CORY

DECARBONISATION

ENVIRONMENTAL STATEMENT: 6.3 APPENDIX 11-4: COASTAL MODELLING STUDIES

Cory Decarbonisation Project

PINS Reference: EN010128

March 2024

Revision A

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations (2009) - Regulation 5(2)(a)

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1. INTRODUCTION

1.1.1. WSP has been instructed by Cory Environmental Holdings Limited (hereafter referred to as the Applicant) to prepare a Coastal Processes Assessment, for the Cory Decarbonisation Project to be located at Norman Road, Belvedere in the London Borough of Bexley (LBB; National Grid Reference/NGR 549572, 180512). The following figures are available in the ES:

- **Figure 1-1: Site Boundary Location Plan (Volume 2)**; and
- **Figure 1-2: Satellite Imagery of the Site Boundary Plan (Volume 2)**.

1.1.1. The Applicant intends to construct and operate the Proposed Scheme to be linked with the River Thames. It comprises of the following key components, which are described below, and further detail is provided within **Chapter 2: Site and Proposed Scheme Description (Volume 1)**:

- The Carbon Capture Facility (including its associated Supporting Plant and Ancillary Infrastructure): the construction of infrastructure to capture a minimum of 95% of carbon dioxide (CO_2) emissions from Riverside 1 and 95% of CO_2 emissions from Riverside 2 once operational, which is equivalent to approximately 1.3Mt CO_2 per year. The Carbon Capture Facility will be one of the largest carbon capture projects in the UK.
- The Proposed Jetty: a new and dedicated export structure within the River Thames as required to export the CO_2 captured as part of the Carbon Capture Facility.
- The Mitigation and Enhancement Area: land identified as part of the **Outline Landscape, Biodiversity, Access and Recreation Delivery Strategy (Document Reference 7.9)** to provide improved access to open land, habitat mitigation, compensation and enhancement (including forming part of the drainage system and Biodiversity Net Gain delivery proposed for the Proposed Scheme) and planting. The Mitigation and Enhancement Area provides the opportunity to improve access to outdoor space and to extend the area managed as the Crossness Local Nature Reserve (LNR).
- Temporary Construction Compounds: areas to be used during the construction phases for activities including, but not limited to office space, warehouses, workshops, open air storage and car parking, as shown on the **Works Plans (Document Reference 2.3)**. These include the core Temporary Construction Compound, the western Temporary Construction Compound and the Proposed Jetty Temporary Construction Compound.
- Utilities Connections and Site Access Works: The undergrounding of utilities required for the Proposed Scheme in Norman Road and the creation of new, or the improvement of existing, access points to the Carbon Capture Facility from Norman Road.

1.1.2. Together, the Carbon Capture Facility (including its associated Supporting Plant and Ancillary Infrastructure), the Proposed Jetty, the Mitigation and Enhancement Area, the Temporary Construction Compounds and the Utilities Connections and Site

Access Works are referred to as the ‘Proposed Scheme’. The land upon which the Proposed Scheme is to be located is referred to as the 'Site’ and the edge of this land referred to as the ‘Site Boundary’. The Site Boundary represents the Order Limits for the Proposed Scheme as shown on the **Works Plans (Document Reference 2.3)**.

1.2. PURPOSE OF THIS REPORT

1.2.1. This report presents the findings of the coastal modelling (hydrodynamic, dispersion and sediment transport studies) undertaken to inform the environmental impact assessment (EIA) for the Proposed Scheme.

1.2.2. Hydrodynamic modelling was required to assess the existing ‘baseline’ conditions and understand the response of the River Thames hydrodynamic regime to the Proposed Scheme’s structures and both the capital and operational dredging requirements. The structures and capital and operational dredging requirements are outlined in **Chapter 2: Site and Proposed Scheme Description (Volume 1)**.

1.2.3. A bespoke 2D hydrodynamic model of the River Thames was developed using the MIKE by DHI Flexible Mesh ‘FM’ modelling software. Calibration and validation of this model has been carried out using local tidal measurements to ensure its accuracy and allow it to be used to predict the flow conditions for the proposed scenarios. To support this, high resolution (<10m) bathymetry data (**Figure 1-1**) for the local area has been purchased from the Port of London Authority (PLA) in 2022 to support these modelling studies.

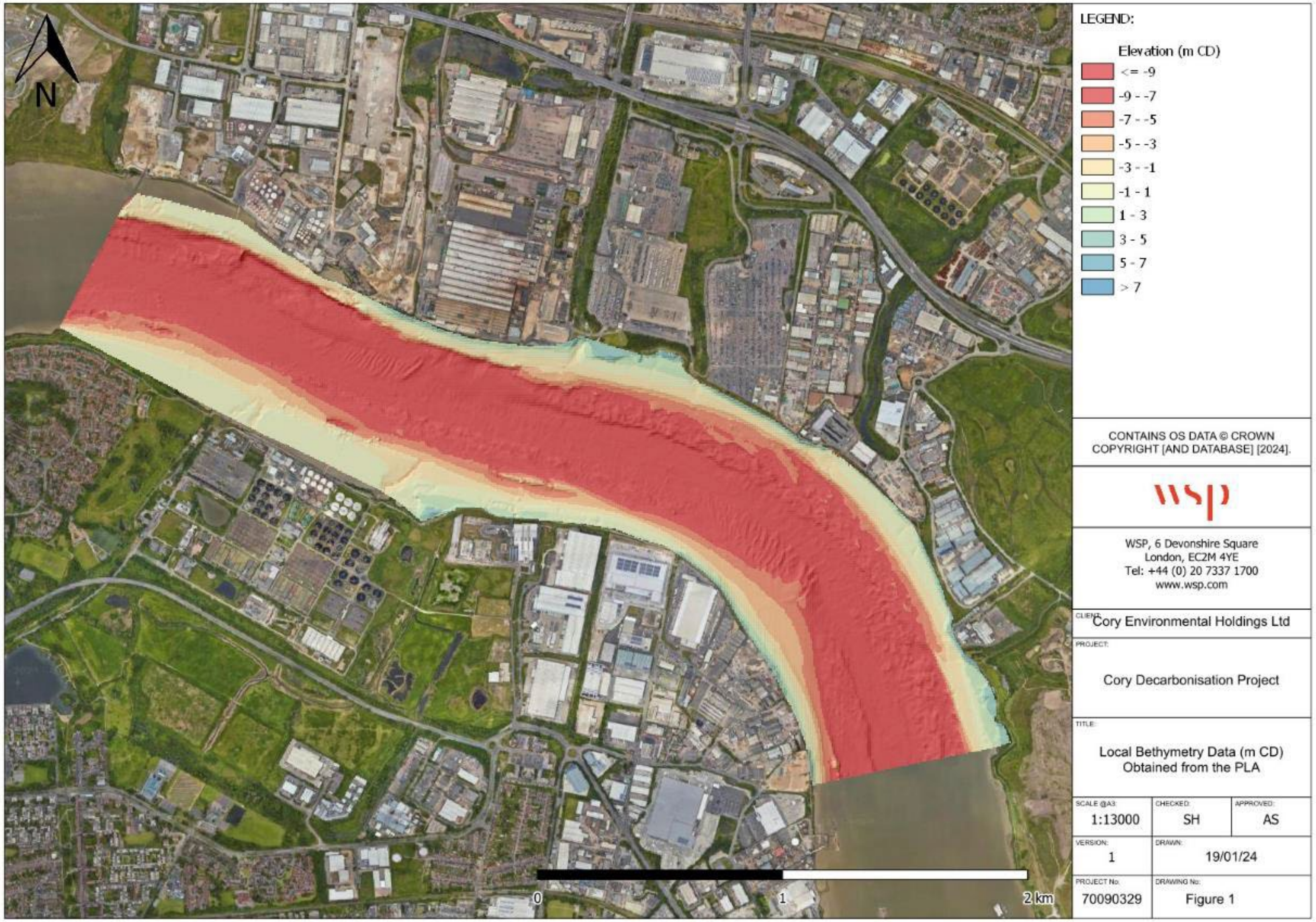


Figure 1-1: Local Bathymetry Data (m CD) Obtained from the PLA

1.3. COASTAL MODELLING CONTEXT

1.3.1. The location for the Proposed Jetty is approximately 130m northeast of the Belvedere Power Station Jetty (disused).

1.3.2. The Proposed Jetty will be located outside of the intertidal mudflat extent, situated in the subtidal region.

1.3.3. The Proposed Jetty is located within the tidal region of the Thames, with a maximum tidal range of approximately 7.2m. **Table 1-1** lists the standard tidal elevation conditions at the Site obtained for Station 0111B from the Total Tide software by UK Hydrographic Office (UKHO).

1.3.4. With the aim of keeping consistency throughout this document and the design overall, the datum level will be kept to Ordnance Datum (OD). Chart Datum (CD) is 3.28m below OD in this location.

Table 1-1: Standard Tidal Elevation Predictions

Tidal Elevation*	m CD (Chart datum)	m OD (Ordnance datum)
Highest Astronomical Tide (HAT)	+7.5	+4.2
Mean High Water Spring (MHWS)	+6.9	+3.6
Mean High Water Neap (MHWN)	+5.8	+2.5
Mean Sea Level (MSL)	+3.6	+0.3
Mean Low Water Neap (MLWN)	+1.5	-1.8
Mean Low Water Springs (MLWS)	+0.9	-2.4
Lowest Astronomical Tide (LAT)	+0.3	-3.0
Note: *Predictions based on UKHO Total Tide Software, correction factor between CD and OD = -3.28m.		

1.3.5. The Proposed Jetty will sit approximately 130m downstream of the existing Middleton Jetty, with its front face at approximately 140m from the southern bank of the River Thames. The design life of the proposed structure will be a minimum of 50 years (as detailed in **Section 2.7** of **Chapter 2: Site and Proposed Scheme Description (Volume 1)**).

1.3.6. The Proposed Jetty, auxiliary structures and associated dredge pocket have been designed to accommodate vessels ranging from approximately 130 to 180m in length, with a draft of up to 9m. The berthing area in front of the Proposed Jetty will be dredged to a level of -10.5m CD (-13.78m Above Ordnance Datum (AOD)). The Proposed Jetty will feature a central loading platform to facilitate the loading of LCO_2 into the storage tanks within the vessels. Further information on the Proposed Jetty is presented in **Section 2.2** of **Chapter 2: Site and Proposed Scheme Description (Volume 1)**.

1.3.7. This coastal modelling assessment has considered both the retention (with modifications that do not affect the marine environment) and demolition of the Belvedere Power Station Jetty (disused).

1.4. HYDRODYNAMIC MODELLING APPROACH

1.4.1. The following modelling approach has been undertaken to determine the impacts of the Proposed Scheme:

- development of a 2D hydrodynamic model using the 2023 MIKE by DHI, Flexible Mesh (FM) hydrodynamic (HD) modelling software, Particle Transport (PT) and Mud Transport (MT) modules;
- calibration and validation of the baseline model (Scenario 1) to ensure water levels and currents were within the specified limits as defined in the Framework of Water Research standards[1] for estuarine model calibration. Model validation was carried out using measurements from the Environment Agency's tide gauge at Erith Wharf (Station ID 9154) approximately 3km downstream of the Site. Data from September to October 2022 was used covering several spring neap cycles; and
- development of 2D hydrodynamic models for the four scenarios and comparison of the outcomes against the baseline model.

1.5. UNITS AND CONVENTIONS

1.5.1. **Table 1-2** describes the units and conventions used in the modelling, expressed using SI notation.

Table 1-2: Units and Conventions

Variable	Unit
Water Levels	metres Above Ordnance Datum Newlyn (m AOD)
Flow Speed	metres per second (m/s)
Bed Shear Stress	Newtons per metre squared (N/m^2)
Position	Relative to British National Grid (Easting & Northing)
Suspended Sediment Concentration	Milligrams per litre (mg/l)
Sedimentation	Metres (m)

1.6. MODELLING SCENARIOS

1.6.1. As part of the modelling assessment, the following scenarios have been considered:

- **Scenario 1: Existing conditions with Belvedere Power Station Jetty (disused)** (prior to any works associated with the Proposed Scheme taking place): **Figure 1-2** shows the baseline model conditions interpolated from the high-resolution PLA data.
- **Scenario 2: Existing conditions without Belvedere Power Station Jetty (disused)** (just prior to any construction works associated with the Proposed Scheme taking place): This scenario is identical to the Scenario 1 except that the Belvedere Power Station Jetty (disused) has been removed (**Figure 1-3**).
- **Scenario 3: Proposed Scheme with Belvedere Power Station Jetty (disused)** – no removal of the disused Belvedere Power Station Jetty (disused), includes the construction of the Proposed Jetty and associated dredging. **Figure 1-4** shows the bathymetry for this scenario. **Figure 1-6** shows the difference between this scenario and the baseline.
- **Scenario 4: Proposed Scheme without Belvedere Power Station Jetty (disused)** (complete removal of the Belvedere Power Station Jetty (disused), with construction of the Proposed Jetty and associated dredging): **Figure 1-5** shows the bathymetry for this scenario. **Figure 1-7** shows the difference between this scenario and the baseline.

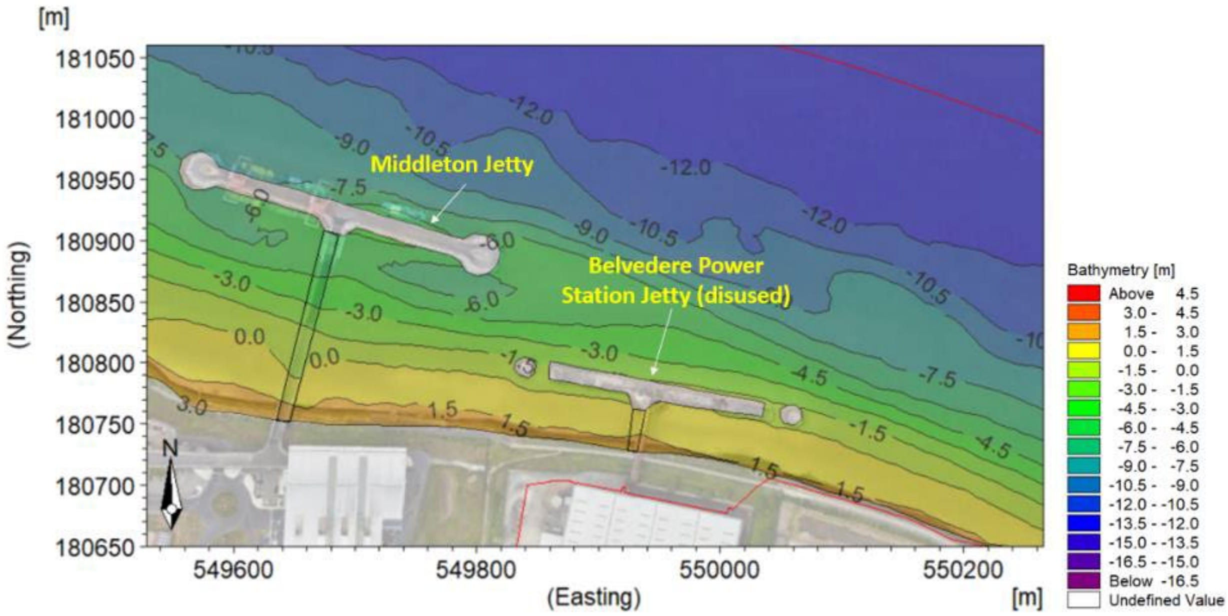


Figure 1-2: Scenario 1 (Existing Condition with Belvedere Power Station Jetty (Disused)) Model Bathymetry

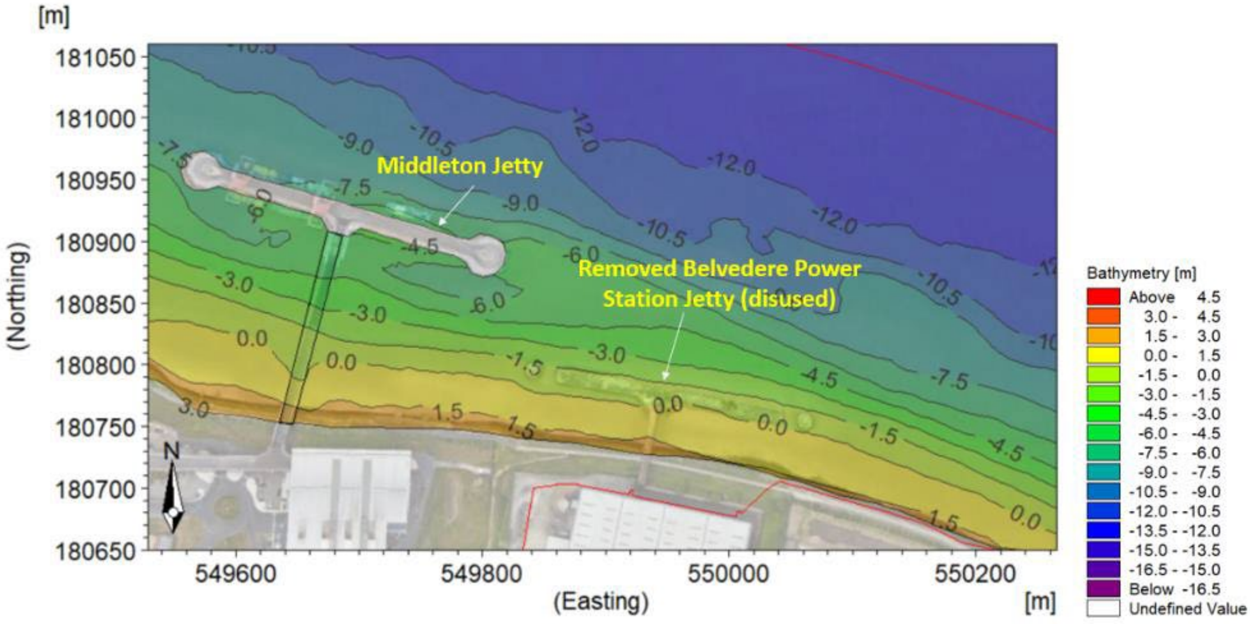


Figure 1-3: Scenario 2 (Existing Condition without Belvedere Power Station Jetty (Disused)) Model Bathymetry

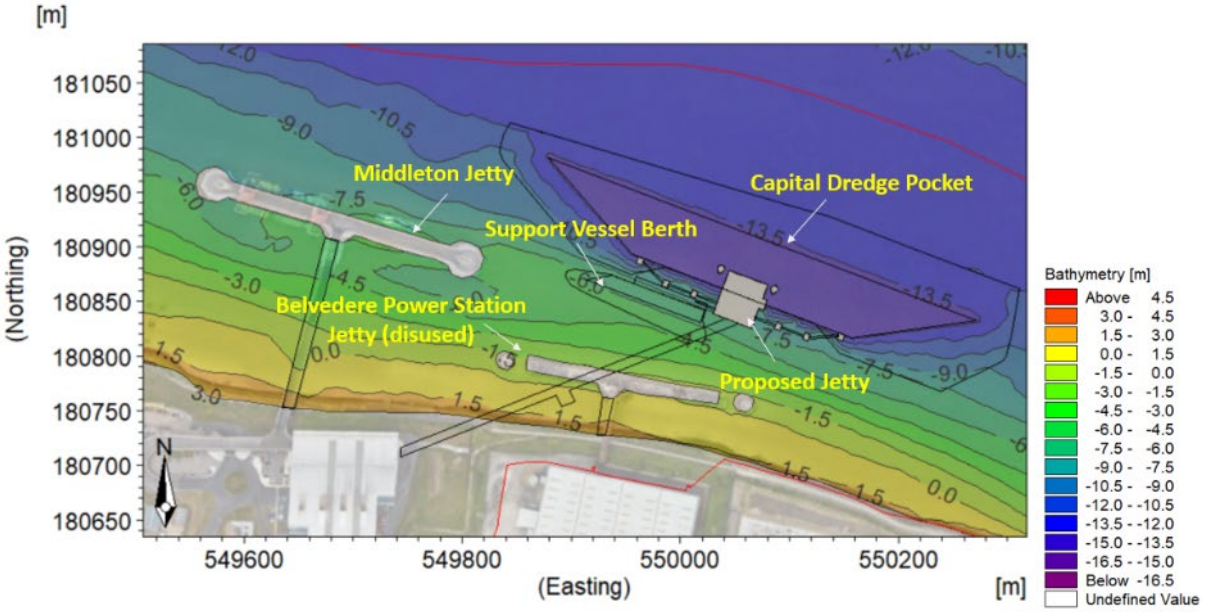


Figure 1-4: Scenario 3 (Proposed Scheme with Belvedere Power Station Jetty (Disused)) Model Bathymetry

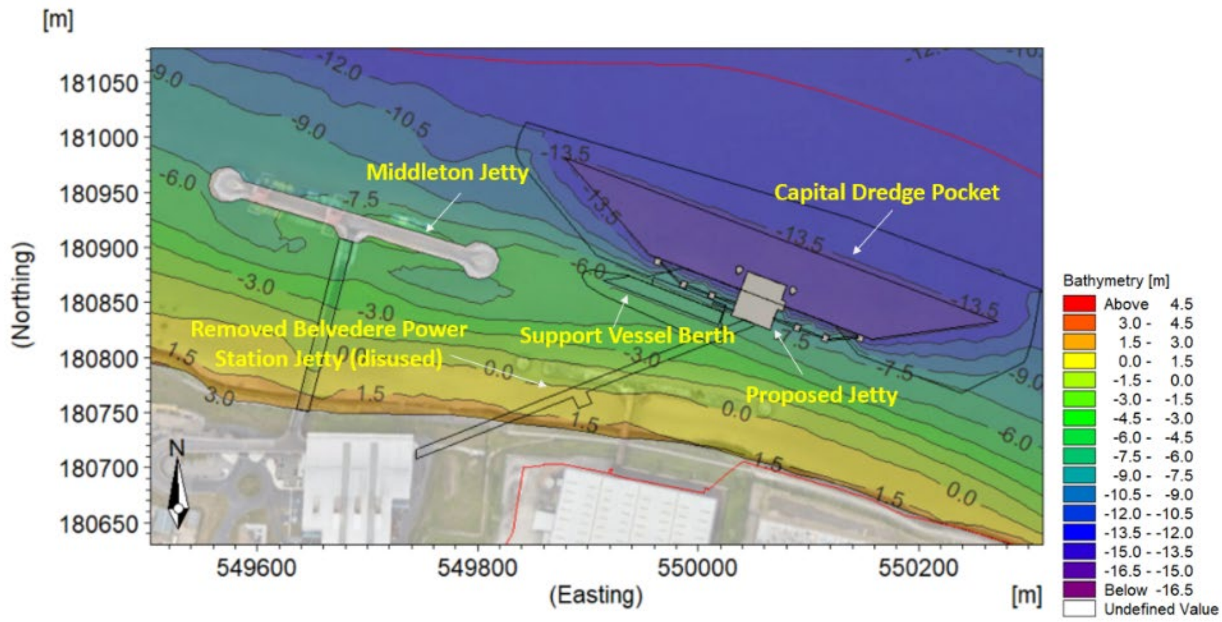


Figure 1-5: Scenario 4 (Proposed Scheme without Belvedere Power Station Jetty (Disused)) Model Bathymetry

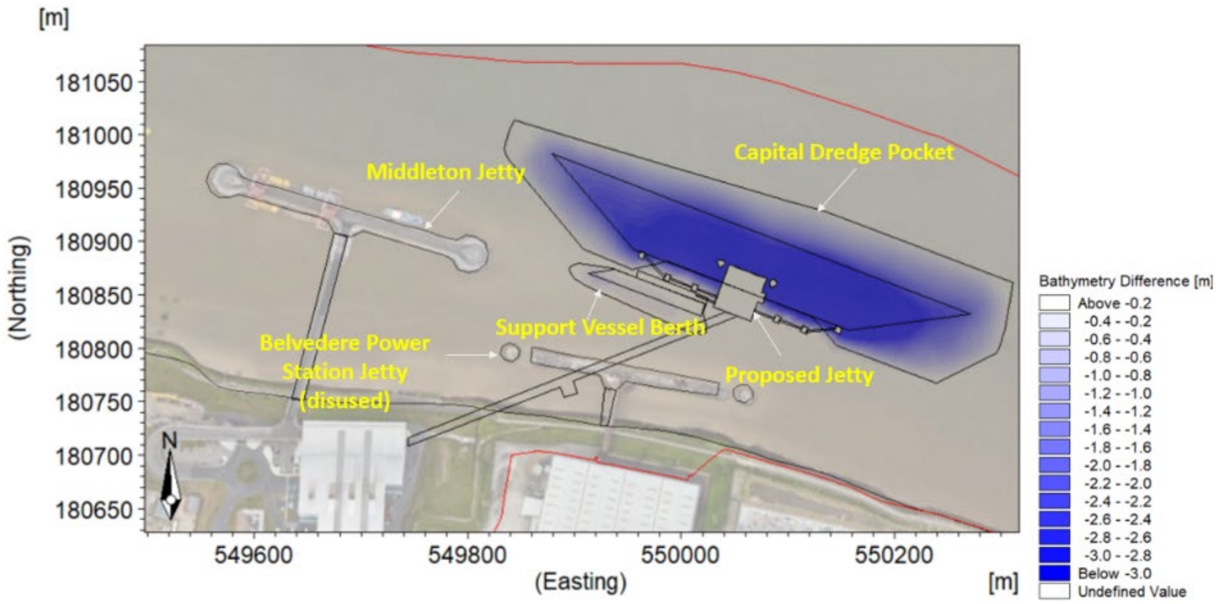


Figure 1-6: Scenario 3 (Proposed Scheme with Belvedere Power Station Jetty (Disused)) Bathymetry Difference to Baseline

