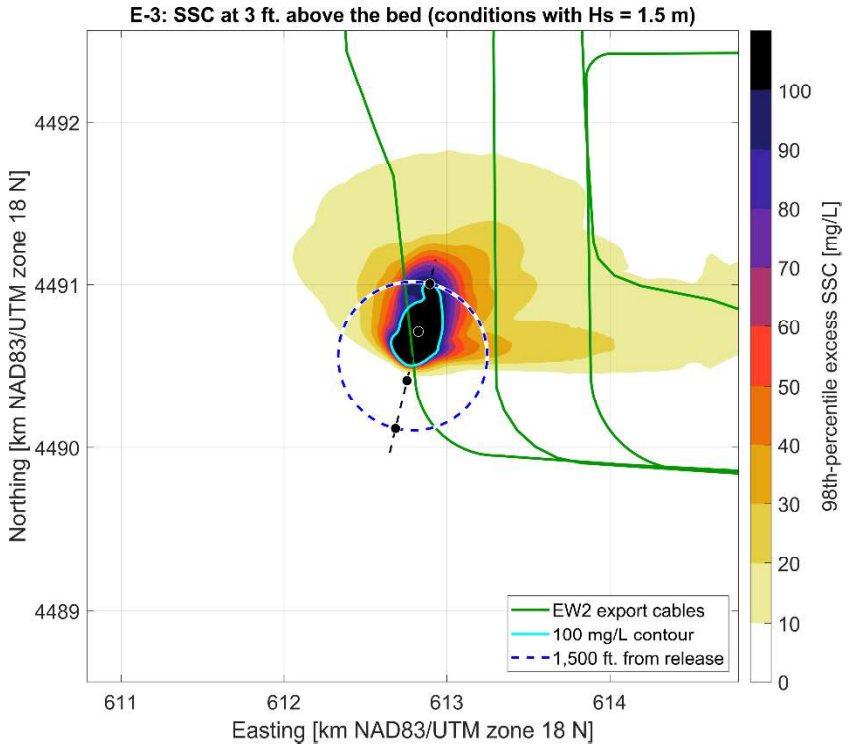
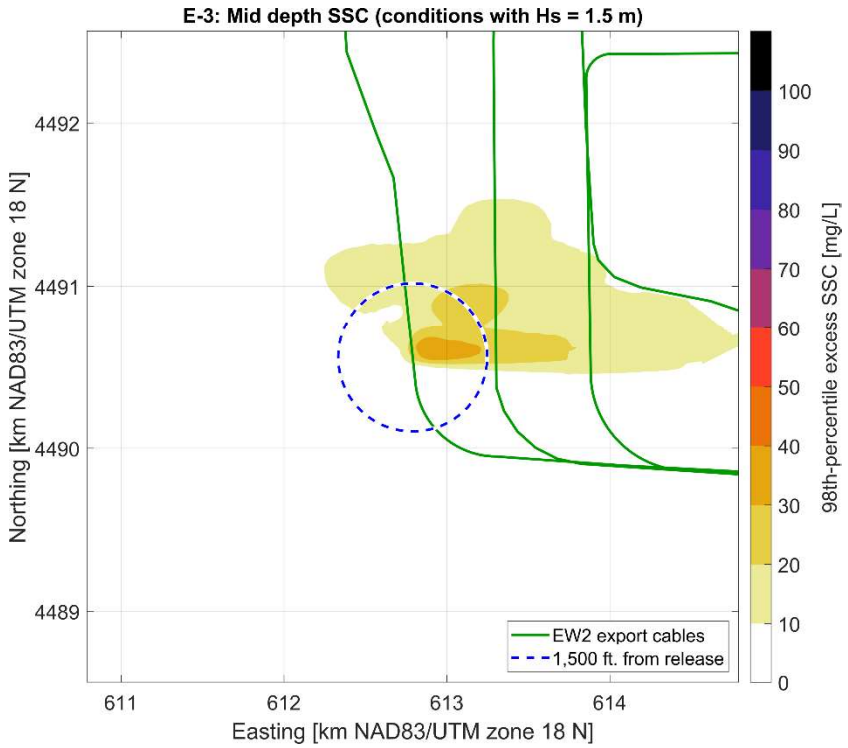
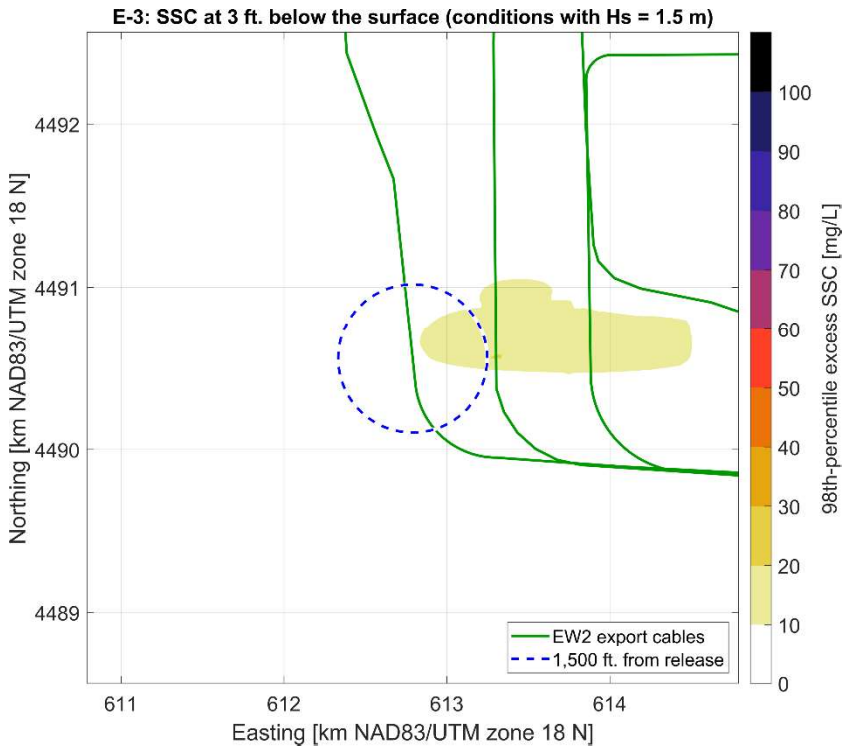
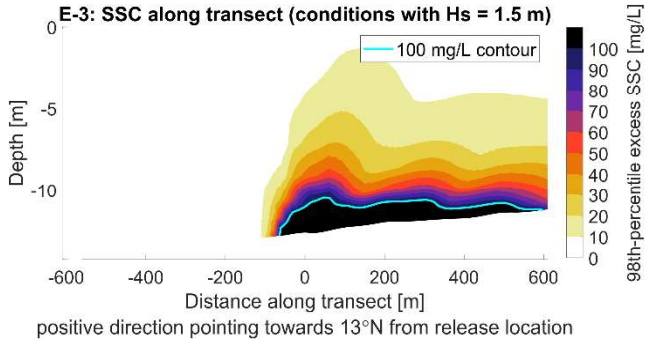
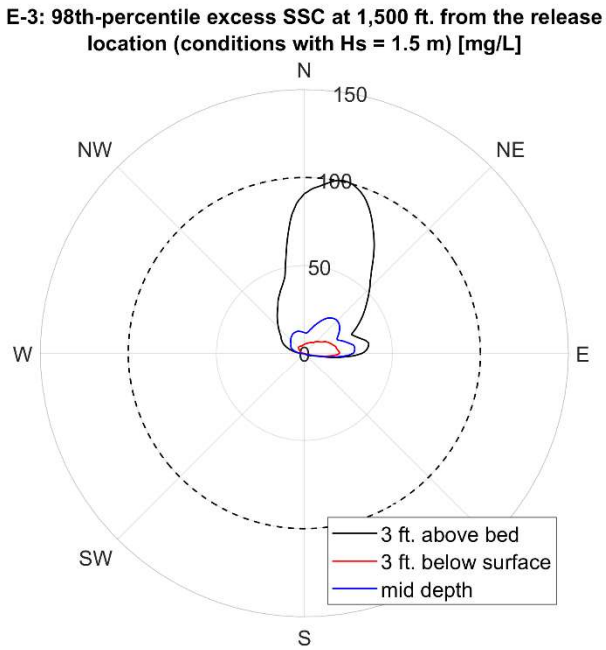
E.19.2 Sediment footprint with significant wave height ≈ 1.5 m



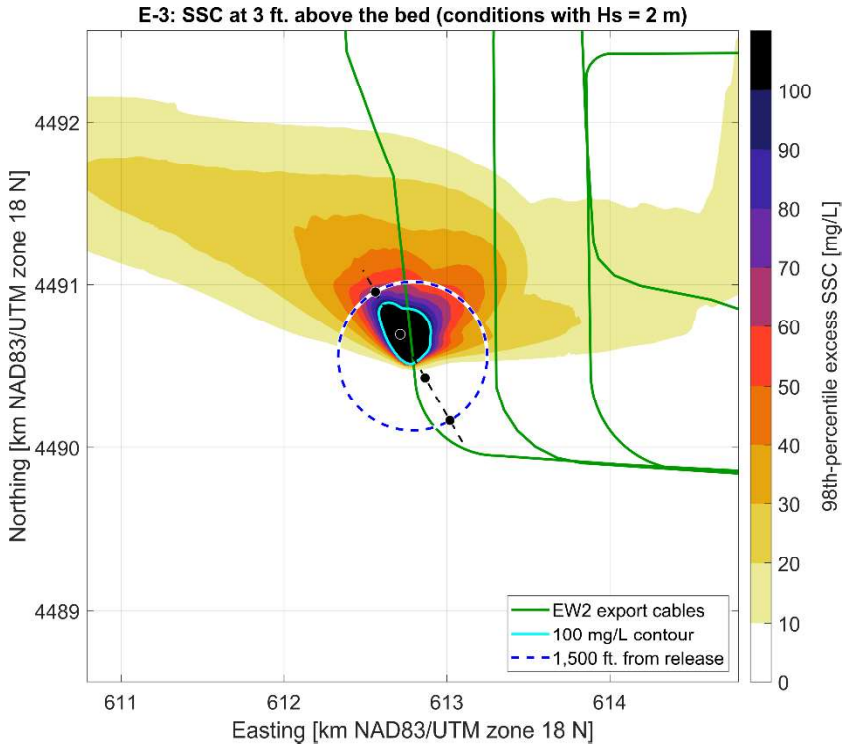


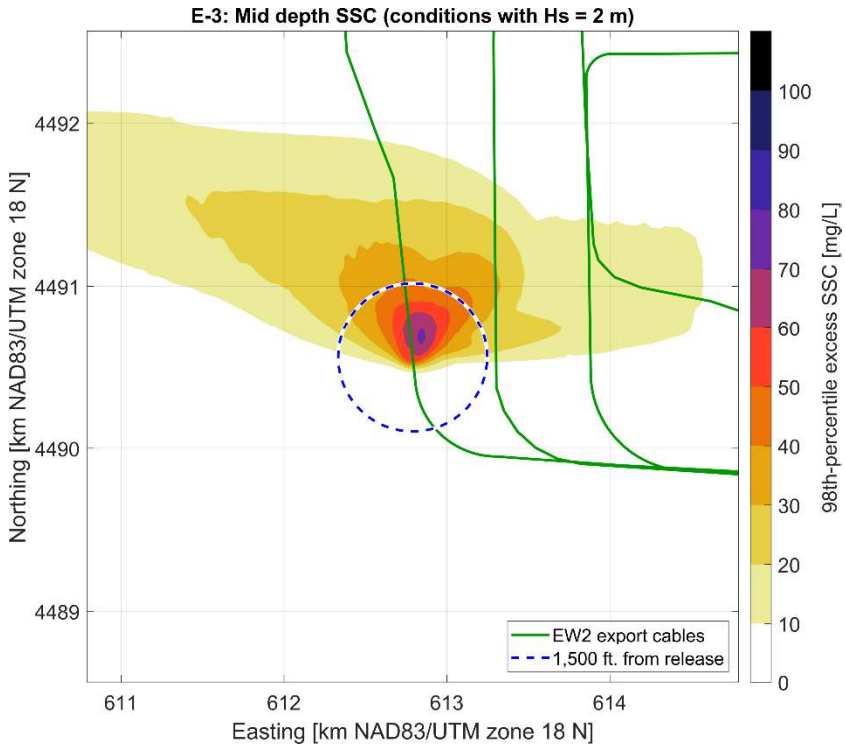

E-3: SSC at 3 ft. below the surface (conditions with Hs = 1.5 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

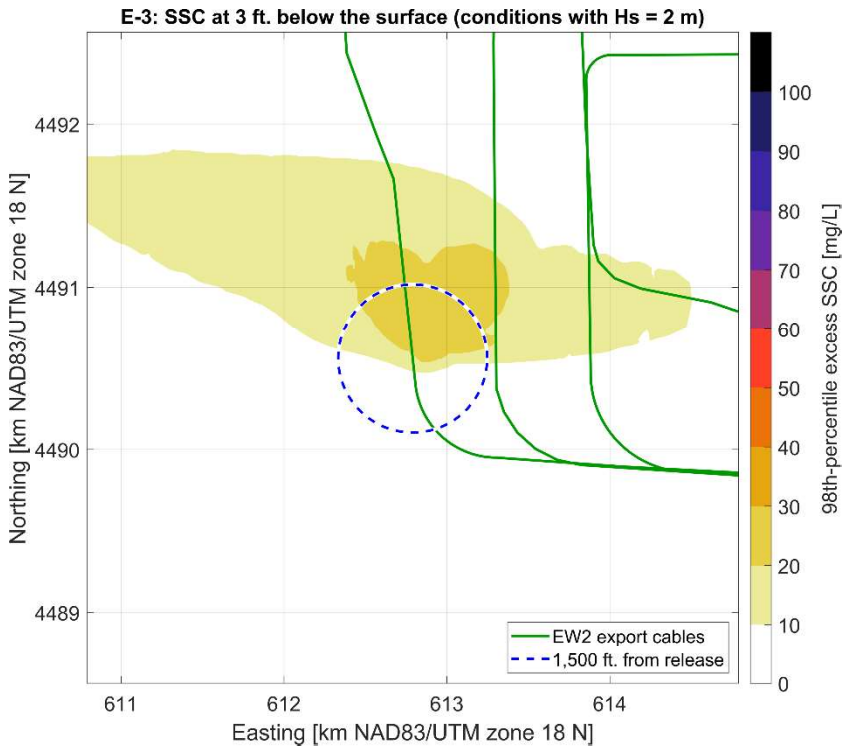

E-3: SSC along transect (conditions with Hs = 1.5 m)
100 mg/L contour
Depth [m]
0
-5
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 13°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

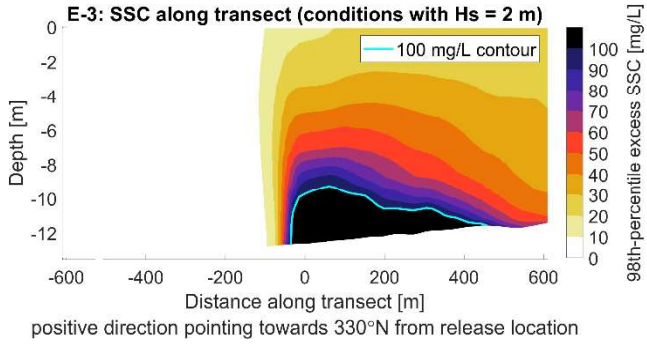

E-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 1.5 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

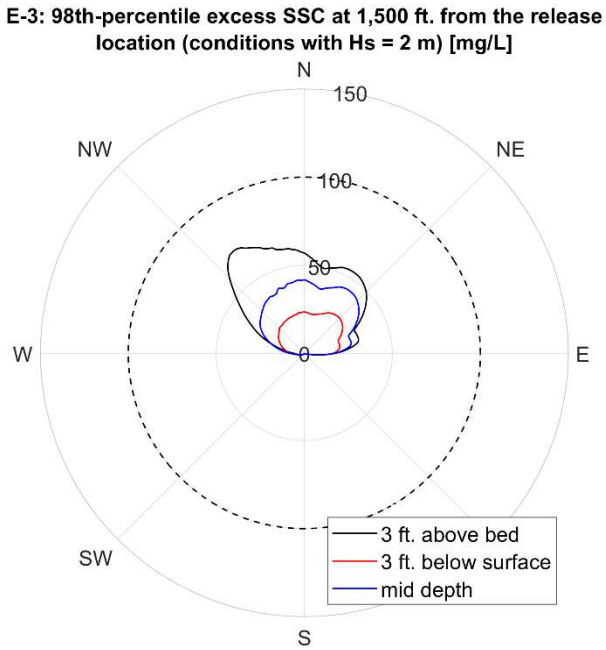
E.19.3 Sediment footprint with significant wave height ≈ 2 m





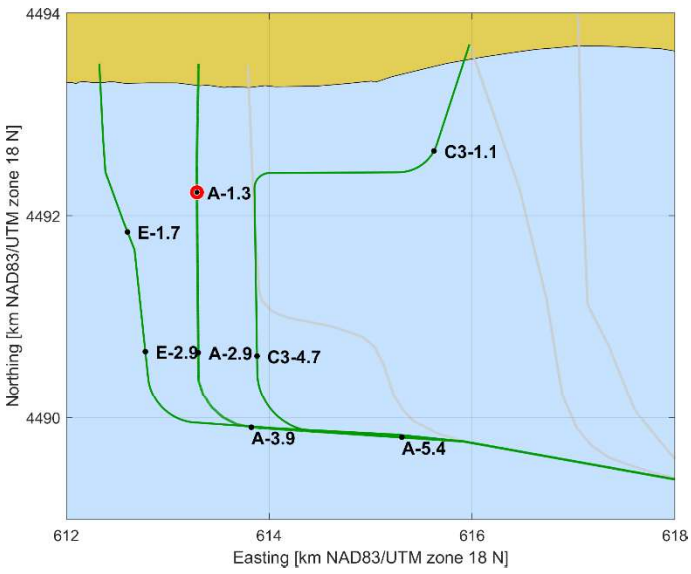

E-3: SSC at 3 ft. below the surface (conditions with Hs = 2 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


E-3: SSC along transect (conditions with Hs = 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 330°N from release location
100 mg/L contour
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

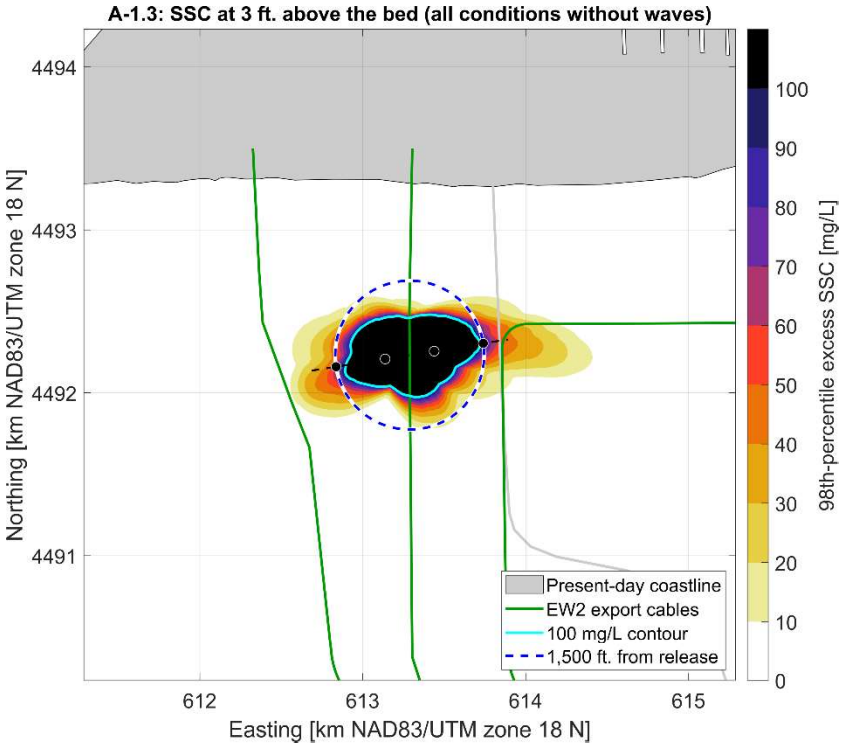

E-3: 98th-percentile excess SSC at 1,500 ft. from the release location (conditions with Hs = 2 m) [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

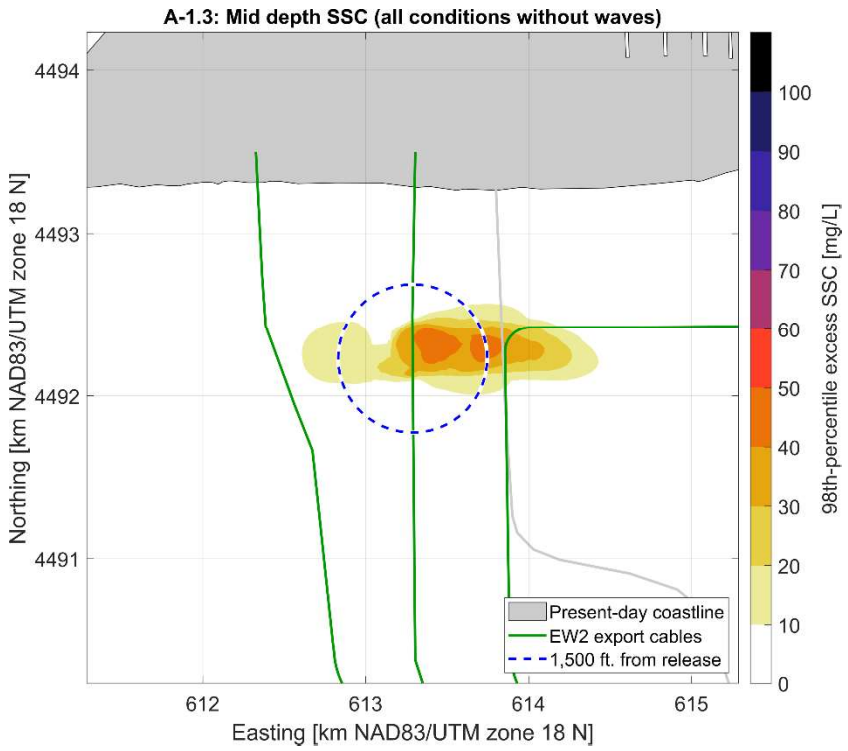
F Far-field modelling results (MFE)

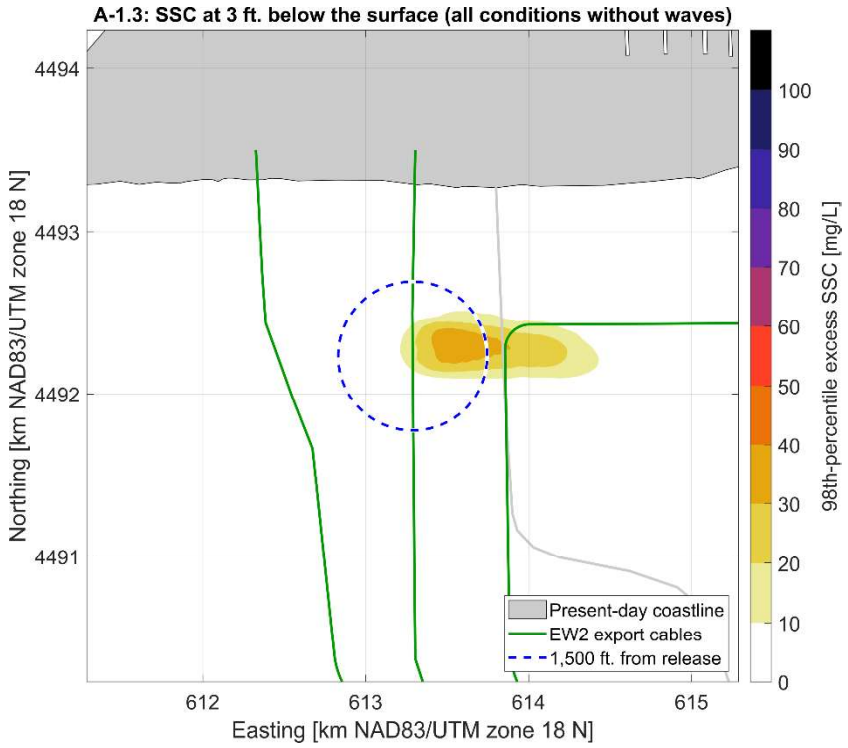
F.1 Release location A-1.3

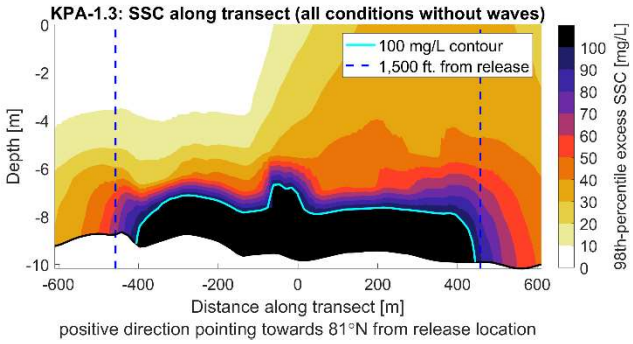


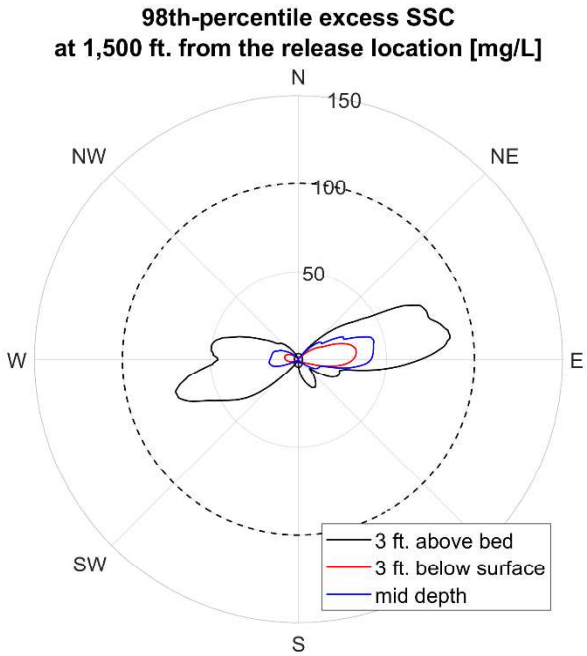
F.1.1 Sediment footprint without waves



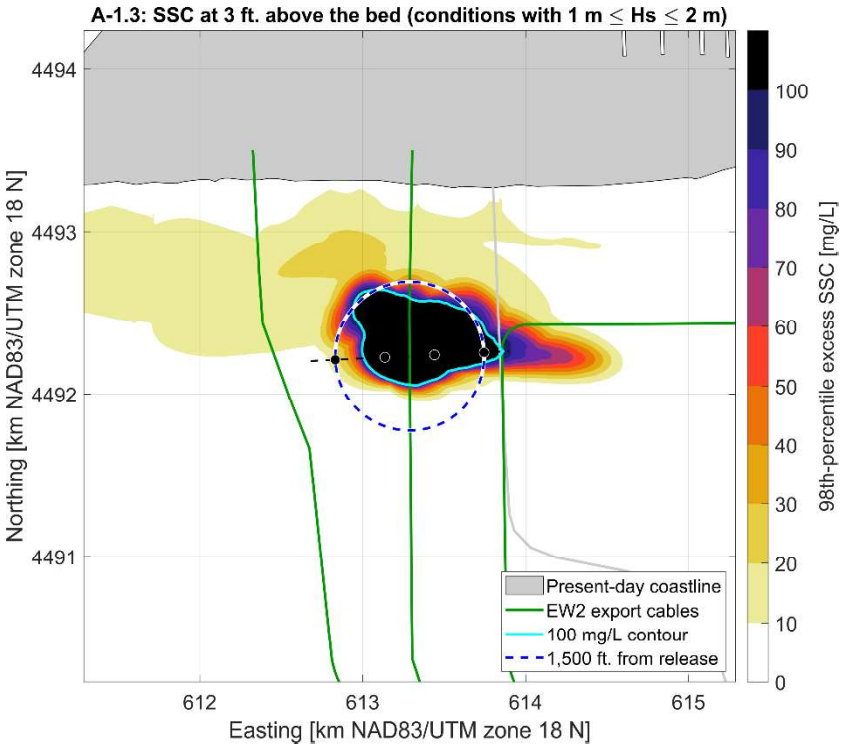

A-1.3: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
1,500 ft. from release

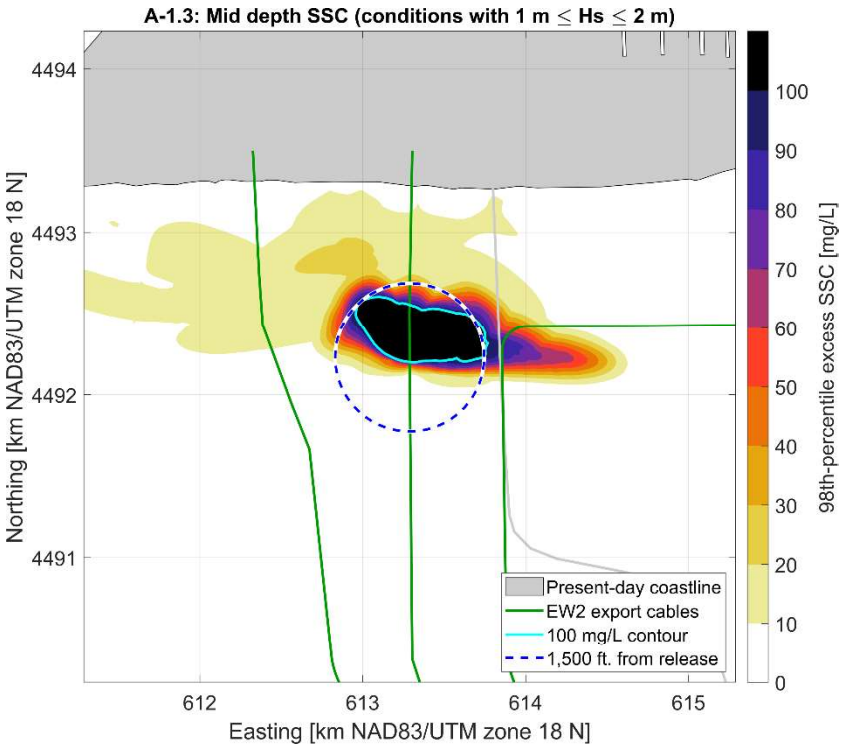

A-1.3: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
1,500 ft. from release

