AECOM

APPENDIX I

Sediment Transport Analysis

Photo credit: Matt Goldsmith, Equinor

June 2023

Prepared for

Beacon Wind LLC

Table of Contents

List of Figures

List of Tables

List of Attachments

List of Acronyms

Abbreviation	Definition
2-D	Two Dimensional
3-D	Three Dimensional
ac	acre
ADCP	Acoustic Doppler Current Profiler
BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
BW1	Beacon Wind 1
BW2	Beacon Wind 2
CC	Correlation Coefficient
CFR	Code of Federal Regulations
CLIS	Central Long Island Sound
CO-OPS	Center for Operational Oceanographic Products and Services
COP	Construction and Operations Plan
CoNED	Coastal National Elevation Dataset
CPTu	Piezocone Penetration Test
CTDEEP	Connecticut Department of Energy and Environmental Protection
CY	cubic yard
D_{35}	35^{th} percentile of grain size
D_{50}	Median grain size
D_{90}	90^{th} percentile of grain size
EFH	Essential Fish Habitat
ERDC	Engineering Research Development Center
ESE	East-southeast
EV	Expected Value
FD	Finite Difference
FM	Flexible Mesh
ft	feet
ft/h	feet per hour
ft/min	feet per minute
ft/s	feet per second
FV	Finite Volume
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information Systems
ha	hectare
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
in	inches
ISO-NE	Independent System Operator New England

Abbreviation	Definition
kV	kilovolt
km	kilometer
LCD	Local Climatological Data
LISICOS	Long Island Sound Integrated Coastal Observing System
m	meters
m^3	cubic meters
m/h	meters per hour
m/min	meters per minute
m/s	meters per second
MAE	Mean Average Error
MBES	Multi-Beam Echo Sounder
MFE	Mass Flow Excavation
mg/L	milligrams per liter
MHW	Mean High Water
mi	mile
MLW	Mean Low Water
MLLW	Mean Lower-Low Water
mm	millimeter
MSL	Mean Sea Level
MW	Megawatt
N	Number of samples
NAVD88	North American Vertical Datum of 1988
NCEI	National Centers for Environmental Information
NetCDF	Network Common Data Form
NDBC	National Data Buoy Center
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NYISO	New York Independent System Operator
NYOFS	The Port of New York and New Jersey Operational Forecast System
NYSDEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
OCS	Outer Continental Shelf
OSAMP	Ocean Special Area Management Plan
PDE	Project Design Envelope
POI	Point of Interconnect
PORTS	Physical Oceanographic Real-Time System
PSU	Prat
PTM	Particle Tracking Model
RMSE	Root Mean Squared Error

Abbreviation	Definition
ROV	Remotely Operated Vehicle
SI	Scatter Index
SMA	Seasonal Management Area
SMS	Surface-water Modeling System
SSH	Sea Surface Height
SSS	Side Scan Sonar
TOGS	Technical and Operational Guidance Series
TOY	Time of Year
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids
US	United States
USACE	United States Army Corps of Engineers
USGS	United States Geologic Survey
WEA	Wind Energy Area
WNW	West-northwest
yd^3	cubic yard

Executive Summary

Beacon Wind LLC (Beacon Wind) proposes to construct and operate an offshore wind facility located in the designated Renewable Energy Lease Area OCS-A 0520 (Lease Area). The Lease Area covers approximately 128,811 acres (ac; 52,128 hectares [ha]) and is located approximately 20 statute miles (mi) (17 nautical miles [nm], 32 kilometers [km]) south of Nantucket, Massachusetts and 60 mi (52 nm, 97 km) east of Montauk, New York. Beacon Wind proposes to develop the entire Lease Area in two wind farms, known as Beacon Wind 1 (BW1) and Beacon Wind 2 (BW2) (collectively referred to hereafter as the Project).

The individual wind farms within the Lease Area will be electrically isolated and independent from each other; however, if BW1 and BW2 both interconnect with the New York Independent System Operator (NY ISO), the Project will assess the possibility of cable linkage between BW1 and BW2. Each wind farm will gather the associated turbines to a central offshore substation and deliver the generated power via a submarine export cable to an onshore substation facility for final delivery into the local utility distribution system at the selected Point of Interconnection (POI). The purpose of the Project is to generate renewable electricity from an offshore wind farm(s) located in the Lease Area. BW1 covers approximately 56,535 ac (22,879 ha) in the northern portion of the Lease Area and BW2 spans the southern portion of the Lease Area for approximately 51,611 ac (20,886 ha).

Each wind turbine will be connected to one offshore substation facility via an interarray cable, which delivers power to the respective POIs via a submarine export cable. Submarine export cables are used for the bulk transmission of power from the offshore substation facility to the onshore substation facility, installed to a depth of approximately 3-6 feet (ft) (0.9-1.8 meters [m]). Routes for the BW1 and BW2 submarine export cables are summarized below. The BW1 submarine export cable is up to 202 nm (375 km) long connecting on land in Queens, New York. BW2 plans to deliver power to identified POIs either in Waterford, Connecticut or Queens, New York. Two locations are under consideration in Queens, New York, for the single proposed BW1 landfall and onshore substation facility. The Queens, New York, onshore substation facility site that is not used for BW1 will remain under consideration, in addition to the Waterford, Connecticut, site, for the single proposed BW2 onshore substation facility. The BW2 submarine export cable is up to 113 nm (209 km) long connecting on land in Waterford, Connecticut or up to 202 nm (375 km) long connecting on land in Queens, New York.

For the purpose of this study, the construction activities associated with the installation of these cables are approximated as sediment releases to the water column followed by sediment transport processes such as advection, diffusion, settling, deposition, resuspension, etc. Project interarray and submarine export cabling will be installed along their respective alignments using the jet trenching methods. Where bedforms such as sand waves, ripples, and dunes are present on the seafloor (see **Appendix EE Potential Scour Analysis**), these features may be removed prior to cable installation through a process called "pre-sweeping". This study assumes mass flow excavation (MFE) will be the dredging method used for pre-sweeping.

This sediment transport study was performed to meet the objective of assessing the sediment fate and transport processes from seabed disturbance during and after BW1 and BW2 interarray and submarine export cable installation. The results of this assessment are discussed in terms of modeled sediment plume extents, depositional thickness, volume of water impacted, and time of total suspended solids (TSS) plume above thresholds. The study included two interrelated tasks:

1. Development of a three-dimensional hydrodynamic model using the Delft 3D Flexible Mesh (FM) Suite (Delft FM). The hydrodynamic model generates time series of currents which serve as the primary forcing to the sediment transport modeling. The hydrodynamic model was reasonably validated against measured sea surface heights and currents.
2. Simulation of suspended sediment transport using the particle tracking model (PTM) (USACE 2006) to assess the TSS concentration, plume migration, and deposition from bed disturbance caused by interarray and submarine export cable installation construction and pre-sweeping.

The 3-D hydrodynamic analysis for this study was performed using the D-Flow module within the Delft 3D FM Suite. The model domain for this study includes the entire Long Island Sound, a portion of the Southern New England OCS extending from the mouth of Long Island Sound to 40 mi (64 km) east of the Lease Area and from the southern New England coastline to 30 mi (48) south of the Lease Area, and a portion of the East River, which connects the New York Harbor to Long Island Sound. The model uses finite volume discretization with six sigma-schemed layers in the vertical dimension. The hydrodynamic model was forced at the open ocean boundary with TPXO9-atlas model tidal harmonics, the Port of New York and New Jersey Operational Forecast System (NYOFS) “nowcast” predicted East River water levels and velocity, and United States Geological Service (USGS) riverine flows for all other modeled rivers. Surface wind stress was applied on the top layer of the model based on measured wind station data. When validated against sea surface height (SSH) and current measurements in two separate month-long periods in September 2010 and January 2019, the model performed reasonably well in capturing the dominate trend of the observation data. The validated model was run from May 1st to November 30th to cover the anticipated construction periods which is determined based on state time of year (TOY) restrictions.

The PTM was used to simulate the suspended sediment transport processes which include advection, diffusion, suspension/resuspension, and deposition, associated with BW1 and BW2 presweeping and interarray and submarine export cable installation, including,

1. The installation and burial of interarray cabling connecting the wind turbines to the offshore substation facilities;
2. The pre-installation clearing (or pre-sweeping) of the submarine export cable routes as needed to remove sand waves and other seabed obstructions; and
3. The installation and burial of submarine export cables connecting the BW1 offshore substation facility to the POI at Queens, New York, and connecting the BW2 offshore substation facility to the POI either at Queens, New York or at Waterford, Connecticut.

PTM requires two groups of input parameters:

1. The seabed sediment characteristics defined by the bed density, porosity, the 35th percentile of bed grain size (D35), the mean bed grain size (D50), and the 90th percentile of bed grain size (D90). Sediment were characterized using 170 surficial grab samples and 439 vibracore samples.

2. Construction activity defined by advance rate, trench dimensions for jet plow hydraulic trenching, and pre-sweeping volume using MFE and sediment loss rate.

Results from the PTM simulations were processed to determine the extent of time-integrated maximum TSS concentration (milligrams per liter [mg/L]) as well as maximum time-integrated depositional thickness (in inches [in] or millimeters[mm]).

Presweeping volumes were defined by the cable installation contractor in submarine cable segments, which were used to define the sediment release rates used in the PTM modeling. These release rates are generally much greater than the release rates associated with cable installation. As a result, the suspended sediment plumes from presweeping activities were predicted to have greater impact in migration extents and TSS concentration. It is noted that this report assumes MFE for presweeping which is most conservative compared to TSHD, which is being evaluated as a viable alternative.

The suspended sediment plumes generated by the interarray cabling oscillate due to the tidally dominated currents of the Lease Area. The maximum extent of the 50 mg/L TSS plume during interarray cabling is approximately 1.79 mi (2.88 km) (**Table I.ES-1**), and the maximum extent of deposited sediment thickness greater than 0.04 in (1 mm) is approximately 0.04 mi. (0.06 km) (**Table I.ES-2**).

The suspended sediment plumes generated by the BW1/BW2 submarine export cable installation have much higher variability in extent and direction. This is caused by the spatial variability in hydrodynamic regions that the submarine export cables pass through, between the Lease Area and the landing site at Astoria, New York. The maximum extent of the 50 mg/L TSS plume is 4.15 mi. (6.69 km) (**Table I.ES-1**) and the maximum extent of depositional thickness greater than 0.04 in (1 mm) is 2.37 mi. (3.81 km) (**Table I.ES-2**). The 50 mg/L TSS plumes tended to be largest where high-current velocities moving perpendicular to the direction of cable installation quickly move particles away from the point of release. The areas where TSS plumes above 5,000 mg/L were observed tended to be regions of lower-magnitude currents, where suspended sediments do not travel far from the release point.

The suspended sediment plumes generated by the BW2 alignment to Waterford, Connecticut are largely similar to the plumes generated by BW1/BW2 to Queens, New York, as much of it traverses the same regions. However, as the BW2 submarine export cable turns north towards the Waterford, Connecticut landing site, there are very strong East-West currents in Long Island Sound that create large 50 mg/L plume extents, 6.92 mi (11.14 km) (**Table I.ES-1**). The maximum extent of depositional thickness greater than 0.04 in (1 mm) is 4.18 mi (6.73 km) and occurs in the same region near the Waterford, Connecticut landing site (**Table I.ES-2**).

TABLE I.ES-1. SUMMARY OF SEDIMENT TRANSPORT TOTAL SUSPENDED SOLIDS PLUME EXTENT

Installation Scenario	Maximum Extent of TSS Plume over Threshold from the Route Centerline				
	500 mg/L	1,000 mg/L	5000 mg/L	10,000 mg/L	50,000 mg/L
Pre-sweeping	5.28 mi. (8.5 km)	4.52 mi. (7.27 km)	3.24 mi. (5.21 km)	1.63 mi. (2.62 km)	1.01 mi. (1.62 km)

Installation Scenario	Maximum Extent of TSS Plume over Threshold from the Route Centerline				
	50 mg/L	100 mg/L	500 mg/L	1,000 mg/L	5,000 mg/L
Representative Interarray Cable	1.79 mi. (2.88 km)	0.93 mi. (1.49 km)	0.55 mi. (0.89 km)	0.45 mi. (0.73 km)	0.1 mi. (0.16 km)
BW1/BW2 Submarine Export Cables to Queens, NY	4.15 mi (6.69 km)	2.98 mi (4.8 km)	0.90 mi (1.44 km)	0.64 mi (1.03 km)	0.27 mi (0.43 km)
BW2 Submarine Export Cable to Waterford, CT	6.92 mi (11.14 km)	5.00 mi (8.04 km)	0.90 mi (1.44 km)	0.59 mi (0.94 km)	0.15 mi (0.25 km)

TABLE I.ES-2. SEDIMENT TRANSPORT SEDIMENT DEPOSITION THICKNESS RESULTS

Installation Scenario	Maximum Extent of Deposited Sediment Thickness over Threshold from the Route Centerline				
	0.04 in. (1 mm)	0.20 in. (5 mm)	0.39 in. (10 mm)	1.97 in. (50 mm)	3.94 in. (100 mm)
Pre-sweeping	6.37 mi. (10.26 km)	3.71 mi. (5.97 km)	3.24 mi. (5.21 km)	1.07 mi. (1.72 km)	1.07 mi. (1.72 km)

Installation Scenario	Maximum Extent of Deposited Sediment Thickness over Threshold from the Route Centerline				
	0.01 in. (0.25 mm)	0.02 in. (0.50 mm)	0.04 in. (1.0 mm)	0.20 in. (5.0 mm)	0.39 in. (10.0 mm)
Representative Interarray Cable	0.38 mi. (0.61 km)	0.06 mi. (0.09 km)	0.04 mi. (0.06 km)	0.01 mi. (0.02 km)	NA
BW1/BW2 Submarine Export Cables to Queens, NY	3.66 mi (5.9 km)	2.85 mi (4.59 km)	2.37 mi (3.81 km)	2.37 mi (3.81 km)	2.37 mi (3.81 km)
BW2 Submarine Export Cable to Waterford, CT	4.18 mi (6.73 km)	2.85 mi (4.59 km)	2.17 mi (3.5 km)	0.88 mi (1.42 km)	0.06 mi (0.10 km)

Note:
NA – Not Applicable

I.1 Introduction

I.1.1 Study Scope, Objectives, and Report Outline

The objective of this study is to characterize the impact of the offshore construction activities associated with Beacon Wind Project interarray and submarine export cable installation on suspended sediment transport in the water column and deposition over the seabed. The scope of study includes two modeling tasks:

1. Development of a three-dimensional (3-D) hydrodynamic model using the Delft 3D Flexible Mesh (FM) Suite (Delft FM). The hydrodynamic model domain extends from the Lease Area OCS-A 0520 to the onshore substation facilities and the submarine export cable routes to Queens, New York and Waterford, Connecticut. The hydrodynamic currents serve as the primary forcing to the sediment transport modeling.
2. Sediment transport modeling using the particle tracking model (PTM) (USACE 2006) to assess the total suspended solids (TSS) concentration, plume migration and deposition from seabed disturbance caused by interarray and submarine export cable installation construction and presweeping.

Appendix I Sediment Transport Analysis is organized as follows:

Section I.1 (this section) provides an overview of the Beacon Wind Project and its key components, construction methods, regulatory framework, and modeling approach.

Section I.2 details the environmental setting for the Beacon Wind Project and summarizes the data used to support the hydrodynamic and sediment transport modeling.

Section I.3 describes the hydrodynamic modeling from the Lease Area in the Atlantic OCS through the Long Island Sound. It provides detailed discussion about modeling approach and assumptions, model development, input parameters, model validation, and hydrodynamic modeling results

Section I.4 describes the sediment transport modeling to simulate the seafloor-disturbance associated with various cable installation and pre-sweeping constructions. It provides detailed discussion about model development, input parameters and assumptions, and results in terms of suspended sediment concentration, depositional thickness, and sediment plume characteristics.

Vertical datum used in this appendix is Mean Sea Level (MSL), unless specified otherwise.

I.1.2 Beacon Wind Project Background

Beacon Wind LLC (Beacon Wind) proposes to construct and operate an offshore wind facility located in the designated Renewable Energy Lease Area OCS-A 0520 (Lease Area). The Lease Area covers approximately 128,811 acres (ac; 52,128 hectares [ha]) and is located approximately 20 statute miles (mi) (17 nautical miles [nm], 32 kilometers [km]) south of Nantucket, Massachusetts, and 60 mi (52 nm, 97 km) east of Montauk, New York. The Lease Area was awarded through the Bureau of Ocean Energy Management (BOEM) competitive renewable energy lease auction of the Wind Energy Area (WEA) offshore of Massachusetts. Beacon Wind is indirectly owned by Equinor U.S. Holdings Inc. and bp Wind Energy North America Inc.

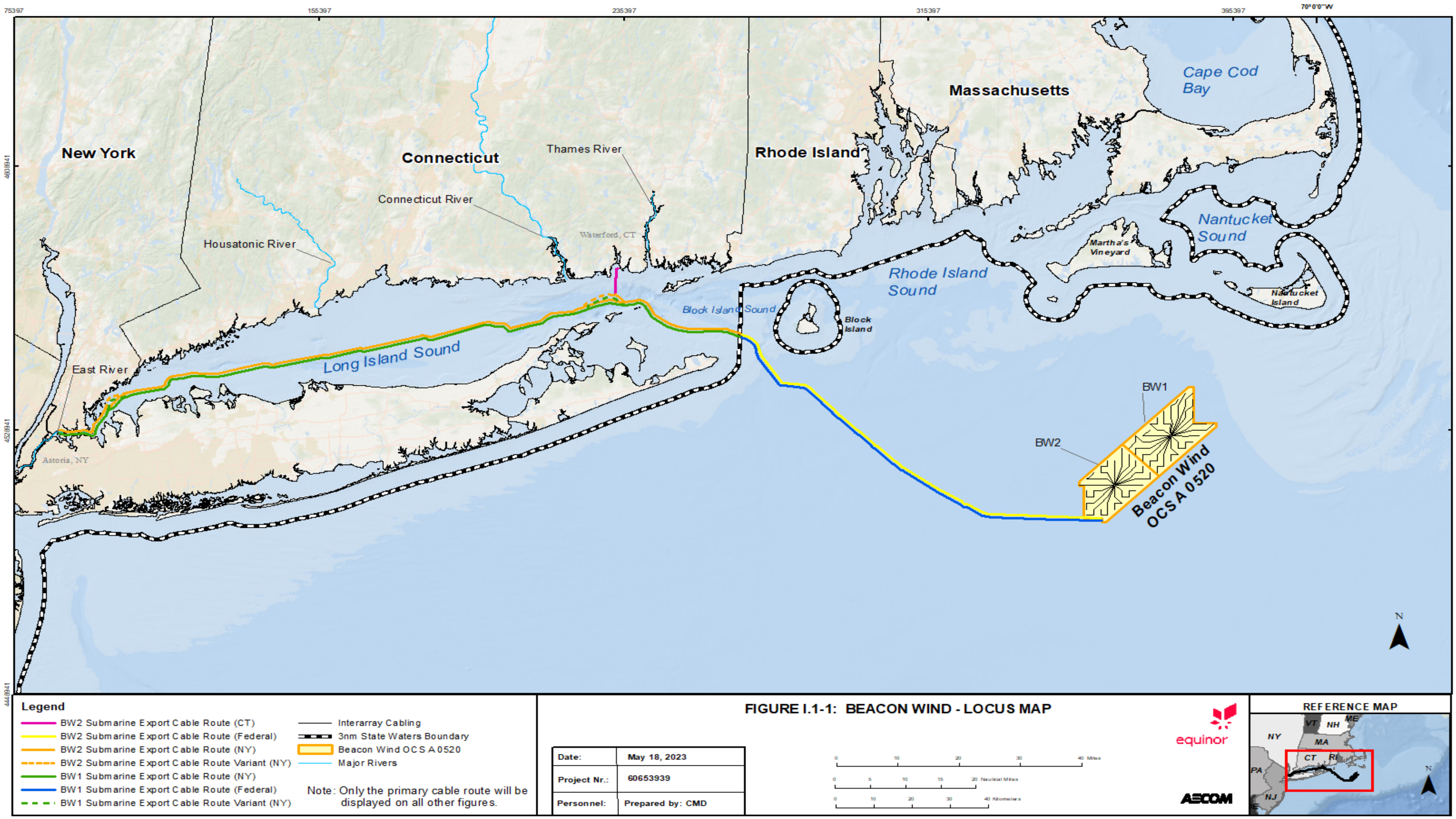
Beacon Wind proposes to develop the entire Lease Area in two wind farms, known as Beacon Wind 1 (BW1) and Beacon Wind 2 (BW2) (collectively referred to hereafter as the Project). The individual wind farms within the Lease Area will be electrically isolated and independent from each other. Each wind farm will gather the power from the associated turbines to a central offshore substation and deliver the generated power via a submarine export cable to an onshore substation facility for final delivery into the local utility distribution system at the selected Point of Interconnection (POI). The purpose of the Project is to generate renewable electricity from an offshore wind farm(s) located in the Lease Area. The Project addresses the need identified by northeast states to achieve offshore wind goals: New York (9,000 megawatts [MW]), Connecticut (2,000 MW), Rhode Island (up to 1,000 MW), and Massachusetts (5,600 MW).

BW1 will be developed first and constitutes the northern portion of the Lease Area. It covers approximately 56,530 ac (22,877 ha). The BW1 wind farm has a 25-year offtake agreement with the New York State Energy Research and Development Authority (NYSERDA) to deliver the power to its identified POI in Queens, New York.

BW2 spans the southern portion of the Lease Area and will be developed after BW1. It covers approximately 51,610 ac (20,886 ha). Beacon Wind is considering an Overlap Area of 20,665 ac (8,363 ha) that may be included in either wind farm. BW2 is being developed to addresses the need for renewable energy identified by states across the region, including New York, Massachusetts, Rhode Island, and Connecticut. The interconnectedness of the New England transmission system, managed by the New England ISO (ISO-NE), allows a single point of interconnection in the region to deliver offshore wind energy to all of the New England states (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine). The magnitude of regional targets for offshore wind and the limited amount of developable area, given current and reasonably foreseeable BOEM leasing activity, demonstrate a need for full-build out of the Lease Area.

Illustration of BW1, BW2, as well as the interarray and submarine export cable routes of the Project are shown in **Figure I.1-1**.

FIGURE I.1-1 LOCUS MAP



Beacon Wind has adopted a Project Design Envelope (PDE) approach to describe Project facilities and activities. A PDE is defined as “a reasonable range of project designs” associated with various components of the Project (e.g., foundation and wind turbine generator [wind turbine] options) (BOEM 2018). The design envelope is then used to assess the potential impacts on key environmental and human use resources (e.g., marine mammals, fish, benthic habitats, commercial fisheries, navigation, etc.) focusing on the design parameter (within the defined range) that represents the greatest potential impact (i.e., the “maximum design scenario”) for each unique resource (BOEM 2017). The primary goal of applying a design envelope is to allow for meaningful assessments by the jurisdictional agencies of the proposed project elements and activities while concurrently providing the Leaseholder reasonable flexibility to make prudent development and design decisions prior to construction.

Appendix I is being submitted as a supplemental filing to the Construction and Operation Plan (COP) submitted to the BOEM in February 2022. The appendix evaluates the impact of the disturbances to the seabed and suspended sediments in the water column associated with the installation of the submarine interarray and export cabling proposed as part of the Project. This is accomplished using a detailed hydrodynamic modeling of the ocean currents and a sediment transport analysis to simulate the proposed interarray and submarine export cable installation constructions outlined in the Project PDE.

I.1.3 Overview of Project Components

Figure I.1-1 provides an overview of the Project, including the Beacon Wind Lease Area (OCS-A 0520) and the submarine export cable routes. The Lease Area is broadly located in the Southern New England Outer Continental Shelf (OCS) directly south of the islands of Martha’s Vineyard and Nantucket.

Beacon Wind is developing up to 155 wind turbines and supporting tower structures, and up to two offshore substation facilities, using up to 157 foundations in the Lease Area (encompassing both BW1 and BW2). BW1 will include between 61 and 94 wind turbines and BW2 will include between 61 and 94 wind turbines. The Overlap Area includes 33 wind turbines that could be incorporated into either BW1 or BW2. The Beacon Wind PDE includes options of up to three types of foundations to support the wind turbines and up to two for the offshore substation facilities.

Each wind turbine will be connected to one offshore substation facility via an interarray cable, which delivers power to the respective POIs via a submarine export cable. Interarray cables will consist of up to 132-kilovolt (kV) High Voltage Alternating Current (HVAC) submarine cables, installed at a depth of approximately 3-6 feet (ft) (1-2 meters [m]) below the seabed of the Lease Area. Submarine export cables have a transmission rate up to 320-kV High Voltage Direct Current (HVDC) for the bulk transmission of power from the offshore substation facility to the onshore substation facility, installed to a depth of approximately 3-6 ft (0.9-1.8 m). Routes for BW1 and BW2 submarine export cables are summarized below.

- BW1: HVDC submarine export cable route to the State of New York:
  - Up to 202 nm (375 km) to the BW1 landfall, in Queens, New York, of which 87 nm (162 km) is in federal waters and 115 nm (213 km) is in state waters; and
- BW2: HVDC submarine export cable route to a landfall location in the State of New York or State of Connecticut.

- Up to 202 nm (375 km) to the BW2 landfall in Queens, New York, of which 87 nm (162 km) is in federal waters and 115 nm (213 km) is in state waters, or
- Up to 113 nm (209 km) to the BW2 landfall in Waterford, Connecticut, of which 87 nm (162 km) is in federal waters and 26 nm (48 km) is in state waters with 21 nm (39 km) in New York state waters and 5 nm (9 km) in Connecticut state waters.

I.1.4 Regulatory Framework

This appendix serves to address, in part, several requirements for COP Submittals set forth in 30 CFR § 585, as bulleted below:

- 30 CFR § 585.621(d), demonstrating that the project will not cause undue harm or damage to natural resources; life (including human and wildlife); property; the marine, coastal or human environment; or sites, structures, or objects of historical or archaeological significant.
- 30 CFR § 585.626(a)(4), "Geotechnical Survey", providing the description of results of any testing programs used to investigate the stratigraphic and engineering processes of the sediment that may affect the foundations or anchoring systems for the facility (30 CFR § 585.626(a)(4)(ii)).
- 30 CFR § 585.626(a)(6), "Overall Site Investigation", providing results of analyses conducted to assess seabed settlements and displacements (30 CFR § 585.626(a)(6)(x)).
- 30 CFR § 585.627(a), providing details regarding "hazard information" 30 CFR § 585.627(a)(1)) and "water quality" (30 CFR § 585.627(a)(2)) impacts associated with the project.

The submarine export cable routes for BW1 and BW2 pass through the territorial waters of the States of New York and Connecticut, as well as the Block Island Seasonal Management Area (SMA). New York and Connecticut territorial waters have time-of-year (TOY) dredging restrictions that limit when dredging activities can be conducted to protect different species of aquatic organisms (Commonwealth of Massachusetts 2015). Further, the Block Island SMA has vessel speed restrictions during certain times of year to protect right whale migratory routes and calving grounds. These restrictions, which are detailed in **Section I.3.5**, affect the construction timeline which is used in the hydrodynamic and sediment transport analysis

Federal regulation does not provide suspended sediment concentration limits for in-water management of dredged materials. The New York State Department of Environmental Conservation (NYSDEC) Technical & Operations Guidance Series (TOGS) No. 5.1.9 provides the criteria for mixing zones and constituent concentrations in New York territorial waters for in-water management of dredged material. The criteria vary by the water body classification and the quality of the sediment. The State of Connecticut does not provide standardized regulations for the in-water management of dredged material in Connecticut waters. The construction impact to sediment plumes and mixing in water column is reviewed by the Connecticut Department of Energy and Environmental Protection (CTDEEP) subject to surface water quality standards on a per-case basis (CTDEEP 2002).

I.1.5 Construction Methods and Generalized Timeline

The proposed construction methods and timeline for the installation of Project submarine cabling are outlined in this section. For the purpose of this study, these construction activities are approximated as sediment source release into the water column followed by the subsequent modeling of sediment transport processes such as advection, diffusion, settling, deposition, resuspension, etc. Further details can be found in **Section I.3.5.1** (timeline) and **Section I.4.2.2** (methods).

I.1.5.1 Cable Installation & Pre-sweeping Methods

Project interarray and submarine export cabling will be installed along their respective alignments (as shown in **Figure I.1-1**) using the jet trenching methods. Jet trenching uses high-pressure jets of water emitted from a "sword" placed in the seafloor to fluidize a small width of bed sediment. The cabling is simultaneously lowered into the fluidized portion of the seabed. Jet trenchers are remotely operated, and the cabling is installed in a linear fashion from the starting to the ending point of the cable.

Where bedforms such as sand waves, ripples, and dunes are present on the seafloor (see **Appendix EE Scour Evaluation**), these features may be removed prior to interarray and submarine export cable installation through a process called "pre-sweeping". While several varying dredge methods can be used in pre-sweeping, this study assumes mass flow excavation (MFE) will be used. Should alternative method(s) be considered during Project design maturity, the modeling will be updated to assessed to the selected methods. Similar to jet trenching, MFE utilizes high-pressure jets of water directed downwards towards the seabed to mobilize sediments, which undergo various transport processes in the water column and with the surrounding dredge area.

For this study, the parameters characterizing the construction methods were based on the Project PDE and where applicable, chosen to be conservative to assess the maximal impact on sediments due to dredging.

I.1.5.2 Construction Timeline

The timeline for installation of the Project is primarily governed by TOY restrictions in place for New York territorial waters and the Block Island SMA (See **Section I.1.4**). As New York restricts work in its territorial waters to a window between mid-September and mid-December, the installation of submarine export cabling is expected to take place in the late summer and fall. The installation of interarray cabling in federal waters is assumed to take place in June during the beginning of Project mobilization.

Cable installation for BW1 is assumed to take place prior to cable installation for BW2, during the same time of year but in different years.

I.2 Environmental Setting and Data Sources

To evaluate the impact of the Project construction on seafloor sediment disturbance and subsequent movement, a broad modeling domain must be used to define the open boundary for the simulation of the ocean hydrodynamics. The study area includes the entire Long Island Sound, a portion of the Southern New England OCS extending from the mouth of Long Island Sound to 40 mi (64 km) east of the Lease Area and from the southern New England coastline to 30 mi (48) south of the Lease Area, and a portion of the East River, which connects the New York Harbor to Long Island Sound. This section discusses the general environmental conditions of the study area and data sources used in the hydrodynamic and sediment transport modeling. Data sources include public domain, commercial sources, and Project-specific data provided by Beacon Wind.

I.2.1 Shoreline and Bathymetry

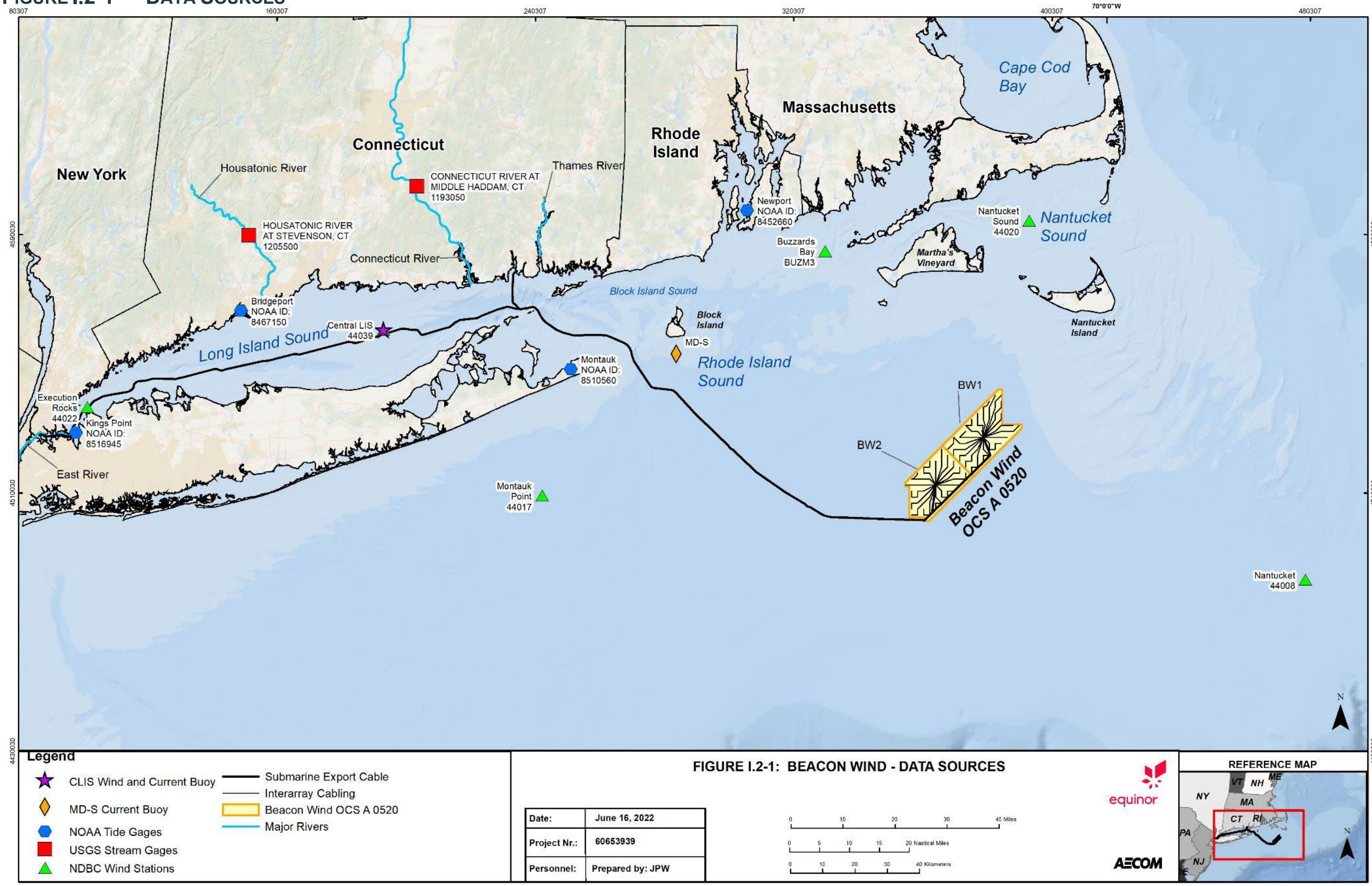
The shoreline makes up the landward boundary of the hydrodynamic model domain. The shoreline boundary in the hydrodynamic model extends approximately from Cape Cod and Buzzards Bay in Massachusetts, the southern New England coast of Rhode Island and Connecticut, to the Long Island Sound in New York. For this study, the National Oceanic and Atmospheric Administration (NOAA) Medium Resolution Shoreline dataset was referenced. This shoreline dataset is a high-quality, Geographic Information System (GIS)-ready digital vector dataset representing the shoreline of the United States (US) at the mean high water (MHW) datum and is compiled from NOAA nautical charts by the Strategic Environmental Assessments Division of NOAA's Office of Ocean Resources Conservation and Assessment (Graham 2021). The NOAA shoreline dataset was verified against the shoreline datasets provided by the state GIS repositories of Rhode Island, New York, Connecticut, and Massachusetts, and was found to be comparable, if not more detailed, than the state datasets.

Bathymetric coverage for the broad study area was compiled from multiple sources including the Project survey in the Lease Area and along the submarine export cable routes, supplemented by public sources from NOAA and United States Geological Service (USGS). The elevations in the Lease Area range from approximately -213 ft (-65 m) in the southwest end to approximately -115 ft (-35 m) in the northeast end of the Lease Area. Sea floor elevation reaches approximately -807ft (-246 m) in the OCS towards the southwest side of the model domain and becomes shallower towards Cape Code in the northeast side of the model domain. Detailed bathymetric data specifications are provided in **Section I.3.3.1**.

I.2.2 Oceanography, Hydrology, and Meteorology Data

In the context of this study, oceanographic data refers to tides, currents, water levels, temperature, and salinity. Hydrology data refers to the inflows from the East River (New York Harbor), the Housatonic River, the Connecticut River, and the Thames River, which are included in the hydrodynamic model domain. Meteorologic data refers to wind data. The locations of these tidal stations key data sources employed in the study are shown in **Figure I.2-1**.

FIGURE I.2-1 DATA SOURCES



I.2.2.1 Tides

Across the study area, water levels fluctuate following a semidiurnal tidal cycle. The magnitude of tidal fluctuations varies significantly across the study area, with mean tidal ranges differing by as much as a meter across the study area.

I.2.2.1.1 Tidal Harmonics

Tides are created by the gravitational forces of the sun and moon pulling on the waters of the earth. These forces change as the relative positions of these interplanetary bodies shift. Tidal harmonics are mathematically represented by aggregate of harmonic constitutes. Each constituent is a cosine function, characterized by its period and amplitude to represent a periodic change or variation in the relative position of the Earth, Moon, and Sun. By superimposing the harmonic curves of all constituents at a given location, the tidal level at that location can be defined.

To characterize tidal harmonics in the open ocean, the Oregon State University TPXO9-atlas model was developed by Egbert and Erofeeva (2002). The database generated by the TPXO9-atlas model contains harmonic constituent data on a 1/30-degree resolution along all coastal areas, and at a 1/6-degree resolution across the globe. TPXO uses altimetry data and the Laplace Tidal Equations to generate the harmonic constituents of fifteen harmonic constituents, including primary, long-period, and non-linear constituents.

I.2.2.1.2 Tidal Observation Data

The NOAA Center for Operational Oceanographic Products and Services (CO-OPS) program operates a series of observation stations that record water level and atmospheric data at coastal sites across the country, eight of which lie within the model domain. Of these, measurements from four stations will be referenced in this study based on data availability and proximity to the Beacon Wind Project. General information on these sites is provided in **Table I.2-1** below. The tidal observation data was used for hydrodynamic model validation in this study.

TABLE I.2-1. NOAA TIDE STATIONS

NOAA Gage Name	Station ID	Year Established	Mean High Water (MHW)*	Mean Low Water (MLW) a/	Average Tidal Fluctuation
King's Point, NY	8516945	1998	3.25 ft (0.99 m)	-3.94 ft (-1.20 m)	7.15 ft (2.18 m)
Bridgeport, CT	8467150	1932	3.15 ft (0.96 m)	-3.61 ft (-1.10 m)	6.76 ft (2.06 m)
Montauk, NY	8510560	1947	0.66 ft (0.20 m)	-1.41 ft (-0.43 m)	2.07 ft (0.63 m)
Newport, RI	8452660	1930	1.57 ft (0.48 m)	-1.90 ft (-0.58 m)	3.48 ft (1.06 m)

Note: Elevations shown in the North American vertical Datum of 1988 (NAVD88)
Source: NOAA Tides & Currents

I.2.2.2 Current Observation Data

The Lease Area is located within the Mid-Atlantic Bight, which extends from Cape Hatteras, North Carolina to the Cape Cod region of Massachusetts. The Mid-Atlantic Bight is a coastal region where both warmer tropical waters brought northward by the Gulf Stream and cooler arctic waters flowing southward via the Labrador Current can be observed.

Two datasets of measured currents collected near the submarine export cable routes were identified for use of the hydrodynamic model validation (**Figure I.2-1**). Both datasets were collected using semi-permanent moorings outfitted with Acoustic Doppler Current Profilers (ADCPs), which measure the magnitude and direction of velocity at defined depth increments throughout the water column.

As part of the University of Connecticut's Long Island Sound Integrated Coastal Observing System (LISICOS), a series of moorings are deployed throughout Long Island Sound to collect a suite of measurements, including atmospheric, wave, current, and nutrient data. As part of their data access program, LISICOS has partnered with various regional and federal agencies to share some measurements with larger observatory programs, such as the NOAA National Data Buoy Center (NDBC). The Central Long Island Sound (CLIS) NDBC Station (No. 44039) is a LISICOS mooring from which weather and atmospheric data can be publicly accessed through the NDBC website. In addition to its atmospheric sensors, the mooring is also outfitted with a surface-mounted RDI 600kHz ADCP unit, which measures currents through the approximately 30 meters of depth at the mooring's location. Observed current profile measurements collected at this mooring during the months of December 2018 to February 2019 were provided by the principal investigator of the LISICOS project, Dr. James O'Donnell of the University of Connecticut (O'Donnell 2021).

A similar dataset was collected from a mooring south of Block Island as part of the Rhode Island Ocean Special Area Management Plan (OSAMP) initiative (Grilli, et al. 2010). As part of the OSAMP initiative, several moorings were deployed within Rhode Island State Territorial Waters between 2009 and 2010. These moorings were outfitted with ADCP sensors that collected depth-variable velocity profiles throughout the water column at the mooring location. While several buoys were deployed as part of this project, data from only one of the moorings (Station MD-S) is publicly available, with observed currents between October 2009 and October 2010, to support the validation of the hydrodynamic model.

I.2.2.3 Temperature and Salinity

Ocean water's density is controlled primarily by temperature and salinity. Twenty years of temporal and spatial distributions of salinity and temperature were included in the long-term hydrodynamic hindcast database developed by DHI Group (DHI Group 2021). The values used for this study, a water temperature of 20 degrees Celsius and salinity of 32 practical salinity units (PSU), are based on spatial and temporal averages of the data during the months of simulation.

I.2.2.4 Hydrology Data: Freshwater and Harbor Inflows

The southern New England shoreline is characterized by several major rivers that discharge into the Long Island and Block Island Sounds, among them, the Housatonic River, Connecticut River, and the Thames River were included in this study. Further, the Long Island Sound connects at its eastern end to the New York Bight via the East River. The hydrodynamic interaction between the East River and Long Island Sound is critical to the hydrodynamics of this study as the Queens POI is situated within the East River.

I.2.2.4.1 New York Harbor & The East River

New York Harbor is known for its strong currents, induced by the region's topography and the influences of tide. The East River is a salt water tidal estuary that connects New York Harbor and the Long Island Sound. Due to differences in the timing of tides between Long Island Sound and the Upper New York Bay in Atlantic Ocean, high-velocity tidal currents have been observed in the river with average peak velocities around 6.6 feet per second (ft/s) (2 meters per second [m/s]) (Gunawan, Neary and Colby 2014). As such, the East River inflow is a critical boundary condition to the modeling of the hydrodynamics in the western end of the Long Island Sound.

As part of its Physical Oceanographic Real-time System (PORTS), NOAA maintains a set of regional operational forecast systems that provide real-time "nowcasts" and forecasts of water levels and currents in port areas across the country. The Port of New York and New Jersey Operational Forecast Model System, abbreviated as NYOFS, receives inputs of real-time water level and wind observations across the New York and New Jersey Harbor to generate hourly "nowcast" predictions of real-time currents and water levels across the Harbor.

The NYOFS program is based on a three-dimensional hydrodynamic model that uses the Princeton Ocean Model framework to compute water levels and sigma-layered velocities on a spatially varying horizontal grid with resolution varying from 1,640 to 3,280 ft (150 to 1,000 m) (Vincent, et al. 2002). The domain of the NYOFS model is shown in **Figure I.2-2**. The results of the hourly "nowcast" model are published to a page on the NOAA PORTS website for public use. In addition, full Network Communication Data Form (netCDF) files containing the model output from the hourly NYOFS nowcast simulations are archived to the NOAA National Centers for Environmental Information (NCEI) servers. These archived model result files are available from the beginning of NYOFS operation in mid-2014 through to the present day.

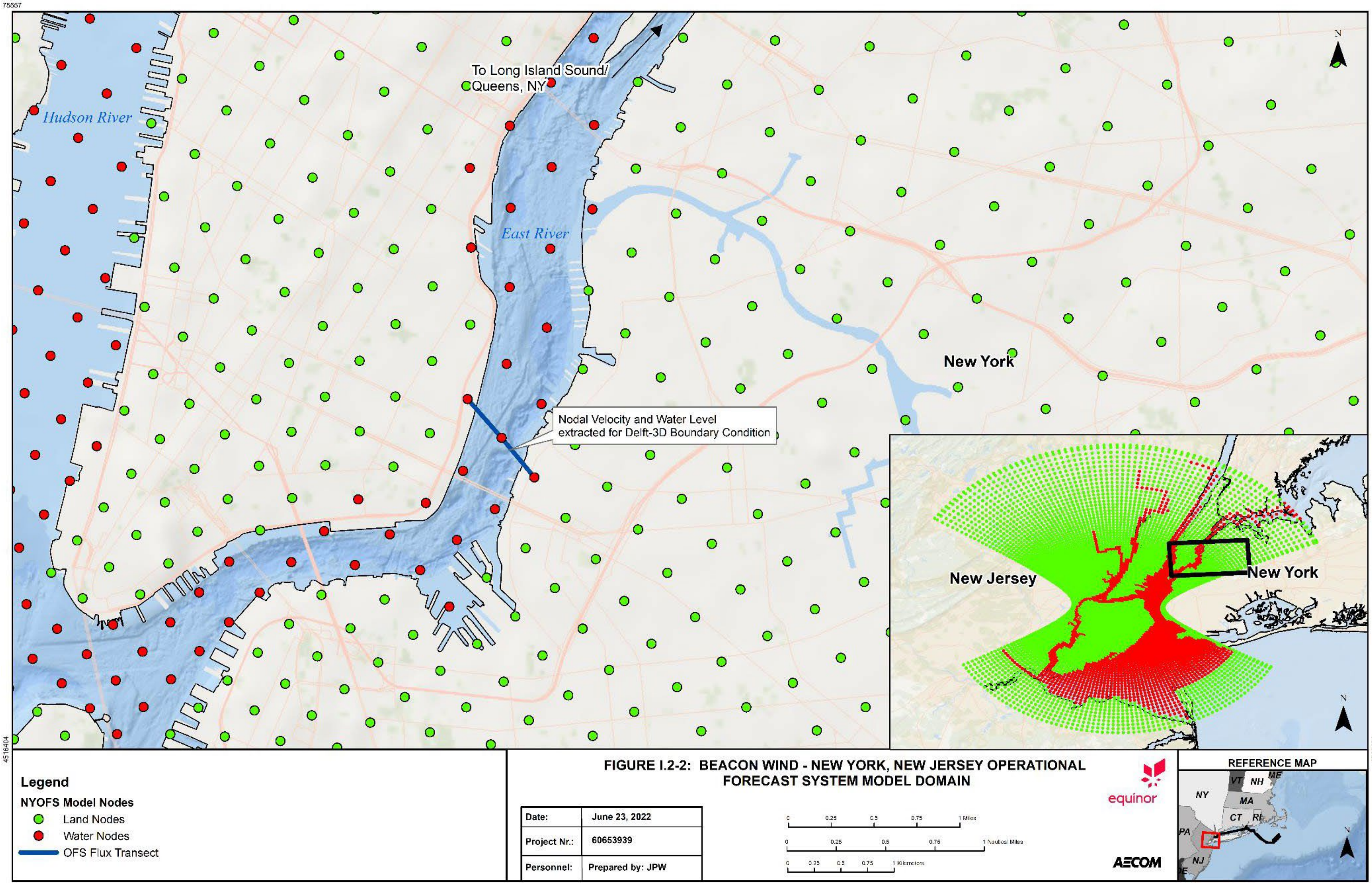
I.2.2.5 Meteorological Data: Wind

Multiple NOAA NDBC stations located within the Project domain have recorded wind speed and direction for the past decade. Based on data availability and proximity to the model domain, NDBC Stations 44020, 44008, 44017, 44022, 44039, and BUZM3 were selected for this study (NOAA 2021). Wind data at these stations was obtained from an anemometer located at varying elevations above sea level, as shown in **Table I.2-2**. The locations of these wind stations are shown in **Figure I.2-1**. Detailed analysis of the wind data is provided in **Section I.3.3.5.4**.

TABLE I.2-2. WIND DATA SOURCES

Station Name	Station ID	Anemometer Height, meters above Mean Sea Level (MSL)
Nantucket Shoals	44008	4.1
Montauk Point	44017	4.1
Nantucket Sound	44020	4.1
Execution Rocks	44022	3.5
Central Long Island Sound	44039	3.5
Buzzard's Bay	BUZM3	24.8
Source: National Data Buoy Center		

FIGURE I.2-2 NEW YORK, NEW JERSEY OPERATIONAL FORECAST SYSTEM MODEL DOMAIN



I.2.3 Seabed Texture and Sediment Grain Size Data

Seabed roughness is a critical input parameter to the hydrodynamic model and the sediment grain size distribution is used in sediment transport modeling.

