DOGGER BANK D WIND FARM

Preliminary Environmental Information Report

Volume 1
Chapter 8 Marine Physical Processes

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Table of Contents

List of Appendices

Appendix	Title
Appendix 8.1	Consultation Responses for Marine Physical Processes
Appendix 8.2	Marine Geophysical Survey Report
Appendix 8.3	Marine Physical Processes Modelling Report

Glossary

Term	Definition
Additional Mitigation	Measures identified through the EIA process that are required as further action to avoid, prevent, reduce or, if possible, offset likely significant adverse effects to acceptable levels (also known as secondary (foreseeable) mitigation). All additional mitigation measures adopted by the Project are provided in the Commitments Register.
Amphidromic Point	The centre of an amphidromic system; a nodal point around which a standing-wave crest rotates once each tidal period.
Astronomical Tide	The predicted tide levels and character that would result from the gravitational effects of the earth, sun, and moon without any atmospheric influences.
Bathymetry	Topography of the seabed.
Beach	A deposit of non-cohesive sediment (e.g. sand and gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively 'worked' by present-day hydrodynamic processes (i.e. waves, tides and currents) and sometimes by winds.
Bedforms	Features on the seabed (e.g. sand waves, ripples) resulting from the movement of sediment over it.
Bedload	Sediment particles that travel near or on the bed.
Clay	Fine sediment with a typical particle size of less than 0.002mm.
Climate Change	A long-term change in global or regional climate patterns, such as seasonal averages and extremes.
Closure Depth	The depth that represents the 'seaward limit of significant depth changes but is not an absolute boundary across which there is no cross- sediment transport.
Coastal Processes	Collective term covering the action of natural forces on the shoreline and nearshore seabed.
Commitment	Refers to any embedded mitigation and additional mitigation, enhancement or monitoring measures identified through the EIA process and those identified outside the EIA process such as through stakeholder engagement and design evolution. All commitments adopted by the Project are provided in the Commitments Register.
Current	Flow of water generated by a variety of forcing mechanisms (e.g. waves, tides, wind).
Array Area	The area within which the wind turbines, inter-array cables and offshore platform(s) will be located.

Term	Definition
Design	All of the decisions that shape a development throughout its design and pre-construction, construction / commissioning, operation and, where relevant, decommissioning phases.
Development Consent Order (DCO)	A consent required under Section 37 of the Planning Act 2008 to authorise the development of a Nationally Significant Infrastructure Project, which is granted by the relevant Secretary of State following an application to the Planning Inspectorate.
Ebb Tide	The falling tide, immediately following the period of high water and preceding the period of low water.
Effect	An effect is the consequence of an impact when considered in combination with the receptor's sensitivity / value / importance, defined in terms of significance.
Embedded Mitigation	Embedded mitigation includes: • Measures that form an inherent part of the project design evolution such as modifications to the location or design of the development made during the pre-application phase (also known as primary (inherent) mitigation); and • Measures that will occur regardless of the EIA process as they are imposed by other existing legislative requirements or are considered as standard or best practice to manage commonly occurring environmental impacts (also known as tertiary (inexorable) mitigation). All embedded mitigation measures adopted by the Project are provided in the Commitments Register.
Enhancement	Measures committed to by the Project to create or enhance positive benefits to the environment or communities, as a result of the Project. All enhancement measures adopted by the Project are provided in the Commitments Register.
Environmental Impact Assessment (EIA)	A process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information and includes the publication of an Environmental Statement.
Environmental Statement (ES)	A document reporting the findings of the EIA which describes the measures proposed to mitigate any likely significant effects.
Erosion	Wearing away of the land or seabed by natural forces (e.g. wind, waves, currents and chemical weathering).

Term	Definition
Evidence Plan Process (EPP)	A voluntary consultation process with technical stakeholders which includes a Steering Group and Expert Topic Group (ETG) meetings to encourage upfront agreement on the nature, volume and range of supporting evidence required to inform the EIA and HRA process.
Expert Topic Group (ETG)	A forum for targeted technical engagement with relevant stakeholders through the EPP.
Flood Tide	The rising tide, immediately following the period of low water and preceding the period of high water.
Glacial Sediment	Unconsolidated sediment carried or deposited by a glacier.
Gravel	Loose, rounded fragments of rock larger than sand but smaller than cobbles. Sediment larger than 2mm (as classified by the Wentworth scale used in sedimentology).
High Water	Maximum level reached by the rising tide.
Holocene	The last 10,000 years of earth history.
Hydrodynamic	The process and science associated with the flow and motion in water produced by applied forces.
Impact	A change resulting from an activity associated with the Project, defined in terms of magnitude.
Inter-Array Cables	Cables which link the wind turbines to the offshore platform(s).
Intertidal Zone	The area that lies between Mean High Water Springs and Mean Low Water Springs.
Landfall	The area on the coastline, south-east of Skipsea, at which the offshore export cables are brought ashore, connecting to the onshore export cables at the transition joint bay above Mean High Water Springs.
Long-term	Refers to a time of decades to centuries.
Low Water	The minimum height reached by the falling tide.
Mean High Water Springs	The average height throughout the year, of two successive high waters, during a 24-hour period in each month when the range of the tide is at its greatest (during Spring tides).
Mean Low Water Spring	The average height throughout the year, of two successive low waters, during a 24-hour period in each month when the range of the tide is at its lowest (during Spring tides).
Mean Sea Level	The average level of the sea surface over a defined period (usually a year or longer), taking account of all tidal effects and surge events.

Term	Definition
Megaripples	Bedforms with a wavelength of 0.6m to 10.0m and a height of 0.1m to 1.0m. These features are smaller than sand waves but larger than ripples.
Mitigation	Any action or process designed to avoid, prevent, reduce or, if possible, offset potentially significant adverse effects of a development. All mitigation measures adopted by the Project are provided in the Commitments Register.
Monitoring	Measures to ensure the systematic and ongoing collection, analysis and evaluation of data related to the implementation and performance of a development. Monitoring can be undertaken to monitor conditions in the future to verify any environmental effects identified by the EIA, the effectiveness of mitigation or enhancement measures or ensure remedial action are taken should adverse effects above a set threshold occur. All monitoring measures adopted by the Project are provided in the Commitments Register.
Neap Tide	A tide that occurs when the tide-generating forces of the sun and moon are acting at right angles to each other, so the tidal range is lower than average.
Nearshore	The zone which extends from the swash zone to the position marking the start of the offshore zone (about 20m).
Numerical Modelling	Refers to the analysis of coastal processes using computational models.
Offshore	Area seaward of nearshore in which the transport of sediment is not caused by wave activity.
Offshore Development Area	The area in which all offshore infrastructure associated with the Project will be located, including any temporary works area during construction, which extends seaward of Mean High Water Springs. There is an overlap with the Onshore Development Area in the intertidal zone.
Offshore Export Cable Corridor (ECC)	The area within which the offshore export cables will be located, extending from the DBD Array Area to Mean High Water Springs at the landfall.
Offshore Export Cables	Cables which bring electricity from the offshore platform(s) to the transition joint bay at landfall.
Offshore Platform(s)	Fixed structures located within the DBD Array Area that contain electrical equipment to aggregate and, where required, convert the power from the wind turbines, into a more suitable voltage for transmission through the export cables to the Onshore Converter Station. Such structures could include (but are not limited to): Offshore Converter Station(s) and an Offshore Switching Station.
Pleistocene	An epoch of the Quaternary Period (between about 2 million and 10,000 years ago) characterised by several glacial ages.

Term	Definition
Project Design Envelope	A range of design parameters defined where appropriate to enable the identification and assessment of likely significant effects arising from a project's worst-case scenario. The Project Design Envelope incorporates flexibility and addresses uncertainty in the DCO application and will be further refined during the EIA process.
Quaternary Period	The last 2 million years of earth history incorporating the Pleistocene ice ages and the post-glacial (Holocene) Period.
Safety Zones	A statutory, temporary marine zone demarcated for safety purposes around a possibly hazardous offshore installation or works / construction area.
Sand	Sediment particles, mainly of quartz with a diameter of between 0.063mm and 2mm. Sand is generally classified as fine, medium, or coarse.
Sand Wave	Bedforms with wavelengths of 10m to 100m, with amplitudes of 1m to 10m.
Scoping Opinion	A written opinion issued by the Planning Inspectorate on behalf of the Secretary of State regarding the scope and level of detail of the information to be provided in the Applicant's Environmental Statement. The Scoping Opinion for the Project was adopted by the Secretary of State on 02 August 2024.
Scoping Report	A request by the Applicant made to the Planning Inspectorate for a Scoping Opinion on behalf of the Secretary of State. The Scoping Report for the Project was submitted to the Secretary of State on 24 June 2024.
Scour Protection	Protective materials used to avoid sediment erosion from the base of the wind turbine foundations and offshore platform foundations due to water flow.
Sea Level	Generally, refers to 'still water level' (excluding wave influences) averaged over a period such that periodic changes in level (e.g. due to the tides) are averaged out.
Sea-level Rise	The general term given to the upward trend in mean sea level resulting from a combination of local or regional geological movements and global climate change.
Sediment	Particulate matter derived from rock, minerals or bioclastic matter.
Sediment Transport	The movement of a mass of sediment by the forces of currents and waves.
Shore Platform	A platform of exposed rock or cohesive sediment exposed within the intertidal and subtidal zones.
Short-term	Refers to a time of months to years.

Term	Definition
Significant Wave Height	The average height of the highest of one third of the waves in a given sea state.
Silt	Sediment particles with a grain size between 0.002mm and 0.063mm, i.e. coarser than clay, but finer than sand.
Spring Tide	A tide that occurs when the tide-generating forces of the sun and moon are acting in the same directions, so the tidal range is higher than average.
Study Areas	A geographical area and / or temporal limit defined for each EIA topic to identify sensitive receptors and assess the relevant likely significant effects.
Surge	Changes in water level because of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and the astronomical tide predicted using harmonic analysis.
Suspended Sediment	Sediment moving in suspension in a fluid kept up by the upward components of the turbulent currents or by the colloidal suspension.
The Applicant	SSE Renewables and Equinor acting through 'Doggerbank Offshore Wind Farm Project 4 Projco Limited'.
The Project	Dogger Bank D Offshore Wind Farm Project, also referred to as DBD in this PEIR.
Tidal Current	The alternating horizontal movement of water associated with the rise and fall of the tide.
Tidal Range	Difference in height between high and low water levels at a point.
Transition Joint Bays (TJB)	An underground structure at the landfall that houses the joints between the offshore and onshore export cables.
Trenchless Techniques	Trenchless cable or duct installation methods used to bring offshore export cables ashore at landfall, facilitate crossing major onshore obstacles such as roads, railways and watercourses and where trenching may not be suitable. Trenchless techniques included in the Project Design Envelope include Horizontal Directional Drilling (HDD), auger boring, micro-tunnelling, pipe jacking / ramming and Direct Pipe.
Wave Climate	Average condition of the waves at a given place over a period of years, as shown by height, period, direction etc.
Wave Height	The vertical distance between the crest and the trough.
Wavelength	The horizontal distance between consecutive wave crests (or alternative troughs).

Term	Definition
Wind Turbines	Power generating devices located within the DBD Array Area that convert kinetic energy from wind into electricity.

8 Marine Physical Processes

8.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) presents the preliminary results of the Environmental Impact Assessment (EIA) of the Dogger Bank D Offshore Wind Farm Project (hereafter 'the Project' or 'DBD') on marine physical processes.

2. **Chapter 4 Project Description** provides a description of the key infrastructure components which form part of the Project and the associated construction, operation and maintenance and decommissioning activities are presented in **Section 8.4.4**.