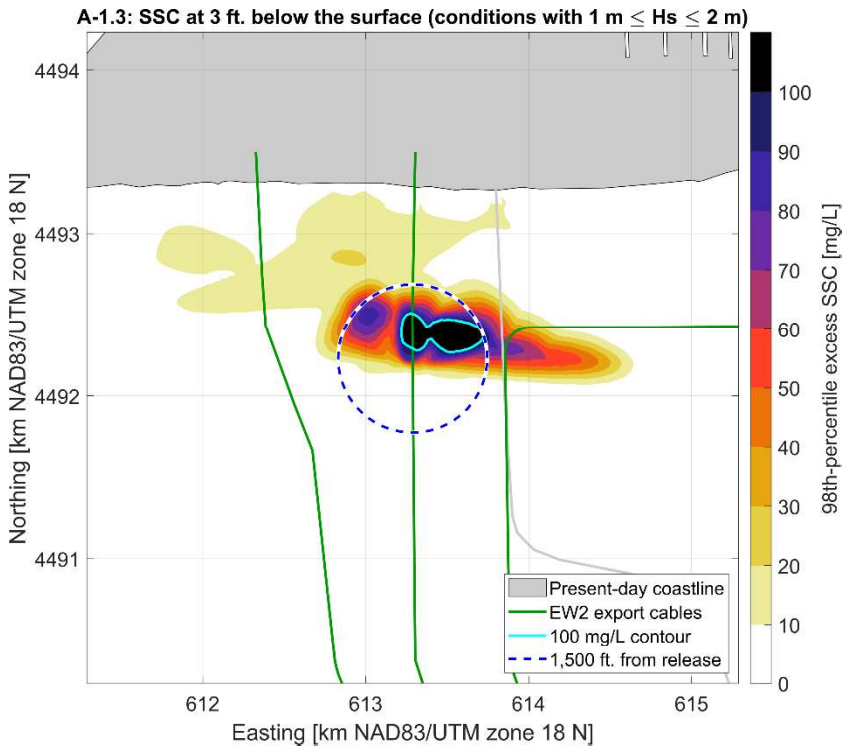

KPA-1.3: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 81°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

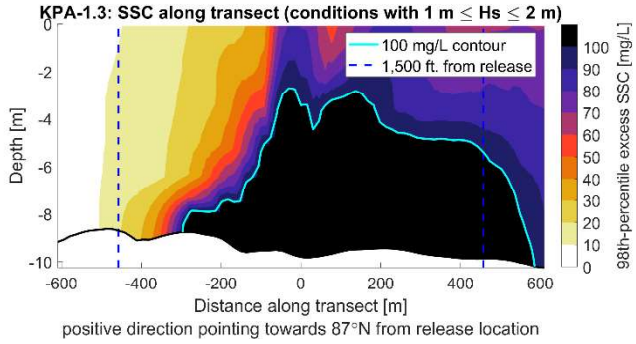

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

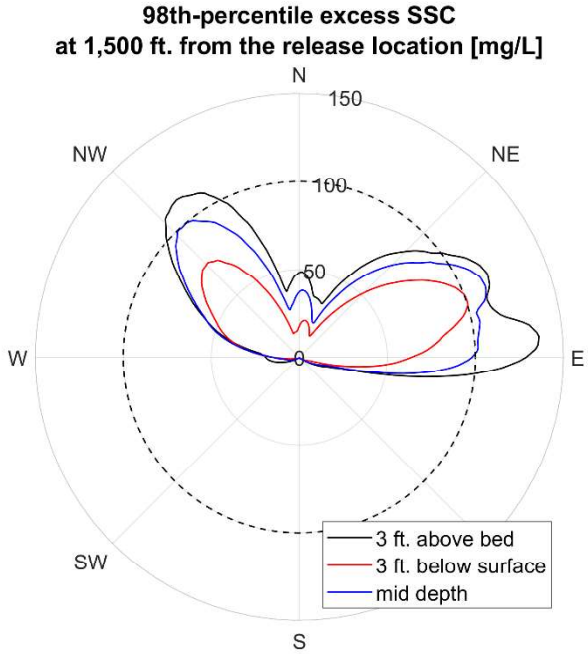
F.1.2 Sediment footprint with waves



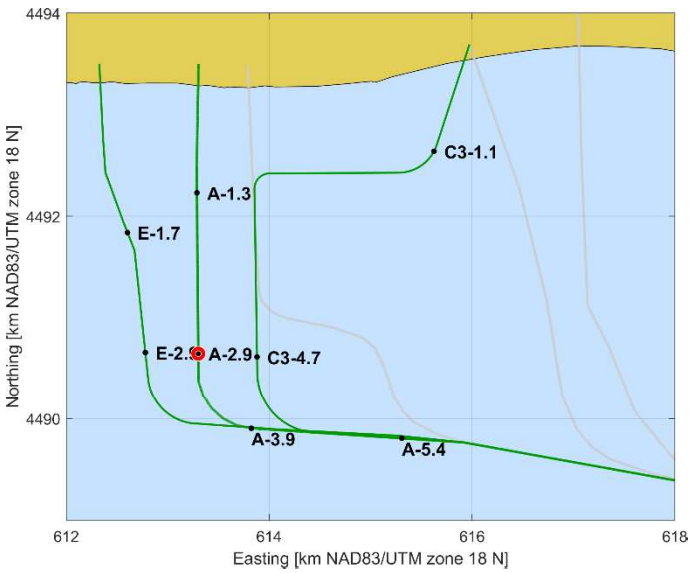



A-1.3: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

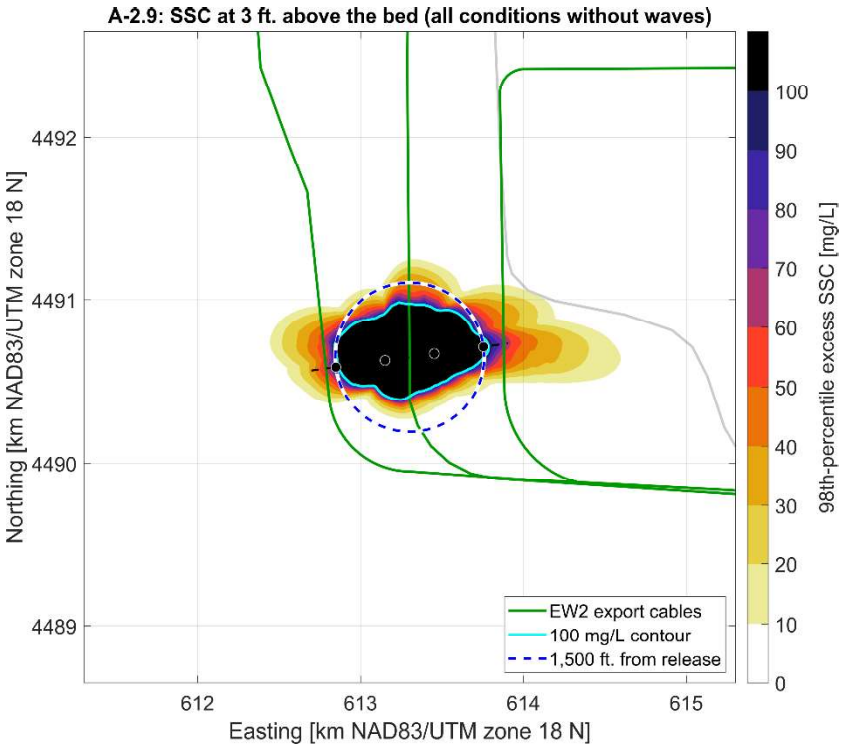

KPA-1.3: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
Distance along transect [m]
positive direction pointing towards 87°N from release location
98th-percentile excess SSC [mg/L]
100 mg/L contour
1,500 ft. from release

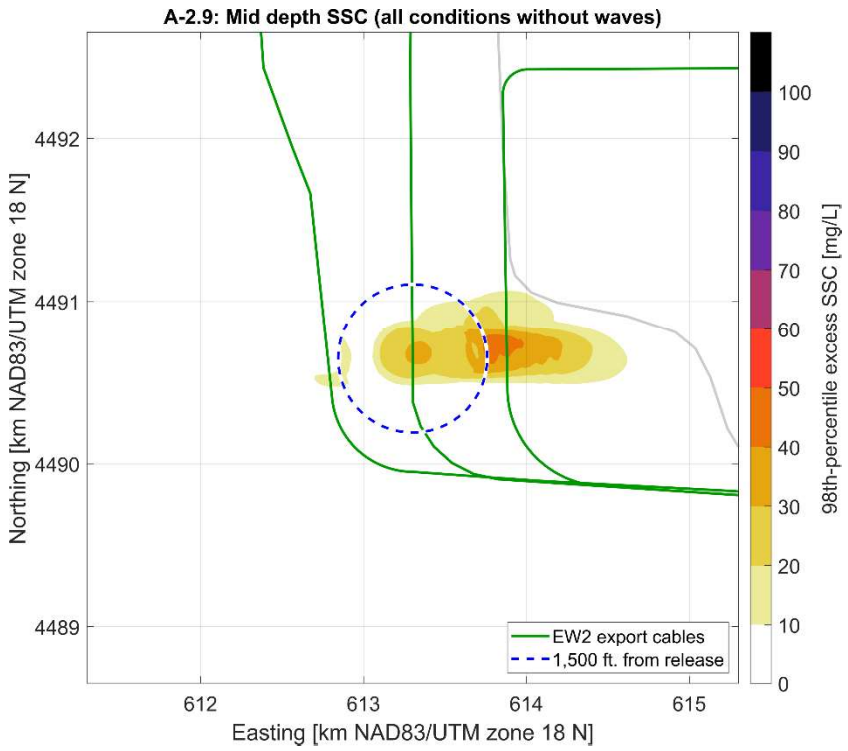

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

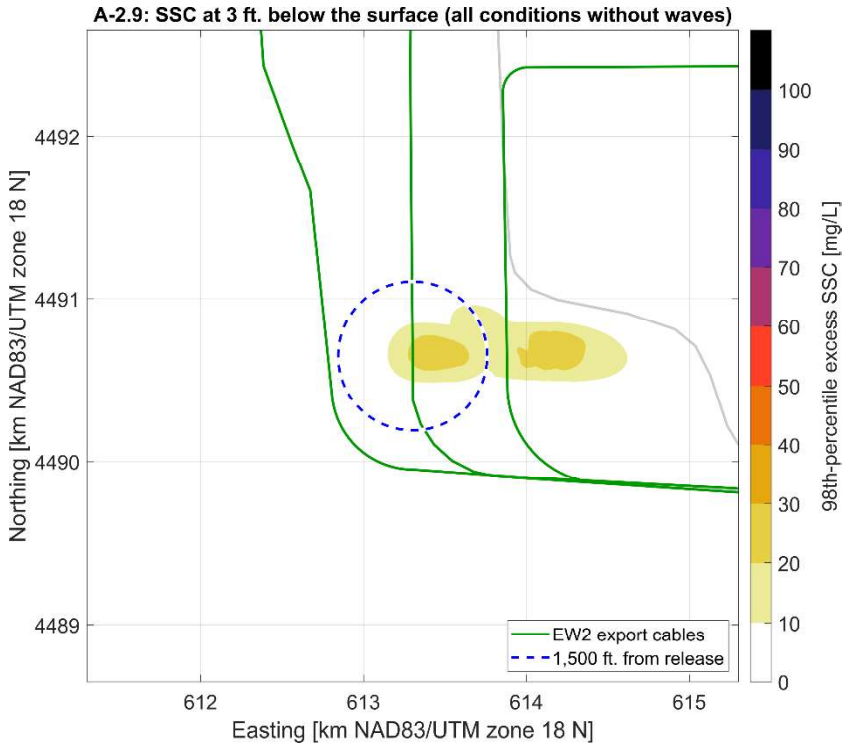
F.2 Release location A-2.9

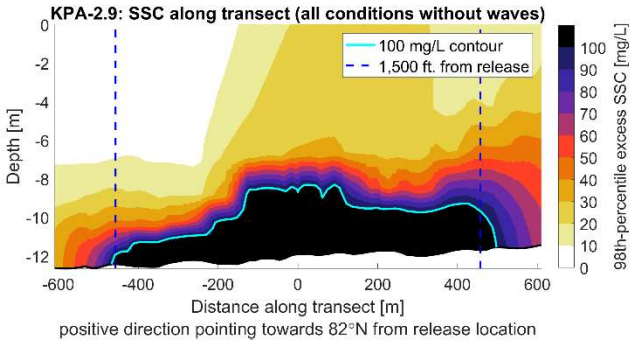


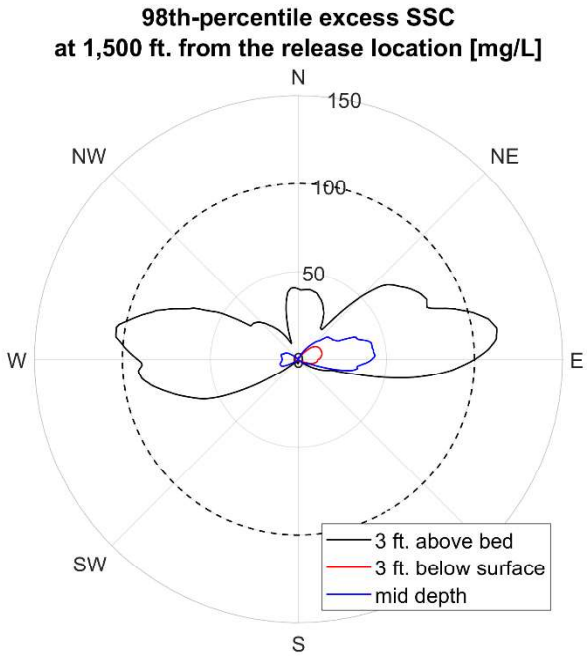
F.2.1 Sediment footprint without waves



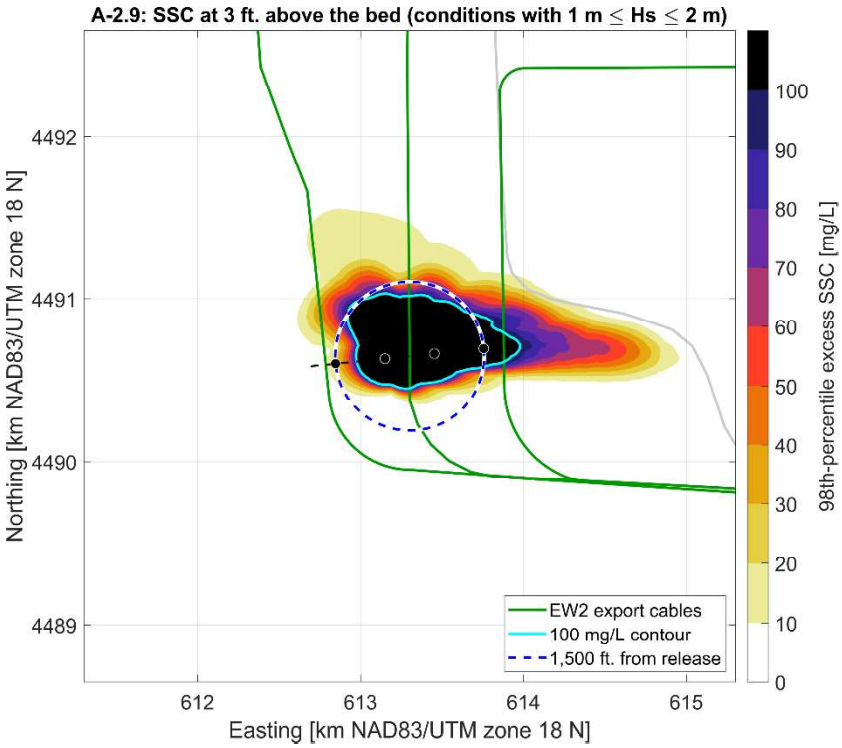

A-2.9: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4492
4491
4490
4489
612
613
614
615
0
10
20
30
40
50
60
70
80
90
100

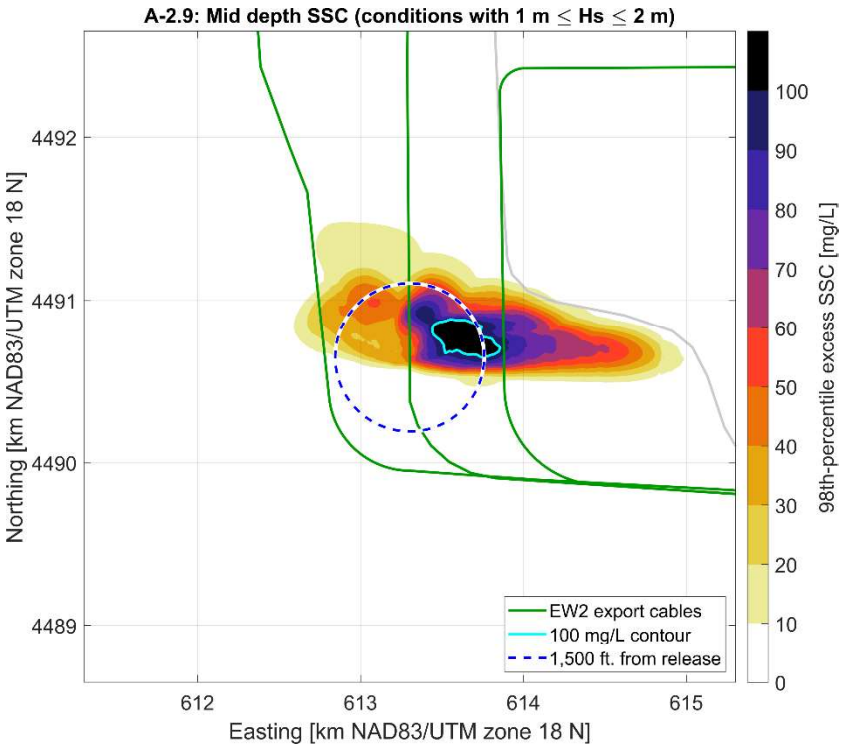

A-2.9: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release
4492
4491
4490
4489
612
613
614
615
0
10
20
30
40
50
60
70
80
90
100

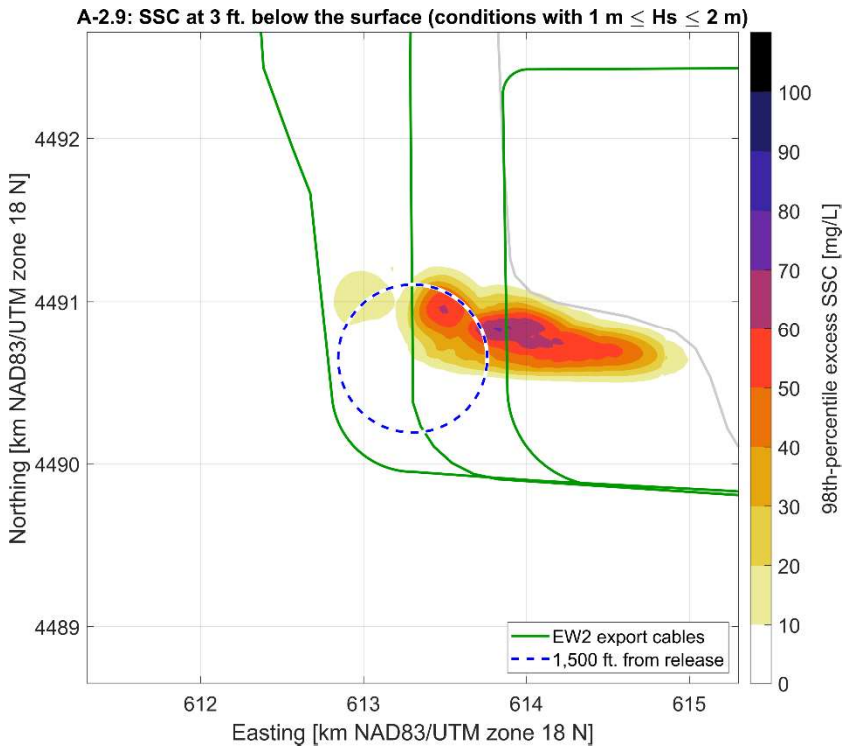

KPA-2.9: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 82°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

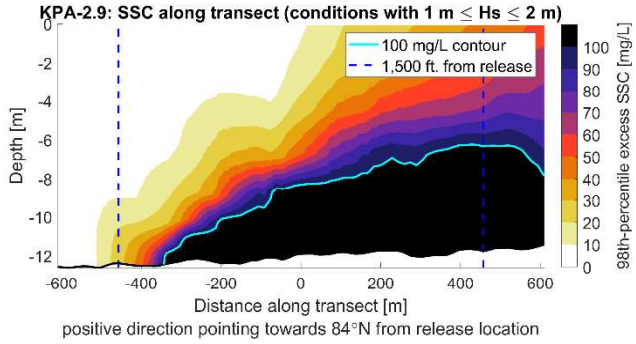

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

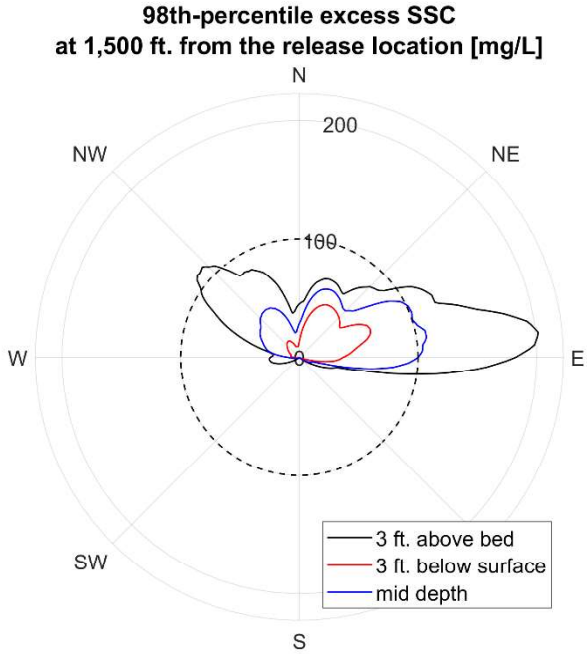
F.2.2 Sediment footprint with waves



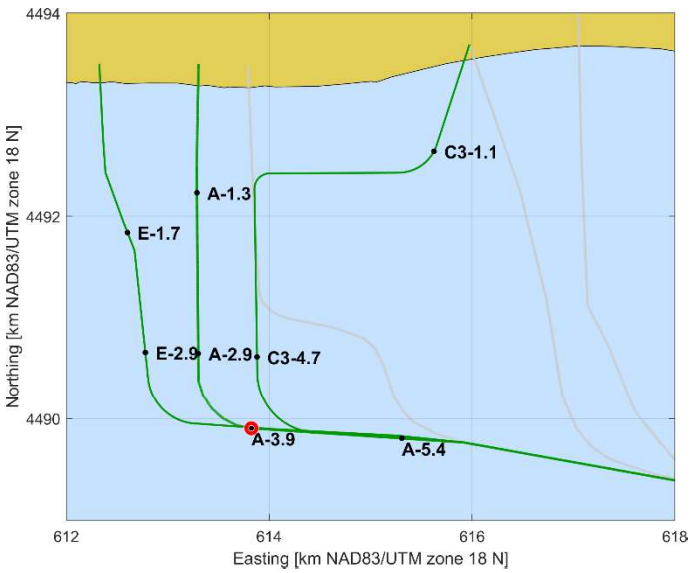



A-2.9: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
EW2 export cables
1,500 ft. from release

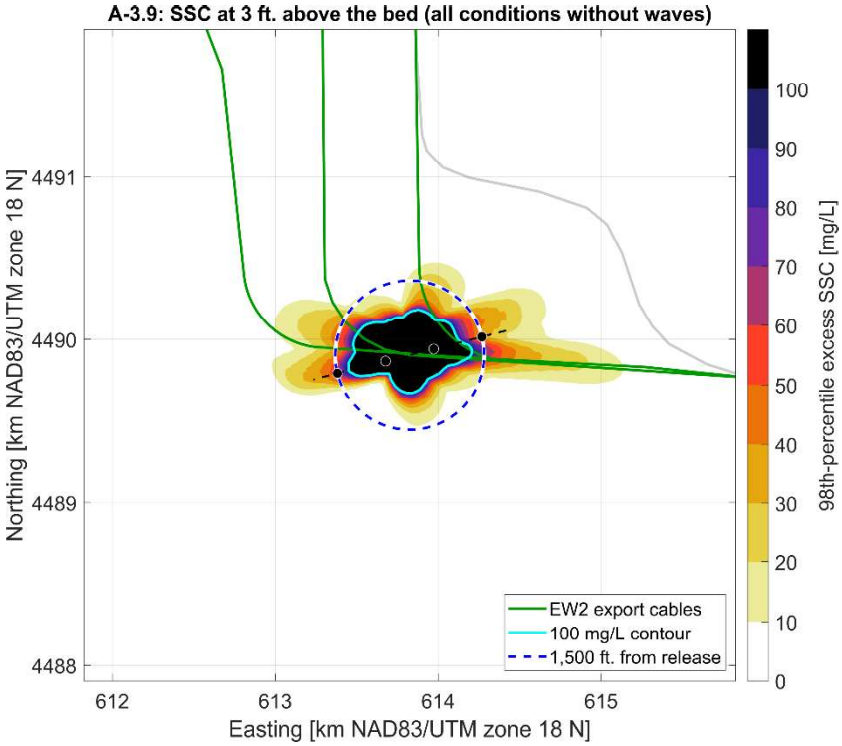

KPA-2.9: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
Distance along transect [m]
positive direction pointing towards 84°N from release location
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]

