Kitty Hawk Wind

AVANGRID

Construction and Operations Plan

Chapter 2 - Project Siting and Design Development

September 30, 2022

Submitted by
Kitty Hawk Wind, LLC
1125 NW Couch Street, Suite 600
Portland, Oregon 97209

Submitted to
Bureau of Ocean Energy Management
45600 Woodland Road
Sterling, Virginia 20166

Prepared by
Tetra Tech, Inc.
10 Post Office Square, 11th Floor
Boston, Massachusetts 02109

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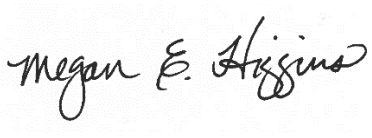
Prepared by:	Checked by:	Approved by:
TETRA TECH **September 30, 2022**	 **September 30, 2022**	 **September 30, 2022**

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01	All	All	Submitted to BOEM
02	All	All	Updated based on BOEM comments and Project updates
03	All	All	Updated based on BOEM comments and Project updates
04	19	2.1.2.3	Typographical correction
05	Many	2.1	Updated based on Project updates
06	Many	Various	Updated based on BOEM comments and Project name

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Abbreviations & Definitions

Acronym	Definition
DoD	Department of Defense
HVDC	high-voltage direct-current
km	kilometer
Lease Area	the designated Renewable Energy Lease Area OCS-A 0508
m	meter
PDE	Project Design Envelope
POI	Point of Interconnection
Project	Kitty Hawk North Wind Project
ROW	right-of-way
the Company	Kitty Hawk Wind, LLC
U.S.	United States
USACE	United States Army Corps of Engineers
VDHR	Virginia Department of Historic Resources
Wind Development Area	approximately 40 percent of the Lease Area in the northwest corner closest to shore (19,441 hectares)
WTG	wind turbine generator

2 PROJECT SITING AND DESIGN DEVELOPMENT

This chapter presents a description of the elements considered as part of Project Design Envelope (PDE) and the refinement of the PDE as it applies to the Kitty Hawk North Wind Project (Project) as conducted by Kitty Hawk Wind, LLC (the Company). As is industry practice, the PDE approach may be informed by several factors, including desktop assessments, site-specific surveys, supply chain capacity, commercial availability, and engagement with regulators and stakeholders. Where existing public data was available, it may also be used to inform the siting assessment. As explained in the Bureau of Ocean Energy Management's *Phased Approaches to Offshore Wind Developments and Use of the Project Design Envelope* (Rowe et al. 2017), a PDE for a typical offshore wind facility located in the United Kingdom would include the following elements within its design:

- Offshore infrastructure within the wind turbine generator (WTG) array;
- Offshore transmission infrastructure;
- Vessel and helicopter details;
- Landfall details; and
- Onshore transmission infrastructure.

The following sections document the criteria used in evaluating various alternatives and refining the components that define the PDE.

2.1 Project Siting

Siting of the designated Renewable Energy Lease Area OCS-A 0508 (Lease Area) was established through the Bureau of Ocean Energy Management commercial wind energy lease process as described in Section 1.1.1. The Company determined that multiple potential locations are available for the Point of Interconnection (POI) to support the energy delivered from up to 69 WTGs for the Project; therefore, cable routing and siting of the landfall were not constrained by the requirement to reach a single, pre-defined POI location. With the Lease Area as the established starting point and multiple POI options available, the Company conducted siting studies to determine constraints and opportunities and the preferred location for the export cable landfall, offshore export cable routing, POI selection, and onshore export cable routing options. Siting of the individual Project components is described below; however, the Company completed a holistic evaluation of constraints and impacts to determine the preferable overall configuration for delivery of energy from up to 69 WTGs into the existing grid.

2.1.1 Landfall

The Company evaluated approximately 90 kilometers (km) of coastline between Virginia Beach, Virginia, and Kitty Hawk, North Carolina for possible landfall locations inclusive of site visits to potential beach landings and the POIs. Nine potential landfall locations were initially identified for more detailed comparative analysis: Neptune, 17th Street, Croatan, Sandbridge, Little Island Park, Corolla, Duck, Kitty Hawk Hotel Parking Lot, and Kitty Hawk Seafood Company Parking Lot. These locations are depicted in Figure 2.1-1 and Figure 2.1-2.

Landfall locations for the export cable transition from offshore to onshore were initially identified using publicly-available data on onshore and offshore characteristics and constraints. Locations in both Virginia and North Carolina were evaluated with due consideration given to accessibility from both on- and offshore, terrestrial routing efficiencies, and suitable interconnection location.

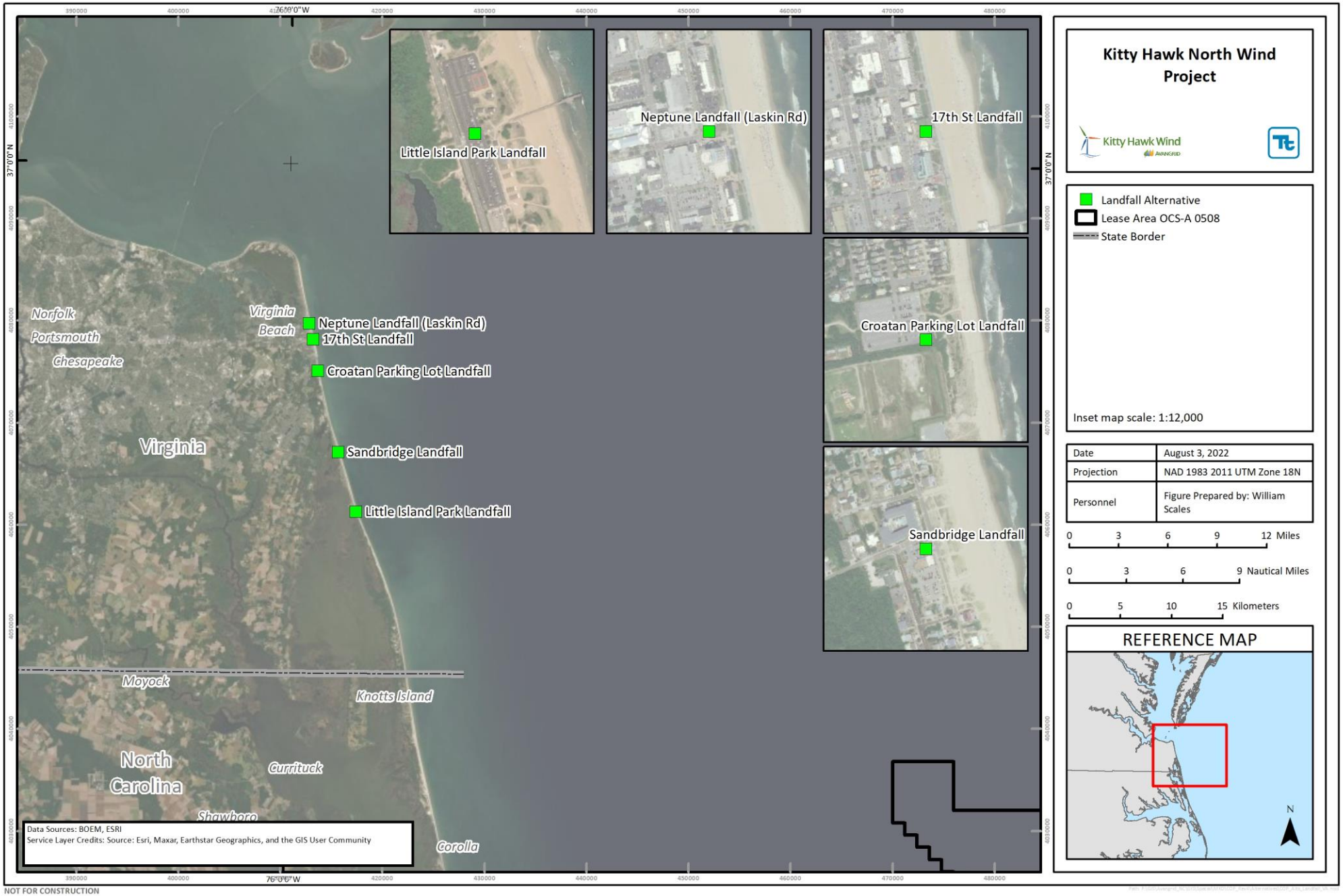

Figure 2.1-1 Potential Virginia Cable Landfall Locations

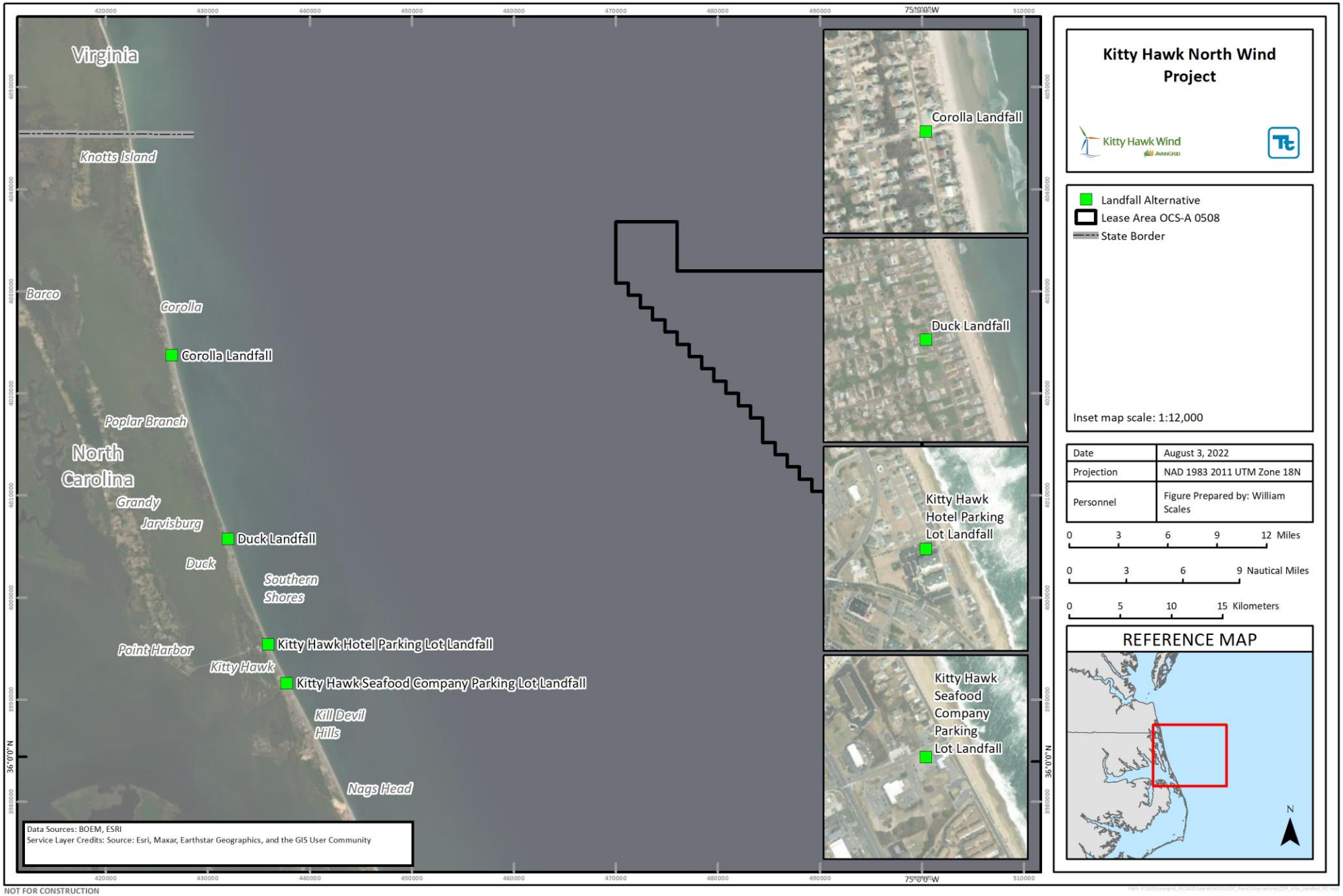

Figure 2.1-2 Potential North Carolina Cable Landfall Locations

The major considerations in the initial landfall analysis consisted of the following:

- the proximity to potential terrestrial grid interconnection locations at existing substations or along existing electric transmission infrastructure;
- the number and relative complexity of constraints on the terrestrial side of the export cable landfall, including environmental considerations such as wetlands and rare species habitat, Department of Defense (DoD) uses, and commercial and residential land and its availability;
- the size and appropriateness of the area for export cable installation operations, such as horizontal directional drilling sites, a laydown or staging area(s) for construction materials and equipment, and the space required to execute the horizontal directional drilling cable pulls;
- the presence of other infrastructure that may preclude construction, such as the terrestrial infrastructure associated with submarine telecommunications cables, including ground beds and flush-mounted access covers; and
- the number and relative complexity of marine constraints and features in the immediate offshore areas proximate to the landfall, including restrictive DoD areas, navigation and dredge projects, sand borrow areas and dredge spoil disposal areas, charted and potential hardgrounds, potentially mobile seabed features, and potential cultural resources such as shipwrecks.

