OCS-A 0501

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VINEYARD WIND

Draft Construction and Operations Plan

Volume I

Vineyard Wind Project

September 30, 2020

Submitted by
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700 Pleasant Street, Suite 510
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Submitted to
Bureau of Ocean Energy Management
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Sterling, Virginia 20166

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In Association with:

Baird & Associates
Biodiversity Research Institute
C2Wind
Capitol Air Space Group
Clarendon Hill Consulting
Ecology and Environment
Foley Hoag
Geo SubSea LLC
Gray & Pape
JASCO Applied Sciences
Morgan, Lewis & Bockius LLP
Public Archaeology Laboratory, Inc.
RPS
Saratoga Associates
Swanson Environmental Associates
Wood Thilsted Partners Ltd
WSP

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Section 4.0

Project Activities

4.0 PROJECT ACTIVITIES

4.1 Construction Schedule

An overview of a representative construction and commissioning schedule for an 800 MW project is provided in Section 1.4.3, specifically Figure 1.5-1.

4.2 Deployment and Construction

4.2.1 Deployment Overview

Deployment of the necessary vessels and construction equipment will be sequenced in a manner similar to the construction schedule provided in Section 4.1. The installation sequence and construction methodology are generally described in Section 1.5. A more detailed discussion is provided in Section 4.2.3.

4.2.2 Health, Safety & Environmental Protection Features during Deployment and Installation

Vineyard Wind is firmly committed to Project safety and full compliance with applicable health, safety, and environmental protection regulations and codes. This commitment extends to all phases of the Project, commencing with deployment, into the construction/ installation phases and through the O&M phase.

The challenges of large-scale construction in a marine environment require that health, safety and environmental protection are rigorously and continually assessed at every stage of the Project. Members of the Vineyard Wind team have many years of experience with safely constructing such projects in the North Sea, the Baltic Sea and other challenging environments. This experience will be applied to the planning, design, procurement and execution of the Vineyard Wind Project.

For the deployment and installation, Vineyard Wind's Safety Management System ("SMS") (Appendix I-B) and related Environmental Management System will be utilized. All equipment suppliers and construction firms will be evaluated per the contractor qualification requirements stipulated in the Project's SMS to ensure compliance with regulatory and Project requirements. The evaluation includes a comprehensive gap analysis review of the equipment supplier and/or construction firm's SMS and Environmental Management System to satisfy Vineyard Wind that work can performed in compliance with the Project's SMS.

A Project specific SMS that includes the site-specific health, safety and environmental policies and procedure requirements will be developed. The Safety Management System will contain the minimum requirements for working on-site, which all parties will have to adhere to. The SMS will include, but not be limited to the following:

- The Project's HSE policy
- Requirements for preparing safe systems of work
- Training requirements and requirements for personal protective equipment
- Vessel requirements
- Requirements to carry out HSE inspections of own works
- Reporting to authorities and to the Project
- Hazardous work identified on the Project

Before starting any work on-site, all contractors and construction firms will need to attend a pre-job meeting for a final check that safe systems of work are in compliance with the Project's SMS and that all health and safety requirements are understood. This will also be inspected regularly by the Vineyard Wind EH&S representatives on-site. Furthermore:

Before any vessels are contracted, they will undergo a vessel inspection to make sure that they are compliant (e.g., IMCA audit). This also includes a check of their Safety Management System and Environmental Management System. Any findings of deficiency or non-compliance will be rectified before work begins. Vessels will also be checked to ensure it is 'fit for purpose' for the work they are expected to carry out.

Vessel owners and construction firms will receive a package of the relevant site information in order for them to carry out their work safely. This can include site layout, geotechnical data, and environmental data such as water depths, wind climate, wave climate (including wind wave misalignment and wind speed-wave height correlation), tidal elevation and currents, extreme sea state and extreme wave height, severe sea state and severe wave height, normal sea state, wave breaking, additional parameters, ice, seismic conditions, ship impact, and wave run up.

Safe systems of work such as risk assessments, method statements, lifting plans, towing arrangements, permit to work system (e.g., lifting operations, confined space working) will be in place before work begins. The safe systems of work will be based on regulatory HSE requirements, Project requirements and best practice. During the planning phase for the Project, HSE workshops will be held where planned procedures are tested for interfaces and unsafe practices.

The safe systems of work will be reviewed and approved by Vineyard Wind and the Marine Warranty Surveyor. During the execution of work, Vineyard Wind representatives will regularly check that the work is carried out according to the safe systems of work.

The information in the safe systems of work will be communicated to employees working on-site through toolbox talks. These toolbox talks will be regularly reviewed and attended by Vineyard Wind representatives.

Management and handling of hazardous substances used on the Project will be reviewed ensure compliance with regulatory requirements. This includes checking that appropriate containers, labeling and equipment are used. Where possible, a hazardous substance will be substituted with a more environmentally-friendly alternative.

Vineyard Wind will implement a system for reporting safety observations and near misses. All construction firms will be encouraged to report any observations and share their experiences with Vineyard Wind to avoid reoccurring unsafe acts.

A marine coordination center will be established to control vessel movements throughout the Offshore Project Area. Expected daily vessel movements, crew transfer vessel manifests, and no-go zones on-site will be handled by the marine coordinator. In addition, daily coordination meetings will be held by Vineyard Wind to coordinate between construction operations and avoid unnecessary simultaneous operations at the staging terminals and including routes to the Offshore Project Area.

The Marine Coordinator will implement communication protocols with external vessels at the harbor and offshore, during project construction. The Marine Coordinator will use tools such as radio communications and guard vessels to address vessels entering construction zones. The Marine Coordinator will also work in advance of, and during Project construction, to coordinate activities within and near the harbor(s) with non-Project vessels. Communication protocols will be developed as part of the Project's SMS.

Before construction and installation activities begin, an Oil Spill Response Plan ("OSRP"), Emergency Response Plan ("ERP"), and Safety Management System will be completed (see Appendices I-A and I-B) and issued to the vessels and construction firms. The OSRP and ERP will provide a method/process for communication protocol, coordination, containment, removal and mitigation of foreseen incidents that may occur on the Project. These plans will minimize confusion and indecision, prevent extensive damage to the Project or injury to personnel, and minimize exposure to personnel within or outside of the Project.

In the event of an actual spill or incident, it will be the vessels and construction firms' plans that will be used to contain and/or stop an incident in compliance with the requirements of the projects OSRP. As such, these plans will be checked and reviewed by Vineyard Wind to make sure that they are in accordance with regulatory and Project requirements and that a spill plan is in place. In addition, routine training and exercises regarding the content of the OSRP and ERP will be carried out regularly to prepare personnel to respond to emergencies, should they occur.

4.2.3 Construction Approach

4.2.3.1 Introduction

The discussion of construction and installation approaches is organized by offshore and onshore elements of the Project. The discussion of offshore elements follows the overall plan of installation set forth in the construction schedule, beginning with scour protection and proceeding through installation of offshore export cables, foundations, Electrical Service Platforms ("ESPs"), inter-array cables, and Wind Turbine Generators ("WTGs"). As shown on Figure 1.5-1, and 4.1-1, there is considerable overlap in the installation periods for each of these Project elements.

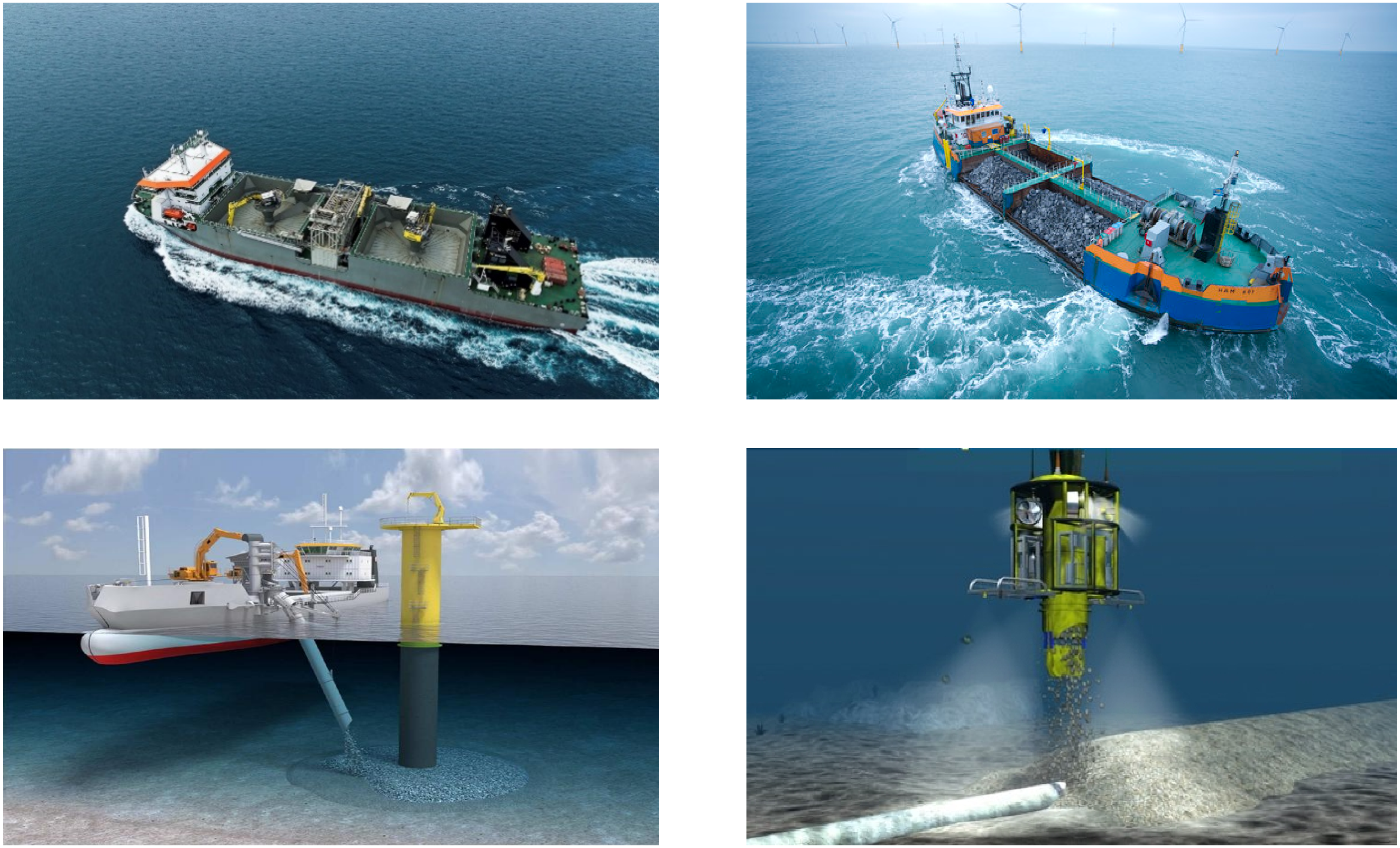
4.2.3.2 Scour Protection

As described in Section 3.1.3, a circular pad of stones or rocks will be placed on the seabed at each foundation location (WTG and ESP) prior to the installation of the foundations. Stone and rock are the most widely used scour protection in the offshore wind industry. Scour protection dimensions are presented above in Table 3.1-3.

The scour protection installation is done in a multi-step process:

1. A pre-construction survey of the bottom bathymetry is conducted.
2. The scour protection material is transported to the site.
3. The scour protection material is placed prior to installation of foundations. If needed, a mud mat may be placed below the scour protection.
4. A post-lay seabed survey of bottom bathymetry is conducted; additional material is added if needed to provide the necessary coverage and thickness.
5. If needed, in limited locations, additional scour protection material may be placed locally to protect the portions of the export or inter-array cables.

Several techniques for placing scour protection exist, including fall pipes, side dumping, and placement using a crane/bucket. The fall pipe method, in which a pipe extends from the vessel to the seafloor in the vicinity of the intended foundation location, is the most precise technique and will be used whereever possible. The fall pipe technique may include a remotely operated vehicle ("ROV") guided lower end. The installation vessel will move along a predetermined pattern to ensure even distribution of the stone and/or rock material. Figure 4.2-1 provides illustrations of typical scour protection vessels.



Note: Figures of scour protection placement are for illustrative purposes only. As described in Section 4.2.3.2 of Volume I, scour protection will be placed prior to foundation installation.

Figure 4.2-1

Scour Protection Installation Vessels

4.2.3.3 Offshore Export Cables

4.2.3.3.1 Overview

The offshore export cables will transmit power from the ESP(s) to the cable Landfall Site. The offshore export cables will likely be transported directly to the Offshore Export Cable Corridor in a cable laying vessel or on a barge and installed by the vessel upon arrival. Vessel types under consideration for cable installation are presented in Table 4.2.3.

In accordance with normal industry practice, a pre-lay grapnel run will be performed in all instances to locate and clear obstructions, such as abandoned fishing gear and other marine debris. Additionally, some dredging may be required prior to cable laying due to the presence of sand waves. The upper portions of sand waves may be removed via mechanical or hydraulic means in order to achieve the proper burial depth below the stable sea bottom. Following the pre-lay grapnel run and any required dredging, offshore export cable laying is expected to be performed primarily via simultaneous lay and burial using jet plowing.[12] However, depending on bottom conditions, water depth, and contractor preferences, other methods may be used in certain areas to ensure proper burial depth. Impacts from cable installation will include an up to 1 m (3.3 ft) wide cable installation trench and an up to 1-2 m (3.3 – 6.6 ft) wide temporary disturbance zone from the skids or tracks of the cable installation equipment, which will slide over the surface of the seafloor. The skids or tracks have the potential to disturb benthic habitat; however, they are not expected to dig into the seabed, and therefore the impact is expected to be minor relative to the trench.