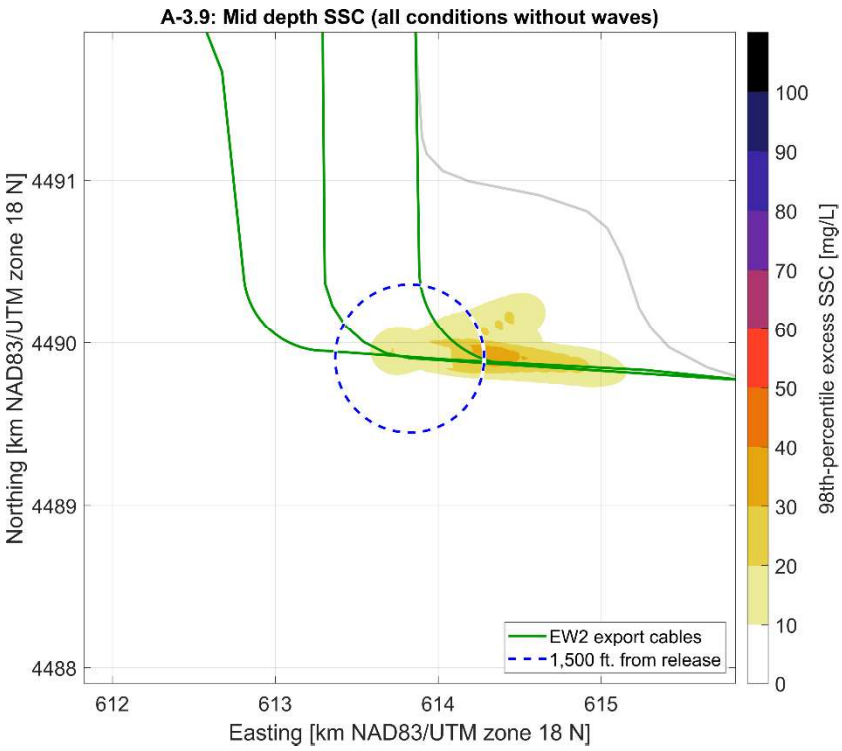

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

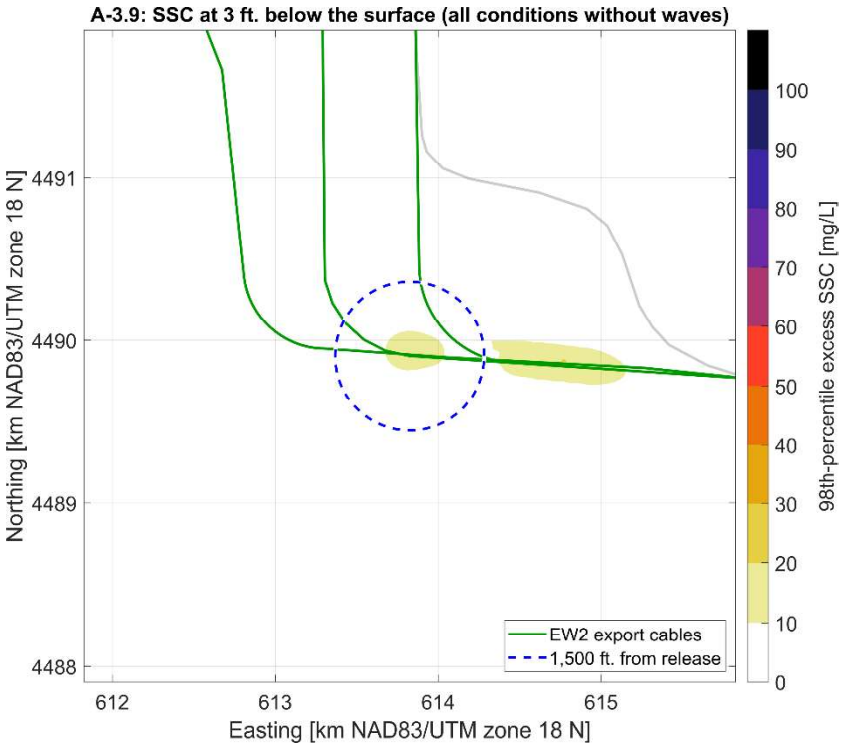
F.3 Release location A-3.9

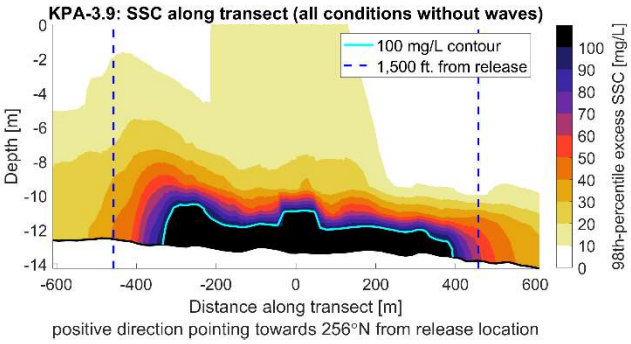


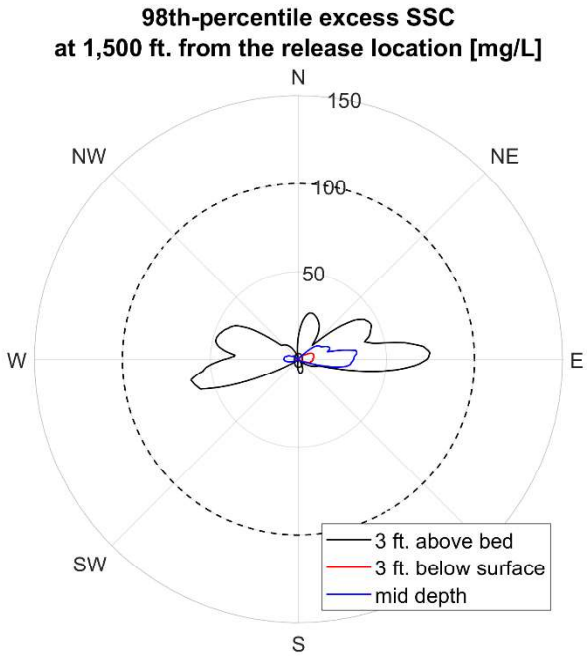
F.3.1 Sediment footprint without waves



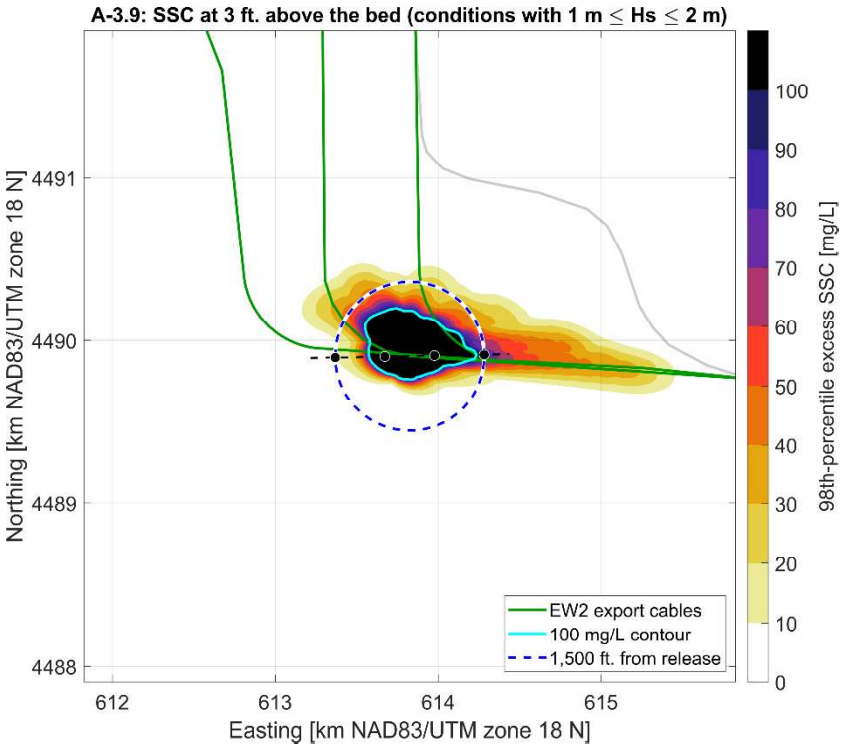

A-3.9: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

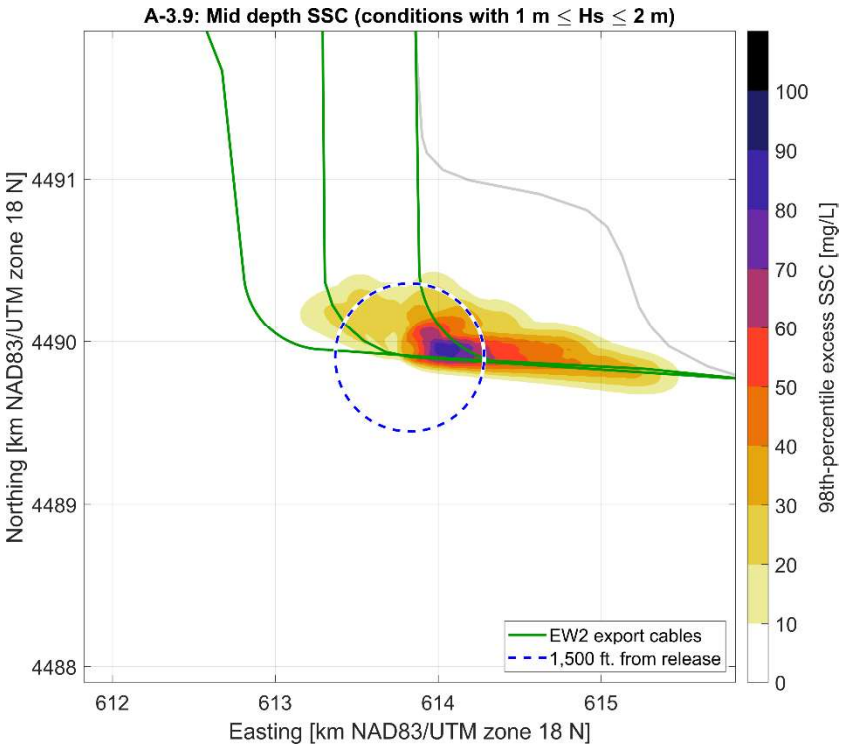

A-3.9: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

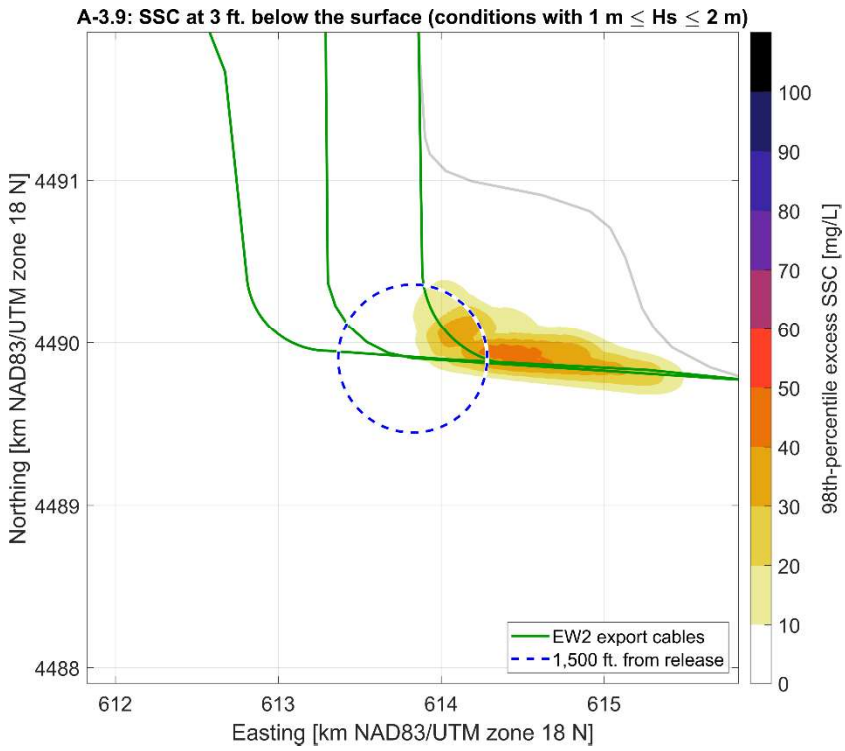

KPA-3.9: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 256°N from release location
98th-percentile excess SSC [mg/L]

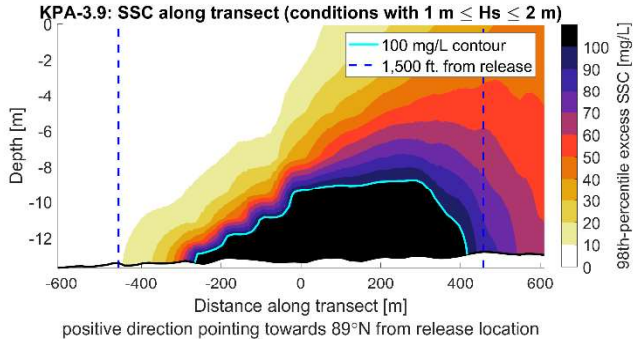

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

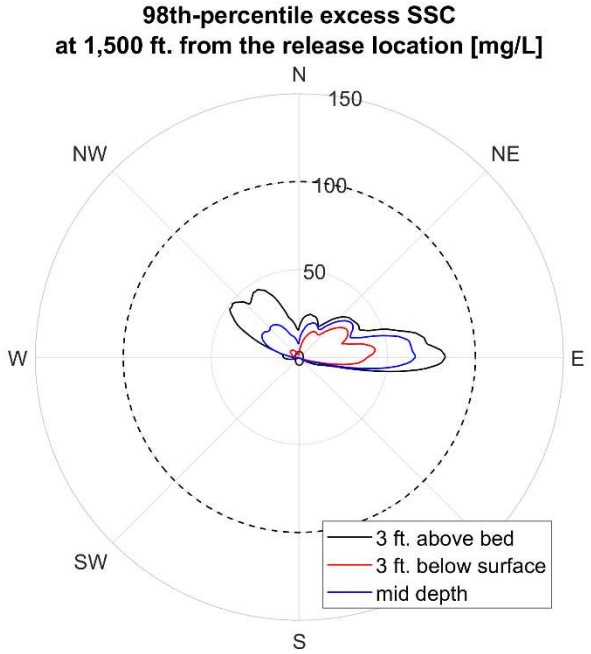
F.3.2 Sediment footprint with waves



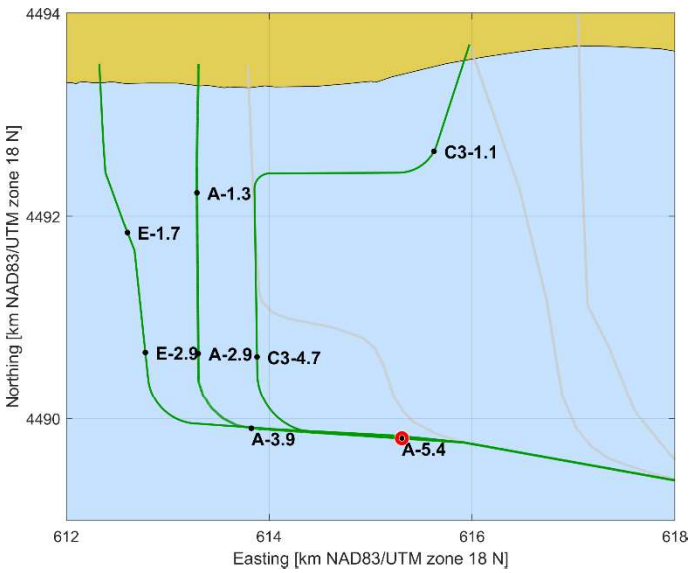



A-3.9: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

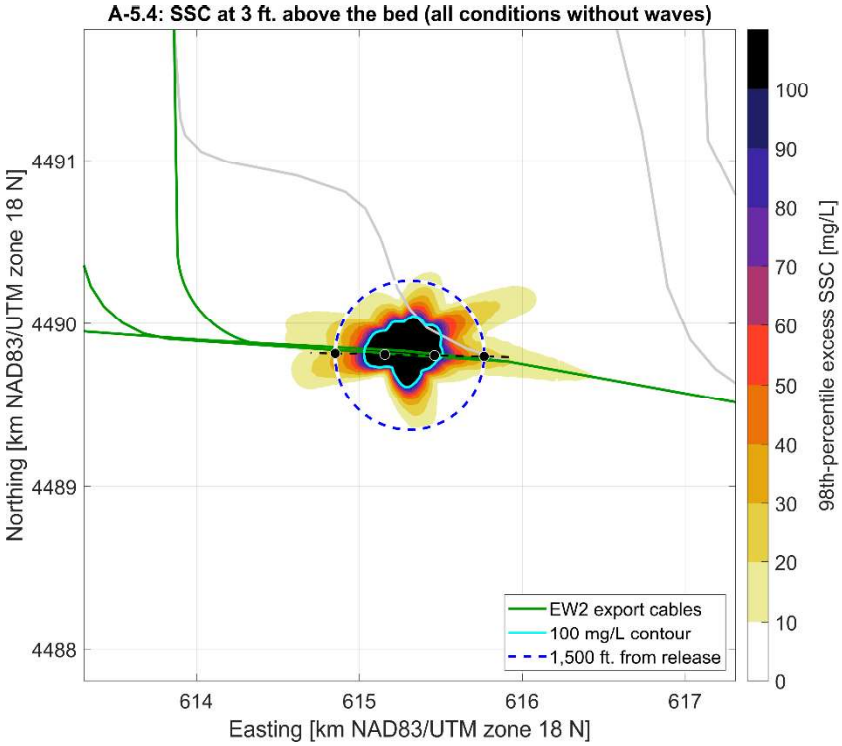

KPA-3.9: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 89°N from release location
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

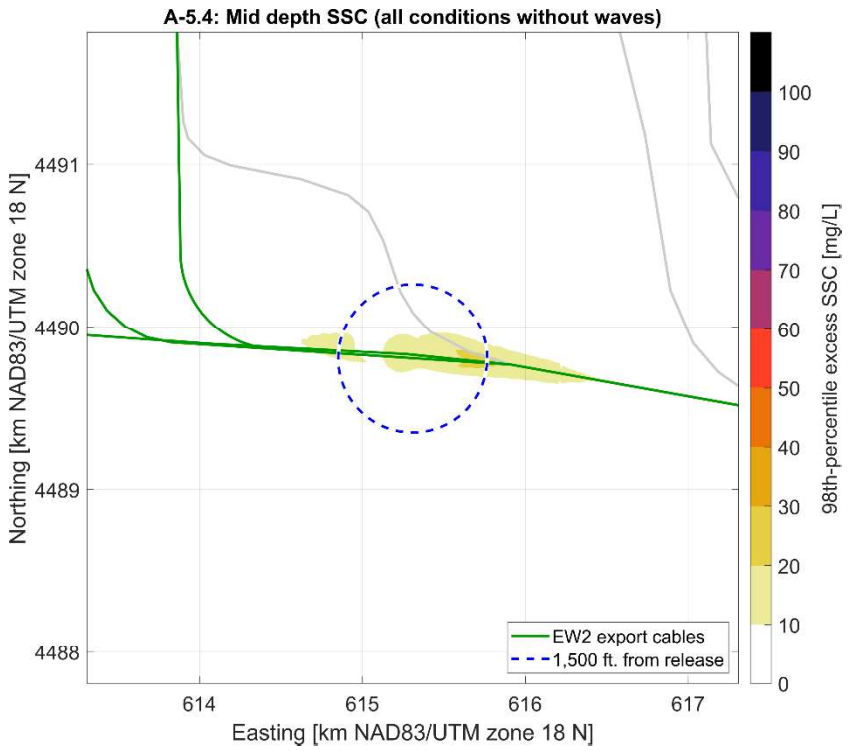

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

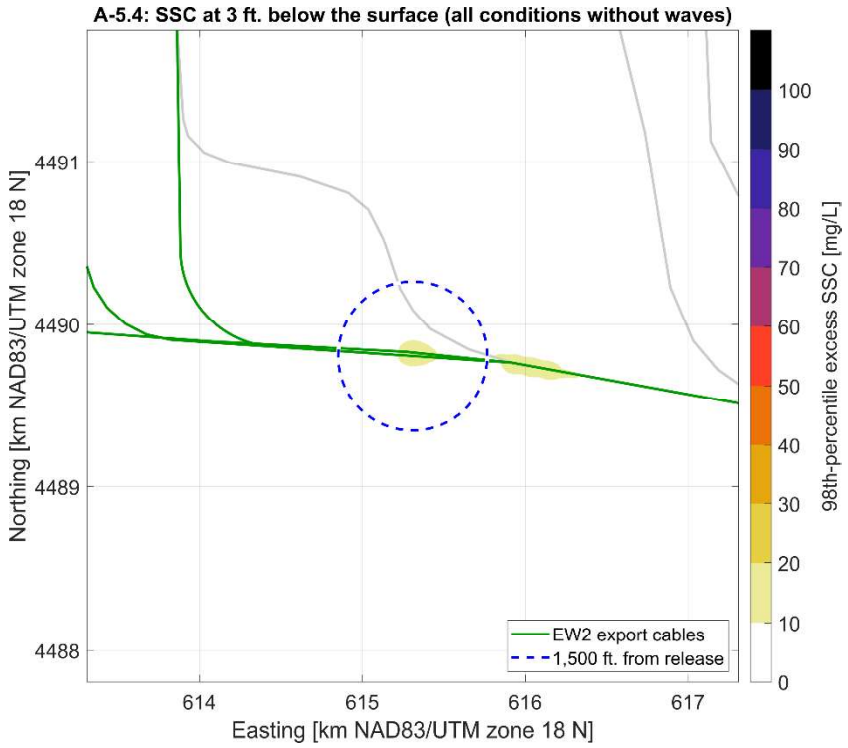
F.4 Release location A-5.4

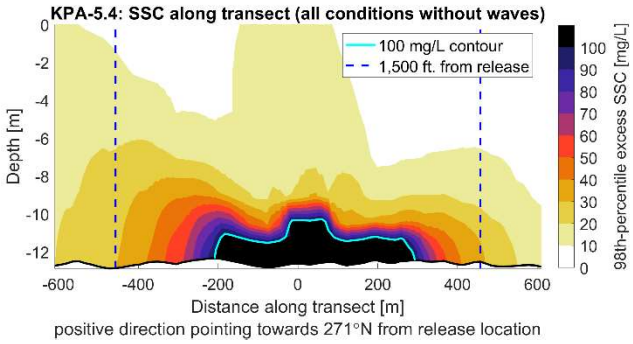


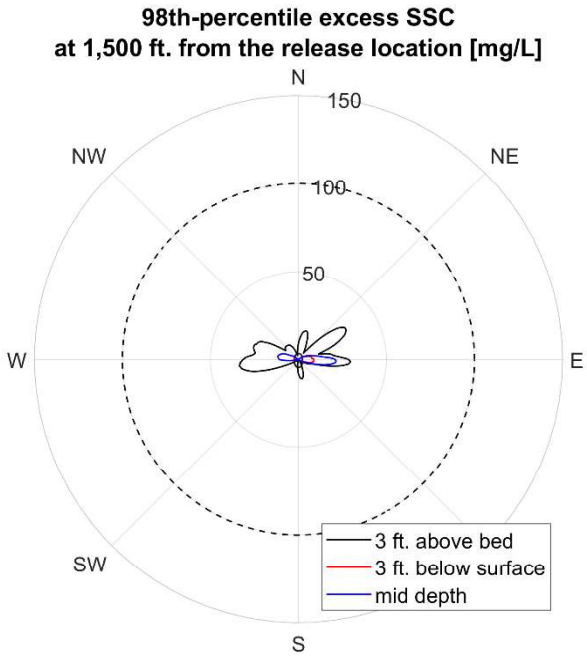
F.4.1 Sediment footprint without waves



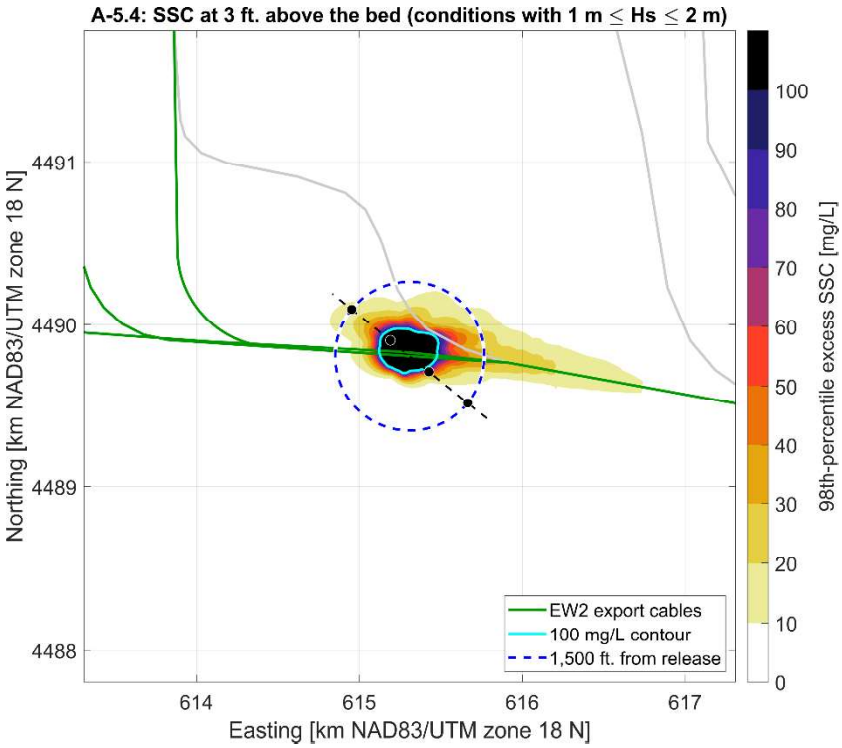

A-5.4: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

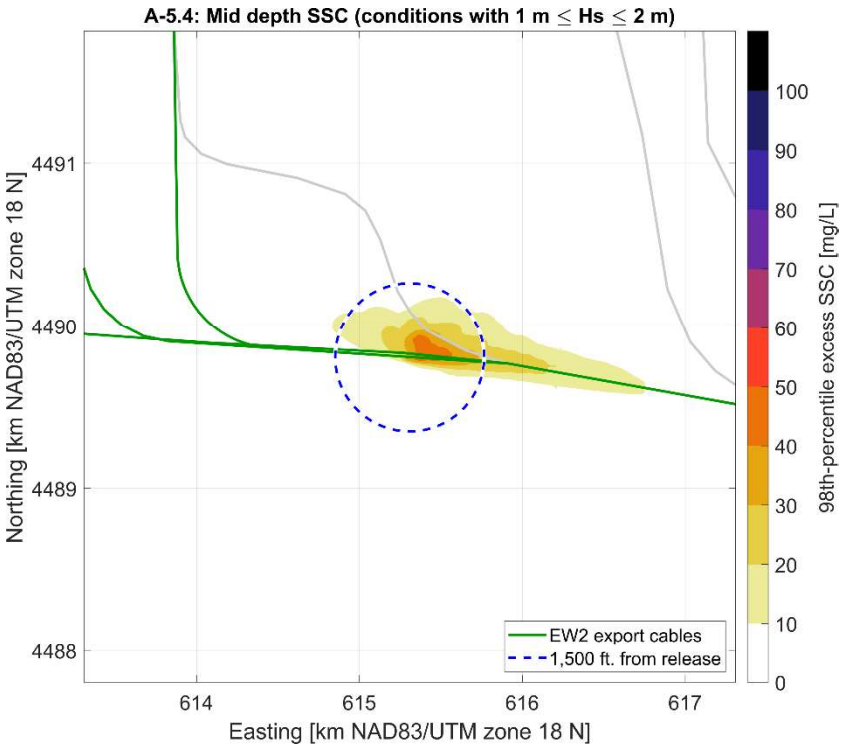

A-5.4: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

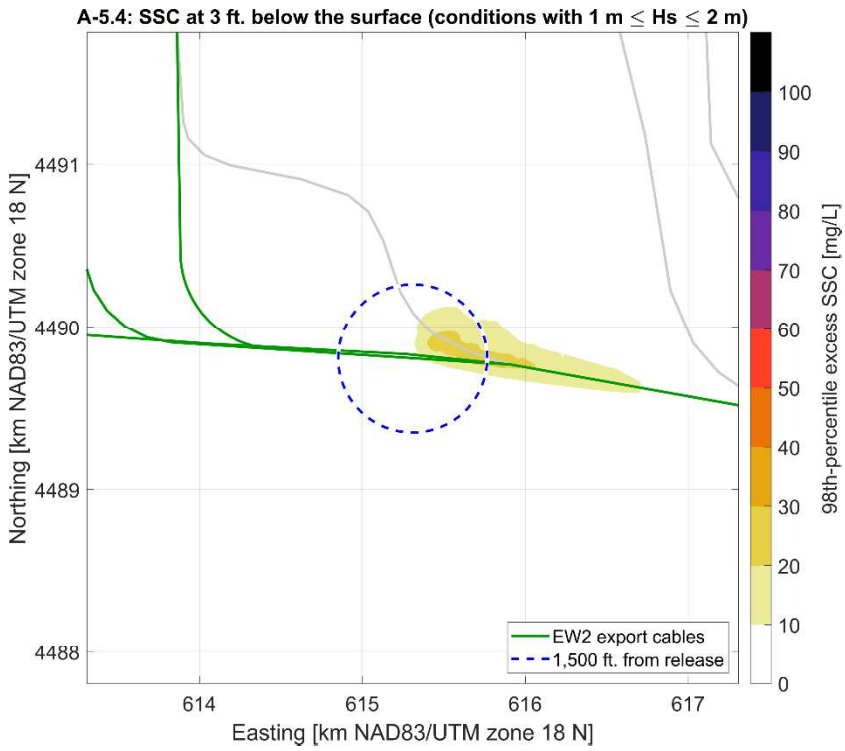

KPA-5.4: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 271°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

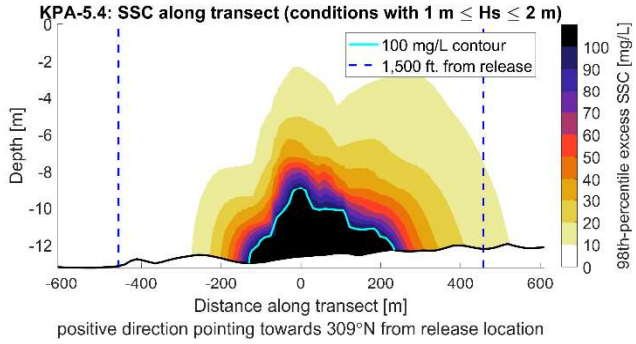

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

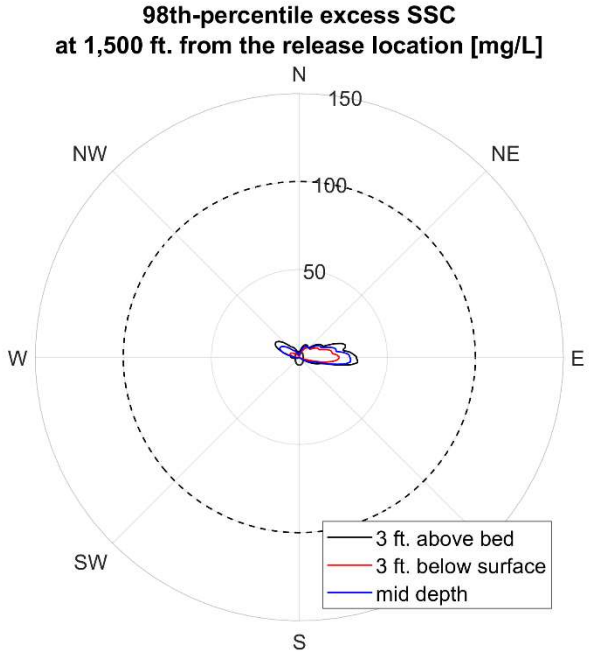
F.4.2 Sediment footprint with waves



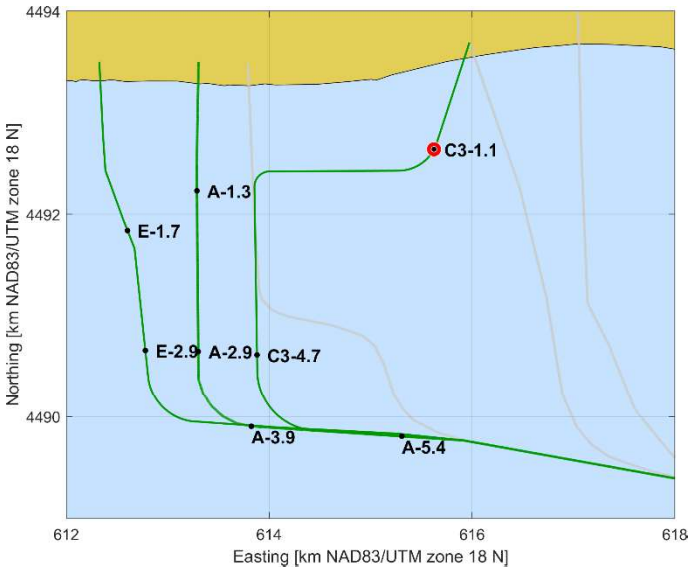



A-5.4: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
4491
4490
4489
4488
614
615
616
617
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

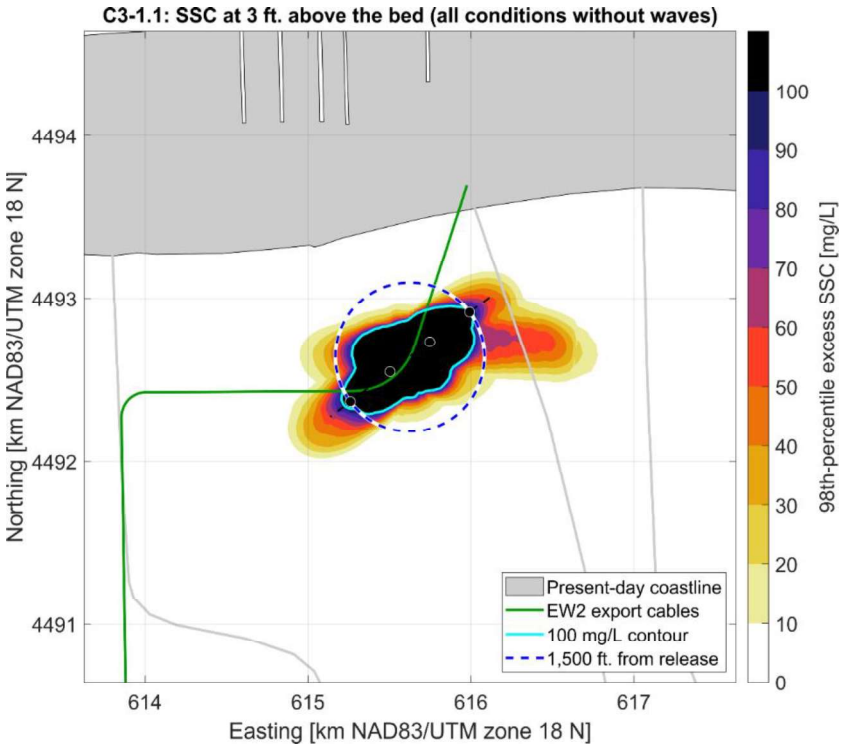

KPA-5.4: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 309°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

