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Appendix W: Preliminary Cable Burial Risk Assessment

Coastal Virginia Offshore Wind Commercial Project

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CONSTRUCTION AND OPERATIONS PLAN

Coastal Virginia Offshore Wind Commercial Project

Appendix W

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APPENDIX W PRELIMIANRY 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

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ACRONYMS AND ABBREVIATIONS

AIS	Automatic Identification System
ALARP	As Low As is Reasonably Practicable
AOC	Atlantic Ocean Channel
AWEA	American Wind Energy Association
BMH	Beach Manhole
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CBRA	Cable Burial Risk Assessment
ECC	Offshore Export Cable Route Corridor
ECC alignment	Export Cable Route Corridor centerline – refers to the study corridor
CFR	Code of Federal Regulations
cm	centimeter
COP	Construction and Operations Plan
CPT	Cone Penetrometer Test
CVOW	Coastal Virginia Offshore Wind
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
ESP	Electrical Substation Platform
ft	foot
HRG	high-resolution geophysical
HVAC	high voltage alternating current
ICPC	International Cable Protection Committee
in	inch
kg	kilogram
km	kilometer
KP	kilometer post
LAT	Lowest Astronomical Tide
Lease Area	the designated Renewable Energy Lease Area OCS-A 0483
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
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
U.S.	United States
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
WD	water depth
WTG	Wind Turbine Generator

EXECUTIVE SUMMARY

This document details the methodology of, and the findings arising from, an initial high-level Cable Burial Risk Assessment (CBRA) for Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion Energy's) Coastal Virginia Offshore Wind (CVOW) Commercial Project (the Project), 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 with regard to, potential alternative export cable routes; and
- A preliminary, modified Carbon Trust–based CBRA along the alignment of the Project's Offshore Export Cable Route Corridor (ECC) 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 "ECC alignment".

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

- Anchoring: The initial probabilistic study indicates that a Depth of Lowering 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. Detailed risk breakdowns are included in Section 6, Modeling of Likely Scenarios and Probalistic Risk Assessment.
- Vessel traffic/navigation channels: The ECC 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.
- 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, NTM's 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.
- Dropped objects: Due to the volume of commercial and military vessels transiting the area, dropped objects are a risk and should be further studied.
- 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.
- Sediment mobility: There is evidence of mobile sediments and sand waves, particularly within the central and eastern sections of the cable corridor, though mobile seabeds 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) through the use of 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 ECC 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

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 (MW) of clean, reliable offshore wind energy. The Project is comprised of a design envelope of 176 to 205 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 2024 with completion scheduled for 2027. At the time of writing of this report, site and soil marine survey campaigns are currently underway.

The Project will be located 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. y.

At the time of writing of this report, potential sites for the Cable Landing Locations are currently being evaluated. There are three Cable Landing Locations under consideration, including the Preferred Alternative in the Proposed Parking Lot, west of the Firing Range at the State Military Reservation (SMR), formerly known as Camp Pendleton (all nine cables), with alternative 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). Additional alternatives at the Croatan Beach Parking Lot, which included five potential locations). However, this study is based on the Offshore Export Cable Route Corridor (ECC) as developed by Ramboll, the centerline of which lands approximately 2,500 feet (750 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 ECC alignment.

The preliminary route of the ECC 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 transit the danger area from the historic Dam Neck naval firing range, hence, munitions and explosives of concern (MEC) will be of particular concern to research and analysis ongoing at the time of writing of this study.

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.

This report has two main areas of focus. First focus is to undertake a modified traditional "linear", risk-based Cable Burial Risk Assessment (CBRA) along the centerline of the ECC alignment. The second focus of the report evaluates an area stretching well to the north and south of the Export Cable Corridor, as well as encompassing the Lease Area, to analyze for commercial vessel activity. This is for two reasons:

- To give the Project Team some flexibility with regard to assessing other potential cable routes; and
- To gain an appreciation as to the extent of vessel anchoring near the approaches to the shipping lanes and channels leading to and from the Chesapeake Bay.

W.1.2 Preliminary Offshore Export Cable Route Corridor

As previously described, this report assesses the ECC 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 final Project will require up to nine HVAC Offshore Export Cables, each with three conductor cores, with three cables each connecting to one of two to three Offshore Substations. A ECC 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 by cable CBRA is outside the scope of this study, which will focus on the alignment of the corridor identified as the "Planned CVOW Commercial Survey Corridor Centerline (Ramboll)" in the following Figure W-1 and Figure W-3 through Figure W-5 and referred to within this document as the "ECC alignment".

While the ECC 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 ECC 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.

While an extensive high-resolution geophysical and geotechnical campaign are currently underway, some preliminary seabed Cone Penetrometer Test (CPT) results and geotechnical borings have been made available at present to inform of seafloor conditions directly along the cable route. Geophysical mapping allows the integration and extrapolation of interpretations across the CC as the survey program progresses.

This section describes the ECC alignment and is broken down into three subsections: the shore approaches (Figure W-3), the mid-section (Figure W-4), and the offshore section that just enters the Lease Area (Figure W-5).

Preliminary KPs have been provided, with KP 0 being at the beach and KP 46 at the end of the ECC approximately 0.9 mi (1.5 km) into the Lease Area. In addition to the main ECC alignment, three offshore alternatives 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 Probalistic Risk Assessment.

Figure W-2 is an overview of the ECC alignment currently being surveyed.

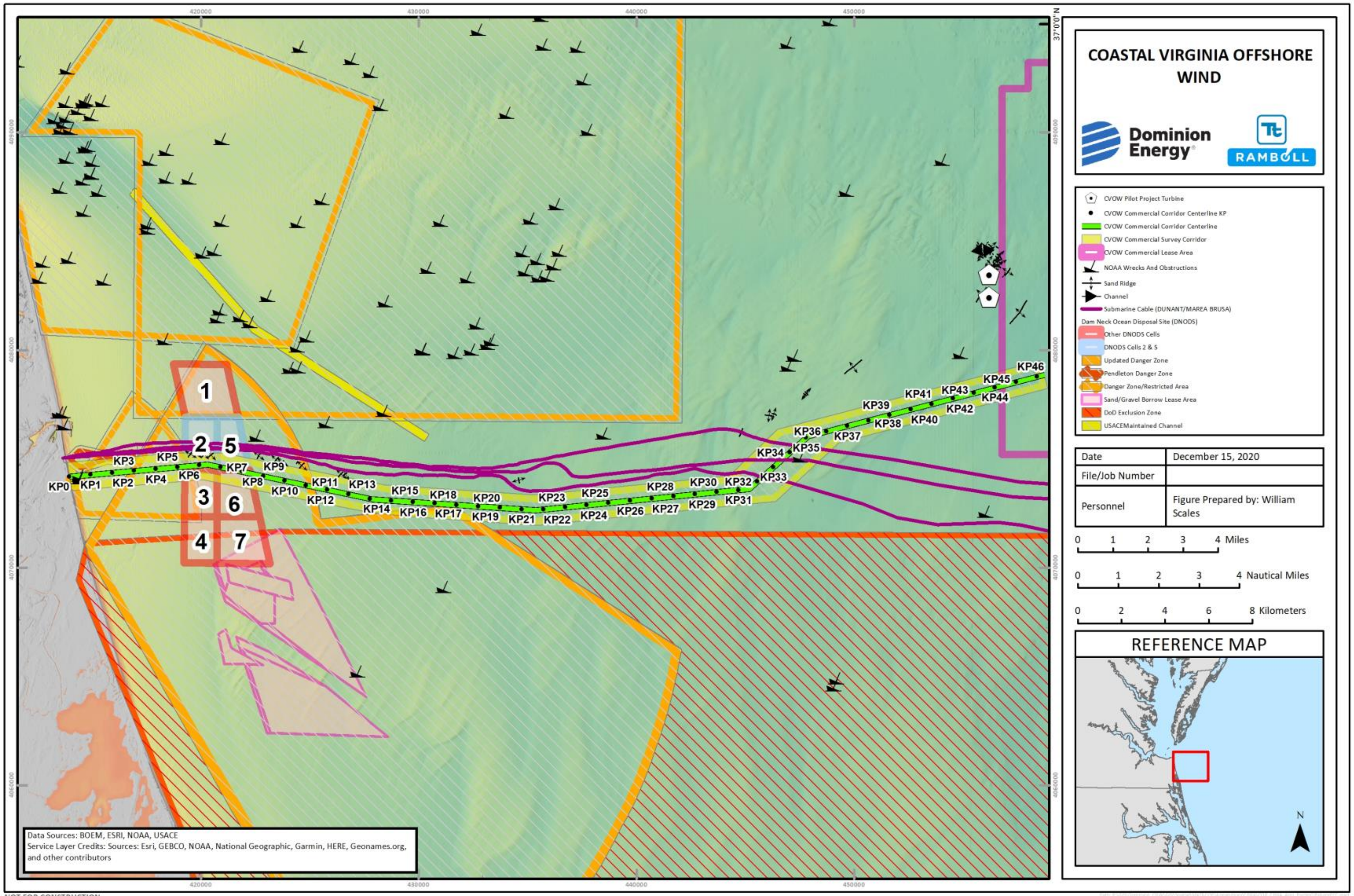


Figure W-1. Preliminary Offshore Export Cable Route Corridor.

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

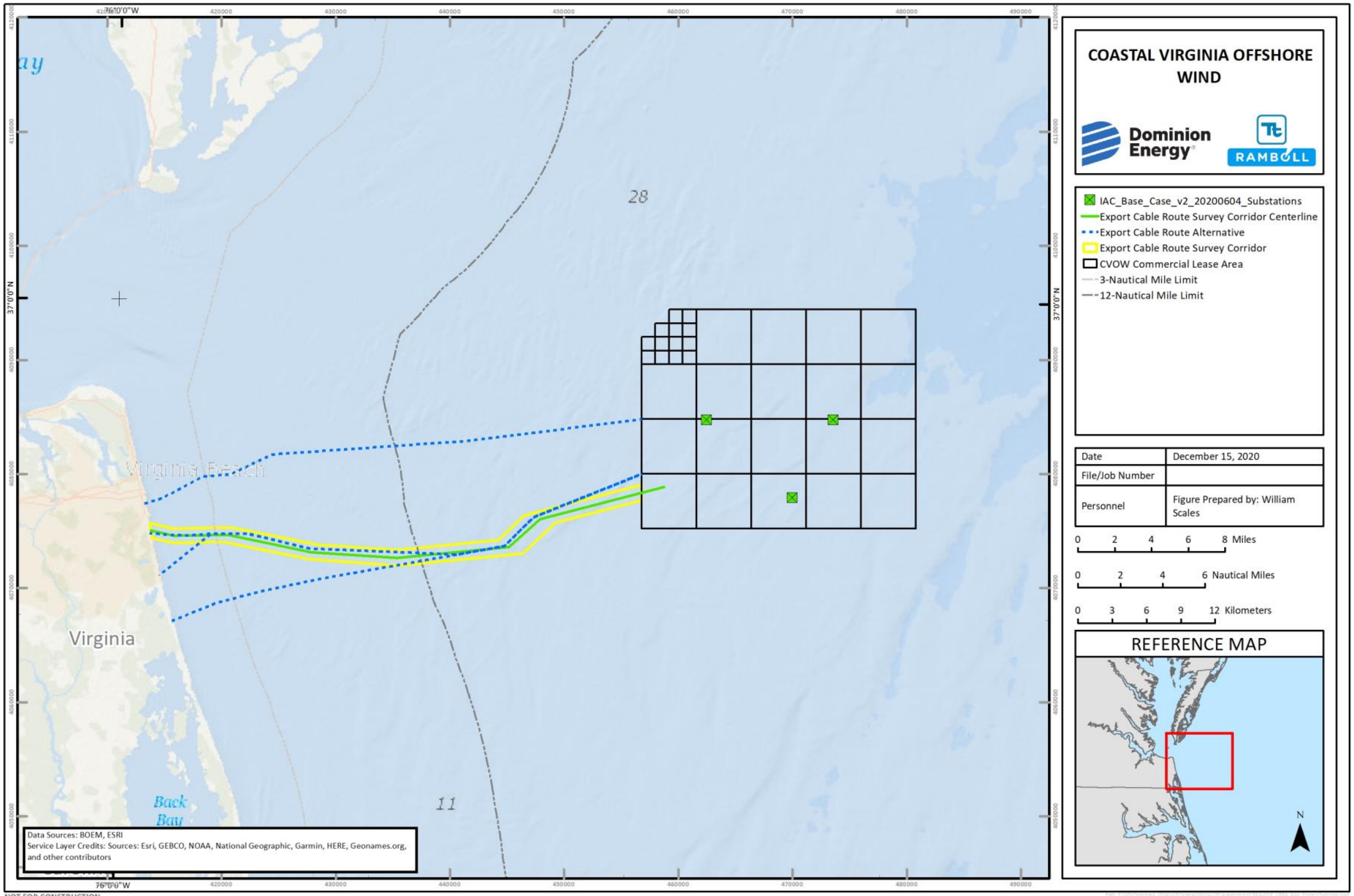


Figure W-2. Offshore Survey Area Showing Export Cable Corridor and Lease Area

W.1.2.1 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 ECC alignment, the nearshore section has been identified as the area from the shore landing out to KP 9.0.

The ECC 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 ECC alignment as depicted within the below charts will be considered. This is due to the fact that the cable risk profile is not likely to alter significantly should the actual shore landing location vary slightly. In order 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 Trenchliss Installations will be approximately 3,000 ft (900 m) to the north-northwest of KP 0.0, with the planned ducts punching out within the surveyed corridor.

However, it is likely that the Trenchless Installation Punch-Out location will fall within an area of unexploded rockets that stretches out to KP 1.0 from KP 0.0. Beyond that, the ECC 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.

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 ECC. In the waters beyond 3 mi (5 km) and through KP 9.000, 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 ECC alignment centerline transits the DNODS. This is a federally maintained disposal site and is subject to USACE oversight. Within this area, the USACE will have their own cable burial requirements. 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 ECC 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.

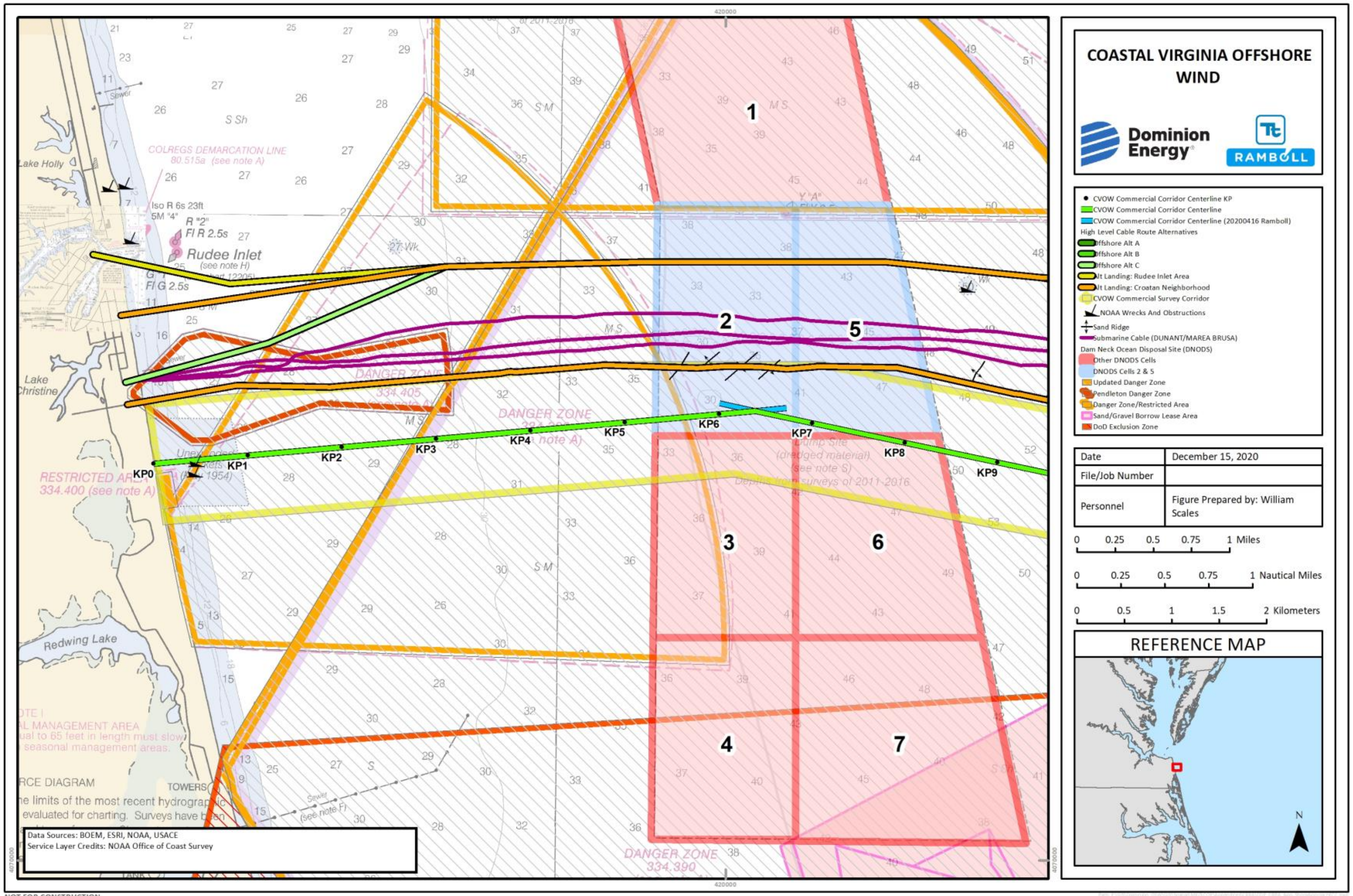


Figure W-3. Export Cable Corridor with Shore approaches detail

**Please note that the study considers the green "Planned CVOW-Commercial Survey Corridor Centerline (Ramboll)"*

W.1.2.2 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 ECC 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 ECC 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 fiberoptic cables vary in their proximity to the ECC alignment, but the closest point of approach is approximately 2,600 ft (800 m) at KP22.2.

At KP 11.5, the ECC 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 as a whole (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.

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 Estuary 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, although vessels have recently been observed anchoring within the ECC alignment. 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.

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.

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.

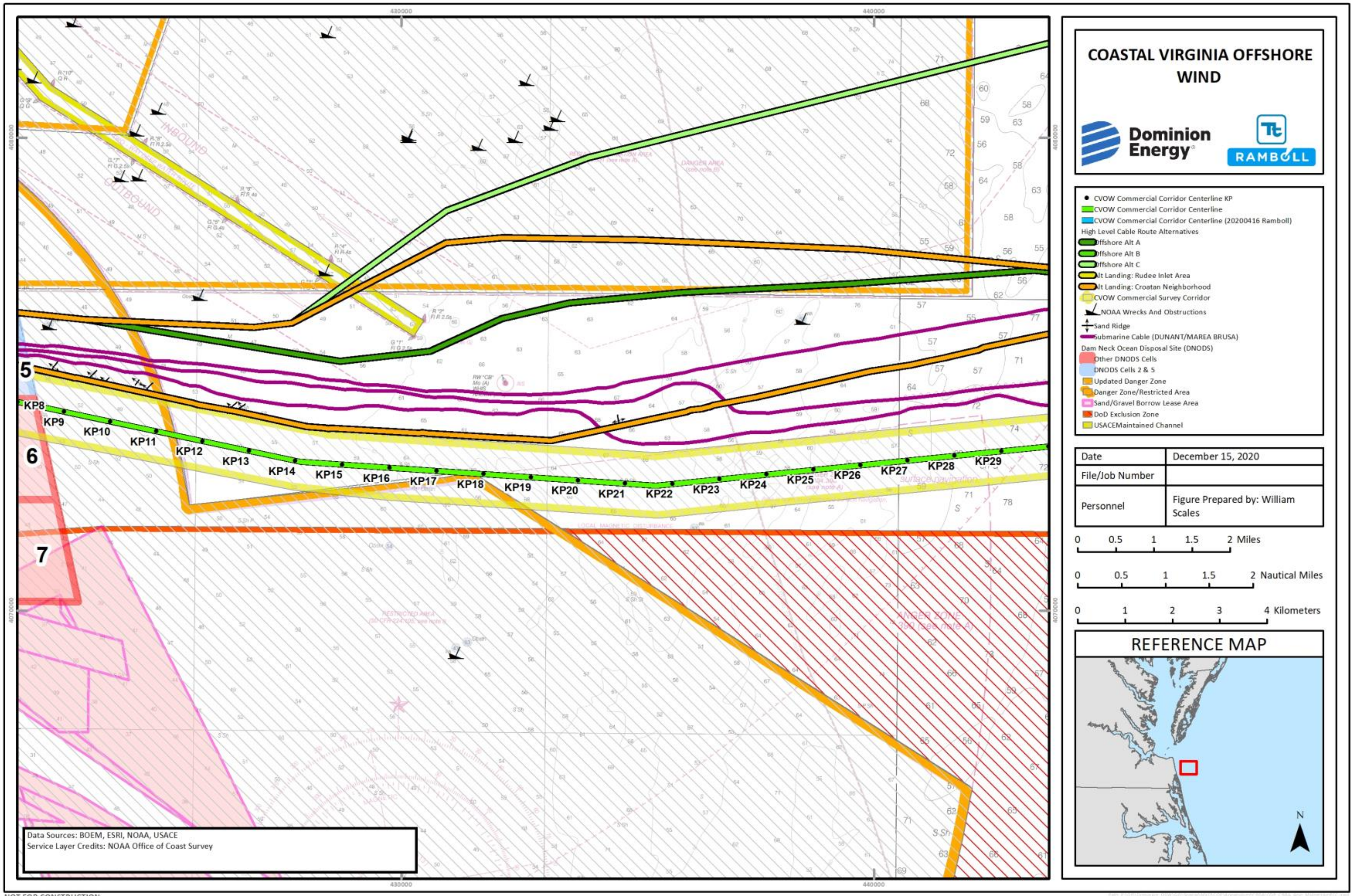


Figure W-4. Export Cable Corridor withMid-section detail

**Please note that the study considers the green "Planned CVOW-Commercial Survey Corridor Centerline (Ramboll)" labelled above*

W.1.2.3 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 ECC 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 ECC 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 on 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 ECC 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 ECC alignment enters the Project Lease Area, the Offshore Alternative routes (described in Section 1.3.2 below) converge. It is worth noting that there will eventually be two to 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.