The offshore export cables can either be installed from the shore towards the Wind Development Area ("WDA") or in the opposite direction. The installation will likely require at least one joint (splice) due to the overall distance of the cables (70-80 kilometers ["km"] or 38 – 43 nautical miles ["nm"]). At the ESP(s), the cable will be pulled in. The cable entry protection system is not yet defined, but the entry system will be installed in the interface between the ESP and offshore export cable.

No cable crossings are planned (see Figure 4.2-2). In the event a cable crossing becomes necessary, it is anticipated that the cable crossing may include the following steps:

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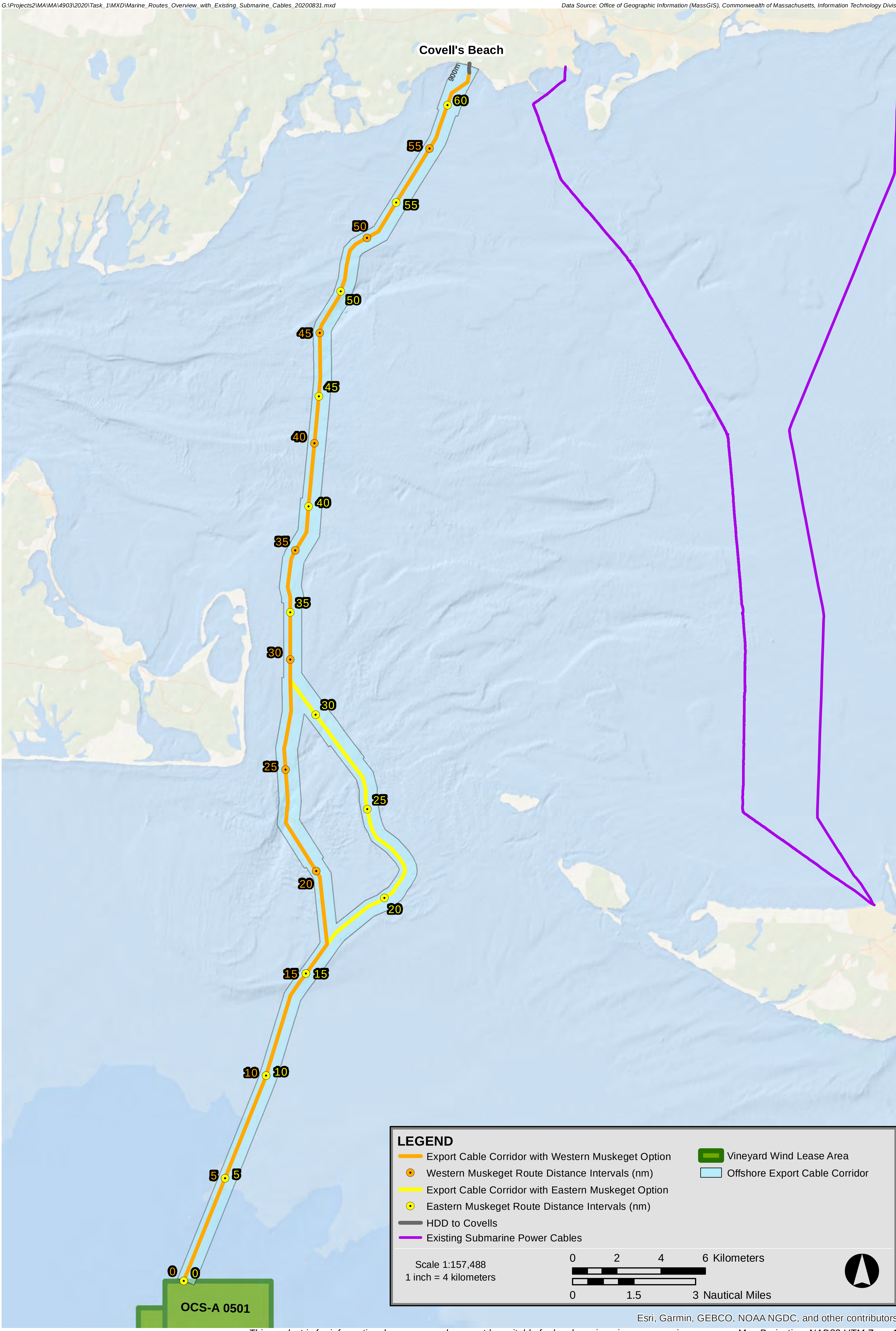
[12] As described in Section 4.2.3.6, the inter-array cables are expected to be installed using a pre-lay/jet plowing approach.



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

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Figure 4.2-2

Existing National Grid Cables Near the Offshore Export Cables

- The existing National Grid power cable will be carefully surveyed and inspected using an ROV, diver, or similar. Any survey will be defined, planned, executed, evaluated and documented according to the rules and regulations set forth by National Grid with agreement by Vineyard Wind.

- Any existing debris surrounding the crossing points will be carefully removed. The plan and procedures for this work will be agreed upon with National Grid.

- Depending on the depth of the National Grid cable and National Grid's requirements, there may be a concrete mattress or other means of protection placed between the National Grid cable and Vineyard Wind's proposed cables. Alternately, if there is sufficient vertical distance between National Grid's cable and Vineyard Wind's proposed cables and it is acceptable to National Grid, there may be no manmade physical barrier between the cables.

- The new export cables will be protected with either additional concrete mattresses, controlled rock placement, or a similar physical barrier. Cable protection measures will be designed to protect the export cables against mechanical impact from above and respect the vertical distance and physical barrier (if any) to the National Grid power cable. The design of the crossing structure will be defined, planned, executed, evaluated and documented according to the rules and regulations set forth by National Grid, and in order to minimize the risk of fouling or snagging of fishing equipment.

- If necessary, scour protection consisting of additional rocks and/or fond mattresses will be carefully placed on and around the crossings.

- Final as-built surveys of the completed crossings will be undertaken. The surveys will be documented according to the rules and regulations set forth by and agreed upon with National Grid. As-built positions will be provided to NOAA for charting purposes.

4.2.3.3.2 Detailed Description of Cable Installation

Pre-lay Grapnel Run

The pre-lay grapnel run will consist of a vessel towing equipment that will hook and recover obstructions such as fishing gear, ropes, and wires from the seafloor.

Dredging

As described in Volume II, marine surveys completed in the summer of 2017 confirmed that portions of the Offshore Export Cable Corridor ("OECC") contain sand waves. Portions of the sand waves may be mobile over time; therefore, the upper portions of the sand waves may need to be removed so that the cable laying equipment can achieve the proper burial depth below the sand waves and into the stable sea bottom.

For each of the two export cables, a 20 meter ("m") (66 feet ["ft]) wide corridor will be dredged. This dredge corridor includes the up to 1 m (3.3 ft) wide cable installation trench and the up to 1-2 m (3.3-6.6 ft) wide temporary disturbance zone from the tracks or skids of the cable installation equipment. For two cables, total dredging may impact up to 279,400 square meters ("m^2") (69 acres)[13] and may include up to 164,000 cubic meters (214,500 cubic yards) of dredged material. The dredge volumes are dependent on the final route and cable installation method. Figure 4.2-3 provides the maximum extent of dredging. The average dredge depth is 0.5 m (1.6 ft) and may range up to 4.5 m (14.7 ft) in localized areas. The total vertical APE within sand waves is up to 8 m (26.2 ft), which includes up to 4.5 m (14.7 ft) of dredging, followed by cable installation to a depth of up to 2.5 m (8 ft), plus a conservative 1 m (3.3 ft) allowance.

Dredging could be accomplished by several techniques. European offshore wind projects have typically used a trailing suction hopper dredge ("TSHD"). Dredges of this type are also commonly used in the US for channel maintenance, beach nourishment projects, and other uses (Figure 4.2-4). For this Project, a TSHD would be used to remove a 20 m (65.6 ft) wide section of a sand wave (for each of the two cables) that is deep enough to allow subsequent installation of the cable using one of the techniques described below. Should a TSHD be used, the sand removed would be discharged from the vessel within the 810 m (2,657 ft) wide cable corridor. It is anticipated that the TSHD would dredge along the OECC until the hopper was filled to an appropriate capacity, then the TSHD would sail several hundred meters away (while remaining within the 810 m [2,657 ft] corridor) and bottom dump the dredged material. No dredging or dumping of dredged materials will be permitted within hard bottom habitat.

A second dredging technique involves jetting (also known as mass flow excavation). Jetting uses a pressurized stream of water to push sand to the side (Figure 4.2-4). The jetting tool draws in seawater from the sides and then jets this water out from a vertical down pipe at a

[13] Impacts will occur from the cable installation's up to one meter (3.3 ft wide) cable installation trench, up to two meter (6.6 ft) wide skid/track disturbance zone, and dredging's 20 m [66 ft] wide corridor. To avoid double- counting impacts, dredge areas are calculated outside of a two meter (6.6 ft) wide cable installation corridor.

G:\Projects2\MA\MA\4903\2020\Task_1\MXD\Marine_Corridors_Overview_with_Dredging_Western_Routes_1_5_20200831.mxd

Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division

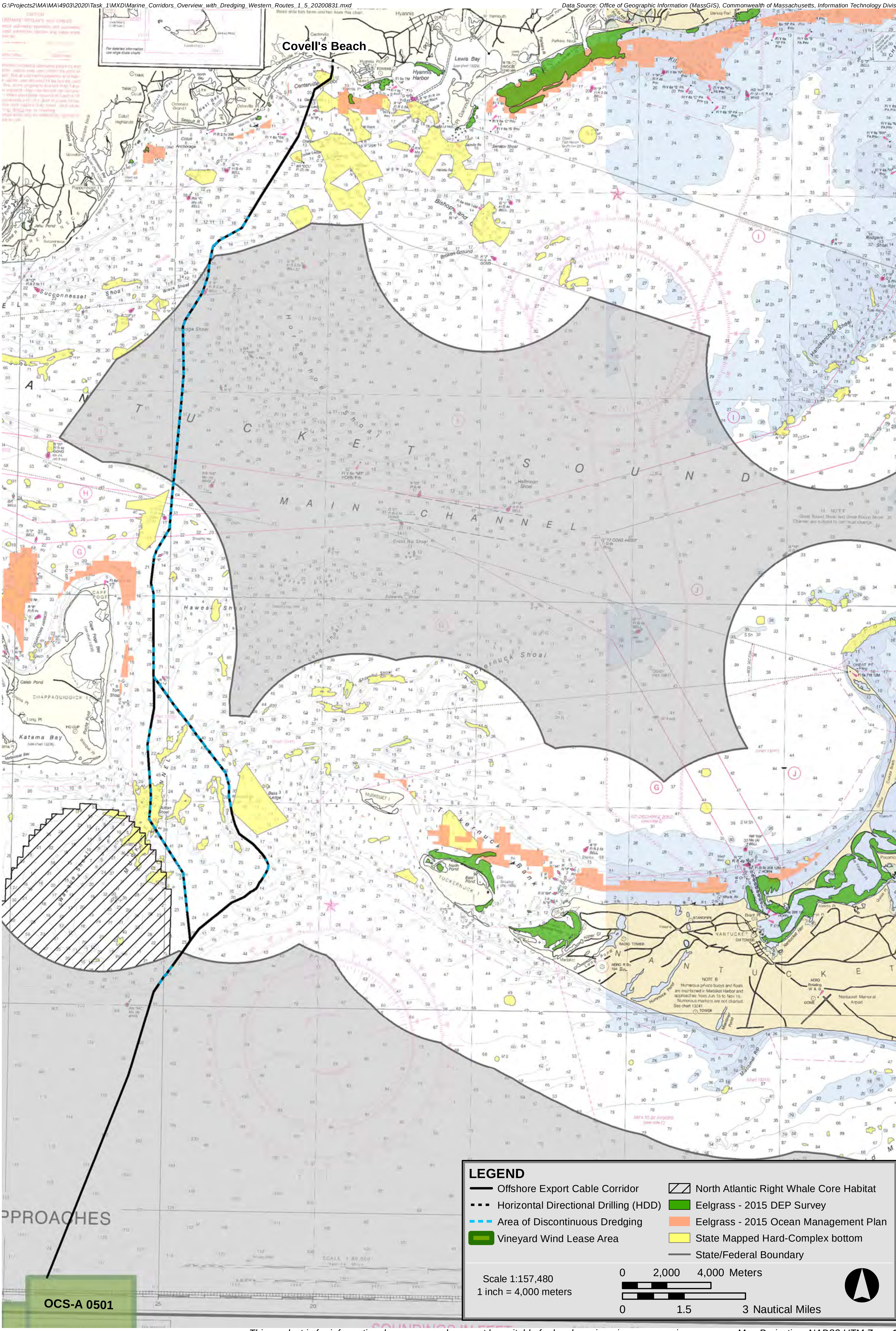

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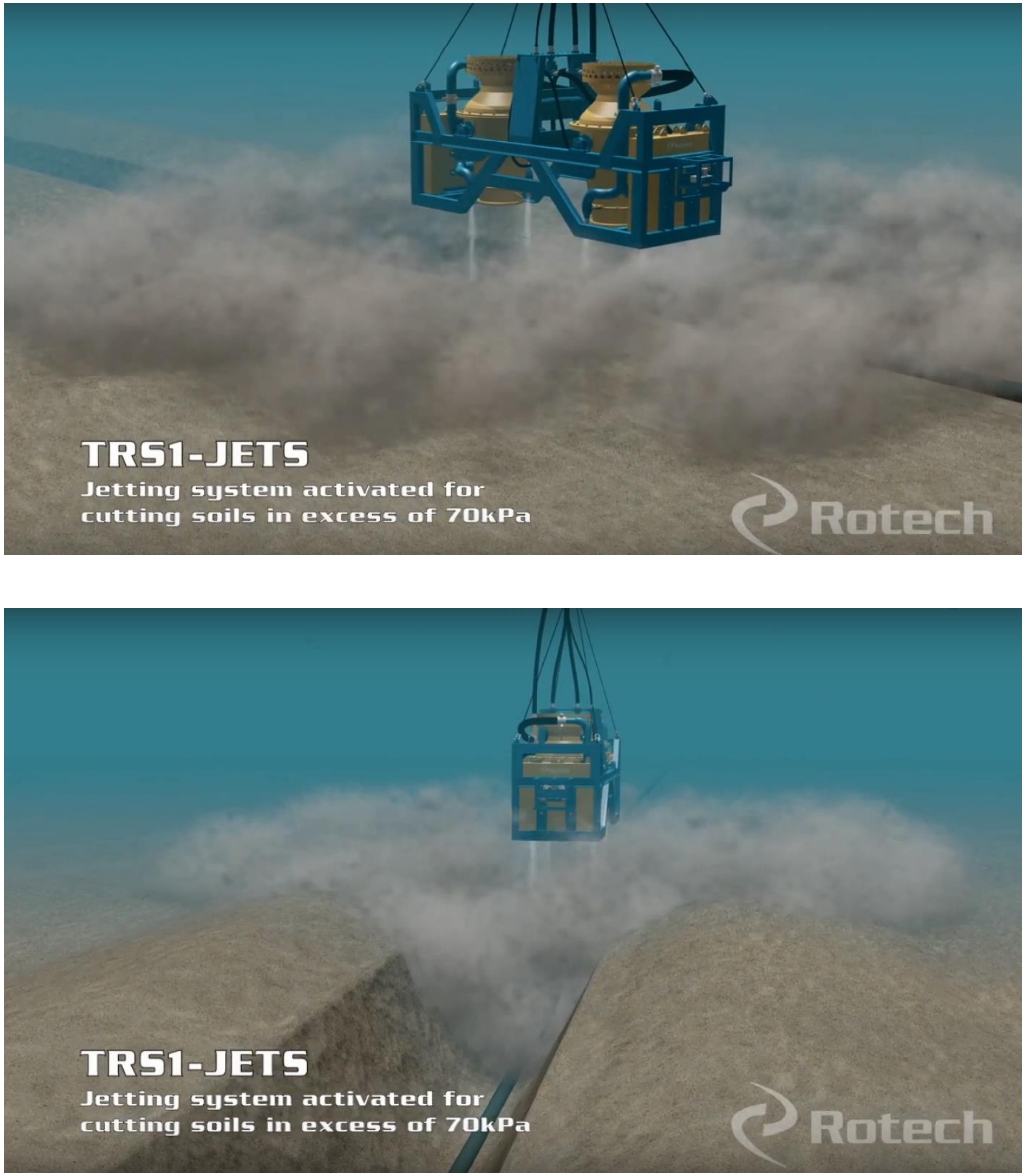
Figure 4.2-3

Export Cable Corridor Dredge Volumes



Source: http://www.rotech.co.uk/subsea-video-gallery.html

Jetting

Source: https://www.flickr.com/photos/jaxstrong/albums/72157637944233765

Trailing Suction Hopper Dredge

Figure 4.2-4

Types of Dredging Equipment

specified pressure and volume. The down pipe is positioned over the cable alignment, enabling the stream of water to fluidize the sands around the cable, which allows the cable to settle into the trench. This process causes the top layer of sand to be sidecasted to either side of the trench; therefore, jetting would both remove the top of the sand wave and bury the cable. Typically, a number of passes are required to lower the cable to the minimum target burial depth.

A TSHD can be used in sand waves of most sizes, whereas the jetting technique is most likely to be used in areas where sand waves are less than 2 m (6.6 ft) high. Therefore, the sand wave dredging could be accomplished entirely by the TSHD on its own, or the dredging could be accomplished by a combination of jetting and TSHD, where jetting would be used in smaller sand waves and the TSHD would be used to remove the larger sand waves.

Cable Installation

The majority of the export and inter-link cable is expected to be installed using simultaneous lay and bury via jet plowing. Likewise, the majority of the inter-array cable is expected to be installed via jet plowing after the cable has been placed on the seafloor. However, other methods may be needed in areas of coarser or more consolidated sediment, rocky bottom, or other difficult conditions in order to ensure a proper burial depth. The three most common methods are described below under "Typical Techniques," additional techniques that may be used more rarely are described below under "Additional Possible Techniques."

The inter-array and offshore export cables will have a target burial depth of 1.5-2.5 m (5-8 ft); the minimum target burial depth is 1.5 m (5 ft). As noted in Sections 3.1.5.3 and 3.1.6, approximately 10% of the inter-array, inter-link, and export cable may not achieve the proper burial depth and will require cable protection.

Typical Techniques

- Jet plowing (jet trenching): This tool may be based from a seabed tractor or a sled deployed from a vessel. This tool typically has one or two arms, or booms, which extend into the seabed and discharge pressurized seawater as the tool moves along the cable route (either simultaneously as the cable is laid on the seafloor or after the cable has been laid), fluidizing the sediment and allowing the cable to sink by its own weight to the appropriate depth or to be placed at depth by the tool. Sediment naturally settles out of suspension thereby backfilling the narrow trench.

- Mechanical plowing: A mechanical plow is deployed from a vessel and uses a cutting edge(s) and moldboard to mechanically push through the seabed while feeding the cable into the trench created by the plow. This narrow trench infills itself behind the tool, either by collapse of the trench walls and/or by natural infill, usually over a relatively short period of time.

- Mechanical trenching: Mechanical trenching (chain or wheel cutter) is typically only used only in the more resistant sediments. A rotating chain or wheel with cutting teeth or blades removes the sediment. The cable is laid into the trench behind the trencher and the trench collapses naturally to cover the cable, or, if required, another tool can be used to push the sediment over the cable to fill the trench.

Additional Possible Techniques

- Shallow-water cable installation tractor: This system uses one of the techniques described above, but is deployed from a tractor that operates in shallow water where vessels cannot efficiently operate. The cable is first laid on the seabed, and then a tractor drives over or alongside the cable while operating an appropriate burial tool to complete installation. The tractor is controlled and powered from a self-elevating platform that holds equipment and operators above the waterline.

- Pre-trenching: A "V"-shaped trench is excavated by a plow or similar device, and the sediment is placed next to the trench. The cable is then laid in the trench. Separately or simultaneously to laying the cable, the sediment is returned to the trench and covers the cable.

- Boulder clearance: In areas of the route where large boulders could be encountered, boulder clearance may be employed prior to cable installation. Boulder clearance leaves the route clear of large boulders, facilitating installation and better ensuring proper burial. Boulder clearance is accomplished either by means of a grab that lifts individual boulders clear of the route, or using a plow-like tool which is moved along the route to push boulders to the side of the area where cable is to be installed.

- Precision installation: In situations where a large tool is not able to operate, or in situations where a specialized installation tool cannot complete installation, a diver or remotely-operated vehicle ("ROV") may be used to complete installation. The diver or ROV may use small jets or other small tools to complete installation.

- Jetting (mass flow excavation): Jetting can be used for cable installation as well as dredging. As described above, jetting uses a pressurized stream of water to push sand to the side. The jetting (mass flow excavation) tool draws in seawater from the sides and then jets this water out from a vertical down pipe at a specified pressure and volume. The down pipe is positioned over the cable alignment, enabling the stream of water to fluidize the sands around the cable, which allows the cable to settle into the trench. This process causes the top layer of sand to be sidecasted to either side of the trench; therefore, jetting would both remove the top of the sand wave and bury the cable. Typically, a number of passes are required to lower the cable to the minimum target burial depth. Jetting is not to be confused with a jet plow used for typical cable installation described above.

Anchor Usage During Cable Installation

To facilitate offshore export cable installation, anchoring may occur along the OECC.[14] It is currently anticipated that anchoring may be used along more challenging portions of the offshore export cable, such as in the stronger currents of Muskeget Channel, though anchoring may occur at any point within the OECC shown in Figure 2.1-1. Vessel anchors will be required to avoid known eelgrass beds (including those near Spindle Rock) and will avoid other sensitive seafloor habitats (hard/complex bottom) as long as it does not compromise the vessel's safety or the cable's installation. Contractors will be provided with a map of sensitive habitats with areas to avoid prior to construction and shall plan their mooring positions accordingly.

Cable Splicing

Due to the length of the offshore export cables (70-80 km or 38-43 nm) and the shallow nearshore installation techniques, the offshore export cables will likely require at least one joint (splice). Upon reaching the joint location, a cable will be retrieved from the seabed and brought inside the cable laying vessel or other specialized vessel. Inside a controlled environment (i.e., a jointing room) aboard the vessel, the two ends of the cable will be spliced together. Once cable splicing is completed, the offshore export cable is lowered to the seafloor. Depending on the design of the cable and joint, the splicing process may take several days, in part, because the jointing process must be performed during good weather.

4.2.3.4 Foundations (Monopile and Jacket)

Monopile Foundations

Seabed preparation may be required prior to foundation installation. This could include the removal of large obstructions at the seabed, or to avoid excessive seabed gradients.

After fabrication, the monopile foundation components (monopile, transition piece, and any secondary items) will be transported to a marshalling port (see Section 3.2.5) or directly to the offshore site.

The installation concept and method of bringing components to the WDA will be based on supply chain availability and final contracting. The monopiles (or jackets) are expected to be installed by one or two heavy lift or jack-up vessel(s). The main installation vessel(s) will likely remain at the WDA during the installation phase and transport vessels, tugs and/or

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14 Within the WDA, anchored vessels will not be used as primary construction and installation vessels. Any anchoring that does take place within the WDA will occur within the Area of Potential Effect as described in Volume II-C.

feeder barges will provide a continuous supply of foundations to the WDA. If Jones Act compliant vessels are available, the foundation components could be picked up directly in the marshalling port by the main installation vessel(s).

At the WDA, using a crane, the main installation vessel will upend the monopile, place it in the gripper frame, and then lower the monopile to the seabed. The gripper frame, which, depending upon its design, may be placed on the seabed scour protection materials, stabilizes the monopile's vertical alignment before and during piling. Once the monopile is lowered to the seabed, the crane hook is released and the hydraulic hammer is picked up and placed on top of the monopile. Figure 4.2-5 shows a vessel lowering a monopile and typical jack-up installation vessels.

The pile driving will then commence, beginning with a soft-start. This will ensure that the monopile remains vertical while also allowing any motile marine life to leave the area before the pile driving intensity is increased. The intensity (i.e., hammer energy level) will be gradually increased based on the resistance that is experienced from the sediments. The expected hammer size for monopiles is up to 4,000 kilojoules ("kJ"); energy use, however, is anticipated to be less than 4,000 kJ.

The typical pile driving operation is expected to take less than approximately three hours to achieve the target penetration depth. It is anticipated that a maximum of two piles can be driven into the seabed per day. If two installation vessels are used for monopile installation, it is not anticipated that two monopiles will be driven into the seabed concurrently. No drilling of monopiles is anticipated, but it could be required if a large boulder or monopile refusal is encountered. If drilling is required, a rotary drilling unit will be mobilized to the monopile top. The interior sediment will then be drilled out and deposited on the seabed adjacent to the scour protection material until the monopile is no longer obstructed. Thereafter monopile installation will recommence, until the monopile reaches target depth. Similarly, use of a vibratory hammer is not anticipated, but could be used if deemed appropriate by the installation contractor.

After installation of the monopile, the transition piece will be picked up and placed on the monopile. The connection between the monopile and the transition piece will be either grouted or bolted. If the main connection is established by bolts, grout is foreseen in a "skirt" holding the boat landing, with the following purposes:

- Support for the lower part of the boat landing
- Protecting against water ingress to the bolted connection
- Corrosion protection underneath the skirt

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Figure 4.2-5

Foundation Installation Vessels

Grout material will be mixed either on the installation vessel or a separate grouting vessel. Grout will be pumped through hoses into the transition piece structure to fill the annulus between the monopile and the transition piece and will be contained at the lower extremity of the transition piece by a high strength rubber grout seal. The design will ensure that any overflow of grout during grouting will be directed to the inside of the foundation.

Grout Spill Management

When grout is used (either for the connection between the monopile and transition piece or as a "skirt" holding the boat landing), the following grout spill management procedures will be used to mitigate the potential for any grout release:

- The grout level will be monitored visually and when grout reaches the top of the monopile, grouting will be halted.
- Special couplings will be attached to the grout hoses to mitigate grout spill when grout hoses are removed after grouting, where feasible. For monopiles, hoses will be disconnected on the upper TP platform to avoid losses of grout into the water column.
- Water and grout from cleaning of hoses and other equipment will be collected on the vessel and disposed of properly on land.
- The risk for accidental grout spill in the sea due to grout seal failure will be mitigated by pressure testing grout seals.

