B2. Offshore Sediment Transport Modeling

Hodge.WaterResources

Suspended Sediment Transport Modeling Study

Offshore Submarine Cable Installation

Maryland Offshore Wind Project

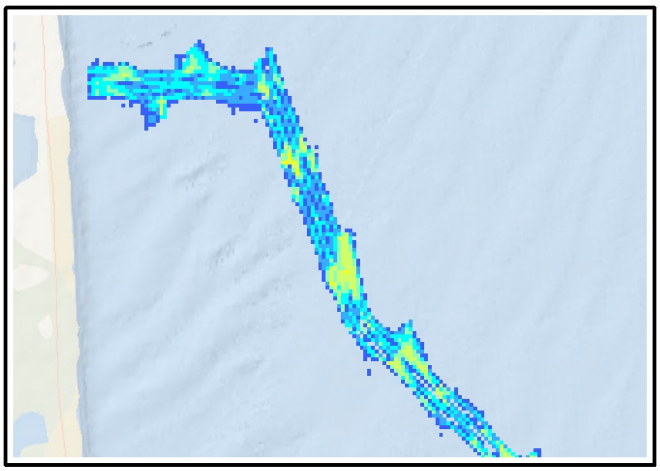

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TABLE OF CONTENTS

SECTION **PAGE**

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

The Maryland Offshore Wind Project includes the construction of as many as 121 wind turbine generators, up to four offshore substations, and one Met Tower in the roughly 80,000-acre Lease area located approximately 27.5 kilometers (km) (17 miles [mi) offshore. In order to connect to the mainland, US Wind is proposing the installation of a set of submarine cables. These cables include four Offshore Export Cables and 26 Inter-array Cables. All of the Inter-array Cables will connect the turbines to four central nodes, and the Offshore Export Cables will connect these nodes to the mainland. The Offshore Export Cables run northwest away from the Lease area and would make landfall in Delaware, at one of two proposed landing locations to Indian River Bay in Delaware. The cables will be buried to specific target depths below the seafloor utilizing jet plow embedment.

ESS Group, LLC ("ESS"), a TRC Company, requested that Hodge.WaterResources, LLC (HWR) conduct a sediment transport modeling assessment of the likely impacts of the proposed project. The assessment used surface and subsurface sediment characterization data from vibracore and geotechnical sampling along the Offshore Export Cable Corridor[1] and within the Lease area, to determine expected sediment transport away from the cables. HWR used this sediment transport assessment to predict where, and how much, in-situ trench sediment will travel before it is deposited back on the sea floor. The assessment predicts relative water quality impacts (i.e., assumed no ambient suspended sediment concentration) of this acute exposure event..

While water jetting technology (jet plow embedment for this project) is regarded as the most environmentally sensitive installation method for this activity when compared to other installation alternatives like mechanical dredging or seafloor displacement plowing, jetting does produce localized and temporary increases in suspended sediment concentrations. Previous modeling and monitoring for installation of a submarine cable in coastal waters (Elliot et al., 2017) has shown that suspended sediments induced by jetting settle out rapidly (i.e., within three to four tidal cycles).

The sediment transport model provides predictions of suspended sediment concentrations and the thickness and location of sediment deposited back on the seafloor away from the cable as the jet plow places the cable.

The sediment transport modeling predicts that most sediments suspended by the jet plowing will remain in a narrow corridor along the Offshore Export Cable Corridor and the Inter-array Cables. The overwhelming majority of deposition thicker than 0.2 mm will occur within 91 m (300 ft) of the proposed cable path. Most of the fluidized sediments lost to the water column are predicted to quickly settle back to the seafloor. Suspended sediment concentrations are predicted to be less than 200 mg/L at distances greater than 137 m (450 ft) from the Offshore Export Cables and Inter-array Cables. Model results indicate that the suspended sediment plume resulting from jet plowing will have a short duration. The model results show that increases in suspended sediment concentrations above 10 mg/L over ambient are only of short duration (hours). All suspended sediment plumes are predicted to disappear within 24 hours after the completion of jetting operations. In conclusion, the sediment transport modeling results indicate that the proposed jet plow embedment process for cable installation will result in short-term and localized effects.

[1] For the purposes of this report, "Offshore Export Cable Corridor" refers to Offshore Export Cable Corridor 1, as defined in Section 2.5.2 of Volume I of US Wind's May 2022 Construction and Operations Plan.

1.0 INTRODUCTION

The Maryland Offshore Wind Project (the Project) is an offshore wind project of up to 2 gigawatts within OCS-A 0490 (the Lease), an area off the coast of Maryland on the Outer Continental Shelf. The Project will include as many as 121 wind turbine generators (WTG), up to four (4) offshore substations (OSS), and one (1) Met Tower in the roughly 80,000-acre Lease area. The Project is proposed to be interconnected to the onshore electric grid by up to four new 230 kV export cables into a substation in Delaware. Additionally, US Wind is proposing the installation of 26 66 kV AC Inter-array Cables. All of the Inter-array Cables will connect the turbines to four central nodes, and the Offshore Export Cables will connect these nodes to the mainland. The Offshore Export Cables run northwest away from the Lease area and will make landfall approximately one mile south of the inlet to Indian River Bay in Delaware. The cables will be buried 1 to 3 m, and no more than 4 m, below the seafloor utilizing jet plow embedment.

ESS Group, LLC ("ESS"), a TRC Company, requested that Hodge.WaterResources, LLC (HWR) conduct a sediment transport modeling assessment of the likely impacts of the proposed project. The assessment used surface and subsurface sediment characterization data from vibracore sampling geotechnical sampling along the Offshore Export Cable Corridor[2] and within the Lease area, to determine expected sediment transport away from the cables. HWR used this sediment transport assessment to predict where, and how much, in-situ trench sediment will travel before it is deposited back on the sea floor. The assessment predicts relative water quality impacts (i.e., assumed no ambient suspended sediment concentration) of this acute exposure event.

While water jetting technology (jet plow embedment for this project) is regarded as the most environmentally sensitive installation method for this activity when compared to other installation alternatives like mechanical dredging or seafloor displacement plowing, jetting does produce localized and temporary increases in suspended sediment concentrations. Previous modeling and installation monitoring for installation of a submarine cable in coastal waters (Elliot et al., 2017) has shown that suspended sediments induced by jetting settle out rapidly (i.e., within a few tidal cycles).

The first step to complete this analysis was to simulate hydrodynamic conditions within the study area using a two-dimensional hydrodynamic model. The domain for the modeling includes a semi-circular region of the Atlantic Ocean just east of the Delmarva peninsula that extends approximately 105 km (65 mi) out into the Atlantic as shown in Figure 1-1. The model domain also includes Delaware Bay and the Delaware River upstream to Trenton, New Jersey. In the second step of the analysis, the results of the hydrodynamic model of this region of the Atlantic Ocean are applied to a complementary sediment transport model to characterize predicted suspended sediment concentrations and deposition associated with the jet plow embedment method. The sediment transport model provides predictions of suspended sediment concentrations and the thickness and location of sediment deposited back on the seafloor away from the cable as the jet plow advances.

The coastal region east of the Delmarva Peninsula is part of the Mid-Atlantic Bight. The Mid-Atlantic Bight is a coastal shelf that extends approximately 105 km (65 mi) miles offshore. Depths in the mid-Atlantic Bight range from 15.2 to 106.7 meters (m) (50 to 350 feet [ft]) (). Near the coastline, water depths are less than

[2] For the purposes of this report, "Offshore Export Cable Corridor" refers to Offshore Export Cable Corridor 1, as defined in Section 2.5.2 of Volume I of US Wind's May 2022 Construction and Operations Plan.

3 m (10 ft), but water depths increase along the Offshore Export Cable Corridor. In the vicinity of the Lease area, water depths are approximately 14 to 41 m (46 to 135 ft). The mean tidal range (mean high water minus mean low water) is 1.2 m (4.0 ft) as measured at the Atlantic City tide gauge (NOAA, 2022a). Currents in the mid-Atlantic Bight are driven by multiple factors, but perhaps the largest driver of currents, especially below the surface, is the Gulf Stream that moves warm water from the south northward paralleling the coastline. Closer to the coast, the Labrador current sends cold water southward. The interaction of the Gulf Stream and the Labrador current create eddies and other gyres in the mid-Atlantic Bight. In the immediate vicinity of the Delmarva Peninsula, freshwater flow from the Delaware Bay influences current speeds and direction as well. Wind can also play a significant role in movement of water in the mid-Atlantic Bight depending on wind speed and direction. All of these drivers are accounted for in the hydrodynamic model that was developed as a part of the sediment transport study.

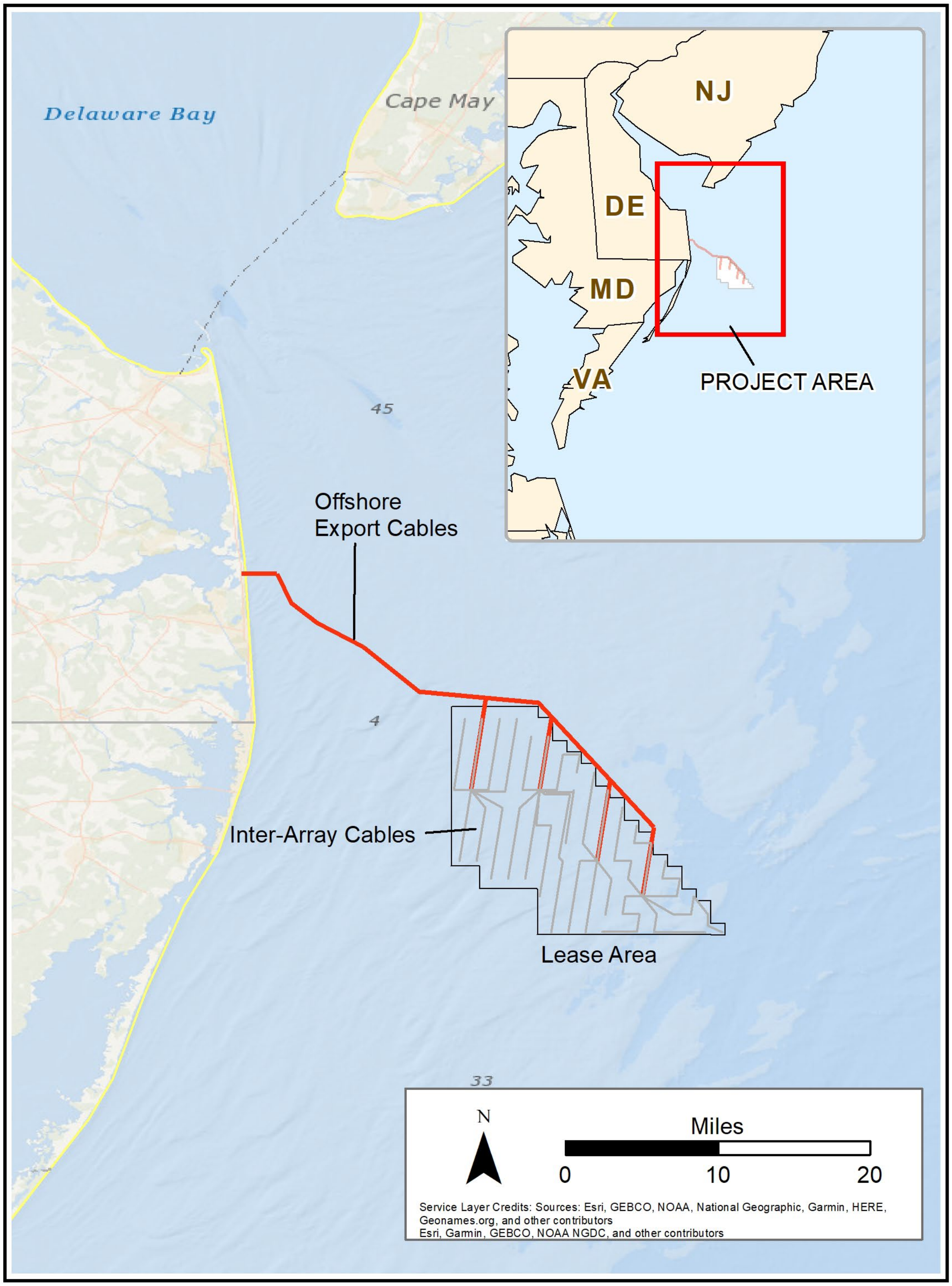

Figure 1-1: Locus Map

2.0 SUBMARINE CABLE ROUTE SEDIMENT CHARACTERISTICS

As a part of the Project, a total of 35 vibracore samples were collected along Offshore Export Cable Corridor 1. These samples and an additional four samples (vibracore locations A-1 through A-4) from previous subsurface investigations provide a clear picture of the dominant sediment type along the Offshore Export Cable Corridor. The locations of these vibracore samples are shown in Figure 2-1.

Figure 2-2 shows the depth-weighted percentage at each vibracore locations for gravel, sand, and fines (i.e., silts and clays) for depth up to 4.0 m (13.1 ft) (i.e., the maximum cable placement depth). The composition of each vibracore is unique with some vibracores indicating a higher percentage of gravel or fines. In all but two samples, sand makes up more than 50% of the sediments. The depth weighted average median grain size (D50) are between 0.075 millimeters (mm) and 2.0 mm (i.e., sandy sediments) for all vibracores. The predominant sediment type is sand.

In addition to the vibracore samples that were evaluated for grain-size distribution, geotechnical evaluations were conducted at six locations within the Lease area. These locations are also shown in Figure 2-1. The geotechnical evaluations included determinations of particle density and sample bulk density. The particle density of measurements made in the top 4.0 m (13.1 ft) of sediment ranged from 2,650 to 2,730 kilograms per cubic meter (kg/m^3). This range is consistent granular sediments in the Atlantic Ocean in the coastal region offshore of the United States. The bulk density provides an indication of the in-situ compaction of these granular sediments (i.e., how much sand is in a given volume). The bulk density ranged from 1,700 kg/m^3 to 2,100 kg/m^3. Based on the consistency of sediments along the Offshore Export Cable Corridor, it is an appropriate assumption to consider these values to be representative of conditions along the entire Offshore Export Cable Corridor.

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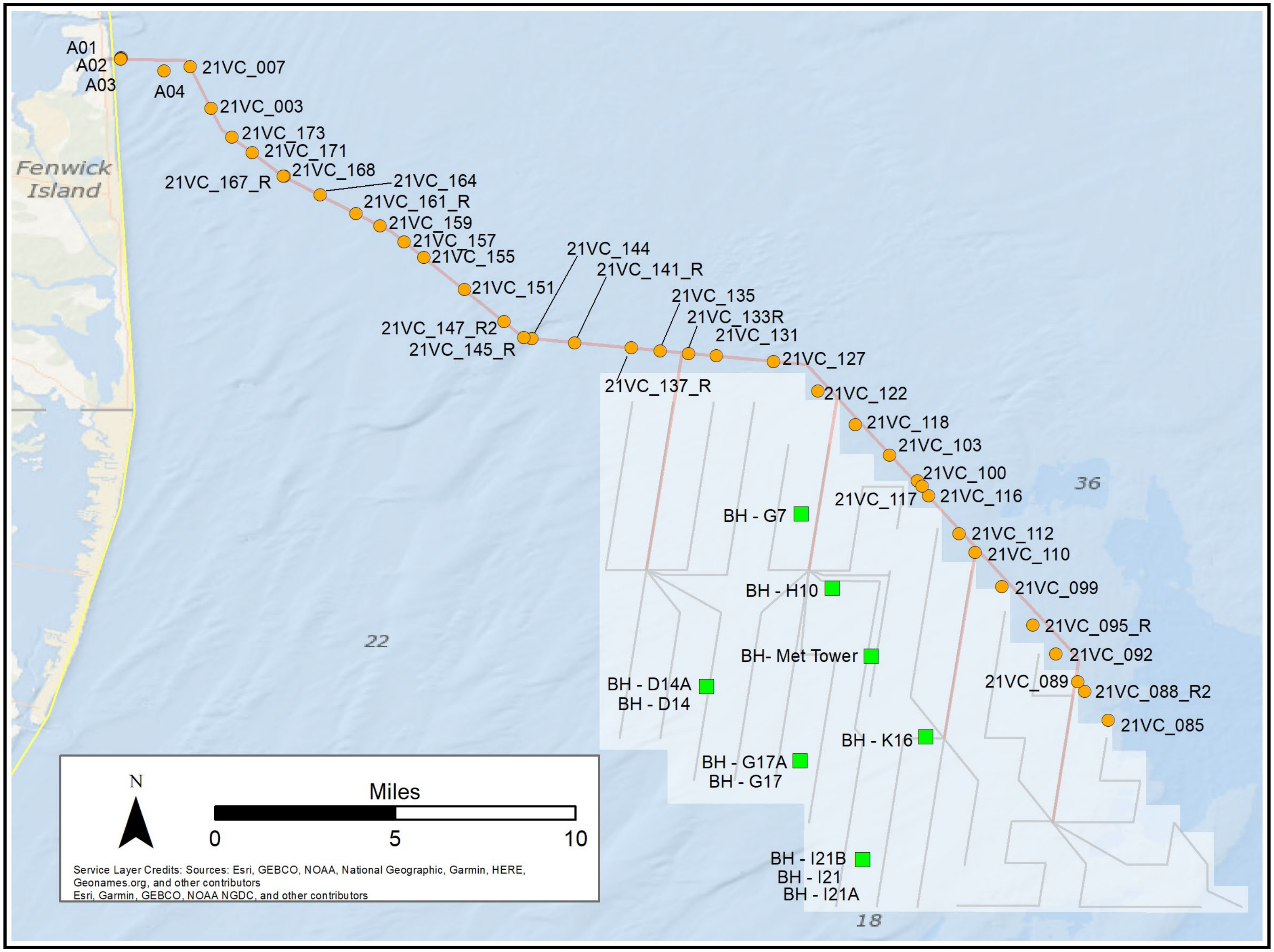

Figure 2-1: Sediment and Vibracore Sampling Locations

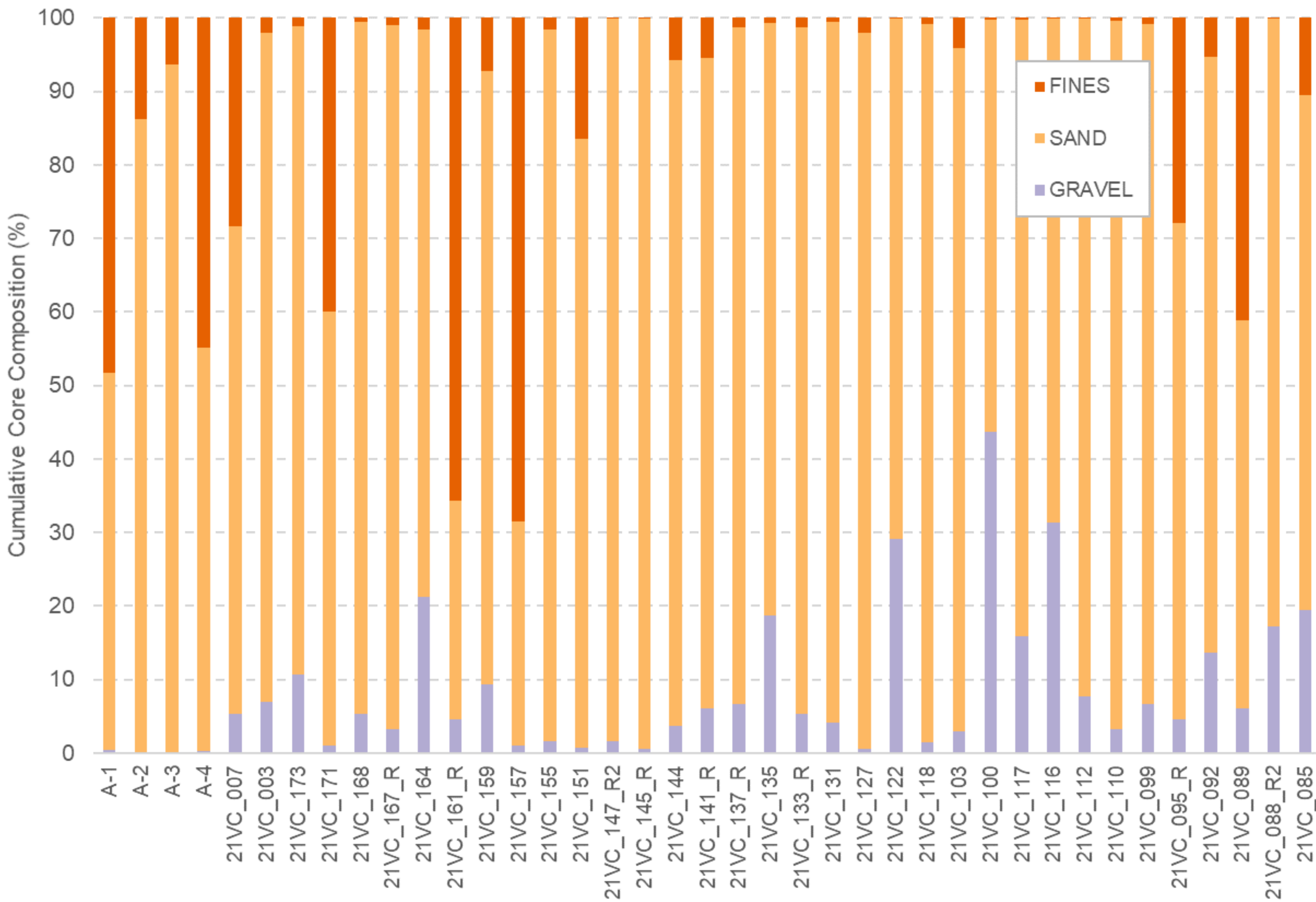

Figure 2-2: Dominant Sediment Type Along Route by Vibracore Location

3.0 MODEL DESCRIPTION

When sediment is suspended by the jet plow, it may be transported away from the trench by advective transport. Advective transport is the transport of suspended materials by the movement of the suspending media (i.e., water and currents in the water). In order to be able to evaluate current speeds and directions, HWR developed a hydrodynamic model of the Project area using ADCIRC (Advanced Circulation Model).

3.1 ADCIRC

ADCIRC is a hydrodynamic circulation model that simulates water levels and current speeds that are driven by tides, wind, or other hydrodynamic forces over a finite element grid. ADCIRC was initially developed by Rick Luettich and Joannes Westerink (2004) at the University of North Carolina in conjunction with the United States Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) and has been certified by the Federal Emergency Management Agency (FEMA) for evaluating storm surge (USACE, 2013a). The ADCIRC model is publicly available and widely used. The model has been used to conduct dredging feasibility and material disposal studies and to evaluate nearshore marine operations (USACE, 2013b) similar to jet plowing along the Offshore Export Cable Corridor.

Version 53 of ADCIRC was chosen for use in this analysis because it can incorporate a tidally reversing flow boundary condition and an open-water boundary condition specified in the form of tidal constituents. In addition to being appropriate for use in evaluating the hydrodynamic characteristics of the study area, ADCIRC version 53 is also readily linked to the selected sediment transport model.

3.2 Particle Tracking Model (PTM)

The sediment transport model selected was the Particle Tracking Model (PTM) version 2.3. PTM is a Lagrangian sediment particle tracker developed to simulate particle (i.e., sediment) transport processes. The model was developed by ERDC as part of the Coastal Inlets Research Program and the Dredging Operations and Environmental Research Program (MacDonald et al., 2006). The model contains algorithms that appropriately represent particle (sediment) transport, settling, deposition, mixing, and resuspension processes. Suspended sediment in PTM is modeled as a discretized finite number of particles that are transported by flow. These particles are representative of all particles coming from a source. Each particle is assigned a mass of sediment to represent, and each particle has individual characteristics that include grain size and density. The transport and eventual deposition of these representative particles can then be used to determine suspended sediment concentrations and deposition thicknesses.

4.0 HYDRODYNAMIC MODEL APPLICATION

4.1 Model Setup

Figure 4-1 shows the limits of the model domain and indicates each boundary condition applied to the hydrodynamic model. The model domain includes most of the mid-Atlantic Bight from northern Virginia to the mid-coast of New Jersey. The model domain extends almost to the limit of the Bight approximately 105 km (65 mi) offshore. The offshore limit of the model domain is a semi-circular boundary that begins at Parramore Beach, Virginia and connects to the New Jersey coast near Barnegat Light House in Barnegat Light, New Jersey. The model domain has one tidal boundary and one flow boundary. These boundaries and their source data are described below.

- **Open water tidal boundary in mid-Atlantic Bight:** The tidal signal at the boundary is calculated within the ADCIRC model using values from the Atlantic Ocean ADCIRC 2015 tidal constituent database (ADCIRC, 2022). The open boundary is approximately 370 km (230 mi) long. The representative tidal constituents change over the length of the boundary. In the model, the tidal constituents were assigned every 4.8 km (3 mi) along the open boundary. The amplitudes and phases shown in Table 4-1 indicate the range of values for each assignment along the boundary.
- **Flow boundary at Trenton, New Jersey on Delaware River:** The area of interest for the study extends into the lower portion of Delaware Bay, but a model domain that extends to the point where the tidal influence in the Delaware River is minimal provides a more appropriate simulation of hydrodynamics in the lower Delaware Bay. The upstream boundary of the model is near the United States Geological Survey (USGS) Flow Gage Station at Trenton, New Jersey (Station ID: 01463500). The recorded flow at this station was used to determine the appropriate flow into the model domain to represent the Delaware River.