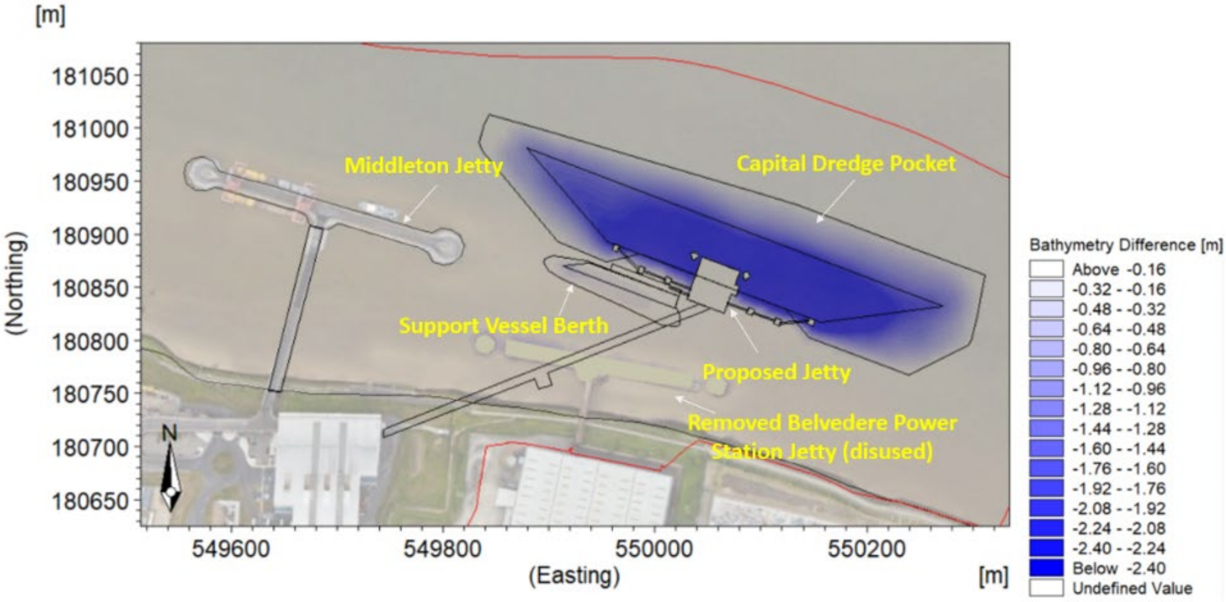


Figure 1-7: Scenario 4 (Proposed Scheme without Belvedere Power Station Jetty (Disused)) Bathymetry Difference to Baseline

2. MODEL CONFIGURATION

2.1. MODEL DOMAIN

2.1.1. The model domain covers the reach of the River Thames between Richmond (approximately 32km west of the Site Boundary) and Coryton (approximately 27km east of the Site Boundary). The boundaries were chosen to be sufficiently distant from the Site so as to not influence the predicted flow conditions. Predicted and measured flow data is available (UKHO, PLA and Environment Agency) at these locations which has been used for the generation of boundary conditions and model calibration.

2.2. BATHYMETRY

2.2.1. Multiple sources of bathymetric data have been used within the model, namely:

- local bathymetric data of the area immediately surrounding the Site sourced from the PLA chart 327 (**Figure 1-1**); and
- bathymetric data downstream and upstream of the Site sourced from C-MAP Admiralty Chart Data owned and licensed to WSP (**Figure 2-1**), consultants for the Applicant.

2.2.2. Where data overlapped, checks were undertaken to ensure each provided consistent results. Boundaries between data sets were buffered to prevent step changes in bathymetry, then interpolated and smoothed using the MIKE modelling software. **Figure 2-2** shows the full extent of the model domain.

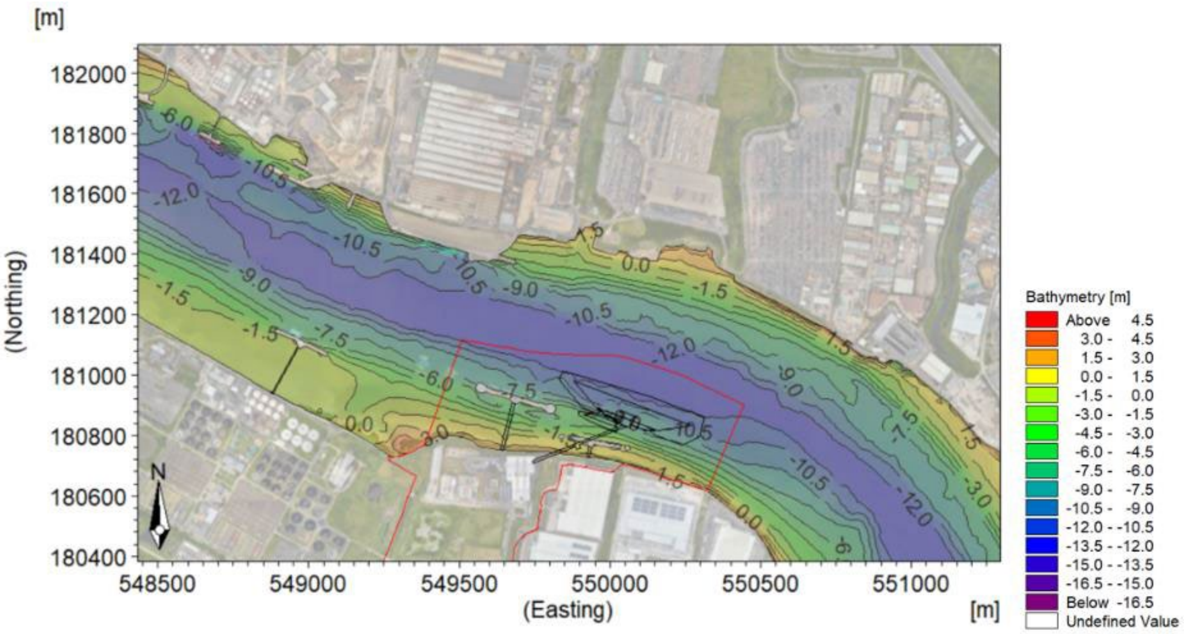


Figure 2-1: Bathymetry (m OD) Adjacent to Site Boundary (Red)

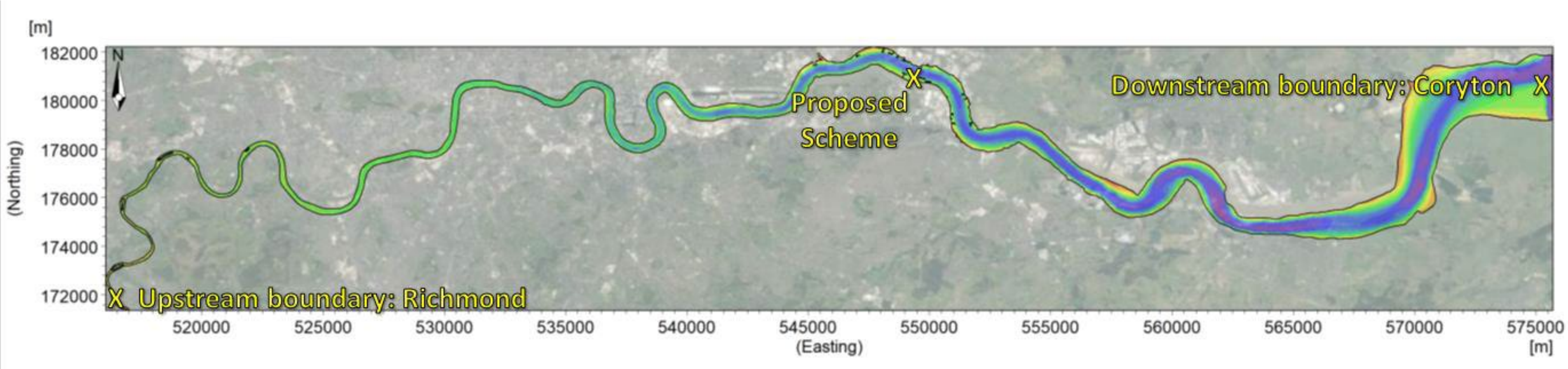


Figure 2-2: Thames MIKE FM Model Domain Boundaries

2.3. MESH

2.3.1. Within the Site Boundary the mesh resolution has been set to approximately 20m, with the resolution increasing up to a maximum of 100m moving further upstream and downstream (**Figure 2-3**). At the very upstream end of the model domain the mesh resolution was reduced to 20m to ensure there were enough cells across the width of the channel to maintain model stability.

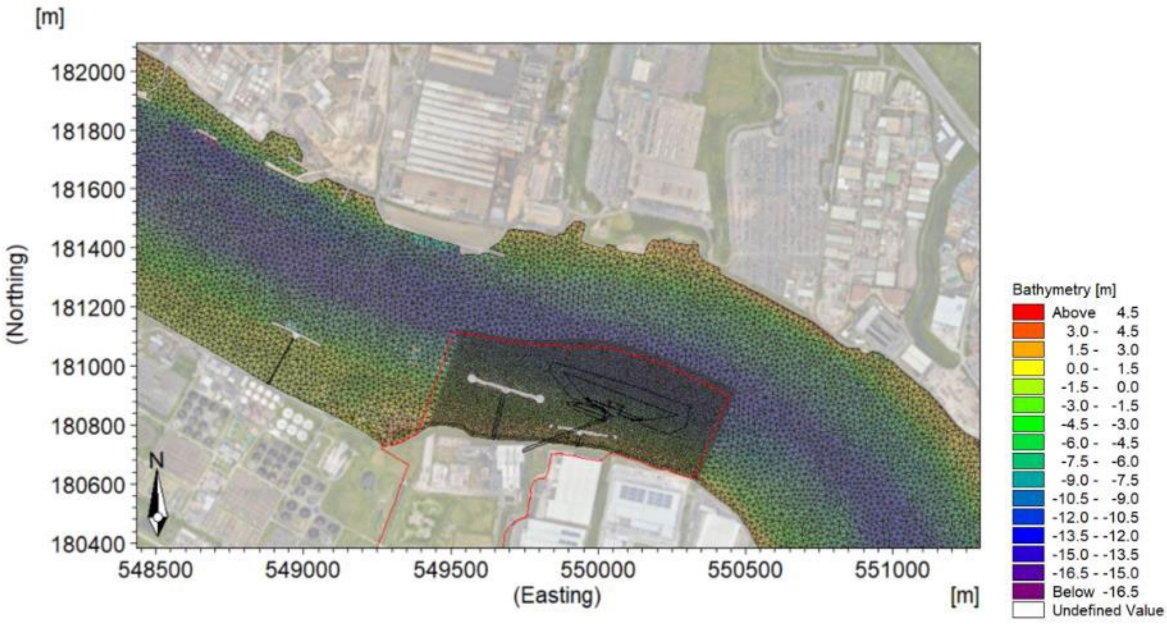


Figure 2-3: MIKE FM Model Mesh Site Boundary (Red)

2.4. BOUNDARY CONDITIONS

2.4.1. Three boundary conditions were applied, in addition to the zero normal velocity land boundary which included:

- a surface water level timeseries at the upstream boundary (Richmond Station);
- a surface water level timeseries at the downstream boundary (Coryton Station); and
- a current velocity timeseries at the downstream boundary (Coryton Station).

2.4.2. Data from UKHO Admiralty TotalTide software was used to generate the tidal boundary conditions.

2.5. BED ROUGHNESS

2.5.1. To improve the predicted current velocities, a varying Manning M bed roughness was applied over the model domain ranging from $55m^{1/3}/s$ to $65m^{1/3}/s$. Areas of deeper bathymetry (subtidal regions) were given a lower value (rougher bed) while higher elevation areas (intertidal regions) were made smoother.

2.5.2. The applied bed roughness numbers are broadly consistent with the subtidal and intertidal bed form types and are further supported by the results from the calibration and validation exercise showing the comparison of water levels and current speeds which showed a good level of agreement between the measured and predicted data sets at positions close to the Site.

2.6. MODEL CALIBRATION AND VALIDATION

2.6.1. The MIKE FM hydrodynamic model was calibrated against surface water level and current velocity predictions taken from UKHO Admiralty TotalTide software at the measurement locations closest to the Site. Surface water elevations were taken approximately 3km downstream from the Site Boundary at Erith, and current velocities and directions were taken approximately 0.5km upstream from the Site Boundary at Station SN011I (**Figure 2-4**). Data from August 2014 was used for model calibration and data from September and October 2022 was used for model validation, both covering a minimum spring neap period.

2.6.2. **Table 2-1** summarises the results of the model calibration and validation. The MIKE software was used to calculate R^2 values, where a value of 1 indicates complete agreement between the two datasets.

Table 2-1: Summary of Model Calibration (2014 data) and Validation (2022 data)

Scenario	Figure	Average Difference	Unit	R^2 value
2014 Surface water levels, Erith	**Figure 2-5**	0.05	m	0.98
2014 Current velocity, Station SN011I	**Figure 2-6**	0.05	m/s	0.71
2014 Current direction, Station SN011I	**Figure 2-7**	-9	°	0.91
2022 Surface water levels, Erith	**Figure 2-8**	0.09	m	0.98
2022 Current velocity, Station SN011I	**Figure 2-9**	0.04	m/s	0.88
2022 Current direction, Station SN011I	**Figure 2-10**	-9	°	0.96

Figure 2-4: Location of Calibration and Validation Data Sources

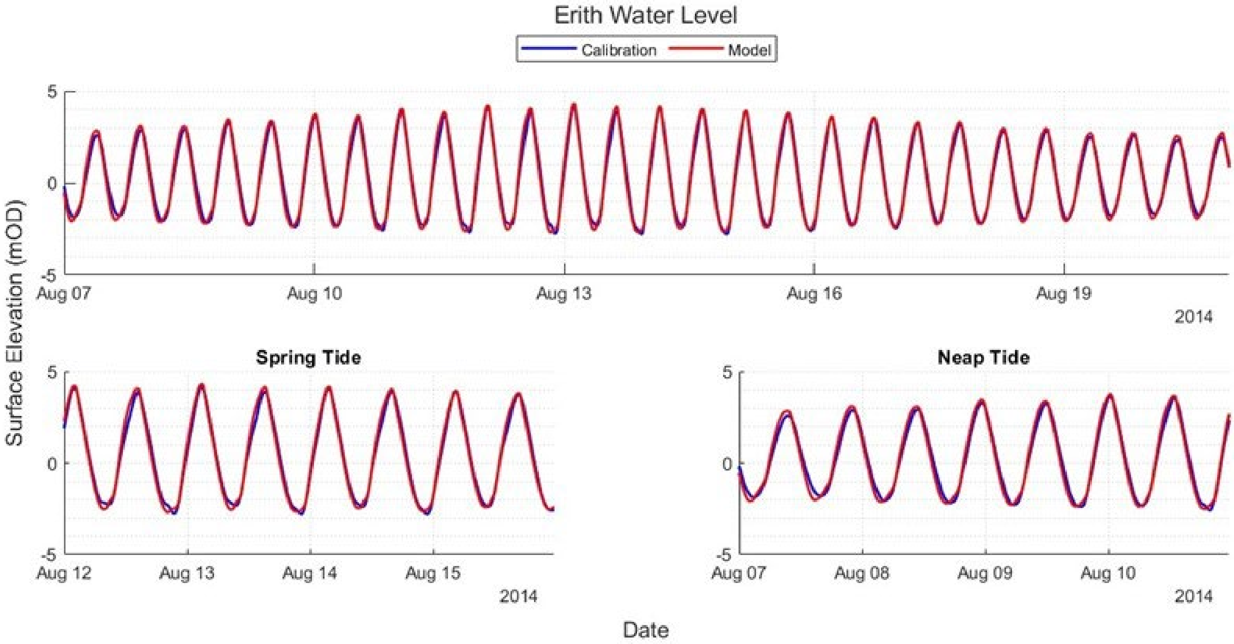


Figure 2-5: Model Surface Elevation (mAOD) 2014 Calibration Data at Erith

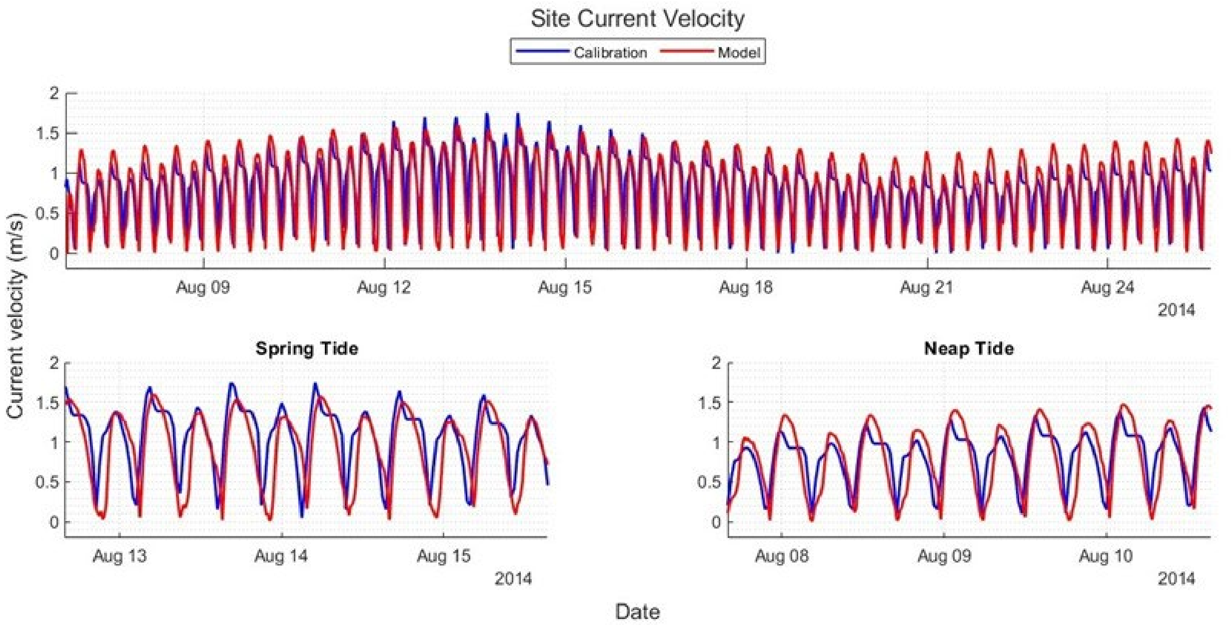


Figure 2-6: Model Current Velocity (m/s) 2014 Calibration Data at Station SN011I

Figure 2-7: Model Current Direction (°) 2014 Calibration Data at Station SN011I

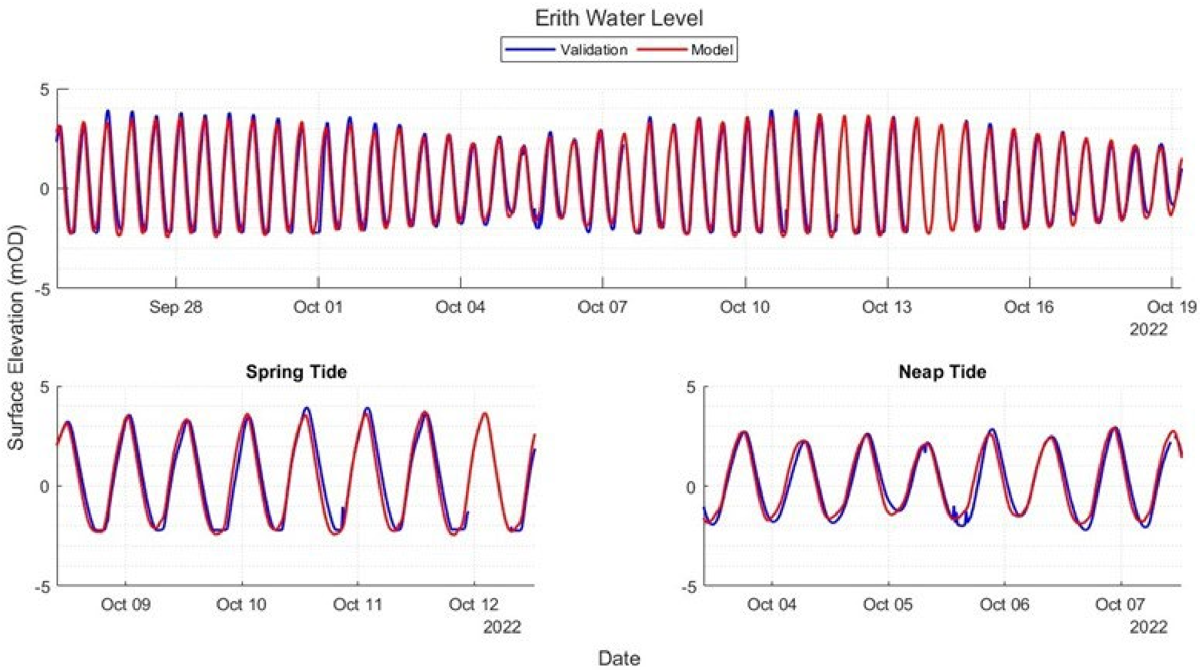


Figure 2-8: Model Surface Elevation (mAOD) 2022 Validation Data at Erith

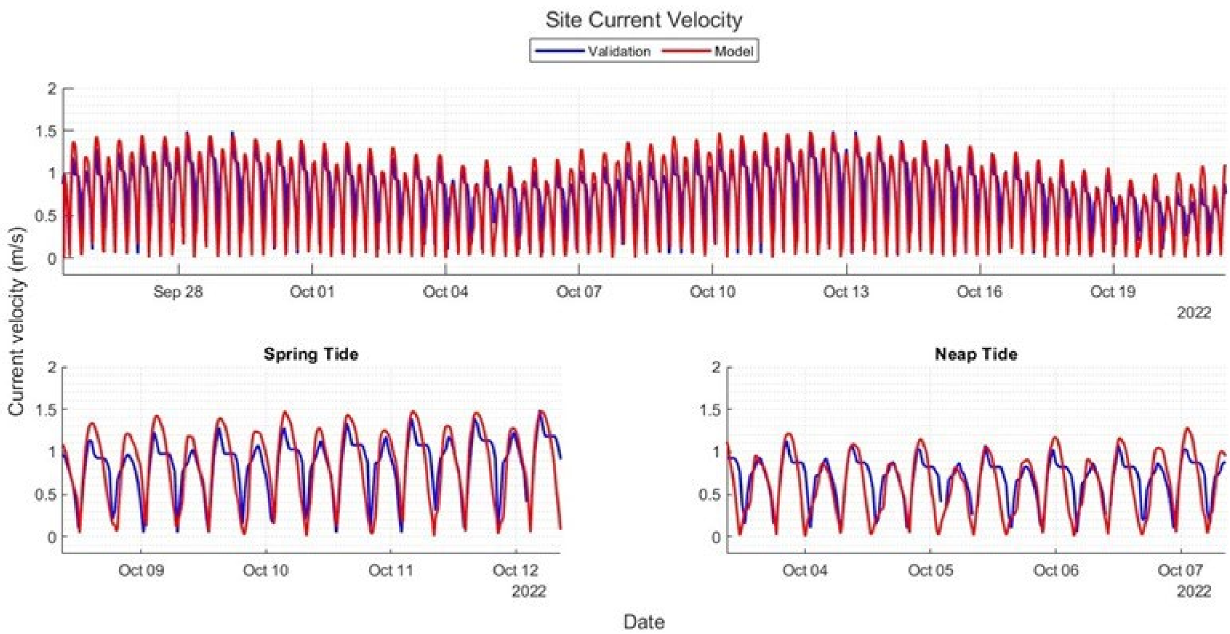


Figure 2-9: Model Current Velocity (m/s) 2022 Validation Data at Station SN011I

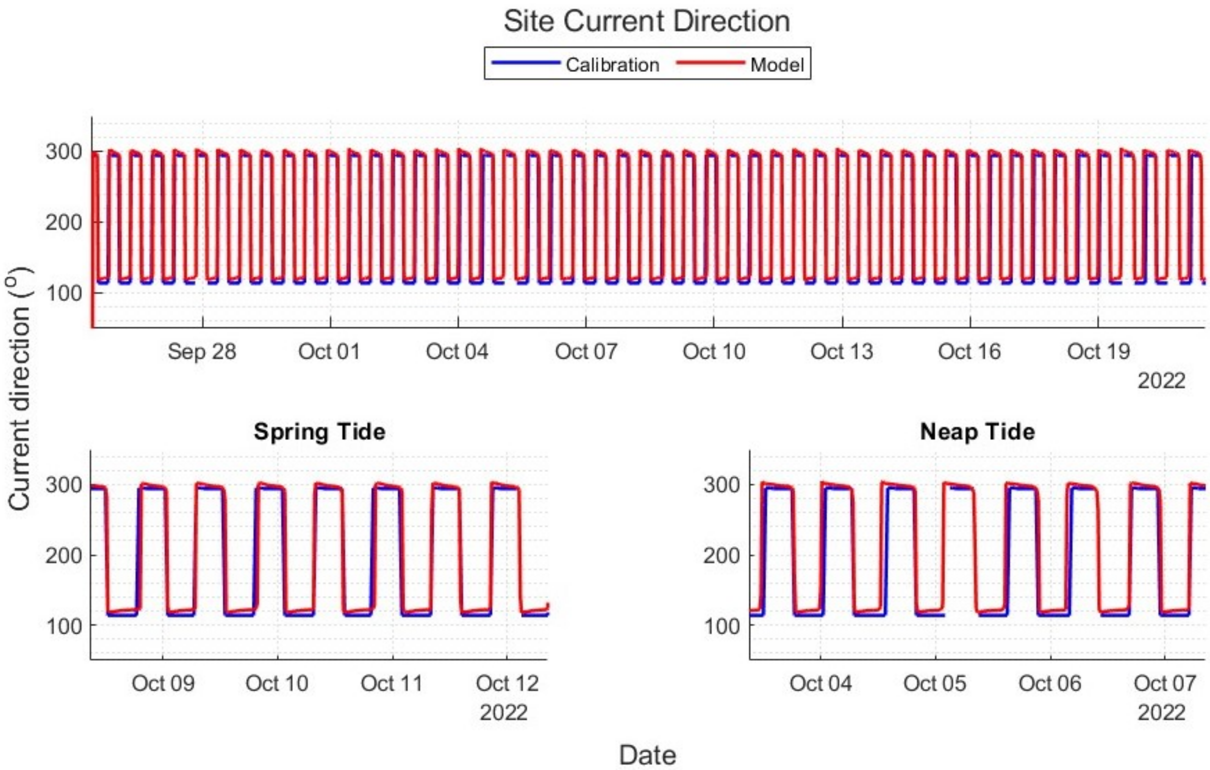


Figure 2-10: Model Current Direction (°) 2022 Validation Data at Station SN011I

2.6.3. The guidance set out in Framework of Water Research[1] for estuaries that should occur for at least 90% of the time include the following:

- Hydrodynamics:
  - Water Levels to within ± 0.1m at the mouth and ± 0.3m at the head;

- Current speeds to within ± 0.2m/s; and
- Current direction to within ± 20°.