Several portions of the shoreline were dismissed from further consideration based on the initial evaluation. A significant portion of the Virginia coastline, between approximately Croatan Beach at the south side of Virginia Beach and immediately north of Sandbridge Road approximately 10 km to the south, has conflicts with land-based DoD operations areas surrounding the Dam Neck Annex to Naval Air Station Oceana and associated onshore and offshore infrastructure, and was therefore dismissed from further consideration. Due to the presence of barrier islands and back-bay estuaries south of Sandbridge, Virginia, potential landfall locations between there and Corolla, North Carolina, approximately 40 km further south, would require extensive, complicated terrestrial routes to reach a suitable interconnection location, and therefore were not considered reasonable and were not assessed further. Landfall in a 11-km stretch between Duck, North Carolina and Kitty Hawk, North Carolina affords some opportunity to reach terrestrial interconnection locations, but is limited by suitable, specific landfall locations due to densely developed commercial and residential areas. Therefore, this area of shoreline was not considered reasonable for a landfall alternative.

The Company evaluated possible landfall locations based on a number of key parameters that would influence feasibility and suitability. These key parameters included factors that would affect engineering and constructability, environmental and social concerns, risks to Project cost and schedule, and permitting considerations. The following is a summary of the comparative analysis for each of the nine evaluated landfall locations.

2.1.1.1 Neptune

The Neptune Landfall (36° 51' 34.05" N, 75° 58' 40.79" W) is located within Neptune's Park (3001 Atlantic Avenue) in the heart of the Virginia Beach Oceanfront at the intersection of Atlantic Avenue and Laskin Road (see Figure 2.1-1), in the City of Virginia Beach, Virginia. The landfall is a mowed, grassy area that houses a concert pavilion in the northwest corner of the site and a smaller gazebo in the southeast. The landfall is bounded by Atlantic Avenue to the west, with the Oceanfront Bike Path, Virginia Beach Boardwalk, and Virginia Beach immediately to the east. A high-rise hotel building is located to the south, and a parking lot is located to the north that is associated with a Hampton Inn. There is also a very prominent statue of King Neptune to the east of the site along the Virginia Beach Boardwalk. The wide, gently sloping beach attracts locals and visitors alike and the park is a family-friendly concert venue during the summer. The ground profile is flat at the landfall location itself.

Challenges associated with the Neptune Landfall, both engineering and environmental, include the highly developed nature of the area, a seawall, offshore cable crossings, potential for offshore unexploded ordnance, the DoD "no-go" areas and seasonal construction restrictions. The site also does not have sufficient space for construction/laydown. High public use of the location and the surrounding areas as well as concerns related to a United States Army Corps of Engineers (USACE) beach stabilization project present a high risk of stakeholder opposition.

The offshore avoidance areas provided by the DoD are a significant challenge. While submarine cables have approached Virginia Beach from the east, any asset approaching from the south would need to do so from over 100 km offshore due to conflicts with DoD uses. This constraint was stated by the DoD to the Company and can be seen in practice when examining the BRUSA fiber optic cable system that lands in the Croatan Parking Lot: it is routed 150 km to the east before turning south to avoid this constraint.

2.1.1.2 17th Street

The 17th Street Landfall (36° 50' 43.87" N, 75° 58' 25.18" W) is on the Virginia Beach Oceanfront located at the intersection of Atlantic Avenue and 17th Street (see Figure 2.1-1) in the City of Virginia Beach, Virginia. The landfall is a mowed grassy area that houses a concert pavilion on the west side of the site. The area is bounded by Atlantic Avenue to the west, the Oceanfront Bike Path, Virginia Beach Boardwalk and Virginia Beach immediately to the east. A high-rise building and a commercial plaza, and associated parking lots abut the site to the north and south, respectively. The ground profile at the site is flat.

Challenges associated with the 17th Street Landfall, both engineering and environmental, include the highly developed nature of the area, a seawall, seasonal construction restrictions, and likely stakeholder concerns. The site lacks sufficient space for construction and is located within a high-density urban tourist area. There is potential to conflict with offshore DoD activities, as offshore military operations are common in the area and there are offshore avoidance areas between the Wind Development Area and the 17th Street Landfall. Of all the aforementioned constraints, the offshore avoidance areas provided by the DoD present the most significant challenges. While submarine cables have approached Virginia Beach from the east, any asset approaching from the south would need to do so from over 100 km offshore due to conflicts with DoD uses. This constraint was stated by the DoD to the Company and can be seen in practice when examining the BRUSA fiber optic cable system that lands in the Croatan Parking Lot: it is routed 150 km to the east before turning south to avoid this constraint.

2.1.1.3 Croatan Parking Lot

The Croatan Parking Lot Landfall (36° 49' 2.54" N, 75° 58' 4.34" W) is located off the southern end of Vanderbilt Avenue, Virginia Beach, Virginia (see Figure 2.1-1). There are entrances both from Vanderbilt Avenue to the north and a private, locked, entrance onto Regulus Avenue from the west and onto Camp Pendleton. The landfall is a paved parking area. The area is bounded along the north side by residences along Vanderbilt Avenue and Lockheed Avenue. There is a walkway out to Virginia Beach that lies to the east, and west lies an open area with a few houses between the parking lot and Lake Christine. Abutting the Croatan Parking Lot to the south is an open, mostly vacant parcel. The ground profile at the site is flat.

Although the site has clear onshore and offshore access and sufficient space for construction, there are significant environmental and stakeholder impacts. Challenges associated with the Croatan Parking Lot Landfall include DoD offshore avoidances areas, required crossings of three fiber optic cables that land into a flush-mounted access cover in the southeast corner of the lot, and the location of the landfall on state property within the Camp Pendleton State Military Reservation (under lease to the city), which is part of a National Register of Historic Places-listed historic district. The landfall would also cause impacts to nearby residents, as the only public access to the parking lot is through the Croatan neighborhood (Croatan Road and Vanderbilt Avenue).

Of all the aforementioned constraints, the offshore avoidance areas provided by the DoD present the most significant challenges. While submarine cables have approached Croatan Parking Lot from the east, any asset approaching from the south would need to do so from over 100 km offshore due to conflicts with DoD uses. This constraint was stated by the DoD to the Company and can be seen in practice when examining the BRUSA fiber optic cable system that lands in the Croatan Parking Lot: it is routed 150 km to the east before turning south to avoid this constraint.

2.1.1.4 Sandbridge

The Sandbridge Landfall (36° 44' 45.97" N, 75° 56' 40.86" W) is located in the parking lot adjacent to the Sandbridge Seaside Market at 209 Sandbridge Road, in Virginia Beach, Virginia (see Figure 2.1-1). The parking lot is bounded by roads on three sides: Sandfiddler Road to east, Sandbridge Road to the north and Sandpiper Road to the west. Dunes along Sandbridge Beach, a public beach, lie to the east on the other side of Sandfiddler Road. To the south of the parking lot is a low building housing the market, and additional parking lots for public beach access. Across Sandbridge Road to the north is a multi-story condominium complex. The ground profile at the site is flat.

The Sandbridge Landfall has a number of benefits compared with other sites considered, both from an engineering and environmental perspective. The area is not as densely populated as locations along Virginia Beach to the north. The site offers sufficient area for construction without disturbing buildings or vegetation. Additionally, offshore routing options to the Sandbridge Landfall are preferable with regards to distance to the Lease Area, the drastic reduction in ship traffic away from the Chesapeake Bay, and avoidance of many DoD activities and the existing submarine cable assets. Based on the comparative analysis, the Sandbridge Landfall was the highest-ranked landfall among those compared.

2.1.1.5 Little Island Park

The Little Island Park Landfall (36° 41' 36.72" N, 75° 55' 28.99" W) is located in a parking lot at 3820 Sandpiper Road, in Virginia Beach, Virginia (see Figure 2.1-1). The parking lot is part of Little Island Park and is owned by the City of Virginia Beach. The parking lot is bordered to the west by Sandpiper Road and to the west by Sandpiper Beach, tennis courts, Little Island Coast Guard Station, and park facilities including a playground area and restrooms. Little Island Coast Guard Station is a historic property owned by the City of Virginia Beach Department of Parks and Recreation, and has not been active as a United States Coast Guard station since 1964 (City of Virginia Beach 2017a). The Little Island Fishing Pier is located east of the center of the parking lot and is open to the public year-round (City of Virginia Beach 2017b).

Similar to the Sandbridge Landfall, the Little Island Park Landfall has a number of benefits compared with other landfall options considered. The parking lot is large, approximately 2 hectares, and provides sufficient area to support landfall activities without disturbing buildings or vegetation. Offshore routing options are comparable to the Sandbridge Landfall but slightly favorable due to an increased distance of 6 km from Chesapeake Bay and many DoD activities, potentially resulting in fewer unexploded ordnance targets along the nearshore route.

Challenges associated with the Little Island Park Landfall include potential stakeholder impacts associated with the proximity to Little Island Coast Guard Station and Fishing Pier. Additionally, the presence of Back Bay immediately to the west would result in a longer onshore route to any onshore substation site. Due to these challenges, Little Island Park was identified as slightly less preferred than Sandbridge; however, Little Island Park may provide a suitable alternative should conditions change to make the Sandbridge Landfall less feasible.

2.1.1.6 Corolla

The Corolla Landfall (36° 21' 18.19" N, 75° 49' 24.70" W) is located in an open site along Herring Street, opposite the intersection of Herring Street and Cane Garden Bay Circle in Corolla, North Carolina (see Figure 2.1-2). The eastern portion of the site contains a parking lot and the western portion is a vacant,

sandy, open area. The Corolla Landfall is bounded by Herring Street to the south. To the east, there is a forested buffer between the site and a few residences located along Corolla Drive. Open areas bound the north and west of the site, with more trees further to the north. The ground profile at the site is flat.

Challenges associated with the Corolla Landfall are primarily engineering considerations due to the long distance from the shoreline, presence of a residential neighborhood between the shore and the landfall, and relatively limited workspace and access. The site could also present stakeholder challenges due to the density of residences between the shoreline and the landfall, which could result in local impacts and/or potential stakeholder concerns. Furthermore, the Town of Corolla is located on the Outer Banks of North Carolina in a low-lying coastal environment with accelerating erosion, which may present potential concerns over coastal resiliency and shoreline stability.

Another challenge that applies to all of the North Carolina landfall alternatives (Corolla, Duck, Kitty Hawk Hotel Parking Lot, and Kitty Hawk Seafood Company Parking Lot) is the lack of existing transmission infrastructure (Figure 2.1-3 and Figure 2.1-4). The northeastern coastal area of North Carolina has few high voltage transmission lines and few large substations. Interconnecting in these locations would necessitate costly large-scale upgrades, which may introduce additional impacts to viewshed in addition to possible environmental and social impacts. Some alternatives could even necessitate additional shallow-water crossings, due to the presence of estuary-backed barrier beaches along the coast.

2.1.1.7 Duck

The Duck Landfall (36° 11’ 37.91" N, 75° 45’ 24.58" W) is located in an open portion of a residential lot along the west side of Bufflehead Road at the intersection with Wood Duck Road in the Carolina Dunes neighborhood of Duck, North Carolina (see Figure 2.1-2). The western portion of the site contains a home, and the eastern portion of the site, the potential landfall, is bounded on the north by Wood Duck Road, on the east by Bufflehead Road, and on the south by an undeveloped portion of an abutting residential lot. The ground profile at the site is flat.

The primary challenge associated with the Duck Landfall is shared use of a residential lot with very limited workspace. In addition, residences are located between the shore and the landfall. The site would likely present stakeholder concerns due to the density of residences in the immediate area, especially along Bufflehead Road between the shoreline and the landfall. The landfall would also be about 1.4 km north of the USACE Field Research Facility and pier, part of the USACE Coastal and Hydraulics Lab, and any cable routing and subsequent installation using this landfall location would need to be coordinated closely with the scientists from the USACE to ensure no impacts to ongoing research. As with other landfalls in northern North Carolina, the lack of existing transmission infrastructure would present an additional challenge.

