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# Appendix W: Cable Burial Risk Assessment

Coastal Virginia Offshore Wind Commercial Project


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The assessment presented herein is consistent with the Project Design Envelope considered by Dominion Energy Virginia (Dominion Energy) prior to summer 2022. Due to maturation of the Coastal Virginia Offshore Wind Commercial Project (Project) design, Dominion Energy was able to refine several components of the Project and has subsequently revised the Construction and Operations Plan (COP) as re-submitted in February 2023. The primary changes are summarized as follows:

- The Maximum Layout includes up to 202 wind turbine generators (WTGs), with a maximum WTG capacity of 16 megawatts. As the Preferred Layout, Dominion Energy proposes to install a total of 176, 14.7-megawatt capacity WTGs with 7 additional positions identified as spare WTG locations. For both the Preferred Layout and Maximum Layout, the Offshore Substations will be within the WTG grid pattern oriented at 35 degrees and spaced approximately 0.75 nautical mile (1.39 kilometers) in an east-west direction and 0.93 nautical mile (1.72 kilometers) in a north-south direction.
- Removal of Interconnection Cable Route Options 2, 3, 4, and 5 from consideration. As the Preferred Interconnection Cable Route Option, Dominion Energy proposes to install Interconnection Cable Route Option 1.

The analysis presented in this appendix reflects the initial 205 WTG position layout as well as Interconnection Cable Route Options 1, 2, 3, 4, 5, and 6 as the maximum Project Design Envelope. Reduction in the Project Design Envelope is not anticipated to result in any additional impacts not previously considered in the COP. Therefore, in accordance with the Bureau of Ocean Energy Management's Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan (2018), the appendix has not been revised. Additional details regarding evolution of the Project is provided in Section 2 of the COP and details regarding the full Project Design Envelope are provided in Section 3 of the COP.

# APPENDIX W CABLE BURIAL RISK ASSESSMENT
# REVISION LOG

| Revision Number | Date | Description | Signed |
| --- | --- | --- | --- |
| 1 | 12/2020 | Initial Report | Tetra Tech |
| 2 | 5/2022 | Response to BOEM comments, made public | Tetra Tech |
| 3 | 3/2023 | Amended CBRA | Tetra Tech |
| 4 | 7/2023 | Response to DNV comments | Tetra Tech |

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## APPENDICES

Appendix A: Probabilistic Risk Assessment Modifiers by Kilometer Post
Appendix B: Large Format Charts of the Area-Based Total Risk

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACP | American Clean Power |
| AIS | Automatic Identification System |
| ALARP | As Low As Reasonably Practicable |
| AOC | Atlantic Ocean Channel |
| BOEM | Bureau of Ocean Energy Management |
| BSEE | Bureau of Safety and Environmental Enforcement |
| CBRA | Cable Burial Risk Assessment |
| CFR | Code of Federal Regulations |
| cm | centimeter |
| COP | Construction and Operations Plan |
| CPT | Cone Penetrometer Test |
| CPTU | Piezocone Penetration Test with pore pressure measurement |
| CVOW | Coastal Virginia Offshore Wind |
| CVOWC | Coastal Virginia Offshore Wind Commercial (Project) |
| DNODS | Dam Neck Ocean Disposal Site |
| DNV GL | Det Norsk Veritas Germanischer Lloyd |
| DoD | Department of Defense |
| DOL | Depth Of Lowering |
| Dominion Energy | Virginia Electric and Power Company d/b/a Dominion Energy Virginia |
| DWT | deadweight tonnage |
| ft | foot |
| G&G | Geophysical and Geotechnical |
| HRG | high-resolution geophysical |
| HVAC | high voltage alternating current |
| ICPC | International Cable Protection Committee |
| km | kilometer |
| KP | kilometer post |
| LAT | Lowest Astronomical Tide |
| Lease Area | the designated Renewable Energy Lease Area OCS-A 0483 |
| m/yr | meters per year |
| m | meter |
| mi | statute mile |
| MARCO | Mid-Atlantic Regional Council on the Ocean |
| MEC | munitions and explosives of concern |
| MMIS | Marine Minerals Information System |
| NASCA | North American Submarine Cable Owners Association |
| Navy | U.S. Navy |
| NOAA | National Oceanographic and Atmospheric Administration |
| OCS | Outer Continental Shelf |
| OECRC | Offshore Export Cable Route Corridor |
| OECRC alignment | Offshore Export Cable Route Corridor centerline – refers to the study corridor |
| Project | Coastal Virginia Offshore Wind Commercial Project |
| QMA | Qualified Marine Archeologist |

| | |
|---|---|
| ROV | remotely operated vehicle |
| SMR | State Military Reservation |
| TSS | traffic separation scheme |
| ULCC | Ultra Large Crude Carrier |
| USACE | U.S. Army Corps of Engineers |
| UTM | Universal Transverse Mercator |
| UXO | unexploded ordnance |
| VACAPES | Virginia Capes naval operating area |
| VC | vibracore |
| VMS | Vessel Monitoring Service |
| VTR | Vessel Trip Report |
| WTG | Wind Turbine Generator |

# EXECUTIVE SUMMARY

This document builds upon the initial high-level Cable Burial Risk Assessment (CBRA) for the Coastal Virginia Offshore Wind (CVOW) Commercial Project (Project) by Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion Energy). The following are main areas of additional focus:

- A review of additional seabed geophysical and geotechnical (G&G) information supplied by Ramboll subsequent to the issue of the preliminary CBRA;
- The amendment of any outcomes and conclusions to the preliminary CBRA as a result of the review of the additional G&G information;
- Further feedback from experience gained during the cable installation and burial options from the proximate and parallel Dominion CVOW Pilot project;
- Anchor penetration data obtained from a set of trials undertaken by the German Transmission System Operator (TSO) Tennet.

This report will:

- Incorporate results and conclusions from the initial high-level CBRA;
- Summarize the additionally provided G&G data and results of the German Transmission System Operator anchor penetration tests;
- Interpret the burial experience from the adjacent CVOW Pilot export cable burial;
- Elaborate on seabed morphology and mobility;
- Discuss generally acceptable recurrence intervals for threats to the cable (predominantly anchor strikes); and
- Make conclusions and recommend next steps regarding cable crossing locations, high seabed mobility areas (identification of such areas and possible deeper burial strategies within those areas), and areas of shallow water near the cable landing and at the horizontal directionally drilled (HDD) duct or direct pipe trenchless shoreline crossing punchout locations.

The following recommendations will be established:

- Propose a Depth of Lowering (DOL) to mitigate risks to the cable to generally acceptable levels;
- Propose a DOL to mitigate increased risk due to seabed mobility as understood from current studies;
- Propose an overall DOL to encompass both above points; and
- Discuss potential measures to mitigate risk at cable crossing locations.

## Preliminary CBRA Summary

The methodology of, and the findings arising from an initial high-level CBRA (the "preliminary CBRA) for the Project were submitted to Dominion Energy in December 2020 with two main areas of focus:

- A high-level, "area-based" assessment encompassing risks present within the designated Renewable Energy Lease Area OCS-A 0483 (Lease Area) itself as well as the surrounding region that will assist with the analysis of, and with the associated decision-making in regard to, potential export cable routes; and

- A preliminary, modified Carbon Trust–based CBRA along the alignment of the Project's Offshore Export Cable Route Corridor (OECRC) with risk factors identified and quantified. This preliminary CBRA considers the centerline of the preferred export cable route that has been surveyed by Ramboll. The surveyed area differs slightly in three locations (the crossing locations, the Dam Neck Ocean Disposal Site (DNODS) and the beach approaches) but for practical purposes, these minor changes do not affect the risk analysis along the corridor centerline. Therefore, in this document, the studied route shall be referred to as the "OECRC alignment".

Further definition of the geographical areas covered, the risks considered, and the methodology are provided within this document. To be complete, a summary of the preliminary CBRA findings are as follows:

- Anchoring: The initial probabilistic study indicates that a Depth of Lowering (DOL) not less than 3.3 feet (ft; 1.0 meter [m]) is necessary, with up to 8.2 ft (2.5 m) in select segments based on risk tolerance and pending more detailed additional information.
- Vessel traffic/navigation channels: The OECRC as studied passes close to the southern extent of the United States Army Corps of Engineers (USACE) maintained deep-water shipping channel (Chesapeake Southern approaches). It is understood that there are potential initial plans to extend the channel, as well as the possibility of deepening it to accommodate larger vessels. The size of commercial vessels and the volume of traffic may increase at many ports along the U.S. east coast in the future. This document examines the current state of the offshore risk with the expectation that adaptive management may then be applied moving forward.
- While the study estimates a statistical probability of the Masters of commercial vessels consulting their charts (and therefore being aware of the presence of submarine cabling) prior to anchoring, actual evidence obtained during the installation of the CVOW Pilot Project's single export cable tells a different story. There were two incidences of a vessel anchoring close to the laid cable, and in one case, the anchor chain impacted the cable **prior to burial**, necessitating a cable repair operation. In both cases, the vessels involved were large commercial vessels with experienced Master Mariners in command. In one case, weather played a role, and in the other, the vessel faced an extended wait for a vacant berth in port. However, in both cases, there was ample time for the Masters to consult charts, Notice to Mariners, etc., yet did not appear to do so. Additionally, two other high-tonnage commercial vessels in the area that were preparing to deploy their anchors were contacted and warned away from the exposed cable.
- Military activity: The approaches to the Chesapeake are heavily trafficked with surface and submarine naval traffic. Such traffic may or may not be visible via Automatic Identification System or Vessel Traffic Service data; therefore, the risk to the cabling is difficult to quantify. However, relevant mitigation measures identified in the Navigation Safety Risk Assessment for the Project are applicable.

- Dropped objects: Due to the volume of commercial and military vessels transiting the area, dropped objects are a risk and should be evaluated as part of the Project's ongoing UXO survey campaigns (see Section W.5.8.3 Ongoing UXO Campaign Status).
- Fishing: The area is lightly fished. Seabed penetration from the fishing gear encountered within this region is expected to be less than 1 ft (0.3 m). Fishing-related risk mitigation is not considered to be a major driver of the overall burial depth along the export route, as DOL to mitigate other risks, such as commercial vessel traffic, will mitigate fishing-related risks as well.
- Sediment mobility: There is evidence of mobile sediments and sand waves, particularly within the central and eastern sections of the cable corridor, and notably in proximity to the DNODS, though mobile bedforms are not anticipated to be extreme and should be mitigated through additional burial depth and/or pre-installation clearing of sand waves or ridges.
- Unexploded ordnance (UXO)/munitions and explosives of concern (MEC): Due to the Virginia Capes naval operating area (VACAPES) firing range, UXO/MEC is a concern, particularly from anti-aircraft munitions.
- Geotechnical (soft seabed, hard soils etc.): Initial indications from the review of existing data in the Project Area and from site-specific data collected by the 2020 survey efforts, seabed conditions are generally suitable to reaching target burial depths of 6.5 to 10 ft (2 to 3 m) using properly selected burial tools. Some areas of dense sands and very stiff clays should be expected; feedback regarding this was obtained from the experience of burial of the CVOW Pilot Project whose Export Cable roughly parallels the study OECRC alignment. Please refer to Section 4.4.1, Previous Studies, for further detail regarding the burial operations for the CVOW Pilot Project export cable. Softer seabed and loose sands may also allow increased penetration by anchors in some limited areas of the cable corridor. Further mapping and sampling will more closely identify these areas and allow refinement of the risk mitigations and cable burial planning.
- Dredging/dumping/borrow areas/mining: The maintained Atlantic Ocean Channel and the associated Dam Neck Ocean Disposal Site both occur in proximity to the Cable Route and will be a part of discussions with the USACE to understand specific burial requirements. Some risk due to these activities will remain and shall be mapped out and refined during later iterations of this study as more data and information become available.
- Crossings/other seabed assets: The preliminary route crosses three in-service fiber optic cables with the nine potential Project export cables, that necessitates 27 individual cable crossing locations. The possibility of reduced burial at these locations may require additional protection measures. Detailed analysis and design of the crossings must occur in conjunction with negotiations with these asset owners and should also account for the risk of anchor strikes and related factors.
- Shore landing: There are potential conflicts with the three in-service fiber optic cables plus an extra installed (unoccupied) duct at the shore landing site.

# W.1 PROJECT OVERVIEW

## W.1.1 Project Understanding and History

This work scope has been completed by Subject Matter Experts from Tetra Tech, Inc., Sea Risk Solutions, LLC, and Ocean Village Maritime Ltd., hereinafter referred to collectively as "the Project Team."

The Virginia Electric and Power Company, doing business as Dominion Energy Virginia (Dominion Energy), is proposing to construct, own, and operate the Coastal Virginia Offshore Wind (CVOW) Commercial Project (the Project). The Project will provide between 2,500 and 3,000-megawatts of clean, reliable offshore wind energy. The Project is comprised of a design envelope of Wind Turbine Generators (WTGs) and three Offshore Substations in federal waters, while the Offshore Export Cable Route would traverse both federal and state territorial waters. The Project will also include Onshore Project Components, including the Cable Landing Location, Onshore Export Cables, Switching Station, Interconnection Cables, and an Onshore Substation. The Onshore Project Components would be located within the municipalities of Virginia Beach and Chesapeake, Virginia. The Project is due to commence construction in 2023 with completion scheduled for 2027.

The Project will be in the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS) Offshore Virginia (Lease No. OCS-A 0483) (Lease Area), which was awarded to Dominion Energy (Lessee) through the Bureau of Ocean Energy Management (BOEM) competitive renewable energy lease auction of the Wind Energy Area (WEA) offshore of Virginia in 2013. The Lease Area covers approximately 112,799 acres (ac; 45,658 hectares [ha]) and is approximately 27 statute miles (mi; 23.75 nautical miles [nm], 43.99 kilometers [km]) off the Virginia Beach coastline.

There were three Cable Landing Locations under consideration, including the decided upon location in the Proposed Parking Lot, west of the Firing Range at the State Military Reservation (SMR), formerly known as Camp Pendleton (all nine cables). Other options considered included locations at a combination of Croatan Beach Parking Lot (five cables) and the SMR Beach Parking Lot (four cables), or the Croatan Beach Parking Lot (all nine cables). However, this study is based on the Offshore Export Cable Route Corridor (OECRC) as developed by Ramboll, the centerline of which lands approximately 2,500 feet (ft, 750 meters [m]) to the south of the Croatan Beach Parking Lot. It is anticipated that once completed, there will be nine High Voltage Alternating Current (HVAC) Offshore Export Cables within the OECRC alignment.

The preliminary route of the OECRC alignment transits in an easterly direction from the SMR area, where it parallels several in-service fiber optic cables as well as the CVOW Pilot Project's export cable. The first 6 mi (10 km) of the route transits the danger area from the historic Dam Neck naval firing range, hence, munitions and explosives of concern (MEC) are of particular concern to research and have been evaluated as part of a MEC survey program in the effort to mitigate potentially hazardous seabed conditions.

In addition to the MEC concerns, there is the Dam Neck Ocean Disposal Site (DNODS) to traverse, as well as the busy maintained Chesapeake Southern approaches shipping lanes to negotiate.

### W.1.2 Overall Objective

The objective of the previous study was to complete a preliminary (Stage 1) CBRA for the Project's OECRC. Furthermore, recommendations were made as to the data requirements needed to undertake a complete subsequent (Stage 2) CBRA and Burial Assessment Study.

The preliminary study made use of the datasets available at that stage of Project development to capture the current best understanding of the DOL and trends in the need for cable protection faced by the system.

While the Preliminary CBRA identified and discussed the relationship between the external aggression risks to the cable and the probabilistic mitigation of risk associated with different DOLs, it did not suggest DOL by cable route segment to optimize that DOL versus residual risk to achieve generally acceptable recurrence intervals. This document captures that next step in this process, identifying the optimized DOL.

### W.1.3 Preliminary Offshore Export Cable Route Corridor

As previously described, this report assesses the OECRC alignment running from the SMR shore landing location out to the Project Lease Area. This section describes this preliminary corridor and details the areas that the cable corridor will traverse, as well as the challenges and hazards encountered along the way.

The Project will require up to nine HVAC Offshore Export Cables, each with three conductor cores, with three cables each connecting to one of three Offshore Substations. A OECRC containing nine individual cables will need to be of a considerable width to allow enough spacing between the cables for:

- Clearance during installation and burial;
- The avoidance of electrical losses due to induced currents, etc.; and
- Access to the cables for future maintenance and the installation of Omega joints in the case of a repair operation.

A cable-specific CBRA is outside the scope of this study, which will focus on the alignment of the corridor identified as the "CVOW Commercial Corridor Centerline" herein. Please note that the study considers the cable corridor (OECRC alignment), which is identified as "CVOW-Commercial Corridor Centerline" within the chart Figure W-1 through W-5 and referred to within this document as the "OECRC alignment."

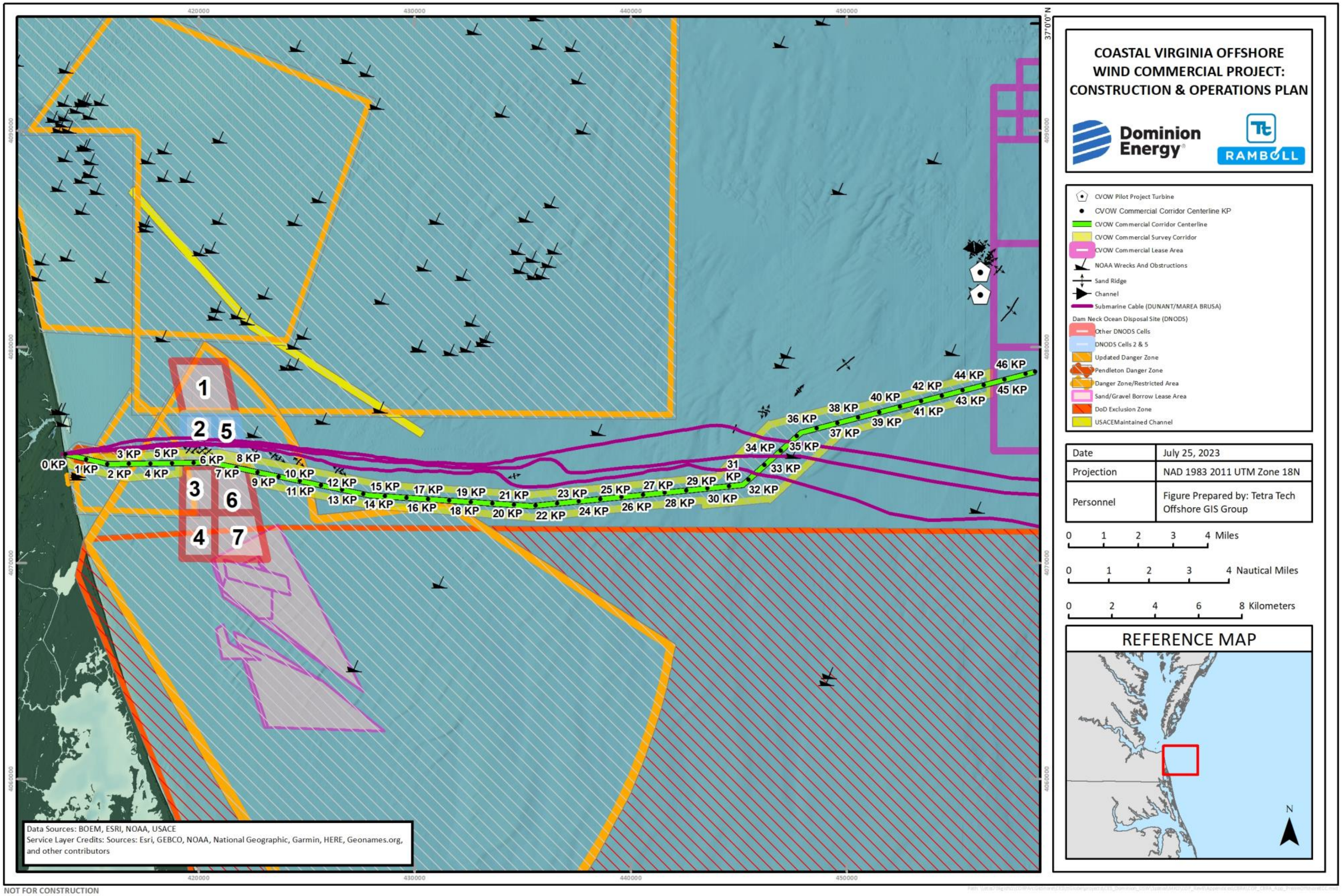
While the OECRC alignment follows the "Planned CVOW Commercial Survey Corridor Centerline (Ramboll)" closely, the survey corridor does vary from the cable corridor in three areas:

1. Offshore at approximately kilometer post (KP) 32 – KP 36 at the crossing locations. The survey corridor has been widened to allow for flexibility when planning and designing the cable crossings.
2. Within the DNODS zone at approximately KP 4.5 – KP 9.5. The survey corridor at this point was wider than the cable corridor.
3. At the shore landing, approximately KP 0 – KP 2. Here, the planned OECRC narrows as it approaches the planned Offshore Trenchless Installation Punch-Out Locations. The 2020 HRG survey only extends approximately 650 ft (200 m) inshore from the planned Offshore Trenchless Installation Punch-Out Locations.

This section describes the OECRC alignment and is broken down into three subsections: the shore approaches, the mid-section, and the offshore section that just enters the Lease Area.

Preliminary KPs have been provided, with KP 0 being at the beach and KP 46 at the end of the OECRC approximately 0.9 mi (1.5 km) into the Lease Area. In addition to the main OECRC alignment, three offshore options have been identified. These are described below, and the risks associated with these route options can be found within the area based CBRA within Section 6, Modeling of Likely Scenarios and Probabilistic Risk Assessment.

Figure W-2 is an overview of the OECRC alignment currently.




*Please note that the study considers the cable corridor (OECRC alignment), which is identified as "CVOW-Commercial Corridor Centerline" within the chart*

**Figure W-1. Preliminary Offshore Export Cable Route Corridor**

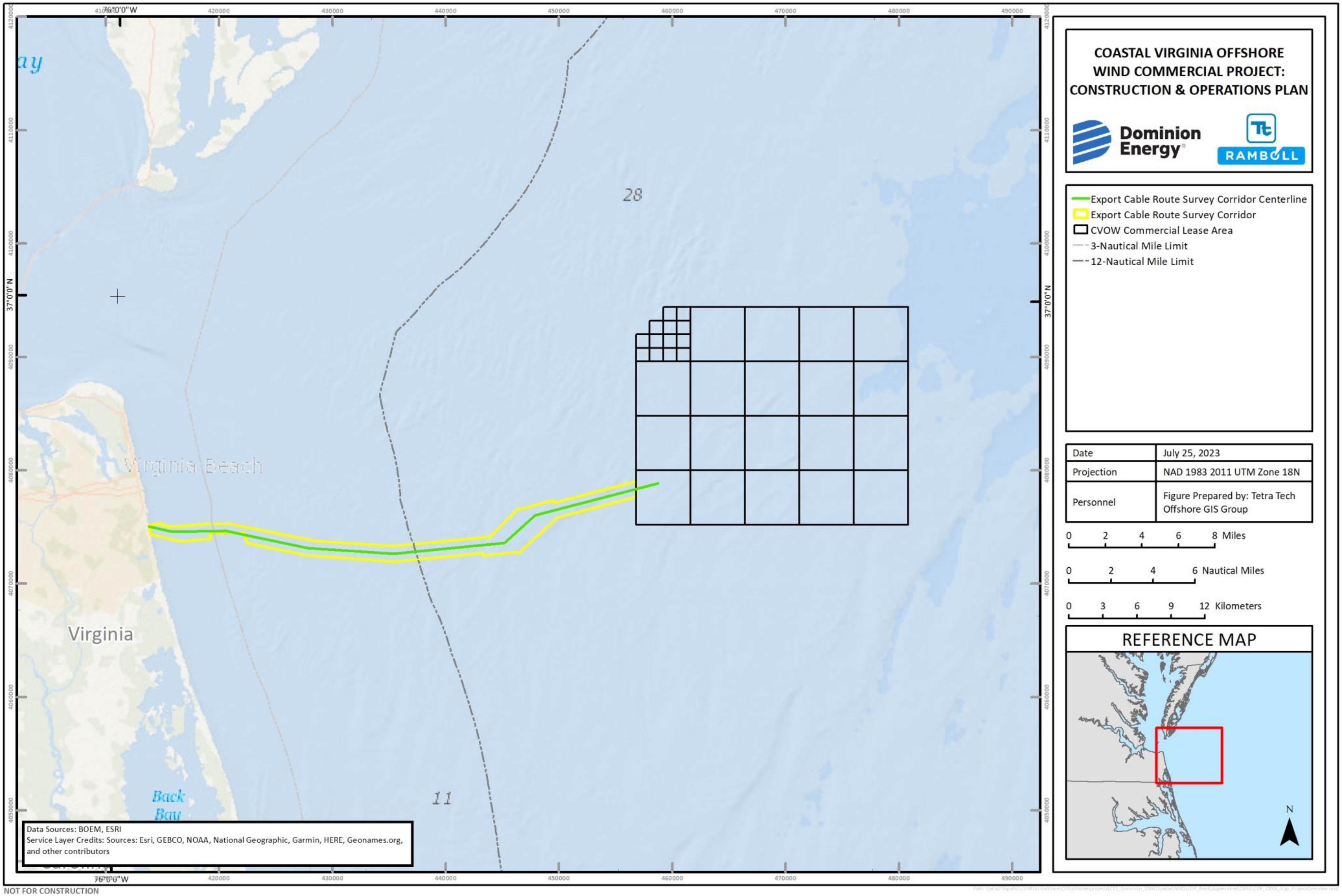



**Figure W-2. Offshore Survey Area Showing Export Cable Corridor and Lease Area**

#### W.1.3.1 Nearshore Section (KP 0.0 – KP 9.0)

This section is accompanied by Figure W-3 below. For the purposes of this description of the OECRC alignment, the nearshore section has been identified as the area from the shore landing out to KP 9.0.

The OECRC survey area shows that the centerline intersects the shoreline within the confines of the SMR, approximately 2,500 ft (750 m) south of the Croatan Beach Parking Lot in Virginia Beach (the location of the CVOW Pilot Project shore landing). The options for the shore landings of the Project's export cables are still under evaluation. However, it is likely that the final locations for the Trenchless Installation operations and accompanying beach transition joint bays (where the land cable is jointed to the submarine cabling) will be at the Proposed Parking Lot, west of the Firing Range at SMR (Preferred Alternative), with alternative locations at a combination of Croatan Beach Parking Lot and the SMR Beach Parking Lot, or the Croatan Beach Parking Lot (all nine cables). Additional alternatives at the Croatan Beach Parking Lot (see Figure W-6 and Figure W-7 for more detail).

For the purposes of this document, the OECRC alignment as depicted within the below charts will be considered. This is since the cable risk profile is not likely to alter significantly should the actual shore landing location vary slightly. To be able to reference points of interest along the cable corridor centerline, KPs have been added. Please note these are preliminary and are intended to be used for this document only.

For the purposes of this study, KP 0.0 is established at the point at which the cable intersects the shoreline, the water depth is zero m at Lowest Astronomical Tide (LAT). It is understood that the method of shore landing will be Trenchless Installation; therefore, the submarine cabling will be contained within ducts well below the beach or seabed at this point. Generally, Trenchless Installation ducts are limited to approximately 0.6 mi (1 km) in length; the exact location of the Trenchless Installation rig onshore will therefore determine the breakout point of the drill head offshore. At the time of preparing this document, the latest understanding is that the onshore endpoint of the Trenchless Installations will be approximately 574 ft (175 m) to the north-northwest of the shoreline (i.e., KP 0.0), with the planned ducts punching out offshore within the surveyed corridor.

However, it is likely that the Trenchless Installation Punch-Out location will fall within an area denoted on nautical charts as containing unexploded rockets that stretches out to KP 1.0 from KP 0.0. Beyond that, the OECRC alignment transits the SMR small arms firing range Danger Zone which ends at KP 5.8. In addition to the small arms Danger Zone, there is the Virginia Capes Naval Operating Area (VACAPES) naval gun line Danger Zone which comes into play from KP 3.0 out to the end of this section at KP 9.0 (see Section 5.8, Unexploded Ordnance/Munitions and Explosives of Concern, for further details of these areas and UXO/MEC concerns).

Due to the military-restricted areas and Danger Zones, vessel anchoring is prohibited; therefore, the risk from deliberate anchoring is minimized within these areas. However, there is coastal shipping traffic that transits north and south through the region, so accidental or emergency anchoring is a possibility. Relevant embedded mitigation measures identified in the Navigation Safety Risk Assessment for the Project are applicable.

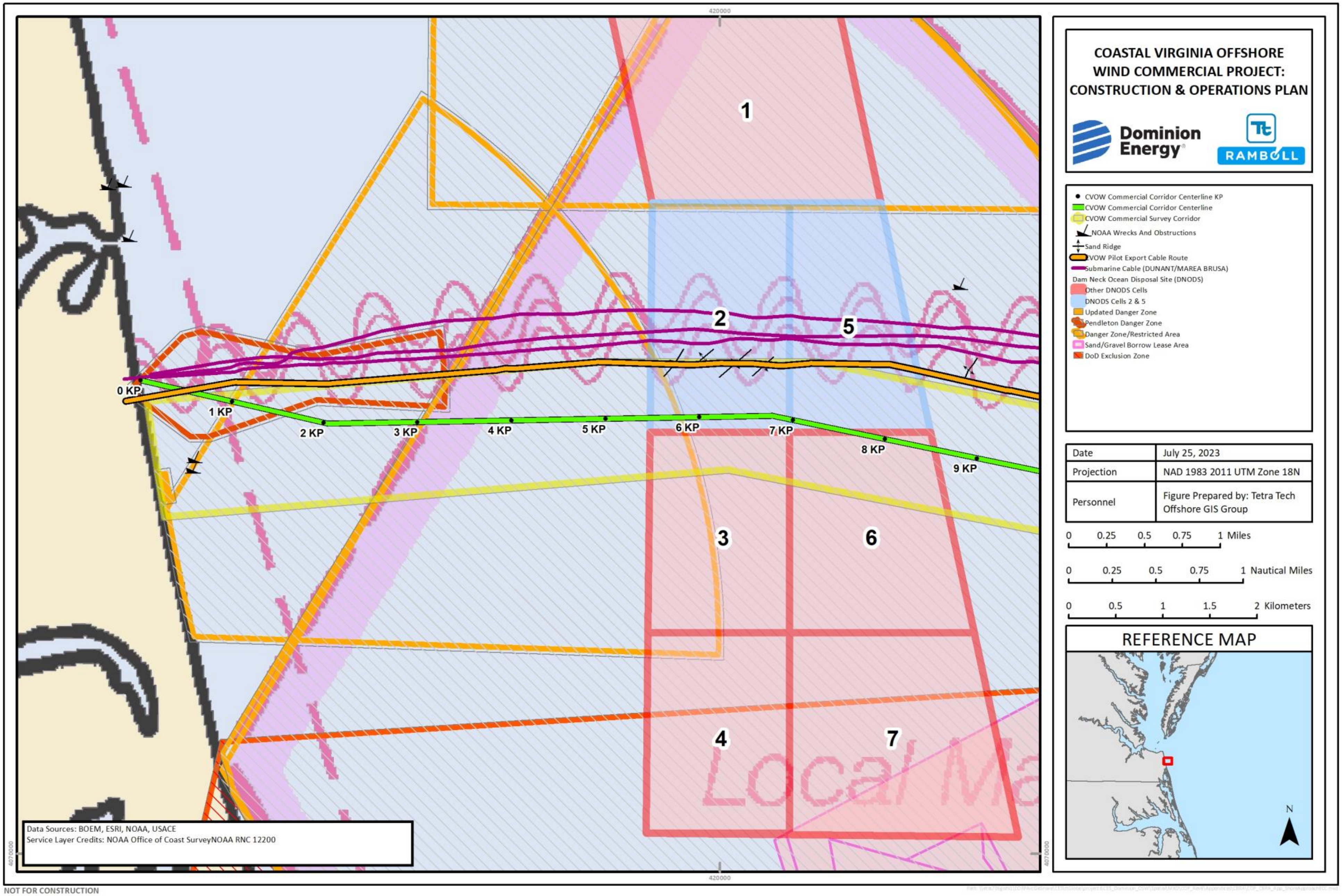
Commercial fishing is solely fixed gear within 3 mi (5 km) from shore, and trawling is prohibited in this area. An experimental fishery using beam trawls takes place within 3 mi (5 km) but is currently restricted to an area south of the OECRC. In the waters beyond 3 mi (5 km) and through KP 9.0, some limited trawling for shrimp and spiny dogfish will take place on a seasonal basis. Fixed gear using gillnets and pots is the primary fishing method in this nearshore section.

At KP 5.3 out to KP 8.5, the OECRC alignment centerline transits the DNODS. This is a federally maintained disposal site and is subject to United States Army Corps of Engineers (USACE) oversight. Within this area, the USACE will have their own cable burial requirements as a condition of the Section 408 permitting process. The Project-specific USACE-mandated burial depth is currently unknown; it is understood (for example) that the two of the most recent fiber optic cables had differing permitted burial depth requirements, despite being installed only 3 years apart. It is understood that the CVOW Pilot Project export cable targeted Depth of Lowering within DNODS was 8 ft (2.4 m).

It is worth noting that adjoining DNODS Zones 2 and 5 have been transited by three fiber optic cables and the CVOW Pilot Project export cable. The Ramboll corridor runs parallel, but south of these existing cables, and part of the corridor infringes into DNODS Zones 3 and 6, which may not be acceptable to the USACE. Further conversations with the USACE would be required to determine the possibility of encroaching upon these more southerly DNODS zones.

Additionally, these two DNODS zones are areas where material including fine sediments is dumped. It is unlikely that this material will be suitable for beach nourishment programs; therefore, the risk from future dredging plans is reduced. However, depending on the amount of material deposited, it may potentially cause increased cover; therefore, thermal and ampacity issues may require consideration.

Water depths along this section of the OECRC centerline range from 28 ft (8.5 m) at KP 1.0 (near the potential Trenchless Installation Punch-Out location) to 54 ft (16.5 m) at KP 9.0 just to the east of the DNODS area.




**Please note that the study considers the green "CVOW Commercial Corridor Centerline"*

**Figure W-3. Export Cable Corridor with Shore approaches detail**

### W.1.3.2 Mid-Section Cable Centerline (KP 9.0 – KP 28.0)

Please reference Figure W-4 (below) alongside this text.

For the purposes of this section of the report, this section of the OECRC alignment has been defined as the "mid-section" and runs from KP 9.0 as the western end to KP 28.0 in the east.

This section of the OECRC centerline parallels the Dominion Energy CVOW Pilot Project export cable, which runs approximately 2,500 ft (750 m) to the north. At approximately KP 19.5, the CVOW Pilot Project export cable diverges away and to the north slightly.

In addition to the existing submarine power cable, there are three in-service fiber-optic submarine cables running parallel to, and north of the study cable centerline. These are the DUNANT, MAREA, and BRUSA cable systems that land at the Croatan Beach Parking Lot. These three fiber optic cables vary in their proximity to the OECRC alignment, but the closest point of approach is approximately 2,600 ft (800 m) at KP 22.2.

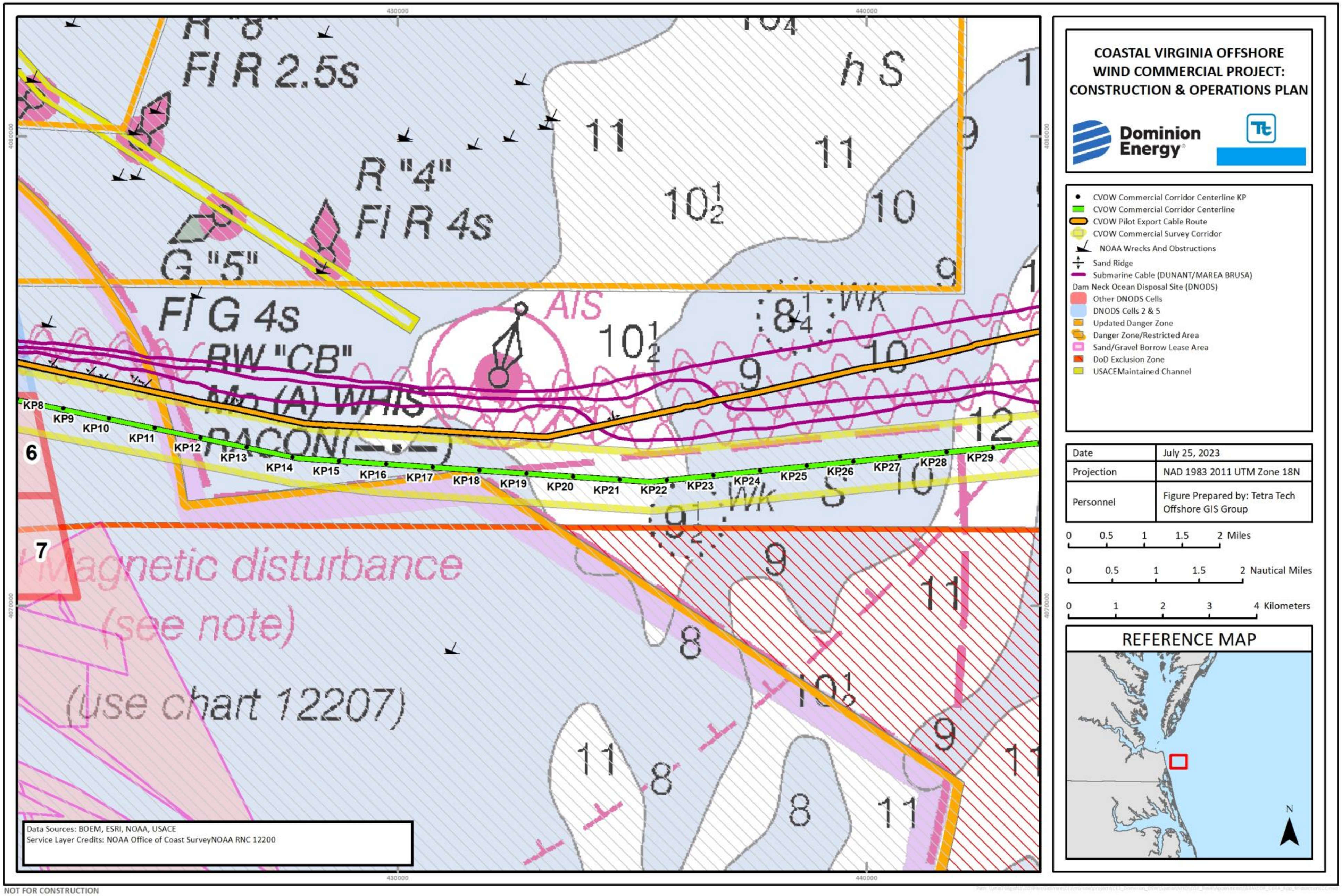
At KP 11.5, the OECRC alignment exits the VACAPES range Danger Zone, but briefly brushes against it at KP 17.8. While the cable centerline barely touches this Danger Zone at this point, approximately 2.5 mi (4 km) of the cable corridor itself does enter. Therefore, this will become a factor to consider when assessing the cable corridor (for multiple cables) rather than just the centerline as for this study. As previously stated, vessels are prohibited from anchoring within the military-restricted areas and Danger Zones, so generally, the risk of damage from planned anchoring should be low along the western half of this section. Here, relevant embedded mitigation measures identified in the Navigation Safety Risk Assessment for the Project are applicable and it is suggested the Project evaluate whether the recommended burial results are sufficient to mitigate potential threat along this corridor span.

There are two inbound and outbound shipping channels, as well as the federally maintained (dredged) deepwater channel that separates them, ending approximately 2.5 mi (4 km) north of the study cable centerline between KPs 18.0 and 25.0. These shipping channels are heavily trafficked by large commercial and military vessels entering and exiting the Chesapeake Bay to and from all points south and east.

The CVOW Pilot Project experience described in the Executive Summary notwithstanding, threats to the cable from deliberate anchoring in this area is expected to be low due to the presence of transiting vessels. Risk will further be reduced once the installed cables are charted; however, unplanned (accidental or emergency) anchoring is possible. Refer to Sections 5.2 and 6 for further information regarding the vessel types and frequencies, as well as the threat posed to the cable from anchors from those types of vessels.

It is common for commercial and military vessels to anchor outside of the main area of shipping intensity to await berth space, customs clearance, or for other purposes. Therefore, there is a potential threat to the cable from planned anchoring east of the main trafficked area. This would be applicable to KP 26.0 and higher. Please refer to Section W.6.2.2 for details regarding the risk to a cable as a function given by the exposure of a hazardous scenario from vessels.

Commercial fishing is primarily fixed gear with pots/traps and gillnets. Some limited trawling for shrimp and spiny dogfish will take place on a seasonal basis. The shrimp fishery is not expected to extend much beyond KP 9.0, the target species remain close to shore, and trawlers targeting spiny dogfish may range throughout the area. Seabed penetration associated with these fisheries is minimal compared to merchant vessels.




*Please note that the study considers the green "CVOW Commercial Corridor Centerline" labelled above

**Figure W-4.** **Export Cable Corridor with Mid-section detail**

Water depths along this section of the cable corridor centerline range from approximately 50 ft (15 m) near KP 10.0 to 63 ft (19 m) at KP 29.0.

#### W.1.3.3 Offshore Section Cable Centerline (KP 28.0 – KP 46.0)

Please reference Figure W-5 (below) alongside this text.

For the purposes of this section of the report, this section of the OECRC alignment has been defined as the “offshore-section” and runs from KP 28.0 as the western end to KP 46.0 in the east.

The eastern end of this cable corridor centerline lies approximately 1 mi (1,700 m) within the Project Lease Area.

At KP 31.5, the OECRC alignment alters course towards the northeast before resuming its course east-northeast at KP 35.0. Within this 2-mi (3.5-km) section, the cable corridor centerline crosses three in-service fiberoptic submarine cables. BRUSA is crossed at KP 32.3, MAREA at KP 33.5 and DUNANT at KP 34.5.

There is a charted obstruction within the cable corridor at KP 34.0 that will need to be micro-routed around, but since this obstruction is 1,600 ft (500 m) to the southeast of the centerline, it can be ignored for the purposes of this report.

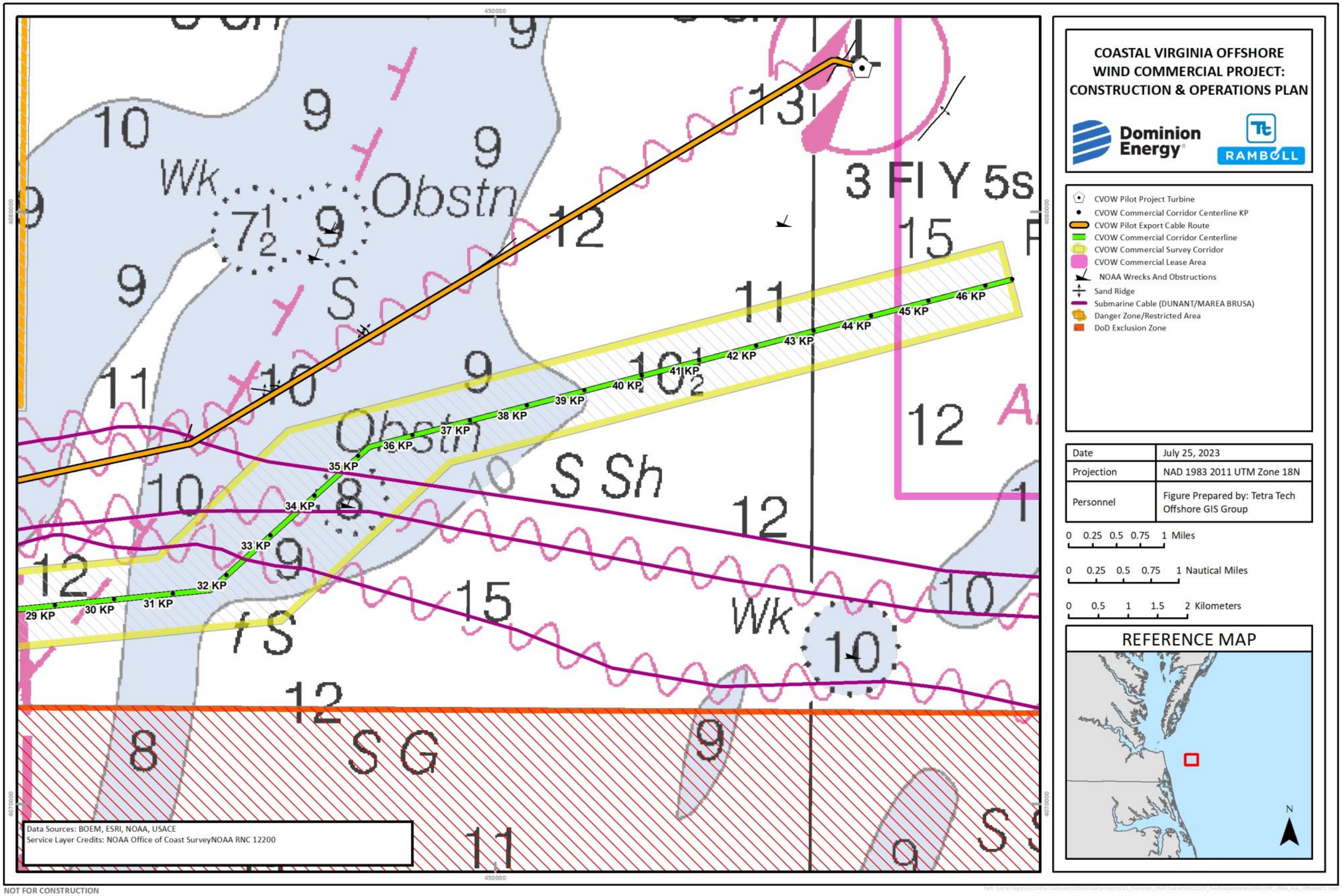
As explained later within this report, commercial fishing activity is very limited in the region; therefore, the main risks to the cable will be from commercial vessel anchoring as well as the threat from mobile sediments on the seabed.

This section of the OECRC alignment is commonly used by commercial and military vessels as an anchorage by vessels waiting for available dock space or customs clearance. Refer to Sections 5.2 and 6 for more information as to the types of vessels encountered, as well as the location and frequency of planned anchoring activity.

Commercial fishing is primarily fixed gear with pots/traps. There has been very little gillnet activity in this offshore portion of the route. Light trawling may also occur in this area. Seabed penetration associated with these fisheries is minimal compared to merchant vessels.

At the point that the OECRC alignment enters the Project Lease Area, the offshore option routes (described in Section 1.4.2 below) converge. It is worth noting that there will eventually be three Offshore Substations with up to three HVAC Offshore Export Cables, each with three conductor cores, going to each one. The routing within the Lease Area to each of the two to three Offshore Substations is outside the scope of this document.

Water depths along this section of the cable corridor centerline range from approximately 50 ft (15 m) near KP 28.0 to 85 ft (26 m) at KP 44.0.




**Please note that the study considers the green "CVOW Commercial Corridor Centerline" labeled above*

**Figure W-5. Export Cable Corridor, Farthest offshore-section detail**

### W.1.4 Additional Route Options

As previously described, the individual cable routes within the OECRC have not yet been finalized. There are ongoing marine survey operations along the Ramboll survey corridor centerline; this centerline is the focus of the preliminary "traditional" CBRA scope within this report. However, several potential variations of the final OECRC are being explored. The "Area" based CBRA is intended to identify, at a high level, risks to the cable associated with the route options, as well as any other potential variations not yet identified. These options are described in greater detail below.

#### W.1.4.1 Offshore Options

As previously discussed, the Project will eventually consist of Offshore Substations with up to nine HVAC Offshore Export Cables, each with three conductor cores, required. A cable corridor accommodating nine cables needs to be wide enough to enable cable installation and burial activities and allow room for future survey, maintenance, and repair operations. For these reasons, and to consider the question of redundancy (to ensure that in the event of an incident, all nine export cables are not at risk), three Offshore Export Cable Route Options have been identified. Figure W-8 below provides an overview.

In all three cases, the options run parallel to, and north of, the three in-service fiberoptic submarine cables that land at the Croatan Beach Parking Lot. This eliminates the requirement for crossing these cables, unlike the Ramboll cable corridor that is the focus of this report. The main impediment for these three route options is the federally maintained shipping channel, which carries a large volume of commercial shipping to and from the Chesapeake ports. The deepwater channel (highlighted in yellow in Figure W-8) is maintained by the USACE; it is probable that there will be a Depth of Lowering (DOL) requirement of 15 ft (4.6 m) below the authorized, maintained depth at this point. As per these requirements, and based a required depth of 59 ft (18 m) at the channel crossing, a targeted DOL of 74 ft (22.6 m) below MLLW is expected.

Offshore Option A diverges from Options B and C to the west of the shipping lanes and stays to the south of the maintained channel. This, in theory, eliminates the need for the deep burial at this location. Option A then heads east before crossing the CVOW Pilot Project export cable at approximately KP 34 before rejoining the Ramboll survey corridor just before entering the CVOW Lease Area.

Offshore Options B and C share the same path and then diverge as they cross the maintained shipping channel. Hence, both Options will require deep burial at this location. Option B then heads east and rejoins Option A approximately 0.6 mi (1 km) west of the CVOW Pilot Project export cable. As with Option A, Option B also crosses the CVOW Pilot Project export cable near KP 34.

Offshore Option C diverges north away from Option B at the maintained shipping channel. Option C then proceeds in a north-easterly direction and enters the Lease Area north of the two CVOW Pilot Project WTGs. Option C does not require any cable crossings.

All three route options traverse the area west of the shipping lanes that serves as an unofficial vessel anchorage. There is no difference in the fishing activity along the alternative routes; all are lightly fished by fixed gear and, to a lesser extent, mobile gear. These options are not covered by the "traditional" CBRA, but the risks associated with commercial vessel traffic and anchoring will be taken into consideration by the area-based CBRA.