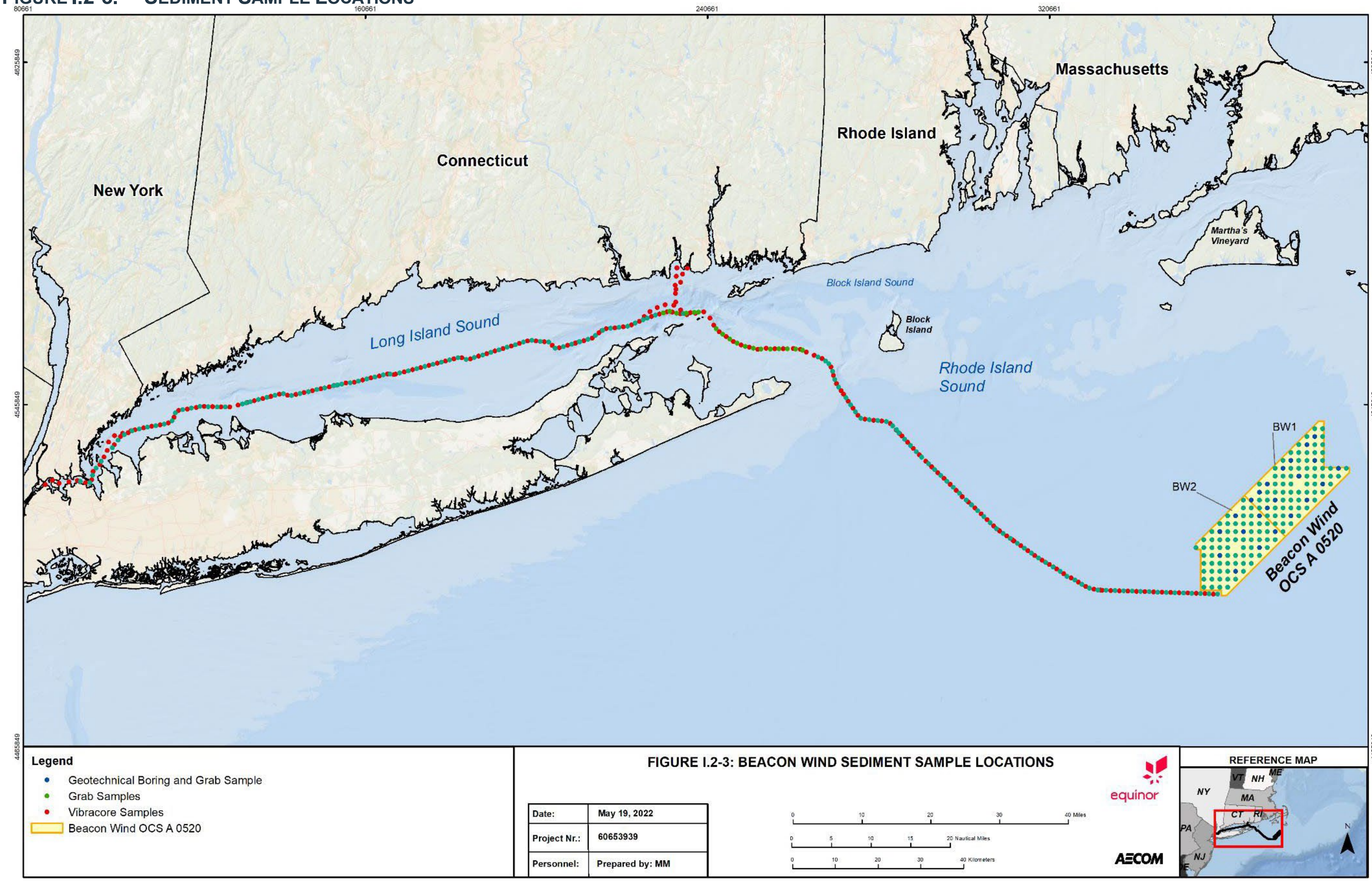
I.2.3.1 Seabed Texture Data

To define the seabed roughness coverage in the study area, the USGS East-Coast Sediment Texture Database was referenced. This database contains information on the collection, location, description, and texture of surficial sediment samples collected along the coast of the US (USGS 2014). The database contains over 28,000 data points across the US territorial waters, over 4,400 of which are located within the Beacon Wind hydrodynamic model domain. The sediment texture data was converted to seabed roughness coverage and is detailed in **Section I.1**.

I.2.3.2 Sediment Sampling & Analysis

To characterize the seabed sediments in the Project Lease Area and along the submarine export cable routes, extensive field sampling and laboratory analysis were conducted between 2020 and 2022 as part of the Beacon Wind Project. Field activities included the collection of surficial grab samples along the submarine export cable routes and within the Lease Area, along with vibracore sampling that was conducted along the full length of the submarine export cable routes. In addition, a portion of data from Project geotechnical borings performed in the Lease Area, was used to support the sediment transport analysis, where applicable. The locations of all the sampling activities are shown in **Figure I.2-3**.

FIGURE I.2-3. SEDIMENT SAMPLE LOCATIONS



I.2.3.2.1 Export Cable Route Vibracore Data

Vibracore samples were collected every 1.24 mi (2 km) along the submarine export cable routes to obtain unconsolidated, undisturbed sediment cores for physical characterization. Samples were collected to a target depth of 6 ft (2 m) at each sample location. Unique samples obtained from the top 2 ft (0.61 m) and the underlying 4 ft (1.22 m) of each sediment core were analyzed for a range of physiochemical parameters, including grain size, bulk density and specific gravity. The grain size analysis was performed using the ASTM D6913/D7928 combined sieve and hydrometer test method. The 439 vibracore samples collected over the length of the submarine export cable routes were used to characterize the particles tracked within the sediment transport model.

I.2.3.2.2 Lease Area Surficial Grab Samples

A total of 170 surficial sediment grab samples were collected in the Lease Area at the proposed 155 turbine locations (155 primary samples and 15 duplicate samples). The grab samples retrieved the top 6 inches (15 cm) of sediment at each sampling location. Each grab sample was analyzed and characterized based on the Wentworth (1922) grain size classification.

I.2.3.2.3 Geotechnical Borings

Geotechnical investigations conducted in the Lease Area included laboratory testing of sediment samples collected from 5 CPTu (Piezocone Penetration Test) boreholes and 6 sampling bumpover boreholes. Samples collected from the geotechnical borings were analyzed for bulk and dry density according to ASTM D7263. For the purpose of characterizing the sediment in the Lease Area, only the samples taken from borings' surficial layer were referenced.

I.3 Hydrodynamic Modeling

I.3.1 Hydrodynamic Modeling Approach and Delft FM D-FLOW

The 3-D hydrodynamic analysis for this study was performed using the D-Flow module within the Delft 3D Flexible Mesh (FM) Suite (Delft FM) (Version 2021.05). Delft FM D-FLOW is a 3-D, sigma-layered, hydrodynamic model developed by Deltares. Delft FM D-FLOW applies the Navier Stokes equations for an incompressible fluid with Boussinesq and shallow water approximations using a finite volume (FV) spatial discretization and a finite difference (FD) temporal discretization. D-FLOW is often applied to wind and tidally dominated flows including coastal applications and accepts a wide range of inputs as boundary conditions and forcings to the hydrodynamic schema. These include:

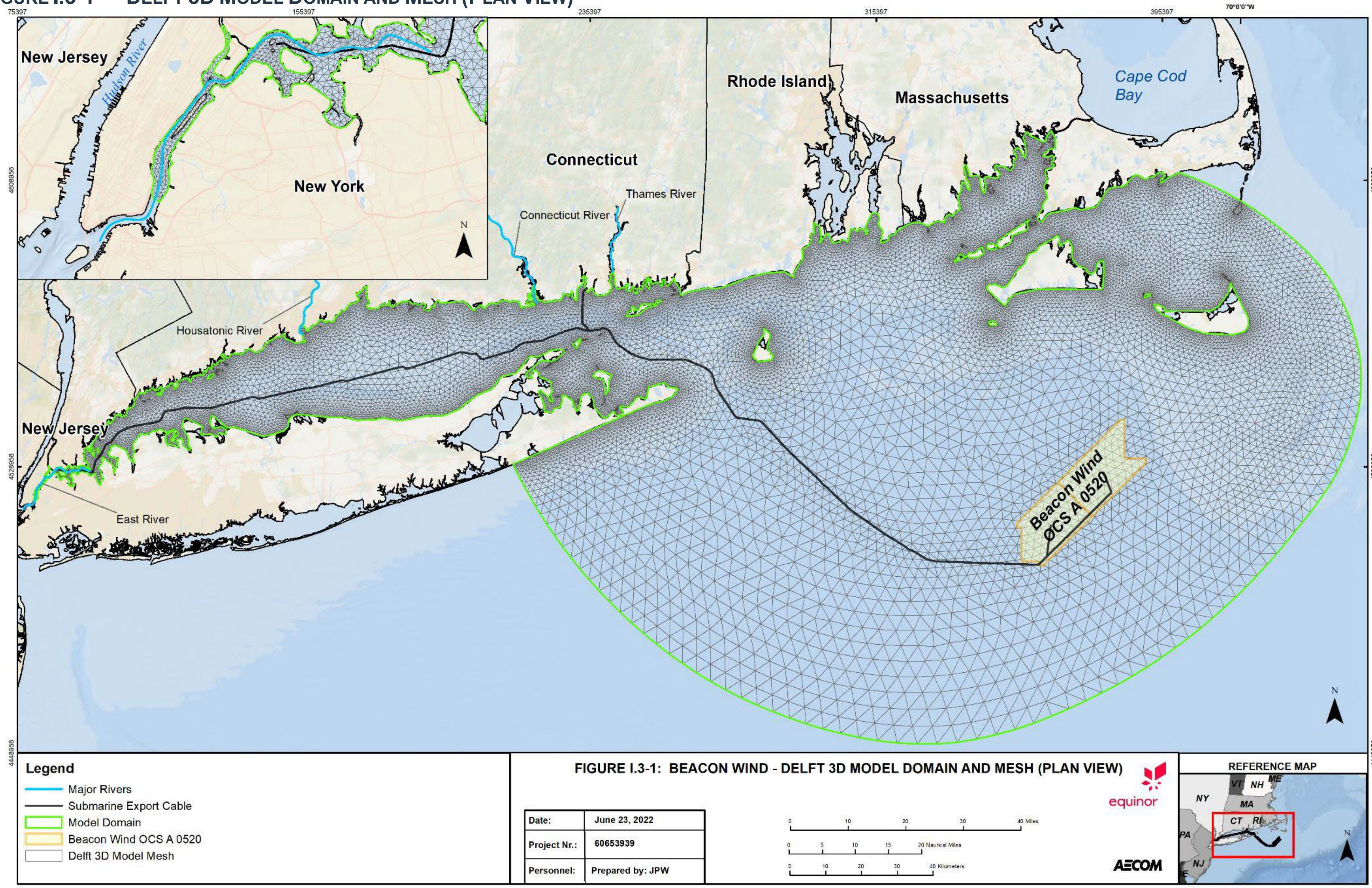
- Tidal harmonic forcing;
- Specified elevation and/or velocity time-series, as well as flow time-series;
- Surface stresses (wind and/or wave radiation stresses);
- Slip or no-slip boundary conditions; and
- Atmospheric pressure.

Notable input parameters to the hydrodynamic model include water levels and bed bathymetry, bed roughness, wind forcing, salinity and temperature, tidal harmonics, and river inflows. For this study, the hydrodynamic currents generated by Delft FM D-FLOW were used to drive a separate Langrangian PTM developed by the USACE (see **Section I.4** for more details).

I.3.2 Hydrodynamic Model Domain

The hydrodynamic model domain for this study extends from 40.19 to 41.75 degrees North to -73.99 to -63.59 degrees West using the WGS 1984 projection. The domain includes the entire Long Island Sound and a portion of the Southern New England OCS extending from the mouth of Long Island Sound to 40 miles east of the Lease Area and from the southern New England coastline to 30 miles south of the Lease Area. A portion of the East River, which connects the New York Harbor to Long Island Sound, is also included in the model domain. As described further in **Section I.3.3.5.3** of this appendix, flow through the East River was represented as a model boundary condition to account for the interaction between the New York Harbor and the Long Island Sound. The hydrodynamic model domain (plan view) is shown in **Figure I.3-1.**

FIGURE I.3-1 DELFT 3D MODEL DOMAIN AND MESH (PLAN VIEW)



The landward limits of the hydrodynamic model domain are made up of shoreline at MHW level using the NOAA Medium Resolution Shoreline dataset. On the open water side, the model boundary was set back away from the Lease Area and the submarine export cable routes to minimize any numerical instability in key Project areas due to the introduction of boundary conditions. Major islands in the study areas were captured as internal no-flow boundaries.

I.3.3 Hydrodynamic Model Development and Parameters

I.3.3.1 Topobathymetric Surface

Multiple sources of data from public domain and Project survey were referenced to create a composite model surface used in the Delft FM D-FLOW model and the PTM model. Project surveys were conducted by MMT Sweden AB between August 2020 and March 2021 (MMT Sweden AB 2021). A surveyor interceptor remotely operated vehicle (ROV) mounted with multibeam echo sounder (MBES), side scan sonar (SSS), sub-bottom profiler, and gradiometer equipment was used to collect the survey data.

To provide bathymetric coverage outside the boundaries of the Project surveys, data was referenced from several US government agencies and non-governmental organizations. In 2016, the USGS Coastal National Elevation Dataset (CoNED) program published a comprehensive digital elevation model of the New England region for emergency planning and modeling purposes. The CoNED Topobathymetric Model for New England covers a majority of the Delft FM D-FLOW domain, and so was chosen as the primary elevation dataset to be used in hydrodynamic modeling (USGS 2016). This dataset was supplemented by NOAA surveys of Long Island Sound and the mouth of the Connecticut River, as available (NOAA 2015, NOAA 2015, USGS 2013). Areas left out by the above-mentioned datasets were referenced using the General Bathymetric Chart of the Oceans (GEBCO), an open-source global bathymetric dataset provided by the International Hydrographic Organization and the British Oceanographic Data Centre (GEBCO 2020).

Source, datum, and resolution data for all bathymetric datasets used in this Project are listed below in **Table I.3-1.** The geospatial extent of each bathymetric data source is presented in **Figure I.3-2**. The resultant combined surface is shown in **Figure I.3-3**.

TABLE I.3-1. TOPOBATHYMETRIC DATASETS SELECTED FOR USE IN HYDRODYNAMIC MODELING

Dataset	Source Agency	Date	Resolution	Vertical Datum
CoNED Topobathymetric Model for New England	USGS	2016	1/9 arc-seconds	NAVD88
Survey H12013 Off the Entrance to the Connecticut River	NOAA	2013	6.56 ft (2 m) & 32.8 ft (10 m)	MLLW
Long Island Sound Pilot Area	NOAA	2014	3.28 ft (1 m)	MLLW
Long Island Sound Phase III Area	NOAA	2016	3.28 ft (1 m)	MLLW
Project Lease Area Survey	MMT Sweden AB	2020-2021	0.82 ft (0.25 m)	MLLW
Project Submarine Export Cable Routes Survey	MMT Sweden AB	2020-2021	0.82 ft (0.25 m)	MLLW

FIGURE I.3-2 TOPOBATHYMETRIC DATA SOURCE COVERAGE

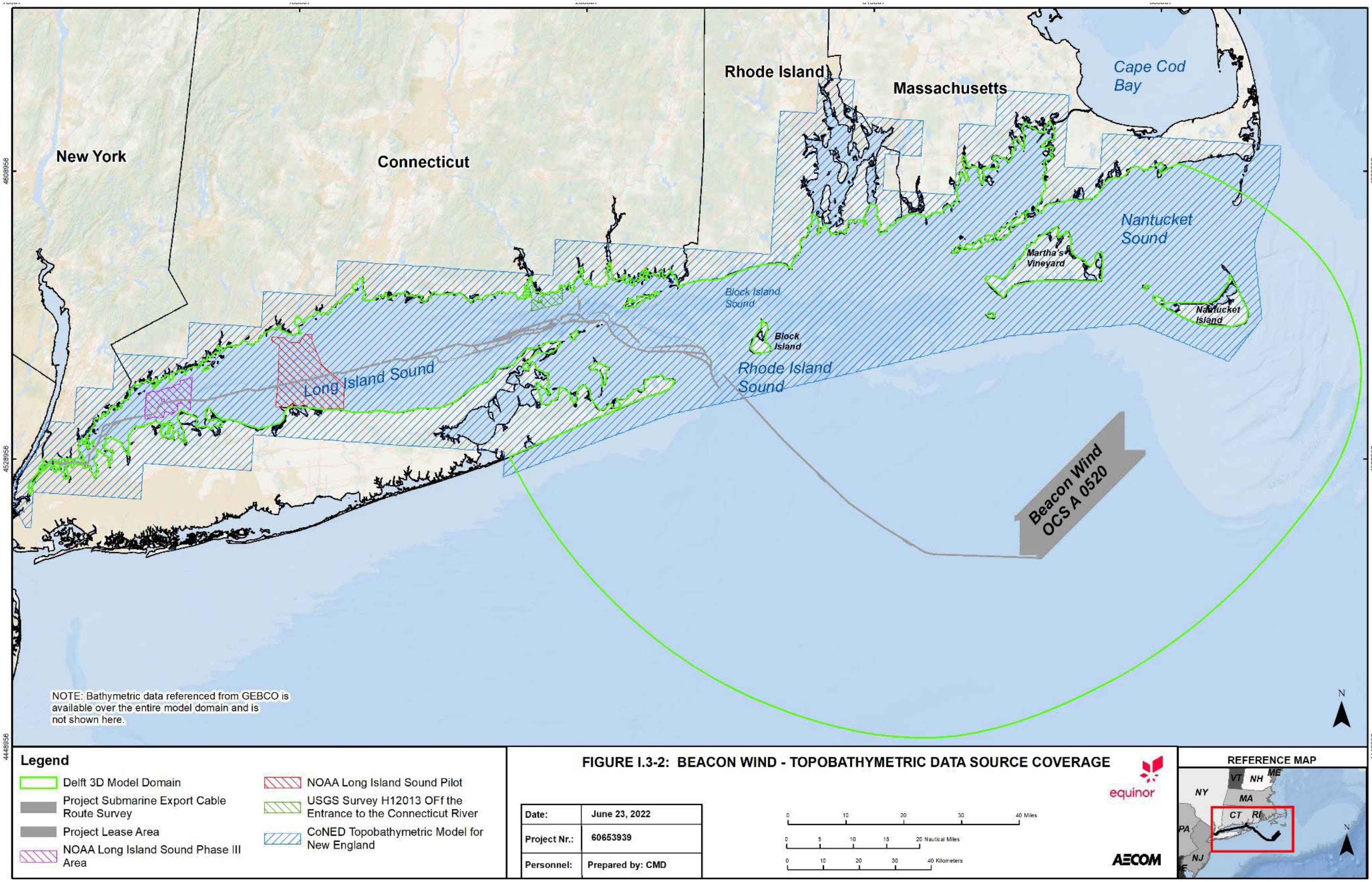
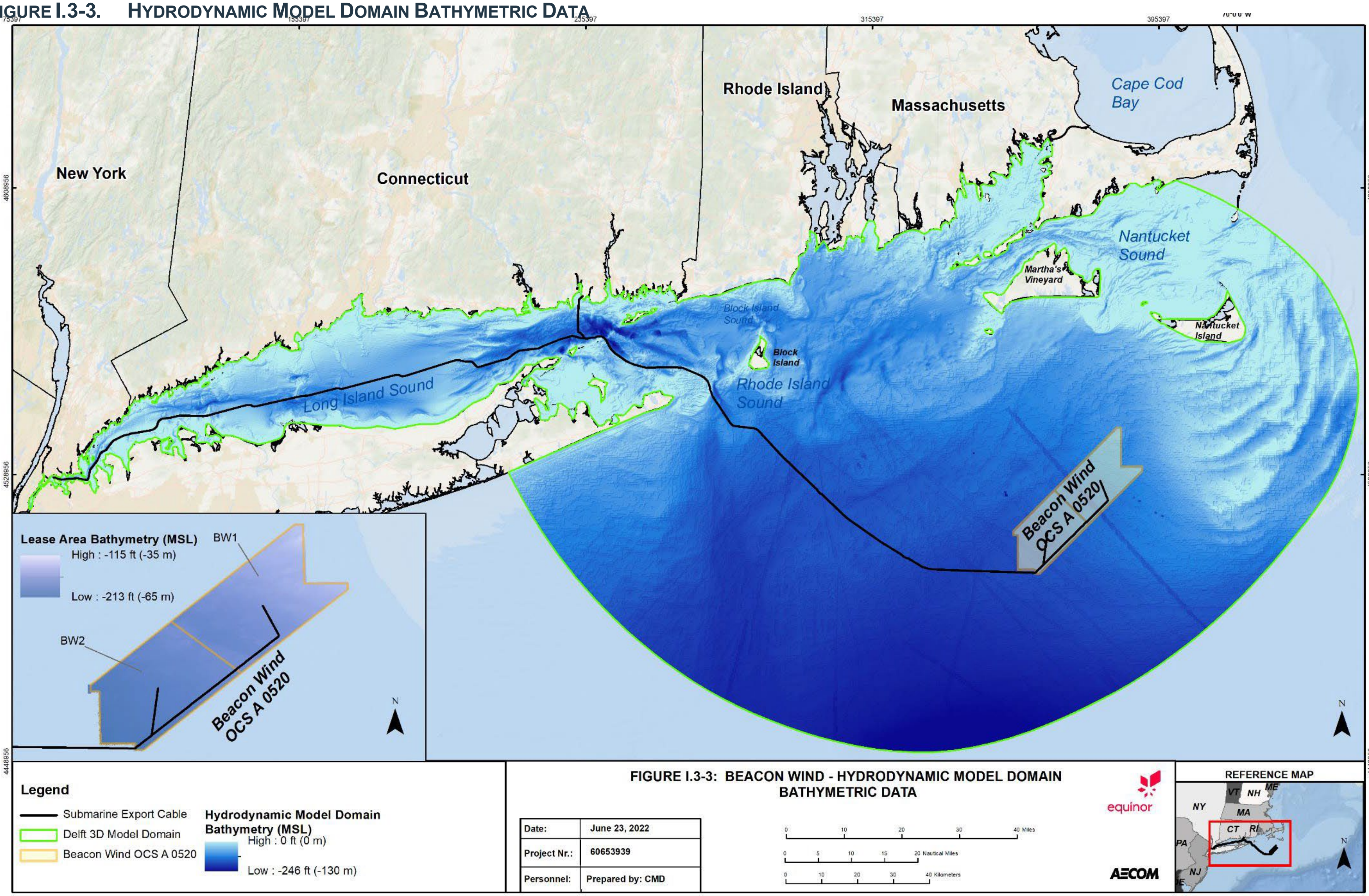


FIGURE I.3-3. HYDRODYNAMIC MODEL DOMAIN BATHYMETRIC DATA



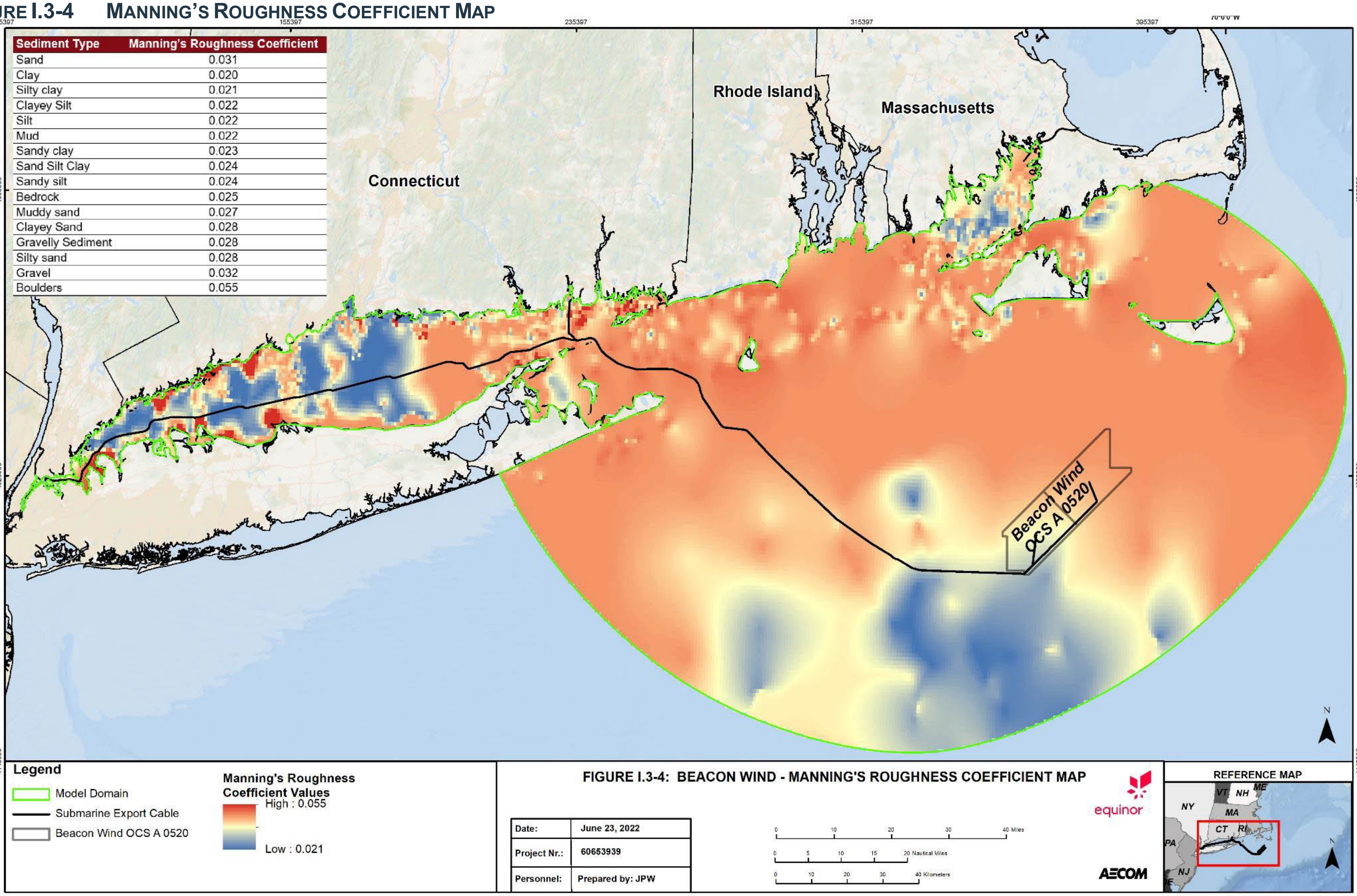
I.3.3.2 Seabed Surface Roughness

The Delft FM D-FLOW model requires the input of Manning's roughness coefficients to represent the seabed roughness characteristics in the model domain. The Manning's roughness coefficients were estimated from the USGS East-Coast Sediment Texture Database described in **Section I.2.3.1**. Based on the general textural classification provided by the USGS (clay, sand, boulders, etc.), Manning's roughness coefficients were assigned to each texture, following **Table I.3-2** below. The spatial distribution of Manning's roughness is shown in **Figure I.3-4.**

TABLE I.3-2. MANNING'S ROUGHNESS COEFFICIENTS APPLIED TO HYDRODYNAMIC MODEL

Sediment Type	Manning's Roughness Coefficient	Source
Sand	0.031	1
Clay	0.020	2
Silty clay	0.021	2
Clayey Silt	0.022	2
Silt	0.022	2
Mud	0.022	2
Sandy clay	0.023	2
Sand Silt Clay	0.024	2
Sandy silt	0.024	2
Bedrock	0.025	2
Muddy sand	0.027	2
Clayey Sand	0.028	2
Gravelly Sediment	0.028	2
Silty sand	0.028	2
Gravel	0.032	1
Boulders	0.055	1
Source: Benson & Dalrymple, 1967; Source 2: Fisher & Dawson, 2003		

FIGURE I.3-4 MANNING'S ROUGHNESS COEFFICIENT MAP



I.3.3.3 Horizontal Finite Element Mesh

The two-dimensional (2-D) planimetric finite element mesh applied to the Delft FM D-FLOW model was developed using a wavelength-based mesh approach, resulting in a mesh resolution that is inversely proportional to depth. High mesh solution was also applied in the vicinity of the Lease Area and along the submarine export cable routes to better capture the details of the site characteristics from the Project survey. The 2-D planimetric mesh developed for this study is shown in **Figure I.3-1** and contains a total of 33,529 elements and 18,821 nodes. The minimum node spacing is approximately 492 ft (150 m) and the maximum node spacing is approximately 16,404 ft (5,000 m).

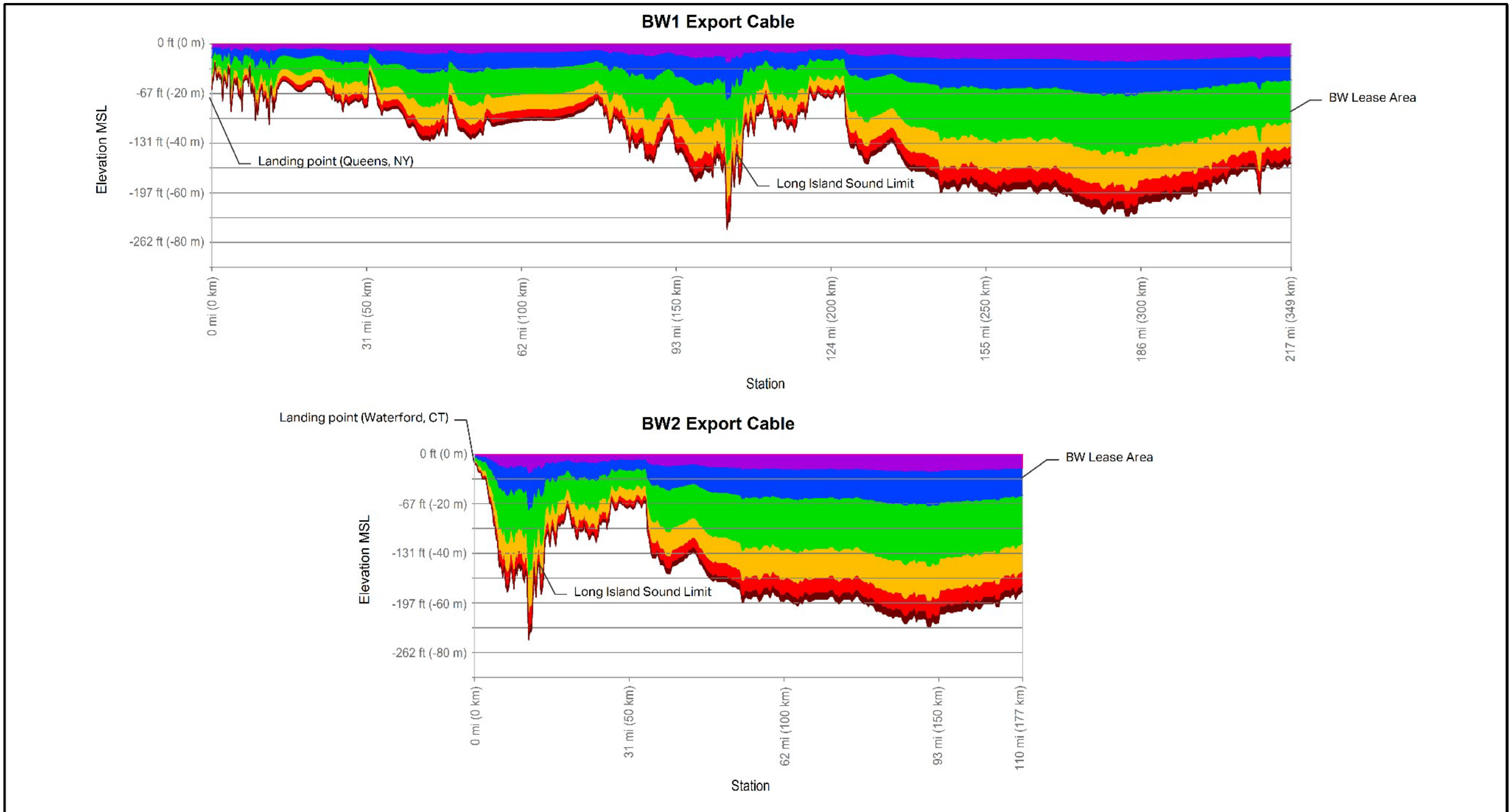
I.3.3.4 Vertical Sigma Layering

In the vertical dimension, Delft FM D-FLOW is layered. For this study a sigma-type layering was used to discretize the depth which is variable throughout planimetric model domain. In the sigma-layering scheme, each layer represents a specified percentage of total water column depth at that element. For this study, six layers were used to discretize the water column depth, each accounting for 5 percent, 10 percent, 20 percent, 35 percent, 20 percent, and 10 percent of the total depth, from seabed to the water surface. Finer vertical resolution was assigned to the bottom layers to achieve greater details in simulating currents in lower water column where sediment release take place. High resolution was also assigned to the top layers near the water surface to apply surficial wind input. The sigma layering scheme is demonstrated in **Figure I.3-5** along the BW1 and BW 2 submarine export cable routes.

I.3.3.5 Hydrodynamic Boundary Conditions

The hydrodynamic boundary conditions applied to the Delft FM D-FLOW model are shown in **Figure I.3-6** and summarized in the following sections.

FIGURE I.3-5 REPRESENTATIVE HYDRODYNAMIC SIGMA LAYERING ALONG THE SUBMARINE EXPORT CABLE ROUTES



Legend	
	Model Layer 6 (10%)
	Model Layer 5 (20%)
	Model Layer 4 (35%)
	Model Layer 3 (20%)
	Model Layer 2 (10%)
	Model Layer 1 (5%)

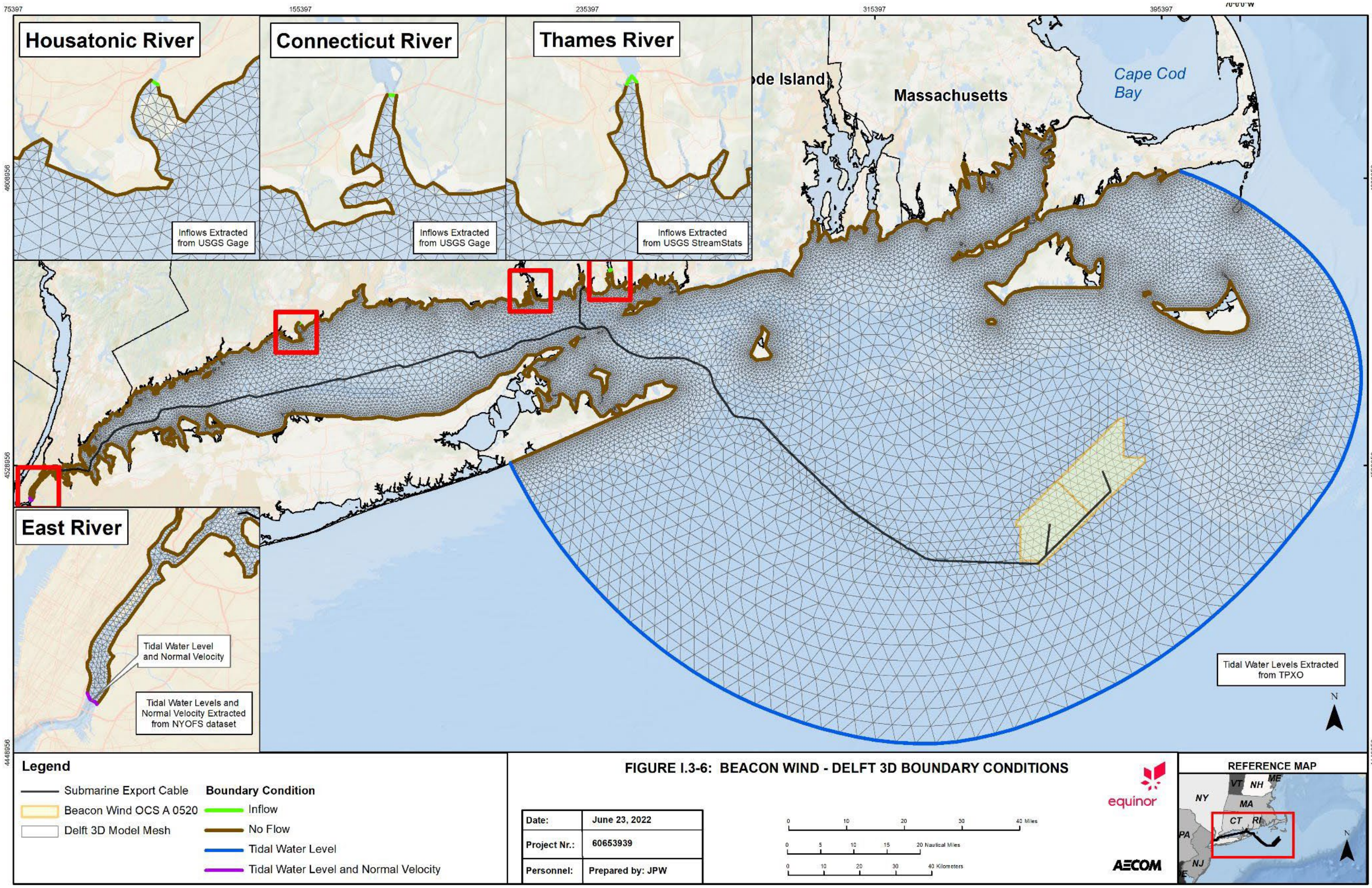
FIGURE I.3-5: REPRESENTATIVE HYDRODYNAMIC SIGMA LAYERING ALONG SUBMARINE EXPORT CABLE ROUTE

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: KMT

equinor

AECOM

FIGURE I.3-6 DELFT 3D BOUNDARY CONDITIONS



I.3.3.5.1 Open Ocean

As shown in **Figure I.3-6**, the open ocean boundary condition of the Delft FM D-FLOW model developed in this study stretches from South Hampton, New York to Harwich, Massachusetts. Along this boundary, the TPXO9-atlas tidal harmonics database described in **Section I.2.2.1.1** was used to define a periodic water surface elevation boundary condition. Following guidance from the USACE Engineering Research Development Center (ERDC), eight tidal constituents were used to define the tidal harmonics at the boundary. These constituents are summarized below in **Table I.3-3**. (Militello and Zundel 1999)

TABLE I.3-3. TIDAL HARMONIC CONSTITUENTS APPLIED TO HYDRODYNAMIC MODEL

Name	Abbreviation	Period, Solar Hour
Luni-Solar Diurnal	K1	23.93
Principal Lunar Diurnal	O1	25.82
Principal Solar Diurnal	P1	24.07
Larger Lunar Elliptic	Q1	26.87
Principal Lunar	M2	12.42
Larger Lunar Elliptic	N2	12.66
Principal Solar	S2	12.00
Luni-Solar Semidiurnal	K2	11.97
Source: Militello & Zundel, 1999		

I.3.3.5.2 Riverine Inflows

As shown in **Figure I.3-6**, three freshwater inflows described in **Section I.2.2.4** were defined as non-periodic riverine boundary condition. Two rivers, the Connecticut and the Housatonic, are monitored by live USGS gages (Nos. 01205500 and 01193050, respectively) that measure river discharge. For these rivers, the observed average daily flow from the USGS gage is applied as the boundary condition for each day modeled within Delft FM D-FLOW. As the Thames River is not monitored by a live gage for discharge, the USGS StreamStats (2021) was used to generate monthly estimates of median daily flow. These estimates were applied to Delft FM D-FLOW as the riverine boundary condition for the Thames River.

I.3.3.5.3 East River Boundary

As discussed in **Section I.2.2.4.1**, the archived datasets produced by the NYOFS nowcast system provide estimations of the magnitude and direction of currents as well as sea surface height (SSH) across the New York Harbor from mid-2014 through to present day. These parameters are reported at an hourly timestep at every node in the NYOFS model mesh. Normal velocity and SSH data from a transect of three nodes (as shown in **Figure I.2-2**) were applied to the model as the East River boundary condition.

I.3.3.5.4 Surface Wind Stress

Temporal trends in wind speed were analyzed at wind stations discussed in **Section I.2.2.5** over a ten-year time span (2010 to 2020). Data from these stations was analyzed to determine the wind conditions throughout the model domain and to select a representative time-series for the construction simulation.

The installation of the interarray and submarine export cabling was assumed to occur between the months of May and November, following the general timeline laid out in **Section I.1.5.2.** In the ten-year window of wind data analyzed, the year with the closest fit to the record average was 2016, as shown in **Figure I.3-7.** Here, the available annual records at each station are plotted against the record average at each station, with the 2016 data emphasized for comparison.

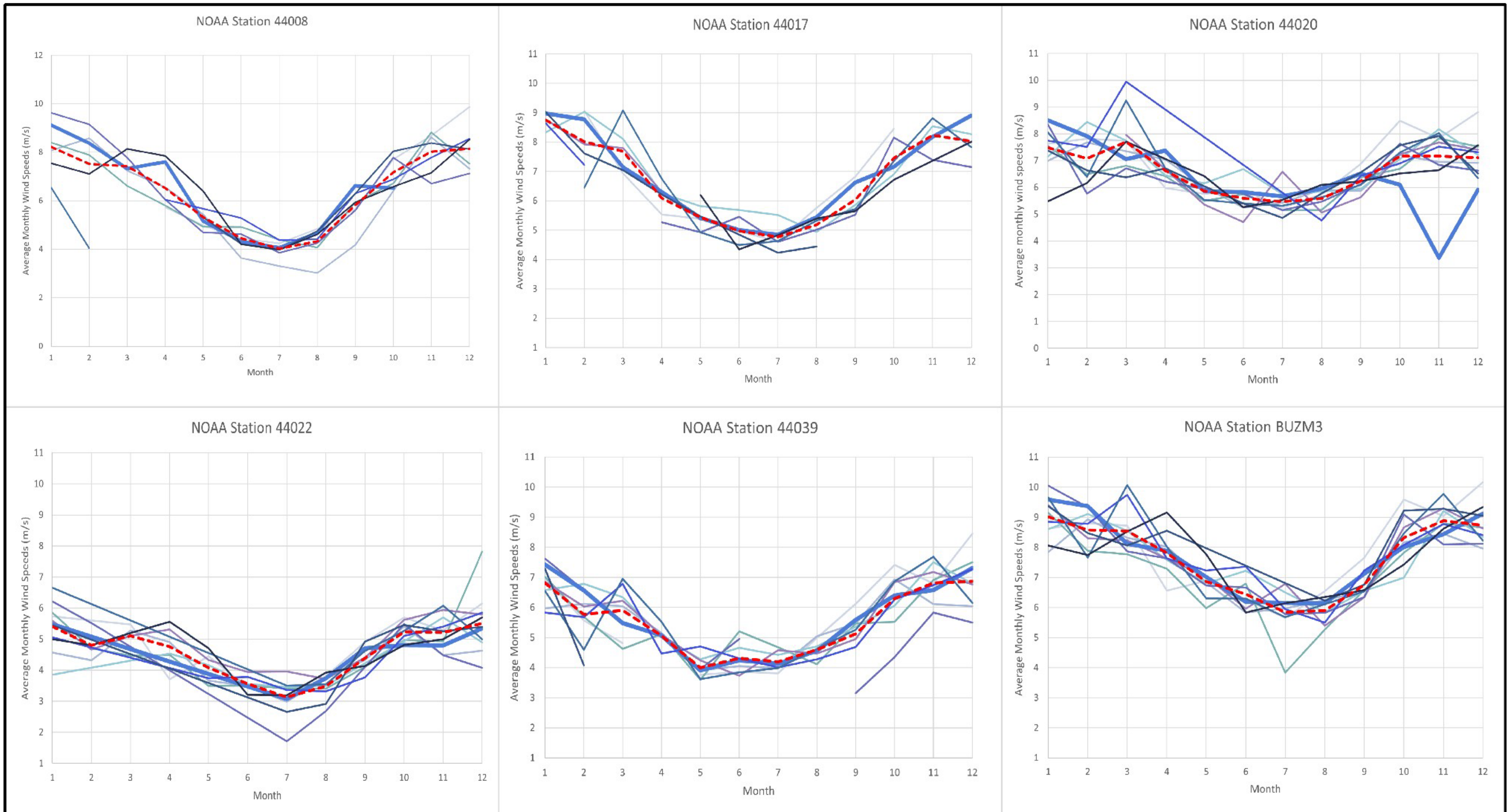
To apply wind stress in the Delft FM D-FLOW atmospheric pressure and the x- and y-components of wind velocity were applied to each node at an hourly timestep to allow the model to calculate the applied surface wind stress at the water surface. All wind stations provide atmospheric pressure measurements except NDBC stations 44039 and 44022, for which the NOAA NCEI Local Climatological Data (LCD) hourly pressure measurements recorded at the nearby Tweed New Haven (KHVN) and LaGuardia (KLGA) airports, respectively, were used. Wind data collected from the six wind stations discussed in **Section I.2.2.5** was converted to reflect standardized wind speed at 33 ft (10 m) above the water surface using the Wind Power Law, shown below. According to Hsu et.al. (1993), the appropriate exponent value for the law over the open ocean is 0.11.

$$\frac{u_2}{u_1} = \left(\frac{z_2}{z_1}\right)^P$$

Where u_i = wind speed at height i
z_i = elevation above MSL at height i
P = open ocean exponent value

Delft FM D-FLOW accepts the input of wind on an equidistant spaced grid. A ½ degree latitude by ½ degree longitude grid was developed, with each node assigned a weighting factor for each of the six wind stations based on inverse weighted distance, shown in **Figure I.3-8**. Note that the wind rose in the figure shows the distribution of wind speed and direction for the representative average year, 2016, for each wind station.

FIGURE I.3-7 WIND STATION AVERAGE MONTHLY WIND SPEEDS



Legend

Wind Data Year

- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- Record Average

Note: Gaps or missing average wind speeds indicate missing wind speed data from the NOAA station for the given year/month.

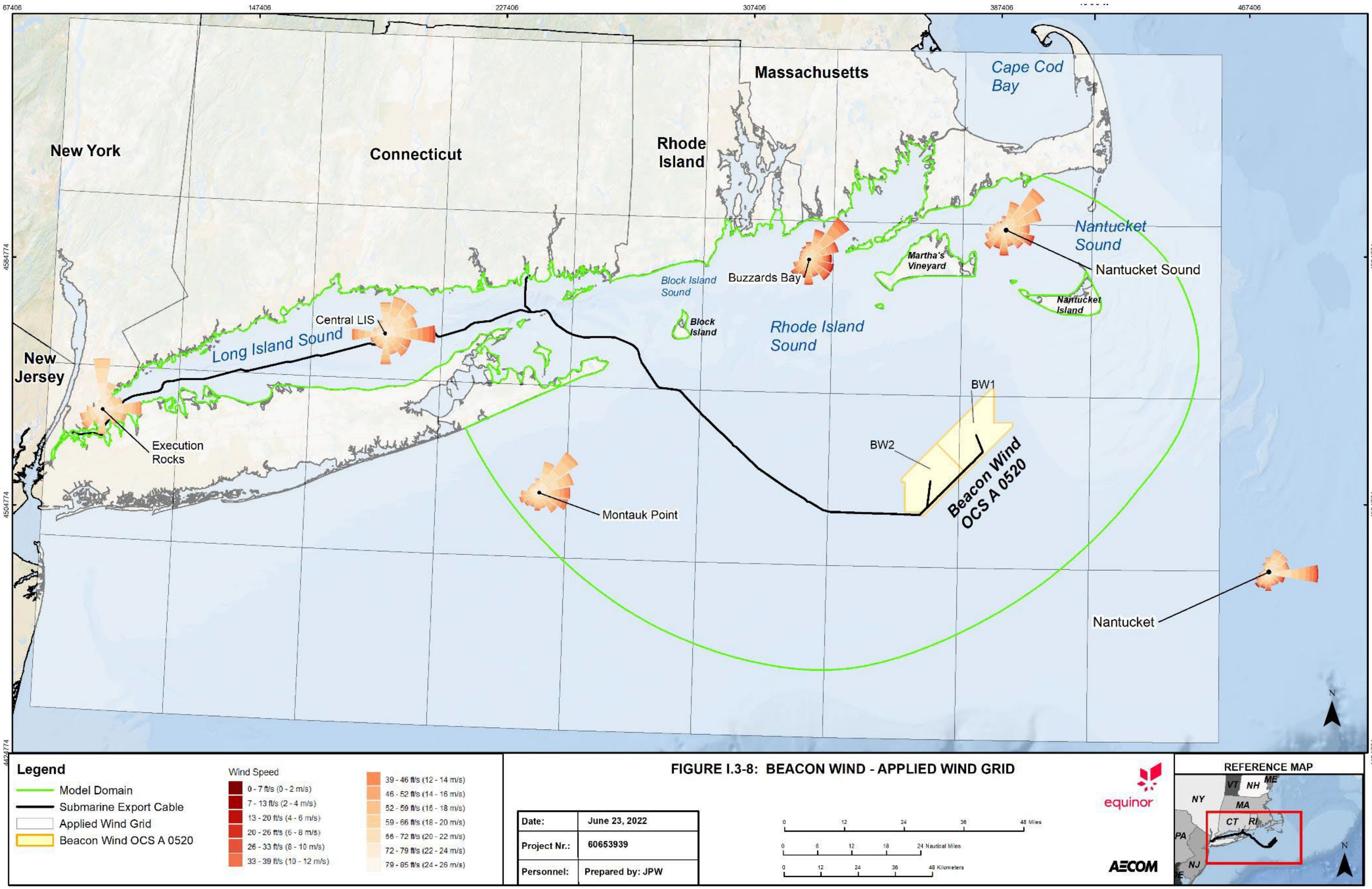
FIGURE I.3-7 : WIND STATION AVERAGE MONTHLY WIND SPEEDS

Date:	June 01, 2022
Project Nr.:	60653939
Personnel:	Prepared by: KMT

equinor

AECOM

FIGURE I.3-8 APPLIED WIND GRID



I.3.4 Hydrodynamic Model Validation

Before the Delft FM D-FLOW model was executed to simulate construction-phase hydrodynamics, the model was validated against two observed events. The validation runs were conducted for two monthlong periods, starting in September 2010 and in January 2019 respectively, based on the timeframes covered by the two measured current datasets described in **Section I.2.2.2**. The two parameters considered in model validation were currents and SSH, as measured at monitoring stations (as shown in **Figure I.2-1**).

I.3.4.1 Model Validation Timeframes

Table I.3-4 below summarizes the data availability for each validation period.