Table 4-1: Open Boundary Tidal Constituents

Tidal Constituent	Amplitude m	Amplitude ft	Phase degrees
K1	0.091 – 0.100	0.299 – 0.329	172.0 – 174.4
M2	0.413 – 0.553	1.354 – 1.814	351.1 – 353.1
N2	0.096 – 0.126	0.316 – 0.413	332.2 – 335.1
O1	0.064 – 0.071	0.211 – 0.234	169.1 – 188.7
S2	0.075 – 0.106	0.245 – 0.347	13.3 – 16.7

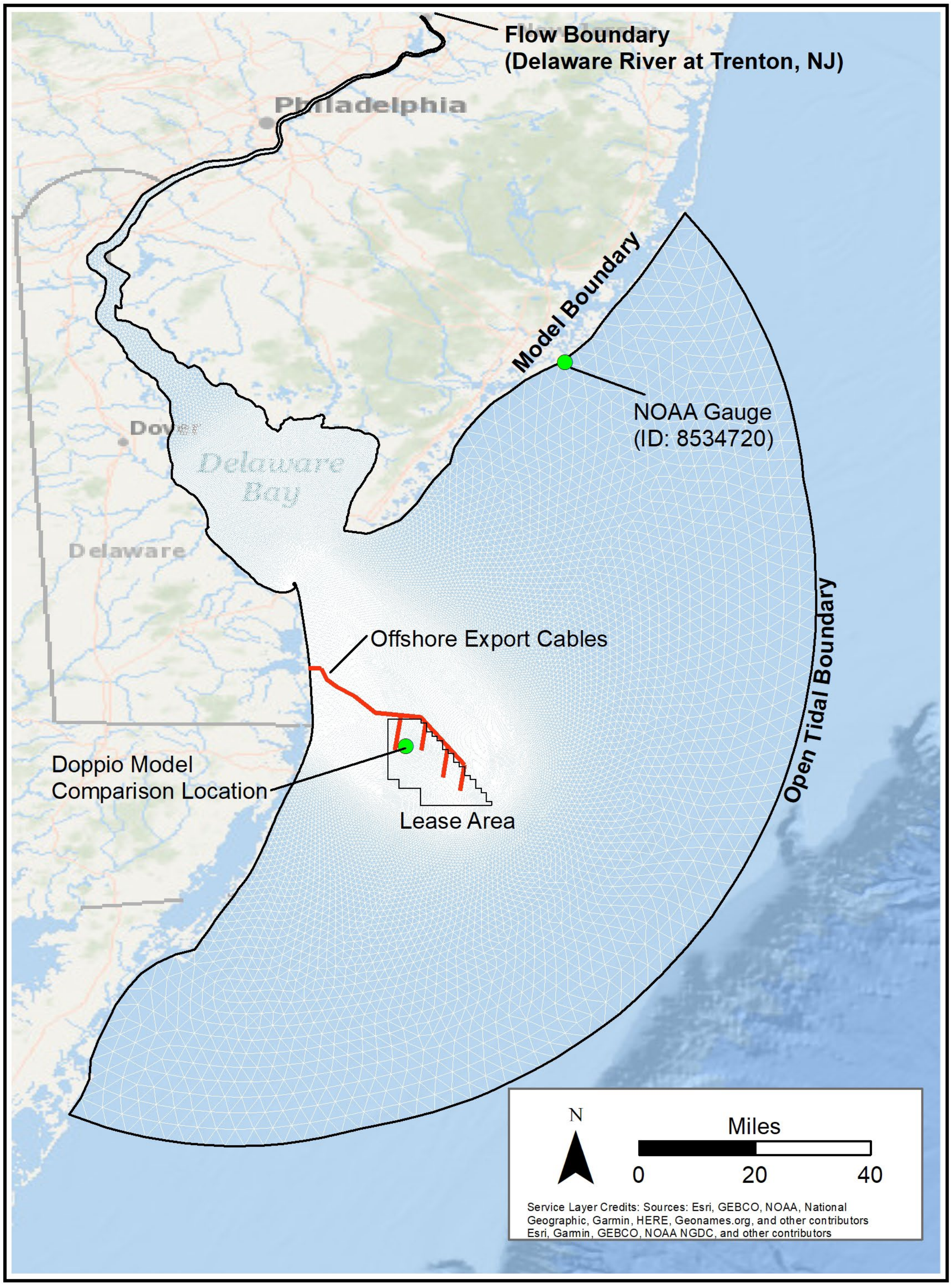

Figure 4-1: Hydrodynamic Model Domain

Figure 4-1 shows the hydrodynamic model grid within the domain. The model grid that ADCIRC uses is an unstructured grid. Near the open water tidal boundary, the grid triangles are approximately 5,000 m (16,400 ft) on each side, whereas near the planned Offshore Export Cable Corridor and Inter-array Cables they are approximately 275 m (900 ft) on each side. The hydrodynamic model is appropriately scaled to simulate current patterns in the model domain and provide the necessary current velocity and water level information for the sediment transport model to assess jet plow induced suspended sediment concentrations and deposition.

The bathymetric data used in the hydrodynamic model is based on the publicly available US Coastal Relief Model (NOAA, 2022b). HWR incorporated meteorological conditions (i.e., wind and atmospheric pressure) into the model based on European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis version 5 (ERA5) model (ECMWF, 2022).

HWR ran the hydrodynamic model for the period from January 1, 2021 to October 1, 2021 to represent and bracket the planned[3] jet plow installation activities for the project. This period was selected to coincide with the anticipated duration of the jet plow installation period.

4.2 Model Results and Comparison

To ensure that the hydrodynamic model appropriately simulates currents and tides in the model domain, HWR evaluated model performance for a 14-day period from January 2, 2021 through January 15, 2021. HWR selected a 14-day period to evaluate model performance because overly long comparison periods can generate misleading performance statistics that result from the length of model run (e.g., R^2 improves when the range of observed values increases). The exact duration of the modeled to observed comparison is a matter of professional judgement, and HWR has found that 14 days is an appropriate duration based on past experience. HWR selected this specific period of time (i.e., January 2, 2021 through January 15, 2021) because there were no large storms during that period and the tides and winds that occurred during that period were variable, but representative of typical conditions. There are many other periods that could have been used as well, but this period of time is both representative of typical conditions and coincident with the period of time required for the sediment transport modeling. The predicted model water levels were compared to observed water levels from the NOAA tide station at Atlantic City, New Jersey (Station ID: 8534720) and to model currents from a regional scale model, the Doppio model.

The Doppio model is a publicly available hydrodynamic model of the Atlantic Bight developed by Rutgers University. Doppio simulates currents from Cape Hatteras, North Carolina to the Gulf of Maine. The model domain extends approximately 350 miles offshore (Lopez et al. 2020) and includes the Offshore Export Cable Corridor and Lease area. Doppio is a Regional Ocean Modeling System (ROMS) model, and it generates predictions of water levels and currents as well as water quality characteristics. The location of the Atlantic City tide station and the Doppio model comparison point are both shown in Figure 4-1.

HWR compared predicted water levels from the hydrodynamic model to observed water levels at Atlantic City, New Jersey (Figure 4-2). The hydrodynamic model shows an equivalent tidal range to the observed data, indicating good model correlation to measured conditions. The mean residual (i.e., the difference

[3] The conditions that will be present during the future installation period are unknown (i.e., tidal range, freshwater flow, wind speed and direction). To account for seasonal variability in boundary conditions, HWR ran the hydrodynamic model for the same period in 2021.

between the modeled values and observed values for water levels is -0.14 m (-0.45 ft). The root mean square error (RMSE) is 0.17 m (0.57 ft). In the process of tuning the hydrodynamic model, it is important to balance both matching water levels and matching currents. Ideally the mean residual water level would be smaller, but the degree of symmetry between observed and predicted water levels is acceptable when evaluated jointly with the degree of matching between the hydrodynamic model currents and Doppio modeled currents.

While water levels are a relevant metric for evaluating the hydrodynamic model performance, current speeds along the Offshore Export Cable Corridor and Inter-array Cables are more important to this study because advective transport (as represented by current speeds) is the process that will control the extent of the suspended sediment plume. Figure 4-3 shows a comparison of current speeds between the hydrodynamic model and the Doppio model at a location within the Lease area. The simulated currents from the two models are in phase, and the numerical agreement between the models is strong with the mean residual current velocity between the models is 0.07 m/s (0.24 ft/s) and the RMSE is 0.05 m/s (0.18 ft/s).

Figure 4-4 provides a comparison of the hydrodynamic model water levels to observed water levels at Atlantic City, New Jersey, and Figure 4-5 provides a comparison of the hydrodynamic model current speeds to Doppio model current speeds within the Lease area. This is an alternative way to view the time series shown in Figure 4-2 and Figure 4-3. The Square of the Pearson Correlation Coefficient (R^2) is a statistic that indicates the degree of correlation between two independent sets of data. The R^2 value for the water level comparison is 0.81, which indicates good correlation between observed and predicted water levels. R^2 for the correlation between the ADCIRC model results and the Doppio model results is 0.61, an indication of correlation with some variability.

Taken collectively, the information presented in Figure 4-2 through Figure 4-5 demonstrates that the hydrodynamic model appropriately simulates the hydrodynamic behavior of mid-Atlantic Bight in the vicinity of the Lease area is acceptable for use in sediment transport modeling.

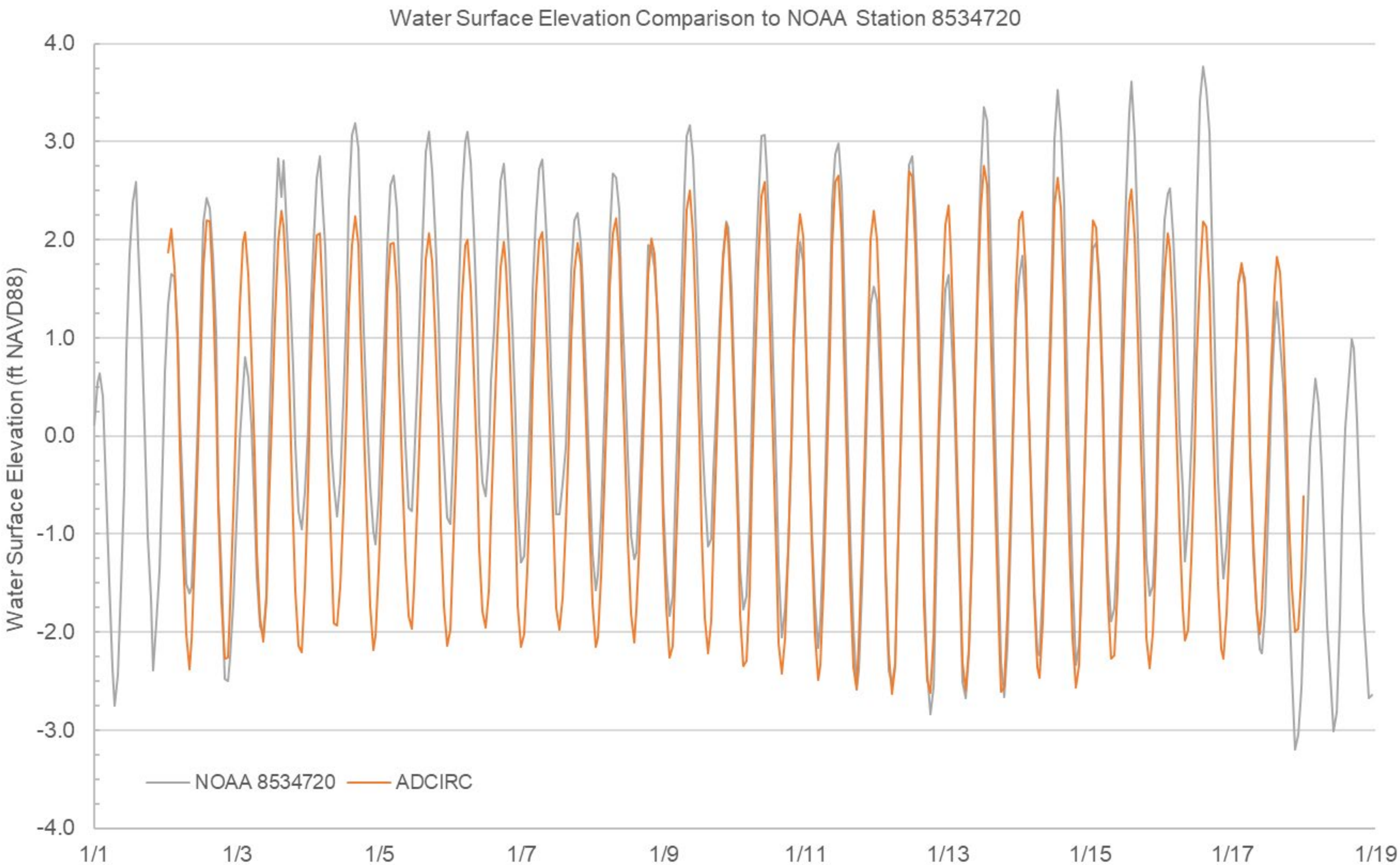

Figure 4-2: Comparison – Hydrodynamic Model and Observed Water Levels

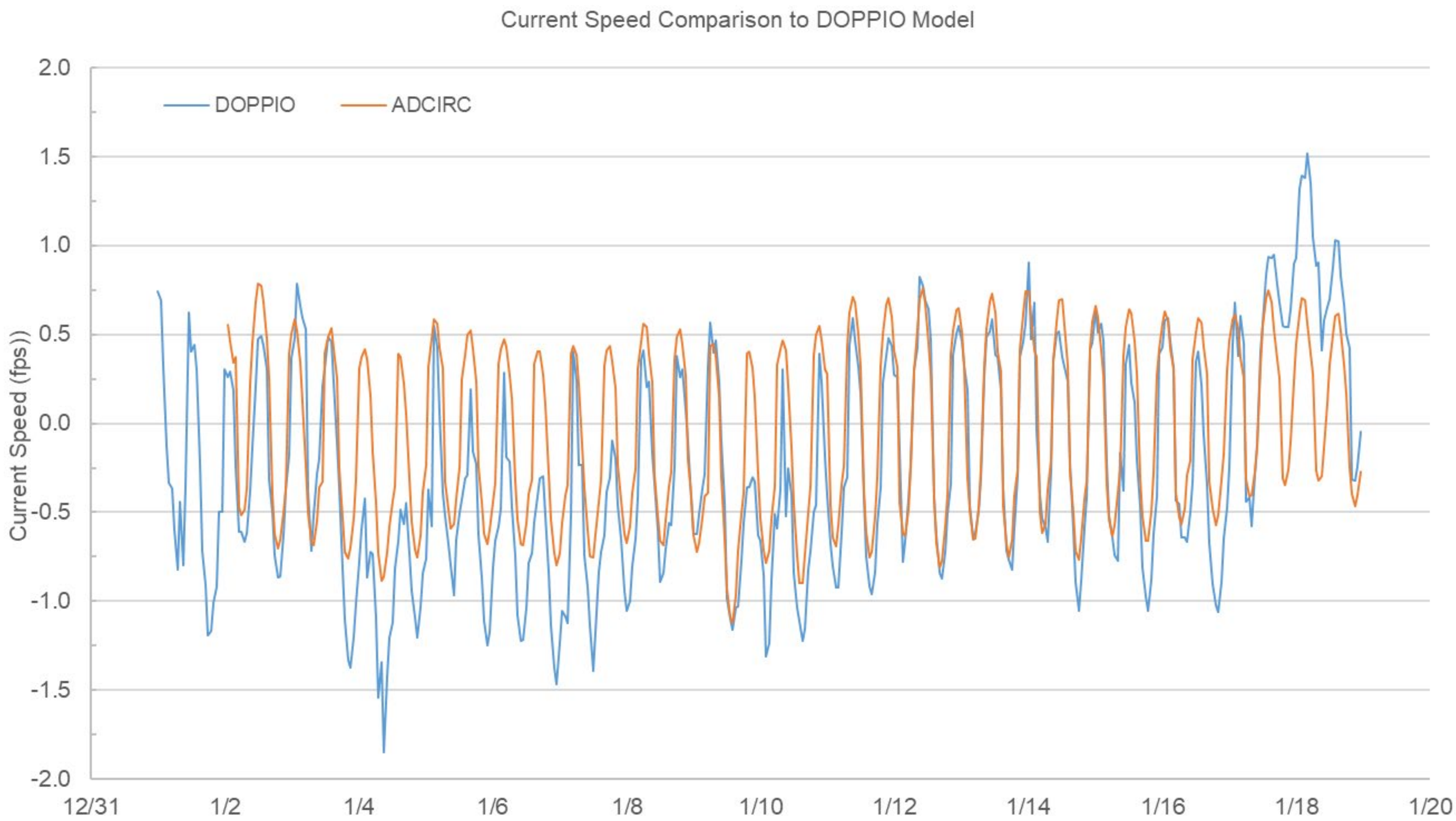

Figure 4-3: Comparison Hydrodynamic Model and Doppio Modeled Current Speeds

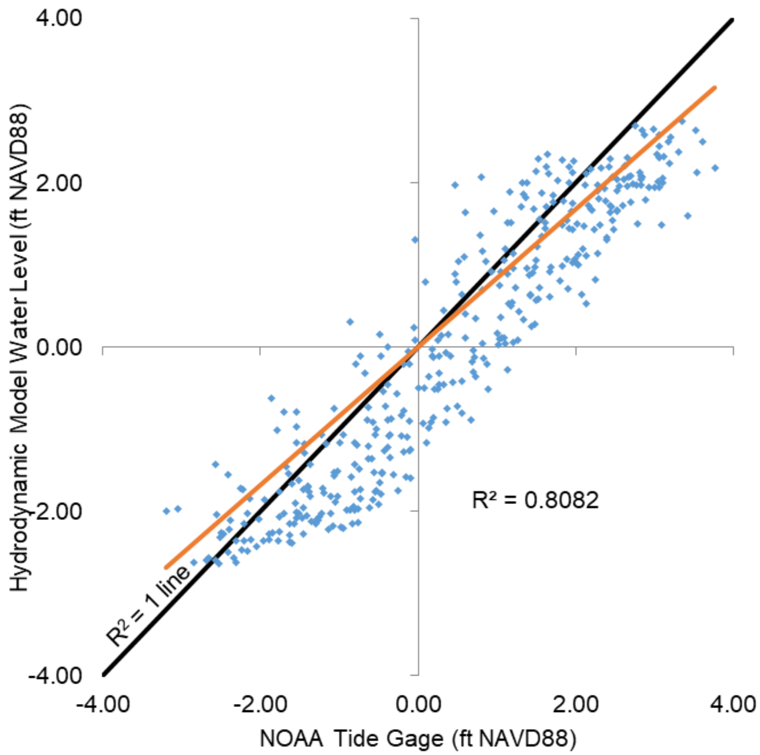

Figure 4-4: Direct Comparison Hydrodynamic Model and Observed Water Level

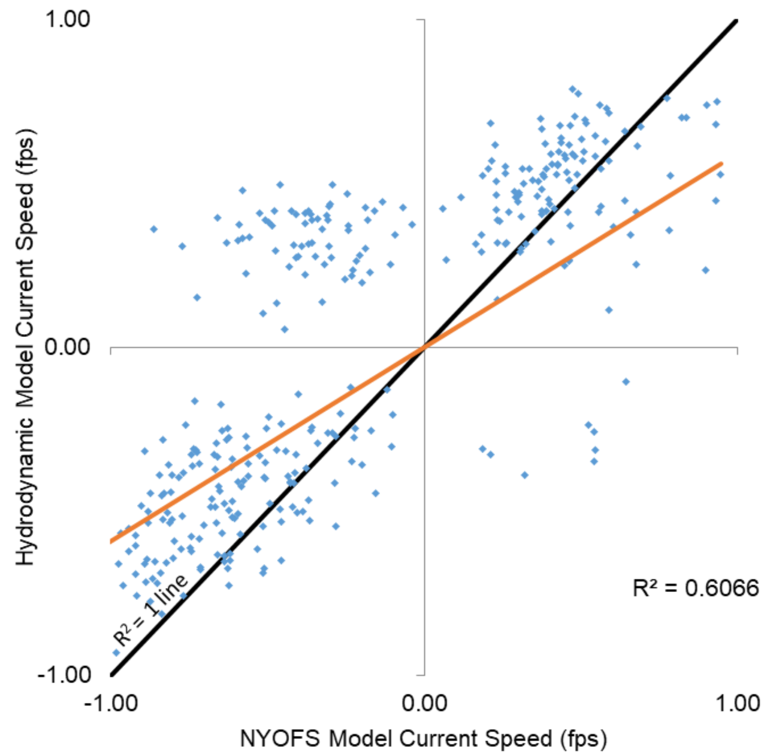

Figure 4-5: Direct Comparison Hydrodynamic Model and Doppio Modeled Current Speeds

5.0 SEDIMENT TRANSPORT MODEL APPLICATION

The planned jet plowing will include the installation of four Offshore Export Cables and 26 Inter-array Cables. Each cable will be placed in a separate jet plowed trench. Jet plowing combines excavation of the trench, cable placement, and backfilling of the trench into a single continuous process. During jet plowing, sediment will be fluidized to allow the placement of the cable. The majority of the fluidized sediment will return to the trench, but some portion of the fluidized sediment will escape the trench. The complexity of the submarine cable layout means that the order of installation and timing of each cable placement will evolve as construction details become finalized. For the purposes of this study, it was assumed that each Offshore Export Cable will be installed from onshore to offshore with the most southerly cable being installed first. Installation of the next most southerly cable will immediately follow the completion of the first cable and so forth until all four Offshore Export Cables are installed. The Offshore Export Cable installation is assumed to start January 3 and be completed in late March. It is assumed that the Inter-array Cables will be installed in sets with the first installed set to be the Inter-array Cables associated with the first installed Offshore Export Cable. The Inter-array Cables will be installed in a clockwise order, and each jet plowing operation will move from the central node away from that node. Inter-array cable installation will repeat this pattern for each set of Inter-array Cables. The Inter-array Cable installation will begin on May 1 and be completed in mid-August. For both the Offshore Export Cables and the Inter-array Cables, it is assumed that jet plowing will occur continuously along each cable with no time between the completion of one cable and the beginning of another cable. Continuous jet plowing of each cable in will not be possible during construction. It is anticipated that the actual construction period will be longer (i.e., January to May for the Offshore Export Cables and May to September for the Inter-array Cables), but the model results shown in this study are representative of what will occur during the actual construction period. For the purposes of the sediment transport modeling, the inclusion/exclusion of delays between cable laying operations does not influence the model results.

5.1 Model Setup

The sediment transport model (PTM) uses the same model domain as the ADCIRC model. PTM requires additional inputs that represent the operation of the jet plow and characterize the sediment suspended into the water column. The anticipated fluidization depth, channel width, and jet plow progress rate are shown in Table 5-1 for Offshore Export Cables and Inter-array Cables.

Table 5-1: Jet Plowing Characterization

Segment Description	Fluidization Depth		Embedment Speed	
	m	ft	m/hr	ft/hr
Offshore Export Cables	2.0	6.6	100	330
Inter-array Cables	1.5	4.9	100	330

The amount of sediment that is lost to the water column is a function of sediment characteristics, jet plow operation, and ambient current speeds. Elliot et al. (2017) found that the sediment loss rate was between 4% and 26% for similar jet plowing in similar sediments. A sediment loss rate of 25% has been selected for this study. This value is consistent with the higher limit of values measured by Elliot et al. (2017), and it is consistent with values used in the previous HWR projects.

The rate of suspended sediment generation (on a volume basis) is the product of trench width, excavation depth, advancement rate, sediment composition, and the loss rate. To calculate the rate of suspended sediment generation on a mass basis, it is necessary to understand the physical properties of the sediments that will be fluidized.

The modeling requires the specification of a median grain size, an estimate of particle sorting (i.e., standard deviation for grain-size distribution), specific gravity, and porosity. The vibracore samples and the geotechnical evaluations discussed in Section 2.0 of this report provide sufficient information to characterize the sediment along the Offshore Export Cable Corridor and Inter-array Cables as summarized in Table 5-2. The model simulates a normal distribution of sediment around the median grain size; therefore, the modeled sediment grain sizes range from fine-grained particles (e.g., silts) to coarse sands. The default standard deviation for the grain size distribution was used (i.e., 0.8 phi).

Table 5-2: Cable Route Sediment Characterization

Sediment Characteristic	Value	Units
Mean Median Grain Size (D50)	0.393	mm
Mean Particle Density	2,673	kg/m^3
Mean Bulk Density	1,913	kg/m^3
Standard Deviation	0.8	phi

5.2 Model Results

The ADCIRC model demonstrated the ability to reproduce observed water levels (i.e., comparison to NOAA tide gage at Atlantic City, New Jersey) and simulated currents from a regional hydrodynamic model (i.e., the Doppio model). Project specific sediment data along the Offshore Export Cable Corridor and within the Lease area was used to characterize the sediments. The combination of an appropriate hydrodynamic model and a site-specific sediment characterization means that the results from the sediment transport model can be considered an appropriate prediction of sediment transport behavior resulting from jet plowing.

The sediment transport model predicts that most coarse-grained suspended sediments will settle back to the seafloor in immediate proximity to the Offshore Export Cables and Inter-array Cables, representing a localized impact to the seafloor. In contrast, the fine-grained sediment will settle more slowly and spread further from the Offshore Export Cables and Inter-array Cables.

5.2.1 Predicted Suspended Sediment Concentrations from Jet Plow Embedment

The sediment transport modeling predicted suspended sediment concentrations for all planned cables. The orientation of the cable relative to the dominant ocean current axis (i.e., north-northeast to south-southwest) was a significant factor in the transport of sediments away from each cable route. When the cable orientation was close to parallel to the current axis, sediments were typically deposited in the immediate vicinity of the cable. When the cable orientation was close to perpendicular to the current axis, sediments were typically deposited further away from the cable.

The sediment transport model results for the Offshore Export Cables and Inter-array Cables predict that the suspension of in-situ seafloor sediments from jet plow will not result in suspended sediment concentrations greater than 200 mg/L above ambient conditions beyond distances of approximately 137 m (450 ft) laterally away from the cables. Jet plow induced suspended sediment concentrations greater than 50 mg/L are not predicted to occur more than 457 m (1,500 ft) from the cables. All suspended sediment concentrations greater than 50 mg/L above ambient conditions are predicted to dissipate in less than 12 hours after the passage of the jet plow. The model analysis predicts that increases in suspended sediment concentrations above 10 mg/L over ambient will also be of short duration, dissipating within 24 hours after the completion of jetting operations.