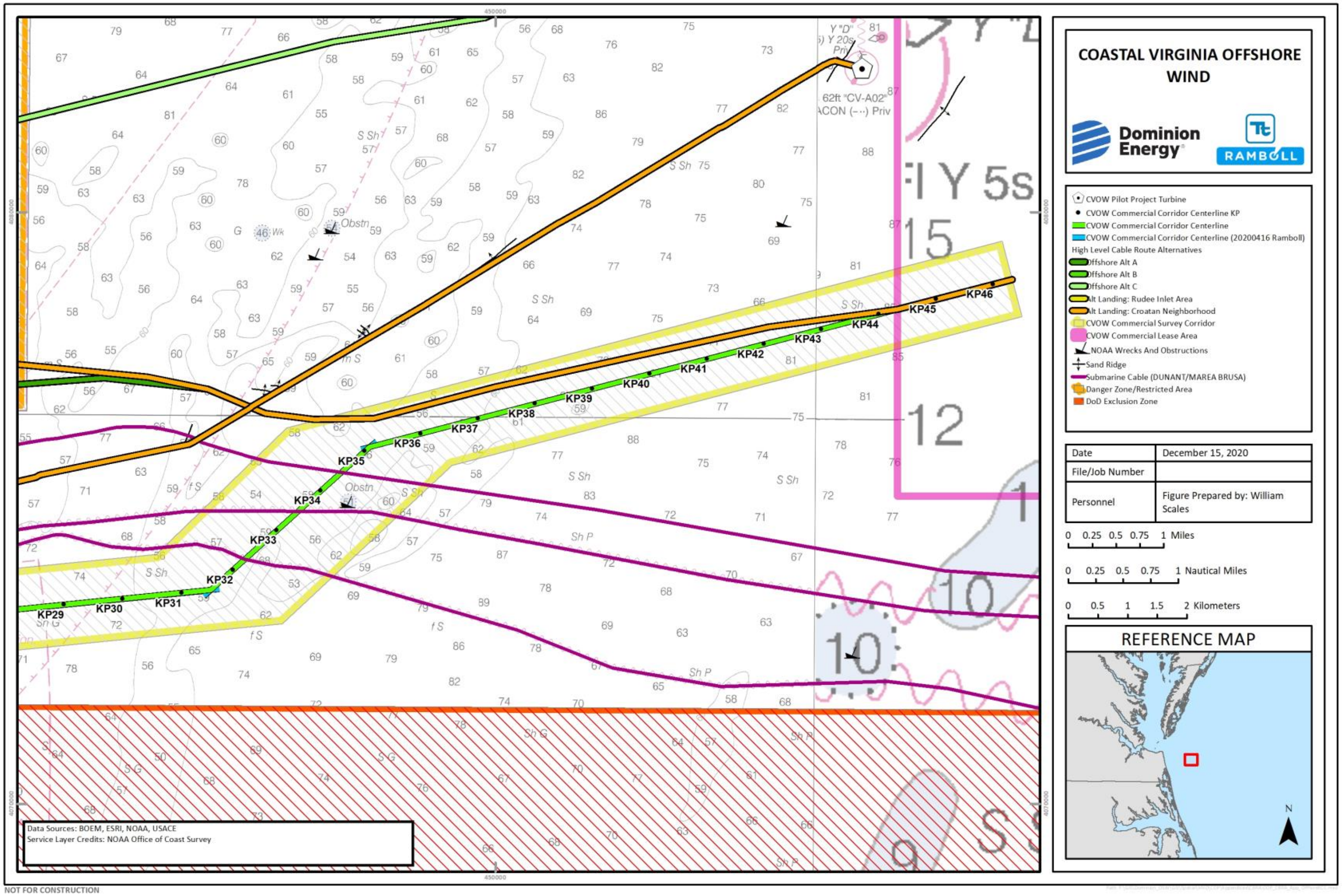


Figure W-5. Export Cable Corridor, Farthest offshore-section detail

Please note that the study considers the green "Planned CVOW-Commercial Survey Corridor Centerline (Ramboll)" labeled above

W.1.3 Additional Route Alternatives

As previously described, the routes of the ECC has 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 ECC are being explored, as well as several potential alternative shore landing points. The "Zonal" based CBRA is intended to identify, at a high level, risks to the cable associated with the alternative routes, as well as any other potential variations not yet identified. These alternatives are described in greater detail below.

W.1.3.1 Shore Landing Alternatives

The ECC alignment that is the focus of this report makes landfall within the confines of the SMR Beach Parking Lot on a stretch of beach approximately 3 mi (5 km) south of Virginia Beach (Figure W-6 and Figure W-7). However, it is likely that the actual cables will come ashore within the SMR firing range, approximately 2,500 ft (750 m) to the north. Another alternative being considered is a landing at the Croatan Beach Parking Lot. It is also possible that both landing sites will be utilized, with several export cables landing at each site. For the purposes of this report, the risk profile of the submarine cabling is assumed to be similar for these alternatives.

Figure W-6. Export Cable Corridor, Cable Landing Location Alternatives

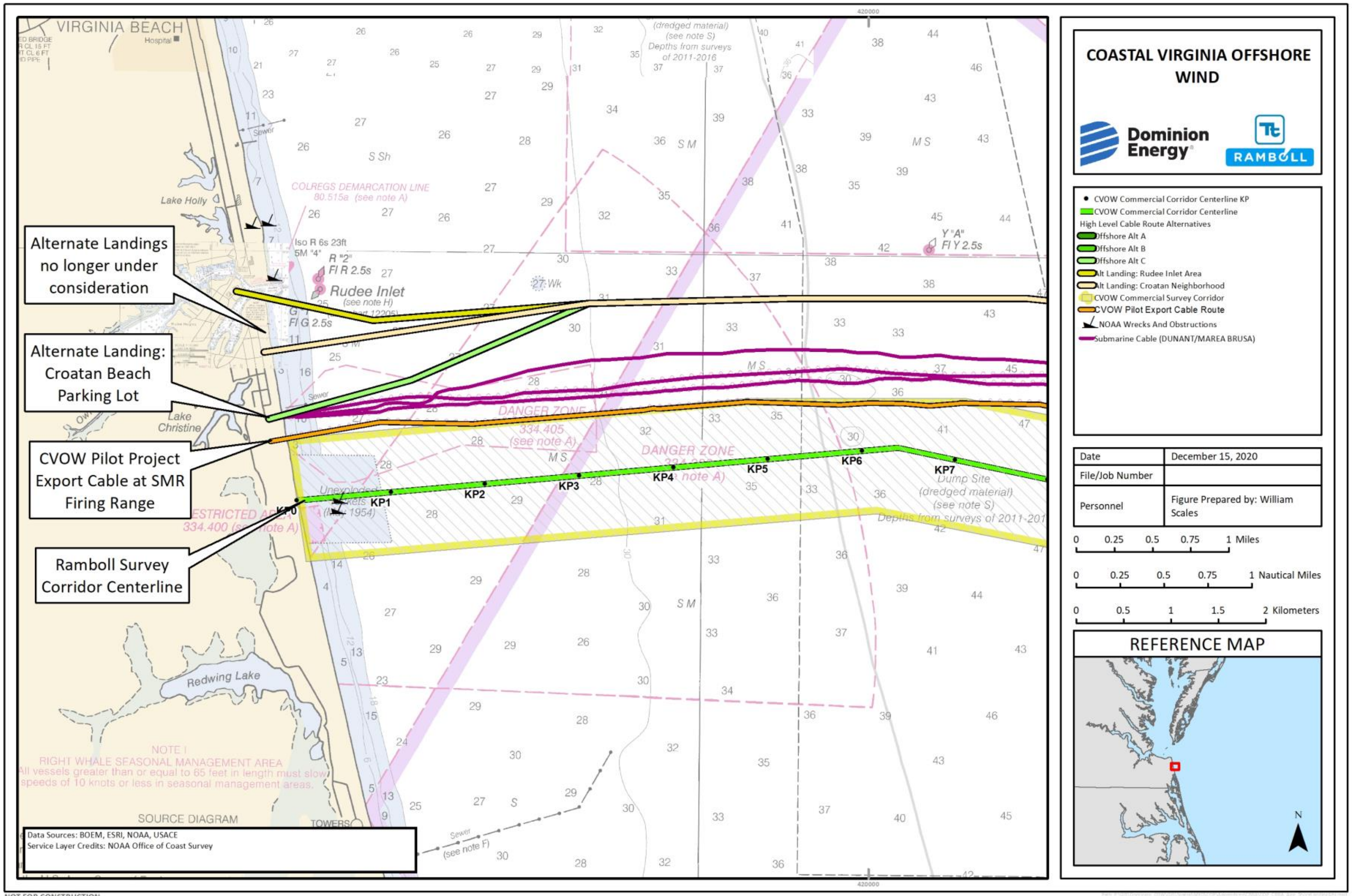


Figure W-7 Export Cable Corridor, Shore Landing Alternatives

W.1.3.2 Offshore Alternatives

As with the shore landings, several offshore alternative routes are under consideration. As previously discussed, the Project will eventually consist of two to three 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 also 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 alternative Offshore Export Cable Routes have been identified. Figure W-8 below provides an overview.

In all three cases, the alternatives 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 alternative routes 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 (4.7 m) below the authorized, maintained depth at this point.

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

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

All three alternative routes 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 Alternatives are not covered by the "traditional" CBRA, but the risks associated with commercial vessel traffic and anchoring will be taken into consideration by the zone-based CBRA.

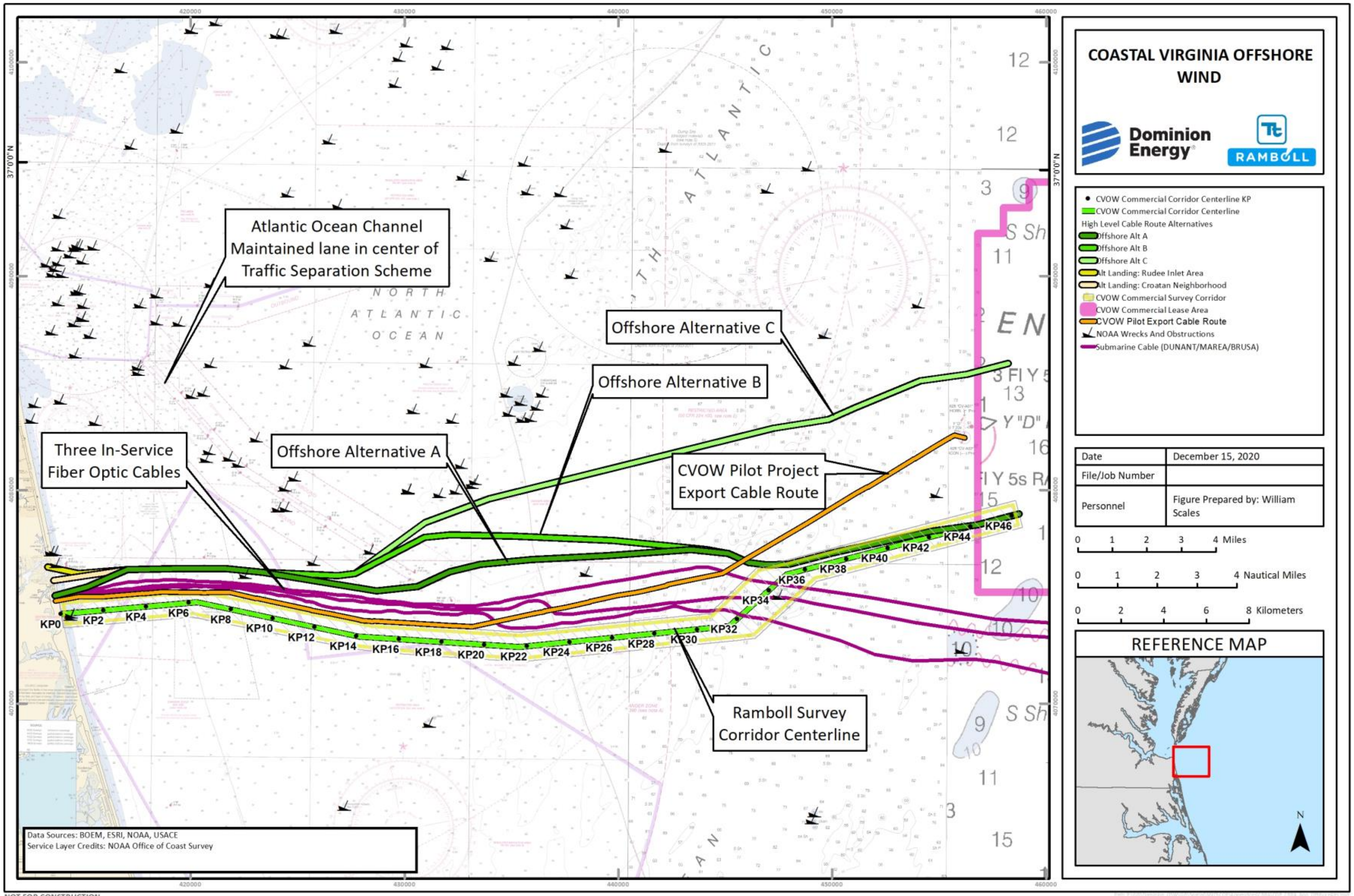


Figure W-8. Export Cable Corridor, Offshore Route Alternatives

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, 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 Wind Energy Association (AWEA).

W.2.1 BOEM Construction and Operation 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 Operation 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

The 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 2016). 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 Wind Energy Association

AWEA is a trade association representing both the onshore and offshore wind industry. They are currently developing a set of Standards and Recommended Practices, including convening working groups under their Wind Standards Committee. One of those working groups is 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*. However, this document is still under development and is expected to be published in 2021.

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 preliminary 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.

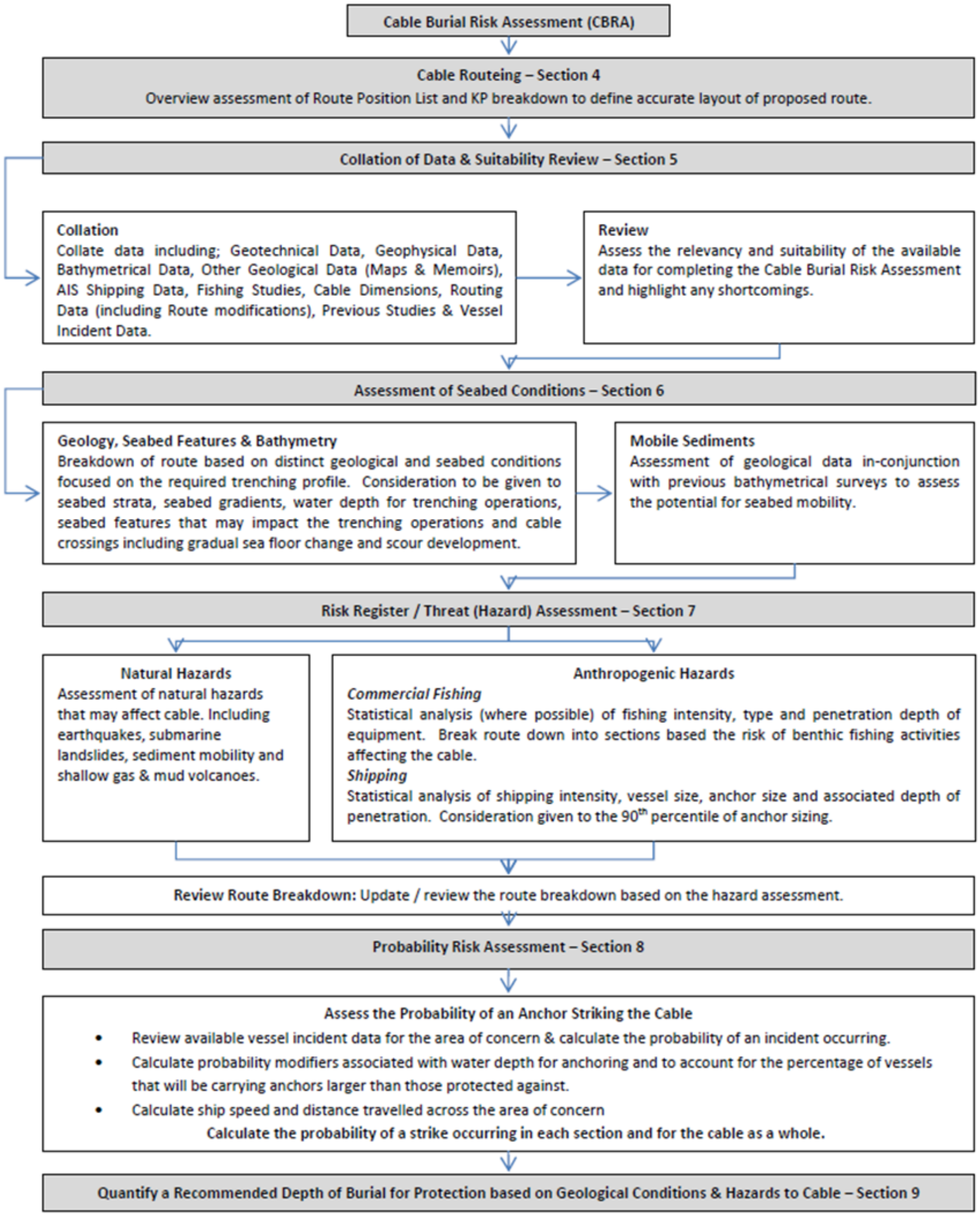


Figure W-9 CBRA Methodology Flowchart (Carbon Trust 2015)

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 at this time).
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.)

Once the full survey data and finalized Route Position List is available, a full CBRA can be undertaken that will enable, for example, completion of dredge volume calculations, finalized probabilistic risk calculations, and final burial recommendations. Final burial recommendations will require further inputs on target risk level tolerance, though this document has provided risk estimates for a range of burial depths to facilitate this discussion.

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 takes into account 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. In order to achieve the Target DOL, a burial tool capable of the Target Trench Depth I 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.

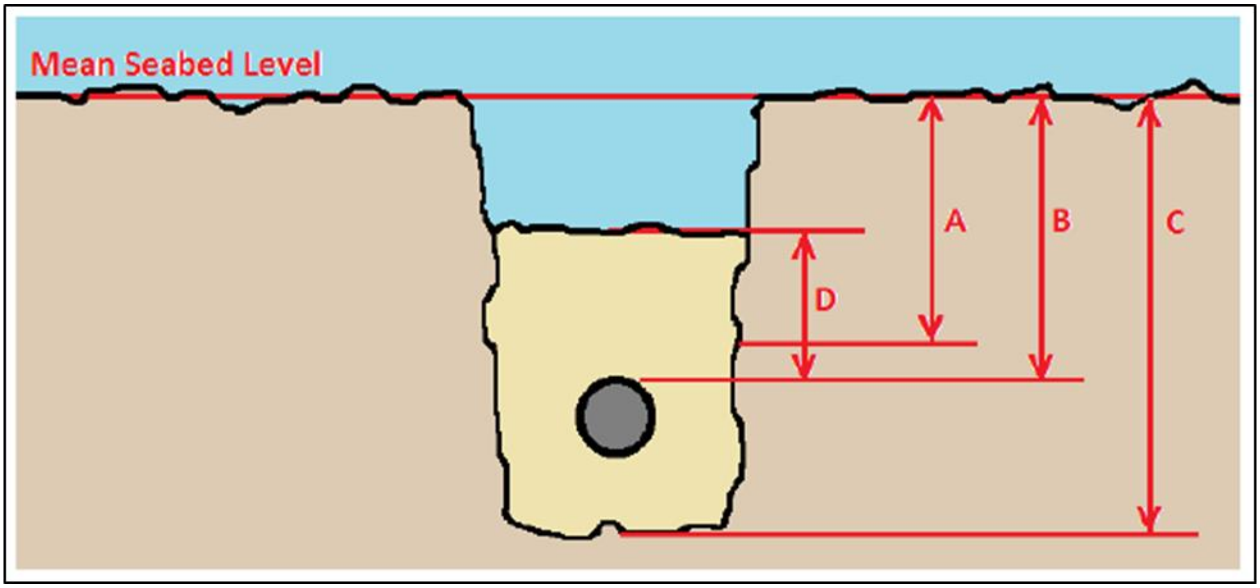


Figure W-10. Trench Definitions (Carbon Trust 2015)

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 a number of inputs required in order to undertake a comprehensive CBRA:

- Marine charts and tide/current tables;
- Geotechnical data gathered utilizing 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 multi beam 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: Primary Export Cable Corridor

The objective of this study is to complete a preliminary (Stage 1) CBRA for the Project's Offshore Export Cable Route Corridor as described in Section 2.2 previously.

Furthermore, recommendations will be made as to the data requirements needed to undertake a complete (Stage 2) CBRA and Burial Assessment Study subsequently.

The scope is limited to the cable corridor as previously detailed. A full assessment of threats from UXO is outside the scope of this document and would require further investigation to fully elucidate. It is understood that Ramboll is commissioning a UXO/MEC DTS separately. However, Tetra Tech has considerable experience with UXO investigations from previous projects in the area and has incorporated high-level UXO threat identification in Section 5.8 below.

Due to the ongoing survey works, the continuing refinement of the ground model and understanding of the expected soil conditions, and the pending nature of a micro-sited route within the corridor, this report can only be considered a "preliminary" CBRA. Once the remaining data identified in Section 8 (Recommended Next Steps), is available, a full, quantitative CBRA can 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. This current study makes use of the datasets available at this 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. These findings will inform later stages of field investigation, technical analyses, installation planning, permitting, and stakeholder outreach.

W.3.3 Area-Based CBRA: 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.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 CBRA, seabed mobility analysis as part of the Seabed Morphology Study for the CVOW Commercial Project are ongoing, but findings are not available for incorporation into this document. The CVOW Pilot Project data used 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

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 feet (1.5 m)
- KP 5.400 – 6.300: 8 feet (2.4 m) (approximate DNODS zone)
- KP 6.300 – 8.700: 6.5 feet (2.0 m) (approximate DNODS zone)
- KP 8.700 – 9.640: 5 feet (1.5 m)
- KP 9.640 – 9.830: 6.2 feet (1.9 m)
- KP 9.830 – 12.760: 5 feet (1.5 m)
- KP 12.760 – 12.890: 5.25 feet (1.6 m)
- KP 12.890 – 16.500: 5 feet (1.5 m)
- KP 16.500 – 23.500: 6.2 feet (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 feet (1.6 m)
- KP 26.500 – 44.753: 5 feet (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). 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.

W.4.4.3 Initial Results of Ongoing Surveys

An examination of the preliminary borehole and seabed CPT data collected along the ECC yields results generally similar to the findings along the CVOW Pilot Project export cable route corridor. Preliminary results from the summer 2020 geotechnical campaign along the ECC provide initial indications to the composition and strength of the seabed.

The available geotechnical information (GeoQuip 2020) covers 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-11), but with several sites exhibiting finer-grained material (e.g., clayey sand and sandy clay), with some units (Figure W-12) exhibiting shear strengths of less than or approximately 40 kilo Pascals (kPa) (a cutoff for anchor penetration as discussed in Section 5.2, Anchorages, Anchoring, and Anchor Drags).