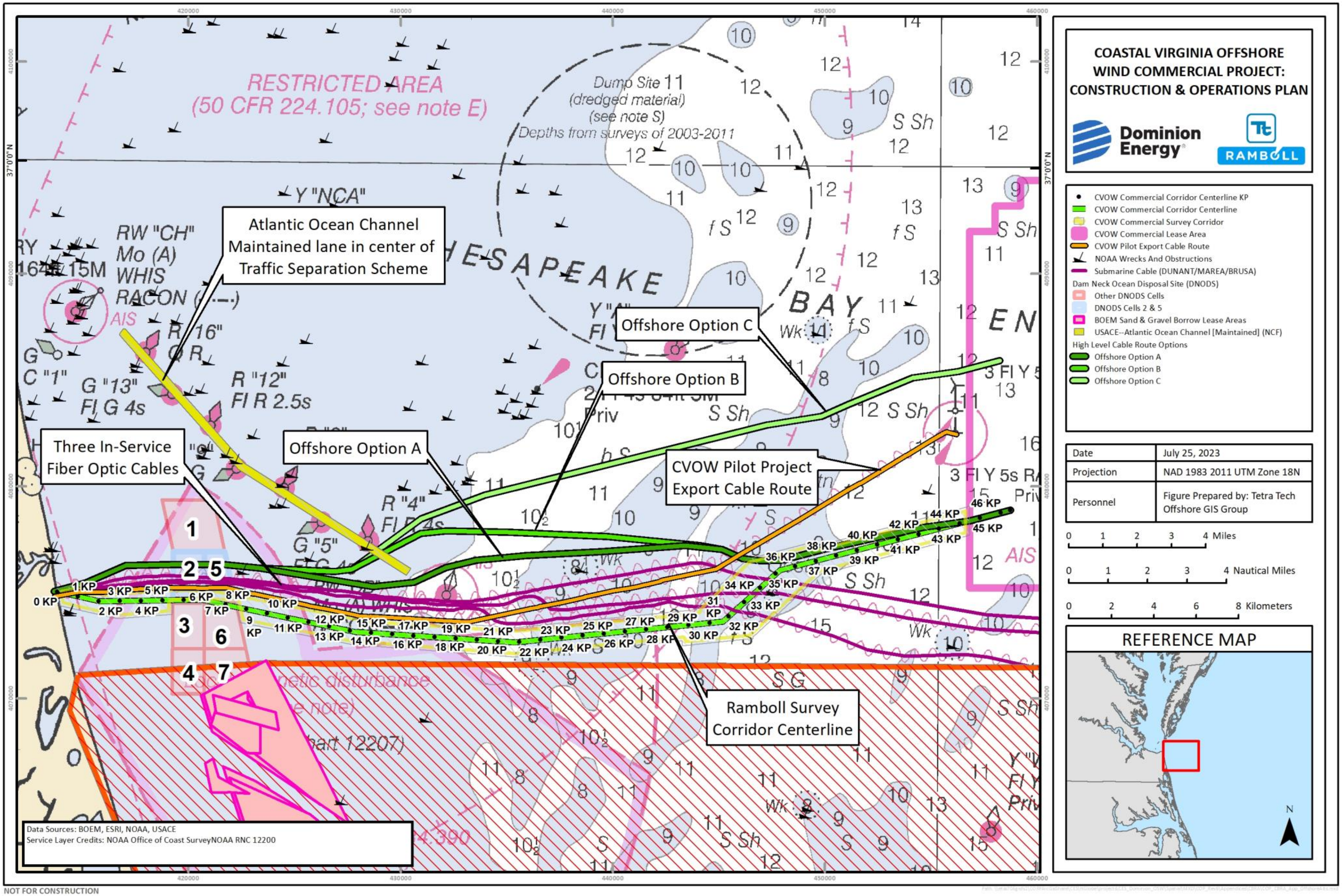



**Figure W-8. Export Cable Corridor and Centerline, Offshore Route Options**

# W.2 REGULATIONS, GUIDANCE, AND THIRD-PARTY REQUIREMENTS

There are a wide variety of sources that inform cable burial recommendations, ranging from governmental agencies to industry bodies that publish codes and best working practices.

It is common for submarine cable projects to receive burial depth requirements from the USACE as a part of the permitting process. These particularly pertain to areas where there are identified and maintained shipping navigation channels and anchorages. These specified burial depth requirements are intended to allow for future dredging activities (i.e., channel deepening, widening, and lengthening).

Although the USACE determines the minimum acceptable burial depth in certain areas (e.g., 15 ft [4.7 m] below the authorized, maintained channels), there is also guidance available from a variety of other sources, including the International Cable Protection Committee (ICPC), BOEM, the Carbon Trust, the Bureau of Safety and Environmental Enforcement (BSEE), and the American Clean Power Association (ACP), (formerly known as American Wind Energy Association).

## W.2.1 BOEM Construction and Operations Plan Guidelines

BOEM is an agency within the U.S. Department of the Interior responsible for managing development of the nation's offshore resources in an environmentally and economically responsible way. The main document that offshore wind developers must assemble to BOEM's satisfaction is the Construction and Operations Plan (COP). Within BOEM's COP guidance (2020a), the following items are identified with respect to cable burial.

### W.2.1.1 Attachment A: Best Management Practices

Seafloor habitats:

- Lessees and grantees shall conduct seafloor surveys in the early stages of a project to ensure that the alternative energy project is sited appropriately to avoid or minimize potential impacts associated with seafloor instability or other hazards; and
- Lessees and grantees shall take all reasonable actions to minimize seabed disturbance and sediment dispersion during cable installation.

Fisheries:

- Lessees and grantees shall avoid or minimize impacts to the commercial fishing industry by burying cables, where practicable, to avoid conflict with fishing vessels and gear operation. If cables are buried, lessees and grantees shall inspect cable burial depth periodically during project operation to ensure that adequate coverage is maintained to avoid interference with fishing gear/activity.

Coastal habitats:

- Lessees and grantees shall avoid hard-bottom habitats, including seagrass communities and kelp beds, where practicable, and restore any damage to those communities.

#### W.2.1.2 Attachment E: Information Requirements for National Environmental Policy Act and Other Relevant Laws

Other Potential Needs for COP Approval – Additional information may be needed to support the evaluation of hazards and physical impacts, including but not limited to:

- Stability analysis of seafloor morphology; and
- Modeling of disturbances associated with WTG and Offshore Substation Foundation installation, cable jetting and burial, and cable landfall.

### W.2.2 Bureau of Safety and Environmental Enforcement

BSEE is an agency within the U.S. Department of the Interior that is responsible for promoting safety, protecting the environment, and conserving offshore resources. The Energy Policy Act of 2005 authorized the Secretary of the Interior to issue leases on the Outer Continental Shelf for activities that produce or support the production, transportation, or transmission of energy from sources other than oil and gas. The Act requires all such operations to be carried out in a manner that provides safety of operations and the protection of the environment.

As a part of its program, the BSEE has commissioned and undertaken many Technical Assessment Programs Projects, all of which are in the public domain, including the following:

- TAP 722 – Offshore Wind Submarine Spacing Guidance (BSEE 2020); and
- TAP 671 – Offshore Electrical Cable Burial for Wind Farms: State of the Art: Standards and Guidance; Acceptable Burial Depths and Separation Distances; and Sand Wave Effects (Sharples 2011).

These documents, for the most part, summarize industry best practices and contain general guidance for Dominion Energy to consider in both turbine layout designs as well as when considering cable burial.

### W.2.3 International Cable Protection Committee Recommendations

The ICPC is an organization founded in 1958 that is comprised of governmental agencies, commercial submarine cable system owners and operators, as well as other companies that are associated with the submarine cable industry. The primary mission of the organization is to increase the security of undersea cables by providing a forum in which technical, legal, and environmental information can be exchanged, and guidance issued. The prime activities can be summarized as follows:

- To promote awareness of submarine cables as critical infrastructure to Governments and other users of the ocean floors;
- To establish internationally agreed recommendations for cable installation, protection, and maintenance;
- To monitor international treaties and national legislation to help ensure that submarine cable interests are fully protected; and
- To liaise with various United Nations bodies.

#### W.2.3.1 General Guidance Documents

The ICPC Recommendations are a set of industry best practices that serve as a guide for burial planning. Since these recommendations are designed to be both generalized best practice as well as global in application, they do not publish a recommended depth of burial. It is widely understood that appropriate burial depth varies by risk profile, regulatory regime, and other factors. The following guidance does pertain to desktop studies and CBRAs such as this one.

#### W.2.3.2 ICPC Recommendation Document 9: Minimum Technical Requirements for a Desktop Study

This document (ICPC 2019) outlines detailed recommendations for what should be considered in a desktop study (cable route study). It does not include specific guidance on how to deal with those factors. This guidance notes that route planners must familiarize themselves with several regional parameters, including:

- Geology;
- Climatology;
- Oceanography;
- Commercial Operations, Hazards and Restricted Areas (shipping, military, fishing, research, dredging, shipwrecks, etc.);
- Biological factors; and
- Permitting.

The guidance is designed to help ensure that a project has done its due diligence in advance such that the environment and the regulations are well understood prior to surveys, installation, and operations and maintenance.

### W.2.4 Det Norsk Veritas Germanischer Lloyd

DNV GL (the abbreviation for the company Det Norsk Veritas Germanischer Lloyd) is an international registrar and classification society headquartered in Norway.

DNV-GL-RP-0360 (DNV GL 2021). This recommended practice document provides guidance throughout a submarine power cable's lifecycle but focuses particularly on the risk analysis and mitigations most applicable to shallow water applications.

### W.2.5 The Carbon Trust

The Carbon Trust is a United Kingdom–based but global organization with the stated mission of accelerating the transition to a sustainable, low carbon economy. As a part of this, they formed the Carbon Trust Offshore Wind Accelerator, a Joint Industry Project consisting of nine major offshore wind project developers and a number of other associated organizations including the UK and Scottish Governments. In the case of submarine cabling, the Offshore Wind Accelerator members all agreed that significant cost savings could be achieved without adding additional risk to the cabling by optimizing the DOL.

To achieve that, the Carbon Trust commissioned a wide-ranging study into the site investigations, trenching assessments, and burial risk assessments that are undertaken at the design stage of offshore wind farm projects. There was a lot of input into the study by cable installation and trenching contractors, various consultancies involved with offshore wind farm development, and the wind farm developers themselves. This study utilizes the basic Carbon Trust methodology for this preliminary CBRA. The probabilistic portion of this preliminary CBRA is accomplished with a model codeveloped by Sea Risk Solutions, LLC and NASH Maritime Ltd. that was educated by the standard Carbon Trust model that seeks to better quantify anchor related risks, especially those near and inshore.

### W.2.6 The American Clean Power Association

ACP is a trade association representing both the onshore and offshore wind industry. They have developed a set of Standards and Recommended Practices, including convening working groups under their Wind Standards Committee. One of those working groups was tasked with drawing information from existing regulations and guidance to create the *Recommended Practice for Design, Deployment and Operation of Submarine Cables in the United States (ORCP5)*. This document was published in 2022.

### W.2.7 The North American Submarine Cable Owners Association

The North American Submarine Cable Owners Association (NASCA) is a non-profit organization comprising a group of companies that own, operate, install, or maintain submarine telecommunications cable in North America. In their experience, the cabling belonging to their members suffered numerous faults due to (predominantly) hydraulic clam dredging during the 1980s and 1990s. At that time, the recommended submarine cable burial depth was between 2 to 3 ft (0.6 to 0.9 m). However, since 2000, all known new telecoms cables along the U.S. Atlantic coast have targeted at least 5 to 6 ft (1.5 to 2 m) burial depth where seafloor conditions permit; as a result, there has been a sharp decrease (to nearly zero) in cable damage rates resulting from fishing and hydraulic clam dredging operations (NASCA 2019). It should be noted that commercial fishing with hydraulic clam dredges has not been observed within the Project study area

## W.3 CBRA METHODOLOGY

Where possible, the methodology of this CBRA follows that of the Carbon Trust (Figure W-9), which has become the approved industry standard for the determination of risk to cabling and associated DOL recommendations, and is supplemented by proprietary probabilistic risk models.

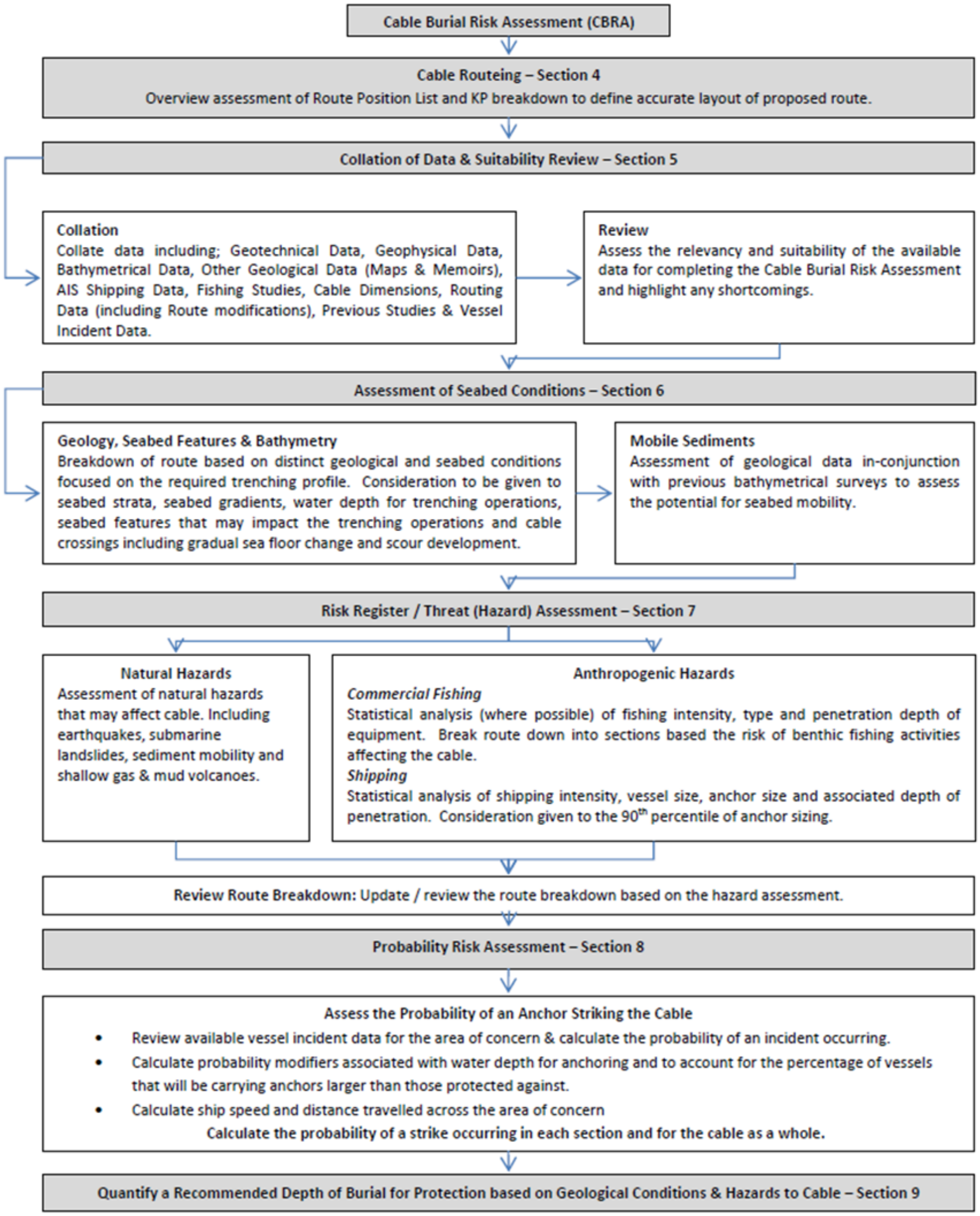



**Figure W-9 CBRA Methodology Flowchart (Carbon Trust 2015)**

A high-level summary of the CBRA flowchart is as follows:

1. Create high-level overview and assessment of the cable corridor.
2. Collate relevant data and review for suitability.

3. Assess the geotechnical and geophysical data and break the route down into sections that share similar soil and seabed characteristics (not fully possible currently).
4. Assess risks from:
   - Natural hazards (seabed features, landslides, etc.); and
   - Anthropogenic hazards (shipping, fishing, UXO etc.).
5. Add risks to route breakdown.
6. Undertake probability risk assessment.
7. Quantify a preliminary recommended DOL for each point along the cable route. (This is a preliminary assessment that can be refined upon review of the geotechnical and geophysical survey data [once available] as well as final route selection and client risk tolerance.)

### W.3.1 Overall CBRA Approach

A full CBRA is a probabilistic method of determining the level of threat to a cable, leading to Cable Protection recommendations that minimize risk to the cable from external factors to As Low As is Reasonably Practicable.

The output of the CBRA is to determine a recommended DOL at each point along the cable route that will protect the cable from external aggression and minimize risk both to and from the cable. Once the CBRA is complete, a Burial Assessment Study may be undertaken, which considers the CBRA findings, as well as the geotechnical and geophysical soil data to identify (at a high level), suitable cable burial methodologies that are most likely to achieve the target DOL.

From this, a contractor will propose (and the developer will approve) a burial method that will achieve the Target DOL (B, see Figure W-10 below); this allows for a slight margin for error in case of unexpected challenges such as sediments outside of the post-survey predictions. To achieve the Target DOL, a burial tool capable of the Target Trench Depth will be specified. This extra margin will allow for backfill that may occur prior to the cable sinking to the bottom of the cut.

The above parameters and their definitions were published by the Carbon Trust (2015) in their industry guidance document “Cable Burial Risk Assessment Methodology: Guidance for the Preparation of Cable Burial Depth of Lowering Specification,” in which the Trench Definitions figure (Figure W-10 below) is provided.

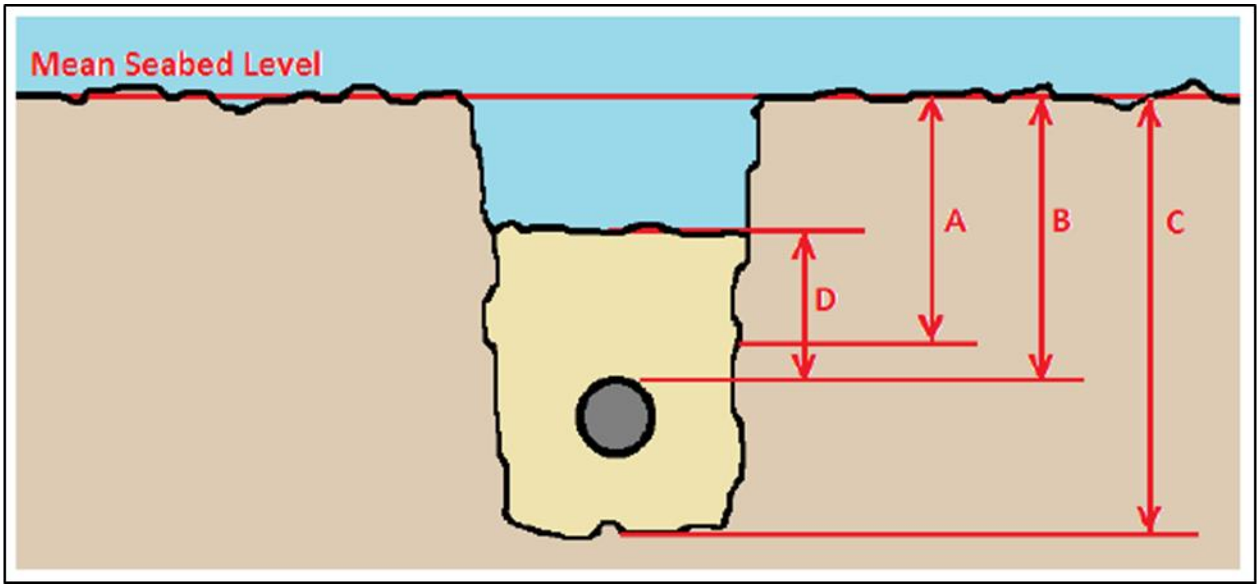



**Figure W-10. Trench Definitions (Carbon Trust 2015)**

It is important to establish a realistic or optimized target DOL for the following reasons:

- To reduce the threat to the cable from external factors;
- To reduce threat from the cable to other seabed users and natural processes;
- To allow for the widest array of potential installation and burial tools, leading to as cost-efficient cable installation as possible;
- To reduce the risk of cable exposure due to shifting seabed sediments;
- To ensure that the ampacity (power carrying capacity) of the cable is not compromised due unnecessary over burial; and
- To ensure easier access to the cable for possible future recovery and repair operations.

The CBRA is a standardized method, based upon project and site-specific data and using probabilistic methods to determine a target DOL that is technically and economically feasible, yet provides adequate cable protection. It is impossible to protect a cable from all threats, but the CBRA adheres to the "As Low As is Reasonably Practicable" philosophy. For example, one of the CBRA's inputs is vessel traffic, whereby Automatic Identification System (AIS) data is used to determine the type and frequency of marine traffic in proximity to the cable route. If, after studying that data, it is found that the frequency of Ultra Large Crude Carrier (ULCC) vessels is negligible, then the risk to the cable from anchor strikes from that type of vessel's anchor is extremely low.

There are several inputs required in order to undertake a comprehensive CBRA:

- Marine charts and tide/current tables;
- Geotechnical data gathered utilizing Cone Penetrometer Tests (CPTs,) vibracore (VC), gravity core, piston cores, followed by lab analysis to determine the soil types, shear strength assessments, presence/percentages of organic matter, etc. that will be encountered along the cable route;

- Geophysical data utilizing multibeam echo sounders, side scan sonar, sub-bottom profilers and magnetometers to determine the seabed profile, the presence of any obstructions (boulders, sand waves, wrecks, etc.), the structure of sub-bottom sediment layers, and the presence of ferrous objects including possible UXO;
- Any previously available area and region-specific documentation including historical or publicly available geological data, archeological data, and marine wildlife data;
- AIS vessel traffic data, which shows the type and frequency of marine traffic. From this, an analysis of anchor types and frequency of deliberate and accidental anchor deployment will be carried out;
- Fisheries input to identify the commercial and recreational fishing activities that occur in the area, including vessel and fishing gear types;
- A sediment mobility assessment, which will determine historical changes in the seabed topography such as the movement of sand waves, erosion due to currents, scour, etc. Repeated surveys are especially helpful in this regard;
- Preliminary cable design and specification;
- Future plans such as potential dredging works to deepen or lengthen shipping channels, and anchorages;
- Other activities such as dumping grounds, areas of subsea mining, and dredging for sand for beach replenishment for example;
- Information on existing and planned seabed infrastructure, including fiber and power cables, pipelines, and outfalls; and
- Any military uses or restrictions, including military vessel transit and practice areas, danger zones from firing ranges, and UXO.

The outcome of all the above will be a CBRA that incorporates a probabilistic, risk-based analysis to ensure that the cable will be buried to a suitable depth to protect both it, and external users, from harm as far as is reasonably practicable. Risks to the cable will be identified along the cable route on a KP by KP basis.

From the CBRA, a Burial Assessment Study can be developed to summarize the CBRA and ascertain suitable burial techniques and methodologies that will have the greatest probability of achieving the targeted DOL.

## W.3.2 Traditional CBRA (Preliminary): Primary Export Cable Corridor

As stated previously, the objective of the previous study was to complete a preliminary (Stage 1) CBRA for the Project's Offshore Export Cable Route Corridor. Furthermore, recommendations were made as to the data requirements needed to undertake a complete subsequent (Stage 2) CBRA and Burial Assessment Study.

The scope was limited to the export cable corridor as aligned with the Preliminary CBRA. A full assessment of threats from UXO was outside the scope of this document and would have required further investigation to fully elucidate.

Due to the ongoing survey works at the time, the continuing refinement of the ground model and understanding of the expected soil conditions, as well as the pending nature of individual micro-sited routes within the corridor, the report could only be considered a "preliminary" CBRA.

Once the remaining data that was identified within Section 8 of that report (Recommended Next Steps) was to be made available, a full, quantitative CBRA could be created from this foundation by using proprietary risk models informed by the Carbon Trust CBRA and in accordance with Dominion Energy's Project team's specific needs. The preliminary study made use of the datasets available at that stage of Project development to capture the current best understanding of the DOL and trends in the need for cable protection faced by the system.

### W.3.3 Area-Based CBRA (Preliminary): Route Alternatives

The above CBRA methodology is supplemented by a grid-based area risk assessment. This grid-based assessment covers the entire study area. It focuses on providing an assessment of relative anchor related risks while holding other factors constant to educate identification and evaluation of alternative cable route options.

The results of this portion of the study are not indicative of absolute risk for any one cable route. After alternative routes are identified individual CBRAs are necessary to accurately estimate absolute risk exposure and appropriate hazard mitigation.

### W.3.4 Amended CBRA Methodology

While the preliminary CBRA identified and discussed the relationship between the external aggression risks to the cable and the probabilistic mitigation of risk associated with different DOLs, it did not suggest DOL by cable route segment to optimize that DOL versus residual risk to achieve generally acceptable recurrence intervals.

To suggest a DOL which mitigates the probabilistic residual risk after burial to generally acceptable levels, this study begins with an optimization for each Offshore Export Cable Corridor centerline segment to identify the minimum burial depth that still achieves the reduction of the residual risk below the desired threshold. The relationship of residual risk to each potential DOL increment is documented in the Preliminary CBRA. Through this method, we identify the shallowest DOL that still provides adequate protection on a segment-by-segment basis for the route centerline.

We then take this DOL required to mitigate the statistical risk to each segment and add to it the additional DOL required to ensure the cable stays buried despite the actions of mobile sediments. This seabed mobility risk is extrapolated from the Seabed Mobility Study conducted by DHI A/S (DHI 2021) and discussed in detail in Section W.4.5.4 where the risk is defined, and in Section W.6.4.2, where the additional DOL is tabulated along the OECRC centerline.

It is important to note that seabed mobility is not equal across the entire corridor, such that some areas in a given KP range may exhibit more intense seabed mobility risk in the southern portion of the OECRC while in other areas, the northern portion of the OECRC may have a higher risk. Future efforts utilizing more detailed seabed mobility information may be able to refine this risk and the subsequent required mitigation.

# W.4 DATA REVIEW

## W.4.1 Shipping and Vessel Traffic Data

AIS data has been sourced from the Marine Cadastre Data Registry (Marine Cadastre Data Registry 2020). AIS signals from the study area were collected for the calendar year 2019. This included approximately 3.4 million AIS signals from 4,394 vessels, covering a true north square of signals with minimum and maximum latitude values of 36.71671, 37.08339, and longitude values of –75.99999 and –75.167, respectively.

This AIS signal data were supplemented with individual vessel characteristics data, where available, from Marine Traffic, including but not limited to vessel size characteristics and deadweight tonnage. Of the 4,394 vessels, 1,921 had deadweight tonnage (DWT) available from this source. The remaining DWT data was predicted using machine learning.

The data is further discussed and explored through vessel traffic plots, risk analysis, and area-based heatmaps provided in Section 6, Modeling of Likely Scenarios and Probabilistic Risk Assessment.

## W.4.2 Commercial Fishing Activity

Fishing effort data for the region were sourced from the Mid-Atlantic Regional Council on the Ocean (MARCO) data portal that includes Vessel Monitoring Service (VMS) data as well as Vessel Trip Report (VTR) data. Additional information was sourced from the BOEM study titled "Collaborative Fisheries Planning for Virginia's Offshore Wind Energy Area" (OCS Study BOEM 2016-040, prepared under BOEM Cooperative Agreement M14AC00029 by Virginia Coastal Zone Management Program, May 2016) as well as personal communications between the Dominion Energy Fisheries Liaison Officer(s) and local fishermen.

## W.4.3 Seabed Mobility

Seabed mobility data was sourced from CVOW Pilot Project site-specific data and BOEM's Marine Minerals Information System (MMIS; BOEM 2020b). At the time of writing of the initial CBRA, seabed mobility analysis as part of the Seabed Morphology Study for the CVOW Commercial Project was ongoing, but later findings have been incorporated into this document. The CVOW Pilot Project data included high-resolution geophysical (HRG) and geotechnical data collected during Project-specific survey campaigns. MMIS data utilized to assess seabed mobility included the "Modeled Shoals" layer, which was developed by the National Oceanic and Atmospheric Administration (NOAA) and is a collection of sediment resource features.

## W.4.4 Assessment Of Seabed Conditions

Over the course of 2 years (2020 and 2021), HRG mapping and geotechnical sampling campaigns greatly enhanced the knowledge of seabed conditions along the OECRC. The results of these efforts provided site-specific information to confirm initial assumptions and better constrain other parameters such as potential seabed mobility. This section describes the information considered in this document.

#### W.4.4.1 Previous Studies

The previous studies for the CVOW Pilot Project indicated that the survey corridor is dominated by low-relief sandy seabed, exhibiting minor undulations, with broad lows and highs related to underlying sand ridges and sand sheets. The seafloor itself is generally either smooth or contains ripples. Seabed slopes range from 2 to 4 degrees, with slightly greater slopes being highly isolated and related to individual ridge features. The shallow subsurface was not expected to contain geological features that would prevent the installation of the proposed CVOW Pilot Project export cable to a target burial depth of 5 to 6.5 ft (1.5 to 2 m). The composition of seabed in the survey corridor is generally interbedded sands and silty sands with some clay. There are numerous sidescan and magnetometer contacts throughout the route, since objects identified within the export cable survey corridor should be avoided and/or otherwise mitigated.

#### W.4.4.2 Burial Performance Along Adjacent Cable Routes

While exact burial metrics and methodology along the installed, parallel telecommunications cables is not known at this time, it is understood that each system was targeted to be buried approximately 5 to 6.5 ft (1.5 to 2 m) below the seabed. Furthermore, it is understood that this campaign was largely successful for each cable, and no known external protection (e.g., mattressing or rock dumping) was necessary to further protect the fiber optic cables should the target burial depth have not been met.

Dominion Energy has provided Tetra Tech with the following reports published by Ørsted that summarize the burial achieved on the parallel CVOW Pilot Project export cable:

- As-Laid Survey Report – Export Cable (CVOW Pilot Project), dated September 24, 2020 (Ørsted 2020a).
- As-Left Survey Report – Export Cable (CVOW Pilot Project), dated September 24, 2020 (Ørsted 2020b).
- As-Trenched Survey Report – Export Cable (CVOW Pilot Project), dated September 22, 2020 (Ørsted 2020c).
- As-Laid Survey Report – Export Cable (CVOW Pilot Project), dated September 23, 2020 (Ørsted 2020d).

The first two reports listed above (Ørsted 2020a,b) concern the repair operation of the CVOW Pilot Project export cable at KP 39.59. The cable was damaged by a commercial cargo vessel anchor post cable lay but prior to burial operations. The fourth report (Ørsted 2020d) only concerns the recovery of the offshore end of the export cable and the pull into the CVOW Pilot Project A02 monopile.

The third report listed above (Ørsted 2020c) is most relevant to this study and details the trenching operations undertaken by Canyon’s jet trenching remotely operated vehicle (ROV) T1200 deployed from the trenching support vessel Siem Dorado between May 27, 2020, and August 29, 2020. This time period included a delay to allow the cable to be repaired at the damaged location between July 26, 2020, and August 11, 2020.

The T1200 ROV trencher is a tracked or free-flying vehicle with 1,200 horsepower of installed power that is claimed to be able to bury flexible or rigid products up to 36 in (915 mm) outside diameter to a depth of

10 ft (3.0 m), depending on soil characteristics. This vehicle can use a variety of jet tool lengths ranging from 3 ft (1.0 m) to 10 ft (3 m), the selection of which is dependent on the desired targeted DOL and the soil conditions encountered.

The CVOW Pilot Project export cable starts at KP 0.0 at the Transition Joint Bay and ends at KP 44.753, which is the A02 monopile foundation. The Offshore Trenchless Installation Punch-Out Location is at KP 1.021, which is where trenching operations commenced, and these operations continued to the A02 monopile. Three fiber optic submarine cables were crossed at KPs 20.779 (BRUSA), 23.510 (MAREA), and 31.757 (Dunant). At these locations, cable protection systems, concrete mattresses, and rock dumping were used for cable protection; therefore, burial via jetting was not attempted.

The CVOW Pilot Project export cable Target DOL is as follows:

- KP 1.000 – 5.400: 5 ft (1.5 m)
- KP 5.400 – 6.300: 8 ft (2.4 m) (approximate DNODS zone)
- KP 6.300 – 8.700: 6.5 ft (2.0 m) (approximate DNODS zone)
- KP 8.700 – 9.640: 5 ft (1.5 m)
- KP 9.640 – 9.830: 6.2 ft (1.9 m)
- KP 9.830 – 12.760: 5 ft (1.5 m)
- KP 12.760 – 12.890: 5.25 ft (1.6 m)
- KP 12.890 – 16.500: 5 ft (1.5 m)
- KP 16.500 – 23.500: 6.2 ft (1.9 m) (approximate area of greater commercial vessel traffic south of the Chesapeake Bay approaches shipping channels)
- KP 23.500 – 26.500: 5.25 ft (1.6 m)
- KP 26.500 – 44.753: 5 ft (1.5 m)

In general, the trenching operations initially utilized the 6 ft (2 m) jetting legs. The exception was the area between KP 17.1 and 19.5 where the 3 ft (1 m) jetting legs were fitted. This implies that the soil conditions were harder there and that the longer jet legs would not penetrate the seabed deeply enough to be efficient.

Another indication of harder soil conditions is the number of jetting passes required to lower the cable to target depth. As a basic rule of thumb, the first pass achieves the greatest amount of burial (approximately 60 to 70 percent); an additional approximately 20 to 30 percent is achieved on the second pass, and subsequent passes have relatively minor effect with diminishing returns.

The burial report shows that four passes were necessary from approximately KP 5.5 to 6.8 and KP 9.3 to 11.9. Despite this, target lowering was achieved with burial depths ranging from 6.5 to 8.5 ft (2 to 2.6 m), with a small exception of 3.6 ft (1.1 m) at KP 9.6.

The main area of burial difficulty, evidenced by multiple burial passes (up to six), the initial selection of the 3 ft (1 m) jet tool and the inability to achieve the target burial was the section between KP 17.1 and 19.9. In this area, the target DOL was 6.2 ft (1.9 m), but the burial achieved fluctuated between 1.6 and 5.7

ft (0.5 m and 1.75 m). In-situ data (e.g., CPT) indicate a very dense sand layer with high cone resistance at shallow depths between 3 ft (1 m) bsf to 16 ft (5 m) bsf within the area (Geoquip 2020). Furthermore, this area coincides with heavy outbound shipping leaving the Chesapeake Bay approach channels and therefore merits special attention.

Note that the above KPs pertain to the CVOW Pilot Project export cable, so the soil conditions and associated burial implications will be slightly different for the Project's export cables. However, since both the CVOW Pilot Project and CVOW Commercial Project cable corridors run roughly parallel, it is reasonable to assume that broadly similar soil conditions will occur, and that they would occur in broadly similar locations.

Based on the results from the CVOW Pilot Project export cable installation, and conclusions provided in this CBRA, the appropriate cable protection measures will be put in place as to mitigate any external aggression to the cable throughout the life cycle of the cable installation process.

### W.4.4.3 Results of Geophysical and Geotechnical Surveys

As mentioned, multiple survey campaigns have been employed to assess seabed conditions along the OECRC. Thus, the OECRC site has been separated into segments A through F proceeding from the Lease Area offshore to the Commonwealth of Virginia. The segment-structure was first implemented in the geophysical surveys to have a straightforward way of referring to areas of the route. An overview map of the OECRC segments is provided as Figure W-11.

#### *W.4.4.3.1 Geophysical Survey Results*

Alpine Ocean Seismic Survey (Alpine) conducted survey operations comprised of bathymetric and geophysical data acquisition along the OECRC in phases. The equipment used during the surveys included multi-beam echo sounder, side scan sonar, transverse gradiometer, parametric sub-bottom profiler, and boomer. Grab sampling was also undertaken during the second survey phase. In addition, a third phase of infill data was also acquired as well as a fourth phase of geophysical data acquisition in the inshore section of the OECRC. These phases are summarized in Table W-1.

Results of the geophysical survey along the OECRC are summarized as follows:

- Seabed slopes generally less than 1°; slopes around natural features occur on the flanks of morphological features and other topographic highs where localized seabed gradients reach up to 4° (e.g., DNODS);
- Seabed sediments across the OECRC are comprised of MUD (lean CLAY with sand) to medium SANDS (poorly graded SAND) with occasional gravel mixes (poorly graded GRAVEL with sand). Areas of CONSTRUCTION HASH (poorly graded SAND with clay) are interpreted within the DNODS;
- The primary natural features of interest are topographic highs and smaller-scale morphological features. The topographic highs have a more elaborate profile in the bathymetry and are likely to represent north-to-south moving sand banks that the route crosses perpendicularly. The movement that these features exhibit is likely to be on the scale of approximately 1 meters per year (m/yr).

- Occasional seabed scarring, observable in the bathymetry and in the side scan sonar imagery distributed sporadically throughout the OECRC. These are generally long indentations, with an approximate depth of 10 to 20 cm compared to the surrounding seabed. These seabed scars are potentially indicative of fishing or anchoring in this area.
- The DNODS is situated across the export cable route between KP5.3 and KP8.4. Numerous regular oblong features occur within this area. The bathymetric dataset, especially, shows an abrupt break in the character of the seabed from the surrounding sediments to the character where these features occur—this variance is detailed in the interpretation as a change from mud to construction hash, interpreted as deriving of the dumped material.
- From KP0.0 to KP0.9, the OECRC traverses an explosive dumping area, denoted as denotes "Unexploded rockets, May 1954" on Nautical ENC US4NC32M. Some targets were interpreted within this area, including magnetic anomalies, but none are definitively interpreted as unexploded rockets. The most complex magnetic field signatures occur outside the 'explosives dumping ground' and seem to be associated with infrastructure.
- The CVOW Pilot export cable route corridor is well-delineated in the bathymetry. Three other cables (BRUSA, MAREA and DUNANT) also cross the OECRC, and are also observed in the magnetic dataset.
- One wreck occurs within the OECRC. This is a charted obstruction, apparent in the bathymetry, side scan sonar, and magnetic datasets, standing approximately 1.8 m proud of the surrounding seabed.
- Numerous side scan sonar targets and magnetic anomalies occur throughout the route with 997 targets and 7,100 anomalies interpreted. Most of the side scan targets are interpreted as objects while two are interpreted as wires. A total of 127 of the objects correlate with magnetic anomalies. Of the interpreted side scan sonar targets, 13 have a measured height greater than 1 m.
- At the shoreward terminus of the OECRC, numerous small depressions are observed in the bathymetry. These are generally between 0.1 m and 0.4 m deeper than the surrounding seabed, and in some cases coincide with anthropogenic debris. These small depressions observed occurring near the landward end of the OECRC may be either natural, anthropogenic, or mixed in origin.
- The shallow soils sequence at the OECRC feature primarily Quaternary soils formations. The uppermost sedimentary sequence is interpreted as Holocene sands. The oldest and deepest interpreted sequence is dated to the pre-Quaternary and interpreted as the Yorktown Formation.
- Numerous palaeochannels occur throughout the survey area, as evidenced both in the parametric sub-bottom profiler and boomer records. None of the channels showed indication of acoustic blanking in the seismic record, i.e., there were no indications of shallow gas within the palaeochannels.

A description of the geophysical interpretation with respect to the various OECRC segments is provided as Table W-2.

#### *W.4.4.3.2 Geotechnical Investigation Results*

In conjunction with the geophysical surveys, geotechnical investigations were performed by both Geoquip Marine (Geoquip) and Alpine in several phases as well. OECRC locations were investigated by seabed CPT, sampling boreholes (e.g., push/piston sampler, vibracores) and alternating CPT and sampling boreholes. These phases are also summarized in Table W-1. Overall, the agreement between the interpreted geophysical geomodel and the observed geotechnical results were good.

Location maps of the respective geotechnical survey campaigns are provided as Figure W-12, Figure W-13, and Figure W-14. Geoquip operations could only be completed in segments A through E due to operational limitations of the vessels. Alpine's investigative scope applied from the shallowest safe water depth to the 10-m water depth contour (Segments E and F).

Geotechnical information from the Geoquip 2020 surveys covered only a portion of the route, from approximately KP 8.5 in 49 ft (15 m) water depth near the outer boundary of the DNODS to approximately KP 45.5 inside of the Lease Area boundary in 88.5 ft (27 m) water depth. Generally, the sites further offshore appear to be dominated by loose to very dense sands in the upper several meters of seabed. The sites further inshore also indicate the same (Figure W-15), but with several sites exhibiting finer-grained material (e.g., clayey sand and sandy clay), with some units (Figure W-16) exhibiting shear strengths of less than or approximately 40 kilo Pascals (kPa) (a cutoff for anchor penetration as discussed in Section W.5.1.2, Anchorages, Anchoring, and Anchor Drags).

The purpose of the Geoquip 2021 geotechnical campaign was to complete investigation at the remaining proposed turbines, Offshore Substation, and OECRC locations following from the 2020 geotechnical campaign. In total, there were 93 seabed CPTU only locations, 34 sampling only locations and 2 locations with combination of CPTU, sampling and oversampling that were investigated for the 2021 campaign utilizing three vessels: MV Geoquip Speer, MV Geoquip Saentis, and MV Dina Polaris (Figure W-12). Results from the geotechnical campaigns along the OECRC provide details to the composition and strength of the seabed.

An overview summarizing the geology of each of the OECRC segments based on these data is provided in Section 1.2 of the 2021 OECRC Campaign Report provided by Geoquip (2022) and described in this report in Table W-2. Examination of the borehole and seabed CPT data collected along the OECRC yields results generally similar to the findings along the CVOW Pilot Project export cable route corridor.

In August 2021, Alpine conducted a geotechnical investigation in the effort to gather data to help identify geological hazards, support export route development and to obtain archaeological assessment for the OECRC engineering. The scope of the geotechnical investigation applied from the shallowest safe water depth to the 10-m water depth contour (Segments E and F), including the DNODS. The planned scope included CPTs in the western third of Segments E and F (Figure W-13) and vibracores in Segments E and F (Figure W-14). An additional location identifier "G" which was used in the shallowest part of the OECRC, between Segment F and the coastline. A further location identifier, "X", was used for samples collected in certain parts of the DNODS.

As observed during the field phase of the Alpine survey, sand and sand-silt mixtures are the dominant soil type encountered across all series of cores within the depth investigated, with clay being the second most common – particularly in the E and G series. Silt was encountered as well, but to a much lesser extent –

primarily identified in the offshore E series of cores. The X group consisted almost completely of fine sands and sand-silt mixtures, with a minor amount of clay layers present.

These results indicated that while much of the seabed along the OECRC alignment should be considered lower risk for excessive anchor penetration, there may be some areas that require an additional factor to account for surficial loose or softer sediment. Further analysis and mapping of the geophysical and geotechnical datasets have allowed for improved detail on the nature of the seabed.