2.6.4. A review of the goodness of fit (R^2) and plots clearly show that the magnitude, phasing and directional differences meets the criteria as set out in the Framework of Water Research[1]. Therefore, in conclusion the model is considered appropriate for use in the assessment.

2.7. DESCRIPTION OF MODEL OUTPUTS

2.7.1. The model outputs are presented in the form of spatial plots to help assess the impacts of the Proposed Scheme compared to the existing baseline scenario. The times of peak flood and ebb tides were chosen to be representative of the largest currents at the Site to provide a worst case result. Where plots are indicating differences, red colours show an increase and blue colours show a decrease.

2.7.2. The following types of spatial plots have been produced:

- surface elevation differences – these plots show the difference between two scenarios (Scheme – Baseline) in water surface elevation (m) at times of peak spring ebb and flood tides;
- flow speed and differences – these plots show the flow velocity (m/s) at times of peak spring ebb and flood tides and the difference between the two scenarios (Scheme – Baseline); and
- bed shear stress and differences – these plots show the bed shear stress (N/m^2) at peak spring ebb and flood tides and the difference between the two scenarios (Scheme – Baseline).

3. MODEL RESULTS

3.1. SCENARIO 1: EXISTING CONDITIONS WITH BELVEDERE POWER STATION JETTY (DISUSED)

3.1.1. The baseline flow speed and bed shear stress outputs are plotted in **Figure 3-1** to **Figure 3-4**.

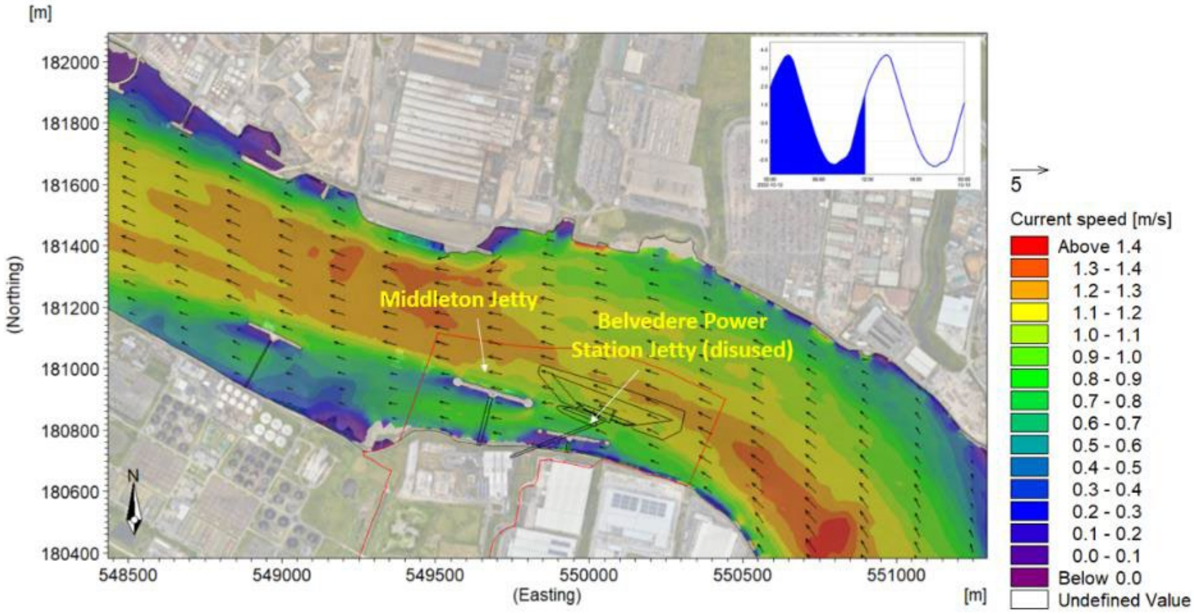


Figure 3-1: Scenario 1 – Flow Speed Magnitude at Peak Spring Flood Tide

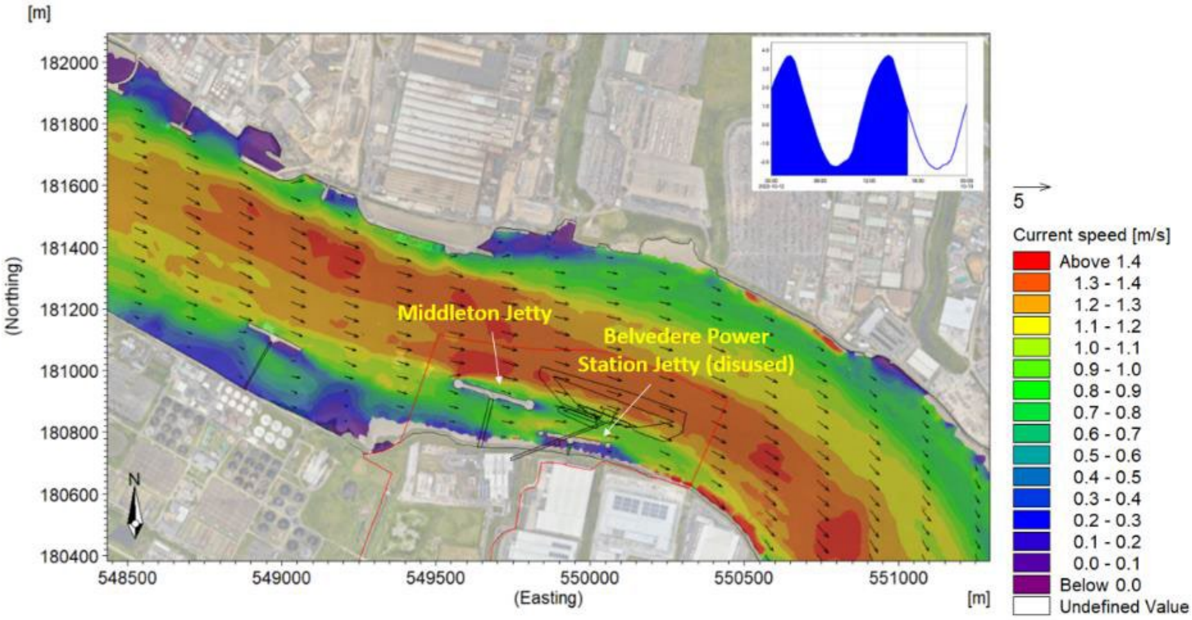


Figure 3-2: Scenario 1 – Flow Speed Magnitude at Peak Spring Ebb Tide

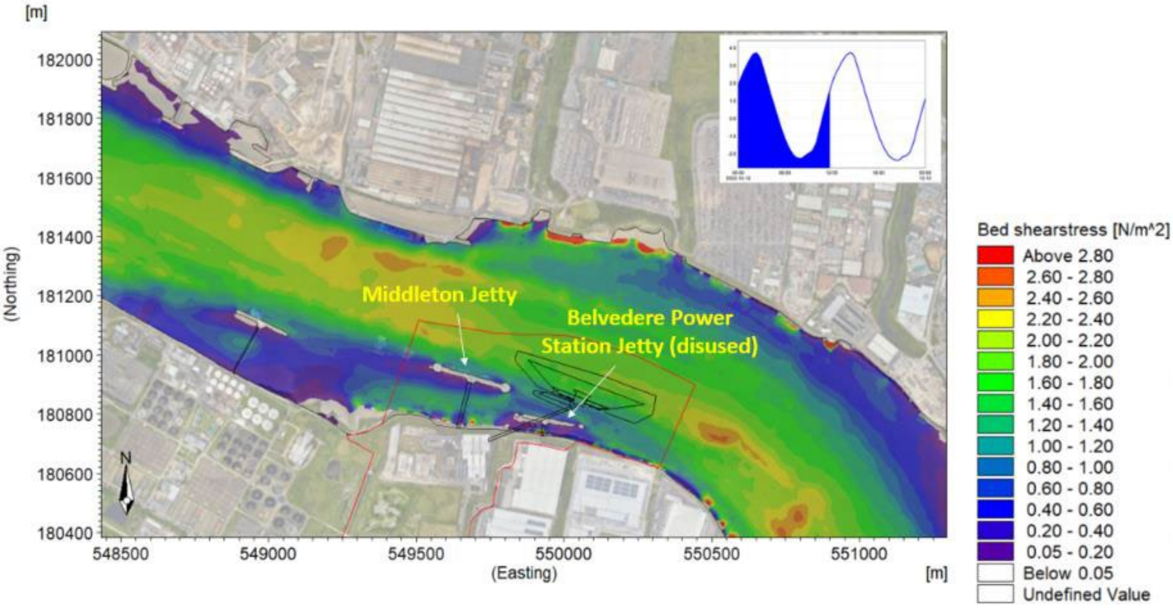


Figure 3-3: Scenario 1 – Bed Shear Stress Magnitude at Peak Spring Flood Tide

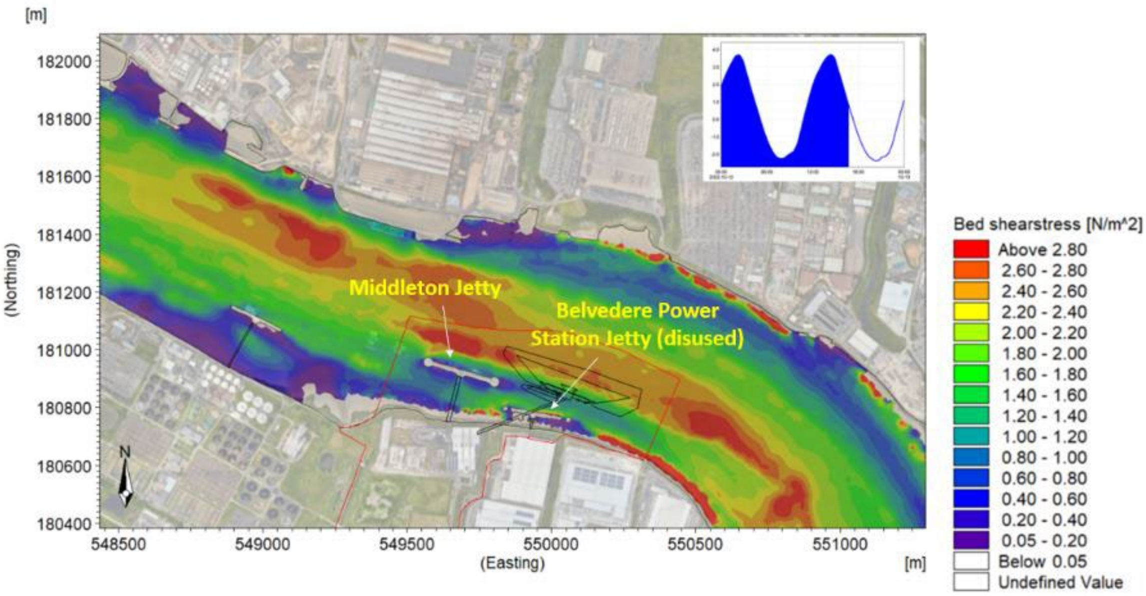


Figure 3-4: Scenario 1 – Bed Shear Stress Magnitude at Peak Spring Ebb Tide

3.2. SCENARIO 2: EXISTING CONDITIONS WITHOUT BELVEDERE POWER STATION JETTY (DISUSED)

3.2.1. As this scenario is a potential temporary construction phase it has not been used to demonstrate the impacts of the operation phase of the Proposed Scheme therefore no results are presented here. However, it has been used alongside Scenario 1 to inform the dredging analysis.

3.3. SCENARIO 3: PROPOSED SCHEME WITH BELVEDERE POWER STATION JETTY (DISUSED)

3.3.1. The maximum change in surface elevation across the peak spring flood and ebb tides is ±35mm, with these changes seen immediately adjacent to the proposed structures (**Figure 3-5** and **Figure 3-6**). No significant change in water elevation is predicted away from the Site.

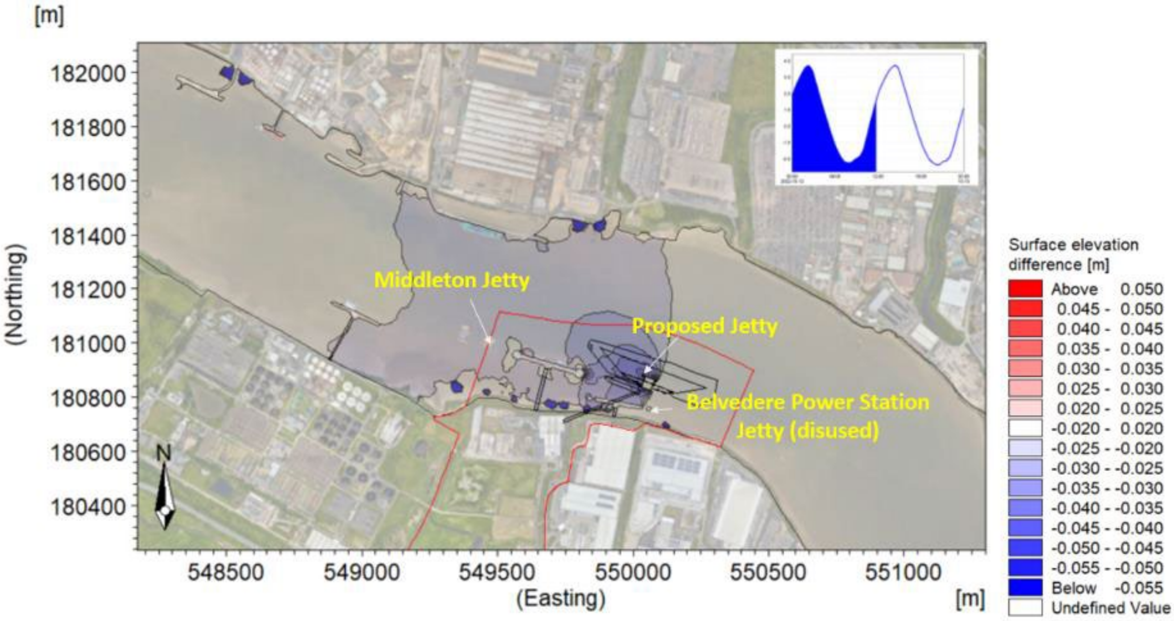


Figure 3-5: Scenario 3 – Difference in Surface Elevation at Peak Spring Flood Tide

