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VINEYARD WIND

Draft
Construction and Operations Plan

Volume III
Text

Vineyard Wind Project

June 3, 2020

Submitted by
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700 Pleasant Street, Suite 510
New Bedford, Massachusetts 02740

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

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June 3, 2020

Section 5.0

Physical Resources

5.0 PHYSICAL RESOURCES

5.1 Air Quality

This section addresses the potential impacts to ambient air quality that are associated with the onshore and offshore portions of the Project.

5.1.1 Description of the Affected Environment

The Project's wind turbine generators (WTGs) will not generate air emissions. Rather, electricity generated by the WTGs will displace electricity generated by higher-polluting fossil fuel-powered plants and significantly reduce emissions from the ISO New England power grid over the lifespan of the Project.

However, air emissions from construction, operations and maintenance, and decommissioning activities may affect air quality in the New England region and nearby coastal waters. There will be air emissions from commercial marine vessels, non-road construction equipment, helicopters, generators, on-road vehicles, and some fugitive emissions. These emissions will occur both onshore and offshore, within Massachusetts, the Outer Continental Shelf ("OCS"), and possibly another Atlantic port. Onshore emissions will occur at the Landfall Site, along the Onshore Export Cable Route, at the onshore substation, and at the construction staging areas. Offshore emissions will occur within the Wind Development Area ("WDA"), along the Offshore Export Cable Corridor, at one or more ports, and along the vessel routes between the WDA and the port(s).

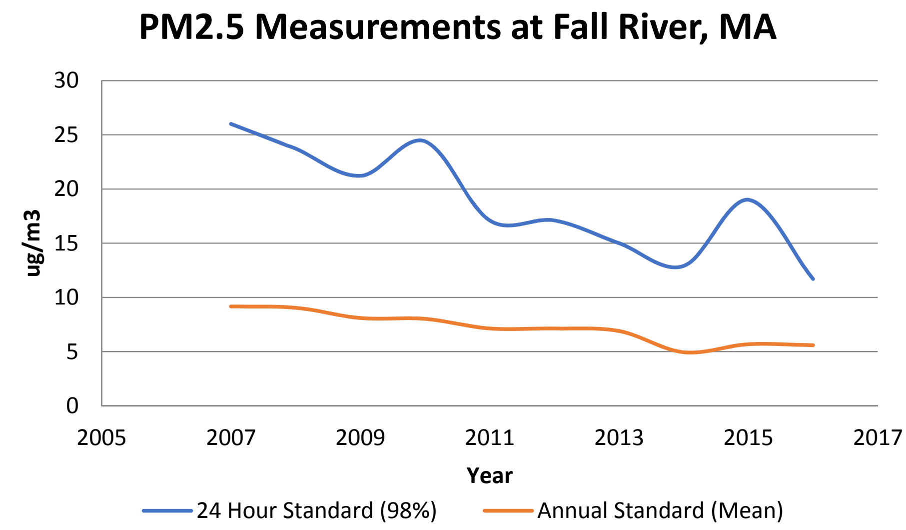
The Project intends to use the New Bedford Marine Commerce Terminal ("New Bedford Terminal") as the Project's primary construction staging area. However, as described in Section 3.2.5 of Volume I, Vineyard Wind may need to stage certain activities from other Massachusetts or North Atlantic commercial seaports as listed in Table 3.2-1 of Volume I. Within Massachusetts, the geographic areas where Project-related air emissions may occur include Barnstable County, Bristol County, Dukes County and Nantucket County (in waters offshore Nantucket only). Within Rhode Island, Project-related air emissions could potentially occur in Washington, Newport, Kent, Providence, and Bristol Counties. It is also possible that a Canadian port will be used.

One of the basic goals of federal and state air regulations is to ensure that ambient air quality, including the impact of background, existing sources, and new sources, is in compliance with ambient standards. The Environmental Protection Agency ("EPA") has developed National Ambient Air Quality Standards ("NAAQS") for six air contaminants, known as criteria pollutants, for the protection of public health and welfare. The criteria pollutants are sulfur dioxide (SO_2); particulate matter (smaller than 10 microns as PM_{10}, smaller than 2.5 microns as $PM_{2.5}$); nitrogen dioxide (NO_2); carbon monoxide (CO); ozone (O_3); and lead (Pb). NAAQS have been developed for various durations of exposure and consist of primary and secondary standards. Primary standards are intended to protect human health. Secondary standards are intended to protect public welfare from known or anticipated adverse effects associated with the presence of air pollutants, such as damage to property or vegetation.

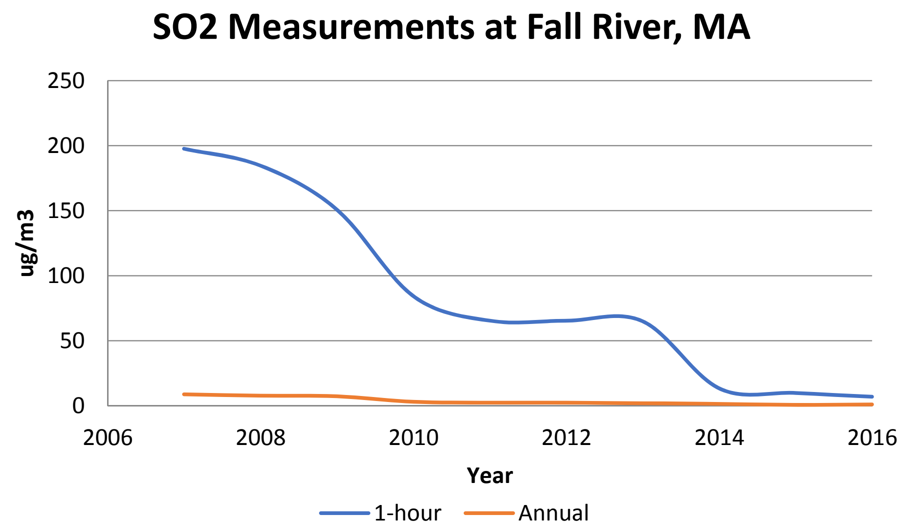
The Massachusetts Ambient Air Quality Standards ("MAAQS") at 310 C.M.R. § 6.00 also establish primary and secondary ambient air quality standards. MAAQS generally follow the EPA's NAAQS, but are not identical (see **bold** text in Table 5.1-1). The more stringent of either the NAAQS or MAAQS is used to document compliance with ambient air quality standards. Table 5.1-1 summarizes the standards as currently presented by the EPA and Massachusetts Department of Environmental Protection ("MassDEP"). The implementation of these standards has led to significant improvement in ambient air quality in Massachusetts. Figure 5.1-1 shows trends of measured ambient air concentrations of key pollutants at nearby monitoring stations, with an overall trend of improvement.

Table 5.1-1 National (NAAQS) and Massachusetts (MAAQS) Ambient Air Quality Standards

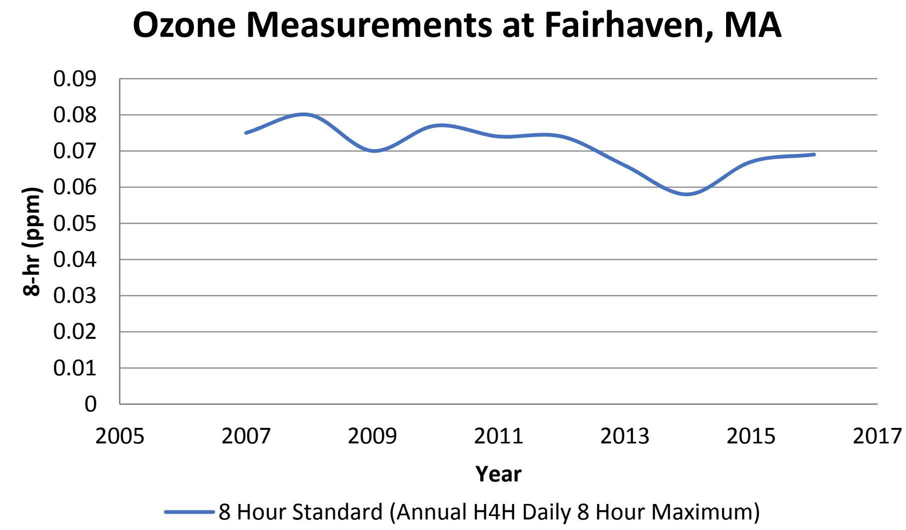
		NAAQS ($\mu g/m^3$)		MAAQS ($\mu g/m^3$)	
Pollutant	Averaging Period	Primary	Secondary	Primary	Secondary
NO_2	Annual (1)	100	Same	100	Same
	1-hour (2)	**188**	None	**None**	None
SO_2	Annual (1)(9)	80	None	80	None
	24-hour (3)(9)	365	None	365	None
	3-hour (3)	None	1300	None	1300
	1-hour (4)	**196**	None	**None**	None
$PM_{2.5}$	Annual (1)	**12**	**15**	**None**	**None**
	24-hour (5)	**35**	**Same**	**None**	**None**



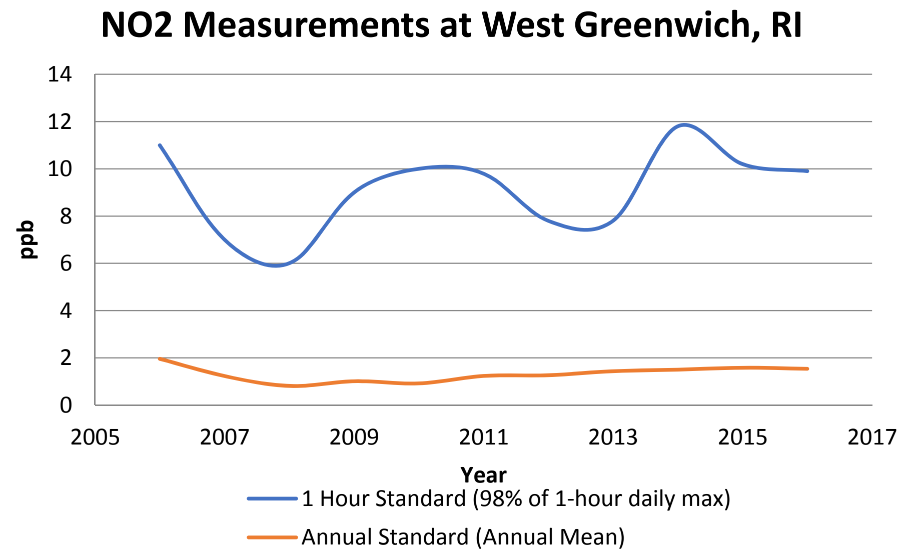
PM2.5 NAAQs: 35 ug/m3 (24-hour, 98th percentile averaged over 3 years) and 12 ug/m3 (Annual, not to be exceeded)



SO2 NAAQs: 196 ug/m3 (1-hour, 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years) and 12 ug/m3 (Annual, not to be exceeded)



Ozone NAAQs: 0.07 ppm (2008 EPA Ozone standard) (8-hour, Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years)



NO2 NAAQs: 100 ppb (1-hour, 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years) and 53 ppb (Annual, not to be exceeded)

Sources: MassDEP Annual Air Quality Reports and US EPA Annual Air Monitor Summary Data

Figure 5.1-1

Background Air Quality

Table 5.1-1 National (NAAQS) and Massachusetts (MAAQS) Ambient Air Quality Standards (Continued)

Pollutant	Averaging Period	NAAQS (μg/m^3)		MAAQS (μg/m^3)	
		Primary	Secondary	Primary	Secondary
PM$_{10}$	Annual (1)(6)	**None**	None	**50**	Same
	24-hour (3)(7)	150	Same	150	Same
CO	8-hour (3)	10,000	None	10,000	Same
	1-hour (3)	40,000	None	40,000	Same
O$_3$	8-hour (8)	**147**	Same	**235**	Same
Pb	3-month (1)	1.5	Same	1.5	Same

(1) Not to be exceeded.
(2) 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
(3) Not to be exceeded more than once per year.
(4) 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
(5) 98th percentile, averaged over 3 years.
(6) EPA revoked the annual PM$_{10}$ NAAQS in 2006.
(7) Not to be exceeded more than once per year on average over 3 years.
(8) Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
(9) EPA revoked the annual and 24-hour SO$_2$ NAAQS in 2010. However, they remain in effect until one year after the area's initial attainment designation, unless designated as nonattainment.
Source: EPA. (2016). NAAQS Table. Retrieved from: https://www.epa.gov/criteria-air-pollutants/naaqs-table; Ambient Air Quality Standards for the Commonwealth of Massachusetts, 310 C.M.R. § 6.04

All areas of the country have been classified by the EPA as in *attainment*, *nonattainment*, or *unclassified* for the criteria pollutants listed in Table 5.1-1, above. An attainment area is defined as an area in compliance with all NAAQS. A nonattainment area is defined as an area that is not meeting NAAQS for one or more pollutants. An unclassified area is defined as an area that cannot be classified as meeting or not meeting NAAQS based on available information, but is treated as an attainment area. Additionally, if an area was in nonattainment within the last 20 years, but is currently in attainment or unclassified, the area is called a maintenance area. The official record of an area's attainment status can be found in Designation of Areas for Air Quality Planning Purposes, 40 C.F.R. Part 81. Revisions to 40 C.F.R. Part 81 are periodically published by the EPA in the Federal Register and made available in the EPA's Green book (EPA, 2017c). For coastal areas, the nonattainment or maintenance area boundary extends to the state's seaward boundary, which is three nautical miles for most states) (EPA, 2010).

At its nearest point, the Vineyard Wind Lease Area is just over 23 kilometers ("km") (14 miles) from the southeast corner of Martha's Vineyard, located in Dukes County. Dukes County, Barnstable County, Bristol County, Nantucket County are presently designated as unclassified, which is treated as attainment, or in attainment for five of the six criteria pollutants: SO$_2$, CO, PM (PM$_{10}$ and PM$_{2.5}$), NO$_2$, and Pb (EPA, 2017c).

The entire Commonwealth of Massachusetts ("Commonwealth" or "Massachusetts") was formerly classified as in moderate nonattainment for ozone under the 1997 8-hour standard of 0.08 parts per million ("ppm"). This standard was replaced with a standard of 0.075 ppm, effective May 28, 2008. The entire Commonwealth, except for Dukes County, was classified as being in attainment with the 2008 8-hour ozone standard. The 1997 standard was officially revoked on April 6, 2015. As a result, the entire Commonwealth, except for Dukes County, is no longer considered an ozone maintenance area (EPA, 2017c). Effective December 28, 2015, the 8-hour ozone standard was further reduced to 0.07 ppm. Initial attainment designations for the 2015 standard were published by EPA on November 16, 2017 and became effective January 16, 2018. Because air quality in Massachusetts has improved, under the new designation, the entire Commonwealth, including Dukes County, is in attainment/unclassifiable with the stricter 2015 ozone standard. If EPA issues a rulemaking to revoke the 2008 ozone standards, Dukes County would no longer be a nonattainment or maintenance area (EPA, 2015).

The entire State of Rhode Island is currently in attainment for all six criteria pollutants and does not include any maintenance areas (EPA, 2017c). Attainment designations for all counties where Project emissions may occur are summarized in Table 5.1-2. All counties potentially affected by the Project's air emissions are in attainment with the NAAQS for Pb, SO_2, and NO_2, which are not included in the following table.

Table 5.1-2 Air Quality Designations for Areas Where Project-Related Emissions May Occur

Area/County	2015 Ozone Standard	2008 8-Hour Ozone Standard	1997 & 2006 $PM_{2.5}$	1987 PM10 standard	1971 CO Standard
Barnstable, MA	Attainment	Attainment	Attainment	Attainment	Attainment
Bristol, MA	Attainment	Attainment	Attainment	Attainment	Attainment
Nantucket, MA	Attainment	Attainment	Attainment	Attainment	Attainment
Dukes, MA	Attainment	Dukes County Marginal Nonattainment Area	Attainment	Attainment	Attainment
All Rhode Island Counties	Attainment	Attainment	Attainment	Attainment	Attainment

The Vineyard Wind Project is not the only offshore activity that could potentially impact ambient air quality in the region. Similar neighboring projects may also have impacts. For example, Massachusetts's *Act to Promote Energy Diversity* requires the Commonwealth to procure cost-effective long-term contracts for 1,600 megawatts ("MW") of offshore wind energy within the next decade (Mass.Gov, 2016). Consequently, other companies have proposed to construct offshore wind farms in response to the solicitation for an additional 800 MW of offshore wind issued by several Massachusetts electric distribution companies, in coordination with the Massachusetts Department of Energy Resources ("DOER").

In addition to the impacts of neighboring offshore wind projects on ambient air quality, emissions from commercial marine vessel activity in US waters will continue to impact offshore ambient air quality. Table 5.1-3 shows the tons of NO_x, PM_{10}, $PM_{2.5}$, SO_2, and volatile organic compounds ("VOC") emitted by commercial marine vessels in US waters in 2014, according to EPA's 2014 National Emissions Inventory. [7]

Table 5.1-3 Total Emissions from US Commercial Marine Traffic, 2014

Pollutant	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC
Total Emissions (tons)	1,215,718	36,614	34,735	167,058	36,654

During the peak year of construction, offshore emissions associated with the Project are expected to be less than 0.32% of the total emissions from commercial marine vessel activity in US waters for any of the above pollutants. Additionally, during operation, the Vineyard Wind Project would provide 800 MW of zero-emission electricity that would displace electricity from conventional power generation thereby resulting in a significant reduction in regional emissions (see table 5.1-7, below).

5.1.2 Potential Impacts of the Project

While the proposed wind turbines do not generate air emissions, there will be air emissions from Project construction, and subsequent operations, maintenance and decommissioning activities.

Some air emissions from the Project are regulated through the EPA's OCS Air Permit process under the Outer Continental Shelf Air Regulations, 40 C.F.R. Part 55. This regulation establishes air pollution control requirements for OCS sources (i.e., stationary sources and vessels directly or indirectly attached to the seabed) located within 25 miles of a state's seaward boundaries. Air emission estimates in the OCS Air Permit application must include emissions from OCS sources and vessels traveling in and around the Project Area when within 25 miles of an OCS source.

The potential direct and indirect impacts of the Project on air quality during construction, operations and maintenance, and decommissioning are summarized in Table 5.1-4. The actions that have the potential to emit air pollutants during the Project are discussed in more detail in the following sections. The following sections also quantify the direct emissions subject to the OCS Air Permitting Program during construction and O&M.

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[7] Based on EPA's *2014 National Emissions Inventory, Version 1 Technical Support Document* (December 2016), Table 4-115. US waters include the waters of the 50 states, Puerto Rico, and US Virgin Islands (out to 200 nautical miles from the US coastline).

Table 5.1-4 Impact-producing Factors for Air Quality

Impact-Producing Factors	Wind Development Area	Offshore Export Cable Corridor	Onshore Export Cable Route and Onshore Facilities	Construction Staging Areas	Construction & Installation	Operations & Maintenance	Decommissioning
Onshore substation installation			x	x	x		
Installation of duct bank and vaults			x	x	x		
Cable pulling			x	x	x		
Horizontal directional drilling		x	x	x	x		
Scour protection installation	x	x		x	x		
Offshore cable installation	x	x		x	x		
Transport of WTGs, ESPs, and foundations	x			x	x		
ESP and WTG installation	x			x	x		
WTG and ESP commissioning	x			x	x		
Scour protection repairs	x			x		x	
Foundation maintenance and repairs	x			x		x	
WTG maintenance and repairs	x			x		x	
WTG and ESP inspections	x			x		x	
Onshore substation and vault inspections			x	x		x	
Offshore cable removal	x						x
WTG and ESP removal	x			x			x
Onshore export cable removal			x	x			x

5.1.2.1 Construction and Installation

5.1.2.1.1 Description of Potential Impacts

The majority of air emissions from the Project will come from the main engines, auxiliary engines, and auxiliary equipment on marine vessels used during construction activities. Emissions from marine vessel engines will occur while vessels maneuver within the WDA, during installation of the offshore export cables, during vessel transit to and from port, and while vessels are in port.

