkfish
White Hake	Windowpane Flounder	Winter Skate
Secretarial Management Species		
Albacore Tuna	Bluefin Tuna	Basking Shark
Sand Tiger Shark		
Mid-Atlantic Management Council Species		
Northern Shortfin Squid	Longfin Inshore Squid	Bluefish
Atlantic Butterfish	Spiny Dogfish	Summer Flounder
Scup	Black Sea Bass	

1.10.13 Species Protected under the Endangered Species Act

Informal consultation with NOAA regarding the proposed Project indicated the following species protected by the Endangered Species Act (ESA) in the general area.

Atlantic Large Whales - Federally endangered North Atlantic right and fin whales occur year-round off the Massachusetts coast in the Atlantic Ocean. Right whales are most likely to occur offshore between January and April and fin whales are most likely to occur between March to August. Right whales feed on copepods and could be foraging if suitable forage is present; right whales are also likely to be migrating along the Atlantic coast. Fin whale sightings off the eastern United States are centered along the 100m isobath, but fin whales are well spread out over shallower and deeper water, including submarine canyons along the shelf break. Fin whales feed on small schooling fish, squid, and crustaceans, including krill.

Sea Turtles - Four species of ESA listed threatened or endangered sea turtles under our jurisdiction are seasonally present off the Massachusetts coast in the Atlantic Ocean and could occur in Nauset Estuary: the threatened Northwest Atlantic Ocean distinct population segment (DPS) of loggerhead, the threatened North Atlantic DPS of green, and the endangered Kemp's ridley and leatherback sea turtles. Sea turtles typically occur along the New Jersey coast from May to mid-November, with the highest concentration of sea turtles present from June through October.

Atlantic Sturgeon - Atlantic sturgeon are present off the Massachusetts coast in the Atlantic Ocean and could occur in Nauset Estuary. The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPS of Atlantic sturgeon are endangered; the Gulf of Maine DPS is threatened. Adult and subadult Atlantic sturgeon originating from any of these DPSs could occur in the

proposed project area. As young remain in their natal river/estuary until approximately age 2, and early life stages are not tolerant of saline waters, no eggs, larvae, or juvenile Atlantic sturgeon will occur within the waters off the Massachusetts coast in the Atlantic Ocean or in Nauset Estuary.

Shortnose Sturgeon - Shortnose sturgeon could be present within the waters off the Massachusetts coast in the Atlantic Ocean or in Nauset Estuary. Shortnose sturgeon are listed as endangered throughout their range. As early life stages are not tolerant of saline water, no eggs, larvae, or juvenile shortnose sturgeon will occur within the saline waters off the Massachusetts coast in the Atlantic Ocean or in Nauset Estuary.

1.11 Historic and Archaeological Resources

Historic and archaeological resources are not generally known to exist in the area; however, consultation with Massachusetts Historical Commission (MHC) and the Bureau of Underwater Archeological Research (BUAR) will also be initiated as part of the regulatory process.

1.12 Previous Dredging in Nauset Estuary

Information on past dredging activities in Nauset Estuary was obtained from the Massachusetts Department of Environmental Protection (DEP) and the Division of Conservation and Recreation (DCR). A total of four (4) permits were identified with issue dates between 1924 and 1974. Table D-11 provides a summary of the relevant permit information and Figure D-46 shows the locations of the specific activities.

Table D-11. Historical Permits for Nauset Estuary Dredging and Associated Placement.

Permittee	Permitted Activities	Permit/License No.	Issue Date
Mass DPW/ Waterways	Dredging at 3 sites with placement at 4 in-harbor sites	Contract No. 97	May 24, 1924
Town of Orleans	Maintain bulkhead, piers, dredged & fill	License No. 6256	Aug. 1, 1974
Goose Hummock Shop	Maintain bulkhead, piers, dredge & fill	License No. 5853	Dec. 22, 1971
Esther & Melville Richardson	Dredge & fill	License No. 4844	Jul. 28, 1964

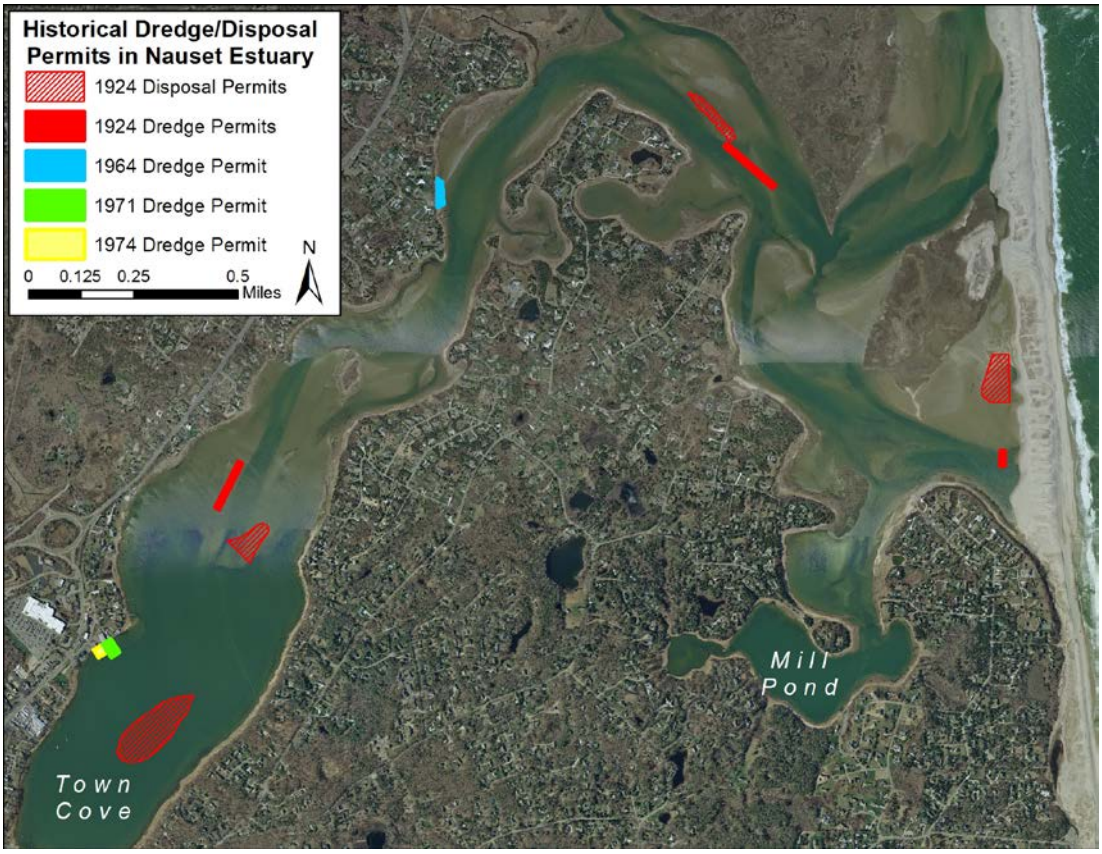

Figure D-46. Historical dredging and disposal activities in Nauset Estuary.

Section E

Alternatives Considered

E. ALTERNATIVES CONSIDERED

A range of alternatives were identified and evaluated for the Nauset Estuary dredging project (Project). The specific goal of the alternatives assessment was to identify and evaluate a number of practicable and feasible alternatives that would achieve the goals and objectives of the overall Project, while avoiding and/or minimizing short and long-term adverse impacts. This section provides a description of the alternatives that were identified and evaluated. Environmental impacts and assessment of the alternatives are discussed in Section F.

The primary goal of the project is to restore navigable waterways to Nauset Estuary and enhance public safety for both commercial and recreational boaters. Shoaling within the estuary has advanced to the point where many commercial fishing vessels can no longer operate from the shelter of Town Cove, Snow Shore Landing, and Pricilla Landing in the Towns of Orleans and Eastham, and instead are operating from exposed moorings in the center of the navigation channel south of Nauset Inlet. To achieve the Project goal, various alternatives for dredging a navigation channel within the estuary were identified and evaluated. These alternatives included different channel layouts, channel designs, and methods of dredging. Given the large volume of sediment generated by the dredging, a secondary goal of the project is to beneficially reuse as much of the dredged sediment as is feasible, either for enhanced coastal resiliency or other beneficial uses in the upland. To achieve this goal a range of alternatives for beneficial reuse of the dredged material were identified and evaluated

A total of thirty-one (31) alternatives based on four (4) key project Elements were evaluated:

- Element #1: Dredge Channel Layout – Fifteen (15) alternatives
- Element #2: Dredge Channel Width – Three (3) alternatives
- Element #3: Placement Areas for Dredged Material – Ten (10) alternatives
- Element #4: Dredge Methodology – Three (3) alternatives

1.0 Alternatives for Element #1: Dredge Channel Layout

Fifteen (15) channel layout alternatives were considered for restoring navigation in Nauset Estuary. The alternatives were developed to address improved access to town landings and mooring areas, improvements to public safety and ability to serve businesses operating in Nauset estuary.

1.1 Alternative 1-1: No dredge scenario - This alternative includes no dredging for improvements to navigation and public safety. The do nothing alternative does not alleviate shoaling problems that currently prevents commercial fishing vessels from operating from the shelter of the thirteen (13) town landings within the estuary. The no dredge alternative also does nothing to address the existing public safety hazards for commercial fishermen, recreational boaters, and emergency first responders.

1.2 Alternatives 1-2A through 1-2G: Access Between Inlet and Town Landings via Channel Behind Barrier Beach - This series of alternatives includes seven (7) channel layout options that provide access between the Orleans and Eastham town landings, areas behind the

barrier beach and the inlet (Figure E-1). Each alternative includes a dredge channel and an associated dredge zone. The dredge zone allows for adaptive management of the channel anywhere within the zone at the time of construction, to minimize the area and volume of dredging while still maintaining the navigation channel.

- Alternative 1-2A provides 32,200 ft of channel access between the inlet and public landings in Town Cove, the Priscilla Rd. and Mill Pond spur channels, and the Eastham landing at Hemenway Rd., via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 428 moorings and users of all 13 town landings.

- Alternative 1-2B provides 28,300 ft of channel access between the inlet and public landings in Town Cove, the Priscilla Rd. and Mill Pond spur channels, via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 411 moorings and users of 12 town landings.

- Alternative 1-2C provides 25,100 ft of channel access between the inlet and public landings in Town Cove, the Eastham landing at Hemenway Rd., via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 183 moorings and users of seven (7) town landings.

- Alternative 1-2D provides 21,200 ft of channel access between the inlet and public landings in Town Cove via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 166 moorings and users of six (6) town landings.

- Alternative 1-2E provides 23,100 ft of channel access between the inlet and public landings along the Priscilla Rd. and Mill Pond spur channels, and the Eastham town landing at Hemenway Rd., via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 269 moorings and users of seven (7) town landings.

- Alternative 1-2F provides 17,000 ft of channel access between the inlet and public landings along the Priscilla Rd. and Mill Pond spur channels via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 245 moorings and users of six (6) of the primary town landings.

- Alternative 1-2G provides 16,000 ft of channel access between the inlet and the Eastham town landing at Hemenway Rd. via the main channel Behind the Barrier Beach. This alternative provides improved access for boats at 24 moorings and users of one (1) town landing.

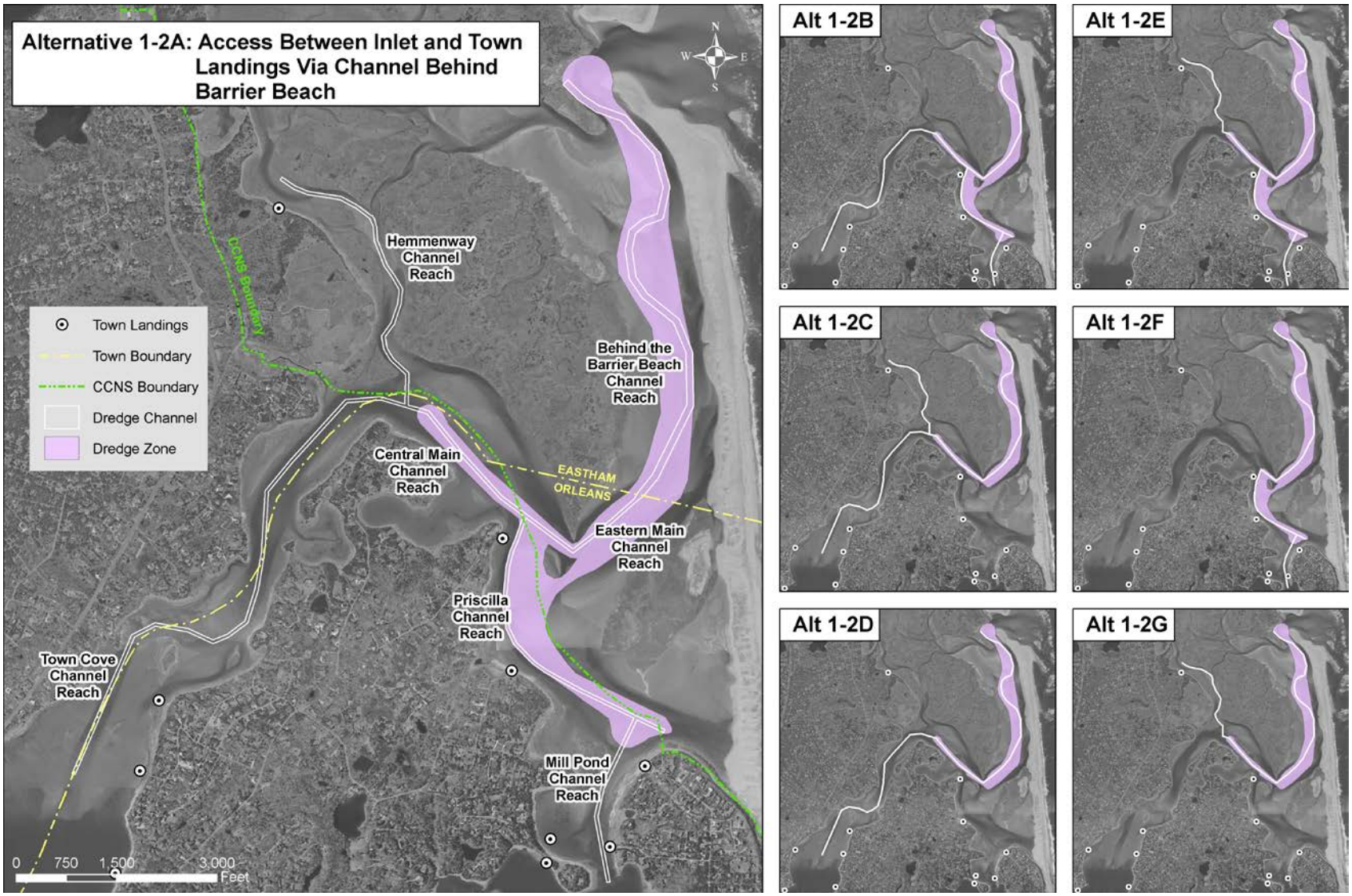

Figure E-1. Dredge channel layout alternatives 1-2A through 1-2G providing access between the inlet and town landings via a channel Behind the Barrier Beach.