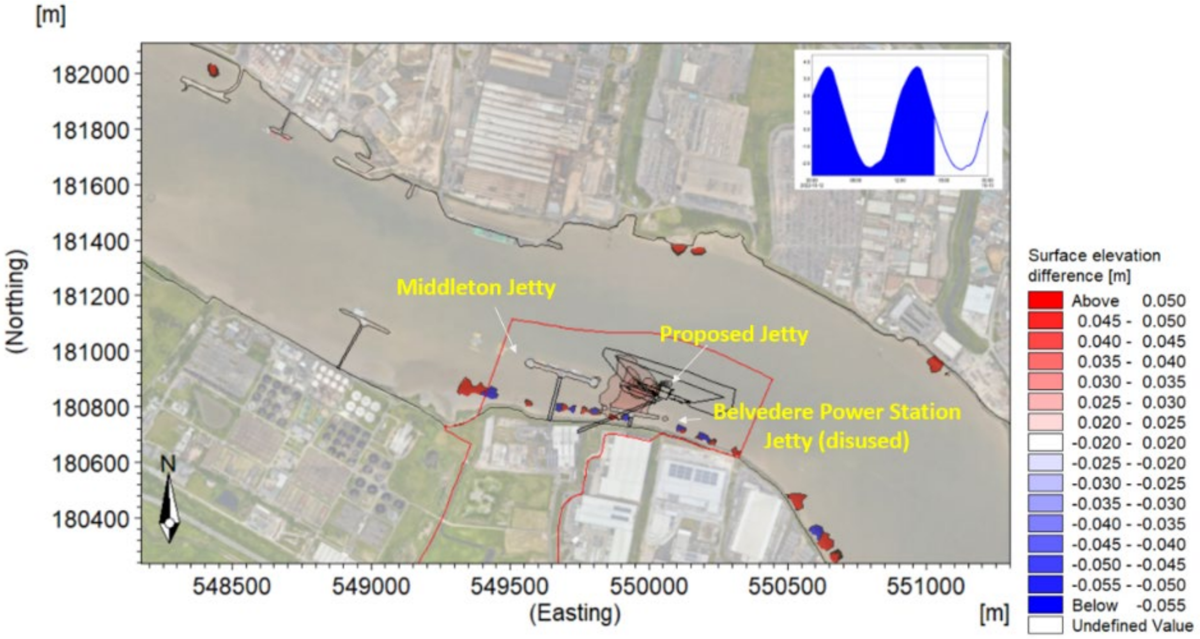


Figure 3-6: Scenario 3 – Difference in Surface Elevation at Peak Spring Ebb Tide

3.3.2. The Scenario 3 flow speed and bed shear stress outputs are plotted in **Figure 3-7** to **Figure 3-10**.

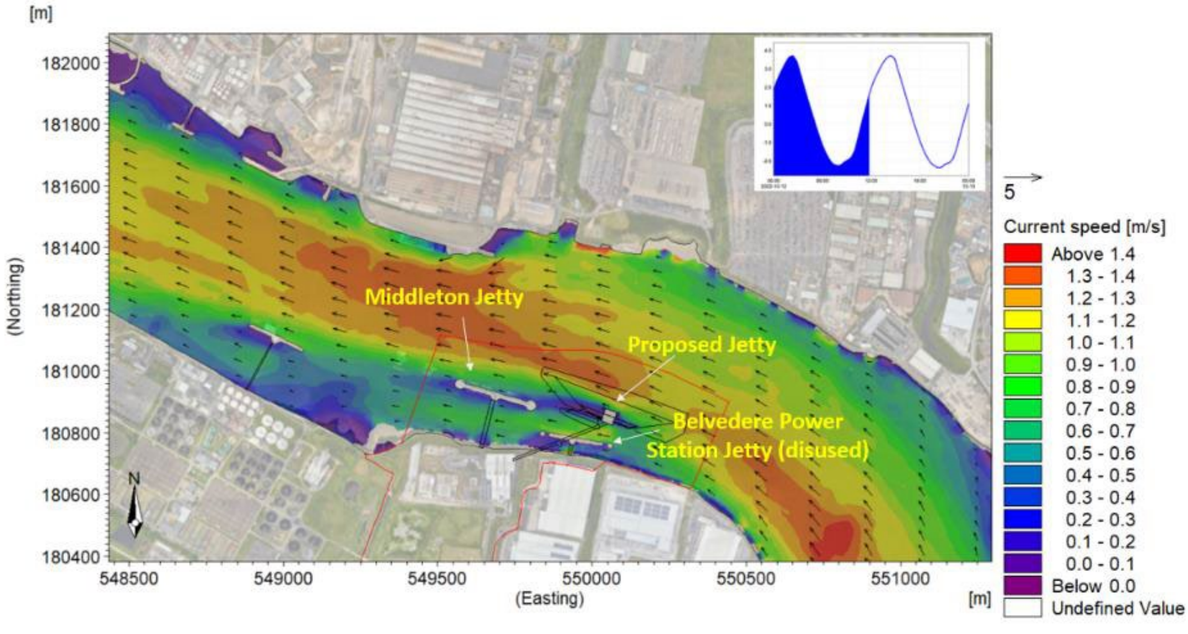


Figure 3-7: Scenario 3 – Flow Speed Magnitude at Peak Spring Flood Tide

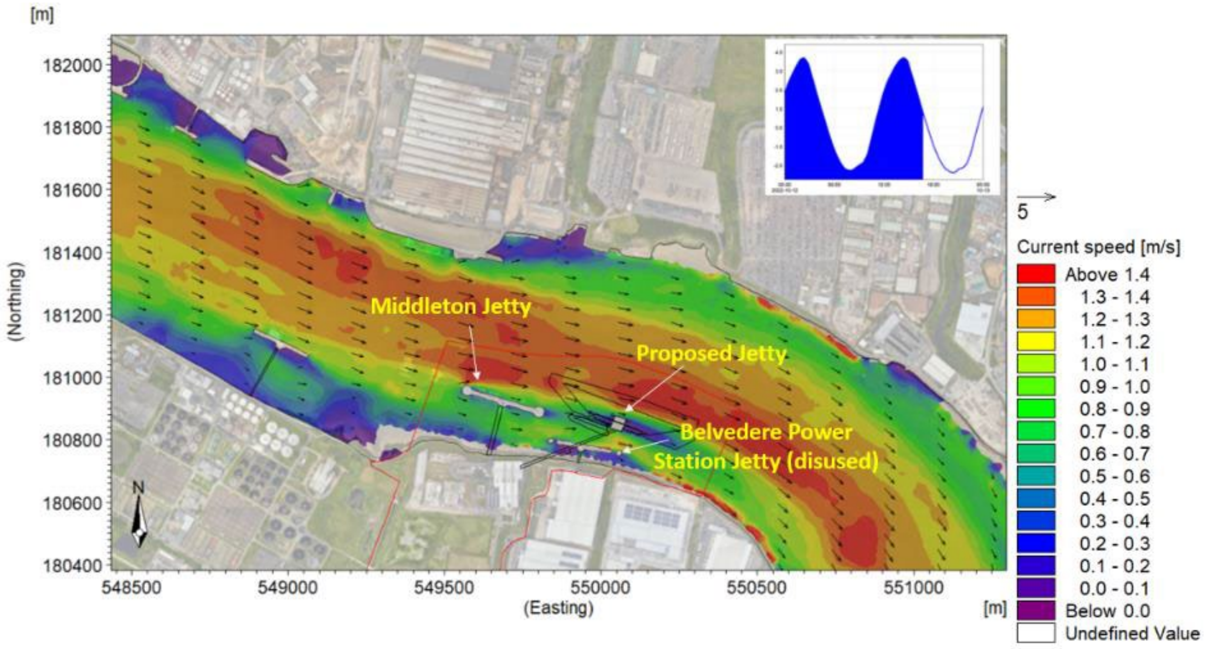


Figure 3-8: Scenario 3 – Flow Speed Magnitude at Peak Spring Ebb Tide

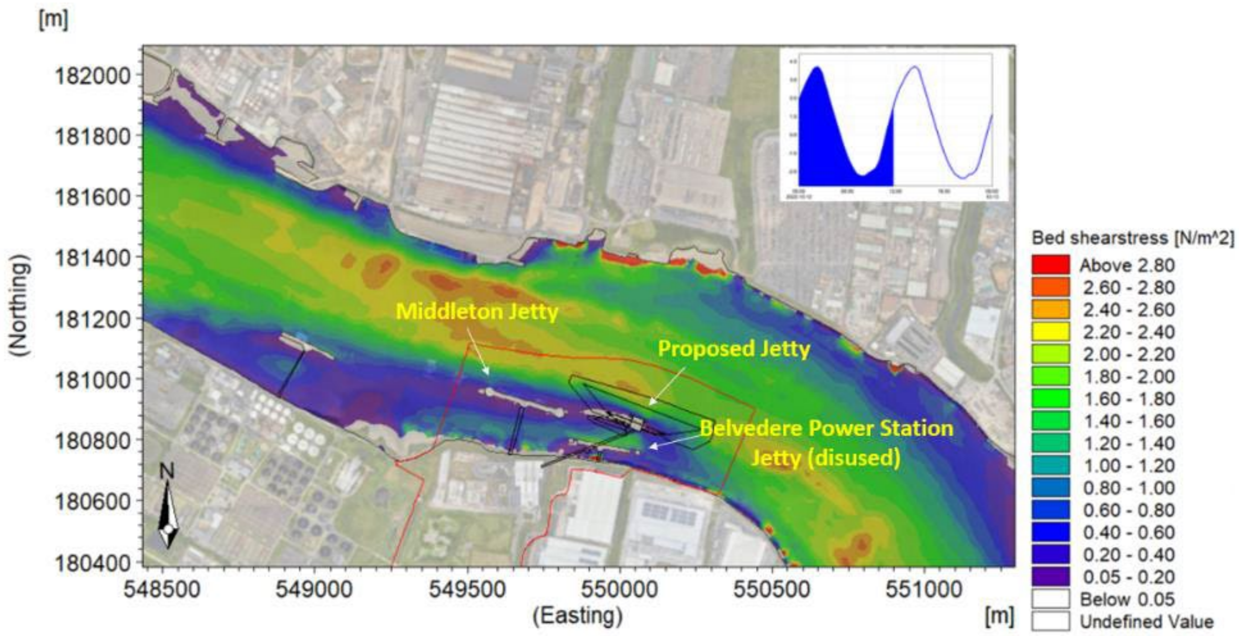


Figure 3-9: Scenario 3 – Bed Shear Stress Magnitude at Peak Spring Flood Tide

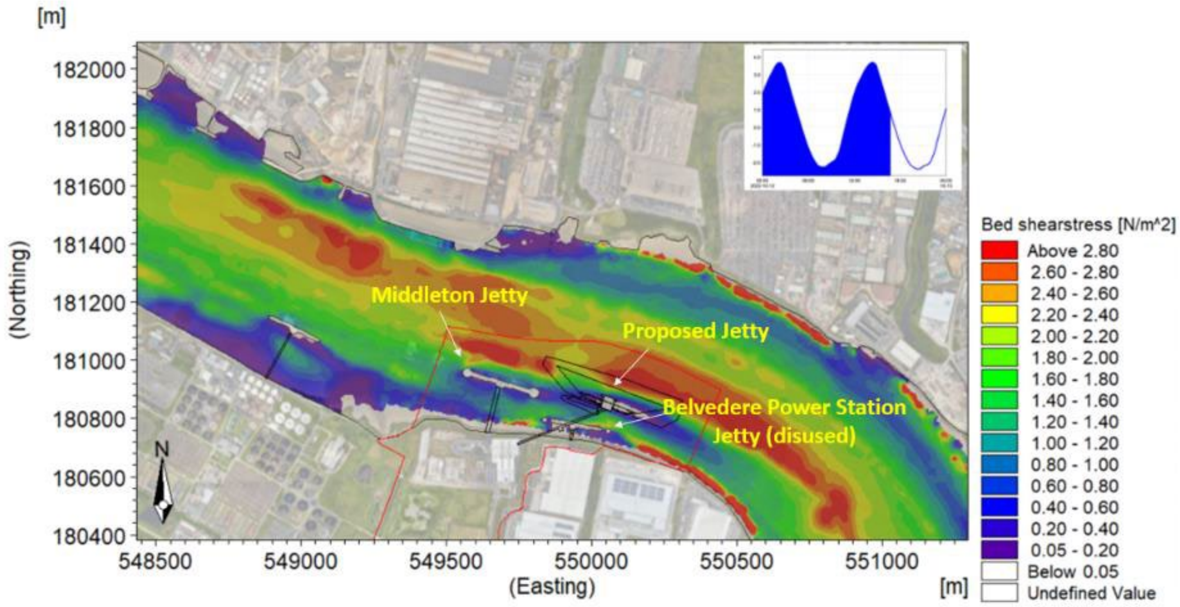


Figure 3-10: Scenario 3 – Bed Shear Stress Magnitude at Peak Spring Ebb Tide

3.3.3. **Figure 3-11** and **Figure 3-14** show the change in current speed at peak spring flood and ebb tides respectively. The implementation of Scenario 3 shows an increase in current speed compared to the baseline (Scenario 1) of up to approximately 0.3m/s, both between the Belvedere Power Station Jetty (disused), the Proposed Jetty and towards the centre of the channel. There is a decrease in current speed of up to approximately 1.1m/s in the wake of the Proposed Jetty, up to 1km up/downstream depending on the direction of the tide.

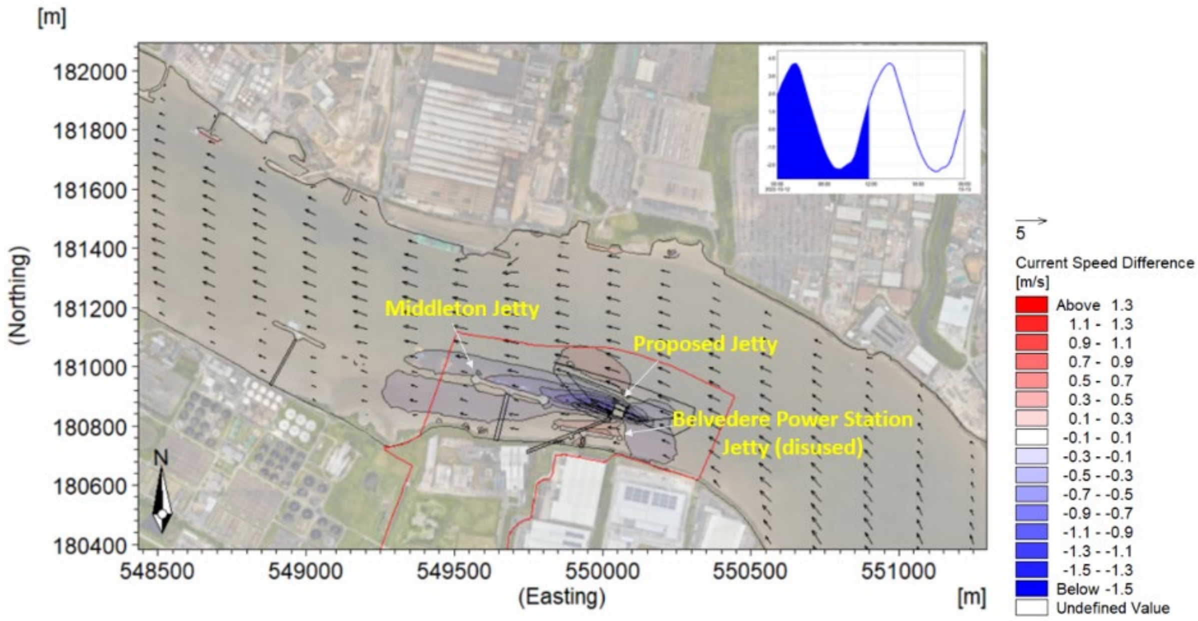


Figure 3-11: Scenario 1 vs. Scenario 3 – Difference in Flow Speed Magnitude at Peak Spring Flood Tide

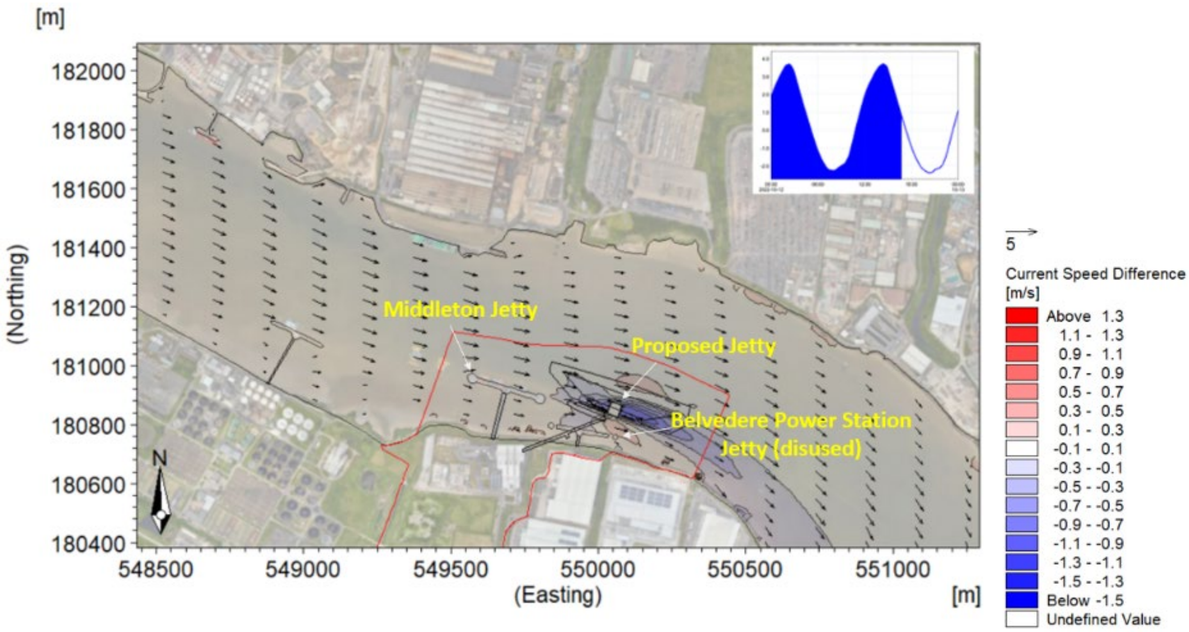


Figure 3-12: Scenario 1 vs. Scenario 3 – Difference in Flow Speed Magnitude at Peak Spring Ebb Tide

3.3.4. **Figure 3-13** and **Figure 3-14** show the change in bed shear stress at peak spring flood and ebb tides respectively. The implementation of Scenario 3 shows an increase in shear stress compared to the baseline model (Scenario 1) of up to approximately 0.8N/m^2 around the area where the Belvedere Power Station Jetty (disused) is removed 0.7N/m^2 and towards the centre of the channel. There is a decrease in shear stress of up to approximately 1.7N/m^2 in the wake of the Proposed Jetty and 1N/m^2 between the Middleton Jetty and the bank, up to 1km up/downstream depending on the direction of the tide. Away from the Belvedere Power Station Jetty (disused), increases in the bed shear stresses are limited so negligible increases in erosion are expected. Where the bed shear stress decreases (around the existing jetties), some sedimentation may occur. This is further explored in the sediment modelling (**Section 4**).

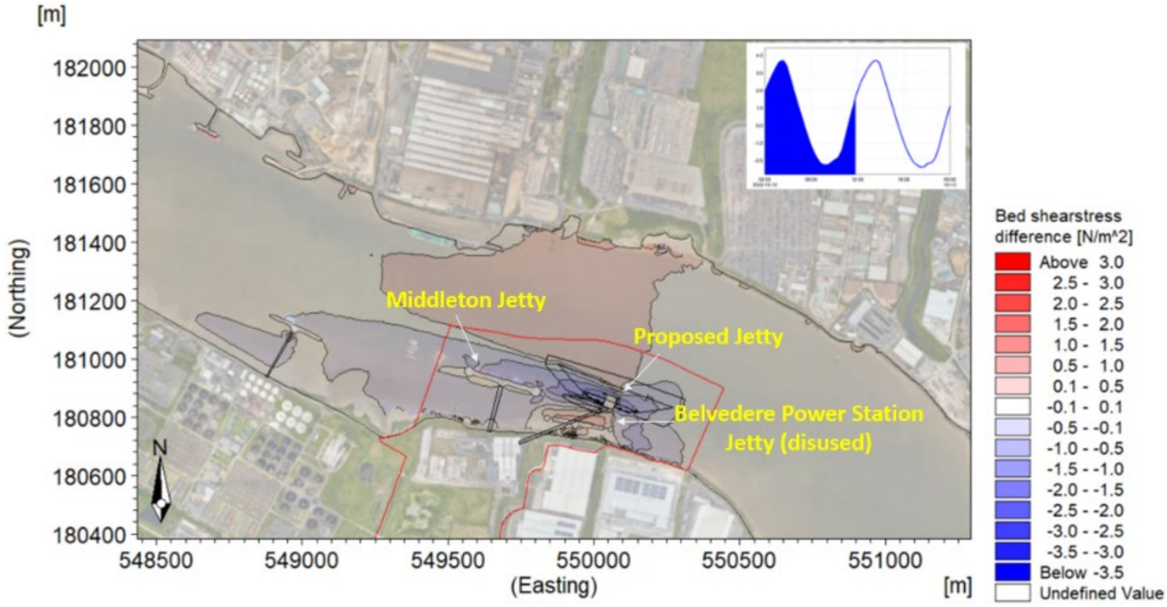


Figure 3-13: Scenario 1 vs. Scenario 3 – Difference in Bed Shear Stress Magnitude at Peak Spring Flood Tide

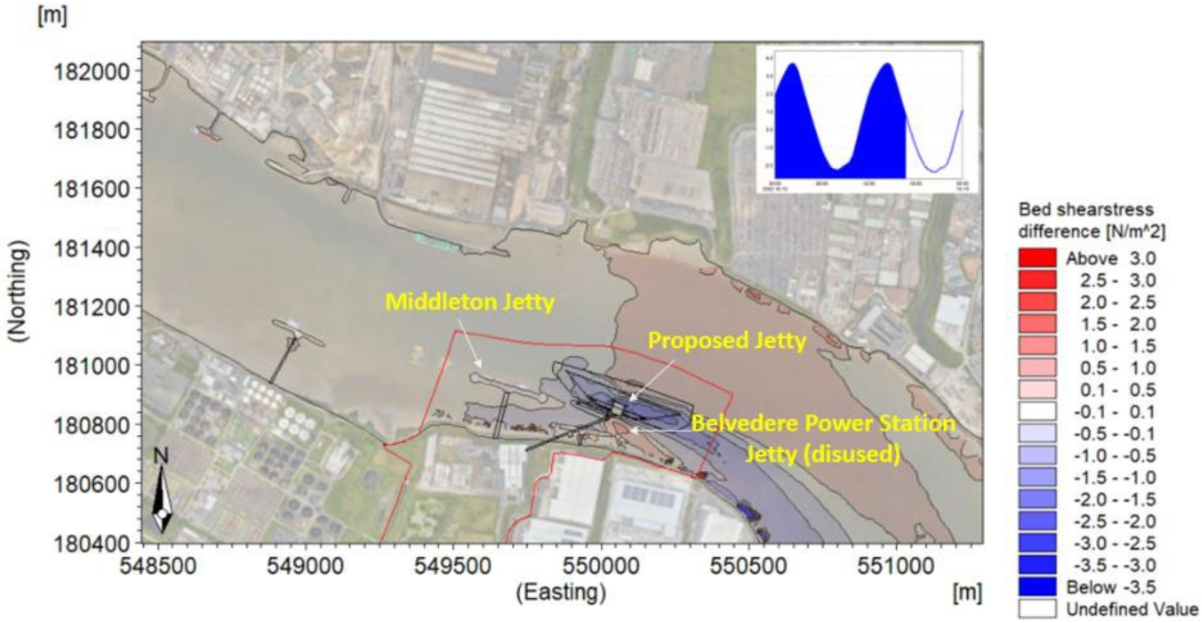


Figure 3-14: Scenario 1 vs. Scenario 3 – Difference in Bed Shear Stress Magnitude at Peak Spring Ebb Tide

3.4. SCENARIO 4: PROPOSED SCHEME WITHOUT BELVEDERE POWER STATION JETTY (DISUSED)

3.4.1. The maximum change in surface elevation across the peak spring flood and ebb tides is ±35mm, with the largest changes in the area immediately around the Proposed Scheme (**Figure 3-15** and **Figure 3-16**). No significant change in water elevation is predicted away from the immediate Site.

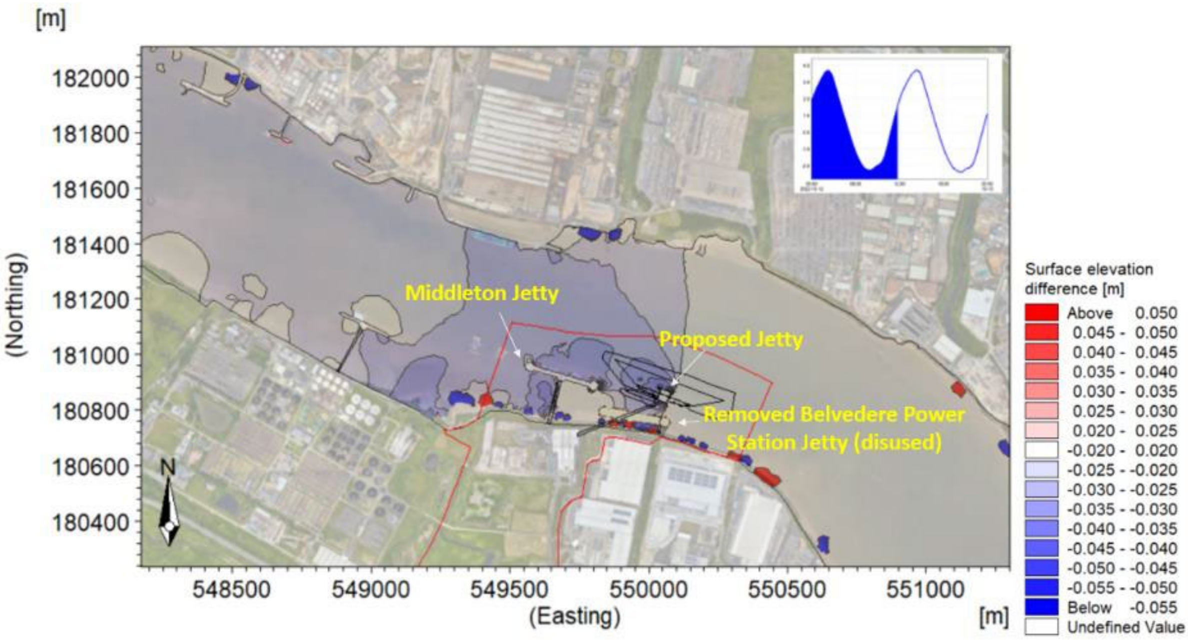


Figure 3-15: Scenario 4 – Difference in Surface Elevation at Peak Spring Flood Tide

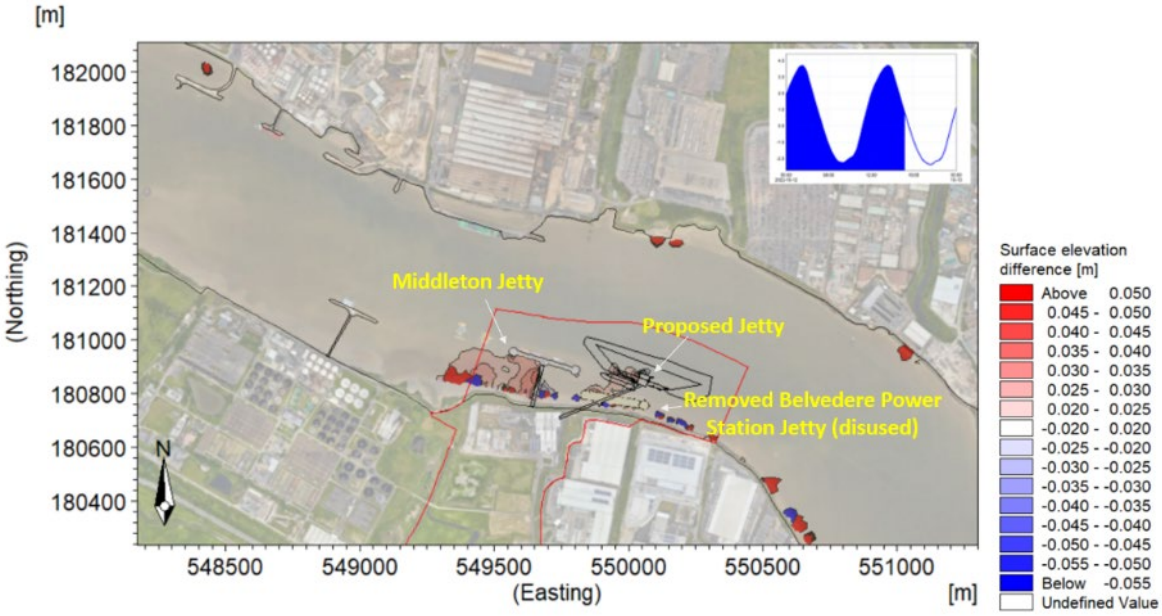


Figure 3-16: Scenario 4 – Difference in Surface Elevation at Peak Spring Ebb Tide