TABLE I.3-4. HYDRODYNAMIC MODEL VALIDATION DATA

Validation Period	September 2010		January 2019	
Time Frame	9/1/2010 to 10/1/2010		1/1/2019 to 2/6/2019	
Variables	SSH	Current	SSH	Current
King's Point, NY (NOAA: 8516945)	X		X	
Bridgeport, CT (NOAA: 8467150)	X		X	
Montauk, NY (NOAA: 8510560)	X		X	
Newport, RI (NOAA: 8452660)	X		X	
MD-S Buoy		X		
CLIS Buoy				X

I.3.4.1.1 2010 Validation Period

The first model validation period spans from September 1, 2010 to October 1, 2010, coinciding with the availability of current data collected by the MD-S buoy (see **Section 2.2.2**). This period also falls within the expected time of year for the installation of Project cabling. As the NYOFS dataset used to define the East River boundary condition does not include periods prior to 2014, representative data from a similar period (September 1, 2019 to October 1, 2019) was used to define the East River boundary.

I.3.4.1.2 2019 Validation Period

The second validation period spans from January 1, 2019 to February 6, 2019, coinciding with the availability of current data collected by the CLIS buoy (see **Section 2.2.2**).

I.3.4.2 Sea Surface Height Validation Results

SSH is inherently dependent on the tidal variation within the model domain over time. While critical across the entire model, special care was taken to validate SSH near the East River, where tidally variable velocities and water levels were applied as a boundary condition based on the NYOFS nowcast model. In addition, the BW1/BW2 Queens, New Yok POI is located immediately adjacent to the East River. Validation of SSH was performed by comparing simulated SSH time-series against the observation data.

I.3.4.2.1 2010 Validation Simulation

The modeled SSH from the 2010 validation closely matched the observed data at all four stations, as shown in **Figure I.3-9** and statistically demonstrated in **Figure I.3-10**. The timing of high and low tide coincides well between the modeled and observed datasets. **Figure I.3-9** plots modeled SSH against observed data at all time steps in the validation period at the four selected NOAA tide stations. The correlation coefficients (CCs) between the modeled and observed data shown in **Figure I.3-10** indicate that the model performed better near King's Point and Bridgeport than at Newport and Montauk. This is likely because the latter two tide gages are located near complex tidal bays that were not included in the model domain.

FIGURE I.3-9 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT RESULTS

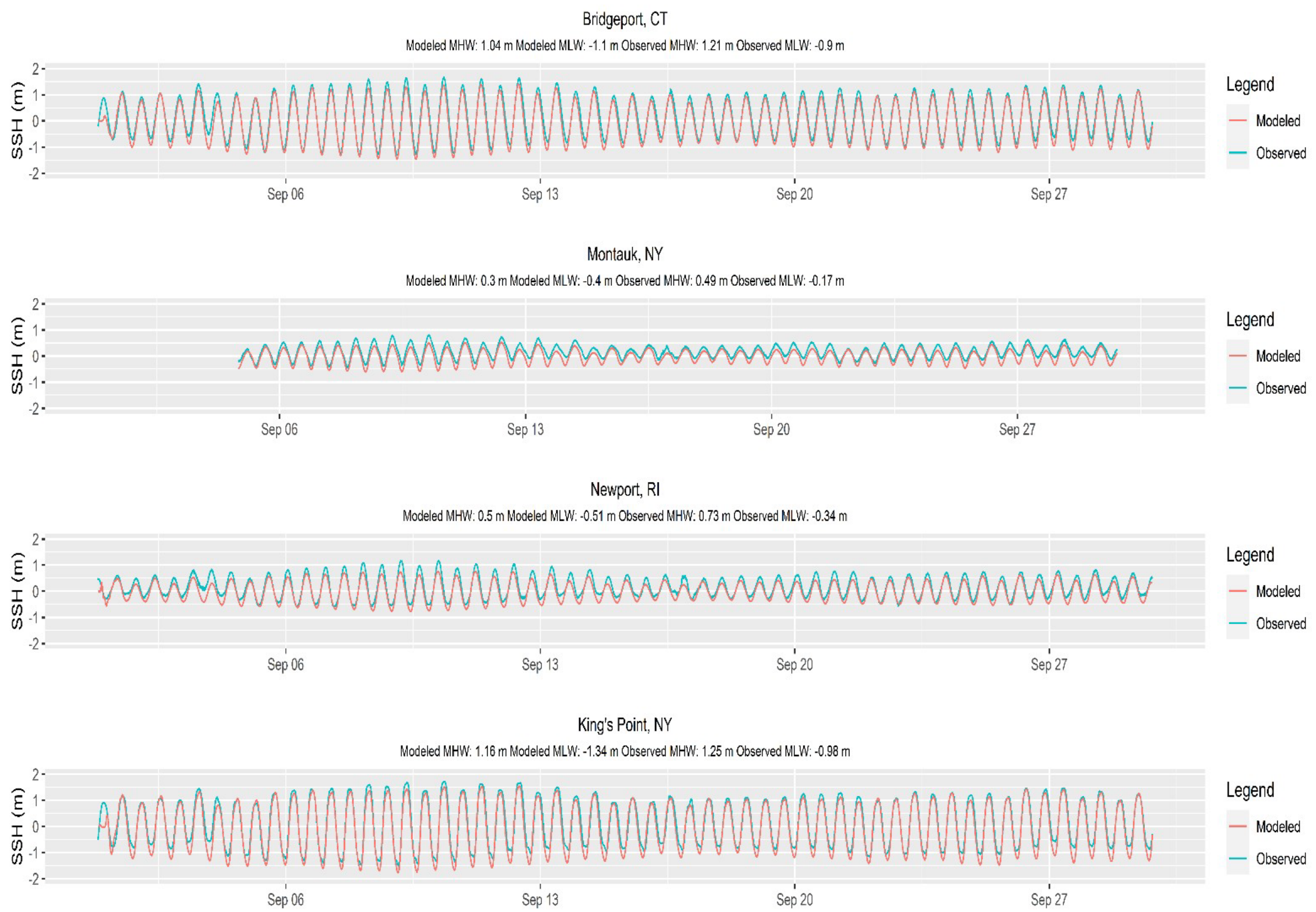


FIGURE I.3-9: 2010 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT RESULTS

Date:	June 03, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

FIGURE I.3-10. 2010 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT STATISTICS

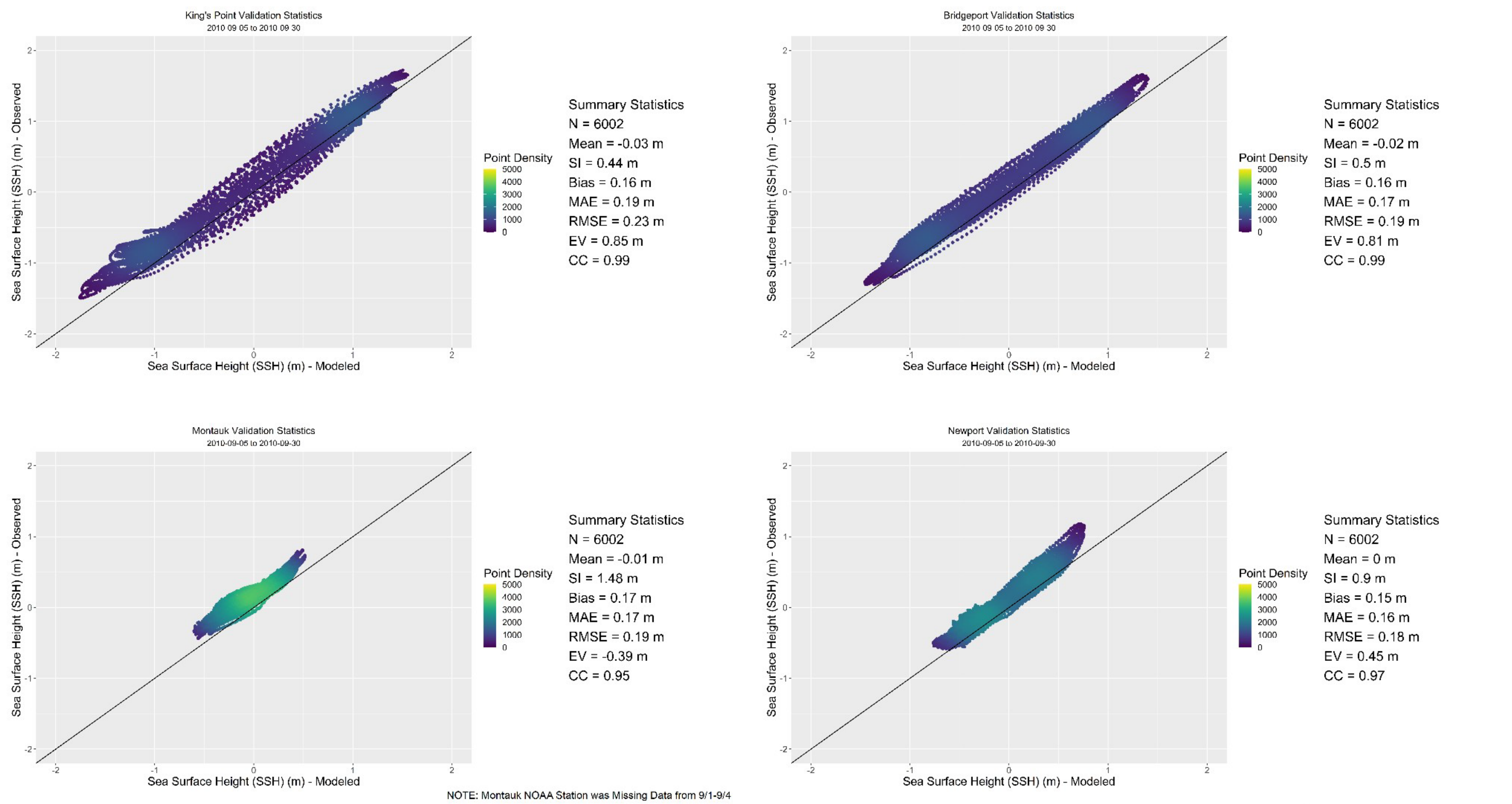


FIGURE I.3-10: 2010 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT STATISTICS

Date:	June 03, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

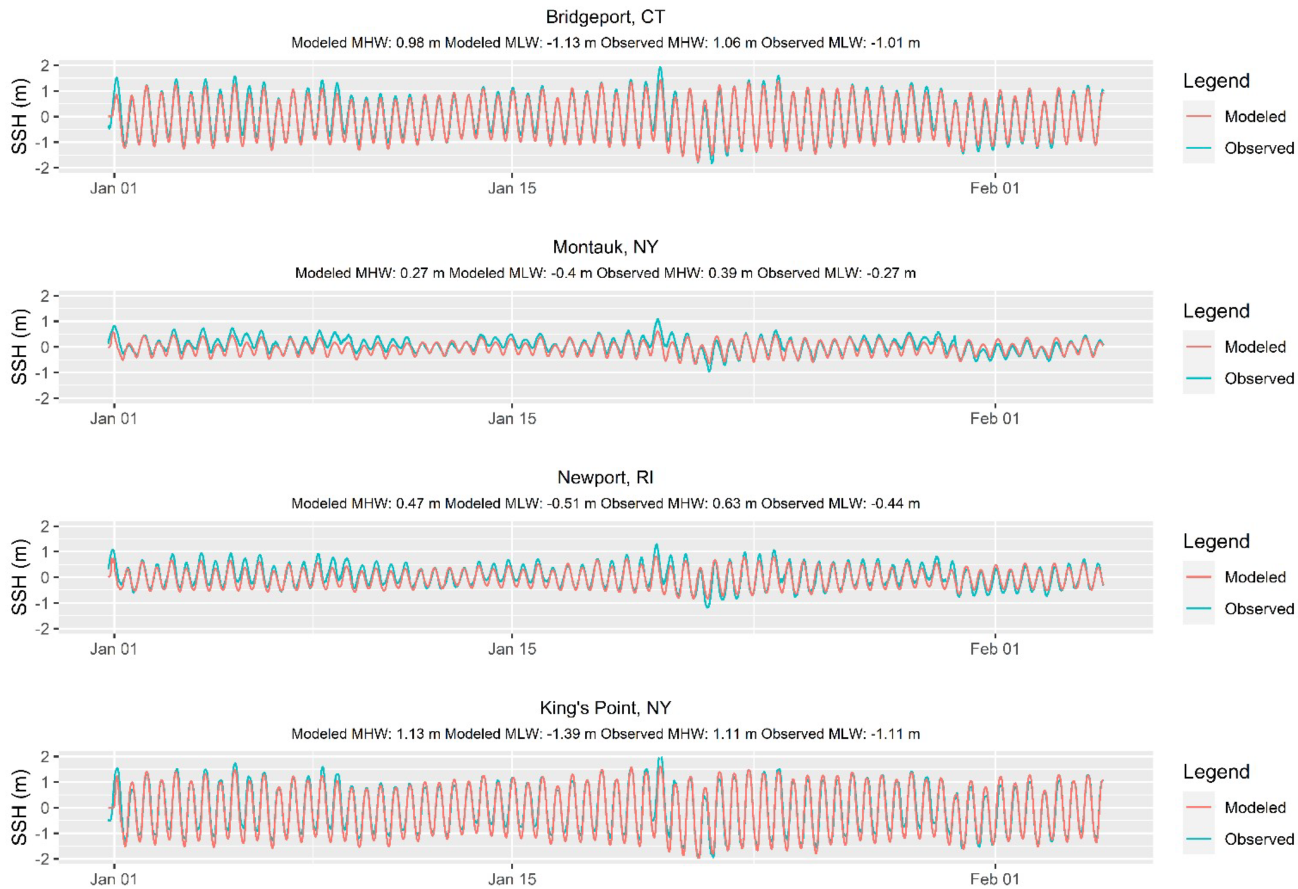
equinor

AECOM

I.3.4.2.2 2019 Validation Simulation

Similar to the 2010 validation simulation, modeled SSH from the 2019 validation simulation closely matched the observed datasets (**Figure I.3-11** and **Figure I.3-12)**. The timing of high and low tide again coincides between the modeled and observed datasets. Differentiation between modeled and observed SSH is more prominent in the 2019 validation run, partially due to the storm events occurring during the validation period, which were not fully captured by the model input data. For example, a spike in observed water levels can be seen at every station on January 20, 2019, due to a low-pressure storm system that was moving across the model domain at the time (NOAA 2019). The real-world effects of this storm system were not fully reproduced by the model because the condition was not reflected in the model input.

FIGURE I.3-11. 2019 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT RESULTS

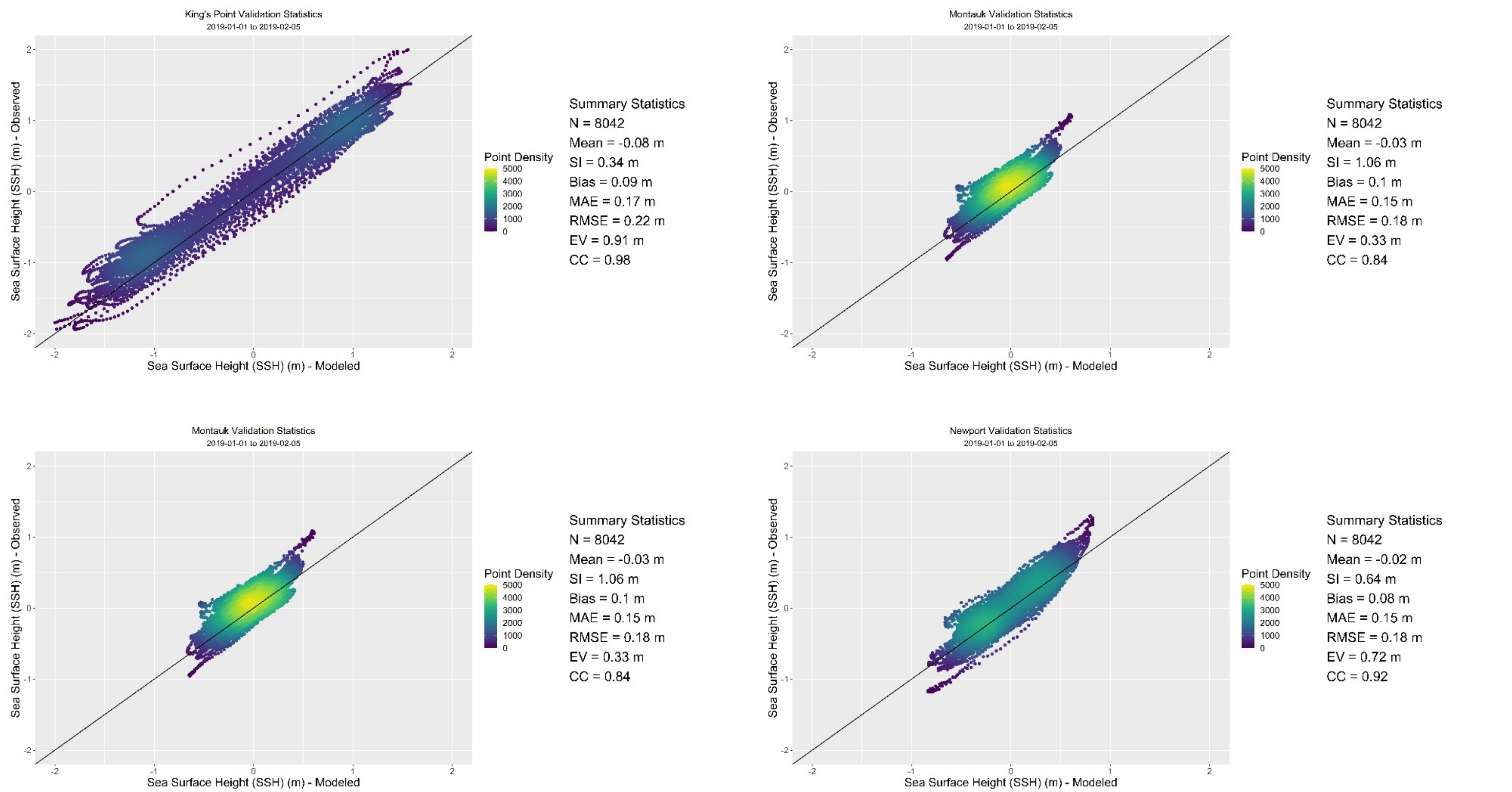


NOTE: Montauk NOAA Station was Missing Data from 9/1-9/4

FIGURE I.3-11: 2019 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT RESULTS

Date:	June 01, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

FIGURE I.3-12. 2019 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT STATISTICS



NOTE: Montauk NOAA Station was Missing Data from 9/1-9/4

FIGURE I.3-12: 2019 HYDRODYNAMIC VALIDATION SEA SURFACE HEIGHT STATISTICS

equinor

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

AECOM

I.3.4.3 Hydrodynamic Current Validation Results

The depth-variant magnitude and direction of currents was also a parameter that considered the validation of the Delft FM-Flow model. Currents within the model are influenced by tides, wind stress, and bottom friction, and are the driving factor in the sediment transport analysis described later in this appendix (see **Section I.4**). Model performance was evaluated through visual inspection of current roses produced from the model output and observed data as well as statistical comparison of observed and modeled magnitude.

I.3.4.3.1 2010 Validation Simulation

Model results from the 2010 validation simulation were compared to current observations collected at the MD-S buoy for the same time period, as shown in **Figure I.3-13** (depth-averaged current rose) **Figure I.3-14** (current rose by layer) and **Figure I.3-15** (current magnitude statistics). The Delft FM FLOW model succeeds in replicating the predominant directionality (WNW-ESE) measured at the MD-S buoy located south of Block Island, but overestimates these directions while underestimating the less dominant directions measured by the buoy. The model does not replicate the high magnitude currents reflected in the measurements, but the difference in mean current magnitude between observed and modeled data is less than 0.05 m/s for layers 2, 3, 4, and 5 where current observations are available at this buoy.

FIGURE I.3-13. 2010 HYDRODYNAMIC VALIDATION DEPTH-AVERAGED CURRENT VELOCITY RESULTS AT MD-S BUOY

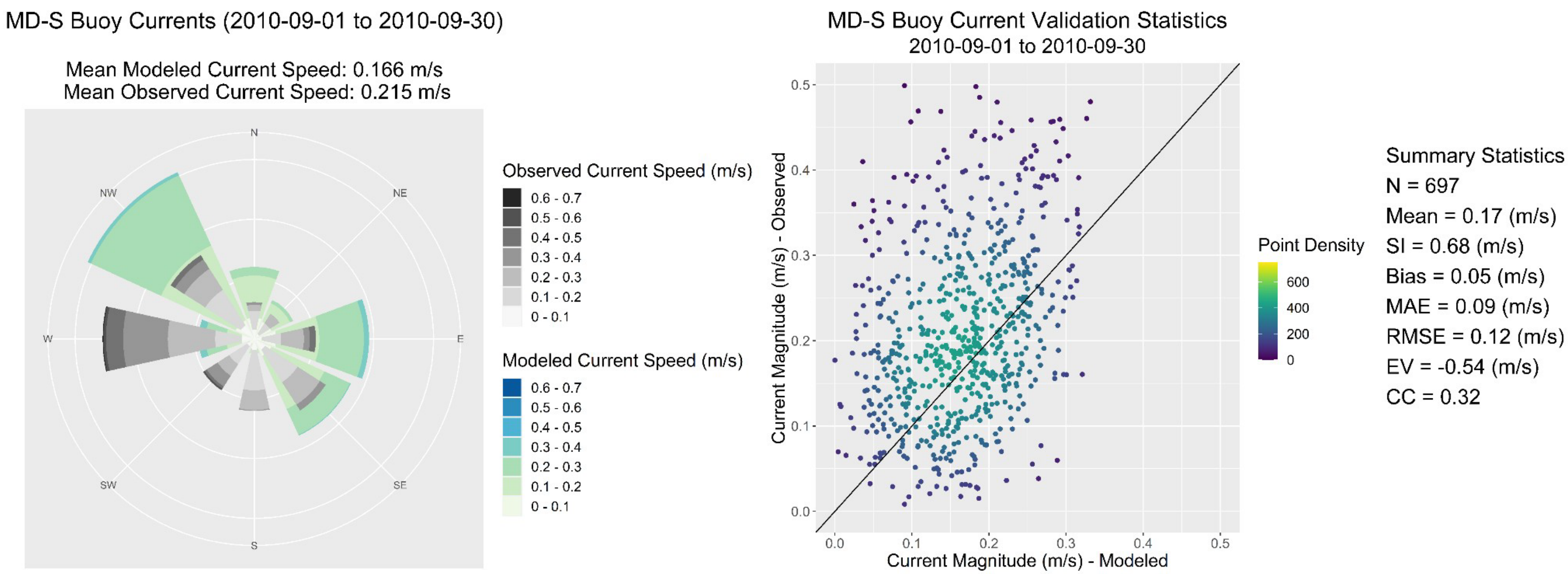


FIGURE I.3-13: 2010 HYDRODYNAMIC VALIDATION DEPTH-AVERAGED CURRENT VELOCITY RESULTS AT MD-S BUOY

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

FIGURE I.3-14. 2010 HYDRODYNAMIC LAYERED CURRENT VELOCITY RESULTS AT MD-S BUOY

NOTE: Layer numbering is from bottom to top.
Layer 1 is the near-bed layer and layer 6 is the near-surface layer.

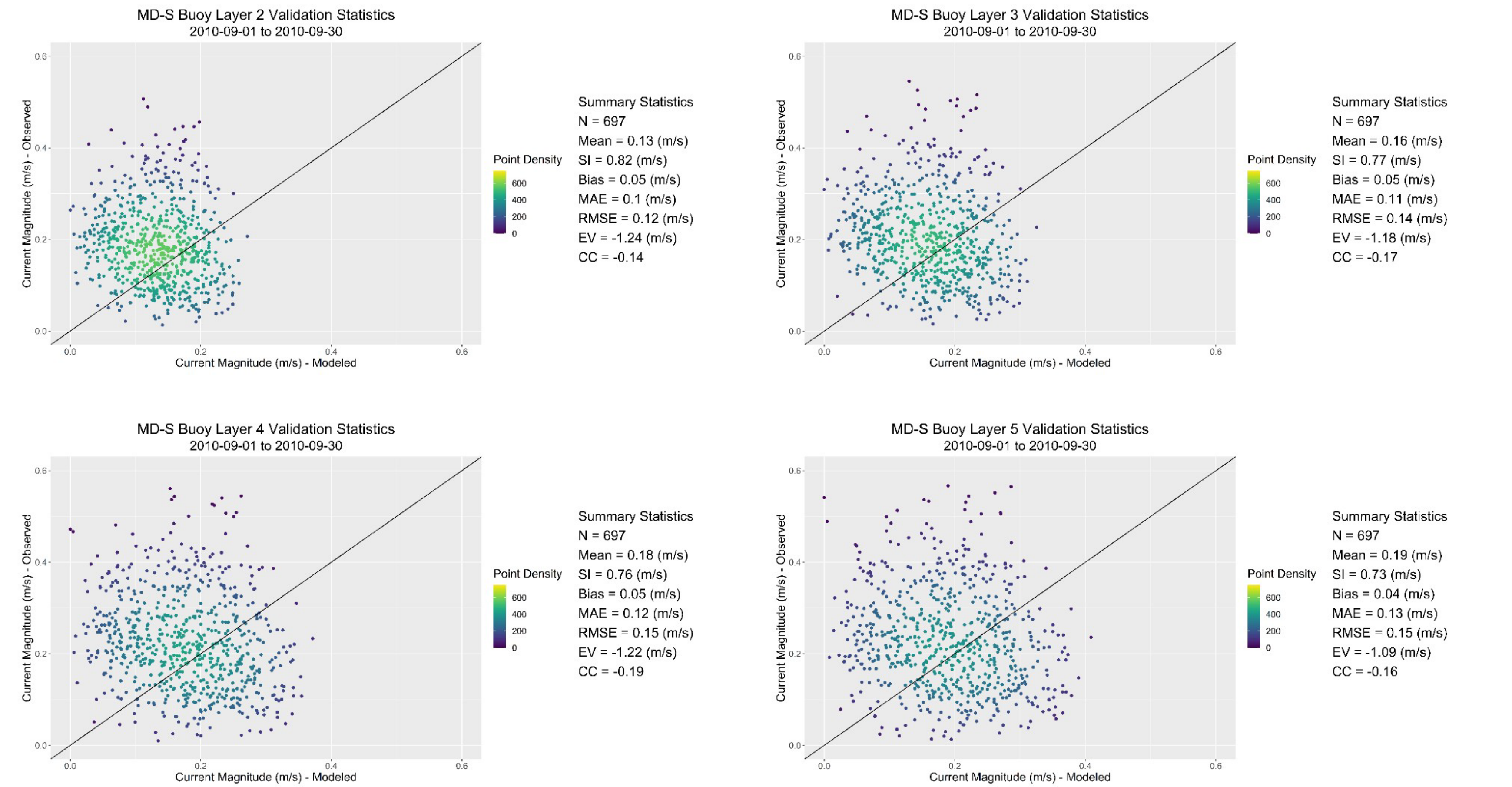
FIGURE I.3-14: 2010 HYDRODYNAMIC LAYERED CURRENT VELOCITY RESULTS AT MD-S BUOY

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

FIGURE I.3-15. 2010 HYDRODYNAMIC VALIDATION LAYERED VELOCITY RESULTS AT MD-S BUOY



NOTE: Layer numbering is from bottom to top.
Layer 1 is the near-bed layer and layer 6 is the near-surface layer.
NOTE: The 2010 current observations at MD-S are only available in depth range covering the model layer 2, 3, 4, and 5.

FIGURE I.3-15: 2010 HYDRODYNAMIC VALIDATION LAYERED VELOCITY RESULTS AT MD-S BUOY

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

I.3.4.3.2 2019 Validation Simulation

As shown in **Figure I.3-16** (depth-averaged current rose) **Figure I.3-17** (current rose by layer) and **Figure I.3-18** (current velocity comparison statistics), the modeled current data consistently reflect a predominant east-west current direction in all layers of the water column, which match the observations at the CLIS buoy. This directionality is driven by the orientation of the Long Island Sound, combined with the frequent tidal flushing that occurs through the Long Island Sound. A low-frequency southwest-northeast current signal that was detected by the CLIS mooring was not replicated in the Delft FM-FLOW model. At the CLIS buoy, the layer-specific CCs between the modeled and observed datasets varies from 0.3 to 0.35, with model performance improving with depth. Overall, the modeled data reasonably matches observed data at this buoy, and the difference in mean current magnitude between the two datasets remained below 0.08 m/s in layers 3, 4, and 5 where current observation data is available at this buoy.

FIGURE I.3-16. 2019 HYDRODYNAMIC VALIDATION DEPTH-AVERAGED CURRENT VELOCITY RESULTS AT CLIS BUOY

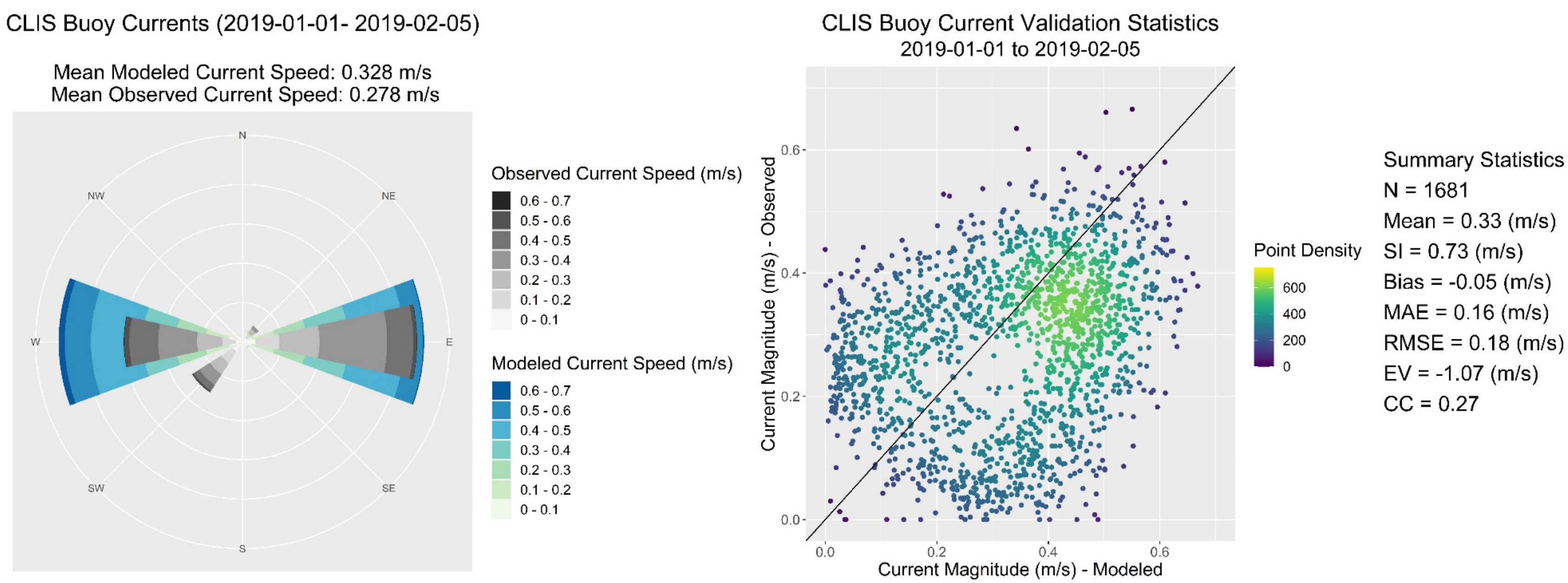


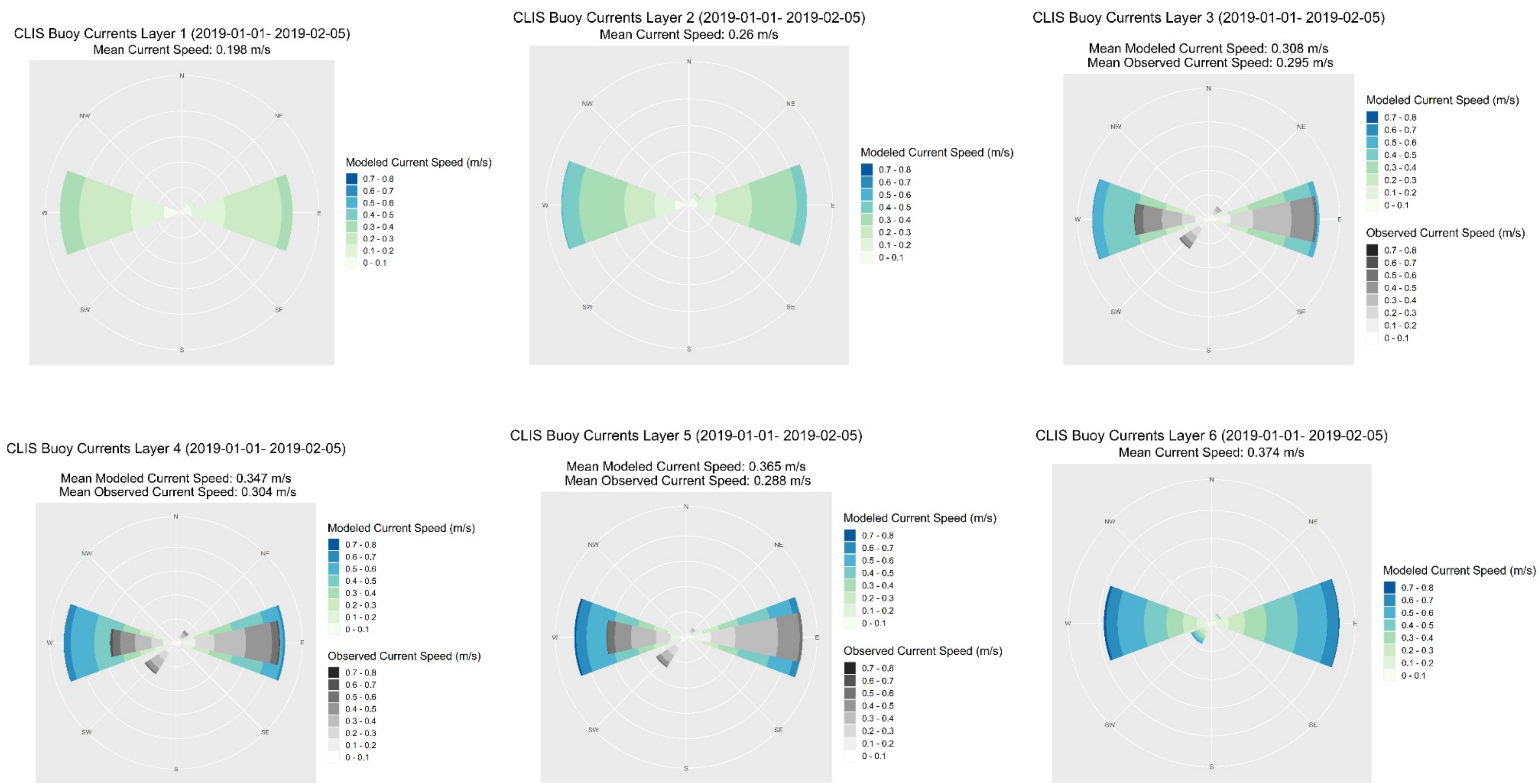
FIGURE I.3-16: 2019 HYDRODYNAMIC VALIDATION DEPTH-AVERAGED CURRENT VELOCITY RESULTS AT CLIS BUOY

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

FIGURE I.3-17. 2019 HYDRODYNAMIC LAYERED CURRENT VELOCITY RESULTS AT CLIS BUOY



NOTE: Layer numbering is from bottom to top.
Layer 1 is the near-bed layer and layer 6 is the near-surface layer.

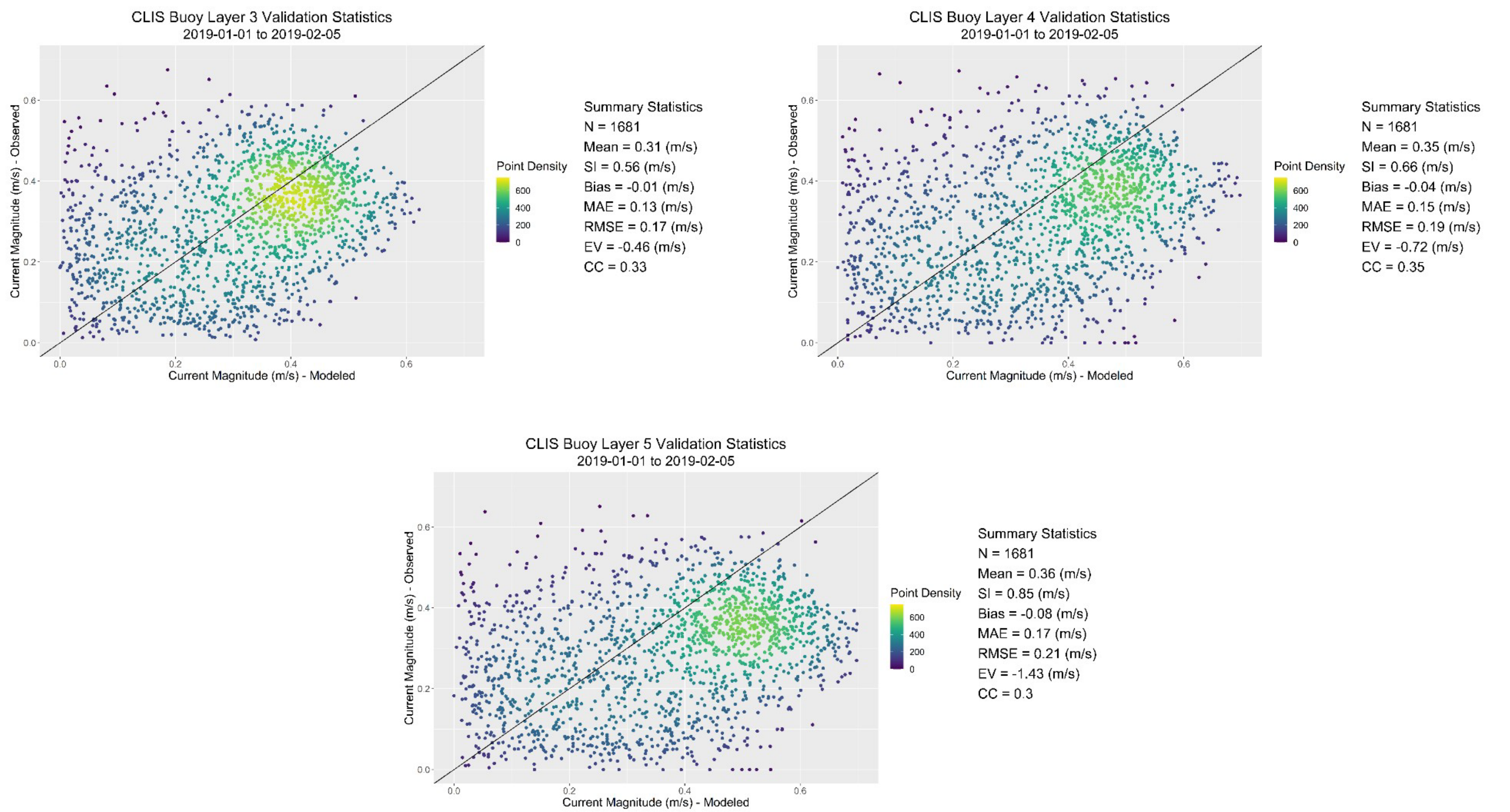
FIGURE I.3-17: 2019 HYDRODYNAMIC LAYERED CURRENT VELOCITY RESULTS AT CLIS BUOY

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

FIGURE I.3-18. 2019 HYDRODYNAMIC LAYERED VELOCITY STATISTICS AT CLIS BUOY



NOTE: Layer numbering is from bottom to top.
Layer 1 is the near-bed layer and layer 6 is the near-surface layer.
NOTE: The 2019 current observations at CLIS are only available in depth range covering the model layer 3, 4, and 5.

FIGURE I.3-18: 2019 HYDRODYNAMIC VALIDATION LAYERED VELOCITY STATISTICS AT CLIS BUOY

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: JPW

equinor

AECOM

I.3.5 Hydrodynamic Modeling of BW Construction

I.3.5.1 Construction Timeline

As mentioned in **Section I.1.4**, construction along the BW1 and BW2 submarine export cable routes are subject to TOY restrictions imposed across the state territorial waters of New Yok and Connecticut, as well as those associated with the Block Island SMA. Vessels passing through the Block Island SMA are speed-restricted to 10 knots or less from November 1st through April 30th to protect right whale migratory routes and calving grounds. Connecticut has imposed two dredging TOY restrictions (during which time dredging typically *cannot* take place, unless allowed through agency permitting and coordination) within state territorial waters from February 1st to May 31st and from April 1st to June 30th to protect winter flounder and anadromous fish, respectively. New York has imposed a standard dredge TOY restriction within state territorial waters from December 15th through September 15th to protect, winter flounder, anadromous fish, shellfish, and other species.

The expected schedule for submarine export cable route pre-sweeping and installation spans between May and November. Activities in May will include grapnel runs and debris clearing, which will result in minimal sediment disturbance. Submarine export cable route pre-sweeping activities are expected to take place primarily in New York waters and therefore cannot begin until the New York TOY restriction is lifted. Trenching and cable installation is expected to begin in June with the interarray cable, with work limited to Federal waters (where no TOY restrictions are applicable). Installation of the submarine export cables will begin in the Lease Area and progress eastward towards the landing point(s). Work within the Block Island SMA will take place outside any relevant TOY restrictions for the area. As the submarine export cable routes for both BW1 and BW2 pass through New York waters (and are subject to the New York TOY restriction), the modeling conducted in this study assumes that work in this area will be limited to September through November. Trenching for the submarine export cable within Connecticut waters will occur after trenching in New York waters, therefore we assume that it will be conducted outside the applicable TOY restrictions listed above**.**

I.3.5.2 Hydrodynamic Model Simulation and Results

The representative time period for hydrodynamic simulation for construction is between May 1st and November 30th, 2016. This time period was chosen to cover the anticipated dredge timeline discussed in **Section I.3.5.1**, and serves as a baseline for modeling until state permitting and agency coordination moves forward on the Project and these TOYs are further reviewed against the Project activities. The hydrodynamic model was executed using boundary condition and input data for this time period as described in **Section I.3.3.5**.

Figure I.3-19 and **Figure I.3-20** show the depth-averaged currents (magnitude shade and directional vectors) simulated by the hydrodynamic model at representative rising and falling tides (as measured at the Montauk, New York tide gage). **Figure I.3-21** shows the modeled currents in the near-bed layer and near-surface layer close to the Race at high tide (as measured at the Montauk, New York tide gage) at representative rising tide. In general, the model predicts higher current velocities in the surface layer than the near seabed layer. The 3-D hydrodynamic results (currents and SSH) produced by this simulation were used as an input to the sediment transport analysis described in **Section I.4**.

FIGURE I.3-19. MODELED DEPTH-AVERAGED HYDRODYNAMIC CURRENTS AT RISING TIDE

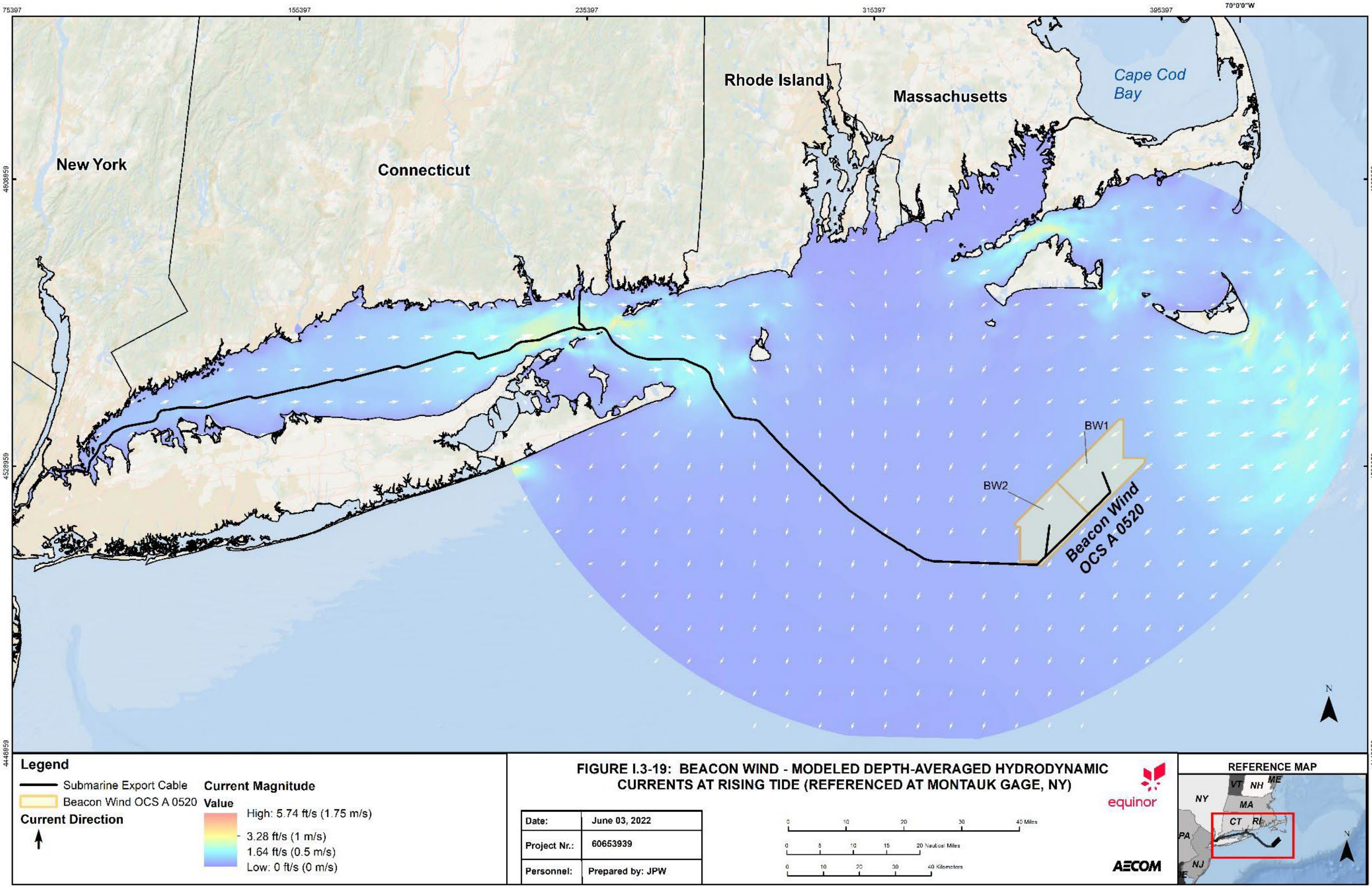


FIGURE I.3-20. MODELED DEPTH-AVERAGED HYDRODYNAMIC CURRENTS AT FALLING TIDE

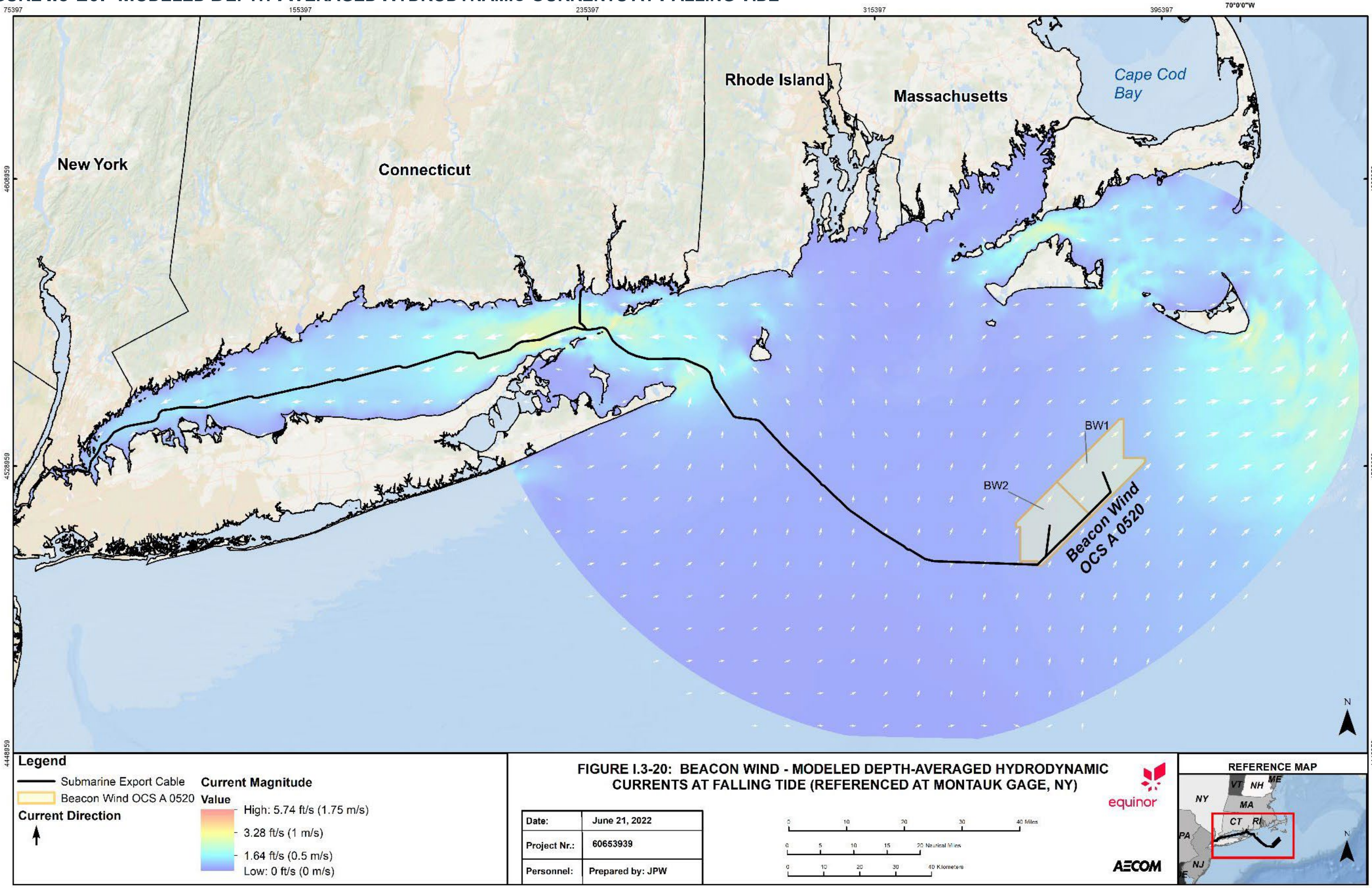
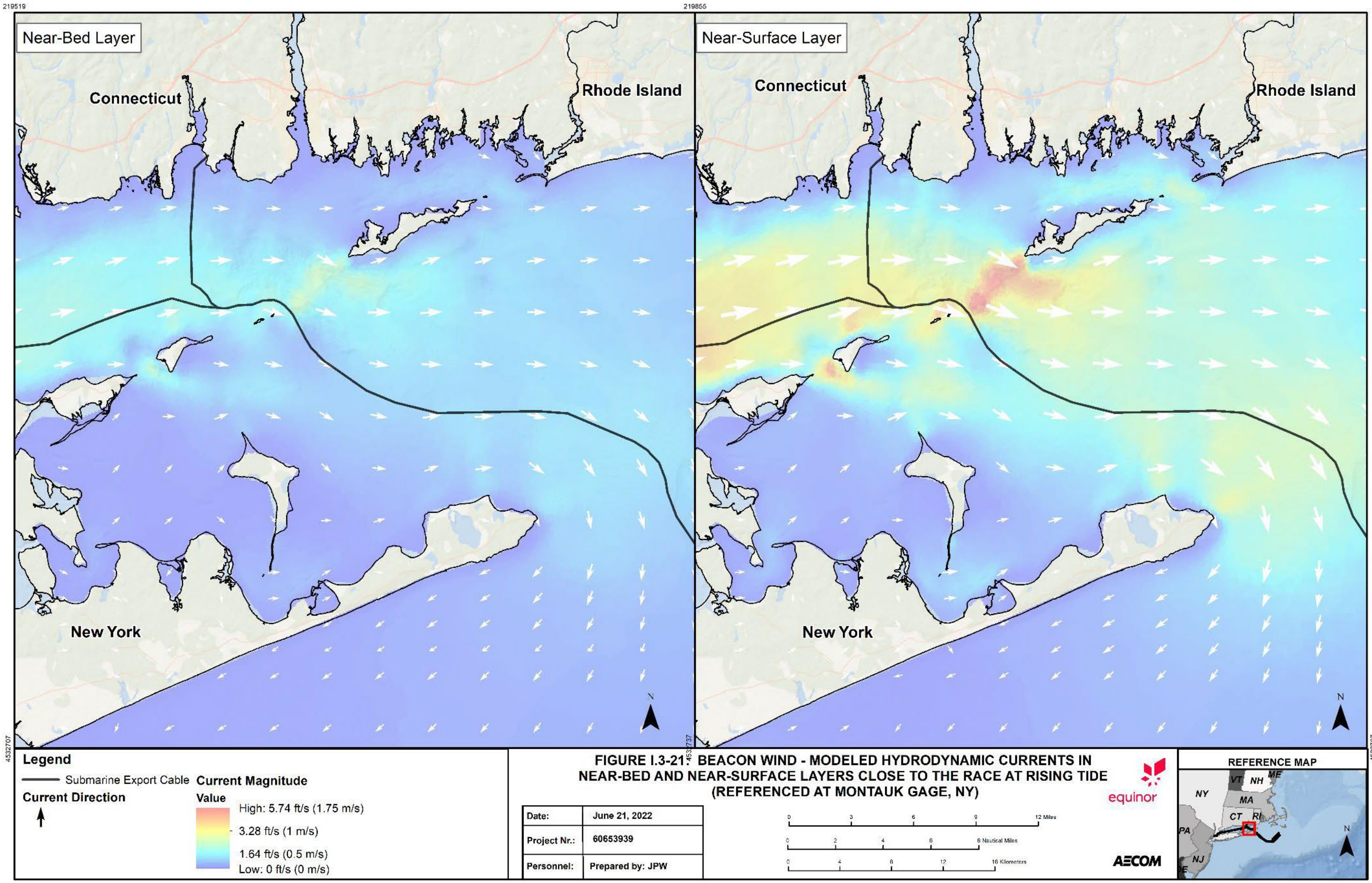


FIGURE I.3-21. MODELED HYDRODYNAMIC CURRENTS IN NEAR-BED AND NEAR-SURFACE LAYERS CLOSE TO THE RACE AT RISING TIDE



I.4 Suspended Sediment Transport Modeling

I.4.1 Suspended Sediment Transport Modeling Approach and PTM

The PTM (Version 2.3) was used to conduct the suspended sediment modeling for this study. PTM is a Lagrangian tracking model developed by the USACE ERDC as part of the Coastal Inlets Research Program and the Dredging Operations and Environmental Research Program. The PTM was developed to model the fate and transport of suspended sediments surrounding dredging and sub-surface construction activity. PTM operates within the Aquaveo Surface-water Modeling System (SMS) modeling environment (Version 13.1).