During construction, heavy lift vessels, tugboats, barges, and jack-up vessels will be used to transport the wind turbine generators ("WTG"), monopiles, transition pieces, and electrical service platforms ("ESP") components to the WDA. Installation of the WTGs, monopiles, transition pieces, and ESPs is expected to be performed using a combination of jack-up vessels and dynamically positioned ("DP") crane vessels. It is anticipated that scour protection will be installed around the WTG and ESP foundations and cable protection will be placed over limited sections of the offshore cable system using specialized rock-dumping or other vessels. Cable-laying is expected to be performed by specialized cable-laying vessels. Prior to cable-laying, a pre-lay grapnel run will be made by multipurpose offshore support vessels to locate and clear obstructions such as abandoned fishing gear and other marine debris from the Offshore Export Cable Corridor. To achieve proper cable burial depth, a specialized dredging vessel may also be used in certain areas prior to cable laying to remove the upper portions of sand waves. Crew transfer vessels and helicopters are expected to be used to transport personnel to and from the WDA and may be used for marine mammal observations.

Additional offshore construction-related emissions will come from diesel generators used to temporarily supply power to the WTGs and ESPs so that workers can power up lights, controls, and other equipment before cabling is in place. There will also be emissions from engines used to power pile driving hammers and air compressors used to supply compressed air to noise mitigation devices (e.g. bubble curtains) during pile driving.

Emission sources used during offshore construction include:

- Crew transfer/service vessels
- Heavy lift crane vessels
- Heavy cargo vessels
- Cable installation vessels
- Scour protection installation vessels
- Multipurpose support vessels
- Tugboats
- Anchor handling tug supply vessels
- Jack-up vessels

- Dredging vessels
- Survey Vessels
- Temporary diesel generators
- Air Compressors
- Pile driving hammer engines
- Helicopters
- Fugitive emissions of solvents, paints, coatings, and diesel fuel storage/transfer

Emission sources from onshore construction activities will include non-road equipment and vehicles used during the unloading and loading of equipment at the construction staging areas, horizontal directional drilling, installation of the onshore export cable, and construction of the onshore substation. Onshore emission sources include:

- Non-road construction and mining equipment, such as backhoes, bore/drill rigs, compactors, concrete trucks, concrete saws, cranes, excavators, forklifts, graders, light plants, off-highway trucks, and pavers
- Non-road commercial equipment, including generators, pumps, and welders
- Non-road industrial equipment, such as AC units and aerial lifts
- Worker vehicles
- Delivery and heavy-duty vehicles
- Fugitive emissions from incidental solvent release
- Particulate emissions from construction dust

A more detailed description of offshore and onshore construction activities can be found in Sections 3.1, 3.2, 4.1, and 4.2 of Volume I.

The estimate of the Project's potential construction emissions in terms of tons per year is shown in Table 5.1-5, below. The estimate of the Project's potential air emissions was conducted assuming that 106 WTG positions, four light-weight ESPs, and the maximum length of inter-array, inter-link, and export cables would be installed for the 800 MW Project, which represents the maximum design scenario.[4] Based on the most aggressive construction schedule under consideration for the 800 MW Project, it was conservatively estimated that half of the WTGs, three quarters of the inter-array cables, and all of the scour protection, offshore export and inter-link cables, electrical service platforms, and foundations could be constructed in one year[8]. It was also conservatively assumed that all

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[8] Several refinements to the Project Envelope and schedule have been made since conducting this estimate of the Project's potential emissions. For example, the Project will only install up 100 WTGs and has eliminated the option to install light-weight ESPs. The Project's Outer Continental Shelf (OCS) Air Permit application, which was submitted to EPA on August 17, 2018 after conducting this air emissions analysis, incorporates these refinements to the Project Envelope.

onshore construction could be completed in one year. To account for the envelope of possible ports used during construction, the emission estimate uses the combination of ports with the longest transit distances to and from the Offshore Project Area within US waters (all state and federal waters within the 200 NM US Exclusive Economic Zone). The emissions estimate also accounts for delays caused by inclement weather and possible time of year restrictions.

Construction-related air emissions are associated with fuel combustion and some incidental solvent use. The air pollutants include NOx, SO_2, CO, PM_{10}, $PM_{2.5}$, VOCs, greenhouse gas emissions as carbon dioxide equivalent (CO_{2e}), and total hazardous air pollutants ("HAPs", individual compounds are either VOC or particulate matter). Table 5.1-5 quantifies the maximum air emissions that could occur within the US in one year during construction.

Table 5.1-5 Maximum Air Emissions During Construction

Activity	CO_{2e}	NO_x	SO_2	VOC	CO	PM_{10}	$PM_{2.5}$	HAPs
OCS Air Permit Emissions (tons/year)[9]	205,780	3,269	32.1	87	699	109	104	7.3
All Construction Emissions (tons/year)	262,461	4,070	35.6	105	899	143	138	10.0

A complete description of all emission points associated with the construction of Vineyard Wind's 800 MW offshore wind project including engine sizes, hours of operation, load factors, emission factors, and fuel consumption rates, along with a description the air emission calculation methodology is provided in Appendix III-B.

During construction, indirect impacts to air quality may result from the activities of additional workers, increased traffic congestion, additional commuting miles for construction personnel, and increased air-polluting activities of supporting businesses. For example, the Project's demand for scour protection rock may increase the rate of quarrying and therefore increase air emissions at a rock quarry. These indirect impacts are no different than the air quality impacts that would result from any other project providing economic development by building infrastructure.

5.1.2.1.2 Avoidance, Minimization, and Mitigation Measures

The Project avoids, minimizes, and mitigates air quality impacts to the extent feasible. The Project itself is an air quality impact avoidance measure, as the electricity generated by the wind turbines will displace electricity generated by fossil fuel power plants and avoid the air quality impacts resulting from those fossil fuel power plants. Air emissions from the construction and installation, operations and maintenance, and decommissioning of the

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[9] The Project's OCS Air Permit application, which was submitted to EPA on August 17, 2018 after conducting this air emissions analysis, reflects refinements to the emission estimates based on updates to planned vessel use during construction.

Project will be minimized through the use of low sulfur fuels, limited engine idling time, and through the use of internal combustion engines designed and operated to minimize the formation of air pollutants. Some emissions from internal combustion engines will be mitigated by post-combustion catalysts and filters. Some NO_x and VOC emissions from the Project will be mitigated through acquiring and retiring emissions offsets, such as Emission Reduction Credits ("ERCs"), if required. ERCs are a type of pollution credits generated by controlling existing NO_x and VOC sources beyond regulatory requirements. These credits can then be sold to projects in the same air quality region to offset emissions.

Avoidance Measures

Emissions of regulated pollutants during construction are temporary and will be quickly offset by emissions reductions on the New England power grid during the operational period. SO_2 and CO_2 emissions from construction activities will be offset within the first year of operation. NO_x emissions from construction will be offset within approximately five years of beginning operation. The avoided emissions are discussed below in Section 5.1.2.2.

Minimization Measures

Project-related emissions are primarily from internal combustion engines. These include marine diesel, non-road diesel, transportation diesel, stationary diesel, and helicopter engines. While the specifics vary by engine type, emissions are generally minimized by ensuring complete combustion to avoid formation of CO, PM, and VOC, and by controlling mixing of fuel and oxygen in the combustion process to avoid hot spots that generate NO_x. Engine manufacturers will optimize the combustion process to avoid incomplete combustion and hot spots. For example, marine engine optimization steps, which will differ from engine to engine, can include changes to "fuel injection timing, pressure, and rate (i.e., rate shaping), fuel nozzle flow area, exhaust valve timing, and cylinder compression volume" (International, 2016). Controls can also include the use of water injection and exhaust gas recirculation to cool the combustion temperature.

The Project will minimize sulfur and particulate emissions through the use of clean, low-sulfur fuels in compliance with the air pollution requirements detailed in this section. Annex VI of the MARPOL treaty is the main international treaty that addresses air pollution from marine vessels. In the US., MARPOL Annex VI is implemented through the Act to Prevent Pollution from Ships, 33 U.S.C. §§ 1901-1905 and Control of NO_x, SO_x, and PM Emission from Marine Engines and Vessels Subject to the MARPOL Protocol, 40 C.F.R. Part 1043. Under MARPOL Annex VI and EPA's corresponding regulations, any foreign vessel used during the Project will comply with the fuel oil sulfur content limit of 1,000 ppm. All domestic vessels will comply with the marine fuel oil sulfur limits under Regulations of

Fuels and Fuel Additives, 40 C.F.R. Part 80.[10] All non-road engines will comply with the non-road diesel fuel sulfur limit of 15 ppm under 40 C.F.R Part 80. Per Air Pollution Control, 310 C.M.R § 7.00, applicable stationary engines will comply with the fuel sulfur limits of 15 ppm under 40 C.F.R. Parts 80.29, 80.500, and 80.520 (a) and (b).

The engines and generators used in this Project will be certified by the manufacturer to comply with applicable on-road, non-road, and marine engine emission standards. Applicable marine engine standards include:

- MARPOL Annex VI for foreign vessels;
- Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines, 40 C.F.R. Part 89, for Tier 1 and 2 domestic marine diesel engines below 37 kilowatts ("kW") (~50 horsepower);
- Control of Emissions from Marine Compression-Ignition Engines, 40 C.F.R. Part 94, for Tier 1 and 2 domestic marine diesel engines over 37 kW; and
- Control of Emissions from New and In-Use Marine Compression-Ignition Engines and Vessels, 40 C.F.R. Part 1042, for Tier 3 and 4 domestic marine diesel engines.

To the extent practicable, non-road engines will be certified as meeting emission standards (i.e., Tier 4) under Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines, 40 C.F.R. Part 1039.

Under the OCS Air Regulations, OCS sources located within the Offshore Project Area are subject to the federal, state, and local requirements of the Corresponding Onshore Area ("COA") set forth in 40 C.F.R. Parts 55.13 and 55.14. Vineyard Wind submitted a Notice of Intent (NOI) for the Project to EPA Region 1, MassDEP, RI DEM Office of Air Resources, and NH DES Air Resources Division on December 11, 2017. A copy of the NOI can be found in Appendix III-B. In the NOI, Vineyard Wind identified Massachusetts as the nearest onshore area (NOA) to the Project Area. EPA did not receive a request from any neighboring state air pollution control agencies to be designated as the COA within the 60-day period allotted in 40 CFR Part 55.5(b)(l). As a result, Massachusetts (the NOA) became the designated COA without further Agency action after 90 days (see 40 CFR Part 55.5(c)(l)). Therefore, the Project's OCS sources will be required to comply with the applicable Massachusetts air quality regulations, which include Best Available Control Technology ("BACT") and Lowest Achievable Emission Rate ("LAER") under 310 CMR § 7.00.

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[10] As of June 1, 2012, under 40 C.F.R. Part 80 Subpart I, all domestic non-road, locomotive, or marine ("NRLM") diesel fuel must have a sulfur content of less than 15 ppm. NRLM diesel fuel does not include heavier residual fuel oils used in Category 2 and Category 3 marine diesel engines or ECA marine fuel (i.e., any fuel oil used in Category 3 marine engines while operating in an emission control area).

The Project's emergency generators will comply with the performance standards of New Source Performance Standards Subpart IIII (Standards of Performance for Stationary Compression Ignition Internal Combustion Engines, 40 C.F.R. Part 60).

Emissions from on-road vehicles will be further minimized by limiting idling to five minutes except when engine power is necessary for the delivery of materials or to operate accessories to the vehicle, such as power lifts, in accordance with Massachusetts' anti-idling law (M.G.L. c. 90, § 16A; M.G.L.c. 111, §§ 142A–142M; 310 C.M.R. § 7.11). Particulate emissions from construction activities will be minimized by removing waste in covered trailers, wetting exposed soils, and minimizing the storage of construction waste onsite.

Mitigation Measures

Engine manufacturers use minimization and mitigation techniques specific to their engine type to ensure compliance with air quality regulatory standards. Depending on the engine's age, type, and size, add-on pollution controls are one approach used to mitigate air emissions formed in the combustion process. For example, selective catalytic reduction reverses the NO_x formation reaction, returning NO_x to nitrogen and water in the presence of a catalyst. Oxidation catalysts can also be used to eliminate products of incomplete combustion (e.g., CO, VOC, and PM) using technology similar to the catalytic converter found in automobiles. A diesel particulate filter can remove PM from some engine exhausts. Vineyard Wind's OCS Air Permit will contain, at a minimum, requirements for emission controls, emission limitations, monitoring, testing, and reporting. Additionally, through the OCS Air Permit Process, the Project will offset applicable NO_x and VOC emissions by acquiring emissions offsets in compliance with the Nonattainment New Source Review, if required.

The General Conformity Rule, codified in 40 C.F.R. Part 93 Subpart B and 40 C.F.R. Part 51 Subpart W, ensures that federal actions do not interfere with states' plans to attain and maintain National Ambient Air Quality Standards in areas that are or have been out of attainment with those standards. BOEM is responsible for determining whether the General Conformity Rule is applicable. If applicable, air emissions will only include direct and indirect emissions from the Project that occur beyond 25 miles from an OCS source *and* within a maintenance or nonattainment area.

If construction emissions within a nonattainment or maintenance areas are below certain *de minimis* thresholds, a General Conformity determination is not required for that area. For all ozone nonattainment or maintenance areas potentially affected by the Project (see Table 5.1-2), the NOx and VOC de minimis thresholds are 100 tpy and 50 tpy, respectively. For CO and PM_{10} maintenance areas, the CO and PM_{10} de minimis thresholds are both 100 tpy. For $PM_{2.5}$ maintenance areas, the $PM_{2.5}$, SO_2, NOx, and VOC thresholds are all 100 tpy.

Regardless of the combination of ports used for the Project, the emissions from the construction of the Project will not exceed de minimis thresholds for VOC, $PM_{2.5}$, SO_2, or CO. However, NOx emissions during construction may require a General Conformity determination for Dukes County as shown in Table 5.1-6 below. See Appendix III-B for more detailed General Conformity calculations.

Table 5.1-6 Maximum NOx Emissions During Construction (tpy)

Port Scenario	NOx Emissions During Construction (tpy) in Dukes County, MA
New Bedford Terminal, exclusively	219

5.1.2.1.3 Summary

As described in Section 5.1.2.1.1, the majority of air emissions from the Project will come from the engines on marine vessels used during construction and will occur within the WDA. These air emissions will be minimized through the use of low sulfur fuels, limited engine idling time, and through the use of internal combustion engines that are in compliance with applicable air quality regulatory standards. Since the WDA is approximately 23 km (14 miles) offshore, to the southeast of the mainland, and prevailing winds are from the west, the emissions within the WDA are unlikely to have any effect on onshore areas. Construction vessel activities within the port(s) are within the realm of normal harbor activities and will likely contribute only a small fraction of air pollution that is already caused by marine vessel traffic within the port(s). Further, both onshore and offshore construction emissions will be temporary. Finally, the Project's impacts will be minimized and mitigated through the OCS Air Permit process and potentially through the General Conformity process.

Since Massachusetts was designated as the COA per 40 C.F.R. § 55.5, emissions from OCS sources during construction will need to meet applicable Massachusetts BACT and LAER limits and will need to offset NO_x and VOC emissions through the use of emissions offsets. Since the Project will meet BACT and LAER and offset NOx and VOC emissions by acquiring emissions offsets, the Project will provide a net air quality benefit.

5.1.2.2 Operations and Maintenance

5.1.2.2.1 Description of Impacts

During the Project's up to 30-year operational period, crew transfer vessels and helicopters will transport crew to the Offshore Project Area for inspections, routine maintenance, and repairs. Jack-up vessels, multipurpose offshore support vessels, and rock-dumping vessels will travel to the Offshore Project Area infrequently for significant maintenance and repairs. Emergency generators located on the WTGs and ESPs will only operate during emergencies and reliability testing. Onshore operations and maintenance activities will include occasional inspections and repairs to the onshore substation and splice vaults, which will require minimal use of worker vehicles and construction equipment. Vineyard Wind intends to use port facilities at both Vineyard Haven on Martha's Vineyard and the New Bedford Terminal to support O&M activities. Smaller vessels used for O&M activities will likely be based out of Vineyard Haven. Larger vessels used for major repairs during O&M (e.g. jack-up vessels, heavy cargo vessels, etc.) would likely use the New Bedford Terminal. Emission sources during the operational period may include:

- Crew transfer/service vessels
- Scour protection installation vessels
- Multipurpose offshore support vessels
- Tugboats
- Jack-up vessels
- Heavy cargo vessels
- Survey vessels
- Emergency generators
- Helicopters
- Non-road construction equipment
- Worker and delivery vehicles
- Fugitive emissions of solvents, paints, coatings, diesel fuel storage/transfer, and sulfur hexafluoride ("SF_6")

A more detailed description of offshore and onshore operations and maintenance activities can be found in Section 4.3 of Volume I. A detailed description of all emission points associated with operations and maintenance of the Project including engine sizes, hours of operation, load factors, emission factors, and fuel consumption rates, along with a description the air emission calculation methodology is provided in Appendix III-B. Table 5.1-7 quantifies the maximum annual air emissions that could occur in one year within US waters during operations and maintenance, assuming a 30-year lifespan. To account for the envelope of ports used during O&M, O&M emissions were estimated assuming all vessels use the New Bedford Terminal, which represents the port with the farthest transit distances to and from the Offshore Project Area that may be used during O&M.

Table 5.1-7 Air Emissions During Operations and Maintenance (O&M)

Activity	CO_{2e}	NO_x	SO2	VOC	CO	PM_{10}	$PM_{2.5}$	HAPs
OCS Air Permit Emissions (tons/year) [11]	5,282	47.2	0.28	1.6	12	1.6	1.5	0.9
All O&M Emissions	8,047	70.8	0.30	2.0	18	2.4	2.3	1.1

The WTGs for this Project will be among the most efficient machines currently demonstrated for offshore use, with an annual capacity factor in excess of 45%. Table 5.1-8 quantifies the emissions associated with conventional power generation that would be avoided by using electricity generated from the 800 MW Project over the Project's up to 30-year lifespan. The displacement analysis uses Northeast Power Coordinating Council New England air emissions data from EPA's Emissions & Generation Resource Integrated Database (eGRID)[12]. The constituents included in the analysis are nitrogen oxides (NO_x), sulfur dioxide (SO_2), and carbon dioxide (CO_2). The methodology used to calculate the air emissions that will be avoided as a result of the Project is described in more detail in Appendix III-B.

Table 5.1-8 Avoided Air Emissions in New England

Pollutant	CO_2	NO_x	SO_2
Annual Avoided Emissions (tons/year)	1,632,822	1,046	855
Avoided Emissions over Project Lifespan (tons)	48,984,670	31,385	25,641

Based on 2015 emissions data from ISO New England (2017), the Project would displace 4% of CO_2 emissions, 6% of NO_x emissions, and 9% of SO_2 emissions produced by New England's electric grid annually.

As shown in this analysis, the Project would result in vastly lower emissions in the New England region. In addition, the Project would decrease the regional reliance on fossil fuels and enhance the reliability and diversity of the energy mix on Cape Cod and in the Commonwealth of Massachusetts. This is particularly important given that several thermal baseload and cycling plants have already retired, are slated for retirement, or are

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[11] The Project's OCS Air Permit application, which was submitted to EPA on August 17, 2018 after conducting this air emissions analysis, reflects refinements to the emission estimates based on minor updates to the planned vessel use during O&M activities.

[12] The displacement analysis uses subregion annual non-baseload output emission rates from eGRID2014(v2) released 2/27/2017 https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

approaching the end of life. According to ISO New England (2017), 1,050 MW of coal, 567 MW of residual oil, and 604 MW of nuclear-fired power generation facilities retired between 2011 and 2015.

5.1.2.2.2 Avoidance, Minimization, and Mitigation Measures

Avoidance, minimization, and mitigation techniques that are employed during the construction of the Project described in Section 5.1.2.1, above, will also be used to minimize air emissions during operations and maintenance.

Equipment at the onshore substation will meet the applicable requirements of 310 CMR 7.72. Per the regulation, "this type of switchgear is pre-charged with SF_6, sealed at the factory, and cannot be refilled by its user." Emissions will be certified by the manufacturer to have a 1.0% maximum annual leak rate, and Vineyard Wind will follow manufacturer-recommended maintenance procedures and best industry practices to avoid leakage. Upon equipment removal, Vineyard Wind will be responsible for the secure storage, reuse, recycling, or destruction of the SF_6. Vineyard Wind expects little to no leakage of SF_6, based on the purchase and maintenance of equipment with leakage guarantees.