3.4.2. The Scenario 4 flow speed and bed shear stress outputs are plotted in **Figure 3-17** to **Figure 3-20**.

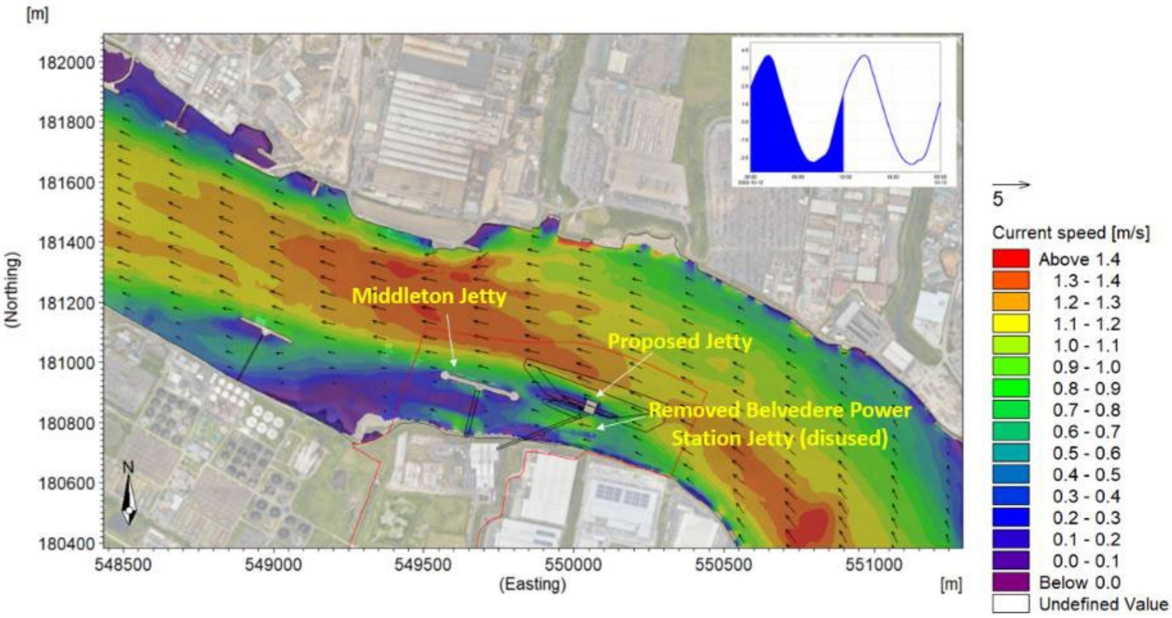


Figure 3-17: Scenario 4 – Flow Speed Magnitude at Peak Spring Flood Tide

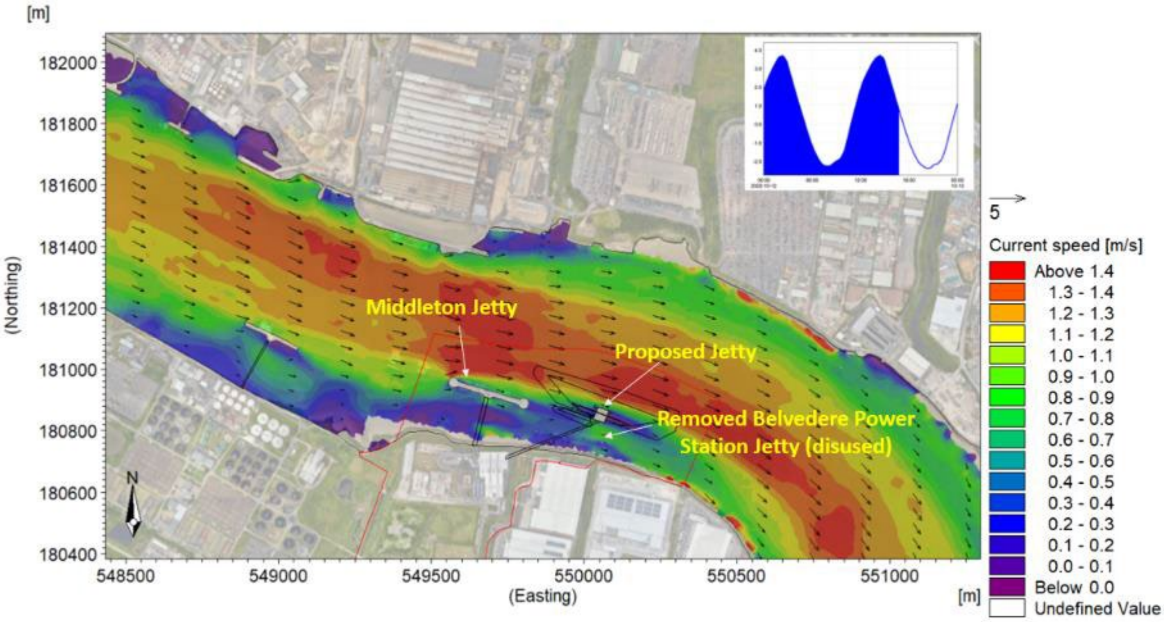


Figure 3-18: Scenario 4 – Flow Speed Magnitude at Peak Spring Ebb Tide

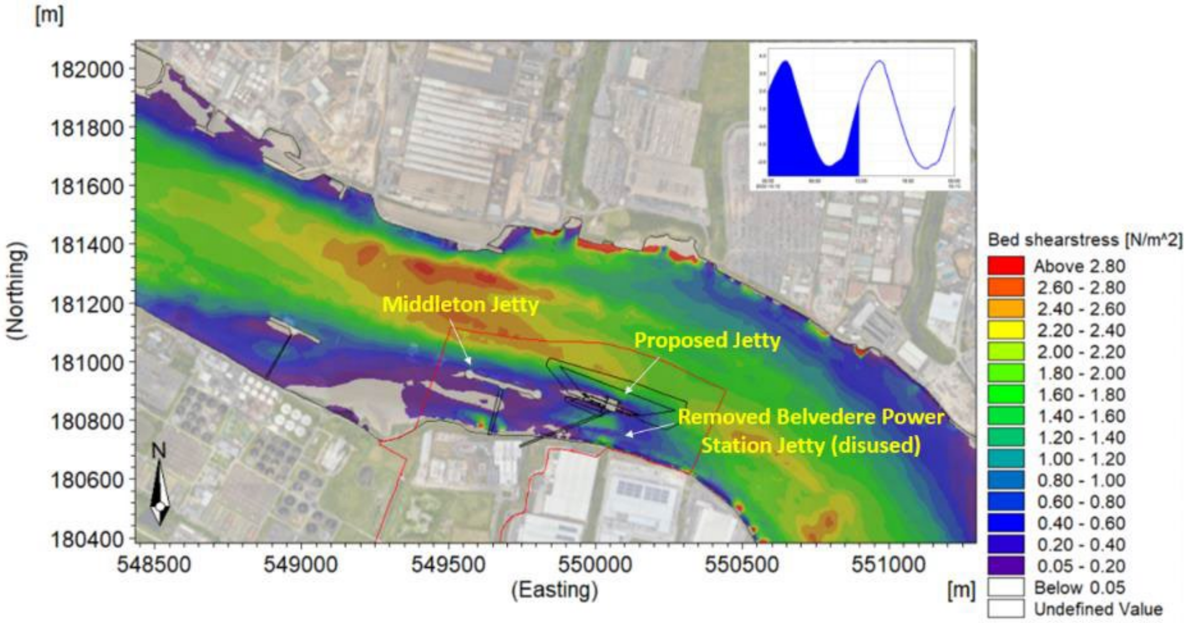


Figure 3-19: Scenario 4 – Bed Shear Stress Magnitude at Peak Spring Flood Tide

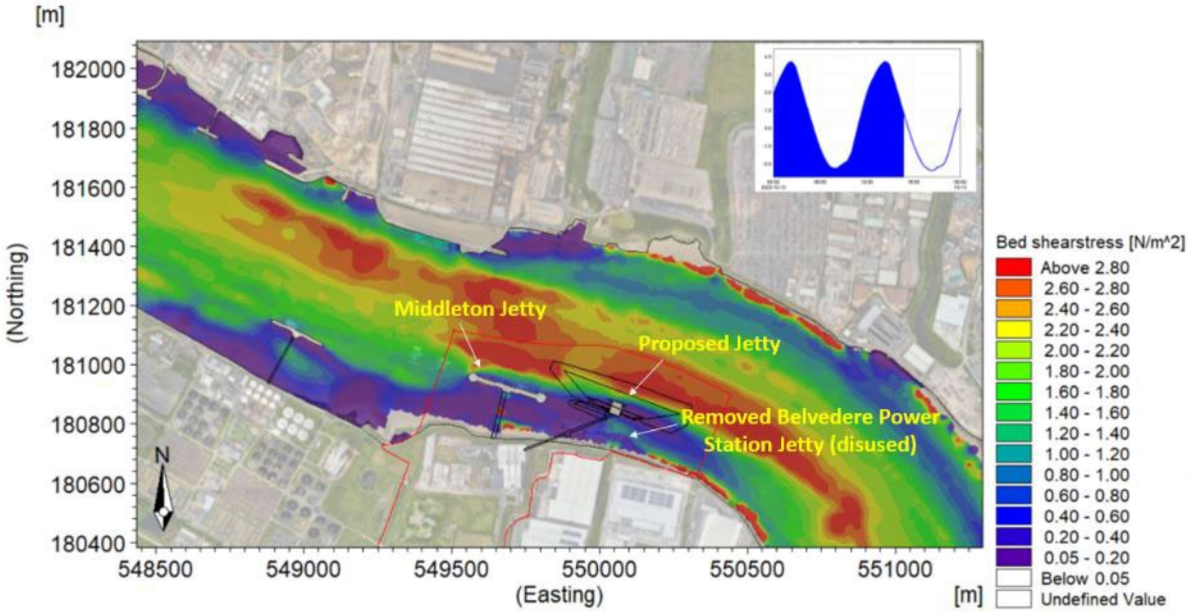


Figure 3-20: Scenario 4 – Bed Shear Stress Magnitude at Peak Spring Ebb Tide

3.4.3. **Figure 3-21** and **Figure 3-22** show the change in current speed at peak spring flood and ebb tides respectively. The implementation of Scenario 4 shows an increase in current speed compared to the baseline model of up to approximately 0.4m/s, both around the area where the Belvedere Power Station Jetty (disused) is removed and towards the centre of the channel. There is a decrease in current speed of up to approximately 1m/s in the wake of the Proposed Jetty, up to 1km up/downstream depending on the direction of the tide.

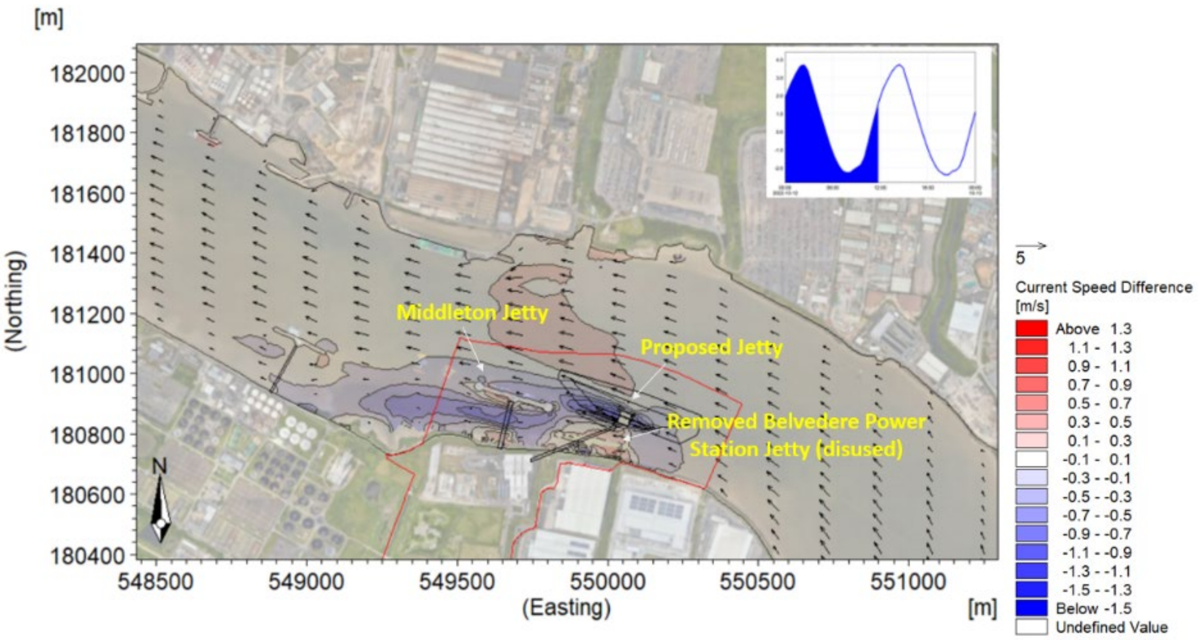


Figure 3-21: Scenario 1 vs. Scenario 4 – Difference in Flow Speed Magnitude at Peak Spring Flood Tide

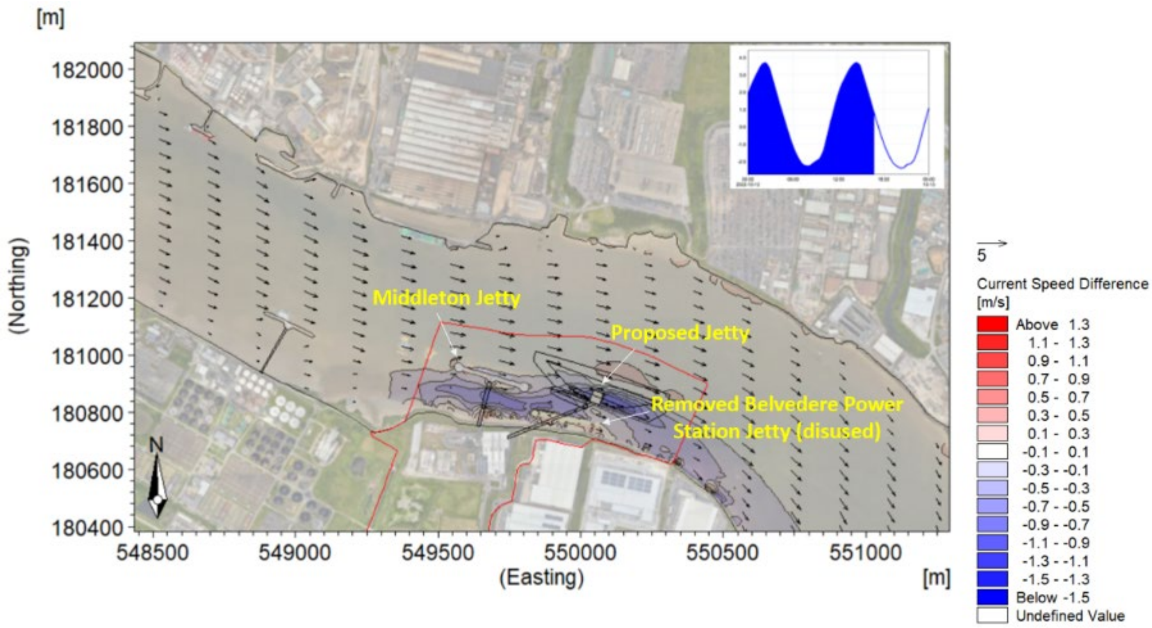


Figure 3-22: Scenario 1 vs. Scenario 4 – Difference in Flow Speed Magnitude at Peak Spring Ebb Tide

3.4.4. **Figure 3-23** and **Figure 3-24** show the change in bed shear stress at peak spring flood and ebb tides respectively. The implementation of Scenario 4 shows an increase in shear stress compared to the baseline model (Scenario 1) of up to approximately 1.0N/m^2 around the area where the Belvedere Power Station Jetty (disused) is removed 0.1N/m^2 and towards the centre of the channel. There is a decrease in shear stress of up to approximately 1.6N/m^2 in the wake of the Proposed Jetty and 1.3N/m^2 between the Middleton Jetty and the bank, up to 1km up/downstream depending on the direction of the tide. Away from the removed Belvedere Power Station Jetty (disused), increases in the bed shear stresses are limited so negligible increases in erosion are expected. Where the bed shear stress decreases (around the existing jetties), some sedimentation may occur. This is further explored in the sediment modelling (**Section 4**).

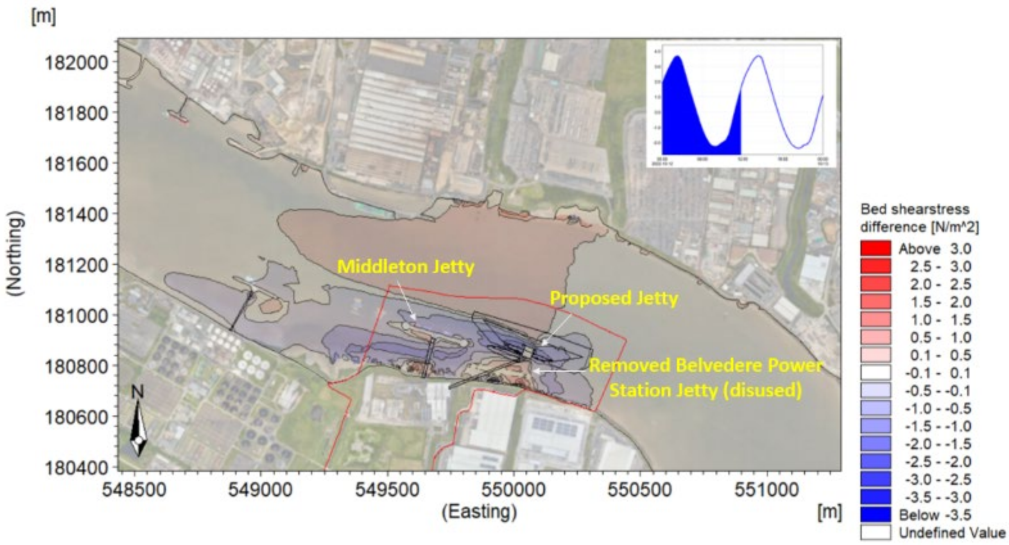


Figure 3-23: Scenario 1 vs. Scenario 4 – Difference in Bed Shear Stress Magnitude at Peak Spring Flood Tide

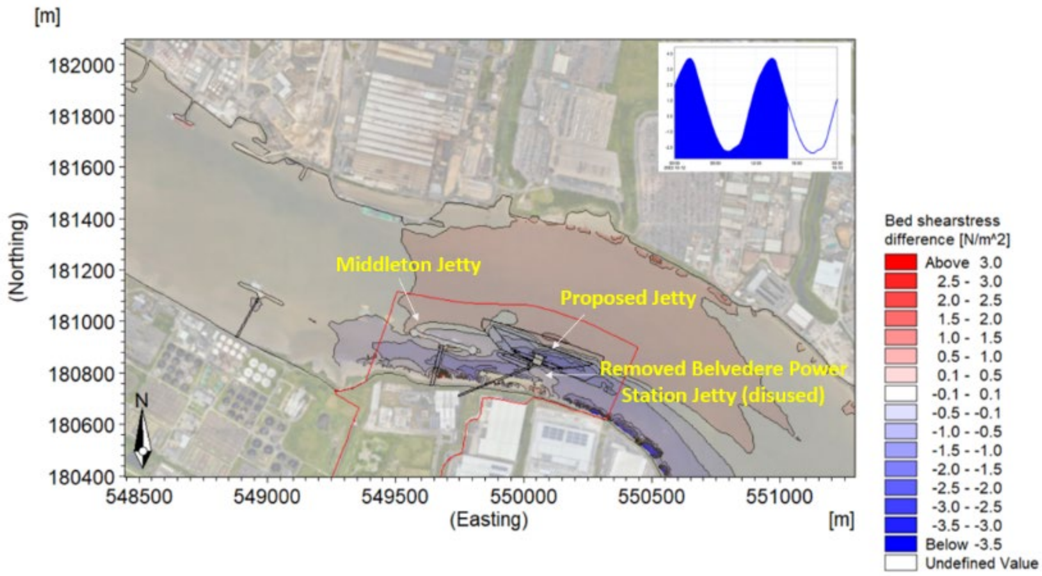


Figure 3-24: Scenario 1 vs. Scenario 4 – Difference in Bed Shear Stress Magnitude at Peak Spring Ebb Tide

4. DREDGE DISPERSION MODELLING

4.1. INTRODUCTION

4.1.1. As described previously, to support the proposed vessel activities as part of the Proposed Scheme, a capital (construction phase) and then subsequent further maintenance dredging (operation phase) of the Proposed Jetty dredge pocket will be required. To understand the impacts of the dredging activities (concentration and dispersion extent), dredge dispersion modelling has been undertaken using the MIKE by DHI FM PT model.

4.2. DREDGE DISPERSION MODEL CONFIGURATION

4.2.1. The calibrated and validated hydrodynamic model of the River Thames was used to drive the Particle Tracking (PT) module. The model allows the flow to be seeded with individual particles which are representative of the characteristics of the suspended sediment. By tracking these particles from their source, the fate of the suspended sediment can be inferred.

4.2.2. The PT model also considers the elevation of the particle release relative to the seabed, allowing the particle trajectory to be affected by changes in the velocity profile with depth before settling on the seabed. The model considers vertical diffusion within the water column and horizontal dispersion of particles to adjacent elements.

4.2.3. The PT model allows for the prediction of bed deposition. The area and depth of accretion will depend on the preceding hydrodynamic flow speeds and directions taken from the calibrated and validated hydrodynamic model. Within the model the seabed deposition remains unconsolidated. Newly deposited sediment accretion would tend to compress lower layers, dewatering the sediment, increasing the sediment density and its resistance to erosion. Therefore, the results predicted from the PT model are considered conservative in nature, giving slightly higher bed levels than would be expected due to sediment consolidation.

4.2.4. **Table 4-1** describes the key sediment parameters included within the MIKE PT model setup.

Table 4-1: Sediment Properties

Sediment Type	Settling Velocity (m/s)	Bulk/ Wet Density (kg/m^3)	Erosion Threshold (N/m^2)
Sand	0.02	2000	0.2
Silt	0.003	1300	0.9

4.3. DREDGE DISPERSION ASSUMPTIONS

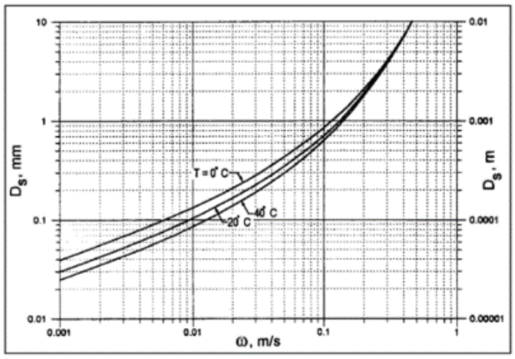
4.3.1. The following key assumptions have been made in the PT modelling approach for the capital and maintenance scenarios:

- the modelling considers dredging over a single working shift of 18.5 hours. This timeframe has been selected based on professional judgement and similar activities in the River Thames reviewed to inform this assessment[2]. Both capital and maintenance dredging will result in the same volume of sediment loss during this working period; and
- it is assumed that the river will reach a morphological equilibrium state in the 5.5 hours between dredging operations, therefore accumulative impacts are not considered.

4.3.2. The key parameters, assumption and notes utilised in the PT modelling are detailed in **Table 4-2**.

Table 4-2: Dredging Assumptions

Parameter	Assumption	Notes
Capital or Maintenance Dredging Volume (per 18.5 hour operation)	1,423m^3	Assume that the capital or maintenance operation would be a continuous operation window of 18.5 hours using a backhoe dredger. Total capital dredge volume 110,000m^3.
Timing	Continuous operation over 18.5 hours per day during all tidal cycles.	Assume 10,000m^3 per week, 130 hour working week.
Sediment Type and Size	Alluvial deposits consisting of both sand and silts within the dredged pocket and side slopes with a d^{50} of 0.2mm and 0.063mm respectively.	Based upon the sediment sampling results within the dredging area. The dispersion studies will consider both sand and silt material separately, this assumes that for each dredging event, the bed material type is uniform in size.
Sediment Distribution	Sample collection is assumed to be sufficient over the project area, limited to surface grab sampling only. If borehole sampling becomes available this can be used to confirm assumptions.	Assumed distribution of sediment based on sampling data.

Parameter	Assumption	Notes
Sediment Fall Velocity	 Figure 6.8. Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units	Calculated using Stokes law based on confirmed d^{50} values. Based on the HEC 18, Whitehouse Muds Manual (2000) a worst case fall velocity value of 0.003 (silt) and 0.02 (fine sand) m/s has been applied.
Dredging Method	Backhoe dredging	Methodology proposed (**Section 2.4** and **Section 2.6** of **Chapter 2: Site and Proposed Scheme Description (Volume 1)**) due to potential high level of contamination.
Losses	1kg/s	Reasonable worst case assumption based on similar work in the Thames i.e., Tilbury2 Modelling[2].
Plant Movement	Moving	A moving source has been specified within the dredged pocket covering the duration of the dredging.
Number of Dredgers	1	Assumed based on proposed size of dredge pocket, consistent with other developments[3].
Depth of Sediment Release	Equal throughout water column	Sediment may be released at any point in the dredge process so losses will be instantaneously and equally distributed between the surface, mid-depth and bed layers.

Parameter	Assumption	Notes
Sediment Disposal	Offsite	As detailed in **Chapter 2: Site and Proposed Scheme Description (Volume 2)** the dredged arisings will be managed in accordance with relevant legislation and will be disposed of offsite (via vessel to a suitably licenced facility) as it is unlikely that the dredged arising will be suitable for reuse on the Proposed Scheme. The removal of the dredged arisings will be undertaken by an appropriately licenced waste carrier. It is assumed that the disposal of the dredged arisings will be beyond the limits of the River Thames model. Therefore, this is excluded from the analysis.
Initial Sediment Concentration	n/a	Outputs from the model will show excess suspended sediment concentration (mg/l) and sedimentation (m).
Boundary Conditions	No additional conditions	Disturbances from waves, wind and ship movements are excluded.

4.4. DREDGE DISPERSION SCENARIOS

4.4.1. A total of four dispersion scenarios have been considered (see **Section 1.6**), following the key assumptions as described in **Table 4-2**. In each scenario, both a sand and silt (mud) condition has been tested, this assumes a worst case condition where the sediment type (size) is uniform over the dredge area during the 18.5 hour dredging window.

4.5. DREDGE DISPERSION MODELLING RESUTS

4.5.1. The results from the dredge dispersion PT modelling are described below for the four scenarios. Information is presented as spatial plots showing the maximum suspended sediment concentration (mg/l) and sedimentation (mm) from a single 18.5 hour dredge operation. Once material has dispersed beyond <1mg/l or has settled to the seabed, then it is assumed to have become entrained. Therefore, it is no longer considered an excess discharge and excluded from any further calculations. This assumption is reasonable given the limited discharge volume (1kg/s) and compared with the high seabed mobility/ turbidity levels within this region of the River Thames.