Additionally, this area is known for nearly perpetual occurrences of severe beach erosion and, in turn, mobile bedforms on the continental shelf just offshore. These bedforms are documented to be large and extremely mobile, which can be challenging for submarine cable burial. This can generally be applied to the Duck Landfall and to both of the Kitty Hawk landfalls in particular. Finally, similar to the Corolla Landfall, the Town of Duck is located on the Outer Banks of North Carolina in a low-lying coastal environment with accelerating erosion, which may present potential concern over coastal resiliency and shoreline stability.

2.1.1.8 Kitty Hawk Hotel Parking Lot

The Kitty Hawk Hotel Parking Lot Landfall (36° 6’ 4.27" N, 75° 42’ 42.97" W) is located in a parking lot adjacent to a hotel at 5353 North Virginia Dare Trail (also North Carolina Highway 12) in Kitty Hawk, North Carolina (see Figure 2.1-2). The entire landfall consists of parking lot, with a multi-story hotel to the south, and the beach to the east. The Kitty Hawk Fishing Pier is located just to the south of the potential landfall. To the north of the site is a cul-de-sac on Pelican Watch Way, with residential houses on either side. Immediately to the east is an open area, with adjacent commercial and residential development east and north. The ground profile at the site is flat.

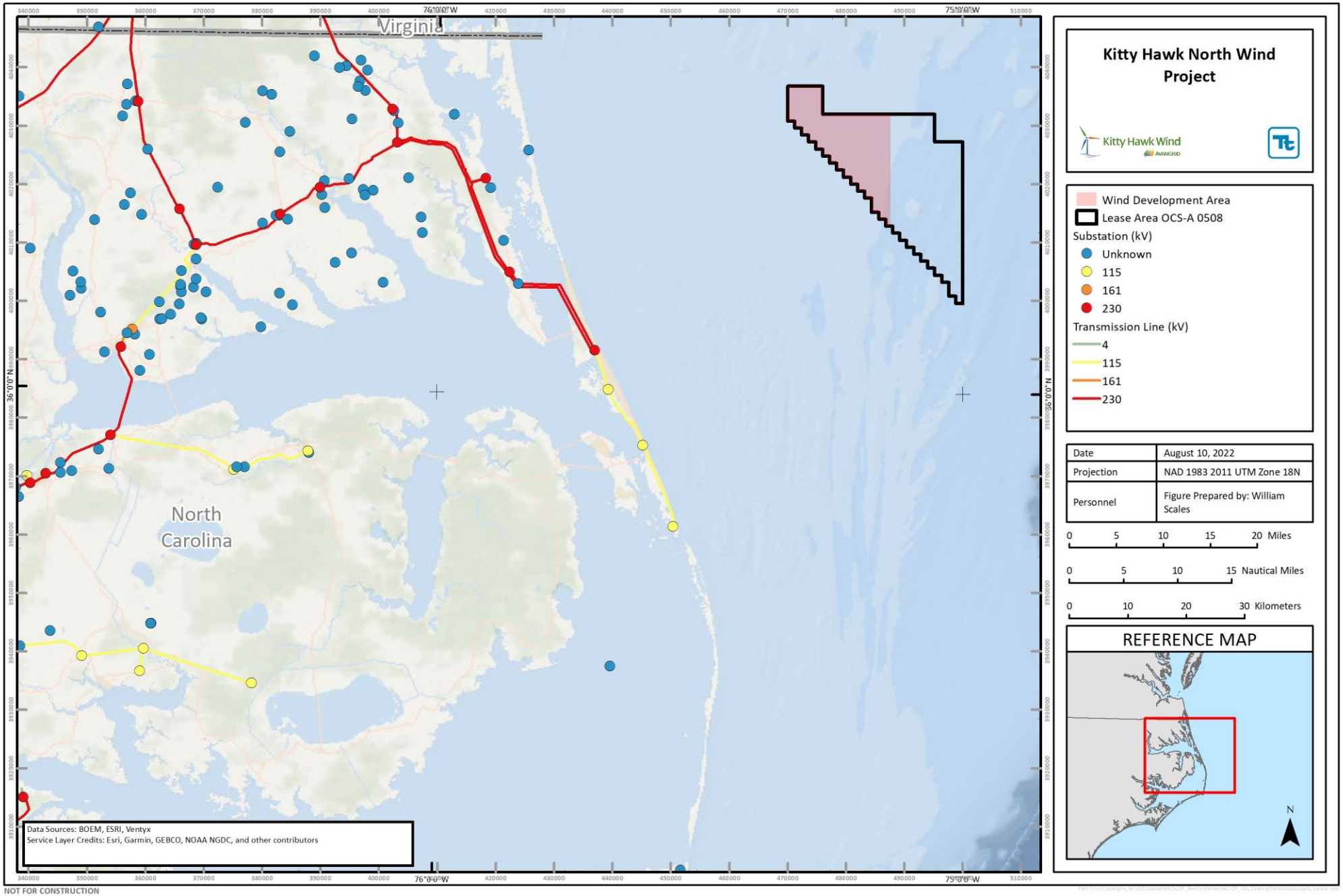

Figure 2.1-3 Existing Electrical Transmission in North Carolina – Ventyx Data

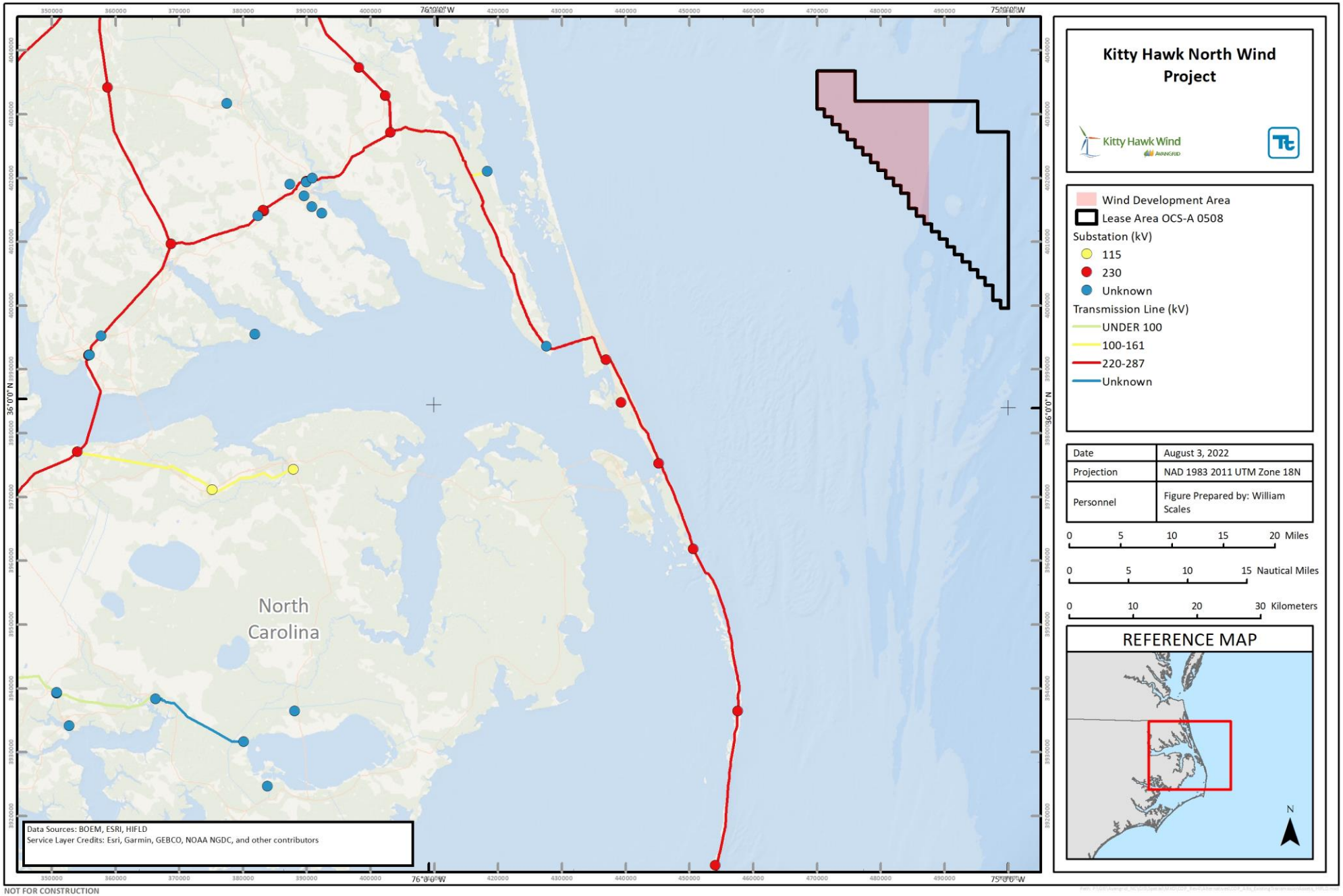

Figure 2.1-4 Existing Electrical Transmission in North Carolina – HIFLD Data

The Kitty Hawk Hotel Parking Lot Landfall presents minimal conflict with DoD activities, sufficient construction space, and clear onshore and offshore access, although a challenging and long horizontal directional drilling operation would be required due to the gradual slope of the beach. There is one North Carolina State Historic Preservation Office designated historic structure, the Kitty Hawk Fishing Pier, within the vicinity of the landfall that has not been previously evaluated for National Register of Historic Places eligibility.

Additionally, coastal resiliency is low because the potential landfall is an area at higher risk associated with sea level rise and is vulnerable to coastal erosion. A beach nourishment project was completed in Kitty Hawk in fall 2017, resulting in the widening of about 6 km of shoreline from the Southern Shores to Kill Devil Hills town lines. Surveys completed one year later (June 2018) showed approximately 15 percent of the beach fill material had been lost due to active shoreline erosion that has occurred post-construction (APTIM 2019). Use of the Kitty Hawk Hotel Parking Lot Landfall would likely include a POI at the Kitty Hawk onshore substation site, which is within a Federal Emergency Management Agency Zone X (0.2 percent annual chance flood hazard) and abuts a special flood hazard area. Similar to the other landfalls located on the Outer Banks of North Carolina, the Kitty Hawk Hotel Parking Landfall is in a low-lying coastal environment with accelerating erosion, which may present potential concern over coastal resiliency and shoreline stability.

2.1.1.9 Kitty Hawk Seafood Company Parking Lot

The Kitty Hawk Seafood Company Parking Lot Landfall (36° 4' 0.72" N, 75° 41' 28.68" W) is located in a parking lot adjacent to the Black Pelican Seafood Company and restaurant along Kitty Hawk Road and the intersection with North Virginia Dare Trail/Highway 12, in Kitty Hawk, North Carolina (see Figure 2.1-2). The entire landfall area consists of parking lot, with the seafood company building to the east, a vacant lot immediately to the south and a State beach access parking lot further to the south, an access road and parking for a United States (U.S.) Post Office facility to the west, and Kitty Hawk Road to the north. The ground profile at the site is flat.

2.1.2 Offshore Export Cable Routing

The Company identified two initial study corridors to evaluate routing for the offshore export cables. The northern corridor would provide a Project connection in Virginia; it originates in the northwest corner of the Lease Area and follows a northwest trajectory towards the Virginia Beach area. The southern corridor would provide a Project connection in North Carolina; it originates along the center of the western edge of the Lease Area and follows a slightly southwest trajectory towards the Outer Banks. Offshore export cable routing options evaluated in each corridor are described below.

2.1.2.1 Northern/Virginia Cable Routing Alternatives

The Company evaluated three offshore export cable routing options that would make landfall in Virginia (Figure 2.1-5). Major offshore constraints for these northern routing options are depicted on Figure 2.1-6.

2.1.2.1.1 Routing Option 1a

Routing Option 1a would start at the northwest corner of the Lease Area and head northwest, passing along the east side of mineral lease areas east of the Virginia Beach area before turning west-northwest to make landfall in downtown Virginia Beach (Figure 2.1-5). The offshore export cable route would be approximately 74 km long. The landfall would be about 6.4 km to the nearest potential POI, the Virginia Beach onshore substation, located in the hilltop area of northeast Virginia Beach off Industrial Park Road, south of Laskin Road.