5.1.2.2.3 Summary

Air emissions from operations and maintenance of the Project will be significantly less than emissions from construction. As with construction air emissions, emissions from operations and maintenance activities will be minimized through the use of low sulfur fuels, limited engine idling time, and through the use of internal combustion engines that are in compliance with applicable air quality regulatory standards. Vessel activities within the port(s) during O&M will be well within the realm of normal harbor activities and will likely contribute only a small fraction of air pollution that is already caused by marine vessel traffic within the port(s). Furthermore, any air emissions during O&M will be quickly offset by reductions in emissions from higher-polluting conventional power generation facilities. Consequently, it is not anticipated that emissions from the Project during O&M will cause any violation of Massachusetts or National Ambient Air Quality Standards. Rather, by displacing emissions from higher-polluting power generation facilities, the Project should aid in the continued improvement of ambient air quality within the New England Region.

5.1.2.3 Decommissioning

5.1.2.3.1 Description of Impacts

As described in Section 4.4 of Volume I, the decommissioning processes will be largely the reverse of the installation process. As a result, the impacts of decommissioning on air quality will resemble the impacts produced during construction. During decommissioning, commercial marine vessels will be used to remove the offshore cable system, WTGs, ESPs, foundations, and scour protection. It is anticipated that equipment and vessels used for decommissioning will be similar to those used during construction, but will likely have lower-polluting engines (historically, emission standards for marine vessels have become increasingly stringent over time). For offshore work, emission sources will likely include:

- Crew transfer/service vessels
- Heavy lift crane vessels
- Cable laying vessels
- Multipurpose offshore support vessels
- Tugboats
- Anchor handling tug supply vessels
- Jack-up vessels
- Generators
- Helicopters

For onshore decommissioning activities, removal of onshore export cables from the duct bank would be performed using truck mounted winches, cable reels, and cable reel transport trucks. The concrete encased duct bank and splice vaults may be left in place for future reuse as would elements of the onshore substation and grid connections. Consequently, onshore decommissioning emissions will be significantly less than onshore construction emissions.

Potential emissions from decommissioning, which is expected to take place in approximately 30 years, were not quantified or included in the estimate of potential emissions generated for the OCS Air Permit program because a separate OCS Air Permit will be issued for decommissioning, if needed. Nevertheless, Vineyard Wind anticipates that emissions during decommissioning will be significantly less than emissions during the Project's construction.

5.1.2.3.2 Avoidance, Minimization, and Mitigation Measures

Avoidance, minimization, and mitigation techniques that are employed during the construction of the Project described in Section 5.1.2.1, above, will also be used during the Project's decommissioning.

5.2 Water Quality

This section discusses water quality in the Offshore Project Area. The area consists of Nantucket Sound, which is located between the south coast of Cape Cod and Martha's Vineyard and Nantucket Island, and the area south of both islands where both the Offshore Export Cable Corridor ("OECC") and the Wind Development Area ("WDA") are located (see Figures 2.1-1 and 2.2-1 in Volume I). Information sources consulted on existing water quality include publicly available resources for the marine waters. The section also includes a discussion of potential impacts of various aspects of the Project to marine water quality.

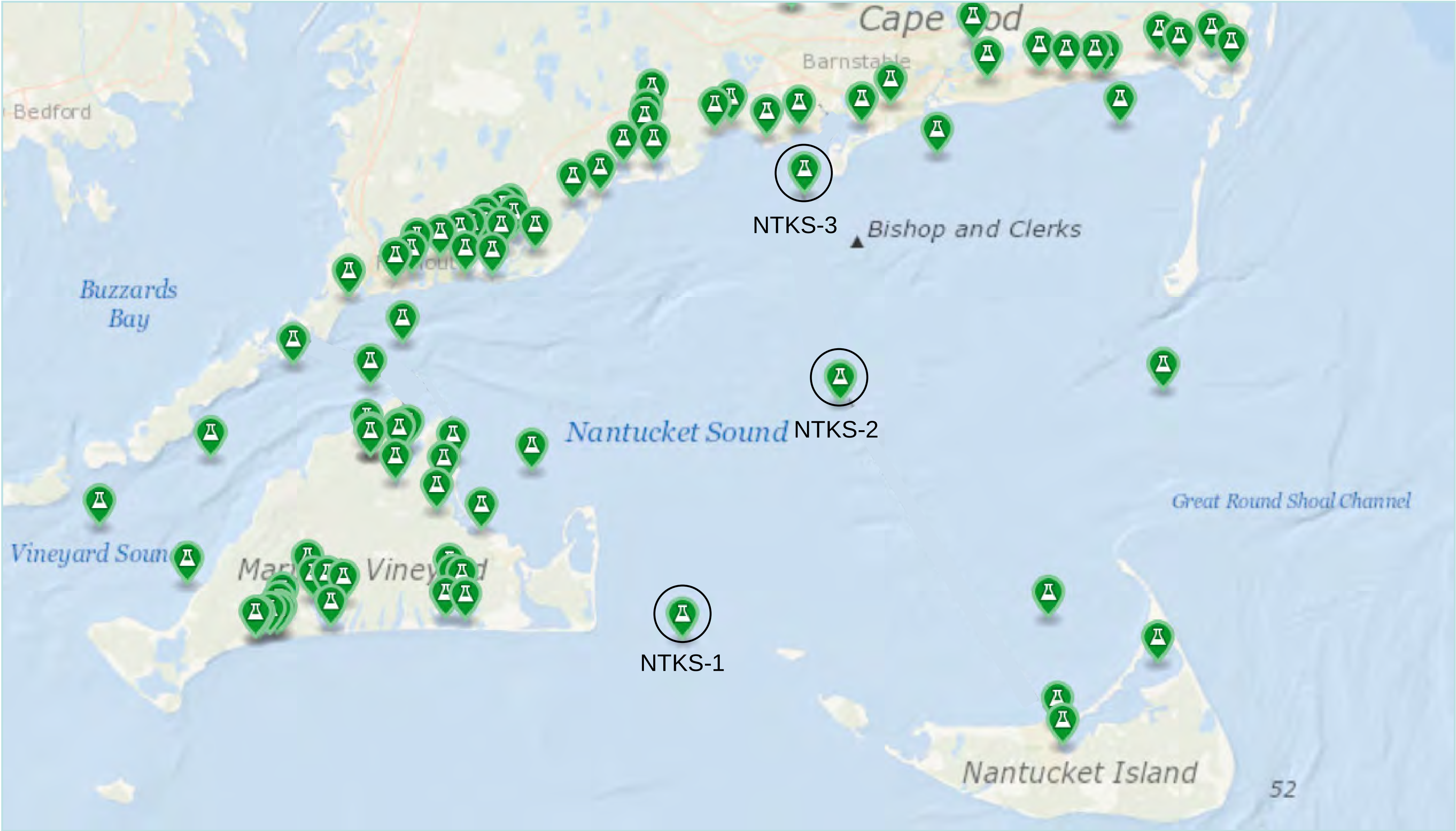
5.2.1 Description of the Affected Environment

Water quality generally refers to the physical, chemical, and biological attributes of water. For the purposes of this section, water quality specifically refers to the ability of waters in the southern New England coastal and shelf areas to maintain their ecosystems. Factors such as pollutant loading from both natural and anthropogenic sources can contribute to changes in water quality, which are usually detrimental. Natural pollutants can be delivered into water systems via atmospheric deposition, freshwater drainage, transport of offsite marine waters, and influx from sediments. Anthropogenic pollutant sources often include those from direct discharges, runoff, dumping, seabed activities, and spills.

For the offshore area south of Martha's Vineyard and Nantucket, known as the Outer Continental Shelf ("OCS"), oceanic circulation (see Section 5.3) patterns play an increasingly larger role in transporting and dispersing anthropogenic contaminants and determining water quality. Water quality data available for coastal and offshore marine waters include temperature expressed in degrees Celsius ("°C") (degrees Fahrenheit ["°F"]), salinity expressed in Practical Salinity Units ("psu"), chlorophyll *a* expressed as microgram per liter ("µg/L"), nutrients expressed micromolar ("µm"), dissolved oxygen expressed as milligram per liter ("mg/L"), and turbidity expressed as Nephelometric Turbidity Unit ("NTU").

Water Quality Data Sources

One of the major water quality data sets available for Nantucket Sound, as well as Cape Cod Bay to the north, is that from the Center for Coastal Studies ("CCS") (CCS, 2017). Sampling is performed through a collaboration of CCS with volunteer citizen scientists and partnering organizations. The sampling stations for Nantucket Sound are shown in Figure 5.2-1. Of particular interest are the set of three offshore stations extending from south to north in the area of the OECC and shown circled and labeled as NTKS-1, NTKS-2, and NTKS-3. The data for these stations included over 60 sampling times between 2010 and 2016. The minimum, mean, and maximum parameter values are shown in Table 5-2.1. The individual parameters will be discussed below.



Vineyard Wind Project

VINEYARD WIND

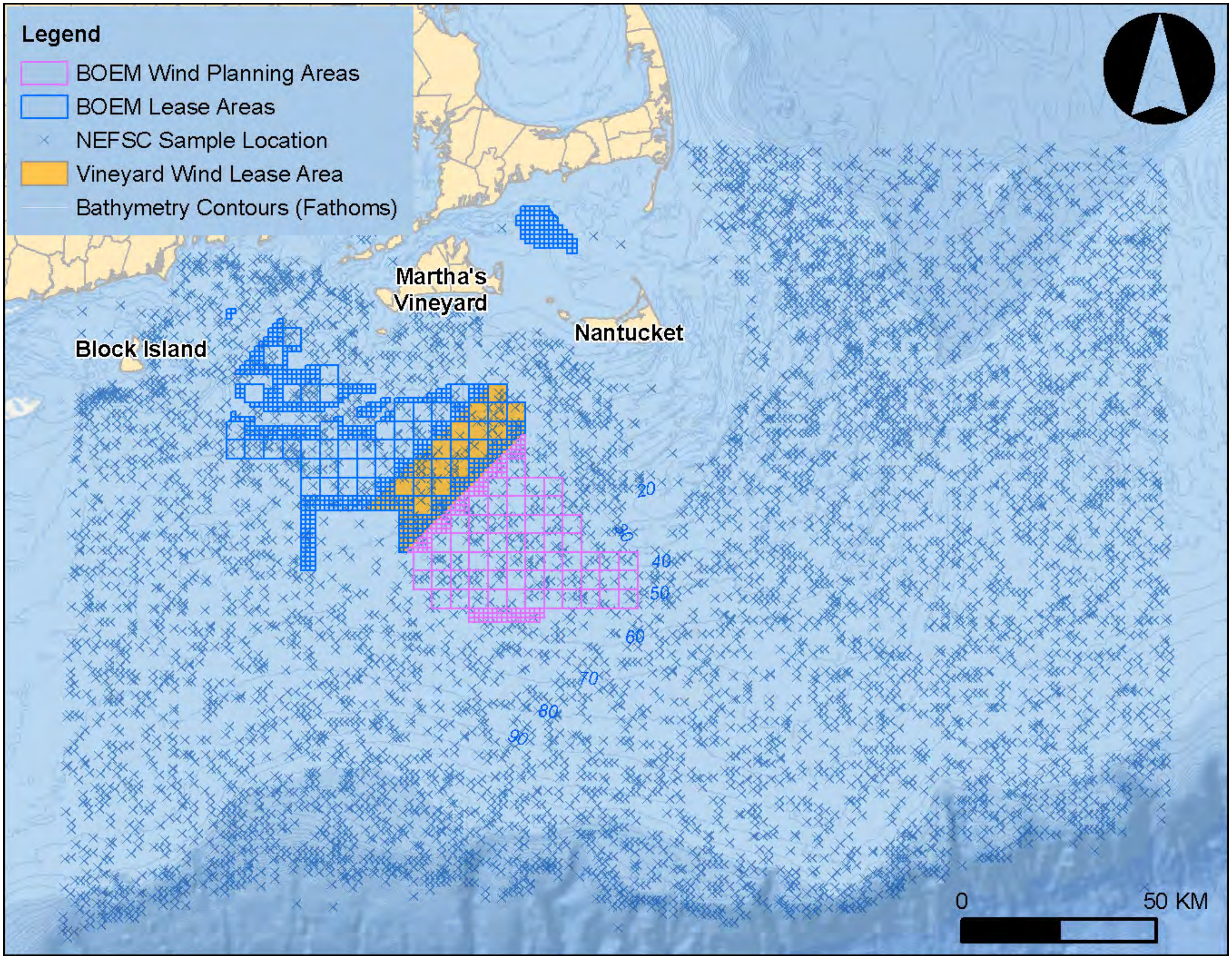
Figure 5.2-1

Locations of Water Quality Data Used from Center for Coastal Studies Stations (Circled)

Table 5.2-1 Minimum, Mean, and Maximum Values of Water Quality Parameters Reported in Nantucket Sound by the CCS for the period 2010-2016

Parameter	Value	Station NTKS_1 (South)	Station NTKS_6 (Central)	Station NTKS_13 (North)
Temperature (°C)	Min	8.70	8.15	9.87
	Mean	17.95	19.21	20.36
	Max	22.76	24.23	26.31
Salinity (psu)	Min	30.72	30.71	30.56
	Mean	31.75	31.76	31.60
	Max	32.71	32.51	32.49
Dissolved Oxygen [DO] (mg/L)	Min	6.89	6.39	5.37
	Mean	8.00	7.59	7.32
	Max	9.63	11.39	8.75
Chlorophyll *a* (mg/L)	Min	0.45	0.23	0.59
	Mean	1.79	1.93	1.81
	Max	4.73	4.80	4.33
Turbidity (NTU)	Min	0.09	0.09	0.13
	Mean	0.66	0.70	0.58
	Max	3.17	2.27	2.19
Total Nitrogen (μm)	Min	4.438	3.285	3.120
	Mean	10.645	11.143	12.984
	Max	18.057	20.420	75.799
Total Phosphorus (μm)	Min	0.285	0.205	0.331
	Mean	0.648	0.814	0.853
	Max	1.627	1.881	2.584

Another large data set is held by the Northeast Fisheries Science Center Multispecies Bottom Trawl Survey ("NEFSC") (NEFSC, 2017). This survey has collected temperature and salinity data in addition to its primary biological data collection function. Three seasons have been monitored for many years: autumn since 1963, spring since 1968, and winter between the years 1992-2007; the summer season has not been monitored. Results are shown in Table 5.2-2. The data collected is mostly for the offshore areas south of Nantucket Sound and includes the Project Area as shown in Figure 5.2-2. The individual parameters will be discussed below.



Vineyard Wind Project

VINEYARD WIND

Figure 5.2-2

Locations of Water Quality Data Used from NEFSC Trawls (1948-2014)

Table 5.2-2 Mean and Standard Deviation for Seasonal (Spring, Fall, and Winter only) Temperature and Salinity Data from the NEFSC Multispecies Bottom Trawl Survey

Season	Average Bottom Depth (m)	Layer	Temperature (ºC) (Mean ± 1 SD)	Salinity (psu) (Mean ± 1 SD)
Spring	94	Surface	6.3 ± 2.0	32.9 ± 0.7
		Bottom	7.2 ± 2.9	33.5 ± 1.1
Summer			(No data taken)	(No data taken)
Fall	88	Surface	17.5 ± 3.2	32.9 ± 1.1
		Bottom	12.7 ± 3.1	33.4 ± 1.2
Winter	104	Surface	5.4 ± 1.6	32.9 ± 0.5
		Bottom	7.5 ± 3.3	33.8 ± 1.1

In addition, the National Oceanic Atmospheric Administration ("NOAA") National Data Buoy Center ("NBDC") has two data collection buoys, one (44020) located in the Nantucket Sound Main Channel in 11 meters ("m") (36 feet ["ft"]) of water and the other (44097) in the offshore area to the west of the WDA between Block Island and Martha's Vineyard in 48 m (157 ft) of water (see Figure 5.2-3). Data were downloaded from the NBDC website (NBDC, 2017) for the period from 2009 through 2016 with seasonal values shown in Table 5.2-3. The individual parameters will be discussed below.

Table 5.2-3 Mean Seasonal Surface Temperature Data from the NOAA NDBC Buoys 44020 and 44097 for the Period 2009-2016

Season	Station 44020 Mean Surface Temperature (ºC)	Station 44097 Mean Surface Temperature (ºC)
Spring	12.5	7.7
Summer	21.8	19.6
Fall	11.8	17.0
Winter	5.9	8.5

A large study conducted by the Environmental Protection Agency ("EPA") evaluated over 1,100 coastal locations in 2010, as reported in their National Coastal Condition Assessment (EPA, 2015). No results from this program after 2010 have been reported. The EPA used a Water Quality Index ("WQI") to determine the quality of various coastal areas including the northeast coast from Virginia to Maine and assigned three condition levels for a number of constituents: good, fair, and poor. Fortunately, the data was available online so that eight individual stations in Nantucket Sound were identified. Figure 5.2-4 shows the larger northeast coastal area as well as the eight stations in Nantucket Sound. It should be noted, however, that the purpose of this study was not designed to characterize conditions on as fine a scale as Nantucket Sound. With that caveat, both the regional and local constituent condition level results are reported in the following paragraphs.