I.4.1.1 PTM Model Theory

Suspended sediments within the PTM model are discretized as a finite number of parcels that are subject to the processes of advection, diffusion, setting, deposition, and re-suspension. These particles are representative of sediments released from dredge-related activities and their movements are tracked in three dimensions. Because each particle carries a certain amount of mass of the sediment which it represents, the total number of particles in suspension and deposition can be used to estimate suspended sediment concentration and deposition thickness.

Parcels represent a mass of sediment defined by a constant grain size, density, and mass. The grain size of released sediment is input into the model as a mean grain size and a standard deviation. The model then uses a Gaussian distribution to assign a grain size to each released parcel. As this distribution is not finite, both very low and high grain sizes can be generated by the model. The mass of each parcel is input by the user and defines the discretization of the total released sediment mass into a finite number of parcels. Note that the input value represents the mass of sediment represented by each parcel, not the mass of an individual sediment particle. The native seabed characteristics are defined by the bed density, porosity, the 35th percentile of bed grain size (D35), the mean bed grain size (D50), and the 90th percentile of bed grain size (D90).

As the parcel is tracked through the model domain, advective, diffusive, and gravitational forces are applied to it. The advective forces are calculated from the user-input hydrodynamic field. The horizontal and vertical diffusive forces are estimated using a random-walk model that is proportional to the square-root of the diffusion coefficient. Parcel settling rates due to gravity are calculated as a function of dimensionless grain size using the equations developed by Soulsby cited in the PTM manual (USACE 2006).

Parcels are considered deposited if their location is below one-quarter of the skin-roughness height, which is calculated based on the native bed D90. Parcels that are deposited can be entrained in the bed or resuspended into flow. Parcels deposited on the bed can be resuspended into the flow if the bottom shear stress, calculated using the Van Rijn approach, is greater than the critical shear stress, defined by the Shields parameter using the approach of Soulsby and Whitehouse. Hiding and exposure is introduced into the model by adjusting the critical shear stress of a parcel based on the ratio of its diameter to the D50 of the native sediments. Bed entrainment is modeled using a probabilistic approach taking into account shear stress, likelihood of mixing with the active layer, and likelihood of burial (USACE 2006).

I.4.2 Particle Tracking Model Setup and Input Parameters

Offshore construction activities associated with the development of BW1 and BW2 include the following:

1. The installation and burial of interarray cabling connecting the wind turbines to the offshore substation facilities;
2. The pre-installation clearing (or pre-sweeping) of the submarine export cable routes as needed to remove sand waves and other seabed obstructions; and
3. The installation and burial of submarine export cables connecting the BW1 offshore substation facility to the POI at Queens, New York, and connecting the BW2 offshore substation facility to the POI either at Queens, New York or at Waterford, Connecticut.

The dredge construction methods are summarized in **Section I.1.5.1** of this appendix. The anticipated timing of these construction activities is summarized **Section I.3.5.1**. For the purposes of this study, the 3-D currents simulated by the Delft FM D-FLOW model are fed into PTM to generate the hydrodynamic forcing for particle movement.

In this study, PTM was used to perform a series of simulations to assess peak TSS concentration and seabed depositional thickness resulting from the installation and burial of the interarray and submarine export cabling. PTM was also configured to model the pre-sweeping activities to be conducted in specified blocks along the submarine export cable routes prior to cable installation. Assumptions and key PTM input parameters made to approximate these construction processes are discussed in the following sections.

I.4.2.1 Characterization of Sediments

PTM incorporates sediment characteristics into both its suspended sediment modeling and native bed interactions. The suspended sediment characteristics input into PTM are D_{50}, the standard deviation of sediment grain size in phi-units (Φ-units), and sediment density. The mean grain size of the sediment samples ranged from 0.002 mm to 3.14 mm with an average of 0.18 mm. Bed density is input as a constant of 68.2 pounds per cubic foot ($lb/ft^{3)}$ (1,092 kilometers per cubic meter [kg/m^3]) for the entire domain and was averaged from the vibracore samples detailed in **Section I.2.3.2**. For sediment density, the density of one grain of sediment, was assumed as constant of 94.1 lb/ft^3 (1508 kg/m^3) and derived from the geotechnical borings. The bed porosity was calculated as 0.28 using the bed and sediment density described above. Sediment grain sizes and sediment type were determined by the laboratory for all vibracore and grab samples as shown in **Figure I.4-1** through **Figure I.4-4**. The sediment samples in the Lease Area range from being dominated by sand, larger D_{50}, in the north-east to a mix of sand and silt, smaller D_{50}, in the south-west. Along the submarine export routes, the sediments samples are dominantly sand and silt. Unlike the Lease Area, it is not a consistent trend but pockets of smaller grain sizes and larger grain sizes. Near the Race and the East River, there is a higher prevalence of gravel grains found, which correspond to the highest D_{50} values. At the vibracore locations, results from each sample are depth-averaged to determine the average grain size and distribution of all sediments to be released from the entire dredging depth.

FIGURE I.4-1. BEACON WIND - INTERARRAY CABLE SEDIMENT SAMPLES

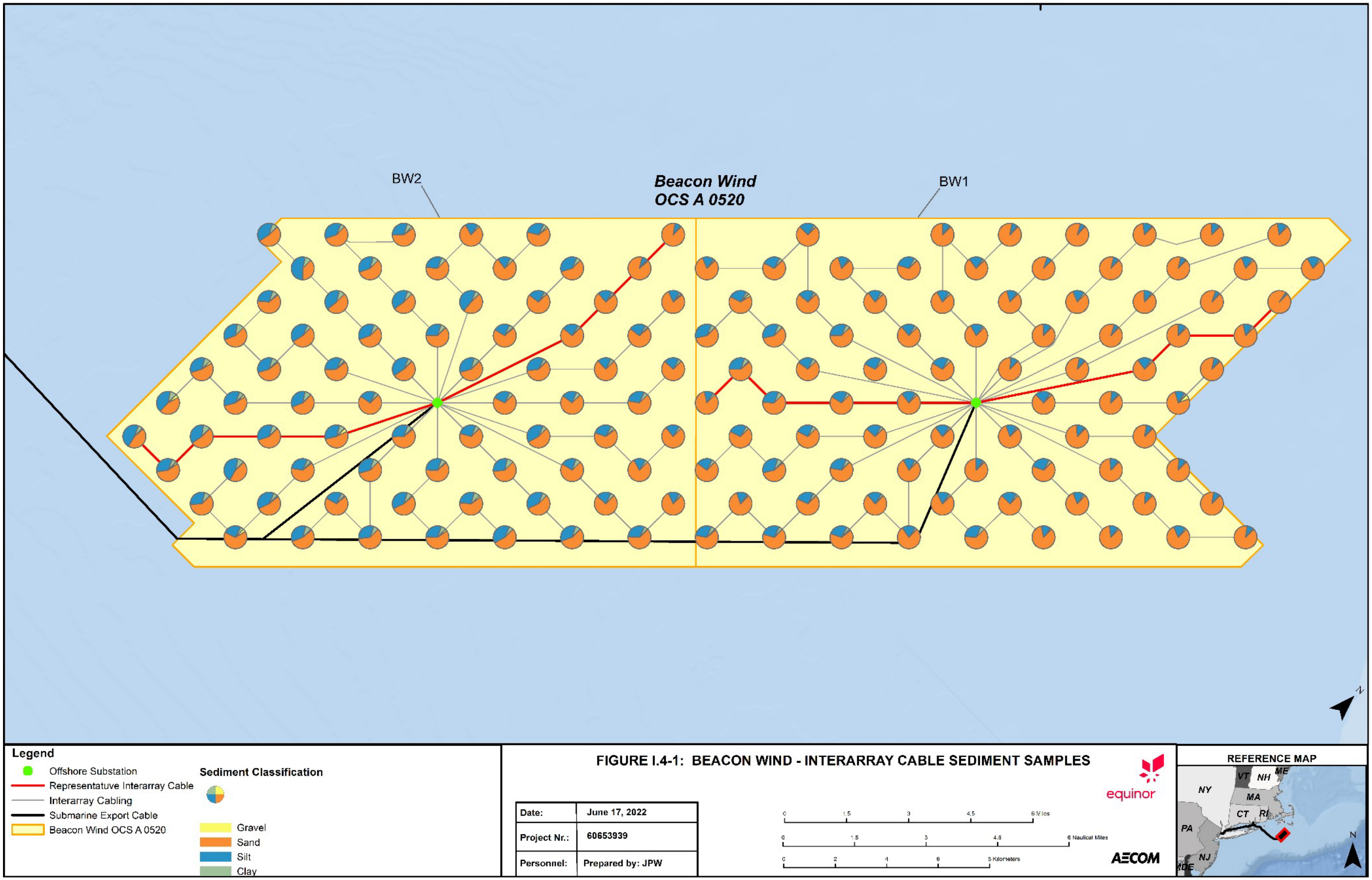


FIGURE I.4-2. SUBMARINE EXPORT CABLE VIBRACORE SEDIMENT SAMPLE FEDERAL WATERS GRAIN SIZE SUMMARY

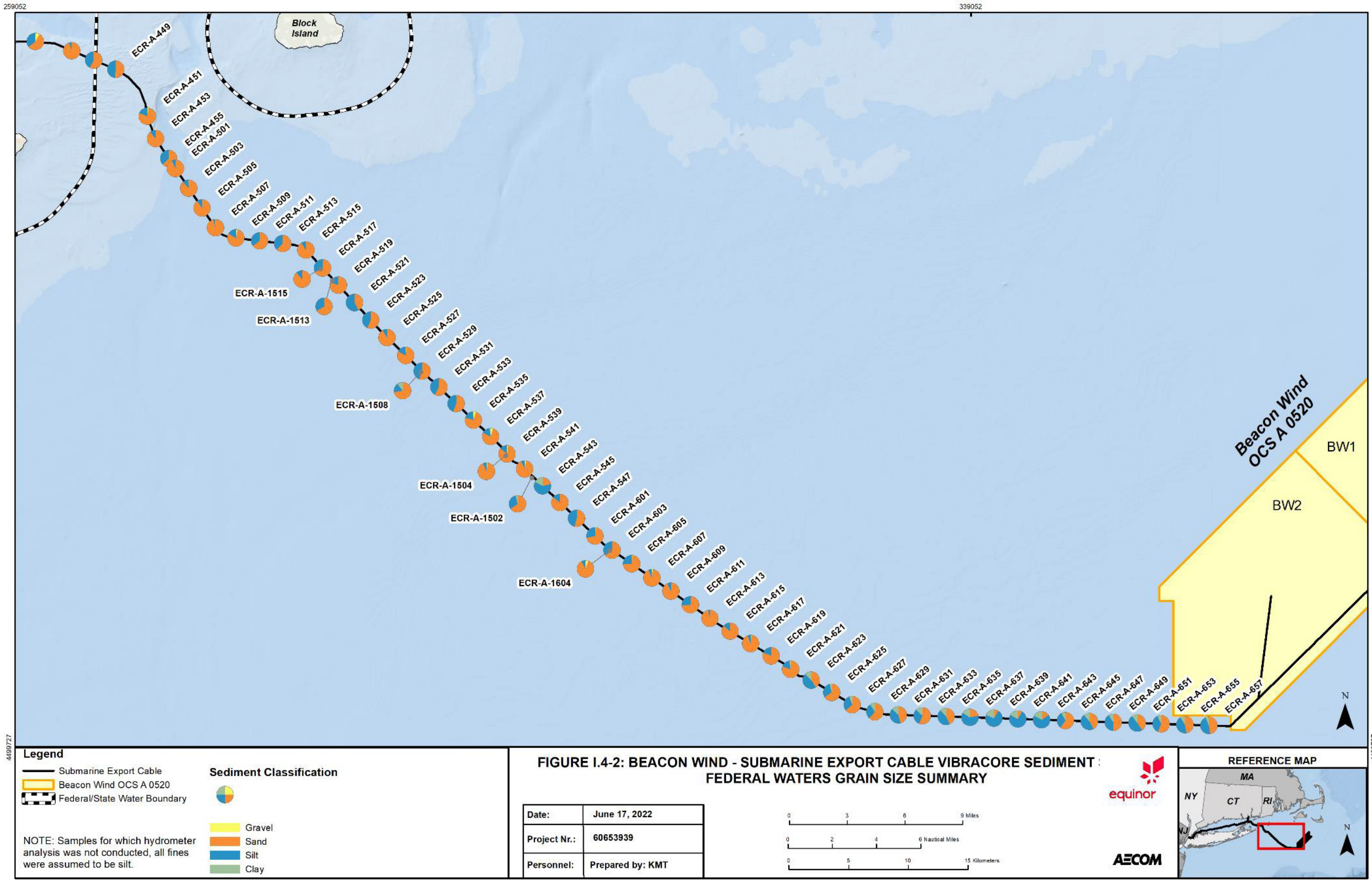


FIGURE I.4-3. SUBMARINE EXPORT CABLE VIBRACORE SEDIMENT SAMPLE GRAIN SIZE SUMMARY – EASTERN LONG ISLAND SOUND

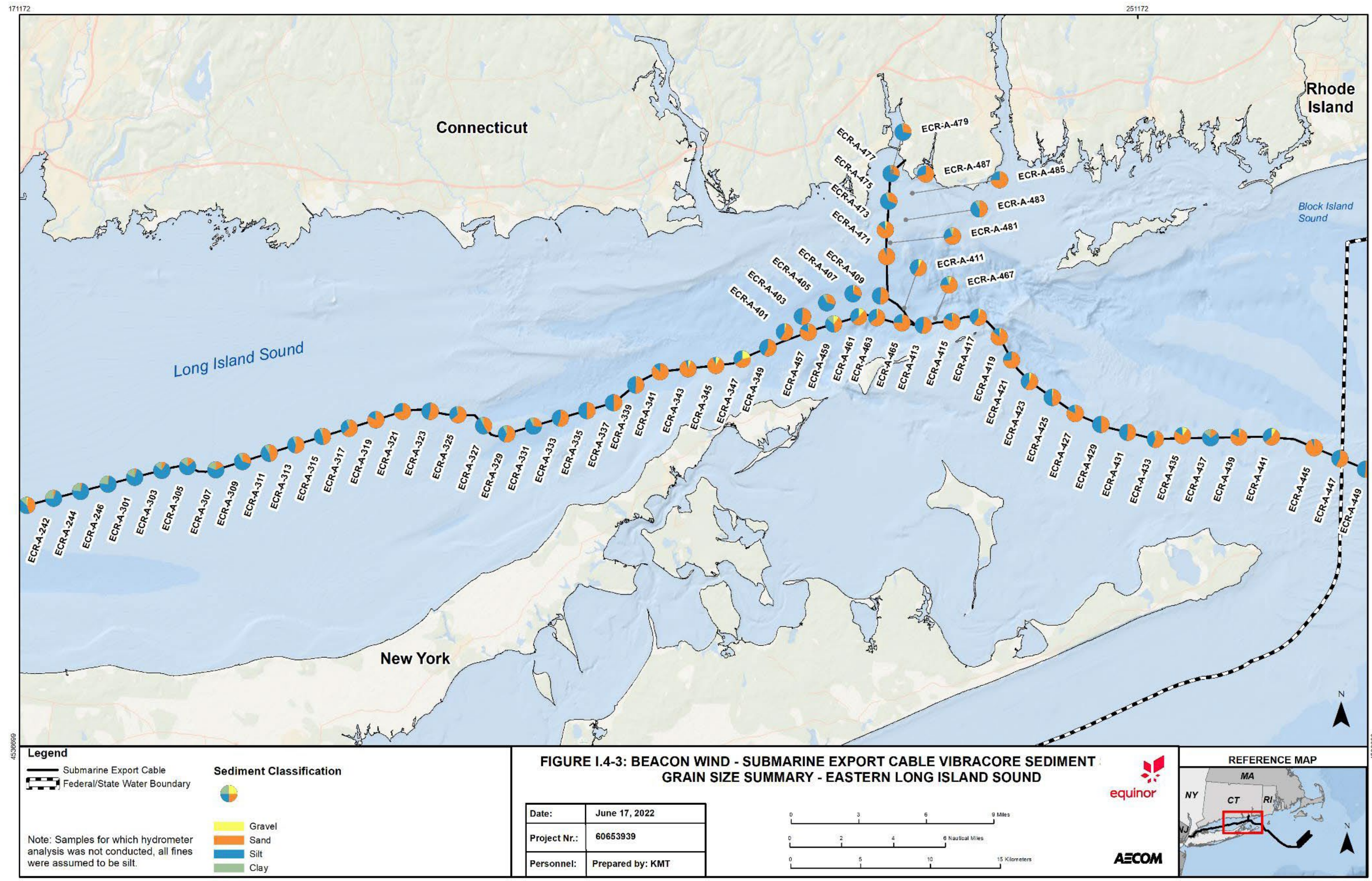
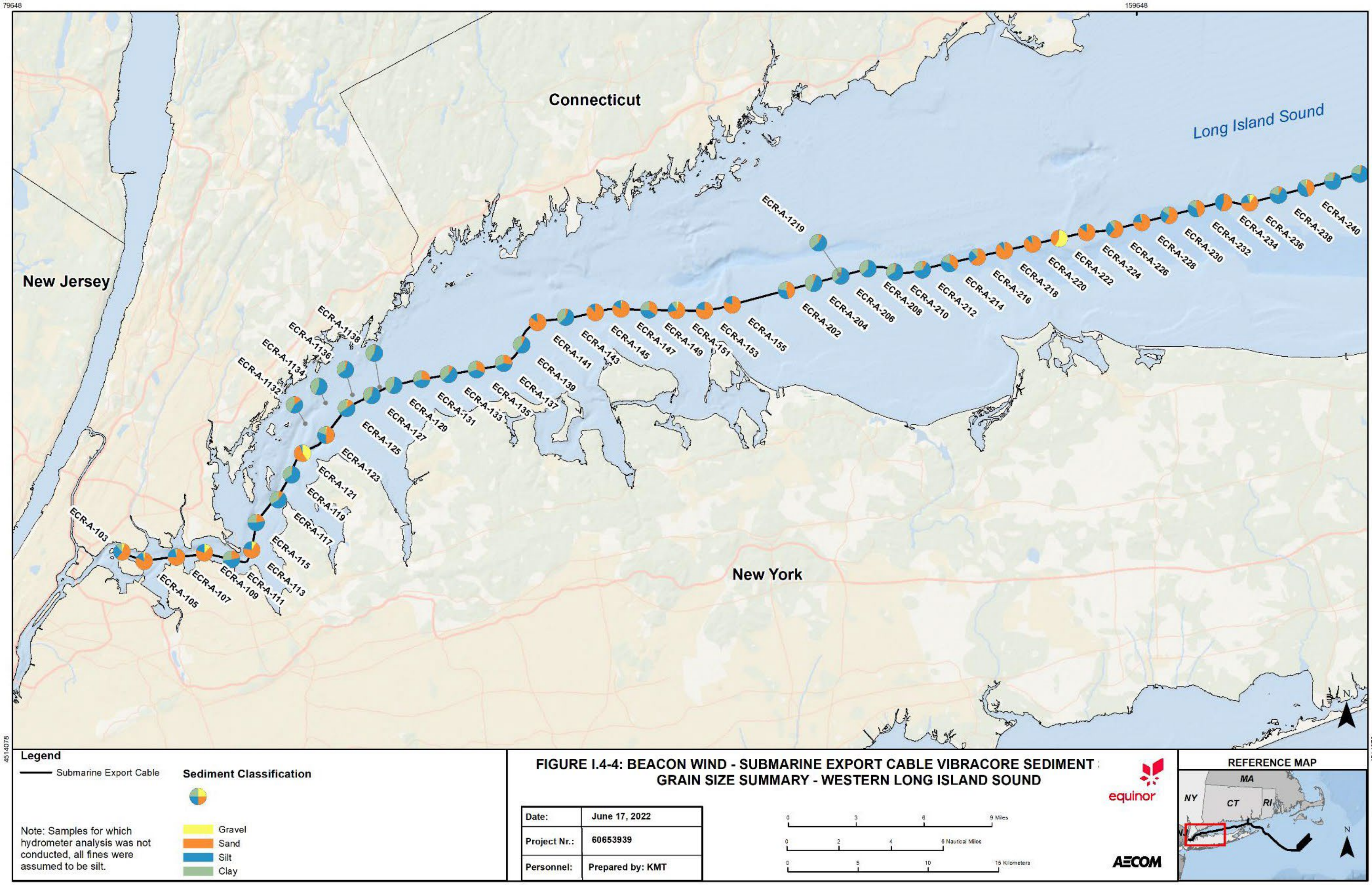


FIGURE I.4-4. SUBMARINE EXPORT CABLE VIBRACORE SEDIMENT SAMPLE GRAIN SIZE SUMMARY – WESTERN LONG ISLAND SOUND



I.4.2.2 Characterization of Construction Methods

Construction methods were characterized to define sediment source release in PTM. For each construction method, the following parameters related to dredge activities must be defined:

1. The advance speed of the dredge construction;
2. The loss rate associated the dredge technology utilized for construction;
3. The volume of sediment to be disturbed; and
4. The vertical distribution of sediments as they are initially released into the water column.

I.4.2.2.1 Characterization of Pre-Sweeping Methods

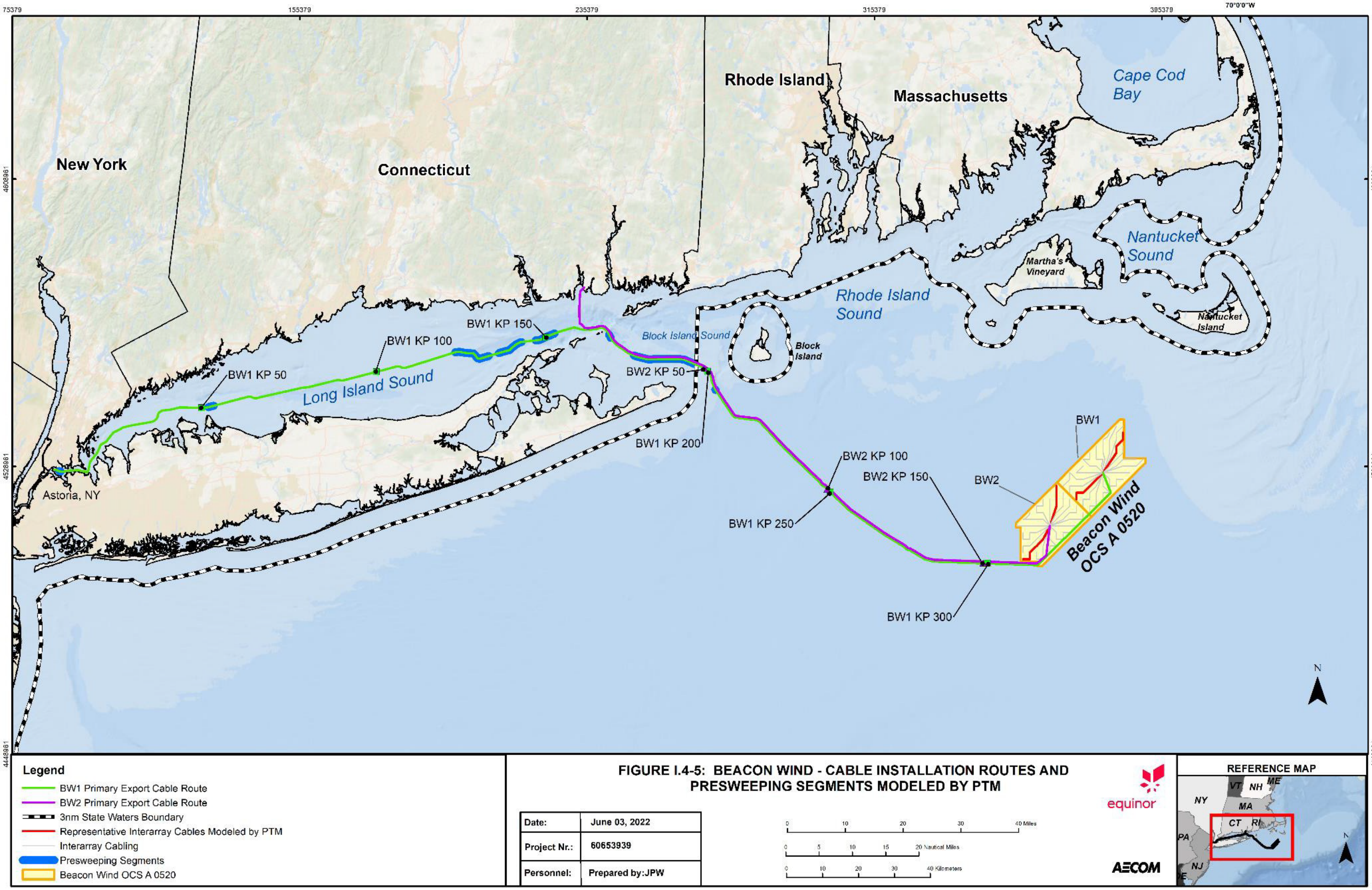
Pre-sweeping will be conducted to eliminate seafloor features, such as sand waves, prior to cable installation and to meet specific burial requirements in state and federal waters. As of the development of this appendix, the proposed pre-sweeping methods for the Project have not been finalized. The PDE lists both mass flow excavation (MFE) and trailing suction hopper dredge (TSHD) as possible methods for pre-sweeping. MFE uses pressured water to fluidize the seabed and excavate precise areas, this results in a 100 percent sediment loss rate to the water column at the point of dredge. TSHD uses a suction force to draw sediments from the seabed, with approximately 1 percent being suspended near-bed. For this appendix, the MFE presweeping method is assessed because it is more conservative (i.e., releases more sediment to the water column per unit length) than trailing suction dredge. Should alternate method(s) be chosen during Project design maturity, the modeling will be updated to assess the impact.

The advance rate of the MFE dredge is assumed at a constant 328 feet per hour (ft/hr) (100 meters per hour [m/hr]). Pre-sweeping will occur at only locations determined by the cable installation contractor; eight segments have been identified and are listed in **Table I.4-1** and shown in **Figure I.4-5**. The volume supplied by the cable installation contractor will be equally distributed along the segment length to simulate the release.

TABLE I.4-1. PRE-SWEEPING DREDGE LOCATIONS

Segment	BW1 Submarine Export Cable KPs (km)	Length	Preliminary Dredge Volume
1	1.57 to 1.93	0.23 mi (0.367 km)	46,173 yd^3 (35,302 m^3)
2	51.9 to 53.4	0.95 mi (1.531 km)	10,673 yd^3 (8,160 m^3)
3	122.9 to 133.0	6.28 mi (10.1 km)	47,592 yd^3 (36,387 m^3)
4	136.0 to 143.1	4.41 mi (7.1 km)	73,147 yd^3 (55,925 m^3)
5	147.1 to 152.7	3.48 mi (5.6 km)	26,404 yd^3 (20,187 m^3)
6	169.2 to 170.2	0.62 mi (1 km)	23,476 yd^3 (17,949 m^3)
7	178.5 to 196.1	10.94 mi (17.6 km)	93,611 yd^3 (71,571 m^3)
8	205.6 to 205.7	0.06 mi (0.1 km)	4,055 yd^3 (3,100 m^3)

FIGURE I.4-5. CABLE INSTALLATION ROUTES AND PRESWEEPING SEGMENTS MODELED BY PTM



I.4.2.2.2 Characterization of Cable Installation Methods

As of the development of this appendix, the proposed trenching methods for the installation of submarine cabling associated with the Project have not been finalized. However, the use of jet trenching, or hydraulic trenching, presents the most conservative scenario in the context of sediment disturbance, and is consistent with similar studies in the Atlantic OCS WEA (RPS 2018, RPS 2018, Tetra Tech 2021, RPS/ASA 2012).

The physical process of hydraulic trenching is high-pressure jets of water are used to fluidize the seabed sediments within a defined trench width. As the seabed is fluidized, a pre-laid cable falls to the bottom of the fluidized trench under its own weight. A portion of the sediment fluidized by the hydraulic jets is lost to the water column (suspended) during the jetting operation, eventually settling to the seafloor in the vicinity of the trench. Based on observations made by BOEM following the installation of submarine export cabling at the Block Island Wind Farm (BIWF), a loss rate of 25 percent of the trench volume will be utilized in this analysis (BOEM 2017).

While the advance speed of the dredge operations will vary depending on the final cable type and seabed conditions, the PDE lists an average advance speed range of 13.1 to 16.4 feet per minute (ft/min) (4 to 5 meters per min [m/min]), leading to a median advance speed of 14.8 ft/min (4.5 m/min) which was used in the modeling.

I.4.2.3 PTM Parameters for Construction Activities

As outlined in the PDE, trenching will be conducted in both the Lease Area and the submarine export cable routes to install the interarray and submarine export cables, respectively. Trenching will be conducted to a target depth of 5-8 ft (1.5-2.4 m) for both the submarine export cable and the interarray cabling. Where the submarine export cable routes cross federally maintained navigational channels, the submarine export cable will be installed at a depth of 15 ft (4.7 m) through a combination of pre-sweeping and hydraulic trenching. To calculate the rate of sediment loss into the water column, trench geometry will be estimated using the appropriate trenching depth and a trench width of 1.6 ft (0.5 m). For pre-sweeping activities, the expected removal volume is used to quantify the sediment release.

Following patterns observed by BOEM during the dredge installation of the submarine cabling for the BIWF, sediment will be released within the PTM model at an elevation of 3.3 ft (1 m) above the seabed for all activities (BOEM 2017). Particles will be released along the submarine export cable routes, interarray cable, and pre-sweeping sections as a moving point-source within the PTM model. The discretization of the release as a point source will result in very high concentrations immediately following suspension near the dredging area before advection and diffusion processes occur.

Table I.4-2 below summarizes the parameters and assumptions made in approximating the dredge activities.

TABLE I.4-2 SUMMARY OF DREDGE MODELING PARAMETERS

Construction Component	Submarine Export Cable Pre-Sweeping	Interarray Cable Installation	BW 1 Submarine Export Cable Installation	BW 2 Submarine Export Cable Installation
Dredging Method	Mass Flow Excavator	Hydraulic Trenching		
Average Advance Speed	328 ft/hr (100 m/hr)	14.8 ft/min (4.5 m/min)		
Sediment Loss Rate	100 percent	25 percent		
Trench Width	Dredge volumes and locations defined in **Table I.4-1**.	1.6 ft (0.5 m)*		
Target Trench Depth		6.6 ft (2.0 m)	5.0 - 8.0 ft (1.5 - 2.4 m	
Start Point		Wind Turbine	Offshore substation facility	
End Point		Offshore substation facility	Queens, NY	Waterford, CT / Queens, NY
Sediment Release Point (Height Above Seafloor)	3.28 ft (1.0 m) (applies to all construction components)			
Duration of Modeled Activity**	19 days	9 days (representative sections)	54 days	28 days

Note:
*Based on average width of jet trencher per cable installation contractor
**Duration of modeled activity is based on assumed advance speeds and working windows for each activity.

I.4.3 Particle Tracking Results

Results from the PTM simulations were processed to determine the extent of sediment plume migration over TSS concentration thresholds (in milligrams per liter [mg/L]) and the maximum depositional thickness (in inches [in] or millimeters[mm]). Note that the TSS concentration and depositional thickness were time-integrated values over the entire life of the particles. The TSS thresholds selected for this appendix for pre-sweeping include 500 mg/L, 1,000 mg/L, 5,000 mg/L, 10,000 mg/L, and 50,000 mg/L and for submarine export cabling include 50 mg/L, 100 mg/L, 500 mg/L, 1,000 mg/L, and 5,000 mg/L. The sediment transport modeling results are discussed in this section through 4 parameters, including 3 for sediments in suspension (TSS) and 1 for deposition, which are defined below. The first is the maximum extent of the TSS plume, which is measured from the release point to the furthest location greater than or equal to the TSS threshold. The second is the volume per unit length impacted which is defined as the volume of water that had a concentration greater than or equal to the threshold at any point sediment suspension/resuspension divided by the length of the release. The third TSS evaluation parameter involves the maximum time that any location experiences a TSS value greater than or equal to the threshold and the average time that all locations experience a TSS value greater than or equal to the threshold (note that locations that never reach a TSS concentration equal to or greater than the threshold are not included in the average calculations). The depositional thicknesses parameter is defined as the maximum extent of the depositional thickness from the release point. This parameter is measured from the release point to the furthest location greater than or equal to the depositional thickness.

Note that summary tables and, and representative results are discussed in the sections. **Attachment I.A** contains completed PTM result figures for all cable sections modeled.

I.4.3.1 *Submarine Export Cable Pre-Sweeping*

The results for particle tracking simulation of the pre-sweeping simulations are summarized in **Table I.4-3** to **Table I.4-6**. The first pre-sweeping segment determined by the cable installation contractor is within the East River. This segment has the highest mass release rate and is subject the strong currents described in **Section I.2.2.4.1** in relatively shallow water. Therefore, the volume impacted by the 500 mg/L TSS plume is much larger than for other longer pre-sweeping segments. The next pre-sweeping segment has a smaller 500 mg/L plume with the maximum extent being 1.65 mi (2.65 km) away from the pre-sweeping location. The third pre-sweeping segment has approximately half the mass release rate of the fourth pre-sweeping segment. However, the volume impacted by the 500 mg/L plume is approximately the same, 2,719 yd^3/ft (6,820 m^3/m) and 3,174 yd^3/ft (7,961 m^3/km), respectively. This is due that pre-sweeping segment 3 has more alignment perpendicular to the general east-west direction of the current within Long Island Sound, while segment 4 has more alignment parallel to the primary current direction in the area. Pre-sweeping segment 5 is a smaller release than segment 4 but is in a similar hydrodynamic region. The maximum extent of the 500 mg/L for segment 5 is 4.06 mi (6.53 km) compared the larger plume, 5.28 mi (8.5 km), generated by segment 4. Like segment 1, Pre-sweeping segment 6 enters a high energy hydrodynamic area, therefore the 500 mg/L plume impacts a large volume of water per unit length, 21,630 yd^3/ft (54,257 m^3/m). The spatial and vertical distribution of the TSS plume for segment 7 is shown in **Figure I.4-6**. Pre-sweeping segment 8 has the second highest mass release rate of the pre-sweeping segments, behind segment 1, however due to the deep water where the sediment release occurs, no depositional thicknesses greater than 1.97 in (50 mm) were predicted by the PTM model.

I.4.3.2 *Representative Interarray Cable Installation*

As described in **Section I.4.1**, the interarray cable installation was modeled using four representative alignments, shown in **Figure I.4-5**. The representative cables were chosen to capture longest continuous path for jet trenching in the Lease Area while accounting for the grain size variation observed.

The results for particle tracking simulation of the representative interarray cables are summarized in **Table I.4-3** to **Table I.4-6**. As shown in **Figure I.4-7**, the 50 mg/L plume extends up to 1.79 miles (2.88 km) away from the cable centerline. The strong tidal influence on the OCS can be seen in the oscillating pattern of TSS concentrations. The extent of TSS concentrations greater than 100 mg/L is larger for BW2 when compared to BW1. This is due to smaller sediment grain sizes in this area resulting in lower fall velocities. The deposited sediment is more contained than TSS with thicknesses greater than 0.04 in (1 mm) extending only 0.03 mi (0.04 km) from the interarray cable. Although concentrations in excess of 500 mg/L are present, TSS plumes impact a volume of water less than 5 cubic yards per mile of cable installation (9 m^3/km) and last for less than one hour.

FIGURE I.4-6. PRESWEEPING SEGMENT 7 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

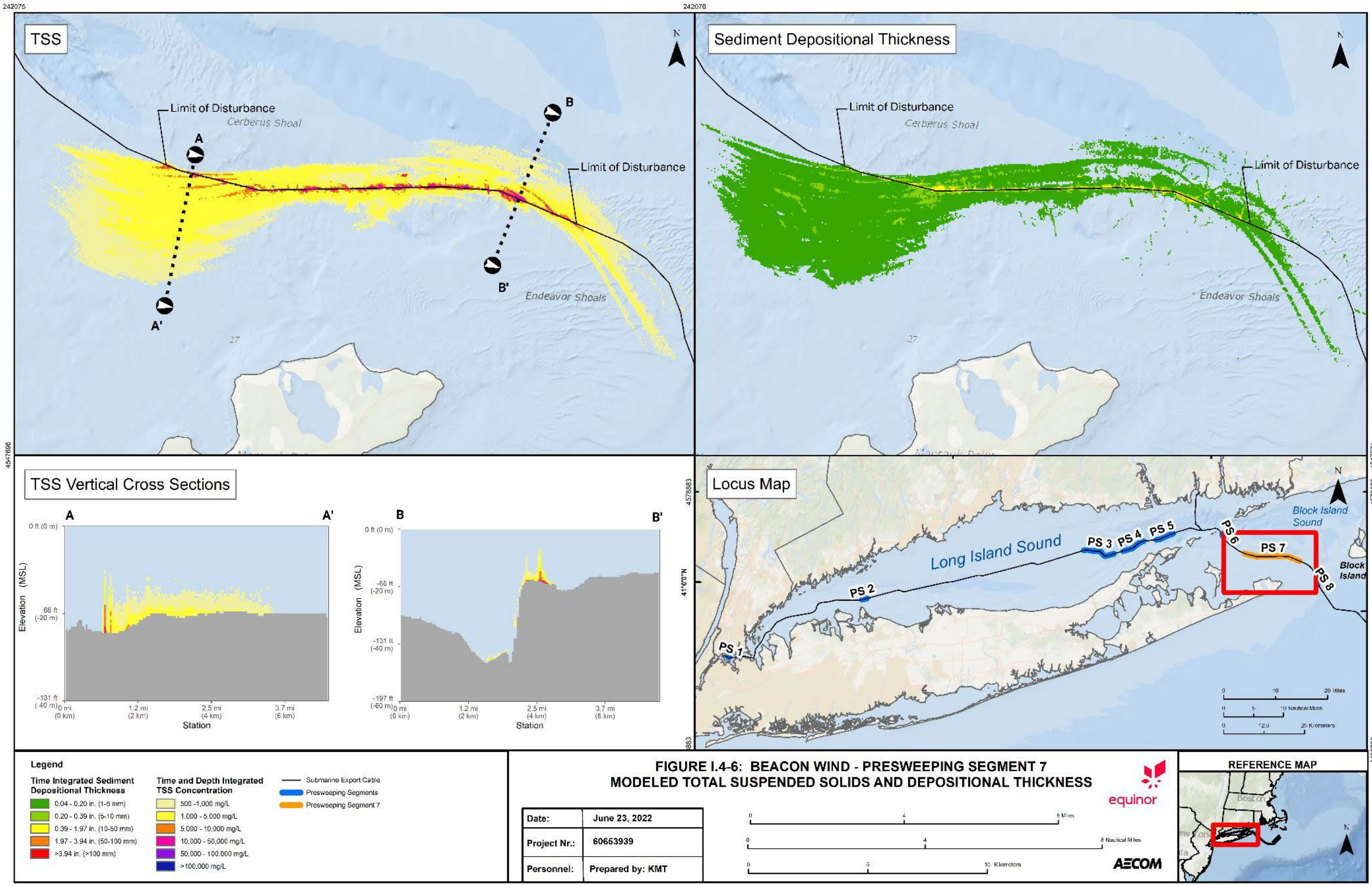
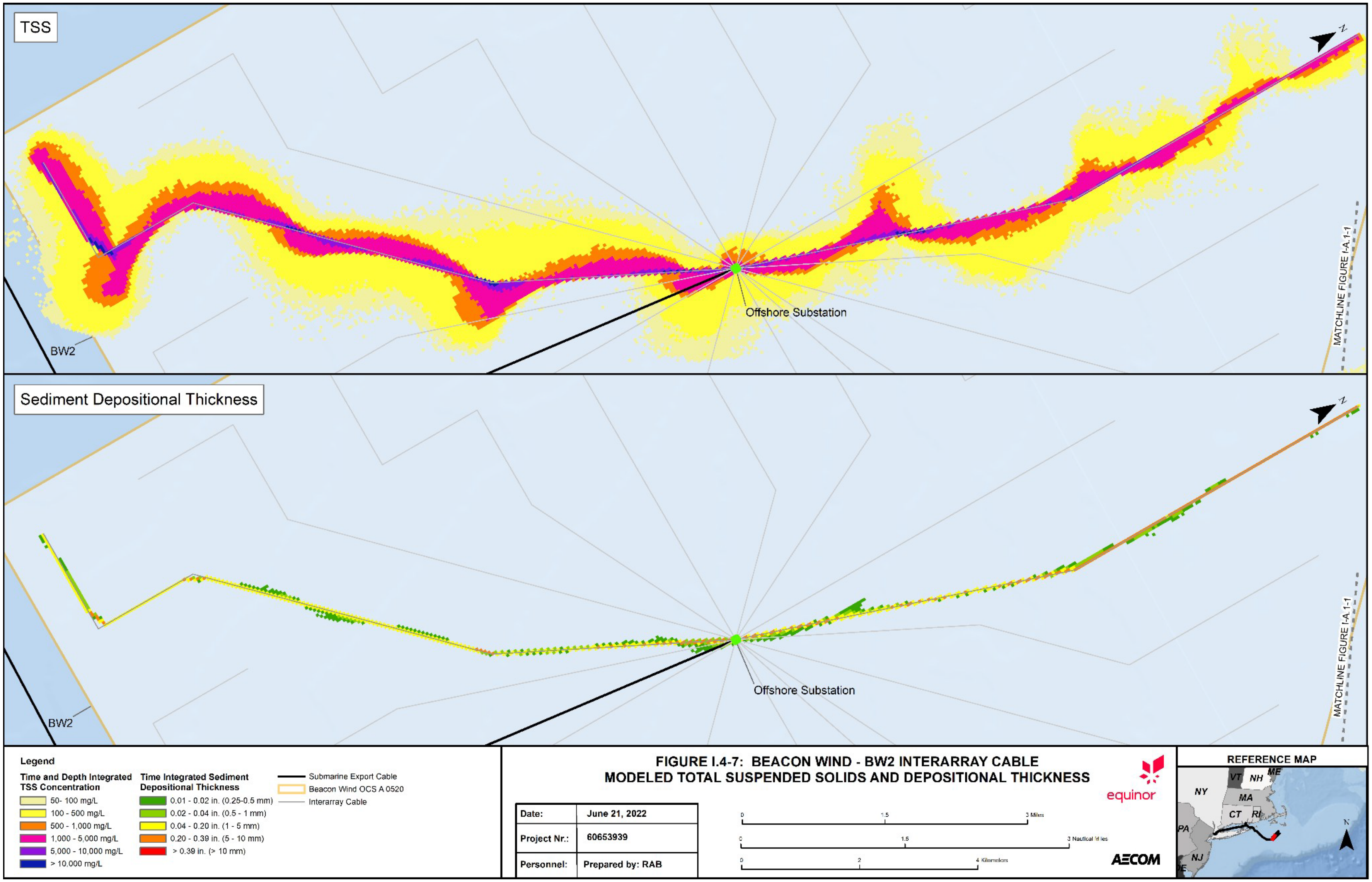


FIGURE I.4-7. BW2 INTERARRAY CABLE MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS



I.4.3.3 BW1/BW2 Submarine Export Cable Installation

The BW1/BW2 submarine export cables pass through many hydrodynamic regions between the Lease Area and landing site in Queens, New York. The particle tracking simulation results are shown in **Table I.4-3** to **Table I.4-6**. The first area (Section BW1-7: KP 300 to 348) to be installed starting from the offshore substation facility has very similar results to the interarray cable installation since it is in close proximity. The submarine export cable dredge depth, and therefore release volume, is greater than the interarray cable, so the extents of the TSS plume and deposited sediment are greater. The next section (Section BW1-6: KP 250 to 300) has low hydrodynamic energy and transitions from a mixture of silt, sand, and clay to predominantly sand. The larger grain sizes result in greater extent of deposited sediment compared to the previous section, but a smaller extent of the TSS plume. The next section (Section BW1-5: KP 200 to 250) transitions from low hydrodynamic energy to higher energy as the dredge approaches Long Island Sound. The largest 50 mg/L plume extent of this cable installation simulation occurs in this section; however, it also has the smallest volume impacted per unit length for a plume greater than 5,000 mg/L. This occurs due to the trenching being perpendicular to the direction of flow. The suspended sediment plume is then quickly carried away from the point of release, not amounting to high concentrations. As shown in **Figure I.4-8**, the next section (Section BW1-4: KP 150 to 200) has very similar results to Section 5 as it is still a high energy region, the plume is constrained in places within this section due to the steep bathymetric contours. In Section BW1-3 (KP 100 to 150), the trenching direction is predominantly parallel to the direction of flow and the energy is lower than at the entrance to Long Island Sound. Therefore, the extent of the 50 mg/L plume is smaller than in Section 4 as shown in **Figure I.4-9**. In the next area (Section BW1-2: KP 50 to 100) the flow regime is very similar to Section 3, so the results reflect that. The final area is the approach to the landing site in Queens, New York (Section BW1-1: KP 0 to 50), the flow area constricts as it nears the East River resulting in higher velocities. The volume impacted by the TSS plumes are similar to the other high energy areas of the model, Sections 4 and 5, but the maximum extent of the TSS plume is smaller due to the constrained width of flow in the area. The maximum extent of depositional thickness greater than 0.04 in (1 mm) is the highest in this area due to sediments depositing on the shoreline. The vertical distribution of suspended sediments along the entire submarine export cable route is shown in **Figure I.4-10**. This figure illustrates the low energy state near the Lease Area, and the high energy regions in Long Island Sound vertically mixing the sediments.