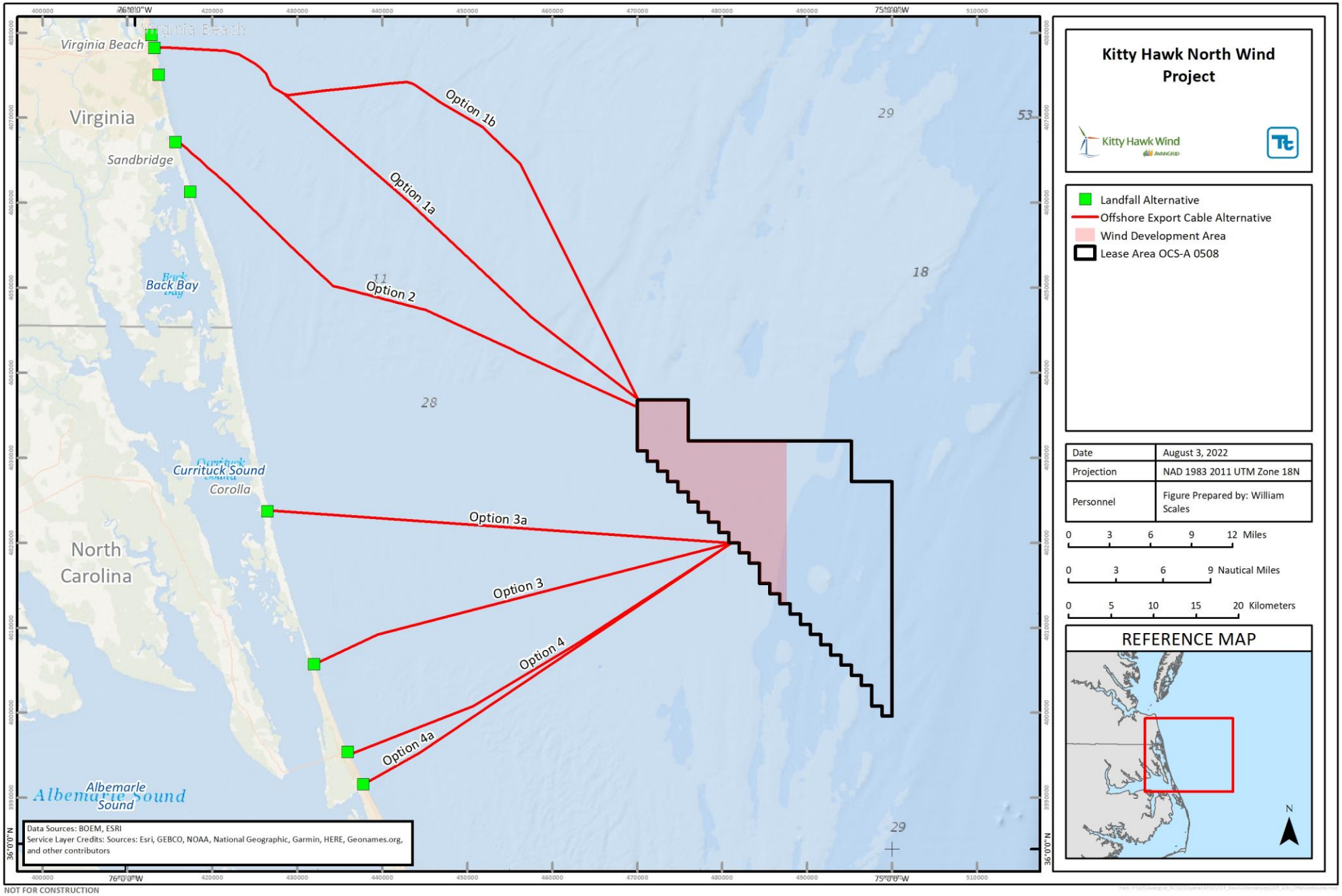

Figure 2.1-5 Offshore Export Cable Routing Options

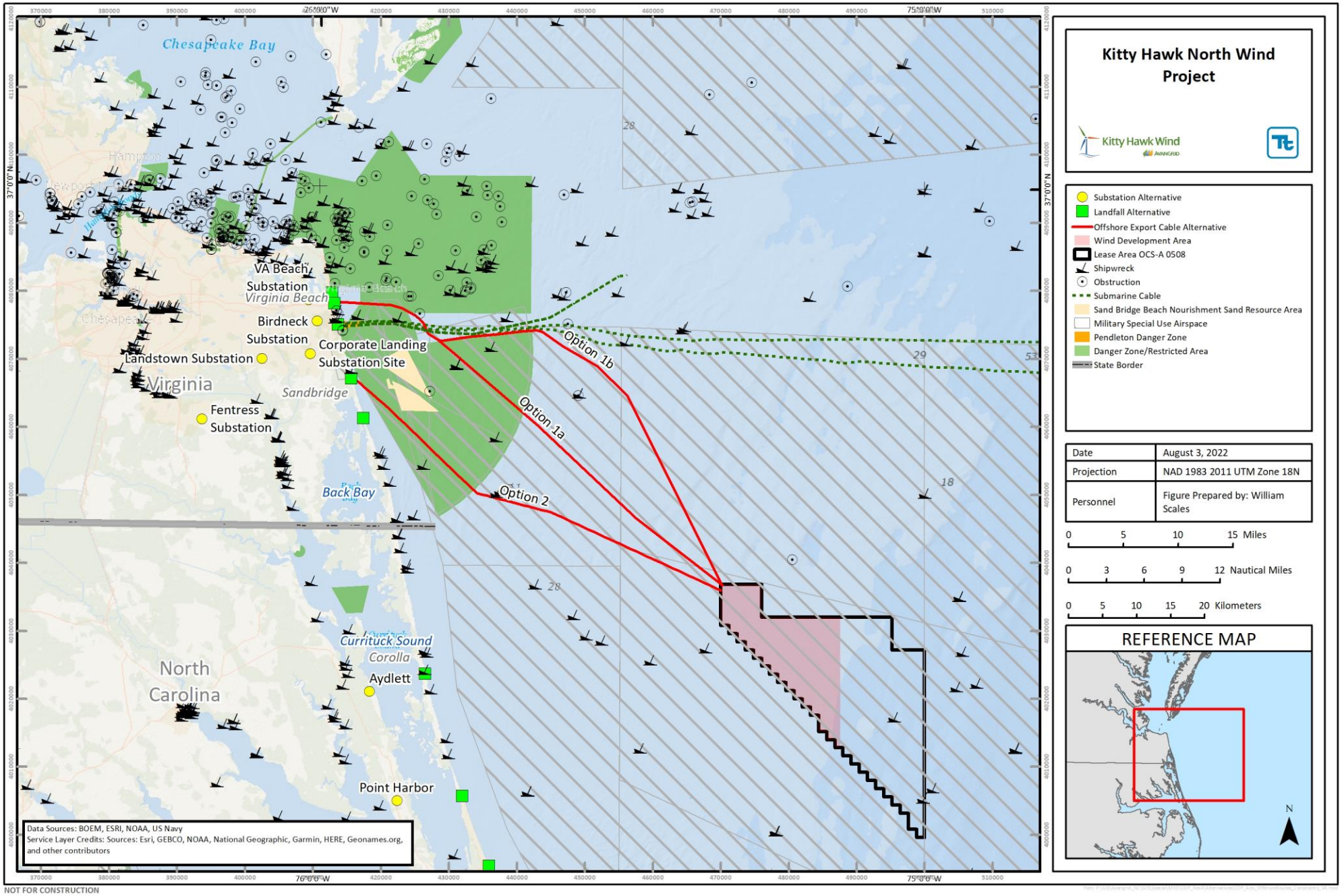

Figure 2.1-6 Offshore Export Cable Routing Major Constraints – Virginia

Major constraints for Routing Option 1a are crossings of a Regulated Navigation Area and a Danger Zone/Restricted Area near the end of the cable route off Virginia Beach (see Figure 2.1-6). The Regulated Navigation Area is in place to regulate traffic transiting to and from the Chesapeake Bay and covers the entire Virginia coast from Chincoteague Island to Knotts Island. Installation of a cable across this Regulated Navigation Area would not be precluded but would require additional coordination with the United States Coast Guard. The Danger Zone extends out from Virginia Beach in a fan-shape and encompasses the U.S. Navy Chesapeake Bay firing range. The Danger Zone is defined under 33 Code of Federal Regulations § 334.390, which instructs vessels to transit the area with caution and utilize the space for transit only. Use of Routing Option 1a would require close coordination with the DoD for the crossing of the Danger Zone, and the DoD may not consider such a crossing desirable or feasible due to the "no-go" areas faced by all submarine cables as described above. Additionally, the sand resource polygons located just east of Sandbridge present challenges to Routing Options 1a and 1b. The USACE's *Supplemental Essential Fish Habitat Assessmen*t regarding beach nourishment states:

> The beach nourishment will occur along a five mile stretch of the Sandbridge Beach between Back Bay NWR at the southernmost extent (36.698017 N, -75.924196 W-WSG84 datum) and the U.S. Naval Fleet Anti-Air Warfare Training Center at the northern most extent (36.760823 N, -75.948829 W) along the beach. The borrow areas (A and B) are located about three miles offshore at Sandbridge Shoal perpendicular to the beach nourishment reach (Appendix A). (USACE 2018, p. 13)

Initial engagement indicated that these areas should be avoided. Routing Options 1a and 1b were designed to avoid this seabed asset; however, the DoD advised that the routes would need to pass much farther east than these two options to satisfy their concerns.

Routing Option 1a would also likely require crossings of three existing fiber optic telecommunications submarine cables, the MAREA, BRUSA, and DUNANT cables, that all land in Virginia Beach and travel eastward from the southeast corner of the Croatan Beach Parking Lot. Routing Option 1a would also cross the submarine cable for the Coastal Virginia Offshore Wind Pilot Project.

2.1.2.1.2 Routing Option 1b

Routing Option 1b would start at the northwest corner of the Lease Area and head north-northwest, passing further east from the coastline than Option 1a, until joining the same route as Option 1a about 16 km from shore and following the same route as Option 1a to make landfall in downtown Virginia Beach (Figure 2.1-5). The offshore export cable route would be approximately 79 km long. The landfall would be about 6 km to the nearest potential POI, the Virginia Beach Onshore Substation, located in the hilltop area of northeast Virginia Beach off Industrial Park Road, south of Laskin Road.

Major constraints for Routing Option 1b would be similar to those for Option 1a, including crossings of the U.S. Navy Danger Zone, the DoD "no-go" areas, and existing submarine cables. These constraints would require crossing the assets as described in Section 2.1.2.1.1. However, Routing Option 1b would include less intrusion into the Danger Zone (see Figure 2.1-6).

2.1.2.1.3 Routing Option 2

Routing Option 2 would start at the northwest corner of the Lease Area and head west-northwest, passing south of mineral lease areas east of the Virginia Beach area before turning northwest to make landfall near Sandbridge, Virginia (Figure 2.1-5). The offshore export cable route would be approximately 63 km long. The landfall would be about 9 km to the nearest onshore substation option, the Corporate Landing Onshore Substation site located on the west side of Corporate Landing Parkway, in Virginia Beach.

Routing Option 2 is the shortest of the northern cable routes evaluated and does not cross any existing submarine cables nor other major offshore constraints besides the U.S. Navy Danger Zone (Figure 2.1-6). However, the route was aligned, through regular discussions with the DoD, to avoid existing infrastructure and to ensure and that no survey vessels or equipment entered any areas they deemed inappropriate. In

addition, the Sandbridge Landfall utilized by Routing Option 2 was identified as a preferred landfall as described in Section 2.1.1.

2.1.2.2 Southern/North Carolina Cable Routing Alternatives

The Company evaluated four offshore export cable routing options that would make landfall in North Carolina. Routing and major offshore constraints for these southern routing options are depicted on Figure 2.1-7.

2.1.2.2.1 Routing Option 3

Routing Option 3 would start along the center of the western edge of the Lease Area and head west-southwest to make landfall in Duck, North Carolina (Duck Landfall, see Section 2.1.1.6) (Figure 2.1-7). The offshore export cable route would be approximately 50 km long. The landfall would be about 10 km to the nearest potential POI, the Point Harbor Onshore Substation located off Griggs Acres Road/Route 1101 in Point Harbor, North Carolina, but would require crossing Currituck Sound (or about 33 km, routed to the south along Wright Memorial Bridge). The landfall would be about 18 km to the Kitty Hawk Onshore Substation located off Shelby Avenue in Kitty Hawk, North Carolina.