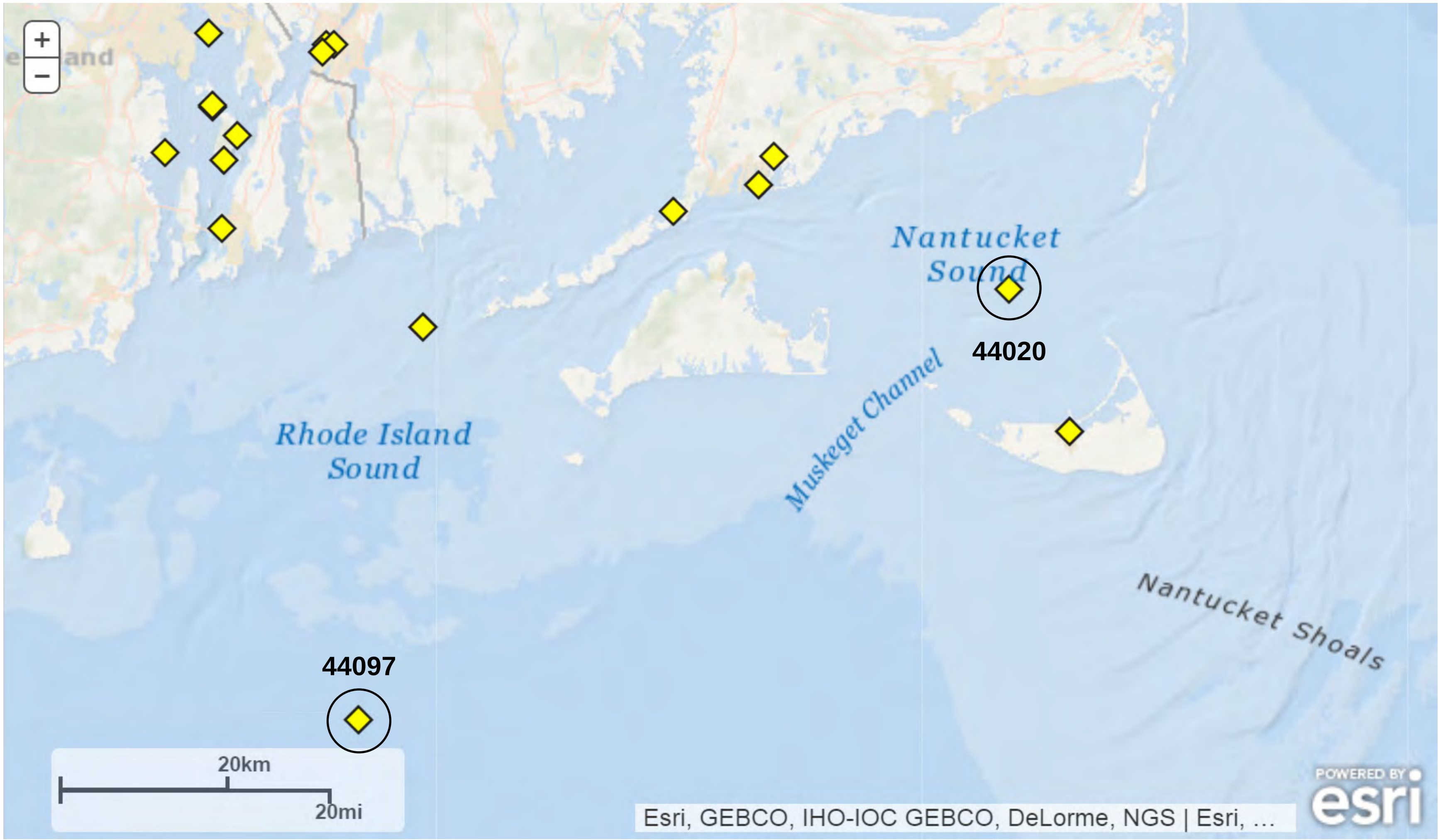
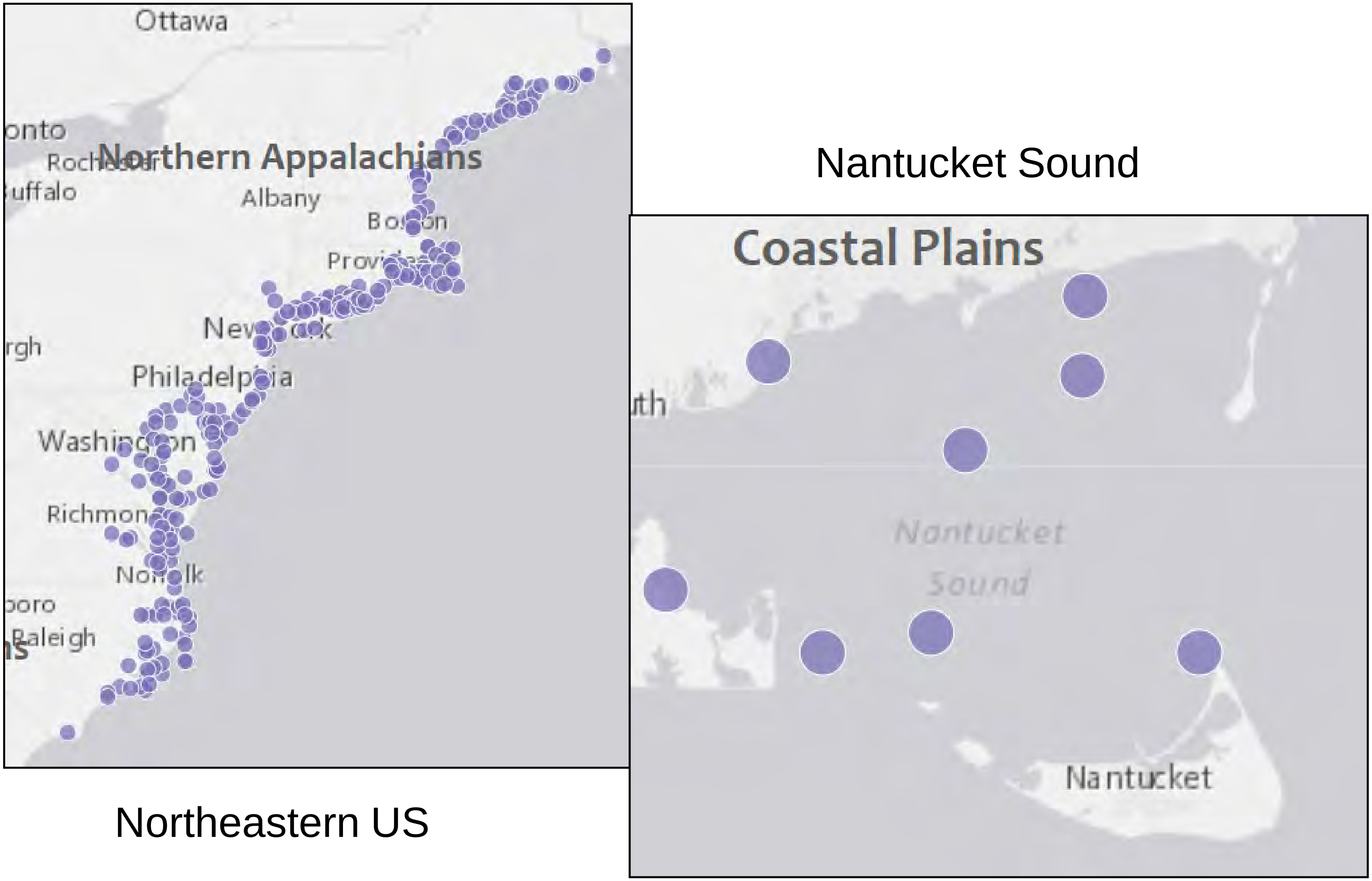


Figure 5.2-3

Locations of NOAA NBDC Buoys (Circled)



Nantucket Sound

Northeastern US

Figure 5.2-4

Locations of EPA NCCA Stations for Northeastern US (Left) and Nantucket Sound (Right)

Temperature

Three of the four data sources identified above reported temperature measurements. The recent seven year (2010-2016) CCS data showed an increase in temperature from south to north for the three stations in Nantucket Sound with means of 17.95, 19.21, and 20.36 °C (64.31, 66.58, and 68.65 °F) that was generally reflected in the minima and maxima as well. The seasonality of mean surface temperature differs between the NDBC stations. The lowest winter mean is 5.9 °C (10.6 °F) and was recorded at Nantucket Station 44020, while the lowest spring mean is 7.7 °C (13.9 °F) and was recorded at Station 44097. Both stations showed warmest mean surface temperatures of 21.8 °C (71.2 °F) (44020) and 19.6 °C (67.3 °F) (44097) during summer. The range over the seasons between mean surface and bottom temperatures in the NEFSC data indicated that surface waters showed a difference of 12.1 °C (21.8 °F) while the bottom waters showed a much smaller difference of 5.5 °C (9.9 °F) at water depths of approximately 90-100 m (300-330 ft).

Salinity

Unlike temperature, only small variations in the salinity of Nantucket Sound are reported in the CCS data. The mean salinities from south to north for the three stations are 31.75, 31.76 and 31.60 psu with similarly small variability of less than 2 psu between maximum and minimum at each station. This effect is also seen in the NEFSC data where the mean surface salinity is the same (32.9 psu) for the three seasons while the mean bottom salinity varies only slightly (between 33.4 and 33.8 psu) over the seasons.

Chlorophyll a

Chlorophyll *a* concentrations, an indicator of primary productivity, vary substantially on a seasonal basis but little spatially in Nantucket Sound. The recent seven year (2010-2016) CCS data show small spatial differences from south to north for the three stations in Nantucket Sound with means of 1.79, 1.93, and 1.81 mg/L that is generally reflected in the minima (0.45, 0.23, and 0.50 mg/L) and maxima (4.73, 4.80, and 4.33 mg/L). The variability seen between minima and maxima is due to natural seasonal variations.

Chlorophyll *a* levels in northeastern coastal waters are generally rated as fair (45%) to good (51%) condition, as measured by the EPA WQI, based on measurements collected in 2010 (EPA, 2015). Further review of the data specific to the eight stations in Nantucket Sound revealed that these eight stations had only single measurements each in 2010, which resulted in 88% identified as good condition and 12% as fair.

Nutrients

Nutrients in the oceanic context consist of nitrogen, phosphorus, and silica (BOEMRE, 2011). Nitrogen in marine environments is mostly derived from dissolved nitrogen gas, with the rest formed by the dissolved inorganic nitrogen forms of nitrate, nitrite, and ammonium ion, as well as dissolved and particulate organic nitrogen. Inorganic phosphate is the primary form of phosphorus, known as orthophosphate, with lower levels of organic phosphate found in surface waters. Silicate makes up most of the silica in marine environments.

Sources of nutrients that enter New England marine waters in general include:

- Recycling or resuspension from sediments;
- River discharges;
- Transport onto the shelf from offshore waters;
- Atmospheric deposition; and
- Upwelling from deeper waters.

Nutrient information is available from the data reported by CCS. This data shows increasing levels from south to north for the three stations in Nantucket Sound with means for total nitrogen ("TN") of 10.645, 11.143, and 12.984 µm. This trend is not reflected in the minima (4.448, 3.285, and 3.120 µm) but is reflected in the maxima (18.057, 20.420, and 75.799 µm). The total phosphorus ("TP") levels also show an increase from south to north for the three stations with means of 0.648, 0.814, and 0.853 µm. This trend is not reflected in the minima (0.285, 0.205, and 0.331 µm) but is in the maxima (1.627, 1.881, and 2.584 µm). The maxima of TN and TP for the northern station is particularly high compared to other measurements at that site.

Nitrogen levels in northeastern coastal waters are generally rated as fair (13%) to good (82%) condition while phosphorus levels are rated as fair (62%) to good (26%), as measured by the EPA WQI, for the northeastern coast based on 2010 data (EPA, 2015). For the eight stations in Nantucket Sound, one measurement at each of the eight stations indicated a rating of 100% good for nitrogen and 100% fair for phosphorous.

Dissolved Oxygen

Dissolved oxygen ("DO") mainly enters the ocean via exchange with the atmosphere. Concentrations are also controlled by physical factors (e.g., water temperature) and biological factors (e.g., respiration, photosynthesis, and bacterial decomposition), which may result in concentration changes through the water column.

The CCS data shows a decrease from south to north for the three stations in Nantucket Sound with means of 8.00, 7.59, and 7.32 mg/L that is reflected in the minima (6.89, 6.39, 5.37 mg/L) but not in the maxima (9.63, 11.39, 8.75 mg/L).

Dissolved oxygen levels in northeastern coastal waters are generally rated as fair (14%) to good (80%) condition, as measured by the EPA WQI, based on results of the 2010 NCCA (EPA, 2015). The eight stations in Nantucket Sound were sampled a total of 14 times in 2010, with 93% rated as good and 7% rated as fair.

Turbidity

Turbidity is a measure of the scattering of light by suspended particulate matter and is different from total suspended sediment, which is a measure of the concentration of sediment particles in the water column. The only accurate way to convert from one to the other is to take simultaneous measurements of both and perform a regression analysis. Historically, turbidity has been measured directly in NTUs, while suspended sediment concentrations were determined in the laboratory in units of mg/L although newer instruments can now measure total suspended sediment directly. Suspended sediment concentrations are typically used to evaluate biological exposure, particularly from seabed activities such as submarine cable burial.

The CCS data does not show a consistent variation from south to north for the three stations in Nantucket Sound with means of 0.66, 0.70, and 0.58 NTU, but these differences are small. The minima show a slight increase (0.09, 0.09, 0.13 NTU) while the maxima show a decrease (3.17, 2.27, and 2.19 NTU) from south to north.

Turbidity levels in northeastern coastal waters are generally rated as fair (10%) to good (78%) condition, as measured by the EPA WQI, based on results of the 2010 NCAA (EPA, 2015). No turbidity data for the eight Nantucket Sound stations was acquired in 2010.

5.2.2 Potential Impacts of the Project

The following impact- producing factors listed in Table 5.2-4 may affect the marine water quality due to activity in the Project Area.

Table 5.2-4 Impact-Producing Factors for Water Quality

Impact-Producing Factor	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommis-sioning
Pile driving for WTG and ESP foundations	X		X		
Offshore cable installation	X	X	X		
Horizontal directional drilling	X	X	X		
Scour protection installation	X		X		
Routine releases from vessels	X	X	X	X	X

5.2.2.1 Construction and Installation

5.2.2.1.1 Pile Driving for Wind Turbine Generator ("WTG") and Electrical Service Platform ("ESP") Foundation Installation

Pile driving is necessary since piles support the WTG and ESP foundations which are located exclusively in the WDA. The potential impacts to water quality via sediment resuspension from repeated hammer blows to the pile would be local to the pile outer diameter. No studies of offshore pile driving were identified that concluded this activity would cause any significant sediment resuspension.

5.2.2.1.2 Cable Installation in Marine Waters

Cable burial operations will occur both in the WDA for the inter-array cables connecting the WTGs to the ESPs and the OECC for the cables carrying power from the ESPs to landfall. In order to assess the impacts of these activities, a set of computer simulation models was used. A hydrodynamic model, HYDROMAP, was used to provide the current velocities necessary for use in the sediment dispersion model, SSFATE, which calculated the resulting excess total suspended sediment ("TSS") concentrations in the water column mobilized by the cable burial activity and the bottom deposition patterns resulting from settling of the mobilized sediment. Details of the models, their applications, and the results of the calculations are provided in Appendix III-A.

The HYDROMAP hydrodynamic model domain extended from approximately Provincetown (northeast extent) at the northern tip of Cape Cod to Sandy Hook, New Jersey (southwest extent) south of New York City, including Nantucket Sound, Martha's Vineyard Sound, Buzzards Bay, Narragansett Bay, Block Island Sound, Rhode Island Sound, and Long Island Sound. This domain is significantly larger than the Project Area, however, but this was chosen to best locate and define open boundary conditions. The model was forced with tidal harmonics and wind so it could reproduce patterns of tides and currents at multiple locations within the domain. After the model application was verified, a second model run was performed for a period exhibiting winds close to the average winds in the region. This second HYDROMAP model application was used as the hydrodynamic forcing in the sediment dispersion modeling using SSFATE.

Sediment dispersion modeling and analysis was performed to simulate the installation (i.e., burial) of multiple offshore cable systems. A representative inter-array cable within the WDA was modeled as were the variants of the OECC. Figure 5.2-5 shows the plan view of the representative inter-array cable and the OECC variants. The simulations utilized the identical HYDROMAP modeling output with a model timestep of 10 minutes with output every 20 minutes, and a concentration grid of 50 m (160 ft) resolution in the horizontal dimensions and 0.5 m (1.6 ft) resolution in the vertical dimension. The sediment source load for each simulation was developed based on sediment and installation characteristics.

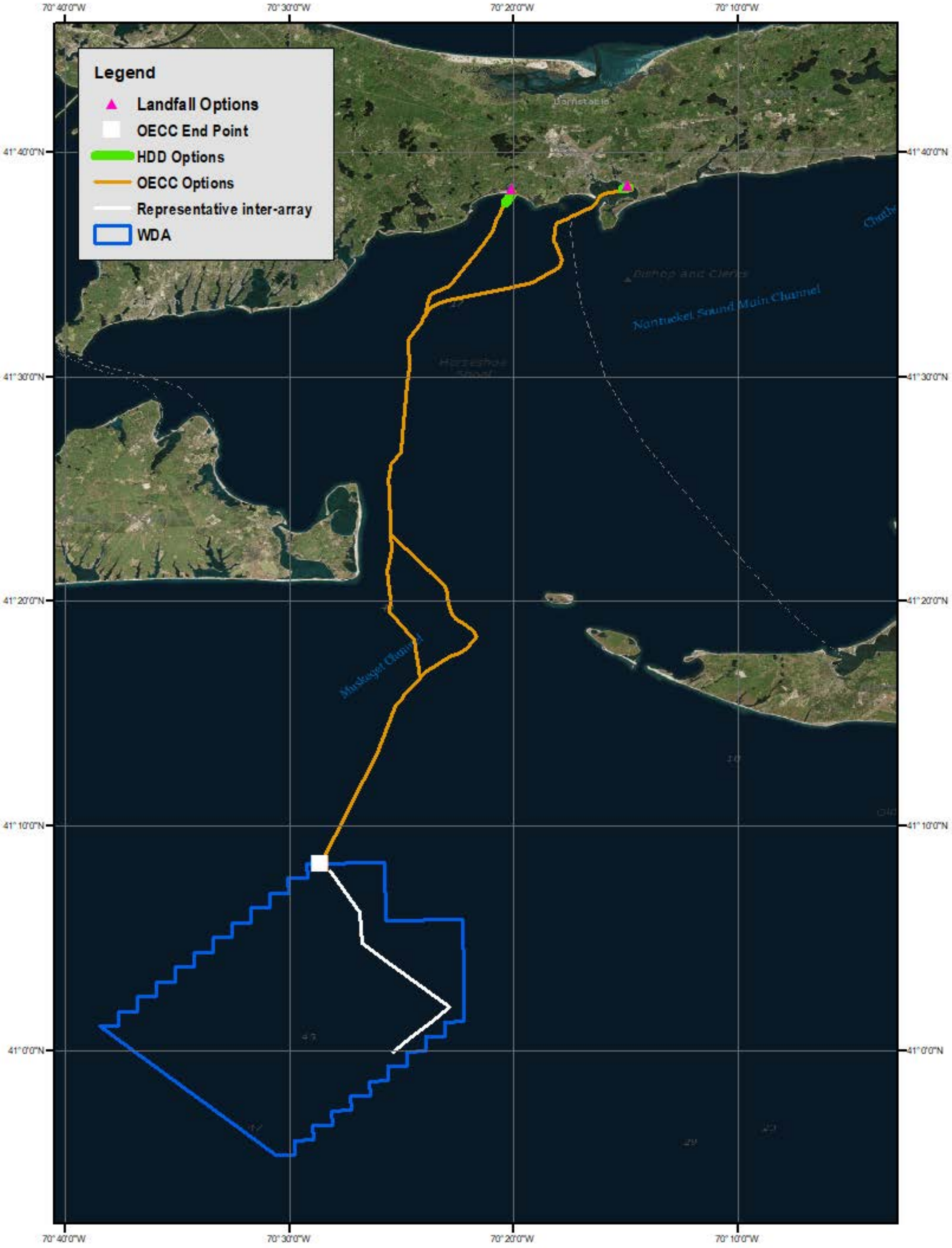


Figure 5.2-5

Location of Project Components for Dispersion Modeling

The simulations were run in SSFATE and post processed to determine the spatial and temporal characteristics of excess (i.e., above ambient) TSS concentrations and the spatial patterns of deposition.

Inter-Array Cable

For the representative inter-array cable, a single inter-array route was simulated which was selected as the longest individual route within a representative configuration (see Figure 5.2-5). The route was simulated for typical and maximum impact installation parameters.

- Typical installation reflected a one meter (3.3 ft) wide x two meter (6.6 ft) deep trench, a production rate (i.e., installation rate) of 200 m/hour ("hr") (656 ft/hr) and a sediment mobilization fraction of 0.25 (25% of total trench volume).

- Maximum impact installation reflected a one meter (3.3 ft) wide x three meter (9.8 ft) deep trench, a production rate (installation rate) of 300 m/hr (985 ft/hr) and a sediment mobilization fraction of 0.35 (35% of total trench volume).

It is anticipated that the typical parameters would be utilized for approximately 90% of the cable installation and that the maximum impact parameters would only be utilized for 10% of the cable installation. The vertical initialization of mobilized sediments was based on the possible burial methods and was limited to the bottom three meters (9.8 ft) of the water column with 85% of the sediment introduced to the bottom one meter (3.3 ft) of the water column.

In order to be conservative, the entire route was assumed to have the sediment characteristics associated with the sample with the greatest relative fraction of fine material, which was ~23% for the two-meter-deep (6.6 ft) trench and ~29% for the three-meter-deep (9.8 ft) trench. The sediment characterization was developed based on depth weighted averages of sediment grain sizes.

The simulation of the typical installation of the inter-array cable predicts the 10 mg/L plume to oscillate about the route centerline and typically extend approximately 200 m (660 ft) from the centerline, though it may extend up to 3.1 km (1.9 mi) from the centerline as shown in Figure 5.2-6. Higher concentrations are limited to a small extent from the centerline, with the 50 mg/L plume extending up to 160 m (525 ft) from the centerline. The associated deposition thickness (see Figure 5.2-7) is 1.0 millimeter ("mm") (0.04 inches ["in"]) or greater within approximately 100 m (328 ft) of the centerline and maximum deposition thickness was less than 5 mm (0.2 in).