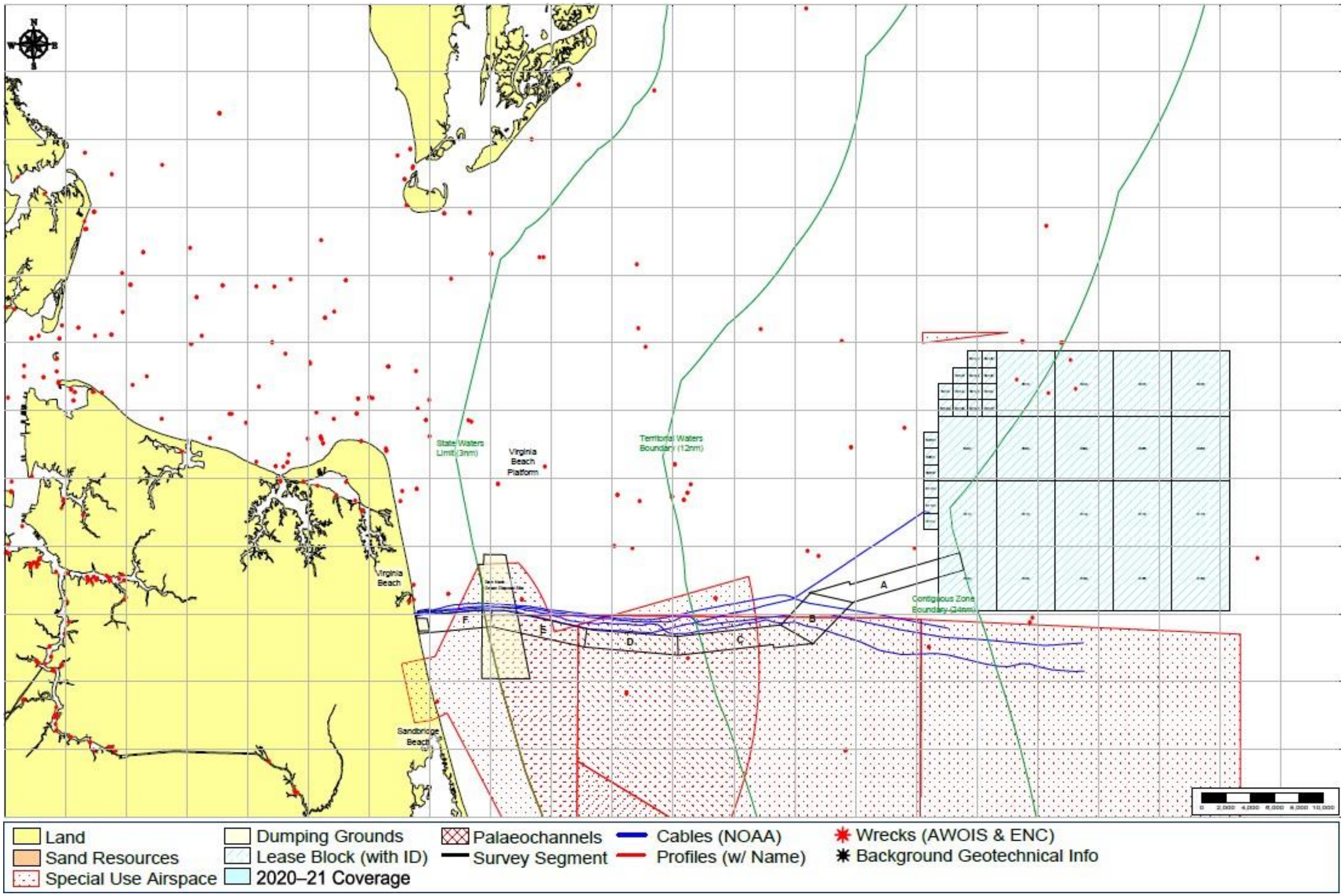



**Figure W-11. OECRC Segment Overview Map**

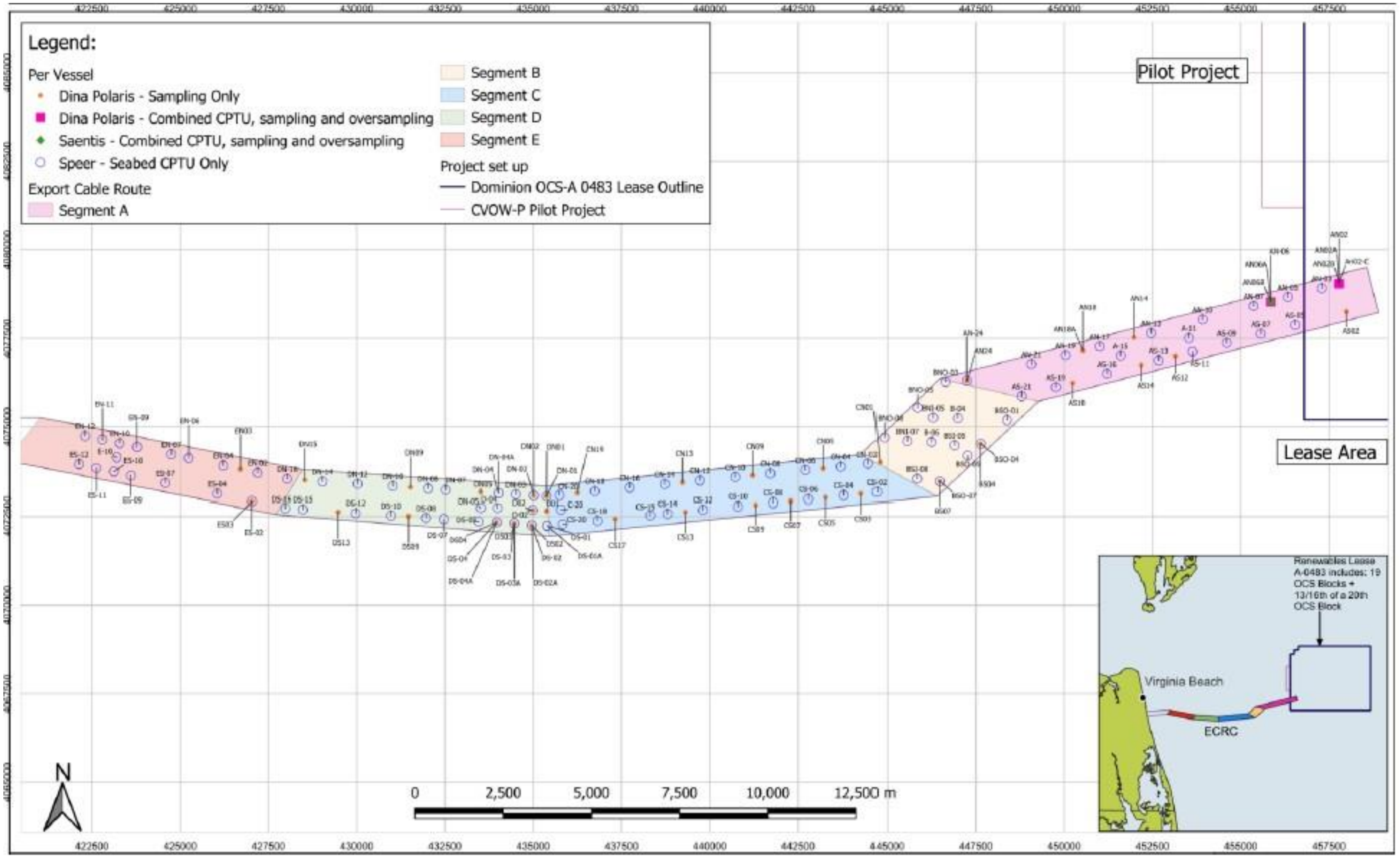



**Figure W-12. Geoquip 2021 Geotechnical Investigation Overview Map**

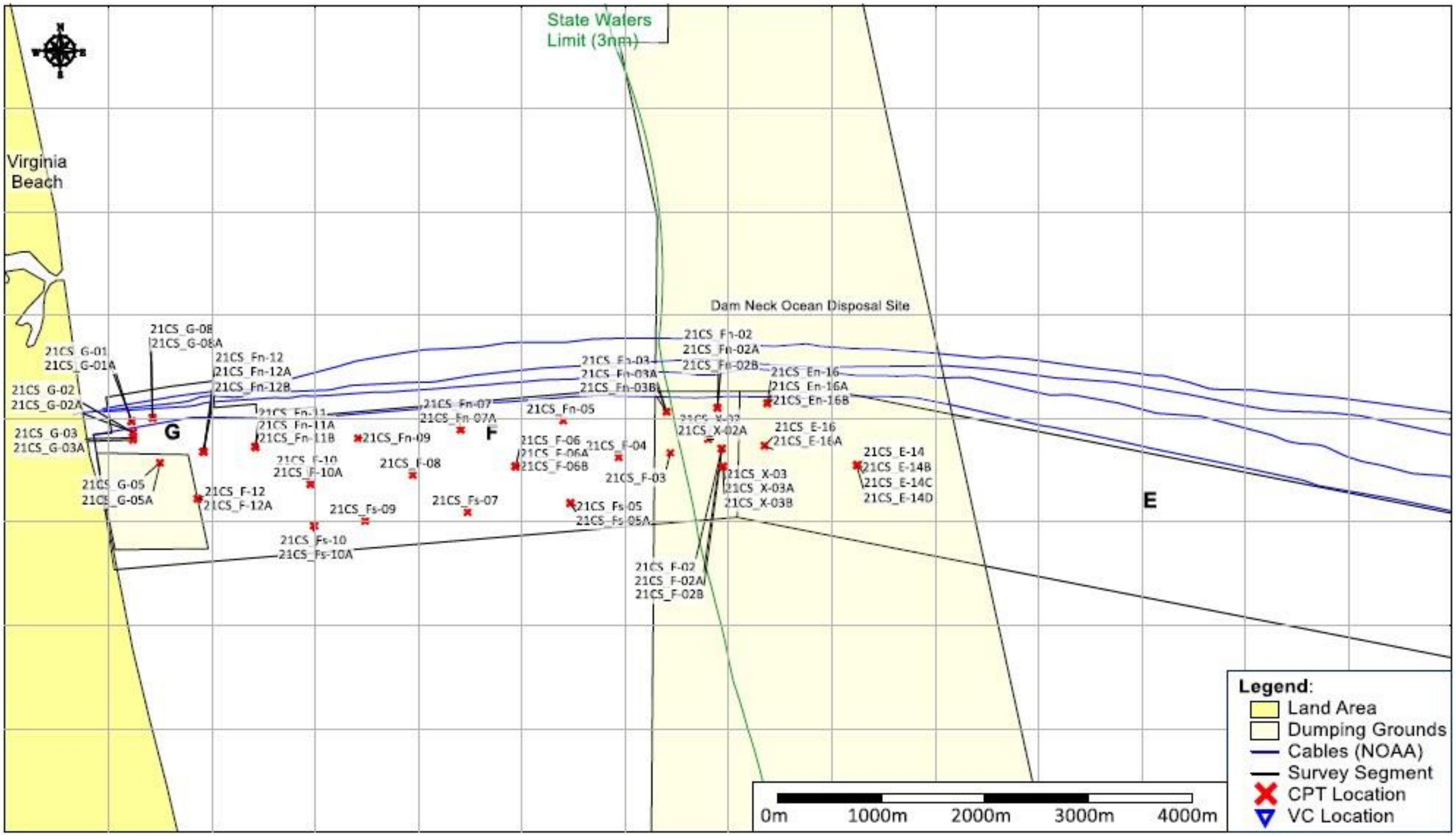



**Figure W-13. Alpine 2021 Geotechnical Investigation (CPT Location) Overview Map**

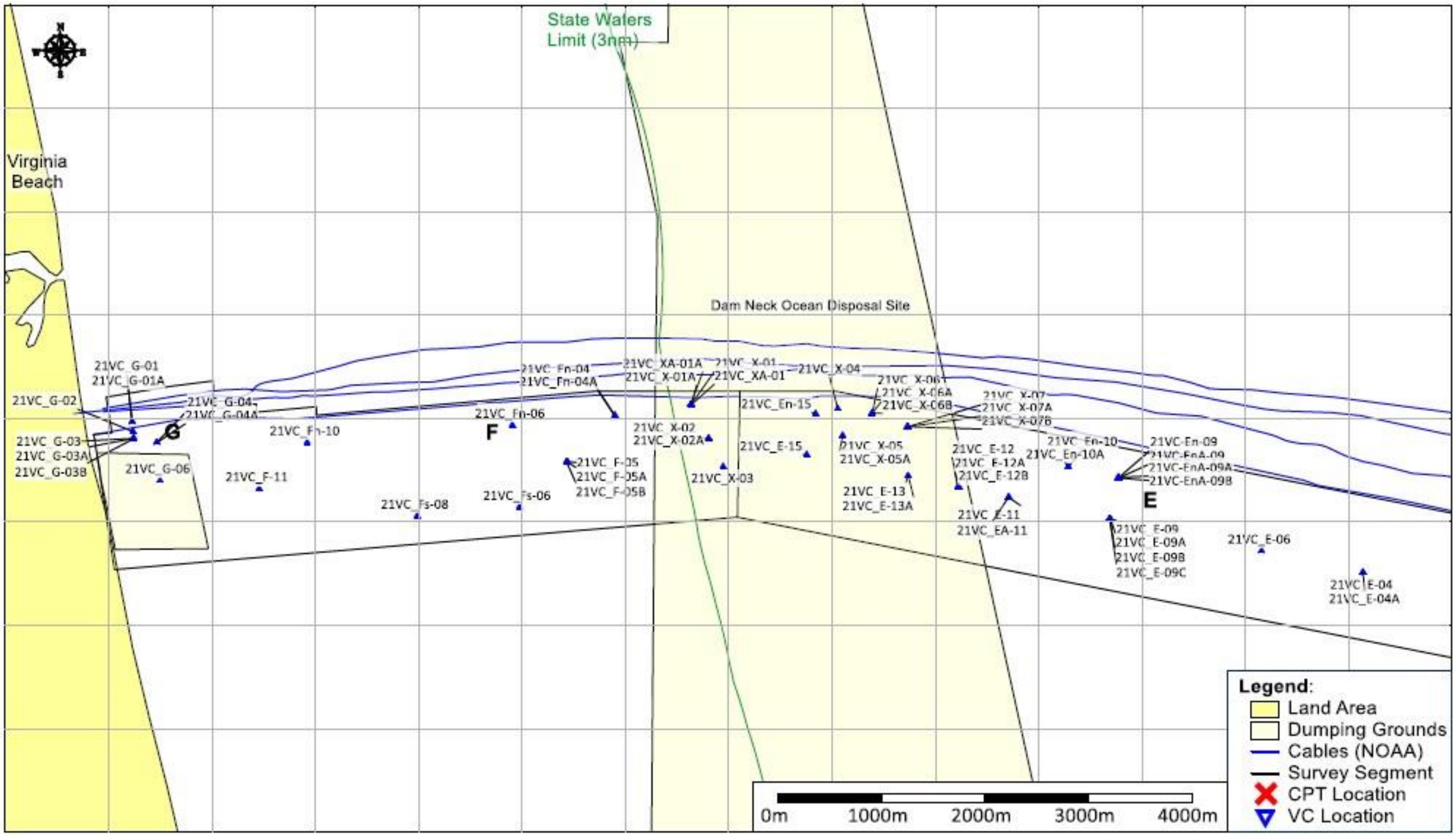



**Figure W-14. Alpine 2021 Geotechnical Investigation (Vibracore Location) Overview Map**

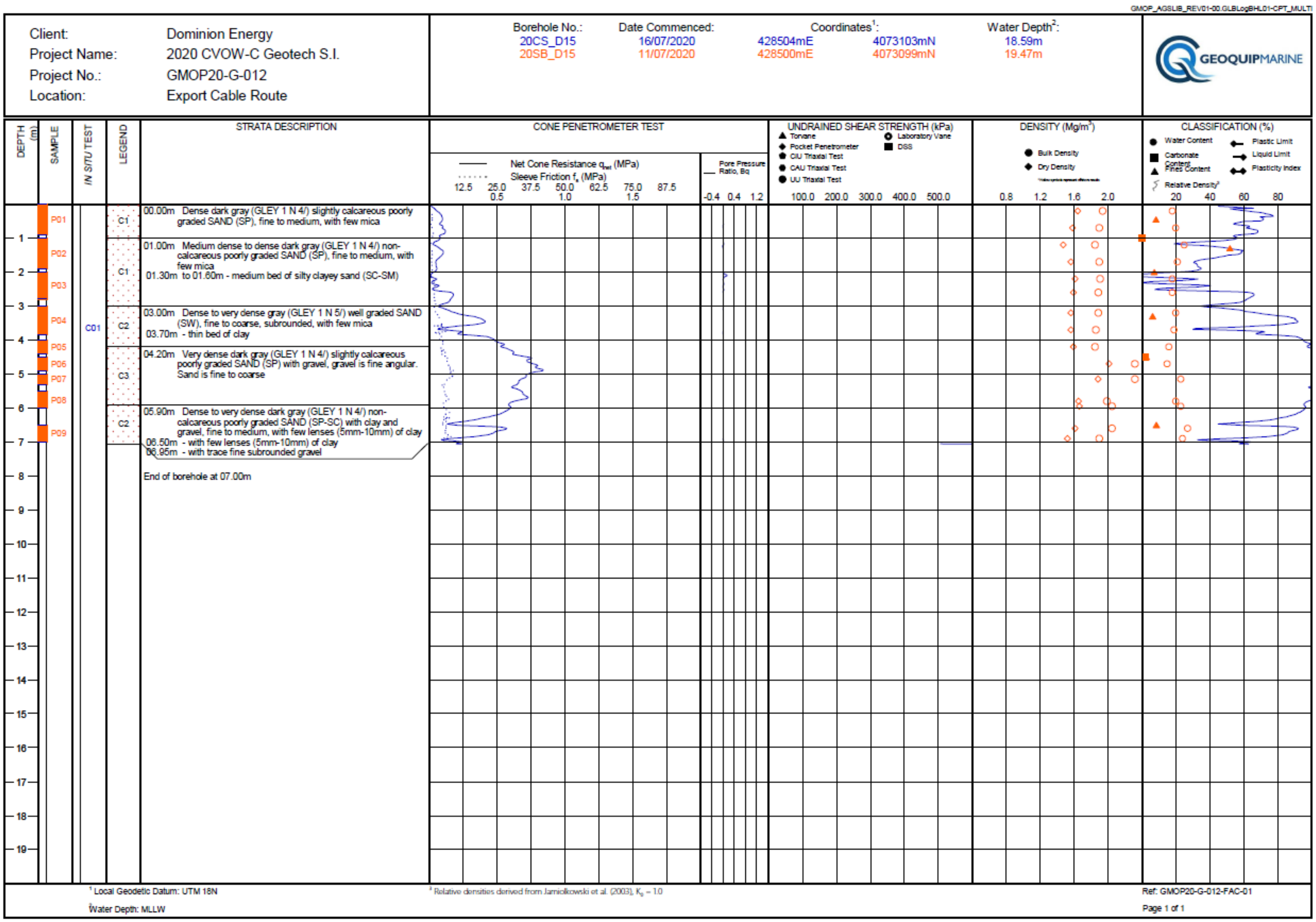



**Figure W-15. CPT site 20CS_D15 Shows Medium to Dense Sands in the Upper 1 to 2 m of the Seabed with Fine Grained Materials Present**

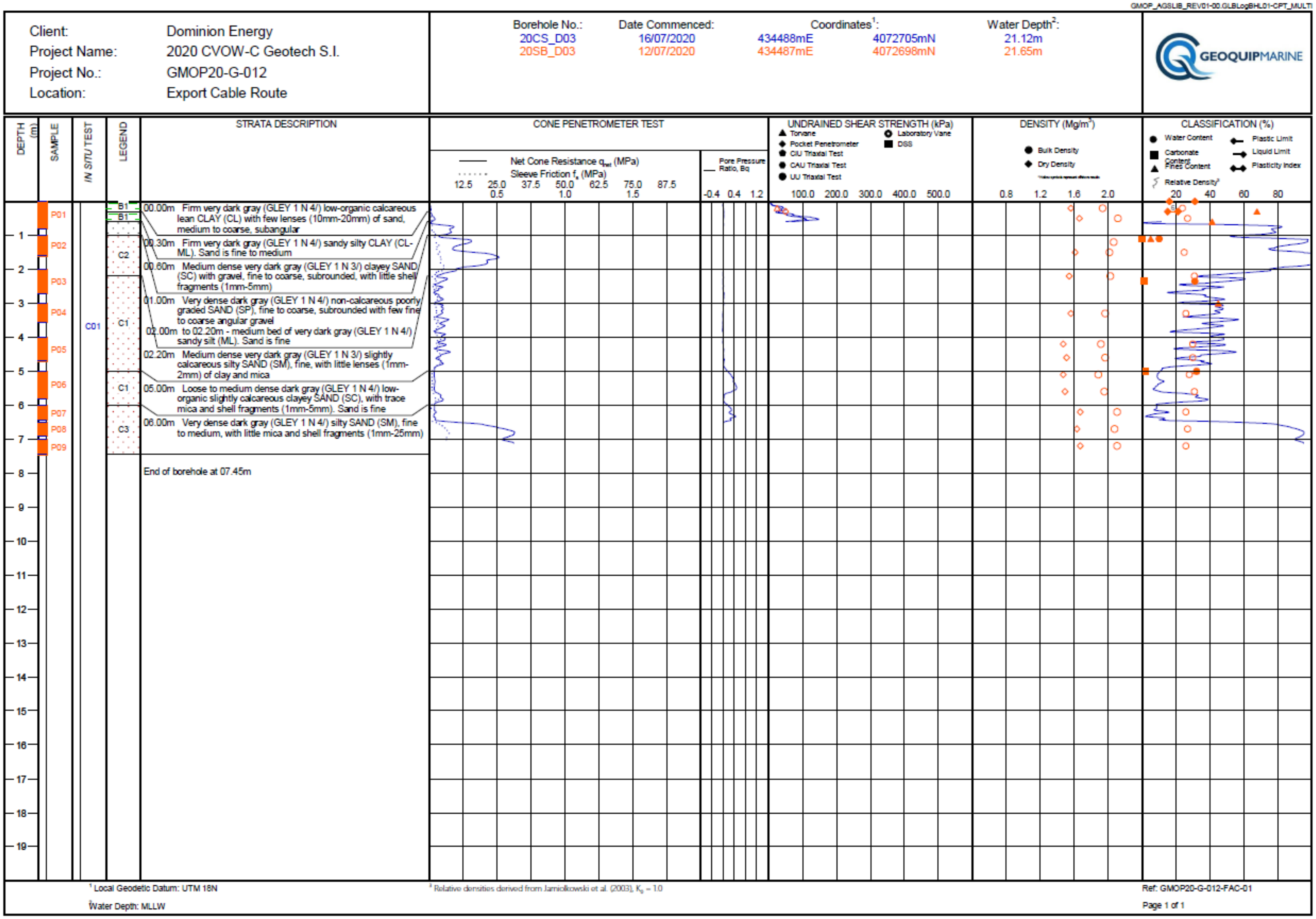


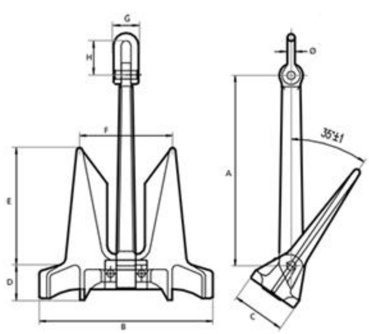

**Figure W-16. CPT Site 20CS_D03 Shows Firm Sandy Clay in the Upper 1 m of the Seabed with Shear Strength of 25 to 50 kPa**

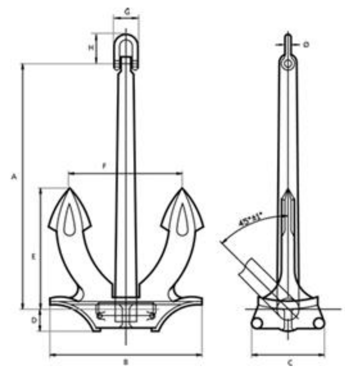
### W.4.5 Data Review: New Data Regarding Seabed Composition

The following sections take into consideration new information provided by Dominion Energy, which is listed in Table W-1 below and summarized thereafter.

**Table W-1. Data and documentation available to update the understanding of the seabed sediments, morphology, mobility, and potential risks to the cables.**

| Ref | Document Title | Synopsis |
|---|---|---|
| 1 | Project Seabed Morphology & Mobility Study | DHI authored sediment mobility study commissioned by Ramboll, dated March 2021.<br>• Studies Lease Area and export cable corridor<br>• Utilizes the following bathymetric data: -<br>  ○ Publicly available National Oceanic and Atmospheric Administration (NOAA) data from 2006, 2010, 2011, 2012<br>  ○ Fugro 2013 report 'Regional Geophysical Survey and Interpretive Report: Virginia Wind Energy Area Offshore Southeastern Virginia'<br>  ○ Terrasond Lease Area Multibeam Echosounder (MBES) data from 2020<br>  ○ Alpine Ocean Export Cable Route Corridor MBES from 2020<br>• Utilizes the following geotechnical data:-<br>  ○ Tetra Tech 2013 report 'Marine Site Characterization survey report Virginia Offshore Wind Technology Advancement Project'<br>  ○ Fugro 2013 report 'Regional Geophysical Survey and Interpretive Report: Virginia Wind Energy Area Offshore Southeastern Virginia'<br>  ○ Terrasond 2020 report 'Geophysical Survey Report – Lease Area – 2020' and annex from Schnabel Engineering 2020 (seabed) 'Surficial sediment sample collection and analysis – Coastal Virginia Offshore Wind (CVOW) Lease Area'<br>  ○ Alpine ECR grab sample data from 2020 in the Export Cable Route Corridor<br>• Utilizes the following Metocean data:-<br>  ○ Metocean assessment – Ramboll 2021<br>  ○ Fugro 2013 metocean criteria for Virginia offshore wind<br>  ○ AWS metocean design assessment 2015<br>By reviewing the aforementioned data, the outcomes of this study included:-<br>• A description of the seabed and bedform characteristics in the Lease Area<br>• Assessment of sand ridge migration within the Lease Area<br>• Assessment of sand wave migration within the Lease Area |

| Ref | Document Title | Synopsis |
|---|---|---|
| | | • Assessment of sand ridge and sand wave migration within the Export Cable Route Corridor<br>• Predictions of future seafloor elevations at each wind turbine location and at selected points along the export cable route<br>Executive Summary:-<br>1. Generally, the Lease Area can be divided into two zones<br>a. Mobile seabed; Northwest and South of the Lease Area<br>b. Mostly immobile seabed; Northeast sector<br>2. The sand ridges in the Lease Area and along the Export Cable Route Corridor migrate towards the Southwest by 1 to 2 meters (m) (3.3 to 6.6 ft) per annum<br>3. The sand waves in the Lease Area migrate at approximately 1 to 3 m (3.3 to 10 ft) per annum (relatively slow)<br>4. The sand waves in the Export Cable Route Corridor have a higher rate of migration, up to 18 m (60 ft) per annum (e.g., the DNODS disposal area [C10])<br>5. The flat areas in the Lease Area and Export Cable Route Corridors are mostly immobile, although some spots erode at about 5 cm (2 inches) per annum |
| 2 | Anchor Tests German Bight – Test set-up and results [Deltares] | The German Transmission System Operator Tennet commissioned Deltares to undertake a series of anchor drop and drag tests in November 2012. Tennet's main area of concern was the vessel separation zone North of Nordeney (North West Germany in the North Sea).<br>Three test areas close to Nordeney were identified and 17 anchor drop tests were performed using two differing anchor types, both with fluke lengths of approximately 2 m (6.6 ft):-<br>• 8.5 T AC-14 High Holding Power anchor<br><br>• 11.5 T stockless Hall anchor |

| Ref | Document Title | Synopsis |
|---|---|---|
| | | <br>Testing protocol:-<br>1. Survey of anchor drop locations<br>2. Position vessel above test site, lower anchor to 10 m (33 ft) above the seabed<br>3. Drop anchor by releasing winch<br>4. Survey anchor by Remotely Operated Vehicle (ROV)<br>5. Move vessel ahead and pay out anchor chain to ensure correct alignment<br>6. Pull until either anchor breaks out or 800 kN (180,000 lbs) of pulling force was reached (this limit was chosen as a safety precaution)<br>7. Survey with the ROV, Multi Beam Echosounder (MBES), Sidescan Sonar (SSS) & Sediment Echo Sounder (SES) equipment<br>Sediment types/packing density (derived from Cone Penetrometer Testing [CPT]) at the three testing locations:-<br>• Northern testing area: Loose to very loose packed, partly fine silt to medium sands for the top 3 m (10 ft). Locally, coarse sands or gravel 'may be present'<br>• Southern testing area: Mainly silty fine to medium sands in the first 3 m (10 ft) with occasional coarse sands and clayey zones. Generally, the first 1 to 1.5 m (3.3 to 5 ft) were generally loose to medium-dense. Beyond that, the density increased to mainly medium dense to dense<br>• VTG (traffic separation zone) area (the most Southerly of the three areas): Loose sand layer for the first 1 m (3.3 ft) below which cohesive sediments (clays and/or silts) were encountered, with localized areas of peat<br>Summary of results:-<br>1. Anchor Dropping: The anchors impacted the seabed at between 2 and 4 m/s and none of the anchors showed significant penetration. Actual penetration depths did not exceed 0.25 m (~1 ft) for the AC-14 anchor and 0.45 m (1.5 ft) for the Hall anchor<br>2. Anchor Dragging: Allowing a small margin for inaccuracies, it was concluded that the 8.5T AC-14 anchor did not penetrate more than 0.8 m (2.6 ft) and the 11.5T Hall anchor did not penetrate deeper than 1.0 m (3 ft). |

| Ref | Document Title | Synopsis |
|---|---|---|
| | | Generally, penetrations were the greatest in the Northern testing area. |
| 3 | OECRC Exploration | Email dated April 22nd 2021 to Stig Marstal and Jan Duehrkop at Ramboll from Tom McNeilan (McNeilan & Associates LLC, a geotechnical consulting firm). The email outlines the burial experience from Dominion Energy's CVOW Pilot project, including the 3 km (2 mi) segment from KP 17.14 to 20.11 where the target 1.5 m (5 ft) burial depth was not met.<br>The email also details some subsurface stratigraphy derived from CPT operations. Document #4 (OECRC Subsurface Stratigraphy, below) was attached to this email. |
| 4 | OECRC Subsurface Stratigraphy | Sectional, linear graphic containing stratigraphy information from CPT activities as well as seabed elevation, the locations of existing and planned borings for Segments A through E of the Southern, Centerline and Northern Wing Corridors of the CVOW-C export cable route.<br>Graphic also highlights areas where the parallel and adjacent CVOW-P export cable burial achieved less than 1.4 m (4.6 ft) Depth of Lowering (DOL). Received 22APR2021. |
| 5 | IMG-7178(1) | <br>Photograph of a cobble-sized rock recovered during geotechnical drillcoring operations along the OECRC (Boring D01, between KP21 and KP22). Received June 6, 2021. |
| 6 | CVOWC Export Cable Route Corridor Geophysical Survey Interpretation Report (Revision 8) – Alpine Ocean | Alpine's interpretations and results for the geophysical survey investigations and incorporation of seabed grab sample results as appendices.<br>Alpine Ocean undertook High Resolution Geophysical (HRG) surveys along the CVOWC export cable corridor in three phases:-<br>1. RV Shearwater – summer of 2020;<br>2. RV Minerva Uno – fall of 2020;<br>3. RV Minerva Uno – spring of 2021; and<br>4. RV Henry Hudson – summer of 2021.<br>Equipment utilized included:-<br>• Sound Velocity Probe (SVP)<br>• Multi Beam Echo Sounder (MBES)<br>• Side Scan Sonar (SSS)<br>• Transverse Gradiometer (TVG)<br>• Sub-Bottom Profiler (SBP_<br>• Single-Channel Ultra-High Resolution Seismic (S-UHRS) |

| Ref | Document Title | Synopsis |
|---|---|---|
| | | • Grab Sampler<br>Surveys undertaken were in line with lease requirements and according to specifications described in BOEM's 'Guidelines for Providing Geophysical, Geotechnical and Geohazrd Information Pursuant to 30 CFR Part 585' and 'Guidelines for Providing Archeological and Historic Property Information Pursuant to 30 CFR Part 585'.<br>The report states limiting factors to survey data collection were due to poor weather, protected species encounters, simultaneous operations-related survey downtime, and some delays due to technical issues. |
| 7 | Geoquip Marine –<br>Measured and Derived Geotechnical Parameters and Final Results –<br>Revision B2 (February 2022) | Geoquip Marine undertook a geotechnical site investigation both at the Lease Area and export cable route. Three vessels were utilized over two campaigns:-<br>1. MV Geoquip Speer (2020 and 2021); and<br>2. MV Dina Polaris (2021); and<br>3. MV Geoquip Saentis (2020 and 2021)<br>All operations took place concurrent with the 2020 and 2021 geophysical investigations.<br>The 2020 results report from 42 shallow seabed CPTs to 7-8.5 m below seabed and 17 shallow boreholes to 7 m depth within the Export Cable Route Corridor.<br>The 2021 results report from 93 seabed CPTU only locations. 34 sampling only locations and 2 locations with combination of CPTU, sampling and oversampling. |
| 8 | Alpine Export Cable Route Corridor Shallow Water Geotechnical Survey (Rev. 2) | Geotechnical information inshore of KP8.3 was carried out by the RV Shearwater (Alpine) in August 2021. The results report from 28 seabed CPTs, 29 geotechnical boreholes and 3 geoarchaeological boreholes within the Export Cable Route Corridor. |
| 8 | DHI CVOW-C HDD Morphology Study (2021) | This is a summary of results prepared by DHI comparing existing datasets to determine patterns in shoreline evolution, upper beach evolution, nearshore seabed dynamics, offshore seabed dynamics, and geotechnical assessment to seabed mobility and dynamics near the shoreline crossing, as this was not evaluated in Ref #1 above. |
| 9 | Dominion Energy - CVOW-C -<br>Owner´s Engineer<br>Marine Site Investigation Report | This report integrates the high-resolution geophysical and geotechnical survey results and summarizes features, characteristics, and conditions in the context of the Project's installation and operation. |

### W.4.5.1 Seabed Composition and Stratigraphy

The high-resolution geophysical surveys and geotechnical sampling of the seabed have allowed for interpretations of the seabed composition and morphology along the OECRC. As mentioned, the survey efforts have divided the OECRC into six survey segments, labeled A through F, with A at the edge of the Lease Area and F reaching the landing.

The purpose of this summary is to ensure that the CBRA methodology used in this study adequately captures the location and types of seabed, as those will drive anchor penetration evaluations and therefore quantitative risks. However, given the relative lack of granularity in the Carbon Trust-style CBRA, the predominant seabed types (i.e., loose to dense sands) identified along the route generally fall into the category of "harder" seabed, as the "softer" category represents low shear strength cohesive sediments where anchor penetrations are much greater. This relates to an anchor staying on the surface of sandy of consolidated sediments when dragged and only engaging up to approximately the depth of the anchor flukes, while in softer cohesive sediments, the anchor may penetrate up to several times its fluke depth as it embeds into the seabed to achieve holding power.

The loose to dense surficial sands expected along much of the route (see Table W-2), as well as the infrequent exposures of older underlying Pleistocene sediment all represent "sandy" or "harder" material in the context above, which will substantially limit anchor penetration much more than if softer unconsolidated clays or muds were present.

Assigning the same KP segments used for the CBRA to those OECRC segments enables the reference of where along the OECRC centerline the different seabed features and sediment types are present.

**Table W-2. OECRC survey segment summary from the Alpine HRG results and the Geoquip/Alpine geotechnical sampling efforts, showing OECRC survey Segment and CBRA KP ranges.**

| OECRC Survey Segment | Approx. | | Alpine Seabed Sediment Description from HRG results | Geoquip/Alpine Seabed Description from CPTs and Boreholes |
|---|---|---|---|---|
| | KP Start | KP End | | |
| F | 0 | 6 | Muddy sand to fine sand with sandwaves, ripples, and megaripples | Samples predominantly comprised fine sands, silts, or a combination of fine sands and silts. Layers of fat clay were present in the base of some Group F cores. |
| E | 6 | 14 | Muddy sand, fine sand, gravelly sand, and sandy gravel. Areas of dumped material are present in the DNODS. Ripples, megaripples, and sand banks present. | Samples predominantly comprised fine sands, silts, or a combination of fine sands and silts. Clay content was regularly mixed in. Layers of fat clay were present in the base of Group E cores. |
| D | 14 | 22 | **Muddy sand, fine to medium sand, fine sand, and gravelly sand. Anchor Scars (** Figure W-17) identified in the HRG data east of KP20 near the entrance to the entrance to the Traffic Separation lanes. Ripples, megaripples, and sand banks present. | Shows less clearly defined shallow stratigraphy with firm to stiff clay clearly visible at seven sites with more non-cohesive material becoming prominent the further west along the cable route. |
| C | 22 | 32 | Gravelly sand, fine to medium sand. Multiple anchor drag scars. Ripples, megaripples, sand banks, and sand waves present. Sand banks, sand waves, ripples, and megaripples present. | Exhibits less clearly defined shallow units with the most easterly locations following a similar shallow stratigraphy to theta of segment B with thin lenses of clay/silt identified from the seabed CPT however as the investigation progressed west the shallow stratigraphy becomes more defined with clearly identifiable clay and sand layers visible within the initial 7.00m below mean seabed level. |

| OECRC Survey Segment | Approx. | | Alpine Seabed Sediment Description from HRG results | Geoquip/Alpine Seabed Description from CPTs and Boreholes |
|---|---|---|---|---|
| | KP Start | KP End | | |
| B | 32 | 35 | Fine sand with limited areas of fine to medium sand. Three fiber optic telecoms cables cross the corridor. | Consist of loose to very dense sands with numerous lenses of silt identified within the seabed CPT. One site tags the underlying cohesive material (stiff clay) at a depth of 6.75 m. |
| A | 35 | 46 | Fine sand and fine to medium sand. Sand bank, ripples, and megaripples present. | Primarily consisted of non-cohesive soils to the completed borehole depth with densities ranging from medium to very dense. The exception being two locations where a clearly defined layer of firm to stiff clay was identified by both the CPT and sampling locations between 3.55-7.00 m. |

Tom McNeilan had assembled a multi-page graphic showing the CPT sounding stratigraphic results along the northern, center, and southern OECRC wing lines, which also shows the OECRC survey segments as shown in Table W-2 above. Tetra Tech has annotated this table with approximate Route Centerline KPs to coincide with the discussions in the CBRA and this addendum. This is provided here for reference as Figure W-18**,** Figure W-19, and Figure W-20.

Notably, even looser sands along the OECRC investigated by the CPT system tend to become more dense and exhibit higher measured cone resistance (CPT parameter $q_c$) with values of 10 Mpa or more at depths below seabed greater than 1 m. This indicates that even in loose surficial sands, an anchor penetrating the seabed would encounter increasing resistance with increasing depth, thus limiting total penetration even in the presence of the upper layer of looser sands. This physical scenario is observed and confirmed by the Deltares (2013) anchoring penetration tests in the German Bight of the North Sea as discussed in Section W.4.5.5.

A review of the seabed HRG interpretation, the available CPT tests, and grab sample lab results and sample photos indicates that all of the samples should be considered to fall into the category of "sands or stiff clays" and no samples or tests indicate that the seabed below any surficial layer is "soft clays or silts" where anchor penetrations would be anticipated to be multiple anchor fluke lengths into the seabed. HRG interpretations of "mud" (CMECS) or "Lean Clay with Sand" (ASTM) do occur within the OECRC within the Dam Neck Ocean Disposal Site and are associated with the mounds of recently dumped dredge spoils. As DNODS Cells 2 and 5 are noted for disposal of materials with fine-grained component and therefore not suitable for beach nourishment uses, it should be expected that these recent deposits may be softer muds. Given the limited lateral extent of these features across the OECRC, the manmade nature of these deposits, and potential for them to continue to be reworked and distributed by marine processes, we suggest that modifying anchor penetration depths across these small features, which are muddy seabed polygons approximately 30-100 m across, does not improve the utility of the CBRA as these short distances are significantly shorter than the OECRC centerline segment span lengths analyzed in the CBRA and would not be adequately resolved. Seabed scars interpreted to be from anchoring activities have been identified in the HRG datasets (Figure W-17).

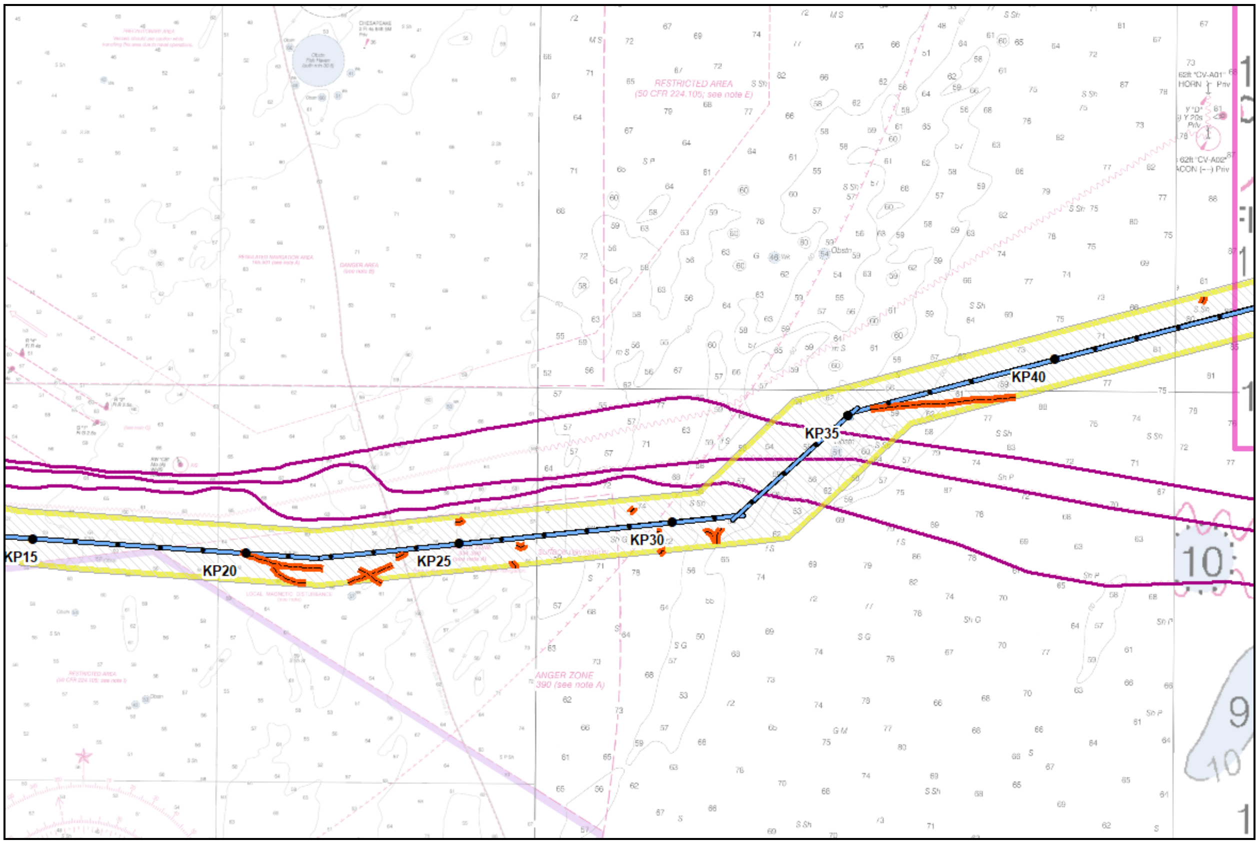



**Figure W-17.** **Observed seabed scars from the Alpine geophysical data interpretation are displayed in red along the route. Scars are interpreted to be anchor drags.**

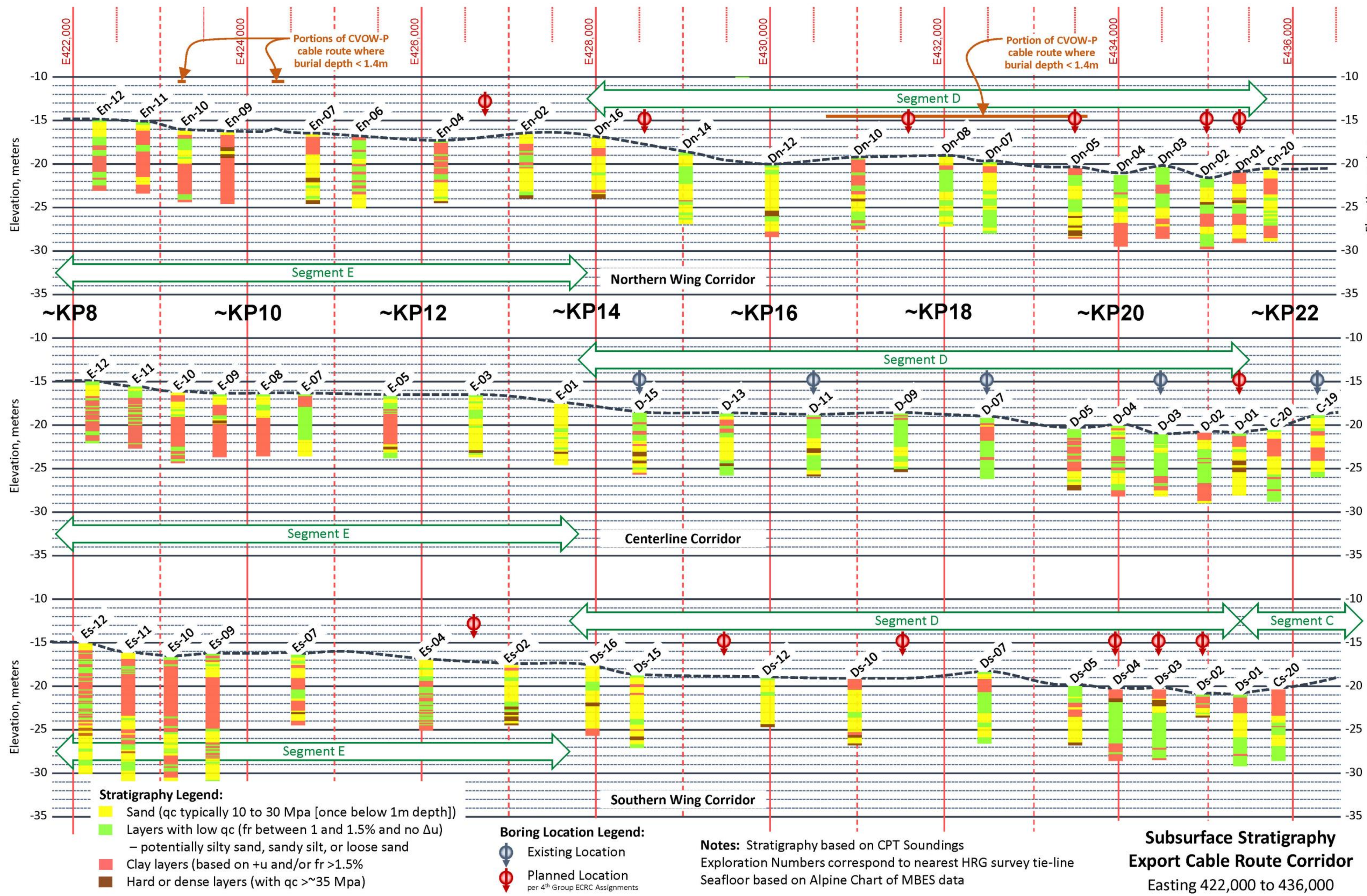



**Figure W-18.** OECRC Stratigraphy after graphic from Tom McNeilan showing approximate centerline KP and CPT sounding stratigraphy from approximately KP8 to KP22.

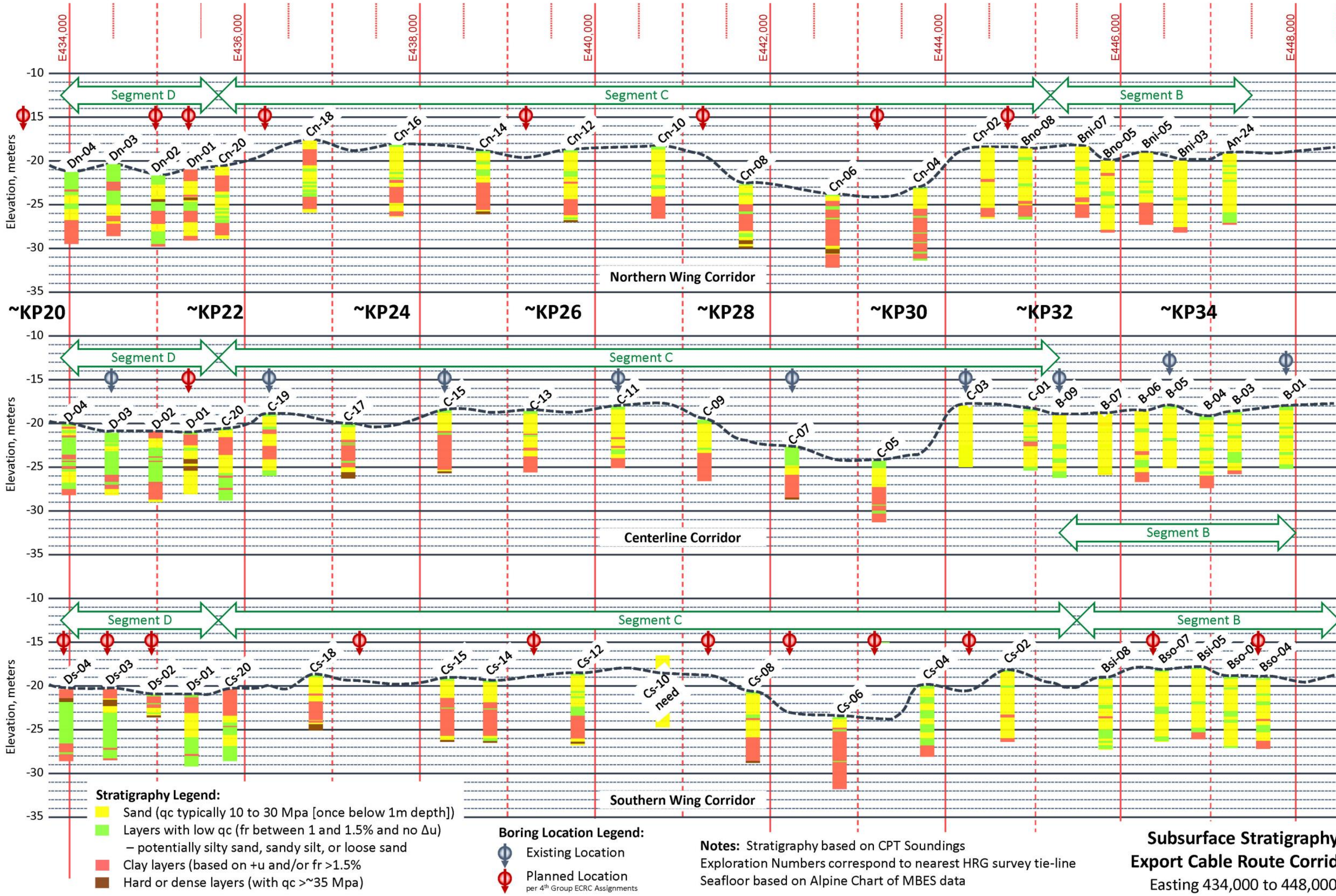



**Figure W-19.** OECRC Stratigraphy after graphic from Tom McNeilan showing approximate centerline KP and CPT sounding stratigraphy from approximately KP20 to KP34.

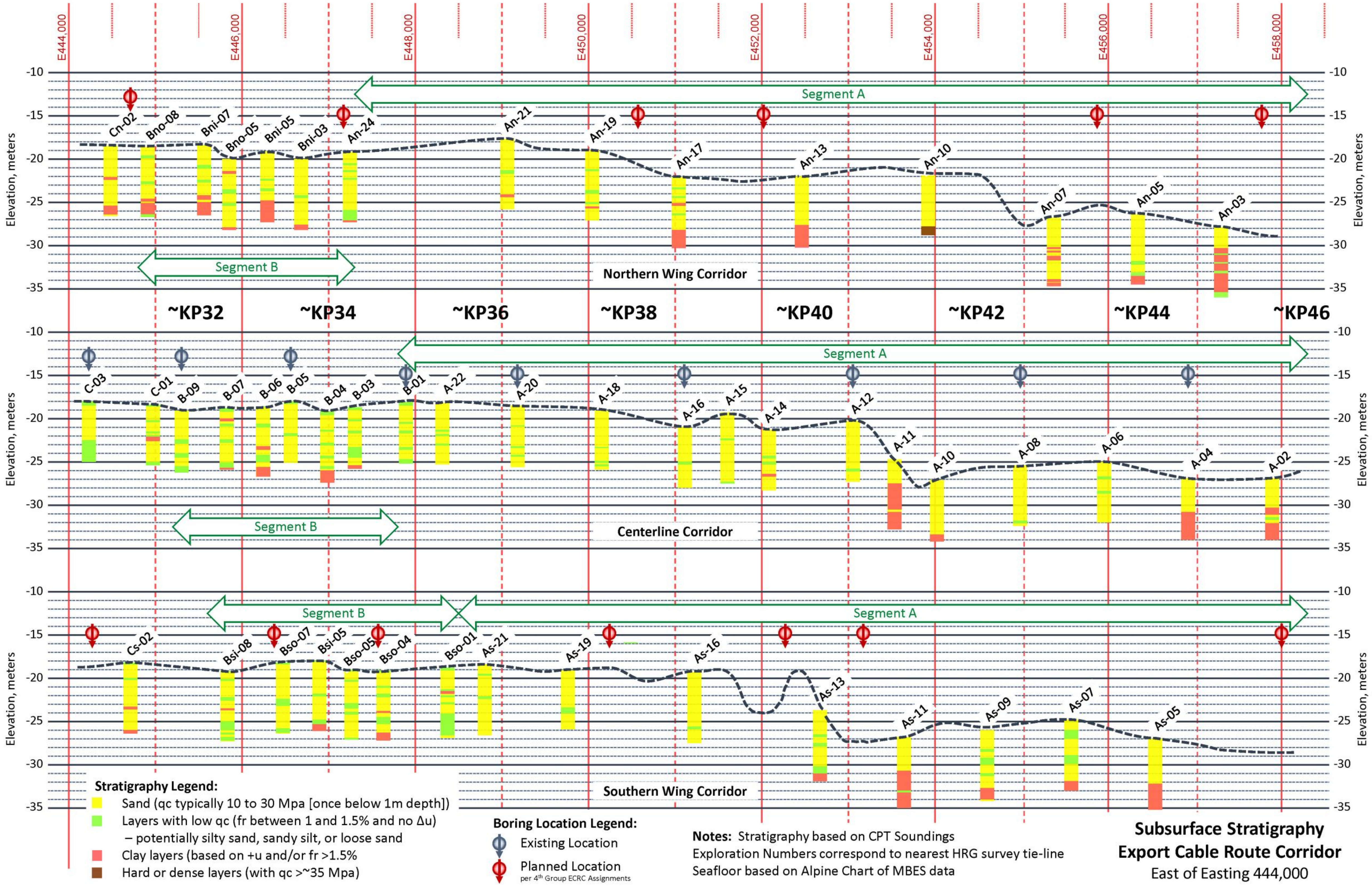



**Figure W-20. OECRC Stratigraphy after graphic from Tom McNeilan showing approximate centerline KP and CPT sounding stratigraphy from approximately KP31 to KP46.**

### W.4.5.2 Burial Results from the CVOW Pilot Cable

Three areas of limited burial success were noted along the CVOW Pilot Cable Route following installation at locations where depth of lowering failed to reach 1.4 m below the seabed. These areas are indicated on Figure W-18. While there are numerous factors that could impact burial success, seafloor geology represents a significant potential reason. While it is beyond the scope of this document to speculate on the causes or mitigations to this limited burial, indications of coarse-grained material including gravels and even cobbles have been identified by the seabed sampling and drill-coring efforts. These areas of coarse-grained material also begin to explain the findings of intermittent regions of very high CPT cone tip resistance ($q_c$ ).

An example of this coarse material is observed in Grab Sample G_D_27, which occurs within this area on the northern portion of the OECRC near KP17, as shown in Figure W-21. The cobble-sized rock shown in the reference image (refer to Figure W-22) was recovered from the drillcoring effort in this area and indicates that oversized material is potentially present and may cause complex readings with the CPT, complicate drillcoring operations, and may impeded burial via a jetting-type tool.

**G_D_27**

**USCS: SP** | **Description: Brown, poorly graded subrounded SAND with shell fragments.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| % Gravel | 12 | %M SAND | 23 | $D_{100}$ (mm) | 25.4 | $D_{10}$ (mm) | 0.42 |
| % SAND | 86 | %F SAND | 8 | $D_{60}$ (mm) | 1.82 | Cc | 0.7 |
| %C SAND | 25 | % FINES | 2 | $D_{30}$ (mm) | 0.73 | Cu | 4.3 |

**Prewash**

**Postwash**

**Figure W-21. Grab Sample G_D_27 extracted from the Alpine OECRC HRG survey report.**

**Figure W-22. Cobble-sized rock recovered by the drill coring effort (from personal communication with Tom McNeilan).**

### W.4.5.3 Marine Site Investigation Report Integrated Geophysical and Geotechnical Results

The Marine Site Investigation Report (Appendix C to the COP) was prepared by Ramboll on behalf of Dominion Energy to characterize the geological conditions and geotechnical characteristics of the seafloor and surface to support the development of the Project (Reference #9 in Table W-1). This report integrates the previous survey and sampling results to provide a consistent and wholistic interpretation and summarization of the conditions and features along the Export Cable Corridor and within the Lease Area (Figure W-23). The Marine Site Investigation Report also provides a section on Cable Burial Feasibility using a variety of typical burial tools.

The seafloor sediments that cover the Lease Area and most of the OECRC are composed of a matrix of poorly graded fine, fine to medium, or medium sand. The exceptions to this generalization occur in the following two locations along the Export Cable Corridor:

- Dam Neck Ocean Disposal Site (DNODS): This area, located 5 to 8 km offshore, is actively used as a disposal site for dredged material by the USACE. Sediments located within this site are composed of a mixture of sand, silt, clay, gravel, and larger materials. Debris and other anomalous materials also may be encountered in in this area as a result of the deposition of dredged materials.

Pre-Holocene Outcrop Area: Older clay is present on the seafloor, or is covered by a thin veneer of sand, within the Export Cable Corridor between about 18 to 21 km offshore from the Virginia Beach shoreline. This area correlates to a minor locally deeper section of seafloor that is seaward of the Atlantic Ocean Navigation Channel. Gravel and cobbles are also present on or a shallow depth below this portion of the OECRC. It is inferred that bottom currents in this area may prevent sedimentation of the typically fine to medium sand that is generally present on the seafloor throughout most of the Project Area.

While the Marine Site Investigation Report contains a wealth of information on seabed and soil conditions, none of these findings directly impact the CBRA methodology. As discussed in Section **W.4.5.1**, the generally sandy seabed along most of the Export Cable Corridor, along with the seabed soils within the DNODS and the Pre-Holocene Outcrop Area, all fall within the seabed type considered “hard” or “sandy” in the context of the CBRA anchor penetration. As such, these results do not require any change to the anchor penetration numbers utilized in this CBRA, due to the relative inability of the Carbon Trust style method to differentiate between anything other than “hard” (e.g., sandy or consolidated cohesive soils) vs “soft” (e.g., low shear strength cohesive sediments).