Routing Option 3 would cross a short portion of mineral lease areas offshore Duck, traverse the area of mobile bedforms (see Section 2.1.1.5), and would also require a crossing of Currituck Sound after reaching landfall in order to reach the Point Harbor Onshore Substation. The crossing of the sound could be routed along an existing overhead transmission line that runs parallel to the Wright Memorial Bridge on North Carolina Highway 158, but would likely require landfalls at the eastern and western shores of the crossing. The landfall in Duck would be about 1.4 km north of the USACE Field Research Facility and pier, part of the USACE Coastal and Hydraulics Lab, and any offshore export cable routing and installation would need to be coordinated closely with USACE to ensure no impacts to ongoing research. There are also concerns regarding the stability of the beach surrounding this landfall over the course of the Project lifespan.

2.1.2.2.2 Routing Option 3a

Routing Option 3a would start along the center of the western edge of the Lease Area and head west to make landfall in Corolla, North Carolina (Corolla Landfall, see Section 2.1.1.5) (Figure 2.1-7). The offshore export cable route would be approximately 55 km long. The landfall would be about 8 km to the nearest potential POI, the Aydlett Onshore Substation located off Narrow Shore Road in Aydlett, North Carolina.

Routing Option 3a would avoid crossing any major offshore constraints other than the nearshore mobile bedforms (see Section 2.1.1.5); however, it would require a crossing of Currituck Sound after reaching landfall in order to reach the Aydlett Onshore Substation. The crossing of Currituck Sound would require landfalls at the eastern and western shores of the crossing. There are also concerns regarding the stability of the beach surrounding this landfall over the course of the Project lifespan.

2.1.2.2.3 Routing Option 4

Routing Option 4 would start along the center of the western edge of the Lease Area and head southwest to make landfall in Kitty Hawk, North Carolina (Kitty Hawk Seafood Company Parking Lot Landfall, see Section 2.1.1.8) (Figure 2.1-7). The offshore export cable route would be approximately 51 km long. The landfall would be about 1 km to the nearest potential POI, the Kitty Hawk Onshore Substation located off Shelby Avenue in Kitty Hawk.

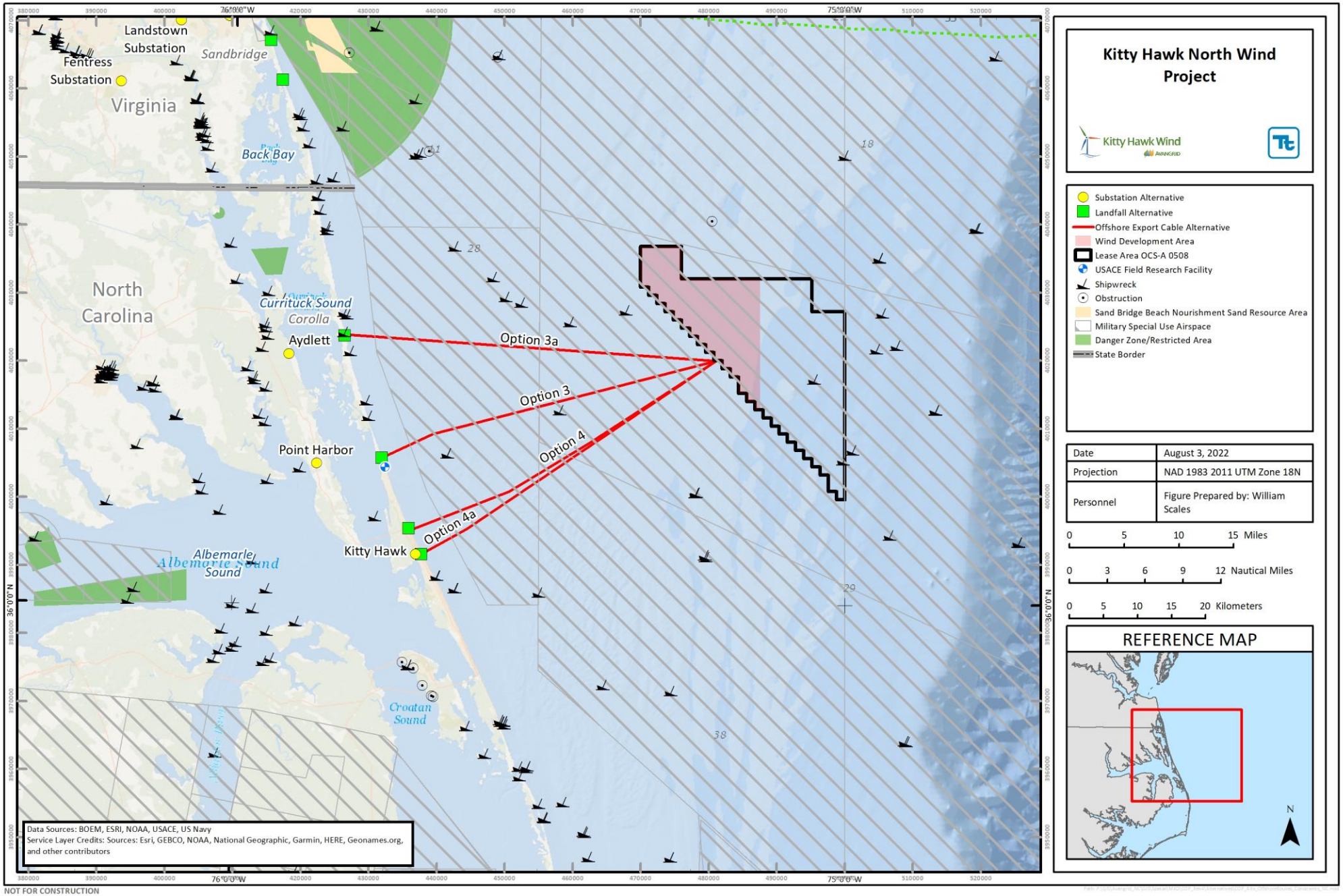

Figure 2.1-7 Offshore Export Cable Routing Major Constraints – North Carolina

Routing Option 4 would have no conflict with DoD activities and would not cross any major offshore constraints other than the nearshore mobile bedforms (see Section 2.1.1.5). The POI for this routing option would likely be the Kitty Hawk Onshore Substation, which is within a Federal Emergency Management Agency Zone X (0.2 percent annual chance flood hazard) and abuts a special flood hazard area. There are also concerns regarding the stability of the beach surrounding this landfall over the course of the Project lifespan.

2.1.2.2.4 Routing Option 4a

Routing Option 4a would start along the center of the western edge of the Lease Area and head southwest to make landfall in Kitty Hawk, North Carolina (Kitty Hawk Hotel Parking Lot Landfall, see Section 2.1.1.7) (Figure 2.1-7). The offshore export cable route would be approximately 51 km long. The landfall would be about 3 km to the nearest potential POI, the Kitty Hawk Onshore Substation located off Shelby Avenue in Kitty Hawk.

Routing Option 4a would have no conflict with DoD activities and would not cross any major offshore constraints other than the nearshore mobile bedforms (see Section 2.1.1.5). The POI for this routing option would likely be the Kitty Hawk Onshore Substation, which is within a Federal Emergency Management Agency Zone X (0.2 percent annual chance flood hazard) and abuts a special flood hazard area. There are also concerns regarding the stability of the beach surrounding this landfall over the course of the Project lifespan.

2.1.2.3 Landfall and Offshore Export Cable Routing Conclusion

The Sandbridge Landfall and offshore export cable routing Option 2 were identified as the preferred landfall and offshore export cable routing option for several reasons. Existing DoD operations areas and existing infrastructure, as well as high density of development and tourism impacts, effectively makes offshore export cable routes and potential landfall to sites north of Sandbridge (Neptune, 17th Street, and Croatan Parking Lot landfalls) highly impractical. The area of the Sandbridge Landfall is not as densely populated as locations along Virginia Beach to the north and the site offers sufficient area for construction without disturbing buildings or vegetation. Offshore export cable routing options to the Sandbridge Landfall are preferable with regards to length and avoidance of DoD activities and existing cable assets. Sandbridge would have the shortest length for the export cables to make landfall (660 to 880-meter [m] horizontal directional drill to reach the -8 m or -10 m contour), comparing favorably against the Kitty Hawk Hotel Parking Lot Landfall, which would have the second-longest. Sandbridge will also allow for a relatively short (9 km) onshore export cable corridor and limits the need for easements from private landowners, as the onshore export cables would be routed through existing city-owned roads, city-owned property, and utility rights-of-way (ROWs); avoiding and minimizing impacts to the environment. While the Kitty Hawk landfalls would offer the shortest offshore export cable routing option and shortest onshore export cable option, these sites are located on the Outer Banks, which has low coastal resiliency and shoreline stability and would require careful engineering consideration and additional investment to ensure reliability and protection of assets. The Sandbridge Landfall would not have these coastal resiliency and shoreline stability concerns.

The Little Island Park Landfall, though not carried forward in the PDE, was identified as a potential alternative landfall should new developments result in the Sandbridge Landfall becoming less favorable.

2.1.3 Onshore Substation and Switching Station

Based on evaluation of potential landfall locations and offshore export cable routing, the Company then identified five locations for the onshore substation and switching station (onshore substation site) within approximately 30 km from the Sandbridge Landfall location and, for existing substations, with existing 230-kilovolt capacity (Figure 2.1-8):

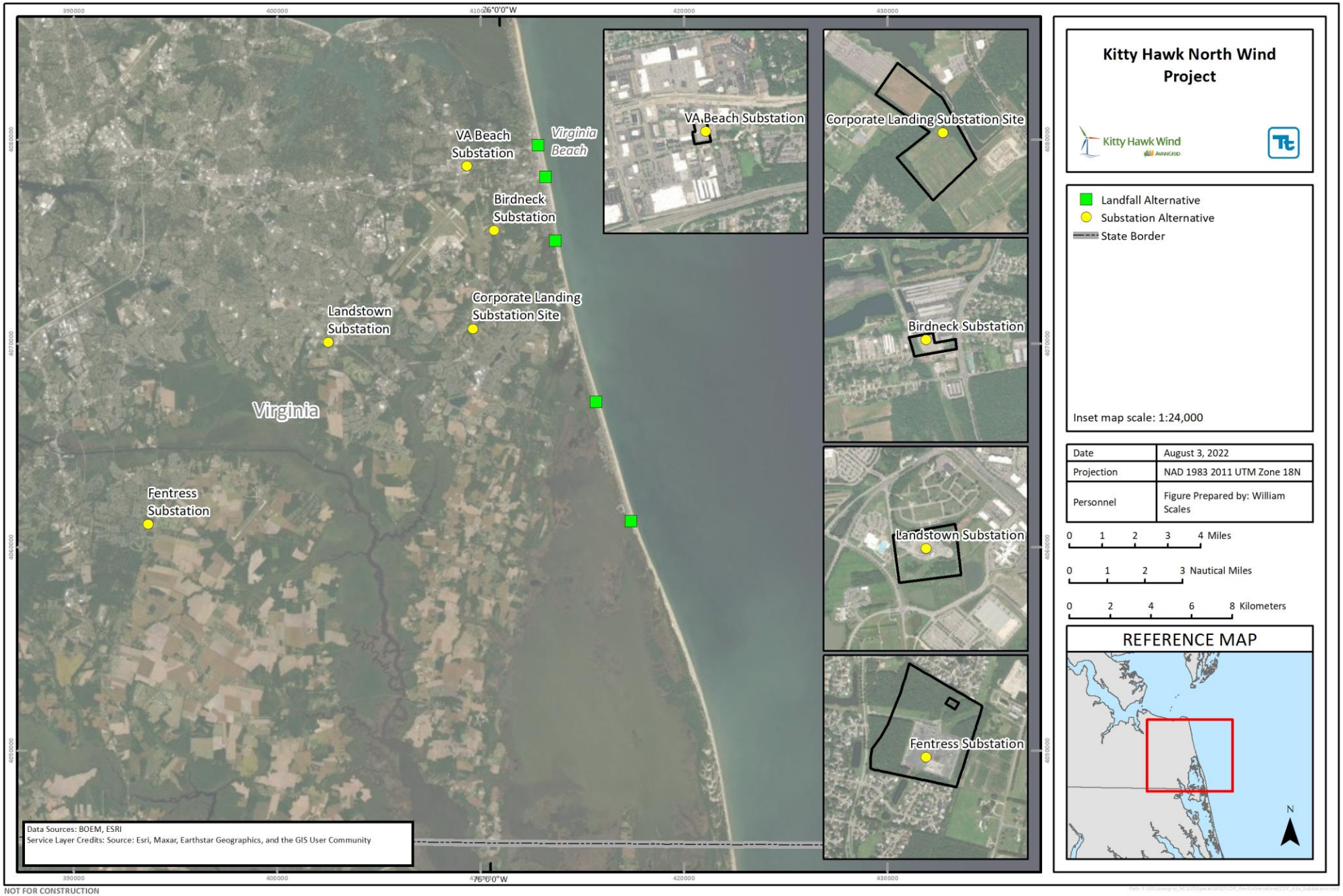

Figure 2.1-8 Potential Onshore Substation Sites from the Sandbridge Landfall

- Virginia Beach Onshore Substation, Virginia Beach, Virginia;
- Birdneck Onshore Substation, Virginia Beach, Virginia;
- Corporate Landing Onshore Substation site, Virginia Beach, Virginia;
- Landstown Onshore Substation, Virginia Beach, Virginia; and
- Fentress Onshore Substation, Chesapeake, Virginia.