The sediment transport model predicts that suspended sediments from the jet plow released into the water column will reach their maximum displacement away from the cable to the north and south for the Offshore Export Cables in the portion of the cables that are oriented west-to-east just offshore, as shown in Figure 5-1. The timing of jet plowing with respect to tides may change the direction of the suspended sediment plume, but the total excursion from the cable is expected to be consistent with excursions shown in this report. Table 5-3 provides mean and maximum distances for a given suspended sediment concentration. The values presented in Table 5-3 and previously in this section exclude the region between the most southerly Offshore Export Cable and the most northerly Offshore Export Cable. For locations within this region, suspended sediment may be further from the cable placement that was the source of suspended sediment and closer to a cable that was not the source of the sediment.

Table 5-3: Mean and Maximum Suspended Sediment Displacement from Cables

Suspended Sediment Concentration	Mean Distance		Maximum Distance	
mg/L	m	ft	m	ft
200	48	157	130	427
100	78	256	366	1,201
50	71	233	457	1,499
10	56	184	607	1,991

Appendix A is a series of figures that present the same information as Figure 5-1, but at a smaller scale to allow a more detailed investigation of the model results. The maximum predicted suspended sediment concentration occurs at different depths within the water column, at different locations in the model, and can occur at any point in time between the start of jet plowing and the return to ambient conditions following the end of jet plowing. This means that the plume of suspended sediment shown in Figure 5-1 and Appendix A is much larger than what would occur at any single time during cable installation.

Figure 5-2 provides a graph comparing displacement from the Offshore Export Cables and Inter-array Cables and predicted suspended sediment concentration. This figure provides a concise summary of the spatially distributed data that is presented in Figure 5-1.

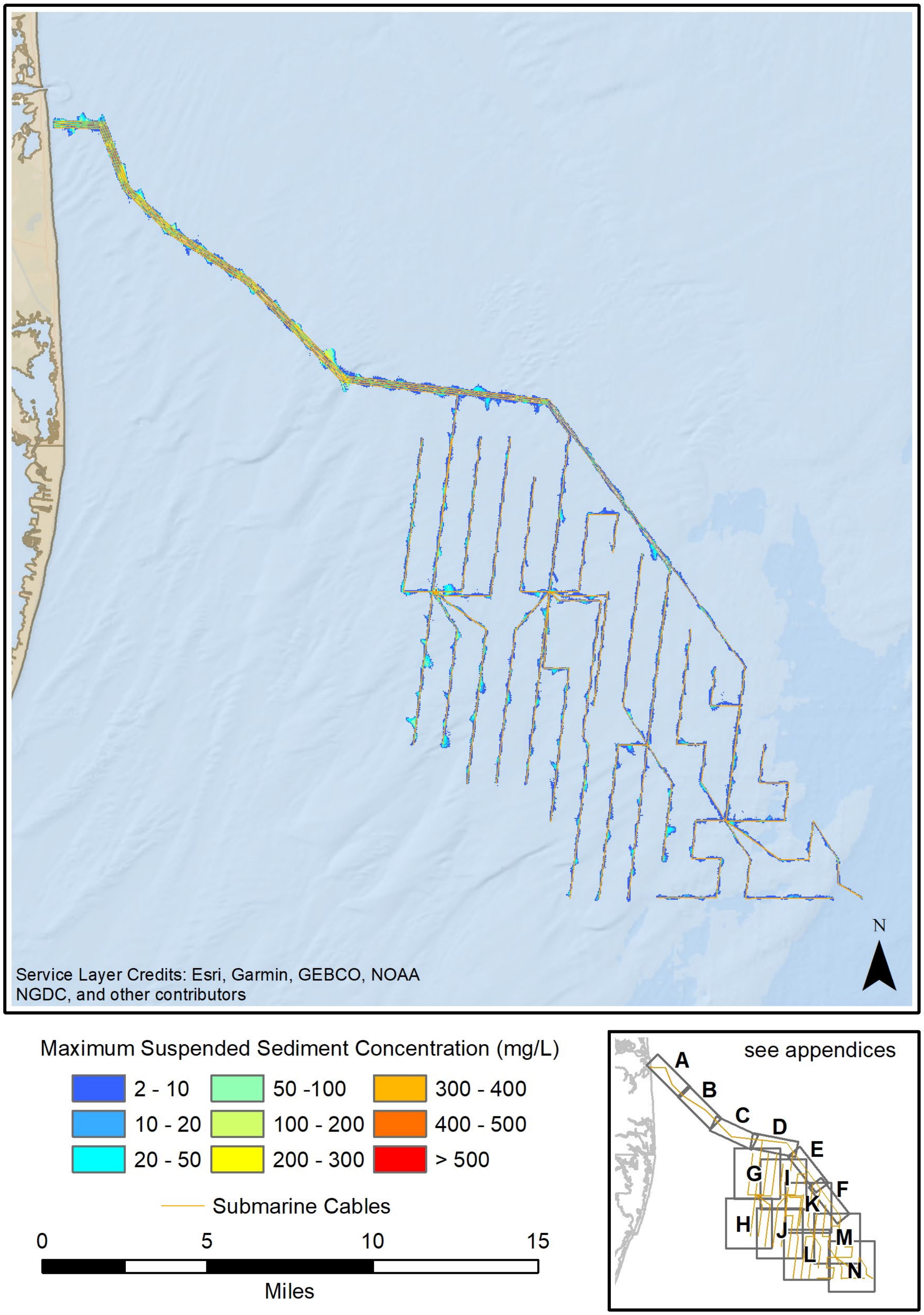

Figure 5-1: Modeled Predicted Maximum Suspended Sediment Concentrations

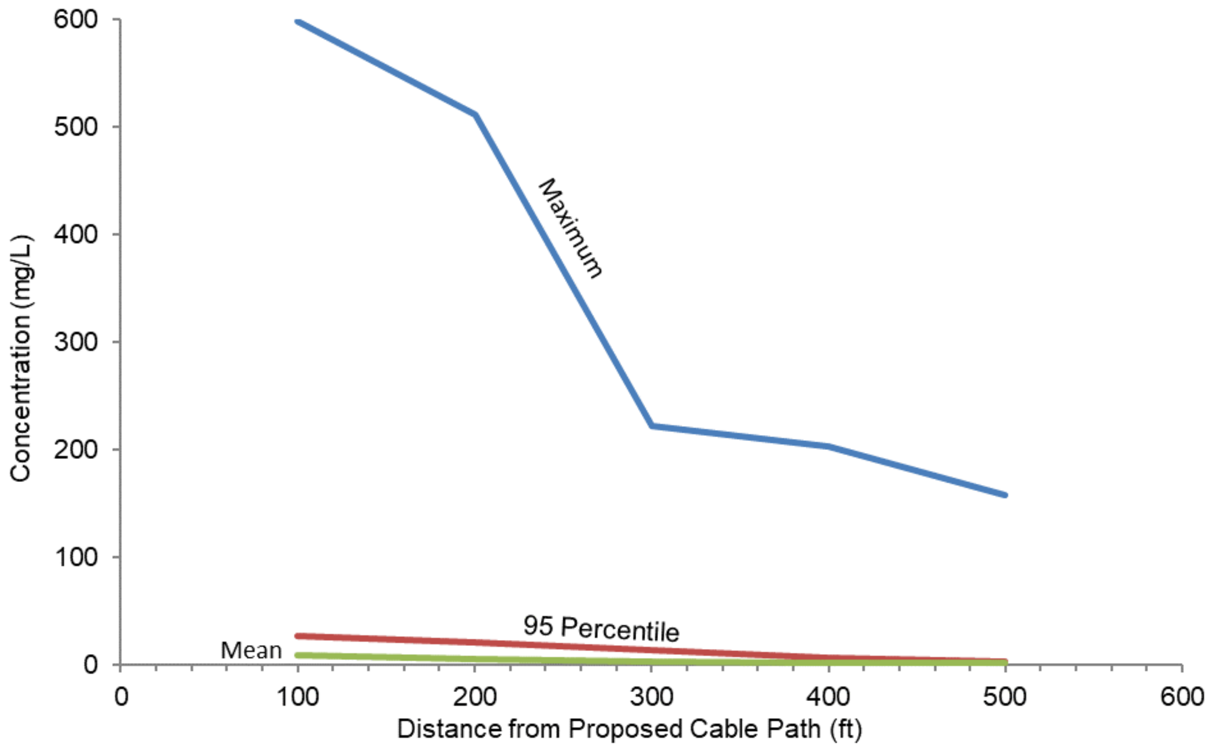

Figure 5-2: Predicted Suspended Sediment Concentration with Distance from Offshore Export Cables and Inter-array Cables

The suspended sediment results summarized in this section are the result of advective transport of sediments by ambient conditions (e.g., currents). This transport can be referred to as far-field effects. Near-field effects are the transport caused by the momentum-driven flow of water from the jet plow fluidization. This study does not take into account near-field effects, which occur within a range of less than 30 m (100 ft) of the jet plow operation. When interpreting the results of the sediment transport models, suspended sediment concentrations are typically highest at the point of the jet plow moving through the seafloor. This area is known to be an area of high turbulent mixing as a result of the swept flow of the jet plow that is designed to pull suspended sediment material into the jetted trench. Such rapidly changing suspended sediment concentrations are not reflected in the model. It is common practice to exclude near-field behavior from sediment transport models. The model assumes uniform distribution within the near-field region in both the horizontal and vertical directions. Consequently, the highest concentrations in the model may not necessarily occur at the height above the seafloor where sediment is disturbed by the jet plow. In cases where there is not adequate water depth above the seafloor to generate uniform sediment distribution, the maximum suspended sediment concentrations are assumed to occur near the water surface. This is a conservative assumption because suspended sediment that is higher in the water column will take longer to settle and have more time to be transported away from the cables.

The model results show that the majority of suspended sediments settle out relatively quickly and remain close to the Offshore Export Cables and Inter-array Cables. Finer-grained sediments (e.g., silts) remain suspended for longer periods of time, but make up a small portion of the total suspended sediment. In general, the model results indicate that suspended sediment concentrations attributable to the jet plowing will drop below 10 mg/L well within 24 hours after the end of jet plowing. The impact of the suspended sediment plume will be limited in both extent and duration.

5.2.2 Predicted Suspended Sediment Deposition from Jet Plow Embedment

The model results show that sediment deposition associated with jet plow embedment will be limited to a narrow corridor along the Offshore Export Cables and Inter-array Cables. Figure 5-3 and Appendix B show the total predicted deposition of sediment on the seafloor from jet plowing activity associated with cable installation. Both the maximum excursion and the average excursion from the Offshore Export Cables and Inter-array Cables for different deposition thicknesses have been determined. The average excursion is considered to be “typical” for any point along the route, and the terms average excursion and typical excursion are used interchangeably in the following discussion. The maximum excursion and average excursion for various deposition thicknesses are shown in Table 5-4. The values presented in Table 5-4 exclude the region between the most southerly Offshore Export Cable and the most northerly Offshore Export Cable. For locations within this region, deposited sediments may be further from the cable placement that was the source of suspended sediment and closer to a cable that was not the source of the sediment.

Table 5-4: Mean and Maximum Deposition Displacement from Cables

Deposition Thickness		Mean Distance		Maximum Distance	
mm	in	m	ft	m	ft
0.5	0.02	82	269	659	2,162
1.0	0.04	68	223	637	2,090
2.0	0.08	52	171	623	2,044
5.0	0.20	27	89	489	1,604

The sediment deposition pattern is consistent with the suspended sediment concentration pattern. Most of the deposition is predicted to occur along the Offshore Export Cables and Inter-array Cables. The model results predict that the average excursion from the Offshore Export Cables and Inter-array Cables for deposition greater than 0.20 inches (5 mm) will be less than 27 m (90 ft) from either side of the Offshore Export Cables and Inter-array Cables. The model predicts that the average excursion for deposition thicknesses of 0.04 inches (1 mm) will be less than 70 m (230 ft) from the Offshore Export Cables and Inter-array Cables.

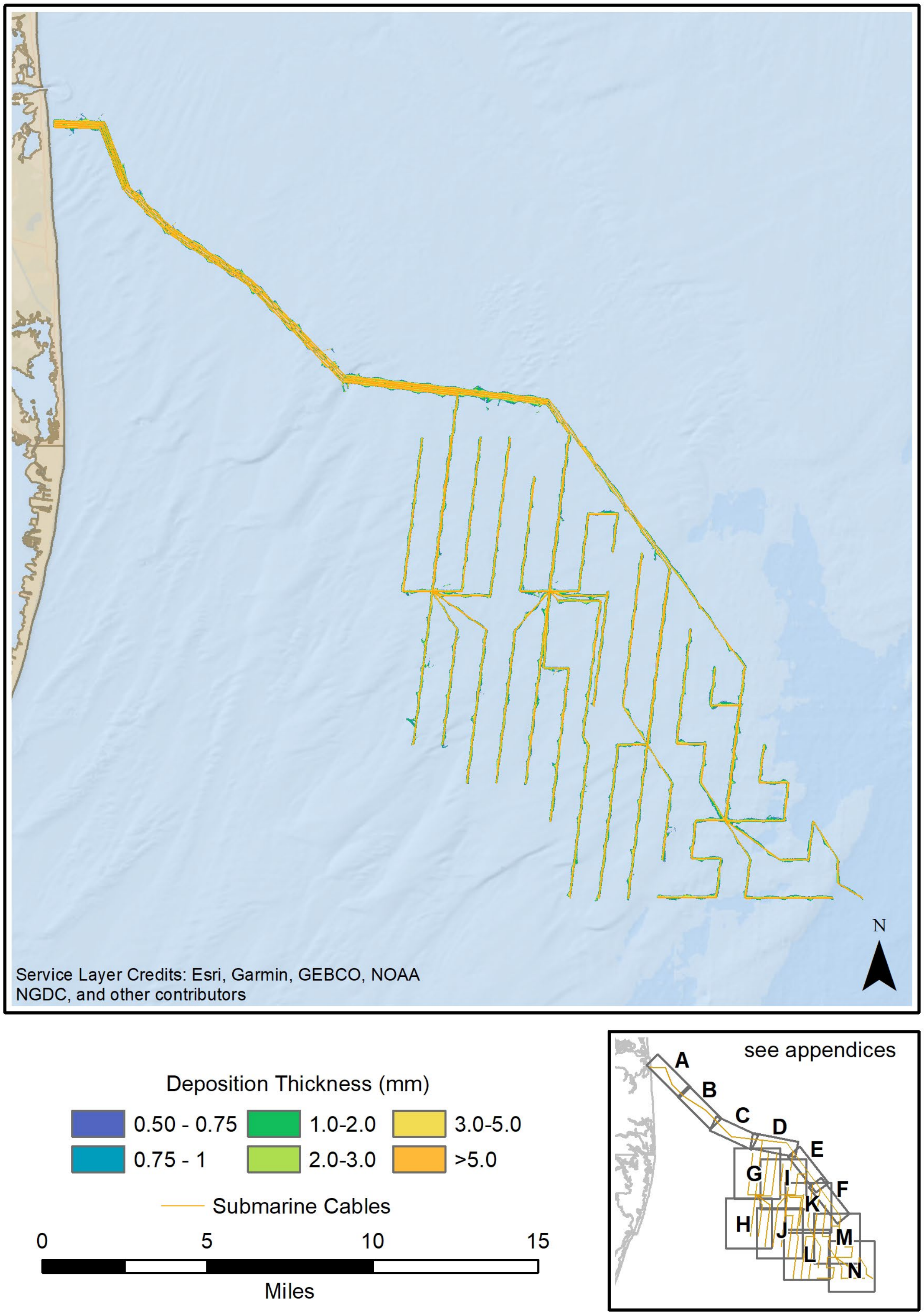

Figure 5-3: Model Predicted Total Deposition Thickness

6.0 SEDIMENT TRANSPORT MODEL FINDINGS AND CONCLUSIONS

The sediment transport modeling predicts that most sediments suspended by the jet plowing will remain in a narrow corridor along the Offshore Export Cables and Inter-array Cables. The overwhelming majority of deposition thicker than 0.2 mm will occur within 91 m (300 ft) of the proposed cable path. Most of the fluidized sediments lost to the water column are predicted to quickly settle back to the seafloor. Suspended sediment concentrations are predicted to be less than 200 mg/L at distances greater than 137 m (450 ft) from the Offshore Export Cables and Inter-array Cables. Model results indicate that the suspended sediment plume resulting from jet plowing will have a short duration. The model results show that increases in suspended sediment concentrations above 10 mg/L over ambient are only of short duration (hours). All suspended sediment plumes are predicted to disappear within 24 hours after the completion of jetting operations. In conclusion, the sediment transport modeling results indicate that the proposed jet plow embedment process for cable installation will result in short-term and localized effects.