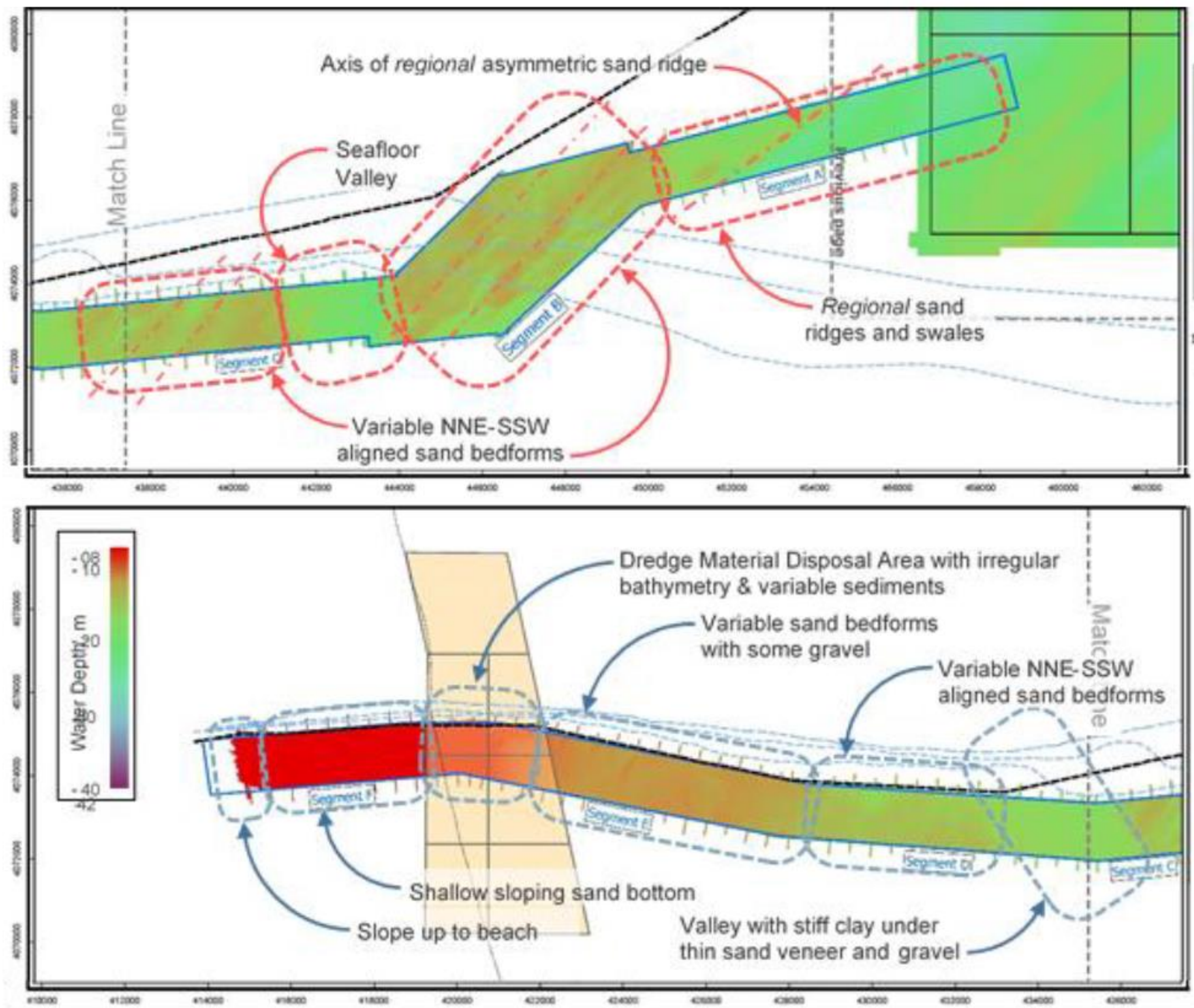



**Figure W-23. Marine Site Investigation Report Seafloor Morphology along the Export Cable Corridor**

### W.4.5.4 Seabed Morphology and Mobility

The Seabed Morphology and Mobility Study conducted by DHI (2021) identified the significant features related to seabed dynamics within the Lease Area and OECRC, estimated lateral migration rates for these features, and then used those migration rates to predict future seabed levels. For the Lease Area, DHI looks at different areas of the Lease and established overarching patterns in their synthesis. Figure W-24 shows the overall synthesis of the Lease Area dynamics identified by DHI.

Similarly, DHI utilized 11 profiles to investigate prominent sediment features along the OECRC. Generally, bedforms were found to have a higher rate of migration in shallower waters and were higher than the migration rates observed in the Lease Area. The highest mobility bedforms were those found near KP6 to KP7 at DHI's profile C10c (see Figure W-25 and Figure W-26), which lies on the western side of the Dam Neck Ocean Disposal Area, and showed migration rates between 1.5 and 18 meters per year, which can induce seabed depth changes of up to 2 to 2.5 m over the next 30 years in the severe sections near profiles paths C10b and C10c and 0.5 to 1 m off of these paths in adjacent areas near C10.

DHI notes that the available bathymetric data does not provide coverage at the shoreline, and therefore very nearshore seabed mobility is not considered.

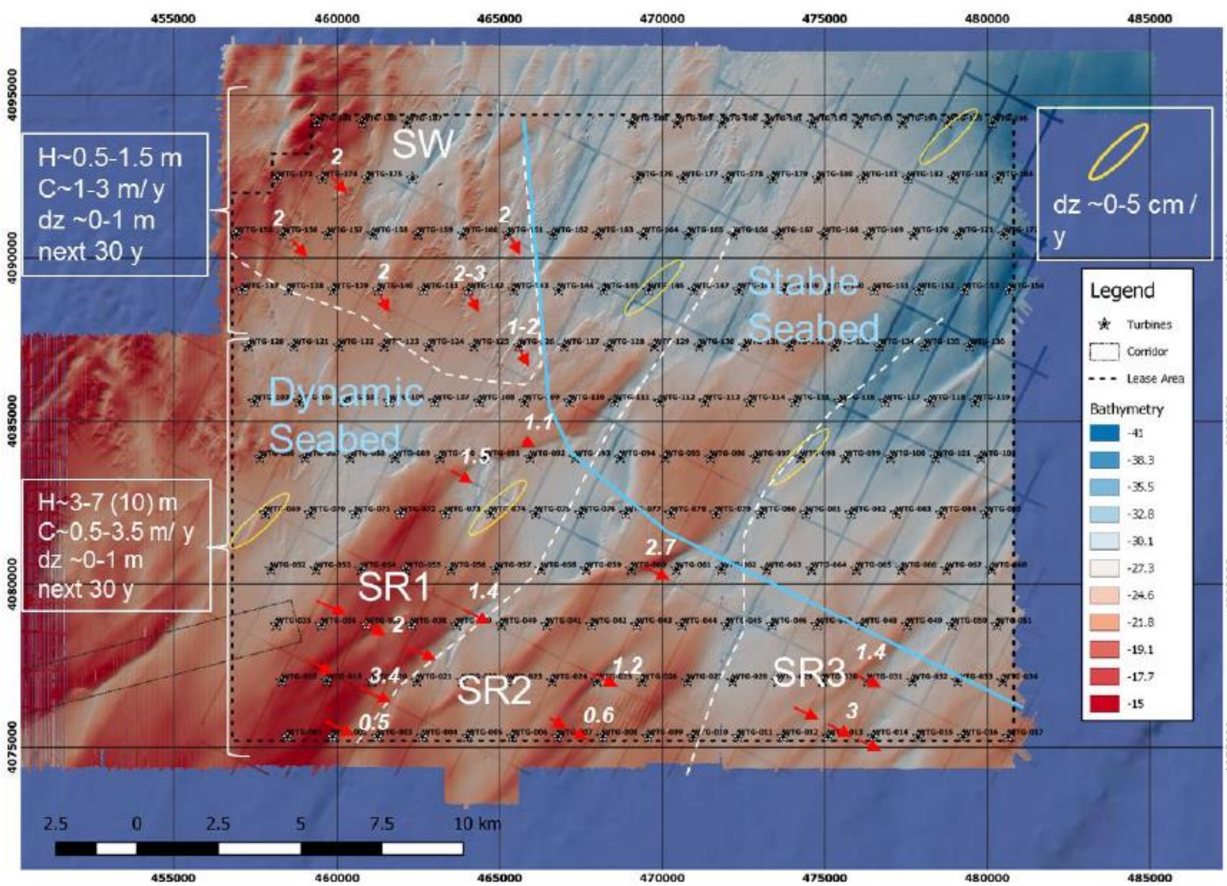



**Figure W-24. Reproduction of Figure 5.5 in the DHI (2021) study showing synthesis results of feature lateral mobility "C" rate (m/yr) and "dz" representing the vertical seabed variation over the 30-year project lifespan.**

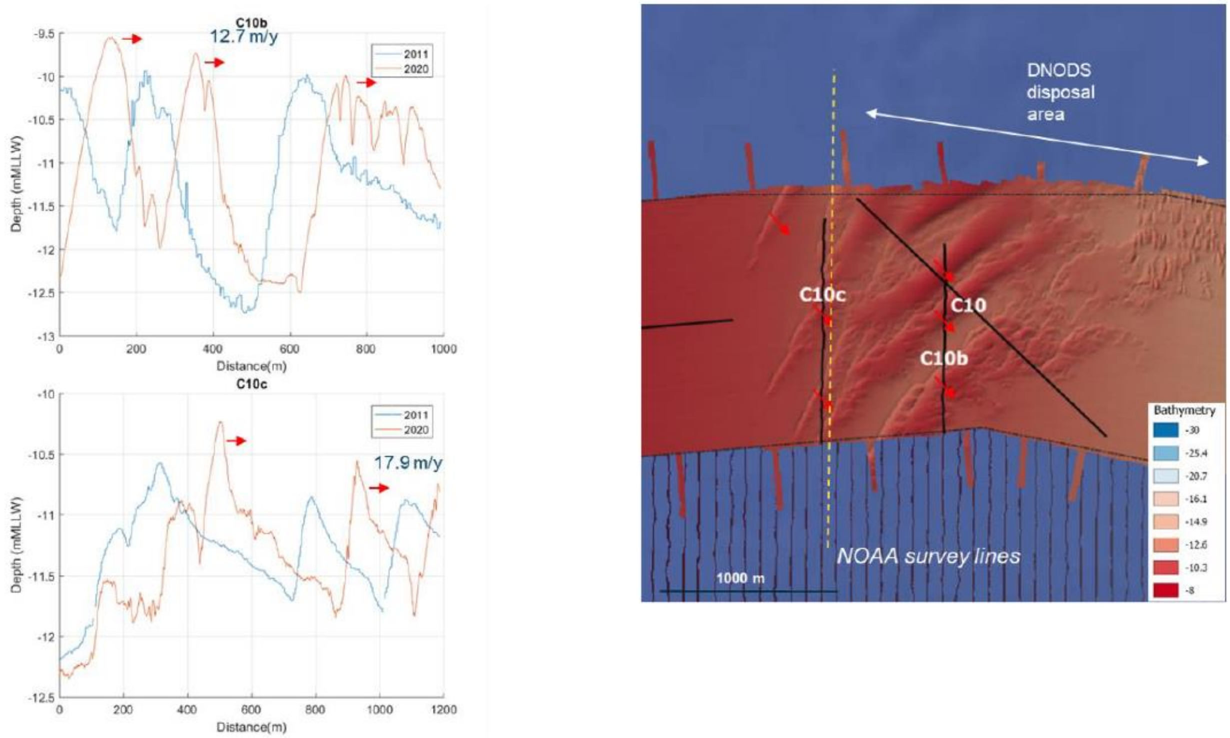



**Figure W-25.** **DHI's (2021) bathymetric profiles, rates of migration, and profile locations for C10b and C10c on the OECRC, which exhibit the greatest mobility along the OECRC.**

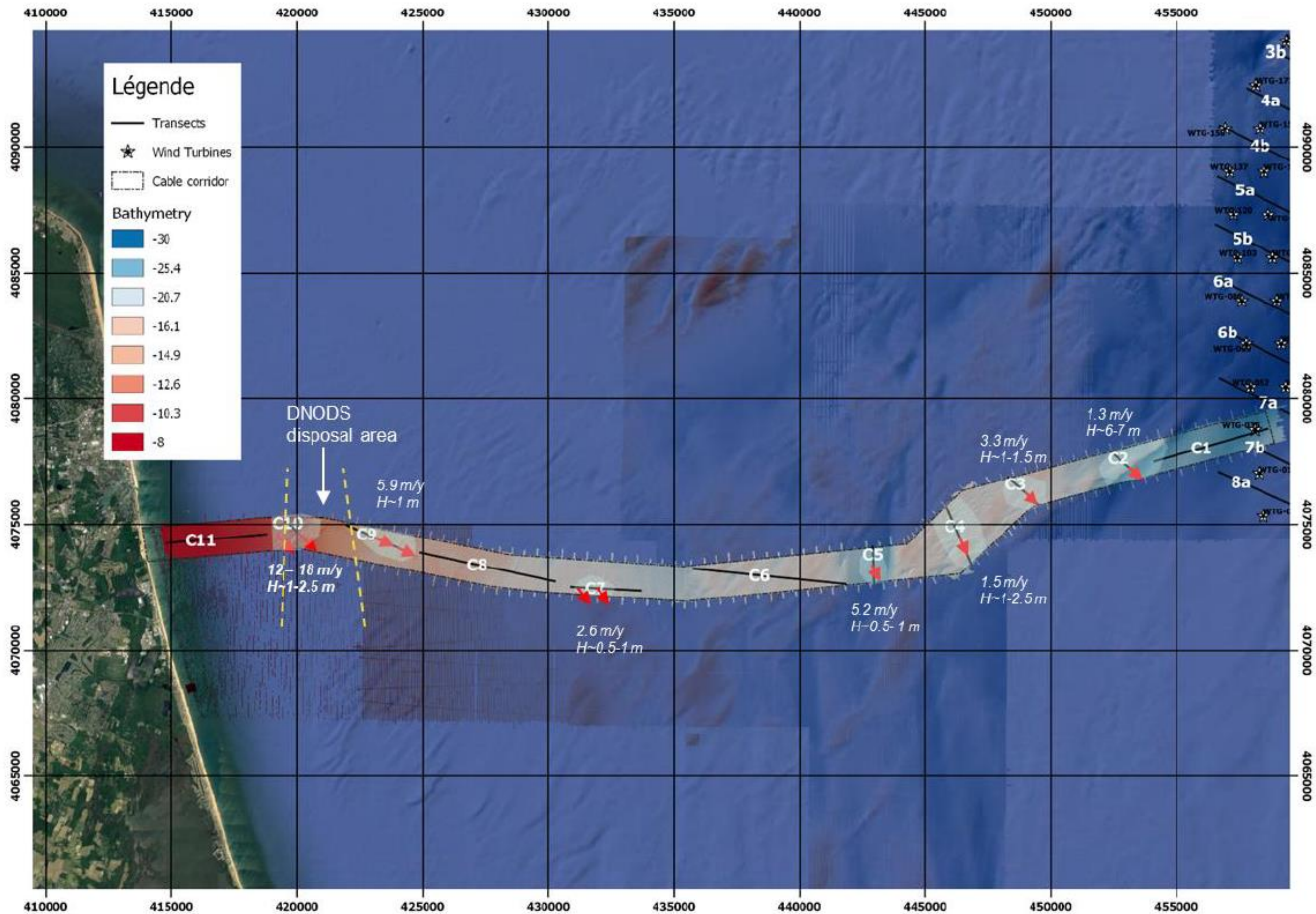



**Figure W-26.** **Figure reproduced from DHI (2021), showing DHI's profile locations within the OECRC. Light blue areas indicate locations where DHI has identified groups of mobile bedform, with other areas not exhibiting signs of significant movement. Rates indicate yearly mobility rates and H indicates feature height in meters.**

Extrapolating these values to the nearest centerline KPs, we can map the spatial variability along the OECRC (Table W-3). Unfortunately, there is not enough granularity in DHI's method to provide more detailed mapping of seabed elevation change. This is important to cable planning because if there are nine potential export cable routes, the one in the northern part of the corridor will face very different sediment mobility threats than the one on the southern side of the corridor at the same relative centerline KP.

**Table W-3. Extrapolated position along the OECRC centerline for each of the analyzed profiles**

| Approx. | | DHI Profile Name | Horizontal Migration Rate | DHI Potential Seabed Elevation Change over 30 years |
|---|---|---|---|---|
| KP Start | KP End | | | |
| 0 | 2 | Not Evaluated | | |
| 2 | 5 | C11 | None noted | 0-0.5 |
| 5 | 7 | C10b/C10c | 12-18 m/yr | Up to 2 m |
| 9 | 11 | C9 | 6 m/yr | ~1 m |
| 11 | 16 | C8 | None noted | 0-0.5 |
| 18 | 20 | C7 | 3 m/yr | ~0.5 m |
| 23 | 28 | C6 | None noted | 0-0.5 |
| 29 | 30 | C5 | 5 m/yr | ~0.5 m |
| 32 | 34 | C4 | 1.5 m/yr | ~0.5 m |
| 35 | 37 | C3 | 3 m/yr | ~1 m |
| 39 | 41 | C2 | 1 m/yr | +1.8 m increase in elevation due to sand ridge migration |
| 41 | 46 | C1 | None noted | 0-0.5 |
| Elsewhere not specifically evaluated by DHI | | | | 0 to 0.5 m elevation change over 30 years |

### W.4.5.5 Deltares Anchor Tests

The Project Team has also considered the results of the tests conducted, interpreted, and reported by Deltares (2013) in the German Bight of the North Sea. This study was conducted to understand the risks posed to buried subsea cables from the accidental, emergency, and intentional deployment of anchors of the types used by commercial shipping vessels. Tests specifically included 17 anchor drops with 8.5 tonnes (t) AC-14 anchor and an 11.5 t Hall anchor. Anchors were then pulled or dragged to anchor breakout or a safety tension limit. Tests were conducted in three areas: one with a seabed of predominantly loose, fine sand (N in table below); one with relatively dense sand (S in table below); and one with thin sand above overconsolidated clay (V in table below). Multiple measurements were taken using sonar profiles to establish depth of penetration relative to the original seabed elevation and are summarized in Table 5.3 of Deltares (2013) which is reproduced here as Table W-4.

**Table W-4. Deltares (2013) Table 5.3 Summarized penetration data per anchor and per testing area**

| Anchor Type | Area | Maximum Penetration [m] | Average Penetration [m] | Standard Deviation [m] | Number of Sonar Profiles [#] |
|---|---|---|---|---|---|
| AC14 8.5 t | N | 0.69 | 0.432 | 0.166 | 22 |
| | S | 0.34 | 0.202 | 0.070 | 22 |
| | V | 0.67 | 0.274 | 0.145 | 19 |
| Hall 11.5 t | N | 0.88 | 0.380 | 0.249 | 31 |
| | S | 0.28 | 0.173 | 0.061 | 15 |
| | V | 0.67 | 0.303 | 0.168 | 13 |

While the test sites in the German Bight are not an exact match for the conditions and seabed sediments anticipated within the CVOWC OECRC, the approximate range of conditions across the multiple test sites, each with an upper layer of loose to dense sand and water depths in the approximate range of much of the OECRC (i.e., 23 to 35 m in the Deltares study areas) are anticipated to be approximately representative of similar anchor interactions with the seabed. The Deltares (2013) study indicates that while there is correlation between the sand density of the test area and the measured anchor penetrations, extrapolation to very coarse sediments (e.g., gravels) or cohesive materials (soft muds, normally consolidated clays, overconsolidated clays, or glacial tills) is not possible.

The authors of the Deltares (2013) study also suggest that the results of the study can be extrapolated to larger anchors than those measured, which they have included as the Maersk "triple-E" class (approximately 210,000 DWT for the 2nd generation vessels) and the *CMA CGM Marco Polo*, which represented the largest container ship at the time of the study. The largest class of containership by gross deadweight tonnage is the *CMA CGM Jacques Saadé*-class vessel, with a deadweight tonnage (DWT) of approximately 221,000. This represents about a 17.5% increase over the *CMA CGM Marco Polo* at approximately 188,000 DWT per the Deltares study.

Rather than extrapolate DWT to anchor penetration directly, the Deltares (2013) study looks at the anchors from 10.5 t to 29 t, which represented from 75th percentile to nearly the 100th percentile of all the anchors in the database they analyzed. The largest of these are noted in Deltares (2013) to be larger than those likely utilized on the Maersk "triple-E" class and the *CMA CGM Marco Polo,* though more recent sources indicate at least some Maersk "triple-E" class vessels carry 31 t anchors.

When corrected for catenary effects, the extrapolated penetration depths for the larger anchor sizes are reproduced from the Deltares (2013) study in Table W-5. In the concluding remarks, the Deltares (2013) study identifies that simply looking at the largest anchors without applying a probabilistic approach to risk reduction leads to overly conservative and costly designs.

**Table W-5. Deltares (2013) Table 6.3 Probability of anchor mass and extrapolated penetration corrected for catenary effect.**

| Case / Area | Penetration depth | Anchor mass | Extrapolated Penetration Depths for Larger Anchors | | | |
|---|---|---|---|---|---|---|
| | | | 75% 10.5 t | 90% 14 t | 95% 17 t | ~100% 29 t |
| Case 1 - VTG | 0.95 m | 8.5 t | 1.00 m | 1.10 m | 1.20 m | 1.45 m |

| Case / Area | Penetration depth | Anchor mass | Extrapolated Penetration Depths for Larger Anchors | | | |
|---|---|---|---|---|---|---|
| | | | 75% 10.5 t | 90% 14 t | 95% 17 t | ~100% 29 t |
| Case 2 - BSH-South | 0.66 m | 8.5 t | 0.70 m | 0.80 m | 0.85 m | 1.00 m |
| Case 3 - BSH-North | 1.22 m | 11.5 t | 1.20 m | 1.30 m | 1.40 m | 1.65 m |

Given the relative similarities in the range of seabed conditions (i.e., variable thicknesses of loose to dense surficial sands, including those potentially overlying cohesive and/or consolidated materials), the Deltares (2013) study provides high-level validation of the assumptions on anchor penetration used in this CBRA's probabilistic analysis. While the numbers and methods utilized in this CBRA account for somewhat larger anchor sizes than tested and extrapolated in the Deltares (2013) study, this CBRA remains on the conservative side of realistic numbers for potential anchor penetration depths, without adding undue conservatism.

# W.5 THREAT ASSESSMENT

## W.5.1 Sediment Mobility

Sediment mobility is a topic of concern for the installation, operation, and maintenance of export cables. In areas of active mobile sediments, sediment can move to or from the OECRC alignment. In the event that mobile sediments move away from the OECRC alignment, the export cable has the potential to become unburied or for the buried depth to decrease. A decrease in burial depth or an exposure of the cable has the potential to create vulnerability to fishing gear, anchors, and other manmade risks, as well as increase the rate of cable wear. In the event that mobile sediments move towards the OECRC alignment, the buried depth may increase which has the potential to impact thermal properties of the cable and complicate future cable maintenance.

### W.5.1.1 Preliminary CBRA

The Project team utilized prior knowledge of the area and HRG datasets of an adjacent cable corridor, the CVOW Pilot Project cable corridor, to assess the potential for mobile sediments. Data along the adjacent cable corridor for the CVOW Pilot Project shows seabed conditions consisting of fine to coarse grain sands, with ripples and sandwaves intermittently throughout the corridor. The intermittent ripples and sandwaves are a strong indication of potentially mobile sediments. While mobile sediments along the Project corridor should be confirmed with a time series (repeated) bathymetric survey, the locations of ripples along the seabed indicate the general areas where mobile sediments may be found.

In addition to the use of the CVOW Pilot Project, BOEM's MMIS was also used to further confirm the potential locations of mobile sediments (BOEM 2020b). The MMIS publishes modeled shoals along the Atlantic east coast (Figure W-27). The region in which the CC is located includes multiple shoals in the MMIS dataset crossing the CC between KP 25 and the Lease Area. The MMIS shoals may be relic features, but likely represent areas where increased potential for mobile seabed should be anticipated.

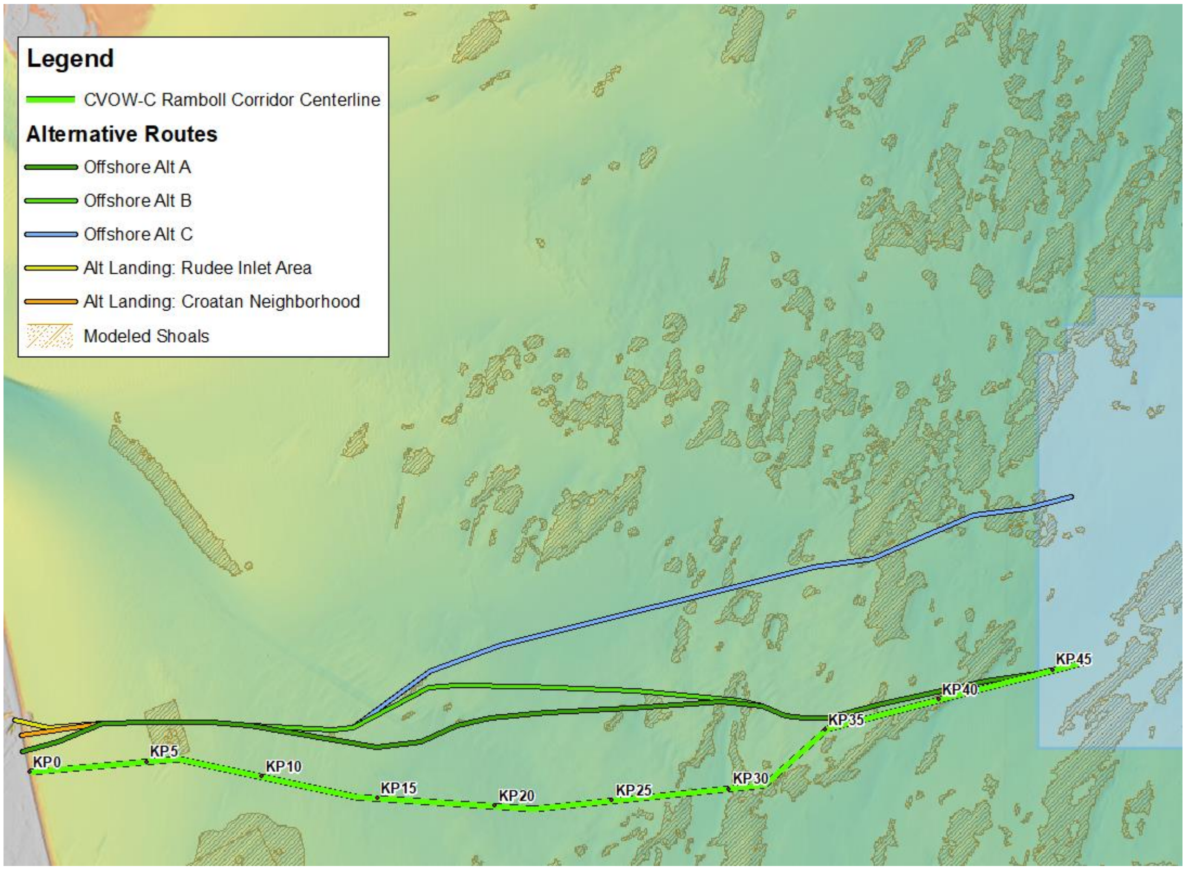



**Figure W-27. BOEM MMIS Modeled Shoals Layer within the Study Area (BOEM 2020b)**

The concentration of mobile sediments within the central to eastern portions of the OECRC alignment is consistent with data from the CVOW Pilot Project, in which the first identification of sand ridges occurs adjacent to KP 6 of the CC. Ripples and sand waves continue to be present along the CVOW Pilot Project corridor until a point along the CVOW Pilot Project corridor adjacent to KP 37 of the OECRC alignment, at which point limited data is available out to the CVOW Pilot Project Lease Area. The limited data does not identify any ripples or sandwaves between the CVOW Pilot Project corridor, at a point adjacent to KP 37 of the OECRC alignment, and the CVOW Pilot Project Lease Area. Additional ripples and save waves were identified in the CVOW Pilot Project Lease Area.

### W.5.1.2 Amended CBRA

As mentioned in Section W.4.5.3, DHI authored sediment mobility study commissioned by Ramboll, dated March 2021. Based on those results, it was determined that the potential for mobile seabed exists Northwest and South within the Lease Area. Conversely, mostly immobile seabed was determined in the Northeast sector of the Lease Area.

The DHI study indicates the sand ridges in the Lease Area and along the Export Cable Route Corridor migrate towards the Southwest by 1 to 2 meters (m) (3.3 to 6.6 ft) per annum. The flat areas in the Lease Area and Export Cable Route Corridors are mostly immobile, although some spots erode at about 5 cm (2 inches) per annum. The sand waves in the Lease Area migrate at approximately 1 to 3 m (3.3 to 10 ft) per annum (relatively slow), while those in the Export Cable Route Corridor have a higher rate of migration, up to 18 m (60 ft) per annum.

Section W.6.4.2 incorporates the results of the DHI study with respect to cable depth of lowering to mitigate seabed mobility. Overall, it is anticipated that the degree of mobile seabed along the corridor is not extreme, with impacts likely mitigatable through additional 1.6 to 3.3 ft (0.5 to 1 m) of cable lowering along specific spans of the route.

#### W.5.1.3 Seabed Mobility Near the Punchout Area

DHI exploited three LIDAR datasets to evaluate nearshore seabed dynamics. The analysis concluded that the beach profile is active down to depth of 5 to 6 m water depth, and that active sandbars are migrating cross-shore along the beach profile. The trenchless direct pipe exit points are located within the active profile, and within a sandbar system, and will most likely experience variations of the depth of several tens of centimeters (cm) from one season to another (in the range 0.2 to 0.5 m). Additional survey transects seaward of the -6 m contour shows that the seabed is likely stable within the past 10 years. DHI recommended to conduct surveys of the beach profile down to a depth of 10 m (at least below 6 m water depth) to investigate the presence of sand bars, ideally before and after a storm has occurred. However, the offshore direct pipe exit points are likely near closure depth of -5 to -6 m as estimated by DHI, beyond which seabed change is due to wave action and cross-shore transport is insignificant compared to other influences.

### W.5.2 Anchorages, Anchoring, and Anchor Drags

While there are no charted anchorage areas along the OECRC alignment, AIS data in the area shows that there are a number of vessels that regularly anchor immediately outside of the traffic separation scheme (TSS). These vessels predominantly stay north of the existing in-service telecoms cables or anchor to the southeast of the exit of the traffic lanes. Provided that there is a good marine liaison and awareness campaign, vessels should be made aware of new cables as they are installed in the area and should continue to avoid them.

Vessel sizes have trended larger over time and anchor sizes have increased accordingly. For example, the Maersk Triple E-class container vessels, which began entering in service in 2013, are 1,312 ft (400 m) in length and have a DWT of 196,000 tons. Their anchors weigh 31 tons (Figure W-28), which is in the range of the largest of those depicted in Table W-6 and would lead to significant seabed penetration depths. Vessels identified transiting the study area of comparative size (and therefore anchor size) include the Hermine Oldendorff, a 984-ft (300-m) 209,331-ton DWT bulk carrier (Figure W-29).

**Figure W-28. Maersk Triple E-class Container Ship Anchor (Courtesy of Maersk)**


**Figure W-29. Hermine Oldendorff (courtesy Robert Weber, MarineTraffic.com)**

There is expected to be deeper anchor penetration in soft clays or silt and shallower penetration in gravel, dense sand, or more consolidated seabed. The penetration will also be governed by the design and size of the anchor, as well as its weight and the weight of the chain connected to it. It can reasonably be assumed that the larger the vessel, the larger the anchors that will be required to secure the vessel when anchoring. Since there are some notable discrepancies between the anchor sizing/penetration depth tables and the anchor sizes actually encountered in the maritime industry, and due to the fact that the Project does not yet have complete geotechnical data to leverage, it may be necessary to conduct further research to calibrate the CBRA and burial depth recommendations.

Generally, the penetration depths listed in Table W-4 would be considered to use values closer to those in the "High Strength Seabed" column, if similar geotechnical characteristic cutoffs are utilized as the NorthConnect Cable Burial Risk Assessment by Cathie Associates, from whom the table is sourced. That is, muddy, fine-grained sediments with less than approximately 40 kPa shear strength are considered "low strength," while seabed with greater than 40 kPa shear strength and those composed of sands are considered "high strength."

As discussed in Section 4.4 (Assessment of Seabed Conditions), the initial indications from preliminary geotechnical results along the cable corridor show predominantly medium to dense sands, and where finer grained materials are encountered in the shallow subsurface, shear strengths are generally on the order of 40 kPa or greater. However, it should be noted that at least several borehole and seabed CPT locations indicate less dense surficial sands and, more rarely, some strata of finer-grained sediments. While the Project lacks fully interpreted data to properly map sub-bottom horizons, extrapolating these locations along the corridor is not feasible at the time of preparing this document. These surficial loose or finer-grained surficial sediment indicate that in some likely small and limited areas, an anchor may penetrate deeper than indicated in Table W-6. Given that much of the route appears to have sandier or "higher-strength" seabed, we suggest it is prudent to note the possibility of needing to achieve an extra 1.6 to 3.3 ft (0.5 to 1.0 m) of burial in limited places, rather than apply such a factor to the entire route.

### W.5.3 Dredging and Channel Maintenance

The USACE maintains the TSS by dredging portions of the Atlantic Ocean Channel (AOC) as needed every 5 years. The location of the end points of the TSS is at the area denoted as "Naturally Deep 60 feet and Deeper" on the USACE's document *Marine Features within the Vicinity of the Atlantic Ocean Channel* (USACE 2012). This should represent the seaward limits of the areas required to be dredged to accommodate larger (i.e., "post-Panamax") vessels, and thus, the cables are located immediately outside off the area requiring dredging. Since the seabed cannot support steep slopes, dredging may occur outside of the target area to establish stable slopes, and thus, current routing may still conflict with future dredging operations. However, the USACE should be reengaged early in the planning and engineering process to fully understand any future plans to re-align or deepen the AOC and confirm where dredged materials will be dumped. While the OECRC alignment is expected to adequately avoid the AOC, several of the high-level alternative routes do cross the AOC and would require detailed discussion with the USACE to understand future plans for any deepening, widening, or lengthening of the channel. Since this is a federally authorized project, Section § 408 considerations apply to the AOC.

### W.5.4 Sand Mining

Two sand borrow areas are known to exist in the vicinity of the cable routes. The first is offshore of the northern part of the city of Virginia Beach, known as the Cape Henry Borrow Area. The other is the Sand Bridge Borrow Area, located off of Dam Neck/Sand Bridge. These areas represent potential sand resources to be used to replenish eroded beaches to provide important protection from tropical storms to local communities. Impacts to the utility of sand resources may complicate permitting considerations. Sand borrow operations in the vicinity of cables also pose an inherent risk of incident. Both of these areas are avoided by the OECRC alignment and do not represent a direct risk to the cable. If additional sand resource areas are developed, proper liaison and awareness should be conducted with the BOEM Marine Minerals group, the USACE, and the state and municipal entities involved with the siting and planning process.

### W.5.5 Ocean Disposal Sites/Dumping

Ocean dumping grounds are areas within the territorial waters of the U.S. that can contain (especially as a result of past unregulated dumping) industrial waste, sewage sludge, biological agents, biological and chemical waste, radioactive waste, and various other wastes. These areas can also contain UXO. NOAA maintains a database of known dump sites based on surveyed areas. No charted dumping grounds are located directly along the cable routes; however, dumped dredged materials are discussed.

The DNODS is located approximately 2.5 nm (4.6 km) off the coast of Virginia between the Dam Neck Naval Air Station and the public portion of Virginia Beach. This dredged material placement area is managed by the U.S. Environmental Protection Agency and USACE and has been used actively for dredged material placement since 1967. The DNODS receives approximately 1.2 million cubic yards of dredged material every 2 years to support the maintenance dredging of federal navigation channels, including the nearby AOC. Since this is a federally authorized project, Section § 408 considerations apply to the DNODS.

Where the OECRC alignment traverses this region, the cables could potentially interfere with planned dumping and/or sand resource extraction activities within the DNODS, and the routing should be discussed with the USACE for concurrence. The in-service telecoms cables and the CVOW right-of-way alignments traverse DNODS Zones 2 and 5, since these are the zones of the DNODS earmarked to receive sediment of a finer nature. Because this material is not suitable for beach nourishment, these cells would not be anticipated to be used as sand borrow areas.

The planned survey corridor traverses across the boundary of DNODS Zones 2 and 5 and Zones 3 and 6; however, it is understood that all cables are planned to be run through Zones 2 and 5 by reducing cable spacing through this area.

Burial to 2 m through this region is likely to be a condition of the permitting process for these export cables according to initial consultation with the USACE. Additionally, a “dropped object” study should be considered to properly assess the potential for damage to the cable from dumped material and potentially entrained debris. Additionally, modeling of the thermal impacts and changes to maintainability of the cable should be studied to understand implications of continued use of the DNODS across the cables by the USACE to ensure the design is capable of tolerating these changes throughout the lifespan of the system. That study is beyond the scope of this initial CBRA, but the results can be referenced or captured in future iterations of this document.

### W.5.6 Other Seabed Assets

One of the risk factors to a submarine cable is that from existing subsea assets, namely other cables (power and fiber optic), pipelines, outfalls, etc. When these other assets need to be crossed, burial is generally not possible, so alternate means of cable protection must be considered. This protection could include, for example, concrete mattresses placed both below and above the cable or rock placement.

In addition to the reduced burial depths, cable crossings also hinder access to (particularly) the crossed asset for survey, maintenance, or repair. Industry best practice is to cross the existing asset as close to perpendicular as is possible. For this reason, the cable corridor in question makes a northward turn at KP 31.5 before resuming the more easterly course at KP 35.0.

In the area between KPs 31.5 and 35.0, the OECRC alignment crosses the following three in-service fiberoptic cables:

- BRUSA at KP 32.30. BRUSA is a submarine fiber optic cable that links Virginia Beach to Rio de Janeiro and Forteleza in Brazil and San Juan (Puerto Rico). The system is 6,800 mi (11,000 km) in length and commenced commercial service in 2018. The system is jointly owned by Facebook, Microsoft, and Telxius.
- MAREA at KP 33.50. MAREA is a submarine fiber optic cable linking Virginia Beach to Bilbao in Spain. The cable is 4,100 mi (6,600 km) in length, and as with BRUSA, entered into commercial service in 2018. The system is jointly owned by Facebook, Microsoft and Telxius.
- Dunant at KP 34.50. Dunant is a 4,100-mi (6,600-km) fiber optic cable linking Virginia Beach with Saint-Hilaire-de-Riez on the Atlantic coast of France. The system is owned by Google and is currently under construction with anticipated commissioning in “late 2020.”

These three cables are spaced approximately 0.6 mi (1 km) apart, in the water depths encountered (approximately 60 ft [18 m]); this leaves enough separation and space for both installation and burial operations, as well as any future required maintenance or repair.

In addition to the three in-service fiber optic submarine cables detailed above, Dominion Energy’s CVOW Pilot Project export cable runs approximately parallel to, and north of the OECRC alignment. However, this cable is not crossed and does not enter the study corridor, hence, it is not considered a factor for this report.

It is possible that there are Department of Defense (DoD) submarine cables present within the survey cable corridor. These military cables do not appear on NOAA charts or in any of the submarine cable databases. Thorough documentation of the cable locations and coordination with the DoD will be critical to ensure the installation of any future cables by the DoD or maintenance on existing facilities are adequately deconflicted with the Project. The U.S. Navy (Navy) Office of Seafloor Cable Protection serves this exact role and deconflicts DoD projects with both commercial cables and other DoD operations. Continued liaison with this office is strongly recommended throughout the design, installation, and operational phases of the Project.

Lastly, there are no known out-of-service submarine cables present, and there are no known outfalls or pipelines. As is standard practice when installing submarine cabling, pre-lay grapnel runs are recommended prior to cable installation to clear any unknown obstructions along the route.

### W.5.7 Fishing

There is active commercial and recreational fishing in the study area. However, the seabed penetration and risk to buried cables are minor compared with the risks presented by merchant vessel anchoring and/or dredging of the shipping channel or in the DNODS area. Recreational fishermen may drift, troll, or anchor in the area, and any anchoring would typically occur on or near structure and/or hard bottom (e.g., rocky seabed, if present) that the cable routes would typically avoid. It should be noted, however, that rock placement used as supplemental cable protection at crossings with existing cables and/or in an area where the cable burial target depth of cover was not achieved, could create desirable habitat for recreational fishermen who may then anchor in the area. In any case, the seabed penetration for the anchors associated with these recreational vessels is minimal compared to merchant vessels.

Much of the commercial fishing in the study area is done by small vessels (under 65 feet) using fixed gear (e.g., pots/traps and gillnets) primarily targeting whelk/conch, black sea bass, and spiny dogfish. There is very little mobile gear fishing that occurs in the study area. Mobile gear is prohibited within the 3-mi (4.8-km) limit of the Virginia Atlantic shoreline (Code of Virginia § 28.2-315), however an experimental beam trawl fishery for shrimp does exist but is currently restricted to areas outside of the OECRC.  A trawl fishery targeting shrimp outside 3 mi (4.8 km) has recently developed and does take place over the OECRC.

The fishing gear posing the greatest risk to the cable in the study area, in terms of seabed penetration, would be bottom trawling (Figure W-30: Schematic of Otter Trawl; NOAA. 2020. “Teacher at Sea Blog”. https://noaateacheratsea.blog/). As per Figure W-31 below, data from the MARCO Data Portal shows the amount in the 2006 – 2010 timeframe was low and has declined to being almost nonexistent in the 2011 – 2015 timeframe. The trawl effort that does exist is likely to be smaller vessels, per the inboard vessel with wooden trawl doors in Figure W-32, targeting spiny dogfish and/or mixed species for a few months out of the year.

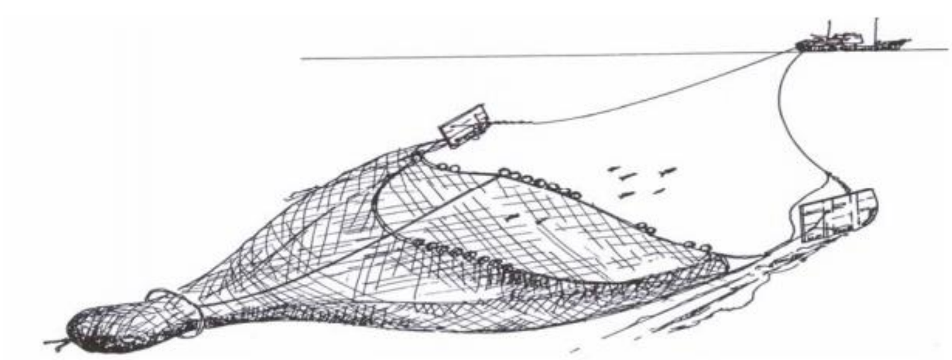


**Figure W-30. Schematic of Otter Trawl[1]**

[1] www.noaateacheratsea.blog

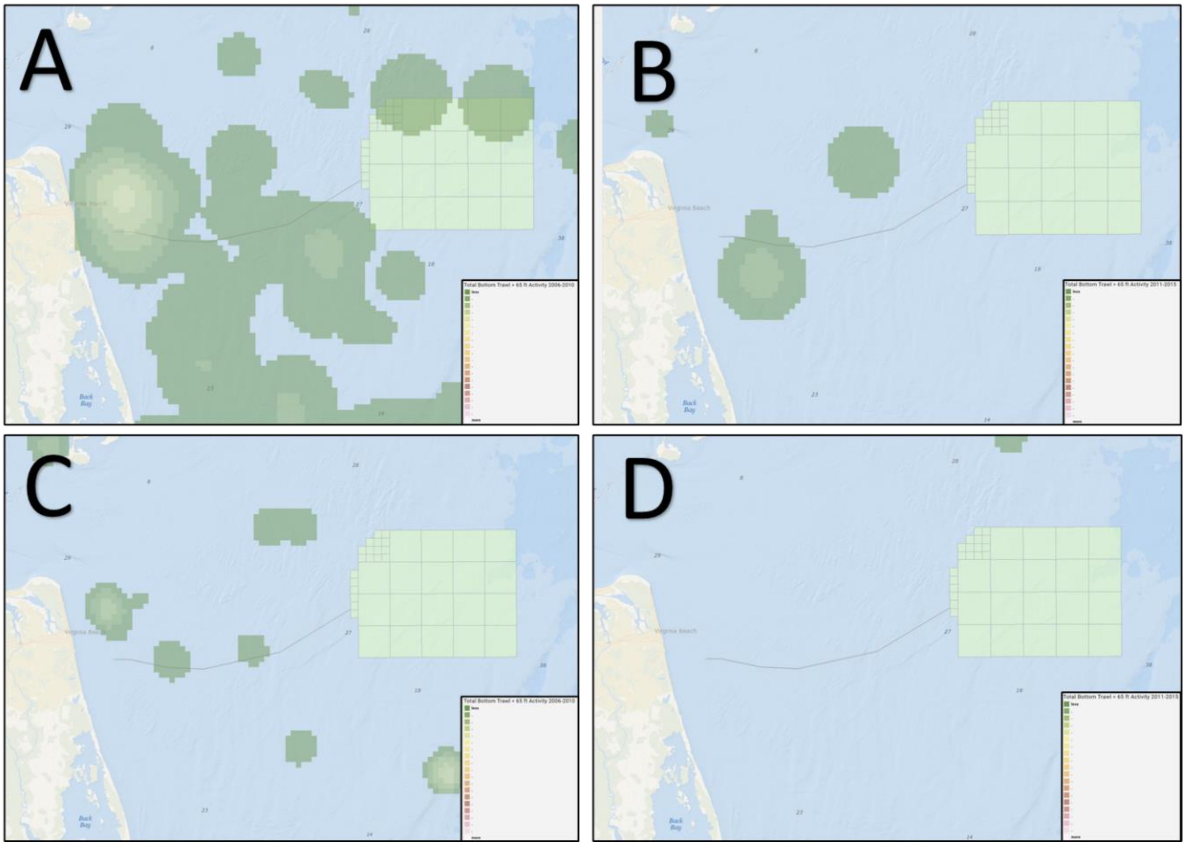



Figure W-31. Trawler Vessel Trip Report (VTR) data (A) Vessels >65' 2006-2010; (B) Vessels >65' 2011-2015; (C) Vessels <65' 2006-2010; and (D) Vessels <65' 2011-2015. (MARCO 2020)


Figure W-32. A Small Otter Trawl Vessel with Wooden Trawl Doors and a Gillnetter Landing Spiny Dogfish at Rudee Inlet (Photo Credit: Unknown)

The experimental fishery being conducted within Virginia's 3-mi (4.8-km) limit uses a lightweight beam trawl with a maximum width of 16 ft (4.9 m) to target shrimp (Figure W-33 and Figure W-34). This fishery is currently limited to eight vessels within a restricted area that is south of the OECRC. If the fishery continues to grow, it may expand over the OECRC within Virginia's 3-mi (4.8-km) limit. Also, since there is no federal regulation that limits the fishery outside 3 mi (4.8 km); a fishery using traditional double-rigged shrimp trawlers (Figure W-35) has recently been observed outside the boundary. These various trawl methods have minimal seabed penetration and pose minimal risk when compared to ship anchors.

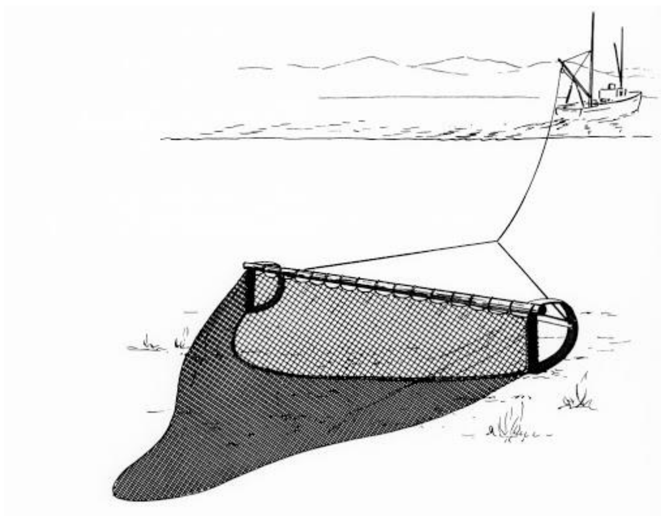


**Figure W-33. Schematic of a Beam Trawl (Credit: FAO 2001)**

**Figure W-34. Beam Trawl, 16 Feet in Width, Secured to the Stern of a Fishing Vessel in Rudee Inlet (Photo Credit: R. Larsen Sea Risk Solutions, LLC)**

**Figure W-35. Double Rig Shrimp Trawl Vessel (Photo Credit: Unknown)**

Fixed gear deployed in the study area consists of pots/traps (Figure W-36) and bottom fixed gillnets **(**Figure W-37). Pots and traps can be in "strings" or "trawls" that consist of multiple pots strung together along a "groundline" anchored to the seabed or as single weighted pots. The pot/trap fishery occurs throughout the study area (Figure W-38) , primarily targeting conch which are typically deployed as single pots weighted with bricks (Figure W-39). In the study area, gillnets are primarily fished within 15 mi (24 km) from shore Figure W-40). Gillnets are subject to oceanographic forces (e.g., current and tide) and must be securely anchored to the seafloor. Local vessels are known to use flatfish anchors (Figure W-41) to secure the gear to the seabed. These fixed gear fisheries will have minimal seabed penetration, approximately 12 inches (in; 30 cm), and pose minimal risk when compared to ship anchors.