Potential land cable routes to each of the five substation sites are described in Section 2.1.4.

These locations were identified for interconnection based on proximity to the existing grid system and commercial considerations. These five locations were evaluated to determine if they provided adequate and appropriate space for construction of a new substation and switching station and/or upgrades to an existing substation. Additional considerations included distance from potential landfall locations, proximity to residences, land use, cultural and historic resources, and environmental resources such as wetlands or forested habitat.

The Corporate Landing Onshore Substation site is located west of the intersection of Corporate Landing Parkway and General Booth Boulevard and is within the Corporate Landing Business Park parcel owned by the City of Virginia Beach (Virginia Beach Development Authority). The area is bordered by a parking lot to the northwest, a stormwater management facility to the north, an overhead high-voltage transmission line and agricultural fields to the south and east, and wooded areas to the south and west. This site was selected as the preferred location for the onshore substation and switching station as it offers a relatively short length of onshore export cable routing (approximately 9 km) to connect from the Sandbridge Landfall, is within a business park setting and allows for use of commercial space, avoids densely populated residential areas and high visitor use areas, and is well sited to allow for interconnection into the existing transmission system.

2.1.4 Onshore Export Cable Routing

Potential onshore export cable routes from the Sandbridge Landfall considered for analysis are depicted in Figure 2.1-9.

2.1.4.1 Sandbridge to Landstown

The Sandbridge to Landstown onshore export cable route begins at the Sandbridge Landfall and travels southwest along the public ROW for Sandbridge Road for 1 km, turning northwest for 0.7 km. At that point, the route leaves Sandbridge Road and follows a utility line ROW for 2.3 km until it reaches Nimmo Parkway, and then continues along Nimmo Parkway for 7.3 km, turning gradually west. At Princess Anne Road, the route again turns northwest for 3 km, then turns off of Princess Anne Road to the southwest for 0.5 km to the Landstown Onshore Substation. The total route length is 14.8 km.

The Sandbridge to Landstown onshore export cable route is one of the longest of the routes considered, and crosses eight major roads and four waterways including Ashville Bridge Creek and West Neck Creek. Seven individual Virginia Department of Historic Resources (VDHR) historic structures, one of which is a cemetery (Colonial Grove Memorial Park), are present within a 50-m buffer of the route. Additionally, there are two emergency service buildings (Fire/EMS), three churches, and three schools along the route.

2.1.4.2 Sandbridge to Birdneck

The Sandbridge to Birdneck onshore export cable route begins at the Sandbridge Landfall and travels southwest along the public ROW for Sandbridge Road for 1 km, turning northwest for 0.7 km. At that point, the route leaves Sandbridge Road and follows a utility line ROW for 2.3 km until it reaches Nimmo Parkway, and then continues along Nimmo Parkway for 3 km, turning gradually west. It turns north at General Booth Boulevard and continues for 5.8 km to South Birdneck Road. It travels north along South Birdneck Road for 1.7 km to the Birdneck Onshore Substation. The total route length is 14.5 km.

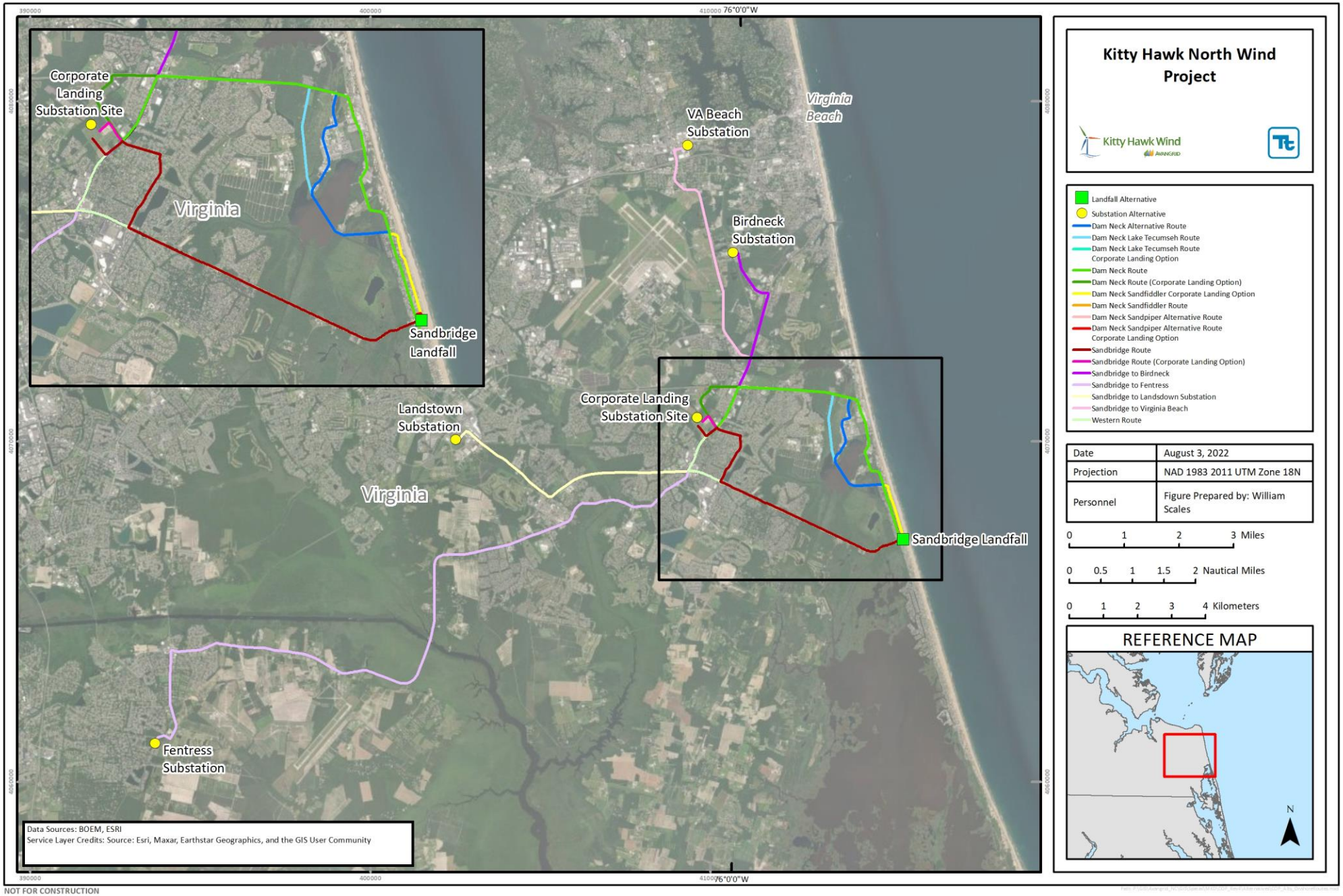

Figure 2.1-9 Potential Onshore Export Cable Routes from the Sandbridge Landfall

Construction complexity would be a challenge along this route, due in part to crossing 11 major roads. The only identified benefit of this route was the relatively flat ground, which is similar throughout the considered routes.

2.1.4.3 Sandbridge to Fentress

The Sandbridge to Fentress onshore export cable route begins like the other Sandbridge routes: beginning at the Sandbridge Landfall the route travels southwest along the public ROW for Sandbridge Road for 1 km, turning northwest for 0.7 km. At that point, the route leaves Sandbridge Road and follows a utility line ROW for 2.3 km until it reaches Nimmo Parkway, and then continues along Nimmo Parkway for 3 km, turning gradually west. At General Booth Boulevard it turns southwest along Princess Anne Road, for 4 km, which then becomes North Landing Road, turning south. The route follows North Landing Road (continuing on to Mount Pleasant Road) for approximately 15.5 km until it reaches the Centerville Turnpike South. The route turns south along the Centerville Turnpike South for 2.7 km, before turning west 0.5 km into the Fentress Onshore Substation. The total route length is 29.7 km.

The Sandbridge to Fentress onshore export cable route is the longest of onshore routes considered, resulting in significantly greater impacts to the surrounding environment and to densely populated areas of Virginia Beach. The route would cross eight major roads and eight water crossings, including the Intercoastal Waterway.

There are also sensitive areas along the route, including two National Register of Historic Places historic districts (Albermarle & Chesapeake Canal Historic District and Centreville-Fentress Historic District), four VDHR historic districts (Virginia Beach Courthouse and Municipal Center Historic District, Princess Anne Courthouse Village Historic District, Albermarle & Chesapeake Canal Historic District, and Centreville-Fentress Historic District), and 55 individual VDHR historic structures (including two cemeteries) within the 50-m search buffer.

2.1.4.4 Sandbridge to Virginia Beach

A route to the Virginia Beach Onshore Substation was also considered. This route is similar to, but longer than, the route to the Birdneck Onshore Substation. Beginning at the Sandbridge Landfall the route travels southwest along the public ROW for Sandbridge Road for 1 km, turning northwest for 0.7 km. At that point, the route leaves Sandbridge Road and follows a utility line ROW for 2.3 km until it reaches Nimmo Parkway, and then continues along Nimmo Parkway for 3 km, turning gradually west. It turns north at General Booth Boulevard and continues for 3.9 km. There, it diverges from the Birdneck route and turns onto Oceana Boulevard, which it follows for 7 km. Soon after crossing Virginia Beach Parkway, it turns east off Oceana Boulevard and traverses approximately 0.4 km to reach the Virginia Beach Onshore Substation. The total route length is 18.3 km.

This route was eliminated from consideration, as it is less efficient than the Sandbridge to Birdneck alternative and provided no significant benefits.

2.1.4.5 Sandbridge to Corporate Landing – Western Route Option

The Sandbridge to Corporate Landing – western onshore export cable route option begins at the Sandbridge Landfall and travels southwest along the public ROW for Sandbridge Road for 1 km, turning northwest for 0.7 km. At that point, the route leaves Sandbridge Road and follows a utility line ROW for 2.3 km until it reaches Nimmo Parkway. It then continues along Nimmo Parkway for 2.9 km, turning gradually west, then turns north at General Booth Boulevard. The route turns off of General Booth Boulevard after 1.2 km and enters the substation site from the south. The total route length is up to 8.5 km.

Engineering benefits of this route include consistently flat ground with lack of any slope challenges, and fairly low complexity construction with only three major bends and four major road crossings. The route is

sited within city streets and utility ROWs, reducing needs for additional easements, which can be costly, time consuming, and may present additional landowner/stakeholder concerns.

The Sandbridge to Corporate Landing – western onshore export cable route option is significantly shorter than other options, minimizing environmental and stakeholder impacts. This route crosses only four major roads and one waterway (Ashville Bridge Creek). Only three VDHR historic structures are located within 50 m of the route.

Impacts associated with this route were also present in all onshore route options and can be appropriately avoided, minimized, and/or mitigated. Overall, impacts associated with this route are much lower than for the other routes. The western onshore route option from Sandbridge to the Corporate Landing Onshore Substation site was therefore selected as an option carried forward in the PDE.

2.1.4.6 Sandbridge to Corporate Landing – Sandbridge Route

The Company evaluated a second routing option between the Sandbridge Landfall and Corporate Landing Onshore Substation site. The Sandbridge to Corporate Landing – Sandbridge onshore export cable route follows the same path as the western route option from landfall, along the public ROW for Sandbridge Road, the city-owned utility ROW, and Nimmo Parkway. The Sandbridge route diverges to turn northeast on Upton Drive for 1.5 km, then turns west on Culver Lane for approximately 0.7 km to General Booth Boulevard. The route then heads southwest on General Booth Boulevard for approximately 0.4 km to the substation site. It then turns northwest to cross an empty field to reach the substation site. The total route length is 9 km. Like the western route option, engineering benefits of the Sandbridge route include consistently flat ground with lack of significant slope challenges, and fairly low complexity construction with only four major bends and three major road crossings.