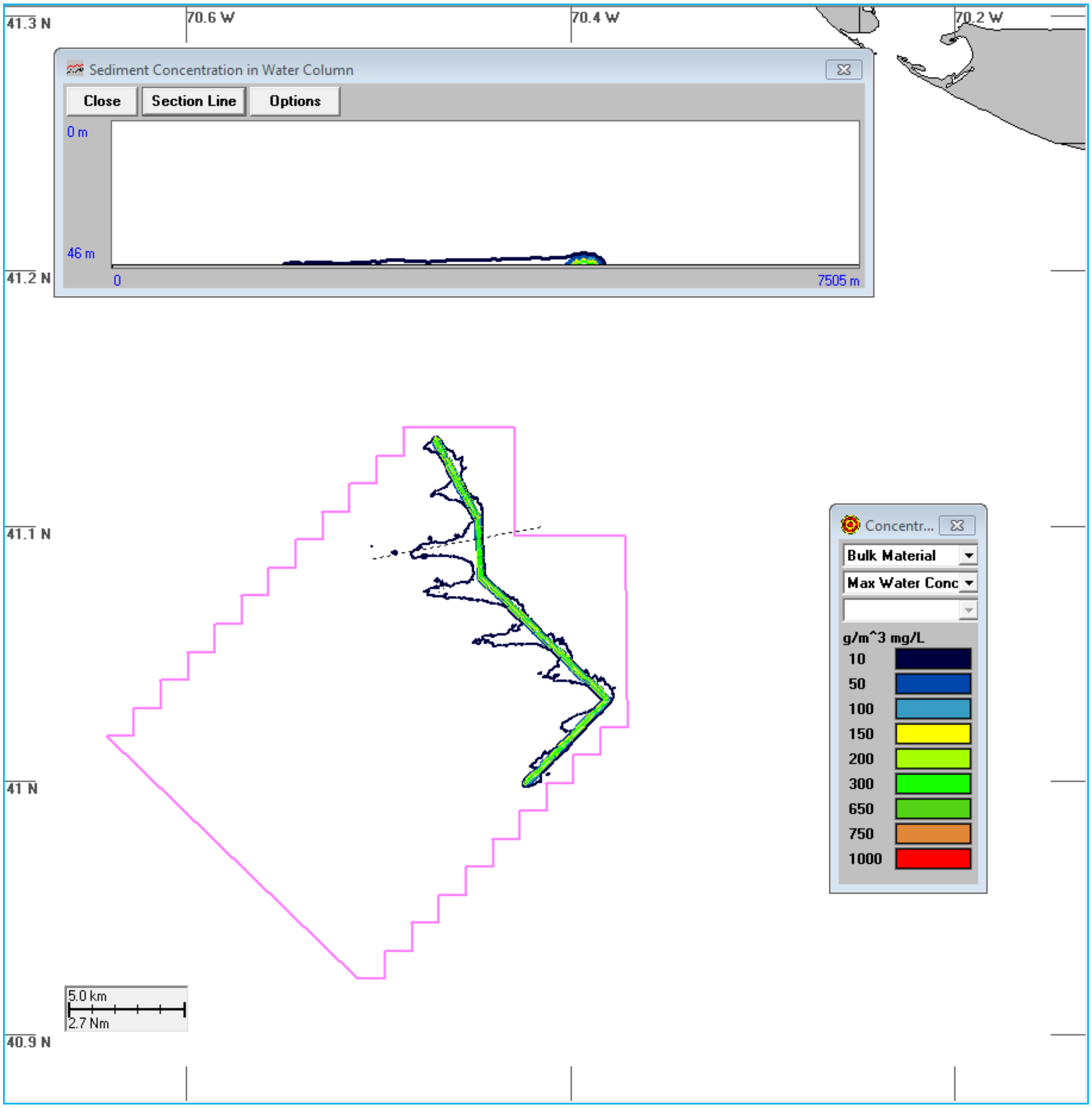


Figure 5.2-6

Time-Integrated Maximum TSS Concentration for Inter-Array Cable Installation Using Typical Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel).

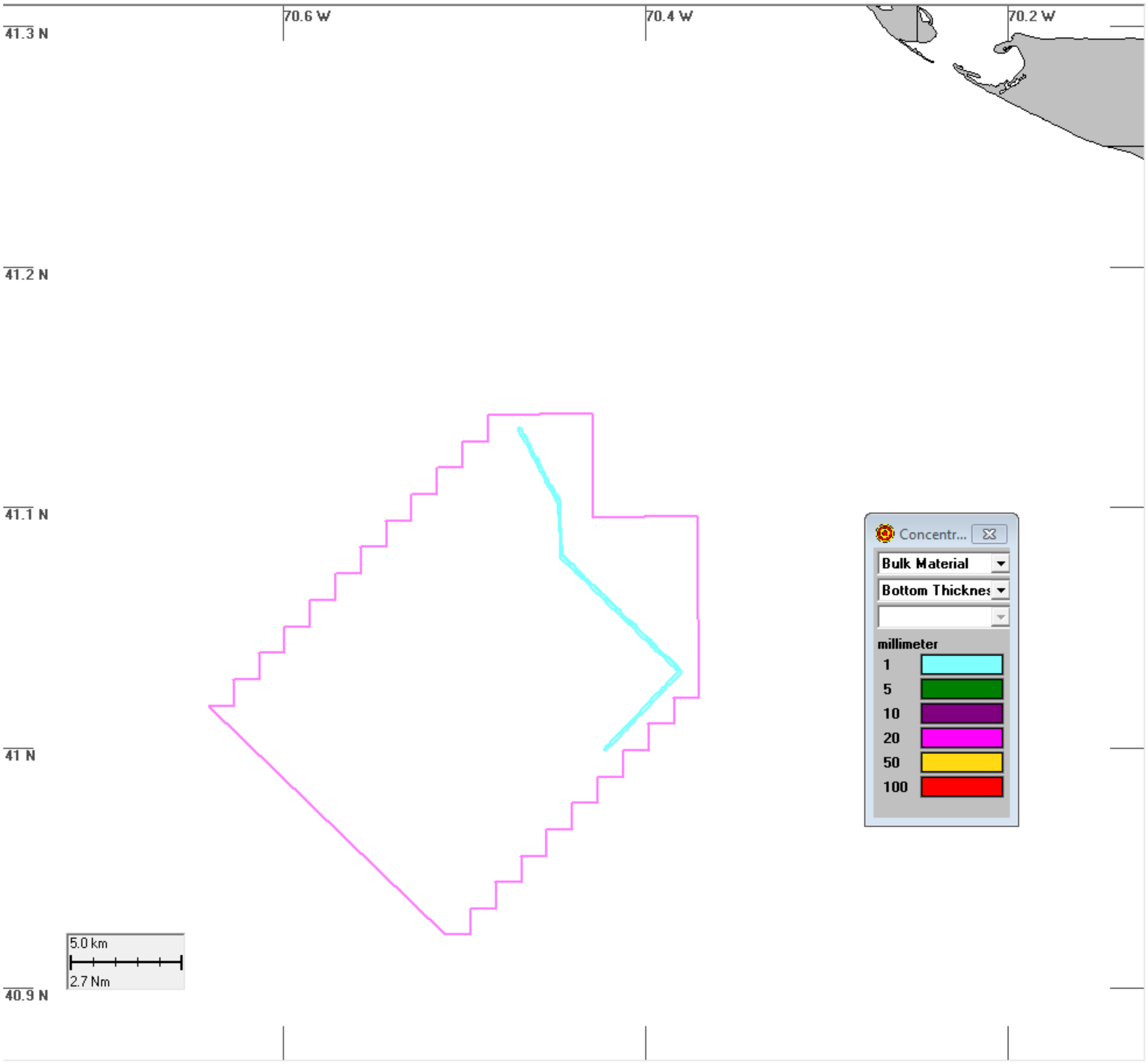


Figure 5.2-7

Plan View of Deposition Thickness for Inter-Array Cable Installation Using Typical Burial Parameters.

The simulation of the maximum impact installation parameters for the inter-array cable in Figure 5.2-8 showed a noticeably larger footprint, with the 10 mg/L, 50 mg/L, and 100 mg/L contours extending up to ~7.5 km (~4.7 mi), ~2 km (~1.2 mi), and ~0.86 km (~0.53 mi) from the centerline, respectively.

The maximum impact deposition (see Figure 5.2-9) of 1.0 mm (0.04 in) or greater is limited to ~140 m (~460 ft) from the route centerline and the deposition thickness is less than 5 mm (0.2 in). These increases are as expected due to the increased total mass and mass flux associated with the maximum impact parameters. As depicted in the vertical section views (top panels) in Figures 5.2-6 and 5.2-8, both simulations showed the maximum concentrations are located near the bottom of the water column, which is expected based on the initialization of sediments due to the bottom activity.

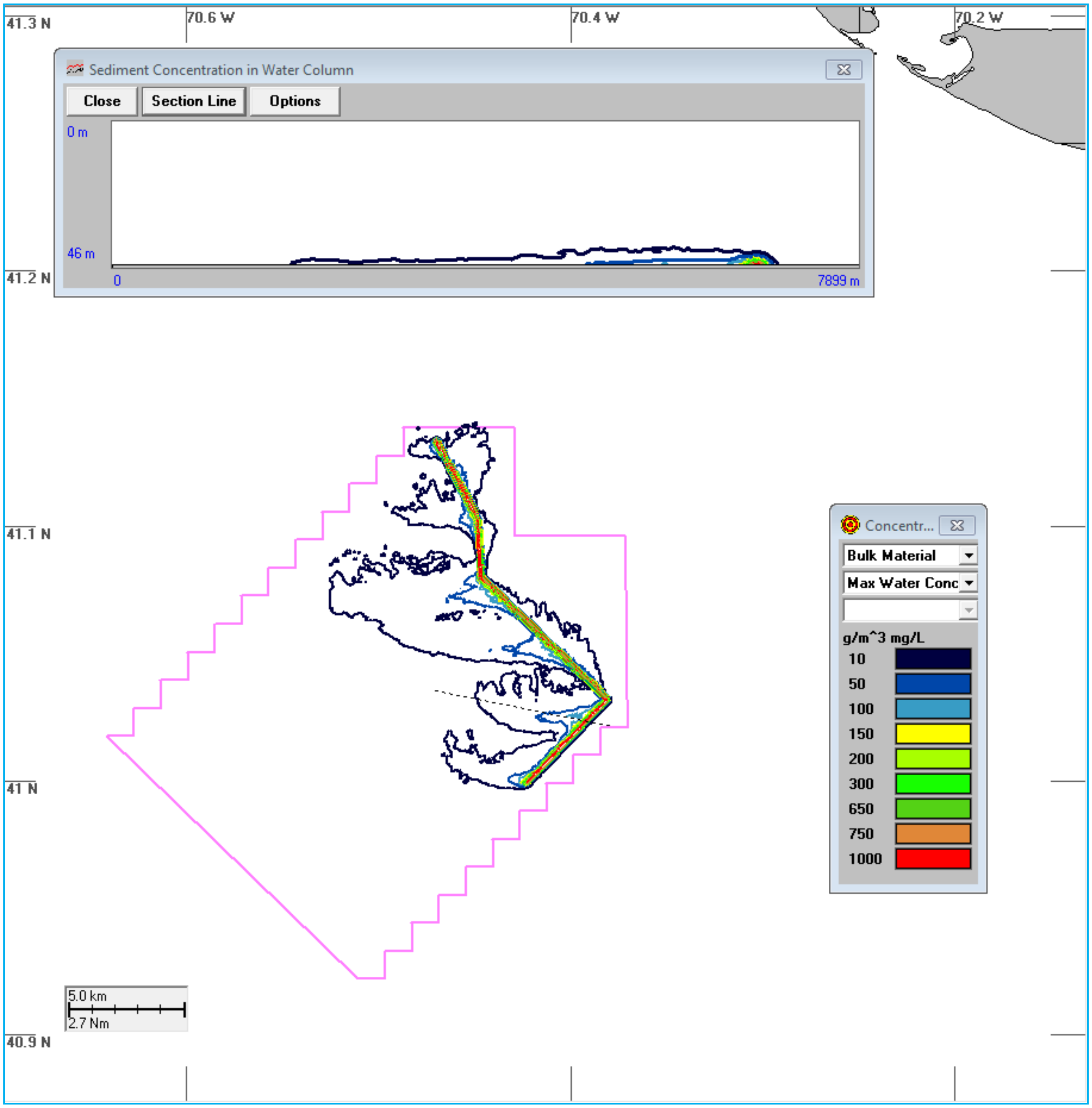
Table 5.2-5 compares the modeling results for the typical and maximum impact scenarios using four metrics: (1) maximum extent in km of the 10 mg/L contour of TSS concentrations, (2) the maximum extent in km of deposition greater than 1 mm (0.04 in) from the inter-array cable centerline, (3) the maximum extent in km of deposition greater than 20 mm (0.8 in) from the inter-array cable centerline, and (4) the area in km^2 with TSS concentrations greater than 10 mg/L for various durations.

Table 5.2-5 Maximum Extents and Duration Areas for Representative Inter-Array Cable for Typical and Maximum Impact Installation Parameters

Project Component	Activity	Typical ("Typ") or Maximum ("Max")	Maximum Extent of 10 mg/L Contour[1]	Maximum Extent of Deposition > 1 mm[1]	Maximum Extent of Deposition > 20 mm[1]	Area (square kilometers ["km^2"]) over 10 mg/L for various durations (hrs)				
			(km)	(km)	(km)	1	2	3	4	6
Representative Inter-array	Cable Installation	Typ	3.1.	0.1	N/A	9.73	4.67	1.3	0.27	-
Representative Inter-array	Cable Installation	Max	7.500	0.14	N/A	36.4	21.4	12.1	6.88	1.33

1. As measured from the route centerline.

In summary, the model results indicate that most of the mass settles out quickly and is not transported for significant distances by the currents. Excess (i.e., above ambient) TSS concentrations higher than 10 mg/L only persist at any given point for less than six (assuming typical installation parameters) or 12 (assuming maximum impact installation parameters) hours. The plume is confined to the bottom three meters (9.8 ft) of the water column, which is only a fraction of the water column in the WDA. Deposition greater than



Vineyard Wind Project

Figure 5.2-8

Time-Integrated Maximum TSS Concentration for Inter-Array Cable Installation Using Maximum Impact Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel).

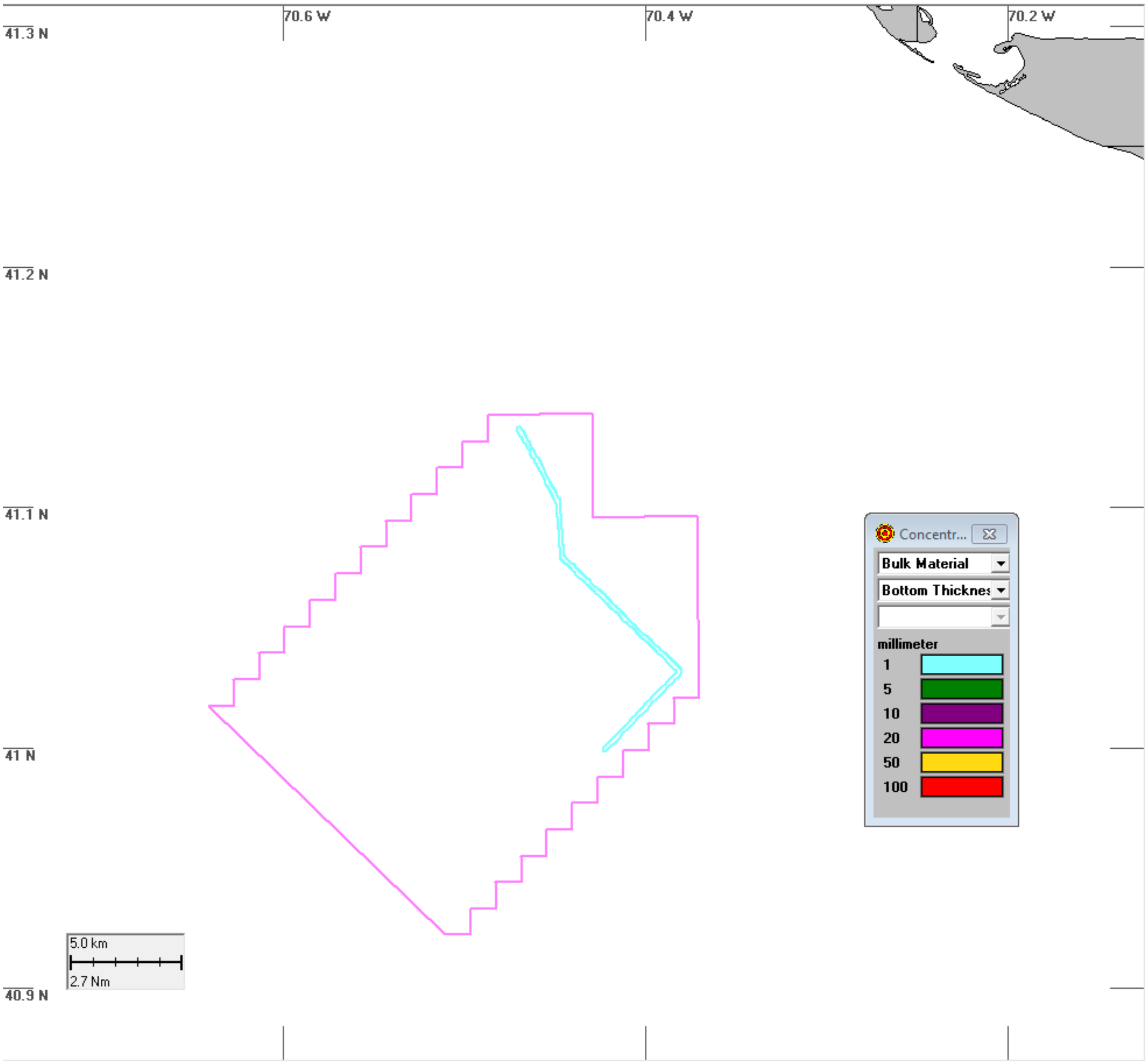


Figure 5.2-9

Plan View of Deposition Thickness for Inter-Array Cable Installation Using Maximum Impact Burial Parameters).

0.2 mm (0.008 in) is confined within 200 m (656 ft) to 250 m (820 ft) of the trench centerline for the typical and maximum impact simulations, respectively, and maximum deposition in both simulations is less than 5 mm (0.2 in). Water quality impacts from the inter-array cable installation are therefore short-term and localized.

Offshore Export Cable Corridor

The Project includes one predominate OECC which has two options through Muskeget Channel (Western Muskeget [WM] and East Muskeget [EM]) and two options for landfall (Covell's Beach and New Hampshire Avenue); these combine for four variants of the OECC:

1. OECC WM to Covell's Beach
2. OECC WM to New Hampshire Avenue
3. OECC EM to Covell's Beach
4. OECC EM to New Hampshire Avenue

Sand waves of varying height occur along the OECC. Portions of the sand waves may be mobile over time; therefore, the upper portions of the sand waves may need to be removed via dredging so that the cable laying equipment can achieve the proper burial depth below the sand waves and into the stable sea bottom. The amount of sand wave dredging required varies depending on the cable installation methods employed. More information on sand wave characteristics are found in Sections 2.0 and 3.0 of Volume II-A.

The Project is considering two distinct approaches to remove the upper portions of the sand waves above the stable seabed where necessary along the OECC. The first technique is a trailing suction hopper dredge ("TSHD"). The second approach involves jetting (also known as mass flow excavation), which uses a pressurized stream of water to push sand to the side. The dredging could be accomplished entirely by the TSHD on its own (the "TSHD Pre Dredge" option) 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 (this is referred to as "Limited TSHD Pre Dredge + Jetting"). Once any needed sand wave removal occurs, burial of the cable will occur.

- For the "TSHD Pre Dredge" approach, cable installation is a separate activity that occurs after dredging is complete (this is referred to simply as "Cable Installation"). Therefore, the model first simulates the TSHD dredging, then separately simulates the cable installation. This combined approach of TSHD dredging followed by cable installation is referred to as "TSHD Pre Dredge + Cable Installation]".

- For the "Limited TSHD Pre Dredge Approach + Jetting" approach, the jetting activity both removes the tops of sand waves and buries the cable. (Such jetting occurs only for very limited portions of the cable corridor.) Therefore, the model accounts for cable installation both through jetting (in smaller sand wave segments only) and through one of the other potential cable burial methods (such as a jet plow) that may be used in areas without sand waves requiring removal; this approach is referred to as "Cable Installation aided by Jetting." Accordingly, the model first simulates the limited TSHD dredging, then separately simulates the cable installation (which consists of jetting in limited segments for sand wave clearance and cable burial plus jet plow or one of the other cable installation techniques listed in the project's Construction and Operations Plan [COP] for the remainder of the route). This combined approach of limited TSHD dredging (in larger sand waves) followed by cable installation via either jetting (in smaller sand waves) or one of the other potential cable burial methods (such as a jet plow) is referred to as "Limited TSHD Pre Dredge + Cable Installation aided by Jetting."

For the two approaches a total of eight simulations were run, the pre cable installation dredging and the cable installation for each of the four route variants. An additional simulation was run with maximum impact burial parameters for one of the route variants. As with the inter-array cable installation described above, it is anticipated that the typical parameters would be utilized for approximately 90% of the offshore export cable installation and that the maximum impact parameters would only be utilized for 10% of the offshore export cable installation.