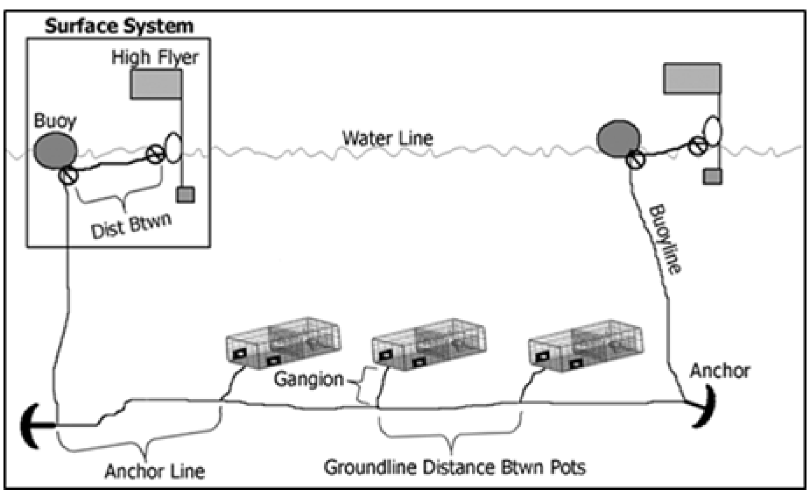



**Figure W-36. Pot/Traps**

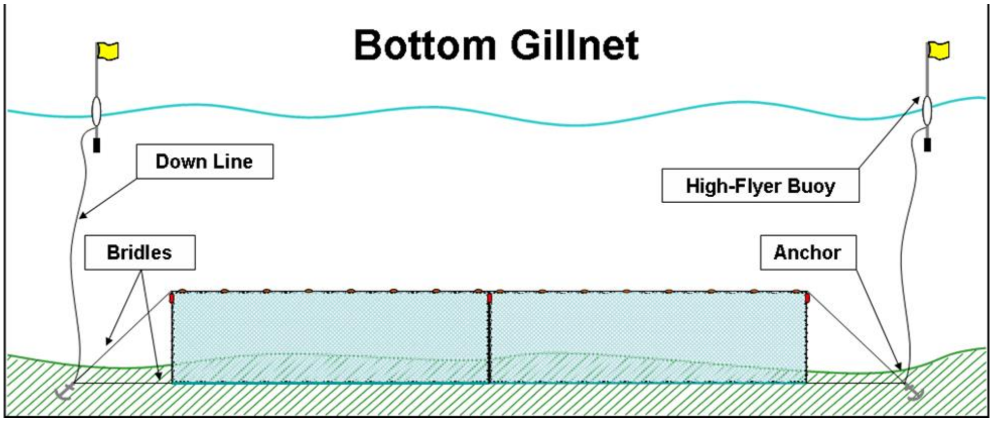



**Figure W-37. Bottom Fixed Gillnet**

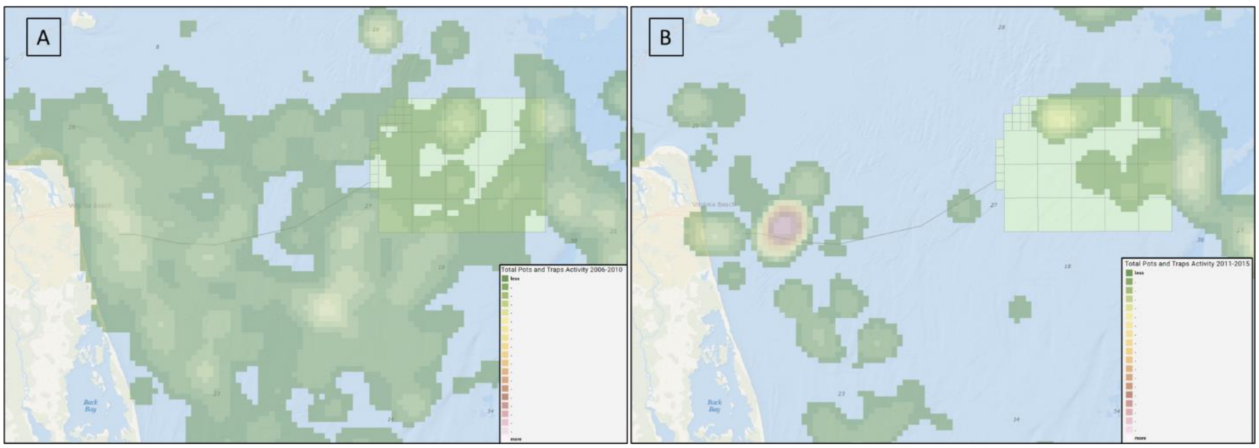



**Figure W-38. Pot/Trap Vessel Trip Report (VTR) Data for the Time Periods (A) 2006-2010; (B) 2011-2015. (MARCO 2020)**

**Figure W-39. Conch Pots, One Buoy and Buoy Line per Pot, Weighted with Bricks (Photo Credit: R. Larsen Sea Risk Solutions)**

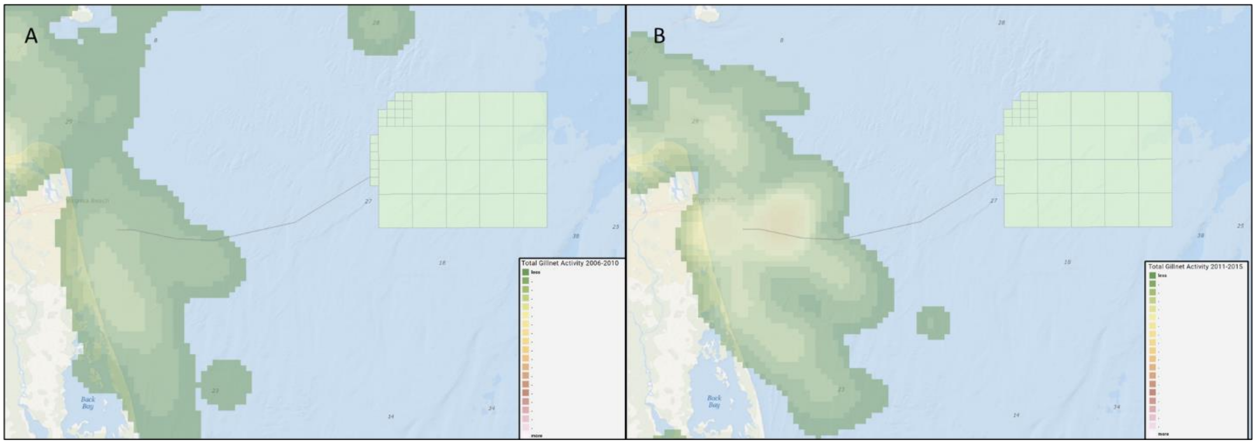



**Figure W-40. Gillnet Vessel Trip Report (VTR) Data for the Time Periods (A) 2006-2010; (B) 2011-2015. (MARCO 2020)**

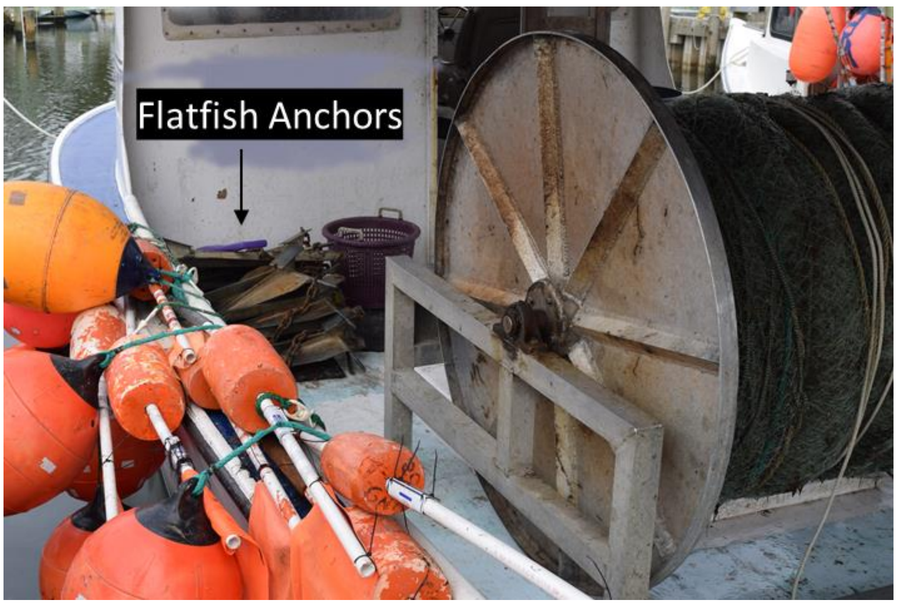



**Figure W-41. Anchors on Bottom Gillnet Vessel in Virginia (Photo Credit: R. Larsen Sea Risk Solutions)**

The recommended minimum burial depth (1.0 m) includes a factor of safety for fishing gear. The deepest penetration from fishing gear these cables will be exposed to is 66 cm, from otter doors deployed during bottom trawl fishing activities. This gives a 50% margin of safety for the worst-case fishing gear. A factor of safety is built into this study through its modified methodology and conservative estimates, further explored by the sensitivity analysis in Appendix A.

## W.5.8 Unexploded Ordnance/Munitions and Explosives of Concern

### W.5.8.1 Munitions and Explosives of Concern Risk Overview

As previously detailed, the OECRC alignment transits a firing range area danger area. While most of the current onshore training activity appears to be small arms fire, the Dam Neck Gun Line range was used historically by the military (primarily the Navy) to test fire and train personnel in the use of naval artillery and anti-aircraft systems. Tetra Tech has extensive experience with assessing risk in the Project Area having worked on previous projects with shore landings in the vicinity of the SMR. This experience will be used in the following preliminary, high-level summary of the possible threat to the Project due to UXO. Modern DoD training operations, including live-fire exercises, occur in these areas as well.

Given the historical and ongoing munitions training activities within this portion of the Project Area, there is potential to encounter and contact unexploded ordnance and other potentially explosive items that may be on the seabed or in the sediments during survey, installation, or maintenance of a portion of the export cable. This section discussed this potential and the currently available information in an effort to estimate the probability and likely consequences of encountering and detonating an explosive item during the Project's construction stage.

The shore approach portion of the Project Area is encompassed by the VACAPES Range Complex, which supports at-sea training exercises, research, development, testing, and evaluation activities for the Navy Atlantic Fleet. Located onshore, to the south and adjacent to the SMR, is Naval Air Station Oceana, Dam Neck Annex (Dam Neck), home to the Fleet Combat Training Center, Atlantic. Founded in 1941 as an anti-aircraft range, Dam Neck has been an active training ground for military personnel since its founding, and operational training continues to the present day on a number of major weapons systems. Historical and current operations at Dam Neck are of particular interest to the Project because the installation route passes through two offshore safety fans associated with historical land-based training ranges located onshore as well as the SMR Danger Zone (see Figure W-42). These two areas are designated by the Title 33 Code of Federal Regulations (CFR) as "Danger Zone 33 CFR 334.380; naval firing range" and "Danger Zone 33 CFR 334.390; firing range." They overlap with the VACAPES Range Complex's Operational Areas and Special Use Airspace areas, including R-6606, W-50, and W-72. These are areas of historical and current naval operations that may affect the Project cable route design, survey, installation, and maintenance.

Historical as well as more recent information regarding range use can be gathered from publicly available online sources and through research conducted at the National Archives and Records Administration. This section provides a brief listing of those historical and current sources of UXO and provides commentary on the potential distribution of UXO and discarded military munitions (hereafter referred to collectively as munitions and explosives of concern [MEC]) that present an explosive hazard with respect to construction in the study area. This initial assessment is meant to be a high-level evaluation of the types of hazards posed to the cable installation workers and equipment by MEC that may be present within the portions of the landfall and offshore OECRC alignment located within the firing ranges.

The following sub-areas of the OECRC alignment should each be identified using Project installation specific parameters and extents and then analyzed for the appropriate potential impacts and risk susceptibility of the associated activity:

- **Nearshore Trenchless Installation Area:** The portion of the Project Area where Trenchless Installation will occur, extending from inland of the preliminary transition joint bay locations to the mean low water line to encompass the Trenchless Installation on-land operations.
- **Offshore Trenchless Installation Punch Out Area:** Offshore location where Trenchless Installation will end. This may include anchored barges or jack-up rigs. During water operations such as jetting, tools may be utilized for cable burial. Divers may be on bottom with the tools, as

well as to affix and remove the Trenchless Installation duct end cap, retrieve the messenger wire, etc.

- **Main Lay Burial Area:** The portion of the Project Area that extends eastward from the Trenchless Installation Punch-Out to the Offshore Substations within the Lease Area. The western portion of this area transits the MEC area of concern.

Very high resolution, full-coverage gradiometer surveys will determine the presence of ferrous items that may or may not be MEC. Generally speaking, such surveys detect ferrous items above a certain size. Objects that are MEC but fall below the threshold of detection, may be small enough to be unlikely to cause damage to equipment, but may pose a threat to personnel, especially if underwater or if the threat item becomes lodged in a tool that is brought onboard the vessel. Because the authors are not aware of any studies that examined the risk to subsea cable due to underwater detonation of MEC in proximity to the cable during installation and burial, this risk should not be discounted. The particular specifications for any MEC survey effort should be driven by the determination of the size of MEC targets of concern for the Project, following a thorough risk analysis.

The review below incorporates publicly available information in order to determine the weapons known to be used and potentially contributing to MEC, which informs the size, type, and at the highest level, the distribution of projectiles that may be potentially encountered.

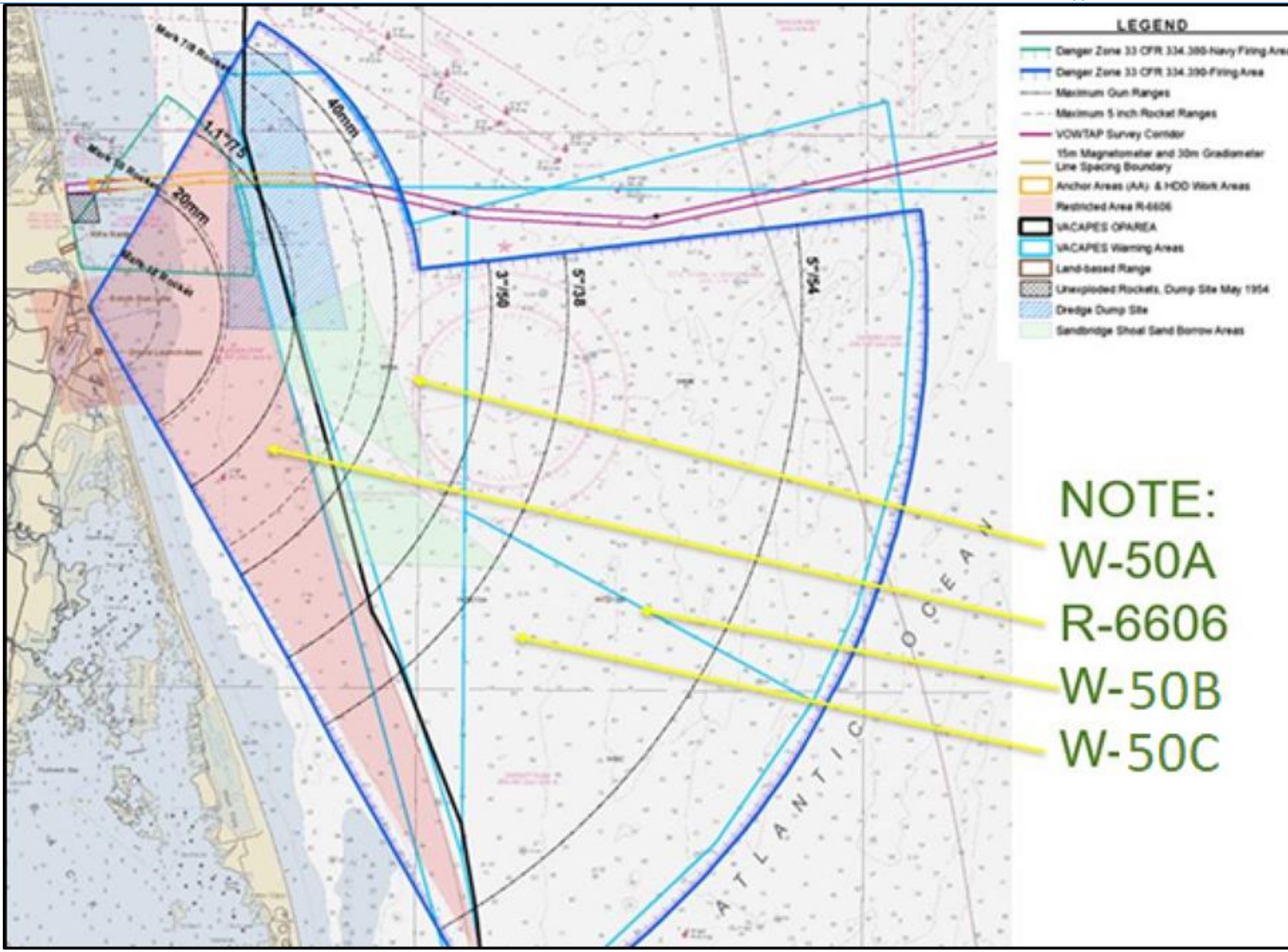



**Figure W-42.** **Military Restricted Zones and Warning Areas**

**R-6606** – The OECRC alignment traverses through the northern extent of Restricted Area R-6606. Activities currently conducted within R-6606 include parachute drops; research, development, testing and evaluation; target transit and recovery; exclusive air operations; remotely piloted vehicle operations; and anti-submarine tactical air control. R-6606 extends from a point on the Dam Neck Annex shoreline to the 3-nm (5.56-km) limit and borders the western limit of Special Use Airspace Warning Area W-50 from the surface to flight pressure level 510 (i.e., 51,000 ft [15,500 m]).

**W-50** – Air-to-surface and surface-to-surface exercises using inert ordnance are authorized, but W-50 is predominantly used for mine counter measure training exercises. W-50 is comprised of three sub-areas (W-50A, W-50B and W-50C) – W-50A is crossed by the OECRC alignment.

**W-72** – Special Use Airspace Warning Area W-72 extends from the boundary with W-50 on the west to the eastern and southern boundaries of the VACAPES Operational Area. Air-to-air, air-to-surface, and surface-to-surface missile, guns, cannons, bomb exercises using conventional ordnance, and air combat maneuvering training are authorized in W-72.

### W.5.8.2 Historical VACAPES Range Operations

The Gun Line was established in 1941 and included guns typically used on a Navy ship of the era (Figure W-43). The guns were positioned on a 930-ft (284-m) -long paved surface along the shoreline, with firing directed over the beach and into the ocean. The Gun Line was active throughout World War II and into the 1970s and is the primary source of potential MEC in the Project.

While the range was still considered active and three guns were still functional in 2004 (used for maintenance training), the guns have not been fired since the late 1980s because of the difficulty of clearing the adjacent ocean of recreational and commercial boaters (Navy 2004). From historical data, it appears that the 5-in 54 caliber (abbreviated 5”/54) naval guns were the biggest used on the Gun Line, and they fire projectiles 5 in (12.7 cm) in diameter weighing approximately 55 pounds (25 kilograms) up to a maximum range of 15 mi (24 km), containing a bursting charge of 7 pounds (3.3 kilograms) of high explosives. Additionally, the 5”/54 had the ability to fire a “rocket assisted projectile” capable of a range of more than 17 mi (27 km), although it is impossible to confirm whether those projectiles were deployed at this location.

**Figure W-43. Historical Photographs Showing Some of the Various Types of Guns Deployed at the Dam Neck Gun Line**

Figure W-44 shows a conceptual image of the VACAPES range and Dam Neck gun line, some of the associated military activities (drone launches, aerial target towing, etc.), the arcs of Warning Areas 50 and 72, and Danger Zone 334.390. Note that the landfall is approximately 2.5 mi (4 km) to the north of the Dam Neck gun line.

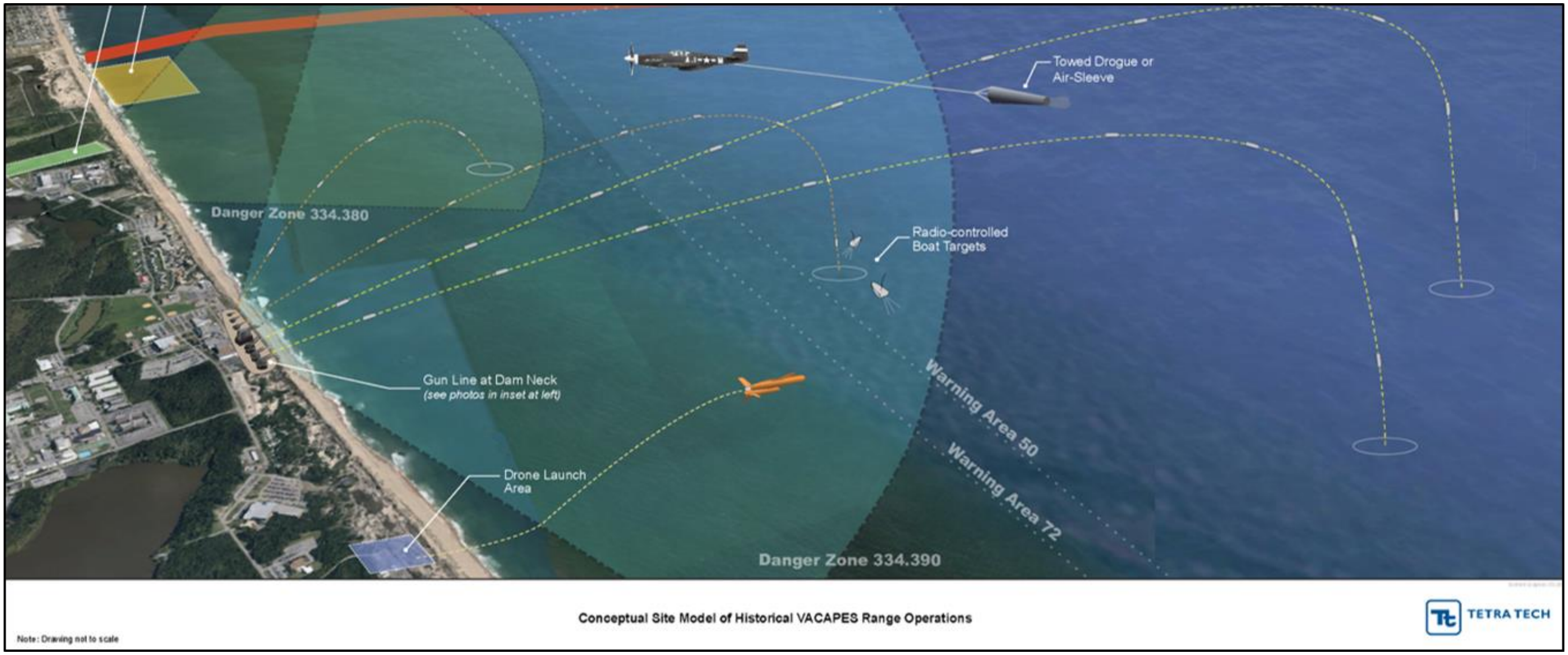



**Figure W-44. Conceptual Image Showing Historical VACAPES Range Operations Including the Dam Neck Gun Line**

#### W.5.8.3 Ongoing UXO Campaign Status

The UXO survey campaign and data associated analysis began in mid-2022 and will continue through 2023, and thus it is ongoing at the time of this CBRA update. Data acquisition consists of five areas covering the offshore export cable routes and the Lease Area, with a planned completion in the second quarter of 2023. Initial indications from completed sections of the acquisition have identified potential targets. These targets will be further interpreted and analyzed for risk as potential UXO. The potential UXO items will be documented in a series of As Low As Reasonably Practicable (ALARP) Certificates. These potential UXO items will then be subject to further investigation through additional offshore campaigns if they are not otherwise avoidable through cable routing.

The findings of these UXO identification and subsequent potential investigations are not anticipated to pose an issue to the findings of this CBRA nor to achieving a suitable depth of lowering for the offshore export cables. Micrositing of cable routes to avoid potential UXO items identified through this effort is not anticipated to change the route at a scale that would impact the findings of the CBRA, as the CBRA is based around the centerline and is relatively insensitive to small scale shifts in cable alignments.

### W.5.9 Marine Debris

Due to the nature and volume of large commercial and military vessel traffic through the study area, the potential exists for marine debris and dropped objects to be deposited on or near the OECRC alignment. As suggested above for understanding the risk in the DNODS, a “dropped objects” study could also investigate the risk to the cable from debris or objects dropped from vessels transiting the area or at anchor. Closer to the Offshore Project Area, there is an increased risk of installation, operations, and maintenance-related objects to be dropped on or near the cables.

### W.5.10 Cultural Resources

Known or charted shipwrecks have been noted within the survey corridor, and additional efforts utilizing gradiometer, sidescan sonar, sub-bottom profiler, and multibeam echosounder HRG data along the OECRC will allow the Project’s Qualified Marine Archeologist (QMA) to identify potential cultural features and provide avoidance buffers as appropriate. As additional data on cultural or historic items of concern are documented by the Marine Archeological Resource Assessment activities, they can be included in later iterations or updates of this CBRA analysis as needed.

The QMA may also assess whether any paleo landform features at the seabed or in the shallow subsurface have the potential to represent cultural resources. If shallowly buried paleo landscape features are identified by the QMA, any plans to bury the cable will need to consider the vertical Area of Potential Effect of the cable installation in relation to the three-dimensional avoidance zone established for the potential cultural resource target. Impacts will likely be able to be mitigated or minimized through route micro siting, modifications to the cable burial plan, and an unanticipated discovery plan.

### W.5.11 Prevailing Metocean Conditions

The Dominion Energy CVOW Commercial Owners Engineer Metocean Assessment (provided as an appendix to the COP) was referenced; however, a detailed review of metocean conditions is outside the scope of this document. It is understood that one of the main threats to the cables would be either the reduction of cover, or potentially the increase in cover caused by shifting sediments due to tropical and winter storm events. The methodology and findings of this CBRA do not consider the met-ocean conditions apart from the impact of those conditions on the potential for seabed mobility, as evaluated in other studies and addressed in other parts of this study, such as section W.6.4.2.

### W.5.12 Department of Defense Vessels and Operations

Due to the number and intensity of transits, training, and other exercises conducted by military vessels in the area of the cable routes, the risk from these vessels should be considered. Most of the statistical analysis in this study depends on AIS data, and it is suspected that due to exercises or other requirements, not all military vessels may consistently report via AIS as reliably as commercial vessels. Furthermore, this study has not yet fully quantified the risks from DoD warships and support vessels. Future efforts directed by the Project may investigate this risk in more detail, but a proper study should involve direct communication with the DoD to understand the range of vessels and anchor sizes utilized in the area, and the frequency and future plans for operations across the route. Investigations into the awareness procedures prior to planned and emergency anchoring by military vessels should also be considered. This knowledge can then inform both the planning of cable burial depth and also the planning for adequate outreach and liaison to the DoD to increase awareness of the cables and prevent potential mishaps.

### W.5.13 Offshore Export Cable Route Corridor Layout

The dense spacing, particularly within the DNODS zones (Figure W-45) and overall number of cables planned for the Export Cable Corridor can be considered as a risk enhancer. Given the geometry of the individual cable routes relative to the vessel traffic, which mostly runs perpendicular to the route, the possibility of one event of an anchor drag or inadvertent anchor deployment may damage not just one cable, but several of the up to nine cables planned to be installed in the corridor. While the power export system may be able to cope with the loss of one cable, the disruption to multiple cables servicing one or more offshore substations may significantly curtail the Project’s power transmission until a repair is made.

This reduced cable spacing also increases the risk of damage to adjacent cables during installation and maintenance or repair operations, and it may preclude some installation or repair methods or vessels. There is also an increased complexity for the crossing negotiations and design of crossing solutions, given the number and spatial density of the crossings.

The spacing of the cables may not allow for avoidance of less-than-ideal geology, resulting in installation across more challenging seabed for cable burial. Features typically avoided through cable routing, such as large debris or potentially historic or cultural wrecks as identified by the QMA, may be more difficult to avoid while maintaining the planned offsets between cables. Similarly, mitigation through avoidance may not be possible to address some or all of the potential munitions targets identified by the UXO survey, which could require more costly and time-intensive intrusive investigation and remediation of potentially hazardous targets.

### W.5.14 Direct-Pipe Offshore Exit Shallow Water Location

Sufficient protection of the offshore exit points for the trenchless shoreline crossings should be considered. As discussed in section W.5.1.3, the offshore exit points for the trenchless shoreline crossings are in approximately 5 to 6 m water depth, corresponding to the depth where seabed mobility related to shoreline processes is expected to become less significant, except perhaps in the most extreme met-ocean events.

The shallow water depths and presence of charted Danger Areas and Warning Areas will limit the number of larger vessels transiting and anchoring in this region. The most significant threat to an installed cable and the trenchless shoreline crossing exit point are likely to be seabed mobility exposing the cables and any cable protection and potentially causing stress and/or abrasion to the cables, as well as increasing the risk of damage from smaller vessel anchors and from fishing gear strike or entanglements.

With seabed mobility understood to be on the scale of 0.2 to 0.5 m of vertical change, ensuring that the offshore exit point and the start of cable burial can be on the order of 1.5 to 2 m below the seabed, the risk from exposure should be greatly mitigated. If these depths are not achievable, additional protection may need to be considered. However, introducing rock cover or mattresses into this higher-energy nearshore environment may increase the possibility for increased scour and related seabed impacts. Although probabilistic modeling of the impacts of distributing additional protective materials to the seabed is outside the scope of this CBRA, the process effectively reduces the water depth, creating a potential shoaling hazard in the area typically utilized by smaller vessels and potentially for Department of Defense training activities.

There would be very little risk of cable damage from fishing gear at the punch out location for a cable that is only slightly buried or even exposed for a short distance on the sea floor. In 2022 the Virginia Marine Resources Commission (VMRC) approved a small boat shrimp trawl fishery in state waters that may operate over or near the HDD punch out sites. This gear is a very light beam-trawl that has very little (if any) penetration into the seabed. The vessels operating this gear are typically under 45 ft (14 m) in length and limited horsepower; not large enough to damage the power cable. However, an exposed or suspended cable could present a hazard/obstacle to this fishing gear but a similar hazard to fishing gear would be presented by placing any cable protection (e.g., rock placement, mattressing, etc.) at the punch out site. There is no known fixed gear (e.g., pots, traps, gillnets, etc.) fishing at that location.

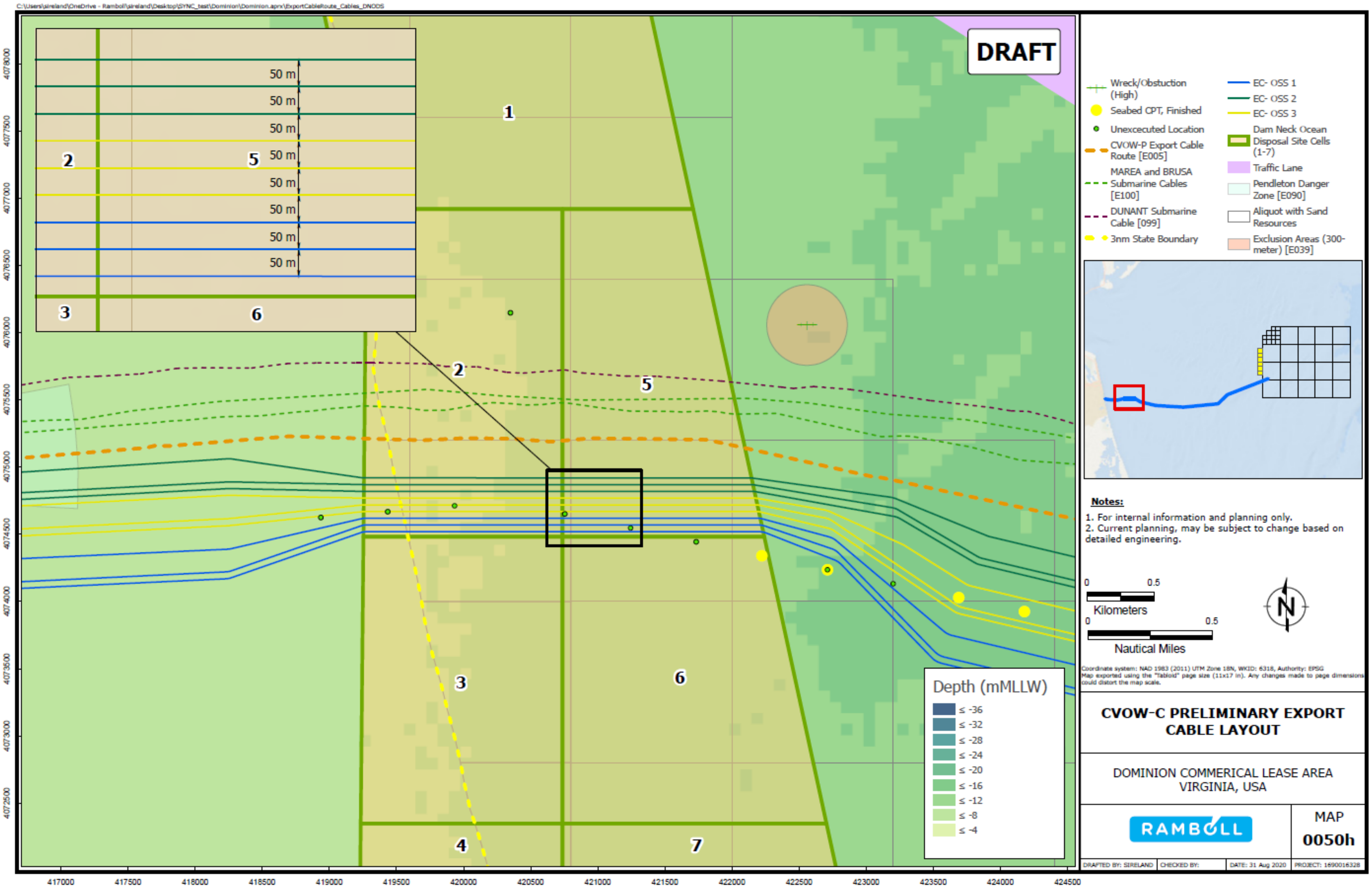



**Figure W-45. Indicative Initial Layout of the Individual Export Cables where the Cables Cross the DNODS and Exhibit Decreased Spacing**

# W.6 MODELING OF LIKELY SCENARIOS AND PROBABILISTIC RISK ASSESSMENT

## W.6.1 Introduction

The probability of an anchor strike on a subsea cable across both the preliminary planned cable route and the study area is evaluated by a model co-developed by Sea Risk Solutions, LLC and NASH Maritime Ltd. This model is informed by the Carbon Trust's Cable Burial Risk Assessment Methodology (Carbon Trust 2015), which has been utilized in cable risk studies across the world. Historical AIS data for the study area for the year of 2019 has been sourced from the NOAA Office for Coastal Management's Marine Cadastre data repository (Marine Cadastre Data Registry 2020). Vessel characteristics data has been sourced from MarineTraffic.com (Marine Traffic 2020).

The model deployed here seeks to quantify the risks from three potential hazard scenarios (Figure W-46). The three potential hazard scenarios are:

1. Emergency anchor deployment under power. In this scenario, an anchor is deployed during a mechanical failure or other emergency to stop a vessel. For example, loss of control of steering or engine failure may lead a vessel to deploy an anchor at speed to prevent running aground.
2. Anchor dragging, where a vessel's anchor is dragged during or after anchoring. This may occur as a result of poor anchor hold, bad weather, or other malfunction.
3. Intentional anchoring, where an anchor is intentionally deployed near or over the cable.

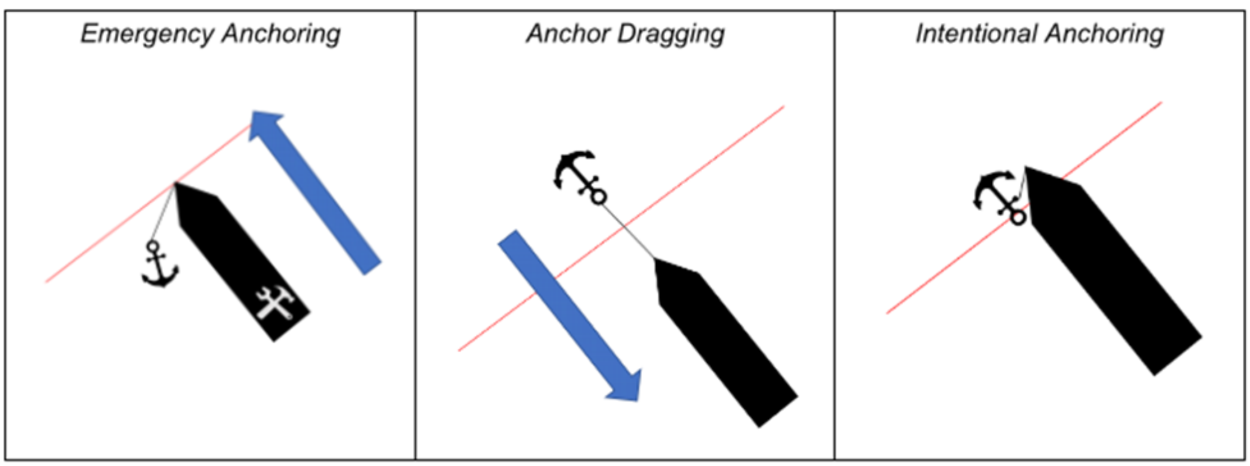



**Figure W-46. Various Anchoring Scenarios**

A fourth potential anchor hazard stems from vessels steaming under power while having an anchor deployed unbeknownst to the crew. This could potentially result from improper use or failures of anchor securing mechanisms. Some of this risk can be presented with the risk statistic associated with emergency anchor deployment under power, though this model is not designed to represent this risk. It is assumed to be minimal due to the low frequency of it occurring and the minimal associated penetration depths. These events are rare and have generally lower depths of penetration than other risks such that the additional risk is assumed to be negligible or nearly so.

## W.6.2 Traditional CBRA along the Primary Offshore Export Cable Route Corridor Centerline

### W.6.2.1 Methodology

This methodology models the risk to a cable as a function given by the exposure of a hazardous scenario from vessels, the probability of a hazard occurring, and a scenario modifier.

$$P_{strike} = \sum_{1}^{\#\ of\ vessels} T_H * P_{incident} * P_{wd}$$

Where:

- $T_H$ is the exposure of the cable to a given hazard
  - For emergency anchor deployment, this is taken as time in hours vessels represent a hazard to the cable.
  - For anchor dragging, this is taken as the time in hours vessels are anchored near the cable.
  - For intentional anchoring, this is either the number of occurrences vessels anchor near the cable or the area of the buffer zone in meters where per meter calculations are used.
- $P_{incident}$ is the probability of a hazard occurring
  - For emergency anchoring, this is the probability of machine failure, given as 2e-5 per hour from DNV-RP-F107.
  - For anchor dragging, this is the probability that a vessel at anchor drags, given as 3.63e-5 per hour as per Doan et al. (2016).
  - For intentional anchoring, this is either the probability a vessel accidently anchors on the cable when choosing to anchor, assumed to be 5e-3 (1 in 200), or for area calculations supplemented by a risk per $m^2$.
- $P_{wd}$ is a scenario modifier
  - A series of situational modifiers is used to capture the varying scenarios across the cable route for emergency anchor. These values are included in Appendix A, Probabilistic Risk Assessment Modifiers by Kilometer Post.
  - 0.5 is used for all segments for anchor dragging to account for a 50 percent chance for an anchor to drag toward, or away from, the cable.
  - 0.5 is used for all segments for anchor drop to account for the same reason as above.

#### *W.6.2.1.1 Segmentation of the Route*

Before applying this model, the cable route was divided into 24 segments, each covering two KPs. The model was applied iteratively across each segment with each relevant set of variables and across a set of burial depths. This establishes a risk surface of the hazards this subsea cable is exposed to.

#### *W.6.2.1.2 Traffic Exposure and Anchor Size Estimation*

$T_H$ is determined by the exposure, in hours, the first two hazards represent and the number of anchoring events that take place in the immediate area. For emergency anchor deployment, this is taken as the total time, in hours, of all vessel activity faster than 0.5 knots in a 1505-ft (459-m) buffer zone around the cable. Anchor dragging uses the same buffer zone, though only considering traffic 0.5 knots or slower. The buffer zone size is determined by an estimated energy absorption algorithm, defined as Dship below, for all traffic in the study area, and the highest value is chosen as a conservative measure. Small vessels represent a significant majority of the traffic in the area. This is not to suggest that there are few large vessels, but rather, that there is a great deal of small vessel activity. This greatly skews Dship in such a way that may underestimate the risk in this study area, and the maximum value of Dship present is chosen as a means for a conservative estimate. Intentional anchoring considers two separate approaches. First, all traffic travelling at speeds under 0.5 knots within a much smaller buffer zone around the cable, targeting approximately 3.5 times water depth across the given cable segment. Second, in the case where anchoring appears to be somewhat randomly and evenly distributed across a broad area, a per-meter risk approach is used with the same small buffer zone. This smaller buffer zone better models the likely zone impacted by an anchor deployment.

The estimated energy absorption function is as follows, courtesy of the Carbon Trust CBRA Application document:

$$D_{Ship\ Drag} = \frac{m * V_{Ship}^2}{4 * UHC}$$

Where:

| | |
|---|---|
| $D_{Ship\ Drag}$ (m) | distance travelled by the anchor in order to be a threat to the cable |
| m | Vessel mass (deadweight + ship light weight), usually taken as displacement (tons) |
| $V_{Ship}$ (m/s) | ship speed when the anchor is deployed |
| UHC | Ultimate Holding Capacity of the anchor |

Of the vessels present, 1,921 of the 4,392 vessels had deadweight information available from the Marine Traffic website. AIS broadcasts do not include this data. The remaining vessel distribution was constructed by the following process: First, the complete dataset of vessels was cleaned, and vessels were reclassified where necessary to a total of eight vessel classes, including both “other” and “unknown”. Next, the dataset of vessels with known deadweight was constructed complete with available vessel characteristics. This data was split into a test train set, and the extreme gradient boosting algorithm XGBoost regressor was implemented and found to explain 93 percent of the variance of deadweight tonnage based on vessel characteristics. This trained algorithm was then used to predict deadweight tonnage across the remaining vessels.

While XGBoost is an effective tool in this application, it has limitations. Data tends to be sparse on smaller vessels, especially with recreational, sailing, and other pleasure boats. This algorithm manages missing data well, though still often overstates anchor penetration for these small vessels. An interrogation of the dataset resulting from this prediction identified many of the smallest vessels with overestimated deadweight tonnage. These small ships tend to have minimal anchor penetration, and this error far overstated risk attributable to this vessel group with anchor penetrations less than 1.6 ft (0.5 m). Because of these factors, vessels under 20 ft (6 m) were assumed to have anchor penetrations less than 1.6 ft (0.5 m).

To calculate anchor size and characteristics, each vessel in the study area is classified into categories based on its deadweight tonnage. Vessels in each category are assumed to have all characteristics, except for deadweight, of the largest in the category. Anchors are assumed to be stockless with holding capacities of 5 times the weight, or an average of the estimated 4 to 6 times the anchor weight as a measure of holding capacity, also known as anchor efficiency. Anchor penetration for each vessel has been estimated in the NorthConnect Cable Burial Risk Assessment (Cathie Associates 2018) and is shown in Table W-6. The material for this area is assumed to be high-strength clays, and sands is used for the entirety of the probabilistic assessment based on information from the Carbon Trust CBRA reports and inputs from Tetra Tech.

**Table W-6. Vessel and Anchor Size and Penetration (Cathie Associates 2018)**

| Category Minimum Deadweight Tons | Category Maximum Deadweight Tons | Displacement Tons | Anchor Weight (kg) | Fluke Length (m) | Anchor Penetration, High Strength (m) | Anchor Penetration, Low Strength (m) |
|---|---|---|---|---|---|---|
| 0 | 10 | 17 | 36 | 0.33 | 0.24 | 0.77 |
| 10 | 100 | 170 | 123 | 0.5 | 0.35 | 1.15 |
| 100 | 1,000 | 1,700 | 524 | 0.81 | 0.57 | 1.86 |
| 1,000 | 10,000 | 17,000 | 2,388 | 1.34 | 0.95 | 3.08 |
| 10,000 | 25,000 | 42,500 | 4,388 | 1.64 | 1.16 | 3.77 |
| 25,000 | 50,000 | 85,000 | 6,959 | 1.91 | 1.35 | 4.39 |
| 50,000 | 75,000 | 127,500 | 9,114 | 2.09 | 1.48 | 4.8 |
| 75,000 | 100,000 | 170,000 | 11,039 | 2.23 | 1.58 | 5.12 |
| 100,000 | 150,000 | 255,000 | 14,461 | 2.44 | 1.72 | 5.6 |
| 150,000 | 200,000 | 340,000 | 17,516 | 2.6 | 1.84 | 5.97 |
| 200,000 | 325,000 | 552,500 | 24,206 | 2.89 | 2.04 | 6.64 |
| 325,000 | 500,000 | 850,000 | 32,255 | 3.18 | 2.25 | 7.31 |

To calculate the risk to each cable, the raw AIS signals collected for calendar year 2019 were split into two sets: one, over 0.5 knots for vessels under way, and the other, 0.5 knots and under for vessels at anchor. $T_H$ was calculated for each vessel and hazard across each cable segment. If a vessel's anchor penetration was not as great as the current iteration's burial depth, it was considered to present no risk. $T_H$ was then multiplied by the probability of the given hazard occurring, $P_{incident}$, and the respective situation modifier, $P_{wd}$.

It is important to note that the modifications for intentional anchoring change this process. $T_H$ here was calculated as the number of individual anchors per vessel in the area irrespective of time. Two cases were used here to enable accurate anchoring risk along the route.

The first case is a modified $T_H$ calculation that attempts to count the number of anchoring incidents by measuring time spent at low speed in the area. While this removed most vessels loitering at slow speed, it is not possible from AIS to accurately distinguish some types of prolonged loitering from short-term anchoring.

The second case deals with anchoring past KP 16. In this area of the study, anchoring spreads out and appears to be a somewhat even distribution across a large area, much of which overlaps the cable. Counting individual anchoring events along the cable, especially with these more targeted buffer zones, lead to overestimating likely risk for some segments and underestimating likely risk at others. To compensate for this, $P_{incident}$ was calculated as a risk per $m^2$ and $T_H$ was calculated as the area of each segment's buffer zone in $m^2$.

In both cases, a modifier of 0.005 (i.e., 1 in 200) was used to assume that a combination of information distribution, cable protection efforts, and a general avoidance of anchoring near and directly over subsea cables would reduce the overall risk present. These modifiers are chosen via input from a panel of knowledgeable experts, though no quantitative information is available for this rate at this time and it is therefore an estimate. This modifier makes a significant impact on the overall risk, demonstrating a need for good cable awareness and informational campaigns. A basic sensitivity analysis of this variable, providing summary statistics for modifiers of 1 in 100, 1 in 50, and 1 in 1 for anchoring, has been provided in Appendix A (Probabilistic Risk Assessment Modifiers By Kilometer Post). A value of 1 (i.e., 1 in 1 probability) effectively assumes that no attempt is made to avoid the cable nor check any charts, Notices to Mariners, nor other outreach materials to confirm anchoring location is clear of cables. A value of .005 (i.e., 1 in 200) would indicate that vessel masters are aware of cables and only anchor without checking for cables once out of every 200 instances of anchoring.

The following vessel traffic maps (Figure W-47 to Figure W-53) show a selection of AIS signals and paths to best demonstrate vessel traffic across the study area. Due to differences in nomenclature and how types were reported, there were originally more than 16 raw values for vessel categories. These categories were collapsed into eight broad types based primarily on similarities in deadweight tonnage, size, the numbers of vessels present in given categories, and likeness with a focus on enabling better prediction from the XGBoost algorithm. The primary reasoning for this focus is that the main quantitative impact of the given ship type is as a categorical feature for this machine learning algorithm, and qualitative information is sacrificed for the quantitative benefits of this feature engineering. Note that these charts include an approximate cable route that is not representative of the exact cable routing used herein but demonstrates the location of the centerline route.