4.5.2. The system is assumed to 'reset' after each dredge campaign; the modelling only considers a single dredge operation lasting 18.5 hours. The model is then allowed to continue until either the mass of each individual particle falls below 0.0001kg or falls to the seabed. This assumption is considered reasonable given the highly mobile seabed and high turbidity values in the River Thames.

SCENARIO 1 (CAPITAL DREDGE): EXISTING CONDITIONS WITH BELVEDERE POWER STATION JETTY (DISUSED)

4.5.3. The modelling results for maximum suspended sediment and sedimentation under existing conditions including Belvedere Power Station Jetty (disused) (Scenario 1) are shown in **Figure 4-1** and **Figure 4-2.**

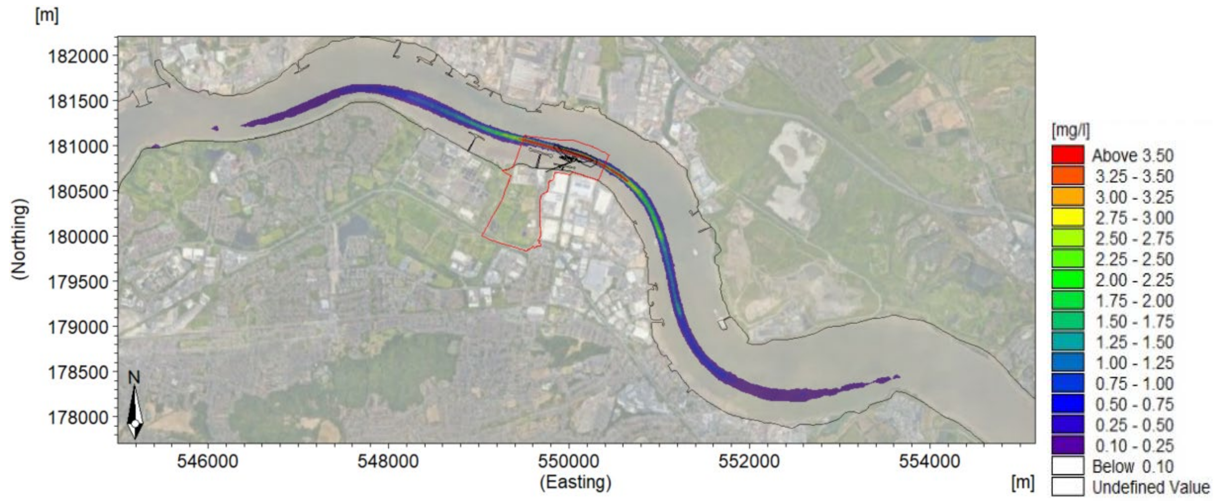
4.5.4. Use of the "maximum" concentration and sedimentation provides a view of the full footprint of potential effect.

4.5.5. The results for maximum suspended sediments show that the smaller silt (mud) material travels significantly further within the River Thames than compared to the sand fraction. The excursion length of the mud material released during the dredging is approximately 3km upstream and downstream of the Proposed Jetty. In comparison, the sand fraction is only expected to travel several hundred metres away from the dredger. In both examples, the dredge plume is not predicted to extend the full width of the river (approximately 650m) but instead, is shown to keep within a narrow (<100m) band.

4.5.6. The maximum concentration of suspended sediment averaged over the model cell and depth for both sediment types range from 10 to 1mg/l. The higher concentration is predicted to occur immediately adjacent to the dredging activity for both the mud and sand sediment types.

4.5.7. Seabed accretion of up to 10mm over the individual dredging campaign is predicted to occur for the larger sand fraction, again this change is limited to the area immediately adjacent the dredging operation. No significant increase (>1mm) in bed level beyond the dredge operation for both sediment types were predicted (**Figure 4-2**).

a) Silt Fraction



b) Sand Fraction

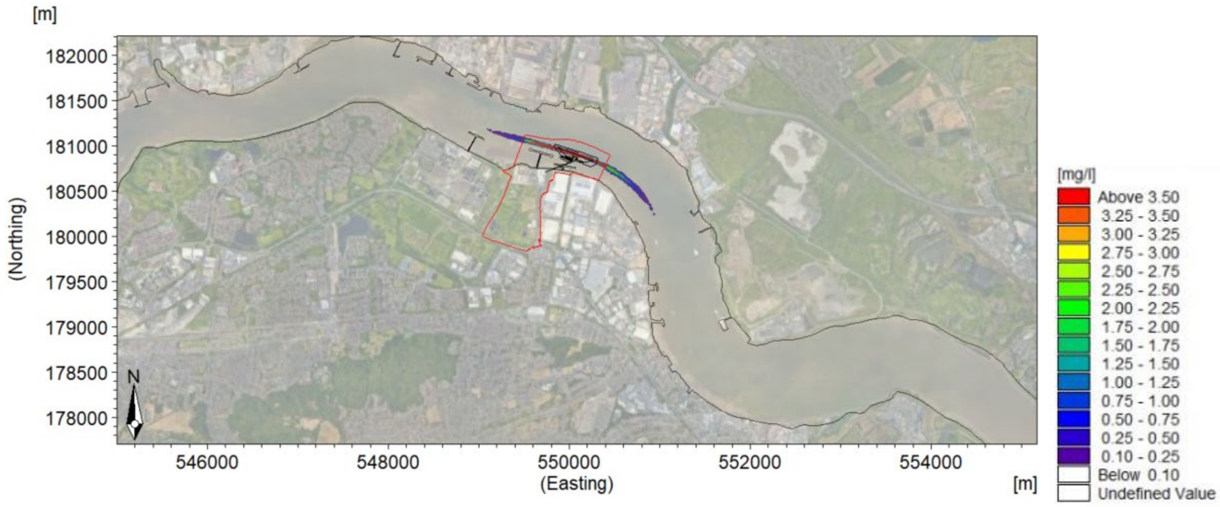
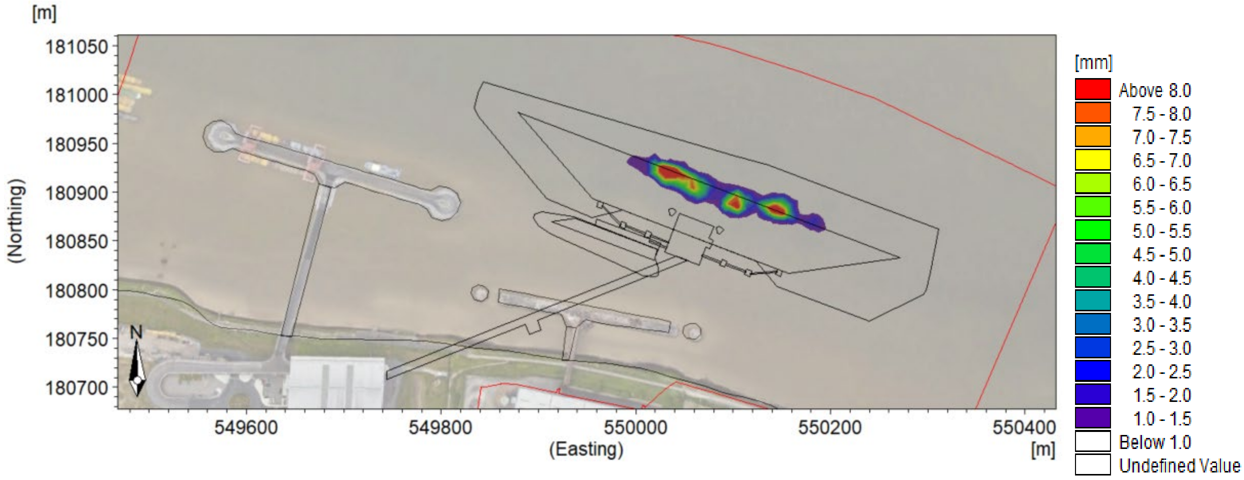


Figure 4-1: Scenario 1 (Capital Dredge) – Maximum Suspended Sediment Concentration (mg/l) – a) Silt Fraction b) Sand Fraction

a) Silt Fraction



b) Sand Fraction

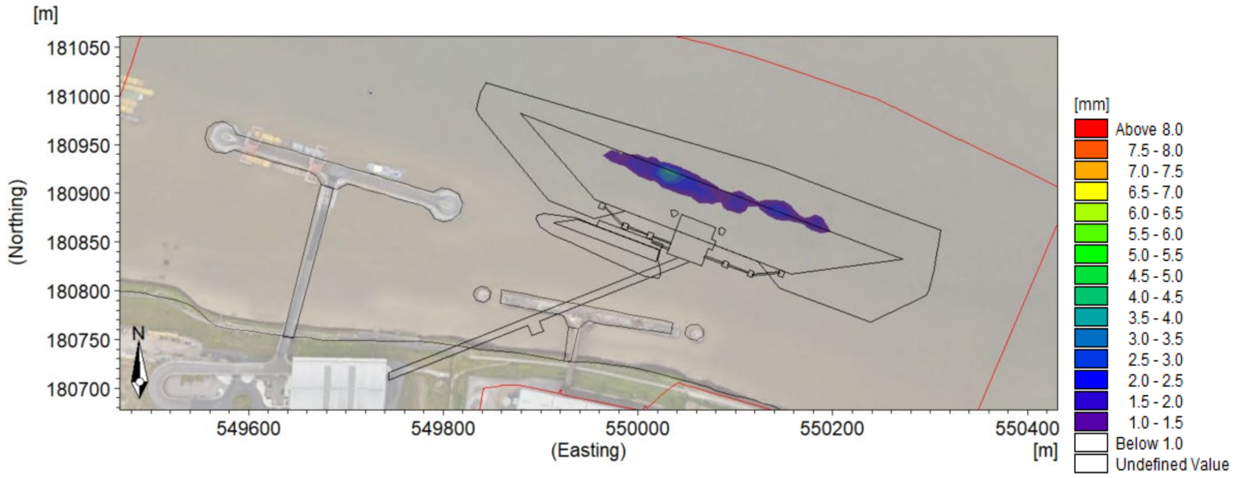


Figure 4-2: Scenario 1 (Capital Dredge) – Maximum Sedimentation (mm) – a) Silt Fraction b) Sand Fraction

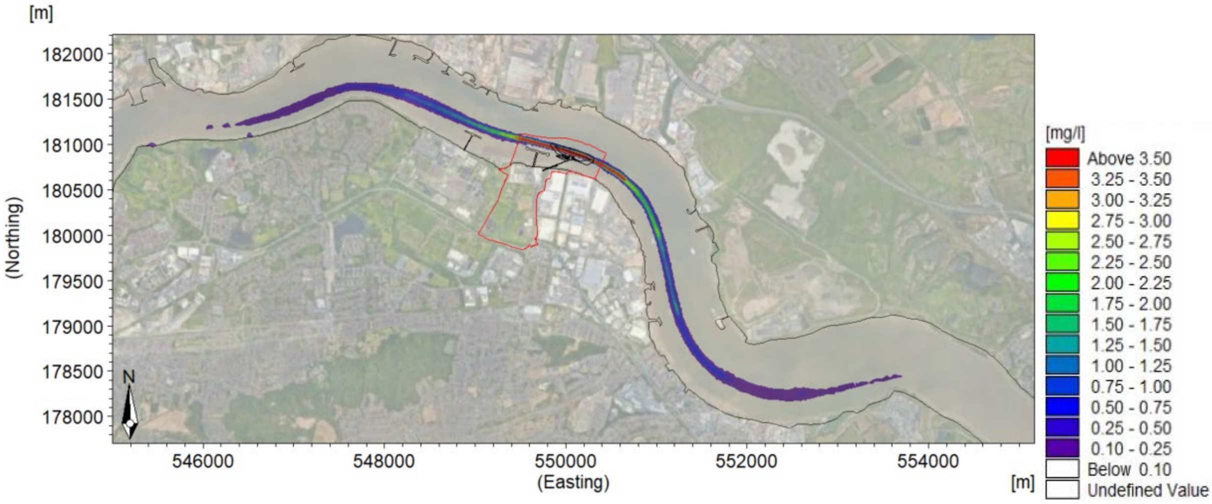
SCENARIO 2 (CAPITAL DREDGE): EXISTING CONDITIONS WITHOUT BELVEDERE POWER STATION JETTY (DISUSED)

4.5.8. The modelling results for maximum suspended sediment and sedimentation under existing conditions excluding Belvedere Power Station Jetty (disused) (Scenario 2) are shown in **Figure 4-3** and **Figure 4-4**. The results for suspended sediments show an almost identical pattern to the scenario including Belvedere Power Station Jetty (disused) (Scenario 1) with maximum excursion lengths of 3km upstream and downstream. The distribution of suspended sediment is almost indistinguishable between scenarios.

4.5.9. Identical to Scenario 1, the maximum concentration of suspended sediment averaged over the model cell and depth for both sediment types again range from 10 to 1mg/l with the higher concentration predicted to occur immediately adjacent to the dredging activity.

4.5.10. As with Scenario 1, seabed accretion of up to 10mm over the individual dredging campaign is predicted to occur for the larger sand fraction with this change limited to the area immediately adjacent the dredging operation. No significant increase (>1mm) in bed level beyond the dredge operation for both sediment types were predicted.

a) Silt Fraction



b) Sand Fraction

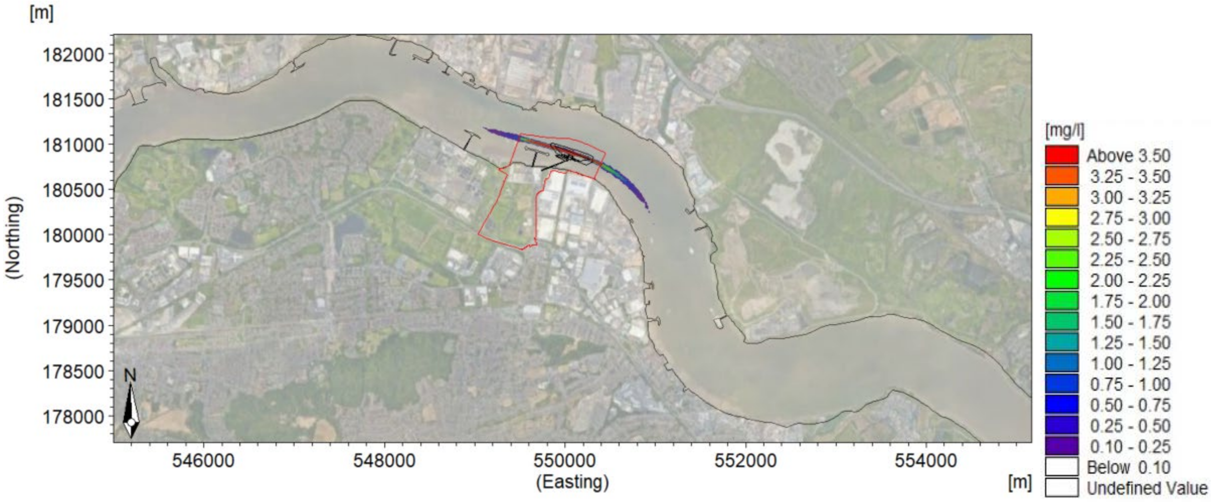
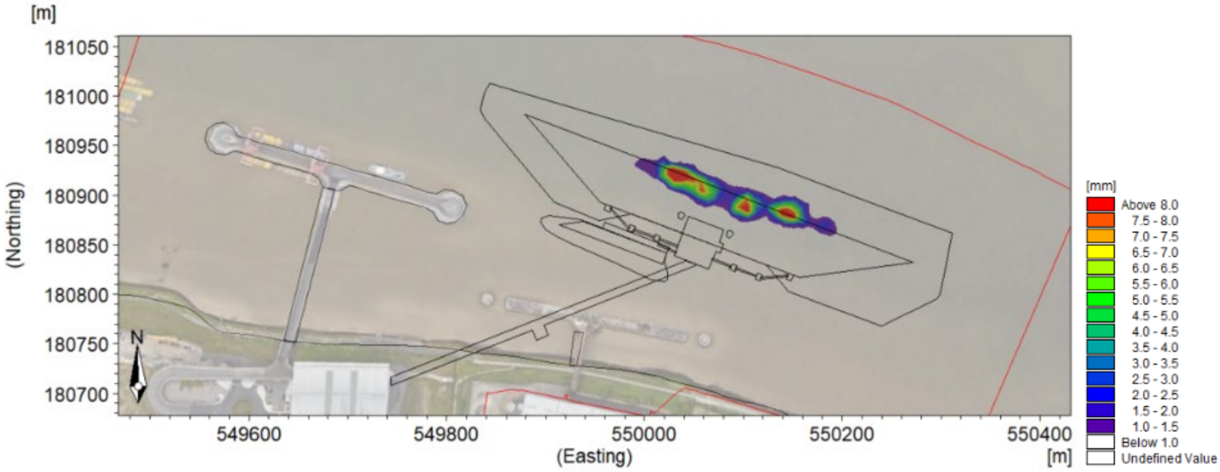


Figure 4-3: Scenario 2 (Capital Dredge) – Maximum Suspended Sediment Concentration (mg/l) – a) Silt Fraction b) Sand Fraction

a) Silt Fraction



b) Sand Fraction

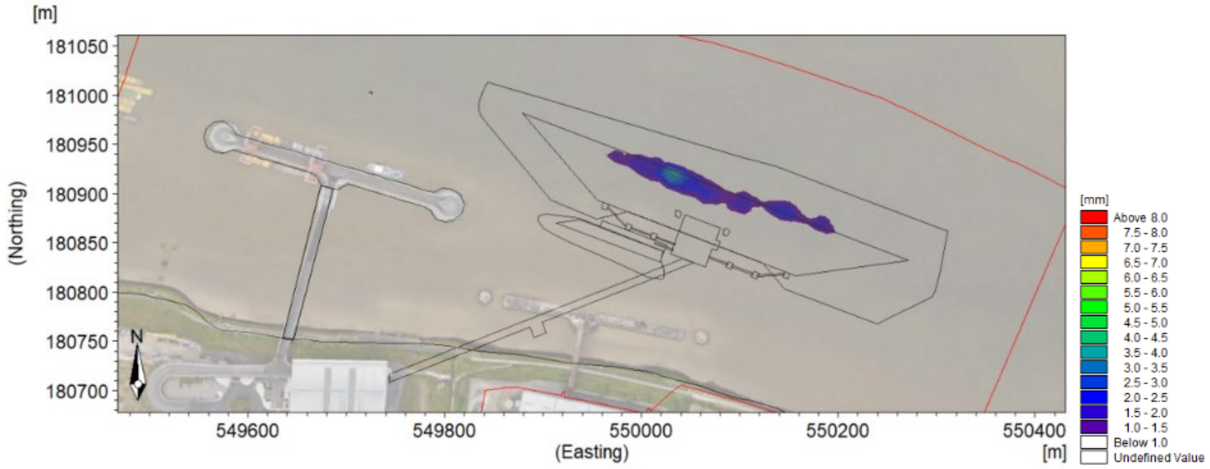


Figure 4-4: Scenario 2 (Capital Dredge) – Maximum Sedimentation (mm) – a) Silt Fraction b) Sand Fraction

SCENARIO 3 (MAINTANENCE DREDGE): PROPOSED SCHEME WITH BELVEDERE POWER STATION JETTY (DISUSED)

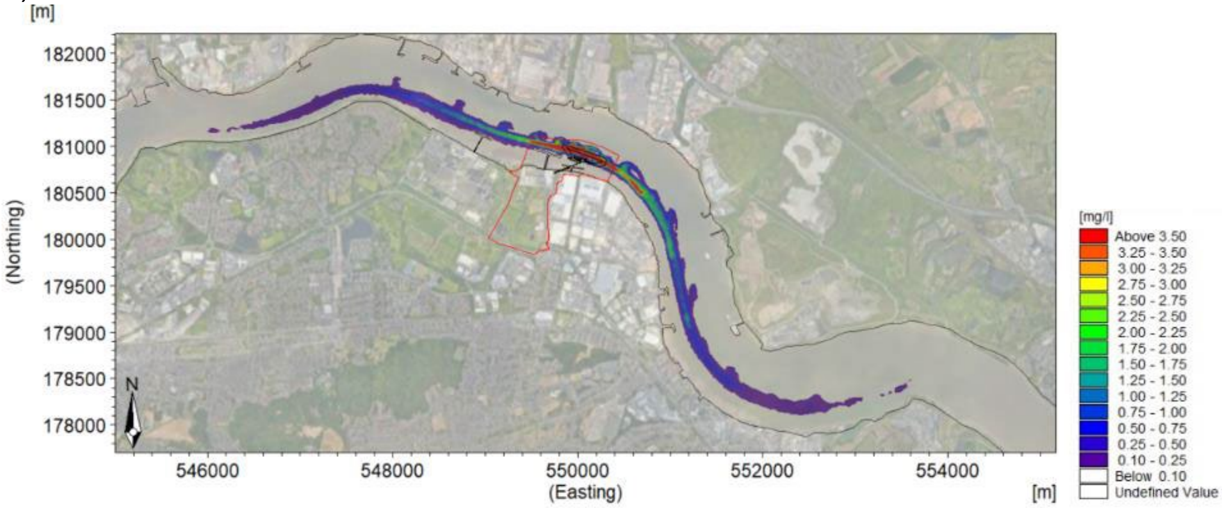
4.5.11. The modelling results for maximum suspended sediment and sedimentation under the proposed scenario conditions including Belvedere Power Station Jetty (disused) (Scenario 3) are shown in **Figure 4-5** and **Figure 4-6**. As described in the dredge assumptions (**Table 4-2**), the same sediment discharge parameters from the existing capital dredge exercise have been assumed but with an updated hydrodynamic condition file reflecting the presence of the dredged pocket and associated Proposed Jetty.

4.5.12. Like Scenarios 1 and 2, the results for suspended sediments show an almost identical pattern with maximum excursion lengths of 3km upstream and downstream for the silt material. This compares to only a few hundred metres for the sand fraction due to the assumed higher fall velocity.

4.5.13. The maximum concentration of suspended sediment averaged over the model cell and depth for both sediment types range from 10 to 1mg/l with the higher concentration predicted to occur immediately adjacent to the dredging activity.