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

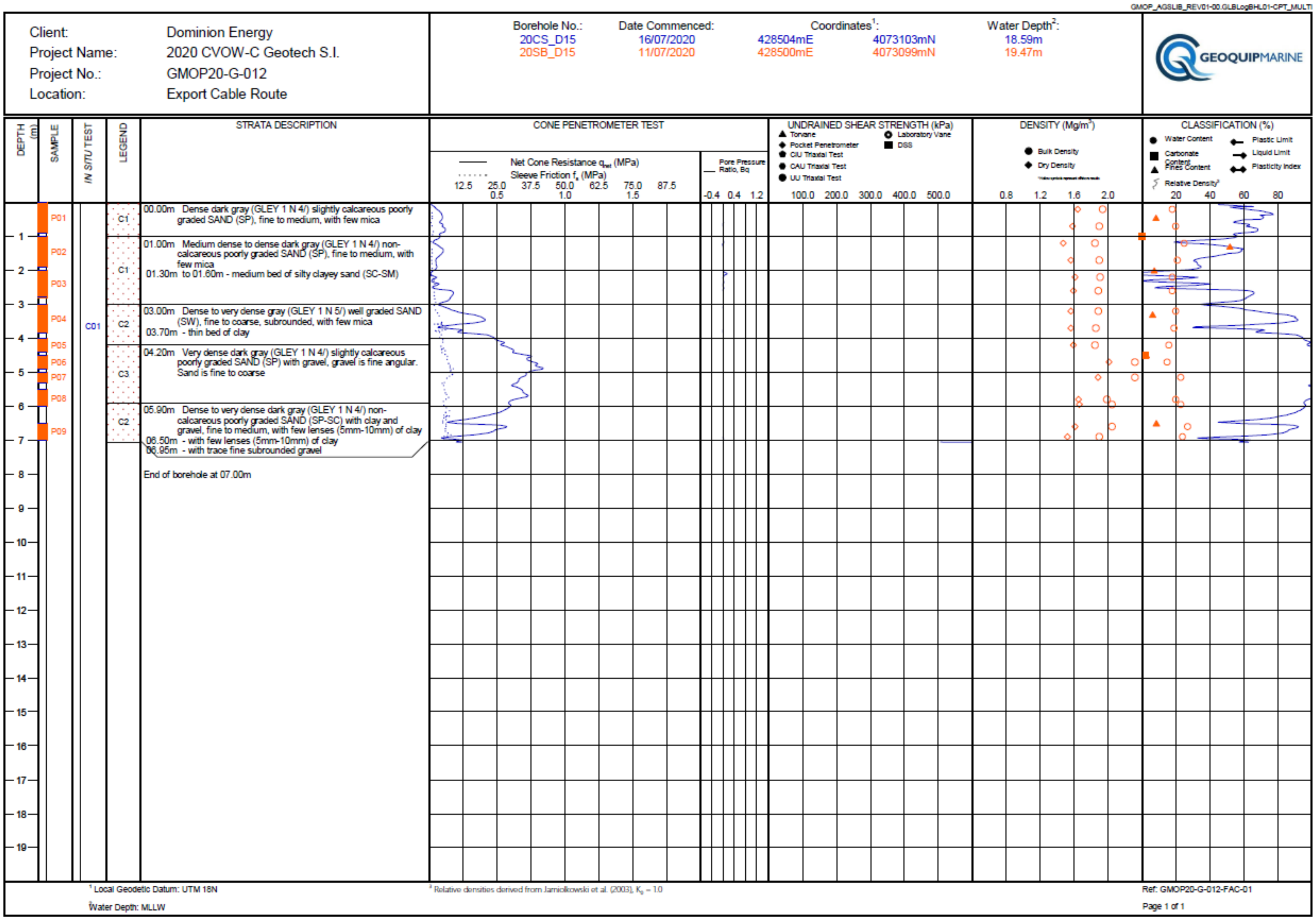


Figure W-11. CPT site 20CS_D15 Shows Medium to Dense Sands in the Upper 1 to 2 m of the Seabed with some Finer Grained Materials Present

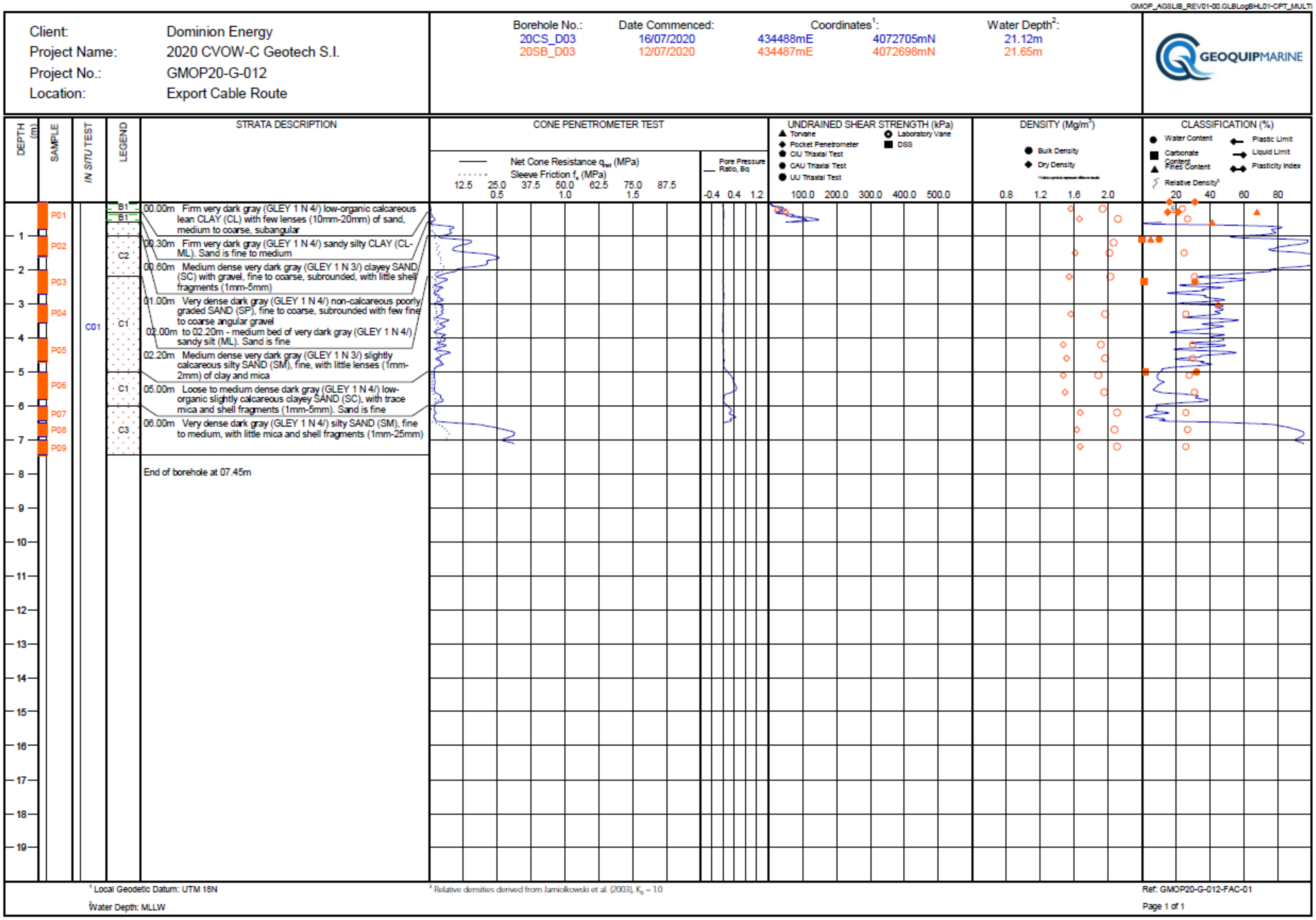


Figure W-12. CPT Site 20CS_D03 Shows Firm Sandy Clay in the Upper 1 m of the Seabed with Shear Strength of 25 to 50 kPa

W.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 ECC alignment. In the event that mobile sediments move away from the ECC 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 ECC alignment, the buried depth may increase which has the potential to impact thermal properties of the cable and complicate future cable maintenance.

While full time series geotechnical, geophysical and bathymetric survey data sets are not available at the time of this study in order to properly assess the potential for mobile sediments, 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. In order to confirm the existence and approximate locations of mobile sediments along the cable corridor, a time series bathymetric survey should be conducted.

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-13). 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.

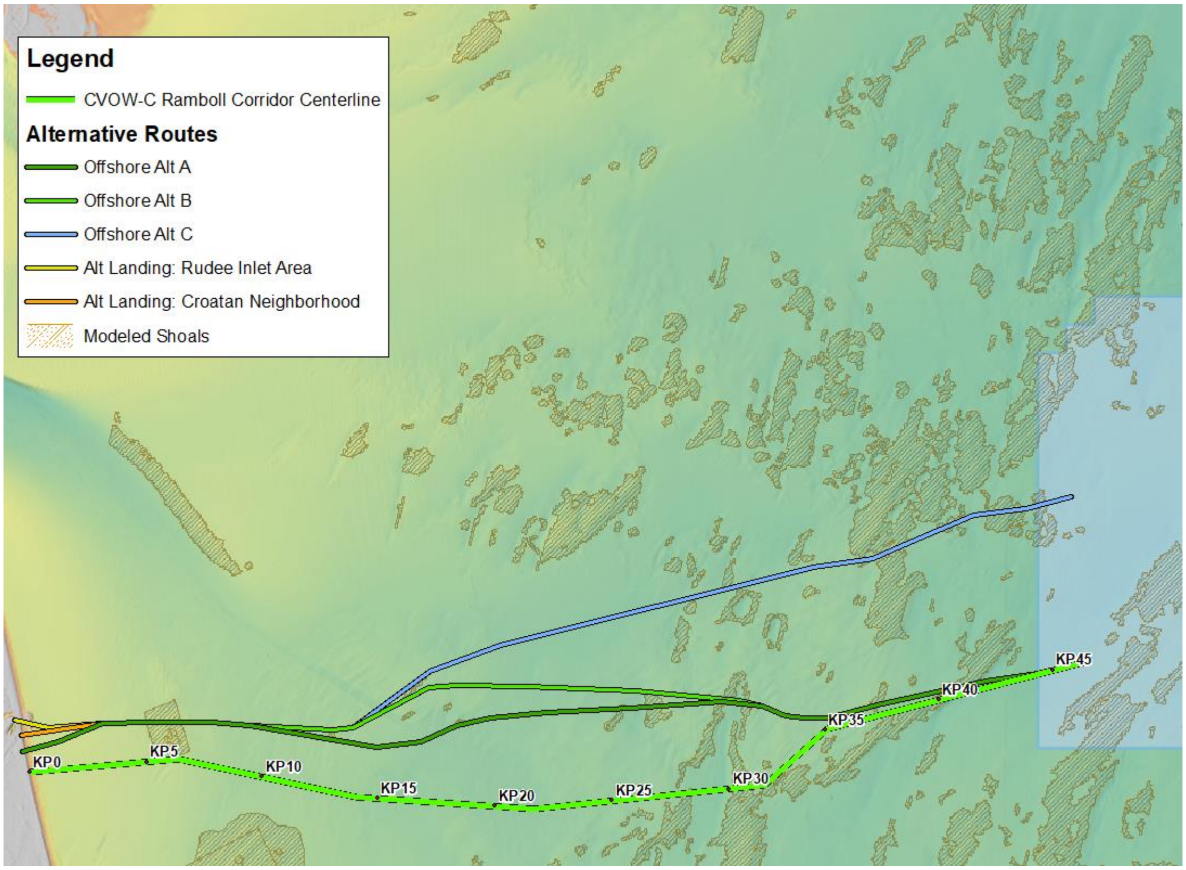


Figure W-13. BOEM MMIS Modeled Shoals Layer within the Study Area (BOEM 2020b)

The concentration of mobile sediments within the central to eastern portions of the ECC 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 ECC 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 ECC alignment, and the CVOW Pilot Project Lease Area. Additional ripples and save waves were identified in the CVOW Pilot Project Lease Area.

Analysis of the multibeam echosounder data along the ECC 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. This initial CBRA should be updated and refined with that new input when available. 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.5.2 Anchorages, Anchoring, and Anchor Drags

While there are no charted anchorage areas along the ECC 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-14), which is in the range of the largest of those depicted in Table W-1 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-15).

Figure W-14. Maersk Triple E-class Container Ship Anchor (Courtesy of Maersk)

Figure W-15. 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-1 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-1. 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 ECC 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.

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 ECC 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 ECC 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 ECC 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 ECC 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 (Figure W-17: MARCO Data). 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 ECC. A trawl fishery targeting shrimp outside 3 mi (4.8 km) has recently developed and does take place over the ECC.

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-16: Schematic of Otter Trawl; NOAA. 2020. "Teacher at Sea Blog". https://noaateacheratsea.blog/). As per Figure W-17 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-18, targeting spiny dogfish and/or mixed species for a few months out of the year.

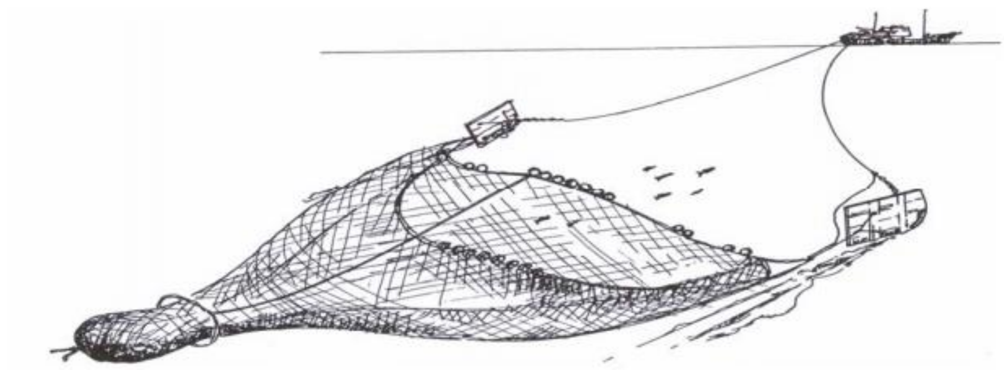


Figure W-16. Schematic of Otter Trawl (www.noaateacheratsea.blog)

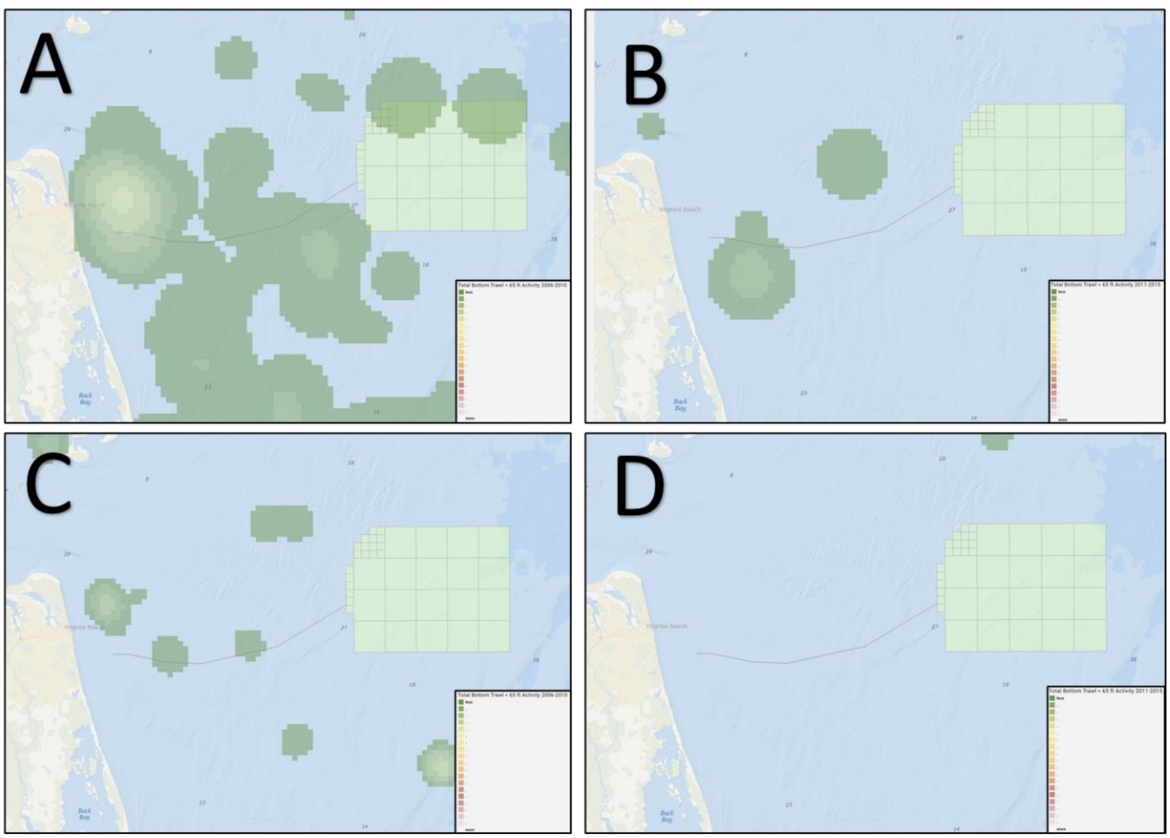


Figure W-17. Trawler Vessel Trip Report (VTR) data (A) Vessels >65' 2006-2010; (B) Vessels >65' 2011-2015; (C) Vessels <65' 2006-2010; and (D) Vessels <65' 2011-2015. (MARCO 2020)

Figure W-18. 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-19 and Figure W-20). This fishery is currently limited to eight vessels within a restricted area that is south of the ECC. If the fishery continues to grow, it may expand over the ECC 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-21) has recently been observed outside the boundary. These various trawl methods have minimal seabed penetration and pose minimal risk when compared to ship anchors.

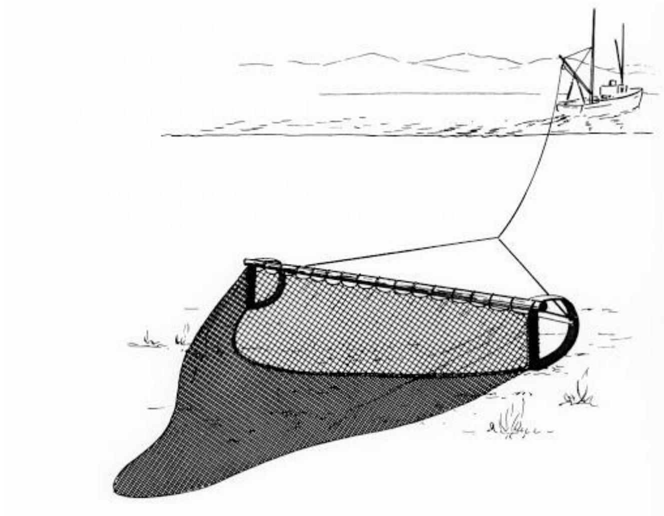


Figure W-19. Schematic of a Beam Trawl (Credit: FAO 2001)

Figure W-20. 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-21. Double Rig Shrimp Trawl Vessel (Photo Credit: Unknown)

Fixed gear deployed in the study area consists of pots/traps (Figure W-22) and bottom fixed gillnets (Figure W-23). 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-24) , primarily targeting conch which are typically deployed as single pots weighted with bricks (Figure W-25). In the study area, gillnets are primarily fished within 15 mi (24 km) from shore (Figure W-26). 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-27) to secure the gear to the seabed. These fixed gear fisheries will have minimal seabed penetration, approximately 12 inches (in; 30 centimeters [cm]), and pose minimal risk when compared to ship anchors.