If the time between the installation of the monopile and transition piece is longer than a few days, the amount of marine growth must be assessed and marine growth may need to be removed with a high pressure washing tool or similar equipment prior to installing the transition piece.

Jacket Foundation Installation

After fabrication, the jackets and pin piles will be transported to a marshalling port (see Section 3.2.5) or directly to the Offshore Project Area. The installation concept and method of bringing components to the WDA will be the same as for the monopile.

The jacket, including transition piece and pin piles, will be transported to the Offshore Project Area on feeder barges/vessels. The jacket will be lifted off the feeder vessel and lowered to the seabed with the correct orientation. Next, the pin piles will be lifted and driven through the pile sleeves to the engineered depth. The maximum anticipated hammer size for jacket foundations is 3,000 kJ; energy use, however, is anticipated to be far less than the hammer size. Once all piles are driven to the target depth, they will be fixed in the pile sleeves, most likely by the use of grouting. Grout material will be mixed either on the installation vessel or a separate grouting vessel. Grout will then be pumped through hoses into the jacket structure to fill the annulus between the sleeves and piles and will be contained at the lower extremity of the sleeve by a high strength rubber grout seal. The grout level will be monitored visually using underwater cameras and when grout reaches the top of the sleeve, grouting will be halted. Grout spill management protocols are similar to those described above for monopile foundations will also be used for jacket foundations. It is also possible that piles may be driven prior to lowering the jacket by using a frame to orient the piles.

The pile driving will then commence, beginning with a soft-start, as described above for the monopiles. It is anticipated that a maximum of one complete jacket can be installed per day. If two installation vessels are used for jacket installation, it is not anticipated that two jacket piles will be driven into the seabed concurrently. No drilling is anticipated, but it could be required if pile refusal is encountered. Similarly, use of a vibratory hammer is not anticipated, but could be used if deemed appropriate by the installation contractor.

4.2.3.5 Electrical Service Platforms

Each ESP is comprised of two primary components: the topside with the electrical components and the foundation substructure. Either a monopile or jacket will be used for the foundation. Seabed preparation may be required prior to foundation installation. This could include the removal of large obstructions at the seabed, or to avoid excessive seabed gradients. The ESP foundation installation concept is similar to the foundation for the wind turbines: a monopile is driven vertically into the seabed with a transition piece or similar connection structure mounted on the pile to provide a stable platform to support the weight of the ESP topside.

If a jacket is chosen as foundation for the ESP, the jacket will be lifted off the vessel and lowered to reach the seabed in the right location and with the correct orientation. Next, the pin piles will be lifted and driven through the pile sleeves to the engineered depth. Once all piles are driven to the target depth, they will be fixed in the pile sleeves by use of grouting. It is also possible that piles may be driven prior to jacket installation. Grout spill management protocols similar to those described above for WTG foundations will also be used for ESP foundations.

The ESP - either the 400 MW or 800 MW conventional ESP – can be transported directly to the Offshore Project Area. Alternatively, it could be transported to a harbor (see Section 3.2.5) and moved offshore on a barge. The installation of the topside is anticipated to be carried out by a vessel that also installs the foundations. The vessel will position itself next to the foundation. The ESP topside will arrive on the feeder vessel or barge and the installation vessel crane will lift the topside and place it on the foundation. The ESP topside and the foundation will be connected either using bolted connections, welding, or a combination of bolts and welding. Figure 3.1-14 shows construction work being performed on an ESP. After the ESP mechanical installation is complete, the 66 kilovolt ("kV") inter-array cables and the 220 kV offshore export cables will be pulled into place and terminated at the ESP. These cables will be routed through J-tubes, or similar means, located on the surface of the foundation/substructure or can be routed through the inside of the foundation/substructure.

4.2.3.6 Inter-array Cables

The 66 kV inter-array cables will be used to connect “strings” of six to 10 WTGs to the offshore ESP (see Figure 3.1-16). Each inter-array cable begins at either an ESP or a WTG and terminates at the next WTG on the string. The inter-array cable installation follows scour protection and foundation installation, and normally precedes WTG installation at a given WTG location. Prior to inter-array cable installation, in accordance with normal industry practice, a pre-lay “grapnel run” will be made in all instances to locate and clear obstructions such as abandoned fishing gear and other marine debris.

The inter-array cables could be transported in a cable laying vessel and directly installed at site upon arrival, or they could be stored onshore then be transferred to a cable laying vessel. For the inter-array cables, the expected installation method is to lay the cable section on the seafloor and then subsequently bury the cable using a jet plow (this is referred to as “post-lay burial”). The jet plow technique is described above in Section 4.2.3.3.

At either end, the inter-array cable crosses the scour protection pad and is brought into a J-tube (see Figure 3.1-9) or similar connection, for subsequent linking to the WTG. Cable pull-in will be conducted at each foundation location and followed by cable termination works. As described in Section 3.1.6, cable protection measures may be required for sections of the inter-array cables where burial was not possible and for the transition from seabed to WTG foundation.

4.2.3.7 Wind Turbine Generators

WTG installation involves feeder barges transporting components from the port to the installation vessel(s). The WTGs are expected to be installed by one or two main installation vessels, which may be a jack-up or a dynamic positioning (“DP”) vessel. The tower will first be erected followed by the nacelle and finally the hub, inclusive of the blades. Alternatively, the nacelle and hub will be installed in a single operation followed by the installation of individual blades. In case the tower consists of more than one section, the sections will be joined with a bolted connection.

Commencement of the WTG installation phase represents the most intense period of vessel traffic in the Offshore Project Area, with wind turbine foundations, array cables, and wind turbines being installed in parallel.

WTG installation will be followed by the commissioning period where the WTGs will be prepared for operation and energized. Wind turbine commissioning involves conducting the necessary tests of the electrical infrastructure and WTGs ahead of passing the WTG to the operations and maintenance teams for the duration of its service life. The WTG commissioning and testing phase will be conducted in parallel with the WTG installation phase.

4.2.3.8 Landfall Site

As described in Section 3.2.1, the offshore cables will transition onshore at the Covell's Beach Landfall Site parking lot in the Town of Barnstable. The ocean to land transition will be made by use of horizontal directional drilling ("HDD"). The HDD rig will be setup in a parking lot or other previously disturbed area, and the drill will be advanced seaward. The length of the drill or bore will depend on the width of the dune and beach area, any nearshore sensitive resources, such as eelgrass, as well as bathymetry and geologic conditions. Two bores will be needed, one for each offshore cable. At the offshore end of each bore site, a temporary cofferdam or other method (e.g., gravity cell) may be used to facilitate cable pull-in. Once the bores are completed, each offshore cable is pulled though a bore to an underground concrete vault. In the vault, the three-core submarine cable is separated and jointed to the single core onshore export cable (three single core cables per circuit).

4.2.3.9 Onshore 220 kV Underground Transmission

As described in Section 3.2.2 and 3.2.3, 220 kV underground transmission cabling will be used to connect the Landfall Site to a 220 kV to 115 kV step down substation and the subsequent interconnection to the 115 kV Barnstable Switching Station.

The construction of the duct bank includes the following steps:

- Survey and mark splice vault locations; survey and mark duct bank location.
- Set up erosion and siltation controls, including silt sacks or similar protection for existing storm drains.
- Set up traffic management measures, in coordination with local police and public works officials.
- Open roads and install duct bank.
- Repave roads as agreed with local town.
- Clean up work area, remove erosion controls.

The duct bank installation is done with conventional construction equipment (e.g., hydraulic excavator, loader, dump trucks, flatbed trucks to deliver PVC pipe, crew vehicles, cement delivery trucks, and paving equipment).

Once the duct bank is in place, the 220 kV cables (one cable per sleeve) will be pulled into place from underground vaults along the cable route. This work is done using a cable reel transport vehicle, a pulling rig and the necessary crew and support vehicles. Installation of the in-road underground cabling will typically be performed during the off-season, where feasible, to minimize traffic disruption.

4.2.3.10 Onshore Substation

As described in Section 3.2.4, the Project's onshore substation is planned for a 0.03 km^2 (8.55 acre) leased site directly to the south of the existing Eversource 115 kV Barnstable Switching Station. The Barnstable Switching Station is located just south of Route 6, in a largely commercial/industrial area north of the Hyannis Airport.

Construction of the onshore substation will include the following steps:

- Install perimeter construction fencing, a security gate, and erosion controls.
- Prepare the site for construction.
- Construct transformer foundations, containment sumps, and spread footings for other equipment.
- Deliver and place major equipment using appropriate heavy-load vehicles and equipment.
- Deliver and place other electrical equipment and a prefabricated control house.
- Complete buswork, bring the 220 kV transmission into the site, and bring the 115 kV cabling to the adjacent Barnstable Switching Station.
- Complete cabling, control wiring, and installation of protection systems.
- Test and commission the onshore substation.

Construction and commissioning of the onshore substation is scheduled to take approximately 18 months.

4.2.4 Vessels, Vehicles, and Aircraft

Construction of the Project will require the use of an array of vessels. A much more limited number of vessels will be used to support routine operations and maintenance activities. Helicopters may be used to supplement crew transport and for Project support during both construction and operations.

Construction of the onshore export cable and onshore substation will require a number of different vehicles. These will primarily be vehicles used for conventional civil construction as well as conventional utility cable pulling equipment. Specialized heavy haul vehicles will be required to transport the substation transformers and other large, heavy components.

Different aspects of the construction will require a specific suite of vessels. For each major element of construction (scour protection, foundation installation, WTG installation, cable laying, etc.), the expected types have been provided in Table 4.2-1. Table 4.2-1 is organized by major construction element and includes the basic data on anticipated vessel type and use. All specifications are subject to change. Vessel data, for example, is highly speculative at this stage of the Project. Vessel details are anticipated to be further refined in the Fabrication and Installation Report ("FIR"). Due to variable availability and limitations associated with the Jones Act, vessels may even be changed out just prior to or during construction.

For the construction of the 800 megawatt ("MW") Project, the average number of vessels on-site during construction is anticipated to be approximately 25. See Section 7.8 of Volume III and the Navigational Risk Assessment in Appendix III-I for further discussion of vessel activity during construction.

Table 4.2-1 Vessels Used for Construction

Role	Vessel Type	#	Approx. Size		Displacement		Approximate Vessel Speed		Type of Propeller System	Approximate Fuel Capacity	Marine Sanitation Device	Crew Size	Vessel Examples
			Width	Length	Gross Tonnage	Deadweight	Operational Speed	Maximum Transit Speed					
Foundation Installation													
Marine Mammal Observers and Environmental Monitors	Fishing Vessel/ Crew Transfer Vessel	2-6	~7 m (23 ft)	~20 m (66 ft)	N/A	N/A	10 kn	25 kn	Blade propeller system / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	~2	[redacted]
Scour Protection Installation	Fall Pipe Vessel	1	30-45 m (98 - 148 ft)	130 - 170 m (427 - 558 ft)	15,000-28,000 t (16,535-30,865 US tons)	25,000 t (27,558 US tons)	10 kn	14 kn	Blade propeller system / blade thrusters	N/A	IMO compliant	20-60	[redacted]
Overseas Foundation Transport	Heavy Cargo Vessel, Deck Carrier, and/or Semi-submersible Vessel	2-4	24-56 m (79 - 184 ft)	120 - 223 m (394 - 732 ft)	12,000-25,000 t (13,228-27,558 US tons)	10,000-62,000 t (11,023-68,343 US tons)	13 - 18 kn	13 - 18 kn	Blade propeller system / blade thrusters	260,000 - 1,800,000 L (68,680 - 475,510 gal)	MSD: Type II and Type III, IMO compliant	15-25	[redacted]
Foundation Installation (Possibly Including Grouting	Jack-up, Heavy Lift Vessel, or Semi-submersible Vessel	1-2	40-56 m (131 - 184 ft)	180-220 m (591 - 722 ft)	20,000-50,000 t (22,046-55,116 US ton)	10,000-80,000 t (11,023-88,185 US ton)	0 - 10 kn	12-14 kn	Blade propeller system / blade thrusters	N/A	IMO compliant	25-220	[redacted]
Noise Mitigation Vessel	DP-2 Support Vessel or Anchor Handling Tug Supply Vessel	1	~15 m (49 ft)	65 - 90 m (213 - 295 ft)	1,900-3,000 t (2,094-3,307 US tons)	2,200-3,000 t (2,425-3,307 US tons)	10 kn	13 kn	Blade propeller systems / blade thrusters	~740,000 L (195,490 gal)	IMO compliant	5-14	[redacted]
Acoustic Monitoring	Multipurpose Support Vessel or Tug Boat	1	~10 m (33 ft)	~30 m (98 ft)	50- 500 t (55-551US tons)	20 t (22 US tons)	14 kn	14 kn	Blade propeller systems / blade thrusters	~215,000 L (56,800 gal)	Non-IMO	5-10	[redacted]
Secondary Work, Snagging, and Possibly Grouting	DP-2 Support Vessel or Tug Boat	1	~10 m (33 ft)	30 - 80 m (98 - 262 ft)	500 - 900 t (551-992 US tons)	120 t (132 US tons)	14 kn	14 kn	Blade propeller systems / blade thrusters	~215,000 L (56,800 gal)	IMO compliant	10-100	[redacted]
Crew Transfer	Crew Transfer Vessel	3	7-12 m (23 - 39 ft)	20-30 m (66 - 98 ft)	100-150 t (110-165 US tons)	20-75 t (22-83 US tons)	25 kn	25 kn	Blade propeller systems / blade thrusters	~8,000 (2,110 gal)	IMO compliant	2-10	[redacted]
Transport of Foundations to WDA	Barge	2-5	~25 m (82 ft)	100 m (328 ft)	N/A	9,600 t (10,582 US tons)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 4.2-1 Vessels Used for Construction (Continued)