4.5.14. As with Scenario 1, seabed accretion of up to 10mm over the individual dredging campaign is predicted to occur for the larger sand fraction with this change limited to the area immediately adjacent the dredging operation. No significant increase (>1mm) in bed level beyond the dredge operation for both sediment types was predicted.

a) Silt Fraction



b) Sand Fraction

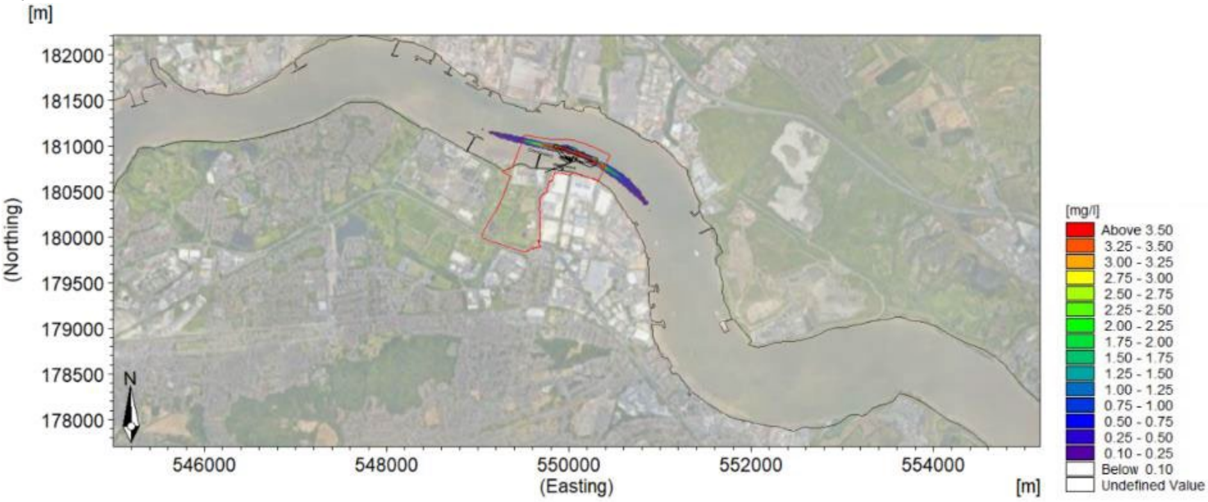
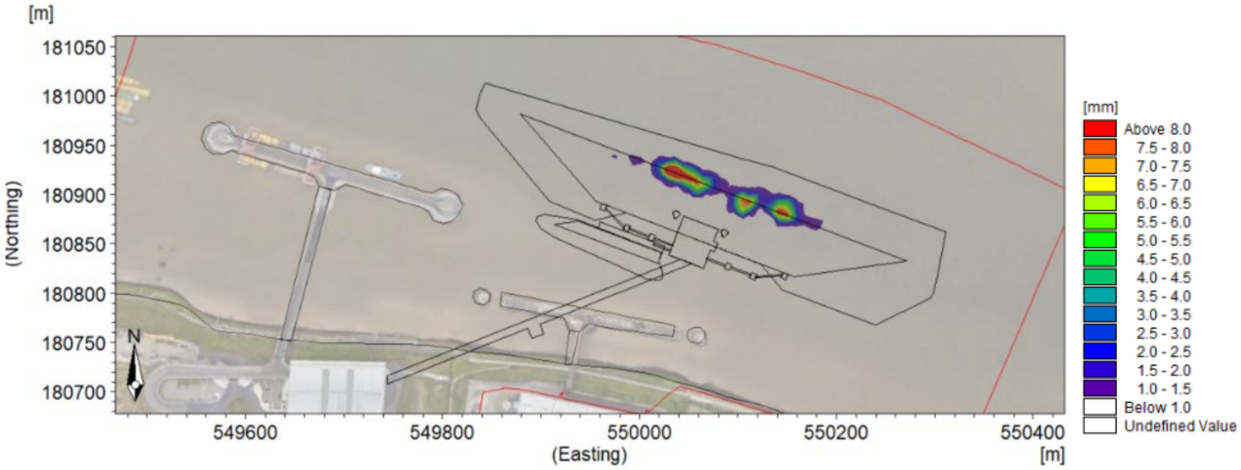


Figure 4-5: Scenario 3 (Maintenance Dredge) – Maximum Suspended Sediment Concentration (mg/l) – a) Silt Fraction b) Sand Fraction

a) Silt Fraction



b) Sand Fraction

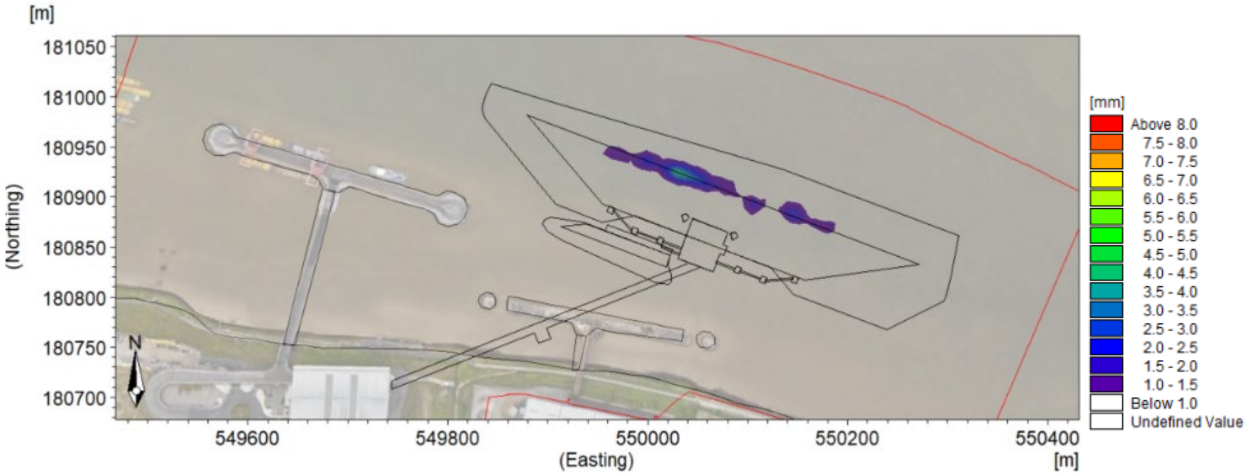


Figure 4-6: Scenario 3 (Maintenance Dredge) – Maximum Sedimentation (mm) – a) Silt Fraction b) Sand Fraction

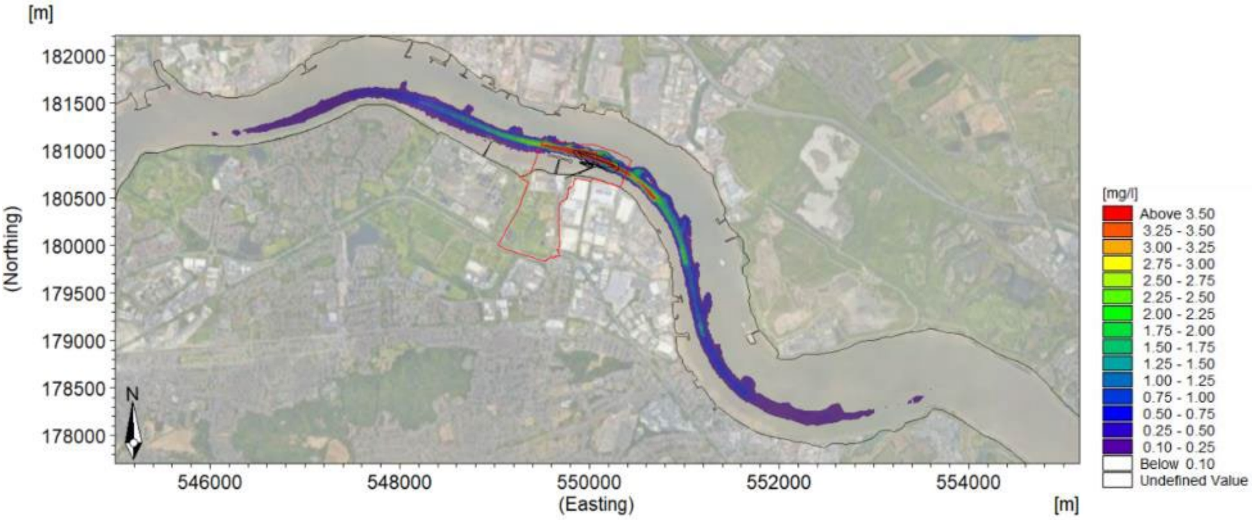
SCENARIO 4 (MAINTANENCE DREDGE): PROPOSED SCHEME WITHOUT BELVEDERE POWER STATION JETTY (DISUSED)

4.5.15. Modelling results for maximum suspended sediment and sedimentation under the proposed scenario conditions excluding Belvedere Power Station Jetty (disused) (Scenario 4) are shown in **Figure 4-7** and **Figure 4-8**. The same dredge assumptions as with Scenario 3 have been applied except with an updated hydrodynamic conditions file.

4.5.16. Similar to the previous scenarios, the results for suspended sediments show maximum excursion lengths of 3km upstream and downstream for the silt material. This compares to only a few hundred metres for the sand fraction due to the assumed higher fall velocity.

4.5.17. The maximum concentration of suspended sediment averaged over the model cell and depth for both sediment types again range from 10 to 1mg/l with the higher concentration predicted to occur immediately adjacent to the dredging activity. Seabed accretion of up to 10mm over the individual dredging campaign is predicted to occur for the larger sand fraction with this change limited to the area immediately adjacent the dredging operation. No significant increase (>1mm) in bed level beyond the dredge operation for both sediment types were predicted.

a) Silt Fraction



b) Sand Fraction

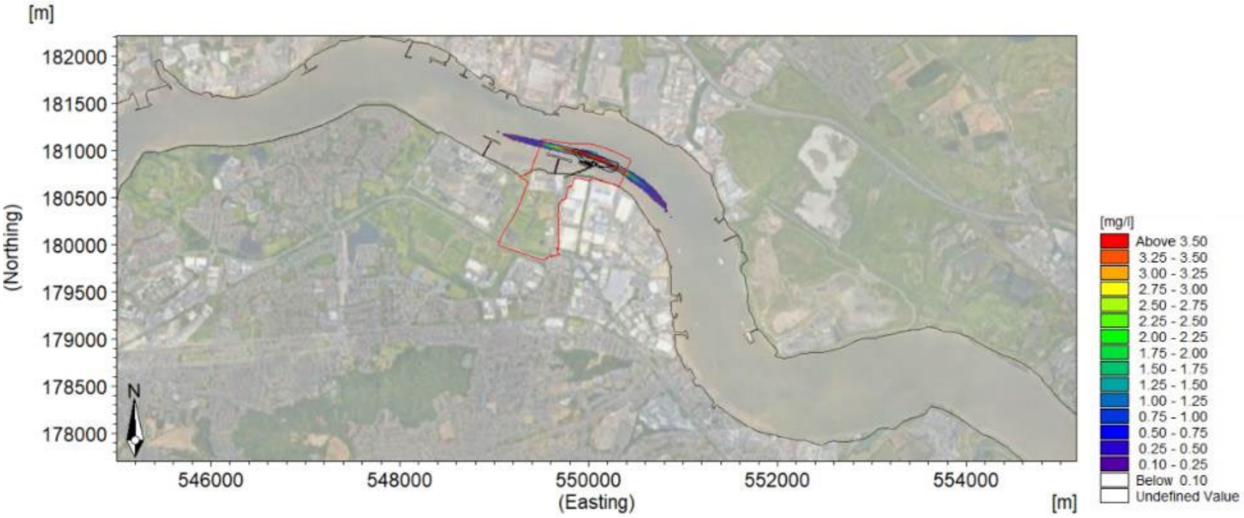


Figure 4-7: Scenario 4 (Maintenance Dredge) – Maximum Suspended Sediment Concentration (mg/l) – a) Silt Fraction b) Sand Fraction

a) Silt Fraction

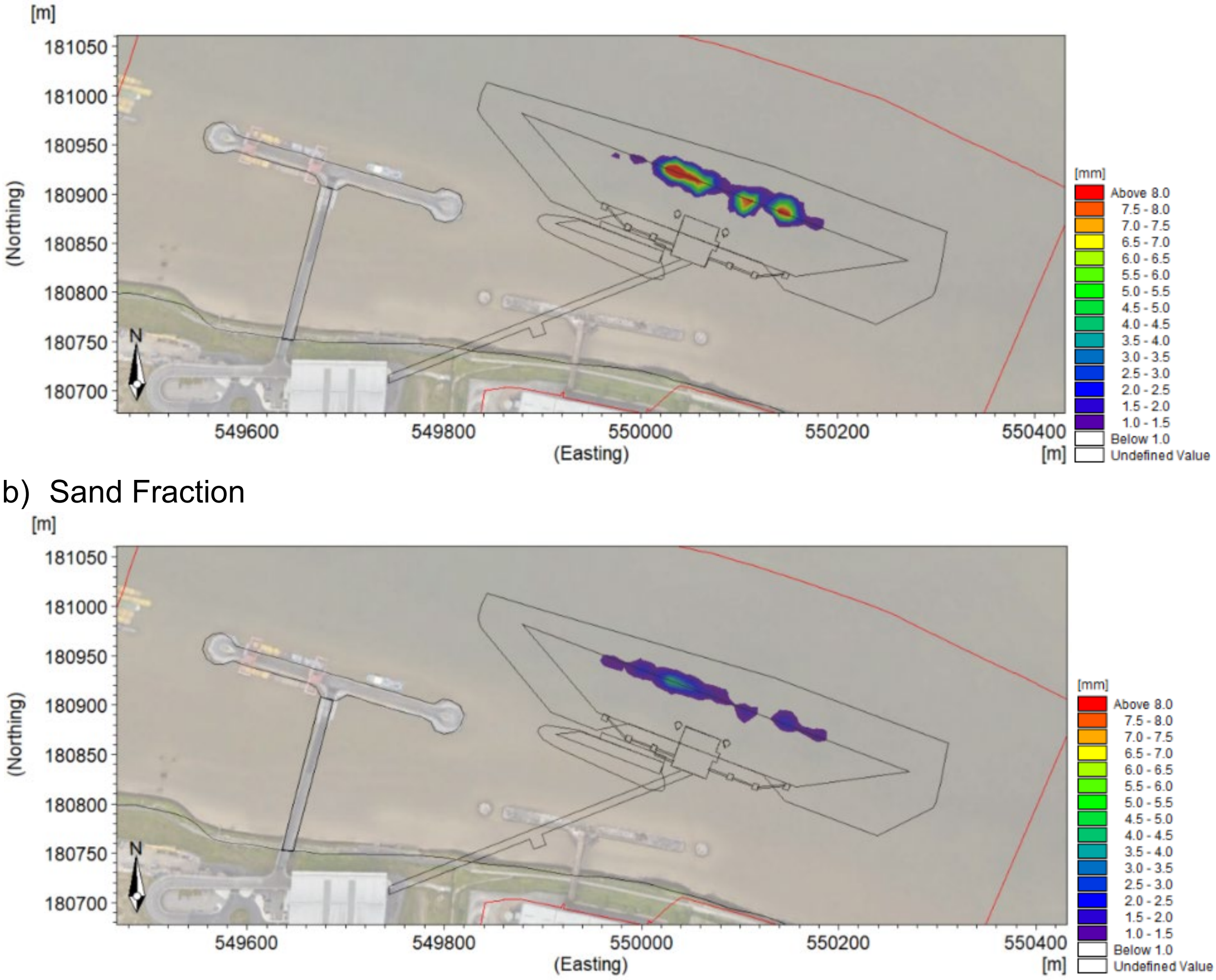


Figure 4-8: Scenario 4 (Maintenance Dredge) – Maximum Sedimentation (mm) – a) Silt Fraction b) Sand Fraction

4.6. DREDGE DISPERSION MODELLING CONCLUSIONS

4.6.1. The dispersion of expected dredge arisings has been successfully considered using the MIKE by DHI particle tracking software. The results show that for all scenarios the average concentration of excess suspended sediment (silt or sand) is likely to be very low (<10mg/l) and limited to a maximum of 3km upstream and downstream of the dredge operation.

4.6.2. The natural range of suspended sediment within this part of the River Thames is in the range of 20 to >200 mg/l based on the limited September 2023 measurements carried out as part of wider project surveys. Measurements collected downstream at Tilbury showed suspended sediment concentration for silt material close to 2,000mg/l[2] illustrating the highly turbid nature of the system. Therefore, the increase of up to 10mg/l in excess suspended sediment concentration and limited extent of change is not considered significant and is considered to be well within the natural variability of the River Thames.

4.6.3. The deposition of sediment for all scenarios considered are typically consistent with the volume of sedimentation (change in bed height) limited to the immediate vicinity of the dredge operation. Away from the Site, no significant change in sedimentation is predicted.

4.6.4. In summary, the predicted impacts from the capital and maintenance dredging operations are not considered significant primarily due to the mechanism of the dredge operation (backhoe) where material is removed from the system and disposed offsite. The findings are based on reasonable worst case assumptions (**Table 4-2**), in particular a working window of 18.5 hours with a loss rate of 1kg/s. Sensitivity of adjusting these parameters did not result in any significant changes, suggesting that the results presented are reasonable.

4.6.5. It is recommended that if the method of dredging or disposal changes, these modelling results should be reviewed and updated to reflect the revised change.

5. SEDIMENT TRANSPORT MODELLING

5.1. INTRODUCTION

5.1.1. The principal objective of the sediment transport study is to provide an estimate of the likely fine sediment transport within the River Thames with and without the Proposed Scheme. Specifically, the key aims of the study are to:

- consider the impacts of the Proposed Scheme on the adjacent priority intertidal habitats (mud flats); and
- estimate the likely siltation of the berth pocket predominantly from the silt material at and around the main berthing structures, to understand the likely future maintenance regime requirements.

5.1.2. Note, an estimate of deposition rates for the coarser grain sand material in the outer sections of the berth pocket has been used based on known maintenance dredging requirements at the adjacent Middleton Jetty. These rates have been added to provide a likely annual maintenance dredging requirement.

5.2. METHODOLOGY

5.2.1. The calibrated and validated MIKE21 Flexible Mesh hydrodynamic model of the River Thames has been used to evaluate the impacts on the mud transport regime within the River Thames resulting from the Proposed Jetty. The model was set up with an initial thickness of sediment (0.5m) and allowed to spin up for a period of 10 days to remove the influence of the initial sediment distribution, with much of this material remobilised within the system. The model was then run for a spring neap cycle running for the period 25th September 2022 to 21st October 2022.

5.2.2. The following assumptions have been applied:

- the impacts on the River Thames are presented for present day conditions. Changes in mean sea level are not considered to have a significant impact on the results presented since the Proposed Scheme is primarily located in subtidal regions. Equally, given the uncertainty in the sediment transport modelling, small changes in water depths are also unlikely to significantly alter the outcomes from the study and are well within the range of expected outcomes;
- due to the sheltered location and short fetch lengths, wave modelling has been excluded from the modelling assessment;
- an erosion threshold (erosion shear stress) of 0.9N/m^2 was calculated for the silt material[4] although it is noted that this threshold is likely to vary over the river from 0.2 to >1.2N/m^2 depending on the bulk density of the material. A range of sensitivity testing was undertaken, with this value being selected based on expert judgement and the predicted distribution of the consolidated seabed material when compared against the measured surface sediment types. The resulting distribution matches against the measured values suggesting that the applied model parameters and setup are reasonable; and

- the MIKE by DHI MT (2023) model was applied in the sediment transport modelling studies.

5.2.3. A total of four scenarios (see **Section 1.6**) have been considered. The modelling has assumed that the mobile dominate layer is a consolidated mud material with a bulk density of approximately 1200 to 1300kg/m^3. This is consistent with onsite observations (**Figure 5-1**).

Figure 5-1: Intertidal Mudflat Adjacent to Middleton Jetty in the River Thames

SEDIMENT CHARACTERISTICS

5.2.4. The dredge pocket is assumed to comprise a mixture of fine materials; generally, clays and silts and a high proportion sand fraction within the main dredge pocket. Surface sediment sampling (September 2023) was undertaken at numerous locations over the dredge area. The key sites of interest for this assessment of the Proposed Scheme are shown in **Figure 5-2** and are sites 7-12, sites 1-6 are beyond the Study Area for this assessment but were of relevance to the marine biodiversity assessment, presented in **Chapter 8: Marine Biodiversity (Volume 1)**.

Figure 5-2: Location of Sediment Sampling Sites of Interest

5.2.5. The calculated particle size distribution for the key subtidal samples is shown in **Table 5-1** and highlighted in **Figure 5-3**. The sampling shows that at sites 7 and 8, the percentage silt and clay fraction is dominant. At sites 9 and 11, the dominant sediment type is finer grain sand and at sites 10 and 12, there is no clear dominance.

Table 5-1: Particle Size Distribution of In Situ Material (%)

Particle size (microns)	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Less than 20	44	61	3	24	7	21
20 to 63	19	22	2	8	4	8
63 to 80	6	6	4	3	6	4
80 to 100	10	5	21	7	22	14
100 to 150	13	5	40	17	29	24
150 to 200	4	1	23	20	13	15
More than 200	5	0	6	20	19	13

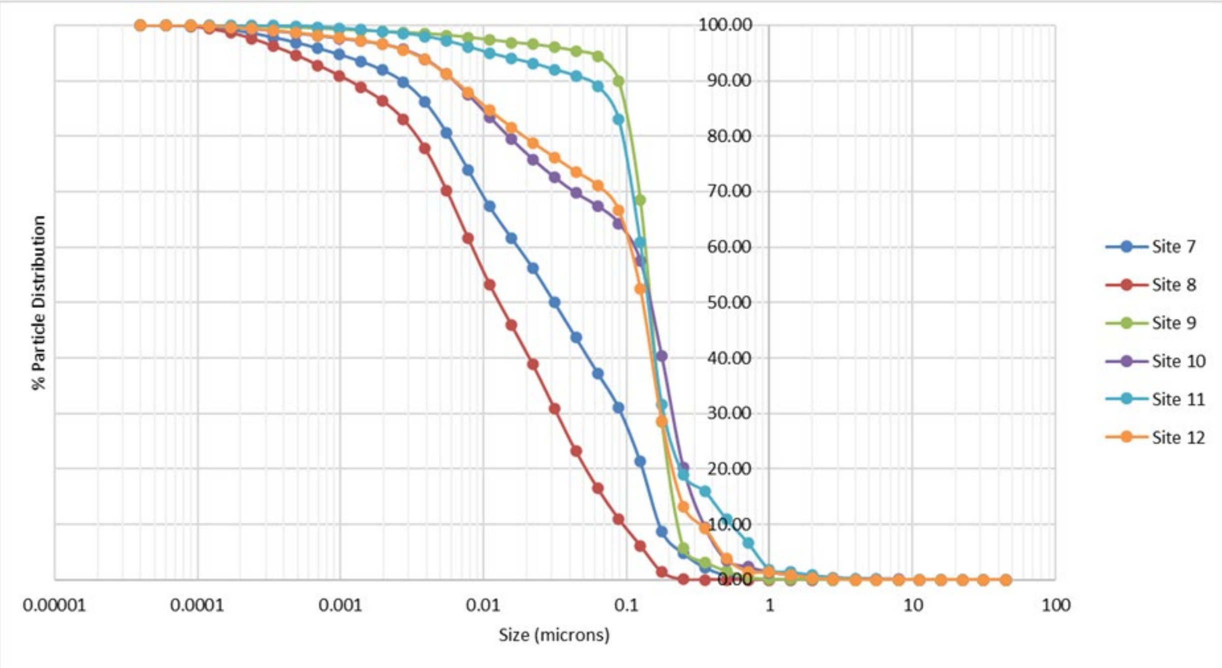


Figure 5-3: Sediment Percentage Distribution

5.2.6. The predicted distribution of the silt material over the Site Boundary is shown in **Figure 5-4** based on the outcomes from the mud transport modelling results. The setup parameters of the MT model were aligned to ensure that the predicted distribution matches well against the surface grab samples with the silt distribution found in the areas of high concentration >80%.

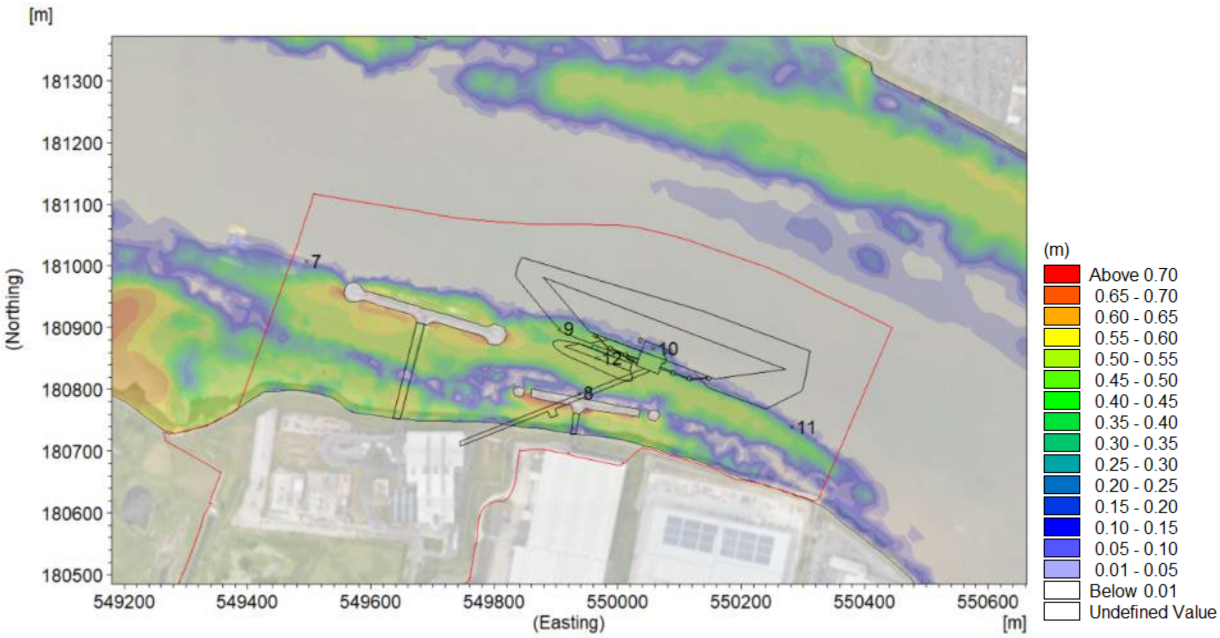


Figure 5-4: Predicted Silt Distribution and Subtidal Seabed Sampling Locations Sites 7 to 12

5.3. SEDIMENT TRANSPORT MODELLING RESULTS

SCENARIOS 1 AND 3: EXISTING CONDITIONS AND PROPOSED SCHEME WITH BELVEDERE POWER STATION JETTY (DISUSED)

5.3.1. **Figure 5-5** and **Figure 5-6** below shows the predicted accretion and deposition for the existing and Proposed Scheme (with Belvedere Power Station Jetty (disused)) after a spring neap cycle.