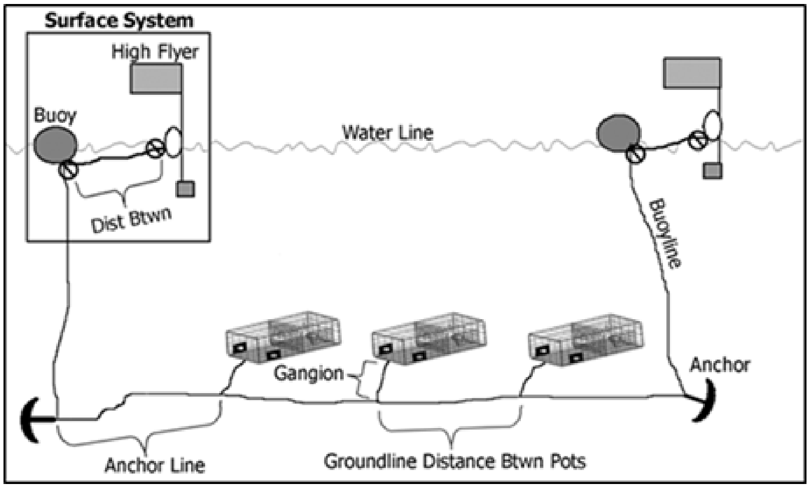


Figure W-22. Pot/Traps

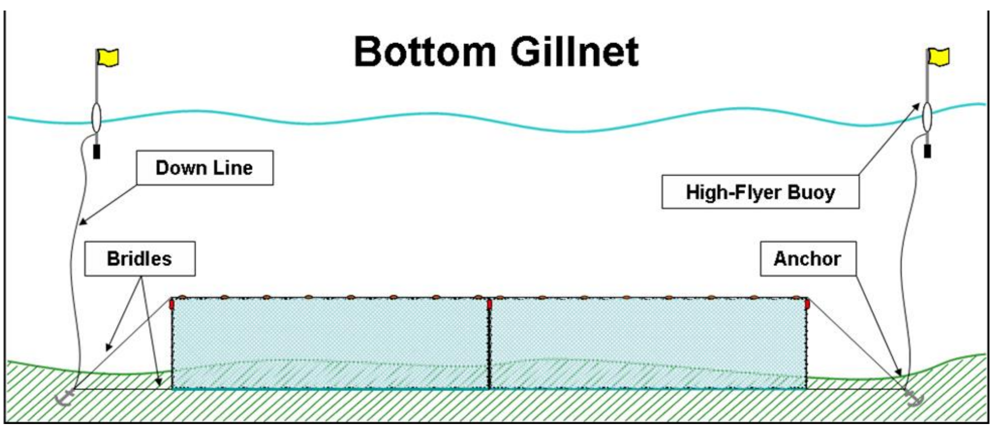


Figure W-23. Bottom Fixed Gillnet

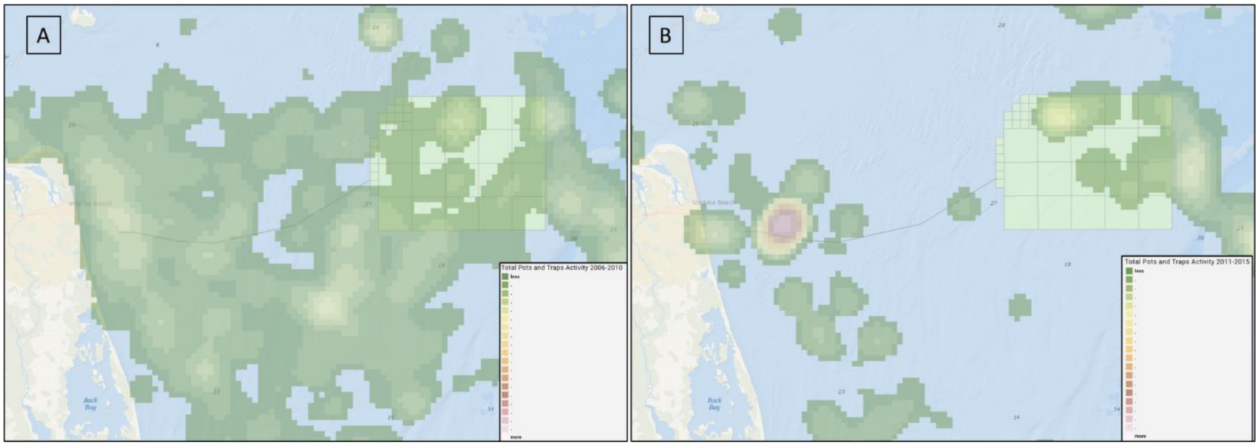


Figure W-24. Pot/Trap Vessel Trip Report (VTR) Data for the Time Periods (A) 2006-2010; (B) 2011-2015. (MARCO 2020)

Figure W-25. Conch Pots, One Buoy/bouy Line per Pot, Weighted with Bricks (Photo Credit: R. Larsen Sea Risk Solutions)

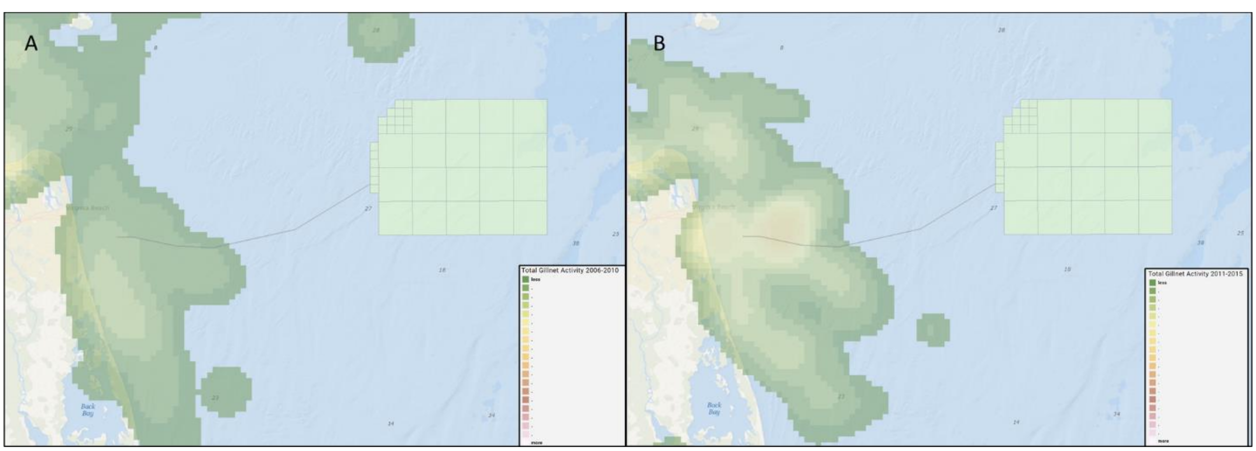


Figure W-26. Gillnet Vessel Trip Report (VTR) Data for the Time Periods (A) 2006-2010; (B) 2011-2015. (MARCO 2020)

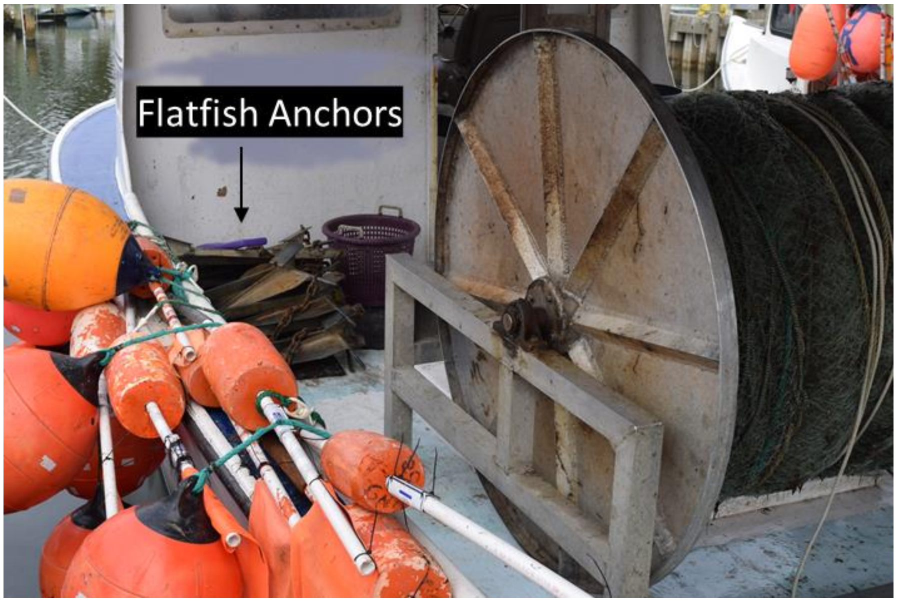


Figure W-27. Anchors on Bottom Gillnet Vessel in Virginia (Photo Credit: R. Larsen Sea Risk Solutions)

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 ECC 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-28). 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 ECC alignment located within the firing ranges.

The following sub-areas of the ECC 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 Installlation 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.

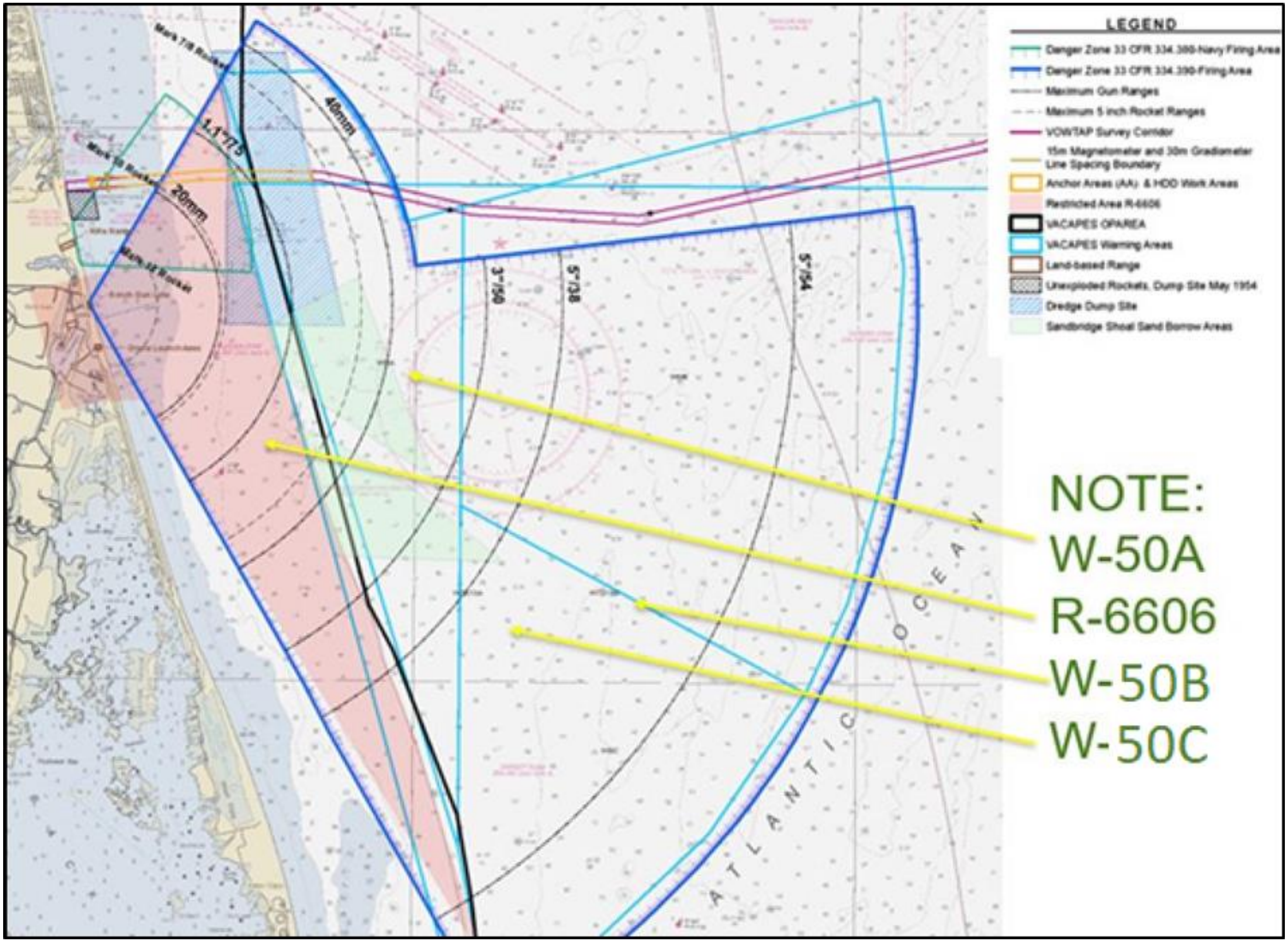


Figure W-28. **Military Restricted Zones and Warning Areas**

R-6606 – The ECC 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 ECC 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. 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 (Figure W-29).

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-29. Historical Photographs Showing Some of the Various Types of Guns Deployed at the Dam Neck Gun Line

Figure W-30 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.

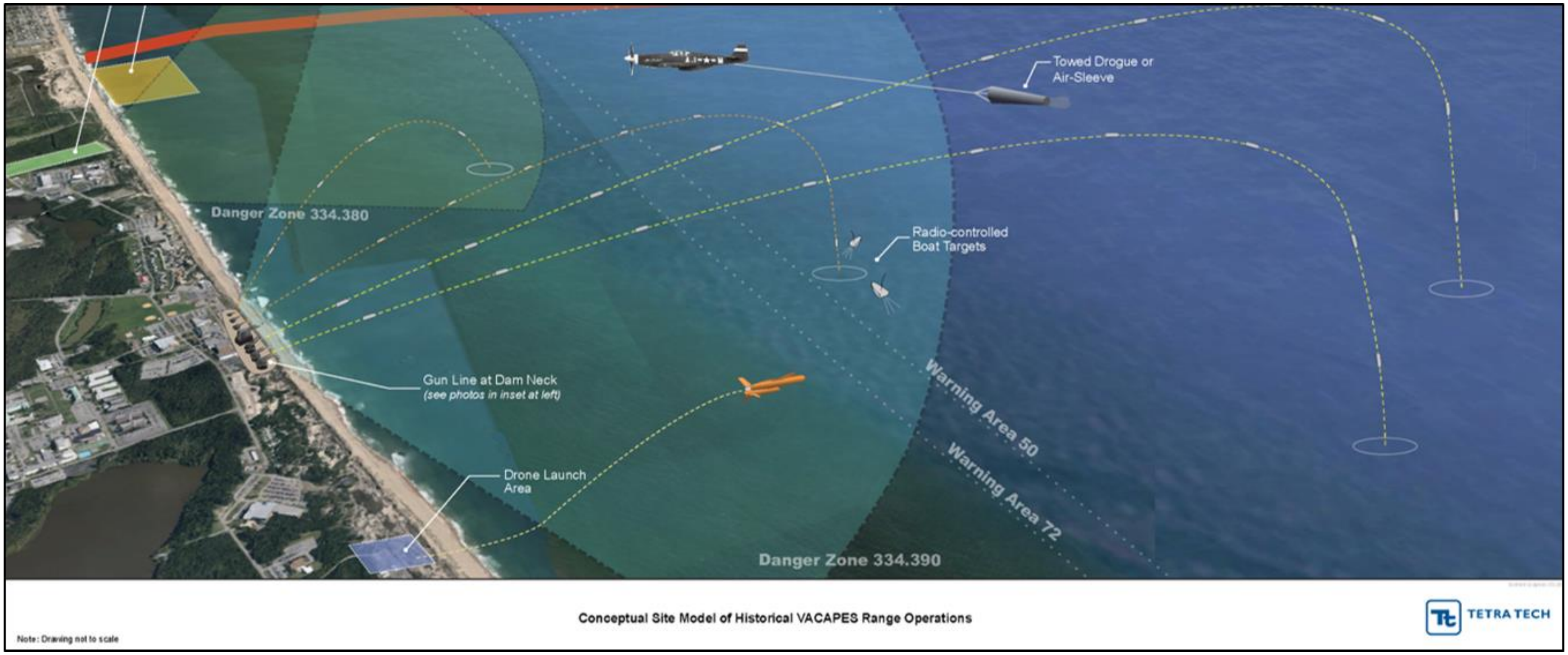


Figure W-30. Conceptual Image Showing Historical VACAPES Range Operations Including the Dam Neck Gun Line

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 ECC 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 ECC 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 CVOWCommercial Owners Engineer Metocean Assessment (Ramboll 2020) 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. A sediment mobility study in conjunction with a review of historical storm and hurricane data is understood to be planned to be conducted by Ramboll in 2021, and the arising data could be incorporated in a later update to this preliminary CBRA.

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. The later full CBRA effort can 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-31) 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.

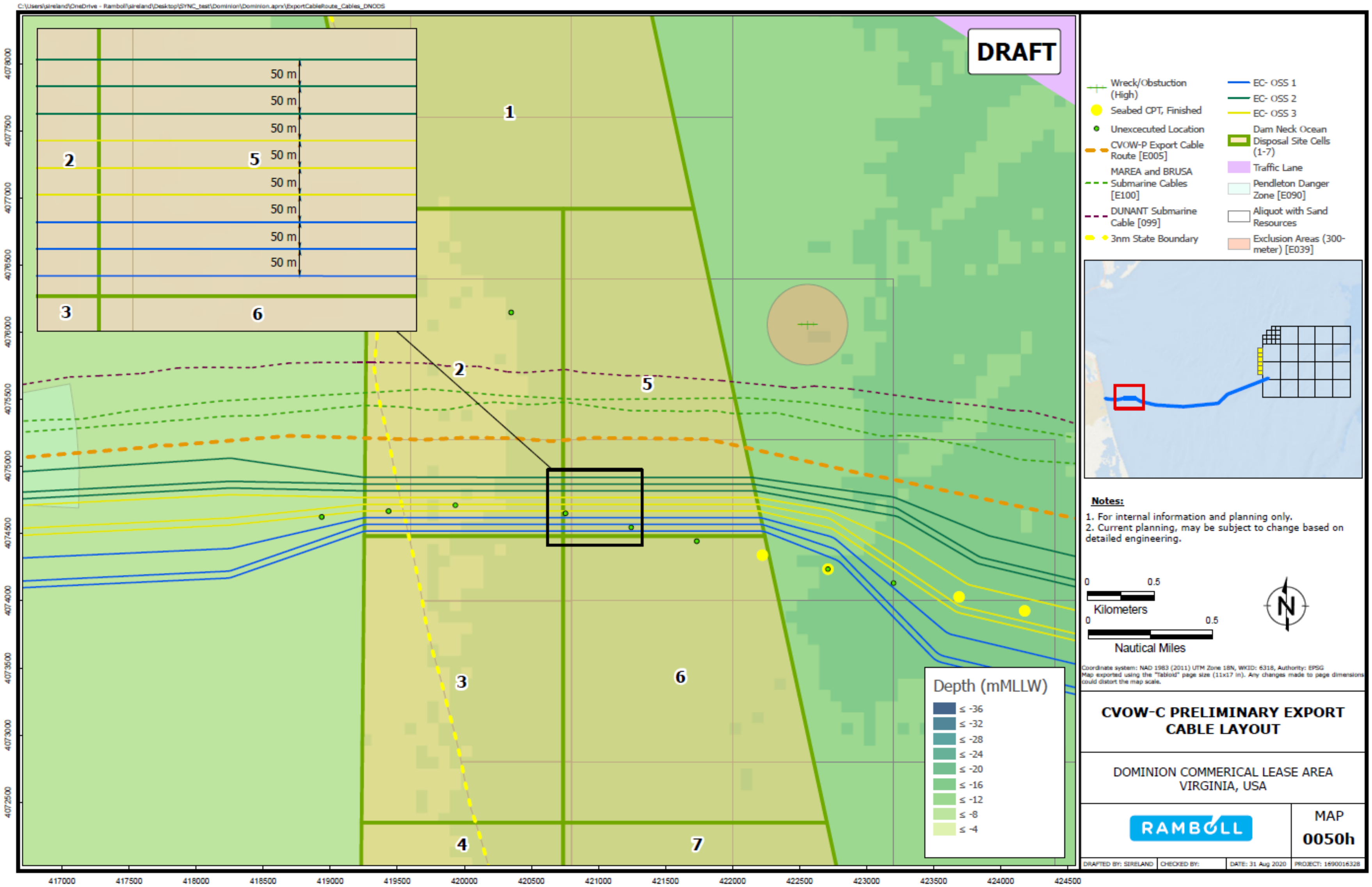


Figure W-31. Indicative Initial Layout of the Individual Export Cables where the Cables Cross the DNODS and Exhibit Decreased Spacing

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-32). 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.

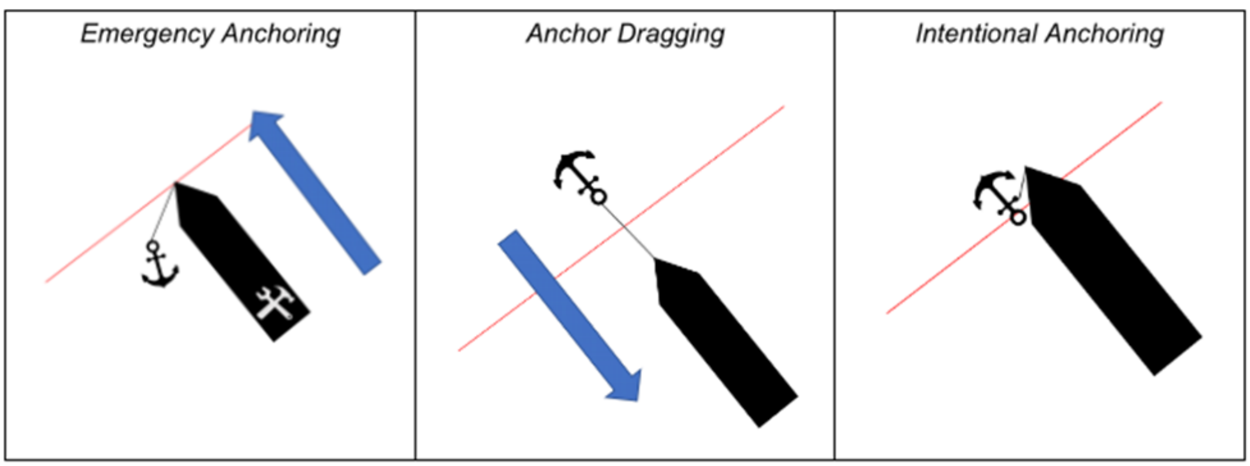


Figure W-32. Various Anchoring Scenarios

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-1. 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-1. 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 values 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 charts 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.