3. The primary purpose of the PEIR is to support the statutory consultation activities required for a Development Consent Order (DCO) application under the Planning Act 2008. The information presented in this PEIR chapter is based on the baseline characterisation and assessment work undertaken to date. The feedback from the statutory consultation will be used to inform the final project design where appropriate and presented in an Environmental Statement (ES), which will be submitted with the DCO application.

4. This PEIR chapter:

- Describes the baseline environment relating to marine physical processes;
- Presents an assessment of the likely significant effects on marine physical processes during the construction, operation and maintenance, and decommissioning phases of the Project;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Sets out proposed mitigation measures to avoid, prevent, reduce or, if possible, offset potential significant adverse environmental effects identified during the EIA process and, where relevant, monitoring measures or enhancement measures to create or enhance positive effects.

5. The assessment process has been informed by the following, as explained in more detail throughout the chapter:

- Interpretation of survey data specifically collected for the project including bathymetry, geophysical, geotechnical, environmental and metocean data;
- The existing evidence base regarding the effects of offshore wind farm developments on the physical environment;
- Detailed numerical modelling studies;
- Discussion and agreement with key stakeholders; and
- Application of expert-based assessment and judgement by Royal HaskoningDHV.

6. This chapter should be read in conjunction with the following related chapters. Inter-relationships are discussed further in **Section 8.10.1**:

- **Chapter 9 Marine Water and Sediment Quality;**
- **Chapter 10 Benthic and Intertidal Ecology;**
- **Chapter 11 Fish and Shellfish Ecology;**
- **Chapter 14 Commercial Fisheries; and**
- **Chapter 17 Offshore Archaeology.**

7. Additional information to support the marine physical processes assessment includes:

- **Volume 2, Appendix 8.1 Consultation Responses for Marine Physical Processes;**
- **Volume 2, Appendix 8.2 Marine Geophysical Survey Report;**
- **Volume 2, Appendix 8.3 Marine Physical Processes Modelling Report; and**
- **Volume 2, Appendix 10.3 Benthic Ecology Baseline Characterisation Report.**

8.2 Policy and Legislation

8.2.1 National Policy Statements

8. The assessment of likely significant effects upon marine physical processes has been made with specific reference to the relevant National Policy Statement (NPS). These are the principal policy documents with respect to Nationally Significant Infrastructure Projects (NSIP). Those relevant to the Project are:

- Overarching NPS for Energy (EN-1) (Department for Energy Security and Net Zero (DESNZ) 2023a); and
- NPS for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b).

9. The specific assessment requirements for marine physical processes, as detailed in the NPS, are summarised in **Table 8-1** along with how and where they have been considered in this PEIR chapter.

Table 8-1 Summary of Relevant National Policy Statement Requirements for Marine Physical Processes

NPS Reference and Requirement	How and Where Considered in the PEIR
Overarching NPS for Energy (EN-1)	
Paragraph 5.6.10: "Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures."	The approach adopted in this ES for all impacts is a combination of conceptual / evidence-based assessment and numerical modelling of waves, tidal currents, and sediment dispersion (**Section 8.6.2.3 and Section 8.8**).
Paragraph 5.6.11: "The ES (see Section 4.3) should include an assessment of the effects on the coast, tidal rivers and estuaries. In particular, applicants should assess: • the impact of the proposed project on coastal processes and geomorphology, including by taking account of potential impacts from climate change. If the development will have an impact on coastal processes the applicant must demonstrate how the impacts will be managed to minimise adverse impacts on other parts of the coast; • the implications of the proposed project on strategies for managing the coast as set out in Shoreline Management Plans (SMPs)207 (which are designed to identify the most sustainable approach to managing flood and coastal erosion risks from short to long term and are long term non-statutory plans which set out the agreed high-level objective for coastal flooding and erosion management for each SMP area), any relevant Marine Plans, River Basin Management Plans, and capital programmes for maintaining flood and coastal defences and Coastal Change Management Areas; • the effects of the proposed project on marine ecology, biodiversity, protected sites and heritage assets; • how coastal change could affect flood risk management infrastructure, drainage and flood risk; • the effects of the proposed project on maintaining coastal recreation sites and features; and • the vulnerability of the proposed development to coastal change, taking account of climate change, during the Project's operational life and any decommissioning period"	The assessment of potential construction and operation and maintenance impacts and likely significant effects are described in **Section 8.7.2** and **Section 8.7.3**, respectively. DBD will not affect the Shoreline Management Plan and allowance has been made for predicated erosion rates during design (further detail is provided in **Chapter 5 Site Selection and Consideration of Alternatives**). Embedded mitigation to minimise likely significant effects at the coast of cable installation and operation are described in **Section 8.4.2**. Effects on marine ecology, biodiversity, and protected sites are assessed in **Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 12 Marine Mammal Ecology**, and **Chapter 13 Offshore and Intertidal Ornithology**. Potential flood risk impacts are considered in **Chapter 21 Water Resources and Flood Risk**. Effects on recreation are assessed in **Chapter 30 Socio-economics, Tourism and Recreation**. As described above, the Project has been designed so that it is not vulnerable to coastal change or climate change.
Paragraph 5.6.13: "The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Protected Areas (MPAs). These could include Marine Conservation Zones (MCZs), habitat sites including Special Areas of Conservation and Special Protection Areas with marine features, Ramsar Sites, Sites of Community Importance, and SSSIs with marine features. Applicants should also identify any effects on the special character of Heritage Coasts"	The principal receptors with respect to marine physical processes are coastal or marine features with an inherent geological or geomorphological value or function which may be affected by the Project. As the conservation objectives of SACs and MCZs are driven by their ecological functioning, they are not considered as receptors for the marine physical processes and are assessed in the relevant chapters **Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 12 Marine Mammal Ecology**, and **Chapter 13 Offshore and Intertidal Ornithology**. The potential marine physical processes receptors relevant to the Project are defined **Table 8-23** and are assessed in **Section 8.7.2.1** to **Section 8.7.2.5** and **Section 8.7.3.5**.

NPS Reference and Requirement	How and Where Considered in the PEIR
NPS for Renewable Energy Infrastructure (EN-3)	
Paragraph 2.8.111: "The construction, operation and decommissioning of offshore energy infrastructure (including the preparation and installation of the cable route) can affect the following elements of the physical offshore environment, which can have knock on impacts on other biodiversity receptors: • water quality – disturbance of the seabed sediments or release of contaminants can result in direct or indirect effects on habitats and biodiversity, as well as on fish stocks thus affecting the fishing industry; • waves and tides – the presence of the turbines can cause indirect effects through change to wave climate and tidal currents on flood defences, marine ecology and biodiversity, marine archaeology and potentially coastal recreation activities; • scour effect – the presence of wind turbines and other infrastructure can result in a change in the water movements within the immediate vicinity of the infrastructure, resulting in scour (localised seabed erosion) around the structures. This can indirectly affect navigation channels for marine vessels, marine archaeology and impact biodiversity and seabed habitats; • sediment transport – the resultant movement of sediments, such as sand across the seabed or in the water column, can indirectly affect navigation channels for marine vessels, could affect sediment supply to sensitive coastal sites and impact biodiversity and seabed habitats; • suspended solids – the release of sediment during construction, operation and decommissioning can cause indirect effects on marine ecology and biodiversity; • sand waves – the modification / clearance of sand waves can cause direct physical and ecological effects both at the seabed and within the water column due to disturbance and suspension of sediment, and potentially indirect effects (e.g. changes to seabed morphology in water depths where waves can influence the seabed, which can in turn affect wave climate and sediment transport; and • water column – wind turbine structures can also affect water column features such as tidal mixing fronts or stratification due to a change in hydrodynamics and turbulence around structures."	Effects on water quality are covered in **Chapter 9 Marine Water and Sediment Quality**. Effects on tides and waves induced by the physical presence of infrastructure during the operation and maintenance phase are considered in **Section 8.7.3.1** and **Section 8.7.3.2**. Scour resulting from the Project is not assessed because scour protection will be used wherever scour is likely to occur, reducing sediment release to negligible quantities. The potential for effects on the form and function of bedload sediment transport processes due to the physical presence of foundations are described in **Section 8.7.3**. Consideration of the risk of increased suspended sediments is described in **Section 8.7.2.1** to **Section 8.7.2.3**. Potential increases in suspended sediment concentrations due to sand wave clearance are assessed in **Section 8.7.2.4**. Effects on water column stratification (Flamborough Front) are covered in **Section 8.7.3.3**.
Paragraphs 2.8.112 and 2.8.113: "Applicant assessments are expected to include predictions of the physical effects arising from modifications to hydrodynamics (waves and tides), sediments and sediment transport, and seabed morphology that will result from the construction, operation and decommissioning of the required infrastructure." "Assessments should also include effects such as the scouring that may result from the proposed development and how that might impact sensitive species and habitats."	Each of the impacts and effects in **Section 8.7.2** to **Section 8.7.3** cover the potential magnitude and significance of the physical (waves, tides, and sediments) effects upon the baseline conditions resulting from the construction, operation and maintenance, and decommissioning of the Project. Scour resulting from the Project is not assessed because scour protection will be used wherever scour is likely to occur, reducing sediment release to negligible quantities.
Paragraph 2.8.119: "Applicant assessment of the effects of installing offshore transmission infrastructure across the intertidal / coastal zone should demonstrate compliance with mitigation measures in any relevant plan-level Habitat Regulations Assessment (HRA) including those prepared by The Crown Estate as part of its leasing round, and include information, where relevant, about: • any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the final choice;	Landfall Site Selection and Assessment of Alternatives are provided in **Chapter 5 Site Selection and Consideration of Alternatives**. Trenchless techniques will be used to install the export cables at the landfall and will exit in the subtidal zone. Therefore, there is no potential for habitat loss in the intertidal zone (see **Chapter 10 Benthic and Intertidal Ecology**). A range of cable installation methods are required, and these are detailed in **Chapter 4 Project Description**. The worst-case scenario for marine physical processes is provided in **Section 8.4.4**.

NPS Reference and Requirement	How and Where Considered in the PEIR
• any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation for the final choice; • potential loss of habitat; • disturbance during cable installation, maintenance / repairs and removal (decommissioning); • increased suspended sediment loads in the intertidal zone during installation and maintenance / repairs; • potential risk from invasive and non-native species; and • predicted rates at which the intertidal zone might recover from temporary effects, based on existing monitoring data; and protected sites.”	Assessment of the potential disturbance and increased suspended sediment concentrations in the nearshore (including the intertidal zone) due to cable installation is provided in **Section 8.7.2.3**. Potential risks from invasive non-native species are assessed in **Chapter 10 Benthic and Intertidal Ecology**. The recoverability of the coastal receptors (Flamborough Head Site of Special Scientific Interest (SSSI) and Holderness Inshore Marine Conservation Zone (MCZ)) is assessed for morphological and sediment transport effects due to cable protection measures at the coast (**Section 8.7.3.5**).
Paragraph 2.8.126: “Applicant assessment of the effects on the subtidal environment should include: • loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes, e.g. sand wave / boulder / Unexploded Ordnance (UXO) clearance; • environmental appraisal of inter-array and other offshore transmission and installation/maintenance methods, including predicted loss of habitat due to predicted scour and scour / cable protection and sand wave / boulder/ UXO clearance; • habitat disturbance from construction and maintenance/repair vessels’ extendable legs and anchors; • increased suspended sediment loads during construction and from maintenance / repairs; • predicted rates at which the subtidal zone might recover from temporary effects; • potential impacts from EMF on benthic fauna; • potential impacts upon natural ecosystem functioning; • protected sites; and • potential for invasive / non-native species introduction.”	An assessment of likely significant effects of the installation and maintenance of cable infrastructure (including consideration of the potential impact of cable protection measures) is undertaken for the relevant construction and operation impacts in **Section 8.7.2**and **Section 8.7.3**, respectively. See above for scour. The quantification and likely significant effect of seabed loss due to the footprints of the Project infrastructure is covered in **Section 8.7.2.5**, **Section 8.7.3.5**, and **Section 8.7.3.5.3**. The worst-case scenario cable-laying techniques are jetting, ploughing or cutting and are considered in all the cable construction assessments. The disturbance to the subtidal seabed caused by indentations due to installation vessels is assessed in **Section 8.7.2.5**. The potential increase in suspended sediment concentrations and change in seabed level is assessed in **Section 8.7.2.1** to **Section 8.7.2.3**. The recoverability of receptors is assessed for all the relevant impacts, particularly those related to changes in seabed level due to export cable installation (**Section 8.7.2.1.1**) and morphological and sediment transport effects due to cable protection measures for export cables (**Section 8.7.3.5.1**). Assessment of likely significant effects and identification of mitigation for the marine ecosystem are discussed is the following ES chapters: • **Chapter 10 Benthic and Intertidal Ecology**; • **Chapter 11 Fish and Shellfish Ecology**; • **Chapter 12 Marine Mammals and Underwater Noise**; and • **Chapter 13 Offshore and Intertidal Ornithology**. Potential risks from Electromagnetic Field (EMF) and invasive non-native species are assessed in **Chapter 10 Benthic and Intertidal Ecology**.