1.3 Alternative 1-3: Access Between Inlet and Inner Estuary Via Channel Behind Barrier Beach - This alternative provides 7,700 ft of channel access between the inlet and the inner estuary via the main channel Behind the Barrier Beach (Figure E-2). This alternative includes a dredge channel and the associated dredge zone. The focus of this alternative is on alleviating shoaling in the channel Behind the Barrier Beach to allow safer and more efficient navigation to the inlet. Alternative 1-3 does not directly address navigation issues at the town landings or mooring areas.

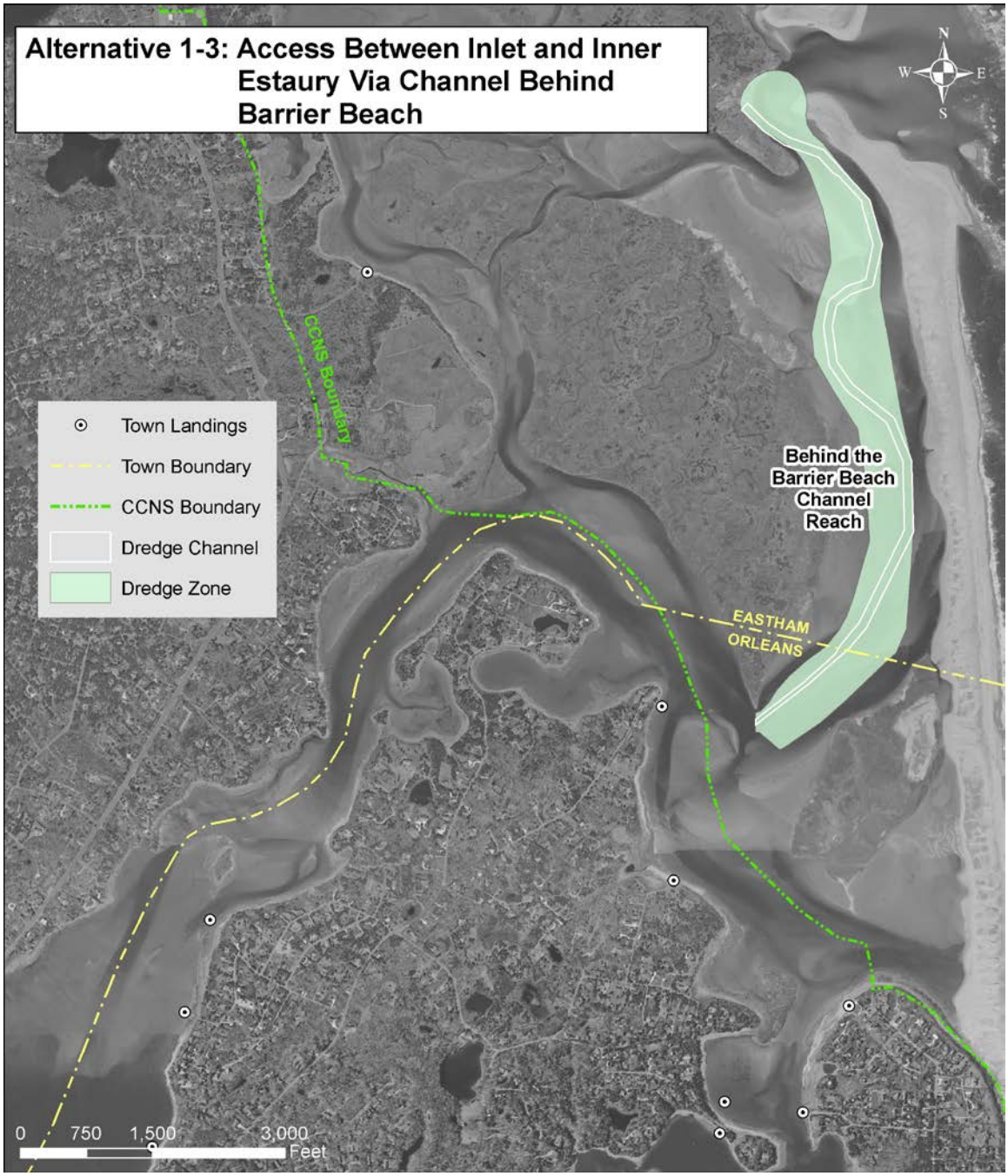

Figure E-2. Dredge channel layout alternative 1-3 providing access between the inlet and the inner estuary via the channel Behind the Barrier Beach.

1.4 Alternatives 1-4A and 1-4B: Access Between Inlet and Town Landings Via Cable Creek - This series of alternatives includes two (2) channel layout options that provide access between the Orleans and Eastham town landings and the inlet via the Cable Creek channel (Figure E-3). These alternatives include a dredge channel and the associated dredge zone.

- Alternative 1-4A provides 26,600 ft of channel access between the inlet and Orleans landings in Town Cove, the Priscilla Rd. and Mill Pond spur channels, and the Eastham landing at Hemenway Rd., via the channel through Cable Creek. This alternative provides improved access for boats at 428 moorings and users of all 13 town landings.

- Alternative 1-4B provides 17,300 ft of channel access between the inlet and Orleans landings in Town Cove and the Eastham landing at Hemenway Rd., via the channel through Cable Creek. This alternative provides improved access for boats at 176 moorings and users of seven (7) town landings.

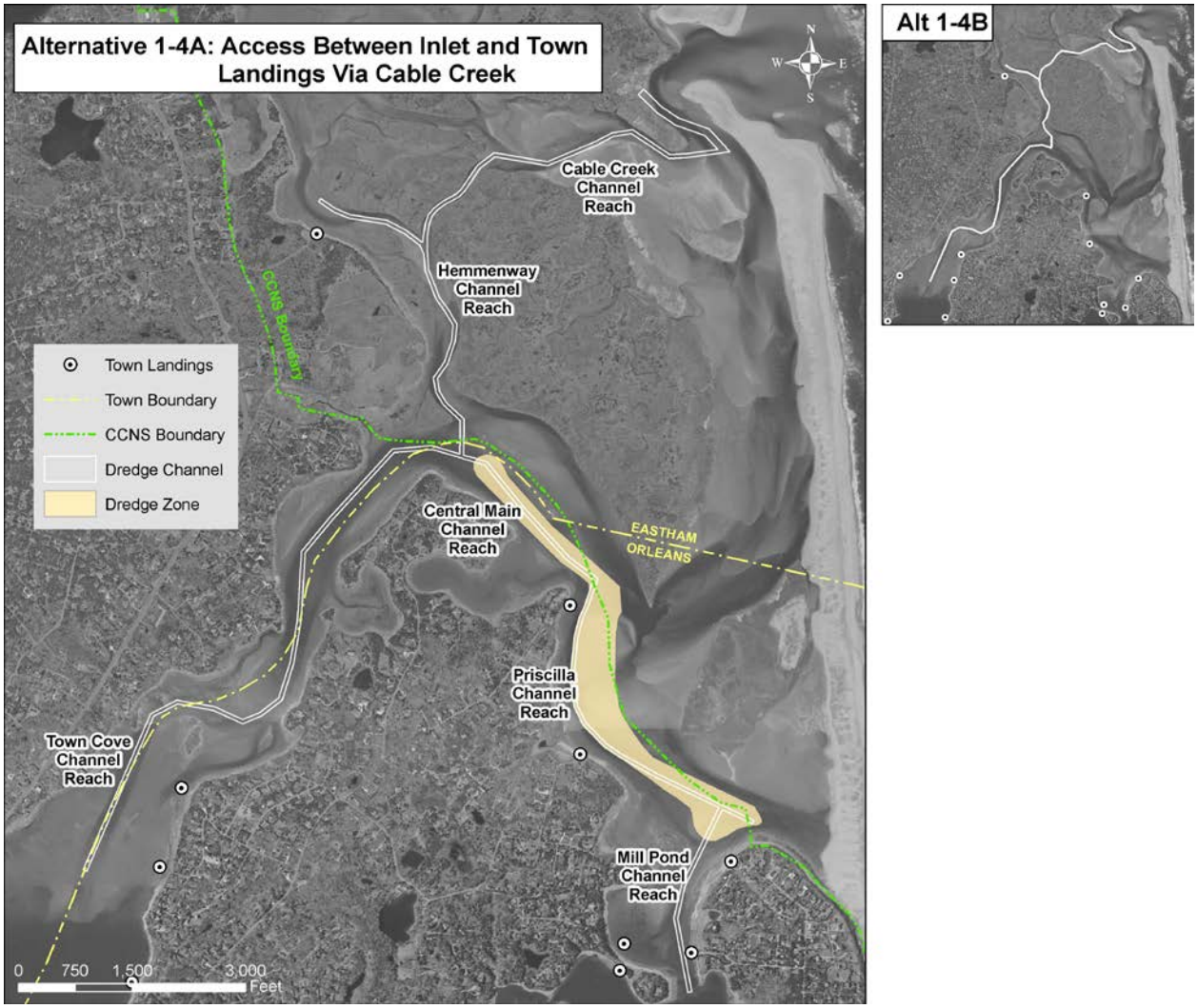

Figure E-3. Dredge channel layout alternatives 1-4A and 1-4B providing access between the inlet and the town landings via Cable Creek.

1.5 Alternatives 1-5A through 1-5D: Access Between Town Landings and Back Side of Barrier Beach - This series of alternatives includes four (4) channel layout options that provide access between the Orleans and Eastham town landings and the back side of the barrier beach just north of Tern Island (Figure E-4). This alternative includes a dredge channel and the associated dredge zone. The focus of this alternative is on alleviating shoaling within the interior estuary channels. Alternatives 1-5A through 1-5D do not directly address navigation difficulties behind the barrier beach.

- Alternative 1-5A provides 24,500 ft of channel access between the back side of the barrier beach and town landings in Orleans and Eastham. This alternative provides improved access for boats at 428 moorings and users of all 13 town landings.

- Alternative 1-5B provides 20,600 ft of channel access between the back side of the barrier beach and Orleans landings in Town Cove and the Priscilla Rd. and Mill Pond spur channels. This alternative provides improved access for boats at 411 moorings and users of 12 town landings.

- Alternative 1-5C provides 17,400 ft of channel access between the back side of the barrier beach and Orleans landing in Town Cove and the Eastham landing at Hemenway Rd. This alternative provides improved access for boats at 183 moorings and users of seven (7) town landings.

- Alternative 1-5D provides 15,400 ft of channel access between the back side of the barrier beach and Orleans landings along the Priscilla Rd. and Mill Pond spur channel and the Eastham landing at Hemenway Rd. This alternative provides improved access for boats at 269 moorings and users of seven (7) town landings.