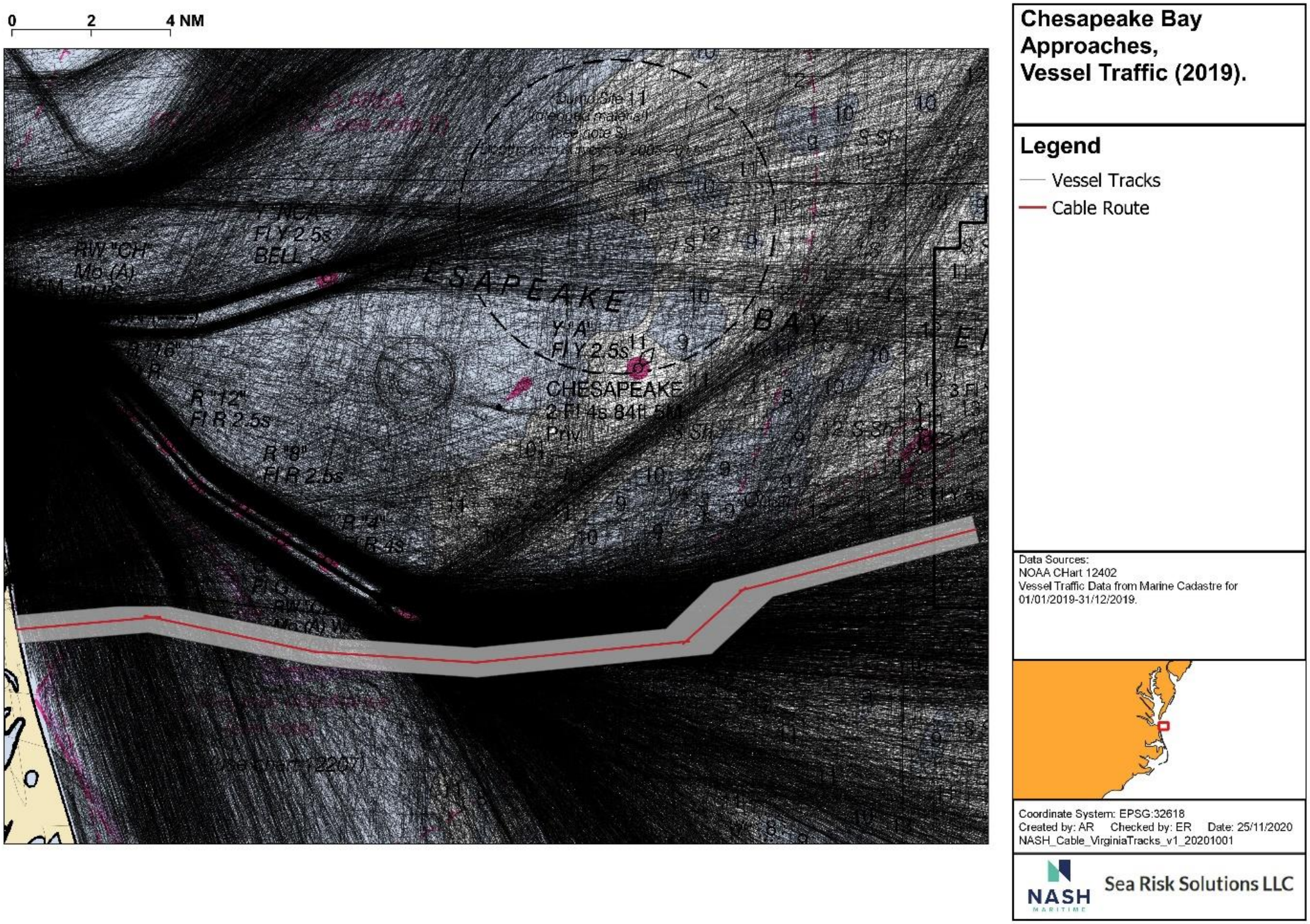


Figure W-33. 2019 AIS Heat Map – All Vessel Traffic

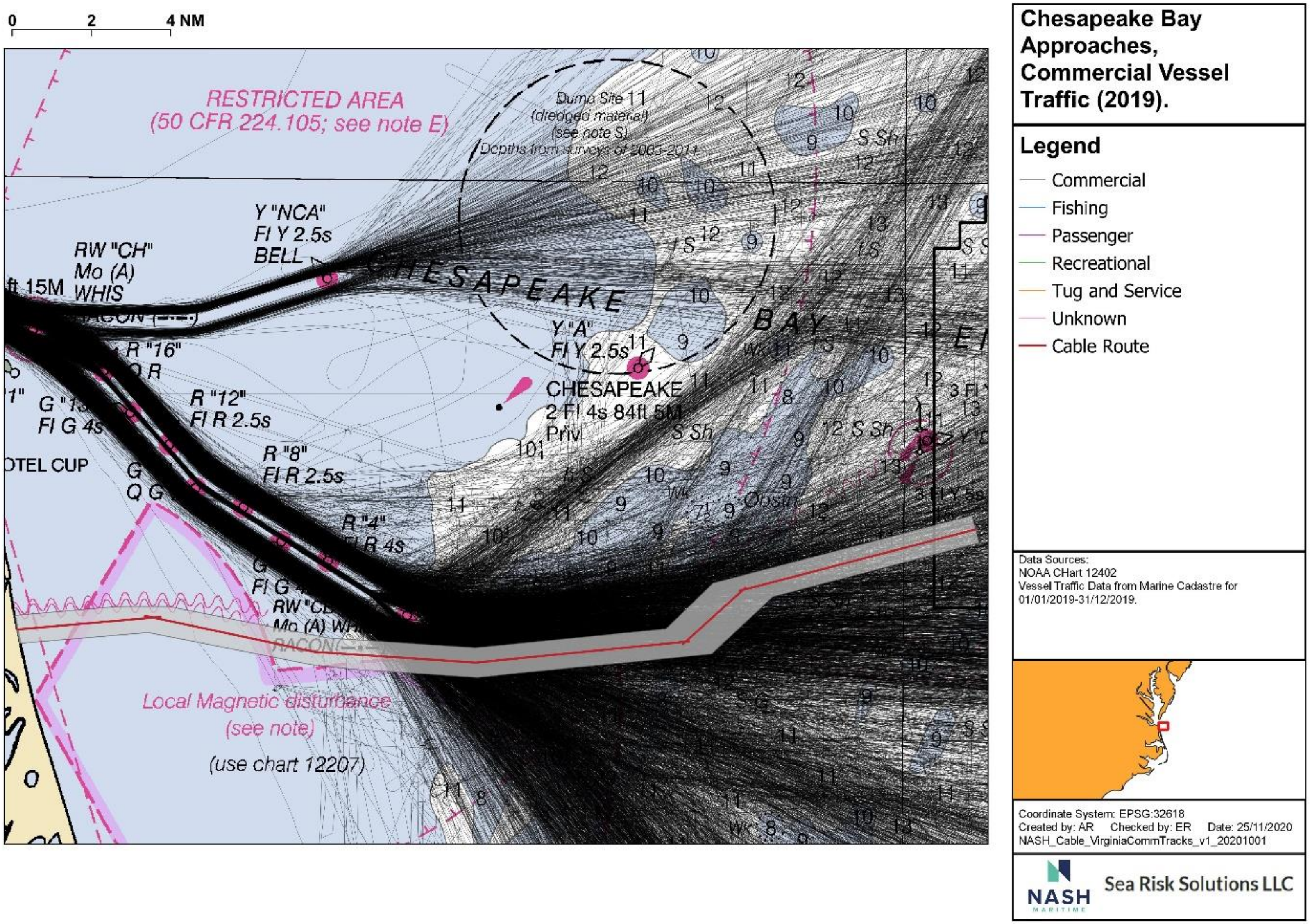


Figure W-34. 2019 AIS Heat Map – All Commercial Vessel Traffic Broken Out by Type

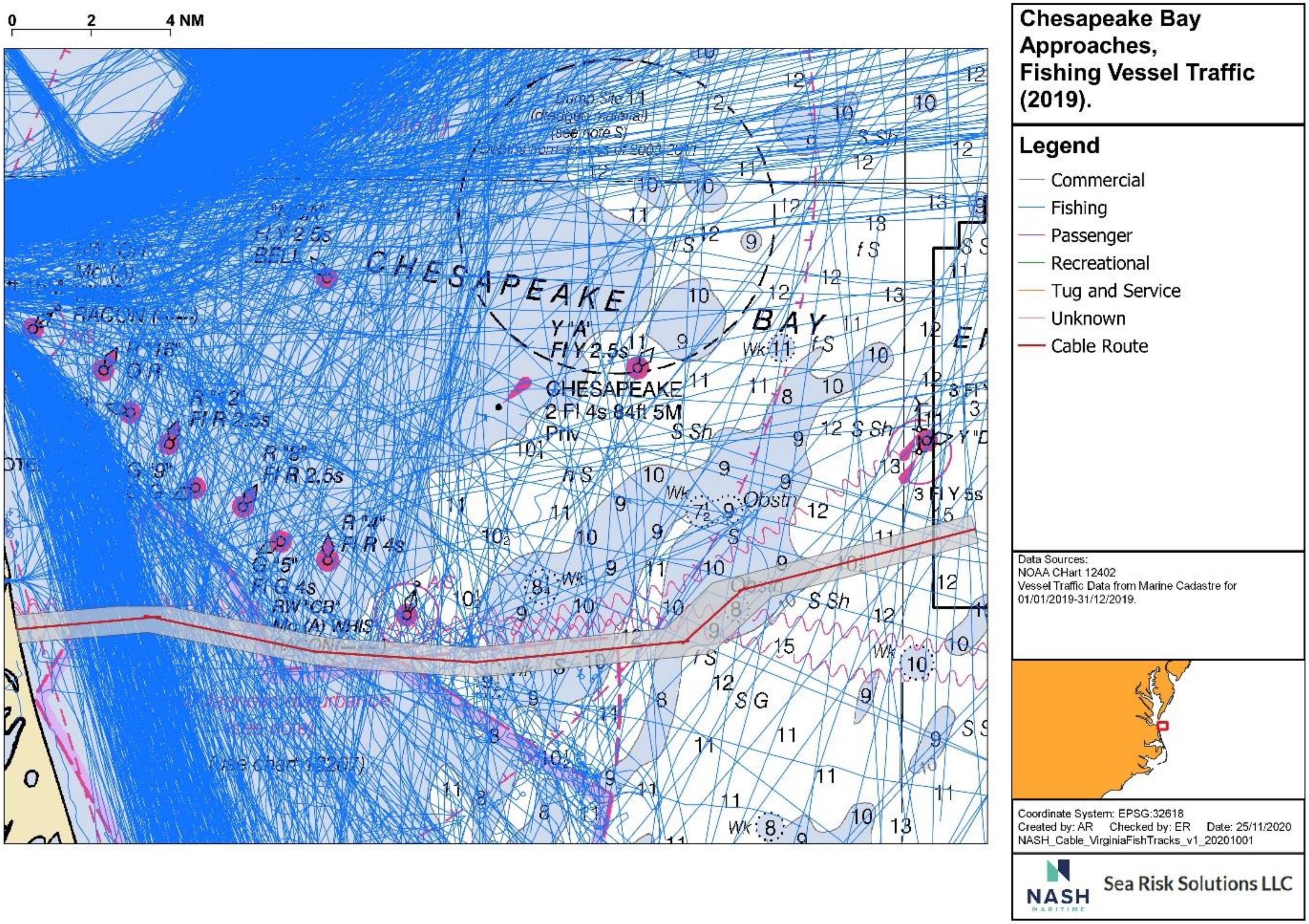


Figure W-35. **2019 AIS Heat Map – Fishing Vessel Traffic**

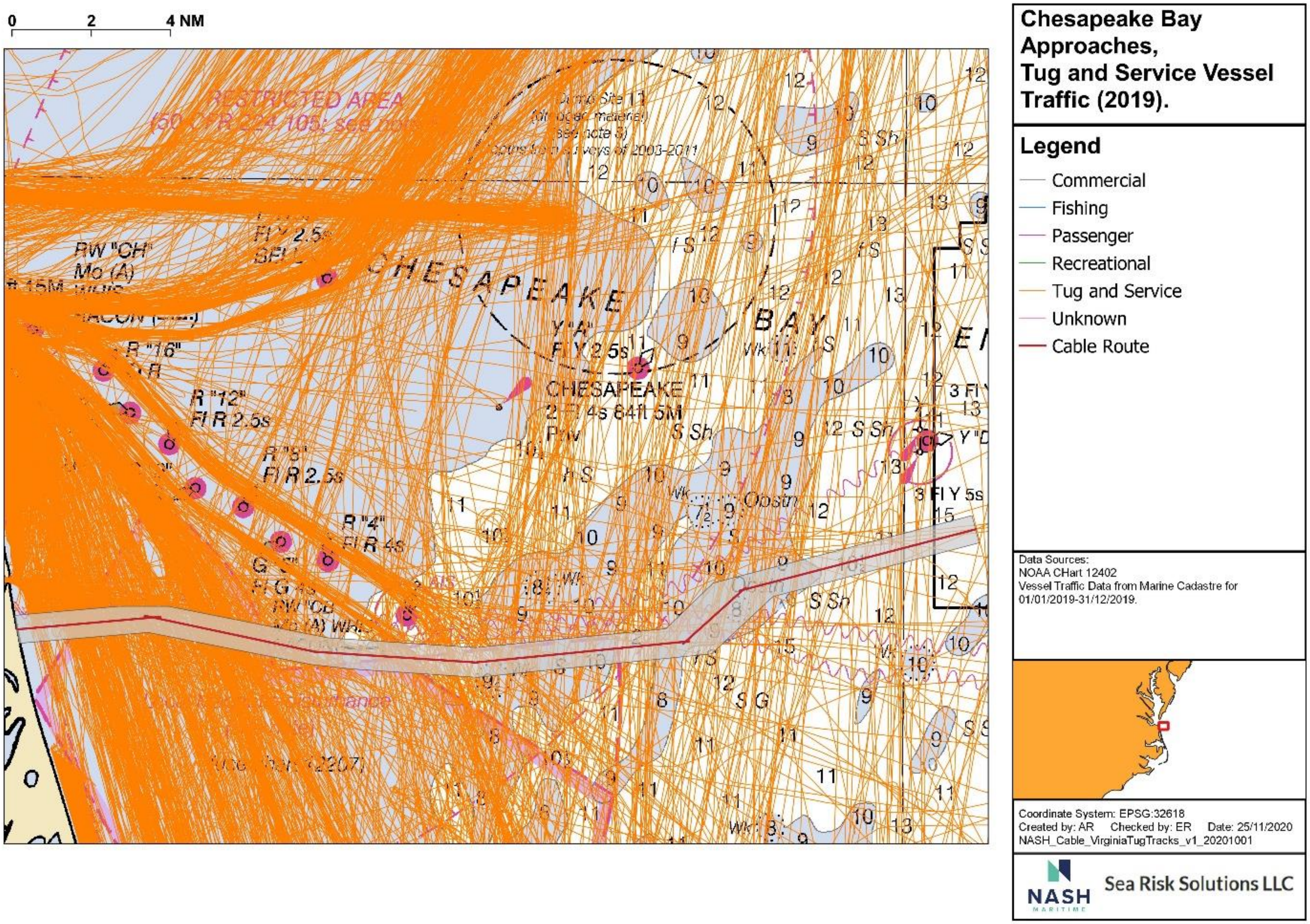


Figure W-36. 2019 AIS Heat Map – Tug and Service Vessel Traffic

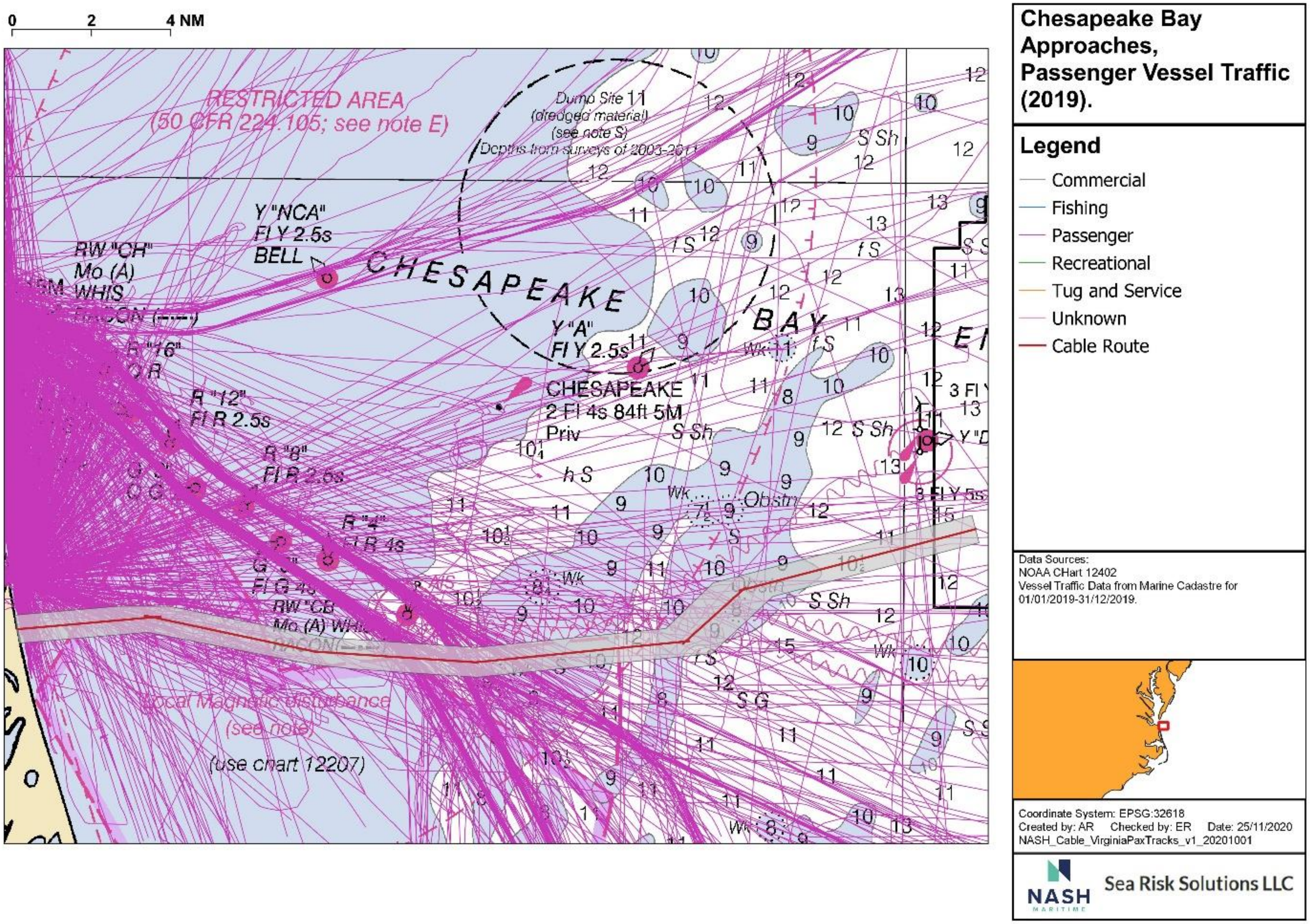


Figure W-37. 2019 AIS Heat Map – Passenger Vessel Traffic

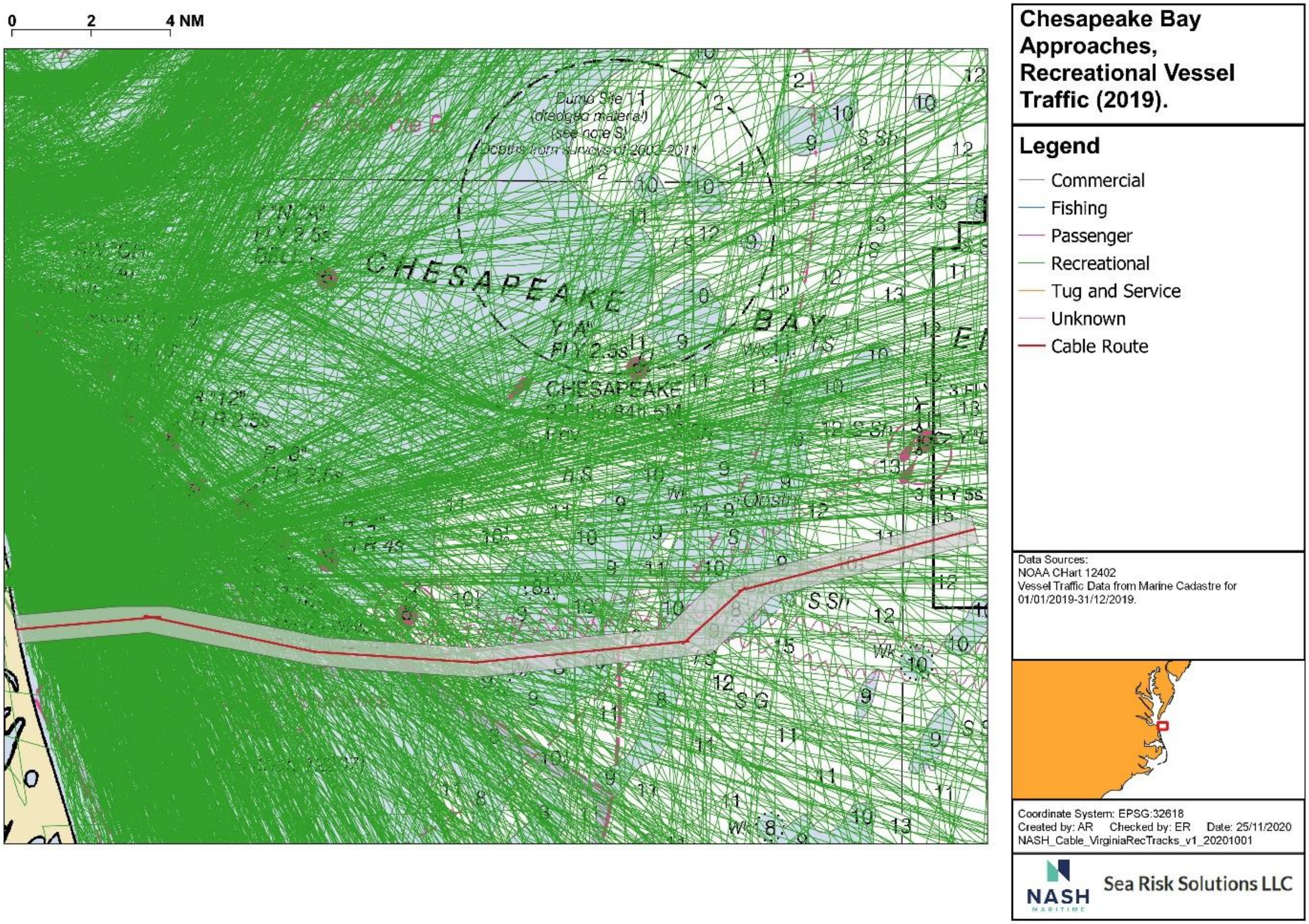


Figure W-38. 2019 AIS Heat Map – Recreational Vessel Traffic

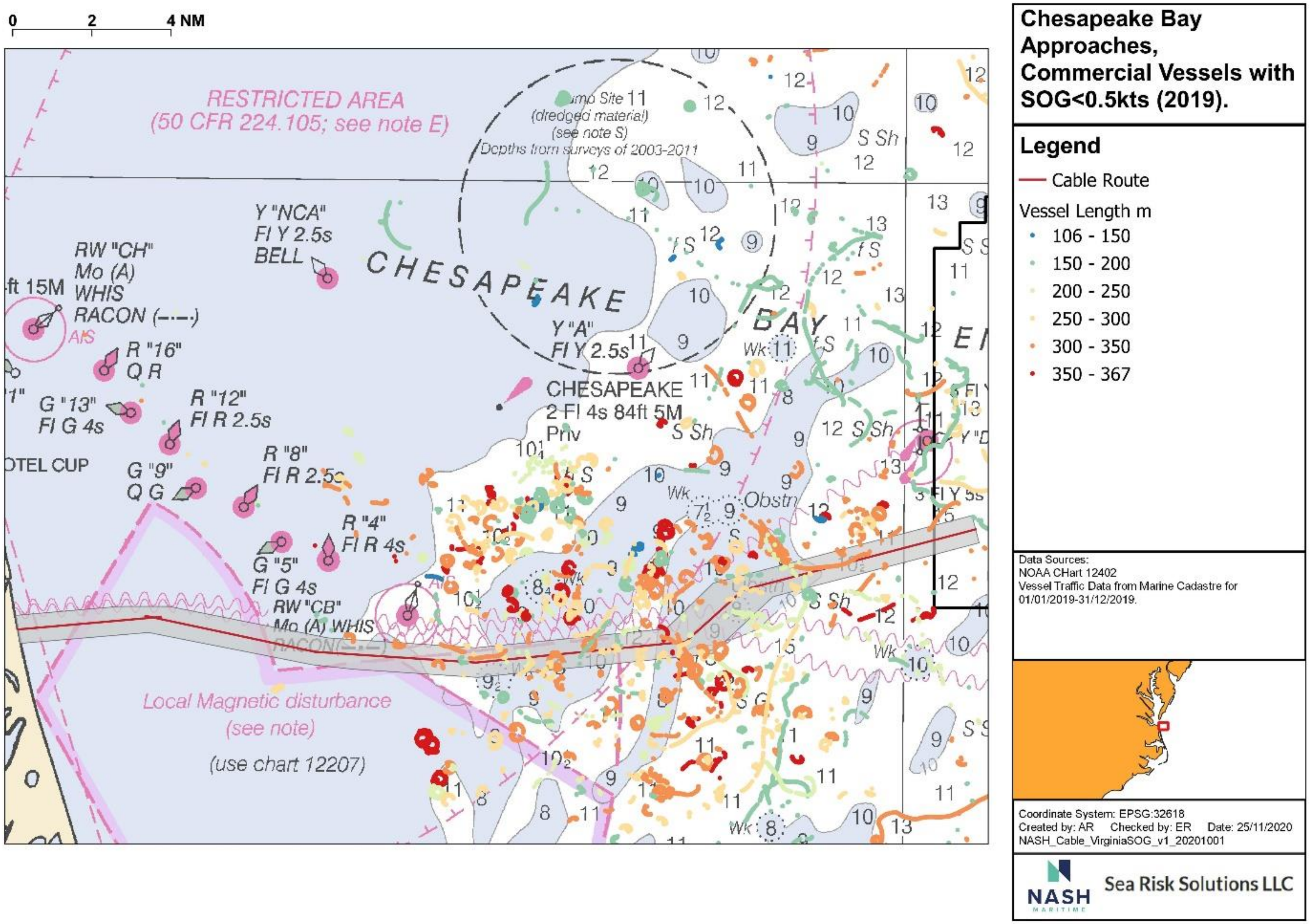


Figure W-39. 2019 AIS Heat Map – Commercial Vessel Traffic with <0.5 kts Speed (assumed anchored)