8.2.2 Other Policy and Legislation

10. In addition to the NPS, there are several pieces of policy and legislation applicable to the assessment of marine physical processes. These include the Marine Policy Statement (MPS, HM Government, 2011) and associated Marine Plans.

11. The Marine Policy Statement provides the high-level approach to marine planning and general principles for decision making that contribute to achieving this vision. It also sets out the framework for environmental, social, and economic considerations that need to be considered in marine planning. Regarding the topics covered by this chapter the key reference is in section 2.6.8.6 of the MPS which states: "…*Marine plan authorities should not consider development which may affect areas at high risk and probability of coastal change unless the impacts upon it can be managed. Marine plan authorities should seek to minimise and mitigate any geomorphological changes that an activity or development will have on coastal processes, including sediment movement.*"

12. The MPS is also the framework for preparing individual Marine Plans and taking decisions affecting the marine environment. The Marine Plan relevant to the Project is the East Inshore and East Offshore Marine Plan (HM Government, 2014). The Array Area and proposed Offshore Export Cable Corridor (ECC) are located within the remit of Objective 6 "*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*" as it covers policies and commitments on the wider ecosystem, including those related to the Marine Strategy Framework Directive and the Water Framework Directive (see **Chapter 3 Policy and Legislative Context** (Document Reference: 3.1.5)), as well as other environmental, social, and economic considerations. Elements of the ecosystem considered by this objective include: "*coastal processes and the hydrological and geomorphological processes in water bodies and how these support ecological features*".

8.3 Consultation

13. Topic-specific consultation in relation to marine physical processes has been undertaken in line with the process set out in **Chapter 7 Consultation**. A Scoping Opinion from the Planning Inspectorate was received on 2nd August 2024, which has informed the scope of the assessment presented within this chapter (as outlined in **Volume 2, Appendix 8.1 Consultation Responses for Marine Physical Processes**).

14. Feedback received through the ongoing Evidence Plan Process (EPP) in relation to Expert Topic Group (ETG) meetings and wider technical consultation meetings with relevant stakeholders has also been considered in the preparation of this chapter. Details of technical consultation undertaken to date on marine physical processes are provided in **Table 8-2**.

Table 8-2 Technical Consultation Undertaken to Date on Marine Physical Processes

Meeting	Stakeholder(s)	Date(s) of Meeting / Frequency	Purpose of Meeting
ETG Meetings			
ETG1 (Marine Physical Processes) Meeting 1	Natural England, Marne Management Organisation (MMO), Environment Agency, IFCA, Cefas	13th September 2023	Discussion of approach to PEIR including modelling scenarios and characterisation of the baseline.
ETG1 (Marine Physical Processes) Meeting 2 [part 1]	Natural England, MMO, Cefas	22nd July 2024	Discussion of approach to PEIR including the study area and modelling, and assessment methodology.
ETG1 (Marine Physical Processes) Meeting 2 [part 2]	Environment Agency, East Riding of Yorkshire Council	23rd September 2024	Discussion of prediction of future coastal erosion at the landfall (methods and results).
ETG1 (Marine Physical Processes) Meeting 3	Natural England, MMO, Environment Agency, Cefas	30th October 2024	Discussion of numerical modelling results, and updated future coastal erosion analysis.

15. **Volume 2, Appendix 8.1 Consultation Responses for Marine Physical Processes** summarises how consultation responses received to date are addressed in this chapter. This chapter will be updated based on refinements made to the Project Design Envelope and to consider where appropriate stakeholder feedback on the PEIR. The updated chapter will form part of the Environmental Statement to be submitted with the DCO Application.

8.4 Basis of the Assessment

16. The following sections establish the basis of the assessment of likely significant effects, which is defined by the Study Area(s), assessment scope, and realistic worst-case scenarios. This section should be read in conjunction with **Volume 2, Appendix 1.2 Guide to PEIR**, **Volume 2, Appendix 6.2 Impacts Register** and **Volume 2, Appendix 6.3 Commitments Register**.

8.4.1 Scope of the Assessment

17. Several impacts have been scoped out of the marine physical processes assessment. These impacts are outlined in the Impacts Register provided in **Volume 2, Appendix 6.2 Impacts and Effects Register**, along with supporting justification and are in line with the Scoping Opinion (discussed in **Section 8.3**) and the project description outlined in **Chapter 4 Project Description**.

18. Impacts scoped into the assessment relating to marine physical processes are outlined in **Table 8-3** and discussed further in **Section 8.6.2.3**. A full list of impacts scoped in / out of the marine physical processes assessment is summarised in the Impacts Register provided in **Volume 2, Appendix 6.2 Impacts and Effects Register**. A description of how the Impacts Register should be used alongside the PEIR chapter is provided in **Chapter 6 Environmental Impact Assessment Methodology**.

Table 8-3 Marine Physical Processes – Impacts Scoped into the Assessment

Impact ID	Impact and Project Activity	Rationale
Construction		
MPP-C-03	Changes in suspended sediment concentration, transport, and seabed level - due to drilling for foundation installation	There is potential for drilling for foundations during construction to change seabed level due to deposition of suspended sediment.
MPP-C-04	Changes in suspended sediment concentration, transport, and seabed level - due to seabed preparation for foundation installation	There is potential for seabed preparation for foundations during construction to change seabed level due to deposition of suspended sediment.
MPP-C-05	Changes in suspended sediment concentration, transport, and seabed level - due to Inter-Array Cable and Offshore Export Cable installation including at the landfall	There is potential for installation of the cables during construction to change seabed level due to deposition of suspended sediment.
MPP-C-06	Interruptions to bedload sediment transport - due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation	There is potential for sand wave levelling for installation of the cables during construction to interrupt baseline bedload sediment transport.
MPP-C-07	Indentations on the seabed - due to the presence of installation vessels	There is potential for installation vessels during construction to directly impact the seabed through creation of indentations.
Operation and Maintenance		
MPP-O-01	Changes in the tidal current regime - due to the presence of infrastructure (wind turbine and offshore platform foundations)	The presence of the monopile foundations and offshore platform foundation structures on the seabed during operation has the potential to alter the baseline tidal current regime.
MPP-O-02	Changes in the wave regime - due to the presence of infrastructure (wind turbine and offshore platform foundations)	The presence of the monopile foundations and offshore platform foundation structures on the seabed during operation has the potential to alter the baseline wave regime.
MPP-O-03	Changes in water circulation - due to the presence of infrastructure (wind turbine and offshore platform foundations)	The presence of the monopile foundations and offshore platform foundation structures on the seabed during operation has the potential to change water column stratification.
MPP-O-04	Changes in bedload sediment transport and seabed morphology - due to the presence of infrastructure (wind turbine and offshore platform foundations)	The presence of the monopile foundations and offshore platform foundation structures on the seabed during operation has the potential to alter the baseline bedload sediment transport regime.
MPP-O-05	Changes in bedload sediment transport and seabed morphology - due to the presence of cable protection measures	Cable protection during operation has the potential to create a barrier to, and interrupt baseline bedload sediment transport.
MPP-O-06	Changes in suspended sediment concentration, transport, and seabed level - due to cable repairs and reburial	There is potential for cable repairs and reburial during operation to change seabed level due to deposition of suspended sediment.
MPP-O-08	Indentations on the seabed - due to the presence of repair and maintenance vessels	There is potential for installation vessels during operation and maintenance to directly impact the seabed through creation of indentations.

Impact ID	Impact and Project Activity	Rationale
Decommissioning		
MPP-D-02	Changes in the wave regime – decommissioning activities not yet defined	Decommissioning impacts are scoped in; however, details of offshore decommissioning activities are not known at this stage. Decommissioning impacts will be assessed in detail through the Offshore Decommissioning Programme (see **Table 8-4**, Commitment ID CO21) where relevant, which will be developed prior to the construction of the offshore works. In this assessment, it is assumed that most decommissioning activities would be the reverse of their construction counterparts, and that their impacts would be of similar nature to, and no worse than, those identified during the construction phase.
MPP-D-03	Interruptions to bedload sediment transport – decommissioning activities not yet defined	
MPP-D-04	Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined	
MPP-D-05	Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined	
MPP-D-06	Indentations on the seabed - decommissioning activities not yet defined	
MPP-D-07	Impacts on water circulation (Flamborough Front) – decommissioning activities not yet defined	

8.4.2 Embedded Mitigation Measures

19. The Project has made several commitments to avoid, prevent, reduce or, if possible, offset potential adverse environmental effects through mitigation measures embedded into the evolution of the Project's design envelope. These embedded mitigation measures include actions that will be undertaken to meet other existing legislative requirements and those considered to be standard or best practice to manage commonly occurring environmental effects. The assessment of likely significant effects has therefore been undertaken on the assumption that these measures are adopted during the construction, operation and decommissioning phases. **Table 8-4** identifies proposed embedded mitigation measures that are relevant to the marine physical processes assessment.

20. Full details of all commitments made by the Project are provided within the Commitments Register in **Volume 2, Appendix 6.3 Commitments Register**. A description of how the Commitments Register should be used alongside the PEIR chapter is provided in **Volume 2, Appendix 1.2 Guide to PEIR** and **Chapter 6 Environmental Impact Assessment Methodology**. In addition, a list of draft outline management plans which are submitted with the PEIR for consultation is provided in **Section 1.10** of **Chapter 1 Introduction**. These documents will be further refined and submitted along with the DCO application. See **Volume 2, Appendix 1.2 Guide to PEIR** for a list of all PEIR documents.

21. The Commitments Register is provided at PEIR stage to provide stakeholders with an early opportunity to review and comment on the proposed commitments. Proposed commitments may evolve during the pre-application phase as the EIA progresses and in response to refinements to the Project's design envelope and stakeholder feedback. The final commitments will be confirmed in the Commitments Register submitted along with the DCO application.