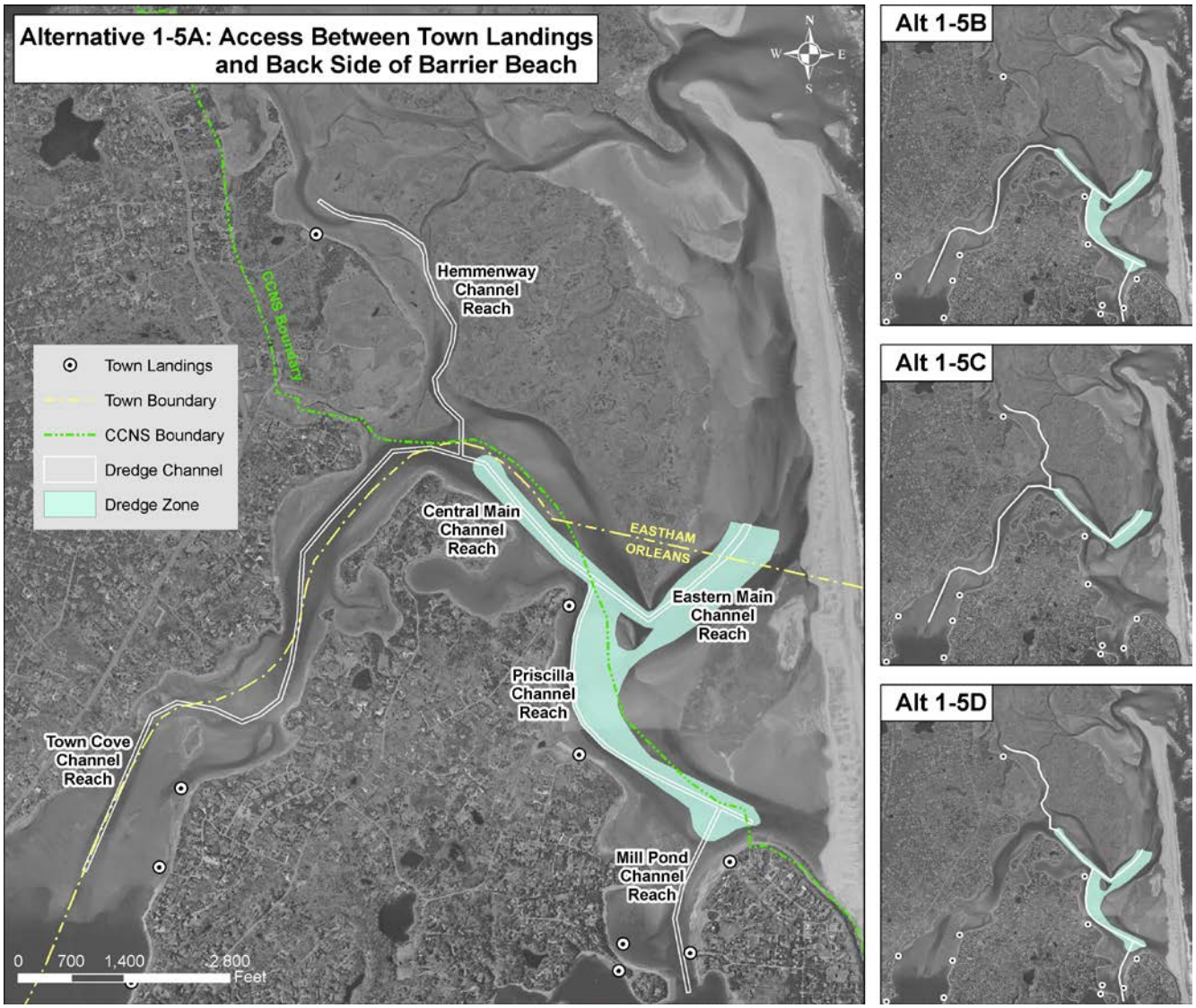

Figure E-4. **Dredge channel layout alternatives 1-5A through 1-5D providing access between the town landings and the back side of the barrier beach.**

2.0 Alternatives for Element #2: Dredge Channel Width

Three (3) channel width alternatives were considered for restoring navigation and public safety in Nauset Estuary. The alternatives were developed based on a combination of factors including safe channel width for passage of two boats, impacts to natural resources and landforms, and the expected frequency of maintenance dredging.

2.1 Alternative 2-1: 100 & 80 ft Channel Widths – This alternative includes a 100 ft wide channel between Town Cove and the inlet, and in the Priscilla spur channel. Channels leading to Hemenway Landing, Cable Creek and Mill Pond would be 80 ft wide. The wider 100 ft channel allows safe passage of boats behind the barrier beach where vessel traffic can be congested and where highly dynamic conditions result in frequent shoaling. The narrower channels leading to Hemenway Landing, Cable Creek and Mill Pond support less vessel traffic and are constrained by natural resources and landforms.

2.2 Alternative 2-2: 50 ft Channel Width – Alternative 2-2 includes a 50 ft wide channel for all dredged channel reaches in the estuary. This alternative seeks to minimize impacts to natural resources while still providing benefits to navigation and public safety. Alternative 2-2 does not focus on proactive measures that could be used to extend the longevity of the dredged channel Behind the Barrier Beach in areas where highly dynamic conditions result in frequent shoaling.

2.3 Alternative 2-3: 100 & 50 ft Channel Widths – This alternative includes a 100 ft wide channel Behind the Barrier Beach and a 50 ft wide channel for all other dredged areas in the estuary. Alternative 2-3 balances the need to provide safe navigation and public safety with protection of environmental impacts. The wider 100 ft channel allows safe passage of boats behind the barrier beach where vessel traffic can be congested and where highly dynamic conditions result in frequent shoaling and strong tidal currents. The wider channel provides safe navigation for a longer period of time than the narrower 50 ft channel. The 50 ft channels in the rest of the estuary focus on minimizing environmental impacts while still providing improvements to navigation and public safety.

3.0 Dredge Volumes Associated with Combination of Alternatives for Elements #1 and #2

The combination of alternatives considered for Elements #1 and #2 resulted in a range of potential dredge volumes. The dredge volumes were further broken into percent sand and fines based on results from the sediment sampling described in Section D.1.7. Table E-1 provides a summary of dredge volumes by sediment type for the combination of alternatives considered for Elements #1 and #2.

Table E-1. Dredge Volumes for Combined Alternatives Considered for Project Elements #1 (channel layout) and #2 (channel width).

Channel Layout Alternatives	Channel Width Alternatives								
	Alternative 2-1			Alternative 2-2			Alternative 2-3		
	Sand Volume (cy)	Fines Volume (cy)	Total Volume (cy)	Sand Volume (cy)	Fines Volume (cy)	Total Volume (cy)	Sand Volume (cy)	Fines Volume (cy)	Total Volume (cy)
1-2A	194,980	45,360	240,340	116,290	30,440	146,730	165,130	30,440	195,570
1-2B	139,970	45,360	185,330	76,280	30,440	106,720	125,120	30,440	155,560
1-2C	194,980	9,480	204,460	116,290	4,360	120,650	165,130	4,360	169,490
1-2D	139,970	9,480	149,450	76,280	4,360	80,640	125,120	4,360	129,480
1-2E	184,250	41,970	226,220	111,530	28,930	140,460	160,380	28,930	189,310
1-2F	128,080	35,880	163,960	70,980	26,080	97,060	119,820	26,080	145,900
1-2G	184,250	6,080	190,330	111,530	2,850	114,380	160,380	2,850	163,230
1-3	109,580	0	109,580	60,730	0	60,730	109,580	0	109,580
1-4A	94,990	45,360	140,350	65,730	30,440	96,170	65,730	30,440	96,170
1-4B	93,820	3,400	97,220	65,190	1,500	66,690	65,190	1,500	66,690
1-5A	85,400	45,360	130,760	55,550	30,440	85,990	55,550	30,440	85,990
1-5B	30,400	45,360	75,760	15,550	30,440	45,990	15,550	30,440	45,930
1-5C	85,400	9,480	94,880	55,550	4,360	59,910	55,550	4,360	59,910
1-5D	74,680	41,970	116,650	50,800	28,930	79,730	50,800	28,930	79,730

4.0 Alternatives for Element #3: Placement Areas for Dredged Material

Ten (10) alternatives were identified and evaluated for placement of the dredged material from Nauset Estuary. The alternatives were developed based on a combination of factors including the potential for beneficial reuse, distance to the dredge channels, permittability, sediment compatibility, placement area capacity, potential impacts to the barrier beach, potential for redistribution of red tide cysts, and impacts to protected wetland resource areas.

4.1 Alternative 3-1: Beach Nourishment on Nauset Barrier Beach – This alternative includes beach nourishment along 2,150 ft of Nauset barrier beach starting at Nauset Heights and extending north to Tern Island (Figure E-5). The nourishment would be placed on 17 acres of ocean facing shoreline within the Town of Orleans and within the boundaries of the Cape Cod National Seashore using a hydraulic cutter suction pipeline dredge. The nourishment footprint would be located on property owned by the Town of Orleans and the pipeline and construction access would cross properties owned by the US Govt, the Town of Orleans, and two (2) private properties in the Nauset Heights area. The beach nourishment template with a 100 ft wide berm at elevation 11.8 ft NAVD88 and a nearshore slope of 1V:10H, would beneficially reuse approximately 130,744 cy of clean sand. Based on sediment compatibility criteria and maximum pumping distance for the dredge, sediment removed from Behind the Barrier Beach and the Eastern Main Channel would be used for this nourishment alternative. Alternative 3-1 provides an opportunity for beneficial reuse of the dredged sediment by increasing storm damage protection for the estuary and nearby developed areas inside the estuary, and by providing additional sediment to the nearshore system.

4.2 Alternative 3-2: Beach Nourishment at Nauset Public Beach – This alternative includes beach nourishment along 1,580 ft of Nauset Public Beach starting approximately 200 ft south of the parking lot and extending 100 ft north of the parking lot (Figure E-6). The nourishment would be directly placed on 11 acres of ocean facing shoreline owned by the Town of Orleans and within the boundaries of the Cape Cod National Seashore. The nourishment footprint would be located on property owned by the Town of Orleans and the pipeline and construction access would cross properties owned by the US Govt, the Town of Orleans, and two (2) private properties in the Nauset Heights area. Using a beach nourishment template with a 100 ft wide berm at elevation 16 ft NAVD88 and a nearshore slope of 1V:10H, this alternative beneficially reuses approximately 128,460 cy of clean sand. Based on sediment compatibility criteria, material dredged from Behind the Barrier Beach and the Eastern Main Channel would be used for the nourishment at Nauset Beach. The sand would be placed directly on the beach using a hydraulic cutter suction pipeline dredge. Alternative 3-2 provides beneficial reuse of dredged sediment for the purpose of increasing storm damage protection and flood control for town-owned facilities and by providing additional sediment to the nearshore system.

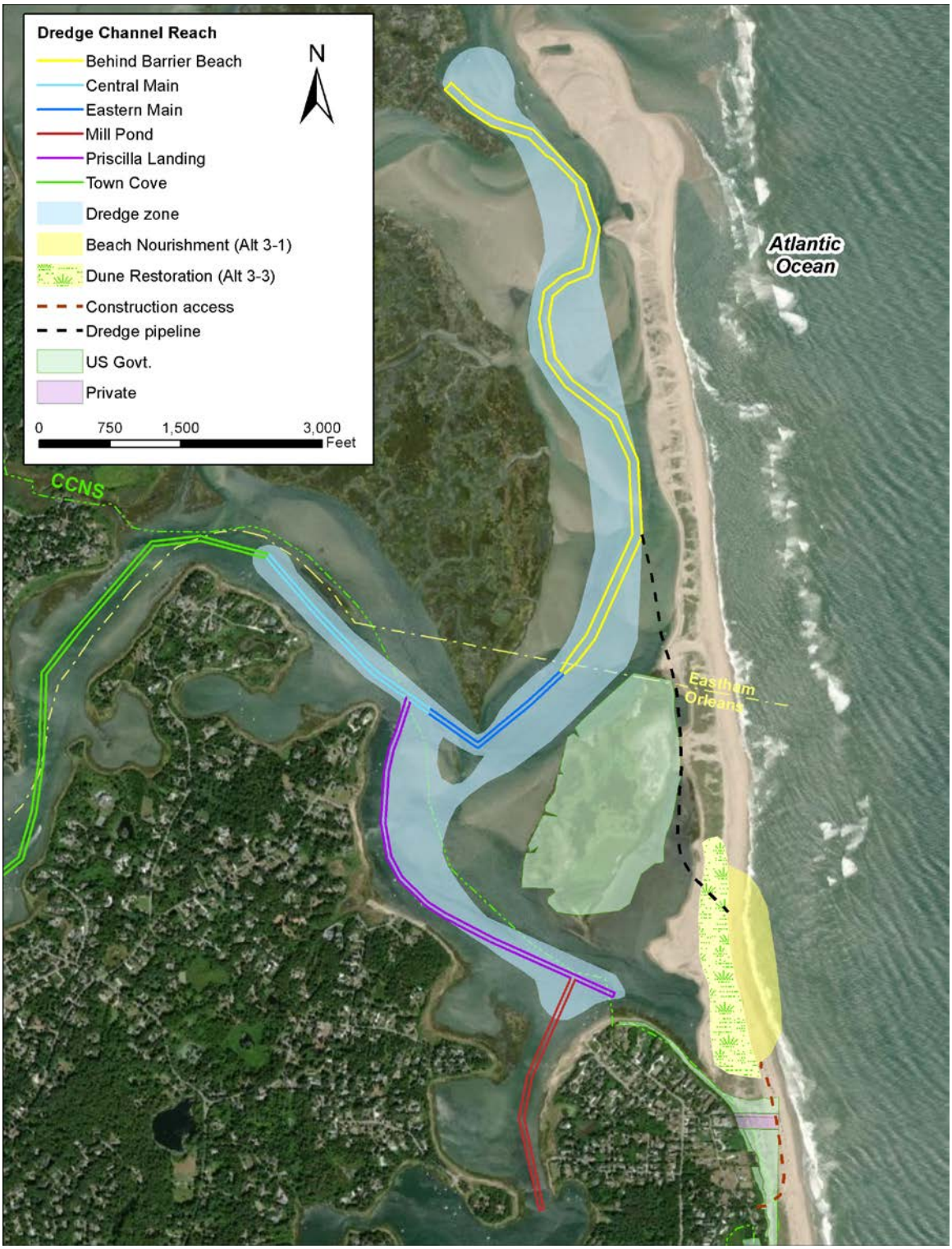

Figure E-5. **Alternatives 3-1 (beach nourishment on Nauset barrier beach) and 3-3 (dune restoration on Nauset barrier beach) for placement of material dredged from Behind the Barrier Beach and the Eastern Main Channel reaches.**