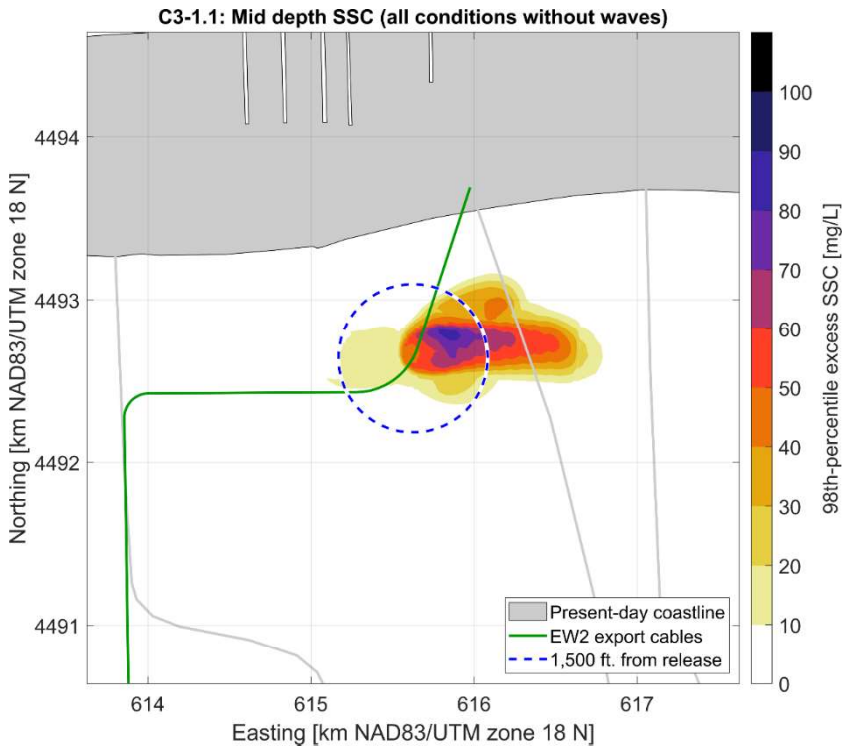

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

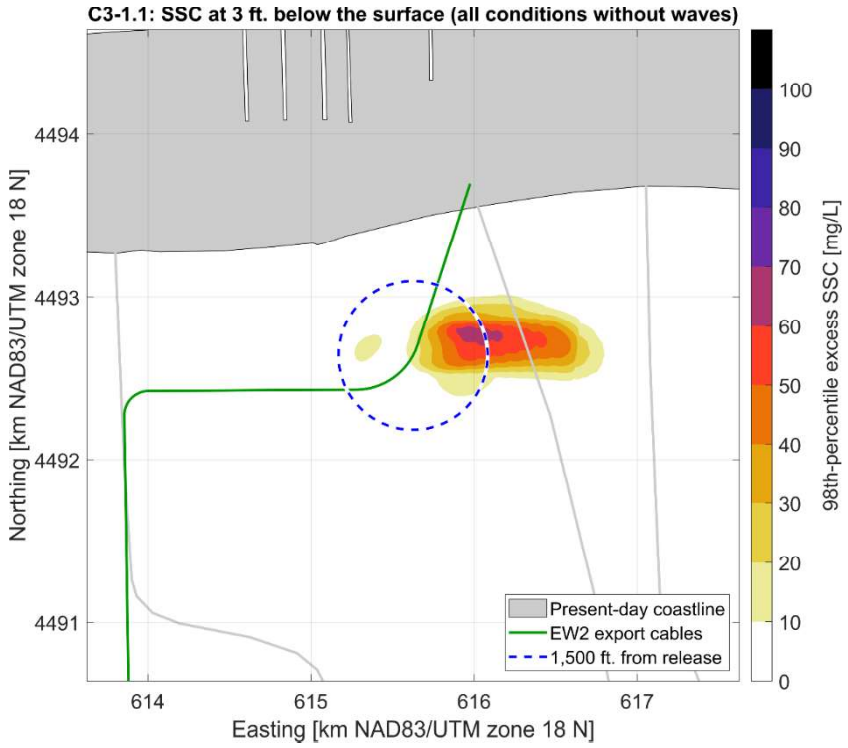
F.5 Release location C3-1.1

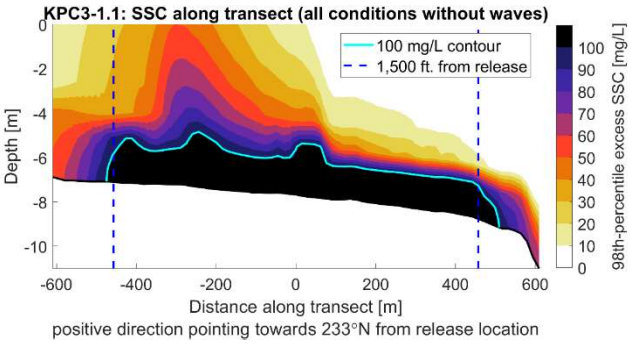


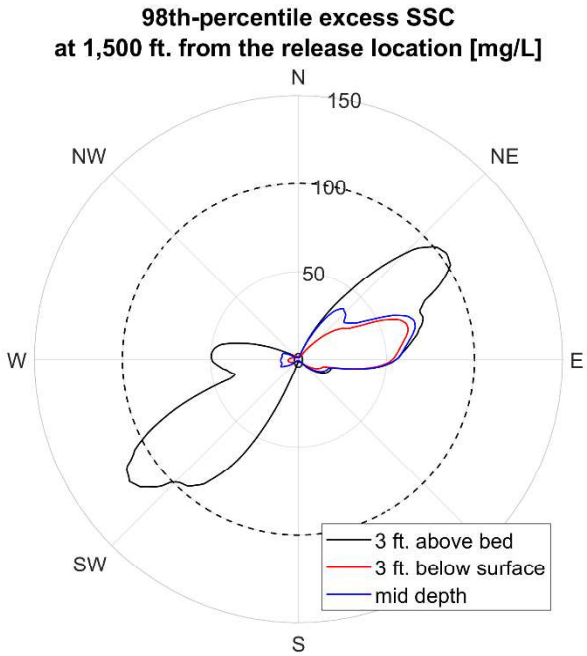
F.5.1 Sediment footprint without waves



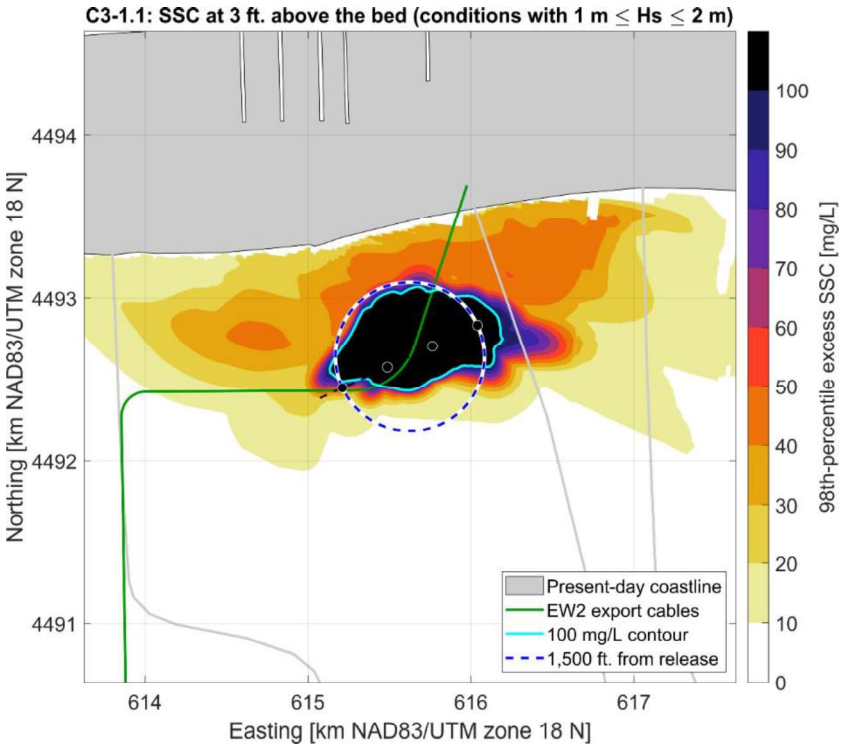

C3-1.1: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
1,500 ft. from release

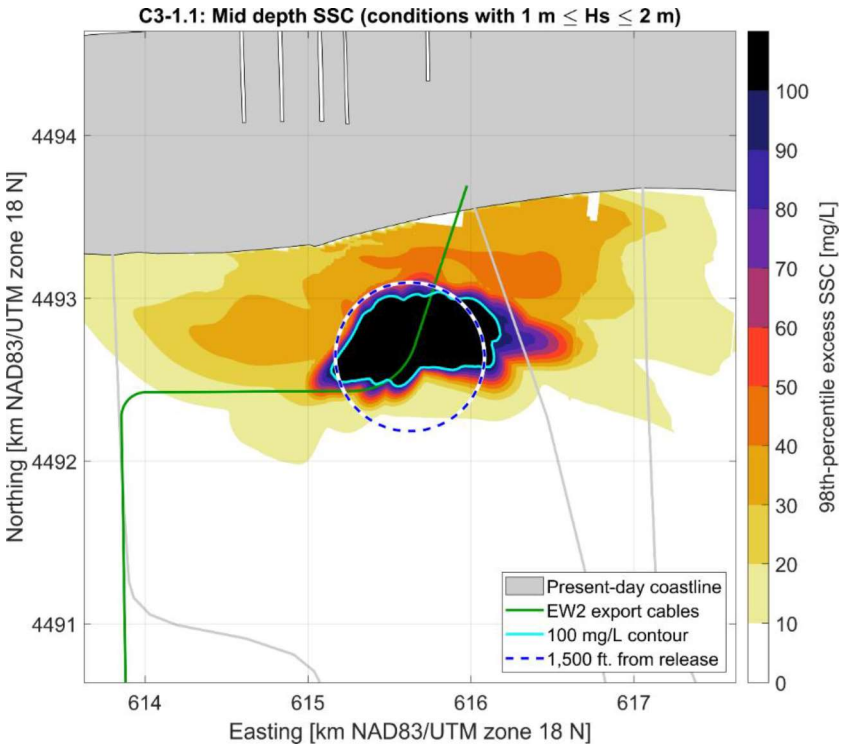

C3-1.1: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
1,500 ft. from release

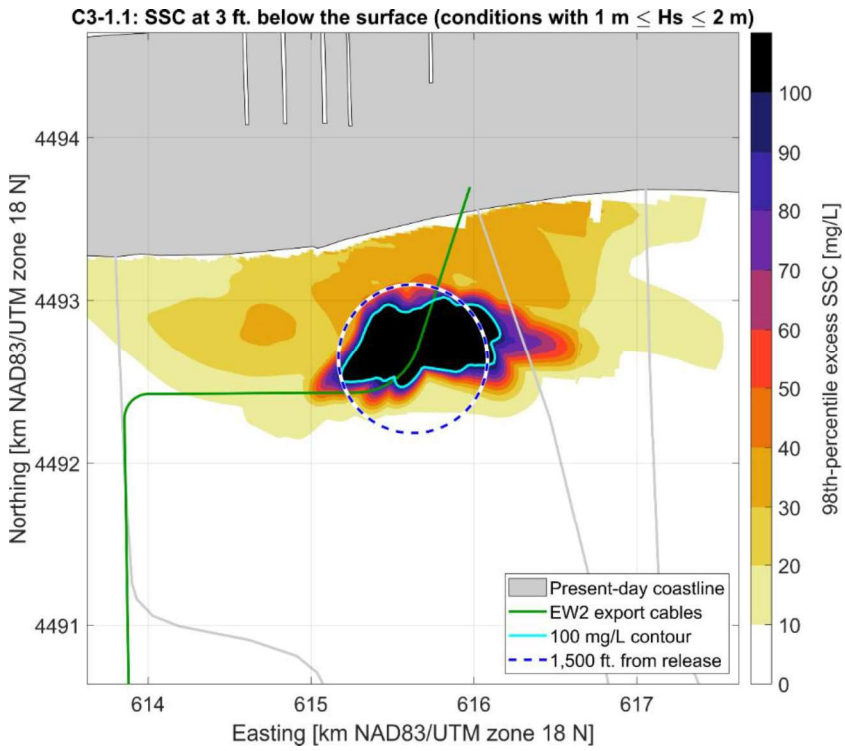

KPC3-1.1: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
Distance along transect [m]
positive direction pointing towards 233°N from release location
98th-percentile excess SSC [mg/L]

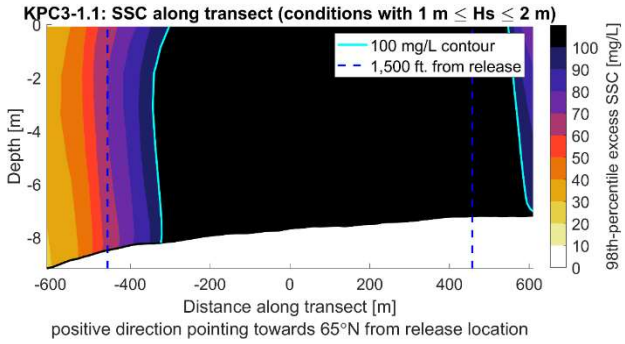

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

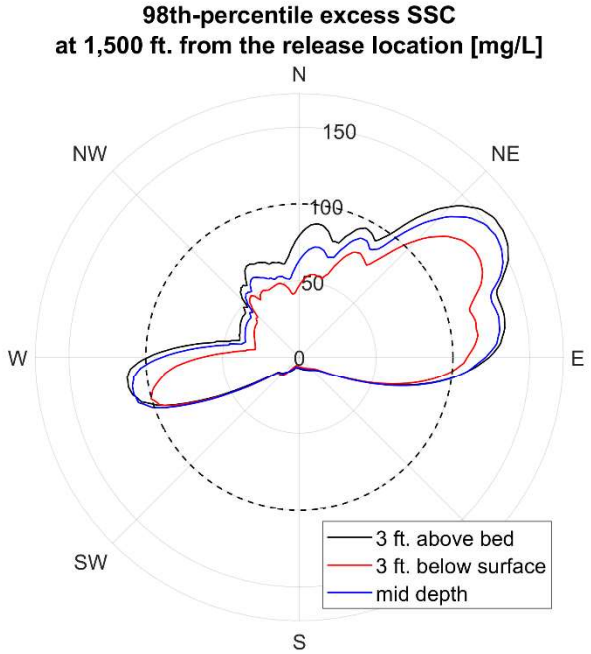
F.5.2 Sediment footprint with waves



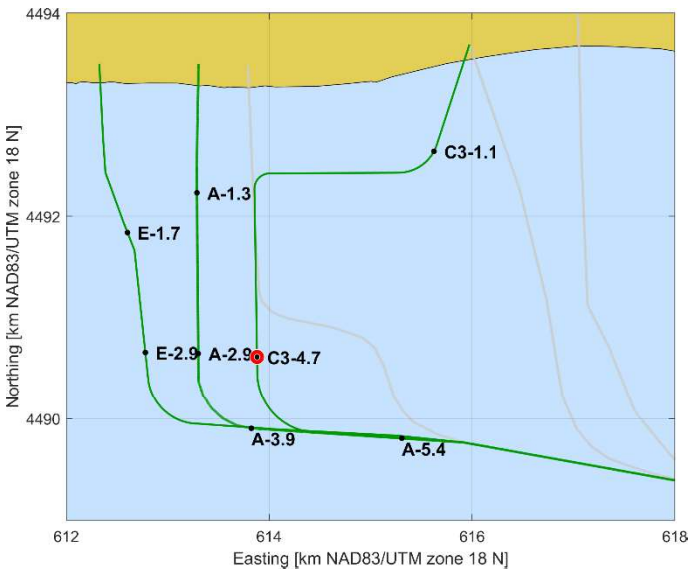



C3-1.1: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

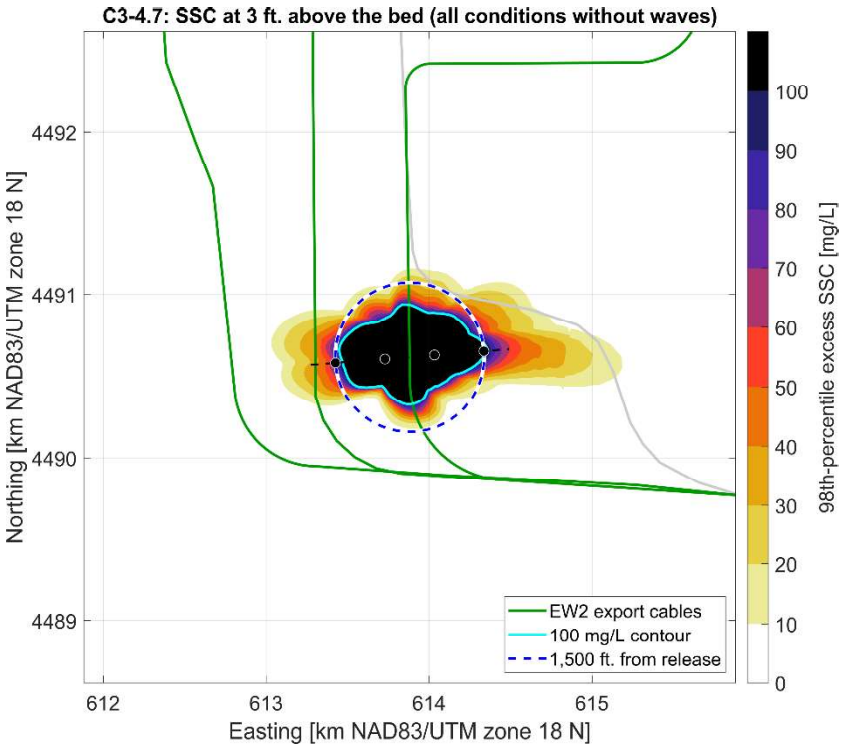

KPC3-1.1: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
Distance along transect [m]
positive direction pointing towards 65°N from release location
98th-percentile excess SSC [mg/L]
100 mg/L contour
1,500 ft. from release

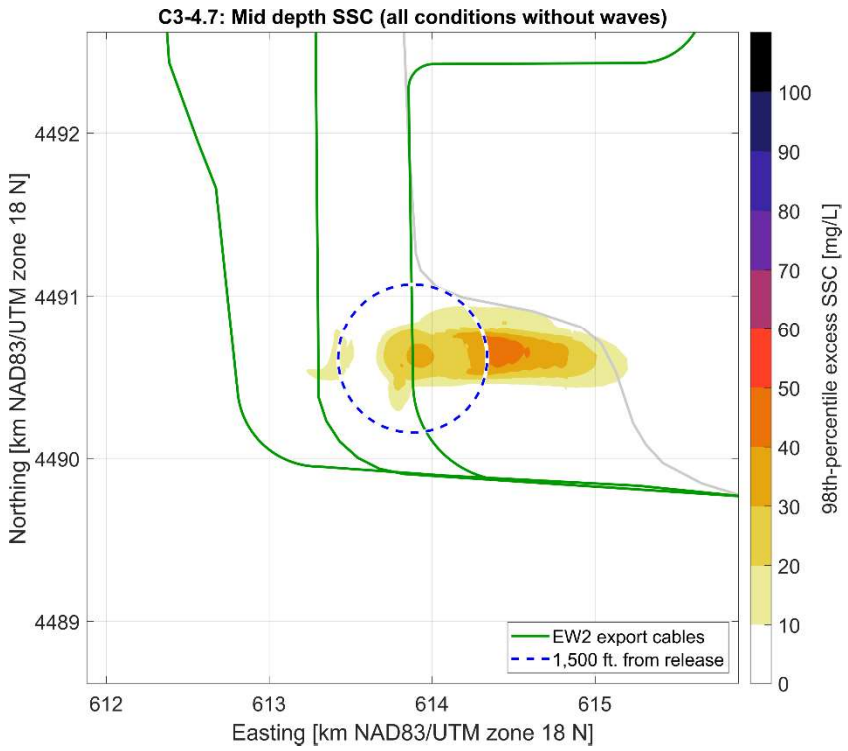

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
3 ft. above bed
3 ft. below surface
mid depth

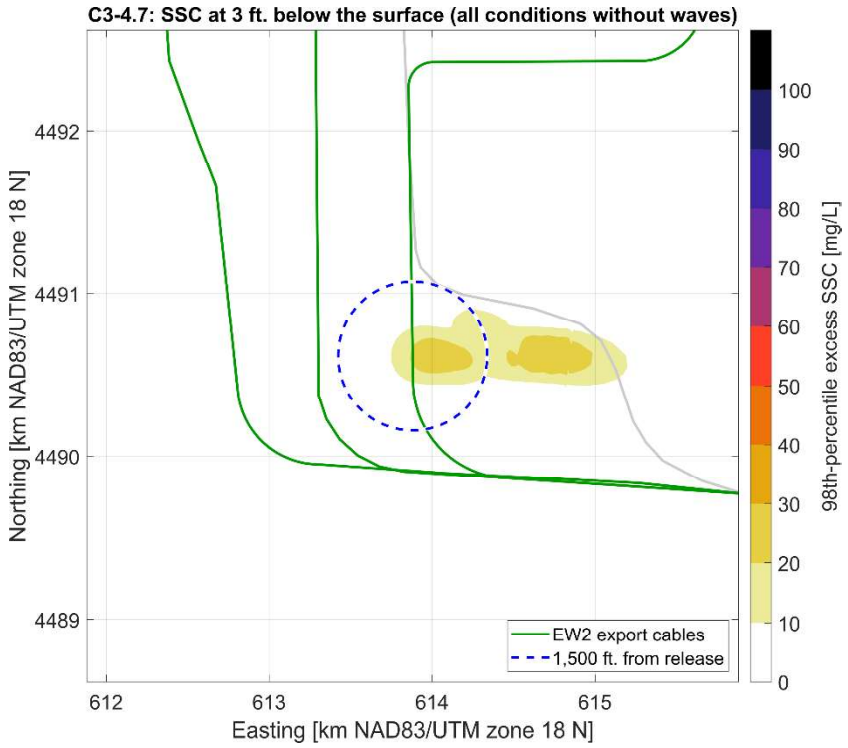
F.6 Release location C3-4.7

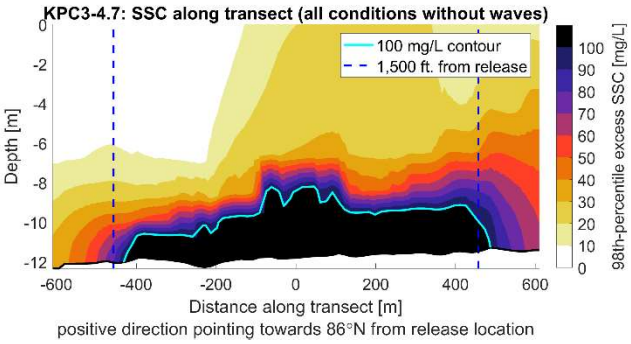


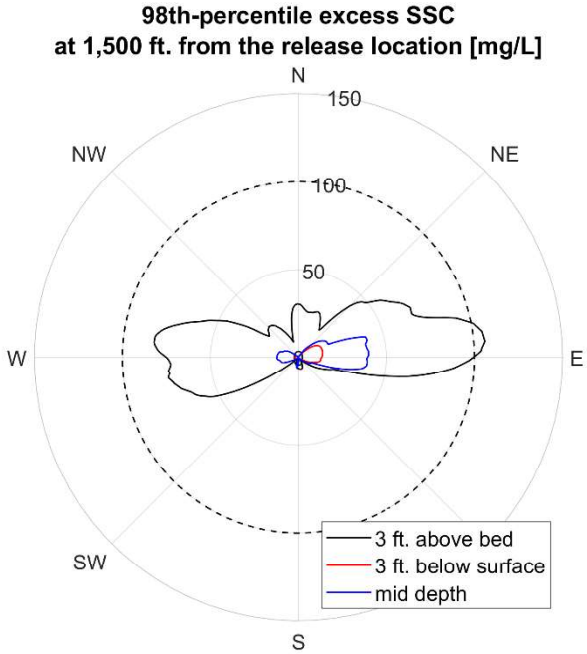
F.6.1 Sediment footprint without waves



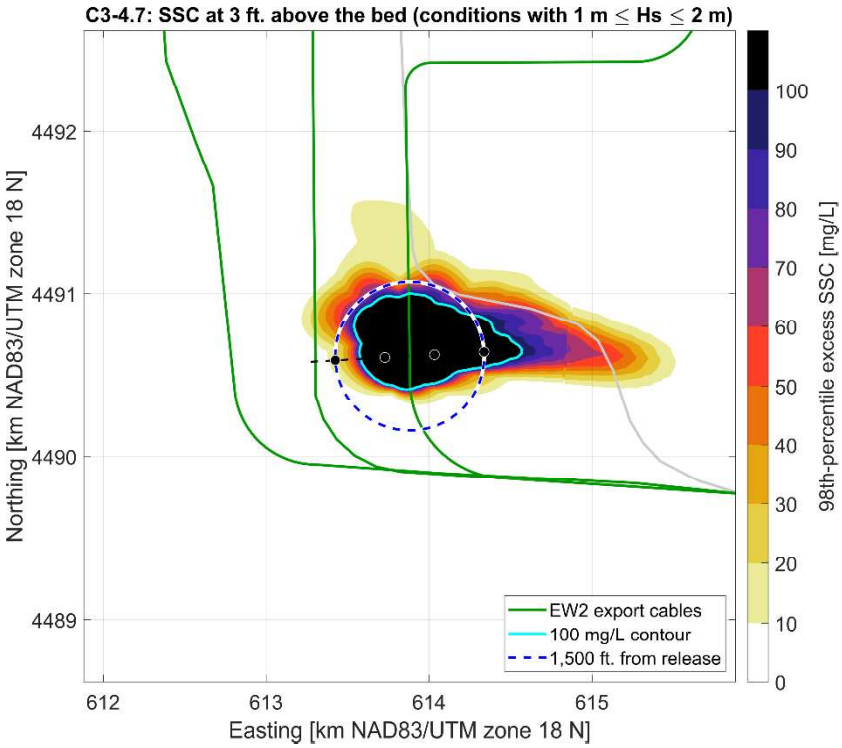

C3-4.7: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

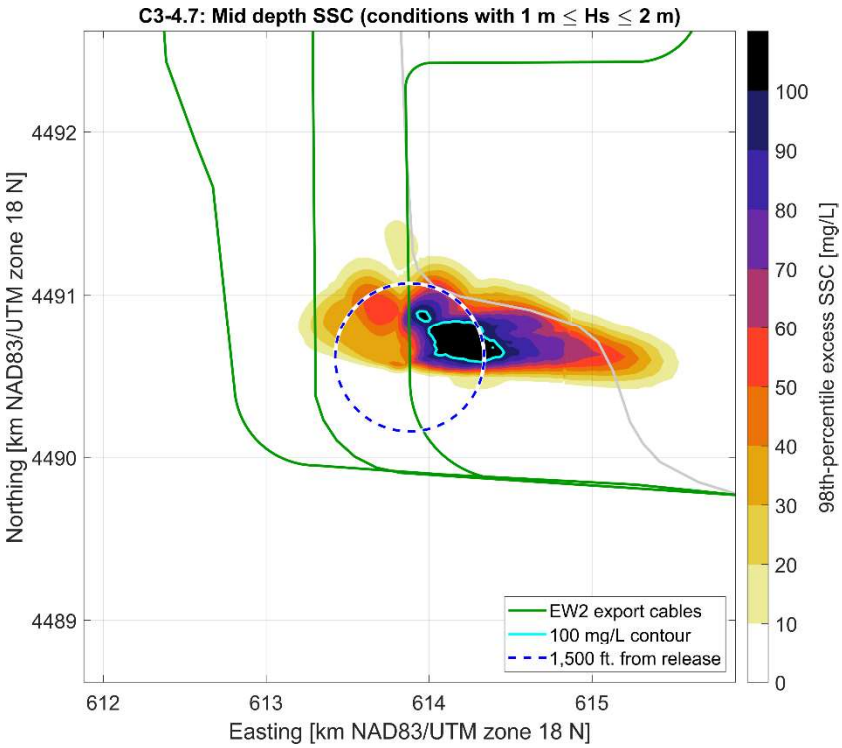

C3-4.7: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

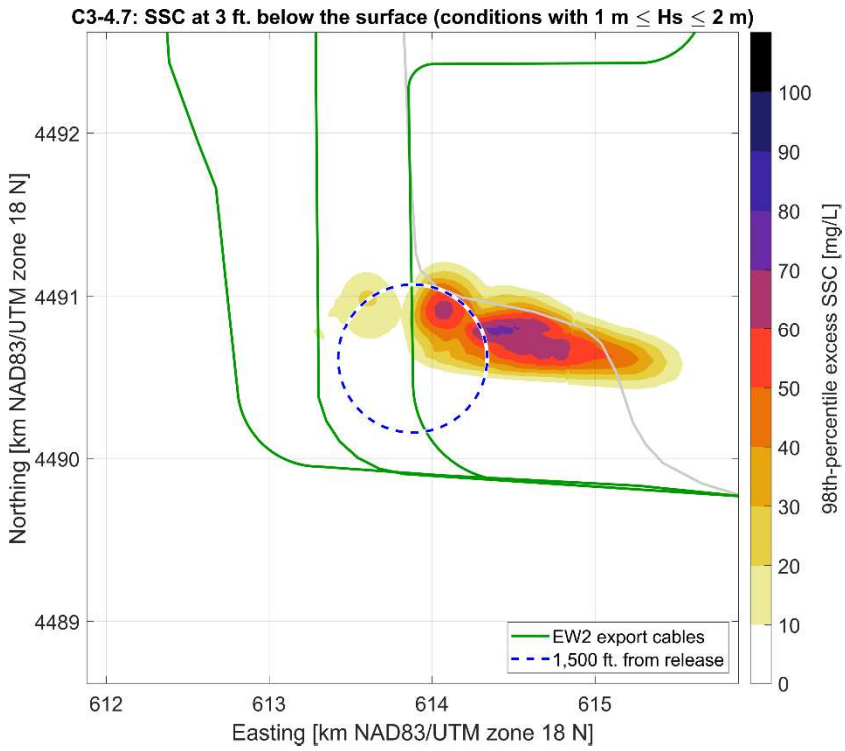

KPC3-4.7: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 86°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