FIGURE I.4-8. BW1 EXPORT CABLE MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS FROM KP 190.2 TO KP 213.7

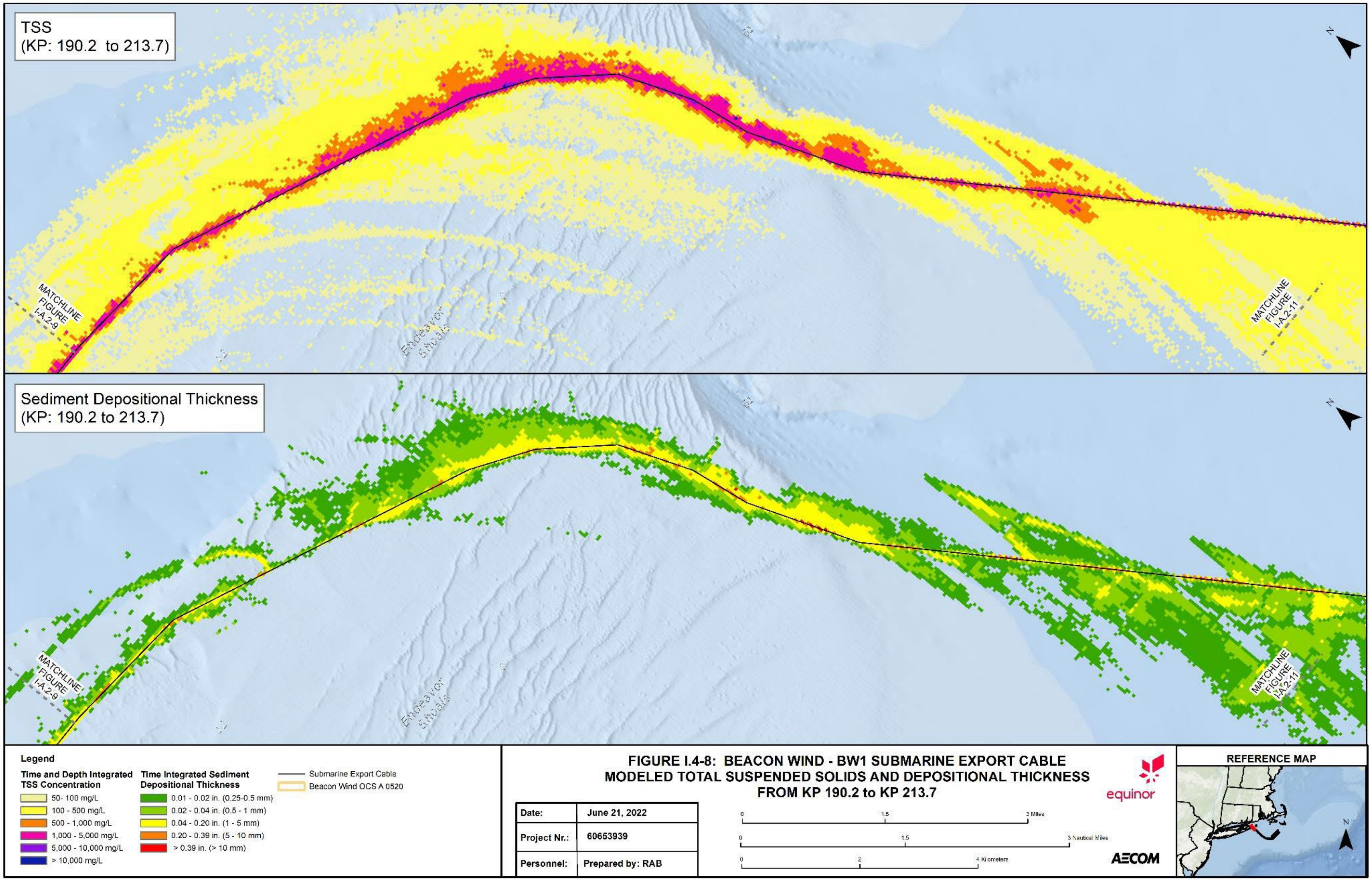


FIGURE I.4-9. BW1 EXPORT CABLE MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS FROM KP 106.4 TO KP 130.6

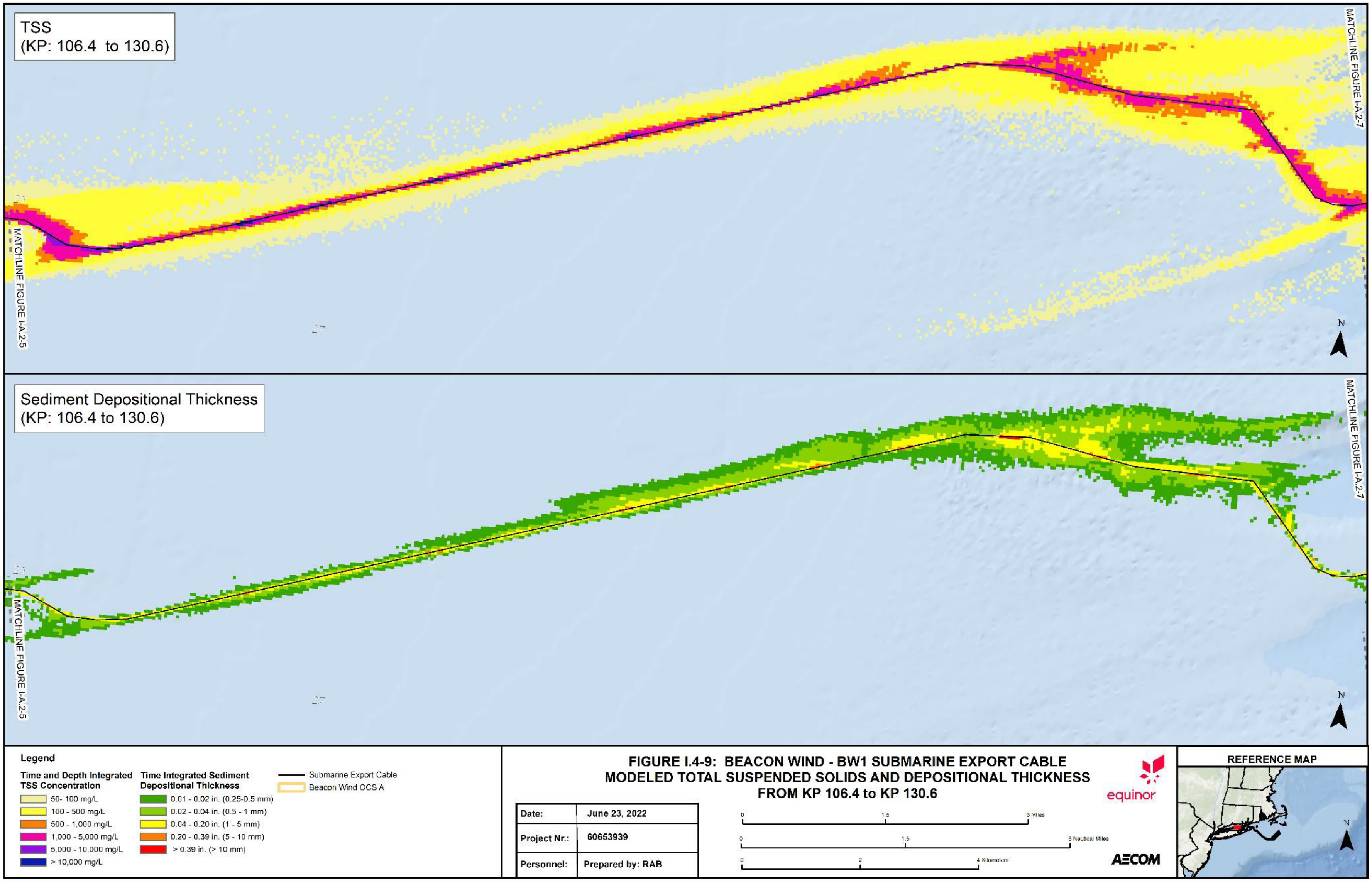


FIGURE I.4-10. BW1/BW2 SUBMARINE EXPORT CABLE MODELED VERTICAL TSS DISTRIBUTION

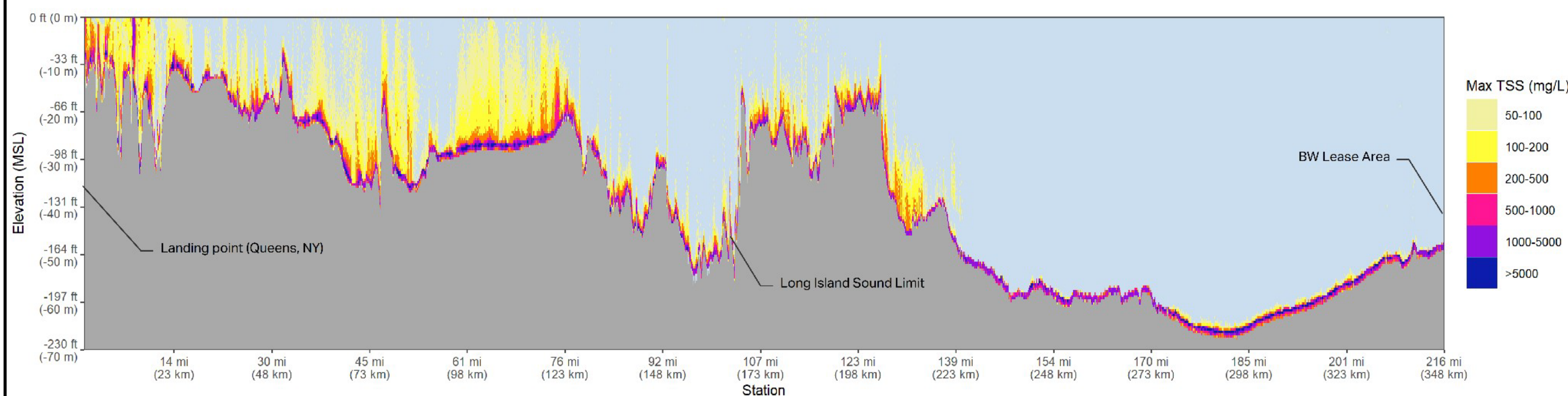


FIGURE I.4-10: BEACON WIND - BW1 EXPORT CABLE MODELED VERTICAL TSS DISTRBUTION

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: KMT

equinor

AECOM

REFERENCE MAP

I.4.3.4 BW2 Submarine Export Cable Installation

The BW2 submarine export cable to Waterford, Connecticut will be installed alongside the BW1 submarine export cable for a majority of the BW1 route and is expected be installed during a similar time of year. Therefore, in areas where the routes overlap, only one submarine export cable installation is modeled. The two areas where the routes do not overlap is the 7.5 mile (12 km) run to the BW2 onshore substation facility and in the Long Island Sound where the BW2 submarine export cable turns north to Waterford, Connecticut. Only these two sections will be modeled separately from the BW1/BW2 to Queen, New York submarine export cable installation.

The particle tracking simulation results are shown in **Table I.4-3** to **Table I.4-6**. In Section BW2-4 (KP 150-176), the results are similar to the results in Section BW1-7, which also begins at the offshore substation facility in the Lease Area. Sections BW2-3 (KP 100-150) and BW2-2 (KP 50-100) overlap with Sections BW1-6 and BW1-5, and therefore yield similar results. The final section (BW2-1: KP 0-50) including the approach to Waterford, Connecticut has the largest extent of the 50 mg/L TSS in both submarine export cable installation simulations, as shown in **Figure I.4-11**. This is due to the trenching being conducting in the north-south direction, with strong currents in the east-west direction. The vertical distribution of suspended sediments along the entire submarine export cable route is shown in **Figure I.4-12**. This figure illustrates that for a majority of the BW2 submarine export cable route suspended sediment concentrations greater than 40 mg/L do not extend above a few meters above the bed.

FIGURE I.4-11 BW2 EXPORT CABLE MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS FROM KP 0.0 TO KP 4.2

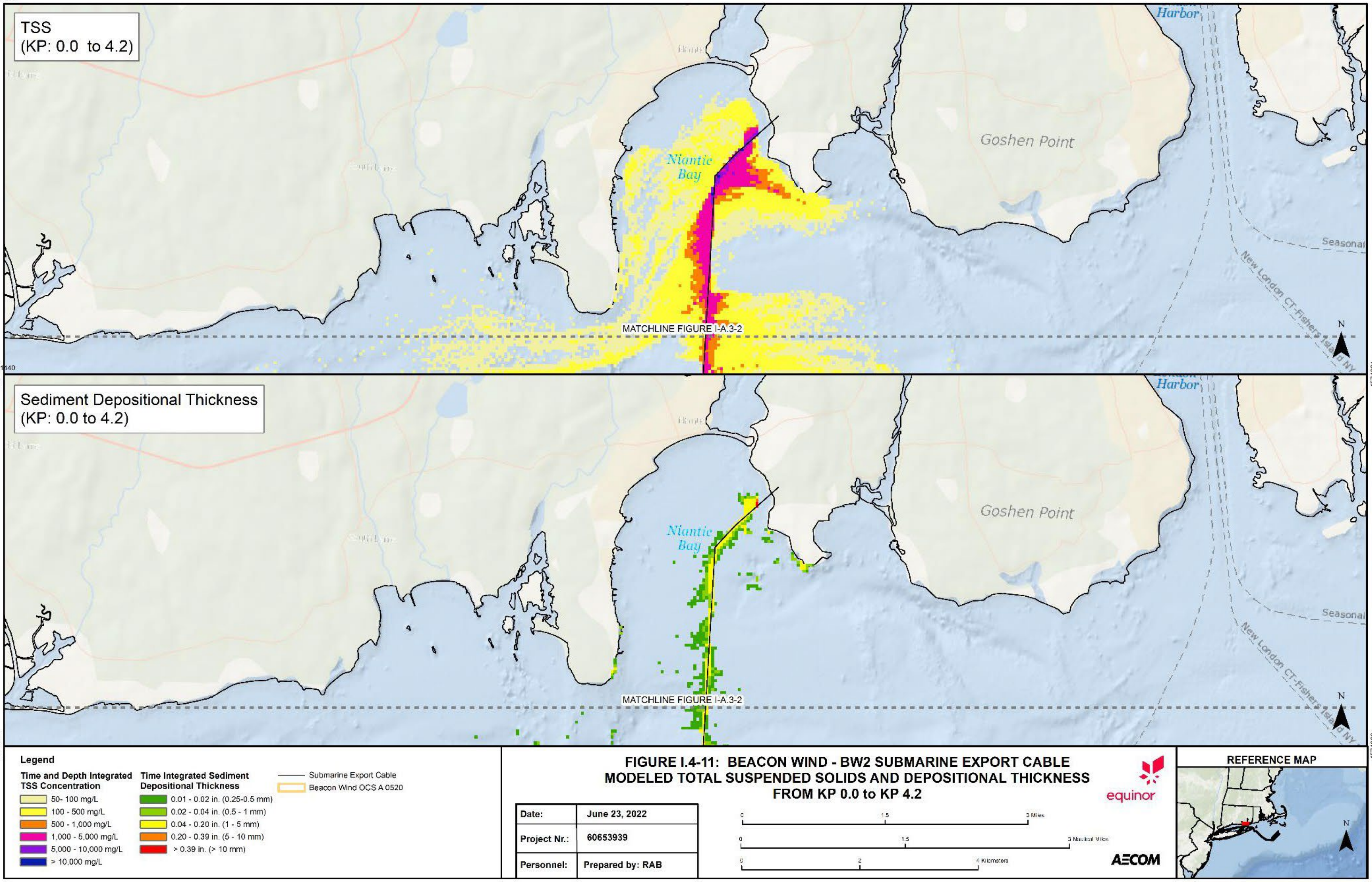


FIGURE I.4-12. BW2 EXPORT CABLE MODELED VERTICAL TSS DISTRIBUTION

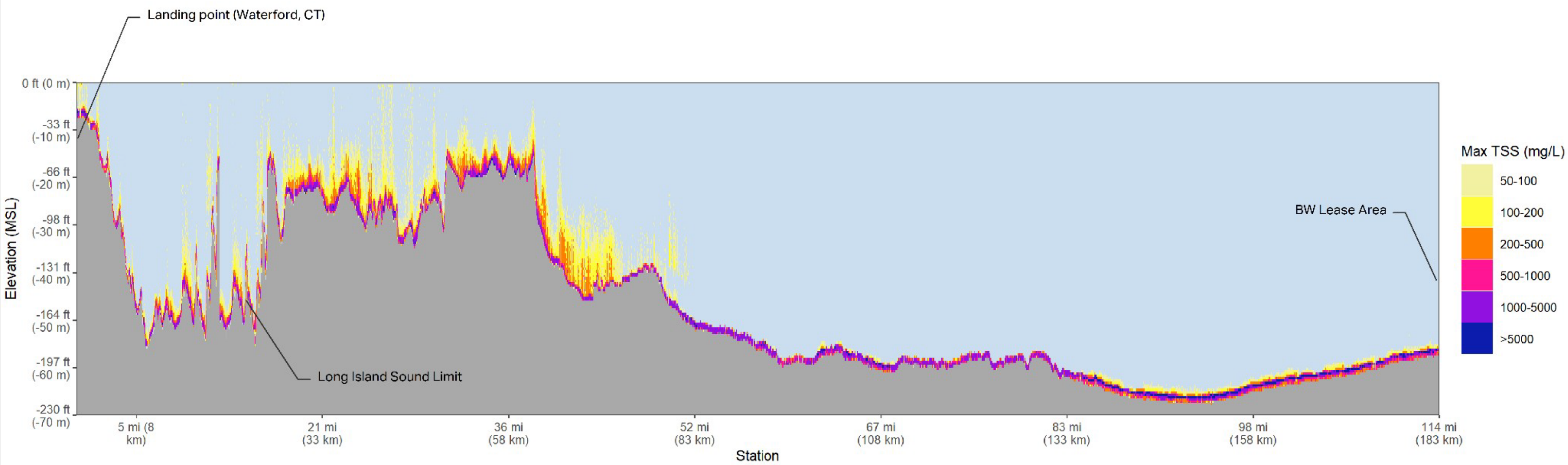


FIGURE I.4-12: BEACON WIND - BW2 EXPORT CABLE MODELED VERTICAL TSS DISTRBUTION

Date:	June 23, 2022
Project Nr.:	60653939
Personnel:	Prepared by: KMT

equinor

AECOM

REFERENCE MAP

Table I.4-3 below summarizes the extent of TSS migration from the release point for five different thresholds.

TABLE I.4-3. SUMMARY OF SEDIMENT TRANSPORT TOTAL SUSPENDED SOLIDS PLUME EXTENT

Section ID	KPs (km)	Maximum Extent of TSS Plume over Threshold from the Route Centerline				
Threshold:		500 mg/L	1,000 mg/L	5,000 mg/L	10,000 mg/L	50,000 mg/L
Pre-Sweeping						
1	1.57-1.93	3.71 mi. (5.97 km)	3.68 mi. (5.92 km)	3.24 mi. (5.21 km)	1.63 mi. (2.62 km)	1.01 mi. (1.62 km)
2	51.9- 53.4	1.65 mi. (2.65 km)	1.2 mi. (1.92 km)	0.95 mi. (1.53 km)	0.41 mi. (0.66 km)	0.15 mi. (0.24 km)
3	122.9-133.0	3.77 mi. (6.07 km)	2.93 mi. (4.71 km)	0.79 mi. (1.27 km)	0.27 mi. (0.43 km)	0.04 mi. (0.06 km)
4	136.0-143.1	5.28 mi. (8.5 km)	4.52 mi. (7.27 km)	0.34 mi. (0.54 km)	0.28 mi. (0.45 km)	0.08 mi. (0.12 km)
5	147.1-152.7	4.06 mi. (6.53 km)	0.54 mi. (0.87 km)	0.2 mi. (0.32 km)	0.17 mi. (0.27 km)	0.02 mi. (0.03 km)
6	169.2-170.2	5.00 mi. (8.04 km)	3.69 mi. (5.94 km)	0.37 mi. (0.59 km)	0.26 mi. (0.41 km)	0.06 mi. (0.09 km)
7	178.5-196.1	4.84 mi. (7.79 km)	3.52 mi. (5.67 km)	0.61 mi. (0.98 km)	0.34 mi. (0.55 km)	0.02 mi. (0.02 km)
8	205.6-205.7	2.93 mi. (4.71 km)	2.4 mi. (3.86 km)	0.88 mi. (1.42 km)	0.57 mi. (0.92 km)	0.02 mi. (0.03 km)

Section ID	KPs (km)	Maximum Extent of TSS Plume over Threshold from the Route Centerline				
Threshold:		50 mg/L	100 mg/L	500 mg/L	1,000 mg/L	5,000 mg/L
Representative Interarray Cable						
IAC-BW1	Length: 24.6	1.79 mi. (2.88 km)	0.93 mi. (1.5 km)	0.45 mi. (0.73 km)	0.27 mi. (0.44 km)	0.1 mi. (0.16 km)
IAC-BW2	Length: 24.5	1.23 mi. (1.98 km)	0.93 mi. (1.49 km)	0.55 mi. (0.89 km)	0.45 mi. (0.73 km)	0.1 mi. (0.16 km)
BW1/BW2 Submarine Export Cable to Queens, New York						
BW1-1	0-50	2.37 mi. (3.81 km)	1.84 mi. (2.96 km)	0.64 mi. (1.03 km)	0.64 mi. (1.03 km)	0.12 mi. (0.20 km)
BW1-2	50-100	1.96 mi. (3.15 km)	1.48 mi. (2.38 km)	0.63 mi. (1.02 km)	0.35 mi. (0.57 km)	0.27 mi. (0.43 km)
BW1-3	100-150	2.80 mi. (4.51 km)	1.64 mi. (2.63 km)	0.58 mi. (0.94 km)	0.40 mi. (0.64 km)	0.06 mi. (0.1 km)
BW1-4	150-200	3.90 mi. (6.28 km)	2.98 mi. (4.8 km)	0.90 mi. (1.44 km)	0.32 mi. (0.52 km)	0.11 mi. (0.18 km)
BW1-5	200-250	4.15 mi. (6.69 km)	2.89 mi. (4.65 km)	0.49 mi. (0.78 km)	0.26 mi. (0.41 km)	0.15 mi. (0.25 km)
BW1-6	250-300	0.89 mi. (1.43 km)	0.69 mi. (1.12 km)	0.28 mi. (0.45 km)	0.20 mi. (0.32 km)	0.06 mi. (0.1 km)

Section ID	KPs (km)	Maximum Extent of TSS Plume over Threshold from the Route Centerline				
Threshold:		**50 mg/L**	**100 mg/L**	**500 mg/L**	**1,000 mg/L**	**5,000 mg/L**
BW1-7	300-348	1.74 mi. (2.80 km)	1.10 mi. (1.77 km)	0.58 mi. (0.94 km)	0.45 mi. (0.72 km)	0.09 mi. (0.15 km)
BW2 Submarine Export Cable to Waterford, Connecticut						
BW2-1	0-50	6.92 mi. (11.14 km)	5.00 mi. (8.04 km)	0.90 mi. (1.44 km)	0.59 mi. (0.94 km)	0.12 mi. (0.2 km)
BW2-2	50-100	3.66 mi. (5.9 km)	2.89 mi. (4.65 km)	0.49 mi. (0.78 km)	0.26 mi. (0.41 km)	0.15 mi. (0.25 km)
BW2-3	100-150	0.89 mi. (1.43 km)	0.69 mi. (1.12 km)	0.28 mi. (0.45 km)	0.2 mi. (0.33 km)	0.06 mi. (0.1 km)
BW2-4	150-176	1.71 mi. (2.75 km)	1.10 mi. (1.77 km)	0.58 mi. (0.94 km)	0.43 mi. (0.69 km)	0.08 mi. (0.13 km)

Table I.4-4 below summarizes the volume of water per unit length that is impacted by the TSS plume above five threshold concentrations during the simulation period.

TABLE I.4-4. SUMMARY OF SEDIMENT TRANSPORT VOLUME IMPACTED RESULTS

Section ID	KPs (km)	Volume Impacted by Construction TSS Plume over Threshold				
Threshold:		500 mg/L	1,000 mg/L	5,000 mg/L	10,000 mg/L	50,000 mg/L
Pre-Sweeping						
1	1.57-1.93	55,821 yd³/ft (140,020 m³/m)	40,132 yd³/ft (100,668 m³/m)	7,573 yd³/ft (18,995 m³/m)	2,835 yd³/ft (7,112 m³/m)	303 yd³/ft (760 m³/m)
2	51.9-53.4	5,688 yd³/ft (14,268 m³/m)	2,968 yd³/ft (7,444 m³/m)	488 yd³/ft (1,225 m³/m)	202 yd³/ft (508 m³/m)	8 yd³/ft (20 m³/m)
3	122.9-133.0	2,719 yd³/ft (6,820 m³/m)	1,031 yd³/ft (2,585 m³/m)	124 yd³/ft (311 m³/m)	41 yd³/ft (103 m³/m)	1 yd³/ft (2 m³/m)
4	136.0-143.1	3,174 yd³/ft (7,961 m³/m)	1,493 yd³/ft (3,746 m³/m)	321 yd³/ft (804 m³/m)	149 yd³/ft (374 m³/m)	14 yd³/ft (36 m³/m)
5	147.1-152.7	825 yd³/ft (2,069 m³/m)	438 yd³/ft (1,100 m³/m)	90 yd³/ft (227 m³/m)	38 yd³/ft (95 m³/m)	2 yd³ft (5 m³/m)
6	169.2-170.2	21,630 yd³/ft (54,257 m³/m)	7429 yd³/ft (18,635 m³/m)	426 yd³/ft (1,069 m³/m)	165 yd³/ft (414 m³/m)	20 yd³/ft (51 m³/m)
7	178.5-196.1	5,344 yd³/ft (13,404 m³/m)	1,519 yd³/ft (3,811 m³/m)	99 yd³/ft (248 m³/m)	33 yd³/ft (82 m³/m)	0 yd³/ft (1 m³/m)
8	205.6-205.7	70,419 yd³/ft (176,637 m³/m)	20,596 yd³/ft (51,662 m³/m)	1,066 yd³/ft (2,675 m³/m)	384 yd³/ft (962 m³/m)	40 yd³/ft (100 m³/m)

Section ID	KPs (km)	Volume Impacted by Construction TSS Plume over Threshold				
Threshold:		50 mg/L	100 mg/L	500 mg/L	1,000 mg/L	5,000 mg/L
Representative Interarray Cable						
IAC-BW1	Length: 24.6	846 yd³/ft (2,122 m³/m)	386 yd³/ft (967 m³/m)	105 yd³/ft (264 m³/m)	51 yd³/ft (129 m³/m)	4 yd³/ft (9 m³/m)
IAC-BW2	Length: 24.5	1,073 yd³/ft (2,693 m³/m)	602 yd³/ft (1,509 m³/m)	137 yd³/ft (344 m³/m)	65 yd³/ft (164 m³/m)	5 yd³/ft (12 m³/m)
BW1/BW2 Submarine Export Cable to Queens, New York						
BW1-1	0-50	5,448 yd³/ft (13,665 m³/km)	2,156 yd³/ft (5,407 m³/m)	165 yd³/ft (414 m³/m)	67 yd³/ft (169 m³/m)	5 yd³/ft (12 m³/m)
BW1-2	50-100	4,936 yd³/ft (12,381 m³/km)	1,238 yd³/ft (3,104 m³/m)	127 yd³/ft (319 m³/m)	59 yd³/ft (149 m³/m)	7 yd³/ft (16 m³/m)
BW1-3	100-150	2,230 yd³/ft (3,158 m³/km)	652 yd³/ft (1,040 m³/m)	76 yd³/ft (191 m³/m)	36 yd³/ft (90 m³/m)	4 yd³/ft (11 m³/m)
BW1-4	150-200	3,158 yd³/ft (7,920 m³/m)	1,040 yd³/ft (2,608 m³/m)	103 yd³/ft (259 m³/m)	41 yd³/ft (102 m³/m)	1 yd³/ft (4 m³/km)
BW1-5	200-250	1,881 yd³/ft (4,718 m³/m)	661 yd³/ft (1,658 m³/m)	63 yd³/ft (157 m³/m)	31 yd³/ft (77 m³/m)	1 yd³/ft (2 m³/m)
BW1-6	250-300	407 yd³/ft	256 yd³/ft (641	92 yd³/ft (232	50 yd³/ft (126	6 yd³/ft (15

Section ID	KPs (km)	Volume Impacted by Construction TSS Plume over Threshold				
Threshold:		**50 mg/L**	**100 mg/L**	**500 mg/L**	**1,000 mg/L**	**5,000 mg/L**
		(1,021 m^3/m)	m^3/m)	m^3/m)	m^3/m)	m^3/m)
BW1-7	300-348	1,070 yd^3/ft (2,684 m^3/m)	571 yd^3/ft (1,433 m^3/m)	153 yd^3/ft (385 m^3/m)	77 yd^3/ft (192 m^3/m)	10 yd^3/ft (24 m^3/m)
BW2 Submarine Export Cable to Waterford, Connecticut						
BW2-1	0-50	3,659 yd^3/ft (9,197 m^3/m)	1,207 yd^3/ft (3,028 m^3/m)	128 yd^3/ft (321 m^3/m)	51 yd^3/ft (128 m^3/m)	2 yd^3/ft (m^3/m)
BW2-2	50-100	1,931 yd^3/ft (4,843 m^3/m)	683 yd^3/ft (1,712 m^3/m)	66 yd^3/ft (166 m^3/m)	32 yd^3/ft (81 m^3/m)	1 yd^3/ft (2 m^3/m)
BW2-3	100-150	403 yd^3/ft (1,012 m^3/m)	253 yd^3/ft (635 m^3/m)	91 yd^3/ft (227 m^3/m)	49 yd^3/ft (123 m^3/m)	6 yd^3/ft (15 m^3/m)
BW2-4	150-176	1106 yd^3/ft (2,773 m^3/m)	633 yd^3/ft (1,588 m^3/m)	171 yd^3/ft (428 m^3/m)	83 yd^3/ft (209 m^3/m)	12 yd^3/ft (30 m^3/m)

Table I.4-5 below summarizes the extent of deposition thickness contours from the release point for five different thresholds.

TABLE I.4-5. SUMMARY OF SEDIMENT TRANSPORT SEDIMENT DEPOSITION THICKNESS RESULTS

Section ID	KPs (km)	Maximum Extent of Deposited Sediment Thickness over Threshold from the Route Centerline				
Threshold:		**0.04 in. (1.00 mm)**	**0.20 in. (5.00 mm)**	**0.39 in. (10.00 mm)**	**1.97 in. (50.00 mm)**	**3.94 in. (100.00 mm)**
Pre-sweeping						
1	1.57-1.93	3.71 mi. (5.97 km)	3.71 mi. (5.97 km)	3.24 mi. (5.21 km)	1.07 mi. (1.72 km)	1.07 mi. (1.72 km)
2	51.9- 53.4	1.76 mi. (2.84 km)	1.12 mi. (1.79 km)	1.05 mi. (1.69 km)	0.14 mi. (0.23 km)	0.01 mi. (0.02 km)
3	122.9-133.0	3.6 mi. (5.8 km)	1.49 mi. (2.4 km)	0.3 mi. (0.49 km)	0.04 mi. (0.06 km)	0.01 mi. (0.02 km)
4	136.0-143.1	5.46 mi. (8.78 km)	2.57 mi. (4.13 km)	0.35 mi. (0.56 km)	0.24 mi. (0.39 km)	0.02 mi. (0.03 km)
5	147.1-152.7	4.09 mi. (6.58 km)	3.14 mi. (5.05 km)	0.21 mi. (0.34 km)	0.05 mi. (0.08 km)	0.01 mi. (0.02 km)
6	169.2-170.2	6.37 mi. (10.26 km)	2.06 mi. (3.31 km)	1.96 mi. (3.16 km)	0.04 mi. (0.07 km)	0.03 mi. (0.04 km)
7	178.5-196.1	4.53 mi. (7.29 km)	2.27 mi. (3.65 km)	1 mi. (1.6 km)	0.02 mi. (0.03 km)	0.01 mi. (0.02 km)
8	205.6-205.7	3.89 mi. (6.26 km)	2.49 mi. (4.01 km)	0.78 mi. (1.25 km)	NA	NA

Section ID	KPs (km)	Maximum Extent of Deposited Sediment Thickness over Threshold from the Route Centerline				
Threshold:		**0.01 in. (0.25 mm)**	**0.02 in. (0.50 mm)**	**0.04 in. (1.00 mm)**	**0.20 in. (5.00 mm)**	**0.39 in. (10.00 mm)**
Representative Interarray Cable						
IAC-BW1	Length: 24.6	0.38 mi. (0.61 km)	0.06 mi. (0.09 km)	0.04 mi. (0.06 km)	0.01 mi. (0.02 km)	NA
IAC-BW2	Length: 24.5	0.14 mi. (0.23 km)	0.06 mi. (0.1 km)	0.03 mi. (0.04 km)	0.01 mi. (0.02 km)	NA
BW1/BW2Submarine Export Cable to Queens, New York						
BW1-1	0-50	2.37 mi. (3.81 km)	2.37 mi. (3.81 km)	2.37 mi. (3.81 km)	2.37 mi. (3.81 km)	2.37 mi. (3.81 km)
BW1-2	50-100	1.28 mi. (2.06 km)	1.03 mi. (1.66 km)	1 mi. (1.6 km)	0.02 mi. (0.04 km)	0.01 mi. (0.02 km)
BW1-3	100-150	1.64 mi. (2.65 km)	1.42 mi. (2.29 km)	0.65 mi. (1.04 km)	0.08 mi. (0.12 km)	0.02 mi. (0.03 km)
BW1-4	150-200	2.9 mi. (4.66 km)	2.09 mi. (3.37 km)	2.01 mi. (3.23 km)	0.88 mi. (1.42 km)	0.02 mi. (0.03 km)
BW1-5	200-250	3.66 mi. (5.9 km)	2.85 mi. (4.59 km)	2.17 mi. (3.5 km)	0.15 mi. (0.25 km)	0.06 mi. (0.1 km)

Section ID	KPs (km)	Maximum Extent of Deposited Sediment Thickness over Threshold from the Route Centerline				
Threshold:		0.01 in. (0.25 mm)	0.02 in. (0.50 mm)	0.04 in. (1.00 mm)	0.20 in. (5.00 mm)	0.39 in. (10.00 mm)
BW1-6	250-300	0.33 mi. (0.54 km)	0.32 mi. (0.51 km)	0.04 mi. (0.07 km)	0.04 mi. (0.06 km)	NA
BW1-7	300-348	0.2 mi. (0.33 km)	0.17 mi. (0.28 km)	0.04 mi. (0.06 km)	0.04 mi. (0.06 km)	NA
BW2 Submarine Export Cable to Waterford, Connecticut						
BW2-1	0-50	4.18 mi. (6.73 km)	2.09 mi. (3.37 km)	2.01 mi. (3.23 km)	0.88 mi. (1.42 km)	0.02 mi. (0.04 km)
BW2-2	50-100	3.66 mi. (5.9 km)	2.85 mi. (4.59 km)	2.17 mi. (3.5 km)	0.15 mi. (0.25 km)	0.06 mi. (0.1 km)
BW2-3	100-150	0.33 mi. (0.54 km)	0.32 mi. (0.51 km)	0.04 mi. (0.07 km)	0.04 mi. (0.06 km)	NA
BW2-4	150-176	0.2 mi. (0.33 km)	0.17 mi. (0.28 km)	0.04 mi. (0.06 km)	0.03 mi. (0.06 km)	NA

Table I.4-6 below summarizes the maximum and average times that the TSS concentration was above five threshold concentrations.

TABLE I.4-6. SUMMARY OF TIME ABOVE THRESHOLD FOR TSS PLUME

Section ID	KPs (km)	Maximum and Average Time above of TSS Plume Threshold (hours)									
		500 mg/L		1,000 mg/L		5,000 mg/L		10,000 mg/L		50,000 mg/L	
		Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
Pre-Sweeping											
1	1.57-1.93	23.3	1.9	23.3	1.5	23.3	1.1	23.2	1.1	23.2	1.4
2	51.9-53.4	5.2	1.7	5.2	1.8	4.5	1.7	4.2	1.4	2.2	0.7
3	122.9-133.0	10.8	2.2	7.2	2.2	5.2	2.3	4.3	1.7	1.5	0.4
4	136.0-143.1	10.8	2.2	10.3	2.6	6	3.8	5.8	3.5	4.5	1.7
5	147.1-152.7	8.8	3.1	8.3	3.6	5.3	3.2	5.2	2.7	1.8	0.5
6	169.2-170.2	6.8	1.2	6.8	1.4	6.5	1.9	6.3	2.2	3.5	1.4
7	178.5-196.1	14.2	2.0	11	1.8	7.3	1.7	5.2	1.3	0.8	0.3
8	205.6-205.7	4.2	1.2	3.3	1.0	2.5	1.0	2.0	1.0	0.7	0.4

Section ID	KPs (km)	Maximum and Average Time above of TSS Plume Threshold (hours)									
		50 mg/L		100 mg/L		500 mg/L		1,000 mg/L		5,000 mg/L	
		Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
Representative Interarray Cable											
IAC-BW1	Length: 24.6	34.8	1.9	31.3	1.9	7.7	0.9	5.0	0.6	0.8	0.3
IAC-BW2	Length: 24.5	63	4.0	46.2	3.1	7.0	1.3	4.8	0.9	0.7	0.3
BW1/BW2 Submarine Export Cable to Queens, New York											
BW1-1	0-50	38	1.2	38.0	1.1	9.5	0.7	3.5	0.5	1.3	0.3
BW1-2	50-100	35.8	1.8	32.3	1.9	11.3	1.4	5.7	1.0	3.7	0.4
BW1-3	100-150	45.8	2.8	39.2	3.1	11.7	2.6	7.3	1.9	2	0.4
BW1-4	150-200	10.2	1.9	8.0	2.0	5.5	2.0	5.2	1.5	2.5	0.3
BW1-5	200-250	39.3	1.4	28.2	1.5	9.8	1.4	4.8	1.2	2.7	0.3
BW1-6	250-300	86.2	10.1	62	8.8	20.0	3.3	12.3	2.0	2.3	0.6
BW1-7	300-348	69.3	5.2	58.8	4.3	15.8	1.8	10.0	1.2	1.0	0.3
BW2 Submarine Export Cable to Waterford, Connecticut											

Section ID	KPs (km)	Maximum and Average Time above of TSS Plume Threshold (hours)									
		50 mg/L		100 mg/L		500 mg/L		1,000 mg/L		5,000 mg/L	
		Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
BW2-1	0-50	10.2	1.7	8.0	1.9	5.5	1.7	4.8	1.2	1.3	0.3
BW2-2	50-100	39.3	1.4	28.2	1.6	5.5	1.6	5.2	1.3	2.7	0.4
BW2-3	100-150	86.2	9.9	62.0	8.7	20.0	3.2	12.3	2.0	2.3	0.6
BW2-4	150-176	69.3	7.4	58.8	6.1	15.8	2.4	10.0	1.5	1.0	0.3

I.5 References

Benson, M. A., and Tate Dalrymple. 1967. *Chapter A1: General Field and Ofice Procedures for Indirect Discharge Measurements*. Alexandria, VA: USGS.

BOEM. 2018. *Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan.* Washington, DC: US Department of the Interior, Bureau of Ocean Energy Management Office of Renewable Energy Programs.

BOEM. 2017. *Observing Cable Laying and Particle Settlement During the Construction of the Block Island Wind Farm.* Englewood, CO: US Department of the Interior.

BOEM. 2017. *Phased Approaches to Offshore Wind Developments and Use of the Project Design Envelope, Final Technical Report.* Washington, DC: US Department of the Interior, Bureau of Ocean Energy Mamanegemt Office of Renewable Energy Programs.

Commonwealth of Massachusetts. 2015. *Recommended Time of Year Rdstrictions (TOYs) for Coastal Alteration Projects to Protect Marine Fisheries Resources in Massachusetts.* Boston, MA: Commonwealth of Massachusetts Executive Office of Energy and Envirnmental Affairs; Department of Fish and Game; Massachusetts Division of Marine Fishries.

CTDEEP. 2002. *Water Quality Standards*. Hartford, Connecticut: CTDEEP.

DHI Group. 2021. "Beacon Wind - Wave and Current Hindcast Data." Horsholm, DK.

Egbert, Gary D., and Y. Svetlana Erofeeva. 2002. "Efficient Inverse Modeling of Barotropic Ocean Tides." *Journal of Atmospheric and Ocean Technology* 183-204.

Fisher, Karen, and Hugh Dawson. 2003. *Review, Reducing Uncertainty in River Flood Conveyance: Roughness Review*. London, UK: DEFRA.

FUGRO. 2011. *Seabed Scour Considerations for Offshore Wind Development on the Atlantc OCS*. Norfolk, VA: BOEM.

GEBCO 2020. *Gridded Bathymetry Data.* https://www.gebco.net/data_and_products/gridded_bathymetry_data/.

Graham, Doug. 2021. *NOAA Medium Resolution Shoreline.* May 27. https://shoreline.noaa.gov/data/datasheets/medres.html.

Grilli, Stephan, Jeffrey Harris, Ravi Sharma, Lauren Decker, David Stuebe, Danny Mendelsohn, Deborah Crowley, and Steve Decker. 2010. *Rhode Island Ocean Special Area Management Plan: Volume 2. High Resolution Modeling of Meteorological, Hydrodynamic, Wave, and Sediment Processes in SAMP Study Area*. University of Rhode Island, 402-520. Accessed May 24, 2021.

Gunawan, Budi, Vincent Neary, and Jonathan Colby. 2014. "Tidal Energy Site Resource Assessment in the East River Tidal Srait, Near Roosevelt Island, New York, New York." Renewable Energy. doi:10.1016/j.renene.2014.06.002.

Hsu, S.A., Eric A. Meindl, and David B. Gilhousen. 1993. "Determining the Power Law Wind-Profile Exponent under Near Neutral Stability Conditions at Sea." *Journal of Applied Meteorology* 33: 757-765.

Militello, Adele, and Alan K. Zundel. 1999. *Surface-Water Modeling System Tidal Constituents Toolbox for ADCIRC*. United States Army Corps of Engineers.

MMT Sweden AB. 2021. *Massachusetts OCS-A 0520 Beacon Wind Survey Campaign: High Resolution Geophysical and Marine Archaeological Assessment Survey*. Vastra Frolunda, Sweden: MMT Sweden AB.

NOAA. 2015. *Bathymetry and Acoustic Backscatter Collected in Long Island SOund for the Phase I Long Island Sound Seafloor Mapping Project 2014. NCEI Accession No. 0167946.* https://coastalscience.noaa.gov/data_reports/bathymetry-acoustic-backscatter-collected-long-island-sound-phase-long-island-sound-seafloor-mapping-project-2014-ncei-accession-0167946/ .

—. 2015. *Bathymetry and Acoustic Backscatter Data Collected in Long Island Sound for the Phase III Long Island Sound Seafloor Mapping Project 2015. NCEI Accession No. 0167532*. https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:167532 .

—. 2019. *Daily Weather Maps: Sunday January 20, 2019. January 20. Accessed June 1, 2022.* https://www.wpc.ncep.noaa.gov/dailywxmap/index_20190120.html.

—. 2021. *Station 44008 - Nantucket 54 NM Southeast of Nantucket*. November 5. https://www.ndbc.noaa.gov/station_page.php?station=44008.

—. 2021. *Station 44017 - Montauk Point - 23 NM SSW of Montauk Point, NY.* May 13. https://www.ndbc.noaa.gov/station_page.php?station=44017.

—. 2021. *Station 44020 - Nantucket Sound.* November 5. https://www.ndbc.noaa.gov/station_page.php?station=44020.

—. 2021. *Station 44022 - Execution Rocks.* May 13. https://www.ndbc.noaa.gov/station_page.php?station=44022.

—. 2021. *Station 44039 - Central Long Island Sound.* May 13. https://www.ndbc.noaa.gov/station_page.php?station=44039.

—. 2021. *Station BUZM3 - Buzzards Bay, MA.* May 13. https://www.ndbc.noaa.gov/station_page.php?station=buzm3.

NYSDEC. 2004. *TOGS 5.1.9. In-Water and Riparian Management of Sediment and Dredged Material.* Albany, New York: NYSDEC Division of Water.

O'Donnell, James. 2021. *University of Connecticut LISICOS Program THREDDS Serve*r. June 1. Accessed 2021.
http://nopp.dms.uconn.edu:8080/thredds/dodsC/ADCP/LISICOS_ADCP/CLIS/catalog.html.

RPS. 2018. *Deepwater Wind South Fork Wind Farm: Hydrudynamic and Sediment Transport Modeling Results*. South Kingstown, RI: RPS.

RPS. 2018. *Hydrodynamic and Sediment Dispersion Modeling Study for the Vineyard Wind Project*. South Kingstown, RI: RPS.

RPS/ASA. 2012. *Sediment Transport Analysis of Cable Installation for Block Island Wind Farm and Block Island Transmission System*. South Kingstown, RI: RPS/ASA.

Tetra Tech. 2021. *Empire Offshore Wind: Empire Wind Project (EW1 and EW2) Constructions and Operations Plan. Appendix J: Sediment Transport Analysis*. Tetra Tech.

USACE. 2006. "PTM: Particle Tracking Model Report 1: Model Theory, Implementation, and Example Applications."

USGS. 2013. *Combined 2-m and Interpolated 10-m Bathymetric Grid of NOAA Survey H12013 off the Entrance to the Connecticut River n Eastern Long Island Sound.* https://data.usgs.gov/datacatalog/data/USGS:88ef82e6-16de-418d-946b-485508fdd184 .

—. 2016. *Hurricane Sandy Region - Topobathymetric Model of New England.* https://www.usgs.gov/core-science-systems/eros/coned/science/hurricane-sandy-region-topobathymetric-elevation-model-new .

—. 2021. "StreamStats Report - Thames River." StreamStats. 03 23. https://usgs.streamstats/gov/ss.

—. 2014. *U.S. Geological Survey East-Coast Sediment Texture Database.* https://woodshole.er.usgs.gov/project-pages/sediment/overview.html.

Vincent, Mark, Eugene Wei, John Kelley, Mike Evans, Kathryn Thompson Bosley, and Rich Bourgerie. 2002. "Implementation Plan: Port of New York and New Jersey Operational Forecast System (NYOFS)." NOAA, Silver Spring, MD.