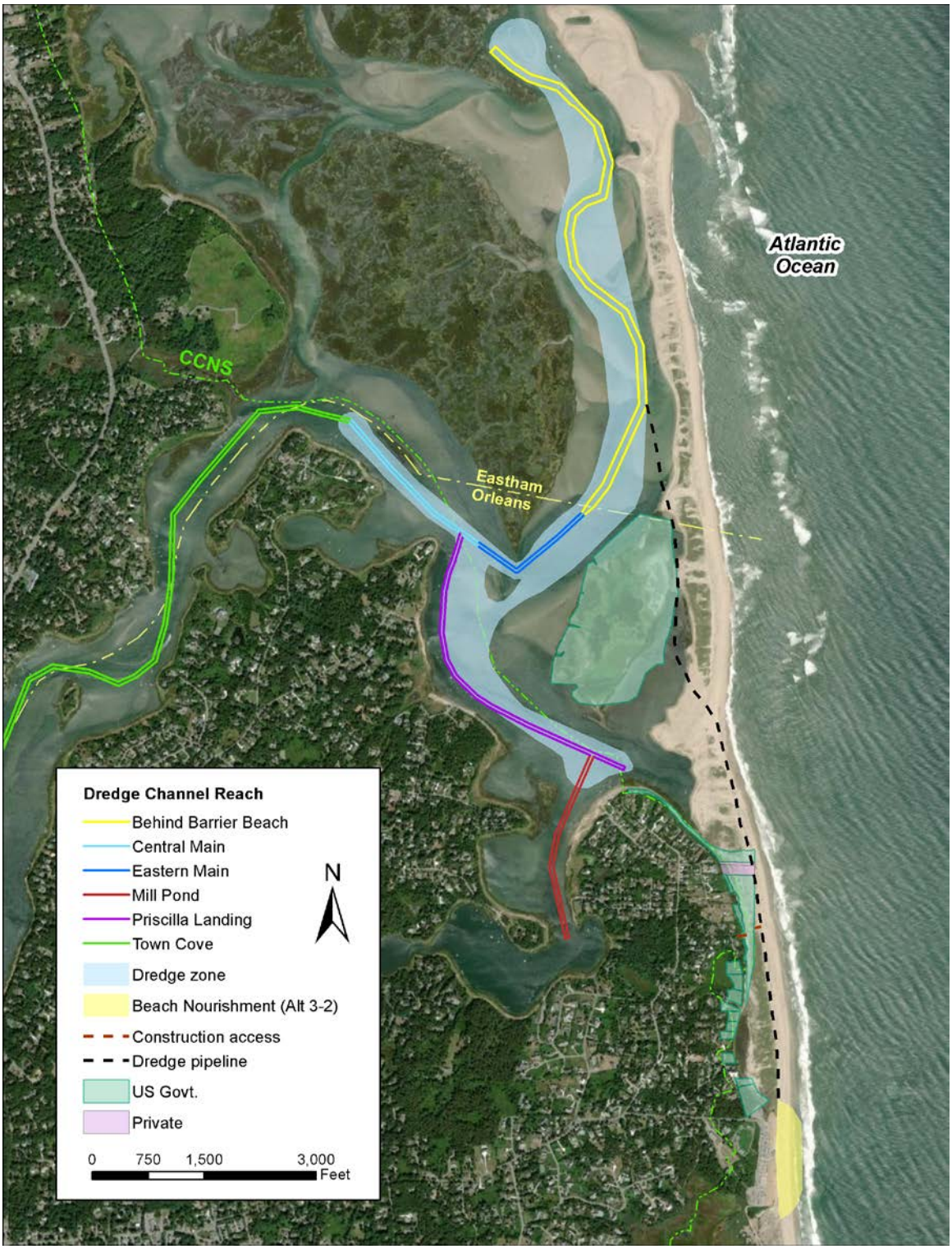

Figure E-6. **Alternative 3-2 (beach nourishment at Nauset Public Beach) for placement of material dredged from Behind the Barrier Beach and the Eastern Main Channel reaches.**

4.3 Alternative 3-3: Dune Restoration on Nauset Barrier Beach – Alternative 3-3 includes restoration of the dunes at the southern end of Nauset barrier beach in the vicinity of Nauset Heights (Figure E-5). The restoration would occur on Town of Orleans property located within the Cape Cod National Seashore using a hydraulic cutter suction pipeline dredge. The pipeline and construction access would cross properties owned by the US Govt, the Town of Orleans, and two (2) private properties in the Nauset Heights area. This alternative would restore coastal dune resources on the barrier beach that have been overwashed during past storms. The dune crest elevation (~ 20 ft NAVD88) and width of the adjacent dunes (~ 170 ft) would be carried through the overwash areas to restore approximately 19 acres of coastal dune. Alternative 3-2 could utilize up to 124,090 cy of clean sand dredged from Behind the Barrier Beach and the Eastern Main Channel. Alternative 3-3 provides an opportunity for beneficial reuse of the dredged sediment by direct placement in the dunes. This alternative would increase storm damage protection for nearby developed areas inside the estuary and by providing additional sediment to the barrier beach system.

4.4 Alternative 3-4A: Dune Enhancement at Nauset Public Beach – This alternative involves enhancement of the coastal dune at Nauset Public Beach by placing dredged material on the western side of the existing dune (Figure E-7). The work would occur along 1,225 linear ft of the Town of Orleans property located within the Cape Cod National Seashore, enhancing 3 acres of coastal dune. The pipeline and construction access would cross properties owned by the US Govt, the Town of Orleans, and two (2) private properties in the Nauset Heights area. Alternative 3-4A would advance the Town's plans for phased retreat of Nauset Public Beach by removing the seaward 2 to 3 rows of parking lot and enhancing the landward (western) edge of the dune. In 2019 the Town implemented Phase I of their retreat plan by enhancing the landward edge of the dune with approximately 27,000 cy of sand. This alternative could utilize up to 26,080 cy of clean fine-grained sand dredged from the Priscilla Rd. and Mill Pond channels. The dune design includes extending the existing dune crest elevation of 20 to 25 ft NAVD88 an additional 40 to 60 to the west. Slopes along the landward side of the dune would be at 1V:5H to meet the new edge of the parking lot.

Construction of Alternative 3-4A would involve use of a hydraulic cutter suction pipeline dredge to pump sand to a temporary dewatering basin constructed along the west side of the existing dunes. The dewatered dredge slurry would be directed to the Atlantic Ocean via a drainpipe installed under the existing dune. Front end loaders would be used to regrade the dewatered sand to the dune design specifications. Alternative 3-4A provides an opportunity for beneficial reuse of dredged material from Nauset Estuary for storm damage protection of public infrastructure via dune enhancement at Nauset Public Beach.

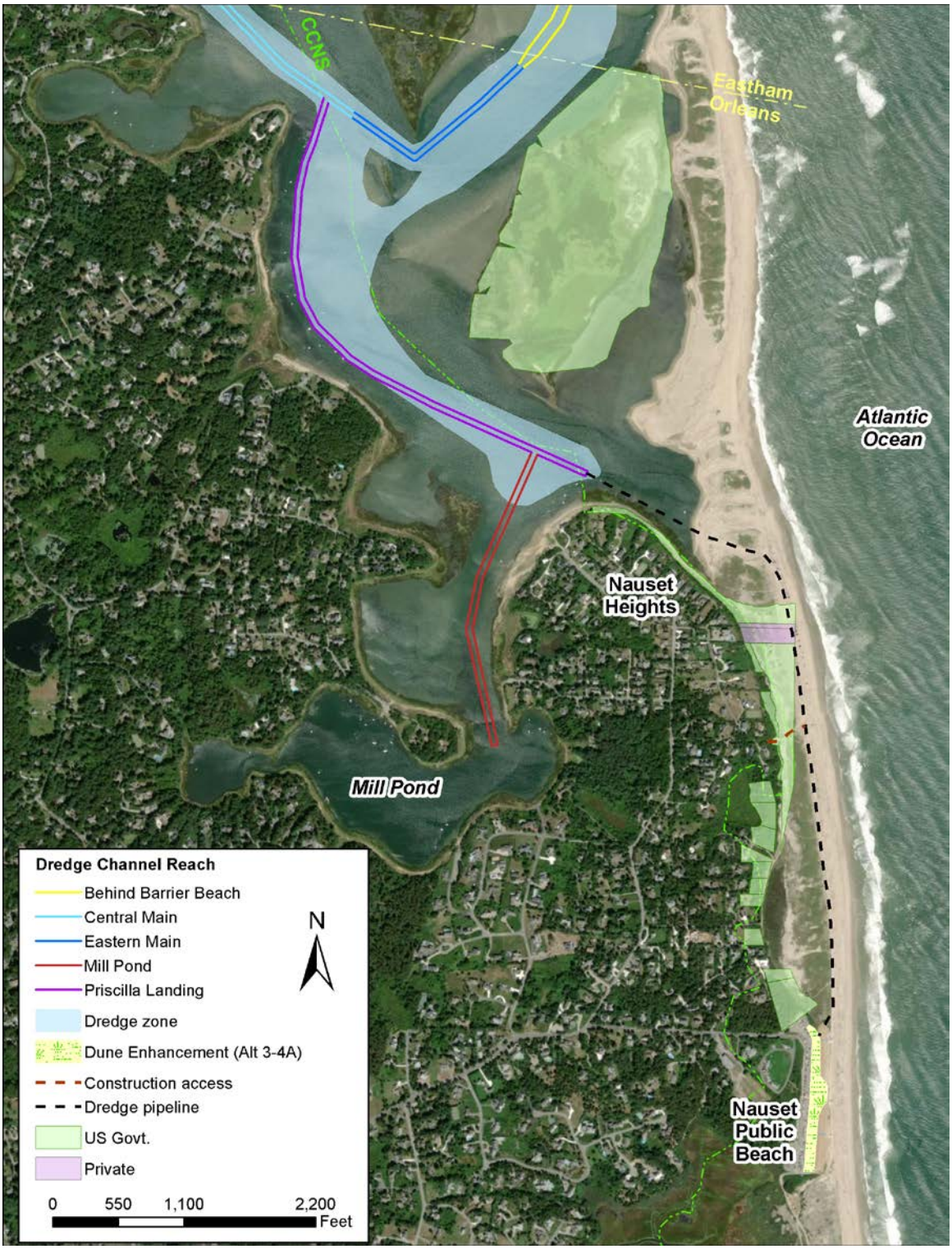

Figure E-7. Alternative 3-4A (dune enhancement at Nauset Public Beach) for placement of material dredged from the Priscilla Rd. and Mill Pond spur channels.

4.5 Alternative 3-4B: Dune Enhancement North of Nauset Public Beach – This alternative involves enhancement of the coastal dune north of Nauset Public Beach by placing dredged material on the western side of the existing dune (Figure E-8). The work would occur along 1,650 linear ft of the Town of Orleans property located within the Cape Cod National Seashore, enhancing 6.8 acres of coastal dune. The pipeline and construction access would cross properties owned by the US Govt, the Town of Orleans, and two (2) private properties in the Nauset Heights area. This alternative could utilize up to 26,080 cy of clean fine-grained sand dredged from the Priscilla Rd. and Mill Pond channels. The dune design includes the addition of a secondary dune feature located west of the primary dune.

Construction of Alternative 3-4B will involve use of a hydraulic cutter suction pipeline dredge to pump sand to a temporary dewatering basin constructed along the west side of the existing dunes. The bottom of the basin will be excavated to an elevation of 3.3 ft NAVD88 over an area of 2.4 acres. Sand excavated from the dunes to create the dewatering basin will be used to build containment berms around the north, south and west sides of the basin. The berms will be built to elevation 17 ft NAVD88 with a crest width of 35 to 40 ft and side slopes of 1V:3H. The existing dune with a crest elevation of 20 ft NAVD88 will form the eastern side of the basin. With the berms included, the basin footprint will cover 6.8 acres. Approximately 22,000 cy of dune material, not needed for berm construction, will be temporarily removed to the northern end of the dune and the Nauset Beach parking lot.

The pipeline between the dredge and the dewatering basin will extend across one of the overwash features in the barrier beach just north of Nauset Heights. From this point the pipeline will follow along the toe of the coastal dune south to Callanan's Pass where it will cross to the landward side of the dune and follow an existing path to the dewatering basin located just north of the Nauset Public Beach parking lot. The total length of pipeline over the beach and dune resources is estimated to be 3,185 linear feet. Two booster pumps will be needed to pump the material from the dredge to the dewatering basin. One pump will be located on a barge anchored offshore of Priscilla Rd. landing and the second pump will be located at the base of the dunes near Callanan's Pass.

The dredged material will be pumped as a slurry of water and sediment to the dewatering basin. Sediment in suspension in the slurry will settle to the bottom of the dewatering basin near the end of the discharge pipe and the water will drain out to the ocean via drainpipes installed under the existing dunes.

Once the dredging is complete and the sediments have dewatered, grades across the dewatering basin will be restored to their pre-existing conditions using material from the temporary berms and the excess material stored at the northern end of the dune and the Nauset Beach parking lot. A portion of the western berm will be regraded to form a secondary dune with a crest elevation of 17 ft NAVD88 and crest width of approximately 10 ft. The dredged sediment and secondary dune added to this area of the site will help to build resiliency to the coastal dune against future impacts of sea level rise and wave-induced erosion. The project will result in an excess of 12,000 cy of dune sand, originally excavated to form the dewatering basin and temporarily stored at the north end of the Nauset Beach parking lot.

Depending on needs at the public beach, the excess sand will either be used for the currently permitted dune enhancement as part of the Town's phased retreat from Nauset Public Beach or taken offsite for beneficial reuse at other permitted resiliency projects.