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), 3.3 ft (1.0 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 (Tables W-2 through W-6) and charts (Figure W-40 through Figure W-44) 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-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	0.05%	0.01%	0.00%	0.06%	1748	1.98%
KP2 – KP4	0.06%	0.01%	0.00%	0.06%	1566	2.21%
KP4 – KP6	0.06%	0.00%	0.00%	0.06%	1789	1.94%
KP6 – KP8	0.04%	0.00%	0.00%	0.04%	2571	1.35%
KP8 – KP10	0.04%	0.00%	0.00%	0.04%	2422	1.44%
KP10 – KP12	0.04%	0.00%	0.00%	0.04%	2711	1.28%
KP12 – KP14	0.03%	0.01%	0.00%	0.03%	3159	1.10%
KP14 – KP16	0.02%	0.00%	0.00%	0.02%	5500	0.63%
KP16 – KP18	0.03%	0.00%	0.07%	0.10%	1042	3.30%
KP18 – KP20	0.10%	0.00%	0.07%	0.18%	558	6.08%
KP20 – KP22	0.10%	0.01%	0.07%	0.17%	574	5.93%
KP22 – KP24	0.13%	0.01%	0.08%	0.22%	465	7.26%
KP24 – KP26	0.10%	0.16%	0.08%	0.34%	294	11.24%
KP26 – KP28	0.08%	0.08%	0.07%	0.24%	419	8.02%
KP28 – KP30	0.08%	0.19%	0.08%	0.35%	288	11.44%
KP30 – KP32	0.07%	0.02%	0.08%	0.17%	589	5.78%
KP32 – KP34	0.05%	0.00%	0.09%	0.14%	719	4.75%
KP34 – KP36	0.05%	0.01%	0.08%	0.13%	746	4.58%
KP36 – KP38	0.03%	0.01%	0.09%	0.13%	777	4.41%
KP38 – KP40	0.03%	0.09%	0.10%	0.22%	450	7.49%
KP40 – KP42	0.02%	0.07%	0.10%	0.19%	515	6.58%
KP42 – KP44	0.02%	0.15%	0.10%	0.28%	360	9.28%
KP44 – KP46	0.01%	0.00%	0.00%	0.01%	8008	0.44%
KP46 – END	0.00%	0.00%	0.00%	0.00%	42768	0.08%
			Total cable Risk:	**3.167%**	**32**	**67.57%**

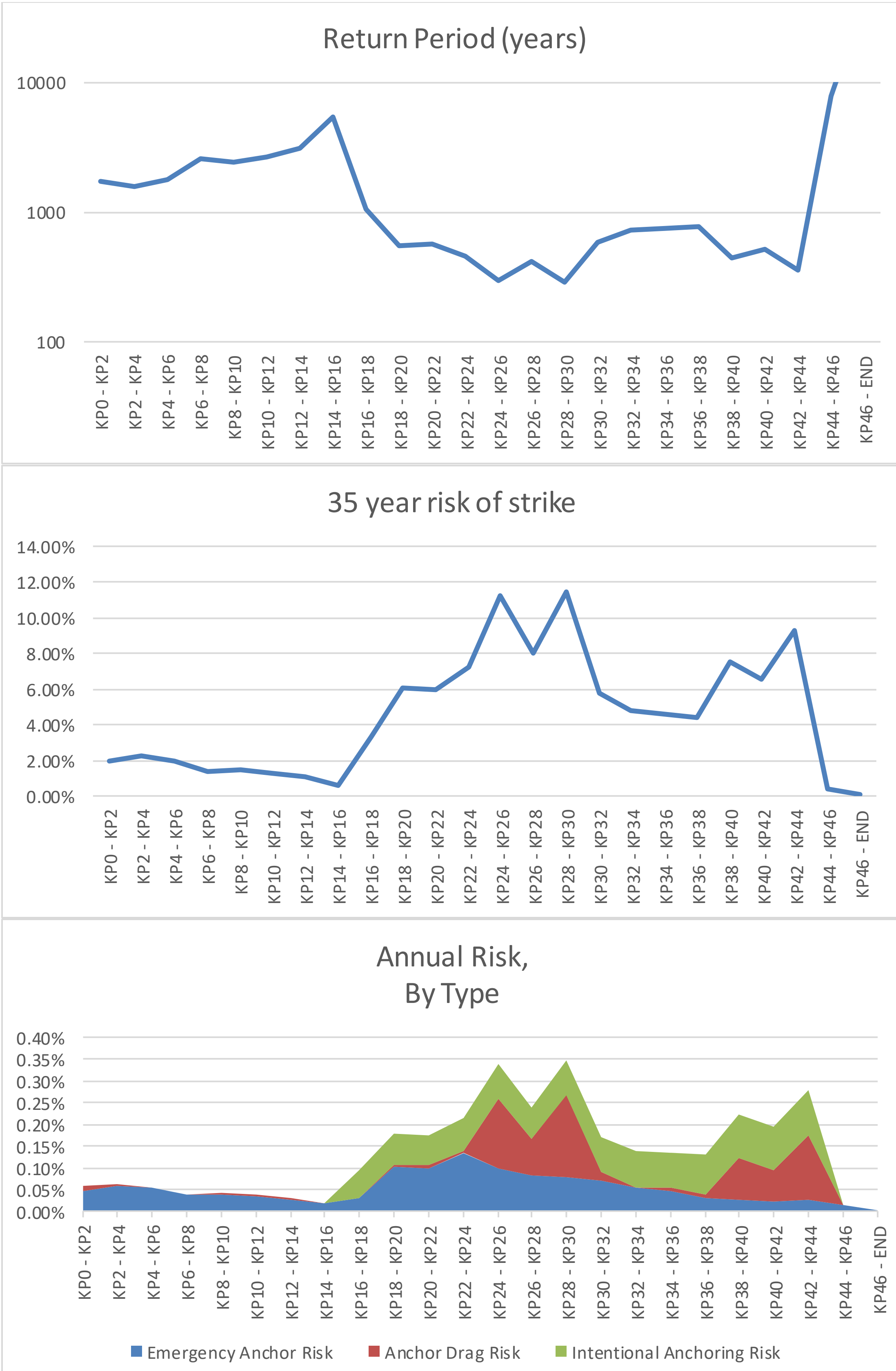


Figure W-40. 0-m Burial Depth Risk Profiles

Table W-3 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	0.05%	0.01%	0.00%	0.06%	1778	1.95%
KP2 - KP4	0.05%	0.01%	0.00%	0.06%	1647	2.10%
KP4 - KP6	0.05%	0.00%	0.00%	0.05%	1941	1.79%
KP6 - KP8	0.03%	0.00%	0.00%	0.03%	2873	1.21%
KP8 - KP10	0.04%	0.00%	0.00%	0.04%	2676	1.30%
KP10 - KP12	0.03%	0.00%	0.00%	0.04%	2844	1.22%
KP12 - KP14	0.02%	0.01%	0.00%	0.03%	3324	1.05%
KP14 - KP16	0.01%	0.00%	0.00%	0.02%	6201	0.56%
KP16 - KP18	0.03%	0.00%	0.07%	0.09%	1061	3.25%
KP18 - KP20	0.10%	0.00%	0.07%	0.18%	564	6.02%
KP20 - KP22	0.10%	0.01%	0.07%	0.17%	579	5.87%
KP22 - KP24	0.13%	0.01%	0.08%	0.21%	469	7.20%
KP24 - KP26	0.10%	0.16%	0.08%	0.34%	295	11.22%
KP26 - KP28	0.08%	0.08%	0.07%	0.24%	421	7.99%
KP28 - KP30	0.08%	0.19%	0.08%	0.35%	289	11.41%
KP30 - KP32	0.07%	0.02%	0.08%	0.17%	592	5.74%
KP32 - KP34	0.05%	0.00%	0.09%	0.14%	722	4.74%
KP34 - KP36	0.05%	0.01%	0.08%	0.13%	750	4.57%
KP36 - KP38	0.03%	0.01%	0.09%	0.13%	780	4.39%
KP38 - KP40	0.03%	0.09%	0.10%	0.22%	451	7.47%
KP40 - KP42	0.02%	0.07%	0.10%	0.19%	516	6.56%
KP42 - KP44	0.02%	0.15%	0.10%	0.28%	360	9.27%
KP44 - KP46	0.01%	0.00%	0.00%	0.01%	8073	0.43%
KP46 - END	0.00%	0.00%	0.00%	0.00%	42768	0.08%
			Total cable Risk:	**3.132%**	**32**	**67.17%**

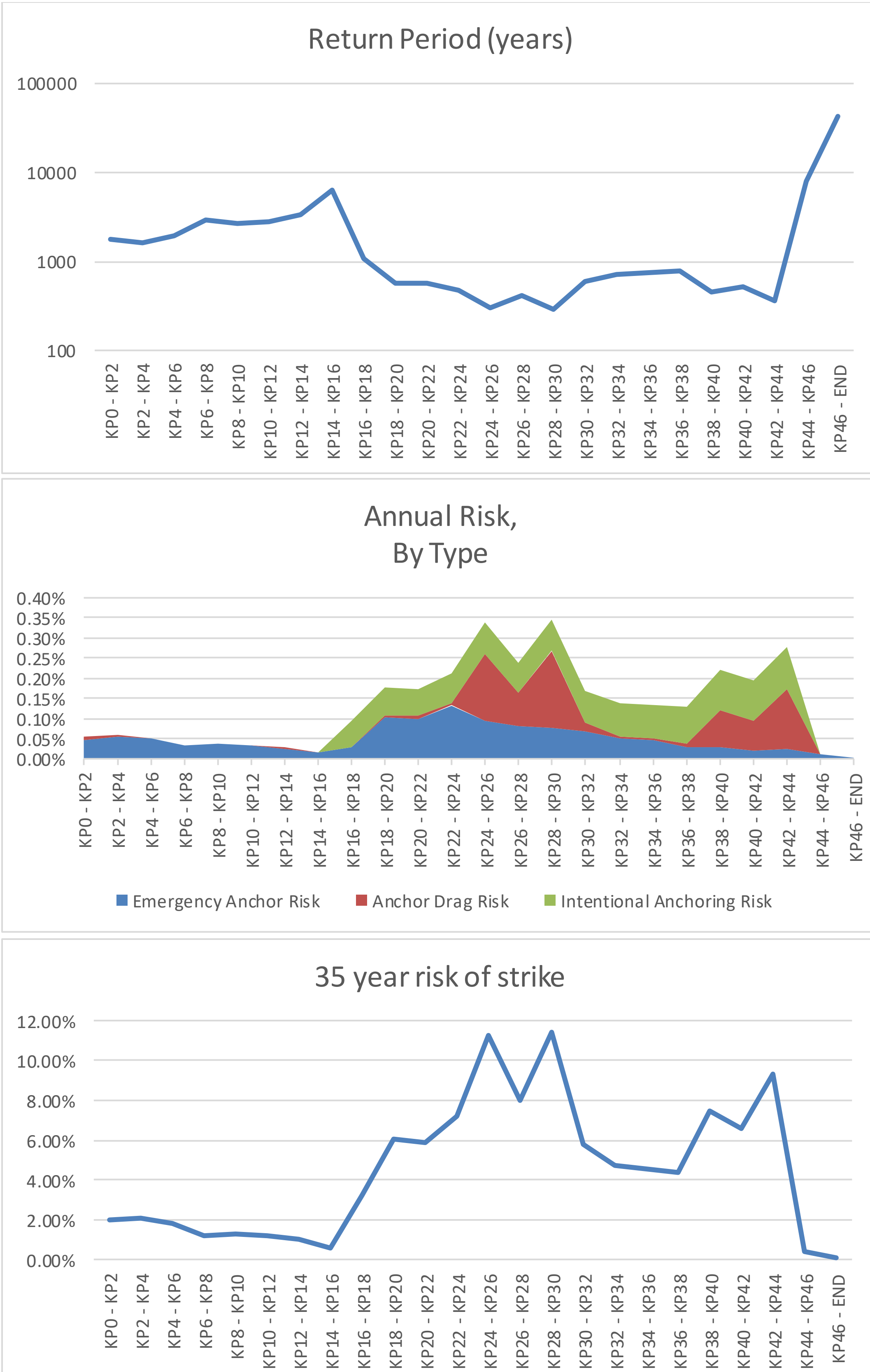


Figure W-41. **1.6-foot (0.5-m) Burial Depth Risk Profiles**

Table W-4 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	0.00%	0.00%	0.00%	0.00%	99900	0.04%
KP2 - KP4	0.00%	0.00%	0.00%	0.00%	28905	0.12%
KP4 - KP6	0.00%	0.00%	0.00%	0.00%	34594	0.10%
KP6 - KP8	0.00%	0.00%	0.00%	0.00%	24731	0.14%
KP8 - KP10	0.01%	0.00%	0.00%	0.01%	14831	0.24%
KP10 - KP12	0.01%	0.00%	0.00%	0.01%	12681	0.28%
KP12 - KP14	0.00%	0.00%	0.00%	0.01%	17584	0.20%
KP14 - KP16	0.00%	0.00%	0.00%	0.00%	21518	0.16%
KP16 - KP18	0.01%	0.00%	0.05%	0.06%	1633	2.12%
KP18 - KP20	0.08%	0.00%	0.05%	0.14%	718	4.76%
KP20 - KP22	0.08%	0.01%	0.05%	0.13%	750	4.56%
KP22 - KP24	0.11%	0.01%	0.06%	0.17%	580	5.86%
KP24 - KP26	0.08%	0.16%	0.06%	0.31%	327	10.15%
KP26 - KP28	0.07%	0.08%	0.05%	0.21%	481	7.02%
KP28 - KP30	0.07%	0.19%	0.06%	0.31%	318	10.43%
KP30 - KP32	0.06%	0.02%	0.06%	0.14%	710	4.81%
KP32 - KP34	0.05%	0.00%	0.06%	0.11%	898	3.83%
KP34 - KP36	0.04%	0.00%	0.06%	0.11%	951	3.61%
KP36 - KP38	0.03%	0.01%	0.07%	0.10%	990	3.47%
KP38 - KP40	0.02%	0.09%	0.08%	0.19%	523	6.48%
KP40 - KP42	0.02%	0.07%	0.07%	0.16%	607	5.61%
KP42 - KP44	0.02%	0.15%	0.08%	0.25%	404	8.32%
KP44 - KP46	0.01%	0.00%	0.00%	0.01%	8932	0.39%
KP46 - END	0.00%	0.00%	0.00%	0.00%	46680	0.07%
		Total Cable Risk:		**2.418%**	**41**	**57.55%**

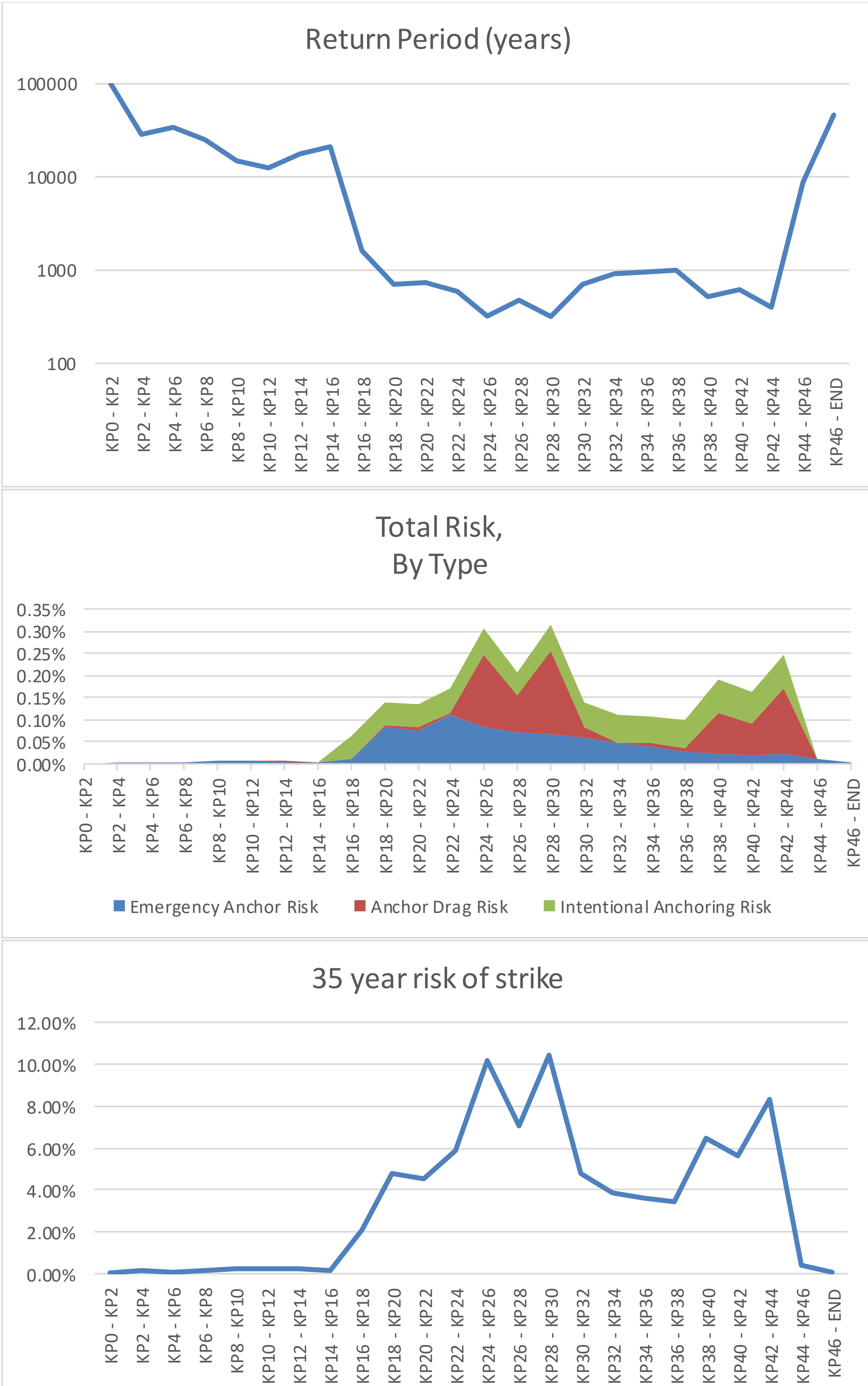
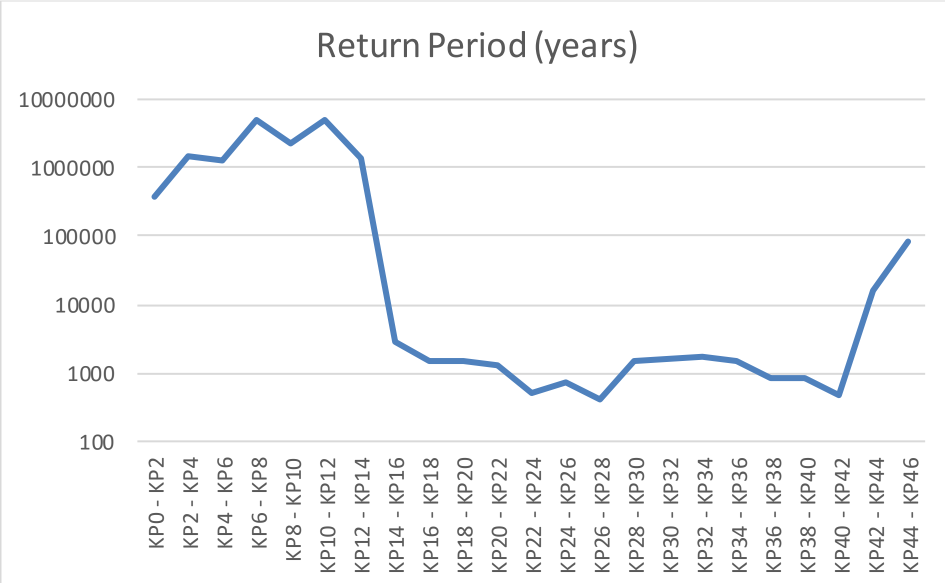


Figure W-42. 3.3-foot (1.0-m) Burial Depth Risk Profiles

Table W-5 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	0.00%	0.00%	0.00%	0.00%	inf	0.00%
KP2 - KP4	0.00%	0.00%	0.00%	0.00%	381518	0.01%
KP4 - KP6	0.00%	0.00%	0.00%	0.00%	1449275	0.00%
KP6 - KP8	0.00%	0.00%	0.00%	0.00%	1239669	0.00%
KP8 - KP10	0.00%	0.00%	0.00%	0.00%	5000000	0.00%
KP10 - KP12	0.00%	0.00%	0.00%	0.00%	2325581	0.00%
KP12 - KP14	0.00%	0.00%	0.00%	0.00%	5000000	0.00%
KP14 - KP16	0.00%	0.00%	0.00%	0.00%	1379310	0.00%
KP16 - KP18	0.00%	0.00%	0.03%	0.03%	2918	1.19%
KP18 - KP20	0.03%	0.00%	0.03%	0.06%	1539	2.25%
KP20 - KP22	0.03%	0.00%	0.03%	0.07%	1524	2.27%
KP22 - KP24	0.04%	0.00%	0.04%	0.08%	1301	2.66%
KP24 - KP26	0.03%	0.13%	0.04%	0.20%	501	6.76%
KP26 - KP28	0.03%	0.07%	0.03%	0.13%	747	4.58%
KP28 - KP30	0.03%	0.18%	0.04%	0.24%	410	8.20%
KP30 - KP32	0.03%	0.01%	0.04%	0.07%	1443	2.40%
KP32 - KP34	0.02%	0.00%	0.04%	0.06%	1621	2.14%
KP34 - KP36	0.02%	0.00%	0.04%	0.06%	1696	2.04%
KP36 - KP38	0.02%	0.01%	0.04%	0.07%	1528	2.27%
KP38 - KP40	0.01%	0.06%	0.05%	0.12%	835	4.11%
KP40 - KP42	0.01%	0.06%	0.05%	0.12%	830	4.13%
KP42 - KP44	0.01%	0.15%	0.05%	0.21%	471	7.17%
KP44 - KP46	0.01%	0.00%	0.00%	0.01%	16089	0.22%
KP46 - END	0.00%	0.00%	0.00%	0.00%	81183	0.04%
			Total Cable Risk:	**1.525%**	**66**	**41.59%**