8.4.3 Study Area

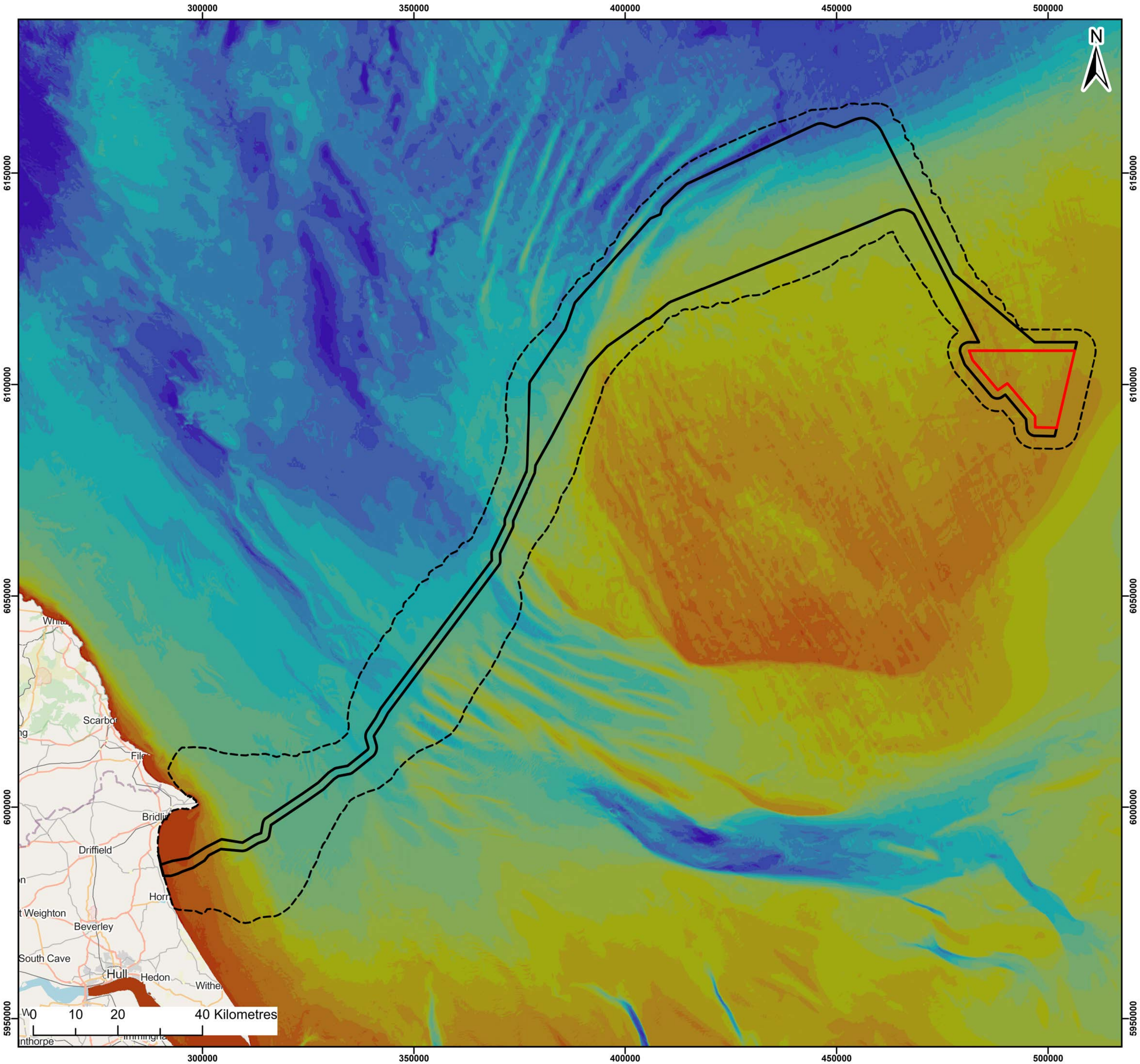
22. The marine physical processes Study Area has been defined based on the direct footprint of the Offshore Development Area (near-field) and wider areas of seabed and coast that could potentially be affected (far-field). The extent of the Study Area has been consulted on as part of the first and second ETG1 meetings with stakeholders (**Volume 2, Appendix 8.1 Consultation Responses for Marine Physical Processes**). Based on feedback from Natural England, a Zone of Influence (ZOI) is defined for each potential effect. These are:

- 'Zone of Influence tide' for changes in tidal currents (and changes in suspended sediment concentration) defined by the outputs of the hydrodynamic modelling supported by tidal ellipse data;
- 'Zone of Influence wave' for changes in wave regime defined by the outputs of wave modelling; and
- 'Zone of Influence coast' for changes in sediment transport at the coast. The offshore ZOI is determined by the closure depth, the onshore ZOI by coastal erosion / shoreline retreat and the longshore ZOI on sediment sources, sinks, availability, transport rates and the tidal ellipse.

23. Although a ZOI has been created for each individual potential effect, consideration is also given to how the zones interact with each other (e.g. wave-current interactions). In this way, an anticipated maximum ZOI is identified which informs the Study Area extent (**Figure 8-1**).

Table 8-4 Embedded Mitigation Measures Relevant to Marine Physical Processes

Commitment ID	Proposed Embedded Mitigation	How the Embedded Mitigation Will be Secured	Relevance to Marine Physical Processes Assessment	Relevance to Impact ID
CO21	An Offshore Decommissioning Programme will be provided prior to the construction of the offshore works and implemented at the time of decommissioning, based on the relevant guidance and legislation.	DCO Requirement - Offshore Decommissioning Programme	Will seek to minimise the potential effects on Marine Physical Processes during decommissioning.	MPP-D-02, MPP-D-03, MPP-D-04, MPP-D-05, MPP-D-06, MPP-D-07
CO23	At the landfall, trenchless installation techniques will be implemented and exit pits will be located beyond Mean Low Water Springs (MLWS). Installation will be at a suitable depth below the base of the cliff to avoid potential impacts to the Withow Gap Site of Special Scientific Interest (SSSI).	DCO Works DCO Requirement – Code of Construction Practice	Will allow continued uninterrupted bedload sediment transport at the landfall during operation.	MPP-O-03
CO24	A Cable Specification and Installation Plan will be provided and submitted for approval prior to offshore construction. The Cable Specification and Installation Plan will detail the methods used for construction of offshore export and inter-array cables. Where possible, cable burial will be the preferred method for cable protection. Where cable protection is required, this will be minimised so far as is feasible. All cable protection will adhere to the requirements of MGN 654 with respect to changes greater than 5% to the under-keel clearance in consultation with the MCA and Trinity House. Any damage, destruction or decay of cables must be notified to Maritime Coastguard Agency (MCA), Trinity House, Kingfisher and United Kingdom Hydrographic Office (UKHO) no later than 24 hours after discovered.	DML Condition - Cable Specification and Installation Plan	Will seek to minimise the potential effects on Marine Physical Processes due to cable installation and operation.	MPP-C-06, MPP-C-07, MPP-O-04, MPP-O-08, MPP-D-05, MPP-D-06
CO26	Micro-siting of the offshore cables will be used to minimise the requirement for seabed preparation as far as is practicable.	DML Condition - Cable Specification and Installation Plan	Will minimise the need for sand wave levelling and the associated seabed disturbance.	MPP-C-05, MPP-C-06, MPP-D-05
CO27	Cable burial will be the preferred method of cable protection where practicable. The target depth of cable burial will be informed by the Cable Burial Risk Assessment (CBRA) and identified in the Cable Specification and Installation Plan.	DML Condition - Cable Specification and Installation Plan	Will allow continued uninterrupted bedload sediment transport across the Offshore Export Cable during operation.	MPP-O-04
CO28	An Offshore Operations and Maintenance Plan (O&M) will be provided prior to commencement of operation and will outline the reasonably foreseeable O&M offshore activities.	DML Condition - Offshore Operations and Maintenance Plan	Will seek to minimise the potential effects on Marine Physical Processes of O&M activities.	MPP-O-04, MPP-O-05
CO29	An In-Principle Monitoring Plan (IPMP) will be provided in accordance with the Outline IPMP for relevant marine receptors, providing for relevant monitoring requirements during the construction and operation and maintenance (O&M) phases.	DML Condition - In Principle Monitoring Plan	Will develop a monitoring strategy to support post-consent monitoring of Marine Physical Processes.	MPP-C-03, MPP-C-04, MPP-C-05, MPP-C-06, MPP-C-07, MPP-O-04, MPP-O-05, MPP-O-08, MPP-D-02, MPP-D-03, MPP-D-04, MPP-D-05, MPP-D-06, MPP-D-07



Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Marine Physical Processes Study Area

Bathymetry (m) (LAT)

- < -90
- -89.9 - -85
- -84.9 - -80
- -79.9 - -75
- -74.9 - -70
- -69.9 - -65
- -64.9 - -60
- -59.9 - -55
- -54.9 - -50
- -49.9 - -45
- -44.9 - -40
- -39.9 - -35
- -34.9 - -30
- -29.9 - -25
- -24.9 - -20
- -19.9 - -15
- -14.9 - -10
- -9.9 - 0
- > 0

Project:

Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title:

Marine Physical Processes Study Area and Offshore Bathymetry

Figure:	8.1	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0365		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:900,000

Co-ordinate system: WGS 1984 UTM Zone 31N

sse Renewables equinor

8.4.4 Realistic Worst-Case Scenarios

24. To provide a precautionary, but robust, assessment at this stage of the Project's development process, a realistic worst-case scenario has been defined in **Table 8-5** for each impact scoped into the assessment (as outlined in **Table 8-3**). The realistic worst-case scenarios are derived from the range of parameters included in the design envelope. They ensure that the assessment of likely significant effects is based on the maximum potential impact on the environment. Should an alternative development scenario be taken forward in the final design of the Project, the resulting effects would not be greater in effect significance. Further details on the design envelope approach are provided in **Section 6.2.4.4** of **Chapter 6 Environmental Impact Assessment Methodology**.

25. The realistic worst-case scenarios used to assess impacts on marine physical processes are defined in **Table 8-5**. Following the PEIR publication, further design refinements will be made based on ongoing engineering studies and considerations of the EIA and stakeholder feedback. Therefore, realistic worst-case scenarios presented in the PEIR may be updated in the ES. The design envelope will be refined where possible to retain design flexibility only where it is needed.

Table 8-5 Realistic Worst-Case Scenarios for Impacts on Marine Physical Processes

Impact ID	Impact and Project Activity	Realistic Worst-Case Scenario	Rationale
Construction			
MPP-C-03	Changes in suspended sediment concentration, transport, and seabed level - due to drilling for foundation installation	**Wind turbines:** NB, drill arising would not occur in the event that suction bucket is used and therefore the following parameters cannot be added to the maximum seabed levelling for suction bucket. • Drill arisings at 50% of WTGs ((60m average drill depth x 254.5m^2 drill area (18m drill diameter)) x 57 WTGs (rounded up 50%)) = 870,390m^3. **Offshore platforms:** • Drill arisings from two OPs (100m average drill depth x 176.7m^2 drill area (15m drill diameter). Based on maximum 12 piles, 50% requiring drilling) = 106,020m^3. **Total:** • Total drill arisings = **976,410m^3**.	Assumes 50% of all wind turbines (57) and OP foundations (6) will be drilled in a worst case scenario. The worse case scenario for OP is two small platforms as opposed to one large platform, both in terms of extent and volumes, hence only the worst case parameters shown.
MPP-C-04	Changes in suspended sediment concentration, transport, and seabed level - due to seabed preparation for foundation installation	**Wind turbines:** • Seabed preparation volume for a single turbine foundation = 35,785m^3 (suction bucket foundation plus scour protection footprint 14,314m^2 x 2.5m levelling depth). • Seabed preparation volume for 113 turbine foundations = 4,043,705m^3. **Offshore platforms:** • Seabed preparation volume for two offshore platform foundations (monopile foundation plus scour protection footprint 25,000m^2 x 4m levelling depth x 2 OPs) = 200,000m^3. **Total:** • **4,243,705m^3** (4,043,705m^3 + 200,000m^3).	Seabed preparation (dredging using a trailing suction hopper dredger and installation of a bedding and levelling layer) may be required. The worst-case scenario assumes that sediment would be dredged and returned to the water column at the sea surface during disposal from the dredger vessel. Assumes all wind turbines (113) and offshore platforms (two small) locations will require seabed preparation. The worse case scenario for OP is two small platforms as opposed to one large platform, both in terms of extent and volumes, hence only the worst case parameters shown.