5.3.2. The results show that under existing conditions, small changes ± 10cm in mudflat levels are predicted with these changes typically local to the Belvedere Power Station Jetty (disused) and Middleton Jetty. For the baseline (Scenario 1) there is little or no significant change at the Proposed Jetty and dredge pocket locations (**Figure 5-5**).

5.3.3. In comparison, with the Proposed Scheme (Scenario 3) there is a significant increase in siltation around the Proposed Jetty (0.1 to 0.3m). Like the baseline (Scenario 1), the change in the intertidal areas adjacent to the Belvedere Power Station Jetty (disused) and Middleton Jetty is similar with mud flat accretion continuing.

5.3.4. No significant erosion of the silt material is predicted over the model domain for the baseline (Scenario 1) and with Proposed Scheme (Scenario 3) suggesting that the Proposed Scheme is unlikely to have any detrimental impacts on the mudflat extent.

5.3.5. **Figure 5-7** below shows the difference in sedimentation between the baseline (Scenario 1) and Proposed Scheme (Scenario 3). Again, this shows that within most of the dredged pocket, there are no significant changes in sedimentation patterns when compared to the baseline (Scenario 1).

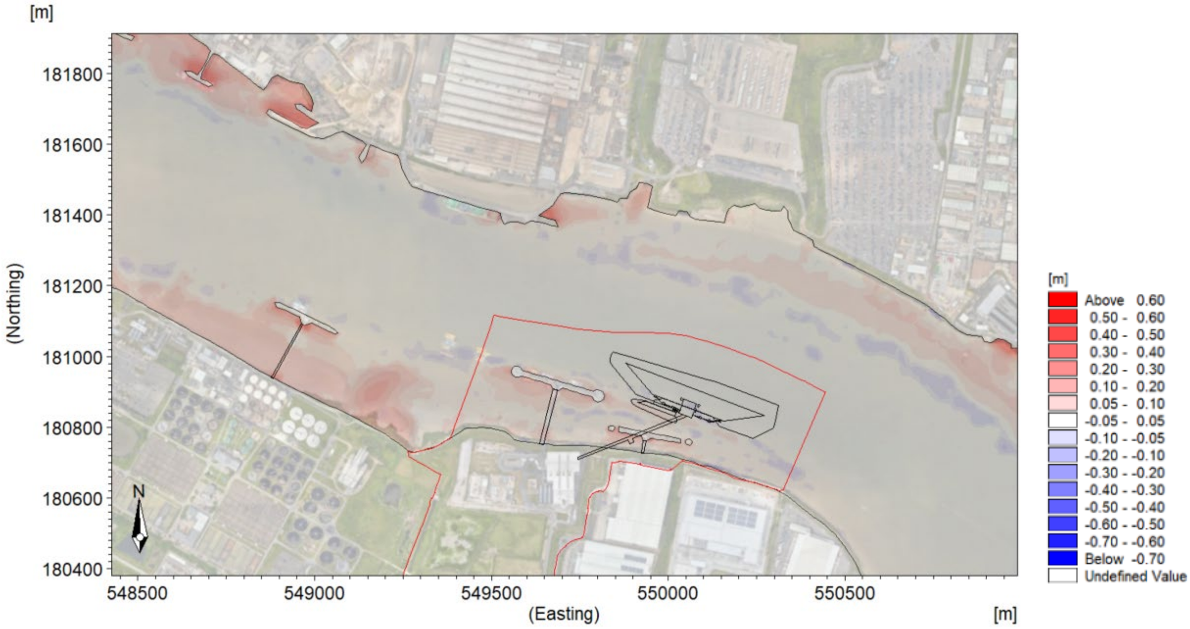


Figure 5-5: Scenario 1 – Sedimentation Pattern Following a Spring Neap Cycle

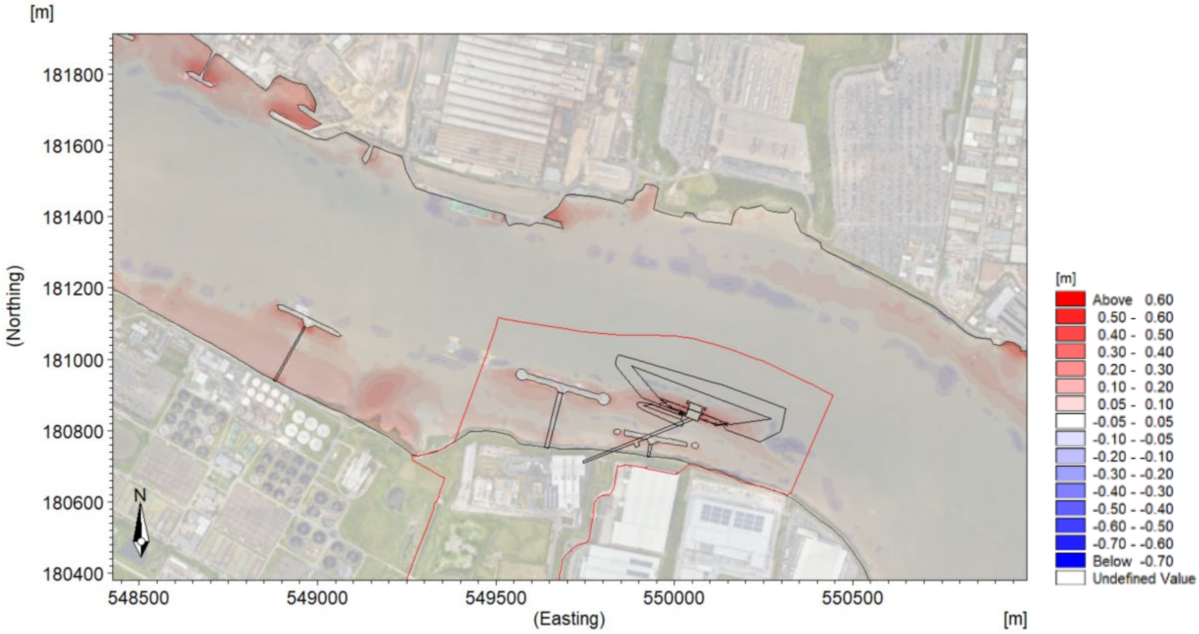


Figure 5-6: Scenario 3 – Sedimentation Pattern Following a Spring Neap Cycle

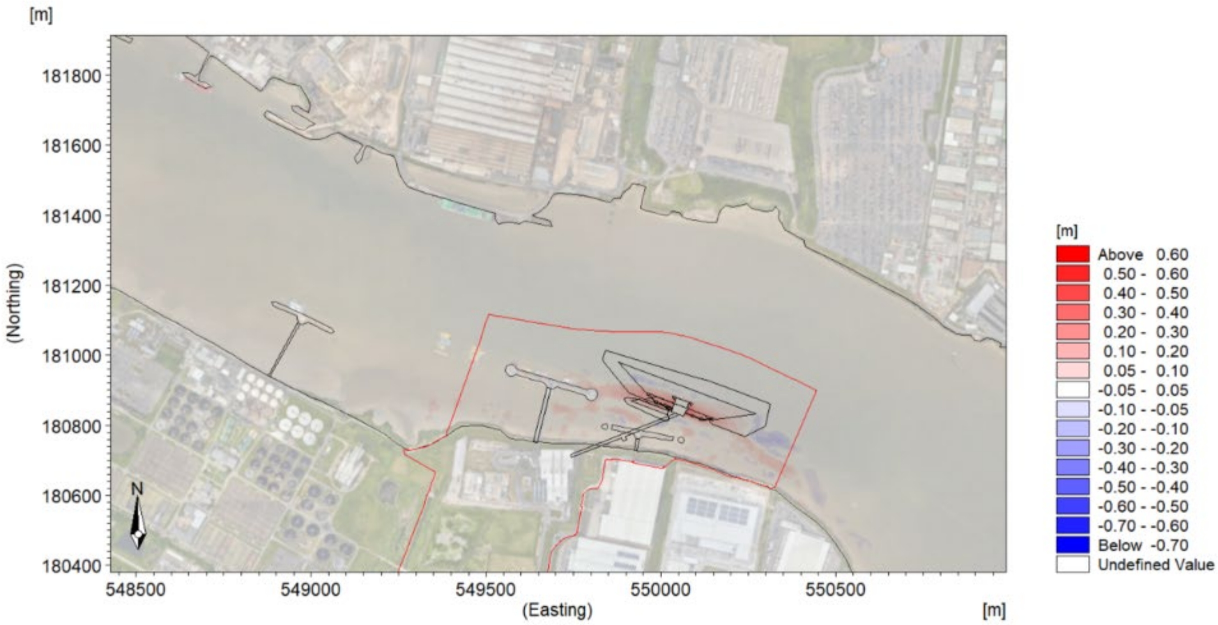


Figure 5-7: Scenarios 1 and 3 – Difference in Predicted Sedimentation (m)

5.3.6. The results presented for scenarios 1 and 3 assume no vessel movements (as a conservative approach to sediment accretion by not including the effects of scour and propeller wash) or variation in sediment consolidation. Therefore, these results represent an assumed worst case and should be considered with a reasonable degree of uncertainty given the highly dynamic nature of the river, vessel movement, and the complex sediment transport regime.

5.3.7. Noting the uncertainty referred to above, the results suggest that sedimentation adjacent the Proposed Scheme structures is unlikely to exceed >2m per year, again this is limited to the immediate location of the piled deck structure and breasting dolphins. Within the outer section of the dredged pocket closer to the main channel, no significant sediment accretion of silt is predicted. Here, accretion is limited by the stronger tidal currents.

5.3.8. In the adjacent intertidal regions, the model predicts a slight increase in sedimentation (**Figure 5-7**) due to the reduced flow conditions. An area of slight erosion (10 to 30cm) is seen along the southeastern edge of the dredge pocket. However, due to the size and localised nature of the area of mud flat erosion compared to the substantially larger areas of predicted seabed level increases, this change is not considered significant.

SCENARIOS 2 AND 4: EXISTING CONDITIONS AND PROPOSED SCHEME WITHOUT BELVEDERE POWER STATION JETTY (DISUSED)

5.3.9. **Figure 5-8** and **Figure 5-9** below shows the predicted accretion and deposition pattern for the muddy material under baseline (Scenario 2) and with the Proposed Scheme (Scenario 4) without the Belvedere Power Station Jetty (disused) after a spring neap cycle.

5.3.10. The results show that under existing conditions over a spring neap cycle, small changes ± 10cm in intertidal mudflat levels are predicted. In comparison, with the Proposed Scheme included the area around the Proposed Jetty is shown to accumulate sediment.

5.3.11. No significant accretion or erosion of sediment is predicted within the main part of the berth pocket over the spring neap cycle.

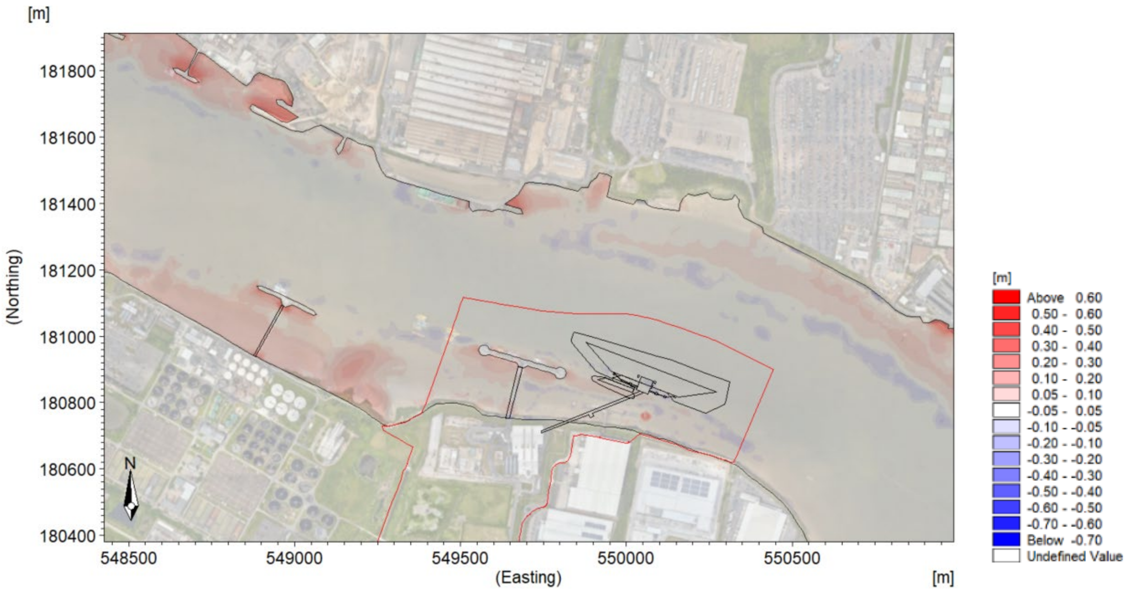


Figure 5-8: Scenario 2 – Sedimentation (m) Pattern following a Spring Neap Cycle

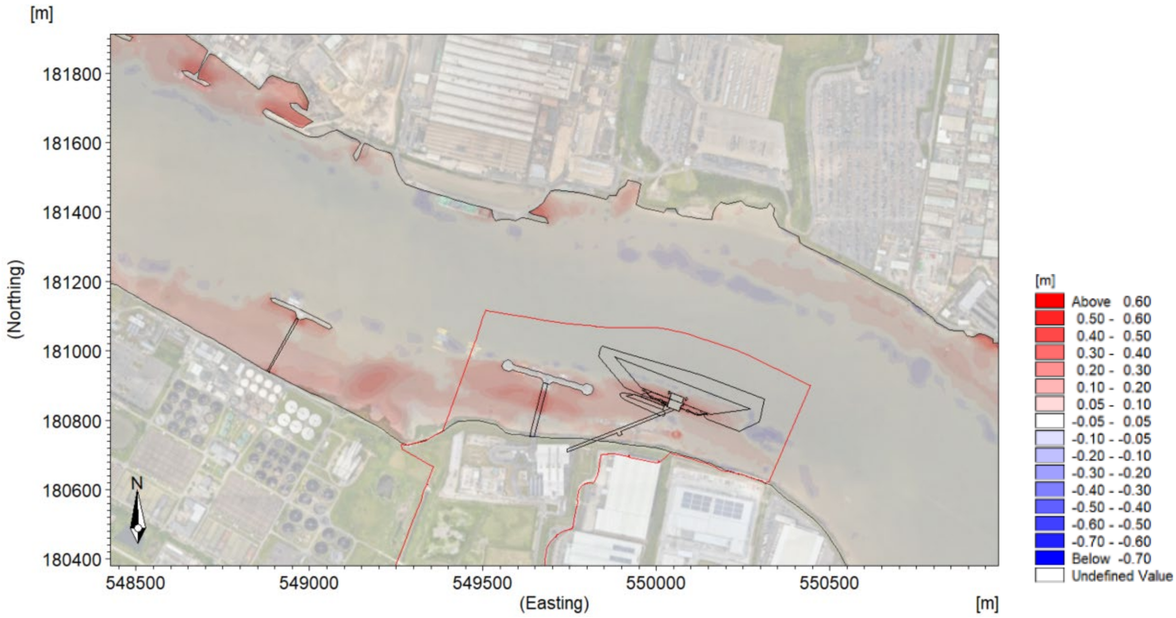


Figure 5-9: Scenario 4 – Sedimentation (m) Pattern following a Spring Neap Cycle

5.3.12. **Figure 5-10** below shows the difference between the baseline (Scenario 2) and Proposed Scheme (Scenario 4). Again, this shows that within most of the dredged pocket, significant change in sedimentation patterns would not be expected compared to the baseline (Scenario 4).

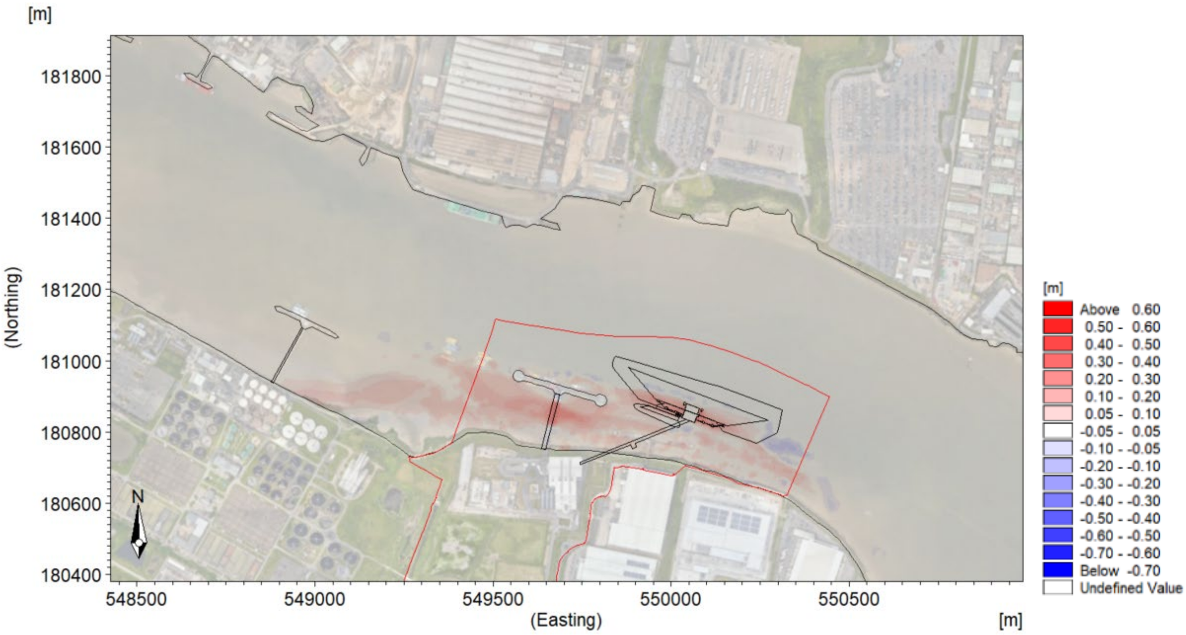


Figure 5-10: Scenarios 2 and 4 – Difference in Predicted Sedimentation (m)

5.3.13. The results from the scenarios where Belvedere Power Station Jetty (disused) is assumed to have been demolished (scenarios 2 and 4) suggest that sedimentation adjacent the Proposed Jetty is unlikely to exceed >1m. Within the outer section of the dredged pocket closer to the main channel, no significant sediment accretion is predicted. Here, accretion is limited by the stronger tidal currents.

5.3.14. In the adjacent intertidal priority mudflat regions, the model predicts a slight increase in sedimentation following the construction of the Proposed Scheme (Scenario 4) compared to the without Proposed Scheme option (Scenario 2) (**Figure 5-10**). These results are similar to the scenarios which include Belvedere Power Station Jetty (disused) (scenarios 1 and 3), suggesting that the removal of this structure is unlikely to have any adverse impacts on the priority intertidal mudflat habitat.

5.3.15. Again, as with scenarios 1 (baseline) and 3 (proposed scenario with Belvedere Power Station Jetty retained, with modifications), an area of slight erosion (10 to 30cm) is seen along the southeastern edge of the dredge pocket. The removal of the Belvedere Power Station Jetty (disused) is not anticipated to impact the erosion in this area. Due to the size and localised nature of this change and modelling uncertainty, this is not considered significant.

5.4. PREDICTED ANNUAL MAINTENANCE

5.4.1. The annual maintenance dredging for both of the Proposed Scheme options (scenarios 3 and 4, i.e. with and without Belvedere Power Station Jetty (disused)), is assumed to be around 9,000m^3 per year based on the following:

- Assumed dredge pocket dimensions excluding side slopes are:
  - L1= 420m (longitudinal length closest to channel centre);
  - L2= 215m (longitudinal length closest to river bank); and
  - W= 55m (transverse width).
- Resulting in:
  - Area = 17,460m^2;
  - Averaged accretion height over the dredge pocket = 0.5m/yr; and
  - Volume = approximately 9,000m^3.

5.4.2. The above maintenance regime is based on the expected increase in bed level derived from the MT model results. The predicted averaged accretion heights of 0.5 to 1m have been interpreted to allow for some level of consolidation of the silt material and integrates expected bedload sand transport over the full berth pocket extent.

5.4.3. The predicted annual maintenance volumes are broadly consistent with similar schemes on the River Thames where dredging is of a similar depth and area[5]. Previous maintenance dredging at Middleton Jetty for the years 2014, 2015, 2016, and 2017 ranged from 6,700 to 17,500m^3 [6] which again is broadly consistent with the modelling conclusions.

5.5. MODELLING UNCERTAINTY

5.5.1. The sediment transport modelling has focused on the primary intertidal silt habitats, with the modelling showing significant accretion of silt material around the Proposed Jetty. However, it should be noted that the predicted annual fine sediment infill rates especially around the berthing structures are difficult to estimate since some of the key processes (vessel induced scour, local 3D flow patterns) are not represented in the modelling approach. However, what is clear is that in the absence of vessel movements and in line with local observations and ongoing dredging activities, a build-up of silt material is expected at the dredge pocket.

5.5.2. A range of sensitivity analysis was undertaken where possible to determine the reliance of the results on modelling assumptions. For example, the critical shear stress for erosion parameter was particularly sensitive with the resulting initial distribution of sediment impacted by the adjustment of this factor. Where possible information used in the modelling assessment is based on best available data (i.e. measured information) to minimise the modelling uncertainty as much as possible.

5.5.3. Where sensitivity testing was not possible i.e. no vessel movement, sediment distribution, the degree of soil consolidation and so on, expert judgement was used to ensure the best possible outcome. Again, these were viewed against available data sets to ensure that the information was robust.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. HYDRODYNAMICS

6.1.1. The data obtained from this assessment provides sufficient evidence to show that the introduction of the Proposed Jetty will only have a comparatively local impact upon flow conditions and that it will not affect the overall hydrodynamic regime of the River Thames.

6.1.2. However, locally the predicted changes to the magnitude of the flow strength in the vicinity of the Proposed Jetty are likely to affect the distribution of the bed sediments and the potential for zones of accretion to occur, especially in the berthing areas.

6.2. SEDIMENT TRANSPORT

6.2.1. The Proposed Scheme will have minor and local effects on the sediment regime of the River Thames. Dredging the berth pocket to depths of several metres below the natural regime depth in an area which is known to be sensitive to sedimentation has shown to lead to the dredge pocket being subject to ingress of sediment. The predicted infill rates for the dredged pocket are up to 9,000m^3 with the majority of this assumed to be a mixture of fine silty and sand sediment fractions. Whilst this total is a maximum, assuming the berth is maintained at its target depth and is likely to be reduced by vessel occupancy, regular maintenance dredging is likely to be required and should be expected, particularly adjacent to the Proposed Jetty. The change in sediment transport associated with the dredging is minor in comparison to the total volume of sediment transport in the River Thames. Therefore, any changes local to the Proposed Scheme are anticipated to have a minor impact on the sediment transport regime of the River Thames.

6.2.2. Additionally, dredging of the berth to the proposed depth would require extension of the dredge side slope through the intertidal zone (resulting in loss of intertidal habitat). The sheet pile wall which forms part of the Proposed Scheme will therefore reduce disruption to the intertidal area. The design of the sheet pile wall will be informed by further knowledge of the strength and depth of the material composition of the bed sediments. This will be undertaken as part of the detailed design of the Proposed Scheme and has been included in the **Mitigation Schedule (Document Reference 7.8)** and **Outline CoCP (Document Reference 7.4)**.

6.3. CAPITAL DREDGING IMPACTS (CONSTRUCTION PHASE)

6.3.1. The relatively small volume of capital dredging (~110,000m^3) and the anticipated mix of bed material as shown by existing BGS borehole records at Middleton Jetty and site-specific surface sediment sampling suggest that a backhoe dredger could be used working continuously for an 18.5 hour day assuming plant machinery of sufficient reach is available.

6.3.2. Due to the extremely low sediment release rate of this dredging method compared to the high ambient suspended sediment concentrations in the area, any impact of the sediment released by the dredging is considered negligible.

6.4. MAINTENANCE DREDGING IMPACTS (OPERATION PHASE)

6.4.1. The sediment modelling has shown a risk of fine sediment accumulation in the dredged pocket, particularly around the key features of the Proposed Jetty including the deck and mooring dolphins. Sedimentation rates averaged over the dredge pocket are estimated to be between 0.5 and 1m per year, meaning an annual maintenance dredge volume of up to 9,000m^3. The proposed backhoe dredging and removal of this material from the river is unlikely to result in any detrimental impacts in the River Thames system with the modelling showing very modest changes in excess suspended sediments.

7. REFERENCES

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[6] Port of London Authority. (2020). 'Maintenance Dredge Protocol Baseline Document Update'. Available at: [redacted]

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