**Figure W-47. 2019 AIS Heat Map – All Vessel Traffic**

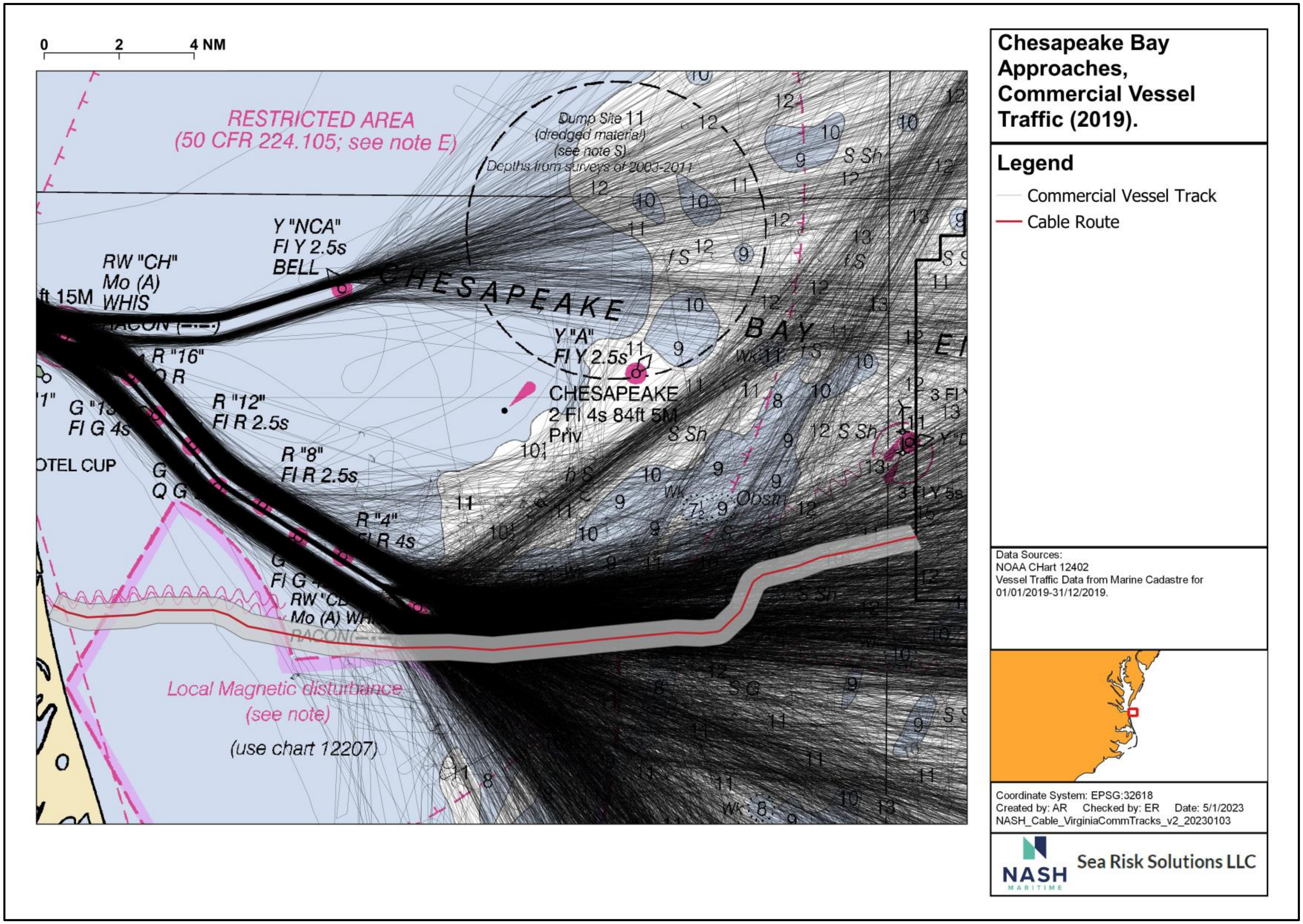



**Figure W-48. 2019 AIS Heat Map – All Commercial Vessel Traffic Broken Out by Type**

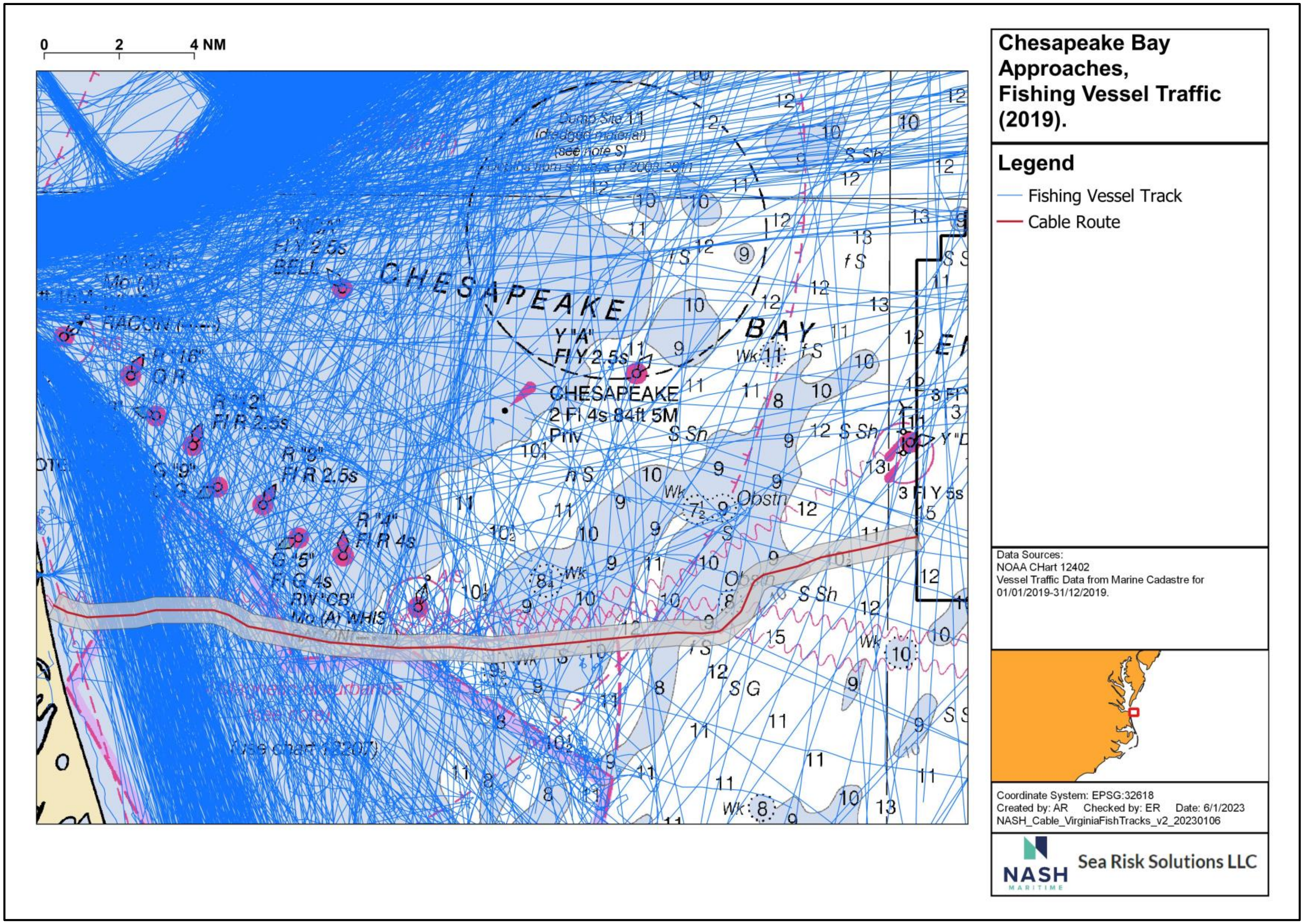



**Figure W-49. 2019 AIS Heat Map – Fishing Vessel Traffic**

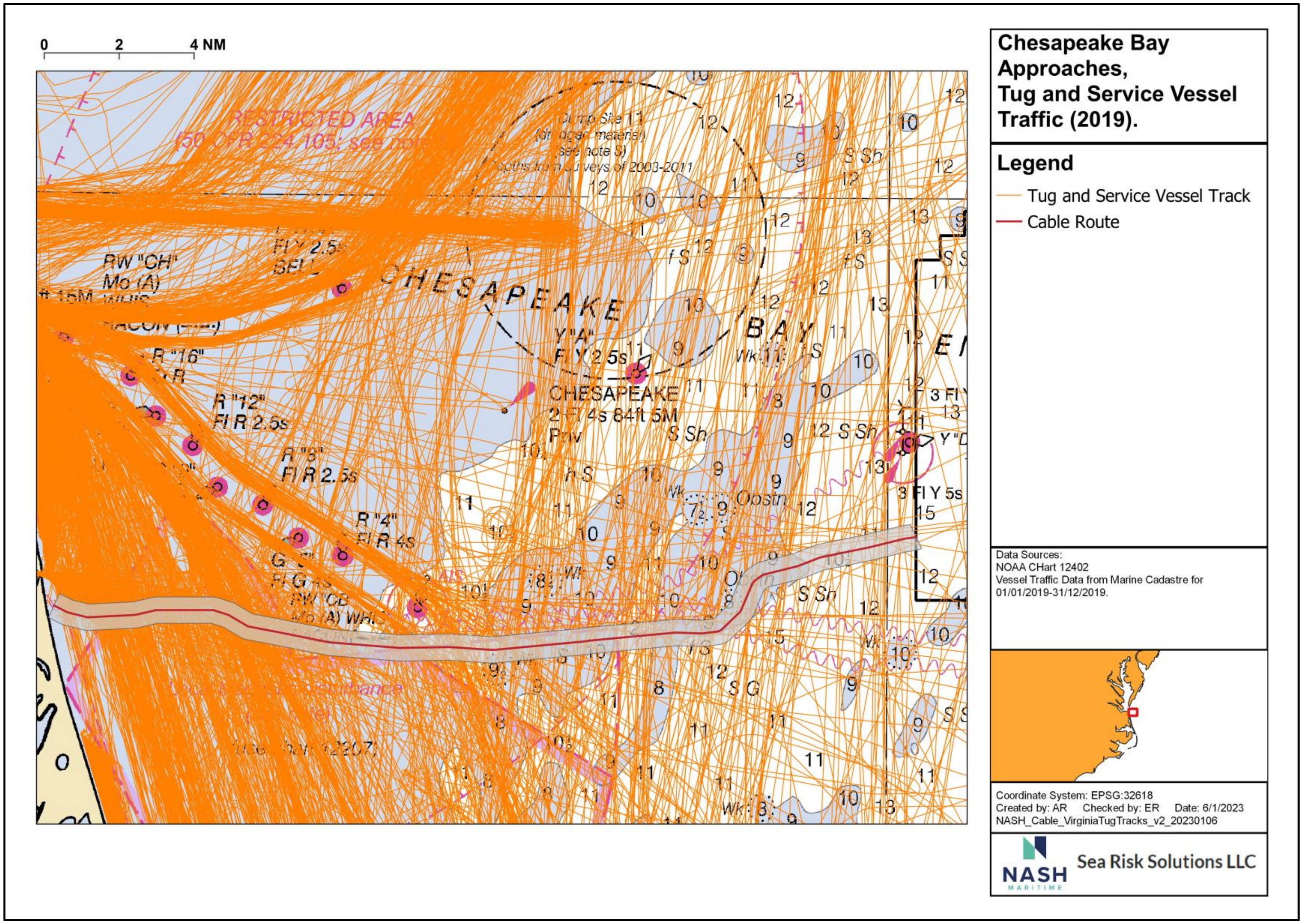



**Figure W-50. 2019 AIS Heat Map – Tug and Service Vessel Traffic**

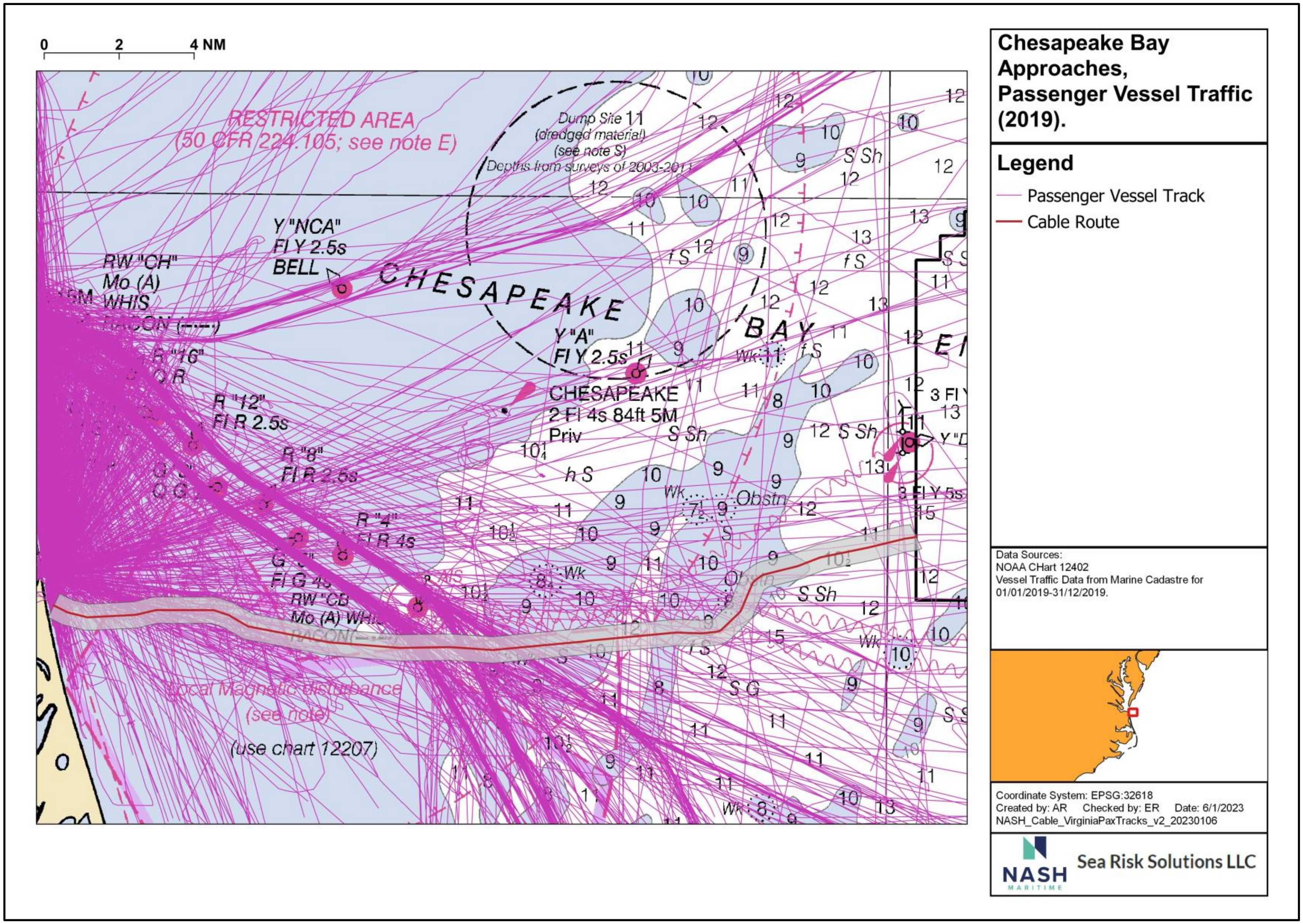



**Figure W-51. 2019 AIS Heat Map – Passenger Vessel Traffic**

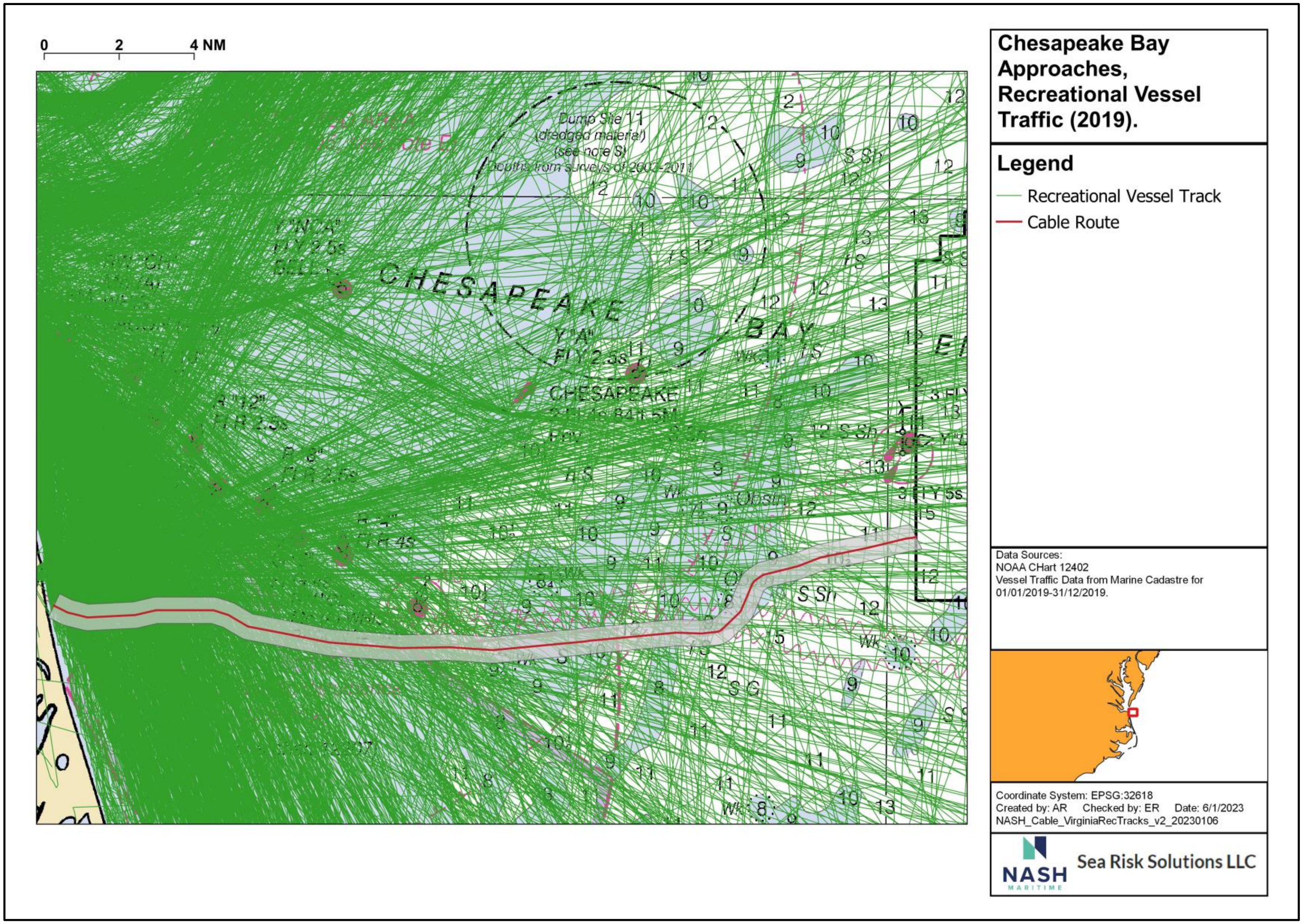



**Figure W-52. 2019 AIS Heat Map – Recreational Vessel Traffic**

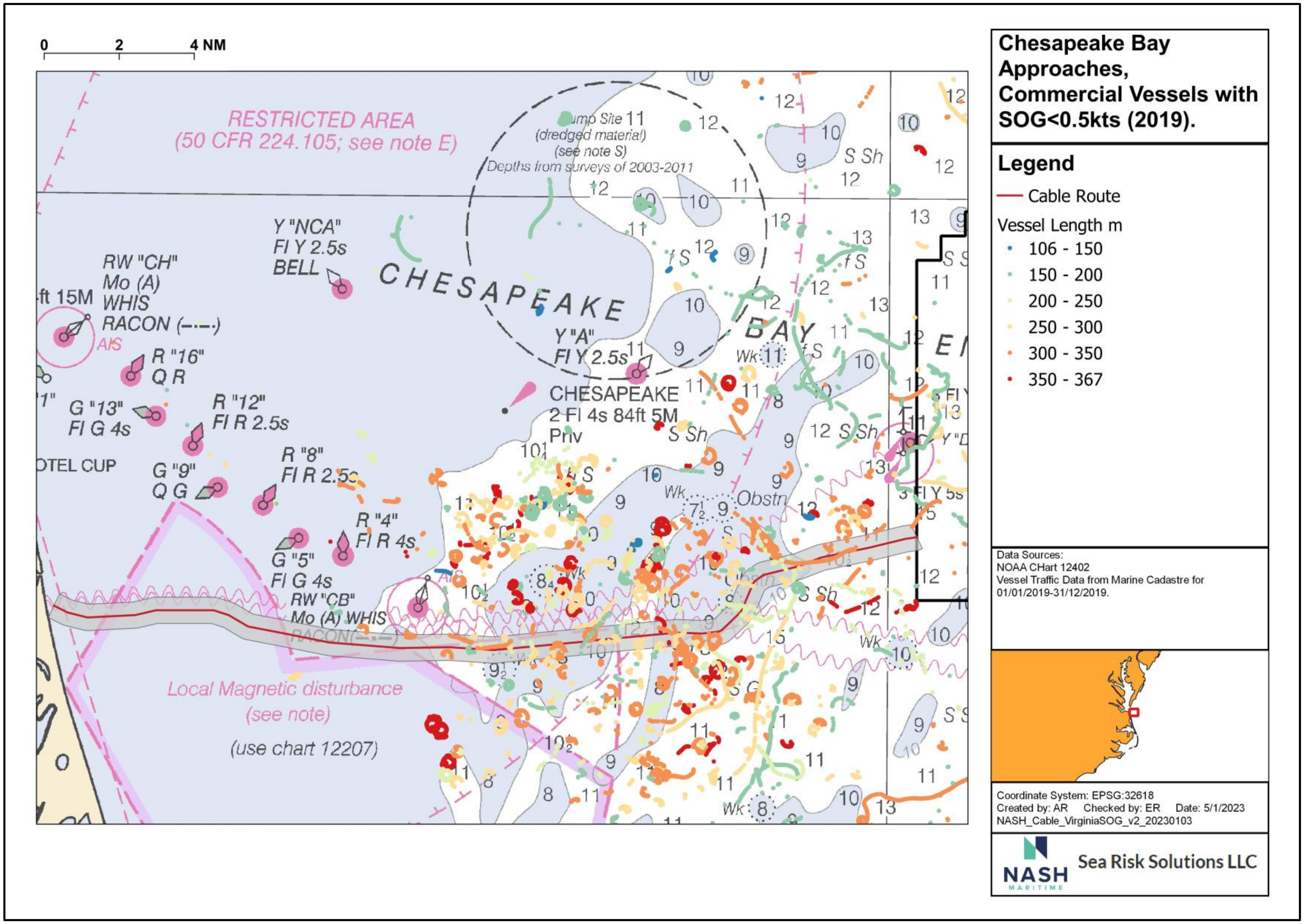



**Figure W-53. 2019 AIS Heat Map – Commercial Vessel Traffic with <0.5 kts Speed (assumed anchored)**

#### *W.6.2.1.3 Scenario Modifier*

The scenario modifiers chosen for $P_{wd}$ modifies the strike risk to account for specific local scenario conditions. These values are listed in Appendix A. These values are chosen by both water depth and navigational considerations across the area. The primary navigational considerations across the cable route include the transit channel, unexploded ordinance zones, and other navigational restrictions. Vessels will generally avoid emergency anchoring unless necessary, and generally have a lower chance of deploying an anchor in an emergency as water depths increase. As such, $P_{wd}$ tends to decrease as water depth increases. The value of 0.5 was chosen for this modifier for both intentional anchoring and dragging to better reflect the chances an anchor will drag, or drop, toward or away from a cable.

#### *W.6.2.1.4 Iterative Depth Assessment*

This Cable Risk Assessment is applied iteratively across segments and burial depths. The set of burial depths evaluated here includes zero ft (zero m), or no cable burial, 1.6 ft (0.5 m), 2.6 ft (0.8m), 3.3 ft (1.0 m), 3.94 ft (1.2 m), 4.9 ft (1.5 m), 6.6 ft (2.0 m), and 8.2 ft (2.5 m). If a vessel's estimated anchor penetration does not reach the current burial depth, it is assumed to represent no risk. In this way, the risk presented by each hazard is reduced as each iteration eliminates vessels exposed to the cable. This enables a comparison of the benefits of differing burial depths across different segments of cable. If no vessels have an estimated anchor penetration that reaches the current burial depth, the probability of a hazard occurring is zero. No vessels have estimated anchor penetrations deeper than 8.2 ft (2.5 m).

### W.6.2.2 Results

The following tables (Table W-7 through Table W-13) and charts (Figure W-54 through Figure W-60) discuss the results of these calculations. Risk is defined as the chance of an event occurring in any one year. Included in these tables are the total risk across the entire cable route, calculated as the chance of one or more cable segments being struck in any one year, and the risk of a strike over 35 years per segment and in total, calculated as the chance of one or more cable strikes occurring over the same period. Return periods are the multiplicative inverse of the given probability.

**Table W-7 0-m Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.1622% | 0.3439% | 0.2500% | 0.7562% | 132 | 23.3300% |
| KP2 - KP4 | 0.0537% | 0.0087% | 0.0000% | 0.0623% | 1604 | 2.1590% |
| KP4 - KP6 | 0.0556% | 0.0005% | 0.0000% | 0.0561% | 1783 | 1.9447% |
| KP6 - KP8 | 0.0467% | 0.0006% | 0.0000% | 0.0473% | 2112 | 1.6438% |
| KP8 - KP10 | 0.0452% | 0.0040% | 0.0000% | 0.0492% | 2031 | 1.7092% |
| KP10 - KP12 | 0.0418% | 0.0016% | 0.0000% | 0.0434% | 2303 | 1.5086% |
| KP12 - KP14 | 0.0291% | 0.0021% | 0.0000% | 0.0312% | 3201 | 1.0875% |
| KP14 - KP16 | 0.0218% | 0.0055% | 0.0000% | 0.0272% | 3671 | 0.9491% |
| KP16 - KP18 | 0.0209% | 0.0005% | 0.0000% | 0.0214% | 4668 | 0.7471% |
| KP18 - KP20 | 0.0779% | 0.0000% | 0.0000% | 0.0779% | 1284 | 2.6907% |
| KP20 - KP22 | 0.1174% | 0.0132% | 0.0000% | 0.1306% | 766 | 4.4710% |
| KP22 - KP24 | 0.1468% | 0.0075% | 0.0000% | 0.1543% | 648 | 5.2609% |
| KP24 - KP26 | 0.1195% | 0.1057% | 0.2500% | 0.4752% | 210 | 15.3558% |
| KP26 - KP28 | 0.0920% | 0.1382% | 0.5000% | 0.7302% | 137 | 22.6247% |
| KP28 - KP30 | 0.0897% | 0.0249% | 0.5000% | 0.6147% | 163 | 19.4101% |
| KP30 - KP32 | 0.0791% | 0.1909% | 0.7500% | 1.0200% | 98 | 30.1521% |
| KP32 - KP34 | 0.0665% | 0.0523% | 0.0000% | 0.1187% | 842 | 4.0728% |
| KP34 - KP36 | 0.0544% | 0.0102% | 0.0000% | 0.0646% | 1549 | 2.2355% |
| KP36 - KP38 | 0.0353% | 0.0022% | 0.0000% | 0.0375% | 2667 | 1.3039% |
| KP38 - KP40 | 0.0322% | 0.0091% | 0.0000% | 0.0413% | 2423 | 1.4344% |
| KP40 - KP42 | 0.0271% | 0.1226% | 0.2500% | 0.3998% | 250 | 13.0811% |
| KP42 - KP44 | 0.0209% | 0.0021% | 0.0000% | 0.0230% | 4346 | 0.8021% |
| KP44 - END | 0.0145% | 0.1492% | 0.0000% | 0.1637% | 611 | 5.5717% |
| | | | Total cable Risk: | 5.146% | 19 | 84.2614% |

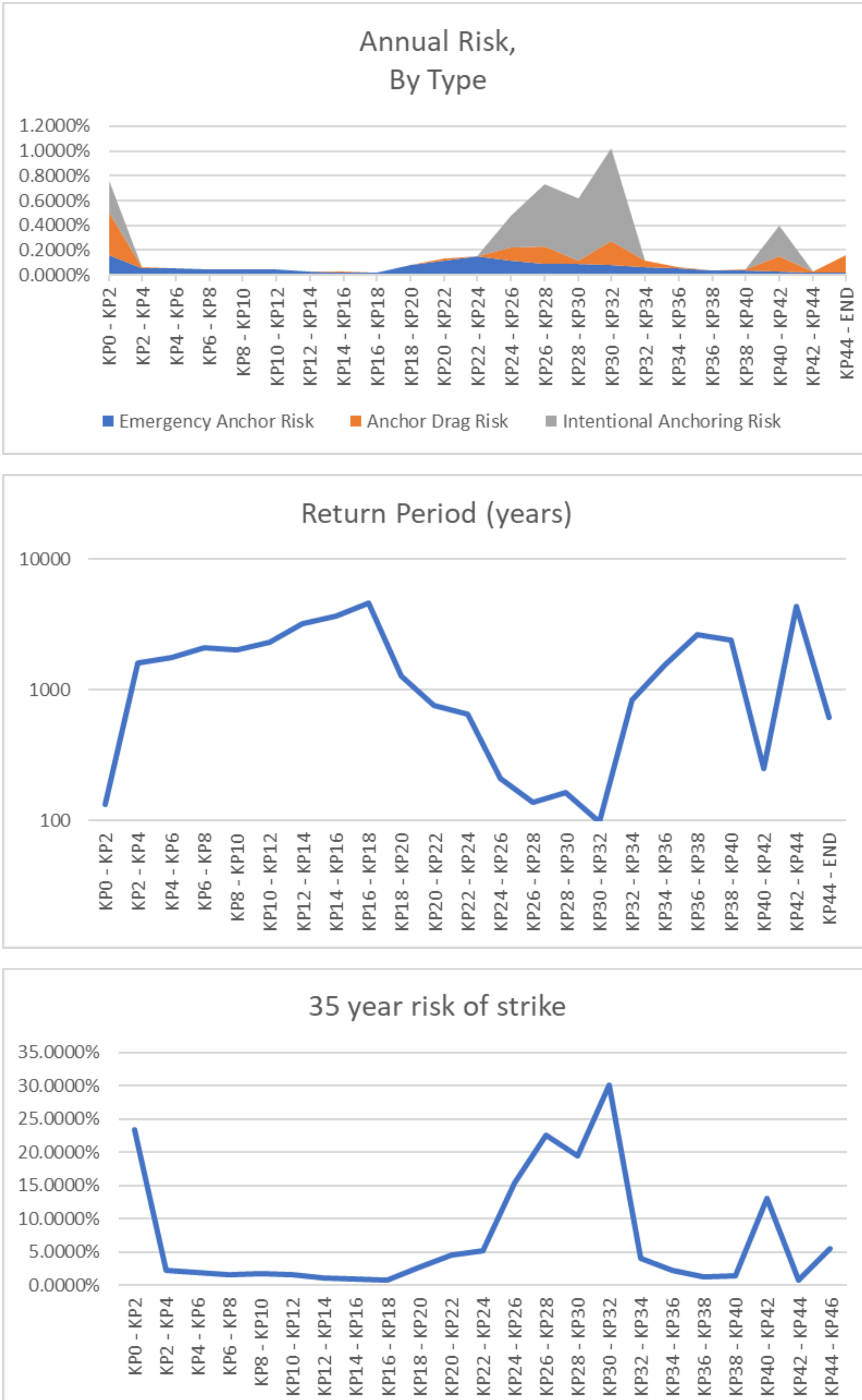



**Figure W-54. 0-m Burial Depth Risk Profiles**

**Table W-8 1.6-foot (0.5-m) Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.1614% | 0.3439% | 0.2500% | 0.7553% | 132 | 23.3073% |
| KP2 - KP4 | 0.0516% | 0.0087% | 0.0000% | 0.0603% | 1659 | 2.0878% |
| KP4 - KP6 | 0.0514% | 0.0005% | 0.0000% | 0.0519% | 1928 | 1.7997% |
| KP6 - KP8 | 0.0422% | 0.0006% | 0.0000% | 0.0428% | 2336 | 1.4873% |
| KP8 - KP10 | 0.0408% | 0.0040% | 0.0000% | 0.0449% | 2229 | 1.5583% |
| KP10 - KP12 | 0.0395% | 0.0016% | 0.0000% | 0.0411% | 2433 | 1.4286% |
| KP12 - KP14 | 0.0273% | 0.0021% | 0.0000% | 0.0294% | 3402 | 1.0238% |
| KP14 - KP16 | 0.0197% | 0.0055% | 0.0000% | 0.0252% | 3970 | 0.8780% |
| KP16 - KP18 | 0.0190% | 0.0005% | 0.0000% | 0.0195% | 5122 | 0.6811% |
| KP18 - KP20 | 0.0765% | 0.0000% | 0.0000% | 0.0765% | 1308 | 2.6413% |
| KP20 - KP22 | 0.1157% | 0.0132% | 0.0000% | 0.1289% | 776 | 4.4152% |
| KP22 - KP24 | 0.1449% | 0.0075% | 0.0000% | 0.1524% | 656 | 5.1989% |
| KP24 - KP26 | 0.1190% | 0.1057% | 0.2500% | 0.4747% | 211 | 15.3426% |
| KP26 - KP28 | 0.0914% | 0.1382% | 0.5000% | 0.7296% | 137 | 22.6081% |
| KP28 - KP30 | 0.0890% | 0.0249% | 0.5000% | 0.6139% | 163 | 19.3883% |
| KP30 - KP32 | 0.0786% | 0.1909% | 0.7500% | 1.0195% | 98 | 30.1378% |
| KP32 - KP34 | 0.0660% | 0.0523% | 0.0000% | 0.1183% | 845 | 4.0580% |
| KP34 - KP36 | 0.0541% | 0.0102% | 0.0000% | 0.0643% | 1555 | 2.2259% |
| KP36 - KP38 | 0.0351% | 0.0022% | 0.0000% | 0.0373% | 2680 | 1.2975% |
| KP38 - KP40 | 0.0321% | 0.0091% | 0.0000% | 0.0412% | 2430 | 1.4304% |
| KP40 - KP42 | 0.0269% | 0.1226% | 0.2500% | 0.3996% | 250 | 13.0749% |
| KP42 - KP44 | 0.0208% | 0.0021% | 0.0000% | 0.0229% | 4374 | 0.7970% |
| KP44 - END | 0.0145% | 0.1492% | 0.0000% | 0.1636% | 611 | 5.5710% |
| | | | Total cable Risk: | 5.113% | 20 | 84.0690% |

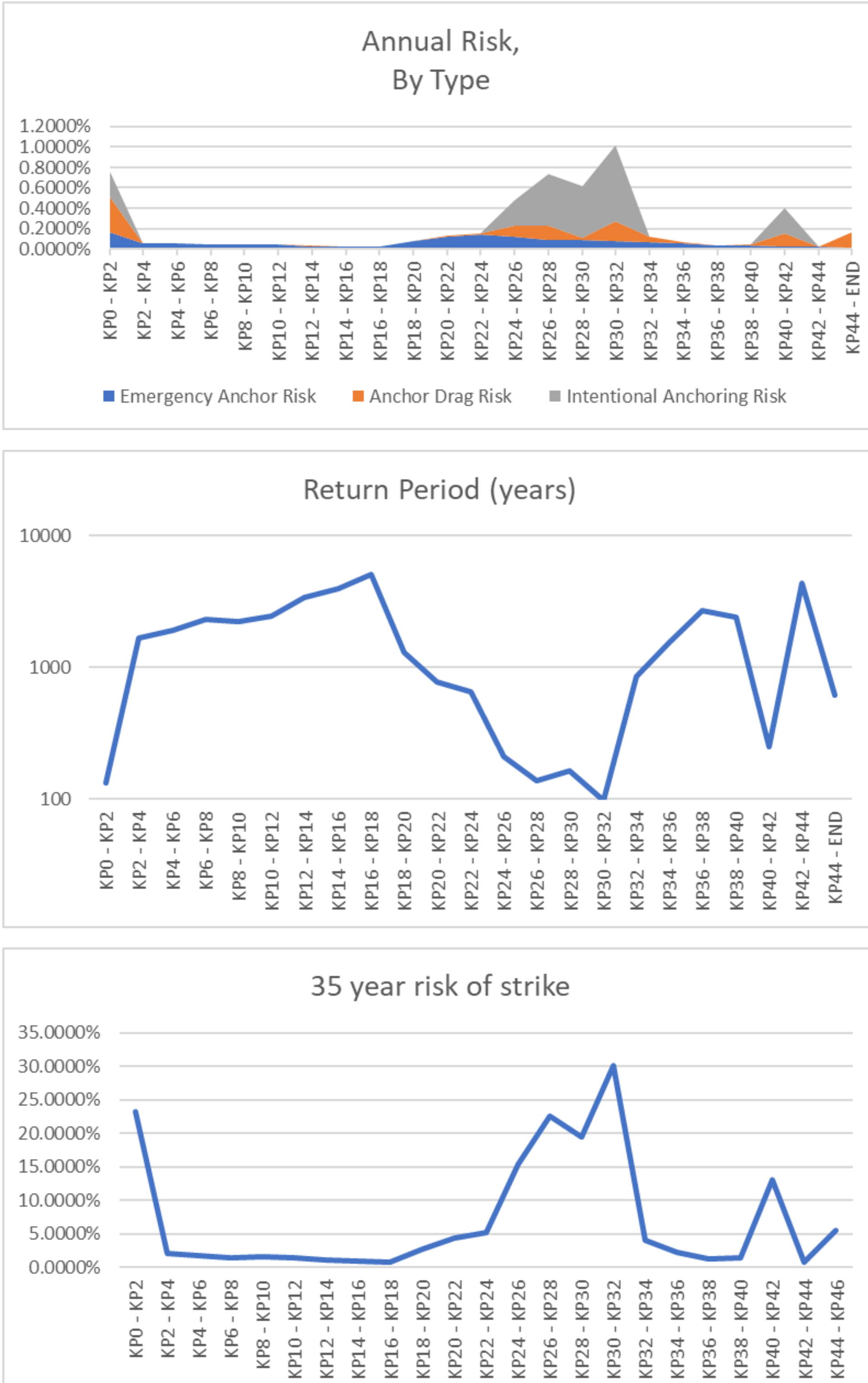



**Figure W-55. 1.6-foot (0.5-m) Burial Depth Risk Profiles**

**Table W-9 2.6-foot (0.8-m) Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.0280% | 0.1080% | 0.0000% | 0.1360% | 735 | 4.6529% |
| KP2 - KP4 | 0.0101% | 0.0000% | 0.0000% | 0.0101% | 9875 | 0.3538% |
| KP4 - KP6 | 0.0117% | 0.0002% | 0.0000% | 0.0119% | 8410 | 0.4154% |
| KP6 - KP8 | 0.0140% | 0.0006% | 0.0000% | 0.0146% | 6866 | 0.5085% |
| KP8 - KP10 | 0.0176% | 0.0040% | 0.0000% | 0.0216% | 4620 | 0.7547% |
| KP10 - KP12 | 0.0188% | 0.0016% | 0.0000% | 0.0204% | 4896 | 0.7123% |
| KP12 - KP14 | 0.0128% | 0.0009% | 0.0000% | 0.0137% | 7301 | 0.4783% |
| KP14 - KP16 | 0.0108% | 0.0054% | 0.0000% | 0.0162% | 6156 | 0.5670% |
| KP16 - KP18 | 0.0104% | 0.0002% | 0.0000% | 0.0106% | 9441 | 0.3700% |
| KP18 - KP20 | 0.0673% | 0.0000% | 0.0000% | 0.0673% | 1486 | 2.3293% |
| KP20 - KP22 | 0.1031% | 0.0132% | 0.0000% | 0.1163% | 860 | 3.9900% |
| KP22 - KP24 | 0.1335% | 0.0074% | 0.0000% | 0.1408% | 710 | 4.8134% |
| KP24 - KP26 | 0.1099% | 0.1051% | 0.2500% | 0.4650% | 215 | 15.0520% |
| KP26 - KP28 | 0.0848% | 0.1382% | 0.5000% | 0.7230% | 138 | 22.4290% |
| KP28 - KP30 | 0.0833% | 0.0249% | 0.5000% | 0.6082% | 164 | 19.2278% |
| KP30 - KP32 | 0.0732% | 0.1909% | 0.7500% | 1.0141% | 99 | 30.0047% |
| KP32 - KP34 | 0.0621% | 0.0523% | 0.0000% | 0.1144% | 874 | 3.9255% |
| KP34 - KP36 | 0.0507% | 0.0101% | 0.0000% | 0.0608% | 1645 | 2.1052% |
| KP36 - KP38 | 0.0317% | 0.0022% | 0.0000% | 0.0339% | 2946 | 1.1811% |
| KP38 - KP40 | 0.0292% | 0.0091% | 0.0000% | 0.0383% | 2613 | 1.3308% |
| KP40 - KP42 | 0.0243% | 0.1226% | 0.2500% | 0.3970% | 252 | 12.9963% |
| KP42 - KP44 | 0.0183% | 0.0019% | 0.0000% | 0.0203% | 4937 | 0.7065% |
| KP44 - END | 0.0135% | 0.1492% | 0.0000% | 0.1627% | 615 | 5.5386% |
| | | | Total cable Risk: | 4.217% | 24 | 77.8663% |

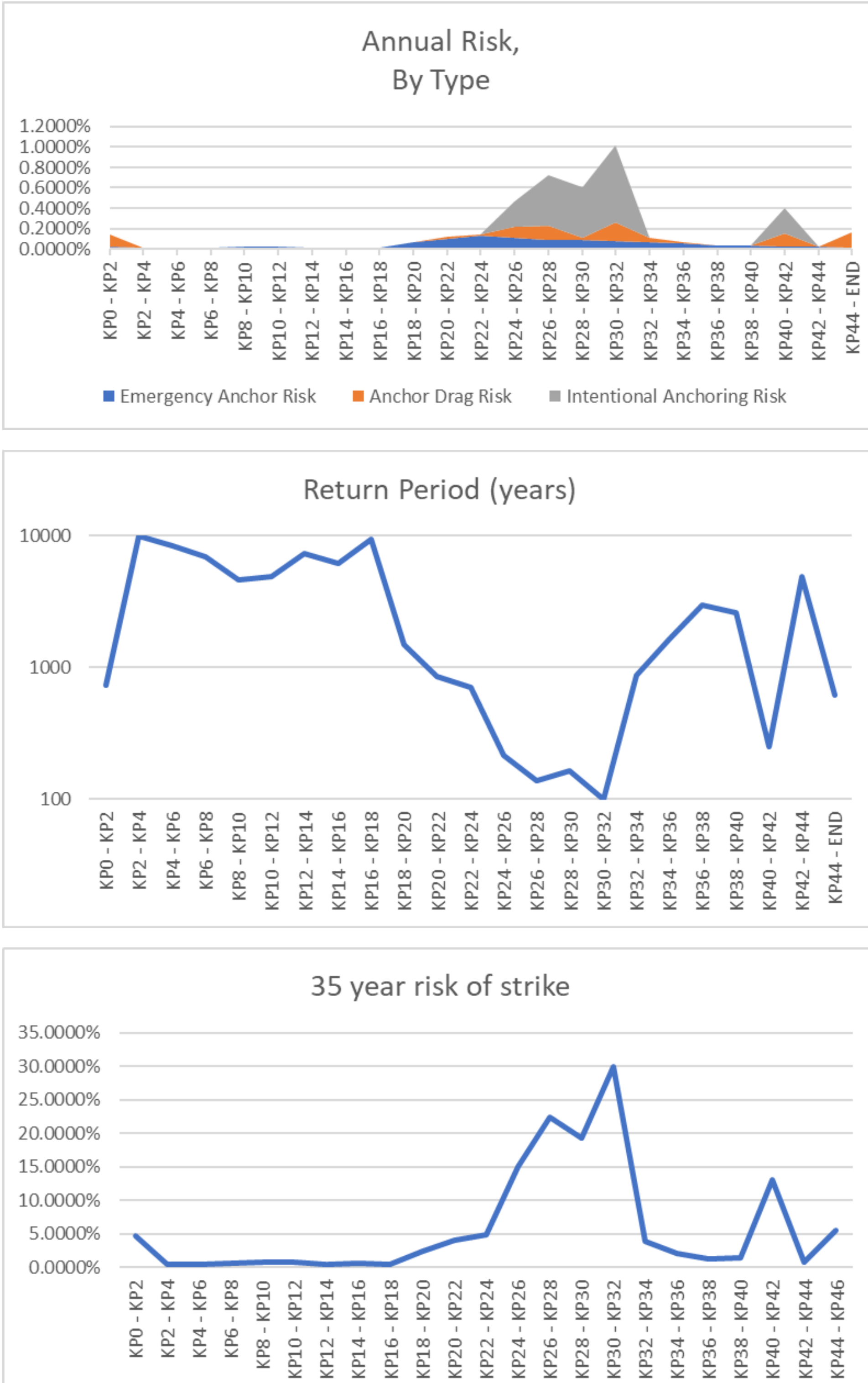



**Figure W-56. 2.6-foot (0.8-m) Burial Depth Risk Profiles**

**Table W-10 3.3-foot (1.0-m) Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.0061% | 0.0000% | 0.0000% | 0.0061% | 16277 | 0.2148% |
| KP2 - KP4 | 0.0041% | 0.0000% | 0.0000% | 0.0041% | 24213 | 0.1444% |
| KP4 - KP6 | 0.0024% | 0.0000% | 0.0000% | 0.0024% | 42373 | 0.0826% |
| KP6 - KP8 | 0.0045% | 0.0005% | 0.0000% | 0.0050% | 20023 | 0.1747% |
| KP8 - KP10 | 0.0070% | 0.0040% | 0.0000% | 0.0110% | 9055 | 0.3858% |
| KP10 - KP12 | 0.0096% | 0.0000% | 0.0000% | 0.0096% | 10427 | 0.3351% |
| KP12 - KP14 | 0.0050% | 0.0006% | 0.0000% | 0.0056% | 17872 | 0.1956% |
| KP14 - KP16 | 0.0045% | 0.0011% | 0.0000% | 0.0056% | 17956 | 0.1947% |
| KP16 - KP18 | 0.0050% | 0.0000% | 0.0000% | 0.0050% | 20161 | 0.1735% |
| KP18 - KP20 | 0.0588% | 0.0000% | 0.0000% | 0.0588% | 1702 | 2.0364% |
| KP20 - KP22 | 0.0915% | 0.0128% | 0.0000% | 0.1043% | 959 | 3.5858% |
| KP22 - KP24 | 0.1221% | 0.0074% | 0.0000% | 0.1294% | 773 | 4.4320% |
| KP24 - KP26 | 0.1029% | 0.1051% | 0.2500% | 0.4579% | 218 | 14.8399% |
| KP26 - KP28 | 0.0787% | 0.1382% | 0.5000% | 0.7169% | 139 | 22.2610% |
| KP28 - KP30 | 0.0778% | 0.0249% | 0.5000% | 0.6027% | 166 | 19.0704% |
| KP30 - KP32 | 0.0692% | 0.1909% | 0.7500% | 1.0101% | 99 | 29.9057% |
| KP32 - KP34 | 0.0591% | 0.0523% | 0.0000% | 0.1113% | 898 | 3.8238% |
| KP34 - KP36 | 0.0489% | 0.0101% | 0.0000% | 0.0590% | 1695 | 2.0442% |
| KP36 - KP38 | 0.0285% | 0.0013% | 0.0000% | 0.0298% | 3359 | 1.0367% |
| KP38 - KP40 | 0.0282% | 0.0091% | 0.0000% | 0.0373% | 2679 | 1.2980% |
| KP40 - KP42 | 0.0237% | 0.1226% | 0.2500% | 0.3963% | 252 | 12.9767% |
| KP42 - KP44 | 0.0178% | 0.0019% | 0.0000% | 0.0197% | 5067 | 0.6884% |
| KP44 - END | 0.0132% | 0.1492% | 0.0000% | 0.1623% | 616 | 5.5280% |
| | | | Total cable Risk: | 3.950% | 25 | 75.6017% |

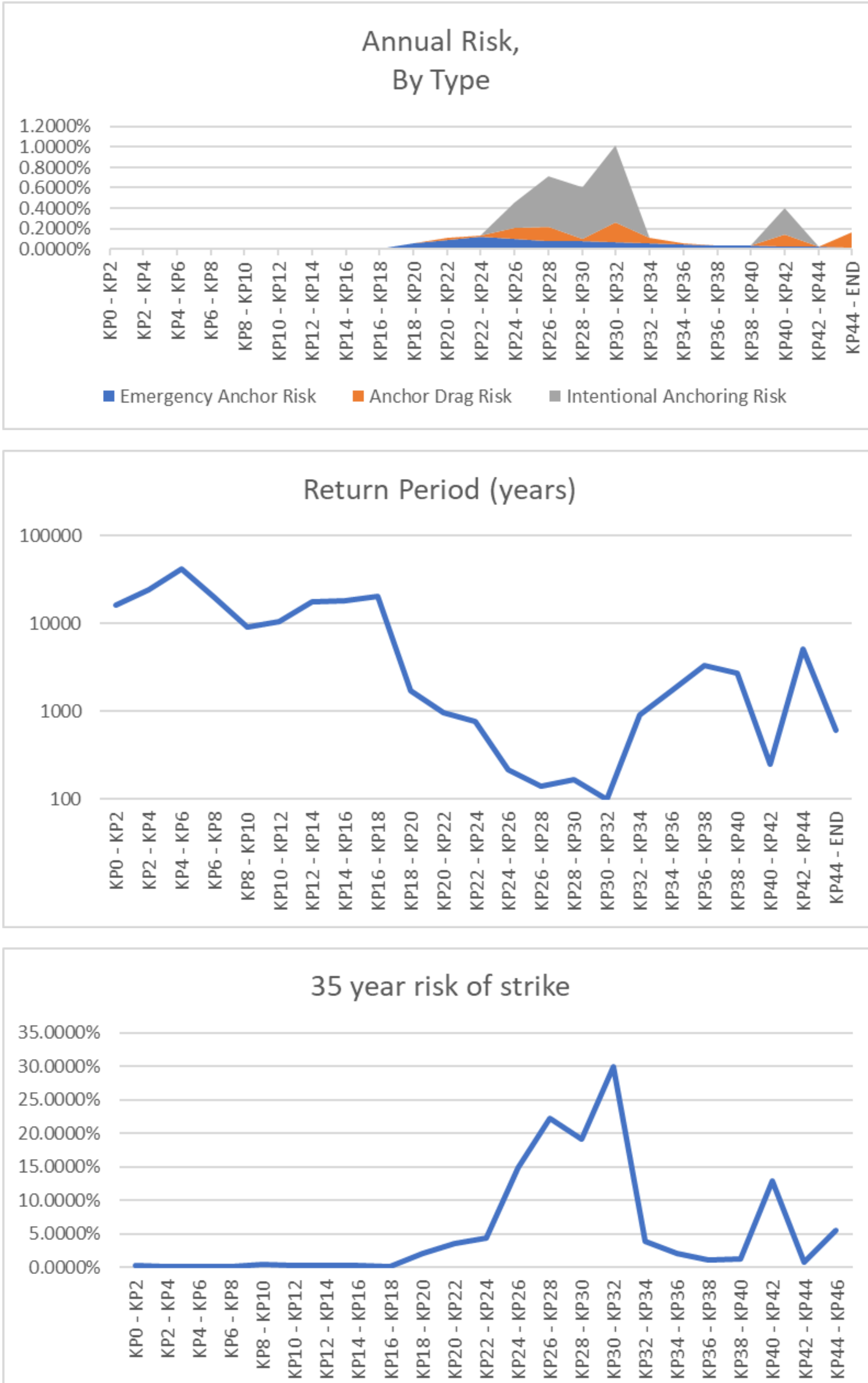



**Figure W-57. 3.3-foot (1.0-m) Burial Depth Risk Profiles**

**Table W-11 3.94-foot (1.2-m) Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 4285714 | 0.0008% |
| KP2 - KP4 | 0.0004% | 0.0000% | 0.0000% | 0.0004% | 225564 | 0.0155% |
| KP4 - KP6 | 0.0004% | 0.0000% | 0.0000% | 0.0004% | 277778 | 0.0126% |
| KP6 - KP8 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1666667 | 0.0021% |
| KP8 - KP10 | 0.0003% | 0.0000% | 0.0000% | 0.0003% | 384615 | 0.0091% |
| KP10 - KP12 | 0.0009% | 0.0000% | 0.0000% | 0.0009% | 106383 | 0.0329% |
| KP12 - KP14 | 0.0005% | 0.0000% | 0.0000% | 0.0005% | 200000 | 0.0175% |
| KP14 - KP16 | 0.0011% | 0.0000% | 0.0000% | 0.0011% | 89552 | 0.0391% |
| KP16 - KP18 | 0.0012% | 0.0000% | 0.0000% | 0.0012% | 81967 | 0.0427% |
| KP18 - KP20 | 0.0400% | 0.0000% | 0.0000% | 0.0400% | 2502 | 1.3894% |
| KP20 - KP22 | 0.0709% | 0.0128% | 0.0000% | 0.0837% | 1195 | 2.8886% |
| KP22 - KP24 | 0.0912% | 0.0074% | 0.0000% | 0.0986% | 1014 | 3.3935% |
| KP24 - KP26 | 0.0764% | 0.1051% | 0.2500% | 0.4314% | 232 | 14.0433% |
| KP26 - KP28 | 0.0674% | 0.1382% | 0.5000% | 0.7055% | 142 | 21.9497% |
| KP28 - KP30 | 0.0674% | 0.0249% | 0.5000% | 0.5923% | 169 | 18.7739% |
| KP30 - KP32 | 0.0599% | 0.1909% | 0.7500% | 1.0008% | 100 | 29.6758% |
| KP32 - KP34 | 0.0511% | 0.0523% | 0.0000% | 0.1033% | 968 | 3.5538% |
| KP34 - KP36 | 0.0415% | 0.0101% | 0.0000% | 0.0516% | 1938 | 1.7900% |
| KP36 - KP38 | 0.0237% | 0.0013% | 0.0000% | 0.0249% | 4013 | 0.8685% |
| KP38 - KP40 | 0.0255% | 0.0091% | 0.0000% | 0.0346% | 2890 | 1.2041% |
| KP40 - KP42 | 0.0215% | 0.0820% | 0.0000% | 0.1035% | 966 | 3.5591% |
| KP42 - KP44 | 0.0151% | 0.0019% | 0.0000% | 0.0171% | 5863 | 0.5952% |
| KP44 - END | 0.0119% | 0.1492% | 0.0000% | 0.1611% | 621 | 5.4869% |
| | | | Total cable Risk: | 3.453% | 29 | 70.7726% |