Impact ID	Impact and Project Activity	Realistic Worst-Case Scenario	Rationale
MPP-C-05	Changes in suspended sediment concentration, transport, and seabed level - due to Inter-Array Cable and Offshore Export Cable installation including at the landfall	**Inter-Array Cables:** Displaced sediment volume during sand wave levelling for Inter-Array Cables = 56,000,000m^3 (400,000m length x 4m depth x 35m width). Displaced sediment volume during Inter-Array Cable installation = 7,000,000m^3 (400,000m length x 3.5m depth x 5m width). **Offshore Export Cable:** • Displaced sediment volume during sand wave levelling for Offshore Export Cables = 32,256,000m^3 (230,400m length x 4m depth x 35m width). • Displaced sediment volume during Offshore Export Cable installation = 14,000,000m^3 (800,000m length x 3.5m depth x 5m width). • Landfall (trenchless exit pits): o Number of trenchless duct installations = 3 (includes 2 + 1 spare) and size of each exit pit – 100m length x 25m width x 3.5m depth. Total volume of sediment disturbed by exit pits – 26,250m^3. **Overall Total:** Worst case =**109,282,250**m^3.	Sand wave levelling may be required prior to offshore cable installation. Any excavated sediment due to sand wave levelling would be disposed of within the offshore development area. It is assumed 100% of inter-array cables will require sand wave levelling. As installation (trenching) results in further disturbance though within the same footprint is an additional activity resulting in movement of sediment and is considered in the modelling scenario. Maximum burial depth for cables is 3.5m (target burial depth of 2.5m with 1m over-burial allowance). This depth has been assumed across the entire length of each cable type to determine the worst-case volume of sediment disturbed. A pre-grapnel run would be required during cable installation. However, this is run along the surface of the seabed and would have minimal suspended sediment concentration volume. A technique for trenchless cable installation is not yet decided, however HDD is preferred. The offshore trenchless technique exit location will be subtidal in 1m to 8m water depth. Sediment displacement is included in the totals for the export cable.
MPP-C-06	Interruptions to bedload sediment transport - due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation	As Per Construction impact MPP-C-03.	
MPP-C-07	Changes in seabed level - due to indentations created by installation vessels	**Anchoring from vessels:** • Vessel jack up assuming 5 jack up locations per WTG / OSP (400m^2 per jack up leg x 6 legs x 5 jack up operations per WTG x 113 WTG and 2 OPs) = 1,380,000m^2. • Anchoring during WTG and OP installation (based on 16 anchors x 100m^2 footprint x 115 (1 anchoring events per 113 WTG and 2 OPs) x 2 vessels) = 187,600m^2. • Anchoring during inter-array cable installation (based on 6 anchors x 100m^2 x 11.5 anchoring events x 2 vessels) = 13,560m^2. • Anchoring during offshore export cable installation (based on 6 anchors x 100m^2 x 24 anchoring events) = 14,400m^2. • Anchoring during trenchless technique exit installation (based on 6 anchors x 100m^2 x 12 anchoring events) = 7,200m^2. • Worst-case scenario total disturbance footprint from installation vessels = 1,602,760m^2.	Total footprint of the jack up vessels across the installation activities.

Impact ID	Impact and Project Activity	Realistic Worst-Case Scenario	Rationale
Operation and Maintenance			
MPP-O-01	Changes in the tidal current regime - due to the presence of infrastructure (wind turbine and offshore platform foundations)	**Wind turbines:** • 113 x 14 MW monopile foundations (18.5m diameter) in the north-east side of the Array Area (Turbine Layout B). • Total worst case turbine footprint with scour protection (14,314m^2 maximum scour protection area per foundation including structure footprint (135m diameter) x 113 WTGs) = 1,617,482m^2. • Minimum north-west to south-east wind turbine spacing = 800m. • Minimum north-east to south-west wind turbine spacing = 1,000m. **Offshore platforms:** • Two small offshore platforms in the centre of the array, each with six 15.5m diameter monopile legs. • Total worst-case scour protection for two OPs with monopile foundations ((25,000m^2 per monopile foundation including scour protection) = 50,000m^2.	The worst-case scenario for changes in the tidal current regime does not include effects caused by cable protection. This is because, although flows would tend to accelerate over the protection and then decelerate on the 'down-flow' side, they would return to baseline values a very short distance from the structure. Hence, the effect on tidal currents would be very small. The numerical modelling of changes in tidal and wave regime added an additional 0.5m to the diameter of the monopiles to account for any ladder or other access structures that may protrude into the water column. Worst case for changes to tidal regime is Layout Option B with Offshore Platform 2 (see **Volume 2, Appendix 8.3. Marine Physical Processes Modelling Report**). The worse case scenario for OP is two small platforms as opposed to one large platform hence only the worst case parameters shown.
MPP-O-02	Changes in the wave regime - due to the presence of infrastructure (wind turbine and offshore platform foundations)	**Wind turbines:** • 113 x 14 MW monopile foundations (18.5m diameter) spread across the entire Array Area (Turbine Layout C). • Minimum north-west to south-east wind turbine spacing = 1,400m. • Minimum north-east to south-west wind turbine spacing = 1,200m. **Offshore platforms:** • Two small offshore platforms in the centre of the array, each with six 15.5m diameter monopile legs.	Assumes the maximum number of wind turbines being installed using monopile foundations. Minimum spacing of turbines would result in largest predicted effects. Worst case for changes to wave regime is Layout Option C with Offshore Platform 2 (see **Volume 2, Appendix 8.3. Marine Physical Processes Modelling Report**). The worse case scenario for OP is two small platforms as opposed to one large platform hence only the worst case parameters shown.
MPP-O-03	Changes in water circulation - due to the presence of infrastructure (wind turbine and offshore platform foundations)	As Operational Impact MPP-O-01 and MPP-O-02.	

<table>
<tr><th>Impact ID</th><th>Impact and Project Activity</th><th>Realistic Worst-Case Scenario</th><th>Rationale</th></tr>
<tr><td>MPP-O-04</td><td>Changes in bedload sediment transport and seabed morphology - due to the presence of infrastructure (wind turbine and offshore platform foundations, and cable protection measures)</td><td>Wind turbine and OP foundations as per Operational Impact MPP-O-01 and MPP-O-02.
Inter-Array Cable protection:
• Inter-array cable rock / remedial protection (10m width of rock berm protection x 40km length of exposed inter-array cables requiring remedial protection) = 400,000m^2.
Inter-Array Cable Crossings
• Assumed 5 inter-array cable crossings (each of 100m length x 10m width) = 5,000m^2.
Offshore Export Cable protection:
• Total export cable rock / remedial protection (10m width of rock berm protection x 160km length of cable requiring protection) = 1,600,000m^2.
Offshore Export Cable Crossings:
• Total footprint of pipeline / cable crossing material (100m length of crossing x 10m width of for cable crossings x 16 cable crossings and 300m length of crossing x 16m width of for pipeline crossings x 3 pipeline crossings) x 2 ECC = 60,800m^2.
Total disturbance footprint = 3,733,282m^2</td><td>Ground conditions may limit cable burial, where cable burial is not possible (assumed to be 10% of the export and inter-array cables) protection will be used.
Assumes all cable crossings require protection.</td></tr>
<tr><td>MPP-O-05</td><td>Changes in bedload sediment transport and seabed morphology - due to cable repairs and reburial</td><td colspan="2">As Operational Impact MPP-O-01 and Operational Impact MPP-O-02.</td></tr>
<tr><td>MPP-O-06</td><td>Changes in suspended sediment concentration, transport, and seabed level - due to cable repairs and reburial</td><td>• Inter-array cable repairs - seabed disturbance over the Project's lifetime (15 visits over project lifetime x 1km (distance per year failure expected) x 15m width of seabed preparation x 3.5m depth) = 787,500m^3.
• Inter-array cable reburials - seabed disturbance over the Project's lifetime (35 visits over project lifetime (1 per year) x 2km (distance per year failure expected) x 15m width of seabed preparation x 3.5m depth) = 3,675,000m^3.
• Anchoring during inter-array cable repairs/reburial (based on 6 anchors x 100m^2 x 50 anchoring events x 6.1m depth) = 183,000m^3.
• Export cable repairs - seabed disturbance over the Project's lifetime (35 visits over project lifetime (1 per year) x 1km (distance per year failure expected) x 15m width of seabed preparation x 3.5m depth) = 1,837,500m^3.
• Export cable reburials - seabed disturbance over the Project's lifetime (35 visits over project lifetime (1 per year) x 2km (distance per year failure expected) x 15m width of seabed preparation x 3.5m depth) = 3,675,000m^3.
Total increased SSCs (sum of above) = 10,158,000m^3.</td><td>Remedial reburial and repair of cables may be required with a proportion of original protection being replenished over its lifetime.
As original protection will be repaired or replaced, there will be no changes in the total seabed footprint of cable protection measures.</td></tr>
<tr><td>MPP-O-08</td><td>Changes in seabed level - due to indentations created by Operation and Maintenance vessels</td><td>Total footprint of jack-up vessel per deployment will be 2,400m^2 (six legs per vessel, individual leg footprint 400m^2). The number of deployments is unknown but will be less than during construction.</td><td>Total footprint of the jack up vessels across the Operation and Maintenance activities.</td></tr>
</table>

<table>
<tr><th>Impact ID</th><th>Impact and Project Activity</th><th>Realistic Worst-Case Scenario</th><th>Rationale</th></tr>
<tr><td colspan="4">Decommissioning</td></tr>
<tr><td>MPP-D-02</td><td>Changes in the wave regime – decommissioning activities not yet defined</td><td colspan="2" rowspan="6">The final decommissioning strategy of the Project’s offshore infrastructure has not yet been decided. For a description of potential offshore decommissioning works, refer to Chapter 4 Project Description.

It is recognised that regulatory requirements and industry best practice change over time. Therefore, the details and scope of offshore decommissioning works will be determined by the relevant regulations and guidance at the time of decommissioning. Specific arrangements will be detailed in an Offshore Decommissioning Plan (see Table 8-4, Commitment ID CO21), which will be submitted and agreed with the relevant authorities prior to the commencement of offshore decommissioning works.

For this assessment, it is assumed that decommissioning is likely to operate within the parameters identified for construction (i.e. any activities are likely to occur within the temporary construction working areas and require no greater amount or duration of activity than assessed for construction). The decommissioning sequence will generally be the reverse of the construction sequence. It is therefore assumed that decommissioning impacts would likely be of similar nature to, and no worse than, those identified during the construction phase.</td></tr>
<tr><td>MPP-D-03</td><td>Interruptions to bedload sediment transport – decommissioning activities not yet defined</td></tr>
<tr><td>MPP-D-04</td><td>Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined</td></tr>
<tr><td>MPP-D-05</td><td>Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined</td></tr>
<tr><td>MPP-D-06</td><td>Indentations on the seabed - decommissioning activities not yet defined</td></tr>
<tr><td>MPP-D-07</td><td>Impacts on water circulation (Flamborough Front) – decommissioning activities not yet defined</td></tr>
</table>

8.5 Assessment Methodology

8.5.1 Guidance Documents

26. The following guidance documents have been used to inform the baseline characterisation, assessment methodology and mitigation design for marine physical processes:

- Best Practice Advice for Evidence and Data Standards for Offshore Renewables Projects (Natural England, 2022);
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Cefas, 2011);
- General advice on assessing potential impacts of and mitigation for human activities on MCZ features, using existing regulation and legislation (Joint Nature Conservation Committee (JNCC) and Natural England, 2011);
- Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment (Lambkin et al., 2009);
- Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind Farm Industry (BERR, 2008); and
- Offshore wind farms: guidance note for Environmental Impact Assessment in respect of Food and Environmental Protection Act (FEPA) and Coast Protection Act (CPA) requirements: Version 2 (Cefas, 2004).