The Sandbridge to Corporate Landing – Sandbridge route is significantly shorter than other options, with the exception of the similar western route option, and minimizes environmental and stakeholder impacts. The Sandbridge route crosses only three major roads and one waterway (Ashville Bridge Creek). Four VDHR historic structures are located within 50 m of the route.

Impacts associated with this route were also present in all onshore route options and can be appropriately avoided, minimized, and/or mitigated. Overall, impacts associated with this route are much lower than for the other routes. The Sandbridge route from Sandbridge to Corporate Landing Onshore Substation site was therefore also selected as an option carried forward in the PDE.

2.1.4.7 Sandbridge to Corporate Landing – Dam Neck Route

The Company evaluated a third routing option between the Sandbridge Landfall and Corporate Landing Onshore Substation site, the Sandbridge to Corporate Landing – Dam Neck route. From the Sandbridge Landfall, the Dam Neck route heads north from Sandbridge Road, crossing between the Sandbridge Dunes condominium complex and St. Simon's by the Sea Episcopal Church to Sandpiper Road. The route follows Sandpiper Road north for approximately 1.5 km. From there, the route follows Regulus Avenue north for approximately 2.8 km. The route then heads west on Dam Neck Road for approximately 3.5 km, then turns south along General Booth Boulevard for approximately 1.7 km, entering the substation site from the southeast. An alternate approach to the substation site follows Dam Neck Road for approximately 4.4 km west to Corporate Landing Parkway. At Corporate Landing Parkway, this route alternative heads generally south-southeast for approximately 1.4 km to General Booth Boulevard. At General Booth Boulevard, this route alternative continues approximately 0.4 km southwest to the substation site, approaching it from the southeast. For both the Dam Neck route and Corporate Landing option, the route may be installed aboveground or overhead. The Dam Neck total route length is up to 10.3 km and the Dam Neck route (Corporate Landing option) is up to 11.3 km. The Company has engaged with the U.S. Navy to use Dam Neck Annex as a potential route through this area and sought input on this proposed route.

The Sandbridge to Corporate Landing – Dam Neck route is similar in length to the Sandbridge route and western route option, and minimizes environmental and stakeholder impacts. This route will require a private easement for the area near the landfall between the condominium complex and the church as well as an agreement with the U.S. Navy to access the Dam Neck Annex. The Dam Neck route is located within existing roadways and previously disturbed areas, to the extent practicable, reducing the need for additional easements beyond those identified, which can be costly, time consuming, and may present additional landowner/stakeholder concerns. After discussions with Dam Neck Annex, this route was eliminated from consideration as it would impact certain functions critical to the Dam Neck mission.

2.1.4.8 Sandbridge to Corporate Landing – Dam Neck Lake Tecumseh Route

The Company evaluated another route from Sandbridge to Corporate Landing through Dam Neck Annex, the Dam Neck Lake Tecumseh route. Dam Neck Lake Tecumseh route follows the same route as the Dam Neck route from the landfall north along Sandpiper Road. At the northern terminus of Sandpiper Road. This route continues on Regulus Avenue for 0.05 km then heads west along paper road South Bullpup Street for approximately 0.8 km. The route then heads northwest through an approximately 0.2-km stretch of undeveloped land towards Lake Tecumseh. The route then crosses an approximately 0.8-km stretch of Lake Tecumseh heading northwest. From the edge of Lake Tecumseh, the route heads generally north-northwest for approximately 2 km through wetlands and undeveloped land to Dam Neck Road. At Dam Neck Road, this route heads west for either approximately 2.8 km to General Booth Boulevard or approximately 3.6 km to Corporate Landing Parkway. The route alternatives to the substation site along General Booth Boulevard and Corporate Landing Parkway are the same as those described above for the Dam Neck route. At General Booth Boulevard, the route then turns south and continues along General Booth Boulevard for approximately 1.7 km, entering the substation site from the southeast. Alternatively, the route continues along Dam Neck Road to Corporate Landing Parkway, then heads generally south-southeast for approximately 1.4 km to General Booth Boulevard. At General Booth Boulevard, this route alternative continues approximately 0.4 km southwest to the substation site, approaching it from the southeast. For the Dam Neck Lake Tecumseh route, the route may be installed underground or overhead. This route is up to 10.6 km from Sandbridge to Corporate Landing via General Booth Boulevard or up 11.5 km from Sandbridge to Corporate Landing via Corporate Landing Parkway.

This route was eliminated from consideration, as it involves additional environmental impacts associated with the Lake Tecumseh and wetland crossing through the Dam Neck Annex property and provides no significant benefits over the Dam Neck route alternative described above.

2.1.4.9 Sandbridge to Corporate Landing – Dam Neck Alternative Route

The Company evaluated another route from Sandbridge to Corporate Landing through Dam Neck Annex, the Dam Neck Alternative route. The Dam Neck Alternative route follows the same route as the Dam Neck route from the landfall north along Sandpiper Road. At the northern terminus of Sandpiper Road, this route continues on Regulus Avenue for 0.05 km then heads west along paper road South Bullpup Street for approximately 0.8 km. The route then heads northwest through an approximately 0.2-km stretch of undeveloped land towards Lake Tecumseh. The route then crosses an approximately 0.8-km stretch of Lake Tecumseh heading northwest. From here, the route heads north through an approximately 0.1-km undeveloped area to Tartar Avenue within Dam Neck Annex. The route follows Tartar Avenue generally north and then east for approximately 1.5 km to Terrier Avenue. At Terrier Avenue, the route heads north for approximately 0.6 km to Dam Neck Road. At Dam Neck Road, the route heads west for approximately 3.3 km to General Booth Boulevard. At General Booth Boulevard, the route then turns south and continues along General Booth Boulevard for approximately 1.7 km, entering the substation site from the southeast. The total route length is up to 11.3 km.

This route was eliminated from consideration, as it involves additional environmental impacts associated with the Lake Tecumseh crossing through the Dam Neck Annex property and provided no significant benefits over the Dam Neck route described above.

2.1.4.10 Sandbridge to Corporate Landing – Dam Neck Sandfiddler Route

The Company evaluated another route from Sandbridge to Corporate Landing through Dam Neck, the Dam Neck Sandfiddler route. From the landfall, the Dam Neck Sandfiddler route heads east on Sandbridge Road to Sandfiddler Road. The route follows Sandfiddler Road generally north and then west for approximately 1.7 km to the intersection of Sandpiper Road and Regulus Avenue. From there, the route heads north on Regulus Avenue for approximately 2.8 km through Dam Neck Annex. The route continues on Regulus Avenue to Dam Neck Road. At Dam Neck Road, this route heads west for approximately 3.5 km, then turns south along General Booth Boulevard for approximately 1.7 km, entering the substation site from the southeast. An alternate approach to the substation site follows Dam Neck Road for approximately 4.4 km west to Corporate Landing Parkway. At Corporate Landing Parkway, this route alternative heads generally south-southeast for approximately 1.4 km to General Booth Boulevard. At General Booth Boulevard, this route alternative continues approximately 0.4 km southwest to the substation site, approaching it from the southeast. This route may be installed aboveground or overhead. The Dam Neck Sandfiddler total route length is up to 10.5 km via General Booth Boulevard or up to 11.4 km via Corporate Landing.

This route was eliminated from consideration, as it is less efficient than the Sandbridge to Corporate Landing – Dam Neck route alternative; it is located closer to the ocean and is more likely to be flooded based on that proximity; Sandfiddler Road is a narrower road than Sandpiper Road; and provided no significant benefits over the Dam Neck route described above.

2.1.4.11 Sandbridge to Corporate Landing – Dam Neck Sandpiper Alternative Route

The Company evaluated another route from Sandbridge to Corporate Landing through Dam Neck, the Dam Neck Sandpiper Alternative route. From the landfall, the Dam Neck Sandpiper Alternative route heads east on Sandbridge Road to Sandfiddler Road. The route follows Sandfiddler Road north for approximately 0.1 km then turns west onto Marlin Lane for approximately 0.1 km. The route then heads north on Sandpiper Road for approximately 1.5 km. Sandpiper Road turns into Regulus Avenue and route heads north into the Dam Neck Annex. The route continues generally north on Regulus Avenue for approximately 2.8 km through Dam Neck Annex to Dam Neck Road. At Dam Neck Road, this route heads west for approximately 3.5 km, then turns south along General Booth Boulevard for approximately 1.7 km, entering the substation site from the southeast. An alternate approach to the substation site follows Dam Neck Road for approximately 4.4 km west to Corporate Landing Parkway. At Corporate Landing Parkway, this route alternative heads generally south-southeast for approximately 1.4 km to General Booth Boulevard. At General Booth Boulevard, this route alternative continues approximately 0.4 km southwest to the substation site, approaching it from the southeast. This route may be installed aboveground or overhead. The Dam Neck Sandpiper Alternative total route length is up to 10.5 km via General Booth Boulevard or up to 11.4 km via Corporate Landing.

This route was eliminated from consideration, as it is less efficient than the Sandbridge to Corporate Landing – Dam Neck route alternative and provided no significant benefits.

2.1.5 Siting Conclusion

As described, the Company evaluated several options to deliver the proposed Project capacity into the existing grid, including options for landfall, offshore export cable routing, points of interconnection, and onshore export cable routing. Based on a holistic evaluation of the preferred solutions for each isolated component, the Company selected a northern offshore route, landfall at Sandbridge, Virginia, and an onshore route to the Corporate Landing Onshore Substation site. This preferred solution minimizes conflicts with existing offshore and onshore DoD operations areas and existing offshore infrastructure, as well as minimizing conflicts with high density development and tourism areas.

The Sandbridge Landfall has adequate space to support construction and would have the shortest length for the offshore export cables to make landfall from the 8 to 10-m contour offshore. An offshore export cable

landfall at Sandbridge will also avoid the coastal resiliency and shoreline stability concerns of the Outer Banks, and will allow for a relatively short onshore export cable route that minimizes potential impact on natural resources, historic resources, and residential areas. The Company is carrying forward in the PDE two potential onshore export cable routes.

2.2 Wind Development Area and WTG Layout

The Wind Development Area covers approximately 40 percent of the Lease Area, in the northwest corner closest to shore (19,441 hectares). This proximity to land results in a shorter offshore export cable route, reducing cost as well as environmental impact. In addition, the western portion of the Lease Area has shallower water depths, which reduces technical constraints for installation of the WTG and electrical service platform foundations and inter-array cables.

In developing the layout options, the Company considered existing marine uses of the area, in addition to engineering constraints and environmental factors. The layout options carried forward in the PDE are the result of communication with stakeholders, particularly the DoD and commercial fishers who use the area.

The Company originally considered an optimized layout to fully maximize wind energy production; this included a dense border with an internal gap on the southwestern side (see Figure 2.2-1). After engagement with stakeholders, the layout was modified to a regularly spaced grid pattern to facilitate transit by local fishers, historical trawl tow directionality by commercial fisheries, search and rescue operations, and other marine navigation. Discussion with local trawlers led to a further modification of the layout, which created wider transit lanes in the northwest-southeast direction, the predominant direction for trawling in the area.

The proposed safety shipping fairways identified in the Atlantic Coast Port Access Route Study[1] were published during Project design development (USCG 2020). The intent of port access route studies is to help facilitate safe navigation through the designation of fairways (e.g., lane or corridor), for the purpose of safe routing around existing and future offshore wind lease areas. One of the proposed fairways intersects with the northwest portion of the Lease Area.[2] In response to discussions with the United States Coast Guard regarding the proposed fairways, the Company committed to moving one WTG location that was previously located in the area of overlap. The WTG location was moved to the north to be outside of the proposed United States Coast Guard fairway and avoid the potential for conflict. No Project features are located within the proposed fairways and the Company understands that no further mitigation is required.

In the scenario proposed in the PDE, the closest WTGs will be spaced approximately 1.4 km apart, with rows about 2.2 km wide. The electrical service platform is included as one of the identified foundation locations within the gridded layout. Selection of the location for the electrical service platform will be determined by engineering and meteorological analysis.

[1] Final report recommendations expected in June 2021.
[2] Portions of BOEM North Carolina Lease OCS–A 0508, in OCS sub-block 6664D are located within protraction NJ18–11. This potential fairway overlaps a portion of this sub-block by 120 m at its widest point.