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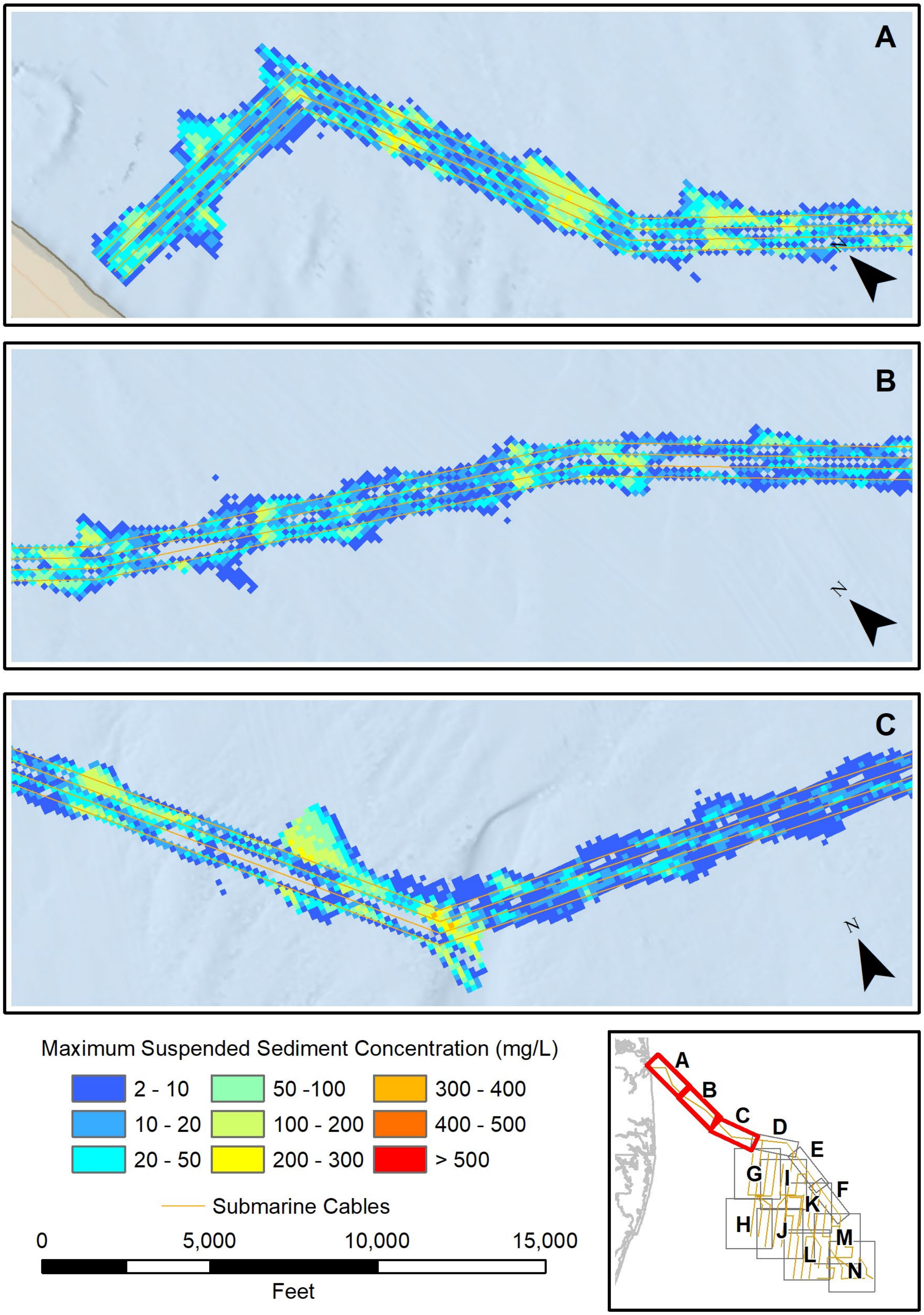
Appendix A: Maximum Suspended Sediment Concentration Figures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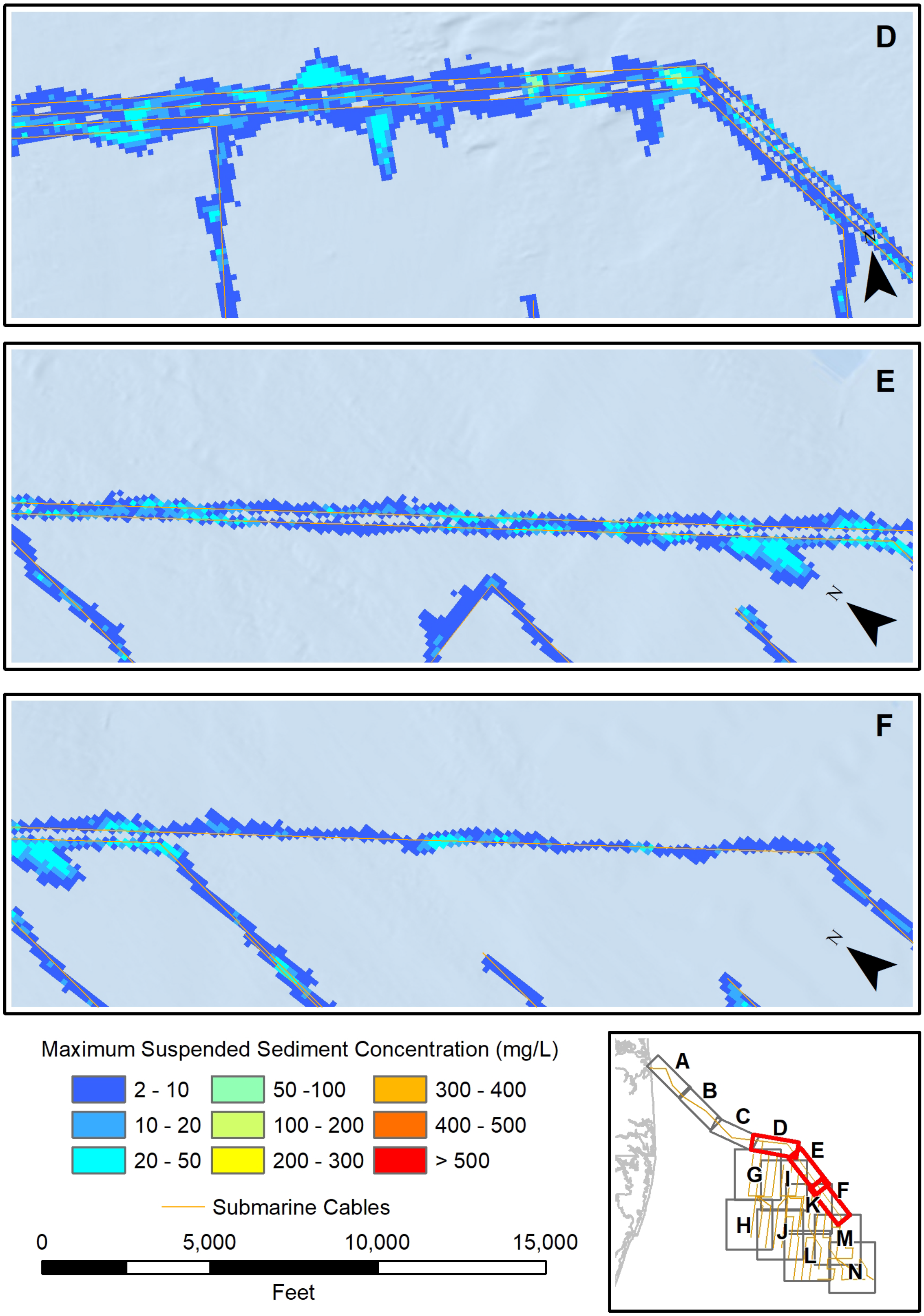
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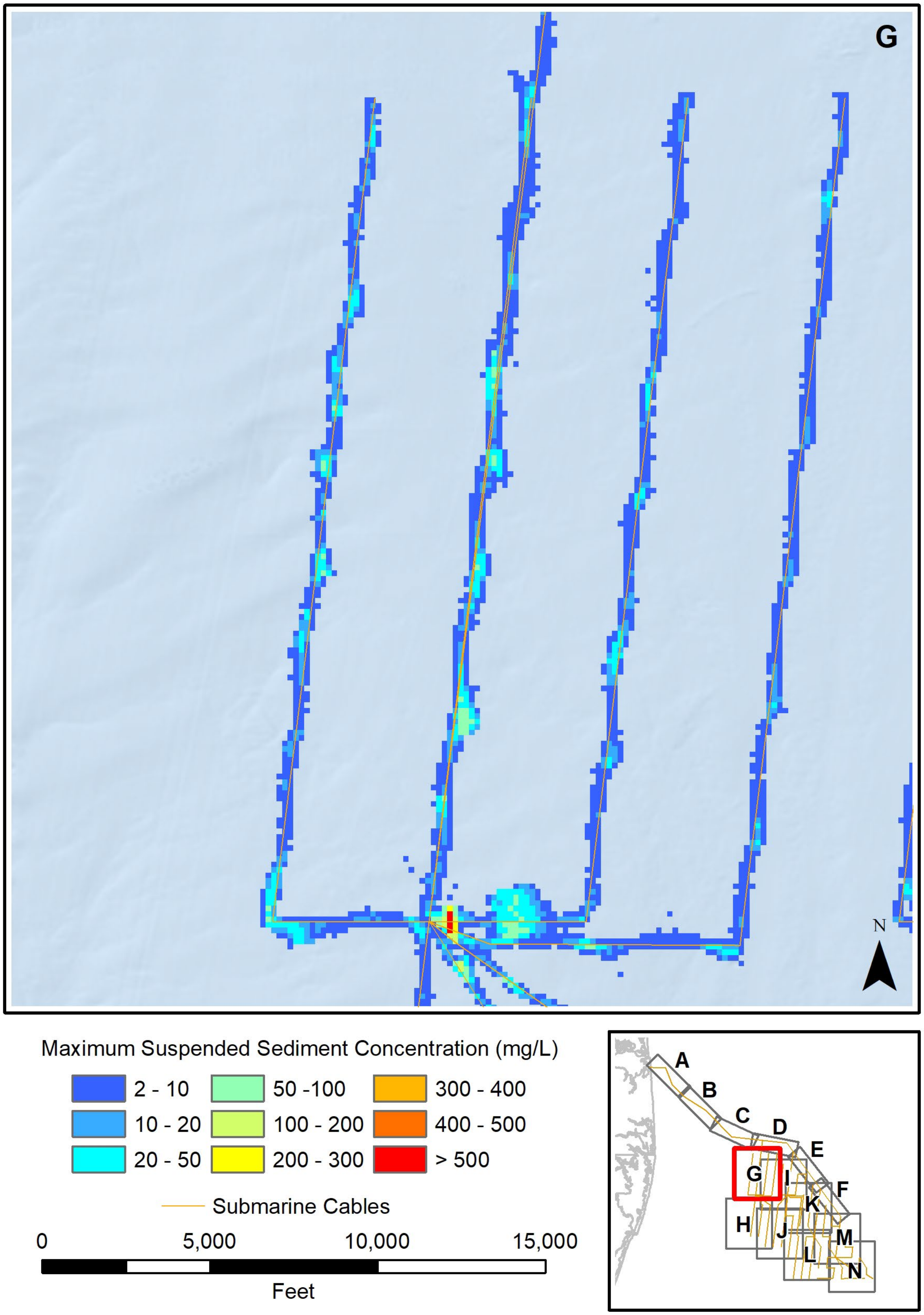
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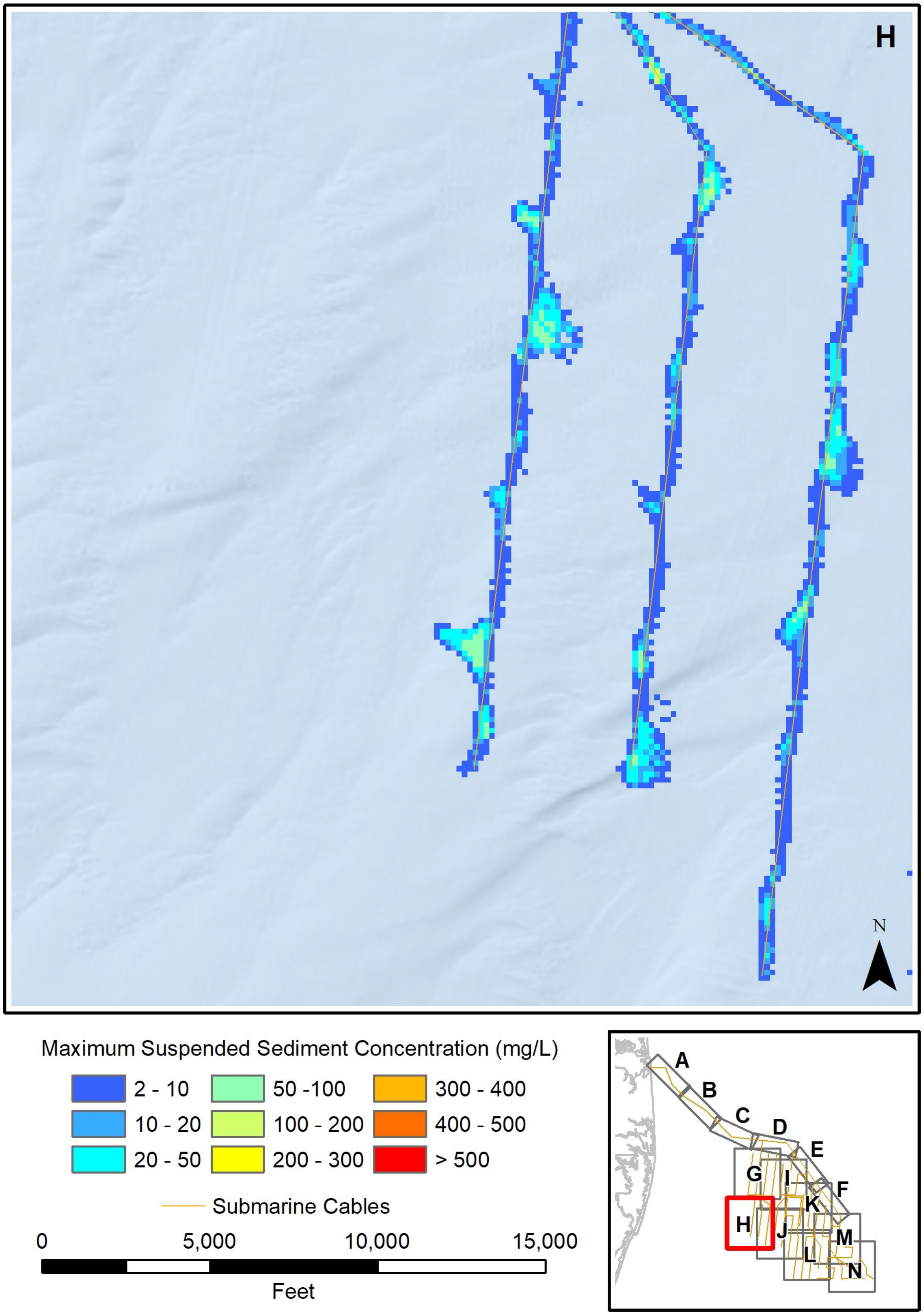
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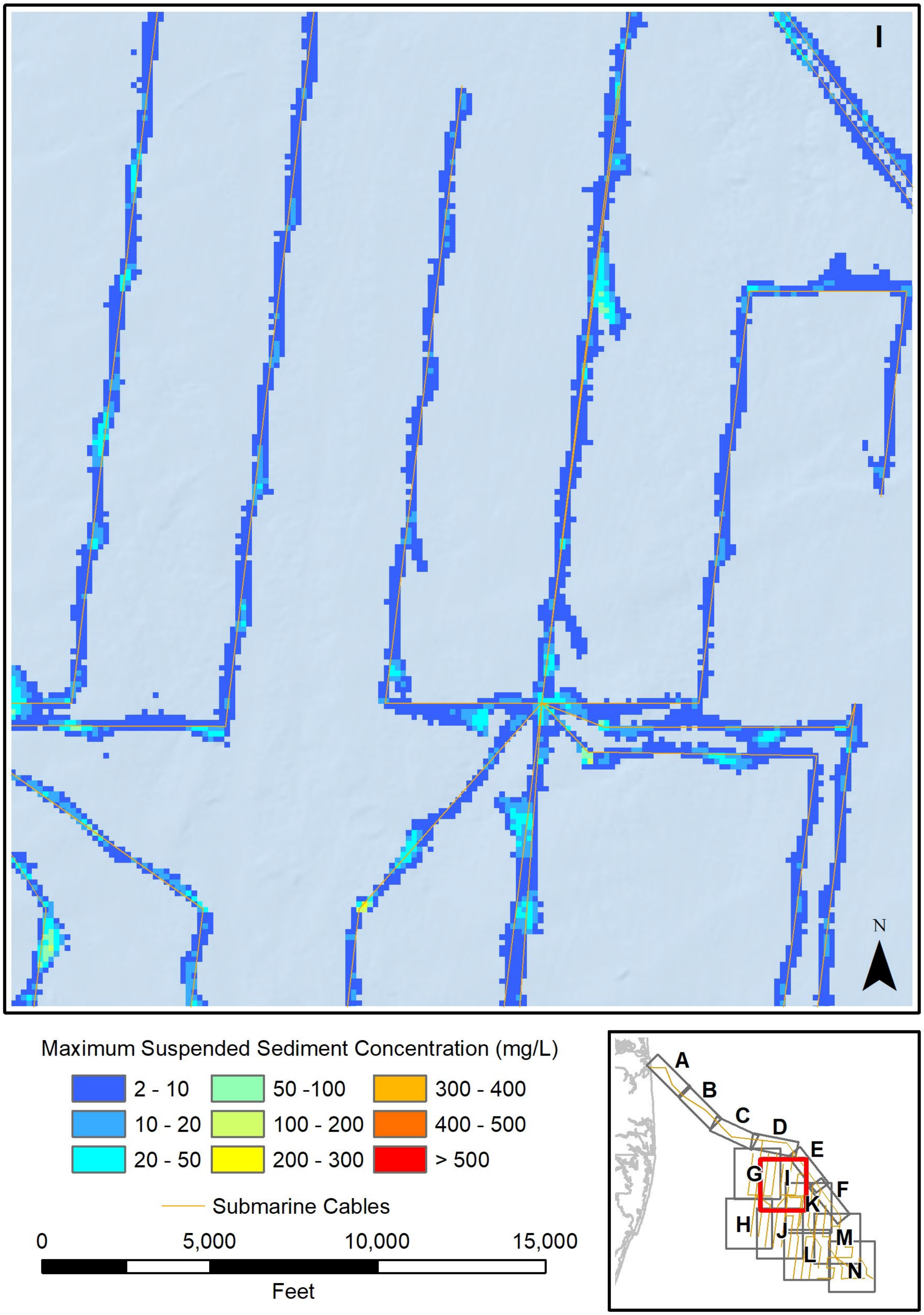
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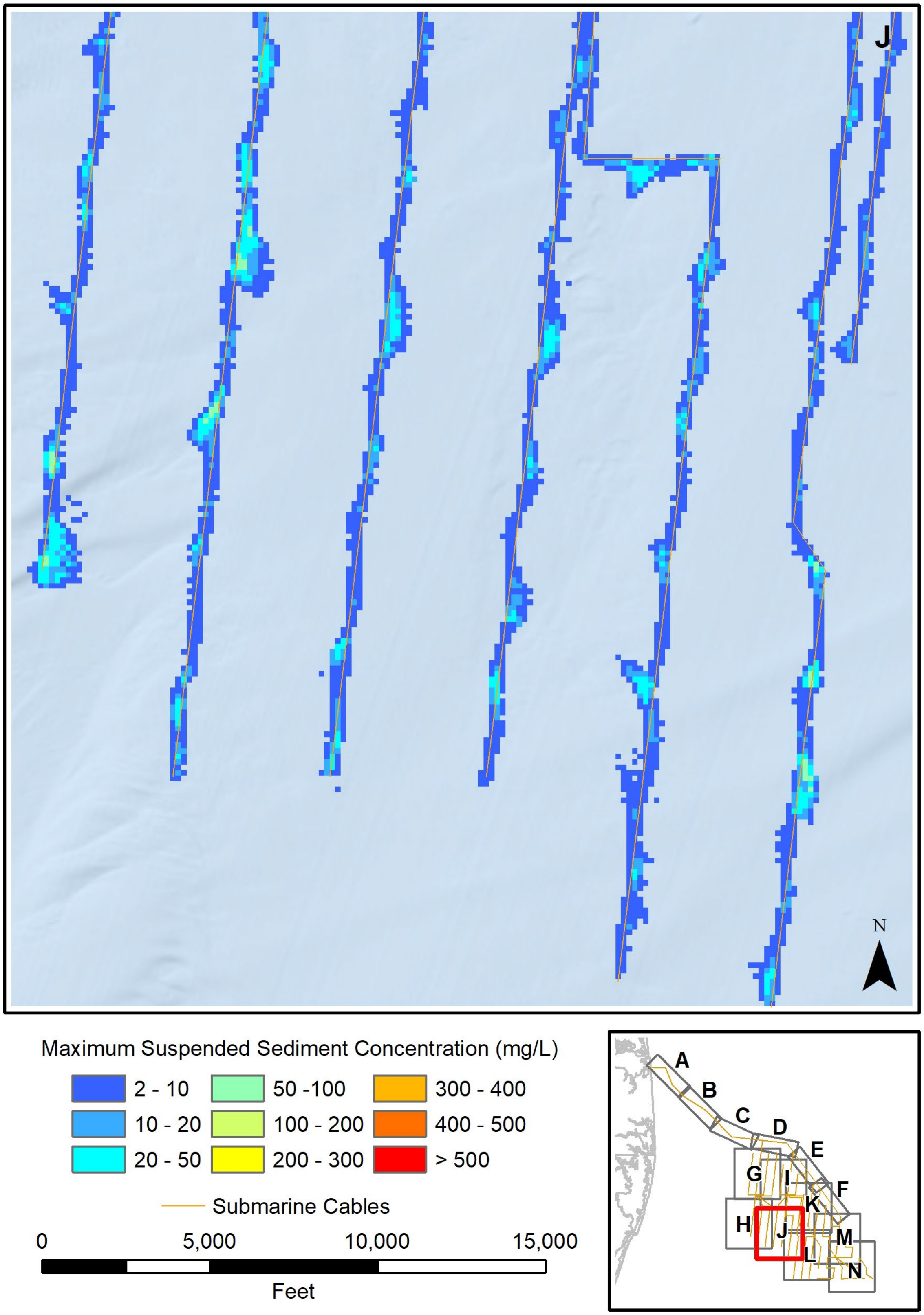
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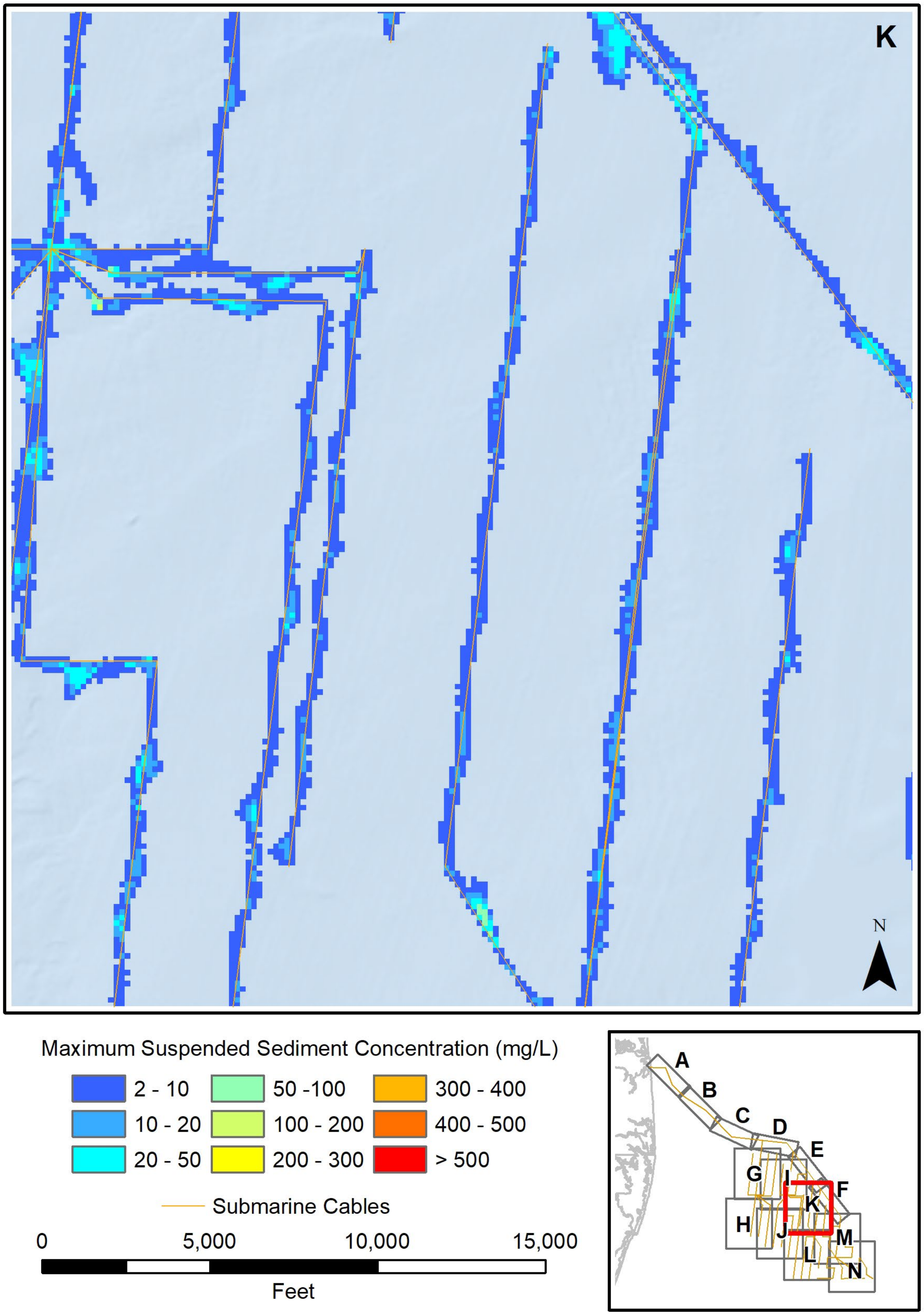
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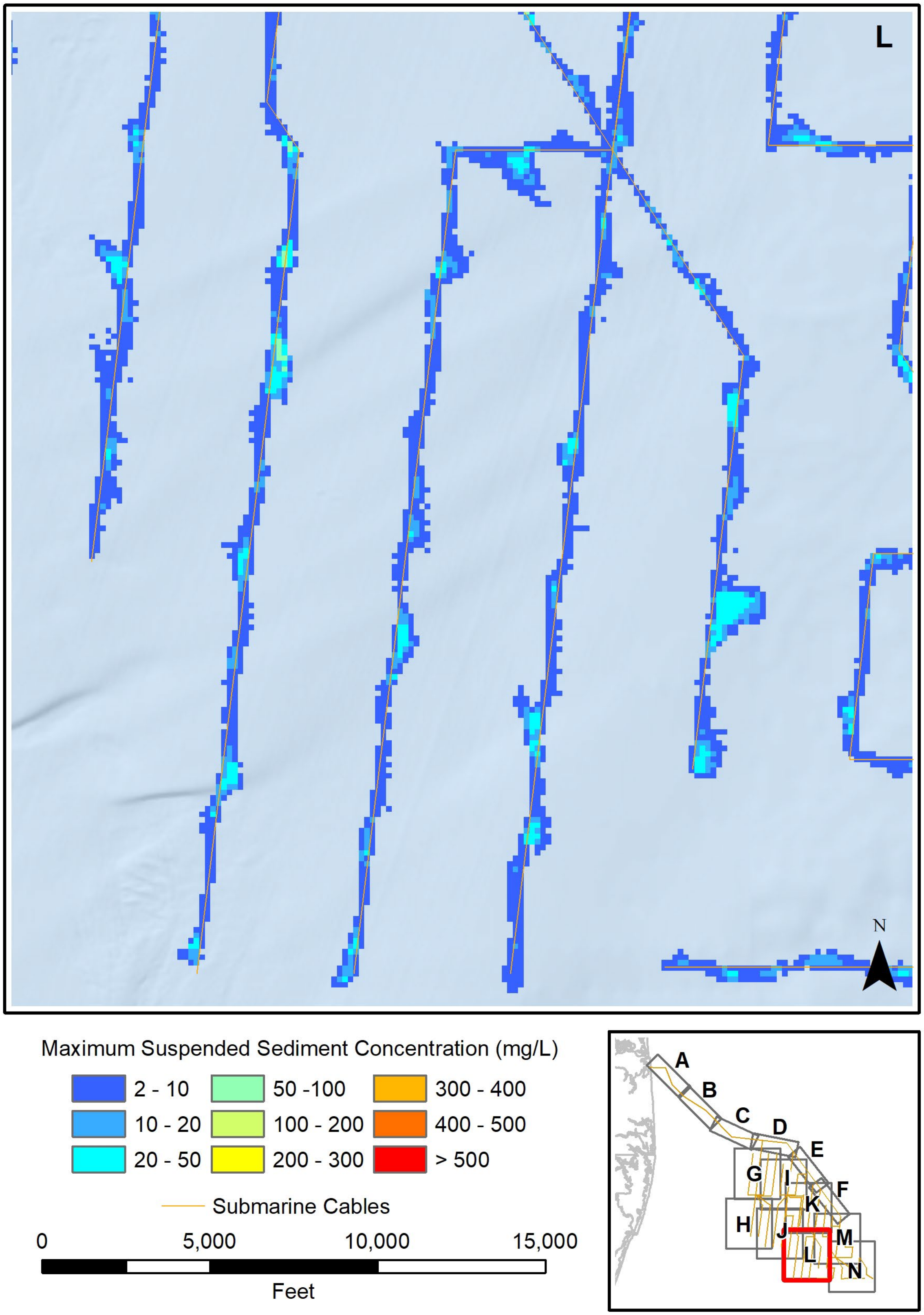