As detailed in Appendix III-A, the sediment characteristics were based on the characterizations from sediment sample analysis along the route and were therefore spatially varied along the route. In general, the total set of sediment grain size distribution analyses showed that the samples were predominately coarse sand with some exceptions.

For each simulation, maps of time integrated maximum excess TSS concentration and seabed deposition were generated. Model results (the area over specific thresholds for specific durations and deposition) were also tabulated.

The results from one OECC route variant (EM to NH Avenue) were presented in greater detail to provide more insight as to the impacts. Due to the similarity between the routes and the impacts, this route serves as a proxy for the results of any of the OECC variants (see Appendix III-A for more details). The cable installation without jetting or aided by jetting are negligibly different; however, the dredging impact footprint associated with the Limited TSHD Pre Dredge + Jetting approach is smaller than that of the TSHD Pre Dredge approach due to the reduced required volume of sediment to be dredging.

TSHD Pre-Dredge

Details of the model results for each OECC are provided in Appendix III-A. Figures 5.2-10 and 5.2-11 show model results for a representative example OEEC, the "EM to NH Avenue using typical installation parameters." In viewing the entire extent of the TSS concentrations (Figure 5.2-10) the plume is more extensive adjacent to the areas where sand wave dredging will occur, which is intermittent along the route. Further it can be seen that the plume may be present at varying orientations relative to the route centerline in response to the prevailing direction of the oscillating current synchronous with the simulated activity; in that sense it is noted that this footprint corresponds to the modeled time period and multiple perturbations of the footprint are possible through the tide cycle, though the general trends are expected to be the same. The footprint and contours for the dredging, overflow and disposal activity show that excess concentrations are expected throughout the water column as shown in the upper panel of Figure 5.2-10. This is due to the overflow release located at the surface and therefore a plume is noted throughout the water column as the sediments settle. Similarly, the dumping will initiate sediments approximately 6 m below the surface (through the opened hull) and therefore the resulting plume occupies waters throughout most of the water column. The plume of excess TSS at 10 mg/L and 750 mg/L extends up to 16 km ((9.9 mi) and 5 km (3.1 mi) from the route centerline, though may be less extensive at varying locations along the route. Relatively high concentrations (>1000 mg/L) are predicted at distances up to 5 km (3.1 mi) in response to the relatively high loading of dumping and swift transport of the dumped sediments.

The map of seabed deposition thickness associated with the TSHD dredging approach (dredging/overflow/dumping of pre-cable installation dredging of sand waves for the EM to NH Avenue OECC) with typical installation parameters is shown in Figure 5.2-11. This figure demonstrates that the deposition above 0.2 mm (0.008 in) is generally in very close proximity to the dredge and dump sites. The deposition greater than 1.0 mm (0.04 in) associated with the TSHD drag arm is mainly constrained to within 80 m (260 ft) from the route centerline, whereas the deposition greater than 1.0 mm (0.04 in) associated with overflow and disposal extends to greater distances from the source (disposal location ~250 m [820 ft] east of the route centerline), mainly within 1 km (0.6 mi) though such deposition can extend up to 2.3 km (1.4 mi) in isolated patches when subject to swift currents through Muskeget Channel. Deposition greater than 20 mm (0.8 in) resulted only from the dumping activities. Since the dumping takes place away from the route centerline the majority of the 20 mm (0.8 in) thickness was located in isolated patches offset from the route centerline. Very small patches of areas greater than 20 mm (0.8 in) were noted up to ~0.9 km (~0.56 mi) from the dumping location, however such occurrences were not typical; typically, the 20 mm (0.8 in) deposition was within 0.35 km (0.22 mi) from the source.

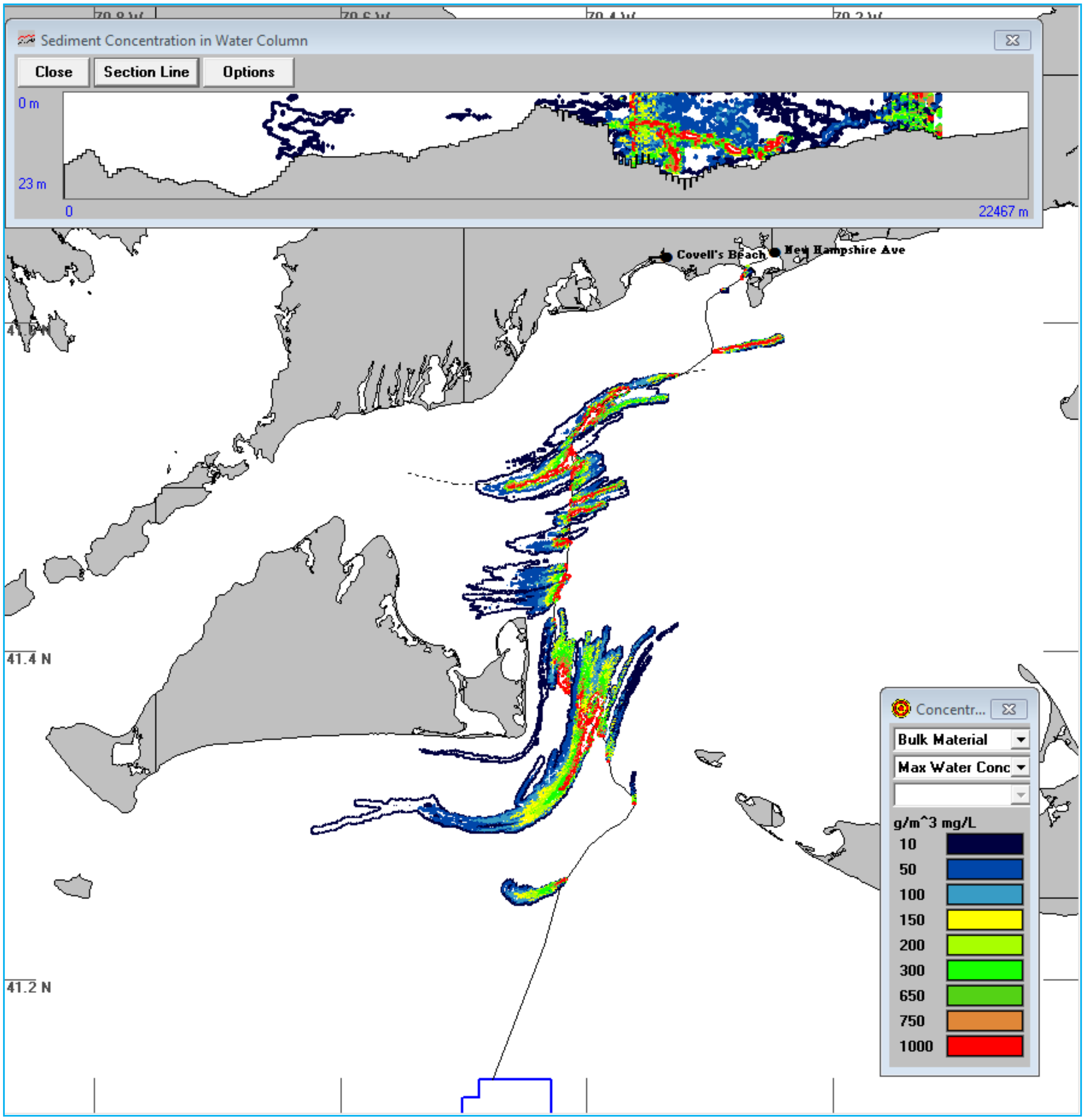


Figure 5.2-10

Time-Integrated Maximum TSS Concentration Associated with Dredging, Overflow and Disposal for ETM to NH Avenue OEEC Using Typical Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel).

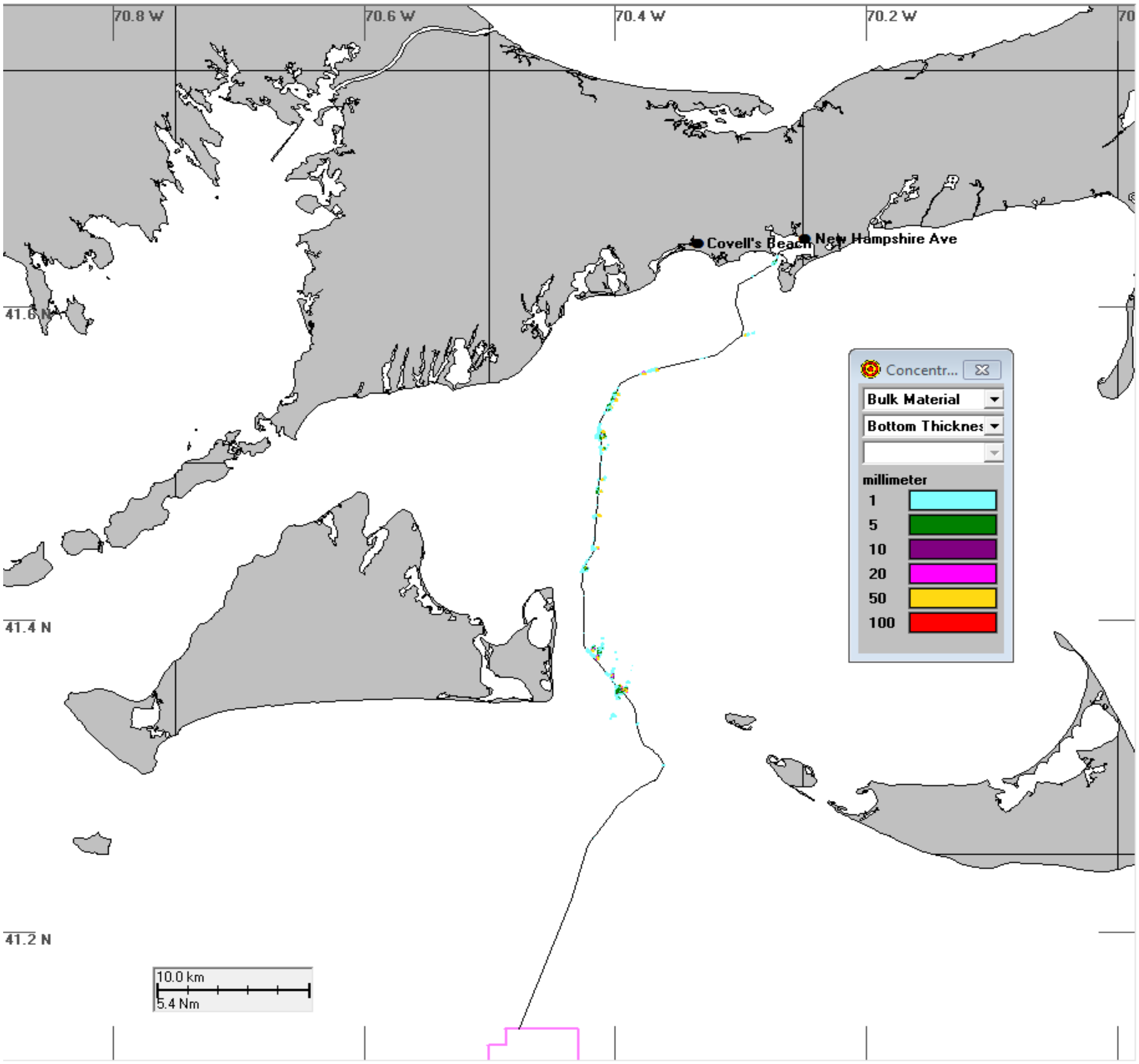


Figure 5.2-11

Plan View of Deposition Thickness Associated with Dredging, Overflow and Disposal for ETM to NH Avenue OEEC Using Typical Burial Parameters.

Cable Installation

Subsequent to the pre-installation dredging via TSHD, cable installation will take place. The map of time-integrated maximum concentrations of the corresponding cable installation using typical installation parameters for the EM to NH Avenue OECC is presented in Figure 5.2-12. This figure shows the entire route with a cross section along the route centerline at the top. The overall plume extent as delineated by the 10 mg/L excess TSS concentration contour remains relatively close to the route centerline for most of the route with some areas extending farther from the centerline in response to the currents or relatively higher volume of finer material within the sediments. The higher concentrations, above 10 mg/L, generally remain centered around the route centerline. The 10 mg/L contour has a maximum excursion of ~2 km (~1.2 mi) from the centerline though typically remains within less than ~200 m (~660 ft) from the centerline. In this figure, the vertical section view (top panel) runs along the centerline and shows that the plume is contained within the bottom of the water column close to the disturbance.

The map of deposition thickness for this scenario is presented in Figure 5.2-13. This figure shows that deposition is centered on the route centerline with deposition of 1 mm (0.04 in) or greater limited to within ~100 m (~330 ft) from the centerline, though was mainly within 80 m (260 ft). Both Figures 5.2-12 and 5.2-13 indicate that most of the mass settles out quickly and is not transported for significant distances by the currents.

A sensitivity run for the EM to NH Avenue OECC using maximum impact cable burial parameters was simulated to assess the impact of some of the uncertainties associated with the cable burial assumptions. The map of time-integrated maximum TSS concentrations associated with this maximum impact scenario is presented in Figure 5.2-14. This figure shows the entire route with a cross section along the route centerline at the top. The overall footprint shows that the plume as delineated by excess concentrations of 10 mg/L and greater remains relatively close to the route centerline for the majority of the route with some areas transported farther from the centerline in response to the currents or relatively higher volume of finer material within the sediments. The higher concentrations, above 10 mg/L, generally remain centered on the route centerline. The 10 mg/L contour has a maximum excursion of ~2.8 km (~1.7 mi) from the centerline though typically remains within less than ~200 m (~660 ft) from the centerline. In this figure, the vertical section view (upper panel) runs along the centerline and shows that the plume is contained within the near bottom of the water column close to the disturbance. The footprint is similar to that associated with the route simulated with typical parameters. Small differences between these two simulations of typical and maximum impact cable burial parameters exists, such as higher concentrations directly along the route and larger excursions of the 10 mg/L plume in places for the maximum impact parameters. Similarly, the map of deposition associated with the maximum impact parameters is similar to that of typical parameters.

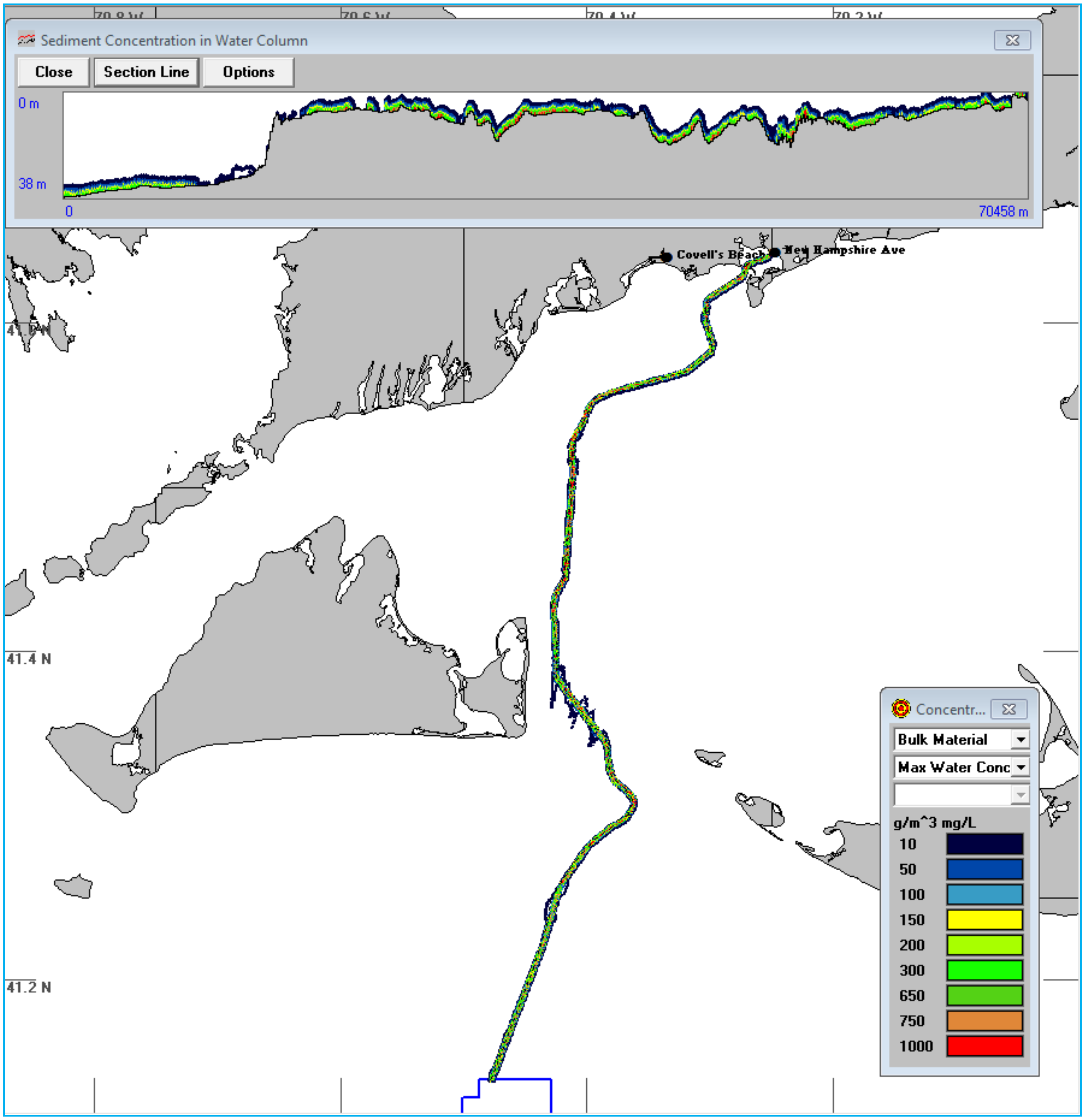


Figure 5.2-12

Time-Integrated Maximum TSS Concentration Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Typical Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel)