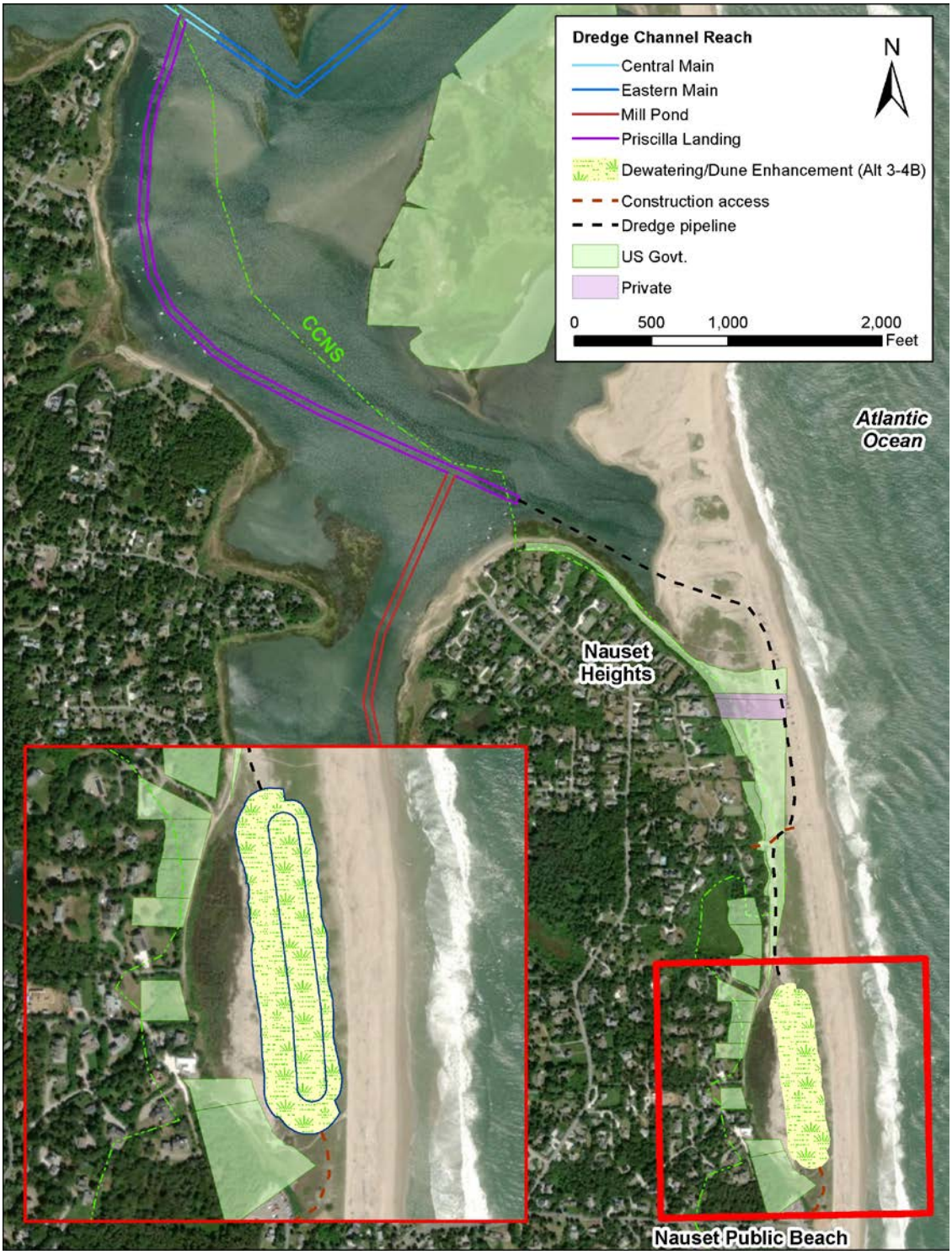

Figure E-8. Alternative 3-4B (dune enhancement north of Nauset Public Beach) for placement of material dredged from the Priscilla Rd. and Mill Pond spur channels.

4.6 Alternative 3-5: Land Under the Ocean Adjacent to Dredged Channel – This alternative includes sidecasting the dredged material into the estuary over a 60 to 80 ft wide area adjacent to the dredged channel (Figure E-9). All work would take place in waters of the estuary and no work would occur on the nearby beaches, dunes, barrier beach, or salt marsh. Alternative 3-5 would occur within the Towns of Orleans and Eastham and a portion of the alternative would occur within the Cape Cod National Seashore. This alternative would be constructed using a hydraulic cutter suction sidecast dredge. Up to 119,830 cy of sandy material from channel reaches Behind the Barrier Beach and the Eastern Main Channel would be sidecast to a 60 to 80 ft wide area west of the dredged channel. Alternative 3-5 provides a practical method for maintaining the navigation channel Behind the Barrier Beach and Eastern Main Channel reaches. Aside from placement Alternatives 3-1 and 3-3, the channel reaches Behind the Barrier Beach and Eastern Main channel are not proximal to other potential placement sites.

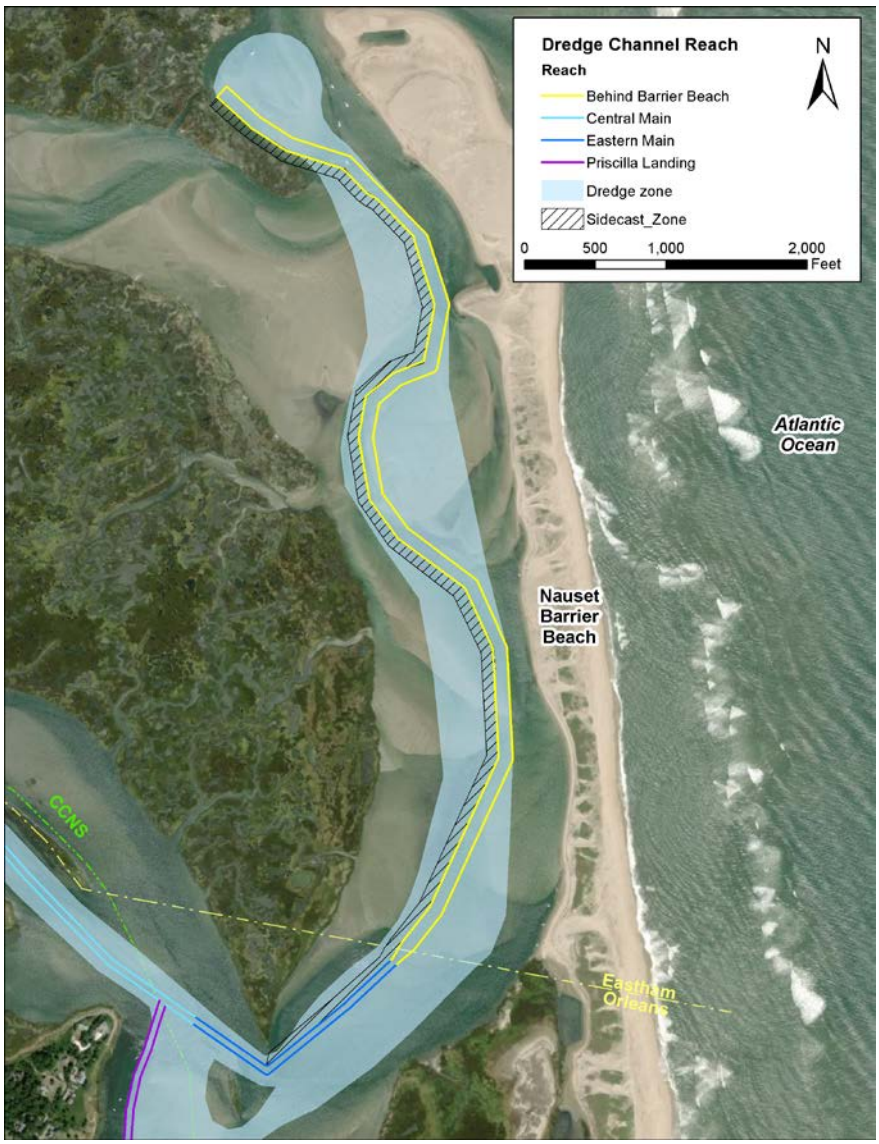

Figure E-9. Alternative 3-5 (sidecast adjacent to channel) for placement of material dredged from Behind the Barrier Beach and the Eastern Main Channel.

4.7 Alternative 3-6: Subaqueous Placement – Subaqueous placement of dredged material was considered as an alternative at the conceptual level. This alternative involves spreading sandy dredge material over the bottom sediments in discreate areas of the distal ponds in Nauset Estuary, thereby burying *Alexandrium* cysts that can lead to harmful algal blooms. Sandy dredged material from Behind the Barrier Beach and the Eastern Main Channel, that contain very few *Alexandrium* cysts, would be used to spread a thin 1 to 1.5 inch thick layer of sand across 17 acres of seafloor in Town Cove and Mill Pond in areas that have particularly high concentrations of *Alexandrium* cysts. If this were done in the late winter, just before the time when the cysts begin germinating, the inoculum for the upcoming algal bloom could be substantially reduced. Not only would the sediments quickly become anoxic below the sand layer which would inhibit germination, but the sandy sediment would make it very difficult for cells that do germinate to successfully swim to the overlying water column. This placement alternative is considered experimental at this point and would accommodate only a small fraction (~11,975 cy) of dredged material from Nauset Estuary.

4.8 Alternative 3-7: Salt Marsh Restoration – This alternative involves the use of dredged sediment to restore salt marsh resources in Nauset Estuary via a technique known as thin layer deposition. The intent is to add a thin layer of sediment to salt marsh areas to help the resource keep pace with rising sea levels. Thin layer deposition has not been applied as a resiliency building tool in Massachusetts, although it has been demonstrated to be a successful beneficial reuse of dredged material in other states throughout the U.S. Assuming thin layer deposition of 4 inches of dredged sediment across the large salt marsh resource in the center of Nauset Estuary, it would be possible to use up to 108,410 cy of material dredged from Behind the Barrier Beach, and the Central and Eastern Main Channels for restoration of the salt marsh. Alternative 3-7 would require placement of the dredged material on salt marsh resources within the Cape Cod National Seashore on property owned by the US Govt.

4.9 Alternative 3-8: Beach Nourishment at Nauset Estuary Shorelines – This alternative includes beach nourishment along 2,450 ft of shoreline inside Nauset Estuary. As most shorelines in the estuary contain salt marsh resources, this alternative targeted the only sandy beach shorelines in the estuary without nearby eelgrass resources. The nourishment would be directly placed on 2.5 acres of estuary shoreline on seven (7) private properties off Freeman Lane, and in the vicinity of Priscilla Landing on five (5) private properties and one Town of Orleans property. Assuming a beach nourishment template with 2.5 cubic yards per linear ft of beach, this alternative would take 4,900 cy of material dredged from Behind the Barrier Beach, and the Central and Eastern Main Channels. The sand would be placed directly on the beach using a hydraulic cutter suction pipeline dredge. Alternative 3-8 provides beneficial reuse of dredged sediment for the purpose of increasing storm damage protection and flood control for private and town-owned properties inside the estuary by providing additional sediment to the nearshore system. This alternative would require permission from the property owners.

4.10 Alternative 3-9: Upland Stockpile/Beneficial Reuse – Alternative 3-9 involves temporary stockpiling at an upland site and subsequent beneficial reuse of the dredged material at previously permitted sites. In Nauset Estuary this alternative would require the use

of mechanical equipment to place dredged sediment into barges that would then be transported to the Goose Hummock town landing for offloading to waiting trucks. The material would then be trucked to temporary upland stockpile locations in the Towns of Orleans and/or Eastham to be used later for permitted coastal resiliency projects. Alternatively, the material could be trucked directly to permitted beneficial reuse sites in the upland. Alternative 3-9 would be used for the beneficial reuse of 9,660 cy of sediment dredged from the Town Cove and Central Main Channel reaches of Nauset Estuary.

5.0 Alternatives for Element #4: Dredge Methodology

Three (3) different dredge methodology alternatives were considered for constructing the Nauset Estuary project. The alternatives were selected based on the different channel layouts (Alternatives 1-2 through 1-5), possible placement alternatives (Alternatives 3-1 through 3-8), and equipment limitations. Given the extensive size of the Project area and the potential to use multiple placement sites, it is possible that a combination of dredge methods could be utilized effectively.

5.1 Alternative 4-1: Hydraulic Cutter Suction Pipeline Dredge – This alternative involves the use of a hydraulic cutter suction pipeline dredge, like that operated by the Barnstable County Dredge program. This type of dredge uses a rotating cutter head attached to the end of a suction pipe to agitate material on the seafloor which creates a slurry of water, sand, and fine-grained material. The slurry is pumped through a dredge pipeline which extends to a dewatering site. At the dewatering site, the dredged material falls out of the slurry solution, accumulates, and is managed by excavation and/or loading equipment. In cases where the dredged material is sandy and can be pumped directly to a beach for nourishment purposes, the dredge slurry of seawater and fine-grained material flows from the beach back into the adjacent waterbody. In other cases where the dredged material is not suitable for beach nourishment (> 10% fines passing the #200 sieve), the slurry can be pumped to a dewatering basin where the fine-grained sediments settle at one end of the basin and seawater from the dredge slurry drains to the adjacent waterbody via drainpipes, or naturally percolates downward through the sediments. Once the sediments have dewatered, they can be trucked to other approved sites or an upland stockpile for later beneficial reuse. In some cases, they can also be left on site for added coastal resiliency.

Small-scale hydraulic cutter suction dredges like those operated by the Barnstable County Dredge program can pump sandy sediments up to 3,500 linear ft at an average of 200-400 cy/hr under ideal circumstances and optimized conditions. Pumping distances greater than 3,500 linear ft require the use of in-line booster pump(s). By adding one booster the pump distance can be increased to 7,000 linear ft, and by adding a second booster to the pipeline the pump distance can be extended to 10,500 linear ft. Hydraulic cutter suction dredges are limited by the availability of suitable dewatering sites located within close proximity of the dredge site. For dewatering sites with longer pumping distances the operations are also limited by suitable locations to stage the booster pump(s).

For the Nauset Estuary dredging project Alternative 4-1 was considered as a method for dredging channel areas Behind the Barrier Beach and the Eastern Main Channel, Priscilla Rd.

and Mill Pond reaches. From these channel reaches, placement alternatives on Nauset barrier beach (Alternatives 3-1 and 3-3) and in the vicinity of Nauset Public Beach (Alternatives 3-2, 3-4A, and 3-4B) were considered.