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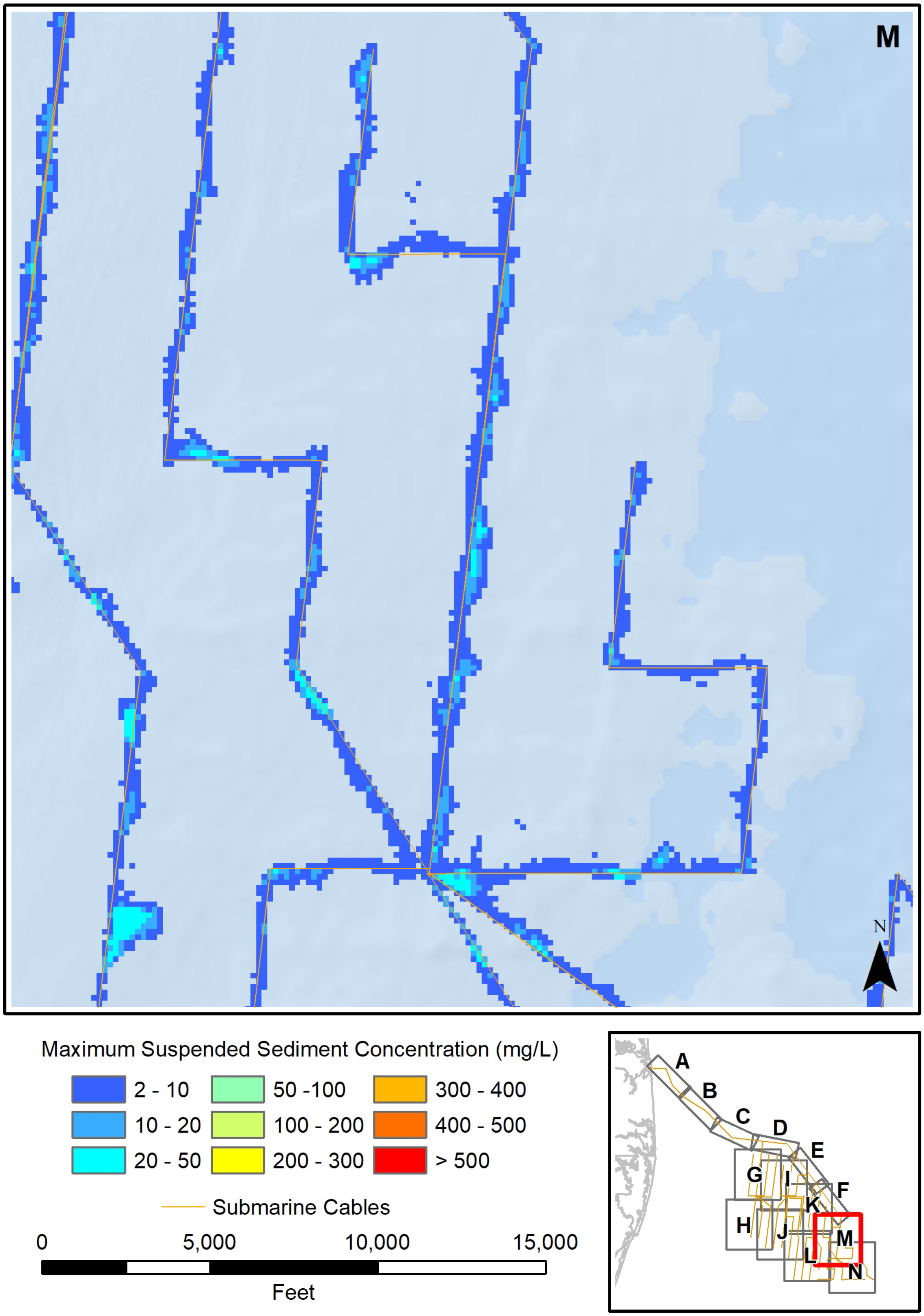
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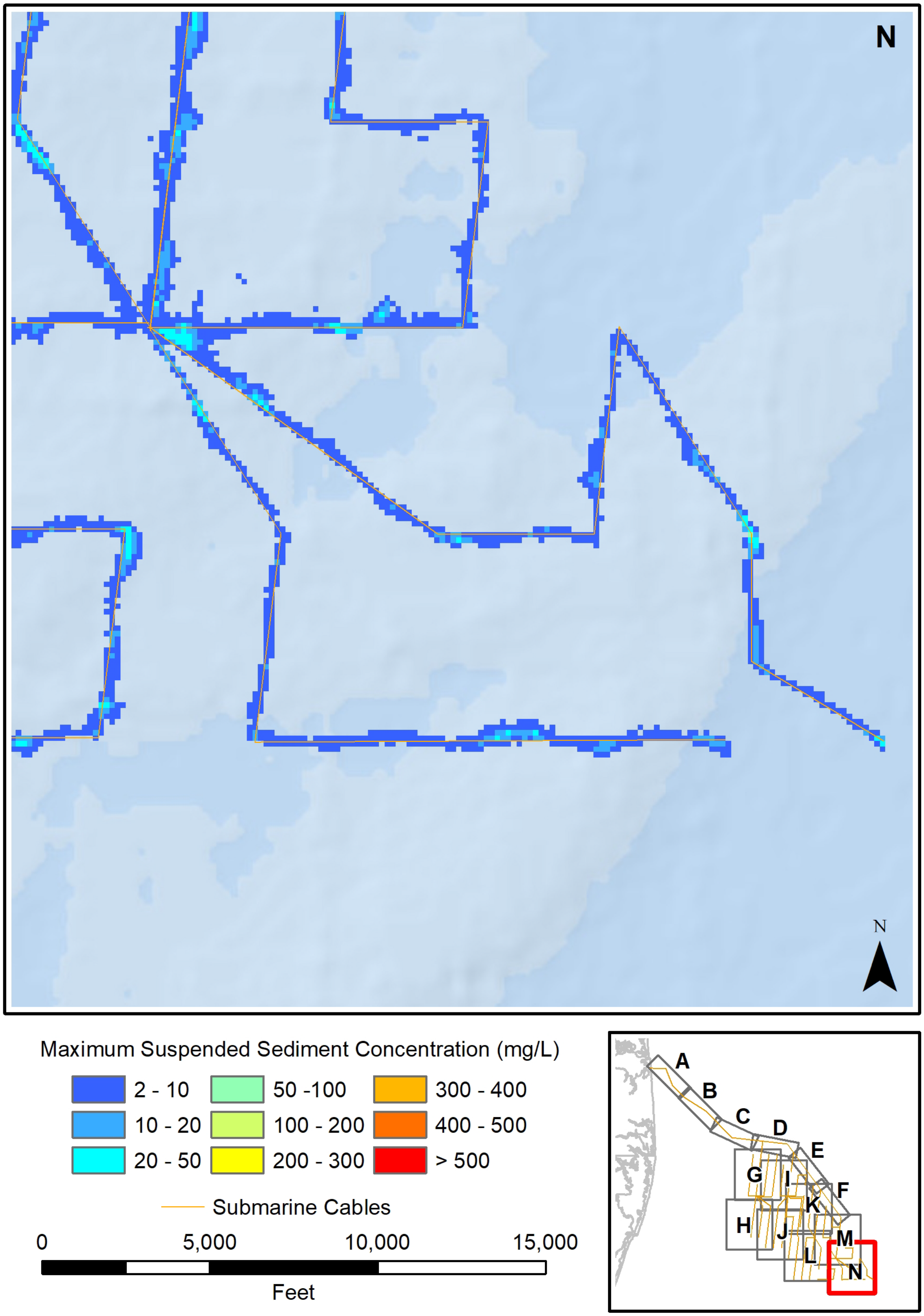
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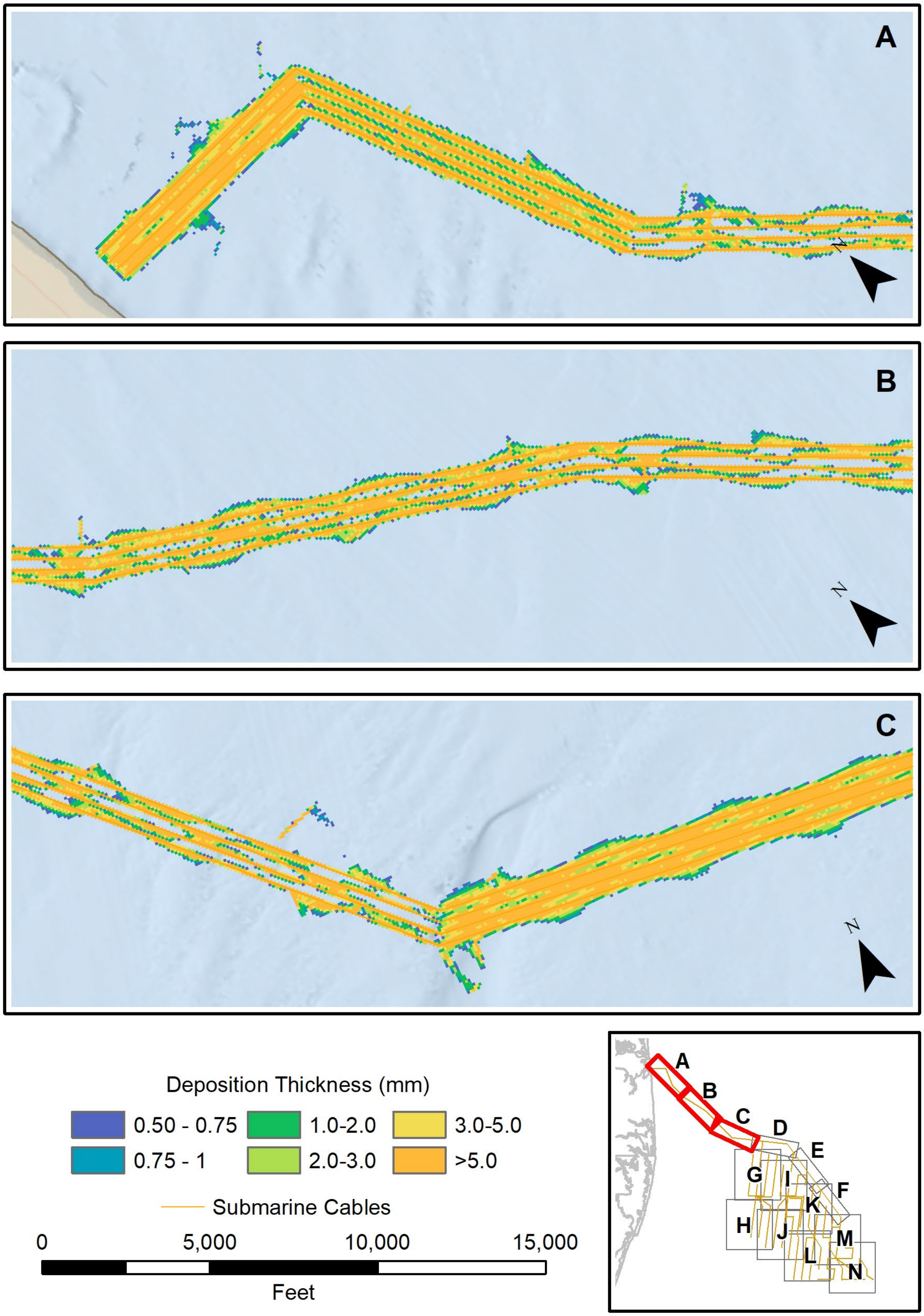
Appendix B: Total Deposition Thickness Figures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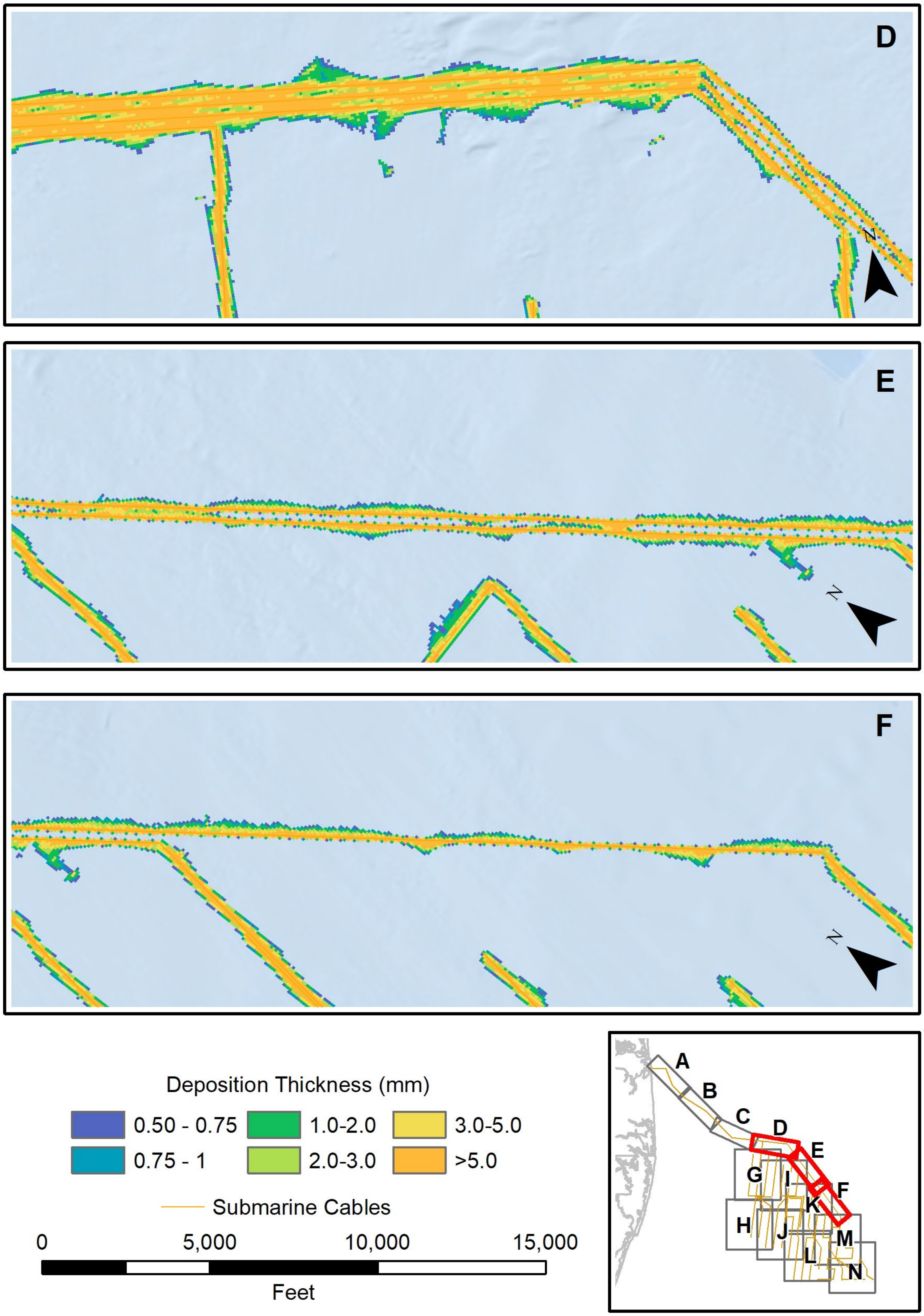
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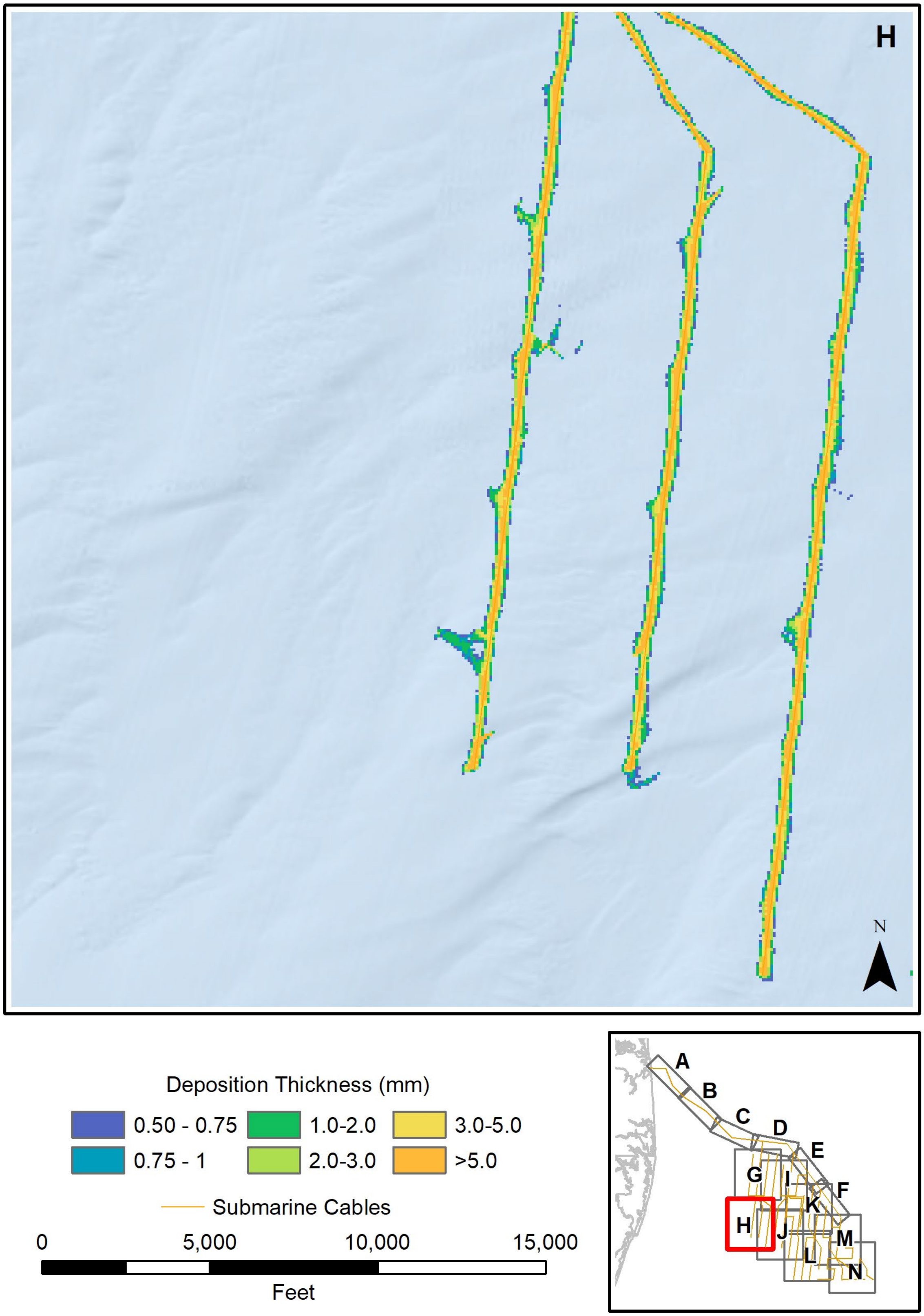
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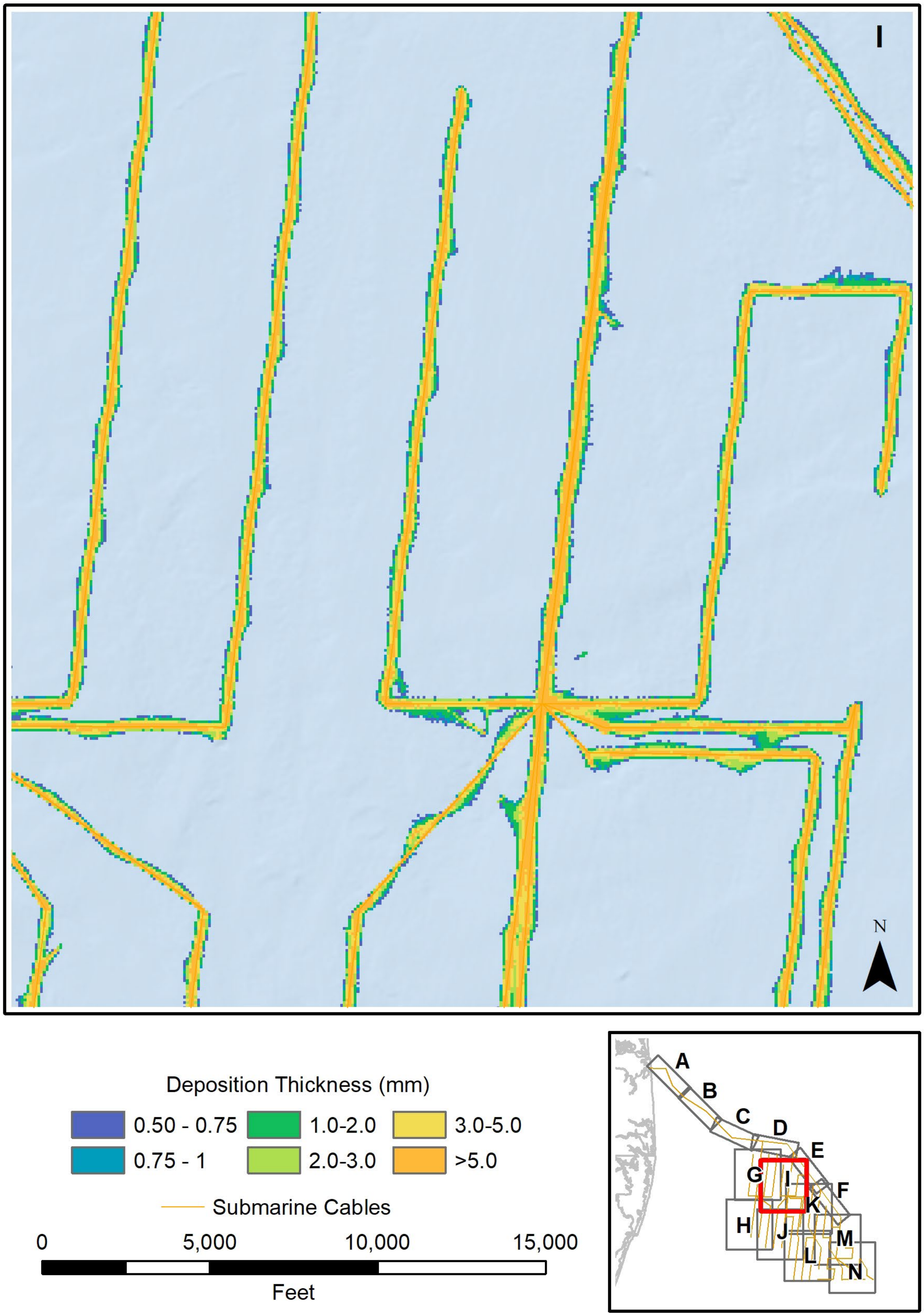
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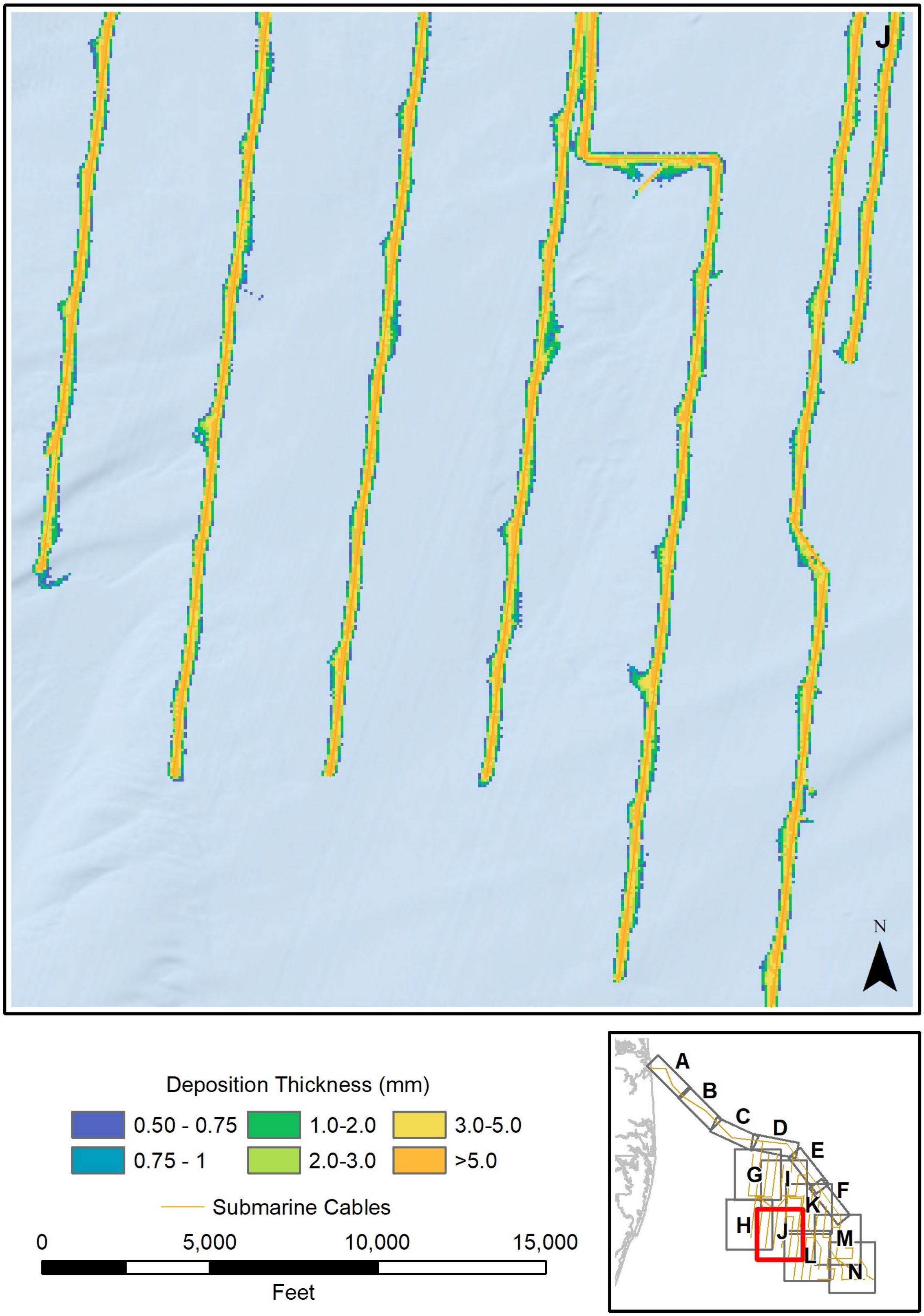
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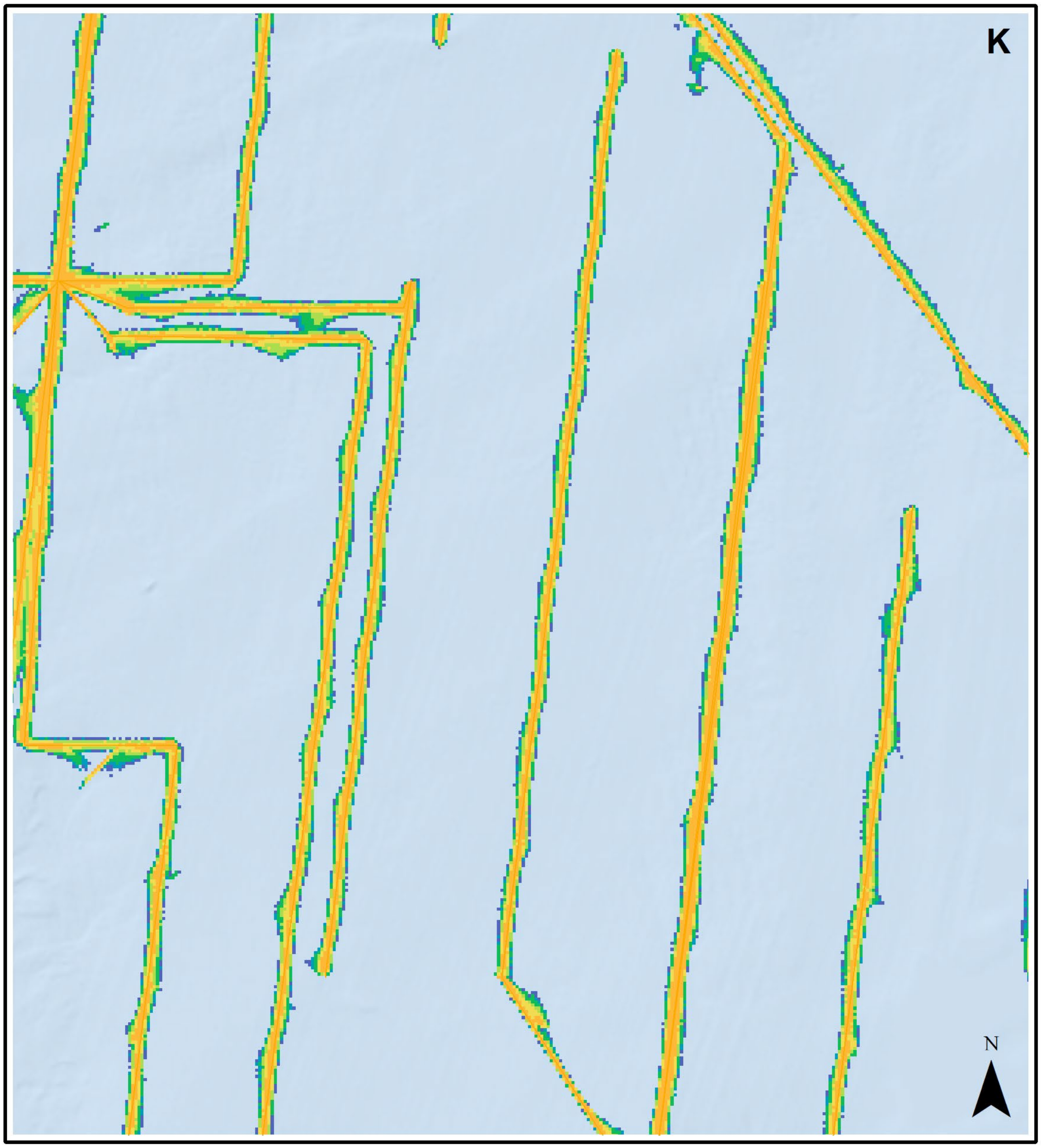