Role	Vessel Type	#	Approx. Size		Displacement		Approximate Vessel Speed		Type of Propeller System	Approximate Fuel Capacity	Marine Sanitation Device	Crew Size	Vessel Examples
			Width	Length	Gross Tonnage	Deadweight	Operational Speed	Maximum Transit Speed					
Foundation Installation (continued)													
Transport of Foundations to WDA	Tugs	3-4	~10 m (33 ft)	~35 m (115 ft)	200-500 t (220-551 US tons)	200-300 t (220-331 US tons)	10 kn	10 - 14 kn	Blade propeller systems / blade thrusters	~215,000 L (56,800 gal)	IMO compliant	5-10	[redacted]
Tugboat to Support Main Foundation Installation Vessel(s)	Site Tug	1	6-10 m (20 - 33 ft)	16-35 m (52 - 115 ft)	75-500 t (83-551 US tons)	50-200 t (55-220 US tons)	10 kn	10 - 14 kn	Blade propeller systems / blade thrusters	~215,000 L (56,800 gal)	not specified	5-10	[redacted]
ESP Installation													
ESP Installation	Floating Crane vessel or Semi-submersible Vessel	1	40-90 m (131 - 295 ft)	180-220 m (591 - 722 ft)	N/A	10,000 - 48,000 t (11,023-52,911 US tons)	10 - 12 kn	14 kn	N/A	N/A	Non-IMO	20-220	[redacted]
ESP Transport	Heavy Cargo Vessel, Deck Carrier, and/or Semi-submersible Vessel	1-2	24-40 m (79 - 131 ft)	20-223 m (66 - 732 ft)	12,000-50,000 t (13,228-55,116 US tons)	10,000-62,000 t (11,023-68,343 US tons)	13 - 18 kn	13 -18 kn	Blade propeller systems / blade thrusters	260,000 - 1,800,000 L (68,680 - 475,510 gal)	MSD: Type II and Type III, IMO compliant	15-25	[redacted]
ESP Transport (if required)	Tugs	2-4	~10 m (33 ft)	~35 m (115 ft)	200-500 t (220-551 US tons)	200-300 t (220-331 US tons)	14 kn	14 kn	Blade propeller systems / blade thrusters	~215,000 L (56,800 gal)	IMO compliant	5-10	[redacted]
Crew Transfer	Crew Transfer Vessel	1	7 - 12 m (23 - 39 ft)	20 - 30 m (66 - 98 ft)	100-150 t (110-165 US tons)	20-75 t (22-83 US tons)	25 kn	25 kn	Blade propeller systems / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	2-10	[redacted]

Table 4.2-1 Vessels Used for Construction (Continued)

Role	Vessel Type	#	Approx. Size		Displacement		Approximate Vessel Speed		Type of Propeller System	Approximate Fuel Capacity	Marine Sanitation Device	Crew Size	Vessel Examples
			Width	Length	Gross Tonnage	Deadweight	Operational Speed	Maximum Transit Speed					
ESP Installation (continued)													
Service Boat	Crew Transfer Vessel	1	7 - 12 m (23 - 39 ft)	20 - 30 m (66 - 98 ft)	100-150 t (110-165 US tons)	20-75 t (22-83 US tons)	25 kn	25 kn	Blade propeller systems / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	2-10	[redacted]
Refueling Operations to ESP	Crew Transfer Vessel	1	7-12 m (23 - 39 ft)	20-30 m (66 - 98 ft)	100-150 t (110-165 US tons)	20-75 t (22-83 US tons)	25 kn	25 kn	Blade propeller systems / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	2-10	[redacted]
Crew Hotel Vessel During Commissioning	Jack-up or Floatel Vessel	1	~40 m (131 ft)	~55 m (180 ft)	500 t (551 US tons)	N/A	0 kn	6 kn	Blade propeller systems / blade thrusters	~280,000 L (73,970 gal)	Non-IMO	20-100	[redacted]
			10 - 12 m (33 - 39 ft)	70 - 100 m (230 - 328 ft)	800-9,000 t (882-9,921 US tons)	120-4,500 t (132-4,960 US tons)	10 kn	13.5 kn	Blade propeller systems / blade thrusters	N/A	IMO compliant	50-201	[redacted]
Offshore Export Cable Installation													
Pre-Lay Grapnel Run	Multipurpose Support Vessels	1	8 - 15 m (26 - 49 ft)	30 - 70 m (98 - 230 ft)	700-4,000 t (772-4,409 US tons)	2,200 - 2,500 t (2,425-2,756 US tons)	10 kn	15 kn	Blade propeller system / blade thrusters	~120,000 L (31,700 gal)	IMO compliant	2-25	[redacted]
Pre-Installation Surveys	Multi-role survey vessel or Smaller Support Vessels	1	6 - 26 m (20 - 85 ft)	13 - 112 m (43 - 367 ft)	1,500-15,000 t (1,653-16,535 US tons)	400-3,000 t (441-3,307 US tons)	18 – 22 kn	25 - 30 kn	Blade propeller system / blade thrusters, except smaller support vessels which are jet drive propulsion	8,000 – 52,000 liters ("L") (2,110 – 13,800 gallons ["gal"])	IMO compliant	25-70, except smaller support vessels which are 2-8	[redacted]
Laying of the Cables (and potentially burial)	Cable Laying Vessel	1	22 - 35 m (72 - 115 ft)	80 - 150 m (262 - 492 ft)	7,000-16,500 t (7,716-18,188 US tons)	1,200-1,5000 t (1,323-16,535 US tons)	5 kn	14 kn	Blade propeller system / blade thrusters	~1,200,000 L (317,010 gal)	IMO compliant	15-45	[redacted]
Boulder Clearance	Cable Laying Support Vessel	1	15 - 20 m (49 - 66 ft)	75 -120 m (246 - 394 ft)	2500-8000 t (2756-8818 US tons)	2,000-7,000 t (2,205-7,716 US tons)	5 kn	12 kn	Blade propeller system / blade thrusters	~960,000 L (253,610 gal)	IMO compliant	20-60	[redacted]
Support Main Vessel with Anchor Handling	Anchor Handling Tug Supply Vessel	1	6 - 15 m (20 - 49 ft)	16 - 65 m (52 - 213 ft)	75-1,900 t (83-2,094 US tons)	50-2,200 t (55-2,425 US tons)	10 - 14 kn	10 - 14 kn	Blade propeller system / blade thrusters	120,000 - 150,000 L (31,701 - 39,626 gal)	not specified	5-20	[redacted]

Table 4.2-1 Vessels Used for Construction (Continued)

Role	Vessel Type	#	Approx. Size		Displacement		Approximate Vessel Speed		Type of Propeller System	Approximate Fuel Capacity	Marine Sanitation Device	Crew Size	Vessel Examples
			Width	Length	Gross Tonnage	Deadweight	Operational Speed	Maximum Transit Speed					
Offshore Export Cable Installation (continued)													
Trenching Vessel	Purpose Built Offshore Construction/ROV/Survey Vessel	1	~25 m (82 ft)	~128 m (420 ft)	N/A	~7,500 t (8,267 US tons)	10 kn	15 kn	Blade propeller system / blade thrusters	~2,000,000 L (528,344 gal)	IMO compliant	N/A	[redacted]
Crew Transfer	Crew Transfer Vessel	1	7 - 12 m (23 - 39 ft)	20 - 30 m (66 - 98 ft)	100-150 t (110-165 US tons)	20-75 t (22-83 US tons)	25 kn	25 kn	Blade propeller systems / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	2-10	[redacted]
Place Rock or Concrete Mattresses	Rock/Mattress Placement Vessels	1	30 - 45 m (98 - 148 ft)	130 - 170 m (427 - 558 ft)	15,000-28,000 t (16,535-30,865 US tons)	25,000 t (27,558 US tons)	10 kn	14 kn	Blade propeller system / blade thrusters	N/A	IMO compliant	20-60	[redacted]
Dredging	Dredging Vessels	1	~30 m (98 ft)	~230 m (755 ft)	33,423 t (36,843 US tons)	59,798 t (65,916 US tons)	10 kn	16 kn	Blade propeller system / blade thrusters	N/A	IMO compliant	30-60	[redacted]
Inter-Array Cable Installation													
Pre-Lay Grapnel Run	Multipurpose Support Vessel	1	8 - 15 m (26 - 49 ft)	30 - 70m (98 - 230 ft)	700-4,000 t (772-4,409 US tons)	2,200 - 2,500 t (2,425-2,756 US tons)	15 kn	15 kn	Blade propeller system / blade thrusters	~120,000 L (31,700 gal)	IMO compliant	2-25	[redacted]
Pre-Installation Surveys	Multi-role survey vessel or Smaller Support Vessels	1	6 - 26 m (20 - 85 ft)	13 - 112 m (43 - 367 ft)	1,500-15,000 t (1,653-16,535 US tons)	400-3,000 t (441-3,307 US tons)	18 – 22 kn	25 - 30 kn	Blade propeller system / blade thrusters, except smaller support vessels which are jet drive propulsion	8,000 – 52,000 liters ("L") (2,110 – 13,800 gallons ["gal"])	IMO compliant	25-70, except smaller support vessels which are 2-8	[redacted]
Laying of the Cables (and potentially burial)	Cable Laying Vessel	1	22 - 35 m (72 - 115 ft)	80 - 150 m (262 - 492 ft)	7,000-16,500 t (7,716-18,188 US tons)	1,200-15,000 t (1,323-16,535 US tons)	5 kn	14 kn	Blade propeller system / blade thrusters	~1,200,000 L (317,010 gal)	IMO compliant	15-45	[redacted]
Burial Support Vessel	Cable Laying Support vessel	1	15 - 20 m (49 - 66 ft)	75 - 120 m (246-394 ft)	2,500-8,000 t (2,756-8,818 US tons)	2,000-7,000 t (2,205-7,716 US tons)	12 kn	12 kn	Blade propeller system / blade thrusters	~960,000 L (253,610 gal)	IMO compliant	20-60	[redacted]
Crew Transfer	Crew Transfer Vessel	2	7 - 12 m (23 - 39 ft)	20 - 30 m (66 - 98 ft)	100-150 t (110-165 US tons)	20-75 t (22-83 US tons)	25 kn	25 kn	Blade propeller systems / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	2-10	[redacted]
Cable Termination and Commissioning	Cable Laying Support vessel	1	15 - 20 m (49 - 66 ft)	75 - 120 m (246 - 394 ft)	2,500-8,000 t (2,756-8,818 US tons)	2,000-7,000 t (2,205-7,716 US tons)	12 kn	12 kn	Blade propeller system / blade thrusters	~960,000 L (253,610 gal)	IMO compliant	20-60	[redacted]
Trenching Vessel	Purpose Built Offshore Construction/ROV/Survey Vessel	1	~25 m (82 ft)	~128 m (420 ft)	N/A	~7,500 t (8,267 US tons)	10 kn	15 kn	Blade propeller system / blade thrusters	~2,000,000 L (528,344 gal)	IMO compliant	N/A	[redacted]

Table 4.2-1 Vessels Used for Construction (Continued)