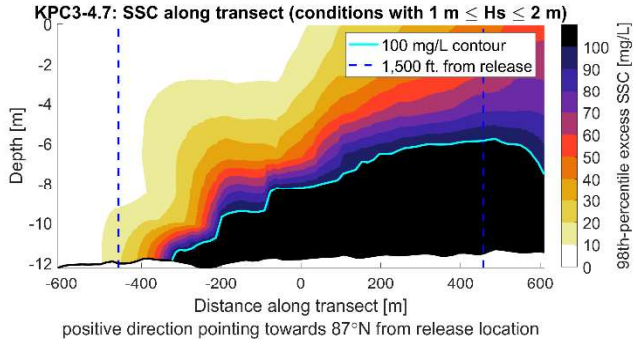

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

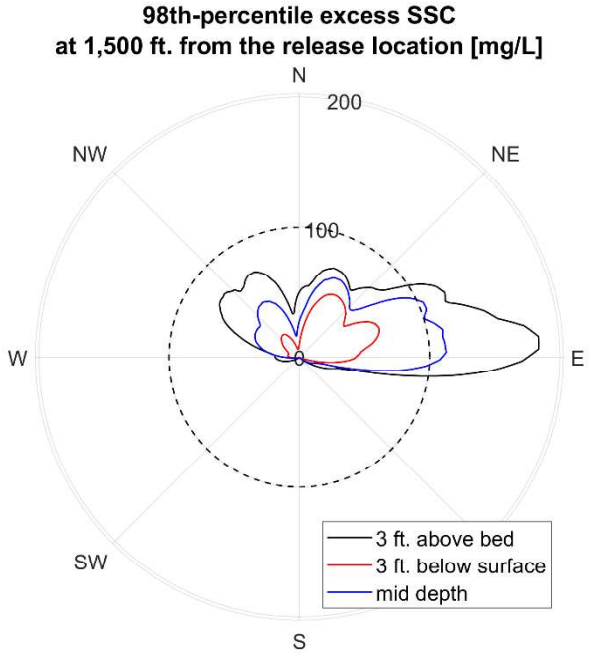
F.6.2 Sediment footprint with waves



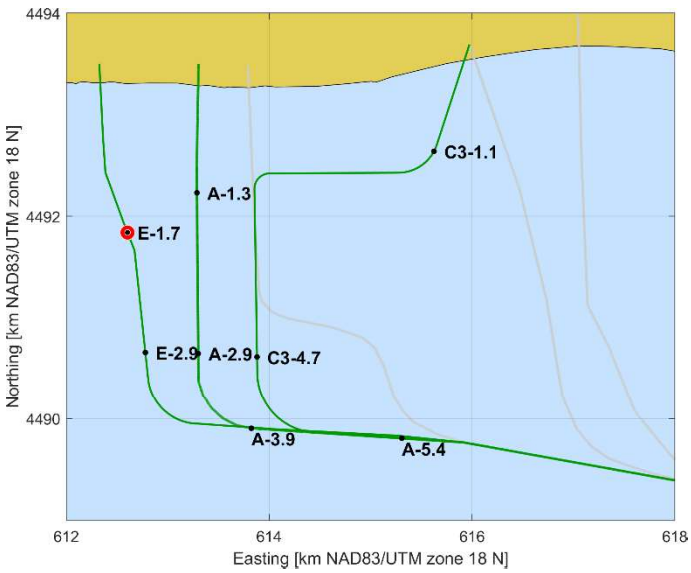



C3-4.7: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
612
613
614
615
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

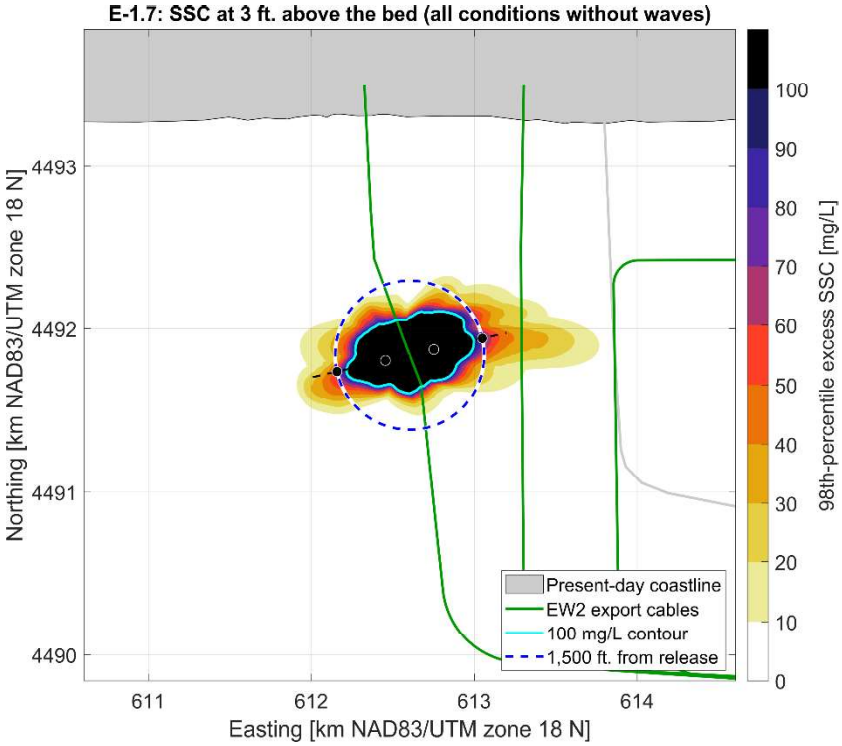

KPC3-4.7: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 87°N from release location
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

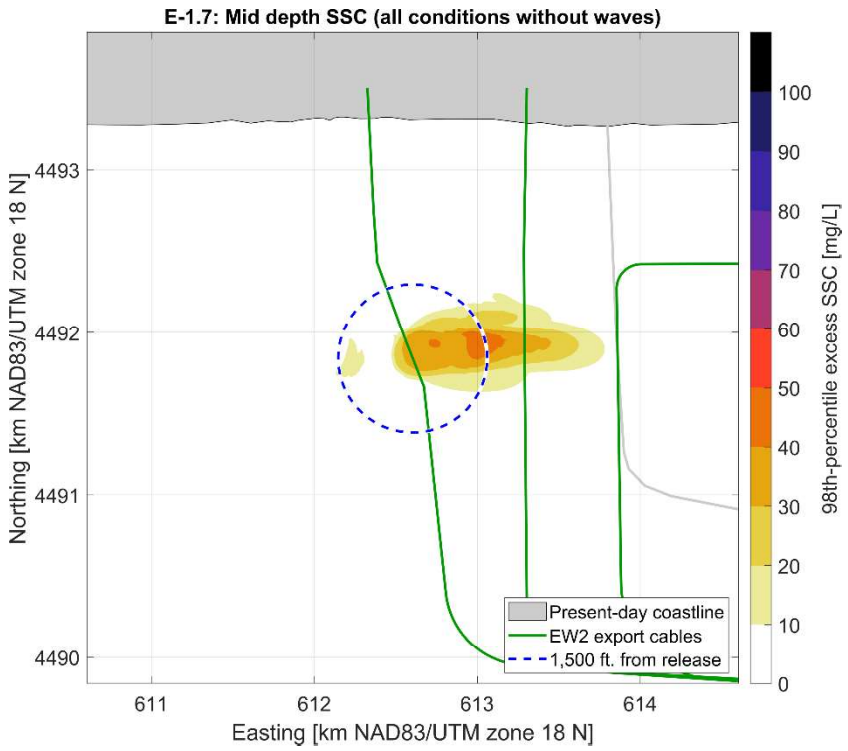

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
200
100
0
3 ft. above bed
3 ft. below surface
mid depth

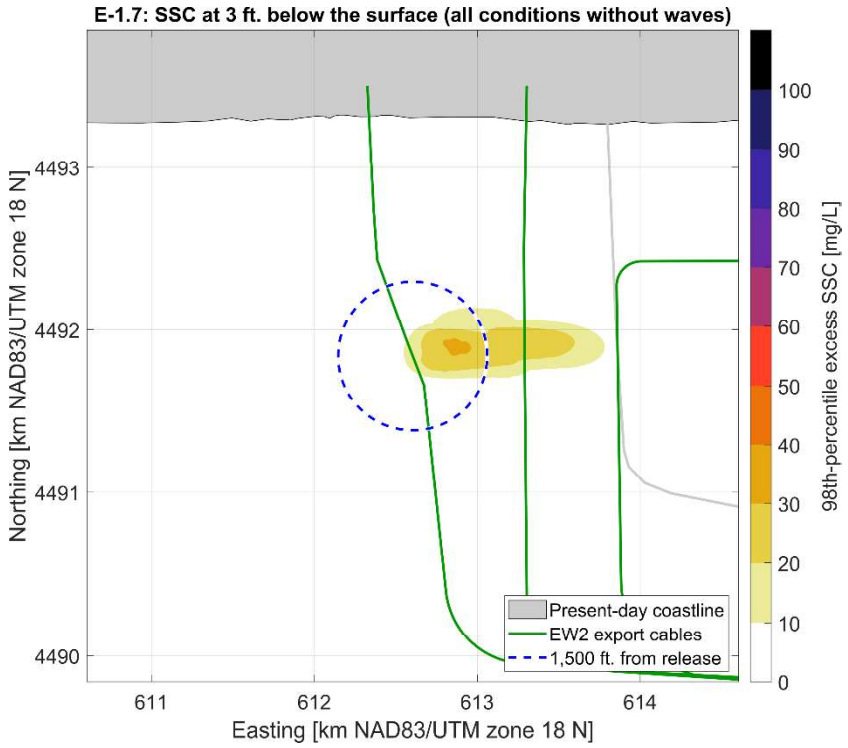
F.7 Release location E-1.7

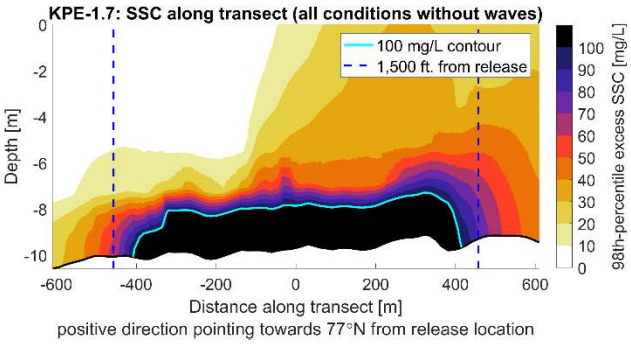


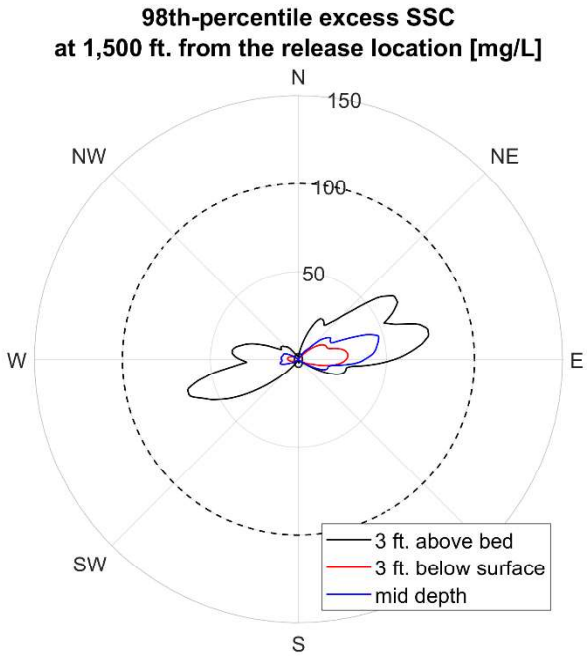
F.7.1 Sediment footprint without waves



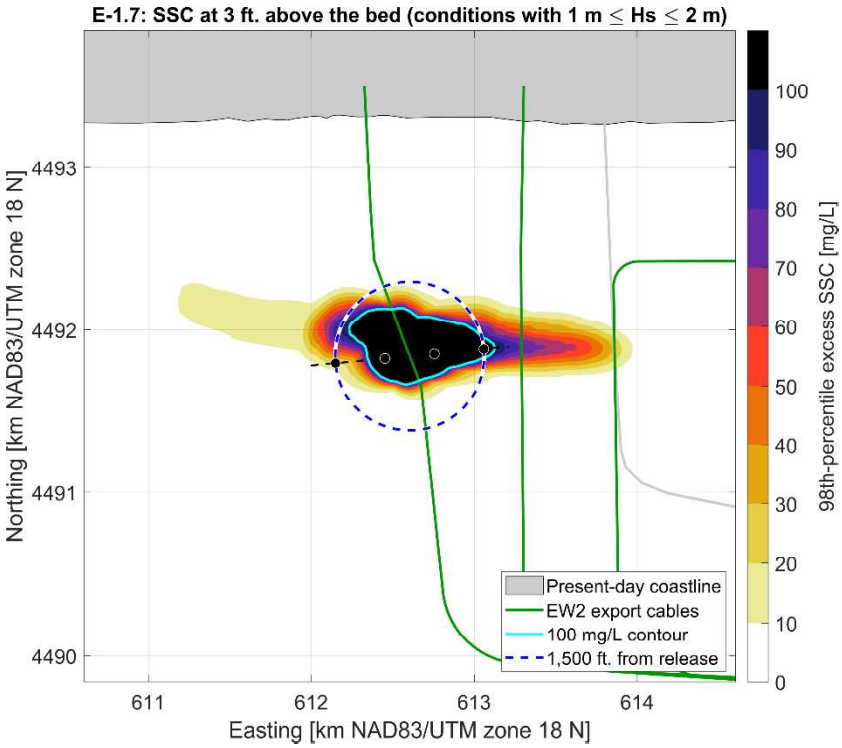

E-1.7: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4493
4492
4491
4490
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0
Present-day coastline
EW2 export cables
1,500 ft. from release

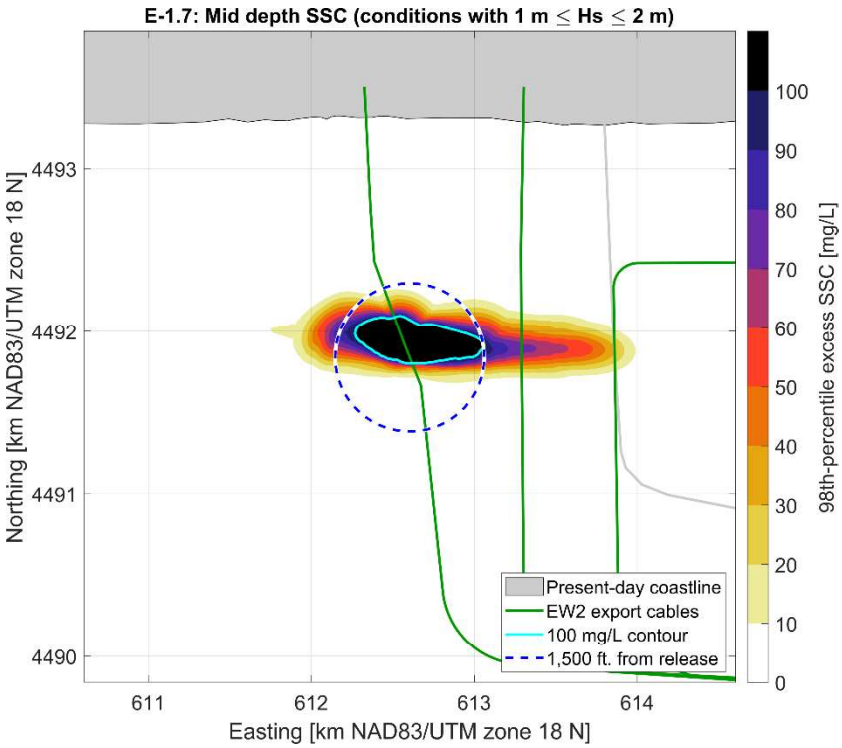

E-1.7: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4493
4492
4491
4490
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0
Present-day coastline
EW2 export cables
1,500 ft. from release

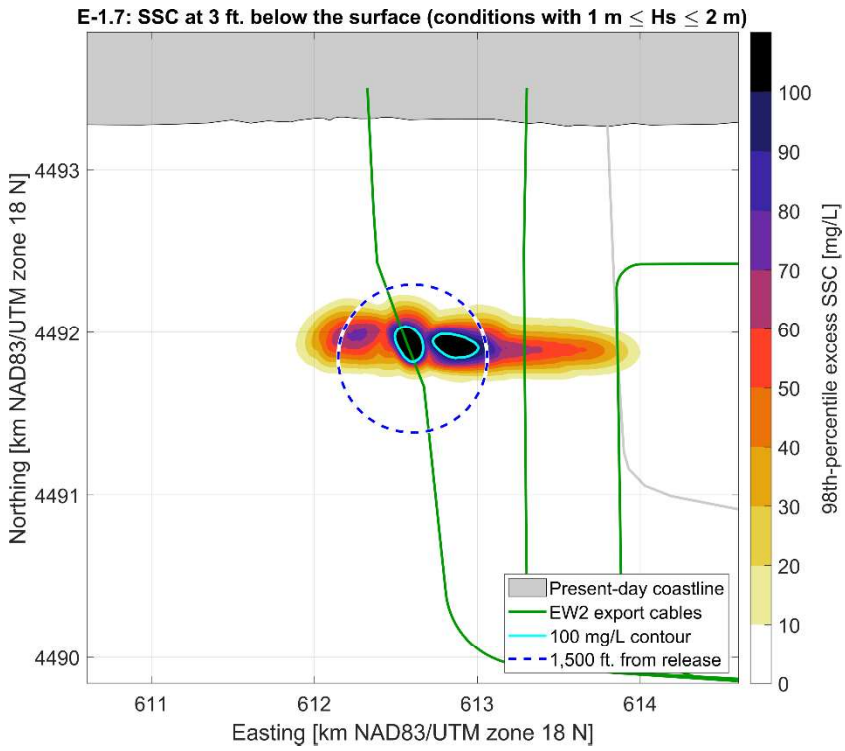

KPE-1.7: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 77°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

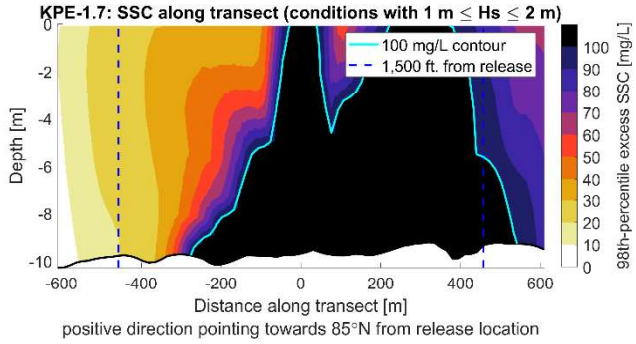

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

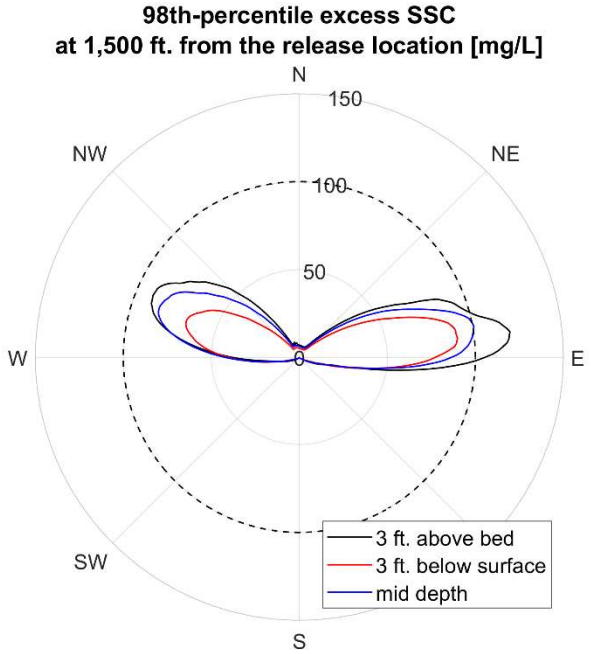
F.7.2 Sediment footprint with waves



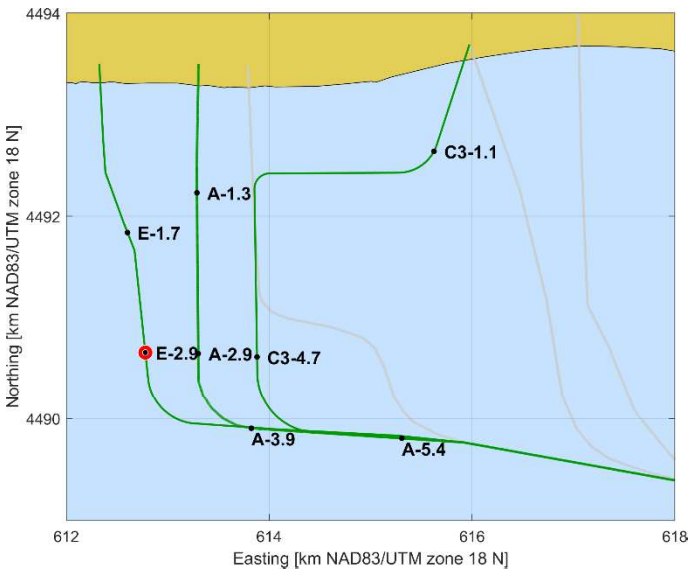



E-1.7: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
4493
4492
4491
4490
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0
Present-day coastline
EW2 export cables
100 mg/L contour
1,500 ft. from release

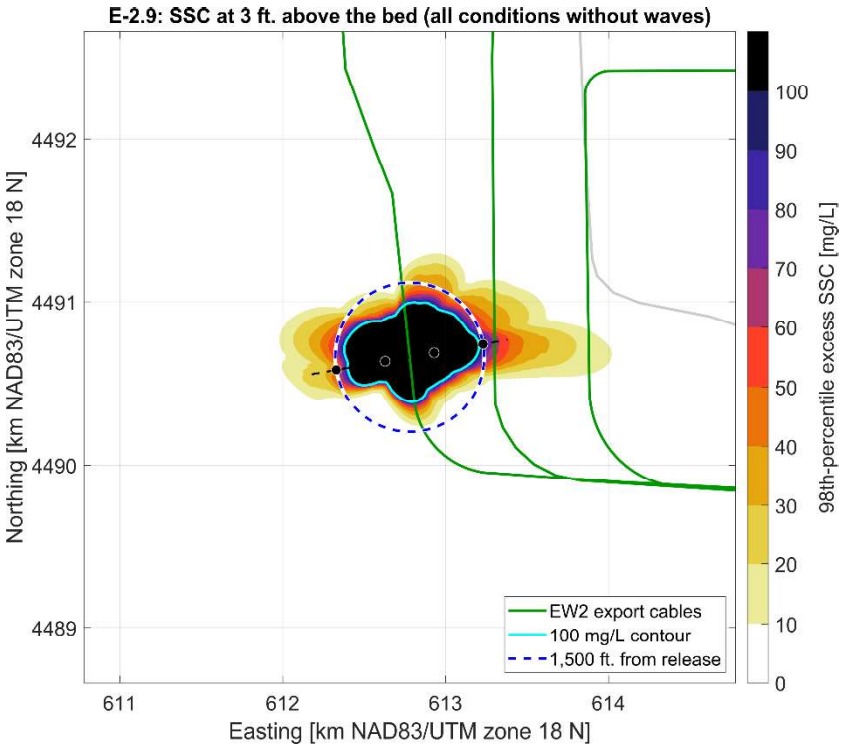

KPE-1.7: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
Depth [m]
0
-2
-4
-6
-8
-10
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 85°N from release location
100 mg/L contour
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

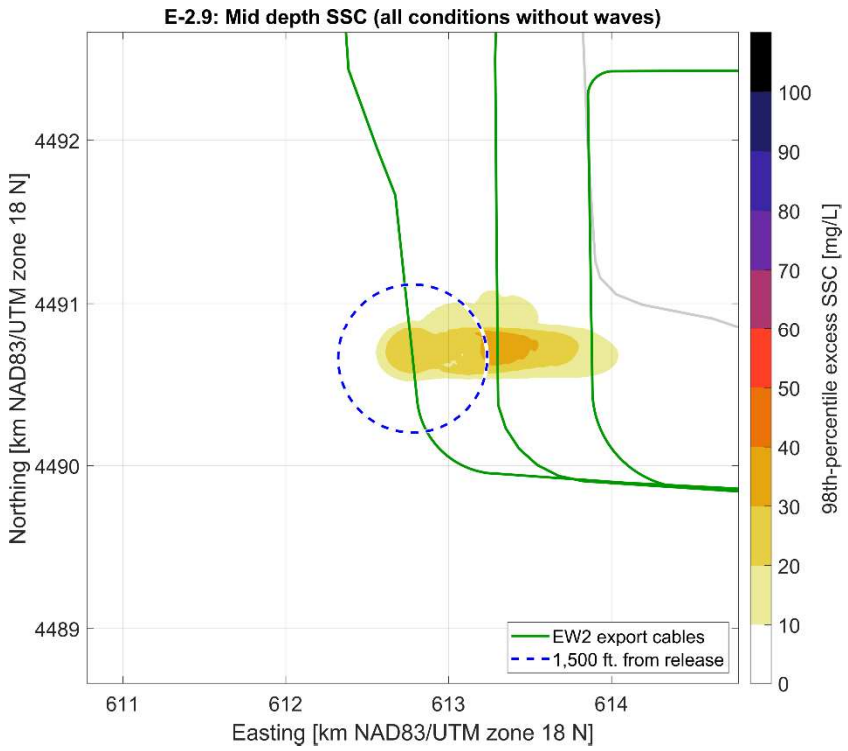

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

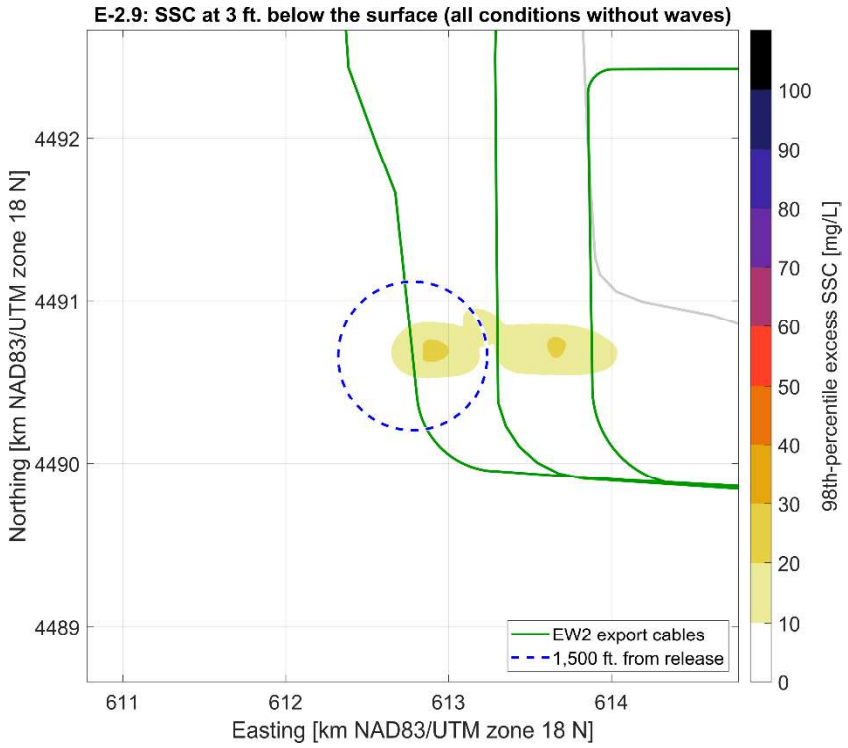
F.8 Release location E-2.9

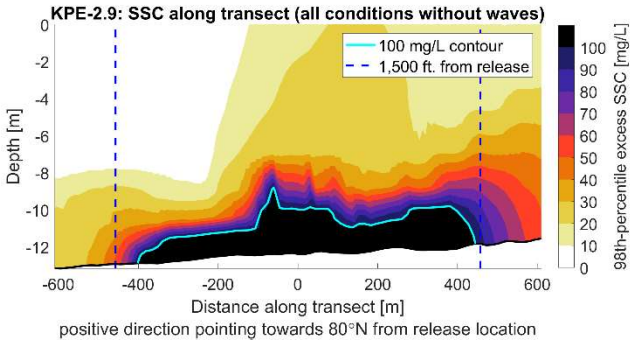


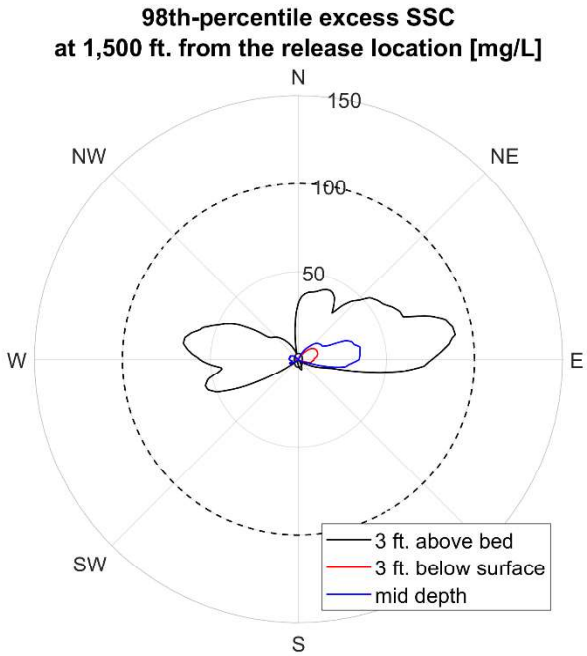
F.8.1 Sediment footprint without waves



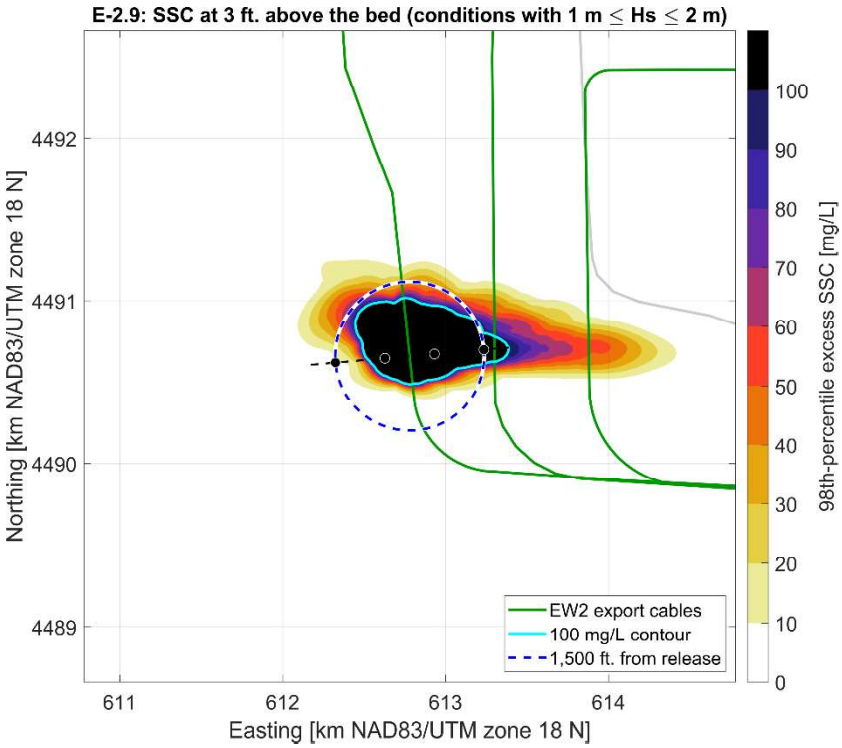

E-2.9: Mid depth SSC (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

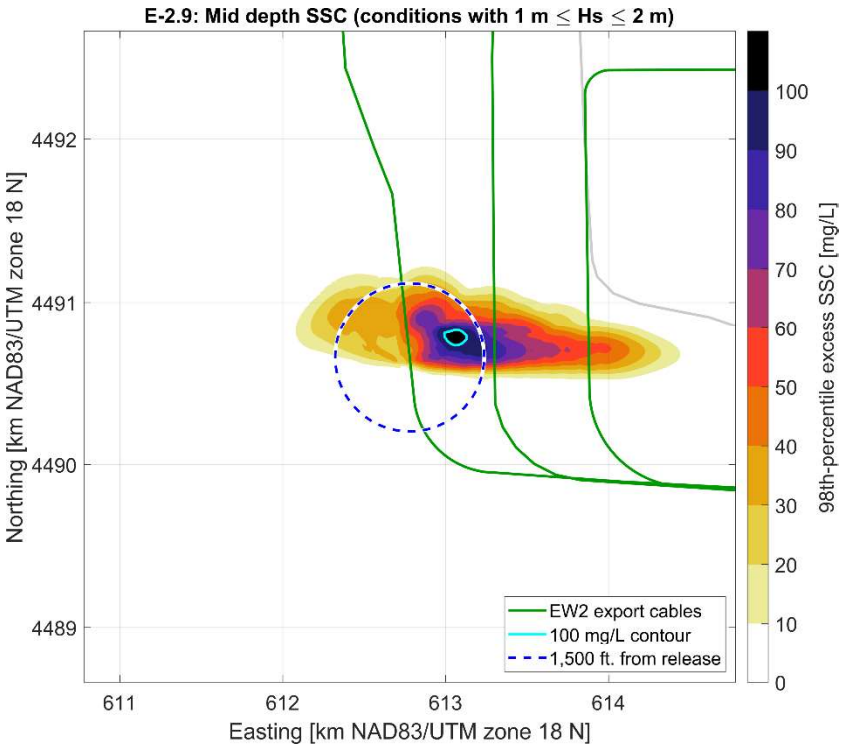

E-2.9: SSC at 3 ft. below the surface (all conditions without waves)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