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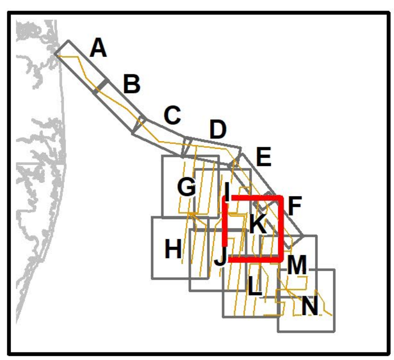

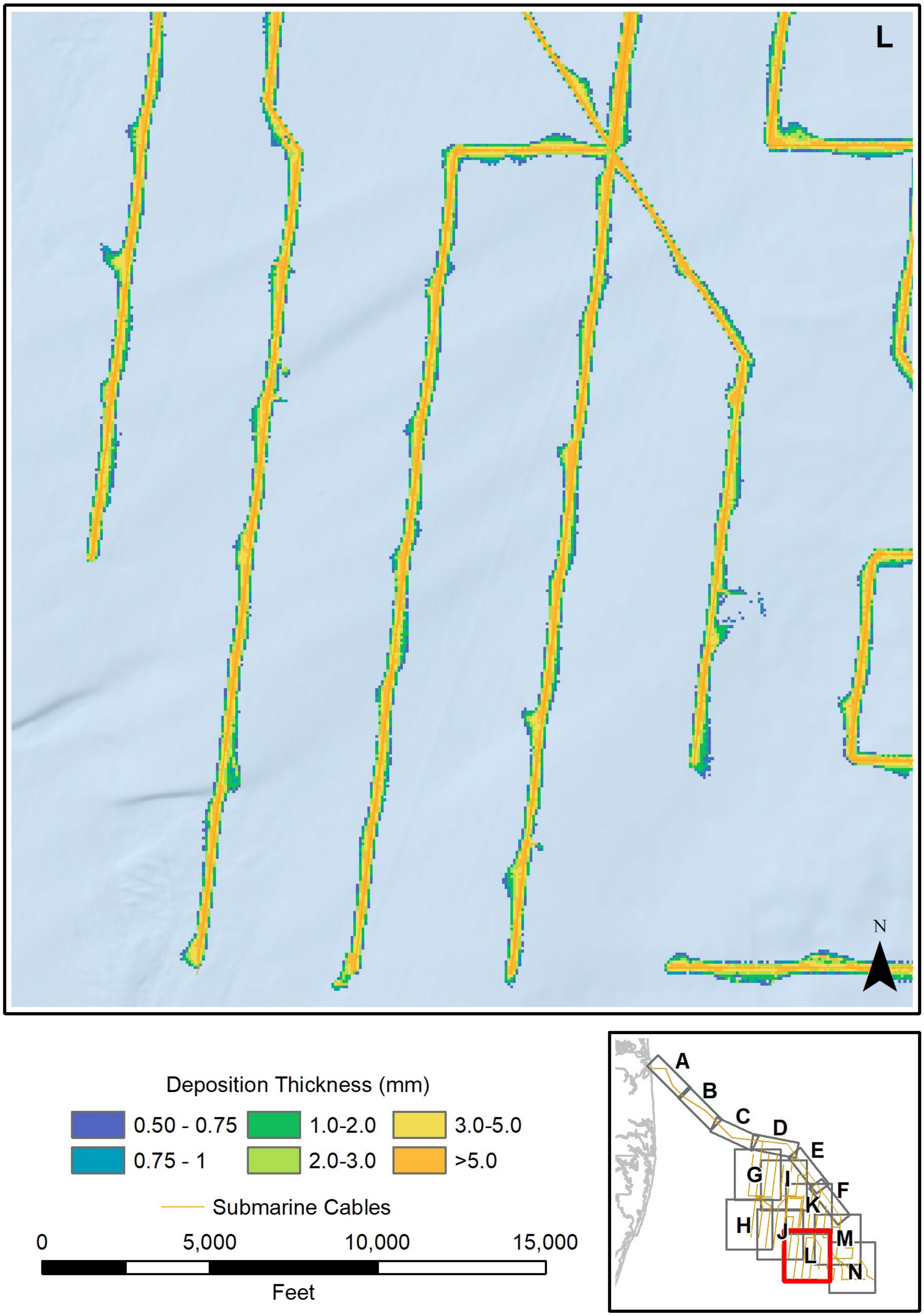
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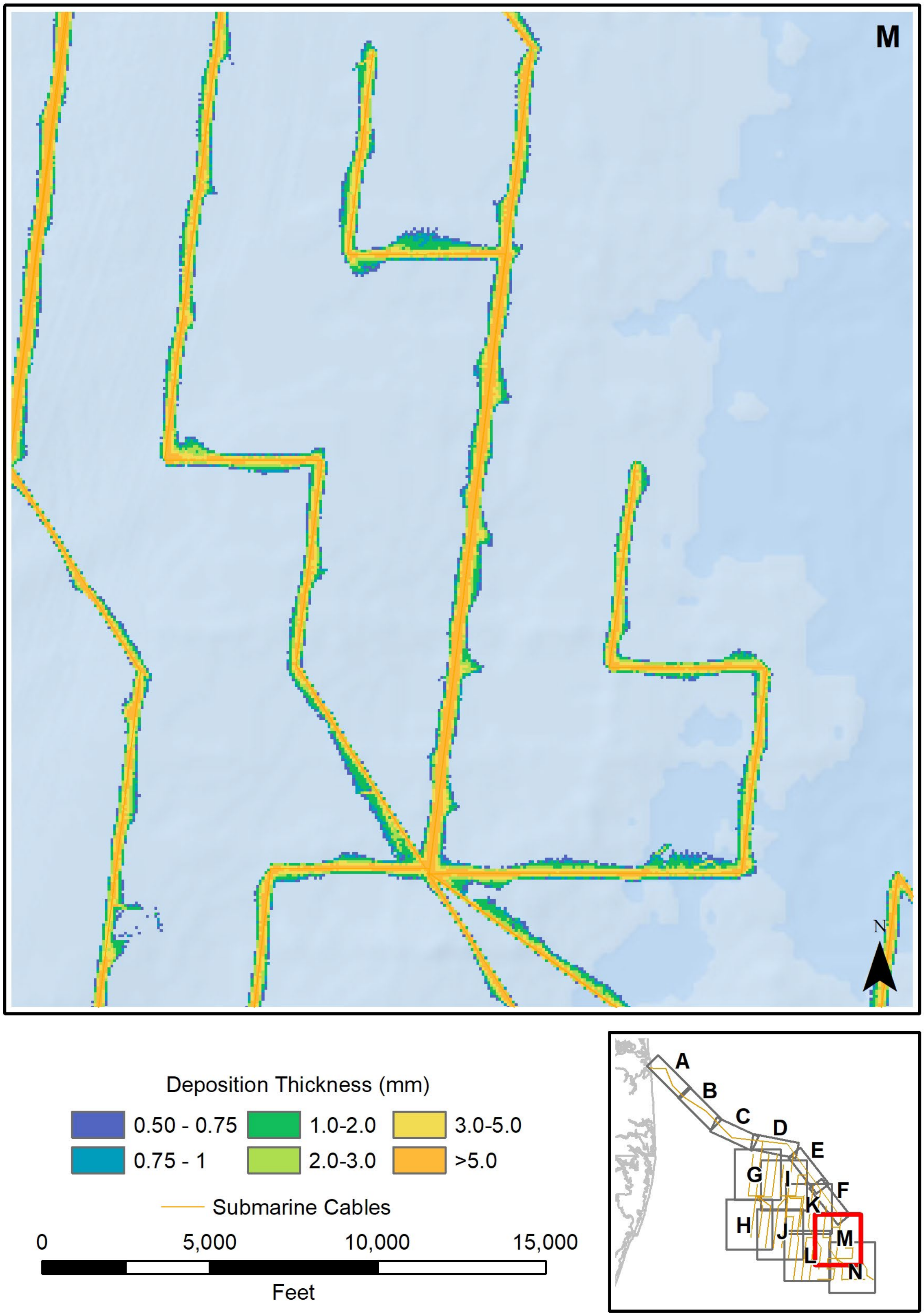
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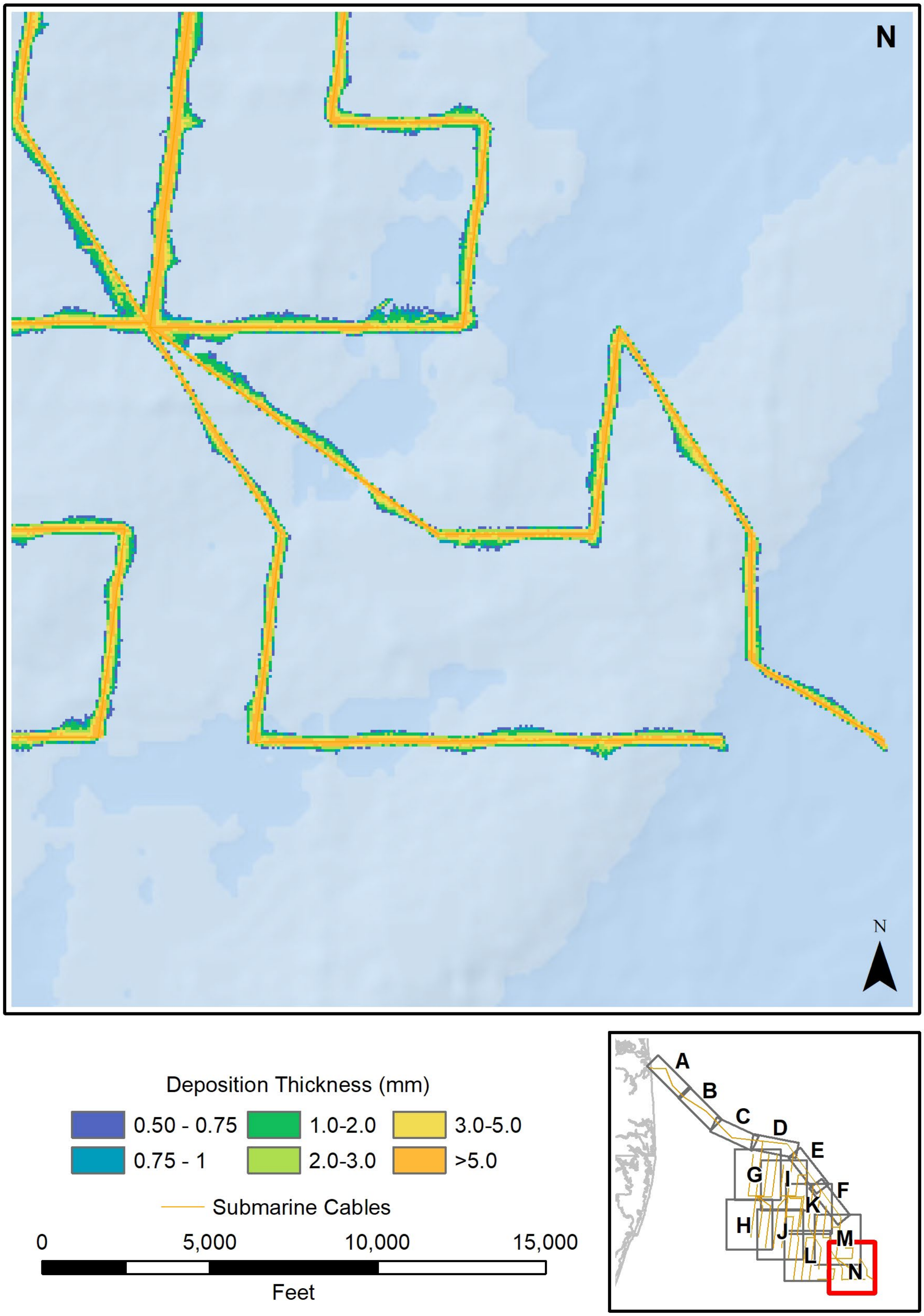
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HodgeWaterResources

Suspended Sediment Transport Modeling Study

Offshore Submarine Cable Installation

Maryland Offshore Wind Project

Addendum 1: Offshore Export Cables, Proposed Route 2

November 21, 2022

Revision: 0.0

1.0 INTRODUCTION

The Maryland Offshore Wind Project (the Project) is an offshore wind project of up to 2 gigawatts within OCS-A 0490 (the Lease), an area off the coast of Maryland on the Outer Continental Shelf. The Project will include as many as 121 wind turbine generators (WTG), up to four (4) offshore substations (OSS), and one (1) Met Tower in the roughly 80,000-acre Lease area. The Project is proposed to be interconnected to the onshore electric grid by up to four new 230 kV export cables into a substation in Delaware. Additionally, US Wind is proposing the installation of 26 66 kV AC Inter-array Cables.

In the original report *Suspended Sediment Transport Modeling Study, Offshore Submarine Cable Installation, Maryland Offshore Wind Project* (dated June 29, 2022), Hodge.WaterResources, LLC (HWR) evaluated Offshore Export Cable Corridor 1. Offshore Export Cable Corridor 1 would make landfall just south of the Indian River Bay Inlet. Offshore Export Cable Corridor 2 would instead deviate to the north, paralleling the shoreline for approximately 12 km (7.5 mi) before heading northwest to make landfall at Dewey Beach, east of Rehoboth Bay. Figure A1-1-1 shows Offshore Export Cable Corridor 2 and how it deviates from Offshore Export Cable Corridor 1.

This Addendum provides sediment transport modeling results for Offshore Export Cable Corridor 2. The results are presented as a series of figures and tables that correlate directly to figures and tables from the original report facilitating comparison between the sediment transport associated with each offshore export cable corridor. Table A1-1-1 provides an index of figures and tables from the original report and the corresponding figures in the Addendum.

Table A1-1-1: Addendum Figure and Table Comparison

Figures	Report	Addendum
Sediment and Vibracore Sampling Locations	2-1	A1-3-1
Dominant Sediment Type Along Route by Vibracore Location	2-2	A1-3-2
Modeled Predicted Maximum Suspended Sediment Concentrations	5-1	A1-4-1
Predicted Suspended Sediment Concentrations with Distance from Offshore Export Cables and Inter-array Cables	5-2	A1-4-2
Model Predicted Total Deposition Thickness	5-3	A1-4-3
Tables	**Report**	**Addendum**
Cable Route Sediment Characterization	5-2	A1-3-1
Mean and Maximum Suspended Sediment Displacement from Cables	5-3	A1-4-1
Mean and Maximum Deposition Displacement from Cables	5-4	A1-4-2

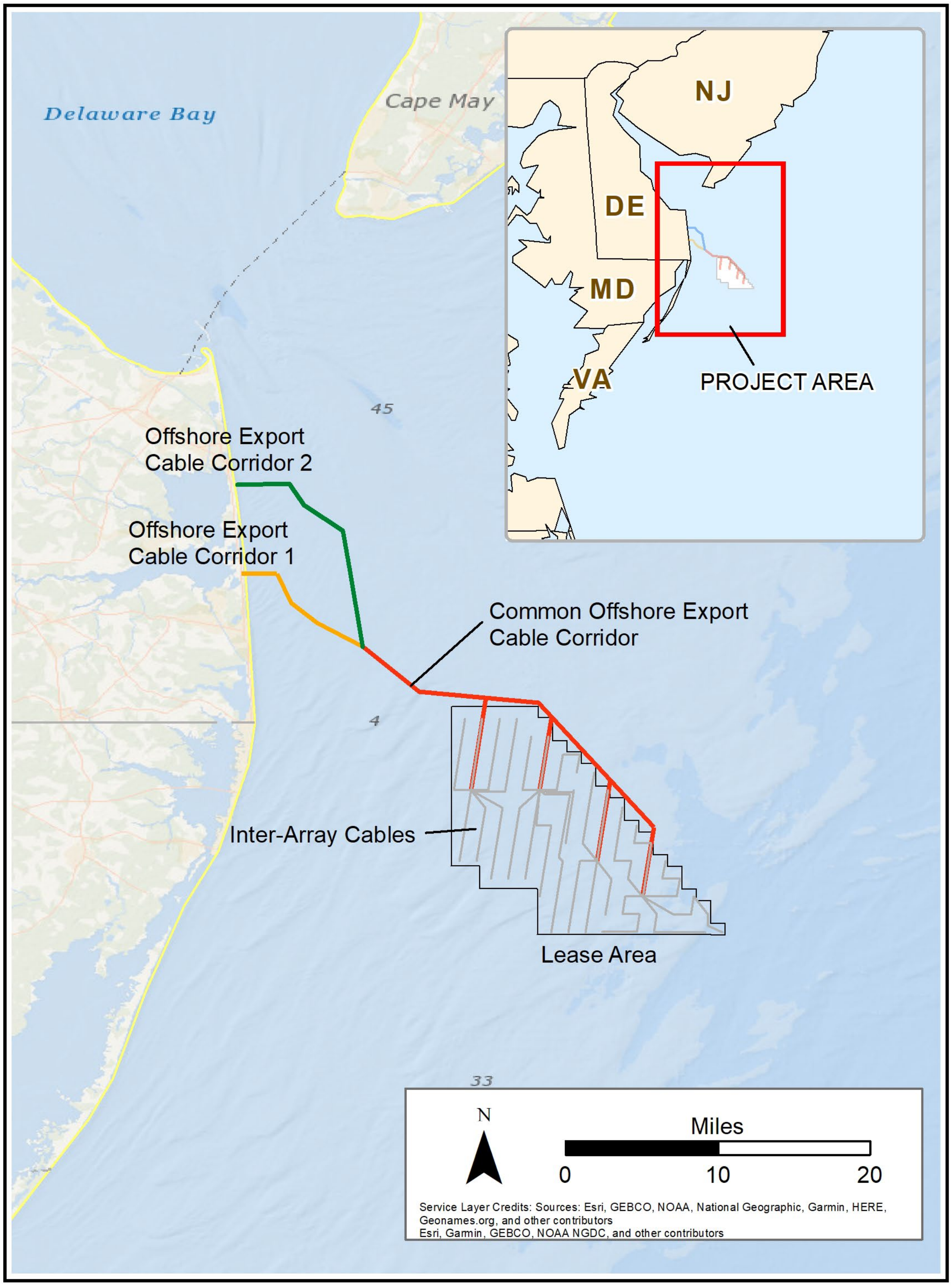


Figure A1-1-1: Cable Route Alternatives

2.0 METHODOLOGY

Offshore Export Cable Corridor 2 does not modify the Offshore Export Cables Corridor beyond 9 km (5.6 mi) offshore nor the Inter-Array Cables. In order to efficiently evaluate the two cable route alternatives, HWR conducted additional modeling of Offshore Export Cable Corridor 2 separately and then post-processed the model results using GIS tools to create the model results presented in this Addendum. The Common Offshore Export Cable Corridor and Inter-Array Cables were not remodeled. The original report provides a full discussion of the modeling approach and detailed model results for the Common Offshore Export Cable Corridor and Inter-Array Cables.

3.0 SUBMARINE CABLE ROUTE SEDIMENT CHARACTERISTICS

As a part of the Project, a total of 18 vibracore samples were collected along Offshore Export Cable Corridor 2. The locations of all vibracore samples are shown in Figure A1-3-1.Three of these locations (21VC_210, 21VC_212, and 21VC_213_R) included at least one vertical segment where a median gran size (i.e., D50) was not recorded in the sediment sampling results. These sample locations are highlighted with a red circle with an “x” in Figure A1-3-1and are excluded from the calculation of representative sediment characteristics.

Figure A1-3-2 shows the depth-weighted percentage at each vibracore locations for gravel, sand, and fines (i.e., silts and clays) for depth up to 4.0 m (13.1 ft) (i.e., the maximum cable placement depth) along Offshore Export Cable Corridor 2. The composition of each vibracore is unique with some vibracores indicating a higher percentage of gravel or fines. Most of the samples indicate that sand makes up more than 50% of the sediments, but HWR identified three samples (21VC_180_R, 21VC_183, and 21VC_185) as outliers. These three samples are sequential along Offshore Export Cable Corridor 2, as shown in Figure A1-3-1, and have median grain sizes (i.e., D50) that are approximately an order of magnitude different from the rest of the samples. Their relative proximity and their variability (i.e., mostly fines for 21VC_180_R and mostly gravel for 21VC_183_R and 21VC_185_R) led HWR to conclude that the samples should be excluded from the calculation of representative grain size for the cable route because they are likely to be representative of localized conditions at the point of sampling as opposed to representative of conditions along the length of a portion of the corridor. Based on the remaining 12 vibracore samples, the predominant sediment type along Offshore Export Cable Corridor 2 is sand with an average median grain size of 0.696 mm.

In addition to the vibracore samples that were evaluated for grain-size distribution, geotechnical evaluations were conducted at six locations within the Lease Area. These locations are also shown in Figure A1-3-1. The geotechnical evaluations included determinations of particle density and sample bulk density. The particle density of measurements from the top 4.0 m (13.1 ft) of sediment ranged from 2,650 to 2,730 kilograms per cubic meter (kg/m^3). This range is consistent with granular sediments in the Atlantic Ocean in the coastal region offshore of the United States. The bulk density provides an indication of the in-situ compaction of these granular sediments (i.e., how much sand is in a given volume). The bulk density ranged from 1,700 kg/m^3 to 2,100 kg/m^3. Based on the consistency of sediments along both offshore export cable corridors, it is an appropriate assumption to consider these values to be representative of conditions along Offshore Export Cable Corridor 2.

Table A1-3-1 provides the cable route sediment characterization used in the modeling of Offshore Export Cable Corridor 2.

Table A1-3-1: Cable Route Sediment Characterization

Sediment Characteristic	Value	Units
Mean Median Grain Size (D50)	0.696	mm
Mean Particle Density	2,673	kg/m^3
Mean Bulk Density	1,913	kg/m^3
Standard Deviation	0.8	phi

The sediment characteristics for Offshore Export Cable Corridor 2 are very similar to those used for Offshore Export Cable Corridor 1, Common Export Cable Corridor, and the Inter-Array Cables. The only difference is a larger mean median grain size (i.e., 0.393 mm for Offshore Export Cable Corridor 1 and Common Offshore Export Cable Corridor compared to 0.696 mm for Offshore Export Cable Corridor 2). The mean median grain size is still in the range of medium sand-sized particles and will behave similar to the sediments simulated in the original modeling.

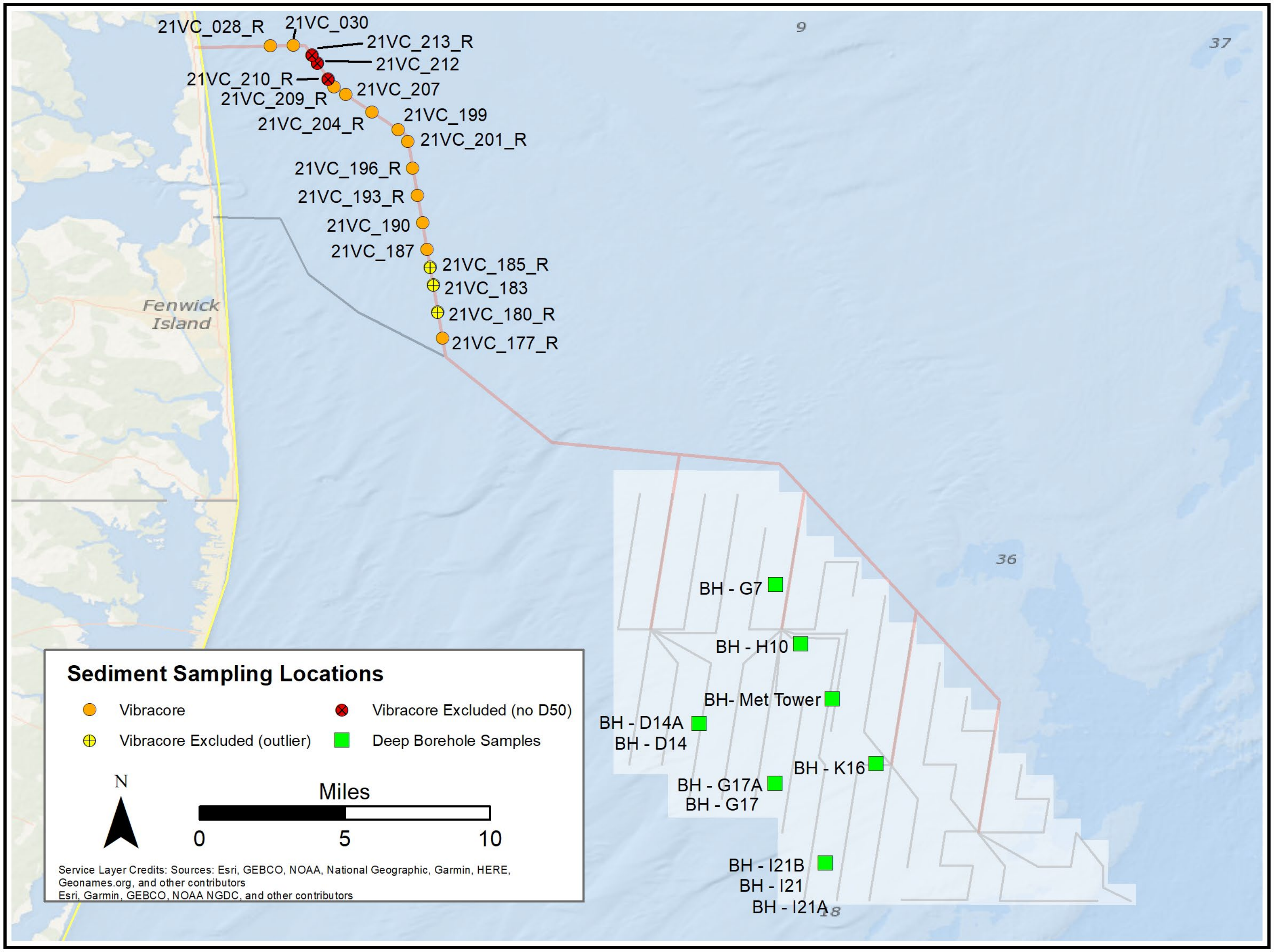


Figure A1-3-1: Sediment and Vibracore Sampling Locations

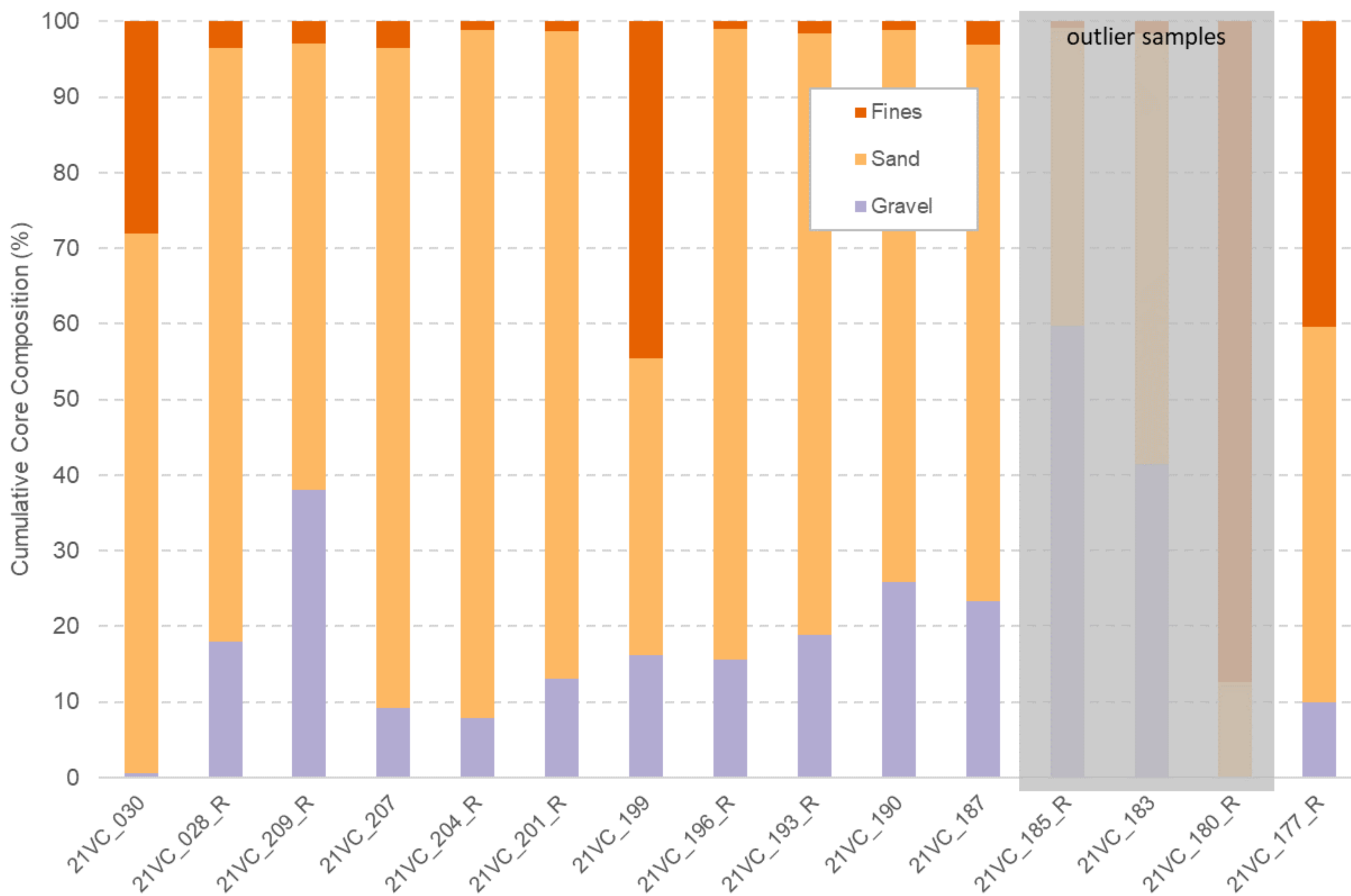


Figure A1-3-2: Dominant Sediment Type Along Offshore Export Cable Corridor 2 by Vibracore Location