Role	Vessel Type	#	Approx. Size		Displacement		Approximate Vessel Speed		Type of Propeller System	Approximate Fuel Capacity	Marine Sanitation Device	Crew Size	Vessel Examples
			Width	Length	Gross Tonnage	Deadweight	Operational Speed	Maximum Transit Speed					
Inter-Array Cable Installation (continued)													
Place Rock or Concrete Mattresses	Rock/Mattress Placement Vessels	1	30 - 45 m (98 - 148 ft)	130 - 170 m (427 - 558 ft)	15,000-28,000 t (16,535-30,865 US tons)	25,000 t (27,558 US tons)	10 kn	14 kn	Blade propeller system / blade thrusters	N/A	IMO compliant	20-60	[redacted]
WTG Installation													
Nacelle and Tower Transport	Heavy Lift Vessels	1-4	~20 m (66 ft)	~150 m (492 ft)	8,600 t (9,480 US tons)	9,400 t (10,362 US tons)	18 kn	18 kn	Blade propeller system / blade thrusters	~1,090,000 L (287,950 gal)	IMO compliant, MSD Type II	17-19	[redacted]
Blade Transport	Heavy Cargo Vessel	1-5	~15 m (49 ft)	~130 m (427 ft)	6,300 t (6,945 US tons)	8,000 t (8,818 US tons)	14 kn	14 kn	Blade propeller system / blade thrusters	~455,000 L (120,200 gal)	IMO compliant	15-18	[redacted]
Feeding WTG Components from Harbor to WDA	Jack-up Vessels[15]/Feeder Barges	2-6	6-50 m (20 - 164 ft)	35 - 100 m (115 - 328 ft)	4,000 t (4,409 US tons)	2,000-8,000 t (2,205-8,818 US tons)	0 -10 kn	14 kn	Blade propeller system / blade thrusters	215,000 - 280,000 L (56,800 - 73,970 gal)	IMO compliant	15-80	[redacted]
Vessel and Feeder Concept Assistance	Harbor Tug	1-6	6-10 m (20 - 33 ft)	15-35 m (49 - 115 ft)	75-500 t (83-551 US tons)	50-200 t (55-220 US tons)	10 kn	14 kn	Blade propeller system / blade thrusters	~215,000 L (56,800 gal)	N/A	4-8	[redacted]
WTG Installation	Jack-up Crane Vessel	1-2	35-55 m (115 - 180 ft)	85-165 m (279 - 541 ft)	15,000-25,000 t (16,535-27,558 US tons)	4,500-20,000 t (4,960-22,046 US tons)	0 -10 kn	12 kn	Blade propeller system / blade thrusters	N/A	IMO compliant	80-150	[redacted]
Crew Transfer	Crew Transfer Vessel	3	~7 m (23 ft)	~20 m (66 ft)	N/A	N/A	10 kn	25 kn	Blade propeller system / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	~2	[redacted]
WTG Commissioning													
Crew Transfer	Crew Transfer Vessel	1-4	6-12 m (20 - 39 ft)	15-30 m (49 - 98 ft)	10-50 t (11-55 US tons)	6-20 t (7-22 US tons)	25 kn	25 kn	Blade propeller system / blade thrusters	~8,000 L (2,110 gal)	N/A	2-10	[redacted]
Main Commissioning Vessel	Service Operation Vessel	1	~18 m (59 ft)	~80 m (262 ft)	N/A	~2,500 t (2,756 US tons)	10 – 12 kn	13 kn	Blade propeller system / blade thrusters	1,140,000 L (301,156 gal)	N/A	~27	[redacted]
Miscellaneous Construction Activities													
Refueling Vessels	Crew Transfer Vessel or Multipurpose Support Vessel	1	~7 m (23 ft)	~20 m (66 ft)	N/A	N/A	25 kn	25 kn	Blade propeller system / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	~2	[redacted]
Guard Vessels	Crew Transfer Vessel	1	~7 m (23 ft)	~20 m (66 ft)	N/A	N/A	25 kn	25 kn	Blade propeller system / blade thrusters	~8,000 L (2,110 gal)	IMO compliant	~2	[redacted]

15 Jacking-up in ports may occur.

Table 4.2-1 Vessels Used for Construction (Continued)

			Approx. Size		Displacement		Approximate Vessel Speed						
Role	Vessel Type	#	Width	Length	Gross Tonnage	Deadweight	Operational Speed	Maximum Transit Speed	Type of Propeller System	Approximate Fuel Capacity	Marine Sanitation Device	Crew Size	Vessel Examples
Miscellaneous Construction Activities (continued)													
Geophysical and Geotechnical Survey Operations	Multi-role survey vessel or Smaller Support Vessels	1	6-26 m (20 - 85 ft)	13- 112 m (43 - 367 ft)	1,500-15,000 t (1,653-16,535 US tons)	400-3,000 t (441-3,307 US tons)	18 – 22 kn	25 - 30 kn	Blade propeller system / blade thrusters, except smaller support vessels which are jet drive propulsion	8,000 – 52,000 liters (“L”) (2,110 – 13,800 gallons [“gal”])	IMO compliant	25-70, except smaller support vessels which are 2-8	[redacted]

Notes:

Vessel descriptions/dimensions are based on the specification sheets for the example vessels listed. Not all specification sheets provided information for each category; values provided may not be representative of all example vessels listed.

“t” = metric tons

With respect to construction of the onshore substation and underground onshore export cables, a complement of conventional construction equipment and vehicles will be used. Portions of the onshore substation site will be cleared and graded using conventional land clearing equipment. Construction of the onshore substation itself will begin with excavation/foundation placement, again using standard equipment (e.g., hydraulic excavators, backhoes, form trucks, concrete delivery trucks and support vehicles). The balance of the work includes delivering and setting the major components (transformers, breakers, etc.), erection of the bus system, and all of the necessary cabling/insulator installation. This element of the onshore substation work involves special over-the-road delivery trucks for the heavy/oversize components, normal delivery vehicles for other materials and parts, a large crane to set the transformers, rough terrain cranes, a variety of mobile lifts, and support vehicles.

Construction and installation of the underground onshore export cable system involves one complement of equipment for construction of the duct bank (excavators, dump trucks, delivery trucks, front end loader, concrete delivery trucks, crew vehicles, etc.), and a second complement of vehicles to support the cable pulling and splicing (cable reel trucks, winch, crew vehicles, etc.).

With respect to all construction activities, but particularly in relation to scour protection and cable installation, additional geophysical work will likely be conducted to ensure adequate understanding of seabed conditions, particularly in areas of seabed change. Geophysical equipment may also be utilized to ensure proper installation of project components such as scour protection. Geophysical instruments may include, but are not limited to, side scan sonar, bathymetry, magnetometers, and sub-bottom profilers.

4.2.5 Waste Generation and Disposal

Construction and commissioning of the Project will generate some quantity of solid wastes and some small quantity of liquid wastes. The solid waste will primarily consist of short lengths of cable trimmings as well as material and equipment packaging or protective wrappings. Nearly all of these materials will be collected for subsequent recycling. Similarly, small lots of leftover paints and finishes will be properly removed for reuse, recycling or proper disposal. The Project does not expect to need a National Pollutant Discharge Elimination System ("NPDES") permit for offshore construction and commissioning activities. However, a NPDES construction general permit will be required for elements of the onshore construction, since it involves disturbance of more than one acre of land area.

The vessels supporting the offshore construction and future operations and maintenance will be equipped with appropriate sanitary systems. Table 4.2-2 below describes potential wastes to be produced by the Project.

Table 4.2-2 List of Wastes Expected to be Produced During all Project Phases

Type of waste and composition	Approximate total amount discharged	Maximum Discharge Rate	Means of storage or discharge method
Sewerage from vessel	95-114 L/person/day (25-30 gal/person/day)	N/A	Tanks / Sewage Treatment Plant
Domestic water	114-151 L/person/day (30-40 gal/person/day)	N/A	Tanks or discharged overboard after treatment
Drilling cuttings, mud, or borehole treatment chemicals, if used	Dependent on final selection of HDD technique	N/A	N/A
Uncontaminated bilge water	Volume subject to vessel type	Rate subject to vessel size and equipment	Tanks or discharged overboard after treatment
Deck drainage and sumps	Volume subject to vessel type	Rate subject to vessel size and equipment	Discharged overboard after treatment
Uncontaminated ballast water	Volume subject to vessel type	Rate subject to vessel size and equipment	Discharged overboard
Uncontaminated fresh or seawater used for vessel air conditioning	N/A	N/A	Discharged overboard
Solid trash or debris	As generated	As generated	Onshore landfill (location to be determined ["TBD"])
Chemicals, solvents, oils, greases	Volume subject to vessel type	Rate subject to vessel size and equipment	Incineration or onshore landfill (location TBD)

1. Final discharge volumes and rates will be provided in the FIR following execution of contract with the construction contractor and the assignment of a Marine Coordinator.

4.2.6 Chemical Products Used

As planning and design proceeds, a detailed chemical and waste management plan will be developed and provided to BOEM. This plan will describe how each waste stream will be handled and stored, together with plans for proper disposal, recovery, recycling, or reuse. Examples of potential chemical products to be used are provided in Table 4.2-3 below.

Table 4.2-3 List of Potential Chemical Products Used

Chemical Type	Product Description	Source/Location	Approximate Volume (Liter [L] or Kilogram [kg])	Method of Bringing Onsite	Number of Transfers	Treatment, Discharge or Disposal Options
Transformer Oil (WTG and ESP)	Bio-degradable oil or highly refined mineral oil	Main 220/66 kV Transformers, 220 kV shunt reactors, 66 kV aux. transformers & 66 kV grounding reactor	6,500 L per WTG 466,400 L on ESPs[16]	To be included at time of WTG and ESP installation During the O&M phase vessels will be transferring the oil to the offshore positions, either in cans/containers that can be hoisted to the foundation platform or in tanks/containers from which it can be pumped via a hose from the vessel	Not anticipated; only changed if needed	To be brought designated O&M port and disposed according to regulations and guidelines
Lubrication Oil (ESP)	Lubricant Oil	Crane Emergency generator	Crane: To be defined during detailed design Emergency generator: 55 L	During the O&M phase vessels will be transferring the oil to the offshore positions, either in cans/containers that can be hoisted to the foundation platform or in tanks/containers from which it can be pumped via a hose from the vessel	Expected every 5-8 years	To be brought designated O&M port and disposed according to regulations and guidelines
General Oil (WTG and ESP)	Different kinds of oil	WTGs: Hydraulics, gear box, yaw gears, transformers, etc. Might also be used for passive damper located in tower ESPs: Hydraulic oil for crane	8,000 L per WTG 3,000 L to be replaced as part of scheduled maintenance 1320 L on ESPs	To be included at time of WTG and ESP installation During the O&M phase vessels will be transferring the oil to the offshore positions, either in cans/containers that can be hoisted to the foundation platform or in tanks/containers from which it can be pumped via a hose from the vessel	Expected every 5-8 years	To be brought designated O&M port and disposed according to regulations and guidelines

[16] For ESPs, quantities of chemicals are given for the higher value of one 800 MW ESP or two conventional 400 MW ESPs, with the exception of grout, which is given per position.

Table 4.2-3 List of Potential Chemical Products Used (Continued)

Chemical Type	Product Description	Source/Location	Approximate Volume (Liter [L] or Kilogram [kg])	Method of Bringing Onsite	Number of Transfers	Treatment, Discharge or Disposal Options
Grease (WTG)	Refill of grease for main bearing, yaw bearing, blade bearing	Bearings including yaw bearing and blade bearing	1,000 L per WTG	To be included at time of WTG installation During O&M vessels will be transferring cans to site	Expected every year	To be brought designated O&M port and disposed according to regulations and guidelines
Diesel Fuel (WTG and ESP)	Fuel for the emergency diesel generator (if any)	Diesel storage tank	3,000 L per WTG 21,560 L on ESPs	To be included at time of WTG and ESP installation Potentially via hose from vessel or container placed at TP	Only as required	To be brought designated O&M port and disposed according to regulations and guidelines
Fire extinguishing Agents (WTG and ESP)	Inert gas extinguishing system (e.g., NOVEC, nitrogen, or similar)	Various rooms	To be defined during detailed design	To be included at time of WTG and ESP installation	Not anticipated; only changed if needed	To be brought designated O&M port and disposed according to regulations and guidelines
Fire extinguishing Agents (WTG and ESP)	Manual extinguishers: powder, CO_2, foam	Various locations	WTG: To be defined during detailed design 11,000 L foam on ESPs	To be included at time of WTG and ESP installation	Depends on fabrication	To be brought designated O&M port and disposed according to regulations and guidelines

Table 4.2-3 List of Potential Chemical Products Used (Continued)

Chemical Type	Product Description	Source/Location	Approximate Volume (Liter [L] or Kilogram [kg])	Method of Bringing Onsite	Number of Transfers	Treatment, Discharge or Disposal Options
Fire extinguishing Agents (WTG and ESP)	Other types (if any)	Various locations	To be defined during detailed design	To be included at time of WTG and ESP installation	Not anticipated; only changed if needed	To be brought designated O&M port and disposed according to regulations and guidelines
Sulphur Hexafluoride ("SF6") (WTG and ESP)	SF6	WTG GIS switch gears ESP GIS switch gears	~13 kg per WTG ~4,120 kg on ESPs	To be included at time of WTG and ESP installation	Not replaced	To be brought designated O&M port and disposed according to regulations and guidelines
Paint & Coating (WTG and ESP)	Corrosion protection of steel structure paints & varnishes	Steel structure, various locations	To be defined during detailed design	To be included at time of WTG and ESP installation; additional paint only needed for repairs	Only for repairs	To be brought designated O&M port and disposed according to regulations and guidelines
Coolants or refrigerants (such as water or glycol) (WTG and ESP)	Air handling unit, HVAC system	Heating, Ventilation, and Air Conditioning (HVAC) unit, Air Handling Unit	1,600 L per WTG Approx. 700 L to be replaced as part of scheduled maintenance 176 L on ESPs	To be included at time of WTG and ESP installation	Expected every 5-8 years	To be brought designated O&M port and disposed according to regulations and guidelines

Table 4.2-3 List of Potential Chemical Products Used (Continued)

Chemical Type	Product Description	Source/Location	Approximate Volume (Liter [L] or Kilogram [kg])	Method of Bringing Onsite	Number of Transfers	Treatment, Discharge or Disposal Options
Grout (WTG and ESP)	Grout	Grout for connection between monopile and transition piece	Up to 40,000 L per WTG and ESP position	To be included at time of WTG and ESP installation	Not anticipated; only changed if needed	To be brought back to port and disposed according to regulations and guidelines

4.3 Operations & Maintenance

4.3.1 Purpose and Objectives

4.3.1.1 Philosophy

The operations and maintenance ("O&M") philosophy for the Project will be based on the following principles:

- *Health, Safety and Environment ("HSE") First Principles* – putting the health and safety of our people and the environment at the forefront of all our operations and maintenance activities.
- *Continuous Improvement* – ensuring that we regularly review our procedures and performance, identify lessons learned and implement improvements.
- *Maximize Plant Reliability and Availability* – ensuring that we diligently design and select robust reliable wind farm components and that we implement a maintenance regime in which preventive (i.e., scheduled) maintenance is such that it reduces or eliminates the requirements for corrective (i.e., unscheduled) maintenance. In this regard, the aim is to deliver a reliable Project with high production.
- *Knowledge Transfer* – ensuring that, wherever possible, Vineyard Wind learns from other offshore projects (especially within the portfolios of the respective shareholders), wider business experience, experienced partners and contractors and the wider industry to develop our skills in order to achieve our O&M objectives.