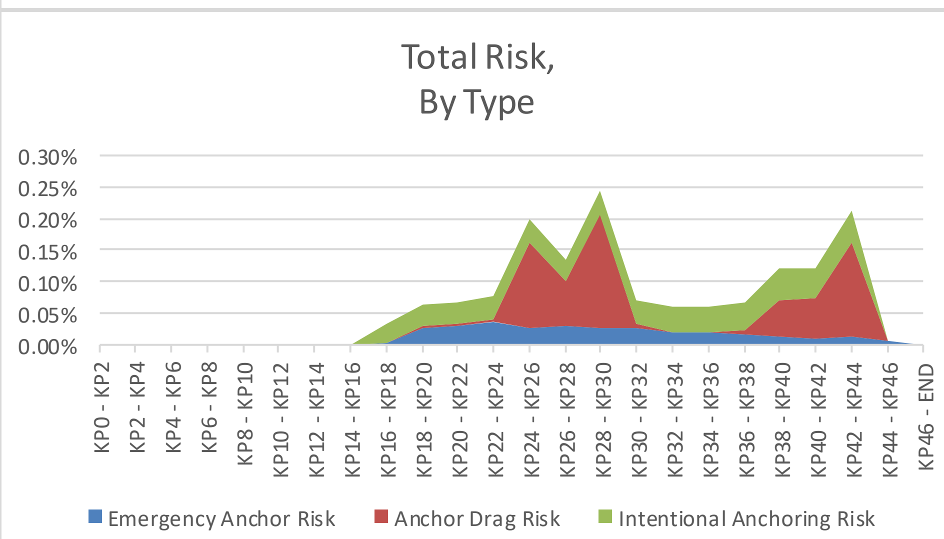


Figure W-43. 5-foot (1.5-m) Burial Depth Risk Profiles

Table W-6 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	0	0	0	∞	0.000%
KP2 - KP4	0	0	0	0	∞	0.000%
KP4 - KP6	0	0	0	0	∞	0.000%
KP6 - KP8	0	0	0	0	∞	0.000%
KP8 - KP10	0	0	0	0	∞	0.000%
KP10 - KP12	0	0	0	0	∞	0.000%
KP12 - KP14	0	0	0	0	∞	0.000%
KP14 - KP16	0	0	0	0	∞	0.000%
KP16 - KP18	0	0	0	0	∞	0.000%
KP18 - KP20	0	0	0	0	∞	0.000%
KP20 - KP22	1.36×10^{-6}	0	0	1.36×10^{-6}	733,198	0.005%
KP22 - KP24	5.40×10^{-6}	0	0	5.40×10^{-6}	185,128	0.019%
KP24 - KP26	2.53×10^{-6}	0	0	2.53×10^{-6}	394,997	0.009%
KP26 - KP28	2.33×10^{-7}	0	0	2.33×10^{-7}	4,285,714	0.001%
KP28 - KP30	0	0	0	0	∞	0.000%
KP30 - KP32	0	0	0	0	∞	0.000%
KP32 - KP34	0	0	0	0	∞	0.000%
KP34 - KP36	1.07×10^{-6}	0	0	1.07×10^{-6}	937,500	0.004%
KP36 - KP38	5.28×10^{-7}	0	0	5.28×10^{-7}	1,894,737	0.002%
KP38 - KP40	1.00×10^{-6}	0	0	1.00×10^{-6}	1,000,000	0.003%
KP30 - KP42	7.58×10^{-7}	0	0	7.58×10^{-7}	1,319,648	0.003%
KP42 - KP44	6.00×10^{-7}	0	0	6.00×10^{-7}	1,666,667	0.002%
KP44 - KP46	0	0	0	0	∞	0.000%
KP46 - END	0	0	0	0	∞	0.000%
			Total Cable Risk:	**0.001%**	**74,169**	**0.0472%**

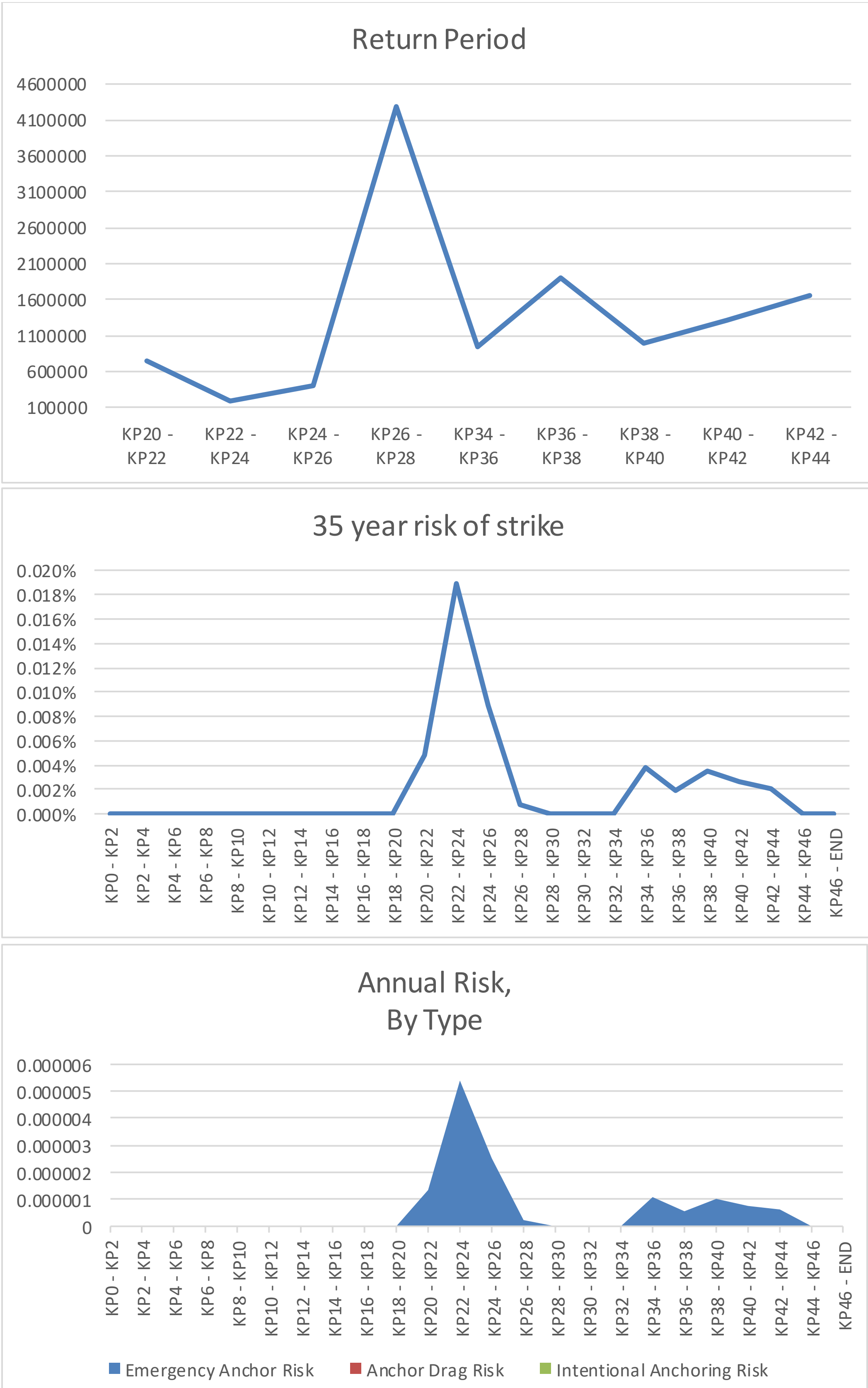


Figure W-44. 6.5-foot (2.0-m) Burial Depth Risk Profiles

W.6.2.3 Conclusions

This ECC 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 arises 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.

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, as will some fishing traffic. 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 risk. 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.

In summary, carefully selecting varying 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. Further, ongoing survey efforts will yield seabed data to inform the potential need for additional static burial below loose, soft, or mobile sediments in areas yet to be determined. Initial information indicates this should be an additive modifier such that target lowering is equal to the specified depth of lowering for a given risk level plus an amount of lowering to get below the surficial soft or mobile seabed.

The following area based cable risk assessment further supports the above general recommendations. Exact series of burial depths can be recommended provided risk appetites per segment and in aggregate.

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-45 through Figure W-59). 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.

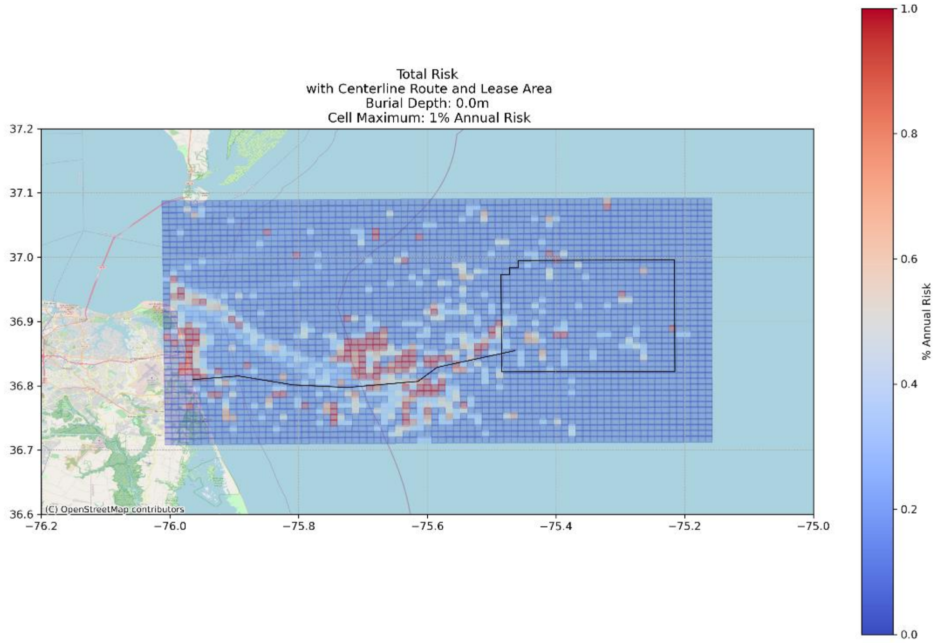


Figure W-45. Area Based Total Risk Chart, 0-m Burial Depth

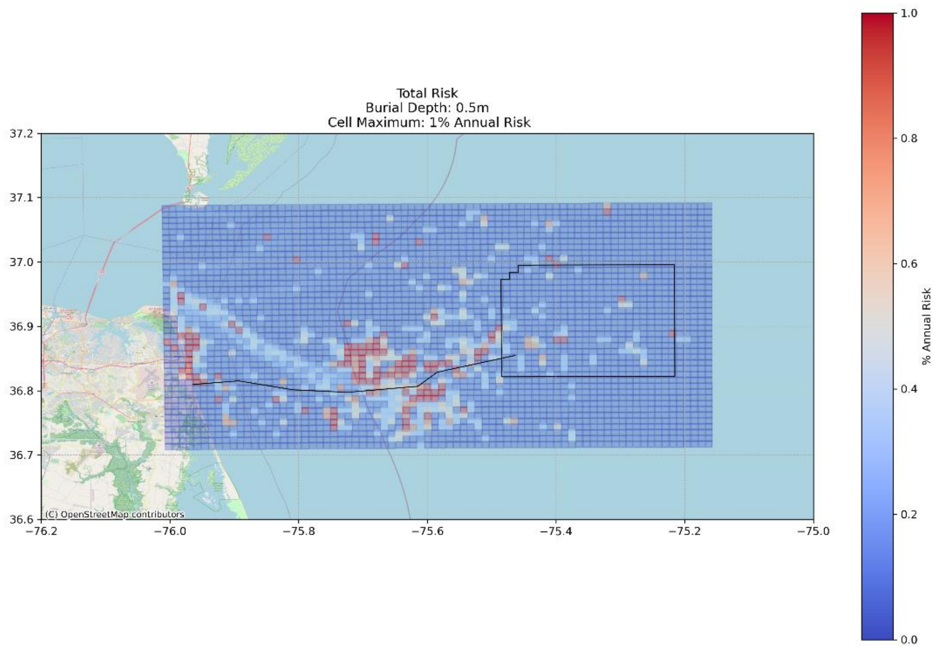


Figure W-46. Area Based Total Risk Chart, 1.6-ft (0.5-m) Burial Depth

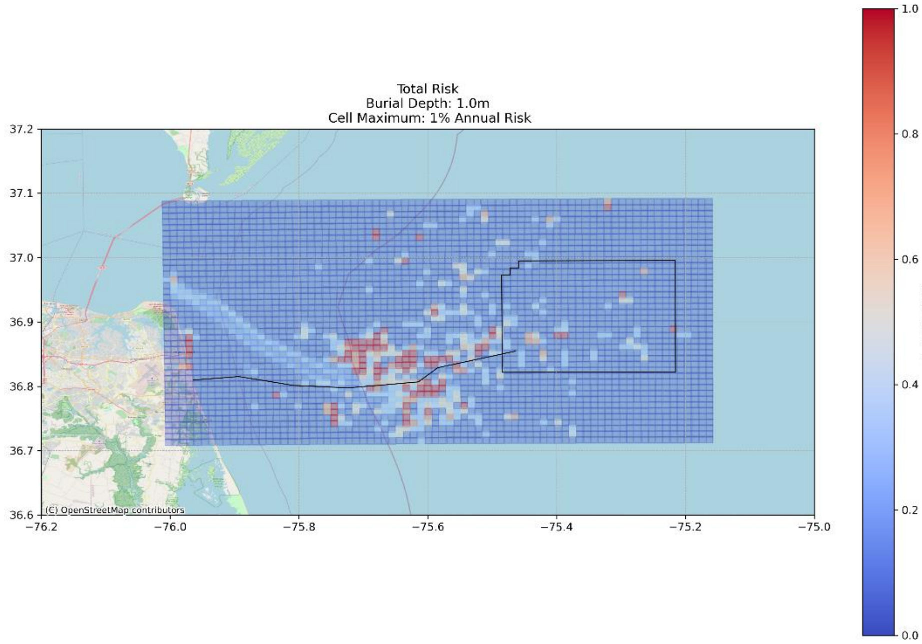


Figure W-47. Area Based Total Risk Chart, 3.3-ft (1.0-m) Burial Depth

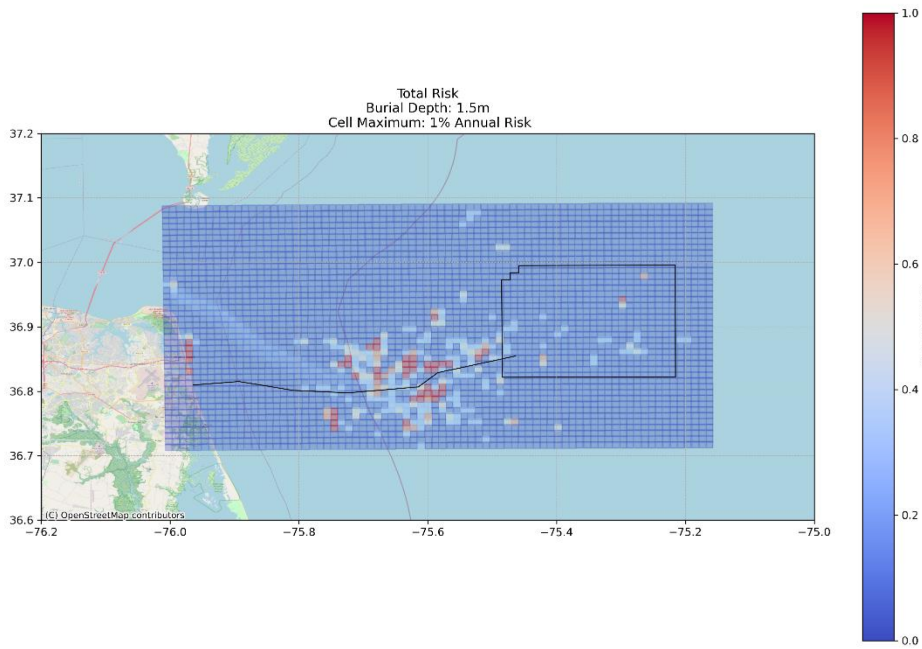


Figure W-48. Area Based Total Risk Chart, 5-ft (1.5-m) Burial Depth

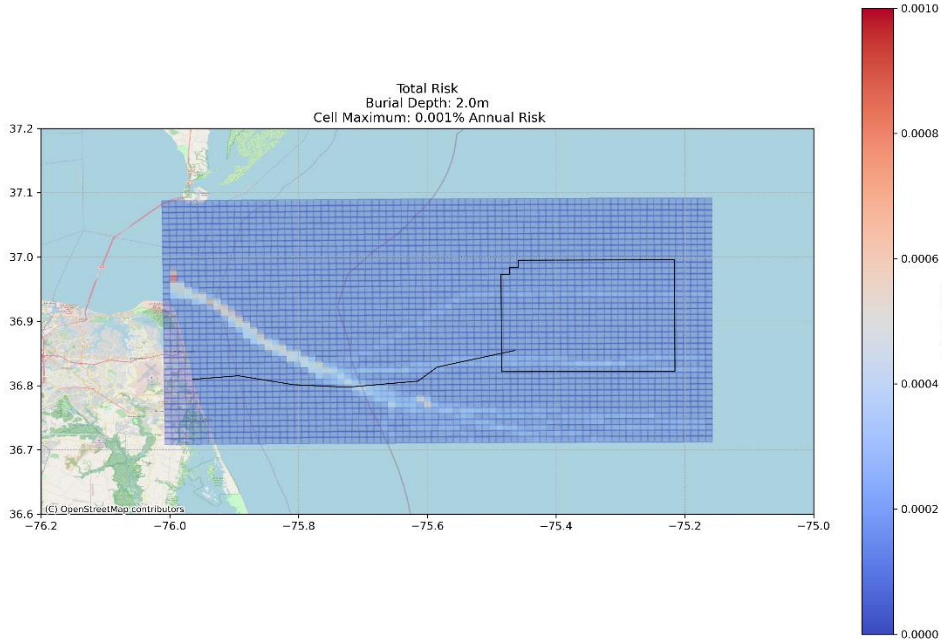


Figure W-49. Area Based Total Risk Chart, 6.6-ft (2.0-m) Burial Depth

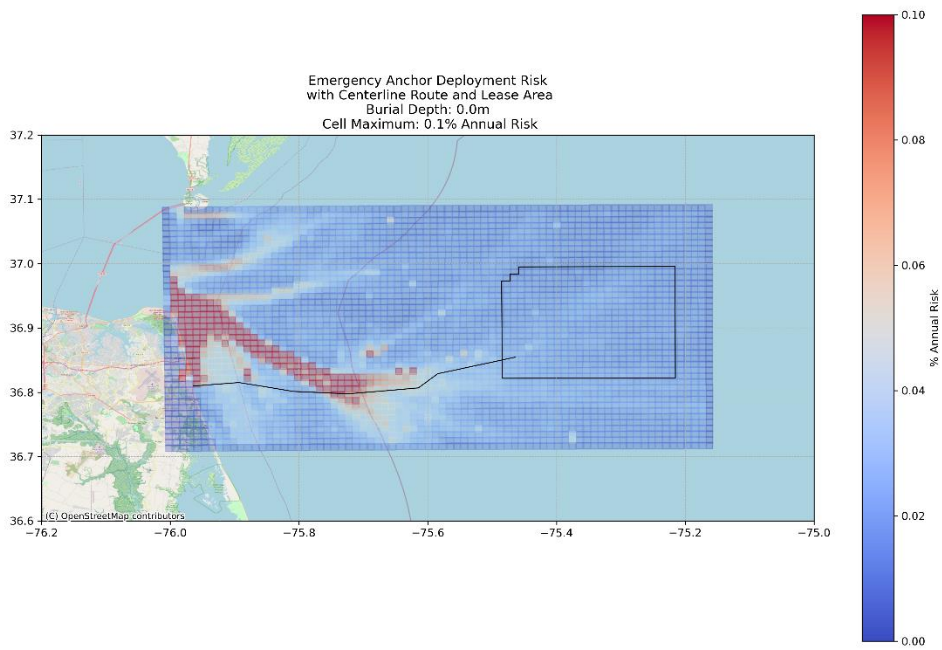


Figure W-50. Area Based Emergency Anchoring Risk Chart, 0-m Burial Depth

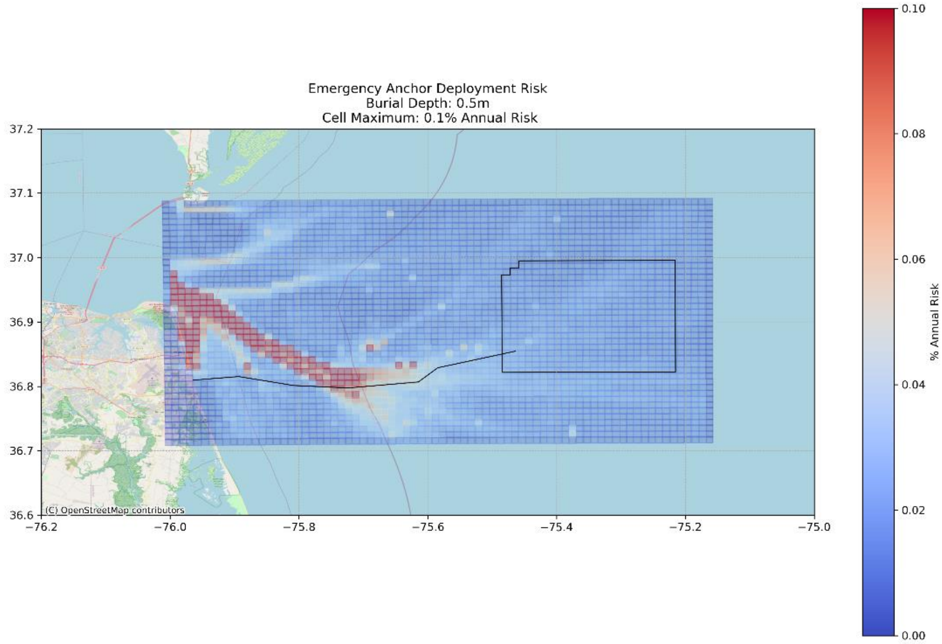


Figure W-51. Area Based Emergency Anchoring Risk Chart, 1.6-ft (0.5-m) Burial Depth