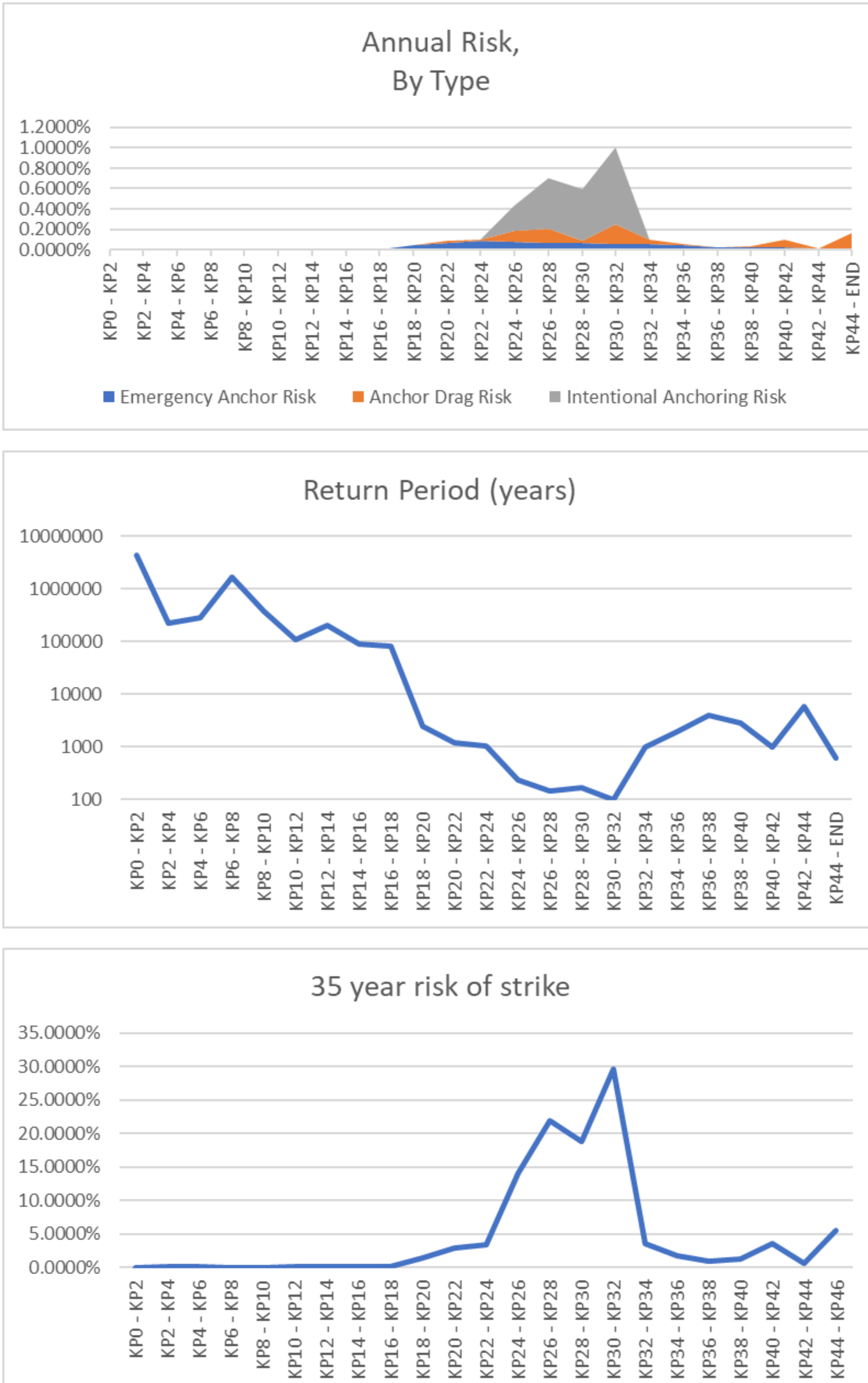



**Figure W-58. 3.3.94-foot (1.2-m) Burial Depth Risk Profiles**

**Table W-12 5-foot (1.5-m) Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP2 - KP4 | 0.0003% | 0.0000% | 0.0000% | 0.0003% | 357143 | 0.0098% |
| KP4 - KP6 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1000000 | 0.0035% |
| KP6 - KP8 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 2500000 | 0.0014% |
| KP8 - KP10 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1250000 | 0.0028% |
| KP10 - KP12 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |
| KP12 - KP14 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |
| KP14 - KP16 | 0.0002% | 0.0000% | 0.0000% | 0.0002% | 666667 | 0.0052% |
| KP16 - KP18 | 0.0006% | 0.0000% | 0.0000% | 0.0006% | 172414 | 0.0203% |
| KP18 - KP20 | 0.0190% | 0.0000% | 0.0000% | 0.0190% | 5268 | 0.6623% |
| KP20 - KP22 | 0.0352% | 0.0094% | 0.0000% | 0.0446% | 2241 | 1.5500% |
| KP22 - KP24 | 0.0430% | 0.0060% | 0.0000% | 0.0489% | 2044 | 1.6979% |
| KP24 - KP26 | 0.0309% | 0.0774% | 0.2500% | 0.3583% | 279 | 11.8065% |
| KP26 - KP28 | 0.0314% | 0.1369% | 0.5000% | 0.6683% | 150 | 20.9187% |
| KP28 - KP30 | 0.0318% | 0.0080% | 0.2500% | 0.2898% | 345 | 9.6602% |
| KP30 - KP32 | 0.0289% | 0.1770% | 0.7500% | 0.9559% | 105 | 28.5500% |
| KP32 - KP34 | 0.0253% | 0.0392% | 0.0000% | 0.0645% | 1551 | 2.2327% |
| KP34 - KP36 | 0.0237% | 0.0101% | 0.0000% | 0.0338% | 2961 | 1.1753% |
| KP36 - KP38 | 0.0147% | 0.0000% | 0.0000% | 0.0147% | 6826 | 0.5115% |
| KP38 - KP40 | 0.0154% | 0.0087% | 0.0000% | 0.0240% | 4166 | 0.8366% |
| KP40 - KP42 | 0.0158% | 0.0820% | 0.0000% | 0.0978% | 1022 | 3.3679% |
| KP42 - KP44 | 0.0091% | 0.0019% | 0.0000% | 0.0110% | 9089 | 0.3844% |
| KP44 - END | 0.0087% | 0.1492% | 0.0000% | 0.1579% | 633 | 5.3818% |
| | | | Total cable Risk: | 2.790% | 36 | 62.8544% |

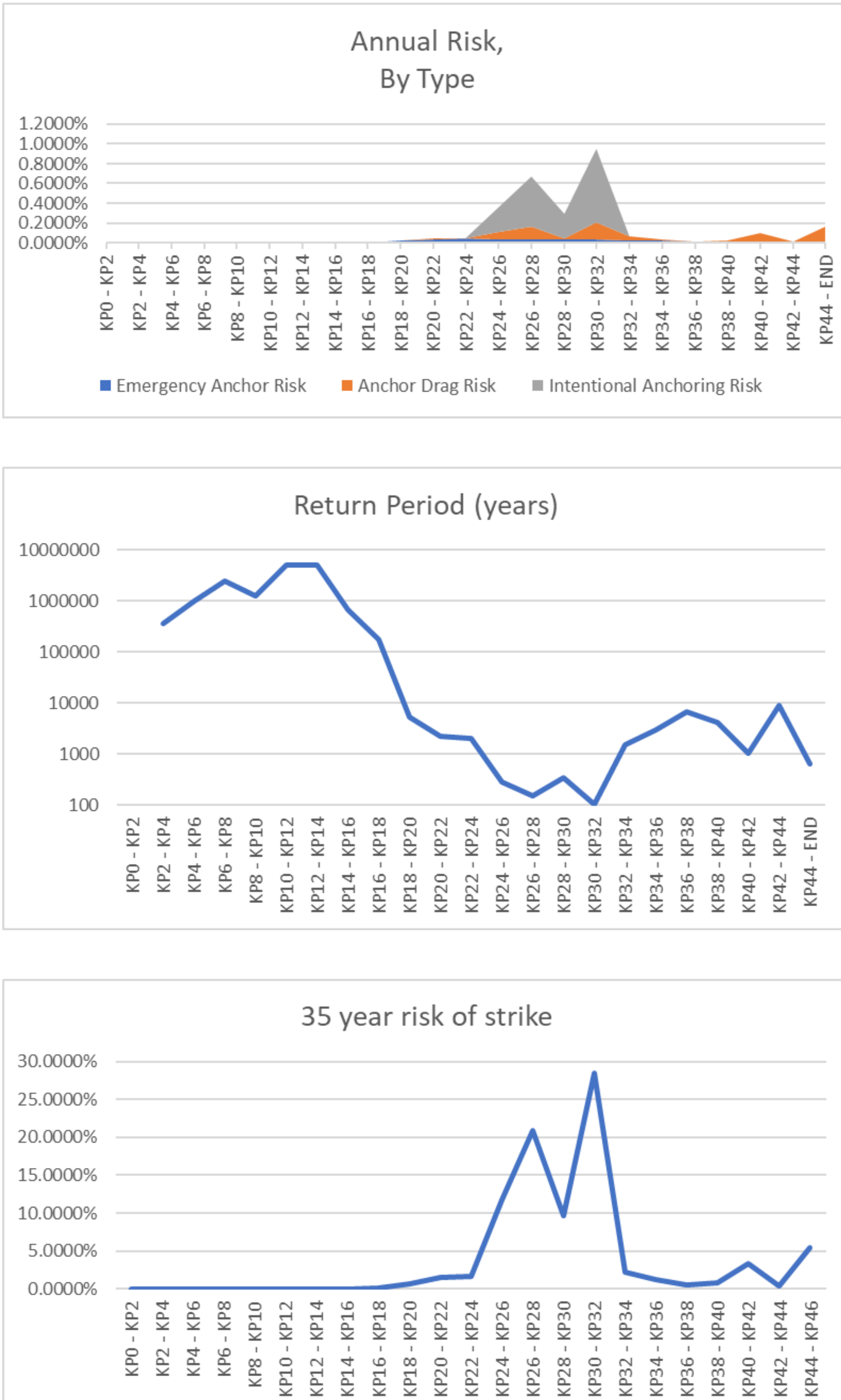



**Figure W-59. 5-foot (1.5-m) Burial Depth Risk Profiles**

**Table W-13 6-5 foot (2.0-m) Burial Depth Risk Probability**

| Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|
| KP0 - KP2 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP2 - KP4 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP4 - KP6 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP6 - KP8 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP8 - KP10 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP10 - KP12 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP12 - KP14 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP14 - KP16 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP16 - KP18 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP18 - KP20 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP20 - KP22 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1000000 | 0.0035% |
| KP22 - KP24 | 0.0005% | 0.0000% | 0.0000% | 0.0005% | 194805 | 0.0180% |
| KP24 - KP26 | 0.0004% | 0.0000% | 0.0000% | 0.0004% | 267857 | 0.0131% |
| KP26 - KP28 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 4285714 | 0.0008% |
| KP28 - KP30 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP30 - KP32 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP32 - KP34 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP34 - KP36 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP36 - KP38 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 857143 | 0.0041% |
| KP38 - KP40 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1000000 | 0.0035% |
| KP40 - KP42 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1500000 | 0.0023% |
| KP42 - KP44 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1250000 | 0.0028% |
| KP44 - END | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 3333333 | 0.0010% |
| | | | Total cable Risk: | 0.001% | 71259 | 0.0491% |

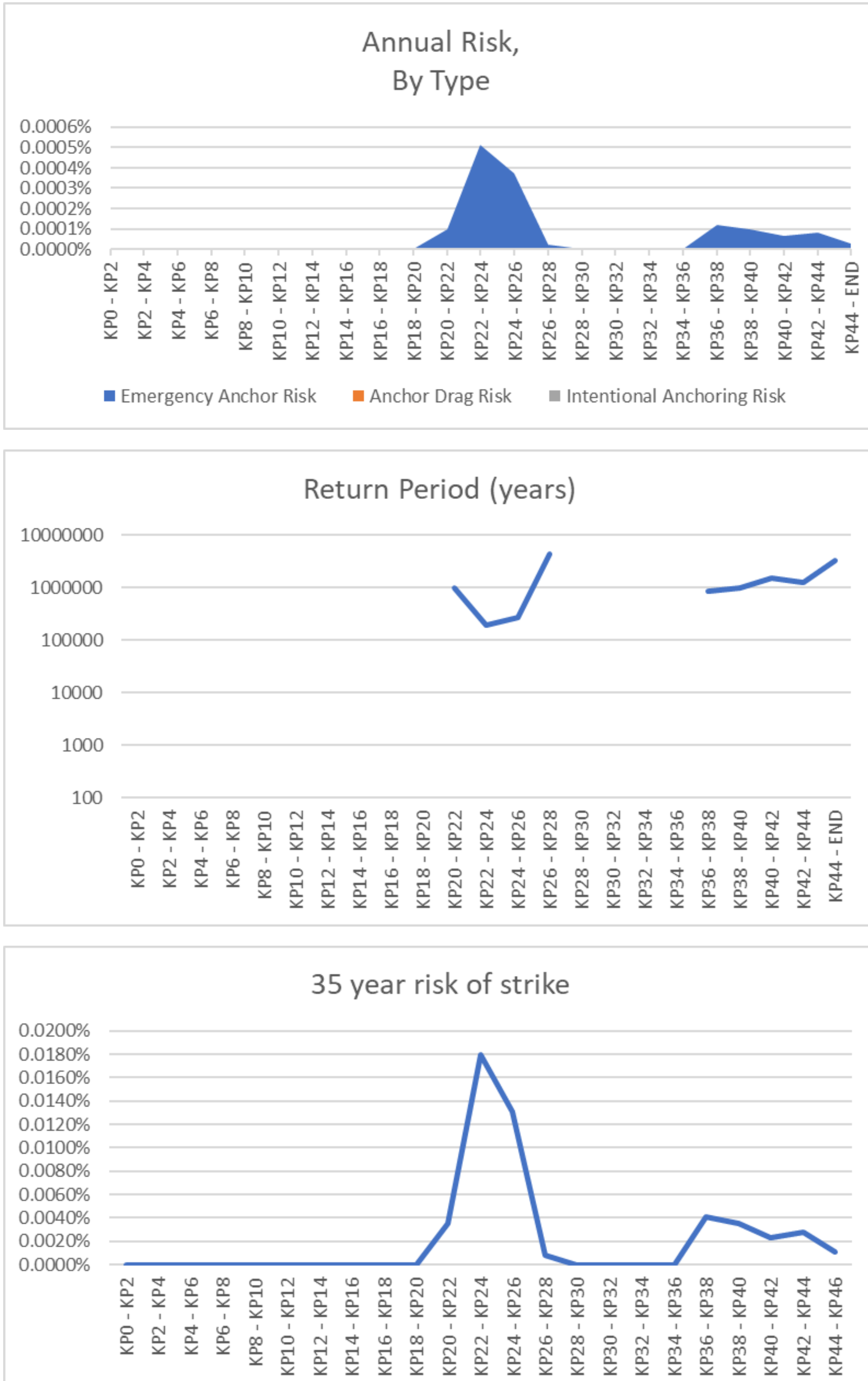



**Figure W-60. 6.5-foot (2.0-m) Burial Depth Risk Profiles**

### W.6.2.3 Depth of Lowering Sensitivity Analysis

A sensitivity analysis has been completed to further explore these results. Firstly, this was to examine the delta between 3.3-ft (1.0 m) and 4.9-ft (1.5 m) risk results, and second, to explore the risk if target burial depths are not reached between KP 4 and KP 9. A complete examination includes a discussion of the factors used in the model driving risk, a quantitative sensitivity analysis, and finally the risk present per kilometer between KPs 4-9.

Firstly, a discussion of the model used can educate the sometimes vast differences in risk across burial depths, especially between 3.3-ft (1.0 m) and 4.9-ft (1.5 m) burial. This model assumes vessels have anchor penetrations by correlating deadweight, or estimated deadweight, to deadweight categories and respective anchor penetrations. Each vessel is assumed to have the largest anchor penetration of its given deadweight category, e.g. a vessel in the 100,000-150,000 dwt category would be assumed to have an anchor penetration of a 150,000 dwt vessel at 5.6-ft (1.72 m). This leads to the model finding "tiered" levels of risk, or, breakpoints at each deadweight category where risk changes. A burial depth of 4.9-ft (1.5 m) protects against risk from ships with dwt of up to 75,000 with anchors penetrating 4.9-ft (1.48 m) while a 3.3-ft (1.0 m) depth only protects up to a vessel with 10,000 dwt carrying anchors penetrating up to 3.1-ft (.95 m).

A quantitative exploration of this was completed by calculating additional burial depths, including 2.6-ft (0.8 m) and from 3.3-ft (1.0 m) to 4.9-ft (1.5 m) in .33-ft (.1 m) increments. Results from 2.6-ft (0.8 m) and 3.9-ft (1.2 m) are included above for additional information. At this and finer burial depth resolutions questions on the accuracy of depth of lowering achieved and accuracy of measuring burial depth from burial tools needs to be considered. Further, as noted previously, a portion of the data used in the CBRA algorithm is conservatively estimated. Very fine scale risk analysis such as in the case of .33-ft (.1 m) increments is possible though these considerations undermine the utility and applicability of such fine scale analysis. Accordingly, it is recommended to maintain burial depths in increments of 1.6-ft (0.5 m).

The results of a risk analysis for 1 km segments between KP4 and KP9 are provided within Table W-14. These offer better insight into the risk present if target burial depths are not achieved. These results are provided per KP. They can be directly used with the above risk tables, e.g. risk from a 3.3-ft (1.0 m) burial for KP4 can be used with risk from a 4.9-ft (1.5 m) burial for KP5 to substitute for KPs 4-6 in the previous result tables to find total risk for the cable assuming only these burial depths are reached.

**Table W-14 (a-g). Risk analysis results for 1km segments between KP4 and KP9, based on modeled DOL.**

a. 0 m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0265% | 0.0004% | 0.0000% | 0.0269% | 3721 | 0.9363% |
| KP5 - KP6 | KP5 - KP6 | 0.0263% | 0.0001% | 0.0000% | 0.0264% | 3784 | 0.9208% |
| KP6 - KP7 | KP6 - KP7 | 0.0245% | 0.0000% | 0.0000% | 0.0245% | 4082 | 0.8538% |
| KP7 - KP8 | KP7 - KP8 | 0.0208% | 0.0006% | 0.0000% | 0.0214% | 4670 | 0.7467% |
| KP8 - KP9 | KP8 - KP9 | 0.0198% | 0.0005% | 0.0000% | 0.0202% | 4946 | 0.7053% |

b. 0.5 m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0245% | 0.0004% | 0.0000% | 0.0248% | 4025 | 0.8658% |
| KP5 - KP6 | KP5 - KP6 | 0.0242% | 0.0001% | 0.0000% | 0.0244% | 4103 | 0.8494% |
| KP6 - KP7 | KP6 - KP7 | 0.0223% | 0.0000% | 0.0000% | 0.0223% | 4477 | 0.7788% |
| KP7 - KP8 | KP7 - KP8 | 0.0189% | 0.0006% | 0.0000% | 0.0194% | 5143 | 0.6783% |
| KP8 - KP9 | KP8 - KP9 | 0.0179% | 0.0005% | 0.0000% | 0.0183% | 5458 | 0.6392% |

c. 0.8m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0049% | 0.0000% | 0.0000% | 0.0049% | 20243 | 0.1728% |
| KP5 - KP6 | KP5 - KP6 | 0.0055% | 0.0001% | 0.0000% | 0.0056% | 17803 | 0.1964% |
| KP6 - KP7 | KP6 - KP7 | 0.0062% | 0.0000% | 0.0000% | 0.0063% | 15949 | 0.2192% |
| KP7 - KP8 | KP7 - KP8 | 0.0078% | 0.0006% | 0.0000% | 0.0083% | 11984 | 0.2916% |
| KP8 - KP9 | KP8 - KP9 | 0.0095% | 0.0005% | 0.0000% | 0.0100% | 9997 | 0.3495% |

d. 1.0 m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0006% | 0.0000% | 0.0000% | 0.0006% | 160686 | 0.0218% |
| KP5 - KP6 | KP5 - KP6 | 0.0013% | 0.0000% | 0.0000% | 0.0013% | 74349 | 0.0471% |
| KP6 - KP7 | KP6 - KP7 | 0.0021% | 0.0000% | 0.0000% | 0.0022% | 46106 | 0.0759% |
| KP7 - KP8 | KP7 - KP8 | 0.0031% | 0.0005% | 0.0000% | 0.0035% | 28172 | 0.1242% |
| KP8 - KP9 | KP8 - KP9 | 0.0050% | 0.0005% | 0.0000% | 0.0054% | 18463 | 0.1894% |

e. 1.2 m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 2500000 | 0.0014% |
| KP5 - KP6 | KP5 - KP6 | 0.0003% | 0.0000% | 0.0000% | 0.0003% | 331126 | 0.0106% |
| KP6 - KP7 | KP6 - KP7 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |
| KP7 - KP8 | KP7 - KP8 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |
| KP8 - KP9 | KP8 - KP9 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 771208 | 0.0045% |

f. 1.5 m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |
| KP5 - KP6 | KP5 - KP6 | 0.0001% | 0.0000% | 0.0000% | 0.0001% | 1449275 | 0.0024% |
| KP6 - KP7 | KP6 - KP7 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf[2] | 0.0000% |
| KP7 - KP8 | KP7 - KP8 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |
| KP8 - KP9 | KP8 - KP9 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | 5000000 | 0.0007% |

g. 2.0 m

| KPs | Segment | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| KP4 - KP5 | KP4 - KP5 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP5 - KP6 | KP5 - KP6 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP6 - KP7 | KP6 - KP7 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP7 - KP8 | KP7 - KP8 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |
| KP8 - KP9 | KP8 - KP9 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.0000% |

These results reinforce that the current design is conservative. Should the protection level be reduced due to either reduced achieved burial or due to seabed mobility reducing the effective depth of lowering, an effective remaining depth of lowering of as little as 1.0 m, provides a return period for a potential cable strike of greater than 10,000 years for each 1 km section from KP4 through KP9. Should shorter spans of

[2] "inf" indicates an "infinite" return period.

cable become exposed due to seabed mobility, the remainder of the cable section should remain adequately protected.

#### W.6.2.4 Cable Crossing Analysis

An analysis of the cable crossing regions has been completed to explore the impacts of lowered burial depths on sections of cable crossing the DUNANT, MARIA, and BRUSA cables. Cable crossing sections are taken as 262-ft (80 m) sections centered on the three intersection locations of the centerline route and the three cables crossed.

Some changes must be made to allow for fine scale geospatial analysis here. The initial traditional centerline CBRA algorithm buffer zones are not well suited when cable segments are as small as 80m. Adjustments are made to the algorithm to better account for risk in this finer scale. Instead of using buffer zones, distances from individual vessel points to each segment are measured. The distances correspond to each risk's buffer zone, e.g. a distance of 459 m, is used to match the buffer zone for the risk from vessels under way. Risk is attributed to the closest segment that each point poses a risk to as measured by previously described distance and anchor penetration parameters. Due to these changes only total cable risk is reported per burial depth combination. Small differences may exist between these numbers and the previous total risk numbers; the difference in calculation methods may lead to rounding errors in some cases, and, ultimately, limits of GIS precision can lead to minor differences in these two calculation approaches. These changes in the algorithmic methodology are limited to how time exposure is measured, and ultimately risk is calculated using the same formula and the same parameters.

**Table W-15. Risk analysis results for impacts of reduced burial depths on sections of cable at the crossings of the DUNANT, MARIA, and BRUSA cables.**

| Burial Depth (m) | Cable Crossing Burial Depth (m) | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| 2 | 0 | 0.0555% | 0.0130% | 0.2500% | 0.3185% | 313.9411 | 10.56% |
| 2 | 0.5 | 0.0551% | 0.0130% | 0.2500% | 0.3182% | 314.293 | 10.56% |
| 2 | 0.8 | 0.0513% | 0.0130% | 0.2500% | 0.3143% | 318.119 | 10.43% |
| 2 | 1 | 0.0476% | 0.0121% | 0.2500% | 0.3097% | 322.8827 | 10.29% |
| 2 | 1.1 | 0.0476% | 0.0121% | 0.2500% | 0.3097% | 322.8827 | 10.29% |
| 2 | 1.2 | 0.0390% | 0.0121% | 0.2500% | 0.3011% | 332.1229 | 10.02% |
| 2 | 1.3 | 0.0390% | 0.0121% | 0.2500% | 0.3011% | 332.1229 | 10.02% |
| 2 | 1.4 | 0.0313% | 0.0121% | 0.2500% | 0.2934% | 340.82 | 9.77% |
| 2 | 1.5 | 0.0226% | 0.0120% | 0.2500% | 0.2846% | 351.3504 | 9.49% |
| 2 | 2 | 0.0014% | 0.0000% | 0.0000% | 0.0014% | 71942.45 | 0.05% |
| 2.5 | 0 | 0.0541% | 0.0130% | 0.2500% | 0.3171% | 315.3171 | 10.52% |
| 2.5 | 0.5 | 0.0537% | 0.0130% | 0.2500% | 0.3168% | 315.6721 | 10.51% |
| 2.5 | 0.8 | 0.0499% | 0.0130% | 0.2500% | 0.3130% | 319.5319 | 10.39% |

| Burial Depth (m) | Cable Crossing Burial Depth (m) | Emergency Anchor Risk | Anchor Drag Risk | Intentional Anchoring Risk | Total Risk | Return Period (years) | 35 year risk of strike |
|---|---|---|---|---|---|---|---|
| 2.5 | 1 | 0.0462% | 0.0121% | 0.2500% | 0.3083% | 324.3383 | 10.24% |
| 2.5 | 1.1 | 0.0462% | 0.0121% | 0.2500% | 0.3083% | 324.3383 | 10.24% |
| 2.5 | 1.2 | 0.0376% | 0.0121% | 0.2500% | 0.2997% | 333.6633 | 9.97% |
| 2.5 | 1.3 | 0.0376% | 0.0121% | 0.2500% | 0.2997% | 333.6633 | 9.97% |
| 2.5 | 1.4 | 0.0299% | 0.0121% | 0.2500% | 0.2920% | 342.4423 | 9.73% |
| 2.5 | 1.5 | 0.0212% | 0.0120% | 0.2500% | 0.2832% | 353.0747 | 9.45% |
| 2.5 | 2 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.00% |
| 2.5 | 2.5 | 0.0000% | 0.0000% | 0.0000% | 0.0000% | inf | 0.00% |

As indicated in Table W-15, intentional anchoring represents the largest component of risk at the cable crossings at nearly 80 percent of the total risk, at these regions where depth of cover and external protection are likely to be reduced due to crossing design considerations. As such, efforts to promote cable awareness through outreach to mariners and via vessel and cable monitoring are likely to have an outsized role in potentially reducing the risks of an anchor strike at the crossing locations.

DEME delivered a Detailed Design Report - Export Cable Crossings, providing a detailed design of rock structures required for the export cable crossing design (DEME 2022). This study considered previous cable crossing concept and design reports, in addition to a metocean report for the export cable crossings (Ramboll 2022). The design has been assessed for the potential risk from anchor drag and provides guidance on the rock berm design requirements to mitigate this risk.

At present, the preferred export cable crossing design will utilize concrete mattresses and will be fundamentally similar to the CVOW Pilot Project mattress design. Here, two concrete mattresses are laid over the existing cable/seabed at the crossing locations (dimensions 3 m wide by 6 m long by 0.3 m in height). The cable is then surface laid over the concrete mattress with the installed protection system (e.g., Uraduct). Lastly, a total length of 50 m of concrete mattress is laid over the laid cable at the crossing location. On each side of this crossing arrangement there is usually a transition zone of 10 m as the trencher grades in or out in order to reach the nominal burial depth of the newly laid cable. This method of cable protection is the preferred solution with minimum footprint on the seabed.

### W.6.2.5 Conclusions

This OECRC alignment requires burial across its entirety to ensure cable safety. Because of the varying risk profile across the length of the cable, varying burial depths according to segment risk will give an optimal risk profile at minimal cost. We can immediately draw several conclusions based on this quantitative assessment.

First, it is advisable to bury all segments of cable to not less than 3.3 ft (1.0 m). Risk rises significantly below the 3.3-ft (1.0-m) burial depth across the entire cable length because a significant portion of the vessels present are under 10,000 DWT. The 3.3-ft (1.0-m) depth offers protection from all of these smaller vessels that are especially prevalent in shallower burial depths, and consequently, a high concentration of anchoring in shallower water depths. However, a 3.3-ft (1.0-m) burial does not protect against significant vessel traffic and anchoring near and across the channel as water depths increase.

Secondly, a significant source of risk to this cable lies across its mid-section, generally from KPs 18 through 34 and across KPs 38 to 44. Here, larger vessels create much more risk both under power and while anchoring. These sections are routinely crossed by large vessel traffic entering and exiting the nearby traffic corridors. Additionally, vessels may drift or anchor in the area awaiting port calls or further instructions around and directly over the centerline cable route. These factors necessitate further burial. No significant risk is present at 8.2 ft (2.5 m) of burial or greater, and no significant anchor drag or drop risk has been quantified at or below 6.6 ft (2.0 m) burial depth.

Special considerations need to be made for cable crossings in the area. In general, the target risk mitigation at each cable crossing is the same as the risk mitigation for its respective cable segment. It is assumed that appropriate additional risk mitigations are used where target risk mitigation is not feasible. For example, additional protections are recommended where target risk mitigation is impossible due to burial depth limitations of a cable crossing, such as with concrete cable matting or rock berms. Cost-benefit calculations must be made to examine the trade-off of the cost of reaching recommended risk mitigation at these crossings. Reaching recommended burial depths may not be a cost effective solution here. Accepting higher risk at lower cost may prove to be a preferred strategy here.

Special considerations need to be made for Inter-Array Cables as well. The implementation of the Offshore Project Area may create significant changes in traffic patterns that need to be modeled to gain an accurate assessment of risk presented to the Inter-Array Cable system. In general, large commercial and shipping traffic will avoid entering the Offshore Project Area, while some fishing traffic may avoid this as well. Risk will be highest around the perimeter of the wind farm from vessels transiting alongside it with the potential of losing control, power, or otherwise drifting into the wind farm. Vessels may have a higher risk of dropping anchor in these cases than otherwise since the risk of turbine collision is much higher in probability and consequence than a cable strike. A cable burial of at least 4.9 ft (1.5 m) will theoretically avoid most, if not all, potential traffic in the Lease Area after construction of the Project, though a formal navigational risk assessment is required for an accurate understanding of relevant risks. A full navigational risk assessment will include both assessments of the risk of turbine collision and give the necessary information for an Inter-Array Cable burial assessment.

### W.6.3 Area-Based CRBA Across the Area of Potential Route Alternatives

The Sea Risk Solutions, LLC – NASH Maritime Ltd. joint model was modified to be applied across the broad study area to enable a vessel anchor risk educated exploration of alternative cable routings. This application is largely identical with a few adjustments to calculate risk over an area. This model does not enable an exact assessment of the risk along any given route; rather, it enables the relative comparison of where risks are present across the entire study area. Specific routes identified using this methodology should also be evaluated using the above route-based approach.

#### W.6.3.1 Methodology

The risk present over a given area, defined here as an individual grid space, is a function of the exposure of a given hazard, a scenario modifier, and the probability of a hazard taking place.

$$P_{strike} = \sum_{1}^{\#\ of\ vessels} T_H * P_{incident} * P_{wd}$$

Where:

- $T_H$ is the exposure of the cable to a given hazard using the above methodologies across an entire grid space. No risk per $m^2$ calculations are used for intentional anchoring.
- $P_{incident}$ is the probability of a hazard occurring. These values are the same as previous.
- $P_{wd}$ is a scenario modifier that is assumed to be 1.0 for all risks and grid spaces.
- All other factors that are usually expressed in this scenario modifier are assumed to be held constant across the study area

This function is applied iteratively across each grid space to establish the risk of an anchor strike across the grid space. Anchor size estimation and the probability of an incident remain unchanged from the original model. The scenario modifier is held constant at 1.0 for all grid spaces to show relative risk of anchoring.

##### *W.6.3.1.1 Raster Cell Division of the Study Area and Traffic Exposure*

The main adjustments made to create this area-based cable burial risk assessment are in the form of calculation traffic exposure and grid construction. First, the study area itself can be viewed as approximately a 47- by 26-mi (76- by 42-km) grid, creating 3,192 individual grid cells covering 0.6 $m^2$ (1 $km^2$). Reprojecting all AIS signals in our dataset to the Universal Transverse Mercator (UTM) 18N coordinate system approximates each point’s latitude, longitude coordinates by an (x, y) combination in meters. The 3,192 cell grid is generated by rounding these UTM coordinates to the nearest thousand. Cells are converted back to latitude-longitude coordinates before plotting.

The iterative application is much the same. Vessels with anchor penetration less than the current iteration burial depth are excluded. $T_H$ is calculated across each vessel and hazard per grid cell, and is multiplied by its respective risk modifiers as detailed above.

The results are presented below by a series of heatmaps. Each heatmap shows a given risk or set of risks as a given burial depth. Note that the maximum cell scale, or the maximum value for a given grid cell in a heatmap, is limited and may be different across different heatmaps. Cells with maximum values may contain much higher risk than the heatmap indicates. The maximum binning process can greatly reduce the impact of an outlier on a heatmap. Where an outlier may drown out the rest of the heatmap, setting a maximum value enables the rest of the heatmap to be seen at the expense of hiding how great the outlier is. A selection of heat maps showing first total risk, then emergency anchoring, and finally the combined risk of anchor dragging and deployment have been included.

#### W.6.3.2 Results

The following three sets of heat maps cover the risk of emergency anchor deployment, the combined risk from anchor drags and drops, and the total risk present across each 0.6-$mi^2$ (1-$km^2$) grid cell. The first includes the centerline drawn in for reference. These are on a percentage scale with a cell maximum applied such that all values above the maximum are shown as the maximum. As such, values may be higher than presented on the following figures (Figure W-61 through Figure W-81). This is done because a few major outliers can drown out much of the information from the rest of the distribution. Accordingly, a heatmap cell showing 1 on a zero to 1 scale should be read as at least 1 percent risk of strike per year in total for that cell. Risk across potential alternative routes can be estimated by adding together the risk in each cell a route crosses, though this will only enable the comparison of relative risk between routes holding all other variables constant.

The results of this portion of the study further highlight the general conclusions presented above. There is a major risk from the time spent in the study area of vessels under 10,000 DWT. Larger vessels present more risk toward the center of the study area where they primarily transit or pause before continuing. The largest class of ships does not loiter in the area though it still presents a small risk from navigating the main transit routes. The model shows no significant anchor dragging or dropping risks past 4.9 ft (1.5 m) of burial nor any significant risk at all at 8.2 ft (2.5 m) (or more) of burial in the study area. Large format plots of the Total Risk in relation to the Lease Area and alternative routes are provided in Appendix B.