4.3.1.2 Objectives

Vineyard Wind's primary O&M objective is to operate a safe and efficient Project. This objective shall be achieved through detailed planning, the use of well-thought-out procedures, the use of experienced and well-trained staff and contractors, and a strong focus on preventive maintenance, data analysis in order to predict/prevent corrective maintenance, and continuous review and improvement.

4.3.1.3 Development of Detailed Maintenance Plans and Processes

Vineyard Wind will develop Project-specific operations and maintenance plans and processes for the wind energy installation. These plans will reflect the installed components. The starting point for all maintenance plans and processes will be the recommendations and instructions set out in the Original Equipment Manufacturers ("OEM") manuals.

Specific maintenance schedules, which set forth the frequency with which maintenance is to be carried out, will be developed for the scheduled maintenance of each primary component (WTG, ESP, onshore substation, etc.). In addition, a scheduled maintenance checklist and or summary method statements for each scheduled task will be developed. These checklists and or summary method statements may be developed by Vineyard Wind and/or their contractors (e.g., WTG OEM).

The final strategy for execution of maintenance works will be largely dependent on the contracting strategy implemented for the maintenance works at the various stages of the Project's life cycle. However, the following principles will be central to the execution of the maintenance:

- Ensuring that experienced operations personnel and/or contractors participate in all phases of the maintenance.
- Ensuring the spare parts and consumables strategy is sufficiently robust and managed such that spares' availability is high allowing for quick repair times in the event of a failure.
- Ensuring that robust maintenance plans and procedures for maintenance are in place, and continually reviewed and updated.
- Ensuring that the organization is structured to efficiently execute the maintenance strategy and that this structure is such that knowledge transfer and continuous improvement are built in to the process.
- Planning and executing maintenance proactively to reduce or eliminate the need for corrective interventions.

4.3.2 Normal Operating Procedures

4.3.2.1 Scheduled and Preventive Maintenance

Vineyard Wind will ensure the offshore wind farm maintenance strategy aligns with best industry practice. This preventive maintenance strategy will be regularly reviewed to ensure maintenance objectives are met and continuously improved. Ultimately, the objective of preventive maintenance is to reduce or eliminate the need for corrective maintenance and contribute to the objective of maintaining good reliability and high availability.

The preventive maintenance plans will be derived from a combination of the experience of the Vineyard Wind shareholders (i.e., CIP and Avangrid) and the maintenance schedules and manuals provided by the OEM's. In addition to the physical preventive maintenance, proactive inspections will be undertaken on a routine basis to ensure the plant remains in a safe condition to enable maintenance activities to be carried out.

Scheduled Inspection and Maintenance Activities

Scheduled inspection and maintenance activities shall generally include the following tasks. A representative inspection and maintenance schedule is provided as Figure 4.3-1.

WTG

- Inspections of components/equipment and proactive replacement of components due to wear and tear (e.g., brake system, pitch system, bolt tightening, and blades).
- Statutory inspections of high-voltage equipment, lifting equipment, safety equipment, hook-on points, etc.

Foundations

- Inspection of external platform, including ladder and boat landing structure, and inspection of internal structures (corrosion measurement, etc.).
- Statutory inspections of lifting equipment, safety equipment, hook-on points, etc.
- Inspection of scour protection and monitoring of performance.

ESP

- Inspection and service of high-voltage equipment (e.g., main transfer, switchgears, and earthing systems) and auxiliary systems (fire protection system, communication system, heating and ventilation system, etc.)
- Statutory inspections of lifting equipment, safety equipment, hook-on points, etc.

Onshore Substation

- Inspection and service of high-voltage equipment (e.g., main transformer, switchgears, and earthing systems) and auxiliary systems (fire protection system, communication system, heating and ventilation system, etc.)
- Statutory inspections of lifting equipment, safety equipment, hook-on points, etc.

Inter-array Cables, Inter-link Cables, Offshore Export Cables, Landfall Site, and Onshore Export Cables

- Bathymetric and other surveys and monitoring cable exposure and/or depth of burial.

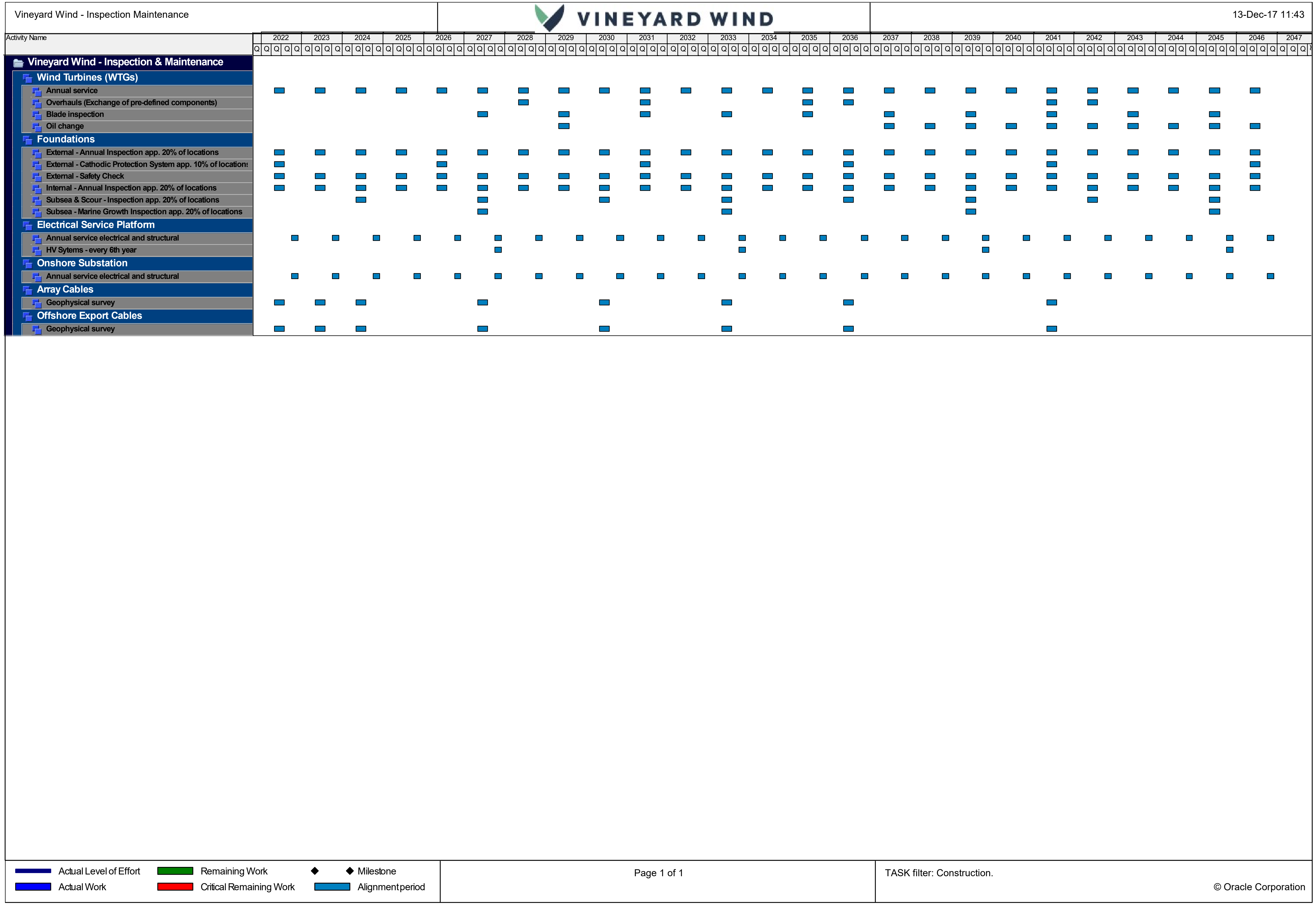

Figure 4.3-1

Representative Inspection and Maintenance Schedule

Equipment

Geophysical work will likely be conducted to ensure adequate understanding of seabed conditions, particularly in areas of seabed change, and to monitor project components such as cables and scour protection. Geophysical instruments may include, but are not limited to, side scan sonar, bathymetry, magnetometers, and sub-bottom profilers.

Equipment to be used for the inspection and O&M activities includes the following types listed in Table 4.3-1.

Table 4.3-1 O&M Activities and Equipment Types

Activity Type	Equipment
Marine inspections and surveys: • Offshore and nearshore multi-beam echosounder inspections • Offshore and nearshore side scan sonar inspections • Offshore and nearshore magnetometer inspections • Offshore and nearshore depth of burial inspections • Other geophysical surveys • Geotechnical surveys	ROV or remotely-operated towed vessel ("ROTV") deployed from a survey vessel. For geotechnical surveys, sampling instrumentation deployed from a survey vessel with geotechnical spread. Cable toner survey.
Cathodic protection inspection and repair	ROV deployed from a survey vessel or divers
Hot work (welding) and ancillary equipment (including subsea)	Crew deployed to the WTG or divers deployed from diving vessel for subsea arc welding
Removal of marine growth and guano	Using a brush to break down the marine growth (where required) followed by high-pressure jet wash (sea water only). Technicians or deck hands will be deployed from crew transport vessels ("CTVs") or similar vessel.
External surface preparation and external protective coating repair	Technicians and equipment deployed from CTVs or similar vessel. Surface preparation to break down existing surface coating and any associated rust via blaster.
Grouted connections • Intrusive core samples • Re-grouting	Intrusive core samples: ROV deployed from a survey vessel or divers Re-grouting: Injected via one of several redundant grouting injection tubes from the TP
External component replacement or repair	Varies according to component in question, could be a crew mobilized to site in CTV, diving spread, construction support vessel (CSV), or jack-up barge.

In addition to the equipment listed in Table 4.3-1, major repairs to Project components could utilize construction-type vessels, including cable-laying vessels.

4.3.2.2 Systems and Processes

Vineyard Wind will develop a number of Project-specific O&M procedures; indicatively, these will cover at least the following topics:

- General Operations
- Preventive Maintenance
- Corrective Maintenance
- Urgent Response Protocol
- Local Operations
- Back up Control Room
- Planning and Monitoring of Works
- Work Control
- Warehouse Management
- Design Modifications
- Marine Coordination
- Warranty and Insurance management and claims
- Maintenance of control room systems
- Permit to work

Vineyard Wind will have a dedicated permit-to-work process in place covering all offshore and onshore works. This permit-to-work system is primarily designed to ensure that maintenance activities are properly planned, risks assessed, and work is carried out by properly trained and qualified individuals. In addition, the permit-to-work system seeks to avoid the execution of multiple works which, if executed at the same time, could result in safety conflict.

4.3.2.3 Monitoring and Control

The WTGs are designed to operate without attendance by any operators. Continuous monitoring is conducted using a supervisory control and data acquisition (SCADA) system from a remote location. Examples of parameters that are monitored include temperature limits, vibration limits, current limits, voltage, smoke detectors, etc. The WTG also includes self-protection systems that will be activated if the WTG is operated outside its specifications or the SCADA system fails. These self-protection systems may curtail or halt production or disconnect from the grid.

While the final SCADA architecture is not finalized at this time, it is likely that that the several SCADA systems will be utilized, for example:

- WTG SCADA
- ESP SCADA
- Onshore Substation SCADA
- Other SCADA's

Monitoring of WTG

Vineyard Wind and the selected turbine manufacturer shall be responsible for the 24/7 operation and monitoring of the WTGs. This shall be executed by utilizing both the Vineyard Wind O&M Facilities and the 24/7 control center of the shareholder companies (for example, Iberdrola/Avangrid has a US-based 24/7 renewables control center capable of providing support).

Monitoring of Weather and Sea

Vineyard Wind will appoint a competent contractor to provide regular weather forecasts. This forecast shall cover key parameters, including meteorological parameters, such as wind, temperature, visibility, and warnings (e.g., lightning), and oceanographic parameters, such as wave conditions. In addition, it is likely that a small weather station, with wind and temperature sensors, will be installed on the ESPs to provide operations personnel an indication of real-time conditions offshore to support the planning and execution of work.

Communications

A dedicated communications system will be implemented for the Project; this system will primarily be designed to facilitate voice communications within the wind farm. The communications system will be designed to provide coverage within WTGs and the ESP.

In addition to this dedicated system, normal marine and aviation communications channels would be utilized for the respective logistics options (e.g., marine VHF for ships).

Standard emergency channels will also be available.

Emergency protocols will be in place for both the installation and O&M phase and will be developed as part of the SMS. The emergency protocols will include steps for external stakeholders such as the USCG and fishermen to alert Vineyard Wind of concerns related to the Project 24/7. Vineyard Wind will review draft emergency protocols with the USCG, fishermen, and other stakeholders, as relevant, prior to finalizing the SMS.

4.3.3 Non-routine Operating Procedures/Unscheduled Maintenance

Subject to sufficiently implementing preventive maintenance, corrective maintenance should be minimized. Analysis and interrogation of SCADA data and, in particular, condition monitoring systems are essential to potentially identify equipment failures in advance.

The key aims of corrective maintenance will be to:

- Minimize downtime of the Project;
- Minimize cost incurred during intervention and revenue loss; and
- Determine the root cause in order to limit potential repetition of failure event.