4.0 SEDIMENT TRANSPORT MODEL RESULTS

The sediment transport model predicts that suspended sediments from the jet plow released into the water column will reach their maximum displacement away from the Offshore Export Cable Corridor 2 in the portion of the corridor that is oriented west-to-east just offshore, as shown in Figure A1-4-1. The maximum displacement occurs to the north and south of the corridor. The timing of jet plowing with respect to tides may change the direction of the suspended sediment plume, but the total excursion from the cable is expected to be consistent with excursions shown in this Addendum. Table A1-4-1 provides mean and maximum distances for a given suspended sediment concentration. The values presented in Table A1-4-1 exclude the region between the most southerly cable and the most northerly cable of the corridor (Offshore Export Cable Corridor 2 and Common Offshore Export Cable Corridor). For locations within this region, suspended sediment may be further from the cable placement that was the source of suspended sediment and closer to a cable that was not the source of the sediment making displacement a less meaningful metric for evaluating impacts.

Table A1-4-1: Mean and Maximum Suspended Sediment Displacement from Offshore Export Cable Corridor 2, Common Offshore Export Cable Corridor, and Inter-Array Cables

Suspended Sediment Concentration	Mean Distance		Maximum Distance	
mg/L	m	ft	m	ft
200	54	177	155	509
100	83	272	366	1,201
50	72	236	457	1,499
10	55	180	631	2,070

Appendix A1-A presents the same information as Figure A1-4-1, but at a smaller scale to allow a more detailed investigation of the model results. The appendix only includes model results for Offshore Export Cable Corridor 2 (i.e., the new modeling). The maximum predicted suspended sediment concentration occurs at different depths within the water column, at different locations in the model, and can occur at any point in time between the start of jet plowing and the return to ambient conditions following the end of jet plowing. This means that the plume of suspended sediment shown in Figure A1-4-1 and Appendix A1-A is much larger than what would occur at any single time during cable installation.

Figure A1-4-2 provides a graph comparing displacement from the cable laying operations (i.e., Offshore Export Cable Corridor 2, Common Offshore Export Cable Corridor, and Inter-array Cables) and predicted suspended sediment concentration. This figure provides a concise summary of the spatially distributed data that is presented in Figure A1-4-1.

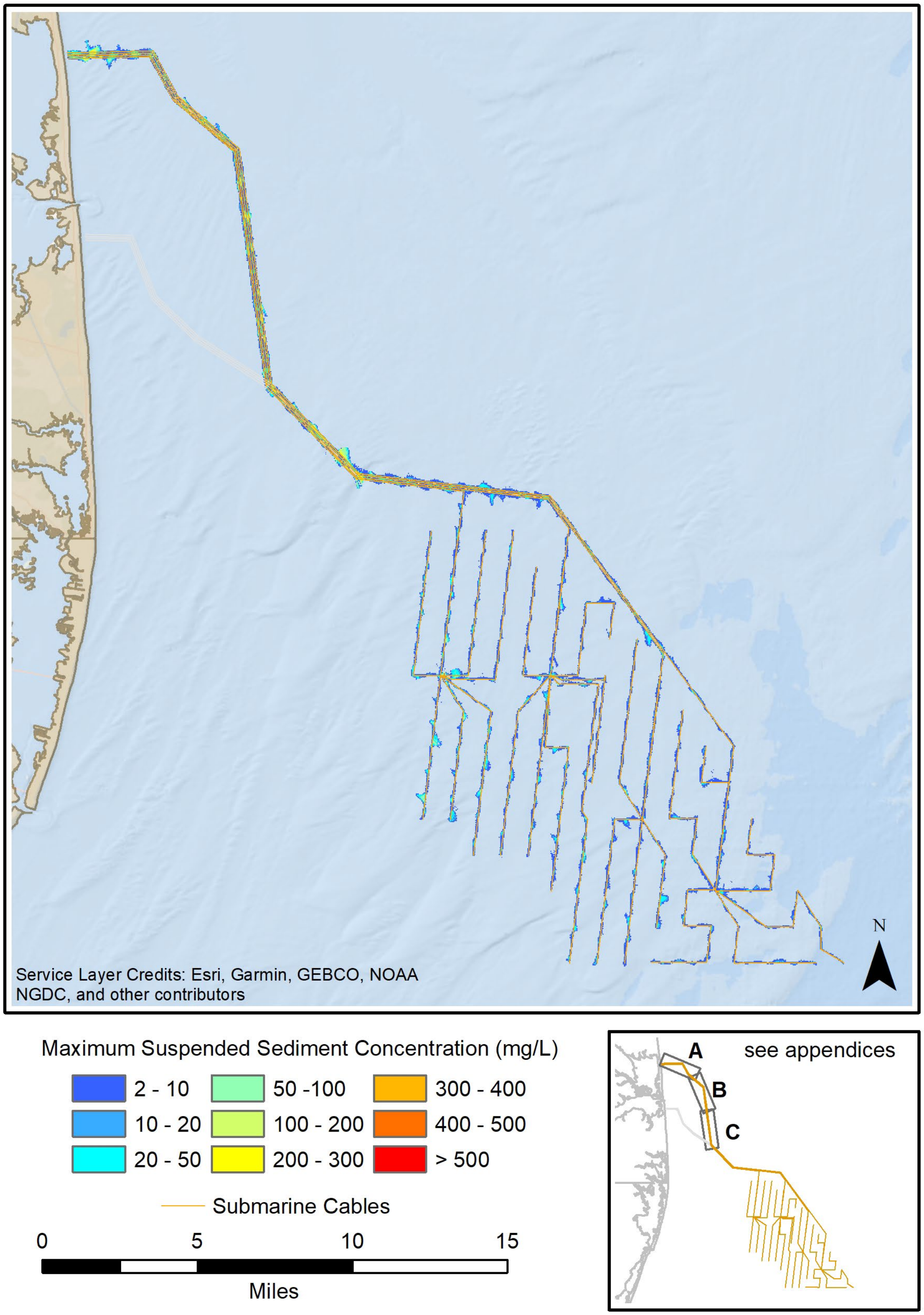


Figure A1-4-1: Modeled Predicted Maximum Suspended Sediment Concentrations

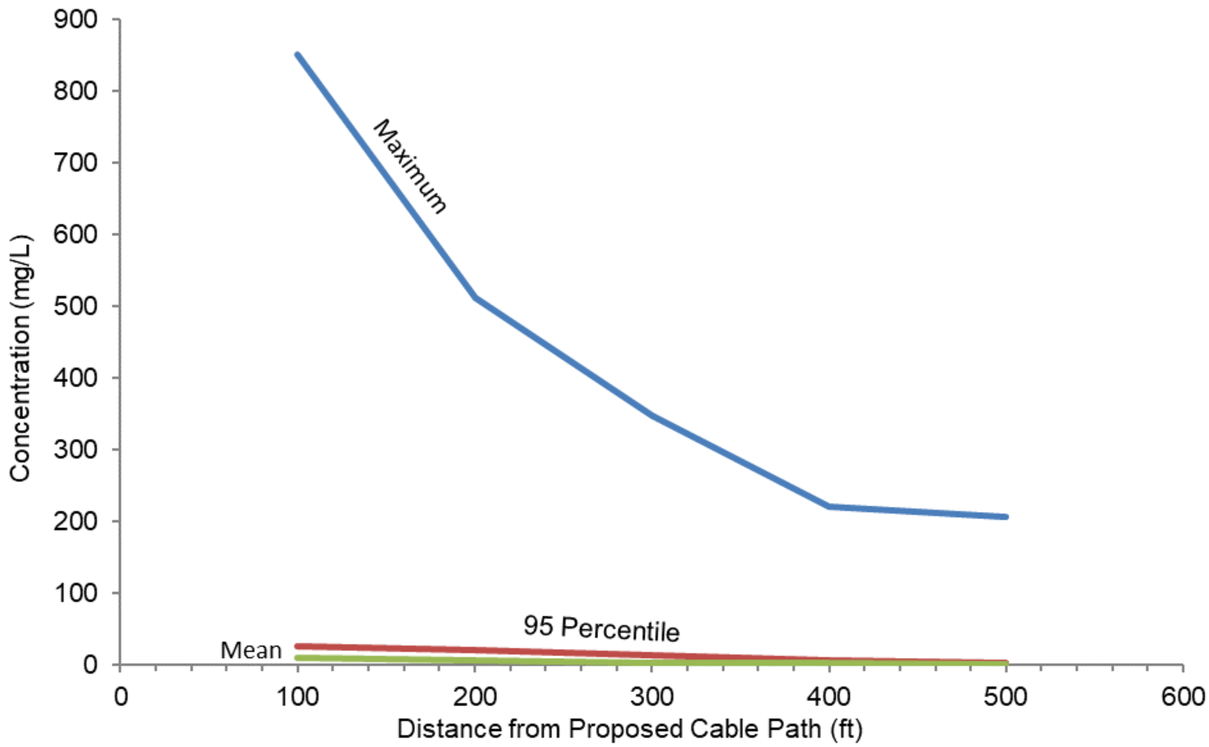


Figure A1-4-2: Predicted Suspended Sediment Concentration with Distance from Offshore Export Cables and Inter-array Cables

The model results show that the majority of suspended sediments settle out quickly and remain close to the Offshore Export Cable Corridor 2, Common Export Cable Corridor, and Inter-array Cables. Finer-grained sediments (e.g., silts) remain suspended for longer periods of time, but make up a small portion of the total suspended sediment. In general, the model results indicate that suspended sediment concentrations attributable to the jet plowing will drop below 10 mg/L well within 24 hours after the end of jet plowing. The impact of the suspended sediment plume will be limited in both extent and duration.

4.1.1 Predicted Suspended Sediment Deposition from Jet Plow Embedment

The model results show that sediment deposition associated with jet plow embedment will be limited to a narrow span along the Offshore Export Cable Corridor and Inter-array Cables. Figure A1-4-3 and Appendix A1-B show the total predicted deposition of sediment on the seafloor from jet plowing activity associated with cable installation. The appendix only includes model results for Offshore Export Cable Corridor 2 (i.e., the new modeling). Both the maximum excursion and the average excursion from the Offshore Export Cable Corridor and Inter-Array Cables for different deposition thicknesses have been determined. The maximum excursion and average excursion for various deposition thicknesses are shown in Table A1-4-2. The values presented in Table A1-4-2 exclude the region between the most southerly cable and the most northerly cable of the corridor (Offshore Export Cable Corridor 2 and Common Offshore Export Cable Corridor). For locations within this region, deposited sediments may be further from the cable placement that was the source of suspended sediment and closer to a cable that was not the source of the sediment making displacement a less meaningful metric for evaluating impacts.

Table A1-4-2: Mean and Maximum Deposition Displacement from Offshore Export Cable Corridor 2, Common Offshore Export Cable Corridor, and Inter-Array Cables

Deposition Thickness		Mean Distance		Maximum Distance	
mm	in	m	ft	m	ft
0.5	0.02	81	266	659	2,162
1.0	0.04	68	223	637	2,090
2.0	0.08	52	171	628	2,060
5.0	0.20	27	89	489	1,604

The sediment deposition pattern is consistent with the suspended sediment concentration pattern. Most of the deposition is predicted to occur along the corridor (Offshore Export Cable Corridor 2 and Common Offshore Export Cable Corridor) and Inter-array Cables. The model results predict that the average excursion from the Offshore Export Cable Corridor (2 and Common) and Inter-array Cables for deposition greater than 5 mm (0.20 inches) will be less than 27 m (90 ft) from either side of the Offshore Export Cable Corridor and Inter-array Cables. The model predicts that the average excursion for deposition thicknesses of 1 mm (0.04 inches) will be less than 68 m (223 ft) from the Offshore Export Cable Corridor and Inter-array Cables.

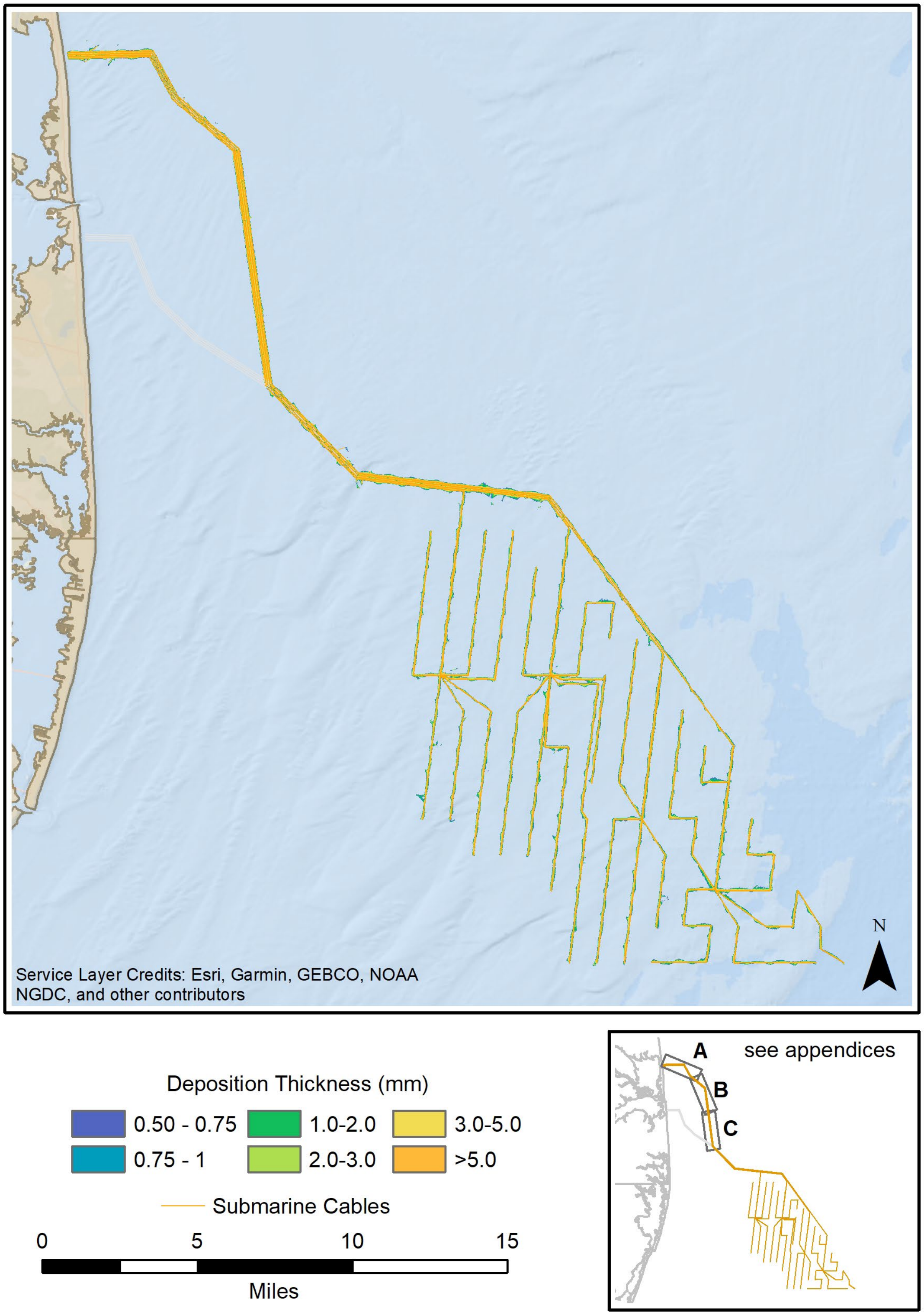


Figure A1-4-3: Model Predicted Total Deposition Thickness

5.0 SEDIMENT TRANSPORT MODEL FINDINGS AND COMPARISON

The sediment transport modeling predicts that most sediments suspended by the jet plowing will remain in a narrow corridor along the Offshore Export Cable Corridor 2, Common Offshore Export Cable Corridor, and Inter-array Cables. The overwhelming majority of deposition thicker than 0.2 mm will occur within 91 m (300 ft) of the proposed cable path. Most of the fluidized sediments lost to the water column are predicted to quickly settle back to the seafloor. Suspended sediment concentrations are predicted to be less than 200 mg/L at distances greater than 160 m (525 ft) from the Offshore Export Cable Corridor 2, Common Offshore Export Cable Corridor, and Inter-array Cables. Model results indicate that the suspended sediment plume resulting from jet plowing will have a short duration. The model results show that increases in suspended sediment concentrations above 10 mg/L over ambient are only of short duration (hours). All suspended sediment plumes are predicted to disappear within 24 hours after the completion of jetting operations. In conclusion, the sediment transport modeling results indicate that the proposed jet plow embedment process for cable installation will result in short-term and localized effects.

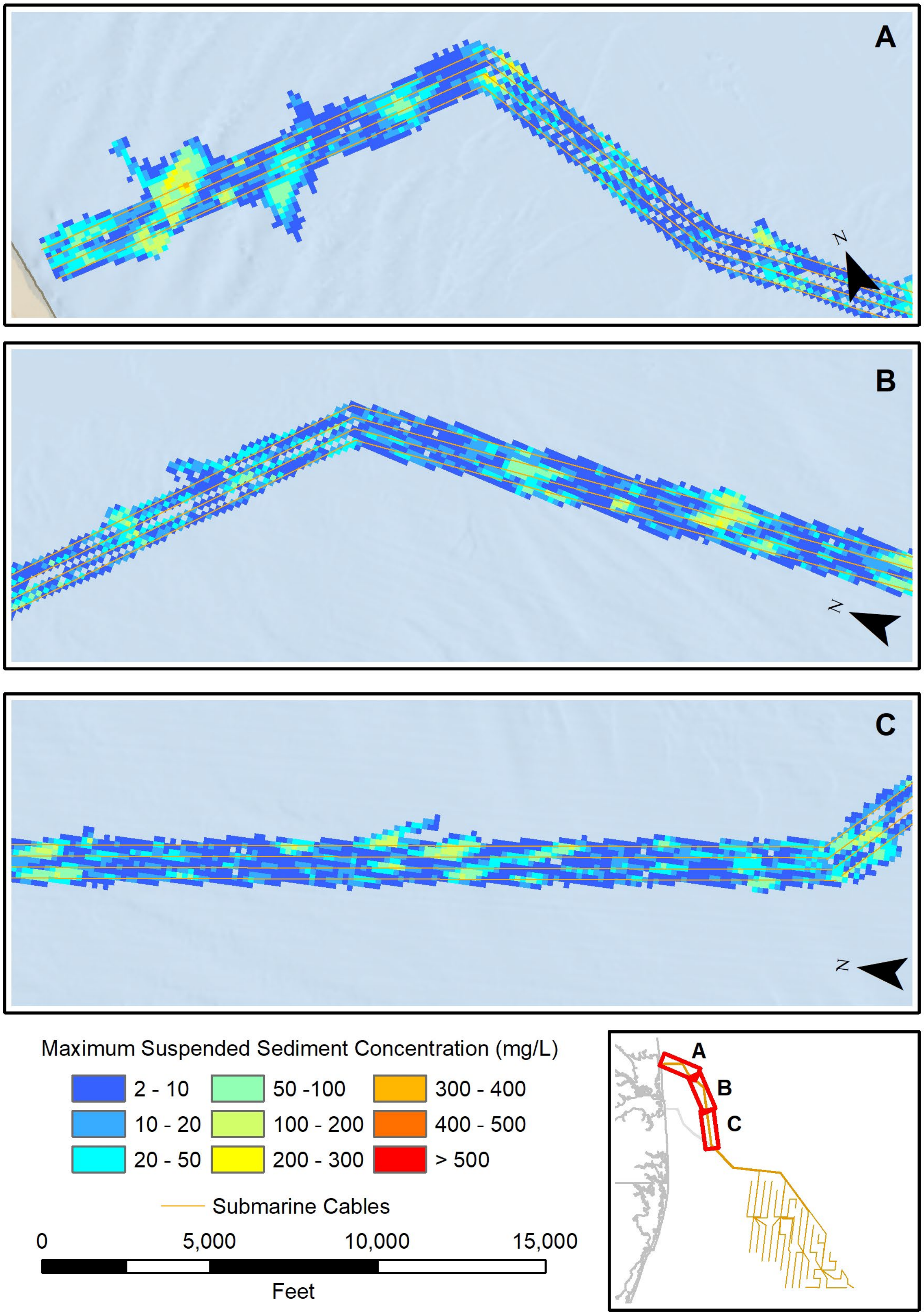
The overwhelming majority of deposited sediments (i.e., thicknesses greater than 0.2 mm) will remain within 91 m (300 ft) of the cable route for both alternative cable routes. Suspended sediment concentrations of 10 mg/L will be limited to a distance of less than 640 m (2,100 ft) from the cables for both cable routes. Suspended sediment concentrations of 200 mg/L will be limited to a distance of less than 160 m (525 ft) for both cable routes. All suspended sediment plumes are predicted to disappear within 24 hours after the completion of jetting operations regardless of cable route.

Table A1-5-1 presents the displacement values for both cable options including suspended sediment concentrations and deposition thicknesses. The results are very similar.