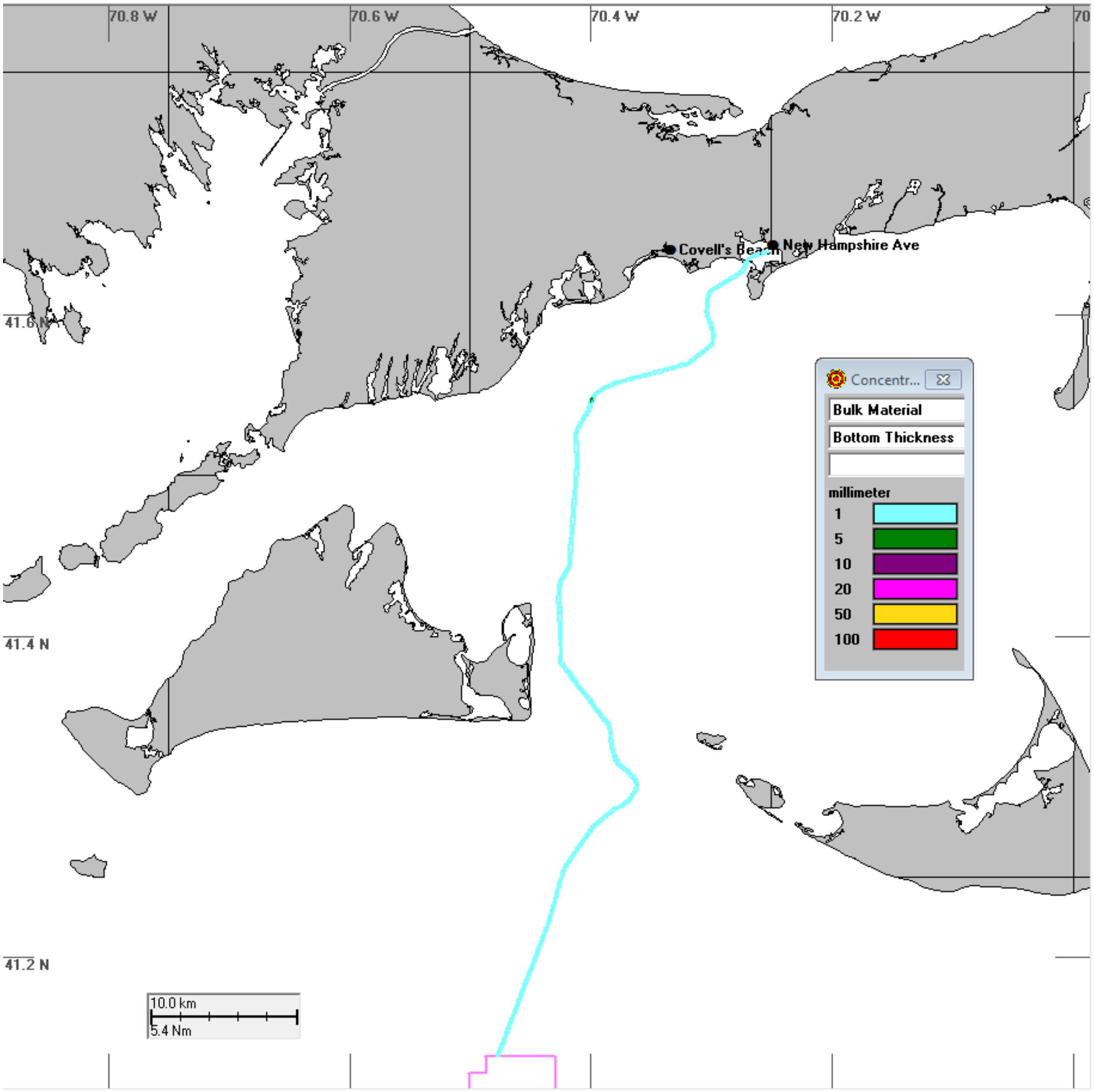
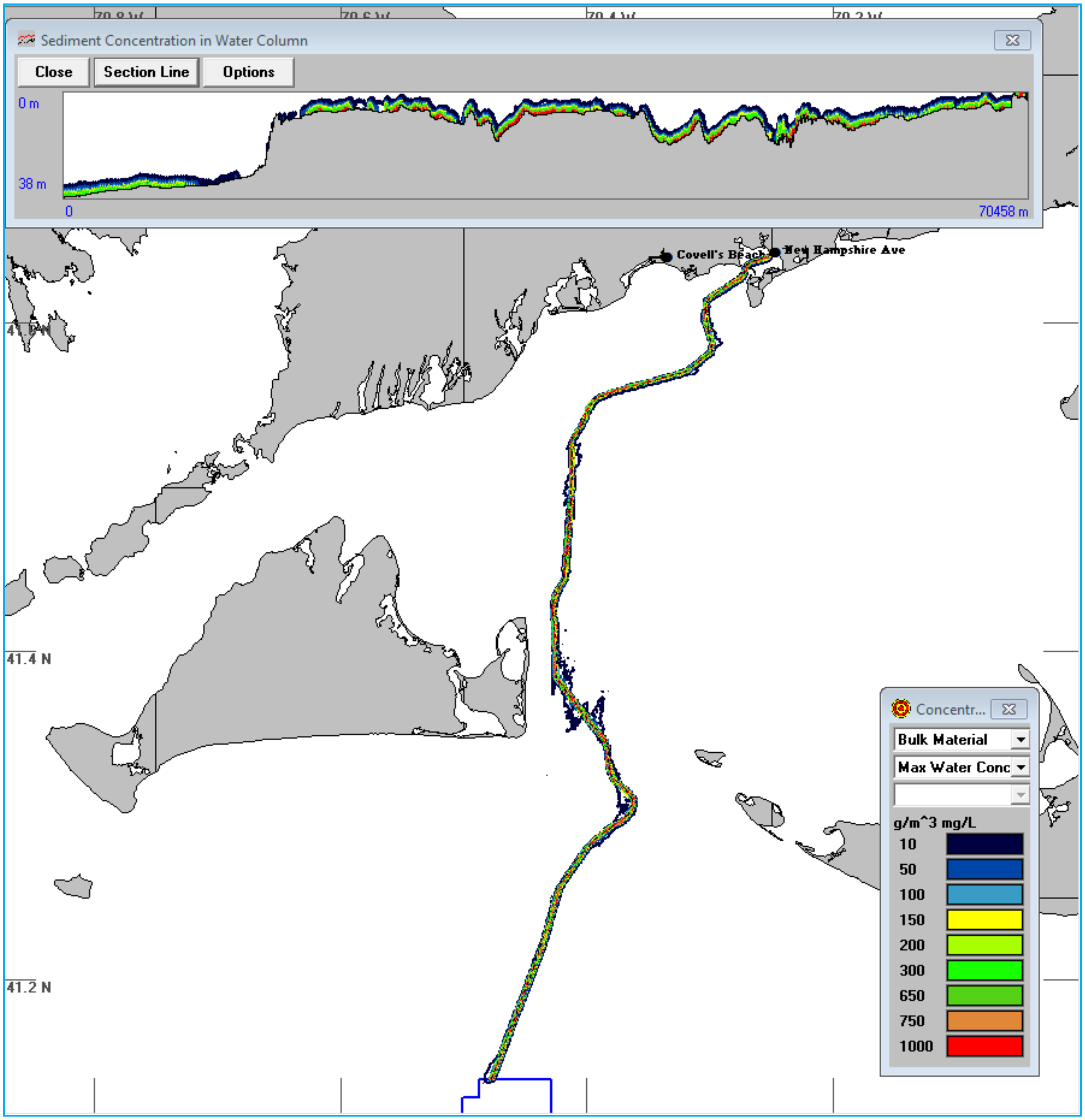


Figure 5.2-13

Plan View of Deposition Thickness Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Typical Burial Parameters.



Vineyard Wind Project

VINEYARD WIND

Figure 5.2-14

Time-Integrated Maximum TSS Concentration Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Maximum Impact Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel)

The map of deposition for the maximum impact OECC is presented in Figure 5.2-15. This figure shows that deposition is mainly centered on the route centerline with deposition of 1 mm (0.04 in) or greater limited to within ~140 m (~460 ft) from the centerline, though typically within 100 m (330 ft). Both Figures 5.2-14 and 5.2-15 indicate that most of the mass settles out quickly and is not transported for significant distances by the currents.

A comparison of modeling results is shown in Table 5.2-6 for the four OECC routes with four dredging and burial activities and typical installation parameters (plus one OECC route with maximum impact installation parameters) using four metrics: (1) maximum extent in km of the 10 mg/L contour of time-integrated maximum TSS concentrations, (2) the maximum extent in km of deposition greater than 1 mm (0.04 in) from the cable centerline, (3) the maximum extent in km of deposition greater than 20 mm (0.8 in) from the cable centerline, and (4) the area in km^2 with maximum TSS concentrations greater than 10 mg/L for various durations.

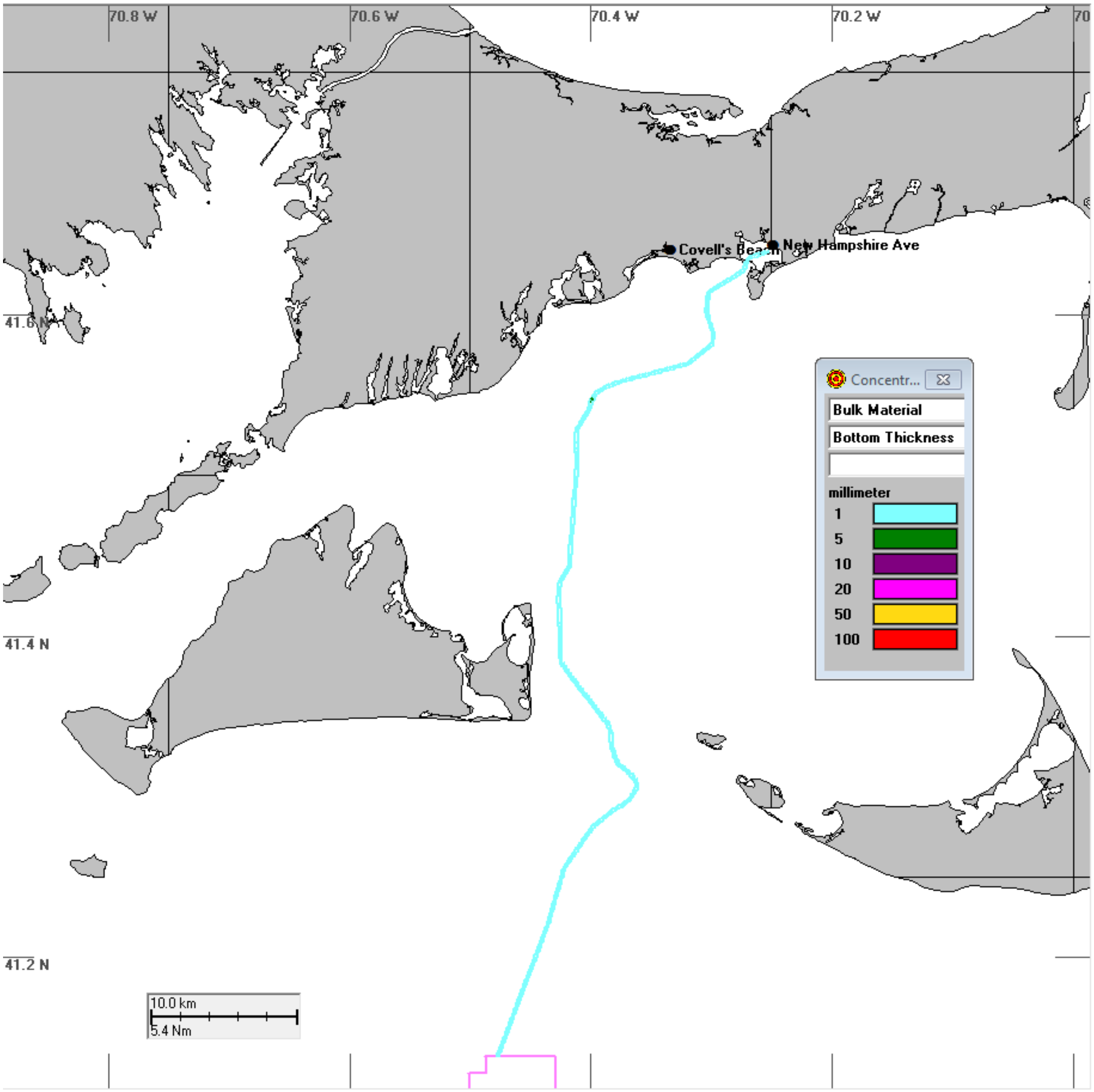


Figure 5.2-15

Plan View of Deposition Thickness Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Maximum Impact Burial Parameters.

Table 5.2-6 Maximum Extents and Duration Areas for the Four OECC Variants for Four Activities with Typical Installation Parameters and a Comparative Maximum Impact

OECC Route	Activity	Typ or Max	Maximum Extent of 10 mg/L Contour[1]	Maximum Extent of Deposition > 1 mm[1]	Maximum Extent of Deposition > 20 mm[1]	Area (km^2) over 10 mg/L for various durations (hrs)				
			(km)	(km)	(km)	1	2	3	4	6
WM to NH Ave	Limited TSHD Pre Dredge	Typ	20	0.95	0.70	2.36	0.168			
EM to NH Ave	Limited TSHD Pre Dredge	Typ	8.5	2.3	0.90	5.27	0.877	0.105		
WM to Covell's Beach	Limited TSHD Pre Dredge	Typ	20	0.95	0.7	2.26	0.178			
EM to Covell's Beach	Limited TSHD Pre Dredge	Typ	8.5	2.3	0.9	5.27	0.877	0.105		
WM to NH Ave	Cable Installation aided by Jetting	Typ	0.67	0.10	N/A	13.7	1.51	0.178		
EM to NH Ave	Cable Installation aided by Jetting	Typ	2	0.10	N/A	14.8	1.14	0.098		
WM to Covell's Beach	Cable Installation aided by Jetting	Typ	0.62	0.10	N/A	12.3	1.06	0.153		
EM to Covell's Beach	Cable Installation aided by Jetting	Typ	2.1	0.10	N/A	13.3	0.722	0.07	0.005	
WM to NH Ave	TSHD Pre Dredge	Typ	15.75	1.3	0.85	19.7	5.94	1.69	0.453	
EM to NH Ave	TSHD Pre Dredge	Typ	16	2.3	0.35	19.7	7.12	3.87	1.9	0.058
WM to Covell's Beach	TSHD Pre Dredge	Typ	1575	1.3	0.85	17.4	3.85	0.833	0.085	
EM to Covell's Beach	TSHD Pre Dredge	Typ	16	2.3	0.35	17.2	5.7	2.78	1.18	
WM to NH Ave	Cable Installation	Typ	1.02	.10	N/A	13.5	1.45	0.181	0.015	

Table 5.2-6 Maximum Extents and Duration Areas for the Four OECC Variants for Four Activities with Typical Installation Parameters and a Comparative Maximum Impact (Continued)

OECC Route	Activity	Typ or Max	Maximum Extent of 10 mg/L Contour[1]	Maximum Extent of Deposition > 1 mm[1]	Maximum Extent of Deposition > 20 mm[1]	Area (km^2) over 10 mg/L for various durations (hrs)				
			(km)	(km)	(km)	1	2	3	4	6
EM to NH Ave	Cable Installation	Typ	2	0.10	N/A	14.7	1.09	0.075		
WM to Covell's Beach	Cable Installation	Typ	0.86	0.10	N/A	12.1	1.06	0.15	0.015	
EM to Covell's Beach	Cable Installation	Typ	1.85	0.10	N/A	13.3	0.714	0.058		
EM to NH Ave	Cable Installation	Max	2.8	0.10	N/A	9.94	0.654	0.14	0.008	

1. Distances were measured from the nearest source, either the route centerline or disposal site. The disposal sites were approximately 250 m (820 ft) east of the centerline. Therefore, the distances listed when measured from the disposal site are either +/- 250 m (820 ft) from the route centerline. The 20 mm (0.8 in) deposition was almost exclusively associated with the disposal site.

Specifically, Table 5.2-6 presents the modeling results for both TSHD (either as part of the "TSHD Pre Dredge + Cable Installation" approach or as part of the "Limited TSHD Pre Dredge + Cable Installation aided by Jetting" approach) and for cable installation. Simulations of pre-cable installation dredging using a TSHD along the OECC show that plumes originating from the source are intermittent along the route, due to the intermittent need for dredging. The plume of excess TSS at 10 mg/L and 750 mg/L extends up to 16 km (9.9 mi) and 5 km (3.1 mi) from the route centerline for 2-3 hours, respectively, though may be less extensive at varying locations along the route. Relatively high concentrations (>1000 mg/L) are predicted at distances up to 5 km (3.1 mi) from the route centerline in response to the relatively high loading of dumping and swift transport of the dumped sediments, but this high concentration only persists for <2 hours. In general, the excess concentrations over 10 mg/L from dredging can extend several km (several mi) from the route centerline and may be present throughout the entire water column but are temporary and typically dissipate within about six hours. The deposition greater than 1.0 mm (0.04 in) associated with the THSD drag arm is mainly constrained to within 80 m (260 ft) from the route centerline whereas the deposition greater than 1.0 mm (0.04 in) associated with overflow and disposal extends to greater distances from the source (disposal locations ~ 250 m (820) east of the route centerline), mainly within 1 km (0.6 mi) though such deposition can extend up to 2.3 km (1.4 mi) in isolated patches when subject to swift currents through Muskeget Channel. Deposition greater than 20 mm (0.8 in) resulted only from the disposal activities. Since the disposal takes place away from the route centerline the majority of the 20 mm (0.8 in) thickness was located in isolated patches offset from the route centerline. Very small patches of areas greater than 20 mm (0.8 in) were noted up to ~0.9 km (~0.6 mi) from the disposal site, however such occurrences were not typical; typically, the 20 mm (0.8 in) deposition was within 0.35 km (0.22 mi) from the source.

The simulations of the cable installation showed that both the footprint of the 10 mg/L excess concentration plume and the footprint of deposition over 1.0 mm (0.04 in) stayed close to the route centerline. The maximum excursion of the 10 mg/L excess plume extended up to ~2 km (~1.2 mi), though typically less than 200 m (660 ft) from the route centerline. The excess concentrations stemming from cable installation, both with and without jetting for sand wave clearance, remain relatively close to the route centerline, are constrained to the bottom of the water column, and are also short-lived (typically dissipating within 4-6 hours). Deposition greater than 1.0 mm was limited to within 100 m (330 ft) from the route centerline, though was mainly within 80 m (260 ft).

A simulation of one variant of the OECC was also run using maximum impact parameters for cable installation. This simulation showed relatively similar results as compared to the simulation with typical cable installation parameters; however, the maximum impact simulation had more areas of higher concentration directly along the route and a slightly larger excursion of the 10 mg/L plume. The deposition patterns of the maximum impact cable installation simulation were similar to the typical cable installation parameters, with deposition greater than 1.0 mm (0.04 in) limited to within 140 m (460 ft) from the route centerline, though typically within 100 m (330 ft).

5.2.2.1.3 Impact of Horizontal Directional Drilling at Cable Landfall

HDD may be used, as described in Section 4.2.3.8 of Volume I, to avoid impacts of standard cable burial techniques in the nearshore region. These activities will only occur in the OECC. HDD operations may involve temporary removal of sediments from within a partial cofferdam. After cable connection activities are completed, the sediment will be replaced. It is possible that potential, limited sediment releases could occur during the refilling operation, but impacts would be localized and short-term.

5.2.2.1.4 Scour Protection Installation

Installation of the rocks or stones for scour protection will occur at each WTG and ESP foundation. The area of scour protection will be limited to 2,100 square meters ("m^2") (0.52 acres) at each WTG and 2,500 m^2 (0.62 acres) at each ESP. Placement of the rock may yield a temporary increase in suspended sediments due to resuspension of bottom sediments as the rock is placed; however, such impacts are anticipated to be a short-term and temporary due to the predominately sandy composition of the upper sediments in the WDA.

5.2.2.1.5 Routine Releases from Vessels

Some liquid wastes are allowed to be discharged to marine waters in both the WDA and OECC. These discharges include domestic water, uncontaminated bilge water, treated deck drainage and sumps, uncontaminated ballast water, and uncontaminated fresh or seawater from vessel air conditioning. As defined, these discharges will not pose a water quality impact. Other waste generation such as sewage, solid waste or chemicals, solvents, oils and, greases from equipment, vessels or facilities will be stored and properly disposed of on land or incinerated offshore and will not generate an impact.

5.2.2.1.6 Avoidance, Minimization, and Mitigation Measures

Water quality related to suspended sediments from cable installation, dredging and other construction activities, as appropriate, will be monitored. Details of the monitoring effort will be developed with the appropriate state and federal agencies (Massachusetts Department of Environmental Protection 401 Regulatory Program and the US Army Corps of Engineers) during other permitting processes. The monitoring is anticipated to consist of using a hand-held or similar turbidity sensor deployed from a small vessel to collect turbidity readings from multiple depths within the water column. If determined to be appropriate, collection of water samples for subsequent analysis for total suspended solids (TSS) could be made from the vessel to quantify the sediment concentration in the plume. Background levels outside of the plume for turbidity (and TSS, if appropriate) could also be acquired.

The Project will require all vessels to comply with regulatory requirements related to the prevention and control of discharges and the prevention and control of accidental spills. All vessels will comply with the USCG ballast water management requirements at 33 CFR Part 151 and 46 CFR Part 162. The USCG regulations include the same discharge standards as the International Maritime Organization (IMO) Ballast Water Management Convention (BWM) standards, but also include additional requirements beyond the IMO's requirements. Under the USCG regulations, additional measures to prevent the discharge of contaminated bilge water include:

- Regular cleaning of ballast tanks to remove sediments
- Rinsing of anchors and chains when anchors are retrieved
- Removing fouling from the hull, piping, and tanks on a regular basis
- Maintaining a ballast water management (BWM) Plan
- Maintaining records of ballast and fouling management
- Submitting a report containing vessel and ballast water management information 24 hours before calling at a US port

Ballast water management options that may be used by the Project's vessels include:

- Performing an exchange of ballast water (refilling the ballast tanks with sea water from the open ocean) beyond the Exclusive Economic Zone in areas more than 200 nm from any shore;

- Retaining the vessel's ballast water on board the vessel in a sealed tank;

- Using only water from a US public water system as ballast water in ballast tanks that have been cleaned; or

- Installing and operating a Ballast Water Treatment System (any system that processes ballast water to kill, render harmless, or remove organisms) which use technologies such as filtration, chemical disinfection using biocides, ultra-violet treatment, deoxygenation, heat, cavitation, electric pulses, and magnetic fields.

Since it is not known exactly which vessels will be used during the Project, the specific ballast water management option used by the Project's vessels are unknown.