Corrective maintenance will, however, be required. By its nature, corrective maintenance is difficult to accurately predict. As such, being adequately prepared for corrective maintenance is key. Key preparations in order to affect corrective maintenance center on the following items:

Spare Part Availability

It is envisioned that a stock of recommended spare parts will be purchased along with the major components (e.g., WTGs, ESPs, onshore substation, cables, etc.). This stock would be based on OEM recommendations; however, it is likely that Vineyard Wind may request additional items based on its own experience.

Thereafter, Vineyard Wind, together with its contractors and service providers, will constantly monitor the use of spare parts in order to maintain recommended stock levels and, where applicable, increase stock levels and or purchase additional parts as deemed necessary.

Smaller spare parts and consumables will be stored at Vineyard Wind's O&M Facilities, while larger spare parts are likely to be stored at either the OEM facilities or other storage facilities, as required.

Workforce Availability

Given the fact that the Massachusetts economy includes significant marine industries and a strong engineering and technology component, an ample workforce is expected to be available. In addition, the rest of the US has a significant renewable energy and offshore oil and gas sector, the skills for which are readily transferable to the offshore wind industry.

While initially some Project works may have to be supported from the European or global supply chain, the local supply chain and workforce are expected to develop quickly. For addition discussion of workforce implications of the Project, see Sections 7.1.2.1.1 and 7.1.2.2.1 of Volume III.

Site Accessibility (i.e., weather conditions)

It is possible that a significant number of issues will be able to be addressed remotely (i.e., a remote reset), and it is envisioned that such remote repairs will be the most common form of corrective repair.

Corrective events which require a physical intervention offshore, will utilize the extensive metocean information described in Volume II to ensure safe and effective maintenance work.

The worst-case scenario, with respect to corrective maintenance, is to have a major component failure (i.e., gearbox, blades, transformer). In this event, a potentially significant period of downtime could be experienced for a portion of the Project.

As such, Vineyard Wind will work to maintain good in-house knowledge of component failure rates, maintenance requirements for such failures, repair periods, and spare part requirements. This allows Vineyard Wind to develop well-founded procedures which can be executed for corrective maintenance.

4.3.4 Vessels, Vehicles, and Aircraft

During operations and maintenance, many of the vessels used during construction (see Table 4.2-1) will be used for daily visits to the WDA, maintenance activities, and periodic significant repairs. Table 4.3-2 summarizes the anticipated annual vessel activity during the O&M period. On average, there will be fewer than three vessel trips per day during the Project's operational period.

Table 4.3-2 Annual Vessel Use during O&M

O&M Activity	Vessel Type	Description of Anticipated Vessel Activities	Annual Round Trips
Scour Protection Repairs			
Scour Protection Repair	Fall Pipe Vessel	One trip every 1.5 years, 2 days per trip	0.7
ESP O&M			
Refueling Operations to ESP	Crew Transfer Vessel or Multipurpose Support Vessel	One trip per year, 1 day per trip	1
WTG O&M			
WTG Transport	Heavy Cargo Vessel and/or Deck Carrier	One trip every 3 years	0.3
Main Repair Vessel	Jack-up Vessel	One trip every 1.5 years, 5 days per trip	0.7
Gearbox Oil Change	Crew Transfer Vessel or Multipurpose Support Vessel	Approximately one trip per WTG (In years 5, 13 and 21)	110
Ad Hoc Survey Work	Multi-role Survey Vessel	Up to 100 surveys over the Project's lifespan, 2 days per trip	3.3
Cable Inspection/Repairs			
Cable Inspection/Repair	Multi-role Survey Vessel	Eight surveys over the Project's lifespan, 20 days per trip (Years 1,2,3,6,9,12,15, and 20)	1
Daily and Miscellaneous O&M Scenario 1 (CTV Concept)			
Daily Crew Transfer	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days)	256
Daily Crew Transfer	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days)	256
Daily Crew Transfer	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days)	256
Miscellaneous Repairs	Multipurpose Support Vessel	One trip every 3 years, 10 days per trip	0.3
Marine Mammal Observations	Crew Transfer Vessel/Fishing Vessel	One trip per year, 5 days per trip	1
Guard Vessels	Crew Transfer Vessel/Fishing Vessel	One trip every 1.5 years, 7 days per trip	0.7
OR Daily and Miscellaneous O&M Scenario 2 (SOV Concept)			
Service Operation Vessel (SOV)	Multipurpose Support Vessel	One round trip every two weeks, lasting approximately two weeks each	26
Daily Crew Transfer from SOV	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days))	256
Marine Mammal Observations	Crew Transfer Vessel/Fishing Vessel	One trip per year, 5 days per trip	1
Guard Vessels	Crew Transfer Vessel/Fishing Vessel	One trip every 1.5 years, 7 days per trip	0.7
Total Annual Round Trips for O&M Vessels			**401 - 887**

As noted in Section 3.2.6, helicopters may be used to supplement crew transport and for Project support during the O&M period.

4.4 Decommissioning & Site Clearance Procedures

4.4.1. Decommissioning Plan Requirements

BOEM's decommissioning requirements are stated in Section 13, "Removal of Property and Restoration of the Leased Area on Termination of Lease," of the April 15, 2015 Lease for Area OCS-A 0501. Unless otherwise authorized by BOEM, pursuant to the applicable regulations in 30 C.F.R. Part 585, Vineyard Wind is required to "remove or decommission all facilities, projects, cables, pipelines, and obstructions and clear the seafloor of all obstructions created by activities on the leased area, including any project easements(s) within two years following lease termination, whether by expiration, cancellation, contraction, or relinquishment, in accordance with any approved SAP, COP or approved Decommissioning Application and applicable regulations in 30 CFR Part 585."

4.4.2. Decommissioning Time Horizon

The WTGs, ESPs, the supporting cabling, and the onshore substation infrastructure will be robustly designed and carefully maintained. As is typical of utility-grade generation and transmission infrastructure, the Project's equipment is expected to have a physical life expectancy of up to 30 years.

The first commercial-scale European offshore wind energy installation was constructed in 1991. Approximately 13,000 MW of offshore wind capacity has been installed in European waters over the past 25 years, and with a single exception,[17] all of this capacity remains in commercial operation. Accordingly, the following discussion outlines decommissioning procedures and methods that would be most appropriate given today's technology. However, it is reasonable to expect that by the end of the Lease term and beyond, experience in the European offshore wind industry and, more generally, technological advances in methods and equipment servicing the offshore industry, may result in some increased level of efficiencies as well as a reduced level of environmental impacts.

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17 In March of 2017, DONG Energy announced that it would be decommissioning the 1991 vintage Vindby (Denmark) project. The Vindby project consists of eleven 0.45 MW turbines (5 MW total) located in shallow waters a few kilometers off the southeast coast of Denmark. One of the 54 m high turbines will be displayed at the "Energimussett" (Danish Museum of Energy). The other turbines will be used for spare parts for other projects or recycled. The concrete foundations will be broken down using demolition shears.

4.4.3 General Decommissioning Concept

Before ceasing operation of individual WTGs or the entire Project and prior to decommissioning and removing Project components, Vineyard Wind will consult with BOEM and submit a decommissioning plan for review and approval. Upon receipt of the necessary BOEM approval and any other required permits, Vineyard Wind would implement the decommissioning plan to remove and recycle equipment and associated materials.

As currently envisioned, the decommissioning process is essentially the reverse of the installation process. Decommissioning of the Project is broken down into several steps:

- Retirement in place or removal of offshore cable system (e.g., 66 kV inter-array and 220 kV offshore export cables).
- Dismantling and removal of WTGs.
- Cutting and removal of monopile foundations (and/or jackets) and removal of scour protection.
- Removal of ESPs.
- Possible removal of onshore export cables.

It is anticipated that the equipment and vessels used during decommissioning will likely be similar to those used during construction and installation. For offshore work, vessels would likely include cable laying vessels, crane barges, jack-up barges, larger support vessels, tug boats, crew transfer vessels, and possibly a vessel specifically built for erecting WTG structures.

For onshore work, subject to discussions with the host town(s) on the decommissioning approach that best meets the host town's needs and has the fewest environmental impacts, the onshore cables, the concrete encased duct bank itself, and vaults would be left in place for future reuse as would elements of the onshore substation and grid connections. If onshore cable removal is determined to be the preferred approach, removal of cables from the duct bank would likely be done using truck mounted winches, cable reels and cable reel transport trucks.

4.4.4 Decommissioning Plan and Procedures

The offshore cables could be retired in place or removed, subject to discussions with the appropriate regulatory agencies on the preferred approach to minimize environmental impacts. If removal is required, the first step of the decommissioning process would involve disconnecting the inter-array 66 kV cables from the WTGs. Next, the inter-array cables would be pulled out of the J-tubes or similar connection and extracted from their embedded position in the seabed. In some places, in order to remove the cables, it may be necessary to jet plow the cable trench to fluidize the sandy sediments covering the cables. Then, the cables will be reeled up onto barges. Lastly, the cable reels will then be transported to the port area for further handling and recycling. The same general process will likely be followed for the 220 kV offshore export cables. If protective concrete mattresses or rocks were used for portions of the cable run, they will be removed prior to recovering the cable.

Prior to dismantling the WTGs, they would be properly drained of all lubricating fluids, according to the established operations and maintenance procedures and the OSRP. Removed fluids would be brought to the port area for proper disposal and / or recycling. Next, the WTGs would be deconstructed (down to the transition piece at the base of the tower) in a manner closely resembling the installation process. The blades, rotor, nacelle, and tower would be sequentially disassembled and removed to port for recycling using vessels and cranes similar to those used during construction. It is anticipated that almost all of the WTG will be recyclable, except possibly for any fiberglass components.

After removing the WTGs, the steel transition pieces and foundation components would be decommissioned. Sediments inside the monopile could be suctioned out and temporarily stored on a barge to allow access for cutting. The foundation and transition piece assembly is expected to be cut below the seabed in accordance with the BOEM's removal standards (30 C.F.R. 250.913). The portion of the foundation below the cut will likely remain in place. Depending upon the available crane's capacity, the foundation/transition piece assembly above the cut may be further cut into several more manageable sections to facilitate handling. Then, the cut piece(s) would then be lifted out of the water and placed on a barge for transport to an appropriate port area for recycling.

The steel foundations would likely be cut below the mudline using one or a combination of: underwater acetylene cutting torches, mechanical cutting, or a high pressure water jet. The sediments previously removed from the inner space of the pile would be returned to the depression left once the pile is removed. To minimize sediment disturbance and turbidity, a vacuum pump and diver or ROV-assisted hoses would likely be used.

As described in Section 3.1.3, each of the WTGs and ESPs would have stone and/or rock scour protection. Vineyard Wind would propose that the scour protection be removed. The stone and/or rock would likely be excavated with a dredging vessel, set on a barge, and transported to shore for reuse or disposal at an onshore location.

The ESPs will be disassembled in a similar manner as the WTGs, using similar vessels. Prior to dismantling, the ESP would be properly drained of all oils, lubricating fluids, and transformer oil according to the established operations and maintenance procedures and OSRP. Removed fluids would be brought to the port area for proper disposal and / or recycling. Similarly, any SF6 in gas insulated switchgear would be carefully removed for reuse. Before removing the ESPs, the 220 kV offshore export cables would be disconnected from the ESP and removed, as discussed for inter-array cables above.

The substation platform itself would then be removed from its supporting monopile or jacket foundation, and placed on a barge for transport to port. Depending on the crane capacity available and design of the substation, some of the major electrical gear could be removed first, followed by the platform itself. The ESP foundation piles will likely be removed according to the same procedures used in the removal of the WTG foundations described above.

During decommissioning activities, a careful inventory of all Project components to be removed would be made. This inventory would include the WTGs, ESPs, foundations, offshore export cables, inter-array cables, inter-link cables, cable protection system, and so forth. As they are removed from the site, Project components would be counted and noted as removed in the inventory. This careful reporting system will ensure that all Project components are removed. No additional site clearance work or surveys are anticipated to be required to confirm site clearance.

The environmental impacts from these decommissioning activities would be generally similar to the impacts experienced during construction.

As noted above, the extent of the decommissioning of onshore components, such as the onshore export cable, will be determined in consultation with the host towns, as many of the onshore components could be retired in place or retained for future use. If decommissioning of the Landfall Site, transition vault, and onshore export cable components is required, the process will consist of pulling the cables out of the duct bank, loading them onto truck-mounted reels, and transporting them offsite for recycling or possible reuse. The splice vaults, conduits, and duct banks will likely be left in place, available for reuse. This approach will avoid disruption to the streets.

In addition, decommissioning of the offshore facilities would require the involvement of an onshore recycling facility with ability to handle the large quantities of steel and other materials from the Project. Such facilities currently in operate in New England. One example is the Prolerized New England, Inc. facility on Boston Harbor in Everett Massachusetts. The Everett facility is located in a heavy industrial area and has deep water access, allowing for the foundations, WTGs, and other large components to be directly offloaded from the barges, cut into manageable sections, shredded into smaller pieces, and then shipped to end-users as scrap metal. This facility also routinely handles large volumes of scrap metal from auto recycling and a variety of demolition projects.

Currently, the fiberglass in the rotor blades has no commercial scrap value. Consequently, it is anticipated that the fiberglass from the blades would be cut into manageable pieces and then disposed of at an approved onshore solid waste facility.