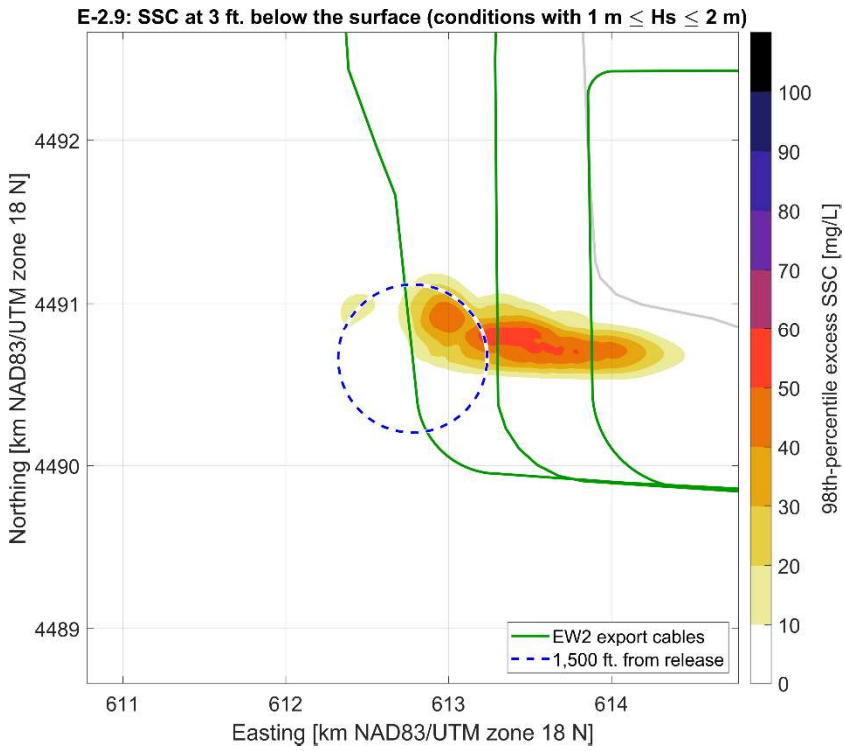

KPE-2.9: SSC along transect (all conditions without waves)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 80°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0

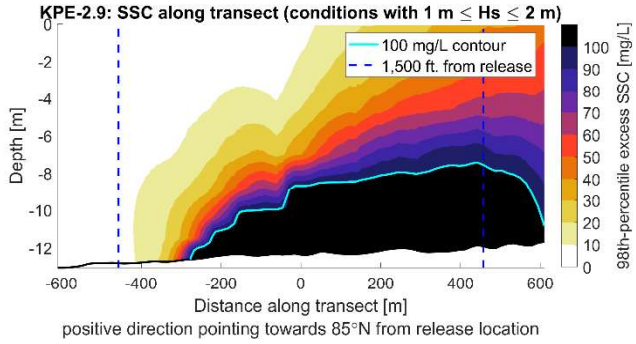

98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
3 ft. above bed
3 ft. below surface
mid depth

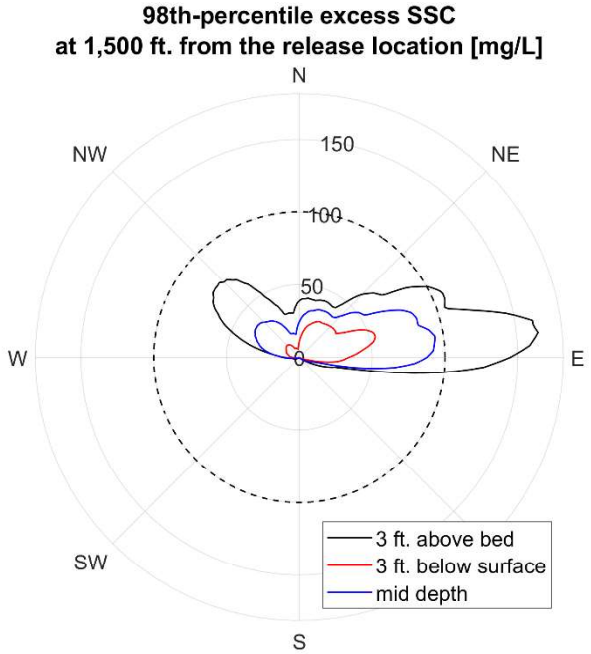
F.8.2 Sediment footprint with waves






E-2.9: SSC at 3 ft. below the surface (conditions with 1 m ≤ Hs ≤ 2 m)
Northing [km NAD83/UTM zone 18 N]
4492
4491
4490
4489
611
612
613
614
Easting [km NAD83/UTM zone 18 N]
EW2 export cables
1,500 ft. from release
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


KPE-2.9: SSC along transect (conditions with 1 m ≤ Hs ≤ 2 m)
100 mg/L contour
1,500 ft. from release
Depth [m]
0
-2
-4
-6
-8
-10
-12
-600
-400
-200
0
200
400
600
Distance along transect [m]
positive direction pointing towards 85°N from release location
98th-percentile excess SSC [mg/L]
100
90
80
70
60
50
40
30
20
10
0


98th-percentile excess SSC
at 1,500 ft. from the release location [mg/L]
N
NE
E
S
SW
W
NW
150
100
50
0
3 ft. above bed
3 ft. below surface
mid depth

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Attachment C-2
Sediment Transport Analysis

Empire Wind 2 Project

Sediment Transport Analysis

Prepared for:

Empire Offshore Wind LLC
600 Washington Boulevard, Suite 800
Stamford, Connecticut 06901

Prepared by:

10 Post Office Square, Suite 1100
Boston, MA 02109

August 2023

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ACRONYMS AND ABBREVIATIONS

BOEM	U.S. Bureau of Ocean Energy Management
cm	centimeter
cm/s	centimeters per second
Empire or the Applicant	Empire Offshore Wind LLC and EW Offshore Wind Transport Corporation
ESPreSSO	Experimental System for Predicting Shelf and Slope Optics
EW 2	Empire Wind 2
ft	foot
ft/s	feet per second
in	inch
km	kilometer
Lease Area	designated Renewable Energy Lease Area OCS-A 0512
m	meter
MFE	mass flow excavation
mg/L	milligrams per liter
mi	statute mile
mm	millimeter
MOCHA	Mid-Atlantic Climatological Hydrographic Analysis
nm	nautical miles
PDE	project design envelope
POI	point of interconnection
ROMS	Regional Ocean Modeling System
Tetra Tech	Tetra Tech, Inc.
TSS	total suspended solids
USGS	United States Geological Survey

1 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) was contracted by Empire Offshore Wind LLC and EW Offshore Wind Transport Corporation (collectively, Empire or the Applicant) to evaluate the potential suspended sediment, transport and deposition associated with Empire Wind 2 (EW 2) Project construction activities, including installation of submarine export cables. Disturbance of sediments during EW 2 Project construction has the potential to affect water quality through increases to total suspended solids into the water column and deposition of sediments away from the location of sediment disturbance, including potentially outside the EW 2 Project Area (i.e. submarine export cable corridor) through resuspension, dispersal, and subsequent sedimentation.

In order to provide a conservative estimate of potential maximum suspended sediment transport and deposition impacts, publicly available sediment and water circulation data covering the EW 2 Project Area was used to develop the sediment transport model. The modeling was undertaken to quantify potential maximum plume dispersion; suspended sediment concentrations; and potential maximum sediment deposition thicknesses that may occur due to EW 2 Project construction.

The sediment transport assessment contained herein includes a description of the EW 2 Project components that were evaluated (Section 1.1); a discussion of the modeling approach undertaken (Section 2); a summary of the data sources and associated hydrodynamic and sediment characteristics applied (Section 3); a description of the model runs executed (Section 4); and results of the analysis and associated conclusions (Sections 5 and 6).

1.1 EW 2 Project Description

The offshore wind farm will be located in Bureau of Ocean Energy Management (BOEM)-designated Renewable Energy Lease Area OCS-A 0512 (Lease Area), which is approximately 14 miles (mi, 12 nautical miles [nm], 22 kilometers [km]) south of the southern shore of Long Island. The EW 2 Project submarine export cables come ashore from the Atlantic Ocean within the City of Long Beach, New York (**Figure 1**).

Based on current understanding of site-specific conditions along the submarine export cable route to shore (submarine export cable corridor), Empire is currently anticipating jetting[3], mechanical plowing, and mechanical trenching as the primary cable burial methodologies. In areas where these methods cannot be employed due to deeper burial requirements or other challenges such as vessel draft requirements, dredging or mass flow excavation (MFE) may be employed. In general, the submarine export cables will be buried to a target depth of 6 feet [ft] (1.8 meters [m])[4] below the seabed surface, and installation will often be to a depth of 8 ft (2.5 m) to account for immediate sediment settling and to achieve the target burial depth.

[3] Jetting includes jet plowing and vertical injection; jet plowing is modeled as the primary jetting method as it provides more conservative values for sediment modeling.
[4] Based upon guidance provided by the U.S. Army Corps of Engineers in letters dated September 20, 2018, and August 20, 2020, submarine export cables will be buried to a minimum target burial depth of 15 ft (4.7 m) below the current (and future) authorized depth or depth of existing seabed (whichever is deeper) of federally maintained navigation features (e.g., anchorages and shipping channels).

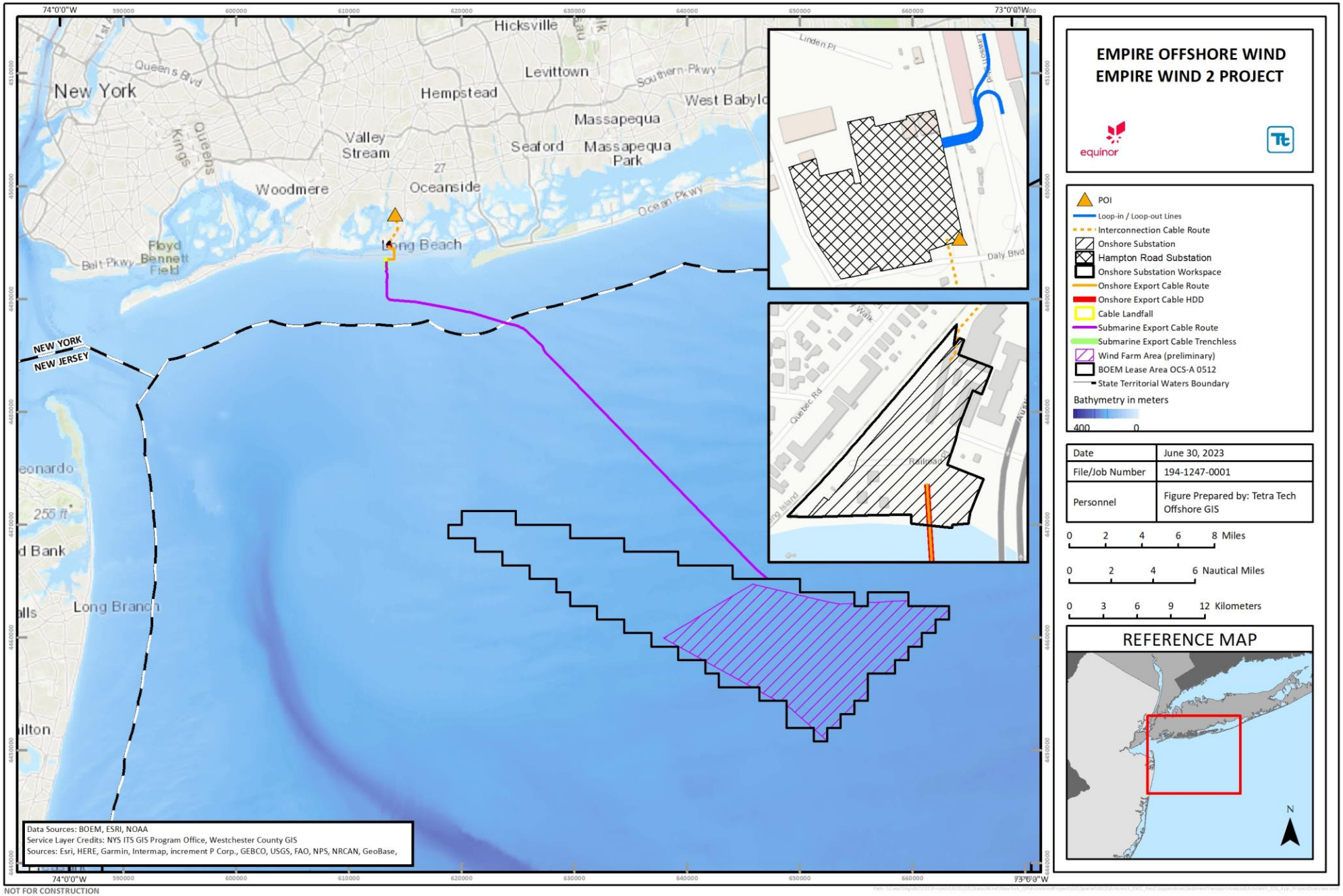

Figure 1 EW 2 Project Overview

1.2 Modeling Assumptions and the EW 2 Project Design Envelope Approach

In order to evaluate how submarine export cable installation will affect suspended sediment concentrations, and transport and deposition, Tetra Tech conducted a sediment transport analysis of the Project. Results from a previously developed publicly available hydrodynamic model were used to gather information regarding current velocity and direction in the Lease Area and submarine export cable siting corridor (EW 2 Project Area). An analytical sediment transport model was developed to predict the fate and transport of sediment suspended by cable installation along the submarine export cable routes. Tetra Tech used existing publicly available sediment data to inform the analytical model.

The analytical model adopted a project design envelope[5] (PDE) (maximum design scenario) approach to evaluate the effects of proposed submarine export cable burial activities in terms of suspended sediment concentrations in the water column and sediment transport and deposition characteristics, such as deposition depth and sediment footprint, to assess potential EW 2 Project effects on surrounding water quality and habitats. The model simulated installation impacts of one trench, although two trenches will be installed during construction and an additional run may be conducted as part of the pre-construction activities (i.e. pre-trenching); the trenches will be conducted at separate times, however. The model simulated jet plow installation, the installation method proposed to be utilized for most of the submarine export cable route, which would result in greater disturbance of marine sediments than mechanical plow or mechanical cutter installation. Jet plowing therefore provides the maximum expected disturbance of seabed sediment in the EW 2 Project Area. This approach is consistent with BOEM's *Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan* (BOEM 2018). This approach provides the EW 2 Project reasonable flexibility to make prudent development and design decisions prior to construction. Therefore, for the purpose of this analysis, the EW 2 Project has assumed the following as the maximum design scenario:

- One proposed submarine export cable route;
- The use of a jet plow[6], since this is anticipated to be the cable installation method used for the majority of the submarine export cable installation and associated pre-installation activities (i.e. pre-trenching);
  - A trench depth for the submarine export cables of 8 ft (2.5 m);
- Activities during construction capture the maximum scenario for sediment disturbance where the disturbance is expected to be equal to or greater than that associated with operations or decommissioning activities; and
- EW 2 Project activities during operations may include inspection and repair of subsea infrastructure (i.e., cables); however, any impacts are expected to be less than those anticipated during construction since they would only involve a portion of the overall EW 2 Project. Thus, this assessment focuses on activities and impacts during the construction phase of the EW 2 Project.

[5] Empire has adopted a 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 [or 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).

[6] The jet plow's water nozzle temporarily loosens the soil, creating a narrow trench. The cable is fed into this trench as the plow moves along the ocean floor. Marine sediment resettles upon the cable, closing the trench with minimal impact to the sea floor. However, some marine sediments may stay suspended in the water column, temporarily increasing total suspended solids, and dispersion of the sediments may cause material to deposit outside the area of disturbance.

2 MODELING APPROACH

The aim of this study is to evaluate the effects of proposed submarine export cable installation and burial activities in terms of suspended sediment concentrations in the water column and sediment deposition characteristics, such as deposition depth and sediment deposition footprint.

The modeling approach uses the publicly available Experimental System for Predicting Shelf and Slope Optics (ESPreSSO) hydrodynamic model to develop information regarding current velocity and flow direction in the EW 2 Project Area. This model has been used to obtain velocities and flows for other sediment transport models in the region (Tetra Tech 2015). ESPreSSO uses the Regional Ocean Modeling System (ROMS). ROMS is a three-dimensional, free-surface, terrain-following ocean model that solves the Reynolds-averaged Navier-Stokes equations using the hydrostatic vertical momentum balance and Boussinesq approximation (Haidvogel et al. 2000; Shchepetkin and McWilliams 2005). The ESPreSSO model domain extends from the center of Cape Cod, Massachusetts southwards to Cape Hatteras, North Carolina, with 3 mi (5 km) horizontal resolution and 36 terrain-following vertical levels. Approximately 95 percent of the EW 2 Project Area falls inside the model domain, which allows model outputs to be used to gather the circulation characteristics within the Lease Area and along the submarine export cable siting corridor. The current speed and direction from the ESPreSSO model help determine the path of the suspended sediments generated by submarine export cable jet plowing activities. More details about the hydrodynamic data used in the sediment transport model are provided in Section 3.1.

An analytical sediment transport model was developed to assess the suspended sediment water column concentrations and sediment deposition characteristics as a result of the submarine export cable jet plowing activities. Regional average sediment data such as density and grain size distribution were derived from previously conducted studies near the EW 2 Project Area (such as the Poseidon Project[7], **Figure 2**, ESS Group 2013). These sediment characteristics were used to inform the calculations of volume and concentrations of suspended sediment due to jet plowing operations.

Calculations were made along the submarine export cable siting corridors based on the different current velocities available from the ESPreSSO model and sediment characteristics from the Poseidon Project. More detail about the sediment characteristics and the analytical model is provided in Sections 3.2 and 4.1, respectively. The final results of the analytical model include the extent and duration of suspended sediment concentrations within the water column along the submarine export cable routes and the final sediment deposition thickness associated with the jet plowing operations.

[7] The Poseidon Project includes approximately 39.2 mi (63 km) of high-voltage direct-current submarine cable bundled with a fiber optic cable to be buried in the seafloor of Raritan Bay and the New York Bight with landfalls at Union Beach, in Monmouth County, New Jersey and Jones Beach on Long Island in Suffolk County, New York. This export cable route covers approximately 70 percent of the submarine export cable evaluation area within 3 nautical miles of Long Island, New York. Sediment data is available for 47 different locations along the submarine export cable route.

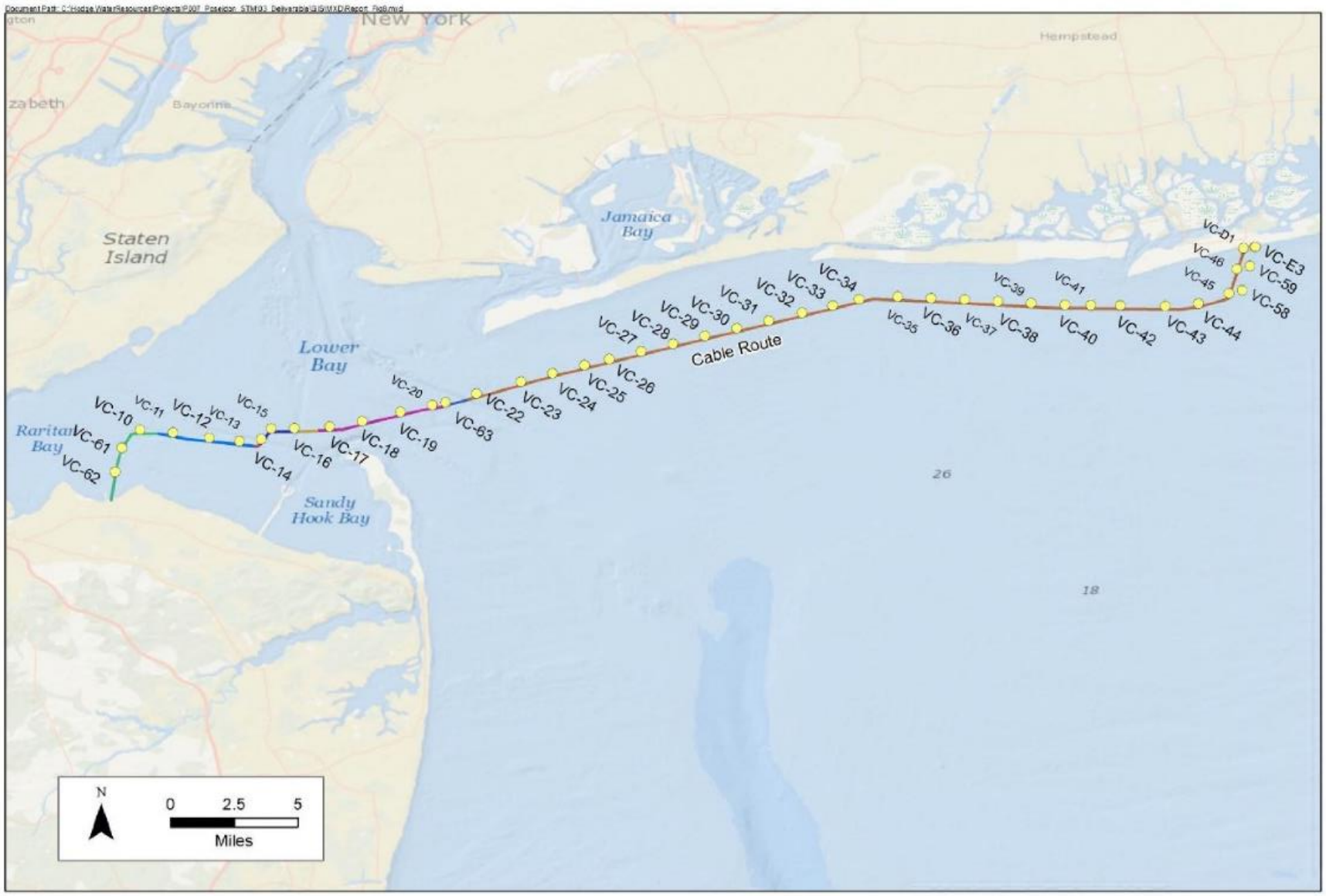

Figure 2 Location of sediment sampling locations for the Poseidon Project (Source: ESS Group 2013)

3 DATA SOURCES

3.1 Hydrodynamic Data

As part of the effort to evaluate the variability of ocean currents within the Lease Area and along the submarine export cable routes, Tetra Tech looked at the precipitation record of Eatontown 1.2 NE (Station US1NJMN0010) located in Monmouth County, New Jersey, approximately 31 mi (50 km) west of the Lease Area. Eatontown has a data coverage of 95 percent and was therefore selected to evaluate the precipitation conditions around the EW 2 Project Area, with precipitation being a proxy for freshwater outflows from major rivers (river flow volume can influence flood and ebb current speeds in nearshore areas). Precipitation data were available for 10 years (2009 through 2018). Total precipitation for each year and the 10-year average of precipitation were calculated (**Table 1**). A normal precipitation year (neither wet or dry) was selected to represent current (velocity) conditions within the Lease Area and along the submarine export cable route. The ESPreSSO model contains hourly velocity outputs from October 2009 through October 2013. To ensure that the ocean current variability was accurately represented, different years were evaluated based on their total annual precipitation and the availability of velocity outputs from the ESPreSSO model. Year 2012 was chosen as a representative year to evaluate the current conditions for the EW 2 Project Area because the velocity data was available for the full year for the ESPreSSO model and the 2012 total annual precipitation at Eatontown was similar to the 10-year total annual precipitation average calculated using data from Eatontown (i.e., normal precipitation).

Table 1 Yearly Precipitation at Eatontown 1.2 NE, New Jersey

Year	Total Annual Precipitation (in)
2009	48.86
2010	37.59
2011	54.88
2012 a/	38.56
2013	36.54
2014	53.22
2015	34.86
2016	37.66
2017	48.52
2018	70.78
Average	46.15

Note:
a/ 2012 was selected for the sediment transport analysis.

The ESPreSSO model uses ROMS, which is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications. ROMS is an open-source model that is developed and supported by researchers at the Rutgers University, University of California Los Angeles and contributors worldwide. (Haidvogel et al. 2000; Marchesiello et al. 2003; Peliz et al. 2003). ESPreSSO open boundary values are taken from global HYbrid Coordinate Ocean Model (HYCOM) with adjustments using Mid-Atlantic Climatological Hydrographic Analysis (MOCHA) climatology and the addition of harmonic tides (Mukai et al. 2002). Meteorology forcing is taken from the North American Mesoscale model. Inflows for the seven largest rivers entering the model are from daily average U.S. Geological Survey (USGS) discharge data.

Strong constraint four-dimensional variational (4D-Var) data assimilation (Moore et al. 2011) is used to incorporate satellite sea surface height from Jason-2, satellite sea surface temperature from infrared and microwave radiometers, monthly MOCHA temperature, salinity, climatology, and hourly Coastal Ocean Dynamics Applications Radar surface currents (Zavala-Garay et al. 2012).

The ESPreSSO data set includes hourly simulations covering the period from October 2009 through February 2014.[8] The ESPreSSO model provides velocity, salinity, and temperature outputs at regularly spaced output stations throughout the EW 2 Project Area. Hourly bottom velocity outputs at ESPreSSO model stations located within the EW 2 Project Area were downloaded for the year 2012. A rolling 4-hour average velocity was calculated at each hourly time step for all stations. The 90th percentile of the rolling 4-hour average ebb and flood velocities was selected to represent the potential high velocities during these tidal periods. To represent the variability in the flow throughout the EW 2 Project Area, data from stations closest to the submarine export cable routes and Lease Area were selected and paired with the sediment data in the analytical model.

The velocity stations used in the analytical sediment transport model are shown in **Figure 3**. All stations close to the river mouth were assigned "Riverine" zone and the rest were assigned "Non-Riverine" zone (this included consideration of Hudson/Passaic river flows associated with the New York/New Jersey Harbor). All EW 2 Project stations in New York waters are considered "Non-Riverine." **Table 2** lists the representative flood and ebb velocities at all the stations in the EW2 Project Area in New York waters. Both ebb and flood velocities were used to calculate the possible maximum extent of sediment deposition and suspended sediment water column concentrations within the EW 2 Project Area under these conditions.

[8] Model information can be accessed at http://www.myroms.org/espresso/.