27. Further detail is provided in **Chapter 3 Policy and Legislative Context**.

8.5.2 Data and Information Sources

8.5.2.1 Desk Study

28. A desk study has been undertaken to compile baseline information in the previously defined Study Area(s) (see **Section 8.4.3**) using the sources of information set out in **Table 8-6.**

Table 8-6 Desk-based Sources for Marine Physical Processes Data

Data Source	Spatial Coverage	Year(s)	Summary of Data Contents
EMODnet	Array Area and offshore ECC	2020	Baseline regional mapping of bathymetry, seabed substrate and sub-surface geology to provide an overview of seabed conditions, complementing site specific surveys.
BERR Atlas	Array Area and offshore ECC	2001-2008	Tidal currents and waves.
ABPmer	Array Area and offshore ECC	2022	Tidal excursion ellipses (mean spring).
British Geology Survey (BGS)	Array Area and offshore ECC	Pre-1987	Seabed sediments.
BGS fine-scale maps	Offshore ECC	2022	Geology offshore Yorkshire.
Cefas	Array Area and offshore ECC	1998-2015	Suspended sediment concentrations.
East Riding of Yorkshire Council	Holderness	2003-2024	Beach profile data to understand beach draw down and sediment transport processes.
East Riding of Yorkshire Council	Holderness	1852-2024	Cliff erosion data.

8.5.2.2 Site-Specific Surveys

29. In addition to desk-based sources, site-specific surveys were undertaken to provide detailed baseline information on marine physical processes. **Table 8-7** summarises surveys that have been completed or are ongoing to inform the ES which are relevant to the marine physical processes baseline characterisation (**Section 8.6**).

Table 8-7 Site-Specific Survey Data for Marine Physical Processes

Survey	Spatial Coverage	Year(s)	Summary of Survey Data	Informed the PEIR
Completed				
Marine geophysical survey	Array Area	2023	Bathymetry, seabed features and shallow geology.	Yes
Benthic survey	Array Area	2023	Grab sampling and particle size analysis at 47 sampling stations in the Array Area.	Yes
Benthic survey	Offshore ECC, Characterisation Area, and Array Area	2024	Grab sampling and particle size analysis at 104 sampling stations along the offshore ECC and in the Characterisation Area, as well as some repeats in the Array Area.	Yes
Metocean	Dogger Bank	2022-2024	Measured waves at three locations; Dogger Bank (North), Dogger Bank (South), and Dogger Bank B.	Yes
Numerical modelling	Offshore ECC and Array Area	2024	Hydrodynamic, wave, and sediment dispersion modelling.	Yes
Ongoing				
Marine geophysical survey	Offshore ECC and Characterisation Area	2024 - 25	Bathymetry, seabed features and shallow geology.	No. This information will be available for the ES.

8.5.2.3 Numerical Modelling

30. To investigate waves and tidal currents and provide a baseline for prediction of changes due to the Project, wave and tidal current models were run using four different turbine layouts (Layouts A, B, C, and D, **Figure 3-1** to **Figure 3-4** in **Section 8.4.3** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**) each with three different offshore platform configurations. Simulations were completed for the effect of the Project both individually and cumulatively with other wind farm developments (either in the planning phase or constructed). For each layout, four scenarios were completed:

- Baseline (no offshore wind farm structures);
- DBD Option (to assess the impact of the Project alone);
- The Project with existing offshore wind farms, including those under construction); and
- The Project with existing offshore wind farms and the planned Dogger Bank South [DBS).

31. To investigate changes in suspended sediment concentrations due to construction activities, sediment dispersion modelling was also carried out.

8.5.2.3.1 Tidal Current Modelling

32. The worst-case scenario for tidal currents was Turbine Layout B (**Table 8-5** and **Figure 8-2**). This layout includes 113 turbines in the north-east side of the Array Area with two small offshore platforms in the centre of the array. The platform locations were chosen indicatively at the worst-case future position. The 113 x 18.5m diameter turbines are spaced at approximately 800m in a north-west to south-east direction and 1,000m in a north-east to south-west direction. Each turbine foundation measures 18m in diameter and is defined as a monopile in the models. The two offshore platforms have six legs which are defined as monopile in the model, measuring 15m in diameter. A buffer of 0.5m was added to all monopile diameters to account for boat ladder and any other protrusions.

33. Tidal currents were simulated using the two-dimensional spectral MIKE21-HD hydrodynamic model (**Section 8.4.5** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**). The model was run for a period of 30 days to assess the potential impact of the Project over a full spring-neap tidal cycle.

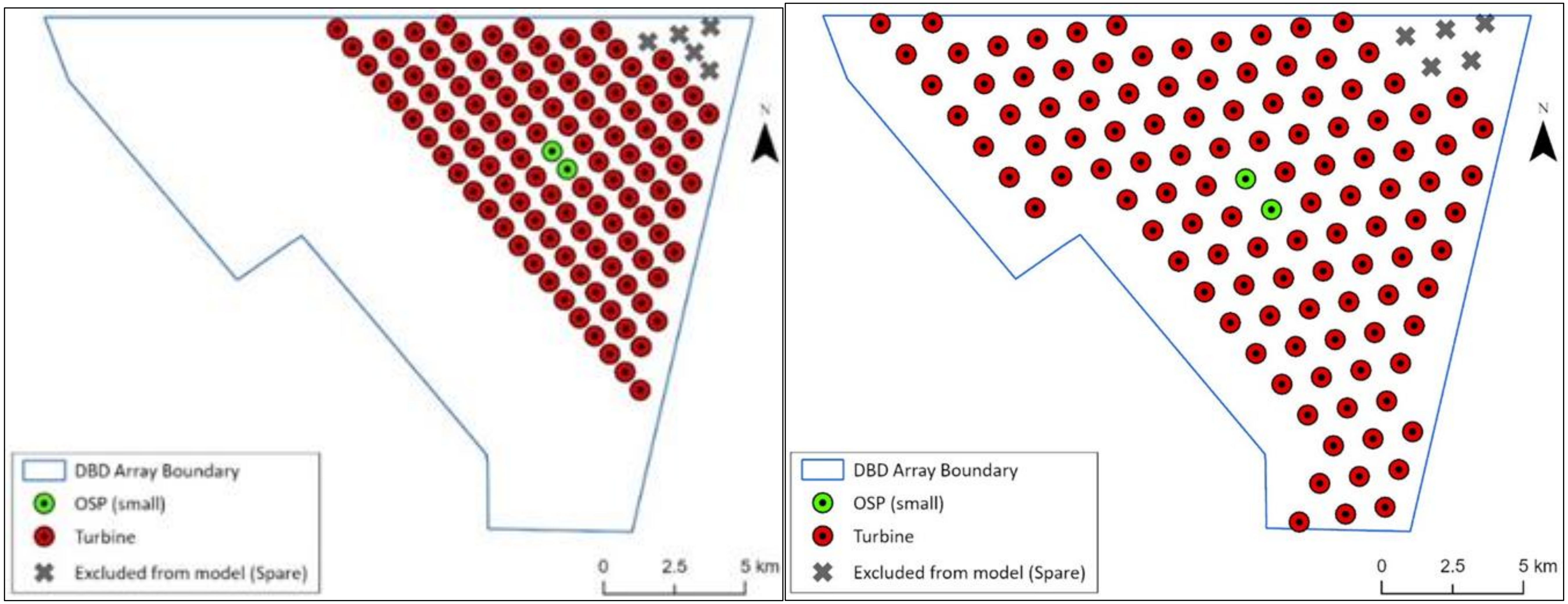


Figure 8-2 Worst-case Scenarios for the Project for tidal currents (Layout B) (left) and for waves and sediment dispersion Layout C) (right)

8.5.2.3.2 Wave Modelling

34. Turbine Layout C was the realistic worst-case Project layout for wave interaction for the DBD Option (**Table 8-5** and **Figure 8-2**). This layout includes 113 x 18.5m diameter monopile turbines with two small offshore platforms (six x 15.5m diameter monopiles per platform) in the centre of the array. The separation distance between the 113 turbines for Turbine Layout C is between 1,200m and 1,400m.

35. Wave conditions were simulated using the two-dimensional spectral MIKE21-SW wave transformation model. The model simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas. MIKE21-SW is a state-of-the-art numerical tool for prediction and analysis of wave climates in offshore and coastal areas (**Section 8.4.4** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**).

36. The results from the model simulations are compared in the assessment to predict the differences between the pre- and post-development wave regimes. The worst potential impacts in terms of wave direction are waves from a northerly, north-easterly, easterly and southerly direction. Hence, model runs were completed for each of these directions for 50th percentile exceedance and return periods of 1 in 1 year and 1 in 100 years.

37. Model outputs with the Project in place (either alone or cumulatively with other nearby wind farms) were compared against the model outputs from the baseline model runs (without the Project) to quantify the changes in wave height at the location of sensitive receptors (coast, sand banks or conservation features sensitive to changes in the wave regime). The individual or cumulative impacts on waves at sensitive receptors should be less than 5% to be considered negligible. This threshold is widely used in several sectors and is based on a pragmatic and risk-based approach to changes in the wave climate that reflects the dynamic nature of the marine environment and the inherent uncertainties in terms of both measurement and modelling accuracies.

8.5.2.3.3 Suspended Sediment Dispersion Modelling

38. The simulation of the release and spreading of fine sediments due to foundation drilling and cable installation activities have been modelled using the 3D model MIKE3-MT (**Section 8.4.6 of Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**). The MIKE3-MT model is coupled with the local 3D MIKE3-HD hydrodynamic model. Turbine Layout C with two small offshore platforms at the wind farm centre was chosen as the worst-case layout (**Table 8-5**).

39. For the purposes of modelling, two Offshore Export Cable route options were considered within the Characterisation Area: Option 1 (a route at the northern extent of the Characterisation Area) and Option 2 (the Project's primary route at the southern extent of the Characterisation Area) (**Figure 8-3**). The routes were selected to understand sediment dispersion at the outer limits of the offshore ECC thus capturing the greatest area potentially affected by changes in suspended sediment concentrations. Any potential changes to the cable route would be within these bounds. Inter-array cable routes are currently not sufficiently defined to progress sediment dispersion modelling from construction at PEIR, however inter-array cable modelling will be presented for DCO submission.

40. The Array Area characterisation (see **Table 8-8**) is based on the average composition of 47 seabed sediment samples collected across it in August 2023 (**Volume 2, Appendix 10.3 Benthic Ecology Baseline Characterisation Report**). Due to changes in the location of the Project offshore ECC post the Fugro (2023) survey (please see **Chapter 5 Site Selection** for further detail on the ECC site selection process), it was not appropriate to use the sediment data collected along the previously surveyed cable route. Seabed sediment samples within the offshore ECC were collected in September 2024 (post the completion of the modelling) and the modelling will therefore be updated to take account of this data within the ES at the DCO application stage. The values for the offshore ECC for PEIR were derived from sediment data from the DBS offshore ECC has the most recent data available across a similar geographical area.