5.2 Alternative 4-2: Sidecast Dredge – Alternative 4-2 involves the use of a hydraulic cutter suction dredge equipped with a sidecast diffuser to broadcast (side cast) the dredged material to a zone adjacent to the channel (Alternative 3-5). This type of dredge uses a rotating cutter head attached to the end of a suction pipe to agitate material on the seafloor which creates a slurry of water, sand, and fine-grained material which is then sidecast to a zone approximately 60 to 80 ft wide along the side of the dredged channel. Sidecast dredge plants are typically used in small inlets and harbors where swift currents can make it difficult for conventional hydraulic cutter pipeline dredge plants to operate due to dangerous and unpredictable conditions. For the Nauset Estuary Dredging Project, this alternative was considered for channel areas Behind the Barrier Beach and the Eastern Main Channel reach where tidal current velocities are high and viable placement alternatives are limited.

5.3 Alternative 4-3: Mechanical Dredge – This alternative involves the use of mechanical dredging equipment to excavate material from the channel. A mechanical, or bucket dredge operates using a clamshell bucket attached to a crane or a large excavator located on the dredge superstructure. Material is excavated from the seafloor and loaded into waiting scows or containers staged on a barge. Production rates vary based on the size of the superstructure, capacity of the bucket, and capacity of the scow or container. Once the scow or containers have been filled, the material must then be transported and offloaded for upland stockpiling, disposal or use at a beneficial reuse site. For the Nauset Estuary Project this alternative was considered for channel areas in Town Cove and the Central Main Channel reaches. These sections of channel are too far from the barrier beach and Nauset Public Beach for use of a hydraulic cutter suction pipeline dredge. From these channel reaches, materials offloading at Goose Hummock town landing was considered with placement at an upland stockpile or upland beneficial reuse site (Alternative 3-10).

Section F

Assessment of Impacts & Selection of Preferred Alternative

F. ASSESSMENT OF IMPACTS AND SELECTION OF PREFERRED ALTERNATIVE

Environmental impacts associated with the range of alternatives considered for this Project are discussed in this section. Both the potential adverse impacts and benefits to the environment from the various alternatives are addressed. Although environmental impacts are unavoidable, the project design has focused on minimizing potential adverse impacts, while achieving project objectives. Improvements to navigation and public safety in Nauset Estuary will have benefits to commercial and recreational boaters, business owners in the community, and to the economies of the Towns of Orleans and Eastham.

1.0 Alternatives for Element #1: Dredge Channel Layout

Fifteen (15) channel layout alternatives were considered for restoring navigation in Nauset Estuary. Identification of a preferred alternative for the channel layout was based on eleven (11) selection criteria which address logistics, benefits, and potential environmental impacts. The channel layout alternatives were assigned scores for each selection criteria and a total overall score was then determined for each alternative (Table F-1). The scoring rationale for each criterion is described below.

1.1 Cost of Dredging

Explanation: The cost for dredging varies depending on method, and the method used is dependent on the location and conditions of each channel reach of Nauset Estuary. The costs per cubic yard of dredging were calculated for each dredge method:

1) Sidecast: $26/cy
2) Mechanical: $50/cy
3) Hydraulic Pipeline: $34/cy

These rates also include mobilization, demobilization, labor, maintenance, repairs, fuel, equipment rental, shoreside transportation of equipment to site, depreciation on equipment, mileage, and post-dredge surveys. These rates do not include operation of the dewatering basin that would be required for the Priscilla Rd. and Mill Pond channel reaches. This criterion considers a weighted average of the per-cubic-yard-cost for each alternative based on 1) which portions of the estuary will be dredged under each alternative, 2) which dredge method is required in each section, and 3) the volume of sediment to be dredged from each area. This allowed the average estimated dredging cost to be compared across alternatives.

Scoring Categories:
5: <$30/cy
3: $30-$35/cy
1: >$35/cy

1.2 Frequency of Maintenance Dredging:

Explanation: This criterion is a qualitative assessment of how frequently the dredge footprint for each alternative would need to be maintained. Due to the dynamic nature of the inlet, the area immediately behind the barrier beach would likely require more frequent maintenance (assumed to be annually), while inner portions of the estuary would likely require less frequent maintenance (every 8 to 15 years depending on location).

Scoring Categories:
5: Low frequency maintenance
3: Alternative includes areas of both Low and High frequency maintenance
1: High frequency maintenance

1.3 Permittability:

Explanation: This criterion evaluates the permittability of each alternative. Although some level of permitting would be required for all alternatives, some alternatives involve dredging in areas of the estuary that would require additional permits or that would be subject to additional regulations (e.g., NEPA, compliance with additional ORW regulations, etc.). For areas within the Cape Cod National Seashore, not only would a NEPA review be required, but it would also be necessary to demonstrate that navigation has been impaired by natural migration of the inlet and barrier beach to comply with the Outstanding Resource Water (ORW) regulations. Overcoming this presumption will be easier for some areas within the CCNS than for others. For example, it will be harder for areas within Hemenway channel and Cable Creek, which are further from the inlet and its effects.

Scoring Categories:
5: Entire alternative is outside the CCNS; No NEPA permit required; No ORW restrictions
4: NEPA permit required; ORW regulations apply, but could possibly be overcome
0: NEPA permit required; ORW restrictions apply, and are likely to preclude portions of footprint

1.4 Improved Access to Landings & Mooring Areas:

Explanation: This criterion addresses the potential improved access to landings and moorings within Nauset Estuary. The 13 landings considered for this comparison include Goose Hummock, Cove Road, Asa's Landing, Gibson Road (a & b), Collins Landing, Tonset Road, Priscilla, Snow Shore, Doane Road, Mill Pond, Robert's Cove and Hemenway. Mooring fields in the Town Cove area (Asa's, Collins Landing, Cove Road, Gibson Road (a & b), Goose Hummock, Prides Path, Rachel's Cove, Snow Point, Town Cove and Yacht Club – a total of 159 moorings), the Priscilla area (Nauset Heights, Priscilla, Snow Shore and Tonset – a total of 174 moorings), the Central Main Channel area (Stoney Island and Woods Cove – a total of 7 moorings), the Mill Pond area (Doane

Road, Mill Pond, Robert's Cove and Sheeps Pasture Point – a total of 71 moorings), and the Hemenway area (17 moorings), as well as the inlet mooring area, were also factored into this comparison. Higher scores were given to alternatives that serviced a greater number of these mooring fields and landings.

Scoring Categories:

10: >400 + inlet moorings, 12 or 13 landings, and improved navigation behind the barrier beach

8: >175 + inlet moorings, 6 or 7 landings, and improved navigation behind the barrier beach

6: >400 moorings and 12 or 13 landings, but no inlet moorings and no improved navigation behind barrier beach

3: >175 moorings and 6 or 7 landings, but no inlet moorings and no improved navigation behind barrier beach

1: <175 moorings, 6 or less landings, may or may not include improved navigation behind barrier beach and/or access to inlet moorings

1.5 Improvements to Safety:

Explanation: This criterion evaluates each alternative's ability to improve safety throughout Nauset Estuary. Benefits to safety could be achieved through increasing safe navigation behind the barrier beach and improving emergency access for water-based response by municipal officials in Orleans and Eastham. Emergency response from Orleans was assumed to be improved if access to the main launching area in Town Cove is enhanced, while emergency response from Eastham was assumed to be improved if access to the main launching area at Hemenway is enhanced.

Scoring Categories:

10: Emergency response from both Towns enhanced, and safety behind the barrier beach is improved

8: Emergency response from one Town enhanced, and safety behind the barrier beach is improved

5: Safety behind the barrier beach is improved OR Emergency response from both Towns is enhanced

1: Emergency response from one Town enhanced but no improvements behind the barrier beach are made

1.6 Businesses Served:

Explanation: This criterion evaluates each alternative's ability to improve access to and from marine-dependent businesses that rely on the ability of their customers to safely navigate the estuary and travel to and from the inlet. There is one main marine-dependent businesses located in Town Cove (Goose Hummock), as well as numerous commercial fishermen that utilize the estuary.

Scoring Categories:

10: Direct business access improvements and improved access behind the barrier beach
7: Direct business access improvements but no improved access behind the barrier beach
4: Indirect business access improvements through improved access behind barrier beach
1: No business access improvements

1.7 Potential Impacts to Eelgrass:

Explanation: This criterion evaluates each alternative's potential impact to existing eelgrass resources. Although none of the alternatives directly overlaps with mapped eelgrass beds, the further away the proposed dredge footprint is from existing eelgrass resources, the less likely it will be to cause adverse impacts.

Scoring Categories:
5: All portions of the dredge footprint are >50' from mapped eelgrass beds
4: Some portions of the dredge footprint are <50' from mapped eelgrass beds

1.8 Potential Impacts to Shellfish:

Explanation: This criterion evaluates each alternative's potential impact to existing shellfish resources. Based on shellfish surveys conducted on September 16 and 17, 2019, areas of shellfish presence and quantities of different various shellfish species have been identified. Alternatives that avoid areas of high-density shellfish populations are ranked higher for this criterion than those that do not. Because the Mill Pond, Hemenway and Cable Creek channel sections were not directly surveyed for shellfish populations, the shellfish densities in these locations are unknown. As a conservative measure, alternatives that contain these channel sections were scored with a lower ranking category for this criterion.

Scoring Categories:
5: Overlaps only with areas of low shellfish densities (<5 shellfish/ft^3)
4: Overlaps with areas of moderate shellfish densities (5-10 shellfish/ft^3)
2: Areas of unknown shellfish densities
1: Overlaps with areas of high shellfish densities (>10 shellfish/ft^3)

1.9 Potential Impacts to Salt Marsh:

Explanation: This criterion evaluates each alternative's potential impact to existing salt marsh resources. Although none of the alternatives directly overlaps with mapped salt marsh areas, the further away the proposed dredge footprint is from existing eelgrass resources, the less likely it will be to cause adverse impacts.

Scoring Categories:
5: > Greatest distance from salt marsh resources

4: Intermediate distance from salt marsh resources
0: Within close proximity to salt marsh resources (unlikely to be permittable)

1.10 Impacts to Intertidal Areas:

Explanation: This criterion addresses the potential for dredging activities to directly impact intertidal areas, which can serve as important foraging areas for shorebirds during low tide. Alternatives that do not impact intertidal areas are ranked higher for this criterion than those that do.

Scoring Categories:
5: No impacts to intertidal areas
1: Direct impacts to intertidal areas

1.11 Potential for Barrier Beach Impacts:

Explanation: This criterion addresses the potential for dredging activities to weaken the barrier beach. The assumption is that dredging activities immediately behind the barrier beach, and to a lesser extent, dredging activities at the southern end of the Priscilla Rd. channel could increase the likelihood of a human-induced breach in the barrier beach. Alternatives were qualitatively scored for their potential to adversely impact the stability of the barrier beach. This criterion was retained as a conservative measure, since a "no dredge zone" is being proposed 100 ft west of the barrier beach to mitigate any potential adverse impacts by not extending the dredge zone too close to the barrier beach.

Scoring Categories:
3: Low
2: Med
1: High

Scoring for the channel layout alternatives identified the highest overall score for Alternative 1-2B which provides access between the inlet and public landings in Town Cove and the Priscilla Rd. and Mill Pond spur channels, via the main channel behind the barrier beach. Therefore Alternative 1-2B was selected as the preferred channel layout.

Table F-1. Selection Criteria and Overall Scoring for Element #1: Channel Layout Alternatives.

	Logistics						Benefits						Impacts										
Alternatives	**Average Cost of Dredging per CY**		**Frequency of Maintenance Dredging**		**Permittability**		**Improved Access to Landings & Mooring Areas**		**Improvements to Safety**		**Businesses Served**		**Potential Impacts to Eelgrass**		**Potential Impacts to Shellfish**		**Potential Impacts to Salt Marsh**		**Impacts to Intertidal Areas**		**Potential for Adverse Impacts to Barrier Beach**		**Overall Score**
Alternative 1-2: Access Between Inlet and Town Landings Via Channel Behind Barrier Beach																							
1-2A: Access between Inlet, Town Cove, Priscilla and Hemenway	$28.25	5	Low: Inner High: Outer	3	NEPA Required; ORW may preclude Hem	0	428 Moorings, Inlet moorings, 13 Landings & Improved navigation behind barrier	10	+ Emergency Response (both Towns) +Improved Safety Behind Barrier	10	Direct Business Access Improvements + Behind Barrier	10	Within 75' of Eelgrass	4	Town Cove - High density; Mill & Hemenway - Unknown	1	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Med: Priscilla; Low: All Other Sections	1	49
1-2B: Access between Inlet, Town Cove and Priscilla	$28.80	5	Low: Inner High: Outer	3	NEPA Required; ORW requirements	4	411 Moorings, Inlet moorings, 12 Landings & Improved navigation behind barrier	10	+ Emergency Response (Orleans only) +Improved Safety Behind Barrier	8	Direct Business Access Improvements + Behind Barrier	10	Within 75' of Eelgrass	4	Town Cove - High density; Mill - Unknown	1	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Med: Priscilla; Low: All Other Sections	1	**51**
1-2C: Access between Inlet, Town Cove and Hemenway	$27.96	5	Low: Inner High: Outer	3	NEPA Required; ORW may preclude Hem	0	183 Moorings, Inlet moorings, 7 Landings & Improved navigation behind barrier	8	+ Emergency Response (both Towns) +Improved Safety Behind Barrier	10	Direct Business Access Improvements + Behind Barrier	10	Greater than 75' from Eelgrass	5	Town Cove - High density; Hemenway - Unknown	1	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Low: All Other Sections	1	48
1-2D: Access between Inlet and Town Cove	$27.78	5	Low: Inner High: Outer	3	NEPA Required; ORW requirements	4	166 Moorings, Inlet moorings, 6 Landings & Improved navigation behind barrier	1	+ Emergency Response (Orleans only) +Improved Safety Behind Barrier	8	Direct Business Access Improvements + Behind Barrier	10	Greater than 75' from Eelgrass	5	Town Cove - High density	1	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Low: All Other Sections	1	43
1-2E: Access between Inlet, Priscilla and Hemenway	$27.53	5	Low: Inner High: Outer	3	NEPA Required; ORW may preclude Hem	0	269 Moorings, Inlet moorings, 7 Landings & Improved navigation behind barrier	8	+ Emergency Response (Eastham only) +Improved Safety Behind Barrier	8	Indirect Business Access Improvements (Behind Barrier)	4	Within 75' of Eelgrass	4	Mill & Hemenway - Unknown	2	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Med: Priscilla; Low: All Other Sections	1	40