Attachment I.A
Complete PTM Results for Beacon Wind Cable Installation

List of Attachment Figures

I-A.1 Representative Interarray Cable Installation

FIGURE I-A.0-2. BW2 INTERARRAY CABLE MODELED TSS AND DEPOSITIONAL THICKNESS

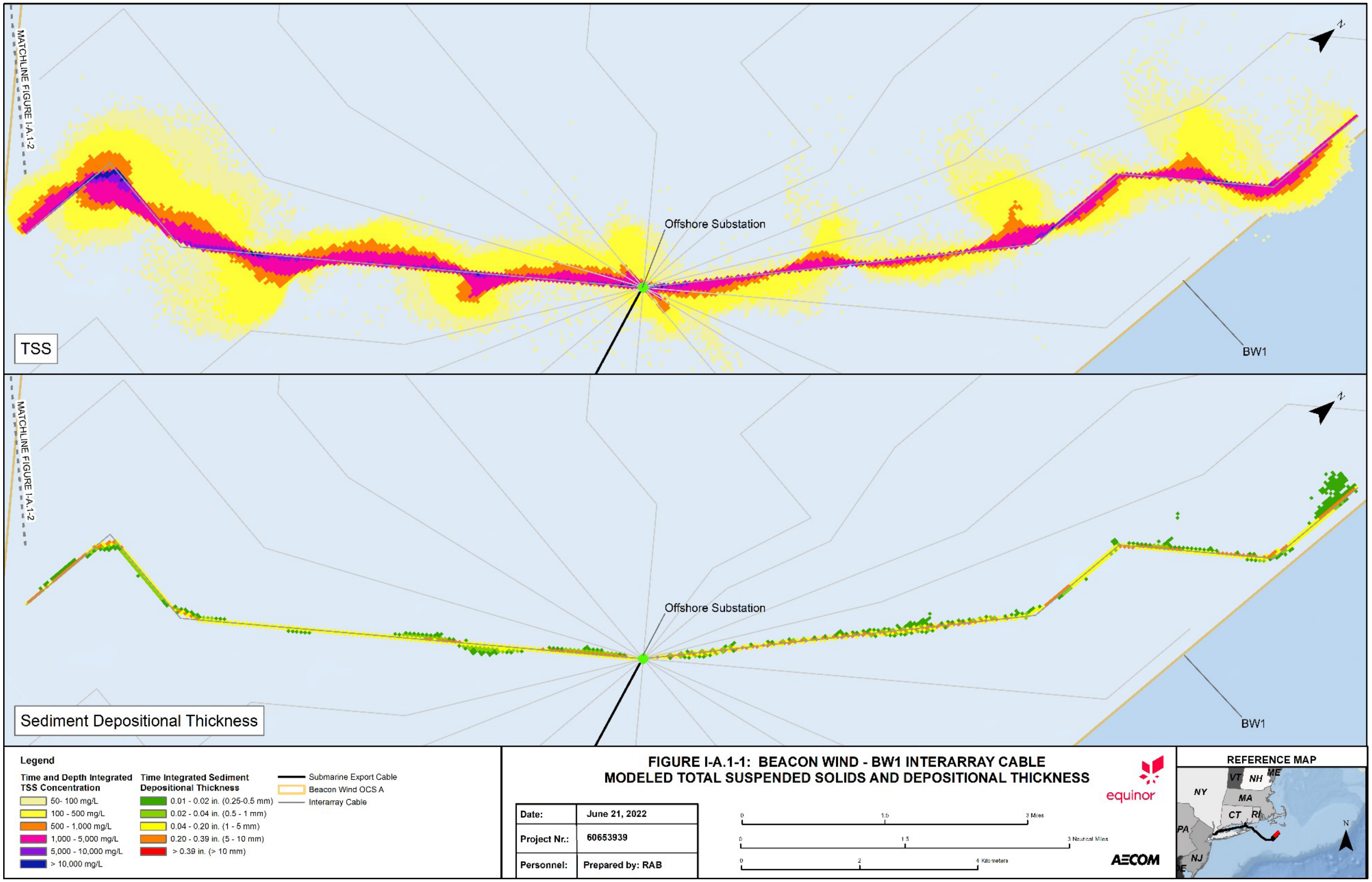
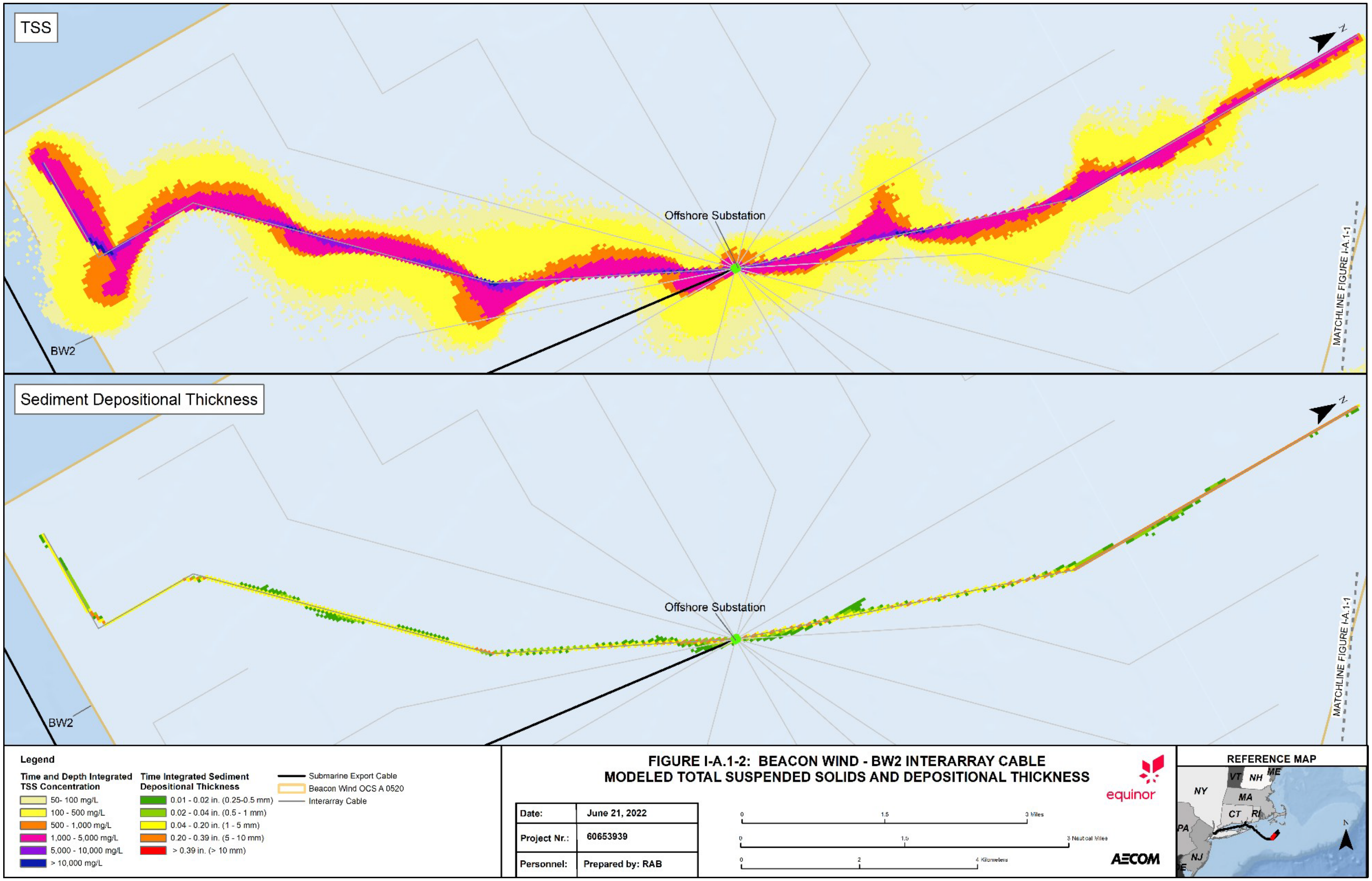


Figure I-A.0-3. BW3 Interarray Cable Modeled TSS and Depositional Thickness



I-A.2 BW1/BW2 Submarine Export Cable Installation

FIGURE I-A.0-3. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 0 TO KP 13.8

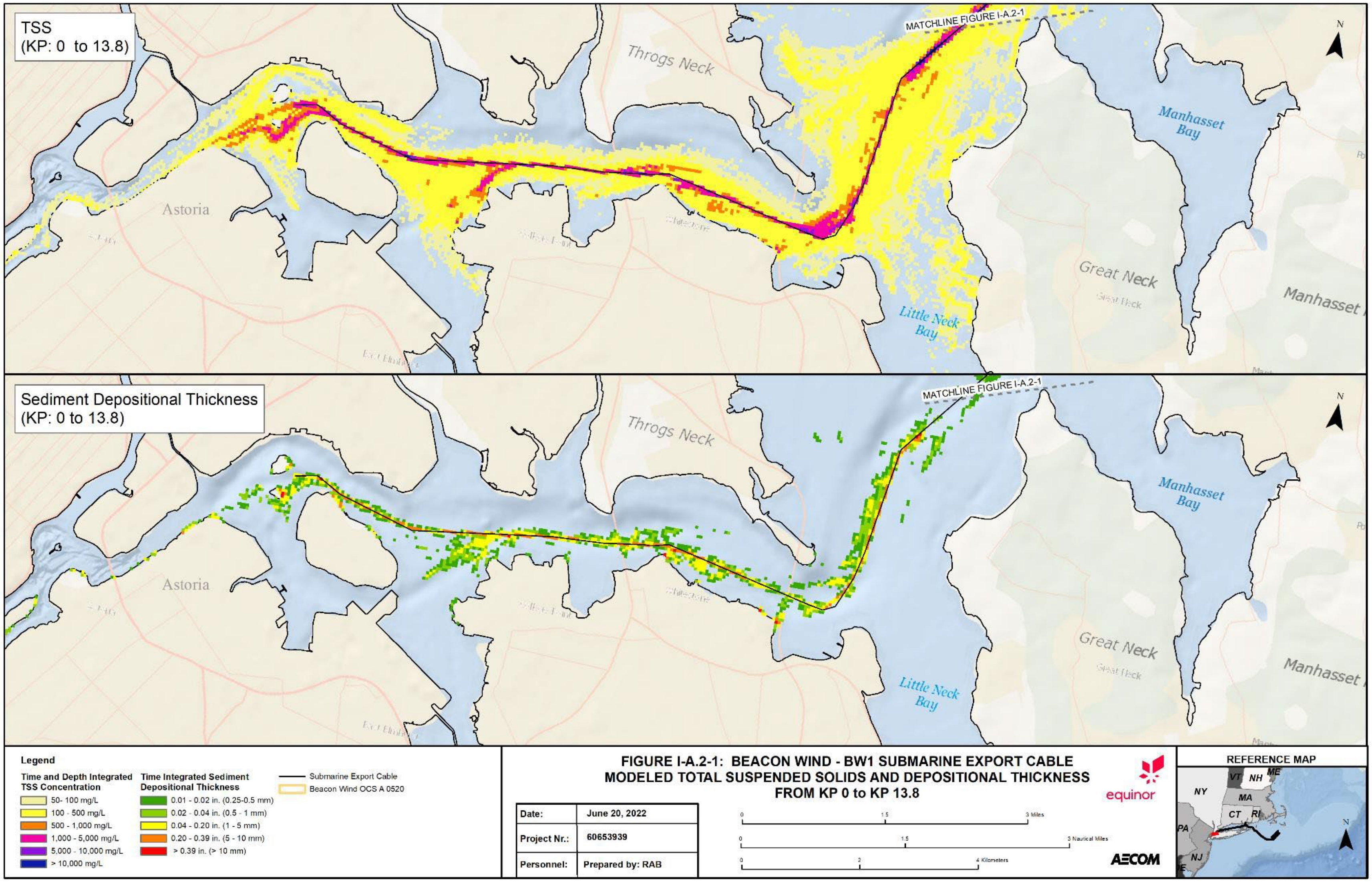


FIGURE I-A.0-4. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 13.8 TO KP 36.4

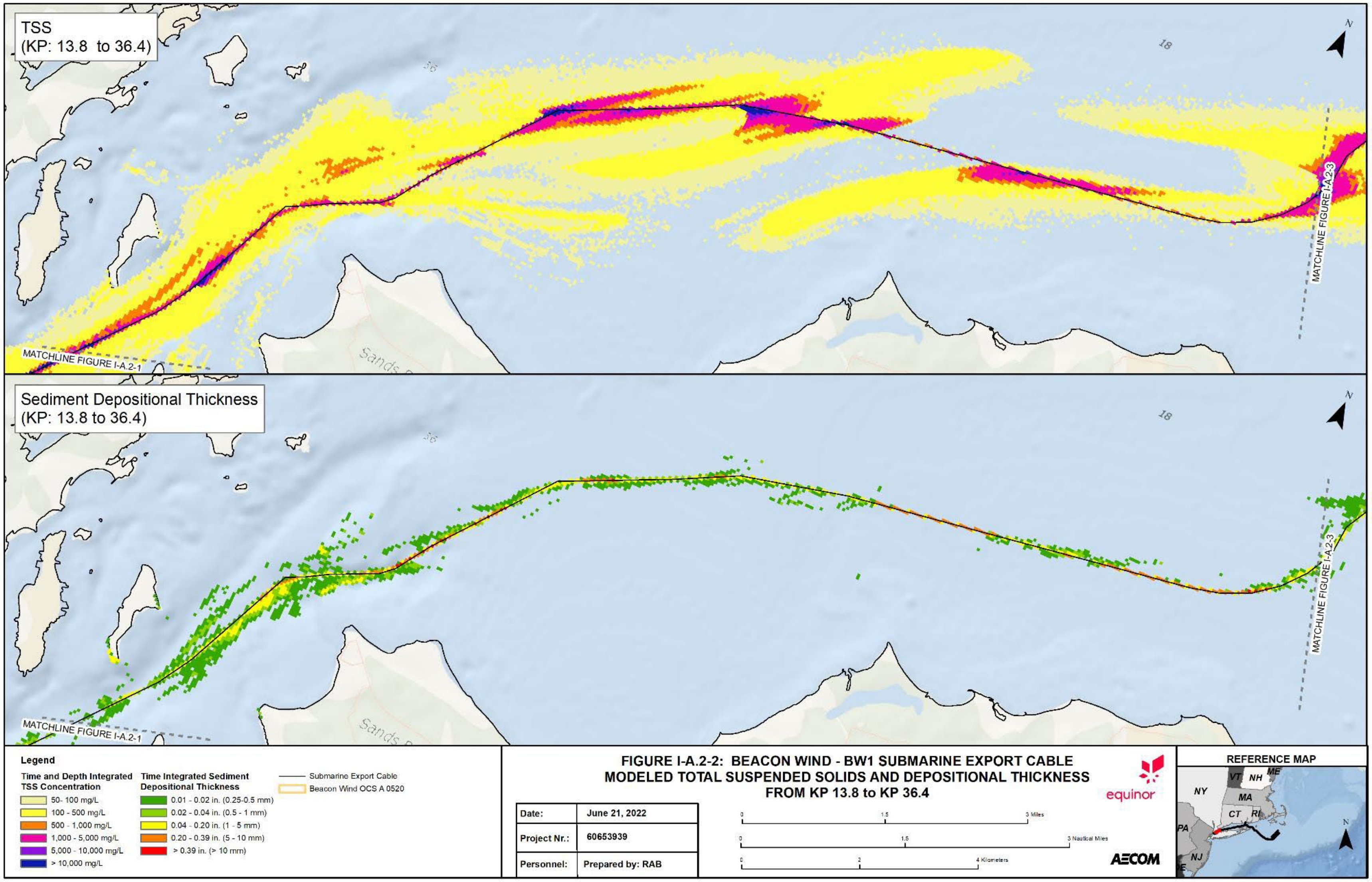


FIGURE I-A.0-5. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 36.4 TO KP 60.0

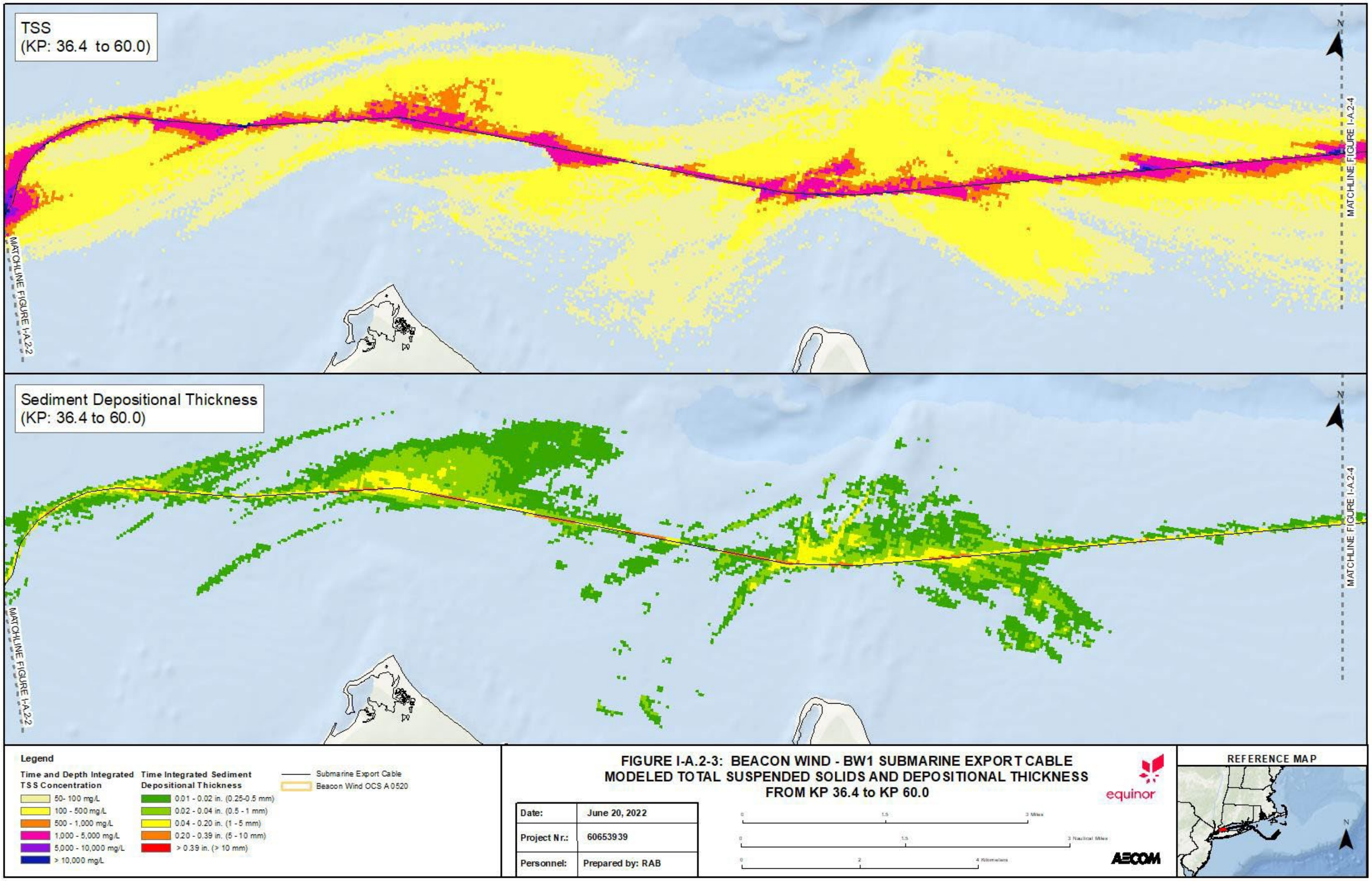


FIGURE I-A.0-8. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 60.0 TO KP 83.3

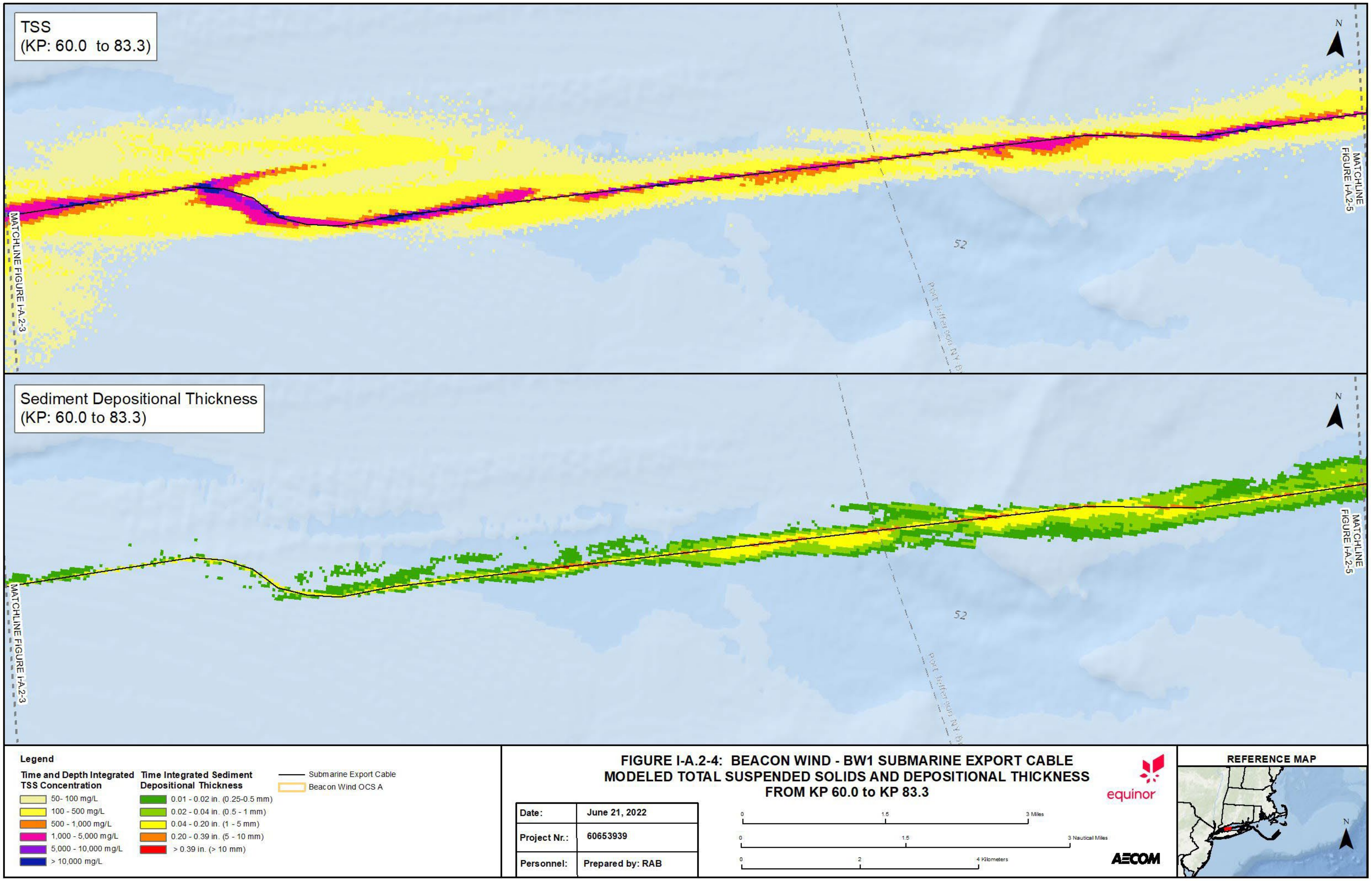


Figure I-A.0-9. BW1 Submarine Export Cable Modeled TSS and Depositional Thickness from KP 83.3 to KP 106.4

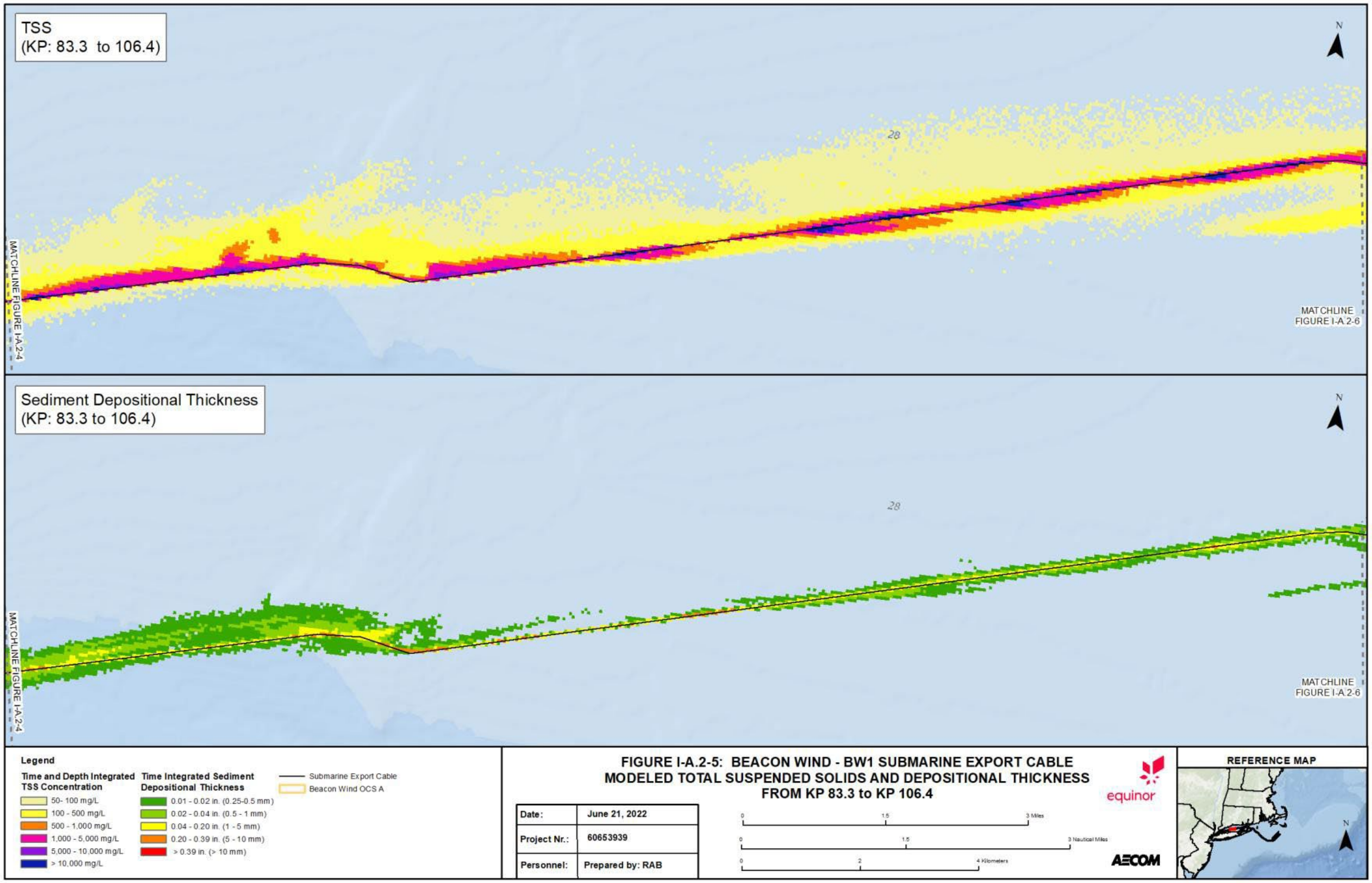


FIGURE I-A.0-10. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 106.10 TO KP 130.

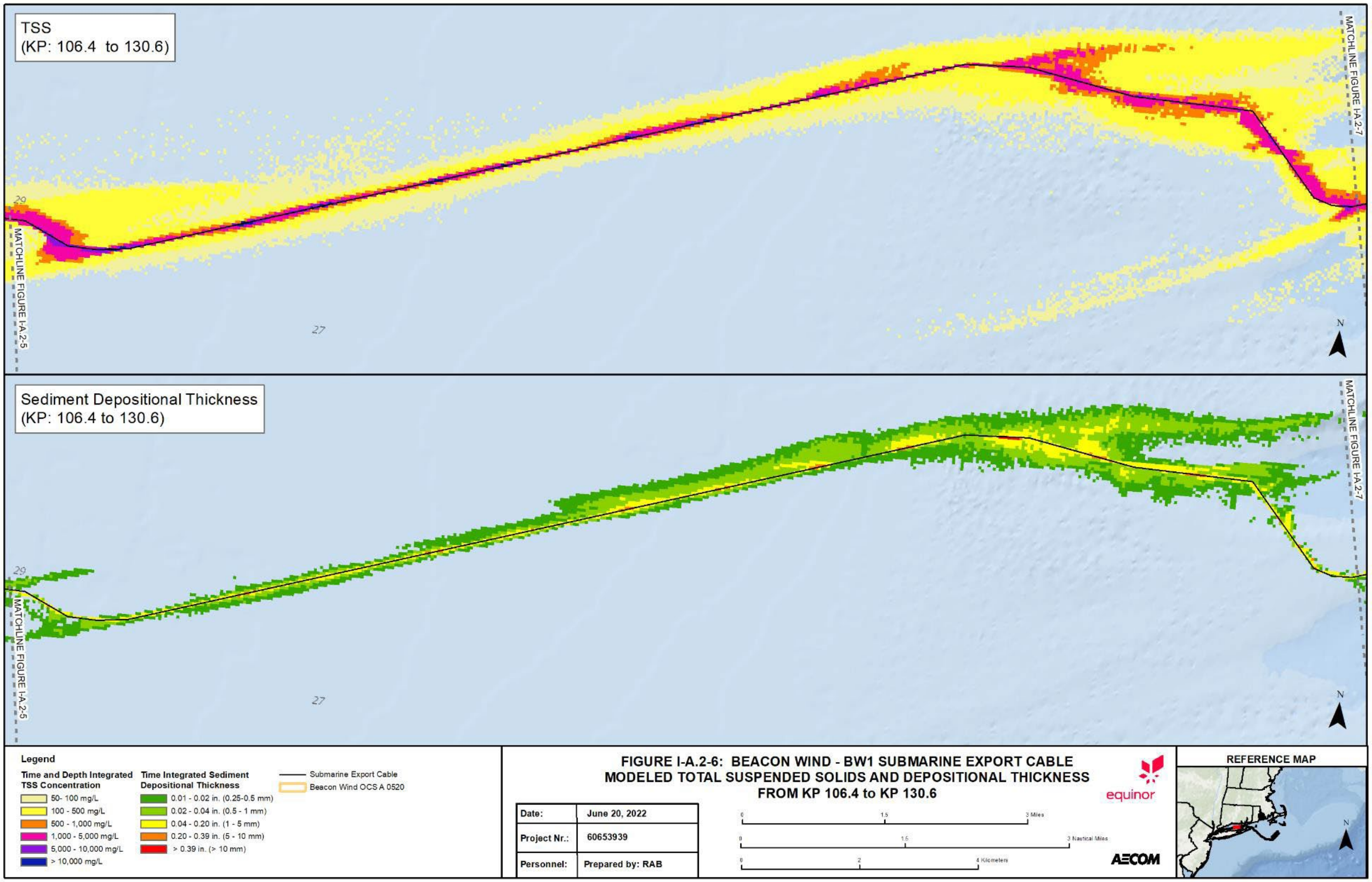


FIGURE I-A.0-11. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 130.11 TO KP 153.

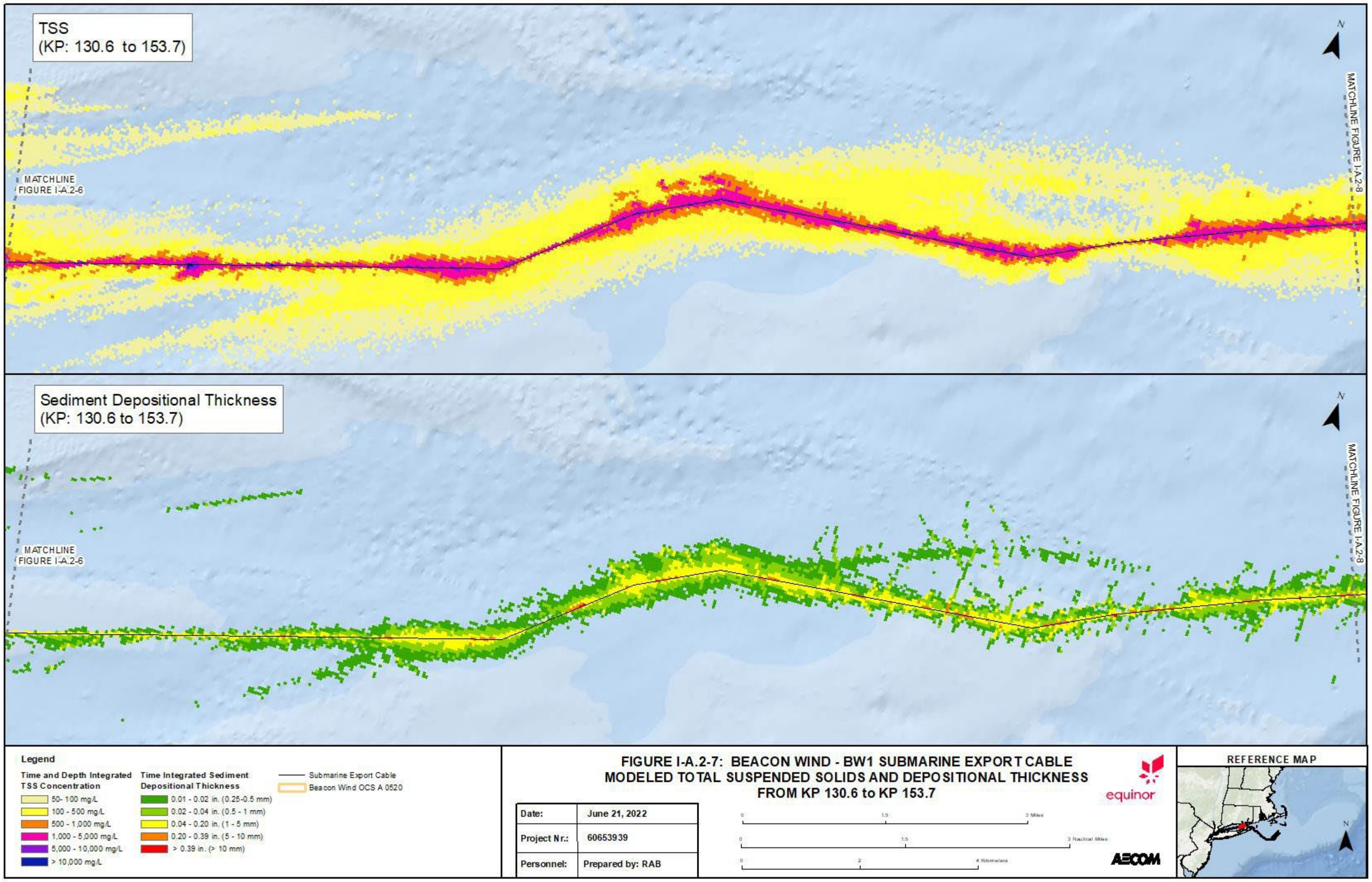


FIGURE I-A.0-12. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 153.12 TO KP 170.0

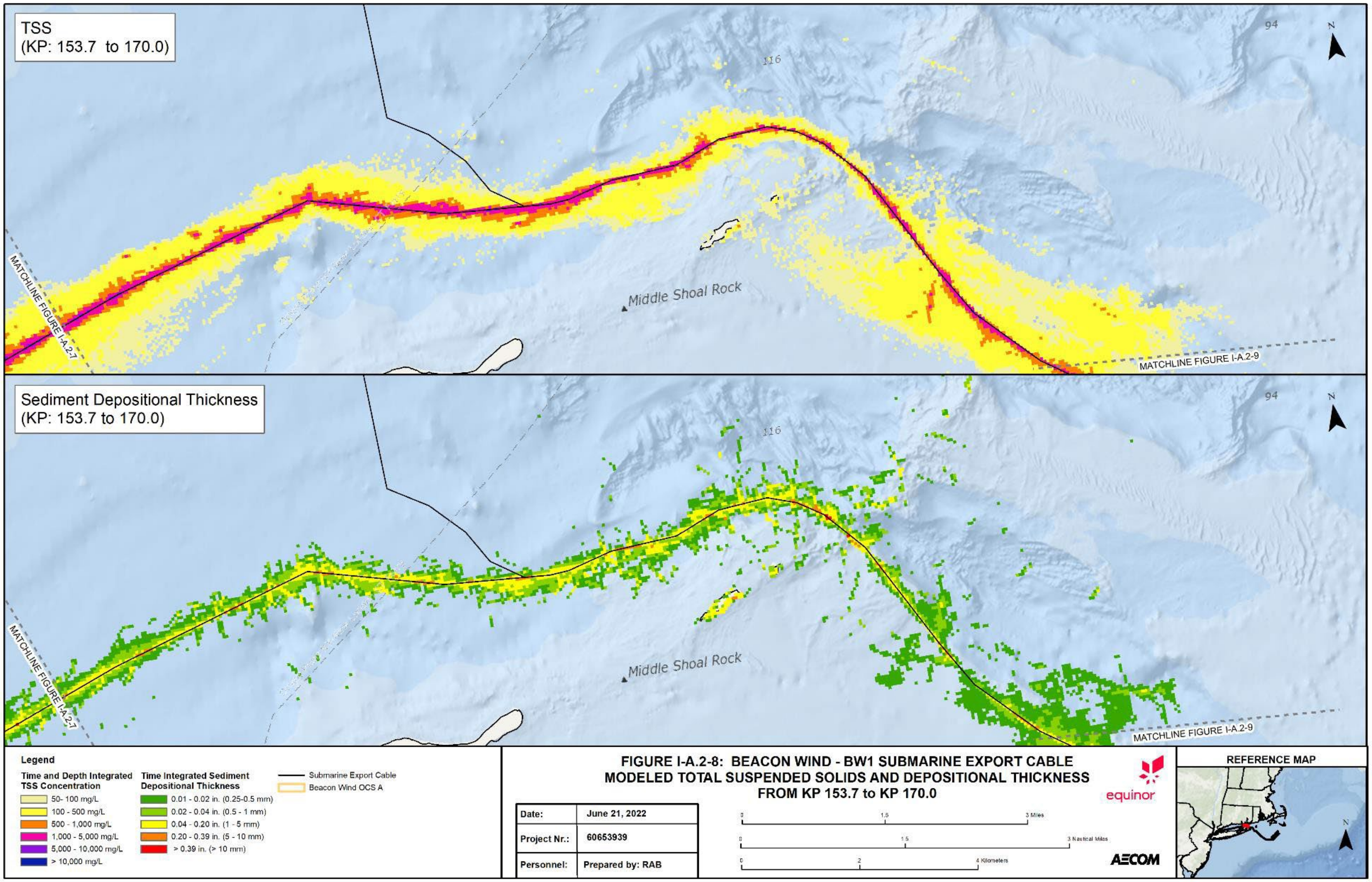


FIGURE I-A.0-13. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 170.0 TO KP 190.13

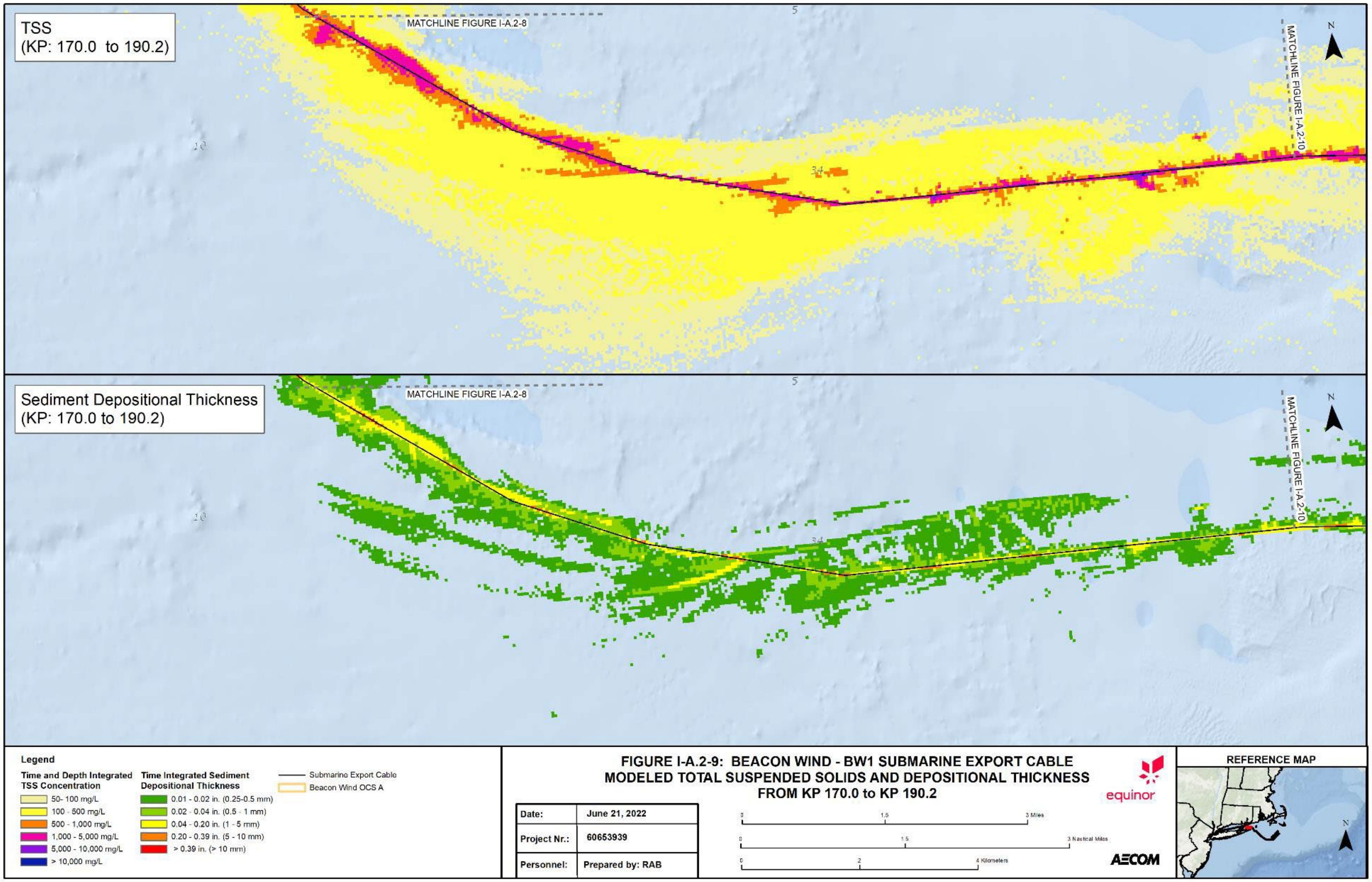


FIGURE I-A.0-14. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 190.14 TO KP 213.14

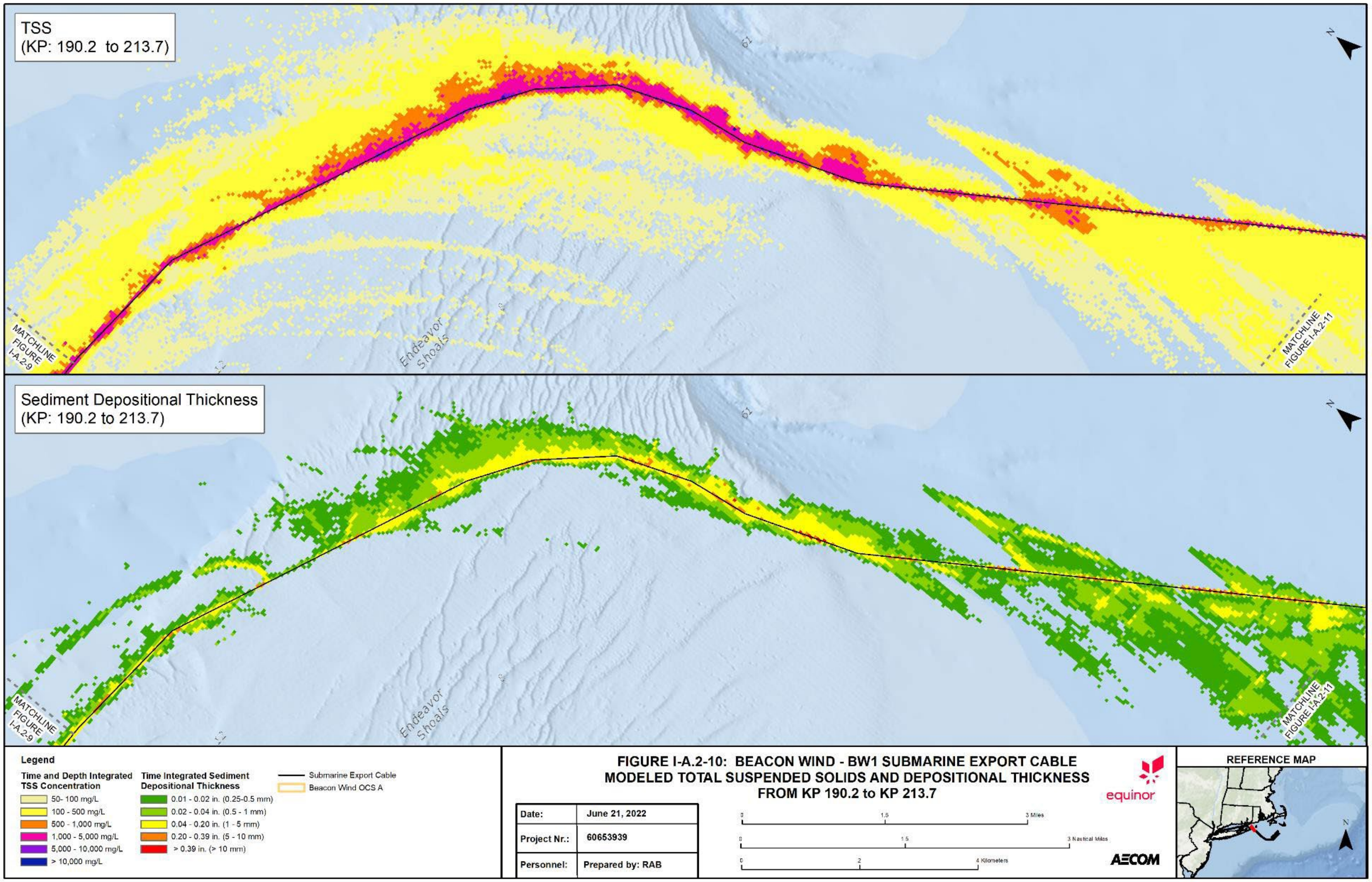


FIGURE I-A.0-15. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 213.15 TO KP 223.15

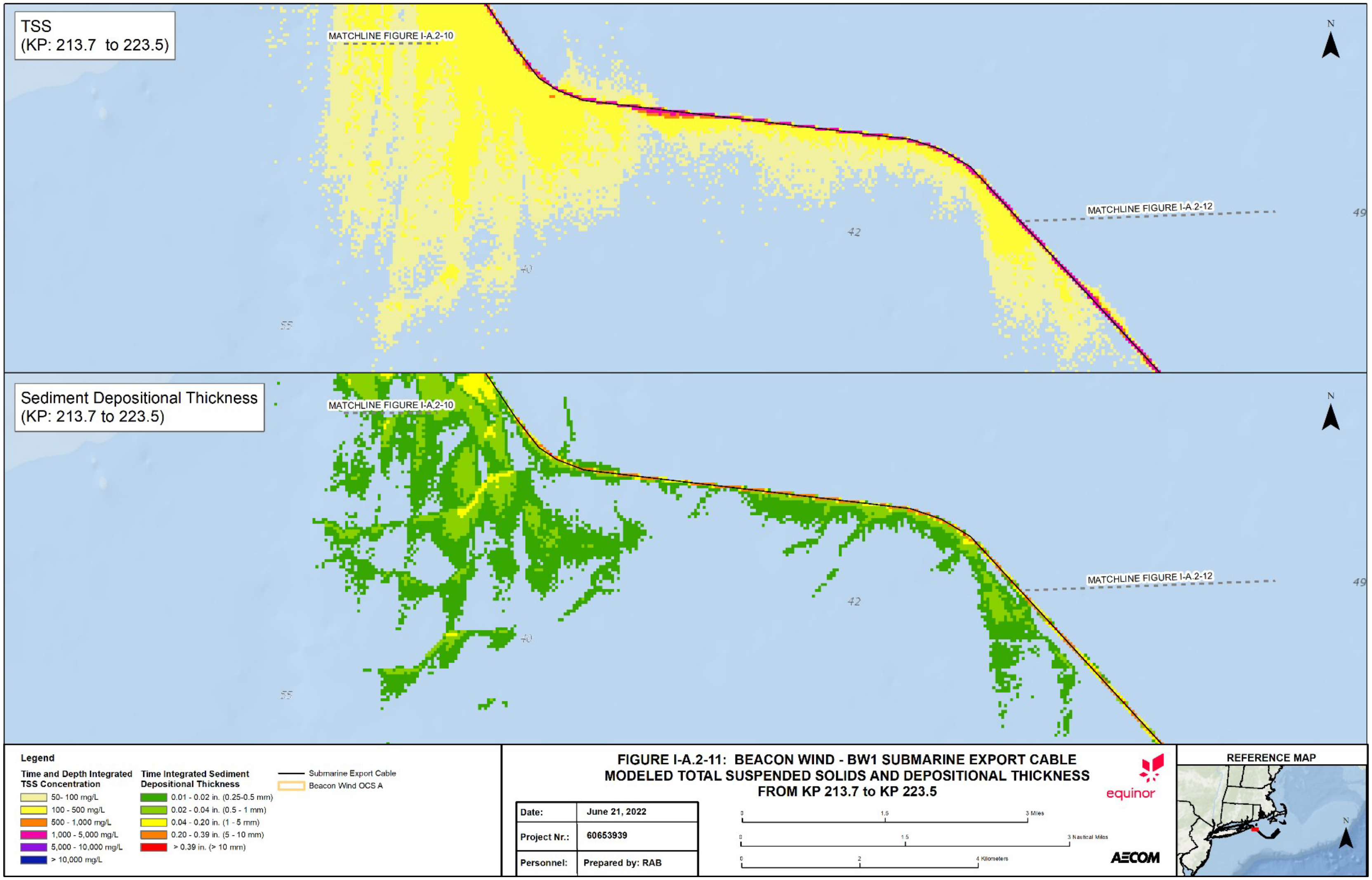


FIGURE I-A.0-16. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 223.16 TO KP 246.16