Table 8-8 Sediment Composition (in percentages) for Suspended Sediment Dispersion Modelling

Sediment size	Array Area (%)	Offshore ECC (%)
Silt / Clay	0.0	4.1
Fine Sand	85.4	46.9
Medium Sand	4.2	30.4
Coarse Sand	8.0	9.6
Gravel / Cobble	2.0	9.1

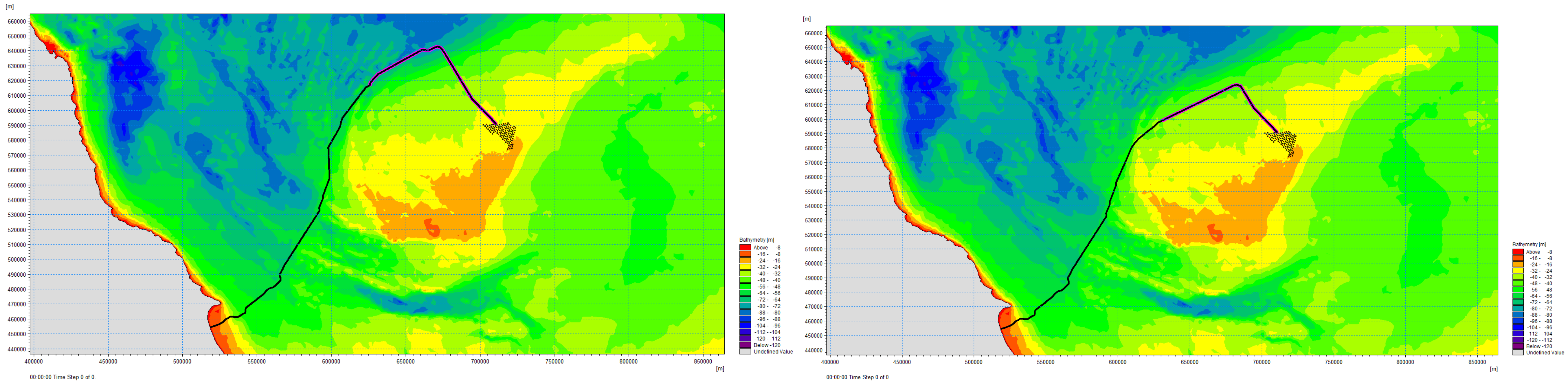


Figure 8-3 Modelled Offshore Export Cable routes. Option 1 (left) and Option 2 (right). The thicker (purple) line shows where sand wave levelling would be required

8.5.2.3.1 Cumulative Impact

41. The cumulative effect of multiple offshore wind farms was modelled for changes in wave regime using the 50 percentile probability wave conditions and the 1 in 1 return period, and for changes in tidal current regime. The cumulative Option 1 run input parameters includes the worst-case for the DBD Option, with existing wind farms Dogger Bank A (DBA), Dogger Bank B (DBB), Dogger Bank C (DBC) and Sofia (**Figure 8-4**). The cumulative Option 2 incorporates Option 1 along with the planned layouts for the DBS wind farm arrays (**Figure 8-4** and **Section 8.8**).

8.5.3 Impact Assessment Methodology

42. **Chapter 6 Environmental Impact Assessment Methodology** sets out the overarching approach to the impact assessment methodology. The topic-specific methodology for the marine physical processes assessment is described further in this section.

43. Consideration of the likely significant effects of Dogger Bank D on the marine physical processes is carried out over the following spatial scales:

- Near-field: the area within the immediate vicinity (tens or hundreds of metres) of the Array Area and along the offshore ECC; and
- Far-field: the wider area that might also be affected indirectly by the Project (e.g. due to disruption of waves, tidal currents or sediment pathways passing through the site).

8.5.3.1 Impact Assessment Criteria

44. For each potential impact, the assessment identifies receptors sensitive to that impact and implements a systematic approach to understanding the impact pathways and the level of impacts (i.e. magnitude) on given receptors. The definitions of sensitivity and magnitude for the purpose of the marine physical processes assessment are provided in Table 8-9 and **Table 8-10**.

Table 8-9 Definition of Sensitivity for a Morphological Receptor

Sensitivity	Definition
High	Tolerance: Receptor has very limited tolerance of impact. Adaptability: Receptor unable to adapt to impact. Recoverability: Receptor unable to recover resulting in permanent or long-term (>10 years) change.
Medium	Tolerance: Receptor has limited tolerance of impact. Adaptability: Receptor has limited ability to adapt to impact. Recoverability: Receptor able to recover to an acceptable status over the medium term (5-10 years).
Low	Tolerance: Receptor has some tolerance of impact. Adaptability: Receptor has some ability to adapt to impact. Recoverability: Receptor able to recover to an acceptable status over the short term (1-5 years).
Negligible	Tolerance: Receptor generally tolerant of impact. Adaptability: Receptor can completely adapt to impact with no detectable changes. Recoverability: Receptor able to recover to an acceptable status near instantaneously (<1 year).

Table 8-10 Definition of Magnitude for a Morphological Receptor

Magnitude	Definition
High	Scale: A change which would extend beyond the natural variations in background conditions. Duration: Change persists for more than ten years. Frequency: The effect would always occur. Reversibility: The effect is irreversible.
Medium	Scale: A change which would be noticeable from monitoring but remains within the range of natural variations in background conditions. Duration: Change persists for five to ten years. Frequency: The effect would occur regularly but not all the time. Reversibility: The effect is very slowly reversible (five to ten years).
Low	Scale: A change which would barely be noticeable from monitoring and is small compared to natural variations in background conditions. Duration: Change persists for one to five years. Frequency: The effect would occur occasionally but not all the time. Reversibility: The effect is slowly reversible (one to five years).
Negligible	Scale: A change which would not be noticeable from monitoring and is extremely small compared to natural variations in background conditions. Duration: Change persists for less than one year. Frequency: The effect would occur highly infrequently. Reversibility: The effect is quickly reversible (less than one year).

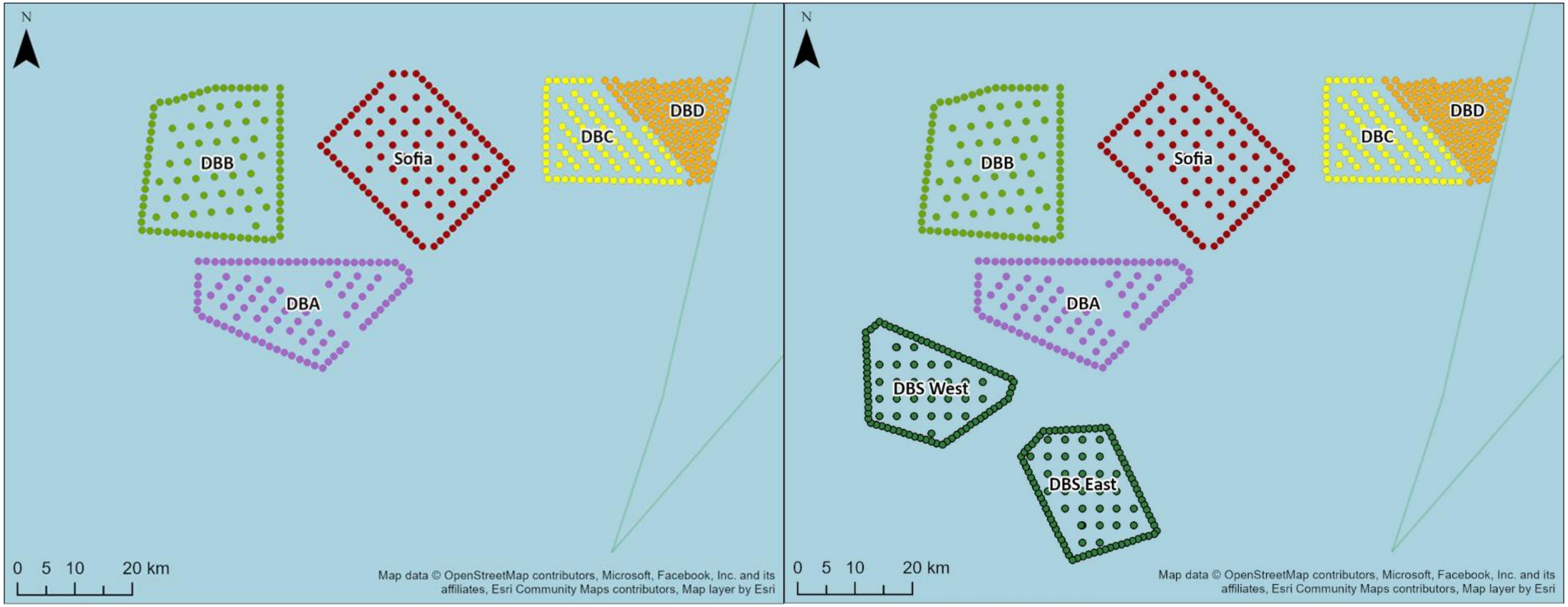


Figure 8-4 Indicative Windfarm layouts included in cumulative Option 1 (left) and cumulative Option 2 (right)

45. In addition, the 'value' of the receptor forms an important element within the assessment, for instance if the receptor is a protected habitat. It is important to understand that high value and high sensitivity are not necessarily linked within a particular effect (**Table 8-11**). A receptor could be of high value (e.g. Annex I habitat) but have a low or negligible sensitivity. Similarly, low value does not equate to low sensitivity and is judged on a receptor-by-receptor basis. The value will be considered, where relevant, as a modifier for the sensitivity assigned to the receptor, based on expert judgement. These expert-based judgements of receptor sensitivity, value and magnitude of impact will be closely guided by the conceptual understanding of baseline conditions.

Table 8-11 Definitions of Value for a Morphological Receptor

Value	Definition
High	Value: Receptor is designated and / or of national or international importance for marine physical processes. Likely to be rare with minimal potential for substitution. May also be of significant wider-scale, functional or strategic importance.
Medium	Value: Receptor is not designated but is of regional importance for marine physical processes.
Low	Value: Receptor is not designated but is of local importance for marine physical processes.
Negligible	Value: Receptor is not designated and is not deemed of importance for marine physical processes.

46. The establishment of an overall magnitude is based on a combination of the individual magnitudes for scale, duration, frequency, and reversibility. If all four individual magnitudes are negligible, then the overall magnitude is negligible. If three of the parameters are negligible with a single low magnitude, then the overall magnitude is still negligible because most of the individual magnitudes are negligible, and the single parameter is only one level above negligible. If one of the parameters is medium or high, with the other three negligible then the overall magnitude is raised to low or medium, respectively, to reflect the significance of the higher individual magnitude. If more than one parameter is medium or high with the others negligible then the overall magnitude is adjusted accordingly to represent the worst-case scenario. If there is a range of individual magnitudes across scale, duration, frequency, and reversibility, the overall magnitude is estimated based on an 'average' of the individual magnitudes, assuming that the weighting is even across the four parameters.

8.5.3.1.1 Significance of Effect

47. The assessment of significance of an effect is a function of the sensitivity of the receptor and the magnitude of the impact (see **Chapter 6 Environmental Impact Assessment Methodology** for further details). The determination of significance is guided using a significance of effect matrix, as shown in **Table 8-12**. Definitions of each level of significance are provided in **Table 8-13**.

Table 8-12 Significance of Effect Matrix

		Adverse Effect				**Beneficial Effect**			
		Impact Magnitude							
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Receptor Sensitivity	High	Major	Major	Moderate	Minor	Minor	Moderate	Major	Major
	Medium	Major	Moderate	Minor	Minor	Minor	Minor	Moderate	Major
	Low	Moderate	Minor	Minor	Negligible	Negligible	Minor	Minor	Moderate
	Negligible	Minor	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Minor

Table 8-13 Definition of Effects Significance

Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision-making process.
Negligible	No discernible change in receptor condition.
No change	No effect, therefore, no change in receptor condition.

48. Likely significant effects identified within the assessment as major or moderate are regarded within this chapter as significant, whether this be adverse or beneficial. Appropriate mitigation has been identified, where practicable, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall significance of effect to determine a residual effect upon a given receptor.