1-2F: Access between Inlet and Priscilla	$27.42	5	Low: Inner High: Outer	3	NEPA Required; ORW requirements	4	245 Moorings, Inlet moorings, 6 Landings & Improved navigation behind barrier	8	+Improved Safety Behind Barrier	5	Indirect Business Access Improvements (Behind Barrier)	4	Within 75' of Eelgrass	4	Mill - Unknown	2	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Med: Priscilla; Low: All Other Sections	1	41
1-2G: Access between Inlet and Hemenway	$26.90	5	Low: Inner High: Outer	3	NEPA Required; ORW may preclude Hem	0	24 Moorings, Inlet moorings, 1 Landing & Improved navigation behind barrier	1	+ Emergency Response (Eastham only) +Improved Safety Behind Barrier	8	Indirect Business Access Improvements (Behind Barrier)	4	Greater than 75' from Eelgrass	5	Hemenway - Unknown	2	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier; Low: All Other Sections	1	34
Alternative 1-3: Access Between Inlet and Inner Estuary Via Channel Behind Barrier Beach																						
1-3: Access Between Inlet and Inner Estuary Via Channel Behind Barrier Beach	$26.00	5	High	1	NEPA Required; ORW requirements	4	Inlet moorings only, No landings, Improved navigation behind barrier	1	+Improved Safety Behind Barrier	5	Indirect Business Access Improvements (Behind Barrier)	4	Greater than 75' from Eelgrass	5	Behind Barrier - Low density	5	Within 50' of Salt Marsh	4	Yes	1	High: Behind Barrier	1	35
Alternative 1-4: Access Between Inlet and Town Landings Via Cable Creek																						
1-4A: Access Between Inlet, Town Cove, Priscilla and Hemenway via Cable Creek	$30.57	3	Low: Inner High: Outer	3	NEPA Required; ORW may preclude Hem	0	428 Moorings, Inlet moorings & 13 Landings	6	+ Emergency Response (both Towns)	5	Direct Business Access Improvements	7	Within 75' of Eelgrass	4	Town Cove - High density; Mill & Hemenway - Unknown	1	Within 5' of Salt Marsh	0	No	5	Med: Priscilla; Low: All Other Sections	2	36
1-4B: Access Between Inlet, Town Cove and Hemenway via Cable Creek	$28.25	5	Low: Inner High: Outer	3	NEPA Required; ORW may preclude Hem	0	176 Moorings, Inlet moorings & 7 Landings	3	+ Emergency Response (both Towns)	5	Direct Business Access Improvements	7	Greater than 75' from Eelgrass	5	Town Cove - High density; Hemenway - Unknown	1	Within 5' of Salt Marsh	0	No	5	Low: All Other Sections	3	37
Alternative 1-5: Access Between Town Landings and Back Side of Barrier																						
1-5A: Access Between Town Cove, Priscilla and Hemenway, and the Back Side of Barrier	$31.12	3	Low	5	NEPA Required; ORW may preclude Hem	0	428 Moorings & 13 Landings	6	+ Emergency Response (both Towns)	5	Direct Business Access Improvements	7	Within 75' of Eelgrass	4	Town Cove - High density; Mill & Hemenway - Unknown	1	Within 50' of Salt Marsh	4	No	5	Med: Priscilla; Low: All Other Sections	2	42

1-5B: Access Between Town Cove and Priscilla, and the Back Side of Barrier	$35.57	1	Low	5	No NEPA; No ORW Restrictions	5	411 Moorings & 12 Landings	6	+ Emergency Response (Orleans only)	1	Direct Business Access Improvements	7	Within 75' of Eelgrass	4	Town Cove - High density; Mill - Unknown	1	Greater than 50' from Salt Marsh	5	No	5	Med: Priscilla; Low: All Other Sections	2	42
1-5C: Access Between Town Cove and Hemenway, and the Back Side of Barrier	$29.86	5	Low	5	NEPA Required; ORW may preclude Hem	0	183 Moorings & 7 Landings	3	+ Emergency Response (both Towns)	5	Direct Business Access Improvements	7	Greater than 75' from Eelgrass	5	Town Cove - High density; Hemenway - Unknown	1	Within 50' of Salt Marsh	4	No	5	Low: All Other Sections	3	43
1-5D: Access Between Priscilla and Hemenway, and the Back Side of Barrier	$29.63	5	Low	5	NEPA Required; ORW may preclude Hem	0	269 Moorings & 7 Landings	3	+ Emergency Response (Eastham only)	1	No Business Access Improvements	1	Within 75' of Eelgrass	4	Mill & Hemenway - Unknown	2	Within 50' of Salt Marsh	4	No	5	Med: Priscilla; Low: All Other Sections	2	32

2.0 Alternatives for Element #2: Dredge Channel Width

Three (3) channel width alternatives were considered for restoring navigation in Nauset Estuary. Identification of a preferred alternative for the channel width was based on a combination of selection criteria including safe channel width for passage of boats, impacts to natural resources and landforms, and the expected frequency of maintenance dredging. Using the preferred channel layout Alternative 1-2B, the three (3) channel width alternatives were assigned scores for each selection criteria and a total overall score was then determined for each alternative (Table F-2). The scoring rationale for each criterion is described below.

2.1 Boater Safety

Explanation: The criterion focuses on quantifying the potential impacts to boater safety provided by the different channel widths. Improved boater safety is one of the goals of the project, especially in areas of the estuary where high current velocities make it difficult to maneuver and the potential for boater conflicts is high. Alternatives that provide the greatest maneuverability in channels with the highest currents are ranked higher than those that provide the least maneuverability channels with the highest currents.

Scoring Categories:
10: Greatest maneuverability in all channels
5: Lowest maneuverability in all channels
1: Greatest maneuverability in channels with high currents and lower maneuverability in channels with lower currents

2.2 Impacts to Land Under the Ocean

Explanation: This criterion addresses the potential for dredging activities to directly impact land under ocean, which can serve as important habitat for benthic communities. Alternatives that impact smaller areas of land under the ocean resource are ranked higher for this criterion than those that impact greater areas of land under the ocean resource.

Scoring Categories:
10: < 1,500,000 sq
8: 1,500,000 to 2,500,000 sq
6: > 2,500,000 sq

2.3 Impacts to Intertidal Areas

Explanation: This criterion addresses the potential for dredging activities to directly impact intertidal areas, which can serve as important foraging areas for shorebirds during low tide. Alternatives that impact smaller areas of intertidal resource are ranked higher for this criterion than those that impact greater areas of intertidal resource.

Scoring Categories:
10: < 1,300 sq
8: 1,300 to 3,500 sq
6: > 3,500 sq

2.4 Impacts to Land Containing Shellfish

Explanation: This criterion addresses the potential for dredging activities to directly impact land containing shellfish, which is important for commercial fisheries and propagation. Alternatives that impact smaller areas of land containing shellfish resource are ranked higher for this criterion than those that impact greater areas of land containing shellfish resource.

Scoring Categories:
10: < 1,500,000 sf
8: 1,500,000 to 2,500,000 sf
6: > 2,500,000 sf

2.5 Impacts to Salt Marsh Resources

Explanation: This criterion evaluates each alternative's potential impact to existing salt marsh resources. Although none of the alternatives directly overlaps with mapped salt marsh areas, the further away the proposed dredge footprint is from existing eelgrass resources, the less likely it will be to cause adverse impacts.

Scoring Categories:
10: All channels > 50 ft from salt marsh
5: One channel reach < 50 ft from salt marsh
1: More than one channel reach < 50 ft from salt marsh

2.6 Impacts to Eelgrass Resources

Explanation: This criterion evaluates each alternative's potential impact to existing eelgrass resources. Although none of the alternatives directly overlaps with mapped eelgrass beds, the further away the proposed dredge footprint is from existing eelgrass resources, the less likely it will be to cause adverse impacts.

Scoring Categories:
10: All channels > 65 ft from eelgrass
5: One channel reach that is 50 ft from eelgrass
1: More than one channel reach within 50 ft of eelgrass

2.7 Frequency of Maintenance Dredging

Explanation: This criterion is a qualitative assessment of how frequently the dredge footprint for each channel width alternative would need to be maintained. Channels

with greater widths were assumed to require less frequent maintenance dredging than channels with smaller widths.

Scoring Categories:
10: Lowest frequency of maintenance
5: Alternative includes areas of higher and lower frequency of maintenance
1: Highest frequency of maintenance

Scoring for the channel width alternatives identified the highest overall score for Alternative 2-3 which includes a 100 ft wide channel behind the barrier beach and a 50 ft wide channel in all other reaches. Therefore, Alternative 2-3 was selected as the preferred channel width.

3.0 Alternatives for Element #3: Placement Areas for Dredged Material

Ten (10) alternatives were considered for placement of the dredged material from Nauset Estuary. Identification of a preferred alternative(s) for placement of the dredged material was based on a combination of selection criteria including the potential for beneficial reuse, distance to the dredge channels, permittability, sediment compatibility, placement area capacity, potential impacts to the barrier beach, potential for redistribution of red tide cysts, and impacts to protected wetland resource areas. Using the preferred channel layout and width alternatives previously selected, the placement areas alternatives were assigned scores for each selection criteria and a total overall score was then determined for each alternative (Table F-3). The scoring rationale for each criterion is described below.

3.1 Potential for Beneficial Reuse

Explanation: This criterion evaluates the potential for dredged material to be beneficially reused at the different placement sites. Given future impacts along the coastline stemming from climate change and sea level rise, the ability to beneficially reuse dredged material for building coastal resiliency is a significant benefit. Dredged material reuse for habitat improvements is also considered a benefit. Placement alternatives that result in the addition of significant quantities sediment to coastal systems (i.e., beach, dune, barrier beach, intertidal) are scored high to moderately high, as they have the potential to improve habitat and storm damage protection and flood control for nearby natural resources and the built environment. Placement alternatives that are considered experimental or not commonly used in Massachusetts are scored as moderate or moderately low.

Scoring Categories:
10: High potential for beneficial reuse
7: Moderately high potential for beneficial reuse
5: Moderate potential for beneficial reuse
3: Moderately low potential for beneficial reuse
1: Low potential for beneficial reuse

Table F-2. Selection Criteria and Overall Scoring for Element #2: Channel Width Alternatives.

	Logistics				Environmental Impacts										
Alternatives	**Boater Safety**		**Frequency of Maintenance Dredging**		**Impacts to Land Under the Ocean (square ft)**		**Impacts to Intertidal Areas (square ft)**		**Impacts to Land Containing Shellfish (square ft)**		**Potential Impacts to Salt Marsh**		**Potential Impact to Eelgrass**		**Overall Score**
2-1: 100 & 80 ft Channel Widths	Greatest maneuverability	10	Lowest frequency of maintenance	10	2,626,300	6	3,720	6	2,639,100	6	Mill Pond channel 35 ft from salt marsh	5	Priscilla Rd. channel < 50 ft from eelgrass	5	48
2-2: 50 ft Channel Width	Least maneuverability	1	Highest frequency of maintenance	1	1,408,070	10	1,250	10	1,414,830	10	All channels > 50 ft from salt marsh	10	All channels > 65 ft from eelgrass	10	52
2-3: 100 & 50 ft Channel Widths	Greatest maneuverability in channels with high currents; lower maneuverability in remaining channels	5	Alternative includes areas of higher and lower frequency of maintenance	5	1,785,110	8	2,540	8	1,793,700	8	All channels > 50 ft from salt marsh	10	All channels > 65 ft from eelgrass	10	**54**

3.2 Sediment Compatibility

Explanation: This criterion assesses the compatibility of sediment dredged from the different channel reaches in the preferred channel layout (Alternative 1-2B) with sediment at each placement site. Finer-grained silty sands from the Priscilla Rd. spur channel, the Central Main Channel and presumed to be in the Mill Pond channel are not considered to be compatible with placement alternatives involving beach nourishment. Because of the relatively low percentages of fines (< 20%) in these three (3) channel reaches, the dredged material is compatible with placement in the coastal dune environment where finer-grained sediments naturally occur. Scoring for sediment compatibility is based on the number of channel reaches with compatible sediment as determined by results of the sampling program described in Section D.1.7 (Channel reaches Behind the Barrier Beach, Eastern Main Channel and Town Cove have sandy sediment; the Central Main Channel, Priscilla Rd. and Mill Pond channel reaches have silty sand sediment). Placement sites having the greatest number of channel reaches with compatible sediment are scored the highest and sites with the lowest number of channel reaches are scored the lowest.

Scoring Categories:
10: Six (6) channel reaches with compatible sediment
5: Three (3) channel reaches with compatible sediment

3.3 Area of Channel Accessible to Placement Site

Explanation: This criterion evaluates the area of dredge channel that is accessible to each placement site when considering the different methods of dredging (i.e., hydraulic cutter suction pipeline and sidecast methods and mechanical dredging). Channel areas were considered accessible only if they passed the sediment compatibility criterion described above in Section F.3.2. Placement sites accessible by the greatest area of dredge channel are scored the highest.