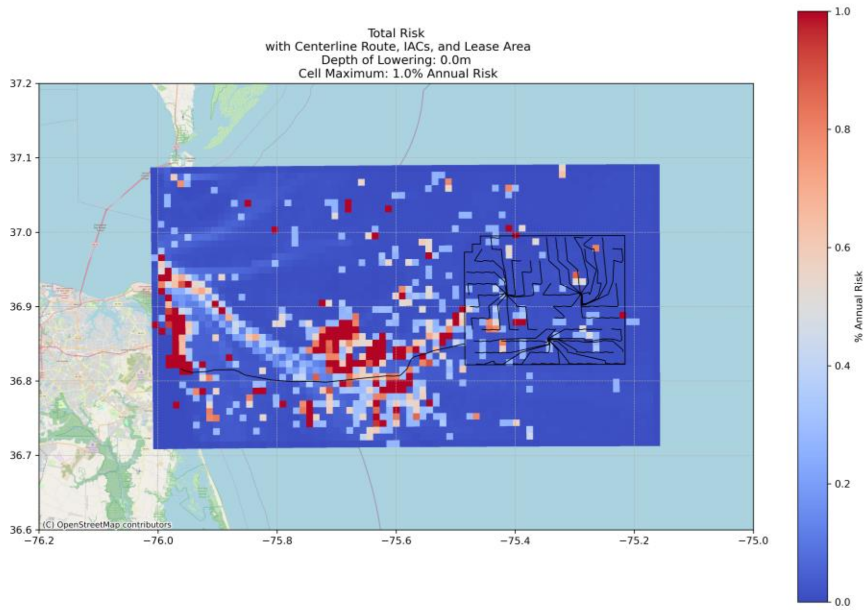



**Figure W-61. Area Based Total Risk Chart, 0-m Burial Depth**

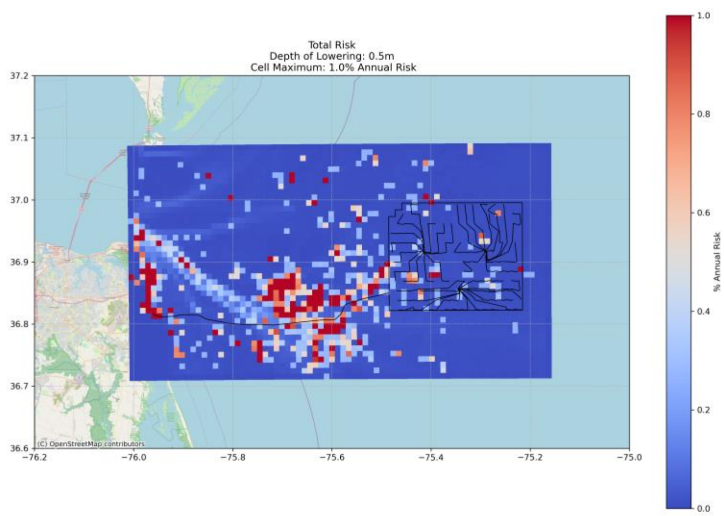



**Figure W-62. Area Based Total Risk Chart, 1.6-ft (0.5-m) Burial Depth**

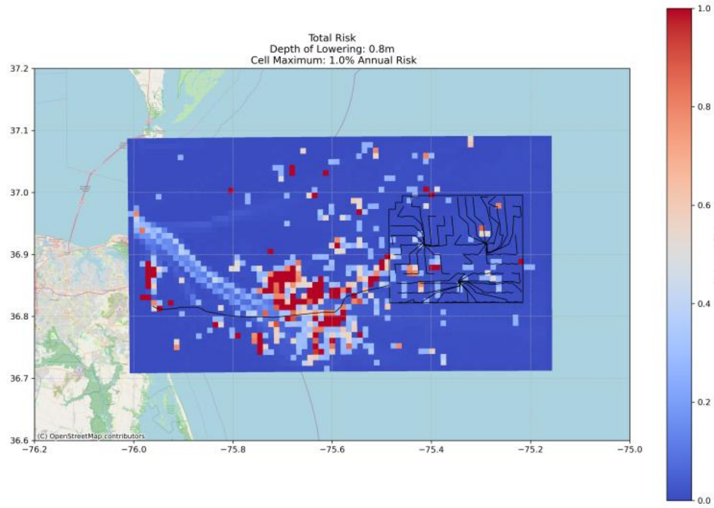



**Figure W-63. Area Based Total Risk Chart, 2.6-ft (0.8-m) Burial Depth**

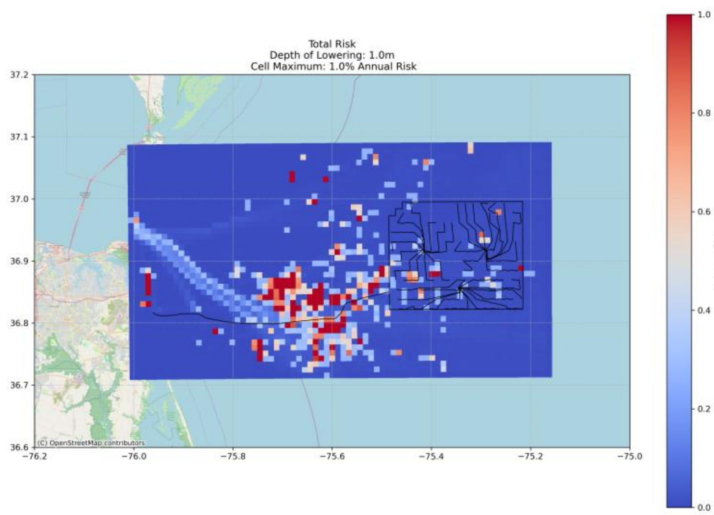



**Figure W-64. Area Based Total Risk Chart, 3.3-ft (1.0-m) Burial Depth**

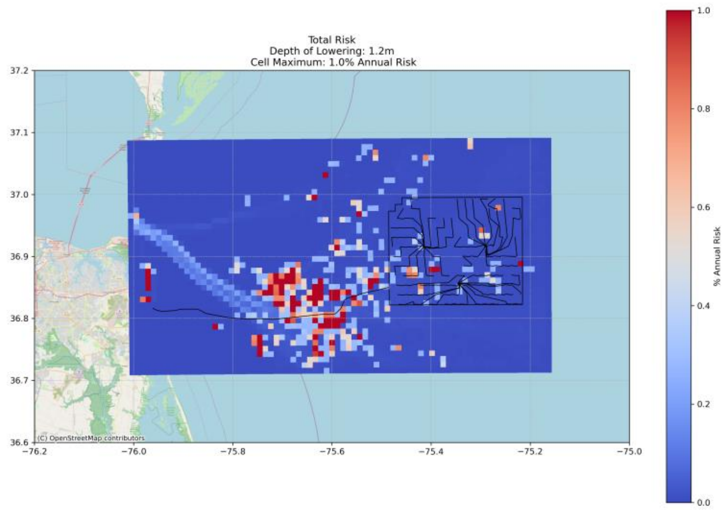



**Figure W-65. Area Based Total Risk Chart, 3.93-ft (1.2-m) Burial Depth**

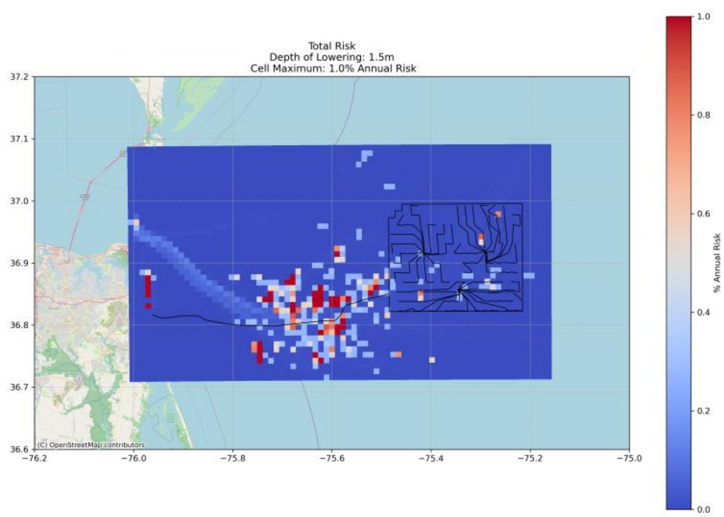



**Figure W-66. Area Based Total Risk Chart, 5-ft (1.5-m) Burial Depth**

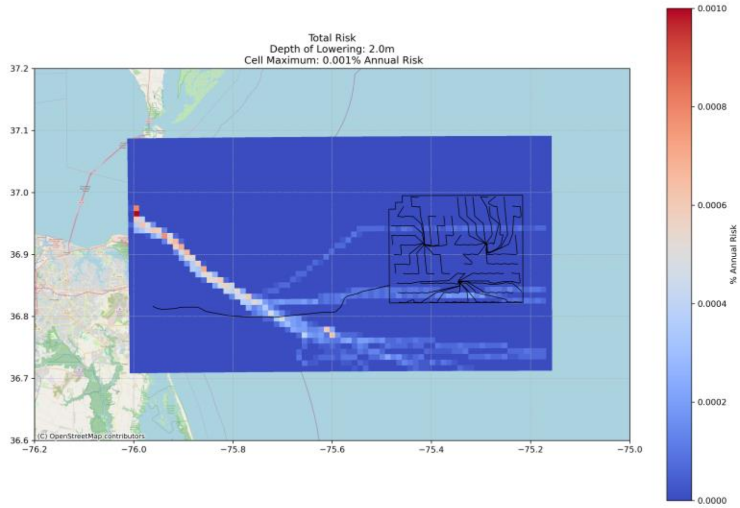



**Figure W-67. Area Based Total Risk Chart, 6.6-ft (2.0-m) Burial Depth**

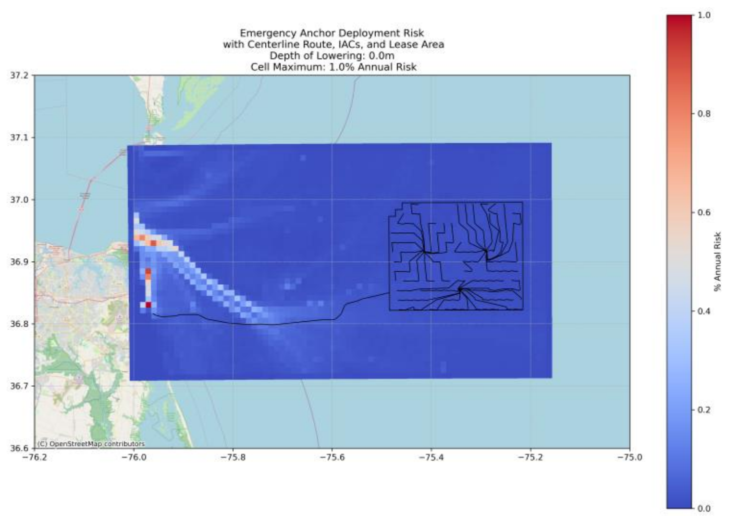



**Figure W-68. Area Based Emergency Anchoring Risk Chart, 0-m Burial Depth**

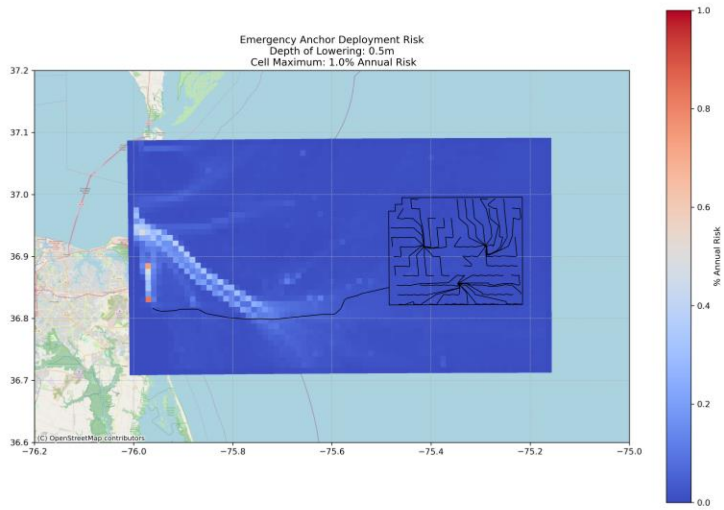



**Figure W-69. Area Based Emergency Anchoring Risk Chart, 1.6-ft (0.5-m) Burial Depth**

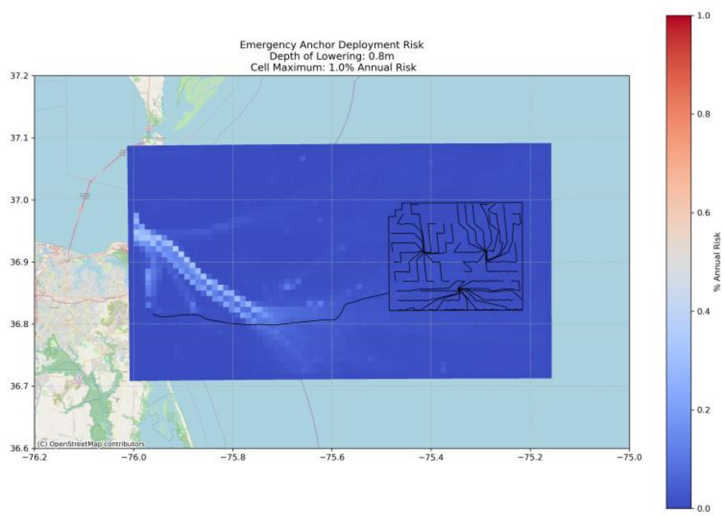



**Figure W-70. Area Based Emergency Anchoring Risk Chart, 2.6-ft (0.8-m) Burial Depth**

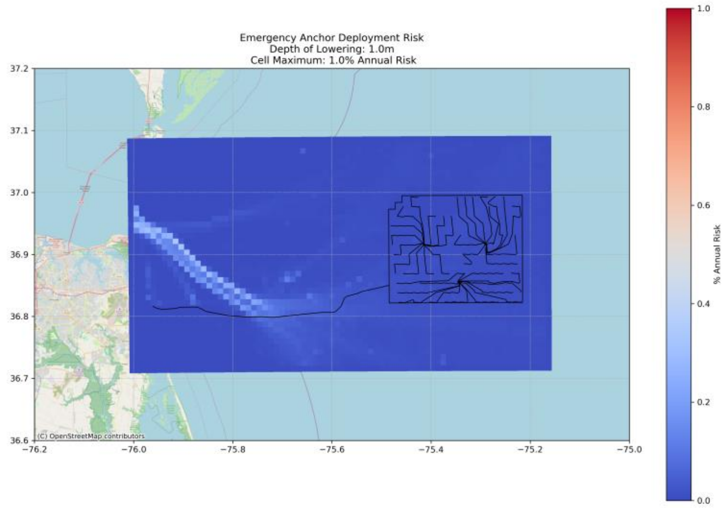



**Figure W-71. Area Based Emergency Anchoring Risk Chart, 3.3-ft (1.0-m) Burial Depth**

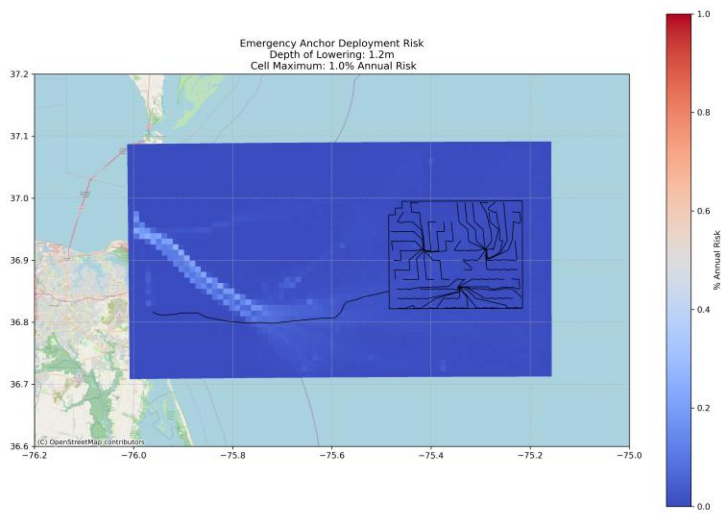



**Figure W-72. Area Based Emergency Anchoring Risk Chart, 3.93-ft (1.2-m) Burial Depth**

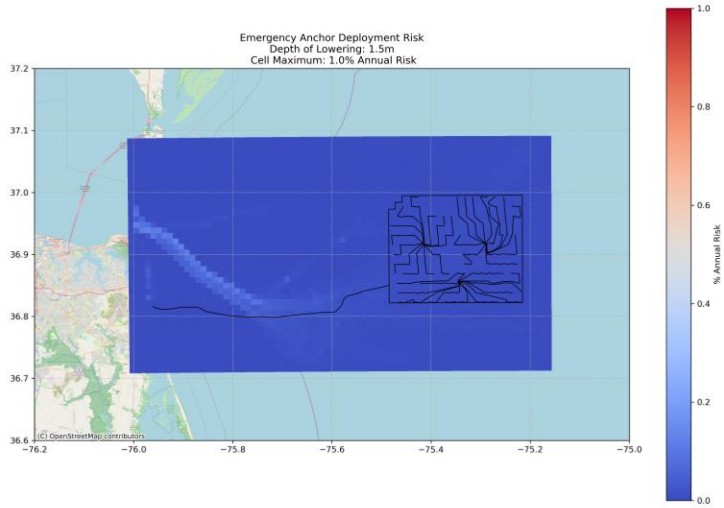



**Figure W-73. Area Based Emergency Anchoring Risk Chart, 5.0-ft (1.5-m) Burial Depth**

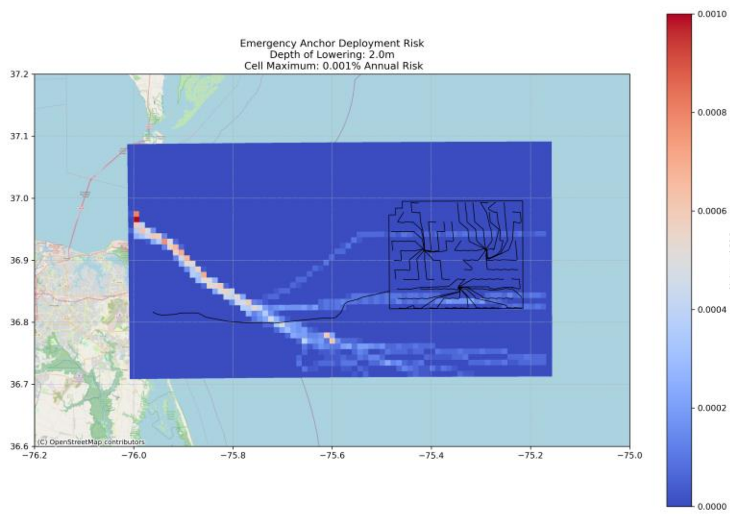



**Figure W-74. Area Based Emergency Anchoring Risk Chart, 6.6-ft (2.0-m) Burial Depth**

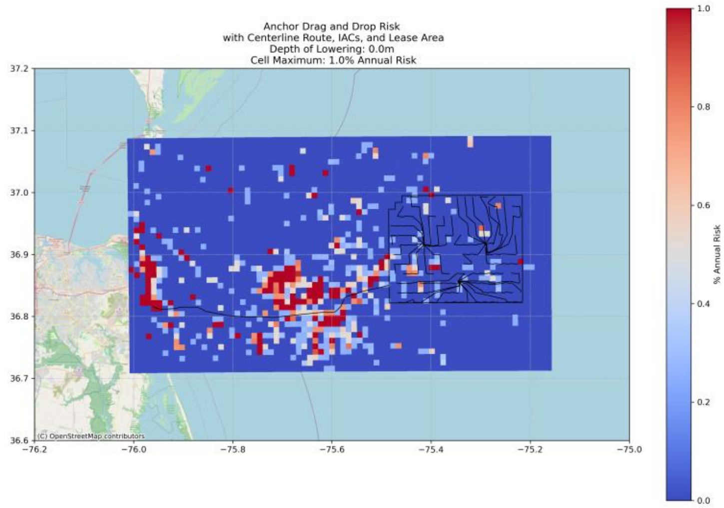



**Figure W-75. Area Based Drag & Drop Anchoring Risk Chart, 0-m Burial Depth**

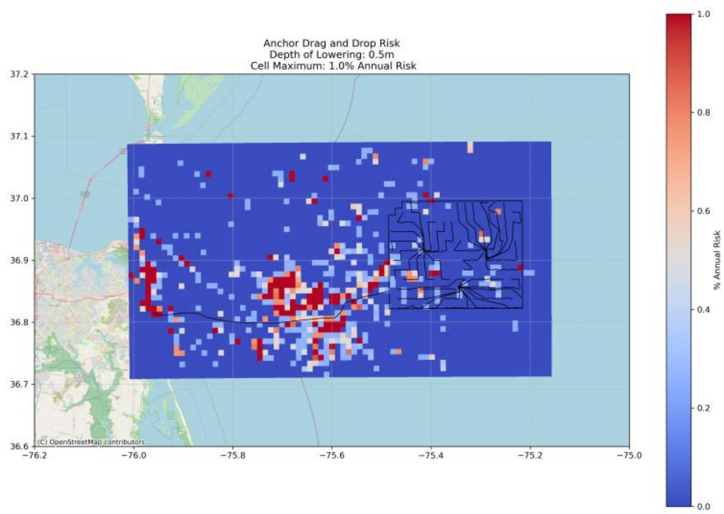



**Figure W-76. Area Based Drag & Drop Anchoring Risk Chart, 1.6-ft (0.5-m) Burial Depth**

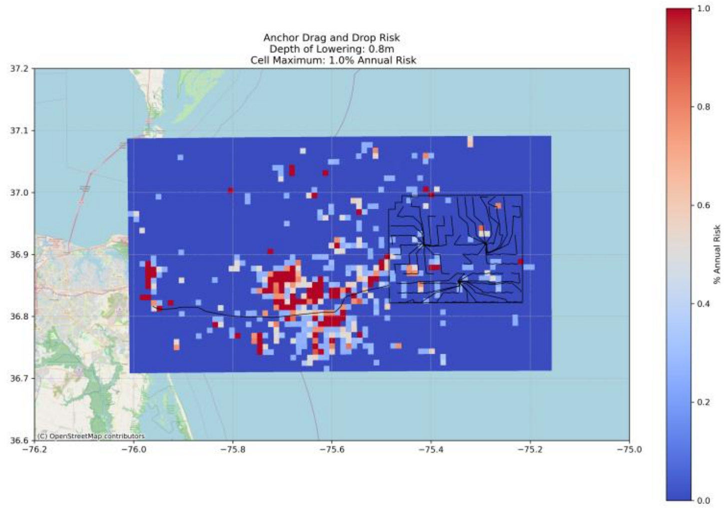



**Figure W-77. Area Based Drag & Drop Anchoring Risk Chart, 2.6-ft (0.8-m) Burial Depth**

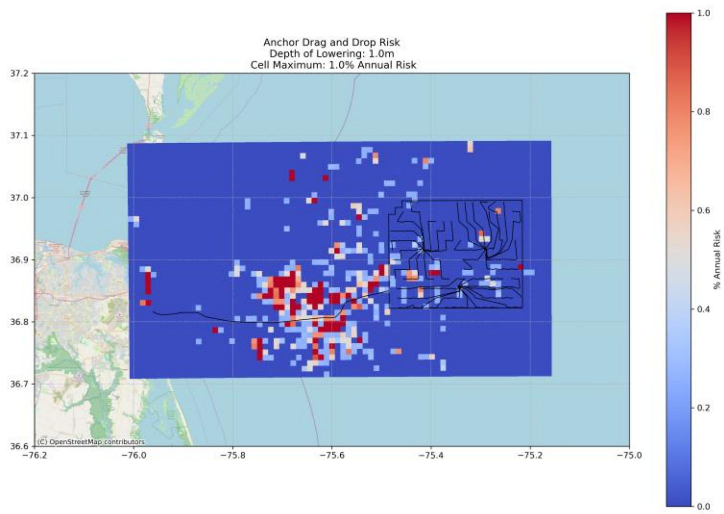



**Figure W-78. Area Based Drag & Drop Anchoring Risk Chart, 3.3-ft (1.0-m) Burial Depth**

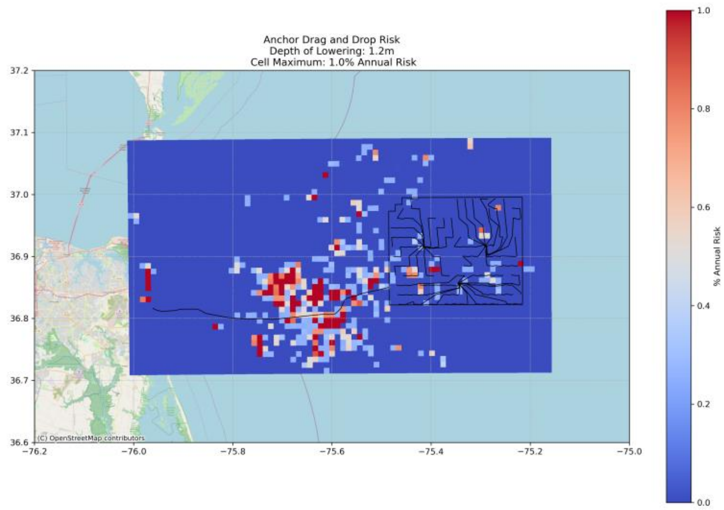



**Figure W-79. Area Based Drag & Drop Anchoring Risk Chart, 3.93-ft (1.2-m) Burial Depth**

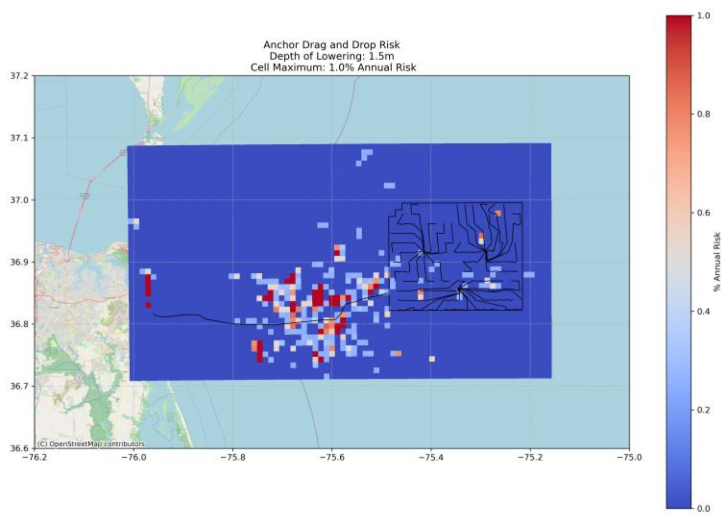



**Figure W-80. Area Based Drag & Drop Anchoring Risk Chart, 5.0-ft (1.5-m) Burial Depth**

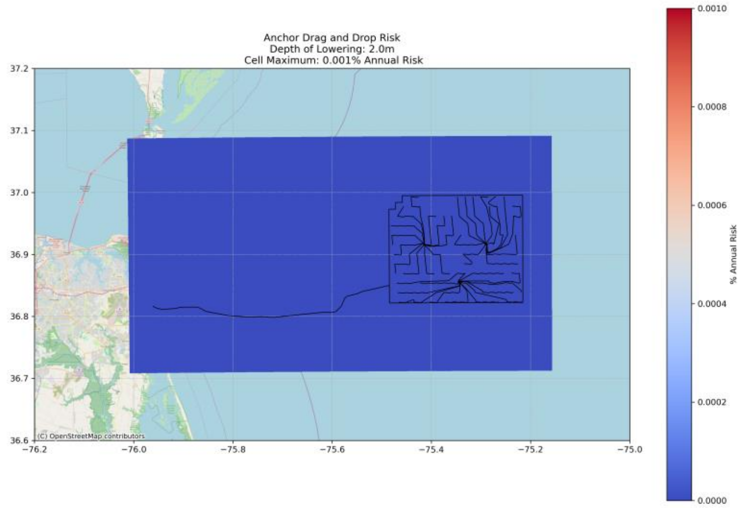



**Figure W-81. Area Based Drag & Drop Anchoring Risk Chart, 6.6-ft (2.0-m) Burial Depth**

## W.6.4 Depth of Lowering Results and Discussion

The overall target DOL is computed by summing the DOL required to mitigate risks to generally acceptable levels plus the DOL required to mitigate the risk of seabed mobility causing a loss of sediment cover. These calculations and discussion of these parameters are included in the sections below.

### W.6.4.1 Depth of Lowering for Risk Mitigation

The target DOL values suggested here are derived from results of the Preliminary CBRA. The Carbon Trust CBRA methodology identifies a target return period of 10,000 years for a very high consequence level. Ideally recommended depths of lowering are found via a cost benefit analysis examining the tradeoff of lower risk versus higher burial cost. To accurately assess that tradeoff, the analysis should be run for each of the cables, given that the spatial differences across the corridor create different risk profiles from both external aggression and risk of seabed mobility. However, in leu of this the Carbon Trust guidance was used to provide a first-order constraint on suggested depths of lowering to mitigate this risk to generally acceptable levels. Furthermore, to promote the safety of fishermen, offshore survey crews and construction crews transiting, working, and fishing in the area, the Project will adhere to the general strategies outlined in the Fisheries Communications Plan.

To find the depth of lowering that reaches this generally acceptable risk level of a recurrence interval of 10,000 years, we begin with an optimization finding the least amount of lowering required to achieve this risk mitigation target. This is an optimization created from the core Preliminary CBRA results, using the same risk per burial depth numbers calculated therein. The optimization result is checked against other intelligence included in this report for qualitative concerns, and then further mitigation seabed and seabed mobility is discussed in Section W.6.4.2. A final depth of lowering specification considering all relevant information is included in Section W.6.4.3.

Here we examine the results of the depth of lowering optimization considering the probabilistic results. The following Table W-16 provides these results, indicating the residual risks of a strike after mitigation to the target DOL is achieved. The project lifetime is assumed to be 35 years. The chance of strike (COS) over the project lifetime and expected return period is provided per segment and for the entire system.

**Table W-16. The target DOL in meters with the 35-year chance of a strike and the return period in years for each cable segment along the OECRC centerline.**

| Segment | | Target DOL (m) | 35 yr COS | Return Period (yr) |
|---|---|---|---|---|
| KP Start | KP End | | | |
| 0 | 2 | 1 | 0.035% | 99,900 |
| 2 | 4 | 1 | 0.121% | 28,905 |
| 4 | 6 | 1.5 | 0.002% | 1,449,275 |
| 6 | 8 | 1.5 | 0.003% | 1,239,669 |
| 8 | 10 | 1.5 | 0.001% | 5,000,000 |
| 10 | 12 | 1.5 | 0.002% | 2,325,581 |
| 12 | 14 | 1.5 | 0.001% | 5,000,000 |
| 14 | 16 | 1.5 | 0.003% | 1,379,310 |
| 16 | 18 | 2 | 0.000% | ∞ |
| 18 | 20 | 2 | 0.000% | ∞ |
| 20 | 22 | 2 | 0.005% | 733,198 |
| 22 | 24 | 2 | 0.019% | 185,128 |
| 24 | 26 | 2 | 0.009% | 394,997 |
| 26 | 28 | 2 | 0.001% | 4,285,714 |
| 28 | 30 | 2 | 0.000% | ∞ |
| 30 | 32 | 2 | 0.000% | ∞ |
| 32 | 34 | 2 | 0.000% | ∞ |
| 34 | 36 | 2 | 0.004% | 937,500 |
| 36 | 38 | 2 | 0.002% | 1,894,737 |
| 38 | 40 | 2 | 0.003% | 1,000,000 |
| 40 | 42 | 2 | 0.003% | 1,319,648 |
| 42 | 44 | 2 | 0.002% | 1,666,667 |
| 44 | 46 | 2 | 0.000% | ∞ |
| 46 | END | 1.5 | 0.043% | 81,183 |
| **Entire cable** | | | **0.257%** | **13,614** |

DOL = depth of lowering
COS = chance of strike
Return periods are in years
Chance of strike is for a single cable during a single project lifetime, 35 years

These target burial depths yield a total expected return period of 13,614 years and a chance of strike for the cable during the 35-year project lifetime of 0.257 percent. Further, the segment at the individual highest risk has only a .121 percent chance of strike over the project lifetime and a minimum return period of 28,905 years. This assessment should be revisited if shipping and vessel behavior change significantly, such as if a catalytic change takes place. Further mitigation for seabed characteristics must be considered for the final recommendations as discussed in the following sections.

#### W.6.4.2 Depth of Lowering to Mitigate Seabed Mobility

In order to assign a DOL necessary to mitigate the risks due to seabed mobility, Table W-17 below summarizes the results from the DHI 2021 study. For values in the DHI study of that are a range or defined as "up to" a value, the upper limit is used to ensure the full range is captured. While this may be an over-estimate in places along the ECR, this provides a factor of safety as well as accounting for the spatial uncertainty in applying the measurements from DHI to the OECRC centerline. The risk of mobile seabed at each section of a specific cable route will vary greatly depending on where that cable is located within the OECRC, as the features related to seabed mobility do not interact with the whole corridor equally and are often oriented at an angle to the corridor, such that effects from one feature would impact different KPs along different cables across this wide corridor. Table W-17 serves as a somewhat conservative summary of these conditions without over-inflating the numbers. Detailed mobility analysis of microsited routes could be conducted on higher-resolution seabed mobility data to better refine these numbers and the locations where applicable, when additional data becomes available.

**Table W-17. Tabulated KP ranges and depth of lowering to mitigate seabed change as identified in the DHI (2021) Morphology and Mobility study.**

| Segment | | Depth of Lowering to Mitigate Mobile Seabed Risk ONLY |
|---|---|---|
| KP Start | KP End | |
| 0 | 2 | Up to 0.2 to 0.5 m (per DHI HDD Morphology 2022 study) |
| 2 | 5 | 0.5 m |
| 5 | 7 | 2 m |
| 9 | 11 | 1 m |
| 11 | 16 | 0.5 m |
| 18 | 20 | 0.5 m |
| 23 | 28 | 0.5 m |
| 29 | 30 | 0.5 m |
| 32 | 34 | 0.5 m |
| 35 | 37 | 1 m |
| 39 | 41 | 0.5 m a/ |
| 41 | 46 | 0.5 m |
| Elsewhere 0.5 m | | |

Note:
a/ DHI study indicates seabed cover will increase sediment over the cable

#### W.6.4.3 Overall Depth of Lowering

In order to capture the DOL necessary to both mitigate the risks from anchor strikes plus the risks of seabed mobility to ensure the cable stays adequately buried over the Project lifetime, the results from sections

W.6.4.1 and W.6.4.2 must be summed. As some of the regions identified for seabed mobility span parts of a cable segment or span multiple cable segments, where there is overlap, the larger value of potential seabed mobility is utilized. As these values approximate the centerline of the route, and individual cables within the full suite of export cables will interact with these seabed features differently, this is intended to provide a level of moderate conservatism relative to the spatial uncertainty. The component DOLs and the Total Combined Target DOL are presented in Table W-18. This overall target DOL ensures that despite DHI's predicted levels of seabed mobility, the recurrence intervals and chance of strike identified in section W.6.4.1 remain applicable.

**Table W-18. The total combined target DOL in meters, which is the sum of the DOL to mitigate risk plus the additional lowering to mitigate seabed mobility.**

| Segment | | Target DOL (m) for external aggression risk | Additional DOL (m) to mitigate seabed mobility | Overall Total Combined Target DOL (m) |
|---|---|---|---|---|
| KP Start | KP End | | | |
| 0 | 2 | 1 | 0.5 | 1.5 |
| 2 | 4 | 1 | 0.5 | 1.5 |
| 4 | 6 | 1.5 | 2 | 3.5 a/ |
| 6 | 8 | 1.5 | 2 | 3.5 a/ |
| 8 | 10 | 1.5 | 1 | 2.5 |
| 10 | 12 | 1.5 | 1 | 2.5 |
| 12 | 14 | 1.5 | 0.5 | 2 |
| 14 | 16 | 1.5 | 0.5 | 2 |
| 16 | 18 | 2 | 0.5 | 2.5 |
| 18 | 20 | 2 | 0.5 | 2.5 |
| 20 | 22 | 2 | 0.5 | 2.5 |
| 22 | 24 | 2 | 0.5 | 2.5 |
| 24 | 26 | 2 | 0.5 | 2.5 |
| 26 | 28 | 2 | 0.5 | 2.5 |
| 28 | 30 | 2 | 0.5 | 2.5 |
| 30 | 32 | 2 | 0.5 | 2.5 |
| 32 | 34 | 2 | 0.5 | 2.5 |
| 34 | 36 | 2 | 0.5 | 2.5 |
| 36 | 38 | 2 | 0.5 | 2.5 |
| 38 | 40 | 2 | 0.5 | 2.5 |
| 40 | 42 | 2 | 0.5 | 2.5 |
| 42 | 44 | 2 | 0.5 | 2.5 |
| 44 | 46 | 2 | 0.5 | 2.5 |
| 46 | END | 1.5 | 0.5 | 2 |

| Segment | | Target DOL (m) for external aggression risk | Additional DOL (m) to mitigate seabed mobility | Overall Total Combined Target DOL (m) |
|---|---|---|---|---|
| KP Start | KP End | | | |

Notes:
DOL = depth of lowering
COS = chance of strike
Return periods are in years
Chance of strike is for a single cable during a single project lifetime, 35 years
a/ Please refer to the below paragraph and Section W.8.2 for further detail

We suggest that Table W-18 should not be interpreted to recommend 3.5 m of burial for the entire 4 km segment from KP4 to KP8, but rather that the data indicates that DOL to 3.5 m may be needed to statistically mitigate risk on some of the segment on some or all of the individual cables within that area. The highest values of seabed mobility occur across relatively small areas. Examination of Figure W-25 shows that the rate of migration of 18 m/yr would cover a distance of 630 m over the 35-year lifespan of the Project for this highest-impact mobile seabed feature captured in DHI's C10c profile. A sensitivity study designed to evaluate the impacts of reduced depth of lowering for smaller sections within the range of KP4 through KP9 is provided in section W.6.2.3. Additionally, other strategies for mitigating risk of seabed mobility are further discussed in section W.8.2. Ultimately, the analysis has established a lower boundary for recommended burial depth along the OERC. The Project will consider the risks along the Project based on these results.

While the CBRA methodology does not capture differences in hard versus even-harder seabed, it should be noted that some locations where burial may be more difficult to achieve, especially like those between KP 17 and KP20, the harder, more gravelly to cobbly seabed may also provide additional resistance to anchor penetration. While this document notes that deeper burial of 2.5 m DOL may be needed, a more nuanced review of the northern individual cables as they cross that area may show that while burial there may be harder to achieve across certain regions, the seabed conditions also provide some additional protection to the cable for the same DOL. Without more detailed study, potentially including anchor drag tests, this is difficult to determine, but may warrant additional consideration relative to the effort to achieve the deeper DOL. The cable burial assessment, which looks at the performance of specific tools in relation to identified seabed conditions should also help inform these decisions.

## W.7 SUMMARY

In summary, carefully selecting burial depths to achieve target risk mitigation levels across the cable will minimize costs and maximize protection. It is prudent for significant burial across the cable segments with the most exposure to large vessels. A lesser DOL may be acceptable for areas of cable with less traffic present, or where the traffic is generally limited to much smaller ships with lesser anchor penetrations. While the estimates and values chosen here have been with a conservative estimate in mind, such as assuming that vessels of each class have anchor penetrations as great as the assumed class maximum, up to a 50 percent increase in DOL beyond the target for a conservative margin of safety has been previously recommended by the Carbon Trust and others.

# W.8 RECOMMENDED NEXT STEPS

## W.8.1 Identification of High Mobility Areas

As discussed in the section W.5.1 above, the relative lack of granularity in the seabed mobility data available at present along with extrapolation of conditions to segments of the OECRC centerline overestimates the distances that the maximum burial depths are needed. Identification of the specific risks of the greatest seabed mobility across specific spans of cable may allow for further optimization of DOL once individual cable layouts are known. An area-based assessment of seabed mobility across the entire corridor could provide additional insights to micrositing of the individual cables within the corridor, as well as for evaluating the specific locations where deeper burial to mitigate mobile seabed is needed.

Analysis of the multibeam echosounder data along the OECRC alignment, especially if viewed in conjunction with the shallow sub-bottom profiler records, will allow for detailed mapping of potentially mobile seabed features throughout the corridor. The repeated acquisition of another multibeam bathymetry dataset during a subsequent survey campaign along all or portions of this alignment could serve to further estimate rates of migration of features. These factors will allow for the determination of whether additional Seabed Preparation to remove mobile seabed features or additional burial to reach a stable level of seabed below the influence of mobility area needed. However, given that the sensitivity analysis in section W.6.2.3 shows that even with reduced depth of cover for relatively short spans, adequately risk levels may be achieved without additional seabed preparation.

## W.8.2 Deeper Burial Strategy for High-Mobility Areas

In addition to achieving the target DOL through deeper cable burial, there may also be the opportunity to mitigate mobile seabed through pre-treatment of the seabed to remove the crests of mobile features prior to cable burial. This may effectively allow a reduced cable burial depth to achieve the same effect DOL relative to the original seabed features. This may be accomplished through "pre-sweeping" the crests of features through mechanical methods, mass-flow excavation, or dredging. While these methods may be more impactful than standard cable burial, and may have permitting, cost, or timing installation considerations, they may provide cost-effective and/or more efficient methods than purely achieving relying on deeper initial burial. As above, given that the sensitivity analysis in section W.6.2.3 shows that even with reduced depth of cover for relatively short spans, adequately risk levels may be achieved without additional seabed preparation.

## W.8.3 Cable Crossings

The crossing locations of the OECRC with the three in-service fiber-optic telecommunications cables need to have additional consideration regarding detailed siting and cable protection design beyond the scope of this CBRA. While the telecommunication cables are buried, the need for physical separation and the desire of the cable owners for their cables to remain undisturbed will likely require no burial for the CVOWC cables at the crossing locations. The unburied CVOWC cables will require some measure of external protection to ensure adequate mitigation from potential anchor strikes or other external aggression. During the design of the external protection there may also need to be considerations on the limitations of potential shoaling due to piled mattresses and/or rock or other material. Given that water depths in the general area of the crossings shoal to as little as 17 m (56 ft), the Atlantic Ocean Channel has been maintained to a depth of 52 ft (15.8 m) to allow transit of deep-draft vessels. Any manmade impediment to safe navigation may face regulator and stakeholder scrutiny.

The nine export cables will cross the three telecom cables approximately 15.7 km (8.5 nautical miles) from the southern terminus of the Atlantic Ocean Channel. The Atlantic Ocean Channel is currently undergoing an effort to increase its maintained depth to 59 ft MLLW to allow for large vessels. The Project has updated the cable routes to push the crossing locations into deeper water and avoids crossing locations at shallower areas within this region. Through design refinement via a reduction in the thickness of cable protection at the crossings, the Project has increased the water depths available to shipping relative to previous designs. The proposed crossings will only decrease the water depth available to shipping by less than 0.3 m (1 ft), and these locations are in proximity to natural shoals that already must be considered by vessels when planning voyages. As such, the proposed cable crossings do not materially impact accessibility of the Atlantic Ocean Channel for vessel traffic.

### W.8.4 Nearshore Shallow Water Areas

It is our understanding that the current plan for the trenchless shoreline crossing from the cable landing to the offshore cable corridor are significantly shorter than the CVOW Pilot and nearby telecom HDDs. This places the CVOW-C HDD punchouts in shallower water, which may be on the order of 5 m water depth, though pending survey currently. Nearshore areas tend to have significant risk of mobile seabed and beach erosion, especially along shorelines known for impacts from severe weather systems such as Virginia Beach. Significant seabed mobility and erosion may cause exposure of the cable at the entrance to the trenchless shoreline crossing, which is an area notoriously difficult to bury and protect on many cable systems.

BOEM is keenly aware of the situation on Block Island, where the offshore wind export cable became exposed due to mobile seabed on a popular beach, causing concern from the public due to safety, EMF, and other impacts. A re-installation of the shore end landing into a new trenchless shoreline crossing punchout in deeper water was required to mitigate the scenario. While there are significant differences between this landing and the situation on Block Island, regulators may approach all offshore wind landings with additional scrutiny in the future.

Evaluation of the seabed conditions and the risks of potential future exposure of the cable at the punchout and in shallow water is described in section W.5.1.3. While typical conditions indicate that risk of exposure is manageable, it is recommended that evaluation and monitoring is conducted to ensure the designed solution remains adequately buried and protected, especially after significant storm event or other unusual conditions.

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# APPENDIX A: PROBABILISTIC RISK ASSESSMENT MODIFIERS BY KILOMETER POST

Table A-1: Probabilistic Risk Assessment Modifiers

| KPs | Segment | Pwd Emergency Anchoring | Anchor Drop, Buffer Zone |
|---|---|---|---|
| KP0 - KP2 | 1 | 0.7 | 16 |
| KP2 - KP4 | 2 | 0.7 | 32 |
| KP4 - KP6 | 3 | 0.6 | 37 |
| KP6 - KP8 | 4 | 0.6 | 48 |
| KP8 - KP10 | 5 | 0.6 | 52 |
| KP10 - KP12 | 6 | 0.6 | 55 |
| KP12 - KP14 | 7 | 0.6 | 56 |
| KP14 - KP16 | 8 | 0.5 | 57 |
| KP16 - KP18 | 9 | 0.6 | 59 |
| KP18 - KP20 | 10 | 0.5 | 64 |
| KP20 - KP22 | 11 | 0.5 | 59 |
| KP22 - KP24 | 12 | 0.7 | 68 |
| KP24 - KP26 | 13 | 0.7 | 71.5 |
| KP26 - KP28 | 14 | 0.7 | 64 |
| KP28 - KP30 | 15 | 0.7 | 70 |
| KP30 - KP32 | 16 | 0.6 | 71 |
| KP32 - KP34 | 17 | 0.6 | 76 |
| KP34 - KP36 | 18 | 0.6 | 72 |
| KP36 - KP38 | 19 | 0.5 | 81 |
| KP38 - KP40 | 20 | 0.5 | 90.5 |
| KP40 - KP42 | 21 | 0.4 | 90 |
| KP42 - KP44 | 22 | 0.4 | 93 |
| KP44 - KP46 | 23 | 0.3 | 85 |
| KP46 - END | 24 | 0.4 | 93 |

Table A-2: Risk per Segment from Intentional Anchoring

| Burial Depth | 0m | 0m | 0m | 0m | 0.5m | 0.5m | 0.5m |
|---|---|---|---|---|---|---|---|
| Prob. Of incident | 1 in 200 | 1 in 100 | 1 in 50 | 1 in 1 | 1 in 200 | 1 in 100 | 1 in 50 |
| risk per segment from intentional anchoring | | | | | | | |
| KP16 – KP18 | 0.07% | 0.13% | 0.27% | 13.30% | 0.07% | 0.13% | 0.27% |
| KP18 – KP20 | 0.07% | 0.14% | 0.29% | 14.43% | 0.07% | 0.14% | 0.29% |
| KP20 – KP22 | 0.07% | 0.13% | 0.27% | 13.30% | 0.07% | 0.13% | 0.27% |
| KP22 – KP24 | 0.08% | 0.15% | 0.31% | 15.33% | 0.08% | 0.15% | 0.31% |
| KP24 – KP26 | 0.08% | 0.16% | 0.32% | 16.12% | 0.08% | 0.16% | 0.32% |
| KP26 – KP28 | 0.07% | 0.14% | 0.29% | 14.43% | 0.07% | 0.14% | 0.29% |
| KP28 – KP30 | 0.08% | 0.16% | 0.32% | 15.78% | 0.08% | 0.16% | 0.31% |
| KP30 – KP32 | 0.08% | 0.16% | 0.32% | 16.00% | 0.08% | 0.16% | 0.32% |
| KP32 – KP34 | 0.09% | 0.17% | 0.34% | 17.13% | 0.09% | 0.17% | 0.34% |
| KP34 – KP36 | 0.08% | 0.16% | 0.32% | 16.23% | 0.08% | 0.16% | 0.32% |

| Burial Depth | 0m | 0m | 0m | 0m | 0.5m | 0.5m | 0.5m |
|---|---|---|---|---|---|---|---|
| Prob. Of incident | 1 in 200 | 1 in 100 | 1 in 50 | 1 in 1 | 1 in 200 | 1 in 100 | 1 in 50 |
| KP36 – KP38 | 0.09% | 0.18% | 0.37% | 18.26% | 0.09% | 0.18% | 0.36% |
| KP38 - KP40 | 0.10% | 0.20% | 0.41% | 20.40% | 0.10% | 0.20% | 0.41% |
| KP40 - KP42 | 0.10% | 0.20% | 0.41% | 20.29% | 0.10% | 0.20% | 0.40% |
| KP42 - KP44 | 0.10% | 0.21% | 0.42% | 20.96% | 0.10% | 0.21% | 0.42% |
| KP44 - KP46 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| KP46 - END | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Total Risk | 3.17% | 4.29% | 6.49% | 92.32% | 3.13% | 4.25% | 6.44% |
| 35 Year Risk | 67.57% | 78.41% | 90.44% | 100.00% | 67.17% | 78.11% | 90.28% |

Table A-3: Risk per Segment from Intentional Anchoring (continued)

| Burial Depth | 0.5m | 1m | 1m | 1m | 1m | 1.5m | 1.5m | 1.5m | 1.5m |
|---|---|---|---|---|---|---|---|---|---|
| Prob. Of incident | 1 in 1 | 1 in 200 | 1 in 100 | 1 in 50 | 1 in 1 | 1 in 200 | 1 in 100 | 1 in 50 | 1 in 1 |
| risk per segment from intentional anchoring | | | | | | | | | |
| KP16 - KP18 | 13.25% | 0.05% | 0.10% | 0.20% | 9.81% | 0.03% | 0.06% | 0.12% | 6.24% |
| KP18 - KP20 | 14.37% | 0.05% | 0.11% | 0.21% | 10.64% | 0.03% | 0.07% | 0.14% | 6.77% |
| KP20 - KP22 | 13.25% | 0.05% | 0.10% | 0.20% | 9.81% | 0.03% | 0.06% | 0.12% | 6.24% |
| KP22 - KP24 | 15.27% | 0.06% | 0.11% | 0.23% | 11.31% | 0.04% | 0.07% | 0.14% | 7.20% |
| KP24 - KP26 | 16.06% | 0.06% | 0.12% | 0.24% | 11.89% | 0.04% | 0.08% | 0.15% | 7.57% |
| KP26 - KP28 | 14.37% | 0.05% | 0.11% | 0.21% | 10.64% | 0.03% | 0.07% | 0.14% | 6.77% |
| KP28 - KP30 | 15.72% | 0.06% | 0.12% | 0.23% | 11.64% | 0.04% | 0.07% | 0.15% | 7.41% |
| KP30 - KP32 | 15.94% | 0.06% | 0.12% | 0.24% | 11.80% | 0.04% | 0.08% | 0.15% | 7.51% |
| KP32 - KP34 | 17.07% | 0.06% | 0.13% | 0.25% | 12.63% | 0.04% | 0.08% | 0.16% | 8.04% |
| KP34 - KP36 | 16.17% | 0.06% | 0.12% | 0.24% | 11.97% | 0.04% | 0.08% | 0.15% | 7.62% |
| KP36 - KP38 | 18.19% | 0.07% | 0.13% | 0.27% | 13.47% | 0.04% | 0.09% | 0.17% | 8.57% |
| KP38 - KP40 | 20.32% | 0.08% | 0.15% | 0.30% | 15.05% | 0.05% | 0.10% | 0.19% | 9.58% |
| KP40 - KP42 | 20.21% | 0.07% | 0.15% | 0.30% | 14.96% | 0.05% | 0.10% | 0.19% | 9.52% |
| KP42 - KP44 | 20.89% | 0.08% | 0.15% | 0.31% | 15.46% | 0.05% | 0.10% | 0.20% | 9.84% |
| KP44 - KP46 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| KP46 - END | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Total Risk | 92.23% | 2.42% | 3.25% | 4.90% | 84.21% | 1.52% | 2.06% | 3.12% | 68.20% |
| 35 Year Risk | 100.00% | 57.55% | 68.55% | 82.75% | 100.00% | 41.59% | 51.74% | 67.06% | 100.00% |

Table A-4 Total Risk by Burial Depth

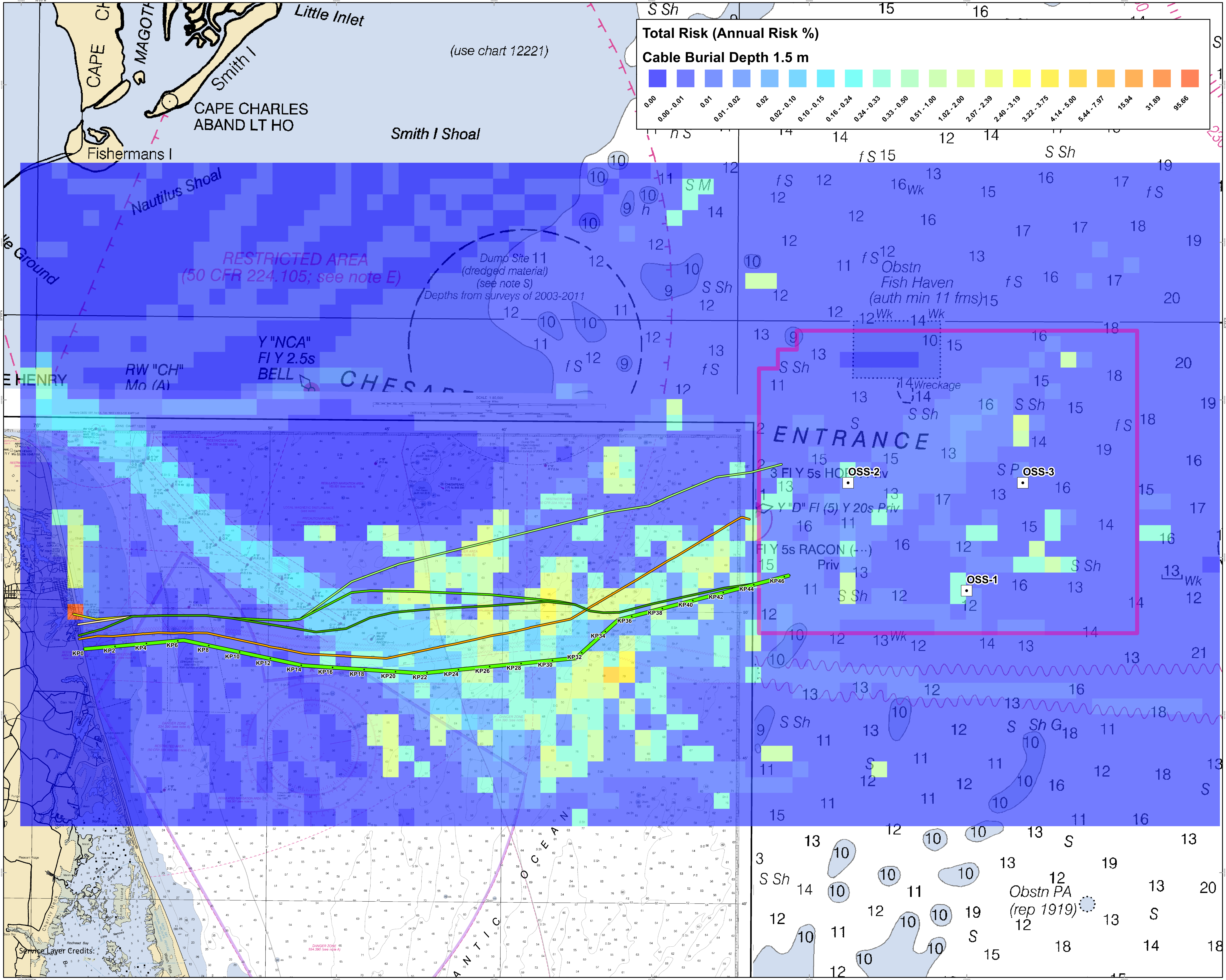
| Total Risk by burial depth and $P_{incident}$ | | | | | |
|---|---|---|---|---|---|
| | | Prob. of incident | | | |
| | | 1 in 200 | 1 in 100 | 1 in 50 | 1 in 1 |
| Burial Depth | 0m | 3.17% | 4.41% | 6.73% | 93.30% |
| | 0.5m | 3.13% | 4.25% | 6.44% | 92.23% |
| | 1m | 2.42% | 3.25% | 4.90% | 84.21% |
| | 1.5m | 41.59% | 51.74% | 67.06% | 100.00% |

# APPENDIX B: LARGE FORMAT CHARTS OF THE AREA-BASED TOTAL RISK


Total Risk (Annual Risk %)
Cable Burial Depth 0.0 m
0.00
0.00 - 0.01
0.01
0.01 - 0.02
0.02
0.02 - 0.10
0.10 - 0.15
0.16 - 0.24
0.24 - 0.33
0.33 - 0.50
0.51 - 1.00
1.02 - 2.00
2.07 - 2.39
2.40 - 3.19
3.22 - 3.75
4.14 - 5.00
5.44 - 7.97
15.94
31.89
95.66
COASTAL VIRGINIA OFFSHORE WIND
Dominion Energy
Legend
CVOW Commercial Corridor Centerline
IAC Base Case Substations
CVOW Pilot Export Cable Route
CVOW Commercial Lease Area
High Level Cable Route Alternatives
Alternative Routes
Offshore Alt A
Offshore Alt B
Offshore Alt C
Alt Landing: Rudee Inlet Area
Alt Landing: Croatan Neighborhood
Date
December 2020
File/Job Number
Personnel
Figure Prepared by: Ryan Earley
0 1 2 3 4 Miles
0 1 2 3 Nautical Miles
0 2 4 6 8 Kilometers
REFERENCE MAP
N
Little Inlet
CAPE CHARLES ABAND LT HO
Fishermans I
Smith I Shoal
Nautilus Shoal
RESTRICTED AREA (50 CFR 224.105; see note E)
Dump Site (dredged material) (see note S)
Depths from surveys of 2003-2011
(use chart 12221)
ENTRANCE
Obstn Fish Haven (auth min 11 fms)
OSS-1
OSS-2
OSS-3
KP0
KP2
KP4
KP6
KP8
KP10
KP12
KP14
KP16
KP18
KP20
KP22
KP24
KP26
KP28
KP30
KP32
KP34
KP36
KP38
KP40
KP42
KP44
KP46
Obstn PA (rep 1919)
Service Layer Credits:


Total Risk (Annual Risk %)
Cable Burial Depth 0.5 m
0.00
0.00 - 0.01
0.01
0.01 - 0.02
0.02
0.02 - 0.10
0.10 - 0.15
0.16 - 0.24
0.24 - 0.33
0.33 - 0.50
0.51 - 1.00
1.02 - 2.00
2.07 - 2.39
2.40 - 3.19
3.22 - 3.75
4.14 - 5.00
5.44 - 7.97
15.94
31.89
95.66
COASTAL VIRGINIA OFFSHORE WIND
Dominion Energy
Legend
CVOW Commercial Corridor Centerline
IAC Base Case Substations
CVOW Pilot Export Cable Route
CVOW Commercial Lease Area
High Level Cable Route Alternatives
Alternative Routes
Offshore Alt A
Offshore Alt B
Offshore Alt C
Alt Landing: Rudee Inlet Area
Alt Landing: Croatan Neighborhood
Date
December 2020
File/Job Number
Personnel
Figure Prepared by: Ryan Earley
0 1 2 3 4 Miles
0 1 2 3 Nautical Miles
0 2 4 6 8 Kilometers
REFERENCE MAP
N
OSS-1
OSS-2
OSS-3
CAPE CHARLES ABAND LT HO
Smith I Shoal
Little Inlet
Fishermans I
Nautilus Shoal
RESTRICTED AREA (50 CFR 224.105; see note E)
ENTRANCE
Service Layer Credits:


COASTAL VIRGINIA OFFSHORE WIND
Dominion Energy
Total Risk (Annual Risk %)
Cable Burial Depth 1.0 m
0.00
0.00 - 0.01
0.01
0.01 - 0.02
0.02
0.02 - 0.10
0.10 - 0.15
0.16 - 0.24
0.24 - 0.33
0.33 - 0.50
0.51 - 1.00
1.02 - 2.00
2.07 - 2.39
2.40 - 3.19
3.22 - 3.75
4.14 - 5.00
5.44 - 7.97
15.94
31.89
95.66
Legend
CVOW Commercial Corridor Centerline
IAC Base Case Substations
CVOW Pilot Export Cable Route
CVOW Commercial Lease Area
High Level Cable Route Alternatives
Alternative Routes
Offshore Alt A
Offshore Alt B
Offshore Alt C
Alt Landing: Rudee Inlet Area
Alt Landing: Croatan Neighborhood
Date
December 2020
File/Job Number
Personnel
Figure Prepared by: Ryan Earley
0 1 2 3 4 Miles
0 1 2 3 Nautical Miles
0 2 4 6 8 Kilometers
REFERENCE MAP
N
Little Inlet
(use chart 12221)
CAPE CHARLES
ABAND LT HO
Fishermans I
Smith I
Smith I Shoal
Nautilus Shoal
RESTRICTED AREA
(50 CFR 224.105; see note E)
Dump Site
(dredged material)
(see note S)
Depths from surveys of 2003-2011
RW "CH"
Mo (A)
Y "NCA"
Fl Y 2.5s
BELL
E HENRY
ENTRANCE
Obstn
Fish Haven
(auth min 11 fms)
Wreckage
OSS-1
OSS-2
OSS-3
Fl Y 5s HOR
Y "D" Fl (5) Y 20s Priv
Fl Y 5s RACON (-··)
Priv
Obstn PA
(rep 1919)
ATLANTIC OCEAN
KP0
KP2
KP4
KP6
KP8
KP10
KP12
KP14
KP16
KP18
KP20
KP22
KP24
KP26
KP28
KP30
KP32
KP34
KP36
KP38
KP40
KP42
KP44
KP46
Service Layer Credits:




**COASTAL VIRGINIA OFFSHORE WIND**

Dominion Energy®

**Legend**

- CVOW Commercial Corridor Centerline
- IAC Base Case Substations
- CVOW Pilot Export Cable Route
- CVOW Commercial Lease Area

**High Level Cable Route Alternatives**

**Alternative Routes**

- Offshore Alt A
- Offshore Alt B
- Offshore Alt C
- Alt Landing: Rudee Inlet Area
- Alt Landing: Croatan Neighborhood

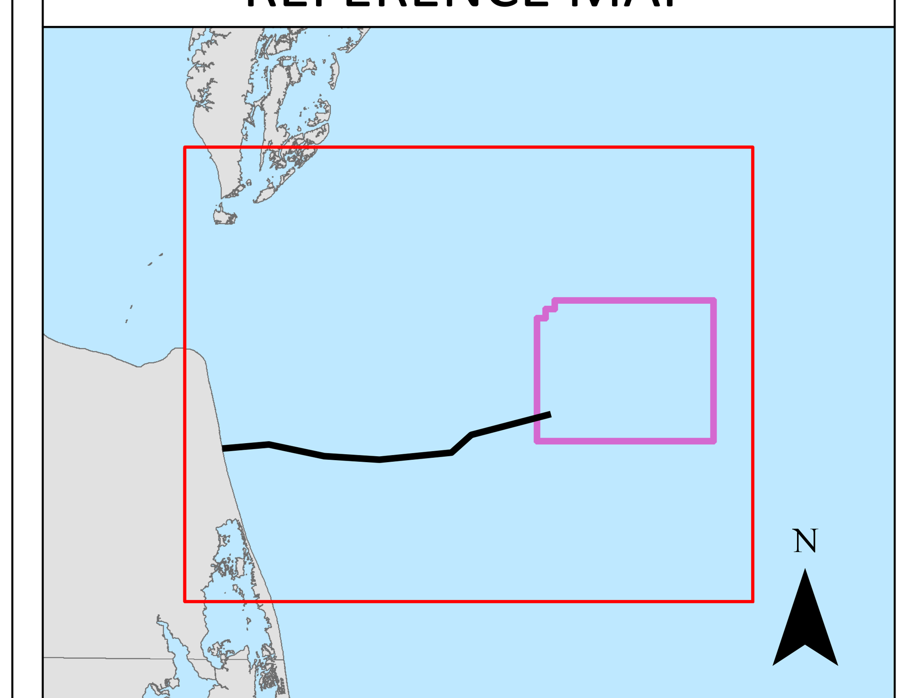
| | |
|---|---|
| Date | December 2020 |
| File/Job Number | |
| Personnel | Figure Prepared by: Ryan Earley |

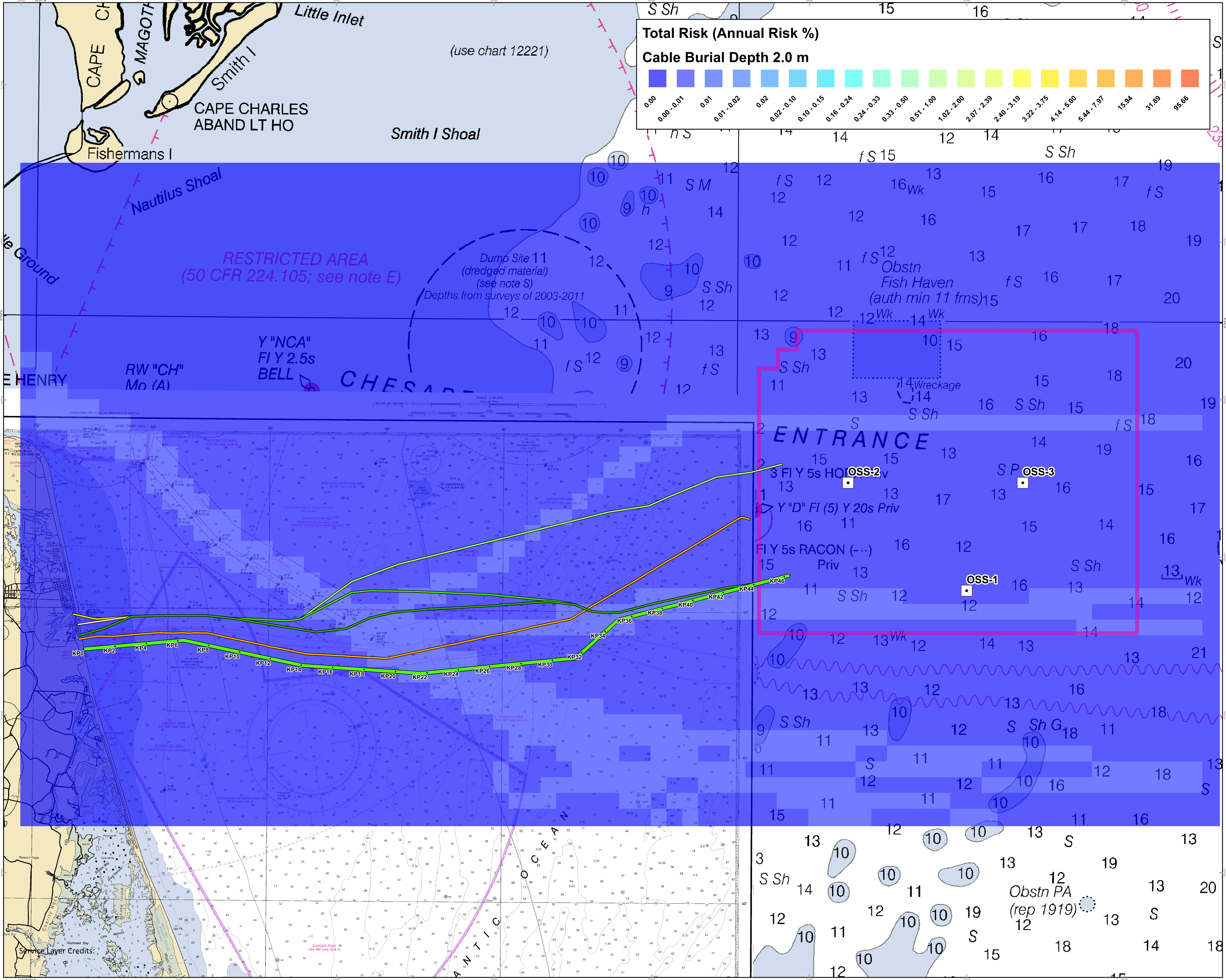
0 1 2 3 4 Miles

0 1 2 3 Nautical Miles

0 2 4 6 8 Kilometers

REFERENCE MAP






## COASTAL VIRGINIA OFFSHORE WIND

Dominion Energy

### Legend

- CVOW Commercial Corridor Centerline
- IAC Base Case Substations
- CVOW Pilot Export Cable Route
- CVOW Commercial Lease Area

**High Level Cable Route Alternatives**

**Alternative Routes**

- Offshore Alt A
- Offshore Alt B
- Offshore Alt C
- Alt Landing: Rudee Inlet Area
- Alt Landing: Croatan Neighborhood

| | |
|---|---|
| Date | December 2020 |
| File/Job Number | |
| Personnel | Figure Prepared by: Ryan Earley |

0 1 2 3 4 Miles

0 1 2 3 Nautical Miles

0 2 4 6 8 Kilometers

REFERENCE MAP