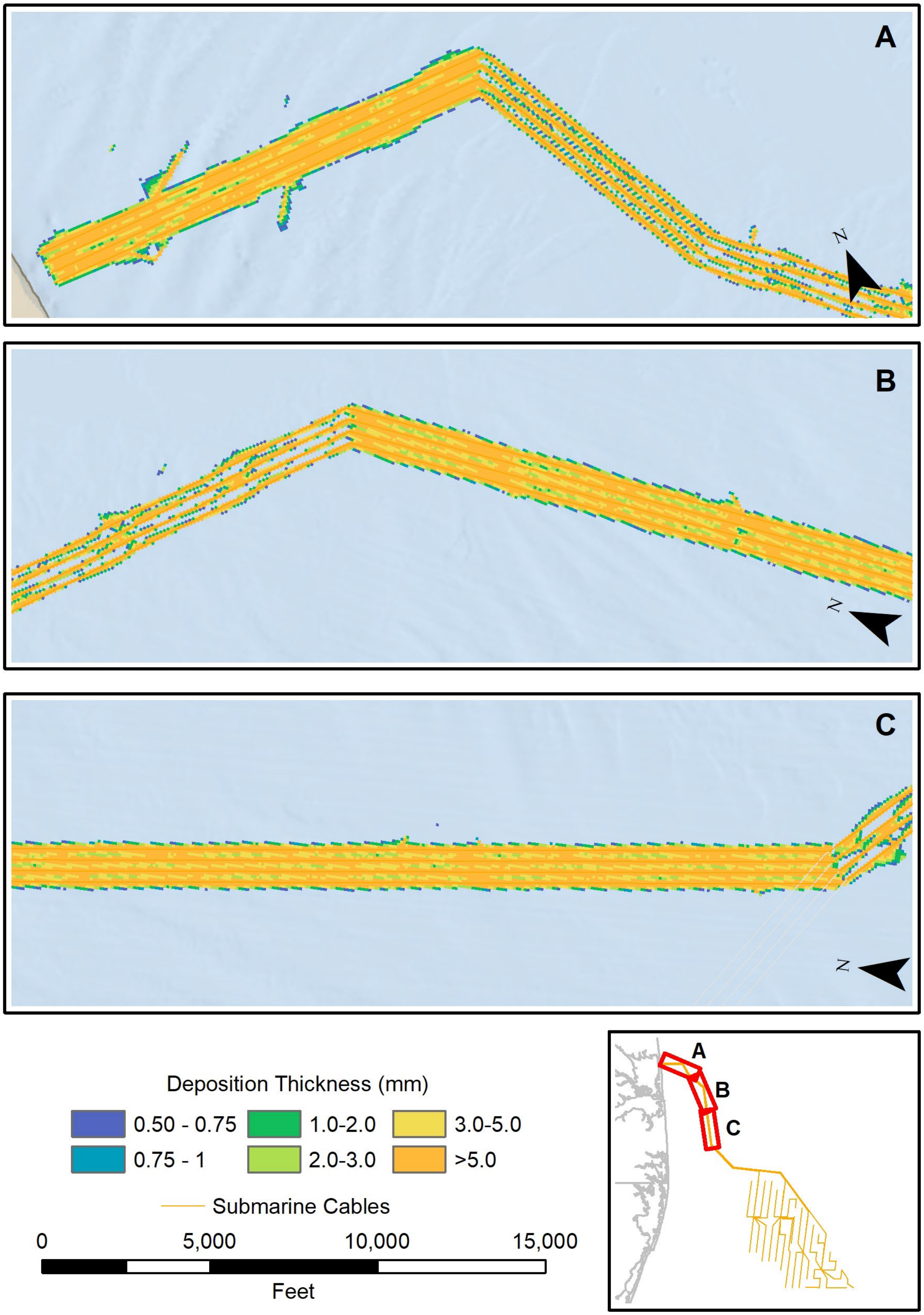
Table A1-5-1: Comparison of Cumulative Model Results Comparing Offshore Export Cable Corridor 1 and Offshore Export Cable Corridor 2

	Cumulative Model Results including:				
	Offshore Export Cable Corridor 1		*Offshore Export Cable Corridor 2*		*Change*
Metric	m	ft	m	ft	%
Suspended Sediments					
200 mg/L mean	48	157	54	177	**13%**
200 mg/L max	130	427	155	509	**19%**
10 mg/L mean	56	184	55	180	**-2%**
10 mg/L max	607	1,991	631	2,070	**4%**
Deposition Thickness					
5 mm mean	27	89	27	89	**0%**
5 mm max	489	1,604	489	1,604	**0%**
0.5 mm mean	82	269	81	266	**-1%**
0.5 mm max	659	2,162	659	2,162	**0%**

Appendix A1-A: Maximum Suspended Sediment Concentration Figures


A
N
B
N
C
N
Maximum Suspended Sediment Concentration (mg/L)
2 - 10
10 - 20
20 - 50
50 -100
100 - 200
200 - 300
300 - 400
400 - 500
> 500
Submarine Cables
0
5,000
10,000
15,000
Feet
A
B
C

Appendix A1-B: Total Deposition Thickness Figures


A
N
B
N
C
N
Deposition Thickness (mm)
0.50 - 0.75
1.0-2.0
3.0-5.0
0.75 - 1
2.0-3.0
>5.0
Submarine Cables
0
5,000
10,000
15,000
Feet
A
B
C

Hodge Water Resources

Suspended Sediment Transport Modeling Study
Offshore Submarine Cable Installation

Maryland Offshore Wind Project

Addendum 2: Trailing Suction Hopper Dredging (TSHD) at Offshore Substations

November 21, 2022

Revision: 0.0

1.0 INTRODUCTION

The Maryland Offshore Wind Project (the Project) is an offshore wind project of up to 2 gigawatts within OCS-A 0490 (the Lease), an area off the coast of Maryland on the Outer Continental Shelf. The Project will include as many as 121 wind turbine generators (WTG), up to four (4) offshore substations (OSS), and one (1) Met Tower in the roughly 80,000-acre Lease area. The Project is proposed to be interconnected to the onshore electric grid by up to four new 230 kV export cables into a substation in Delaware. Additionally, US Wind is proposing the installation of 26 66 kV AC Inter-array Cables.

In the report *Suspended Sediment Transport Modeling Study, Offshore Submarine Cable Installation, Maryland Offshore Wind Project* (dated June 29, 2022), Hodge.WaterResources, LLC (HWR) evaluated Offshore Export Cable Corridor 1. Offshore Export Cable Corridor 2 was evaluated in Addendum 1 to the report. This Addendum (Addendum 2) provides sediment transport modeling results for the proposed trailing suction hopper dredging (TSHD) that may be needed to prepare the seafloor for construction at each of the four proposed OSS locations.

The dimensions of the dredged area for each OSS will be approximately 30 meters (m) (98 feet [ft]) by 30 m (98 ft). The depth of dredging will be no greater than 1 m (3.28 ft), and the total volume of dredged material is not expected to exceed 1,000 cubic meters (m^3). The location of each OSS is shown in Figure A2-1-1.

A TSHD vessel uses high-pressure water jets, similar to jet plowing, to suspend sediment and then suction that material onboard the vessel via a hose. The dredged material is stored on board the vessel in hoppers until the dredged material is released at the desired location. The planned disposal location is assumed to be 800 m (2,624 ft) away from the OSS. In the absence of an exact location, HWR assumed that the disposal location would be east of each OSS. Once the TSHD vessel reaches the planned disposal location, the dredged material will be released through the opening of trap doors at the bottom of the vessel/hopper.

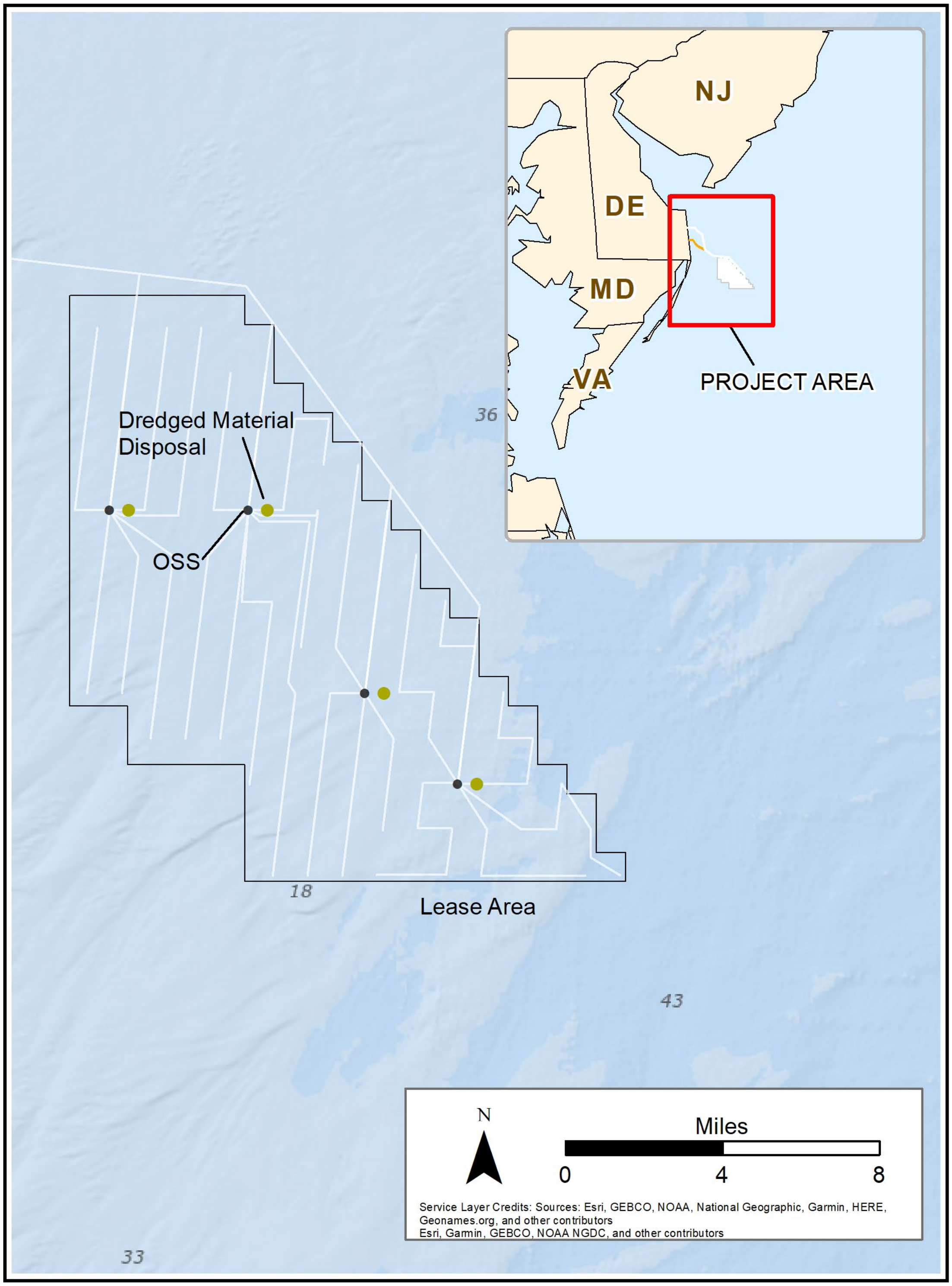


Figure A2-1-1: OSS and Dredged Material Disposal Locations

2.0 MODELING METHODOLOGY

TSHD operations are intended to minimize uncontrolled release of sediments during dredging. The suspension and efficient removal of sediments is the intent of TSHD. HWR evaluated the relative suspended sediment and sediment deposition impacts of TSHD and dredged material disposal and concluded that the impacts related to disposal will be orders of magnitude greater than the impacts associated with TSHD. HWR concluded that modeling of the TSHD would not be necessary because the suspension and transport of suspended sediment would be necessarily short-lived by virtue of the dredging approach (i.e., suction removal). HWR also concluded that sediment transport modeling of dredged material disposal would be necessary. Dredged material disposal is the focus of this Addendum and the associated sediment transport modeling.

In order to model the disposal of the dredged material, HWR employed a two-phase modeling approach. In the first phase of modeling, HWR used the STFATE (Short-Term FATE) model to simulate the initial release of suspended sediment from the bottom of the TSHD vessel. In the second phase of modeling, HWR used the results from the STFATE modeling to establish the initial dimensions of the suspended sediment plume.

STFATE is a model originally developed the United State Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC). STFATE models the disposal of dredged material in open water with components that evaluate: convective descent, bottom encounter, and the dynamic collapse of dredged material (USACE, 1998). STFATE has been used for more than 20 years as a regular tool for evaluating the environmental impacts related to the disposal of dredged materials. STFATE includes the option for modeling the release of sediment from a hopper dredge. The explicit simulation of a hopper release makes STFATE an acceptable tool to evaluate the initial stages of the suspended sediment plume that will form as a result of the release of material from the TSHD vessel.

HWR used the initial plume dimensions from STFATE as inputs to PTM (particle tracking model). Section 3.2 of the original report provides a discussion of PTM. By utilizing PTM to evaluate the eventual deposition of the dredged material, the suspended sediment concentrations and the deposition thicknesses can be combined with the previously completed sediment transport study results in order to depict cumulative impacts of each of these activities that disturb seafloor sediments.

3.0 DREDGED MATERIAL DISPOSAL CHARACTERISTICS

3.1 Sediment Characteristics

Section 2.0 of the original report discusses the sediment characteristics along Offshore Export Cable Corridor 1. Of the original 35 vibracore sampling locations, a total of 19 vibracore samples were collected along the boundary of the Lease Area (i.e., vibracore samples 21VC_137_R to 21VC_085). HWR used grain size measurements from these vibracore samples to determine an appropriate representative grain size for modeling. In addition to using a subset of the vibracore locations, we only evaluated grain size measurements in the first 1 m (3.28 ft) of each vibracore because the TSHD will only remove the first 1 m (3.28 ft) of sediments. The average median grain size for this subset of grain size measurements is 0.48 millimeters (mm) (i.e., medium-sized sand per STFATE). STFATE includes a set of representative values based on the median grain size of dredged material. Table A2-3-1 shows the values used in the STFATE modeling. Given that the sediments in the subset vibracore samples are sand (82% on average of each core), HWR concluded that it was appropriate to assume a single solid fraction for the STFATE modeling.

Table A2-3-1: STFATE Model Inputs for Disposed Material

Sediment Characteristic	Value	Units
Distinct Solid Fractions	1	--
Fall Velocity	0.1	fps
Deposit Void Ratio	0.6	--
Critical Shear Stress	0.02	lbs/ft^2
Cohesive	no	--
Stripped During Descent	no	--

3.2 Disposal Characteristics

STFATE requires substantial information about the method of dredged material disposal. Many of the necessary details are not yet available. HWR made a set of conservative assumptions about the dredged material release. Table A2-3-2 shows the assumed values used in STFATE to simulate the convective descent phase of the dredged material release.

Table A2-3-2: STFATE Model Inputs for TSHD Vessel

Disposal Characteristic	Value	Units	Rationale
Ambient Water Density	1,025	kg/m^3	Representative value for saltwater
Ambient Current Velocity	1.0	fps	Based on typical max ebb/flood velocities from ADCIRC model
Length of Disposal Vessel	100	ft	Assumed
Width of Disposal Vessel	15	ft	Assumed
Distance Between Hopper Bins	10	ft	Assumed
Pre-Disposal Draft	26	ft	Minimum estimated value provided by US Wind
Post-Disposal Draft	26	ft	Weight of disposed material assumed to be small relative to full vessel
Time to Complete Disposal	360	sec	US Wind provided time estimated at less than one hour, assumed 10 minutes
Hoppers Open Simultaneously	1	--	Assumed
Discrete Hopper Openings	1	--	Assumed
Vessel Velocity	0	fps	Assumed
Dredged Material Volume	1,560	yds^3	1,000 m^3 with bulk density: 1,913 kg/m^3 and in-hopper void ratio of 0.6, specific gravity 2.673

4.0 SEDIMENT TRANSPORT MODEL RESULTS

4.1 STFATE Results

HWR used STFATE to evaluate the initial sediment plume that would be generated during the release of material from the vessel. Given that the assumed characteristics would be the same for all four OSS locations, HWR only completed one STFATE model run. The results of this model run indicate that the expected initial dimensions of the sediment plume after release from the vessel are a plume with a radius of 8.3 m (27 ft) and a centroid located 11.0 m (36 ft) below the water surface. Based on these initial dimensions, a conservative estimate of the highest suspended sediment concentration that would be expected is approximately 800 milligrams per liter (mg/L) assuming 100% of the sediment being discharged from the vessel were to be present within these initial dimensions.

HWR used this initial plume dimensions from STFATE as initial conditions for the incorporation of the dredged material disposal into the existing ADCIRC/PTM model.

4.2 PTM Results

The sediments, especially surficial, in the Lease Area are primarily sand. In previous sediment transport modeling, the results have indicated that the suspended sediment plumes will have a short duration and deposition thicknesses will be limited to the vicinity of jet plowing. The results from this sediment transport modeling for dredged material disposal demonstrate that these findings are also true for dredged material disposal.

Figure A2-4-1 shows the location of each dredged material disposal site and the maximum modeled suspended sediment concentration at that location. The concentrations associated with dredged material disposal are opaque, and the concentrations associated with jet plowing are transparent in order to highlight the impacts associated with dredged material disposal. At each disposal location, the maximum suspended sediment concentration increases significantly, but suspended sediment concentrations remain close to the disposal location. Suspended sediment concentrations greater than 10 mg/L are limited to within 250 m (820 ft) of the disposal locations. The model results indicate that the sediment plume generated by each disposal will be short-lived with conditions returning to ambient in less than six hours.

Figure A2-4-2 shows the location of each dredged material disposal site and the total predicted deposition of sediment on the seafloor from jet plowing activity and dredged material disposal. The deposition associated with dredged material disposal are opaque, and the deposition associated with jet plowing are transparent in order to highlight the impacts associated with dredged material disposal. At each disposal site, the total deposition thickness increases relative to the deposition associated with jet plowing. The maximum deposition associated with jet plowing is on the order of 10 mm whereas the maximum deposition associated with dredged material disposal is on the order of 100 mm. This ten-fold increase is expected given the release of a substantial amount of sediment at a specific location. Most of the disposed sediment settles in the vicinity of dredged material disposal location. Cumulative deposition thicknesses greater than 0.5 mm are limited to within 1,150 m (3,772 ft) of the disposal locations.

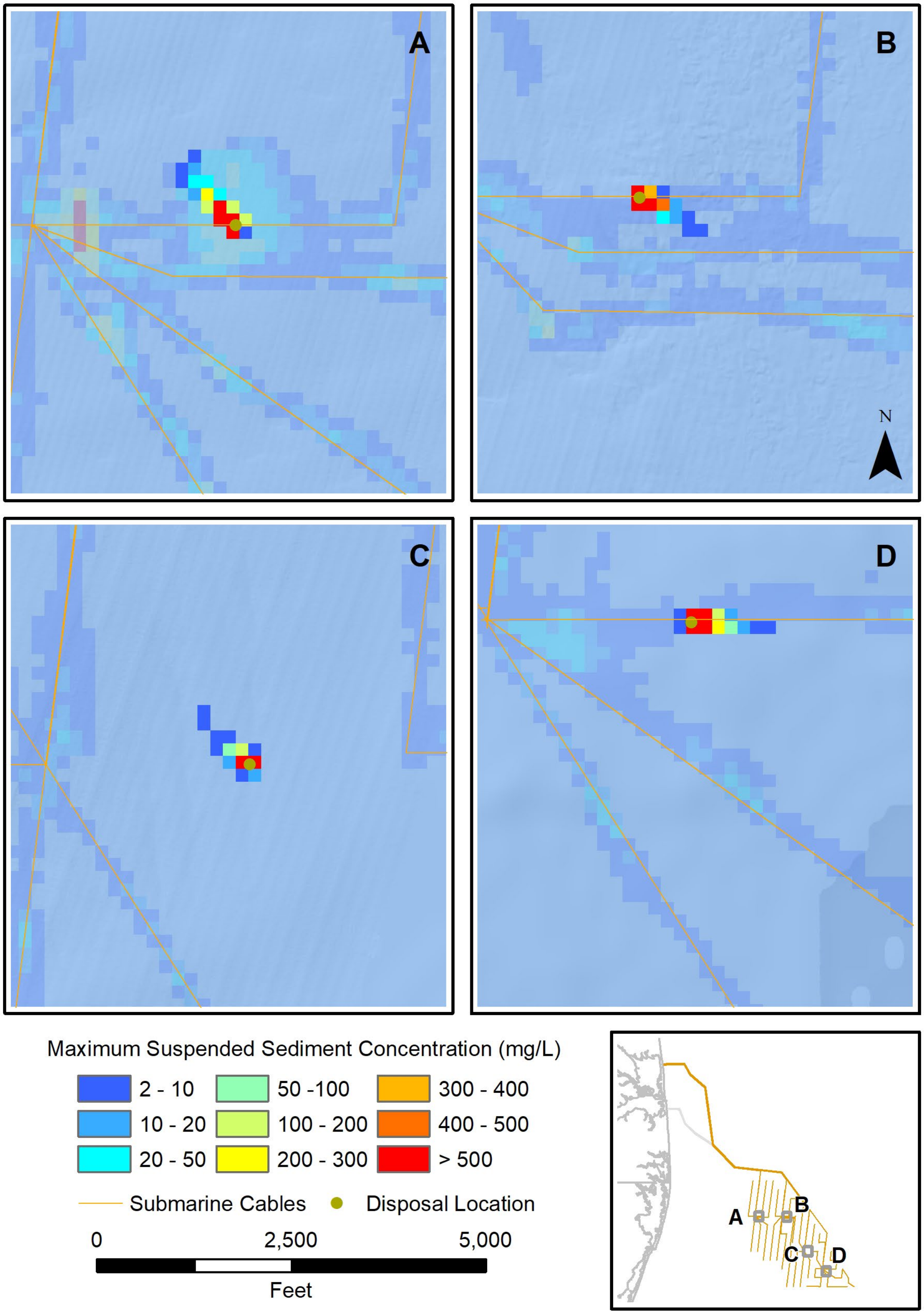


Figure A2-4-1: Modeled Predicted Maximum Suspended Sediment Concentrations

*Offshore Export Cable Corridor modeling results shown as transparent colors. Dredged material disposal modeling results shown as opaque.

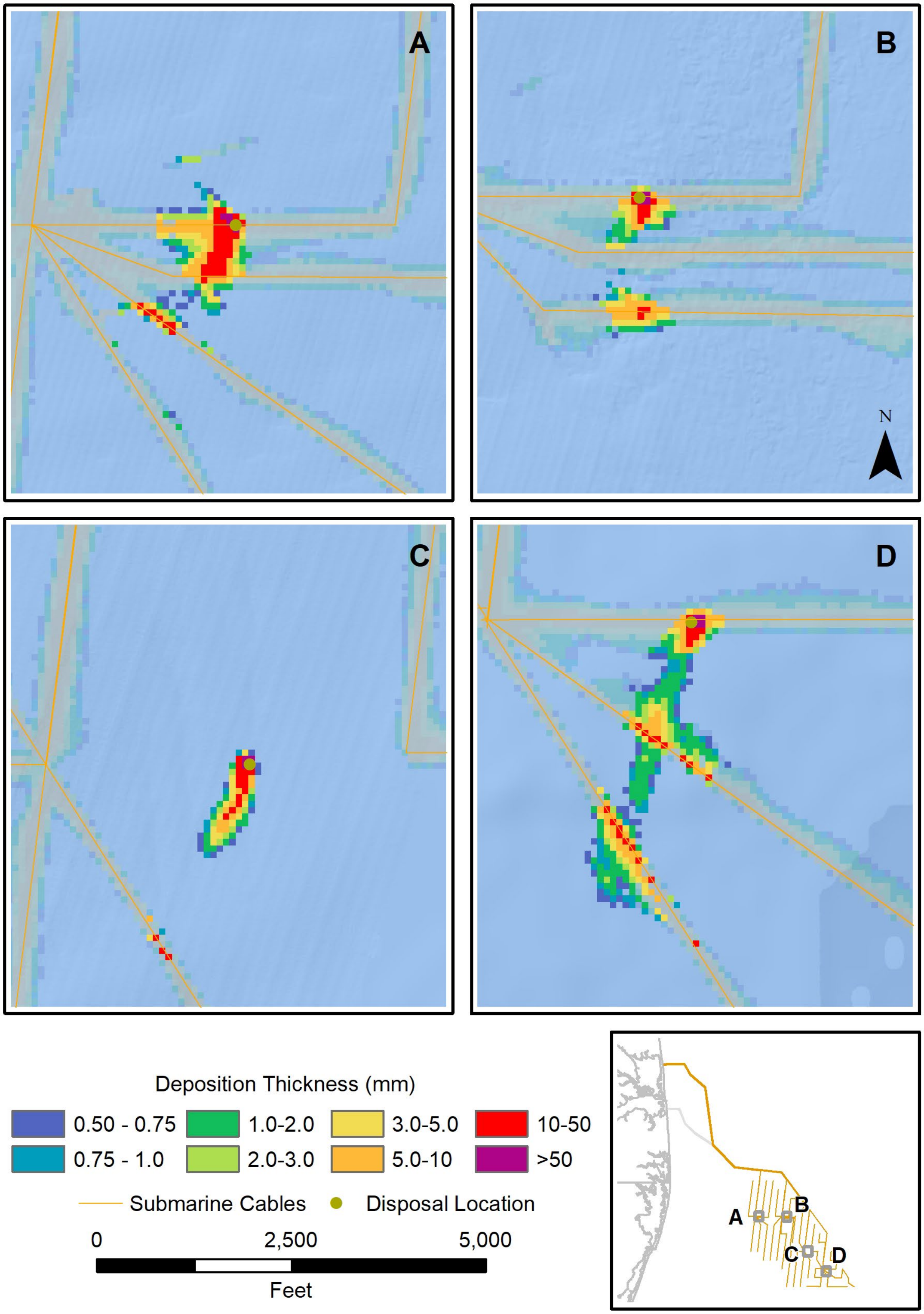


Figure A2-4-2: Model Predicted Cumulative Deposition Thickness

*Offshore Export Cable Corridor modeling results shown as transparent colors. Dredged material disposal modeling results shown as opaque.

5.0 SEDIMENT TRANSPORT MODEL FINDINGS

The use of TSHD in preparation for placement of the OSSs will result in negligible increases in suspended sediment concentration at the location of dredging. The disposal of dredged material from TSHD will result in a temporary increase in suspended sediment concentrations and the deposition of sediment away from the location of dredging. The suspended sediment plume will have initial concentrations in excess of 500 mg/L based on the PTM results, but the duration of the plume will be short-lived with conditions returning to ambient in less than six hours. Deposition thicknesses greater than 100 mm will also result from the disposal of dredged material. The highest deposition thicknesses will be in the immediate vicinity of the dredged material release. Deposition thicknesses greater than 0.5 mm will be limited to within 1,150 m (3,772 ft). Deposition thicknesses approaching 100 mm will be limited to the immediate vicinity of the discharge location (i.e., 50 m or less).