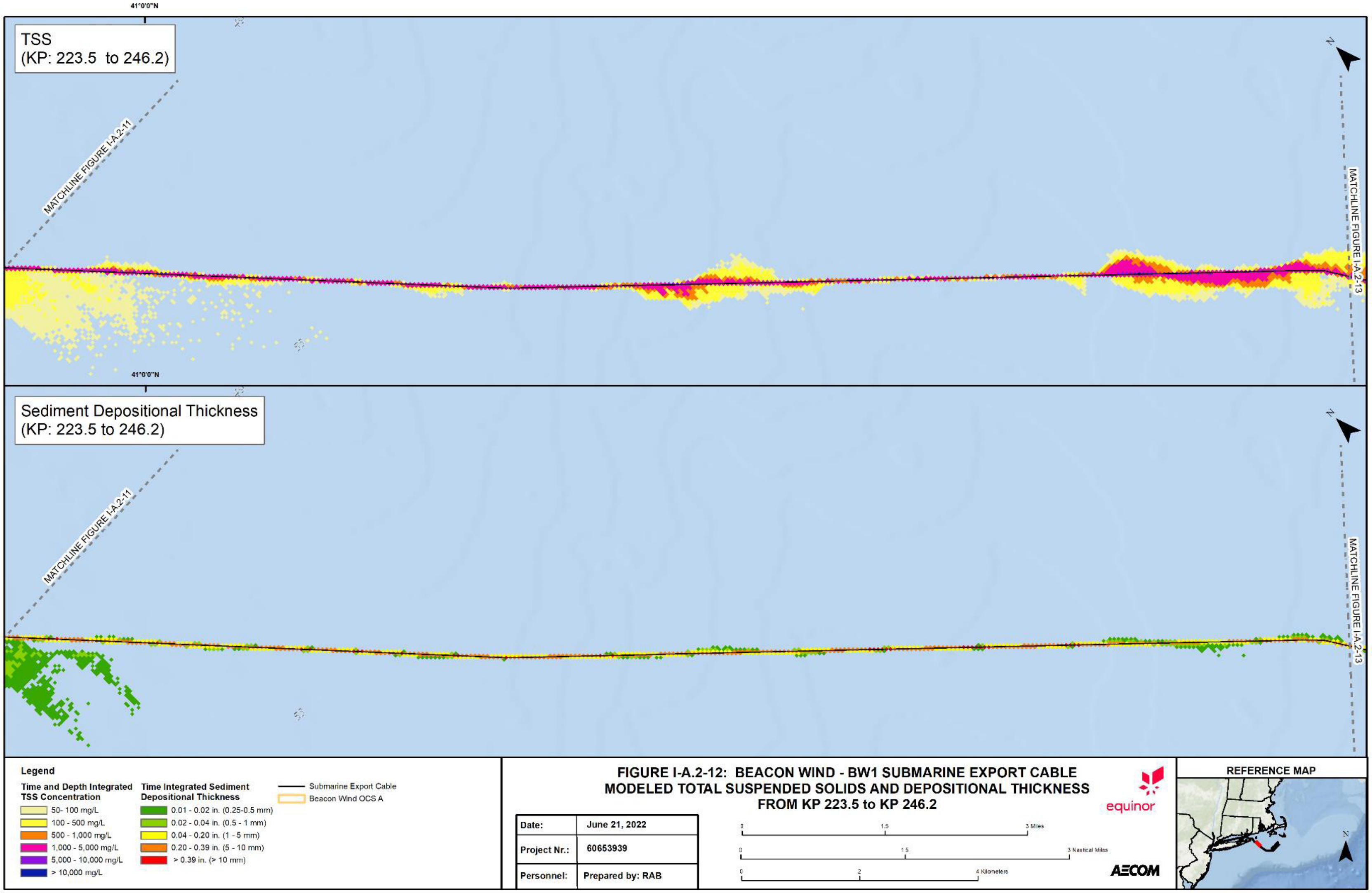


FIGURE I-A.0-17. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 246.17 TO KP 268.17

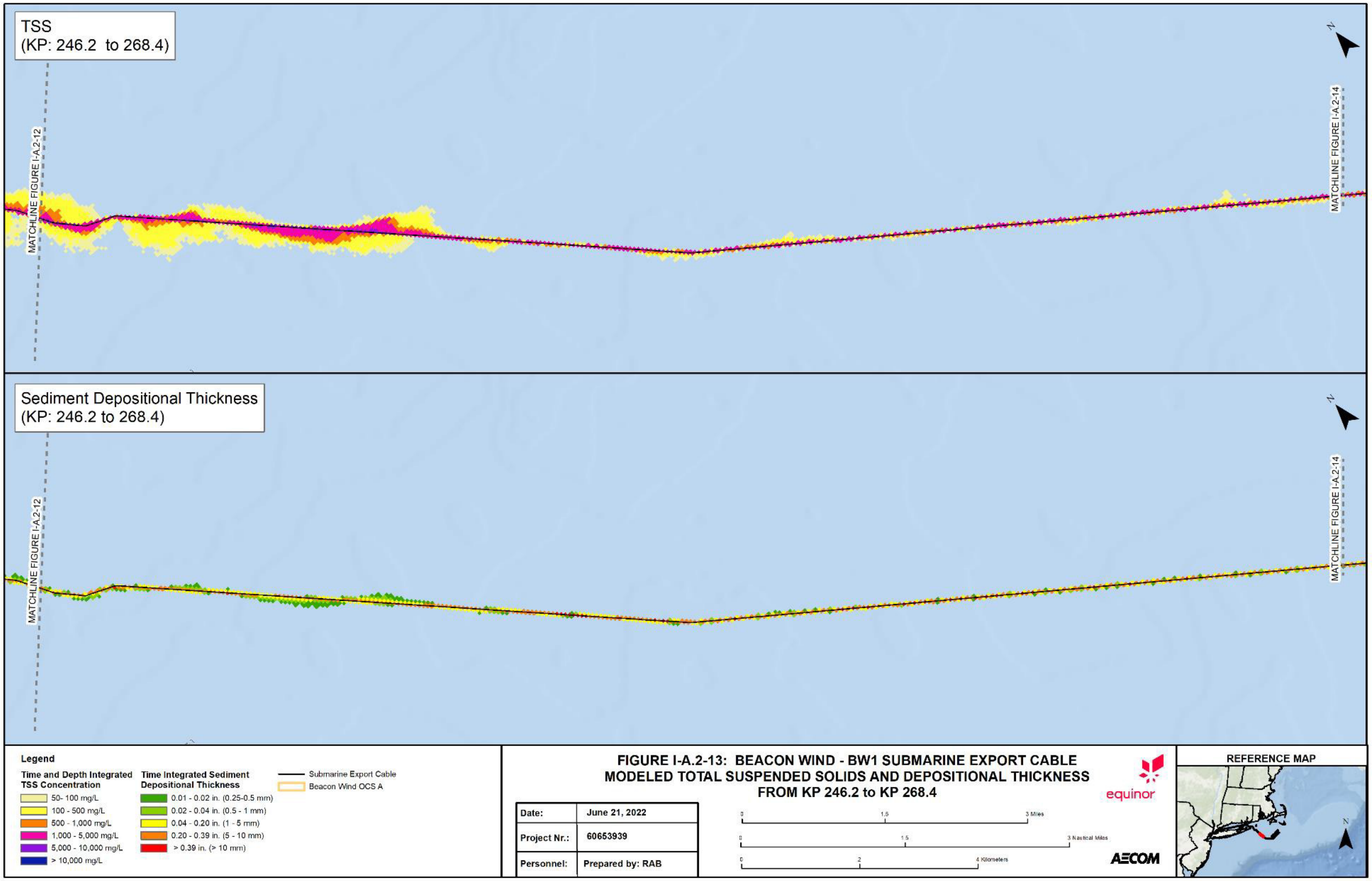


FIGURE I-A.0-18. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 268.18 TO KP 291.18

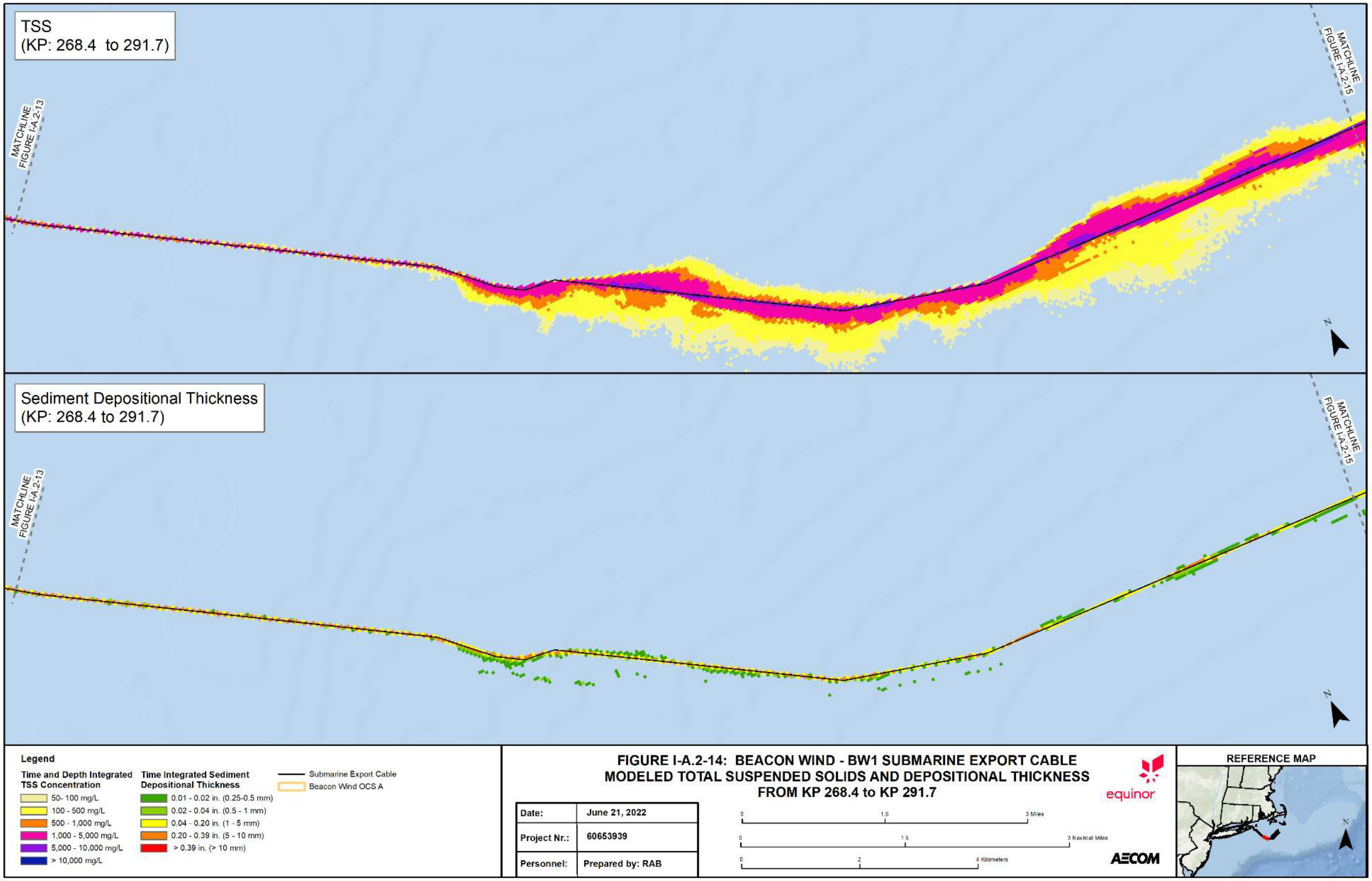


FIGURE I-A.0-19. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 291.19 TO KP 313.19

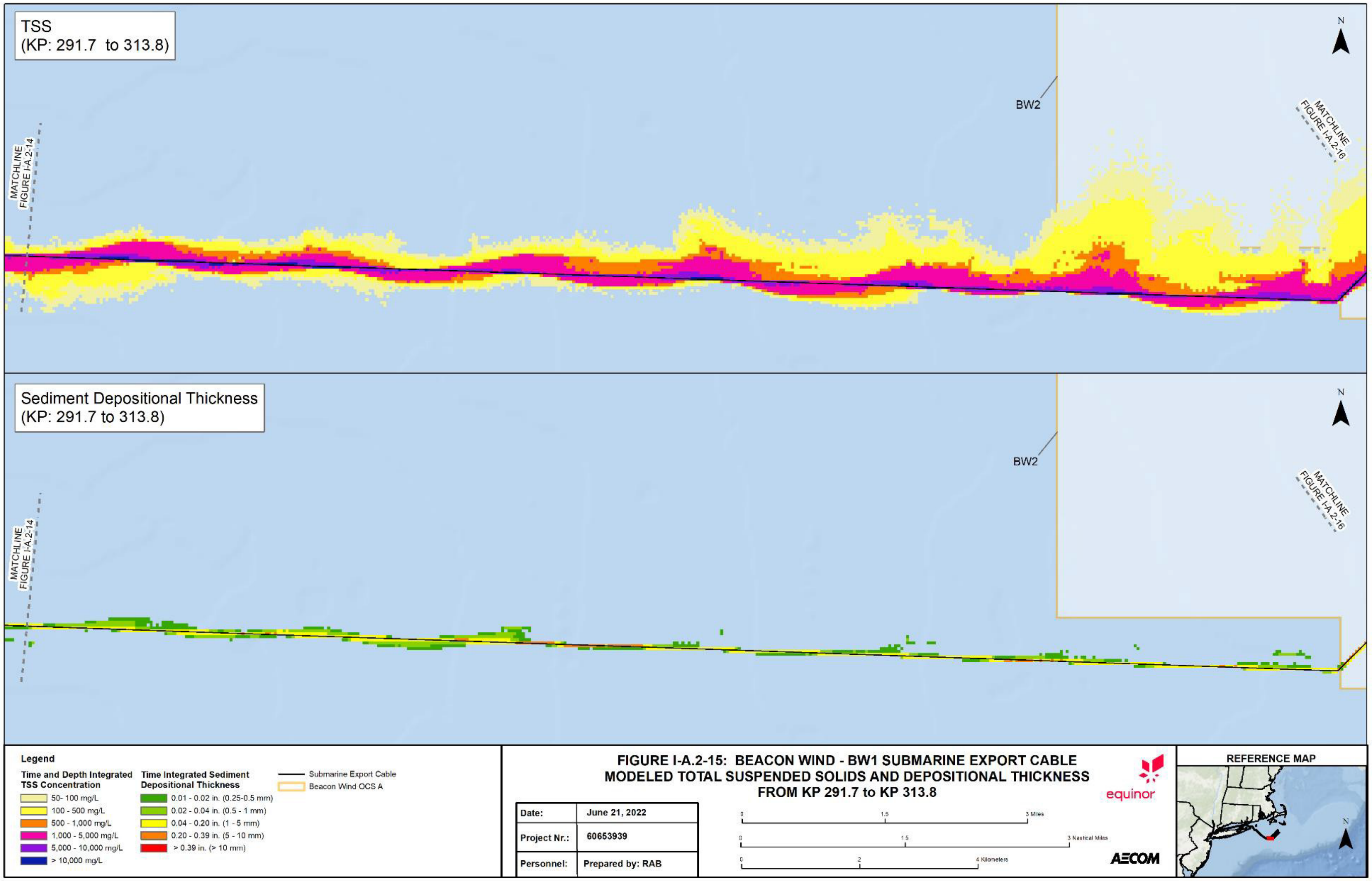


FIGURE I-A.0-20. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 313.20 TO KP 338.0

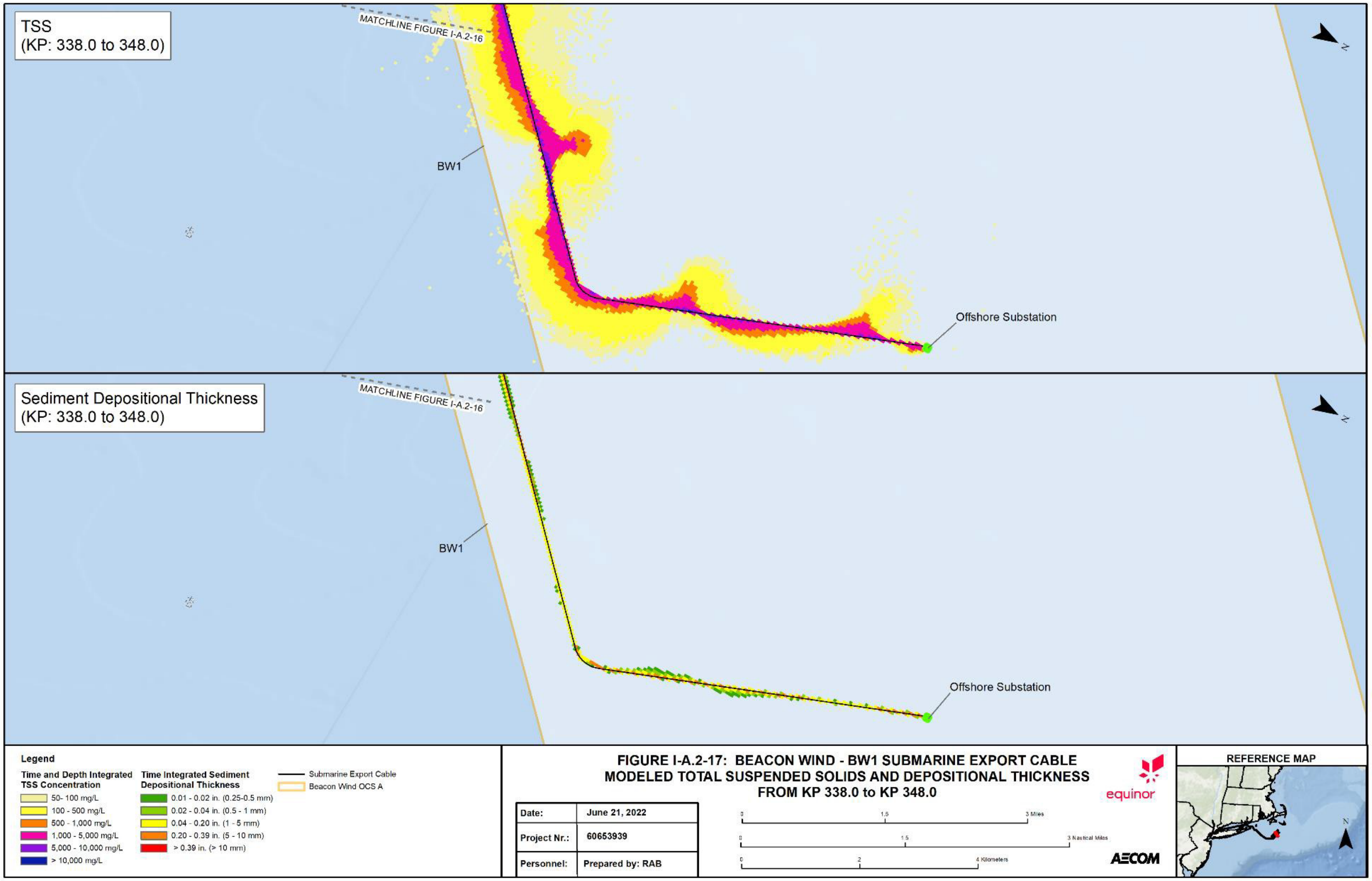
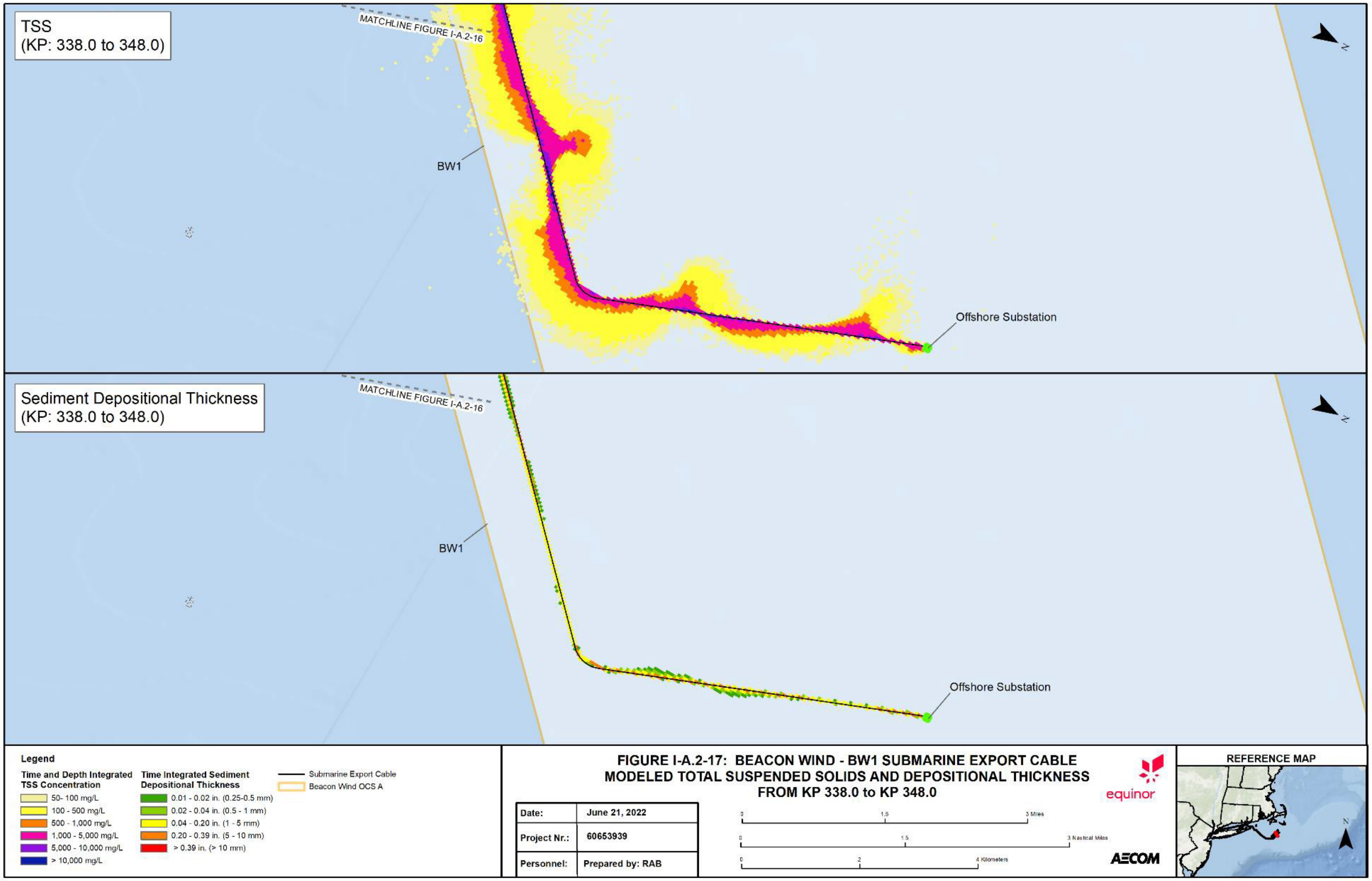


FIGURE I-A.0-21. BW1 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 338.0 TO KP 21.0



I-A.3 BW2 Submarine Export Cable Installation

FIGURE I-A.0-20. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 0 TO KP 4.2

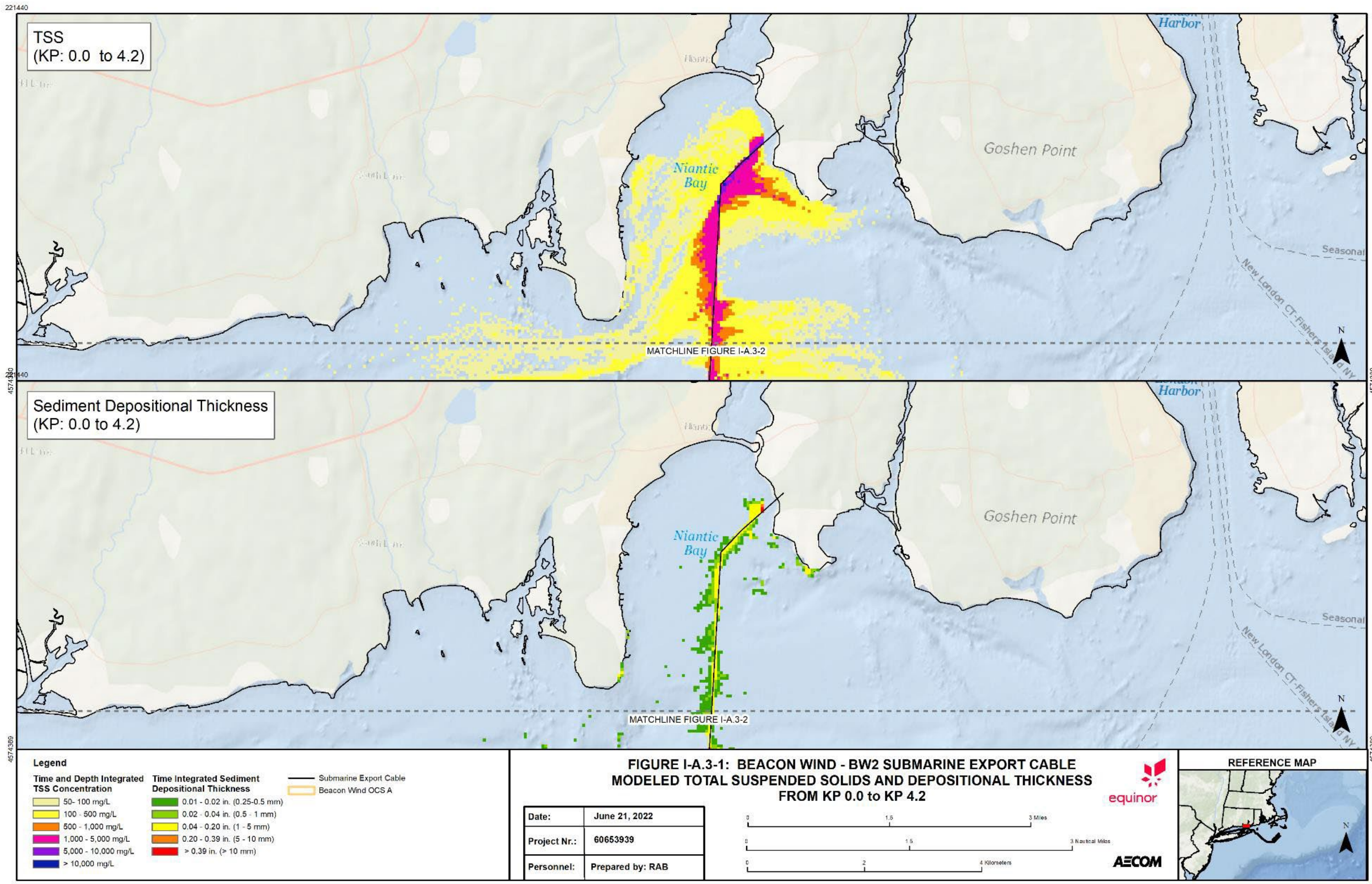


FIGURE I-A.0-21. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 4.2 TO KP 8.7

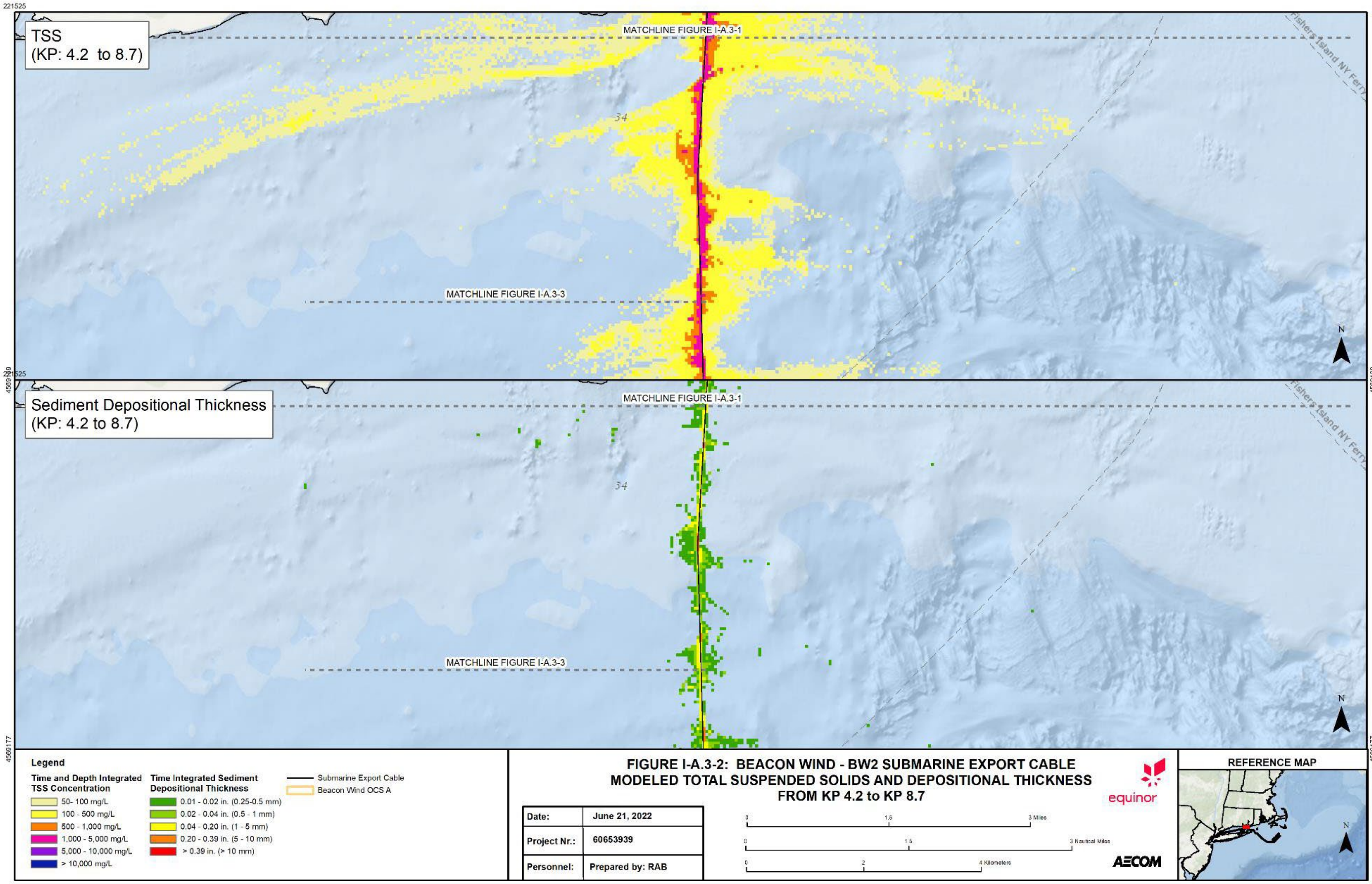


FIGURE I-A.0-22. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 8.7 TO KP 24.1

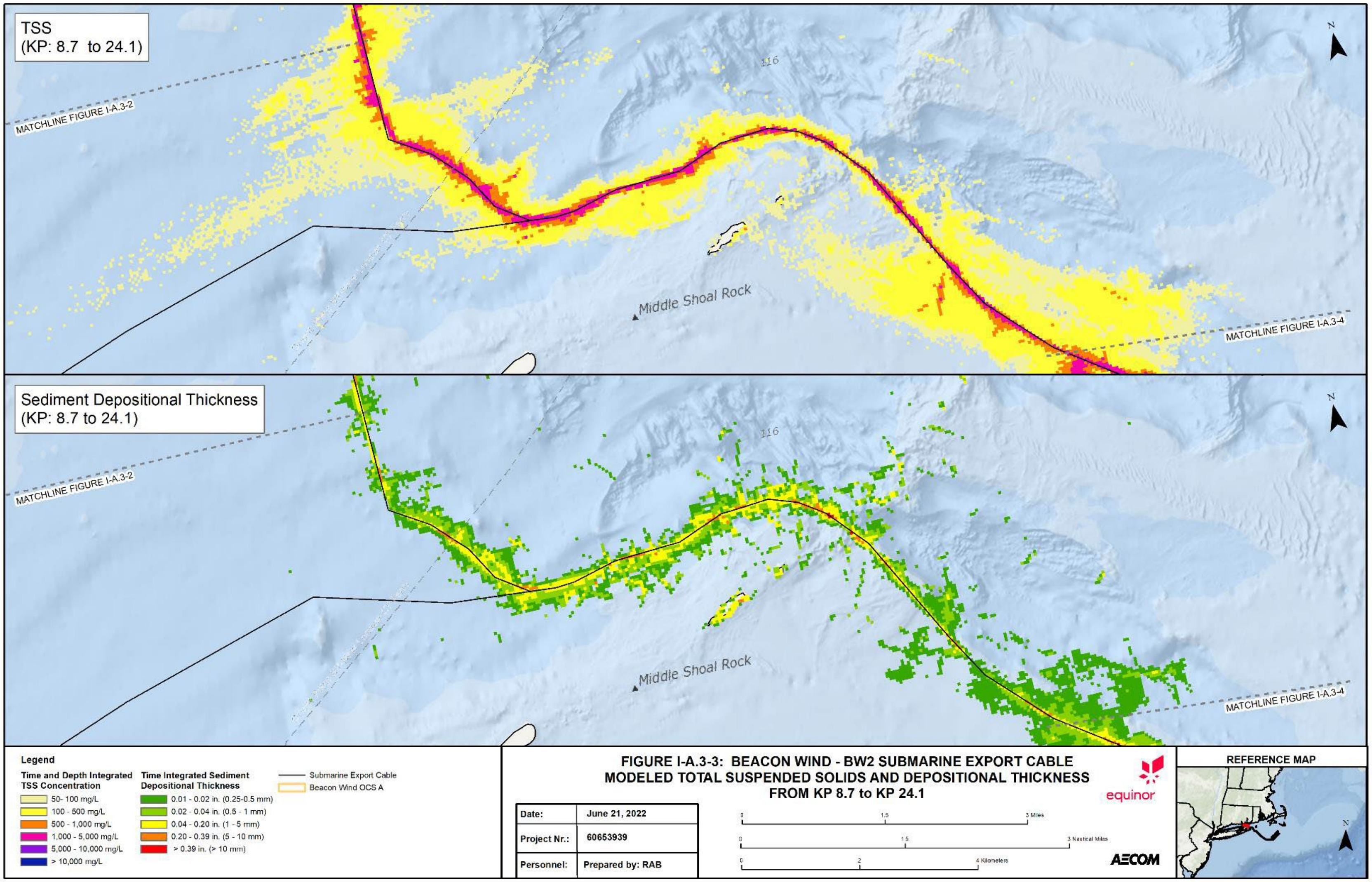


FIGURE I-A.0-23. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 24.1 TO KP 40.3

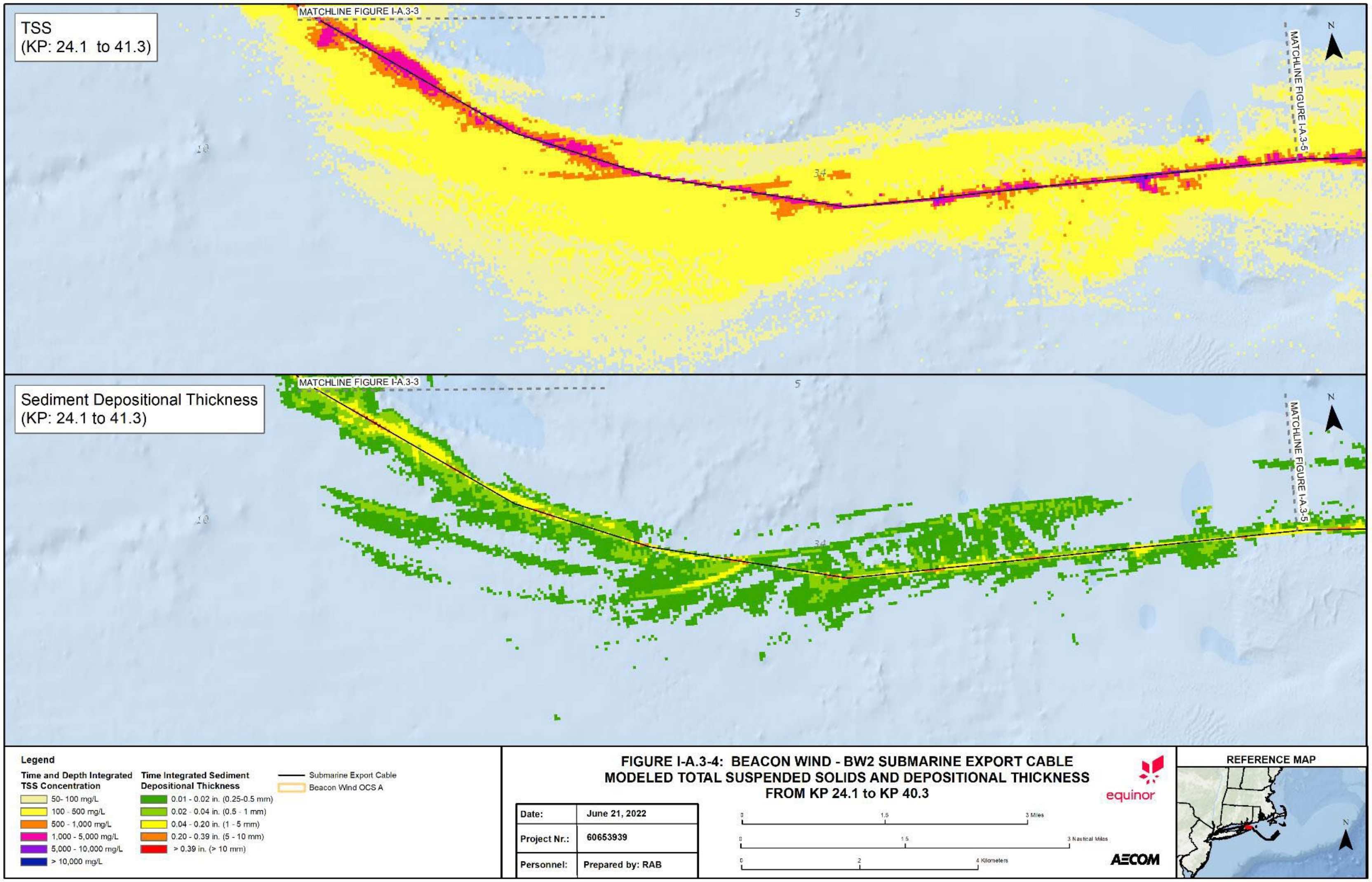


FIGURE I-A.0-24. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 41.3 TO KP 65.0

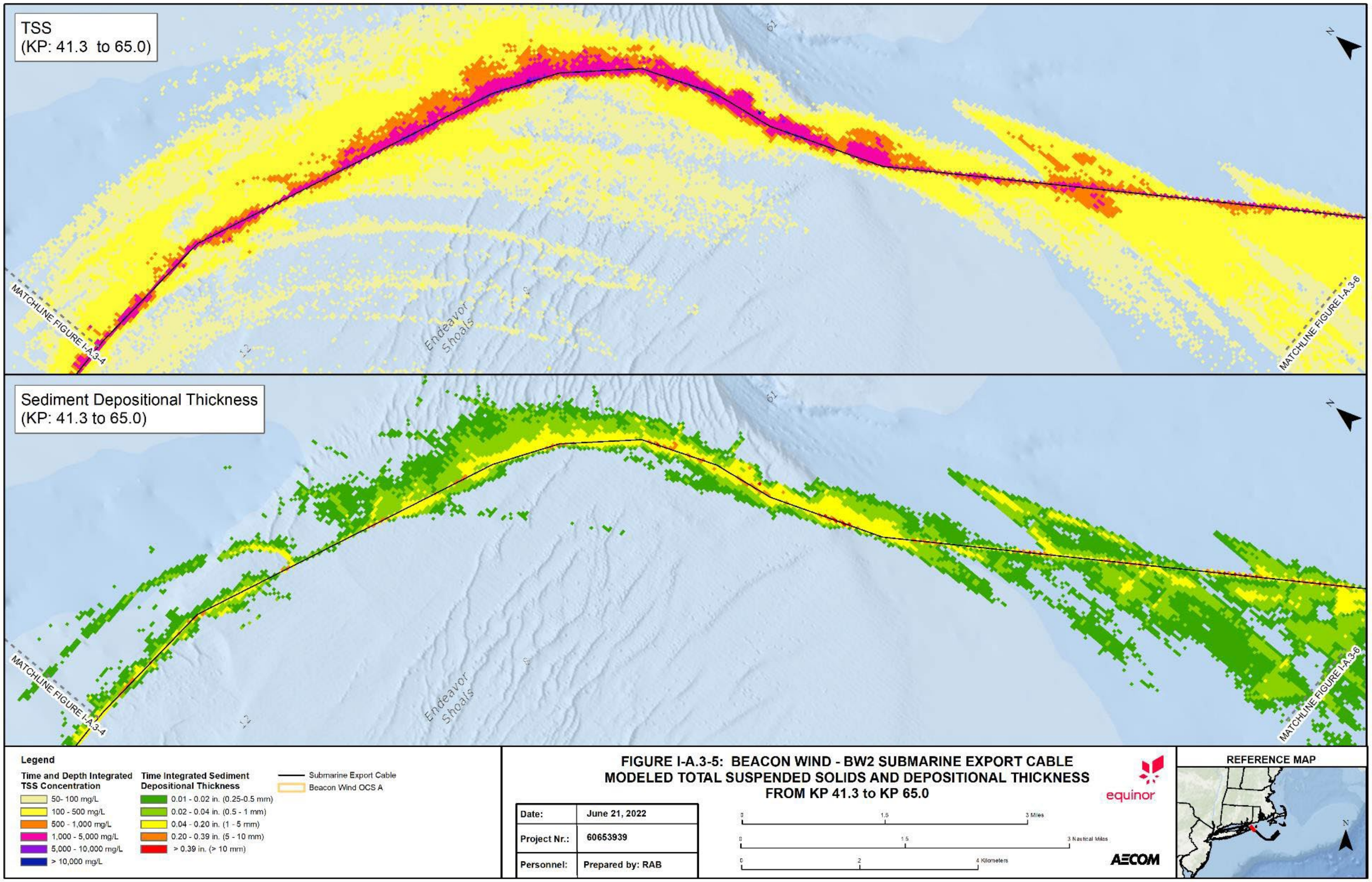


FIGURE I-A.0-28. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 65.0 TO KP 74.7

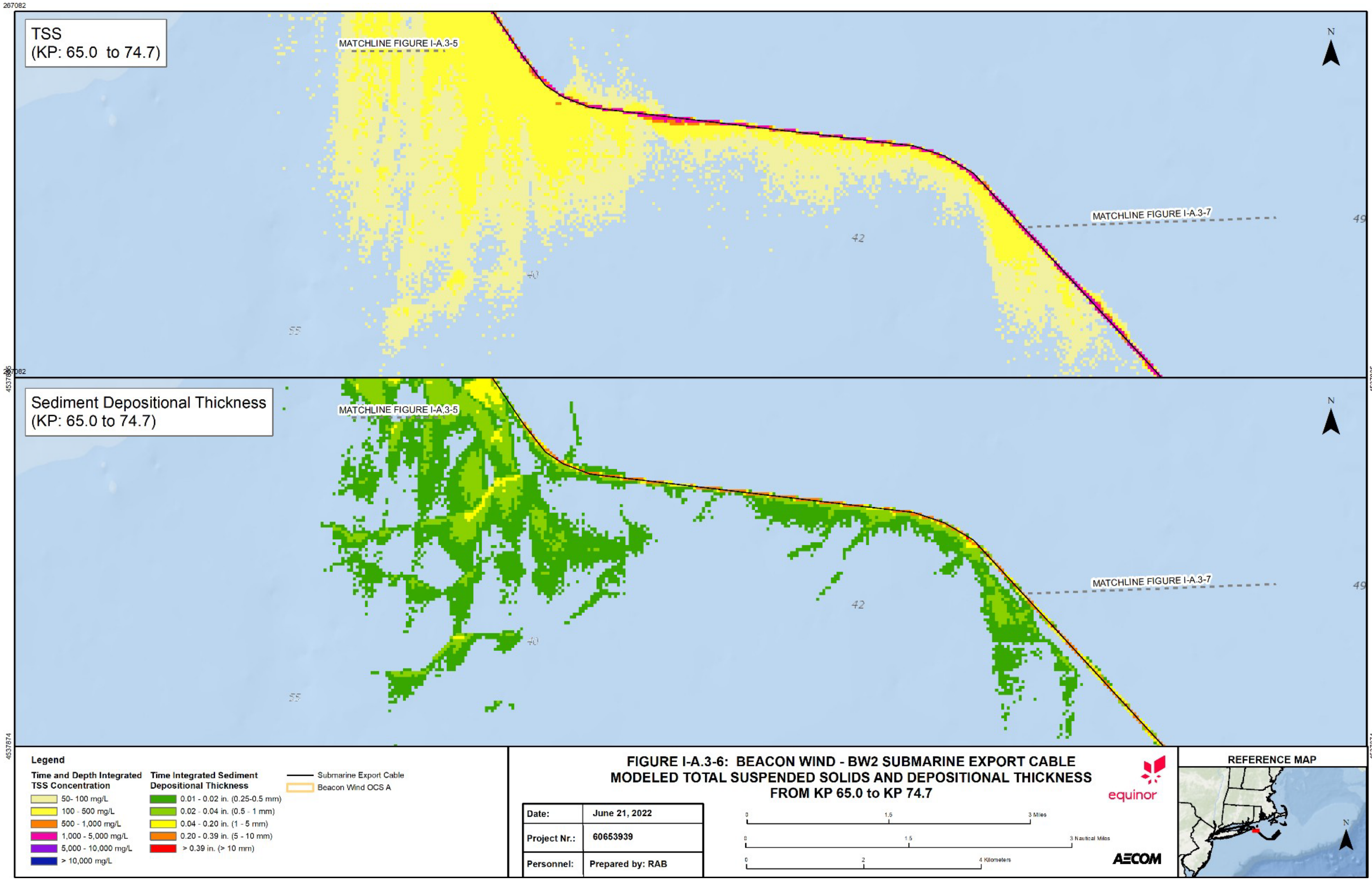


FIGURE I-A.0-29. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 74.7 TO KP 97.4

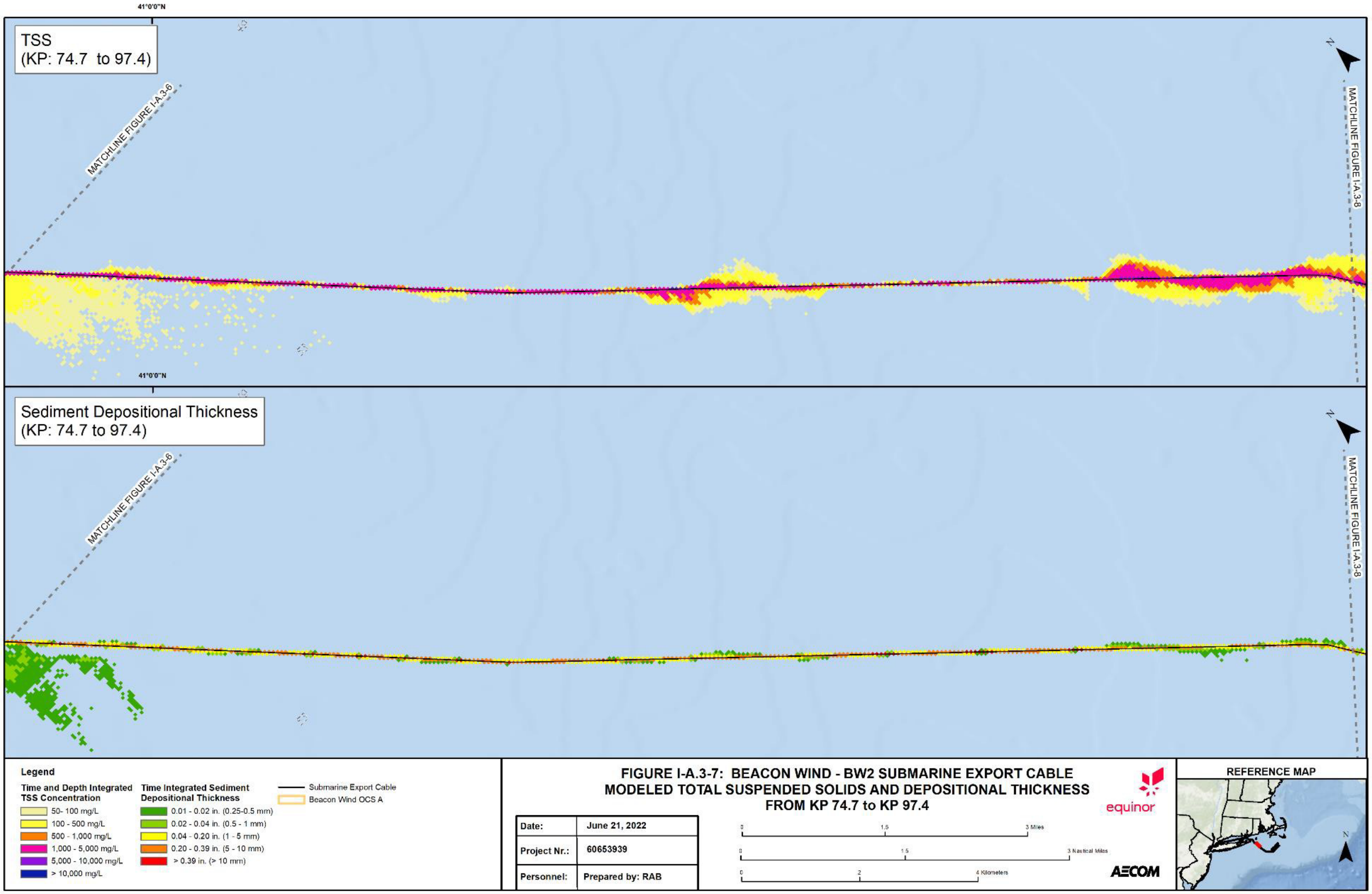


FIGURE I-A.0-30. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 97.30 TO KP 119.