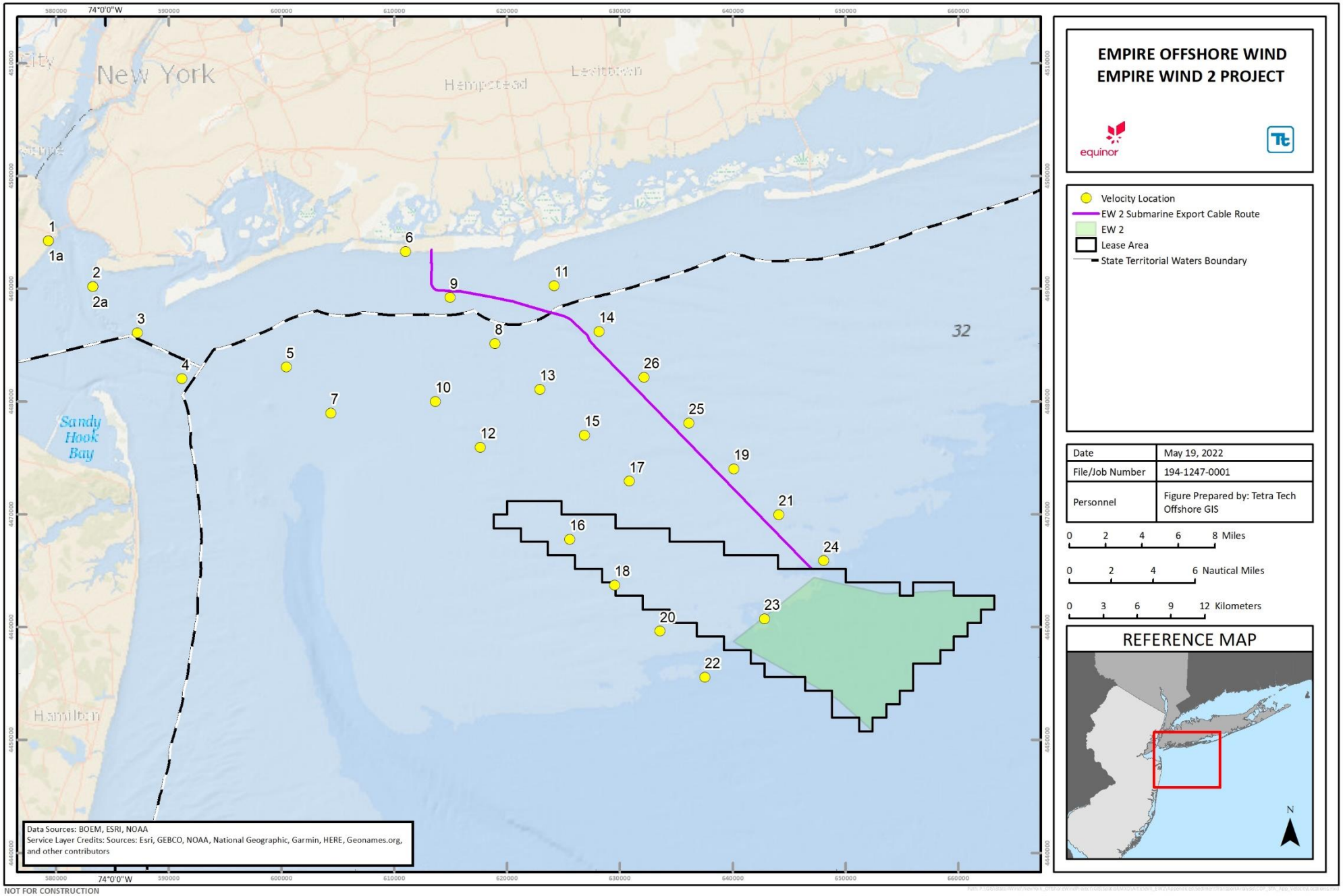

Figure 3 Velocity Station IDs

Table 2 Maximum Flood and Ebb Current Velocity from the ESPreSSO Model

Station ID	Longitude (W)	Latitude (N)	Depth (ft)	Flood Velocity (ft/s)	Ebb Velocity (ft/s)	Zone
6	-73.69	40.58	24	0.53	0.39	Non-Riverine
9	-73.64	40.55	37	0.57	0.44	Non-Riverine
11	-73.53	40.55	36	0.54	0.48	Non-Riverine

3.2 Sediment Characteristic Data

As project-specific sediment density data and grain size distribution data were not available when the model was developed, Tetra Tech used publicly available Poseidon Project sediment data to inform the analytical sediment model (**Figure 2**, ESS Group 2013). The Poseidon Project data included percent gravel, sand, and fines; specific gravity; and D50 data for 47 locations along a submarine electric cable route in Raritan Bay and the New York Bight. The Poseidon Project cable route covers approximately 70 percent of the submarine export cable route evaluation area, all within 3 nautical miles (5.56 km) of Long Island, New York.

Based on the sediment characteristics of the stations in the Poseidon Project, the stations were divided into two zones:

I. Riverine: For stations close to the river mouth, sediment characteristics were calculated by averaging all stations that were close to the river. These stations typically had high fine sediment content.
II. Non-Riverine: For stations not close to the river mouth, sediment characteristics were calculated by averaging all other stations. These stations typically had high sand content.

The EW 2 Project Area was located in the non-riverine zone. Other than percent gravel, the sediment data only provided percent sand and percent fines as the sediment breakdown, Tetra Tech made an assumption to divide the sediment equally into finer classes. The percent sand class was equally divided into percent coarse sand and percent fine sand. Fine sand was further equally divided into percent fine sand and percent very fine sand. The percent fines class was equally divided into percent silt and percent clay. This was done so that a finer scale modeling effort could be completed with the sediment distribution presented in an un-biased manner and for a broader range of size classes consistent with the full range of particle size distribution typical for marine sediments in the region. Settling velocities were assigned to these classes. Density values were calculated by averaging the density for the two different zones. **Table 3** shows the fine sediment particle percentages for the two zones.

Table 3 Sediment Particle Size Distributions

Sample	Density (kg/m^3)	Fine Sand (%)	Very Fine Sand (%)	Silt (%)	Clay (%)	Total Fine Sediment (%)
Riverine	2,746	9.38	9.38	30.87	30.87	80.49
Non-Riverine	2,692	21.93	21.93	4.79	4.79	53.44

When cables are buried using jet plowing, only fine sand and smaller particle sizes are suspended into the water column sufficiently to be transported away from the immediate trench. Larger particle sizes re-settle immediately into the trench. Therefore, the fine sand and smaller sediment particle classes were most appropriate to assess jet plowing impacts in the analytical sediment transport model and the percent gravel was not used.

Mass flow excavation (MFE) may be used in New York state waters along the EW 2 submarine export cable route in nearshore areas The MFE tool generates a large volume column of water that travels vertically down to the seabed fluidizing the sediments. For this process, only fine sand and very fine sand are assumed to be suspended into the water column and transported away due to ambient currents. This area is close to 50 percent fines, most of which is classified as fine sand and very fine sand (ESS Group 2013). MFE was not simulated for the EW 2 Project.

4 SEDIMENT TRANSPORT MODEL

This section describes the methodology followed to develop the conservative analytical sediment transport model to characterize the potential maximum sediment transport and deposition scenario for the jet plow activities. Assumptions used to develop a PDE approach for the sediment transport analysis are listed in detail in Section 4.1.

4.1 Model Setup and Parameterization

Jet plowing utilizes high-pressured water jets to fluidize soil as the machine traverses along a submarine export cable route. The submarine export cable descends into a temporary trench incised by the jetting blades and is subsequently buried as the fluidized sediments re-settle inside the trench. During jet plow operations, monitoring of burial allows the operator to adjust the angle of the jetting blades and the water pressure to obtain desired burial depth while minimizing sediment mobilization into the water column.

By design, coarser sediments settle immediately to fill the trench and bury the submarine export cable or settle in the immediate vicinity (typically within a foot) (Tetra Tech 2012, 2015; Vinhateiro et al. 2013). Earlier studies have shown that sediments coarser than 0.2 millimeter (mm) settle immediately over the trench (Tetra Tech 2015). A conservative approach was taken by assuming that sediments finer than 0.25 mm (fine sand) would be mobilized into the water column and transported by the ambient currents varying distances depending on a number of factors.

The height of the sediment plume above the seabed is dependent on local hydrodynamics, sediment size distribution, and the jet plow operating parameters. Previous studies have shown that the plume of sediment released during jet plowing reaches heights of roughly 7 ft (2 m) above the seabed (Tetra Tech 2012, 2015). The suspended sediment plume is then dispersed by local tidal currents and moves in the direction of the dominant current, which for this project could be northward during flood tides and southwards during ebb tides. Tidal conditions and currents will be dependent on current conditions during EW 2 Project construction. The analytical sediment transport model simulated transport for both the maximum flood and ebb conditions to better estimate potential transport in both directions.

Settling velocity determines the time it takes for a fine grain sediment to settle down based on Stokes Law. Based on the sediment grain size distribution, representative sediment classes were selected and settling velocities assigned to those classes (USGS 2005). However, in many instances, the fine clay and silt sediment particles become cohesive when they are forced into resuspension by the jet plow, causing them to have settling velocities similar to larger sized particles (Van Rijn 2018; Swanson et al. 2015). The settling velocities determine the duration for which the resuspended sediment stays in the water column before eventually settling to the seabed. These velocities have been assigned to each sediment class based on a USGS study (USGS 2005). **Table 4** lists the different sediment classes and the associated settling velocities used for the modeling.

Table 4 EW 2 Project Sediment Particle Diameter Classes and Settling Velocity

Sediment Class	Settling Velocity (cm/s)
Fine Sand	3.000
Very Fine Sand	1.000
Silt	0.126
Clay	0.023

4.2 Methodology

This section describes how the analytical sediment transport model was implemented to calculate the maximum suspended sediment water column concentrations and deposition depths. The approach assumes that the fine sediments released from the jet plow are released at a fixed height. The sediment particles are then transported by local tidal currents and settle down at fixed rates over the horizontal sea floor (Tetra Tech 2012, 2015; Vinhateiro et al. 2013; Swanson et al. 2015). No secondary resuspension of sediment particles was considered. Resuspension is a result of the naturally occurring bottom currents and turbulence and is therefore not directly related to jet plowing activities. The model focuses on the initial dispersion of particles due to jet plowing activities that may generate brief episodes of elevated fine sediment concentrations in the water column and the resulting transport and deposition of these suspended sediments.

The expected sediment transport was calculated for each velocity location. It was assumed that these stations would be representative of the general conditions of the Lease Area and submarine export cable routes. Each station was assigned the representative flood and ebb velocities that corresponded to the velocity station and sediment characteristics based on the project zone it fell in. The flood and ebb velocities were used to calculate the maximum extent of sediment deposition and the duration for which the sediment remained in suspension for each sediment class at all stations.

The travel speed of the jet plow was assumed at 656 ft per hour (200 m per hour). For the model analysis, it was assumed that 30 minutes of trenching activities were suspended at each time step. Based on the provided specifications, for most stations, the trench was assumed to be 328 ft (100 m) long[9], 3.5 ft (1 m) wide, and 8 ft (2.5 m) deep. Therefore, for each sediment location, the maximum volume of potential sediment fluidized in the water column was 8,830 cubic feet (250 cubic meters) if all of it is fine sand or smaller. For stations with a target burial depth of 18 ft (5.5 m), the volume of sediment fluidized in the water column was 19,423 cubic feet (550 cubic meters). This volume of sediment was assumed to be instantaneously suspended at time step 0 seconds in the analytical sediment transport model. This conservative assumption results in a higher concentration of suspended sediments in the water column than if a smaller volume of sediments at a shorter time step were suspended. However, it does not impact deposition depths.

The sediment concentration at the release location was determined based on the estimated bed sediment and the percentage of sediment in each class. The sediment concentrations of each class were added together to calculate the total volume of sediment resuspended at the release point. With time, the sediment plume was allowed to grow based on the velocity at that location. The sediment plume does not grow in the vertical direction and is always close to the bottom of the water column. The duration of suspension for each sediment class was calculated using the release height and sediment class settling velocity. The maximum extent of travel

[9] As a conservative assumption, the model assumed that all the fine material dislodged by the jet plow during the 30 minute time interval would be dispersed into the water column at the same time.

for each sediment class was calculated using the current velocity and sediment settling velocity. Sediment particles in each class were assumed to settle out of the water column at a linear rate. The suspended sediment concentrations at each location along the trench were calculated based on the sediment left in the water column at the time and the size of the plume.

The point of deposition for each particle was calculated based on the settling velocity of each sediment class. Coarser sediments with higher settling velocity settle out of the water column faster and closer to the release point as compared to finer sediments. The finer sediment classes stay in the water column for longer periods of time and are advected further than the coarser sediments. In addition, the finer clay and silt sediment particles, which are typically cohesive, undergo enhanced settling due to flocculation and settle out of the water column with large-sized particles (Van Rijn 2018; Swanson et al. 2015). Sediments were assumed to settle out of the water column at a linear rate for each sediment particle class. This assumes that varying sized sediments within each class are evenly distributed within the plume. Sediment classes larger than medium silt all deposited within an hour, while fine silts and clays stayed in suspension for several hours. In addition, the model did not explicitly simulate dispersion, which could cause some particles to be transported further than estimated and could result in a larger area of deposition. Instead, dispersion was represented by the plume growth in terms of spreading of the sediment particles based on the ambient currents and the settling velocity.

5 RESULTS

This section describes the sediment transport analytical model results in terms of suspended sediment concentrations, deposition depth, and distance at which the sediment is deposited. Results of the conservative analytical sediment transport model representing the submarine export cable route are provided.

5.1 Suspended Sediment Concentrations

Table 5 and **Table 6** list the predicted maximum suspended sediment concentrations by distance from the trench centerline at locations perpendicular to the trench centerline for sample stations for flood and ebb currents. **Figure 4** and **Figure 5** shows the estimated maximum suspended sediment concentrations at a representative "Non-Riverine" station, for maximum ebb and flood tides. **Figure 6** through **Figure 9** show the expected maximum instantaneous suspended sediment concentrations along the submarine export cable route at any given time step along the submarine export cable siting corridor.[10,11] It is important to note that these concentrations do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable route and Lease Area would be disturbed at any given time during EW 2 Project construction and that is why the model used the volume of sediment put into suspension in 1 hour of jet plow travel (200-meter trench length). In addition, due to the depth of water within the EW 2 Project Area, the plume should not be visible from the surface.

5.1.1 Non-Riverine Stations

Overall, at the Non-Riverine stations for the EW 2 Project in New York State, which are comprised of sandier bed sediments, maximum plume distances were typically 1,640 to 3,280 ft (500 and 1,000 m). The plume

[10] **Figure 6** through **Figure 9** represent the instantaneous maximum suspended sediment concentrations at any given point of time predicted for the representative EW 2 submarine export cable routes. These concentrations do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable siting corridor and Lease Area would be disturbed at any given time during Project construction.
[11] Sediment transport analysis **Figure 6** through **Figure 9** reflect a difference in route centerline from the proposed route that is depicted in **Figure 1** but is representative for the EW 2 Project.

travelled further distances during the flood tide as compared to the ebb tide. The total distance the sediment plumes traveled was dependent on the current velocities. Suspended sediment concentrations were always below 500 mg/L at a distance of 820 ft (250 m) from trench centerline during flood and ebb tides. Results indicated that the plume would travel to a maximum distance of 3,280 ft (1,000 m) during the flood tide, although the maximum suspended sediment concentrations at that distance would be less than 15 mg/L. During ebb tides, the maximum plume distance travelled is typically around 1,640 ft (500 m). Expected maximum suspended sediment concentrations drop to anywhere between 22 to 42 mg/L at 1,640 ft (500 m) from the trench centerline. Maximum plume distance at any station depends on the current velocity and its components perpendicular and parallel to the direction of trench movement.

The sediment transport model predicted that maximum suspended sediment concentrations would be around $1.79*10^6$ mg/L for Non-Riverine stations in the EW2 Project Area at the release point during flood and ebb conditions. The plumes were predicted to travel 1,640 to 3,280 ft (500 to 1,000 m) from the trench centerline. For flood tides, the suspended sediment concentration averaged around 100 mg/L at a distance of 1,640 ft (500 m), and for ebb tides, the concentrations averaged around 100 mg/L at a travel distance of 1,148 ft (350 m). In addition to current velocity, the type of fine sediments at the stations impact the maximum plume concentrations. Fine sand, the coarsest fine sediment particle class that was modelled, has a settling velocity of 3 cm/s and remains in suspension for approximately one minute. Therefore, at the Non-Riverine EW2 Project Area stations, suspended sediment concentrations decreased by close to 75 percent within one minute of jet plowing operations and within 33 ft (10 m) of the trench centerline (**Figure 4**, and **Figure 5** considered representative). This reduced the amount of sediment that could be transported in the water column due to currents, and most of the fine sand deposits within 33 ft (10 m) of the trench centerline. **Table 5** and **Table 6** present the results specifically for the three Non-Riverine stations along EW 2 within New York State waters (Stations 6, 9 and 11).

5.1.2 General Observations

While the maximum suspended sediment concentrations were relatively high for both Riverine and Non-Riverine stations, these concentrations decreased rapidly with time. The coarser fine particles, such as fine sand, remained in suspension for about one minute, while the very fine sediments (clay) remained in suspension for about four hours, a relatively short period of time. In areas that consist predominantly of gravels and sands, the analysis indicates a limited extent of increased sediment concentrations, as the larger grain size sediments immediately deposit in the trench. In locations that are dominated by fine sand, silts, or clays, these sediments can be released into the water column and temporarily increase total suspended solids near the trench and cause sediment deposition outside of the trench, but eventually settle down to background concentrations (Tetra Tech 2012, 2015; Vinhateiro et al. 2013). The concentrations decreased rapidly with time, and water column concentrations are expected to return to ambient conditions within 4 hours (7,200 seconds). **Table 7** and **Table 8** present the time varying suspended sediment concentrations for flood and ebb tides, respectively, for Non-Riverine stations within New York State waters for EW 2.

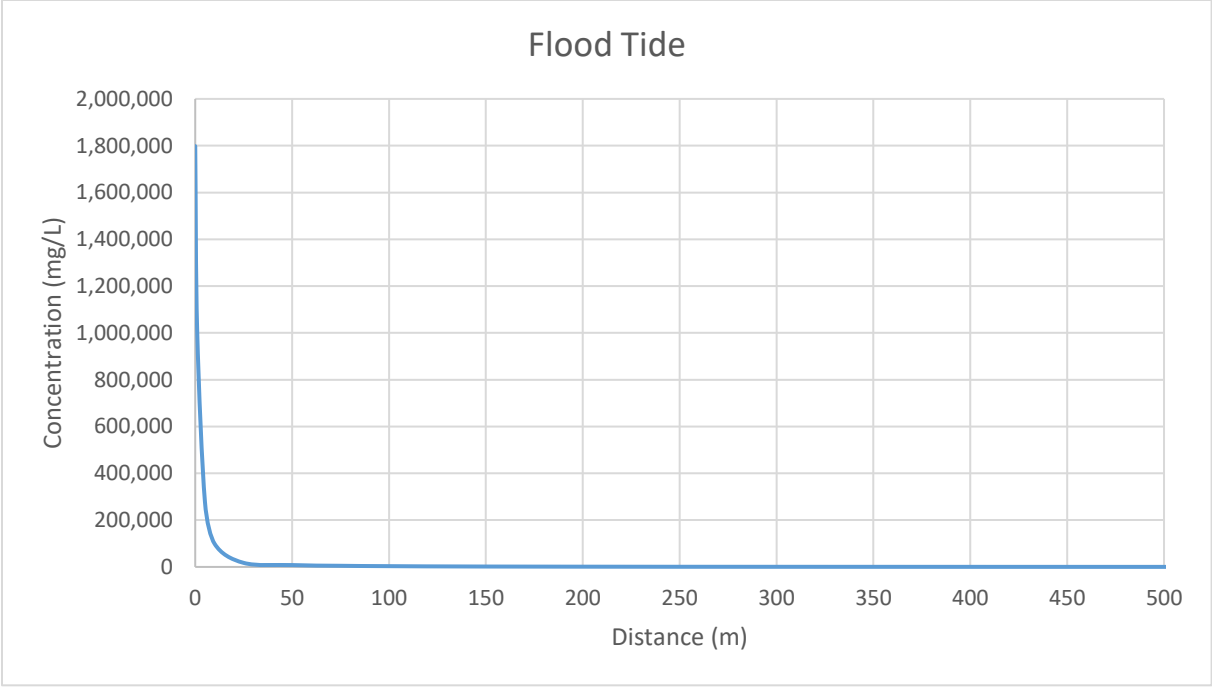

Figure 4 Maximum Flood Tide Suspended Sediment Concentrations at Representative Non-Riverine Station

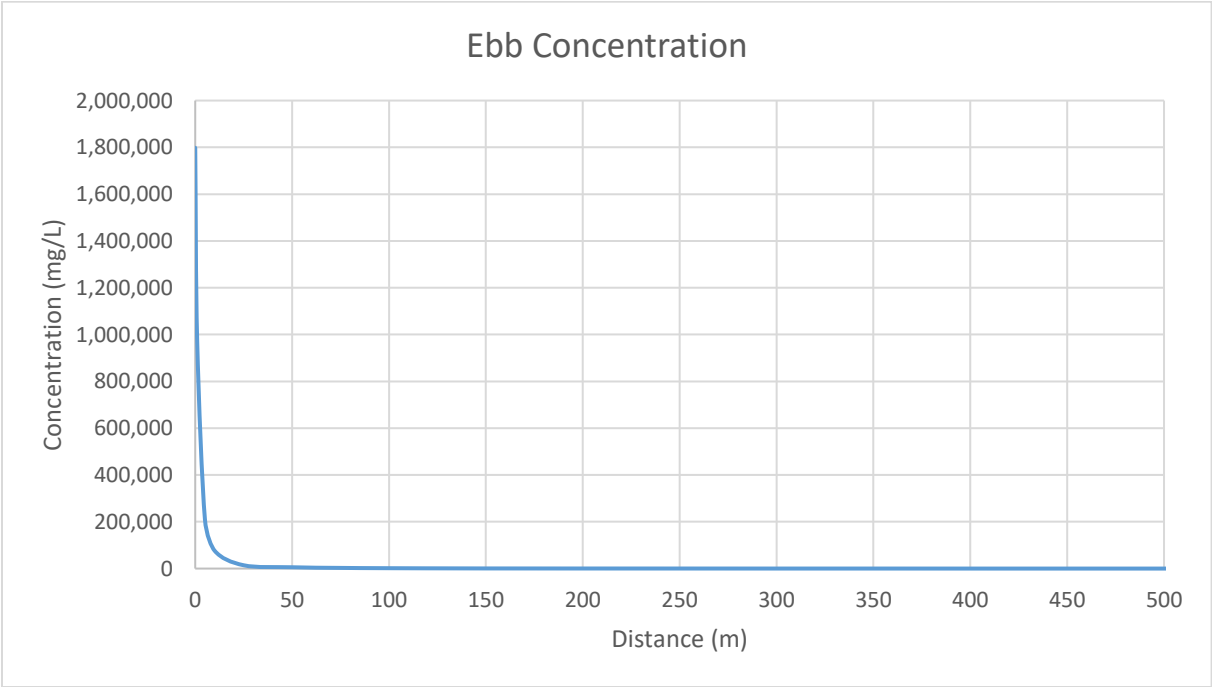

Figure 5 Maximum Ebb Tide Suspended Sediment Concentrations at Representative Non-Riverine Station

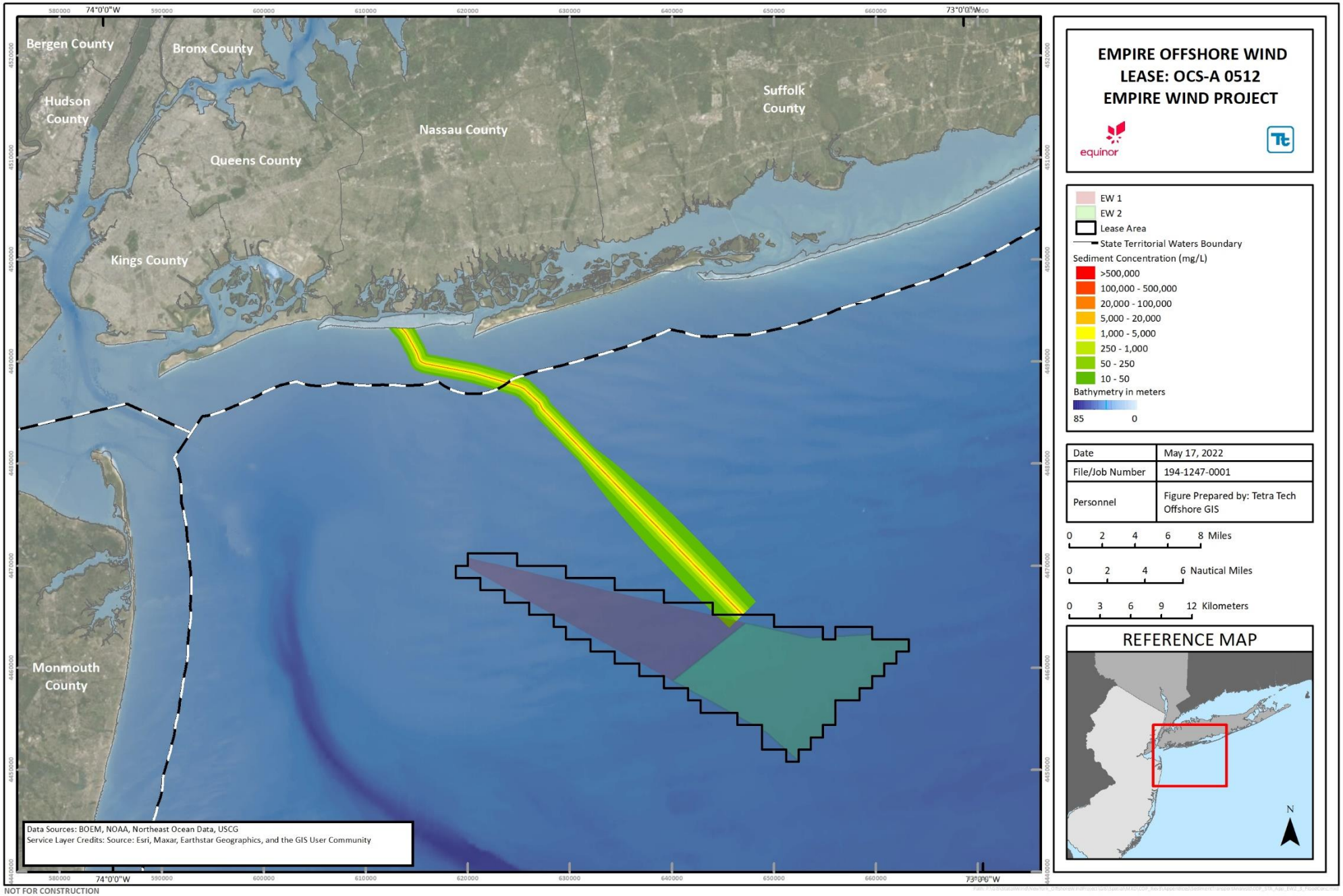

Figure 6 Maximum Flood Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route[10]

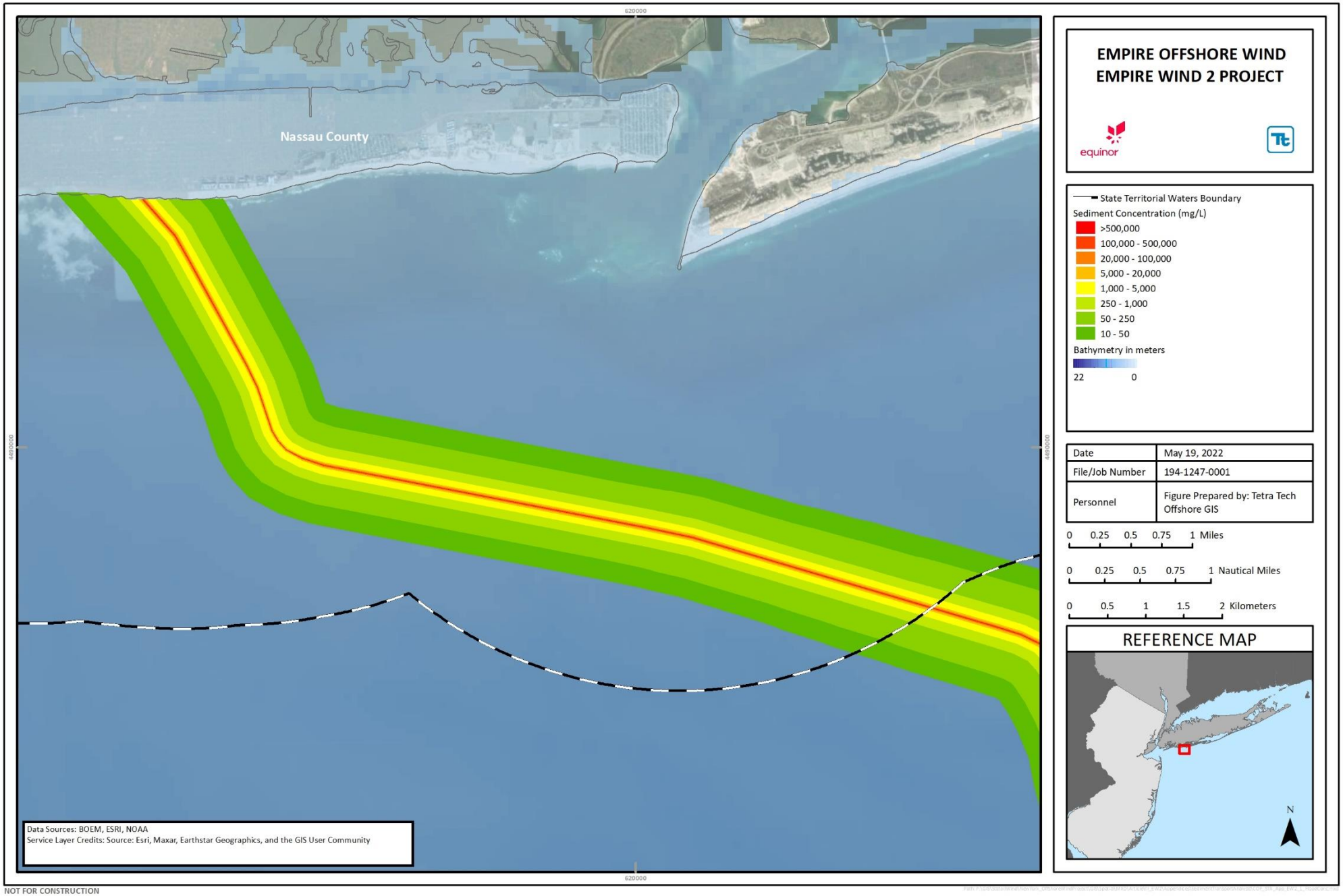

Figure 7 Maximum Flood Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route (NY)