The Project's vessels will meet USCG bilge water regulations in 33 CFR Part 151, which are based on the MARPOL Annex I Regulations for the Prevention of Pollution by Oil. Bilge water will either be retained onboard vessels in a holding tank and discharged to an onshore reception facility or treated onboard with an oily water separator, after which the treated water can be discharged overboard. Among several other conditions, bilge water cannot be discharged into the sea unless the oil content of the bilge water without dilution is less than 15 ppm. For vessels operating within 3 nm from shore, bilge water regulations under EPA's NPDES program apply to any vessel of the Project's vessels that are covered by a Vessel General Permit (those that are 79 ft or greater in length). Bilge discharges within 3 nm from shore are subject to the rules in Section 2.2.2 of Vessel General Permit and must occur in compliance with 40 CFR Part 110, 40 CFR Part 116, 40 CFR Part 117, and 33 CFR 151.10.

The Project has also developed a draft Oil Spill Response Plan, which is included in Appendix I-A.

5.2.2.1.7 Summary

The modeling analyses conducted above indicate that, for both the inter-array cables and the OECC, mobilized sediment is not transported far by the currents in most cases and settles rapidly. Sediment plumes greater than 10 mg/L typically persist at any given point for less than six hours, and in no case for more than 12 hours. The plume is generally confined to the bottom three meters (9.8 ft) of the water column, which is usually only a fraction of the water column, and maximum deposition is typically less than 5 mm (0.2 in). The plume from dredging, however, extends from the surface to the bottom due to overflow and disposal. Other water quality impacts from HDD operations or scour protection installation are similarly anticipated to be short-term and localized. Routine release from vessels will be limited to uncontaminated or properly treated liquids. Therefore, impacts to water quality from the Project will be short-term and localized.

5.2.2.2 Operations and Maintenance

5.2.2.2.1 Routine Releases from Vessels

Routine releases from vessels used during operations and maintenance, such as crew transfer vessels, are expected. These discharges may include domestic water, bilge water, engine cooling water, deck drainage and/or ballast water. BOEM (2014) determined the following related to potential water quality impacts from routine vessel discharges: "[I]n the WEA, coastal and oceanic circulation and the large volume of water would disperse, dilute, and biodegrade vessel discharges relatively quickly, and the water quality impact would be minor."

5.2.2.2.2 Avoidance, Minimization, and Mitigation Measures

Similar to the requirements above for construction and installation, the Project will require all vessels to comply with regulatory requirements related to the prevention and control of discharges and the prevention and control of accidental spills. The Project has also developed a draft Oil Spill Response Plan, which is included in Appendix I-A.

5.2.2.3 Decommissioning

The decommissioning of Project facilities and equipment will likely include removing the WTGs and ESPs above the mudline, removal of scour protection, and may include retirement in place or removal of offshore export cables. Removal of export cables and scour protection may cause short-term and localized generation of suspended sediments. To the extent feasible and appropriate, the Project will follow the avoidance, minimization and mitigation measures listed above under construction and installation for the decommissioning of the Project. Due to the long lifespan of the Project, it is also expected that technology will be enhanced by the time decommissioning occurs and impacts reduced.

5.3 Geology

5.3.1 Description of the Affected Environment

This section presents an overview of the site geology in the Wind Development Area ("WDA") and the Offshore Export Cable Corridor ("OECC"). For a more detailed and comprehensive description of site conditions, see Volume II-A.

Geology Background

The upper veneer of the earth's crust forms the foundation of the northern Atlantic Ocean and Nantucket Sound underlying the Project Area, and is comprised of thick deposits of coastal plain sediments that accumulated over hundreds of thousands of years. Multiple glacial advances then scoured and transported pieces of bedrock and coastal plain materials south, depositing thick discontinuous sheets of sediments in a variety of sub- (under) and pro- (in front of) glacial environments. Meltwater streams further reworked and deposited materials under the ice and carried sediment farther south, away from the glacier (outwash plains), sorting the material with distance. Associated sea level fluctuations subsequently reshaped this landscape at the land-sea interface as periods of transgression and regression further modified the coastal zone. Ultimately, the majority of the sediments on and around the Cape and Islands were deposited there by the last major glacial episode during the Wisconsin stage (18,000-24,000 years ago) of the Pleistocene Epoch (Oldale, 1992).

At the end of the last Ice Age (20,000–26,000 B.P.), when the Wisconsinan glacier started to retreat, sea level is believed to have been 120-130 m (394-427 ft) lower than it is today. Sea level began to rise, but not in a linear fashion, with periods of faster and slower increase (BOEM, 2013; National Aeronautics and Space Administration ["NASA"], 2015). Since that time, the sea has risen at different rates, but has continued to inundate the coast, submerging and eroding previously exposed land areas and features during its transgression landward throughout the Holocene Epoch. The process of transgression is a destructive mechanism that removes and reworks the upper layers of the land surface; the depth of erosion depends on the location along the coast (open and exposed vs. in an estuary). Initially, the ocean floods low lying areas, such as river channels and embayments, infilling those depressions with reworked sediment from shoreface retreat. As a result of this transgression, depressions in the onshore topography scoured by the glacier were eventually inundated by the sea and formed coastal estuaries and sounds. Today's sea level elevation was attained 3,000-5,000 years ago.

Existing Geologic Conditions

Geologically, conditions today are not much different than 10,000 years ago; coastal processes continue to modify the nearshore geomorphology as the shoreline retreats due to sea level rise. The general lack of any major rivers in southeastern Massachusetts means there is no terrigenous sediment supply to the nearshore environment and inner continental shelf. As a result, sediments on the seafloor are primarily reworked from older glacial deposits. Sediment is transported by longshore drift and tidal currents on a daily basis, with episodic storm events causing more severe erosion and redistribution.

Sediments in the WDA and along the OECC in water depths greater than 30 m (98.4 ft) are predominantly fine sand with some silt, becoming slightly finer in the offshore direction. Heading north through Muskeget, median grain size increases, with sand and gravel dominant, along with coarser deposits (cobbles and boulders) locally. This zone of coarse material between Martha's Vineyard and Nantucket is believed to mark the position of the terminal moraine deposited at the southernmost limit of the Wisconsin glacier. Continuing north into the main body of Nantucket Sound, sand still dominates the seabed, with coarser deposits concentrated around shoals and in high current areas; finer grained sediments occupy deeper water and/or more quiescent flow areas. Bedforms (see Hazards and Unique Geologic Features, below) are common due to the response of the sandy surficial layer to tidal currents with active sediment transport in many areas.

Environmental Conditions

While met-ocean data offshore in the vicinity of the WDA are scarce, publicly available datasets acquired for nearby projects (RICRMC, 2010) and estimates from a tide and wind driven model indicate currents throughout the water column are generally low at <0.36 m/s (0.7 kn) with average bottom current flows <0.2 m/s (0.39 kn). Refer to Appendix III-K for a discussion of currents and scour.

Oceanographic factors around Cape Cod and the Islands can be dramatic, as the coastal geomorphology plays a significant role in constricting the movement of water masses horizontally, between land and shoals, as well as vertically over shoals, which increases the flow velocity locally. Muskeget Channel is an excellent example of this, routinely experiencing tidal flow velocities in excess of 3.5 knots (1.8 + meters per second ["m/s"]). Elsewhere in the main body of Nantucket Sound (the "Sound"), tidal currents are generally 1-1.5 knots (0.51-0.77 m/s) with higher flows locally. The tides are semi-diurnal (two highs and two lows daily) and thus redistribute material and reshape the bottom during each maximum flow period, four times each day.

In the central portion of the Sound on and around Horseshoe Shoal, sand is transported in both directions by the tide but an overall net movement to the east has been suggested by previous research (Sanford & Flick, 1975), as the flood tide (easterly flow) is slightly stronger than the ebb (flows west). In the southern portion of the Sound along the OECC and east of Martha's Vineyard, flood and ebb directions turn more north-south as the water transits in and out through Muskeget Channel. Recent studies in this area suggest the ebb tidal component of the tide may be slightly stronger than the flood (SMAST study; Howes et al., 2011). Relative strength and velocities of the tidal currents also change with the lunar cycle and may be enhanced or reduced by episodic environmental conditions (discussed below).

Wind and seas are more of a factor offshore south of the islands, since any southerly component (SW, S, and SE) to the wind can result in large seas and swell in open water. Conversely, while seas can build in Nantucket Sound and create difficult conditions, there is limited fetch available between the islands and Cape Cod such that, for most wind speeds and directions, wave height will be less in the Sound than offshore. Numerous shoals also force waves to build and break, acting, to some extent, as barriers that prevent longer period wave trains from reaching the coastlines.

Coincidental opposition or alignment of these natural forces is simply a function of timing and can cause worse conditions than normal. Strong winds opposing maximum tidal flow can create above average wave heights and even standing waves, particularly in constricted waterways like Muskeget Channel. Similarly, water levels can rise above normal and flood low lying coastal regions when a passing storm system pushing water onshore combines with spring tides (new moon or full moon tidal phases). While Category 3 hurricanes are fairly rare in New England, nor'easters are much more common and also bring increased winds, seas, and coastal water levels.

The annual average wind speed is approximately 13 knots (6.7 m/s) just above the sea surface, compared to a higher average value calculated for the Project Envelope hub height of 109-144 m (358-473 ft). The highest maximum mean wind speeds for the year occur during the months of October and November. The resulting waves generated by the average wind speeds produce mean significant wave heights of less than 1 m (3.3 ft) in Nantucket Sound and 1.8 m (5.9 ft) offshore south of the islands. Maximum average significant wave heights offshore range from 5.0 m (16.4 ft) in August to 11.5 m (37.7 ft) in September (NOAA buoy 44008, 1982-2008) with larger waves generated during isolated storm events. The protected waters of Nantucket Sound exhibit much lower maximum wave conditions, with an average of 1-2 m (3.3-6.5 ft), which may be exceeded during episodic meteorological events. Dominant wind and sea direction is from the southwest and south with a secondary component from the northwest.

Hazards and Unique Geologic Features

A dynamic equilibrium exists on the seabed between the tidal currents and surficial sediment, which in many locations around Nantucket Sound generates extensive fields of bedforms (ripples, megaripples, and sand waves) indicating active sediment transport and scour on the bottom. The sediment moves back and forth with the flood and ebb tidal currents, often with a slight net movement in one direction over the other. These conditions frequently maintain the bedforms over long periods of time, with the size of the features dependent upon the velocity of the currents, sediment grain size, water depths, bottom slope, and more. Average bedform relief in the WDA is 0.3-0.5 m (1.0-1.6 ft) within discontinuous patches of ripples-megaripples; in the vicinity of the OECC, average relief is 1-1.5 m (3.3-4.9 ft). Increased sand wave heights of up to 5-9 m (16.4-29.5 ft) exist locally in high current areas within the Sound.

Coarse material (gravel, cobbles, and boulders in a sand matrix) is prevalent in the region due to proximity to the southernmost extent of the ice sheet in the last glacial episode during the Wisconsin stage. The glacier deposited huge volumes of coarse material as a terminal moraine that follows the north shore of Martha's Vineyard and Nantucket, extending slightly south of the islands in-between Martha's Vineyard and Nantucket. Sonar and video data thus reveal an abundance of surficial coarse deposits in the Muskeget Channel area, ranging from a sparse distribution to a high concentration locally; boulders greater than 1 m (3.3 ft) diameter have been identified. In a number of places, sandy bedforms are migrating over this coarse layer which is exposed in the troughs between individual sand waves.

Offshore in the WDA, coarse deposits do not exist on the seafloor but are interpreted from seismic profiles to be buried deeper below the surface, primarily in the southwestern portion of the area. Potential boulders and associated coarse/dense sediments may be found at depths of 20-45 m (65.6-147.6 ft) below the seafloor, and appear to be related to an extensive buried channel that crosses the southwestern portion of the WDA. The location and distance of the WDA from the mapped southern extent of the last glacial maximum (during the late Pleistocene), and depth of the deposits in the stratigraphic column, indicate this coarse material was likely deposited here during earlier glaciations (early-mid Pleistocene, >130,000 years ago), which are believed to have extended farther south on the then-exposed coastal plain. In addition, several buried channel systems are evident on the seismic profiles at similar and shallower depths below the seafloor that are indicative of former glacial meltwater drainage. Like the lithologic units the channels are incised into, fill materials range from clay to gravel and boulders. No large sediment type changes or stratigraphic inconsistencies have been identified across the channel basal unconformities.

5.3.2 Potential Impacts of the Project

Table 5.3-1 below summarizes the analysis of the impact of Project activities on geologic resources.

Table 5.3-1 Impact-producing Factors on Site Geology

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Pile driving for WTG and ESP foundations	X		X		X
Scour protection installation	X		X		X
Cable installation	X	X	X	X	X
Cable protection		X	X	X	X
Dredging		X	X		
Horizontal directional drilling		X	X		X

5.3.2.1 Construction and Installation

5.3.2.1.1 Pile- Driving for WTG and ESP Foundations

Wind Development Area

Pile-driving WTG and ESP foundations into the subsurface will displace and disturb sediments slightly during this action. Some sediment will be suspended locally in the water column and will settle back out on the seafloor on the same sediment type. Generally, low current velocities means that suspended material will not be transported very far (see Section 5.2). This impact is anticipated to be short-term and localized.

5.3.2.1.2 Scour Protection

Wind Development Area

Placement of scour protection materials around the WTG and ESP foundations will cover, but not alter, the finer granular soils (fine sand-silt) around the offshore component bases. The scour protection material may be rocks or stones placed on the bottom around the WTG and ESP foundations. The area of scour protection will be limited to 2,100 m^2 (0.52 acres) at each WTG and 2,500 m^2 (0.62 acres) at each ESP. Some finer sediment will be suspended during placement of this material and moved laterally by currents, but it will be redeposited on the same sediment type nearby.

While the *in situ* sediment composition of the existing geologic resource is not being changed, and the material is only being covered by the scour protection, after installation, the surficial geology could be viewed as having a long-term modification since rock would be on the seafloor instead of finer grained sediment.

5.3.2.1.3 Cable Installation

Wind Development Area

During installation of the export and inter-array cables, finer grained sediment offshore (fine sand to silt) will be displaced by the cable installation tool (cable installation methods are described in Section 4.2.3.3 of Volume I). Sediment suspension will occur with minimal transport and settling on the adjacent seafloor, resulting in a very thin veneer of newly deposited sediment (see Section 5.2). No change in sediment type will occur as all materials in the upper 2 m (6.5 ft) of the seabed are similar.

Offshore Export Cable Corridor

Prior to cable installation, dredging is planned in discrete locations along the cable corridor where sand waves exceed a height tolerance and prevent the cable from being installed at a suitable depth below the seabed. Sediment from the top portion of individual bedforms will be removed and side-cast temporarily. Seabed disturbance from any dredging is temporary due to the high mobility rate of the surficial sands, which would immediately work toward attaining the original dynamic equilibrium that existed prior to construction activity.

After any needed dredging is completed, cable installation will occur. Greater variability in geologic conditions along the ECCs will require a range of installation techniques to be employed. Finer granular sediments (silt-sand-gravel) will be displaced during cable installation. As sediments become coarser and more concentrated, particularly for materials larger than gravel, different installation tools may have to be used to achieve suitable cable burial (as described in Section 4.2.3.3 of Volume I, these include plowing, trenching, boulder clearance, etc.). As grain size increases, the amount of suspended sediment is reduced with more material redeposited closer to the installation tool. Additionally, vessel anchoring may occur during cable installation. Overall, the geology resource is not being modified by the construction activity and sediment deposition; rather, the sediments are simply being reworked in place.

Finally, where planned burial depths cannot be achieved, cable protection may be deployed. See the section on cable protection below for additional information.

5.3.2.1.4 Cable Protection

Wind Development Area and Offshore Export Cable Corridor

Where coarse material may prevent export cable burial deep enough below the seafloor or in other instances where sufficient burial cannot be achieved, protective covering such as rock or concrete mattresses may be placed on top to reduce risk to the cable (see Section 3.1.5.3 of Volume I). In areas of existing coarse material, the cable protection will not modify the coarse deposits underneath (though if concrete mattresses are used, a man-made hard bottom material will be placed over a natural hard bottom layer). This may increase the seafloor relief slightly in that localized area.

5.3.2.1.5 Horizontal Directional Drilling

Offshore Export Cable Corridor

Horizontal directional drilling ("HDD") may be conducted under the shoreline at the Landfall Sites to avoid impact to the nearshore subtidal, intertidal, and beach or backshore zones. As described in Section of 4.2.3.8, after completion of the HDD, all portions of the

HDD conduit are safely buried below the seafloor and offshore ground surface. Since HDD involves drilling a relatively small borehole through the sediment layers underlying the coastal zone, it will not affect the stability or structural integrity of the stratigraphic units that are the foundation of the shoreline.

5.3.2.1.6 Avoidance, Minimization, and Mitigation Measures

Methods to avoid, minimize, and mitigate impacts during construction and installation are summarized below.

- Site WTG and ESP foundations in suitable geologic locations to minimize maintenance due to geotechnical issues over the structure's life span. Micro-siting after the 2018 survey will further refine WTG and ESP positions.
- To the extent feasible, avoid areas with adverse seabed conditions during cable route feasibility and planning.
- Micro-site cable positions within the final export corridor to minimize impact to sensitive habitats.
- Use appropriate installation methods and tools to minimize disturbance.
- To the extent feasible, avoid using cable protection in sand wave fields by allowing dredging and using the appropriate installation tool to achieve deep burial into the underlying stable sediment layer.

5.3.2.1.7 Summary of Impacts

Geologic resources include the seafloor and subsurface materials, as well as any features or structures associated with the local and regional geology (e.g. stratigraphic formations, faults, buried channels). The installation of Project components does not change the sediment composition or overall context of the geological resource. Construction will simply displace and rework some of the materials locally. Further, the localized disturbance may be modifying sediments from the same layer with common physical characteristics (grain size, shell and water content, etc.).

Accordingly, pile driving, dredging, HDD, cable installation, and scour protection installation will primarily result in short-term, localized impacts that are limited to the area of the activity. Cable installation may result in a slight modification to the seafloor morphology (seabed scar), though impacts will be limited to the immediate and narrow cable installation trench. Additionally, cable protection may replace existing hard bottom with rock or man-made hard bottom. Overall, Project impacts to geological resources are largely expected to be short-term and localized.

5.3.2.2 Operations and Maintenance

Limited activities during operations and maintenance are anticipated to impact geologic resources. If a section of an export cable becomes exposed on the seafloor due to the natural removal of sand by the bedform migration process or an extreme storm event, maintenance operations in that area will need to be performed to rebury or cover the cable. The activities involved in this maintenance are generally the same as previously discussed above under Construction and Installation.

5.3.2.2.1 Cable Reburial

Offshore Export Cable Corridor and Wind Development Area

As described above under Construction and Installation, some displacement of sediments may occur during any needed cable reburial, though no change in sediment type will occur.

5.3.2.2.2 Cable Protection

Offshore Export Cable Corridor and Wind Development Area

If exposure, scour, or risk to the export cable(s), inter-array cables, or inter-link cables cannot be mitigated through reburial or other means, adding cable protection for exposed sections may be considered. As described above under Construction and Installation, the cable protective material will cover but not alter the underlying sediments. Some suspended sediment will occur during installation and may be transported down current from the point of construction.

5.3.2.2.3 Avoidance, Minimization, and Mitigation Measures

Methods to avoid, minimize, and mitigate impacts to geologic resources during operations and maintenance are summarized below.

- Conduct post-construction monitoring for cable exposure.
- Should cable reburial be necessary, rebury the cable into the stable seabed.

5.3.2.2.4 Summary

In summary, any cable reburial or protection activity is anticipated to be a localized, short-term impact to geologic resources.

5.3.2.3 Decommissioning

As described in Section 4.4 of Volume I, decommissioning includes removing WTGs and ESPs, cutting each monopile or jacket at the mudline (including removing and then replacing sediments from inside the foundation), removing scour protection and cable protection, and potentially removing the offshore export cable system (export cables, inter-array cables, and inter-link cables). Removal of Project components will create some suspended sediment locally that will only be transported a short distance away and produce only a thin veneer of new accumulation. If cable removal is required, some impact to seafloor morphology may occur, including the creation of new seafloor relief. Likewise, removal of the scour protection at each foundation or cable protection materials may result in a long-term change in surficial geology from rock, stones or other hard bottom materials back to finer grained sediments or the previously-exposed hard bottom sediments. Overall, removal of the WTG and ESP foundations above the seafloor is interpreted as a short-term, localized impact.