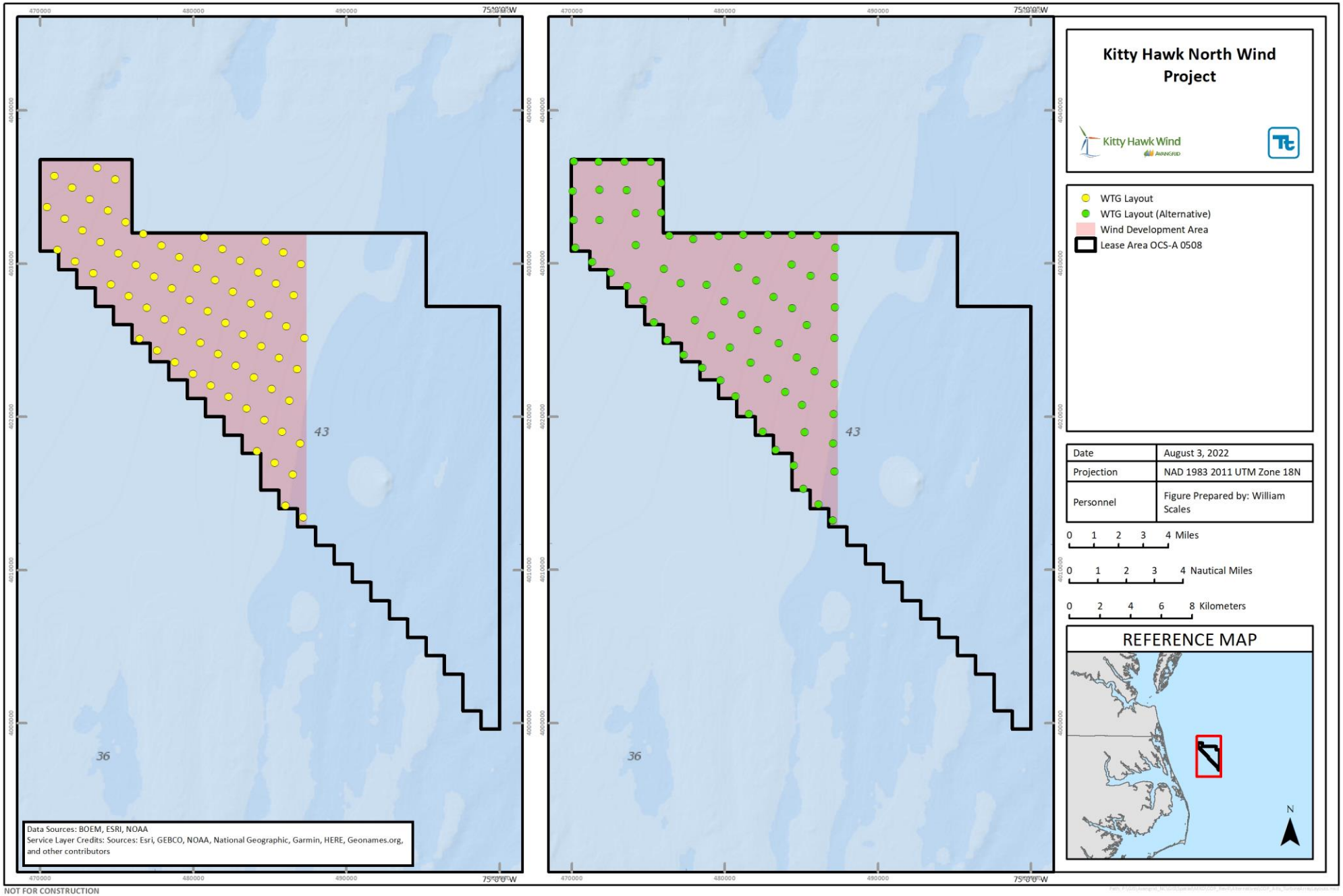

Figure 2.2-1 Original Optimized WTG Layout

2.3 Project Components and Technology

2.3.1 Foundations

The Company evaluated several potential types of foundations:

- **Monopile**: a single vertical, broadly cylindrical steel pile driven into the seabed;
- **Suction Caisson** (monobucket): an inverted bucket-like structure embedded in the seabed sediment by suction force;
- **Piled Jacket**: a vertical steel lattice structure consisting of three or four legs, from which piles are inserted, connected through cross bracing;
- **Suction Caisson Jacket**: a vertical steel lattice structure consisting of three or four legs that contain inverted bucket-like structures at the base, embedded in the seabed sediment by suction force, connected through cross bracing;
- **Tripod** (tetrabase): a hybrid between jacket and monopile construction, with three piles or caissons connected to a single main shaft;
- **Gravity Base Structure**: a concrete or steel structure consisting of a circular base slab covered by a conical shell; and
- **Floating**: A floating structure, typically a spar or semi-submersible, which is tethered to the seafloor through a set of anchoring devices.

Each foundation type was evaluated based on the following criteria:

- Subsurface conditions;
- Water depths;
- Supply chain capacity; and
- Commercial availability.

Three foundation types were deemed suitable against the criteria identified above: monopile, piled jacket, and suction caisson jacket. Floating foundations were not considered feasible for the PDE as water depths in the Wind Development Area are not deep enough to justify the additional costs and engineering requirements. Gravity base structures were removed from consideration due to the large area of seafloor that would be impacted by the large structure and required scour protection, resulting in increased sediment disturbance and larger areas of habitat loss; increased risk of invasive species spread; unsuitable water depth; and the lack of available heavy lift vessels required for installation (BOEM 2020). There is additional risk in using this shallow foundation type due to the presence of sands and silts in the seabed at some sites, leading to lower strength in the seabed that may preclude gravity base structures. Dredging and ground improvement campaigns may be required to mitigate this, further increasing sediment disturbance and habitat loss. Tripod structures provided no significant benefits compared to jacket and monopile options, are more costly, are less technically mature, and have joints that are more fatigue prone compared to jacket foundations; thus, tripod structures were not carried forward in the PDE. Suction caisson foundations (monobuckets) were also removed from consideration due to water depth limitations, geotechnical conditions, the lack of a mature supply chain, and because this foundation type is not yet proven for large WTGs (see Appendix E Foundation Structure Concept Screening).

2.3.2 Offshore Export Cables

The Company evaluated use of high-voltage direct-current (HVDC) as well as high-voltage alternating-current cables for the offshore export cables. HVDC is primarily used for long-distance power transmission, as it minimizes electrical losses along the length of the cable. However, high-voltage alternating-current is a more traditional and cost-effective solution for a project of up to 69 WTGs with multiple circuits. Additionally, the WTGs produce alternating currents, and the electrical grid onshore is a primarily alternating-current system. Use of HVDC cables would therefore require converter stations both on land

and within the Lease Area to convert the energy produced by the WTGs to direct current for transmission, then back to alternating currents for interconnection. Construction of these converter stations would likely lead to greater environmental impacts as well as additional cost.

Based on the relatively short transmission distance and the power rating of the offshore export cables, the additional cost and impacts of an HVDC system are not justified. Existing offshore wind facilities in Europe as well as existing and planned offshore wind facilities in the U.S. use high-voltage alternating-current systems for energy transmission at distances comparable to the Project. HVDC transmission was therefore not selected as an option and not carried forward into the PDE.

2.4 References

See Table 2.4-1 for data sources used in the preparation of this chapter.

Table 2.4-1 Data Sources

Source	Includes	Available at	Metadata Link
BOEM (Bureau of Ocean Energy Management)	Lease Area	https://www.boem.gov/BOEM-Renewable-Energy-Geodatabase.zip	N/A
BOEM	Sand Borrow Area	http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Federal-Sand-n-Gravel-Lease-Borrow-Areas_gdb.aspx	https://mmis.doi.gov/boemmmis/metadata/PlanningAndAdministration/LeaseAreas.xml
BOEM	State Territorial Waters Boundary	https://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/ATL_SLA(3).aspx	http://metadata.boem.gov/geospatial/OCS_SubmergedLandsActBoundary_Atlantic_NAD83.xml
HIFLD (Homeland Infrastructure Foundation-Level Data)	Substations	https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-substations	https://www.arcgis.com/sharing/rest/content/items/755e8c8ae15a4c9abfceca7b2e95fb9a/info/metadata/metadata.xml?format=default&output=html
HIFLD	Transmission Lines	https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-power-transmission-lines	https://www.arcgis.com/sharing/rest/content/items/70512b03fe994c6393107cc9946e5c22/info/metadata/metadata.xml?format=default&output=html
USACE	Pendleton Danger Zone	https://www.nao.usace.army.mil/Media/Public-Notices/Article/601227/nao-2014-0044/	N/A
NOAA (National Oceanic and Atmospheric Administration)	Shipping: Speed Restrictions (Right Whales), Precautionary Area, Separation Zone, Traffic Lane/Fairway, Area to Be Avoided	http://encdirect.noaa.gov/theme_layers/data/shipping_lanes/shippinglanes.zip	https://inport.nmfs.noaa.gov/inport-metadata/NOAA/NOS/OCS/inport/xml/39986.xml
NOAA	Shipwreck/ Obstruction (AWOIS)	ftp://ftp.coast.noaa.gov/pub/MSP/WrecksAndObstructions.zip	https://www.fisheries.noaa.gov/inport/item/39961
NOAA	Shipwreck (ENC)	https://opendata.arcgis.com/datasets/46dafe60b47e46a78099c3e62bc935b3_14.zip	https://www.arcgis.com/home/item.html?id=46dafe60b47e46a78099c3e62bc935b3
NOAA	Danger Zone/ Restricted Area	ftp://ftp.coast.noaa.gov/pub/MSP/DangerZonesAndRestrictedAreas.zip	https://inport.nmfs.noaa.gov/inport/item/48876

Source	Includes	Available at	Metadata Link
NOAA	Territorial Sea (12-nm Limit)	http://maritimeboundaries.noaa.gov/downloads/USMaritimeLimitsAndBoundariesSHP.zip	https://inport.nmfs.noaa.gov/inport-metadata/NOAA/NOS/OCS/inport/xml/39963.xml
U.S. Navy	Military Special Use Airspace	ftp://ftp.coast.noaa.gov/pub/MSP/MilitaryAreas.zip	https://www.fisheries.noaa.gov/inport/item/48898

APTIM (APTIM Coastal Planning & Engineering of North Carolina, Inc.). 2019. *Town of Kitty Hawk & Kill Devil Hills, North Carolina: 2018 Shoreline & Volume Change Monitoring Report.* Available online at: https://23fw321trq9c3wwiyfy66giv-wpengine.netdna-ssl.com/wp-content/uploads/2019/02/FINAL_Town-of-KH_KDH-Monitoring-Report_2019_02_7.pdf. Accessed 30 Oct 2020.

BOEM (Bureau of Ocean Energy Management). 2020. *Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations*. Prepared by ICF Incorporated, L.L.C. U.S. Dept. of the Interior, OCS Study BOEM 2020-041. 42 pp.

City of Virginia Beach. 2017a. "Little Island Coast Guard Station." Available online at: https://www.vbgov.com/government/departments/planning/boards-commissions-committees/pages/vb%20historical%20register/little-island-coast-guard.aspx. Accessed 09 Sep 2020.

City of Virginia Beach. 2017b. "Little Island Park." Available online at: https://www.vbgov.com/government/departments/parks-recreation/parks-trails/city-parks/pages/little-island-park.aspx. Accessed 09 Sep 2020.

Rowe, J., A. Payne, A. Williams, D. O'Sullivan, and A. Morandi. 2017. *Phased Approaches to Offshore Wind Developments and Use of Project Design Envelope*. Final Technical Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2017-057. 161 pp. Available online at: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/Phased-Approaches-to-Offshore-Wind-Developments-and-Use-of-Project-Design-Envelope.pdf. Accessed 20 Oct 2020.

USACE (U.S. Army Corps of Engineers). 2018. *Supplemental Essential Fish Habitat Assessment: Sandbridge Beach Erosion Control and Hurricane Protection Project; Virginia Beach, Virginia.* Available online at: https://www.boem.gov/sites/default/files/non-energy-minerals/Sandbridge-EA-All-Appendices.pdf. Accessed 06 Jul 2020.

USCG (United States Coast Guard). 2020. Shipping Safety Fairways Along the Atlantic Coast, 85 Fed. Reg. 37034 (June 19, 2020) (codified at 33 CFR 166).