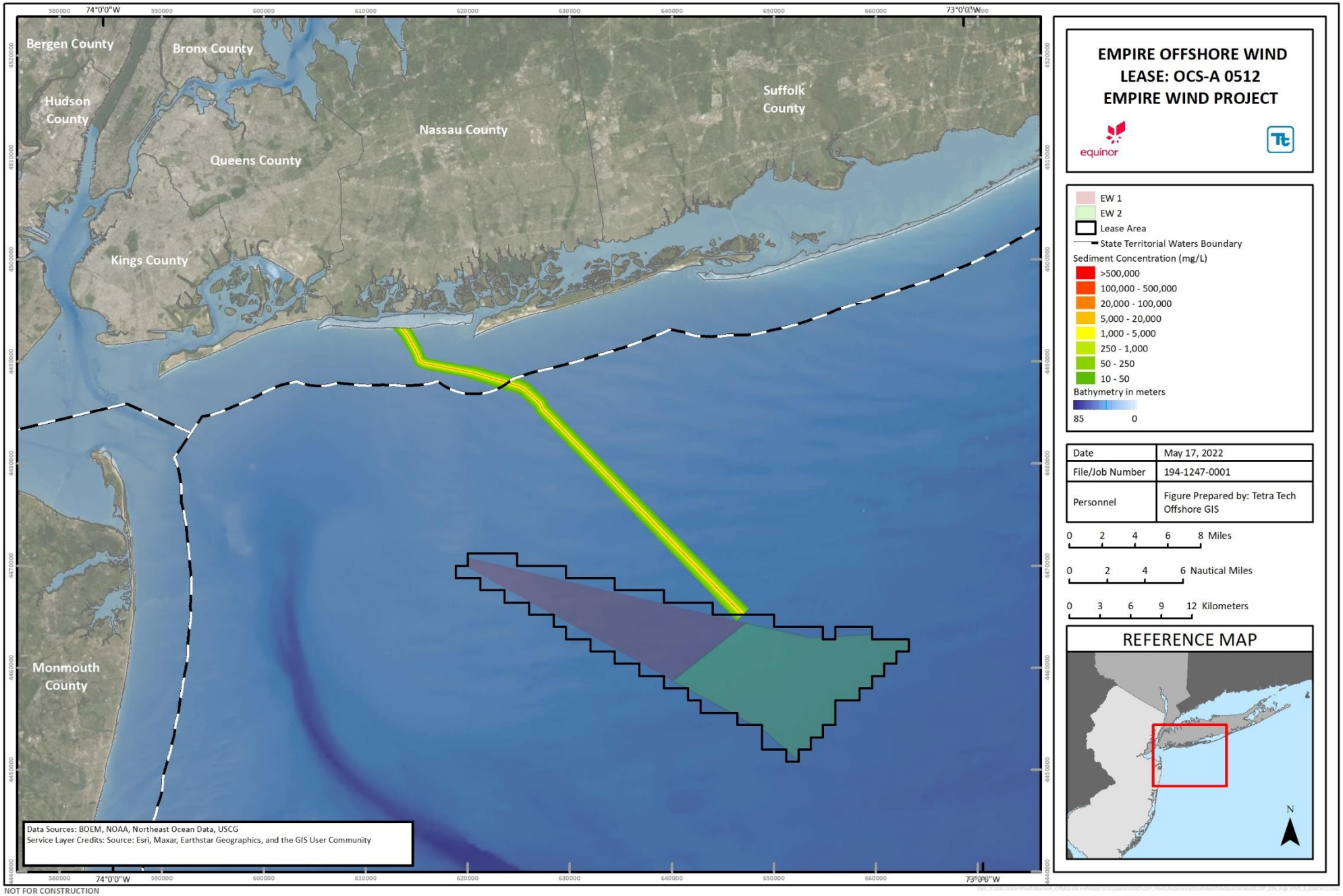

Figure 8 Maximum Ebb Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route

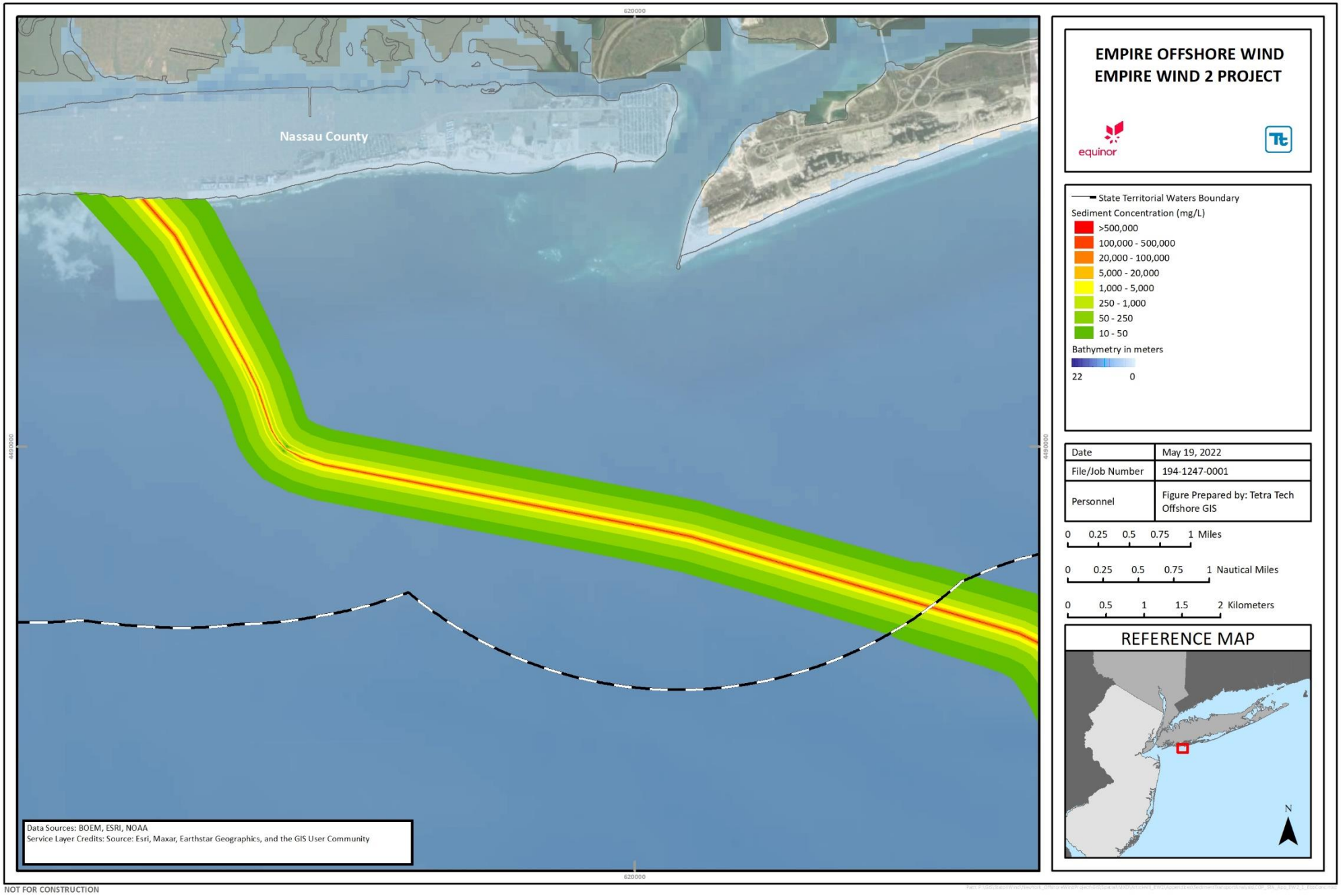

Figure 9 Maximum Ebb Tide Suspended Sediment Concentrations along a Representative EW 2 Submarine Export Cable Route (NY)[1]

Table 5 Maximum Suspended Sediment Concentrations for Flood Conditions (With Distance) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	1,009,568	280,454	97,486	17,514	6,884	3,954	2,534	1,204	400	214	98	24	7	0	0
9	Non-Riverine	53%	1,798,287	1,015,346	291,471	100,685	20,766	7,014	4,072	2,641	1,294	416	226	107	29	11	0	0
11	Non-Riverine	53%	1,798,287	1,012,834	286,759	99,446	19,398	7,027	4,078	2,641	1,284	423	230	108	28	9	0	0

Table 6 Maximum Suspended Sediment Concentrations for Ebb Conditions (With Distance) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	954,412	180,125	66,617	13,831	5,333	2,652	1,430	623	224	95	24	0	0	0	0
9	Non-Riverine	53%	1,798,287	955,276	179,997	66,689	13,545	5,142	2,529	1,355	577	204	86	22	0	0	0	0
11	Non-Riverine	53%	1,798,287	976,992	218,313	78,591	14,231	5,690	2,969	1,715	664	254	118	42	0	0	0	0

Table 7 Maximum Suspended Sediment Concentrations (mg/L) for Flood Conditions (With Time) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Time (s)															
			0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	877,659	542,370	369,121	141,545	77,939	49,906	32,507	12,065	9,269	3,677	1,085	441	112	10	0
9	Non-Riverine	53%	1,798,287	841,254	512,039	345,737	131,159	71,875	45,890	29,829	11,026	8,454	3,331	974	394	99	9	0
11	Non-Riverine	53%	1,798,287	858,269	526,217	356,710	136,119	74,828	47,883	31,183	11,578	8,900	3,543	1,052	429	110	10	0

Table 8 Maximum Suspended Sediment Concentrations (mg/L) for Ebb Conditions (With Time) for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Time (s)															
			0	10	20	30	60	90	120	150	240	300	600	1,200	1,800	3,600	7,200	14,400
			Maximum Sediment Concentration (mg/L)															
6	Non-Riverine	53%	1,798,287	1,107,295	756,441	544,531	226,019	128,773	84,033	55,397	20,951	16,199	6,504	1,927	784	199	18	0
9	Non-Riverine	53%	1,798,287	1,103,110	751,815	540,251	223,372	126,874	82,567	54,292	20,391	15,699	6,193	1,790	716	177	16	0
11	Non-Riverine	53%	1,798,287	1,029,979	679,124	478,580	192,231	107,762	69,601	45,539	16,962	13,018	5,096	1,464	584	144	13	0

5.1.3 Sediment Deposition Rates

Table 9 and **Table 10** list the deposition thicknesses at locations perpendicular to the trench centerline for all stations under the maximum flood and ebb currents for the EW 2 Project in New York State waters. **Figure 10** through **Figure 13** show the maximum predicted sediment deposition along the representative submarine export cable route.[12][13] It is important to note that deposition does not occur at all locations simultaneously due to the jet plow travel speed. The sediment resuspended due to jet plow operations moves in the direction of the local ambient current and then eventually settles and deposits in a layer along the marine seabed. For the analytical sediment transport model, it was assumed that sediments finer than 0.25 mm (fine sand) would be mobilized in the water column and transported by the ambient currents, which would distribute sediments in each particle class uniformly over the marine seabed. All sediments coarser than 0.25 mm would re-deposit in or immediately adjacent to the trench (and therefore, not be considered suspended).

The deposition thickness was highest in the vicinity of the jet plow, as fine sand tends to deposit close to the trench centerline due to its higher settling rate. Most of the coarser fine sediments settled to the marine floor within 33 ft (10 m) of the trench, and deposition depths decreased rapidly.

[12] **Figure 10** through Figure 13 represent the instantaneous maximum sediment deposition at any given point of time. These depositions do not occur at all locations simultaneously. Due to jet plow speed, only small sections of the submarine export cable route and Lease Area would be disturbed at any given time during Project construction.
[13] Sediment transport analysis in **Figure 10** through **Figure 13** reflect a difference in route centerline from the proposed route that is depicted in **Figure 1**, but is representative for the EW 2 Project.

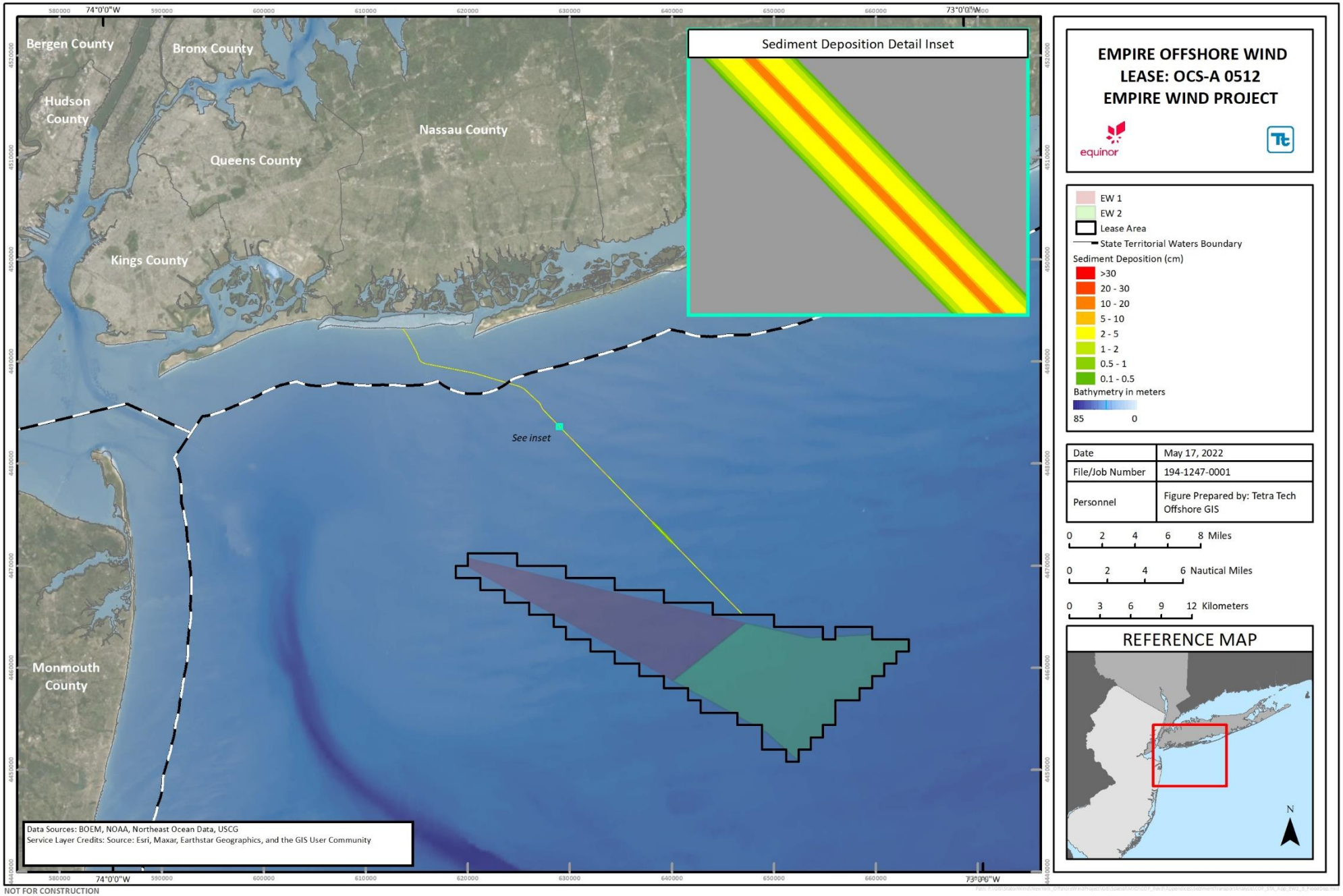

Figure 10 Maximum Flood Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route[13]

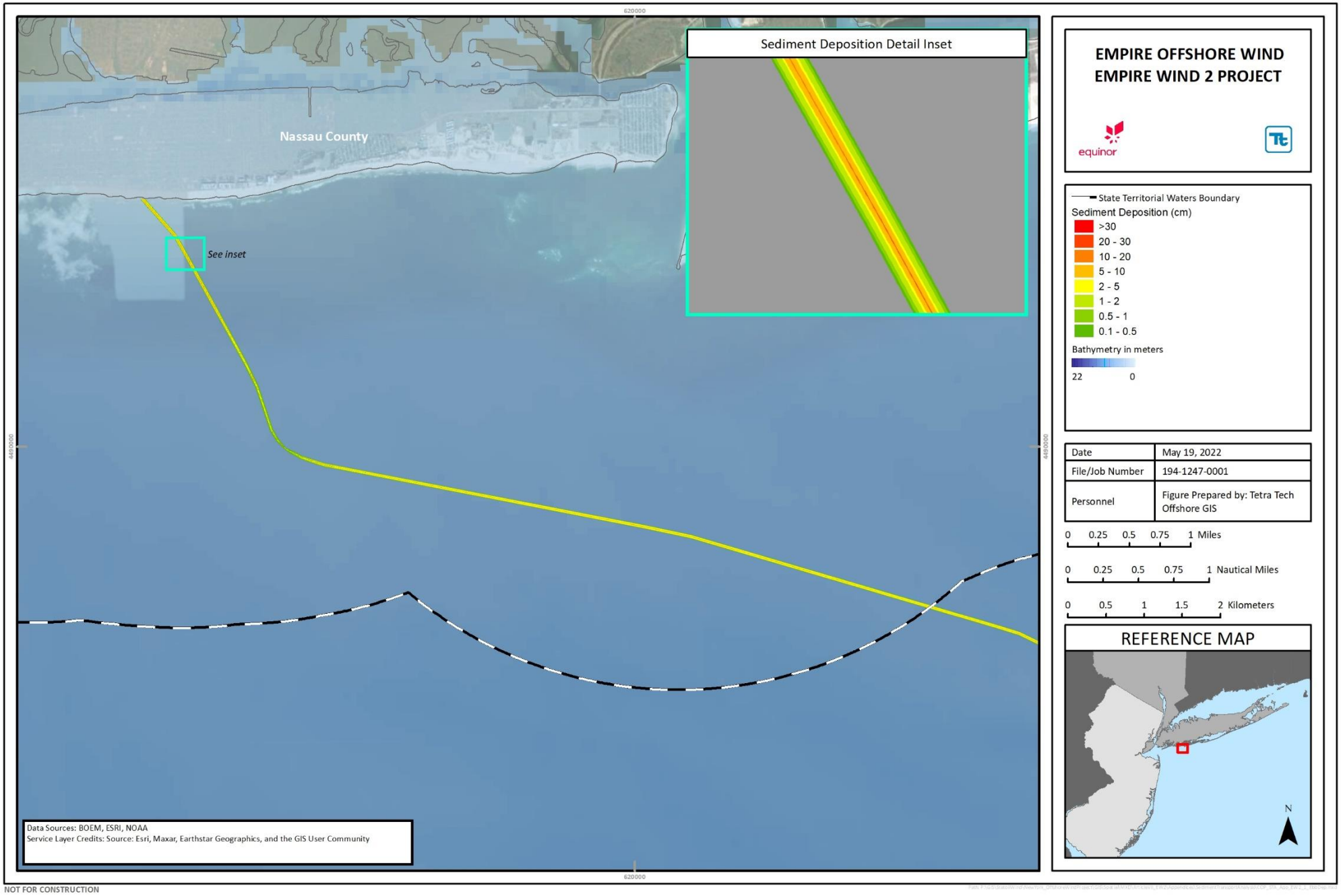

Figure 11 Maximum Flood Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route (NY)

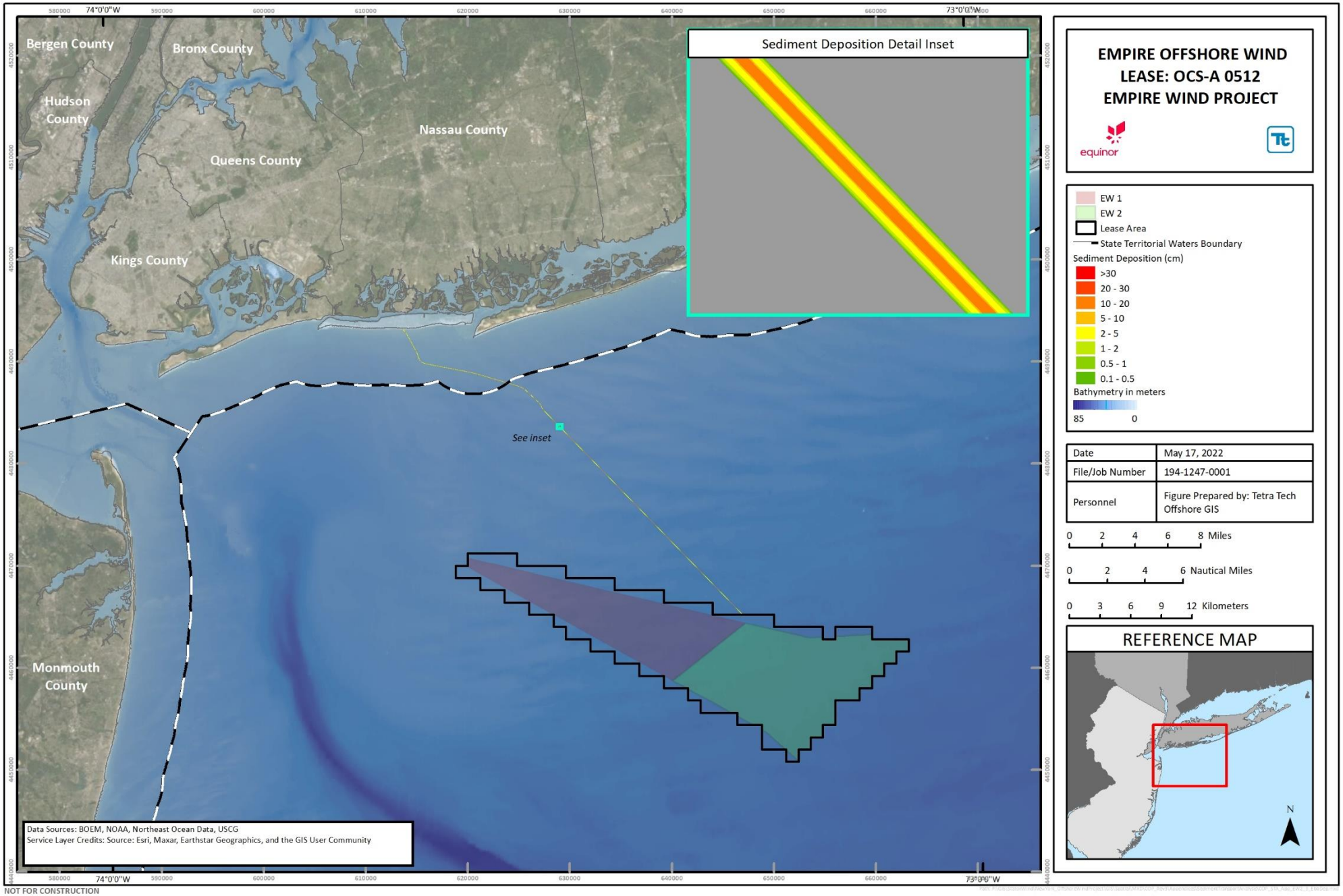

Figure 12 Maximum Ebb Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route

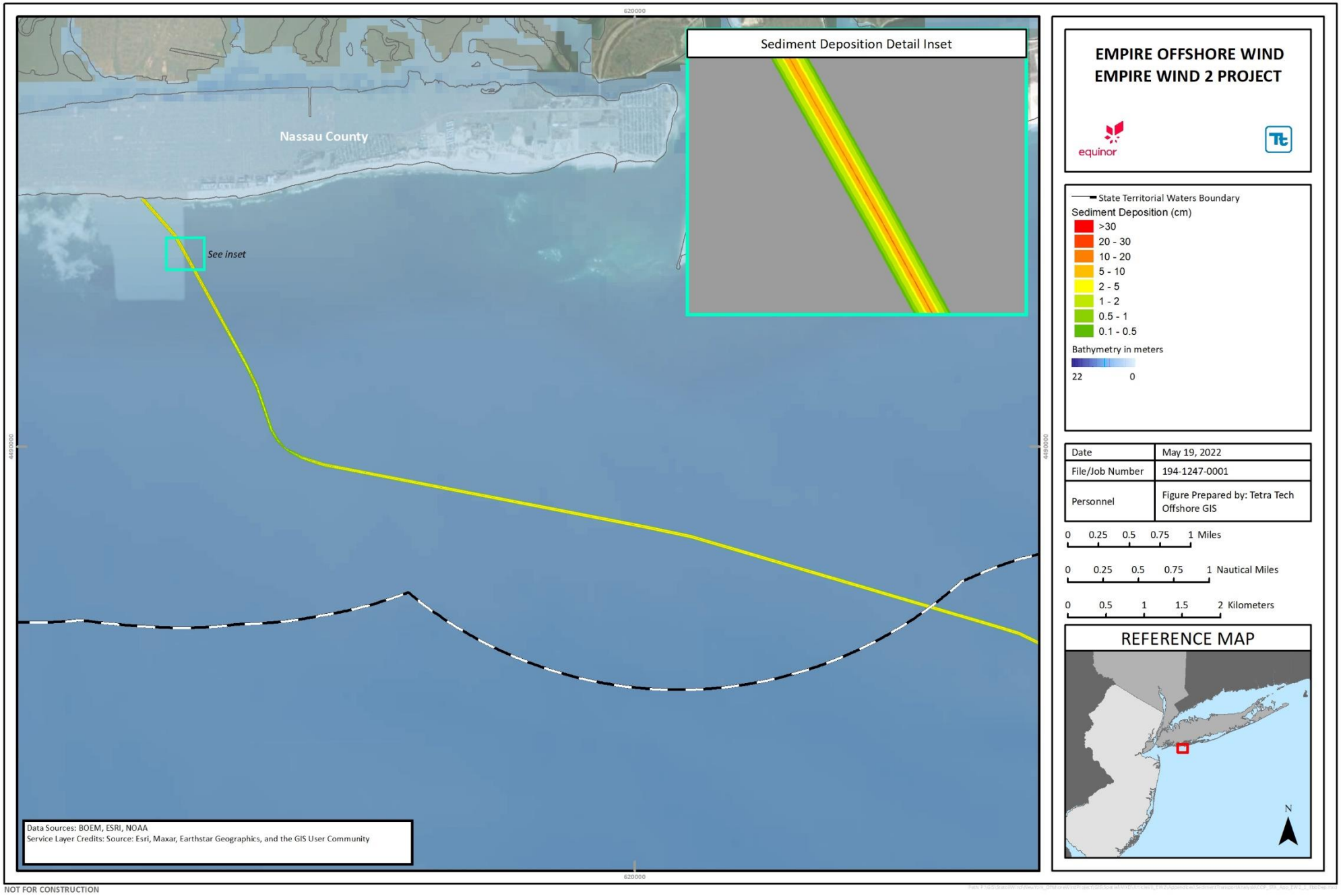

Figure 13 Maximum Ebb Tide Sediment Deposition along a Representative EW 2 Submarine Export Cable Route (NY)[12]

Table 9 Deposition Depths for Flood Conditions for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Deposition (cm)															
6	Non-Riverine	53%	10.59	10.59	10.59	2.78	2.78	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Non-Riverine	53%	9.77	9.77	9.77	2.54	2.54	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Non-Riverine	53%	10.17	10.17	10.17	2.66	2.66	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 10 Deposition Depths for Ebb Conditions for the EW 2 Project (New York Stations Only)

Sample	Project Element	Total Fines (%)	Distance from Trench (m)															
			0	1	5	10	25	50	75	100	150	250	350	500	800	1,000	2,500	5,000
			Maximum Sediment Deposition (cm)															
6	Non-Riverine	53%	17.39	17.39	4.79	4.79	0.09	0.09	0.09	0.09	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
9	Non-Riverine	53%	17.11	17.11	4.67	4.67	0.09	0.09	0.09	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Non-Riverine	53%	14.56	14.56	14.56	3.90	0.07	0.07	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6 CONCLUSIONS

Tetra Tech performed an analytical sediment transport study to conservatively evaluate the potential suspended sediment transport and deposition characteristics of installation of the EW 2 Project's submarine export cables. The modeling was conducted using existing available data and a PDE approach to evaluate the effects of proposed submarine export cable burial activities in terms of suspended sediment concentrations in the water column, and sediment deposition characteristics such as deposition depth and deposited sediment footprint, to allow for an assessment of potential EW 2 Project effects on surrounding water quality and habitats. The conservative model assumed maximum trench dimension parameters and that all fine sediment (fine sand and smaller grain size sediment) disturbed by the jet plow during cable burial would be suspended in the water column; however, jet plow operations, including the angle of the plow blade and water pressure through the jet nozzles, can be adjusted during cable installation and could result in less sediment mobilizing in the water column.

The analytical sediment transport model yielded the following general conclusions:

- The suspended sediment concentration, deposition depth, and area of influence is dependent upon flood and ebb current velocities, burial depth, and the percentage of fine sediments in the sediment sample;
- The very fine sediments particles (silt and clay) remain in suspension for about 4 hours after being mobilized in the water column. Coarser particles (fine sand) settle at a faster rate, about 1 minute after being mobilized;
- For jet plow during peak flood and ebb tides:
    - The initial maximum concentration at the release point is dependent on the percentage of fine particles (defined as particles in the fine sand class and smaller). Stations in the EW 2 Project Area are 53 percent fine particles, and maximum concentrations at the trench line are approximately 1.8*106 mg/L for a trench depth of 8 ft (2.5 m) and 6.1*106 mg/L. This instantaneous concentration is conservatively high and assumes that all particles finer than fine sand are instantly mobilized in the water column and remain in suspension until they settle;
    - The suspended sediment concentrations diminish rapidly away from the release point, and at most stations over 85 percent of the suspended particles deposit within 16 ft (5 m) of the trench centerline. The typical concentration at 328 ft (100 m) is about 2,500 mg/L above background concentration for flood tides and about 1,300 mg/L above background concentration for ebb tides;
    - The suspended sediment concentrations drop rapidly with time. At most locations, the concentration drops by 75 percent within two minutes of jet plowing activity. The maximum concentration at two minutes is $5.0*10^4$ mg/L for flood tide and $8.4*10^4$ mg/L for ebb tide;
    - The deposition thicknesses were predicted to be greatest closest to the centerline trench. The maximum expected sediment deposition thickness under simulated conditions is 6.74 in (17.11 cm) at 0 m from the trench centerline;
    - Deposition thicknesses were predicted to decrease rapidly away from the trench. Average deposition thicknesses were less than 1.09 in (2.78 cm) within 82 ft (25 m) of the trench centerline for flood tides and less than 0.04 in (.09 cm) within 82 ft (25 m) of the trench centerline for ebb

tides. Deposition thicknesses were less than 0.004 in (0.01 cm) at all stations within 492 ft (150 m) of the trench centerline.

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