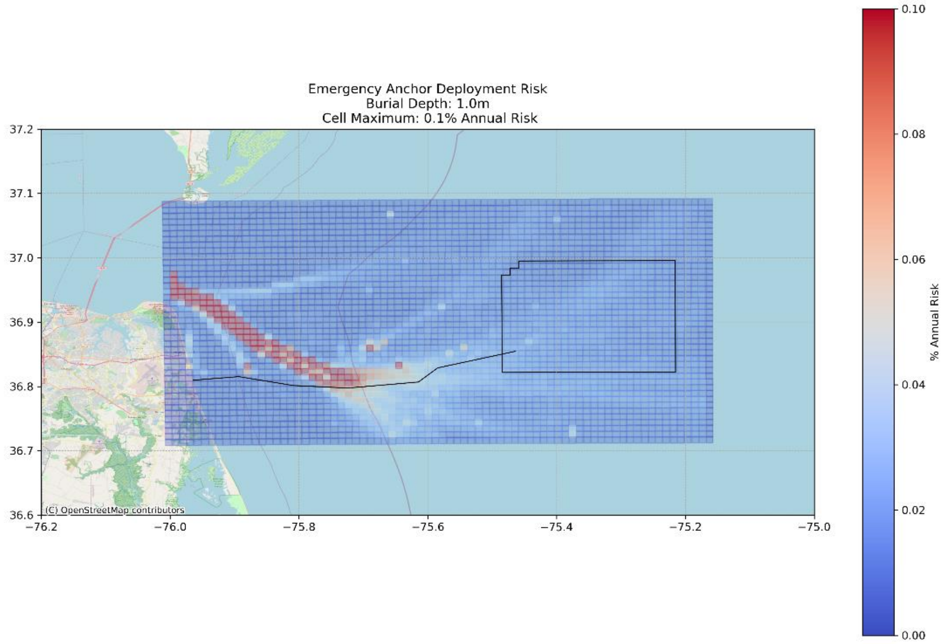


Figure W-52. Area Based Emergency Anchoring Risk Chart, 3.3-ft (1.0-m) Burial Depth

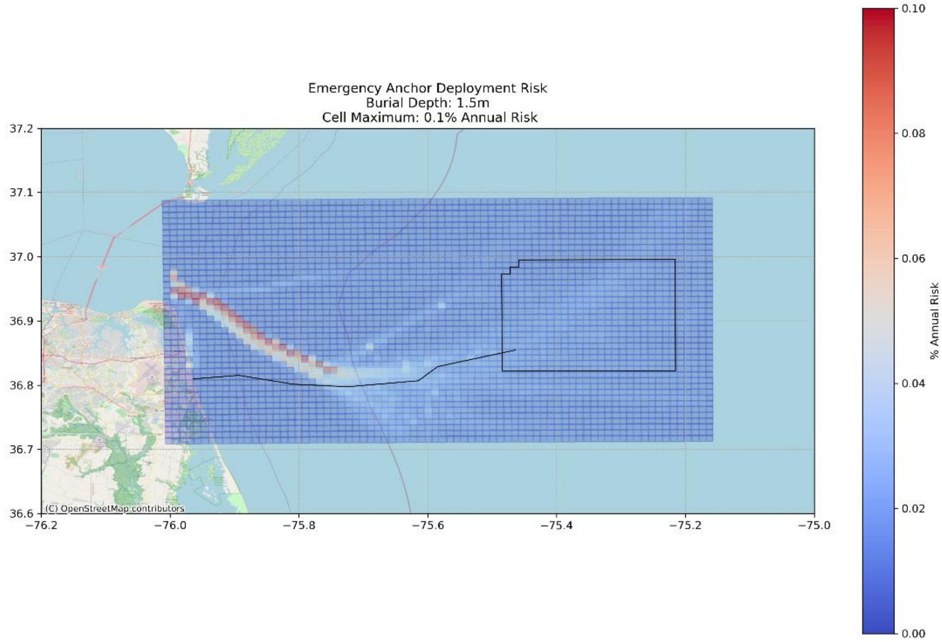


Figure W-53. Area Based Emergency Anchoring Risk Chart, 5.0-ft (1.5-m) Burial Depth

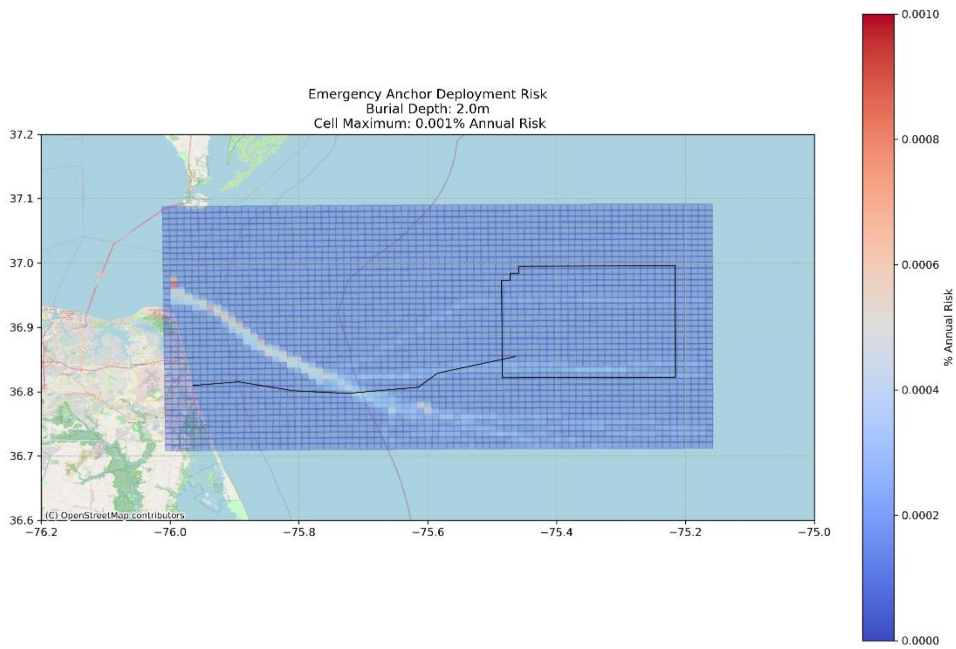


Figure W-54. Area Based Emergency Anchoring Risk Chart, 6.6-ft (2.0-m) Burial Depth

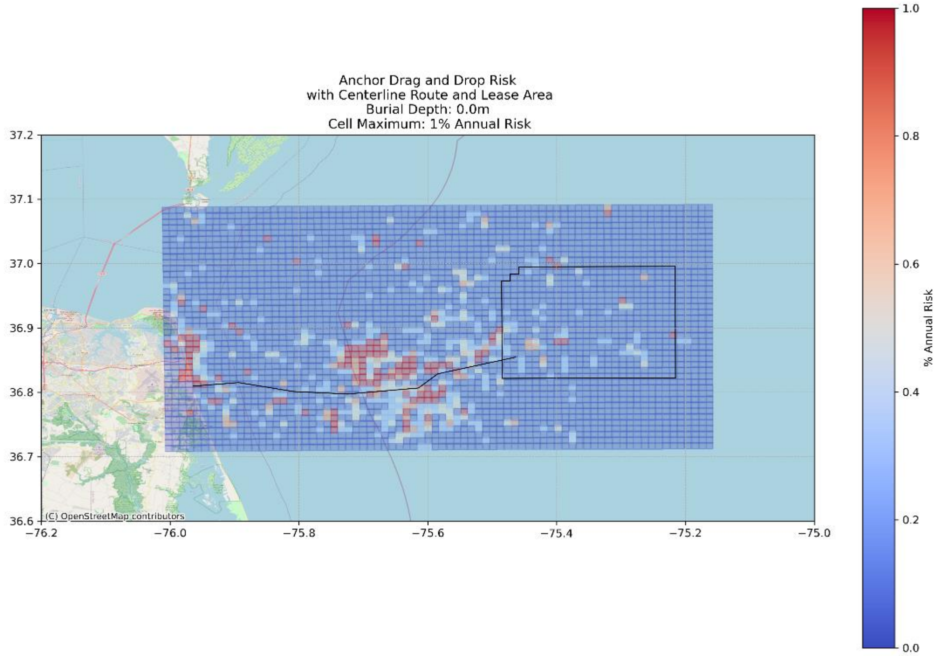


Figure W-55. Area Based Drag & Drop Anchoring Risk Chart, 0-m Burial Depth

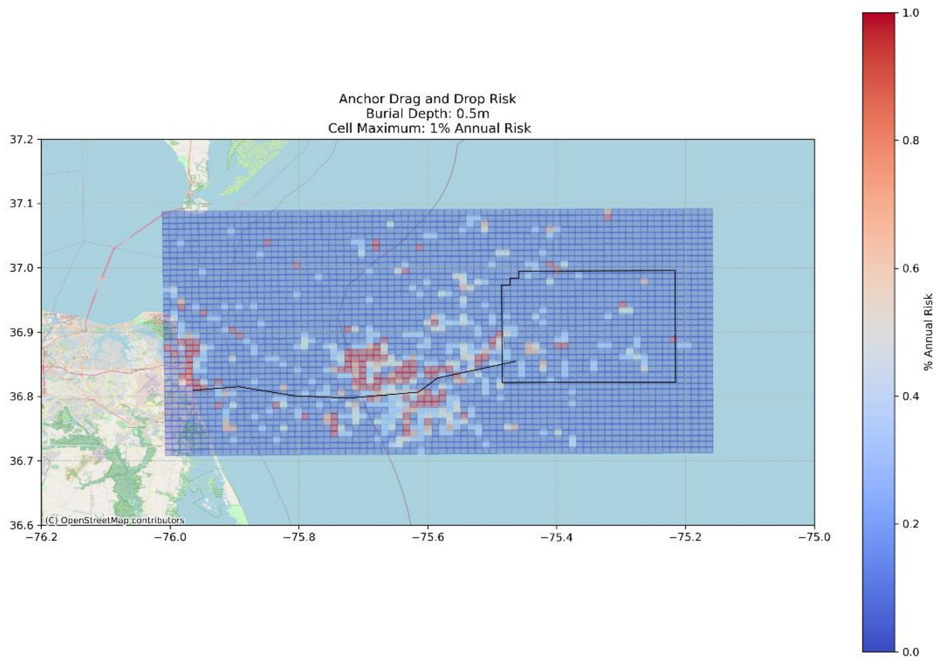


Figure W-56. Area Based Drag & Drop Anchoring Risk Chart, 1.6-ft (0.5-m) Burial Depth

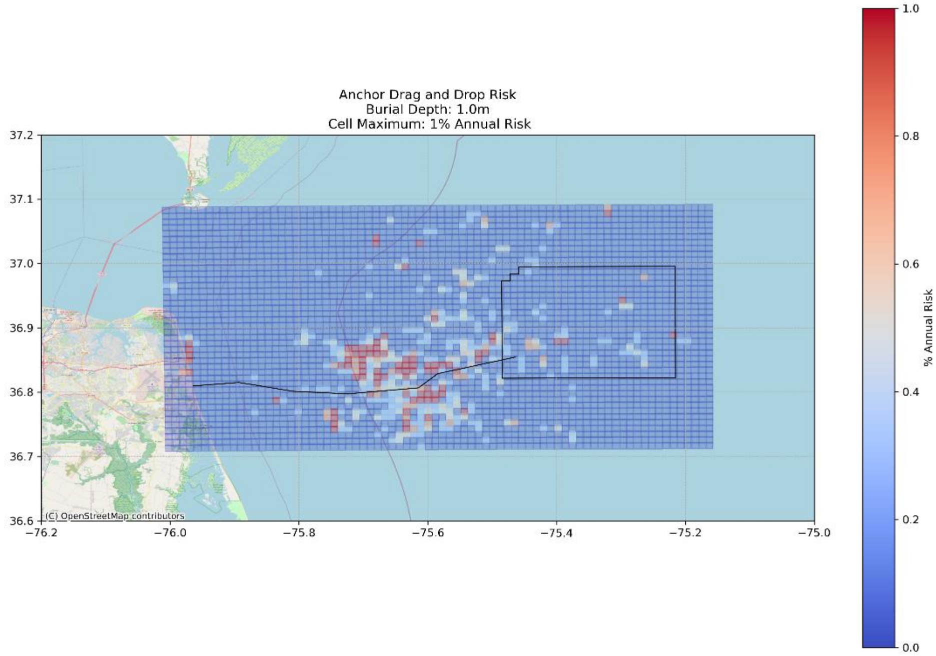


Figure W-57. Area Based Drag & Drop Anchoring Risk Chart, 3.3-ft (1.0-m) Burial Depth

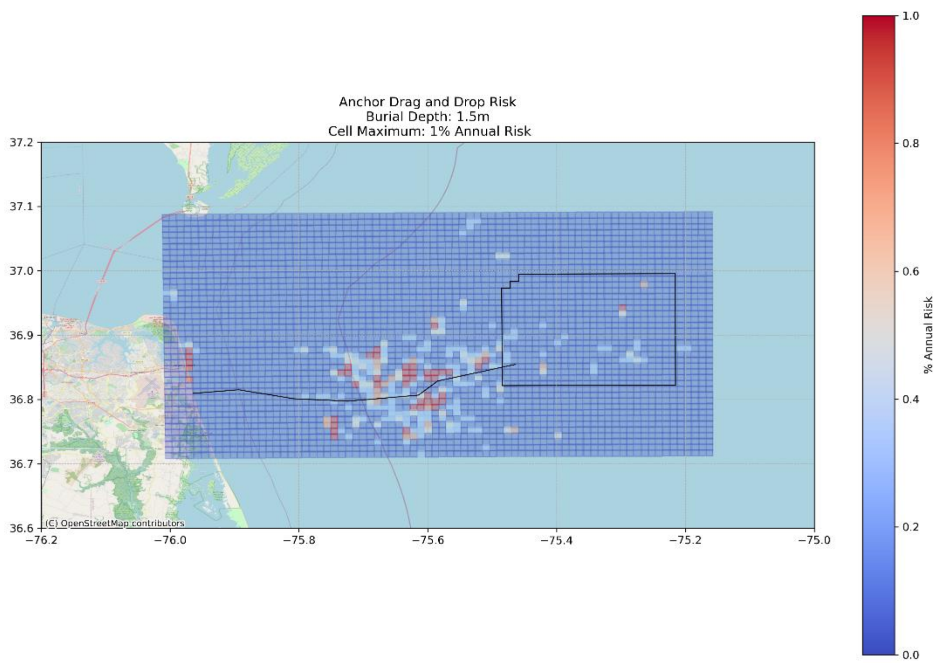


Figure W-58. Area Based Drag & Drop Anchoring Risk Chart, 5.0-ft (1.5-m) Burial Depth

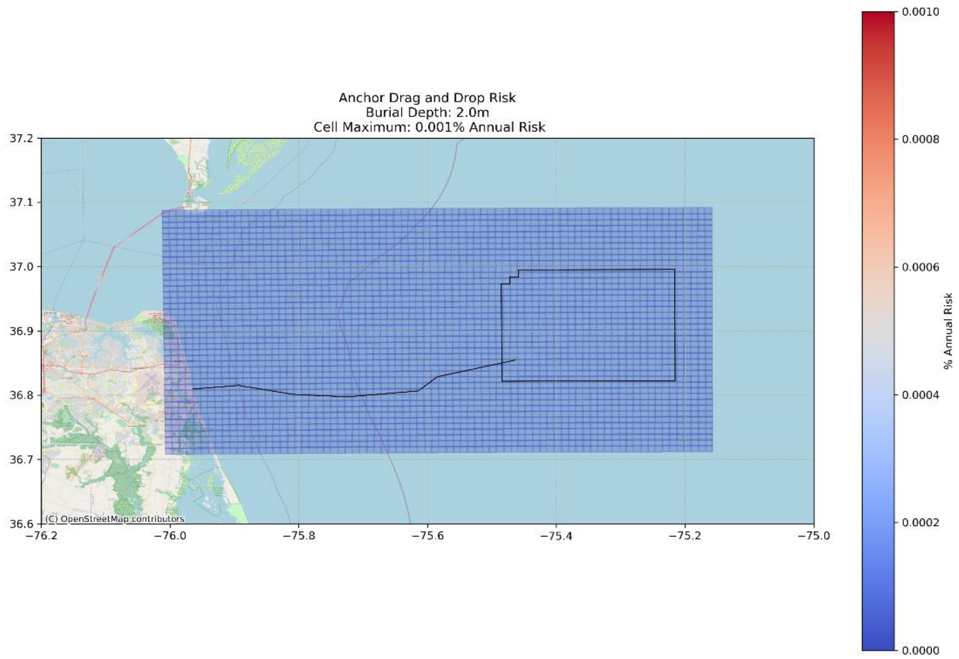


Figure W-59. Area Based Drag & Drop Anchoring Risk Chart, 6.6-ft (2.0-m) Burial Depth

W.7 OVERALL CONCLUSIONS

This section summarizes the preliminary conclusions and results arising from this preliminary CBRA.

- **Commercial Vessel Traffic:** AIS data shows heavy commercial vessel traffic both transiting across the Export Cable Corridor as well as anchoring in the vicinity. Such vessels include those of approximately 200,000 tons DWT with potential anchor penetrations of 6.6 ft (2.0 m) in high-strength soils and 21.6 ft (6.6 m) in low-strength soils. The threat to the cable from commercial vessel anchoring (planned, accidental, or emergency) is considered the greatest risk factor. However, the burial depths required to mitigate this risk would vary along the route and would be determined by the size of vessels encountered at any particular point.
- **Commercial Fishing:** Commercial fishing does occur within the study area, but the types of fishing gear encountered are not generally considered high risk. Fixed gear fishing that utilizes gear affixed to the seabed with anchors is considered the highest risk fishing method in the study area. The anchors are likely to penetrate up to 1 ft (30 cm), well below the expected penetration of vessel anchors.
- **Sediment Mobility:** This is considered a risk in that it increases the difficulty of achieving the desired burial depth, as well as increasing the probability of reducing or increasing the burial depth during the operational life of the cables. With the information available, sediment mobility (via sandwaves) is most likely in the central and eastern areas of the cable corridor.
- **Soil and Sediment Types:** Even though no detailed geotechnical information has been made available, evidence from the parallel CVOW Pilot Project export cable has shown that while the majority of the route is suitable for cable burial via water jetting, there are harder areas that may require differing burial techniques. Further survey information, as well as the risk tolerance of the asset owner, would be required to determine suitable recommended depths of lowering, as well as the suitability of burial tools to achieve them.
- **Unexploded Ordnance/Munitions and Explosives of Concern:** UXO/MEC is a potential threat, particularly during installation operations. Additionally, the number of export cables planned for the corridor restricts the ability to micro-site around any potential UXO targets.
- **Dredging and Dumping:** The cable corridor transits the DNODS disposal site. In theory, cells 2 and 5 (which have been transited by in-service fiber optic cables as well as the CVOW Pilot Project export cable) will have material deposited that is not suitable for beach nourishment; therefore, the risk of dredging is reduced. However, there are potential dropped object risks, as well as the risk of increasing the depth of cover, which could lead to ampacity reductions. Additionally, it is rumored that the federally maintained deep water shipping channel may be extended and deepened in the future. If so, this introduces the risk of damage from USACE dredging operations around KP 20 to KP 26.
- **Cable Crossings:** As things stand, there will be three cable crossings of in-service fiber optic cables per export cable (27 crossings in total) to engineer. Reduced burial is always likely at crossing locations, and within the study area, crossings will occur in an area where commercial vessels anchor to await customs clearances, etc. Therefore, undertaking a detailed evaluation of

risks at these locations and developing detailed engineering solutions to mitigate these risks is recommended.

- **Military Activity:** The area of the study encompasses an extremely busy naval operations area. The risk to the cable cannot yet be fully identified because of the lack of publicly available vessel navigational data. It is also possible that uncharted military submarine cables exist which need to be considered.
- **General:** The requirement to accommodate multiple export cables within a cable corridor that is quite narrow increases the risk by reducing the ability to micro-route, by decreasing available space for cable installation and potential repair operations, and by increasing the chances of multiple cable strikes in the event of, for example, a deployed vessel anchor.

W.8 RECOMMENDED NEXT STEPS

The following items are recommended next steps that will be useful to further refine many of the parameters used in this study and to better tailor risk mitigations through cable burial:

- **Naval/DoD Study and Liaison:** The available AIS shipping data is considered to be unproven at best and unreliable at worst for capturing the presence, movements, and particulars related to anchor risk of DoD vessels. It is recommended that a study of DoD vessels, DoD seabed asset awareness procedures, and emergency anchoring protocols be conducted to ensure that the risk from these vessels is adequately captured and mitigated in future refinements of this study.
- **Engagement of the USACE:** The USACE should be engaged as part of the permitting process for both the traverse of the seabed near the seaward end of the AOC and across the DNODS. Additional required burial is likely to be indicated by the USACE and should be considered in future versions of this study.
- **Goephysical and Geotechnical Survey Data Integration:** The interpretation and results of the 2020 and 2021 high-resolution geophysical and geotechnical survey campaigns should be integrated into the analysis of anchor penetration along the cable corridor. Additional planning and design of the cable installation should contain a cable burial tools assessments to carefully consider the required depths of lowering and detailed seabed geotechnical properties along the routes.
- **Sediment Mobility Analysis:** The results of a seabed mobility study should be integrated into future versions of this document to better understand where additional depths of lowering or potential areas of pre-sweeping or other Seabed Preparation may be required to ensure the cables can be installed at a maintainable depth below seabed throughout the life of the Project. It is understood that a sediment mobility study will be commissioned in 2021.
- **Munitions Study**: A detailed munitions study should be undertaken to evaluate the types of munitions, suitable detection strategies, and appropriate mitigations. Due to the planned cable spacing, minimal space is anticipated to be available within the corridor for micrositing to avoid potential hazards. This may require expensive and time-consuming intrusive investigation. The munitions study also needs to account for the potential vertical impact of the installation, which will be driven by the need for deeper cable burial in some places along the route. It is understood that a UXO/MEC study will be commissioned in 2021.
- **Area Approach for Export Cable Alternative Routing:** The work in this study to evaluate the risk more broadly in the "Area-Based CBRA" will allow understanding of the opportunities to utilize alternative landings or routes to provide some diversity of the routes and to mitigate problems with the crossings or dense routing within a relatively narrow corridor, should concerns arise.
- **Crossing Discussions/Negotiations**: Detailed design of the cable crossings and related Cable Protection will need to account for the risks to seabed assets, as well as the requirements of the crossed assets. It is strongly urged that these discussions are initiated as early as possible to allow maximum flexibility in the design of the crossings.

- **Risk Tolerance to Define DOL Recommendations**: This preliminary version of the CBRA identifies the major risks to the subsea export cable and evaluates a range of depths of lowering at which that risk can be mitigated. However, the decision on the suitable DOL should consider both the mitigation of the risk and the costs to mitigate that risk. The future versions of this report can integrate feedback from Dominion Energy on the risk tolerance of the system to cable faults and the potential costs to implement that reduction.
- **Area-based Risk Assessment Process:** Refine the area-based risk assessment process and evaluate the survey data to determine a recommended DOL for the Inter-Array Cable. A navigational risk assessment is required to determine an accurate Cable Burial Risk Assessment which considers significant traffic and risk changes after the Project has been developed. Based on current assumptions and traffic a DOL of at least 1.5 m to 2.0 m is recommended, pending this further detailed assessment.

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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%
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%

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
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