Scoring Categories:
10: > 1,500,000 sq ft
7: 1,000,000 to 1,500,000 sq ft
4: 850,000 to 1,000,000 sq ft
1: < 850,000 sq ft

3.4 Permittability

Explanation: This criterion provides an evaluation of the permittability of each placement alternative. Scoring is based on review of local, state, and federal regulations that govern dredging and dredged material placement (i.e., Wetlands Protection Regulations 301 CMR 10.00; Waterways Regulations 310 CMR 9.00; Water Quality Certification 314 CMR 9.00; Section 10 of the Rivers and Harbors Act of 1899; Section 404 of the Clean Water Act). Consistency of each placement alternative with the 1998 General Management Plan for the Cape Cod National Seashore and the Cape Cod

Commission's Regional Policy Plan is also factored into the scoring. Placement alternatives that comply with the regulations, that are more commonly permitted in Massachusetts, that avoid impacts to sensitive resource areas, that occur on municipal land, and that benefit or enhance the resource area functions are scored the highest.

Scoring Categories:
10: High
7: Moderately high
5: Moderate
3: Moderately low
1: Low

3.5 Site Capacity

Explanation: This criterion provides a quantitative assessment of the volume of dredged material that can be utilized at each placement site. Calculations for placement site capacity only consider dredge material that passes the sediment compatibility and channel accessibility criteria described above in Sections F.3.2 and F3.3. Alternatives that can hold the largest volume of dredged material are ranked the highest, and alternatives that can hold smaller volumes of material are ranked lower.

Scoring Categories:
10: < 130,000 cy
7: 120,000 to 130,000 cy
5: 60,000 to 120,000 cy
3: 20,000 to 60,000 cy
1: < 20,000 cy

3.6 Potential for Impacts to Barrier Beach

Explanation: This criterion addresses the potential for placement alternatives to impact the barrier beach, either through building the elevation and/or width of the barrier, or by adding sediment to the littoral system which can then feed material to the barrier beach via littoral drift. The 1998 General Management Plan for the CCNS seeks to allow natural shoreline processes within the park boundaries to take place without human disturbance. Further, any placement sites that directly strengthen the barrier beach are assumed to reduce the potential for a natural breach, which would be a benefit to navigation and water quality to the Nauset Estuary system. Alternatives that have the potential to enhance the stability of the barrier beach are ranked lower than alternatives that have no impact on the barrier beach.

Scoring Categories:
10: No impacts on barrier beach
7: Low potential for impacts to barrier beach through longshore transport
4: Moderate potential for impacts to barrier beach through longshore transport
1: Direct impacts to the barrier beach

Table F-3. Selection Criteria and Overall Scoring for Element #3: Placement Areas for Dredged Material.

	Logistics										Impacts						
Alternatives	**Potential for Beneficial Reuse**		**Sediment Compatibility**		**Area of Channel Accessible to Placement Site (square ft)**		**Permittability**		**Site Capacity (cubic yards)**		**Potential for Impacts to Barrier Beach**		**Potential for Redistribution of Red Tide**		**Resource Area Impacts (acres)**		**Overall Score**
3-1: Beach Nourishment on Nauset Barrier Beach	High	10	3 channel reaches	5	1,503,144	10	Moderately low	3	130,744	10	Direct impacts	1	Low potential	7	19	5	51
3-2: Beach Nourishment at Nauset Public Beach	High	10	3 channel reaches	5	465,200	1	High	10	128,460	7	Moderate potential for impacts	4	Low potential	7	14	5	49
3-3: Dune Restoration on Nauset Barrier Beach	High	10	6 channel reaches	10	1,503,144	10	Low	1	124,090	7	Direct impacts	1	Moderately high potential	4	21	5	48
3-4A: Dune Enhancement at Nauset Public Beach	High	10	6 channel reaches	10	817,357	1	High	10	27,000	3	Low potential for impacts	7	No potential	10	5	7	58
3-4B: Dune Enhancement North of Nauset Public Beach	High	10	6 channel reaches	10	1,159,105	7	Moderately high	7	26,080	3	Low potential for impacts	7	No potential	10	8	7	**61**
3-5: Land Under the Ocean Adjacent to Dredged Channel	Moderately high	7	6 channel reaches	10	2,466,126	10	High	10	119,830	5	No impacts	10	High potential	1	17	7	**60**
3-6: Subaqueous Placement	Moderate	5	3 channel reaches	5	1,029,906	7	Low	1	11,975	1	No impacts	10	High potential	1	59	1	31

3-7: Marsh Restoration	Moderate	5	3 channel reaches	5	1,029,906	7	Low	1	108,409	5	No impacts	10	Moderately high potential	4	269	1	38
3-8: Beach Nourishment on Nauset Estuary Shorelines	Moderately high	7	3 channel reaches	5	1,029,906	7	Moderate	5	4,896	1	No impacts	10	High potential	1	2.5	10	46
3-9: Upland Stockpile/Beneficial Reuse	Moderate	5	6 channel reaches	10	2,466,126	10	High	10	11,200	1	No impacts	10	No potential	10	0	10	**66**

3.7 Potential for Harmful Redistribution of Red Tide

Explanation: This criterion addresses the potential for placement of dredged material to result in harmful redistributions of red tide to areas that currently have low, or no, red tide concentrations. The scoring is based in part on analyses conducted on the viability of *Alexandrium* cysts in dredged material from Nauset Estuary that is used for dune enhancement (Anderson Consulting Associates, 2020; Section L). The analyses indicate that *Alexandrium* cysts buried in dunes subject to freezing temperatures during the winter and low saline conditions experience mortality within five (5) months. Provided the dredged material remains buried for at least five (5) months through the winter, the risk of spreading the cysts to other areas is avoided. Other factors considered in the scoring include potential for the dredged material to be released to the open ocean or estuarine environments. The Nauset Estuary Dredging Feasibility Assessment (Woods Hole Group, 2016; Section L) indicates there are two types of red tide blooms that can affect Nauset Estuary: (i) widespread blooms along the open coast from the Gulf of Maine to Massachusetts and outer Cape Cod, and (ii) localized blooms that start in the distal ponds of the estuary. Blooms that occur along the open coast, or release of *Alexandrium* cysts to the open ocean from dredge material placement as beach nourishment, are diluted by the large volume of ocean water, and therefore represent lower risk of creating a harmful algal bloom in the estuary. Conversely, localized blooms that start in Nauset Estuary, or placement alternatives that release dredged material with *Alexandrium* cysts directly to the estuary, present a greater risk of harmful blooms in the estuary. Placement alternatives with no, or low potential to redistribute red tide to other areas of the estuary are ranked high, while alternatives with high potential to redistribute the cysts within the estuary are ranked low.

Scoring Categories:
10: No potential for redistribution (burial in dunes/subaqueous that would kill cysts_
7: Low potential to redistribute to estuary via ocean
4: Moderately high potential to redistribute to estuary
1: High potential to redistribute within estuary

3.8 Resource Area Impacts

Explanation: This criterion addresses the potential for the placement alternatives to directly impact wetland resources, including coastal beach, coastal dune, barrier beach, bordering vegetated wetland, land containing shellfish, land under the ocean, land subject to coastal storm flowage, and NHESP protected habitat. Alternatives that impact smaller areas of resource are ranked higher for this criterion than those that impact greater areas of resource.

Scoring Categories:
10: < 1 acre
7: 1 to 18 acres
5: 18 to 25 acres

3: 25 to 50 acres
1: > 50 acres

4.0 Alternatives for Element #4: Dredge Methodology

Three (3) different dredge methodology alternatives were considered for constructing the Nauset Estuary project. The alternatives were evaluated for each channel reach using the preferred channel layout, width, and selected placement alternates. Given the extensive size of the Project area and the use of multiple placement sites, it is possible that a combination of dredge methods can be utilized effectively. The dredge methods were evaluated using the following criteria. Results of the evaluation are summarized in Table F-4.

Selection criteria:

- Channel extent assessable by dredge method – This criterion evaluated the extent of each channel reach that can be dredged by the different methods.
- Suitability of dredge equipment for use in channel reach – This criterion was used to evaluate the suitability of the dredge methods for use in each channel reach based on operational constraints such as high current velocities and environmental conditions such as high red tide cyst concentrations.
- Project duration – This criterion used the volume of material required for dredging in each channel reach in combination with the production rate of the dredging methods to evaluate whether the work can be completed in a single dredging season.
- Materials handling and transportation – This criterion evaluated trucking traffic and materials handing for each channel reach and dredge method.
- Not applicable – Certain combinations of dredge method and placement location were noted as not applicable if it is not feasible to use the placement site with the dredge method.

Table F-4. Selection Criteria and Overall Scoring for Element #4: Dredge Methodology.

Channel Reach & Placement Alternative	Alternative 4-1: Hydraulic Cutter Suction Pipeline Dredge	Alternative 4-2: Sidecast Dredge	Alternative 4-3: Mechanical Dredge
Behind Barrier Beach			
Alt 3-4B: Dune Enhancement North of Nauset Public Beach	Portion of channel	NA	Equipment not well suited for work in areas with high current velocities
Alt 3-5: Adjacent to Dredged Channel	NA	100% of channel; Equipment well suited for work in areas with high current velocities	
Alt 3-9: Upland Stockpile/Beneficial Reuse	NA	NA	
Eastern Main Channel			

Alt 3-4B: Dune Enhancement North of Nauset Public Beach	100% of channel; equipment may experience difficulties operating at maximum currents	NA	Equipment not well suited for work in areas with high current velocities
Alt 3-5: Adjacent to Dredged Channel	NA	100% of channel; Equipment well suited for work in areas with high current velocities	
Alt 3-9: Upland Stockpile/Beneficial Reuse	NA	NA	
Central Main Channel			
Alt 3-4B: Dune Enhancement North of Nauset Public Beach	Portion of channel	NA	100% of channel; trucking impacts between Goose Hummock and Nauset Beach
Alt 3-5: Adjacent to Dredged Channel	NA	Method not appropriate for areas with red tide cysts	Method not appropriate for areas with red tide cysts
Alt 3-9: Upland Stockpile/Beneficial Reuse	NA	NA	100% of channel; minimizes transport of dredged materials
Town Cove			
Alt 3-4B: Dune Enhancement North of Nauset Public Beach	Channel excees maximum pumping distance	NA	100% of channel; trucking impacts between Goose Hummock and Nauset Beach
Alt 3-5: Adjacent to Dredged Channel	NA	Method not appropriate for areas with red tide cysts	Method not appropriate for areas with red tide cysts
Alt 3-9: Upland Stockpile/Beneficial Reuse	NA	NA	100% of channel; minimizes transport of dredged materials
Priscilla Rd. Spur			
Alt 3-4B: Dune Enhancement North of Nauset Public Beach	100% of channel	NA	Multi-year project with trucking impacts between Goose Hummock and Nauset Beach
Alt 3-5: Adjacent to Dredged Channel	NA	Method not appropriate for areas with red tide cysts	Method not appropriate for areas with red tide cysts

Alt 3-9: Upland Stockpile/Beneficial Reuse	NA	NA	Multi-year project with trucking impacts between Goose Hummock and upland storage facility
Mill Pond Spur			
Alt 3-4B: Dune Enhancement North of Nauset Public Beach	100% of channel	NA	Multi-year project with trucking impacts between Goose Hummock and Nauset Beach
Alt 3-5: Adjacent to Dredged Channel	NA	Method not appropriate for areas with red tide cysts	Method not appropriate for areas with red tide cysts
Alt 3-9: Upland Stockpile/Beneficial Reuse	NA	NA	Multi-year project with trucking impacts between Goose Hummock and upland storage facility

5.0 Selection of Preferred Alternatives

A summary of preferred alternatives selected for the Nauset Estuary Dredging Project Table F-5.

Table F-5. Summary of Preferred Alternatives for the Nauset Estuary Dredging Project Elements #1 through #4.

Element #1: Channel Layout
Alternative 1-2B: Access between the inlet and public landings in Town Cove and the Priscilla Rd. and Mill Pond spur channels via the main channel Behind the Barrier Beach
Element #2: Channel Width
Alternative 2-3: 100 ft wide channel Behind the Barrier Beach and 50 ft wide channel for all other channel reaches
Element #3: Placement Areas for Dredged Material
Alternative 3-4B: Dune Enhancement North of Nauset Public Beach
Alternative 3-5: Land Under the Ocean Adjacent to Dredged Channel
Alternative 3-9: Upland Stockpile/Beneficial Reuse
Element #4: Dredge Methodology
Alternative 4-1: Hydraulic Cutter Suction Pipeline Dredge for the Priscilla Rd. and Mill Pond spur channels to Alternative 3-4B Dune Enhancement North of Nauset Public Beach
Alternative 4-2: Sidecast Dredge for channel reaches Behind the Barrier Beach and the Eastern Main Channel to Alternative 3-5 Land Under the Ocean Adjacent to Dredged Channel
Alternative 4-3: Mechanical Dredge for the Town Cove and Central Main Channel reaches to Alternative 3-9 Upland Stockpile/Beneficial Reuse

Section G

Construction Methodologies

Section H

Regulatory Reviews & Compliance

Section I

Avoidance, Minimization, & Mitigation Measures

Section J

Post Construction Monitoring and Maintenance

Section K

Review of Consistency w/CZM Policies

Section L

Engineering Reports & Memorandums

Section M

Dredge Sediment Grain Size & Chemistry Data

Section M

Phase 2 Core Logs & Lab Data from Sampling on 12/10/2015

Section M

Request for Approval of SAP to ACOE & DEP - 6/7/2017

Section M

SAP Supplemental Information to ACOE – 7/27/2017

Section M

Approved SAP from ACOE – 8/18/2017

Section M

Phase 3 Core Logs & Lab Data from Sampling on 10/3/2017

Section M

Phase 4 Core Logs & Lab Data from Sampling on 7/29/2019

Section N

Shorebird Monitoring Reports

Section O

Support Letters

Section P

Public Notice and EENF Distribution List

Section Q

Project Map & Plans

Dredge Plans are Currently Under Development