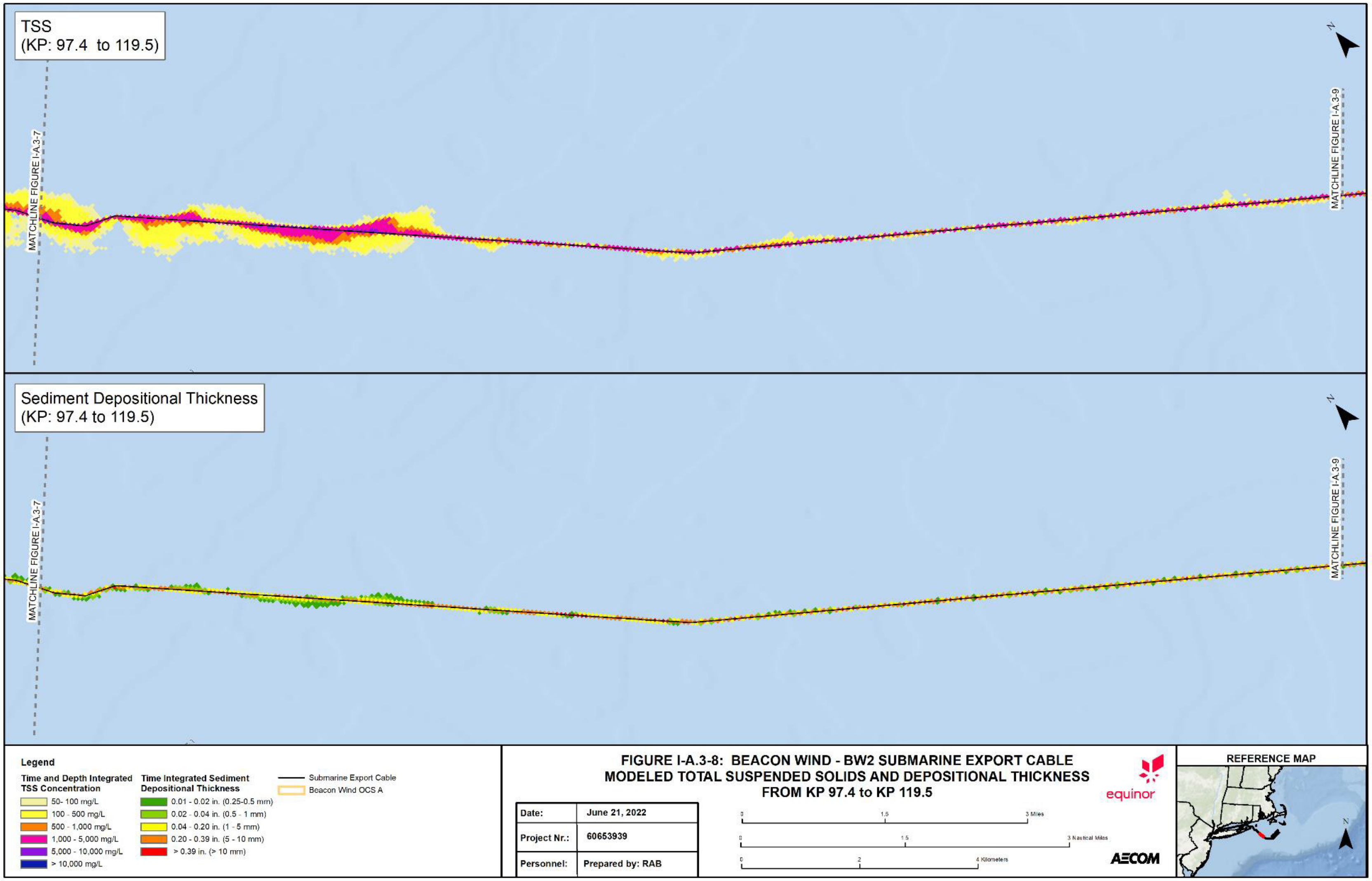


FIGURE I-A.0-31. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 119.31 TO KP 142.31

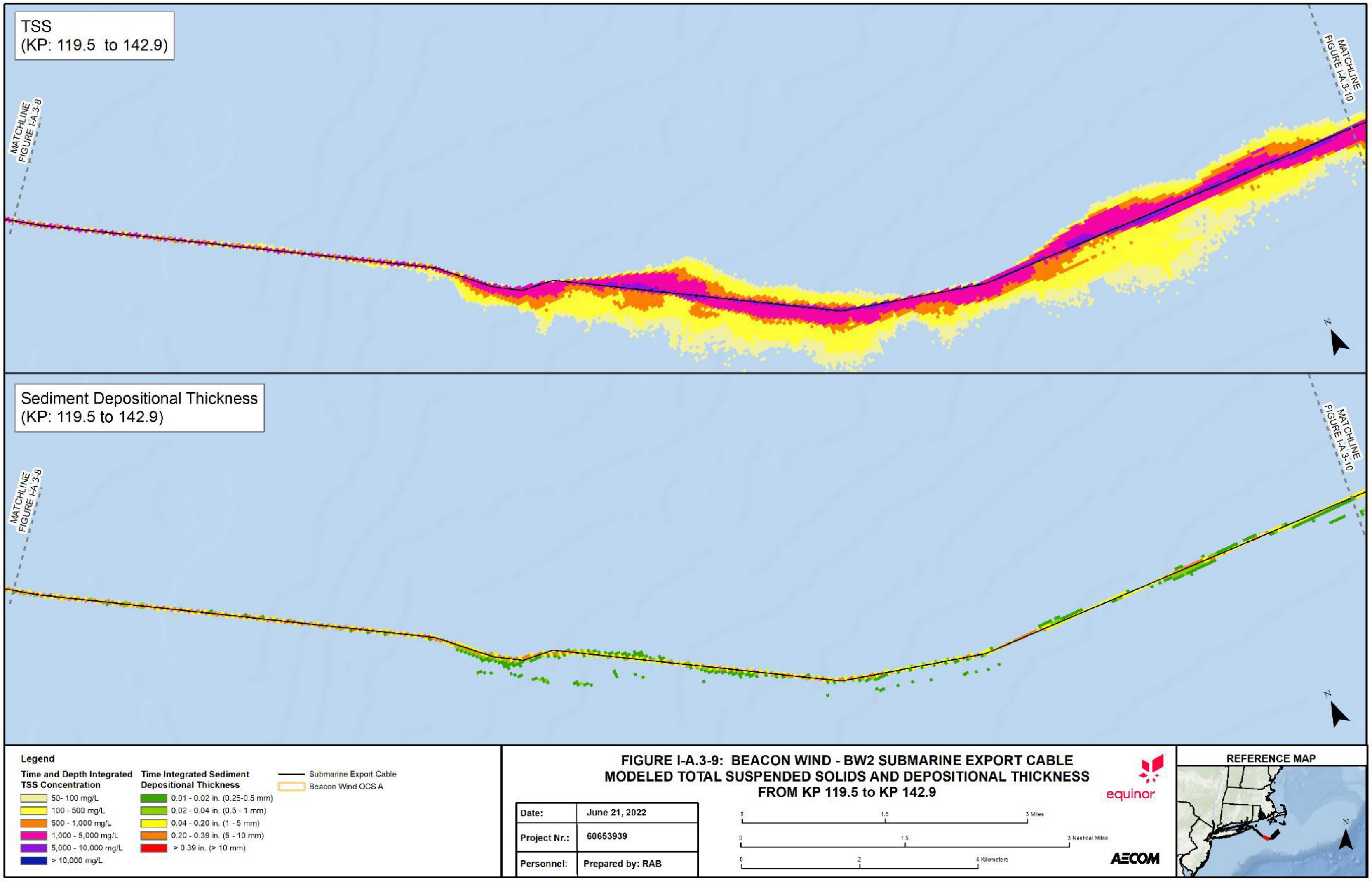


FIGURE I-A.0-32. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 142.32 TO KP 164.32

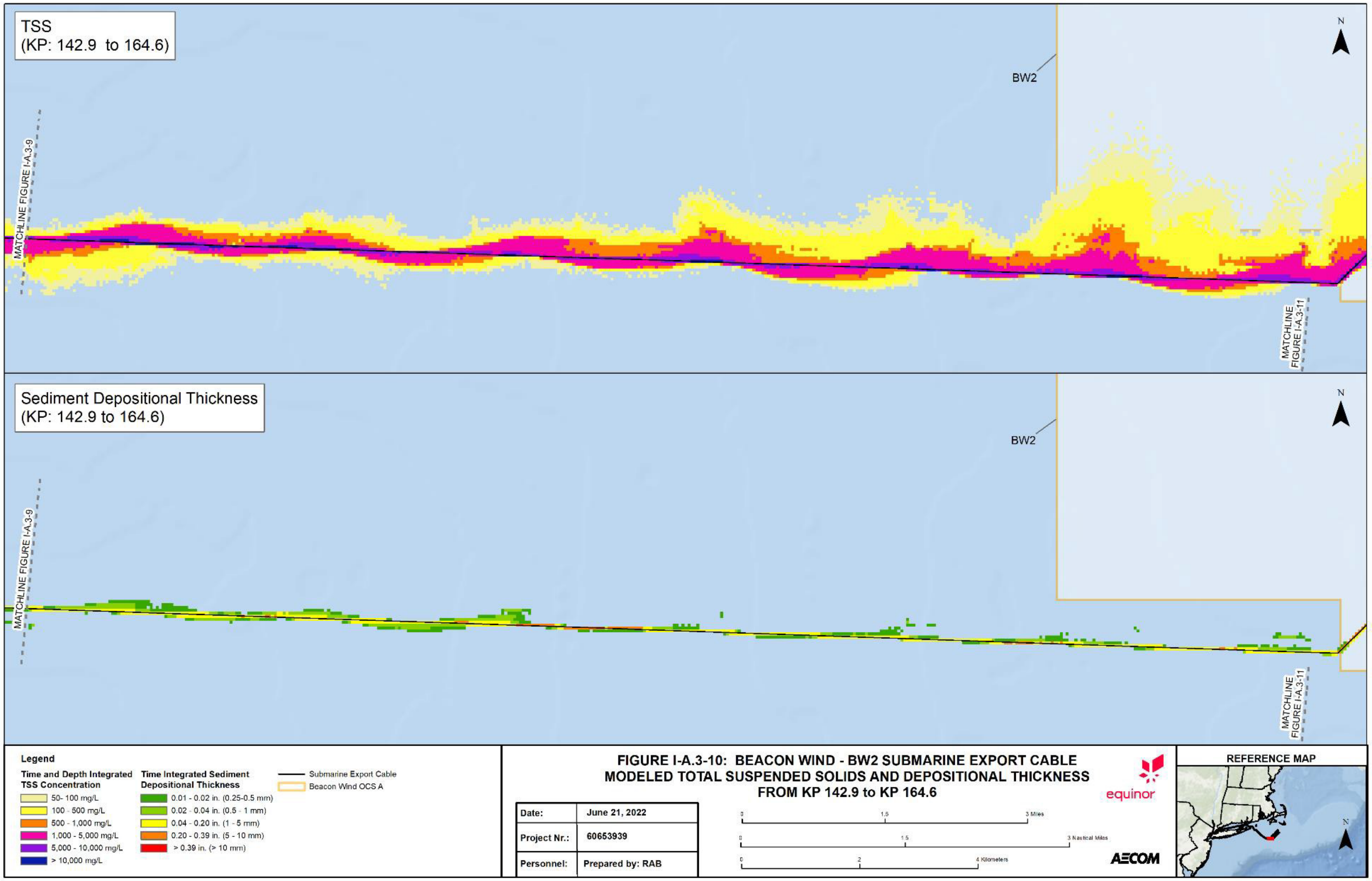
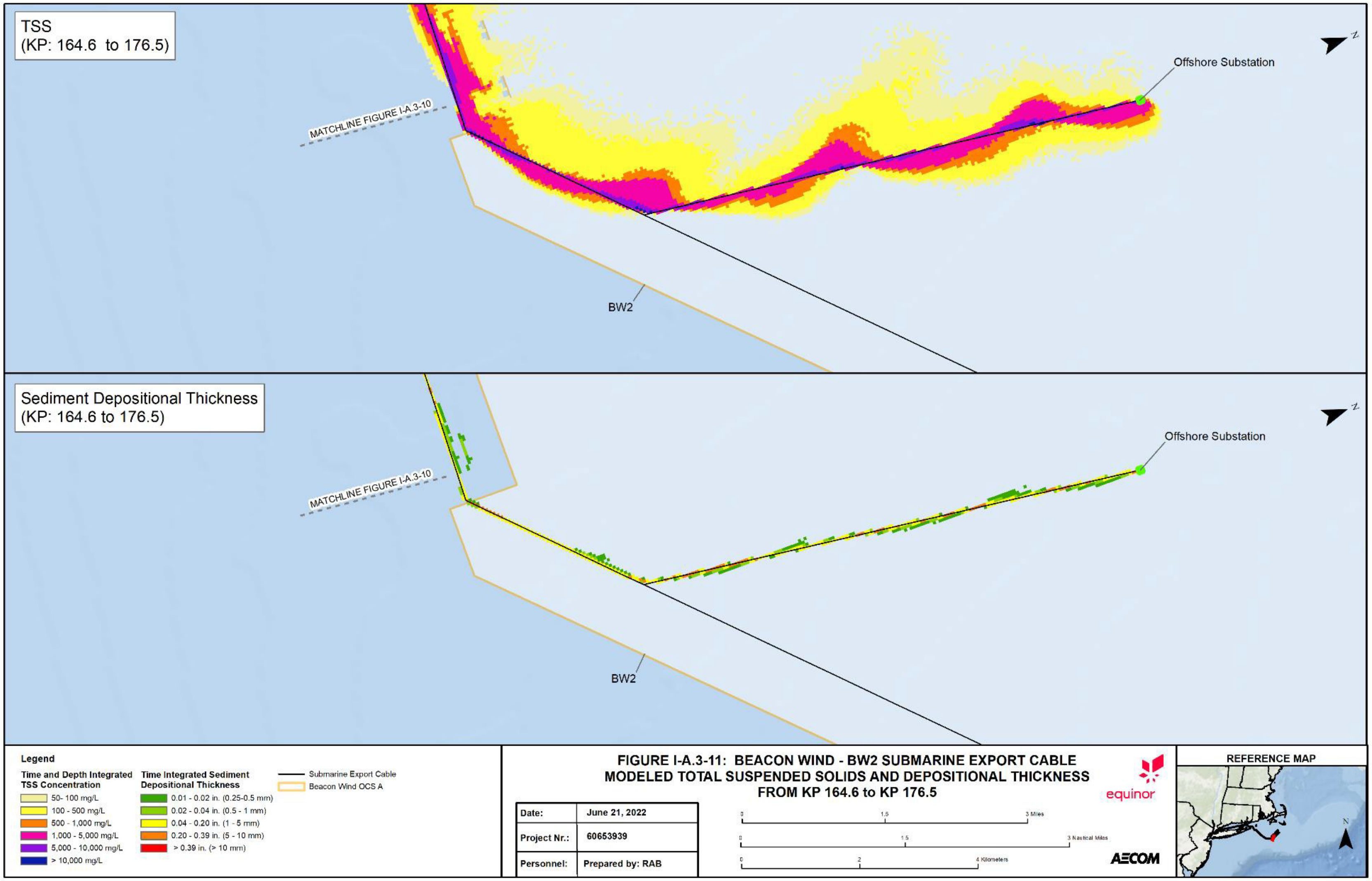


FIGURE I-A.0-30. BW2 SUBMARINE EXPORT CABLE MODELED TSS AND DEPOSITIONAL THICKNESS FROM KP 164.6 TO KP 176.5



Attachment I.B
Complete PTM Results for Beacon Wind Cable Route Presweeping

List of Attachment Figures

FIGURE I-B.1. PRESWEEPING SEGMENTS MODELED BY PTM

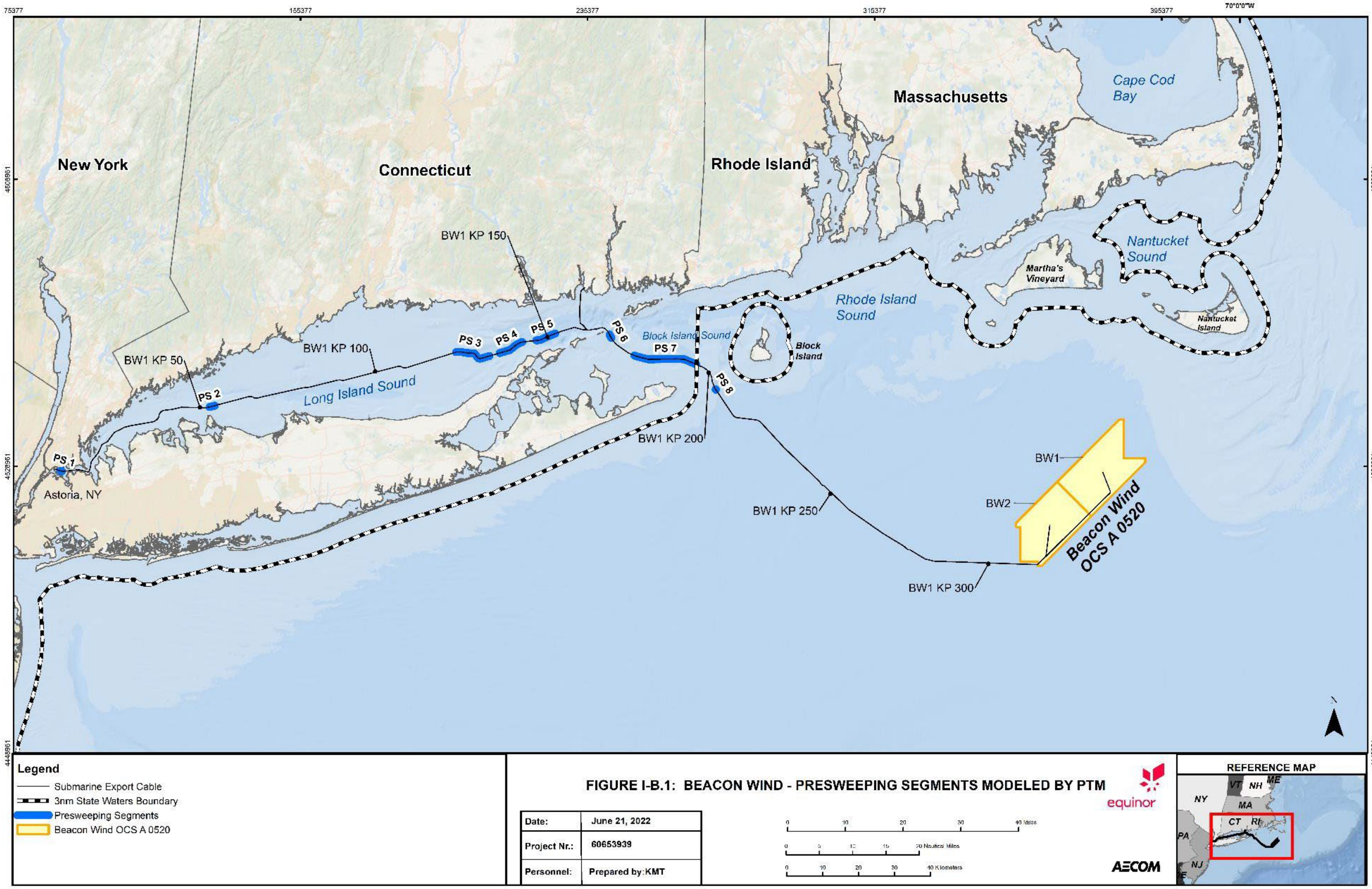


FIGURE I-B.2 PRESWEEPING SEGMENT 1 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

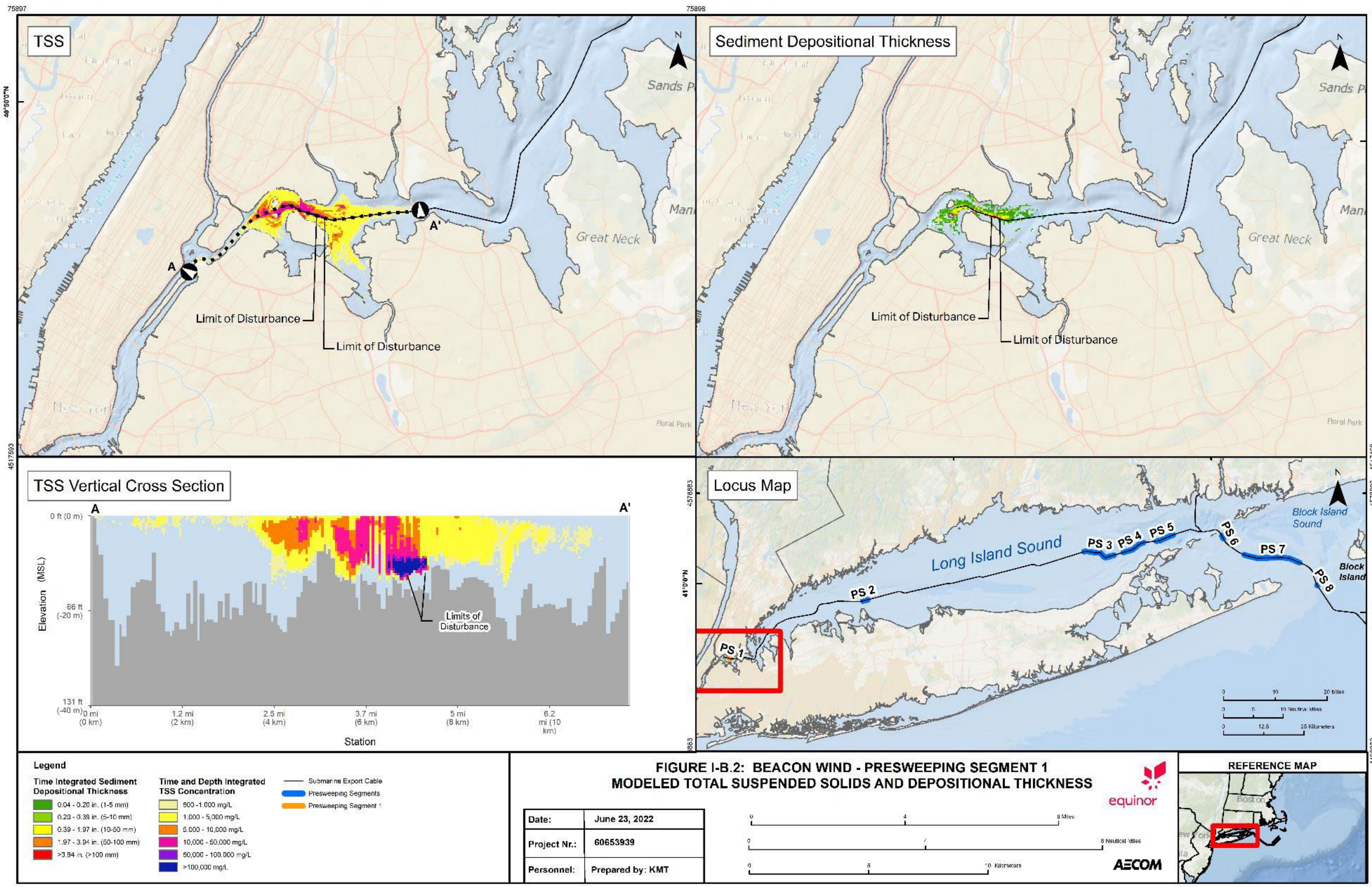


FIGURE I-B.3 PRESWEEPING SEGMENT 2 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

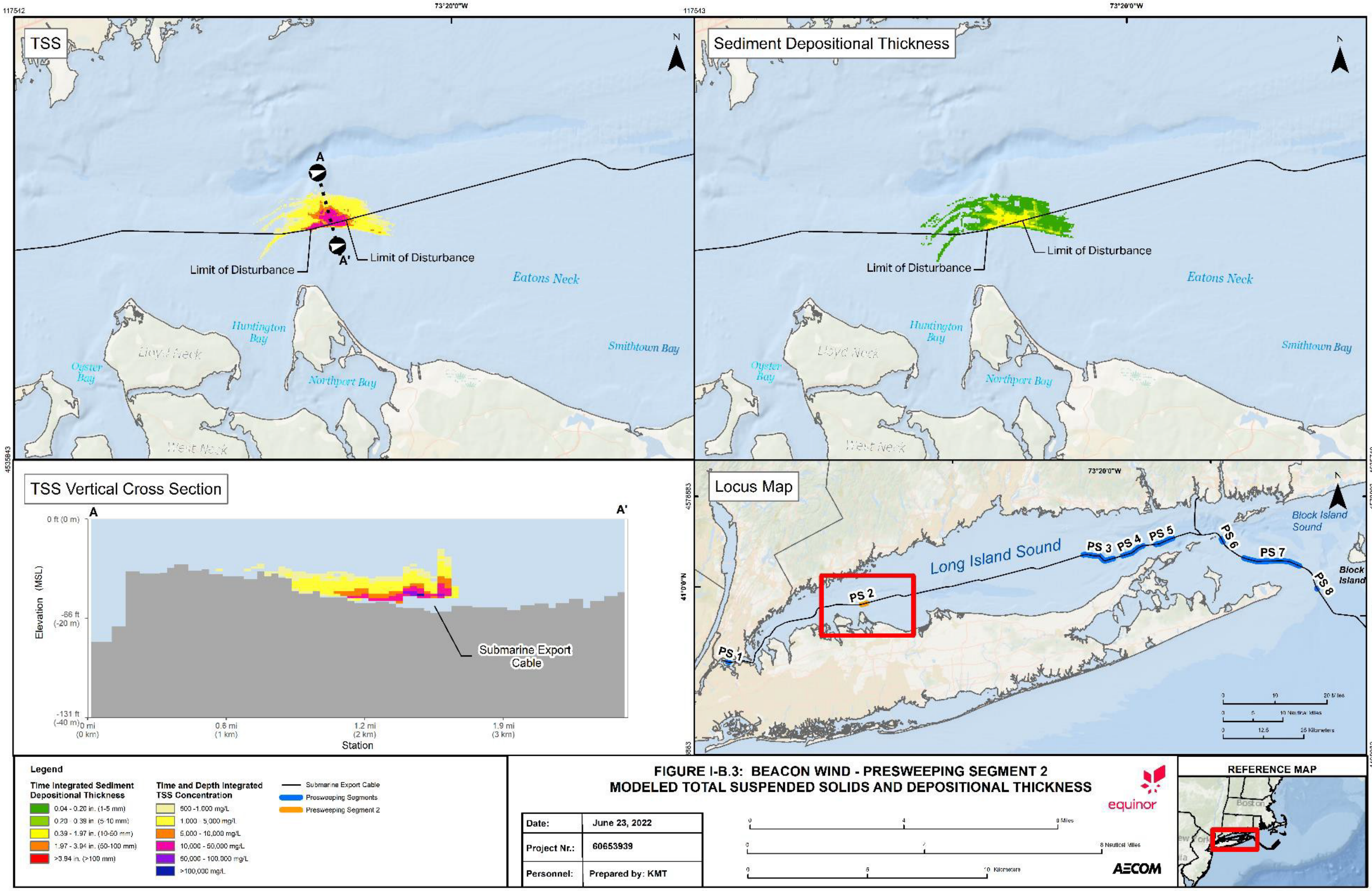


FIGURE I-B.4 PRESWEEPING SEGMENT 3 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

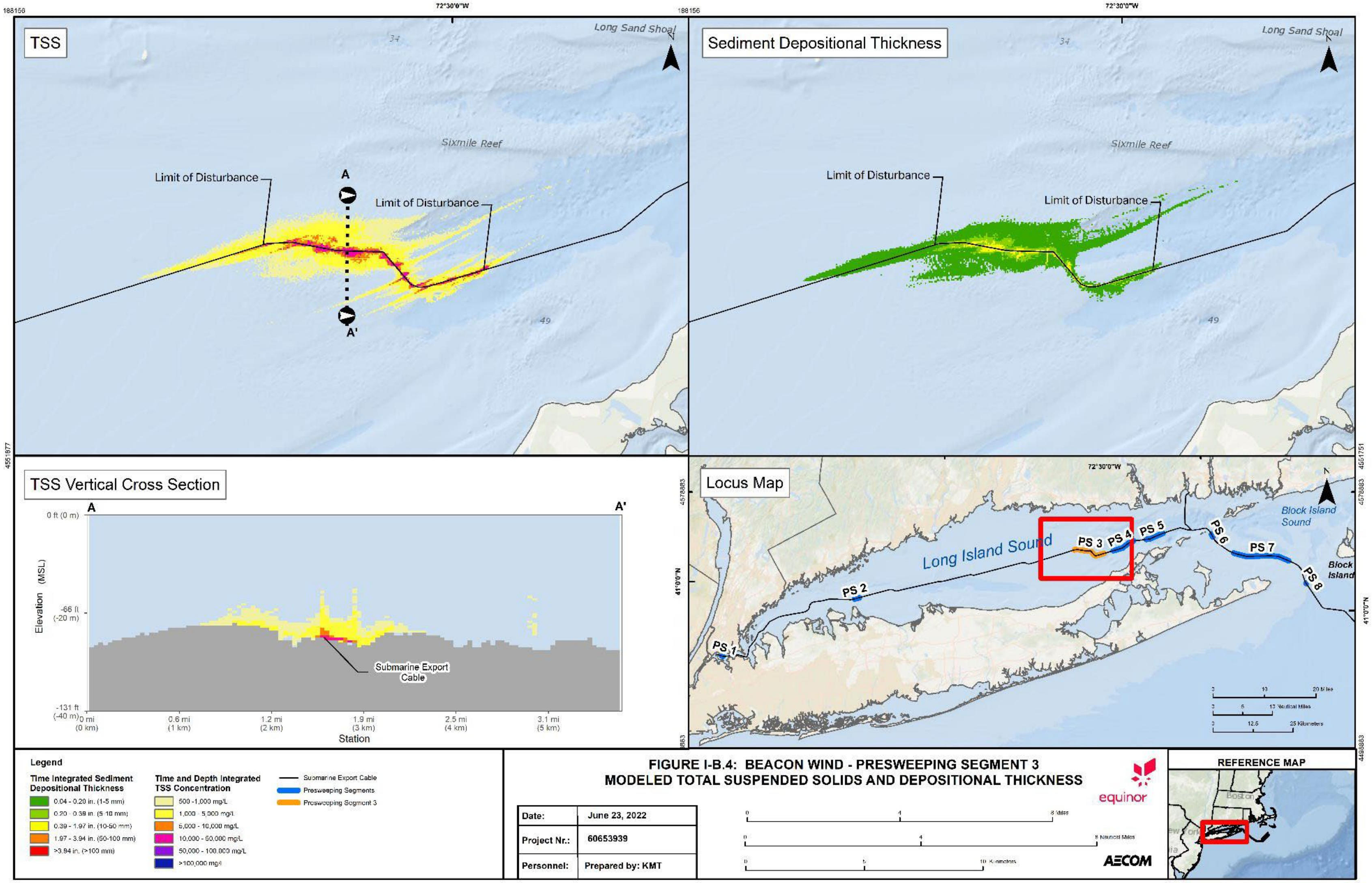


FIGURE I-B.5 PRESWEEPING SEGMENT 5 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

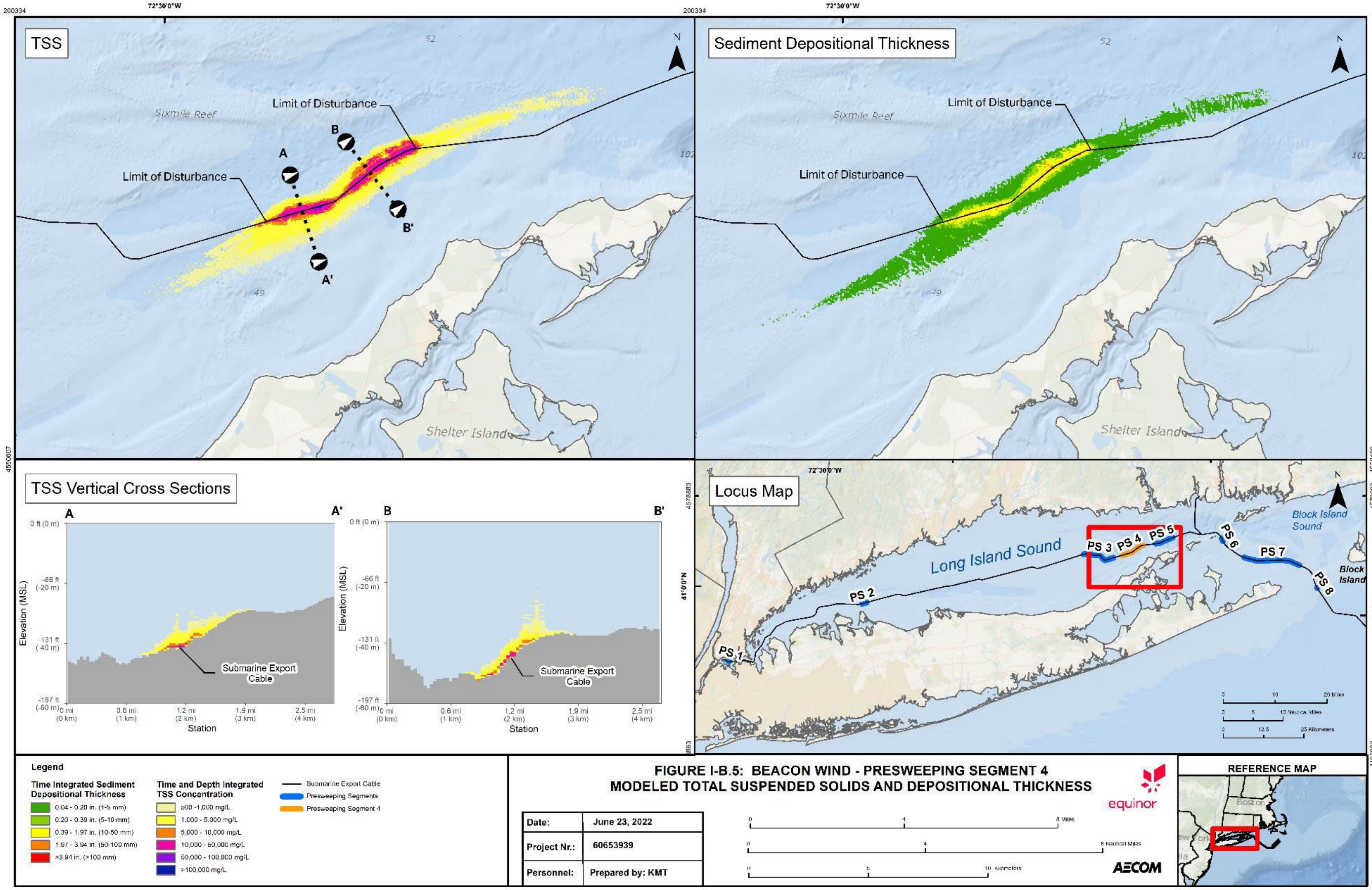


FIGURE I-B.6 PRESWEEPING SEGMENT 6 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

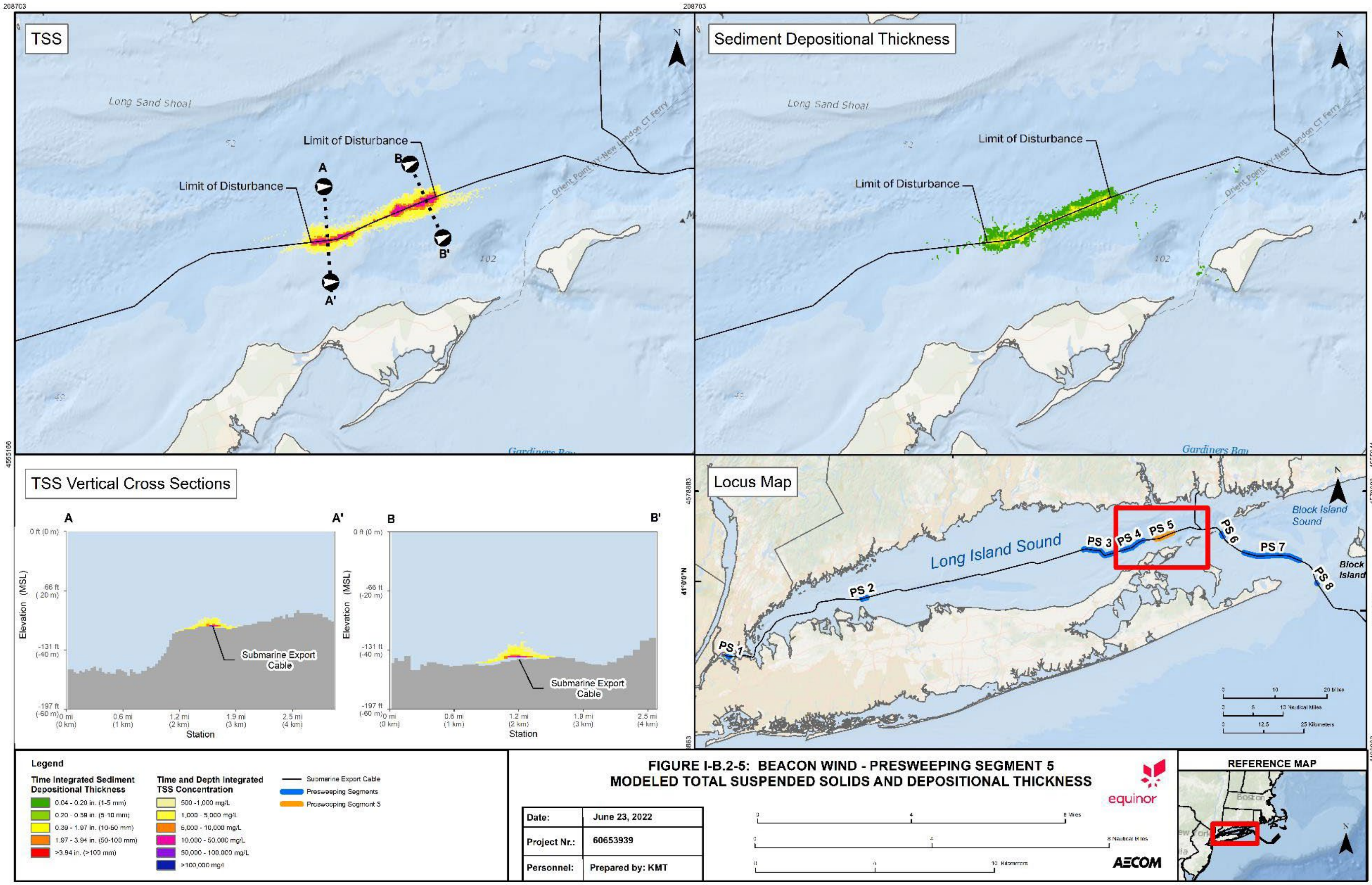


FIGURE I-B.7 PRESWEEPING SEGMENT 7 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

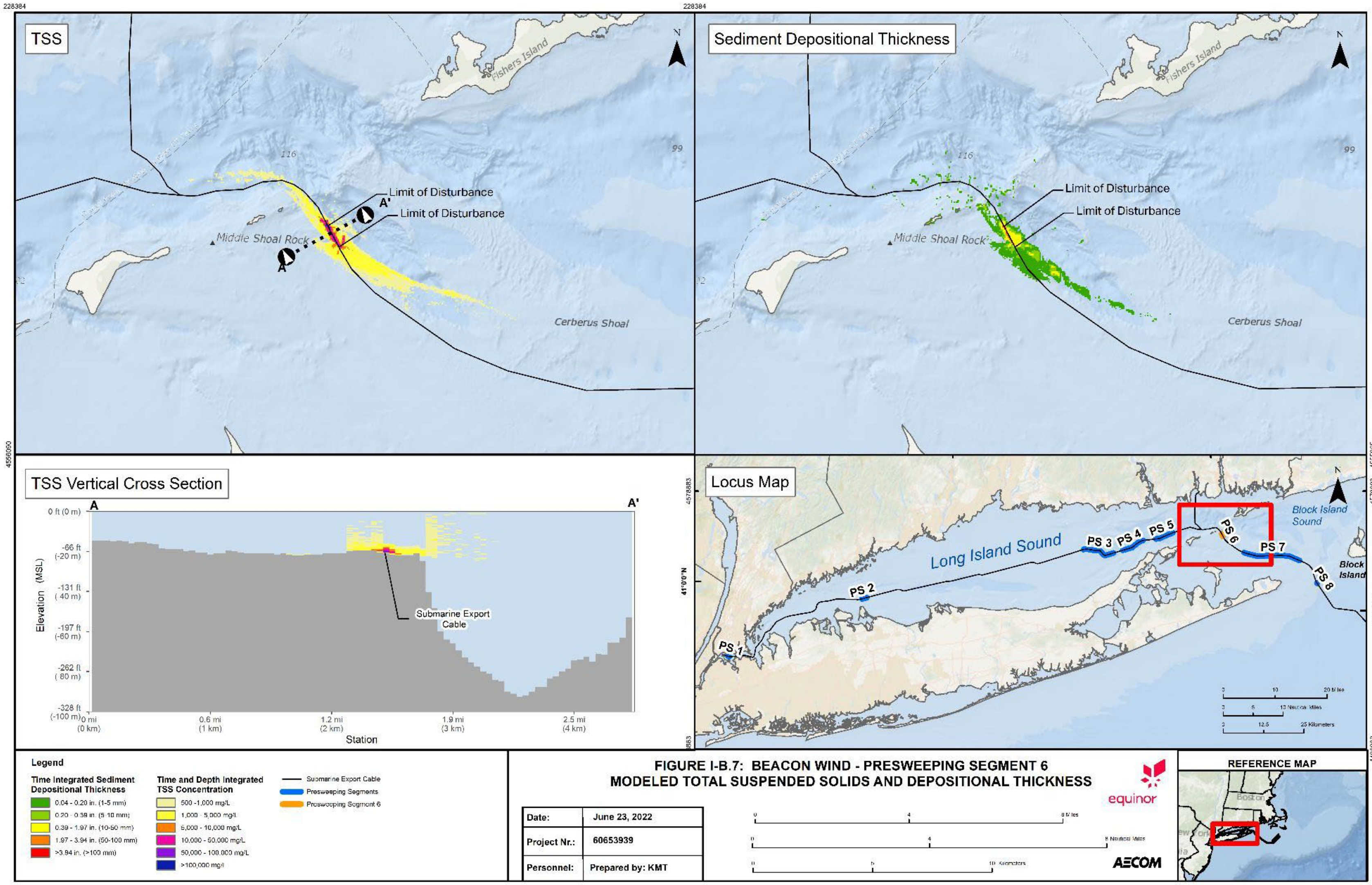


FIGURE I-B.8 PRESWEEPING SEGMENT 8 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

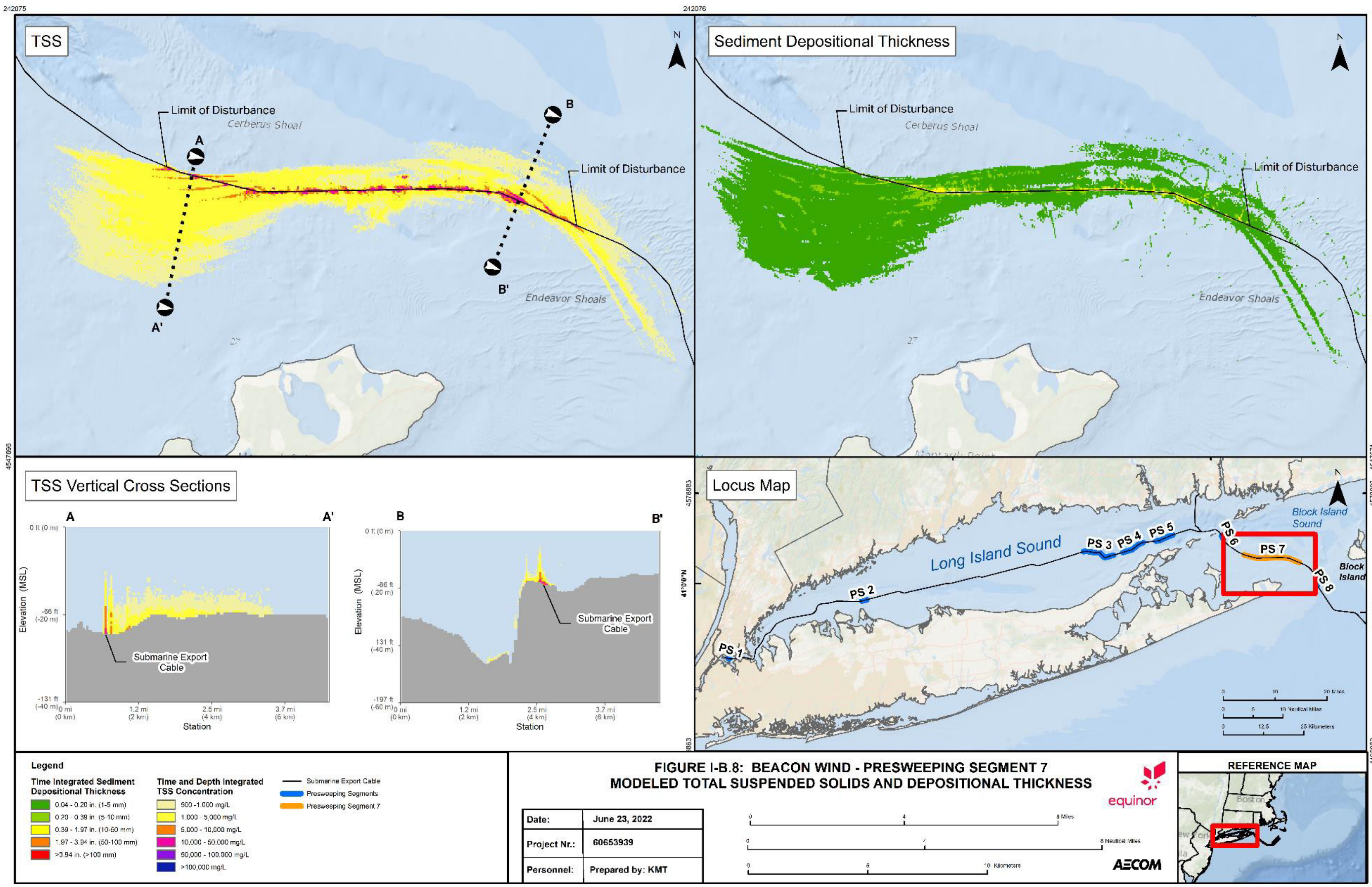


FIGURE I-B.9 PRESWEEPING SEGMENT 9 MODELED TOTAL SUSPENDED SOLIDS AND DEPOSITIONAL THICKNESS

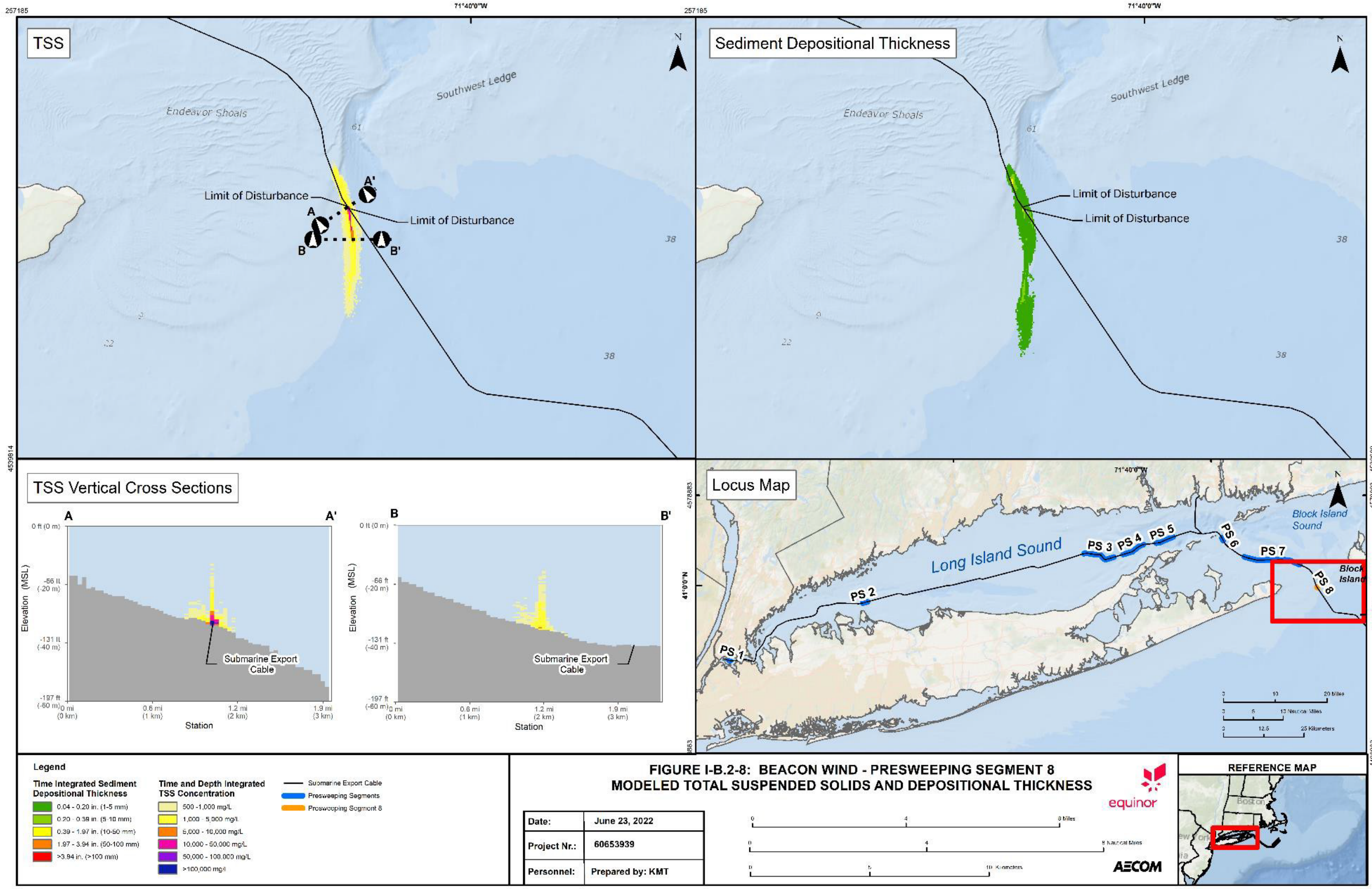


Photo credit: Matt Goldsmith, Equinor