8.5.4 Cumulative Effects Assessment Methodology

49. The cumulative effect assessment (CEA) considers other plans and projects that may act collectively with the Project to give rise to cumulative effects on marine physical processes receptors. The general approach to the CEA for marine physical processes involves screening for potential cumulative effects, identifying a short list of plans and projects for consideration and evaluating the significance of cumulative effects. **Chapter 6 Environmental Impact Assessment Methodology** and **Volume 2, Appendix 6.4 Cumulative Effects Screening Report – Offshore** provide further details on the general framework and approach to the CEA.

8.5.5 Transboundary Effects Assessment Methodology

50. The transboundary effect assessment considers the potential for effects to occur on marine physical processes receptors because of the Project; either those that might arise within the Exclusive Economic Zone (EEZ) of other European Economic Area (EEA) member states or other interests of EEA member states. **Chapter 6 Environmental Impact Assessment Methodology** provides further details on the general framework and approach to the transboundary effect assessment.

51. For marine physical processes, there is potential for the effects on tidal currents and waves to cross into adjacent international waters, with potential secondary effects on sediment transport or seabed morphology. Therefore, transboundary impacts are scoped in and will be assessed. Changes to the wave and tidal regimes during operation of the Project have been modelled for the worst-case foundation layout and cumulatively with existing and proposed wind farms.

8.5.6 Assumptions and Limitations

52. Given the large amount of data that was collected for the site-specific surveys, Dogger Bank A, B, and C, and Sofia offshore wind farms, there is a good baseline understanding of marine physical processes at the Project and its adjacent areas.

8.6 Baseline Environment

8.6.1 Existing Baseline

8.6.1.1 Bathymetry and Seabed Features

53. The Array Area is located on Dogger Bank which is a bathymetric high in the central North Sea. Water depths across the Array Area vary between 21m below Lowest Astronomical Tide (LAT) and 34.5m below LAT (**Figure 8-5**). The seabed is shallowest in the south-eastern part of the Array Area and gently slopes towards the north-west. In the central part of the Array Area, a trough runs north-south and within this trough there are a series of elongate linear deeps, also oriented north-south that are up to 5m deep (relative to the surrounding seabed).

54. The bathymetry of the Characterisation Area of the offshore ECC is shown on **Figure 8-6**. The bathymetry describes a south to north sloping seabed, lowering from about 30m below LAT in the south to 80m below LAT in the north.

8.6.1.2 Marine Geology

55. The Quaternary geology of the Array Area comprises a sequence of sands and clays that are over 100m thick (BGS, 2024). The underlying bedrock is characterised by undifferentiated mudstone and sandstone (BGS, 2023). The sequence of Quaternary deposits below the Array Area is provided in **Table 8-14**.

Table 8-14 Geological Formations Present Beneath the Array Area (Cotterill et al., 2017)

Era	Formation	Expected geology
Holocene	Bligh Bank	Modern mobile sands (marine).
	Indefatigable Grounds	Gravelly sands and sandy gravel, lag deposit (marine).
	Nieuw Zeeland Gronden Terschellinger Bank	Muddy fine-grained sand (marine).
	Well Hole	Laminated sand and sandy mud, infills depressions (shallow marine).
	Elbow	Muddy sand and interbedded clay, and basal peat (transitional terrestrial to shallow marine).

Era	Formation	Expected geology
Weichselian	Botney Cut	Stiff to soft glaciomarine to glaciolacustrine muds (glacial).
	Volans	Clay with variable silt, sand, and gravel content (glacial).
	Bolders Bank	Firm to stiff silty sandy gravelly clay (glacial).
	Dogger Bank	Very heterogenous deposits. Includes clay with variable silt, sand, and gravel content (glacial) and dense sand in areas (aeolian or periglacial). Organic matter has been recorded indicating possible sub-aerial exposure. Can contain shell fragments.
Eemian	Eem	Shelly sands, can be muddy in places (marine).
Saalian	Tea Kettle Hole	Fine-grained sand with organics (periglacial and aeolian).
	Cleaver Bank	Laminated clays and / or fine-grained sand (marine to proglacial).
Holstenian	Egmond Ground	Gravelly sands interbedded with silt and clay (marine).

8.6.1.3 Water Levels

56. The astronomical tidal range across the southern North Sea varies depending on location relative to an amphidromic point between East Anglia and the Netherlands. As a result, the mean spring tidal range gradually increases from east to west across the offshore ECC from approximately 1m in the Array Area to 5m near the landfall (BERR, 2008).

57. The tidal regime at the landfall is semi-diurnal; the water level rises and falls twice a day. The water levels for the landfall have been estimated using the tide gauge at Bridlington (the closest reference location for tides) (**Table 8-15**). The mean spring tidal range for Bridlington is around 5m, with a mean neap tidal range of around 2.4m.

Table 8-15 Water Levels from Tide Gauge at Bridlington

Datum	HAT	MHWS	MHWN	MLWN	MLWS	LAT
mCD	6.87	6.13	4.85	2.43	1.16	0.25
mOD	3.87	3.13	2.85	0.43	-1.84	-2.75

Note: -3.0m used to convert CD to OD based on levels for Whitby.

58. These regular, predictable astronomical tides can be influenced by meteorological effects such as surge or wind set-up, causing extreme water levels. High waters on spring tides combined with a positive surge influence enable waves to reach the base of the soft cliffs at the landfall. The UK Coastal Flood Boundaries (CFB) Project indicates that extreme water levels at Immingham (the nearest CFB site) during 1 in 1 year return period events are 4.17m above OD and during 1 in 200-year return period events are 5.06m above OD.

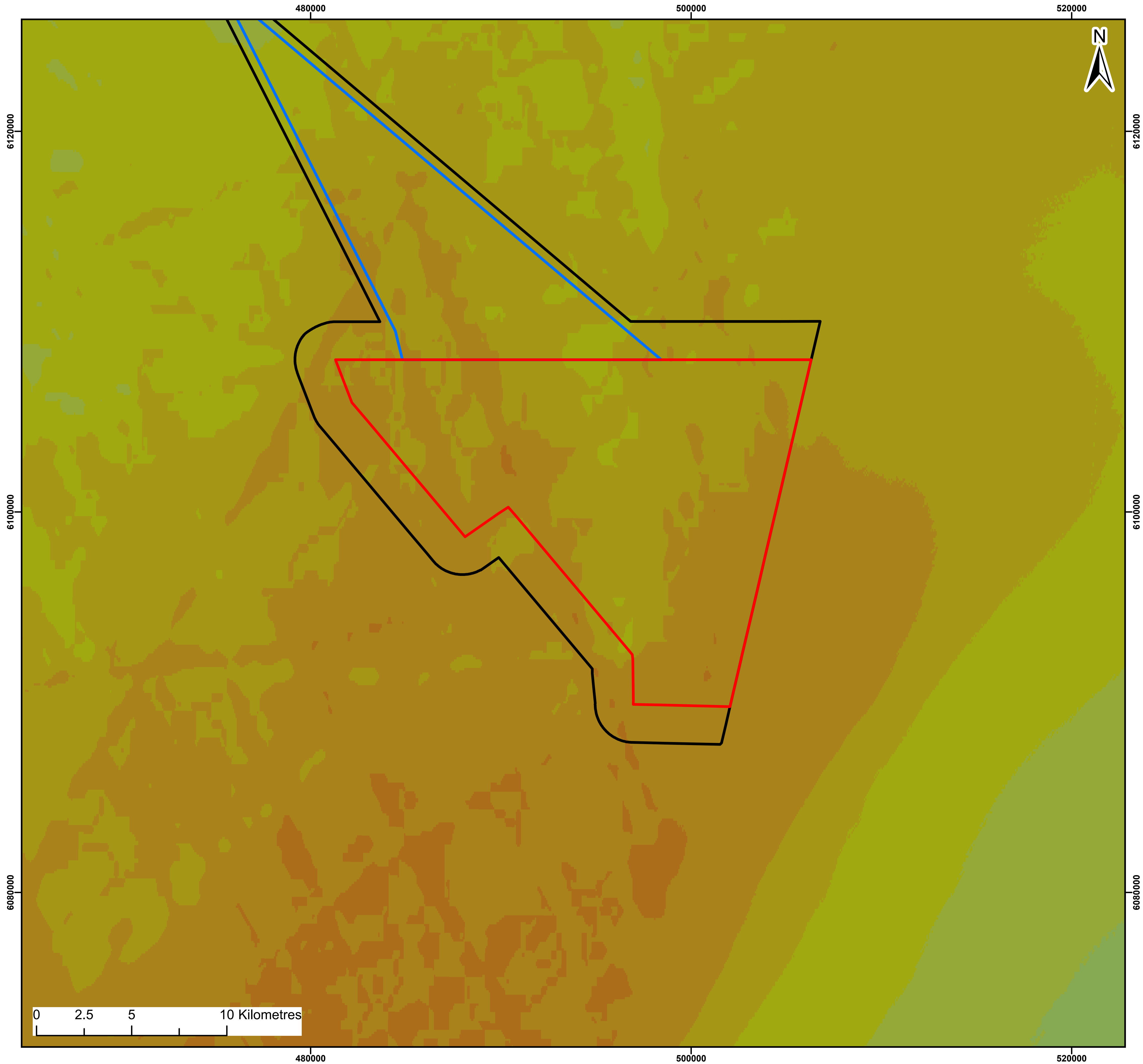
8.6.1.4 Historic Sea-level Rise

59. Woodworth (2018) used recent mean sea level information from the UK tide gauge network along with short records of sea level measurements by the Ordnance Survey (OS) in 1859-1860, to estimate the average rates of sea-level change around the coast since the mid-19th century. The nearest historic data to the landfall analysed by Woodworth (2018) is at Scarborough, which includes OS data from 1859-1860 and tide gauge data for 24 of the years between 1955 and 2014 (with a central year of 1997). The estimated long-term rate of sea-level rise between mean sea level in 1859-1860 and the average mean sea level between 1955 and 2014 (1997) was 1.73mm/year.

8.6.1.5 Tidal Currents

60. An understanding of tidal currents in the Offshore Development Area provides insight into how they drive sediment transport. Tidal excursion ellipses can be used to illustrate the distance and direction over which a water particle will travel in one complete tidal cycle (over a flood and ebb tide). The mean spring tidal excursion ellipses for the Offshore Development Area are provided on **Figure 8-7**. The lengths of tidal excursion ellipses are between 3km and 4km in the Array Area where they are aligned broadly east-west. The tidal excursion ellipse length increases along the offshore ECC from the Array Area to a maximum of 14km to the south of Flamborough Head. The axis of the ellipses also changes along the offshore ECC rotating from east-west near the Array Area to north-east-south-west then north-south becoming aligned along a north-west-south-east axis near the coast.

61. Tidal currents were simulated across the Offshore Development Area using the two-dimensional spectral MIKE21-HD hydrodynamic model (**Section 8.4.5** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**). Modelled peak flows gradually increase landward from the Array Area along the offshore ECC, from 0.3m/s to 0.4m/s furthest offshore, to greater than 1.5m/s closer to the coast (**Figure 8-7**). Across the Array Area, modelled peak flows for mean spring tides increase from north-west to south-east. Speeds in the north-west corner of the site are predicted to be 0.34m/s increasing to 0.46m/s in the south-east corner (**Figure 8-8**).



Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor

Bathymetry (m) (LAT)

- -44.9 - -40
- -39.9 - -35
- -34.9 - -30
- -29.9 - -25
- -24.9 - -20
- -19.9 - -15

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: Bathymetry of the Array Area

Figure: 8.5 Drawing No: PC6250-RHD-XX-OF-DR-GS-0367

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: WGS 1984 UTM Zone 31N

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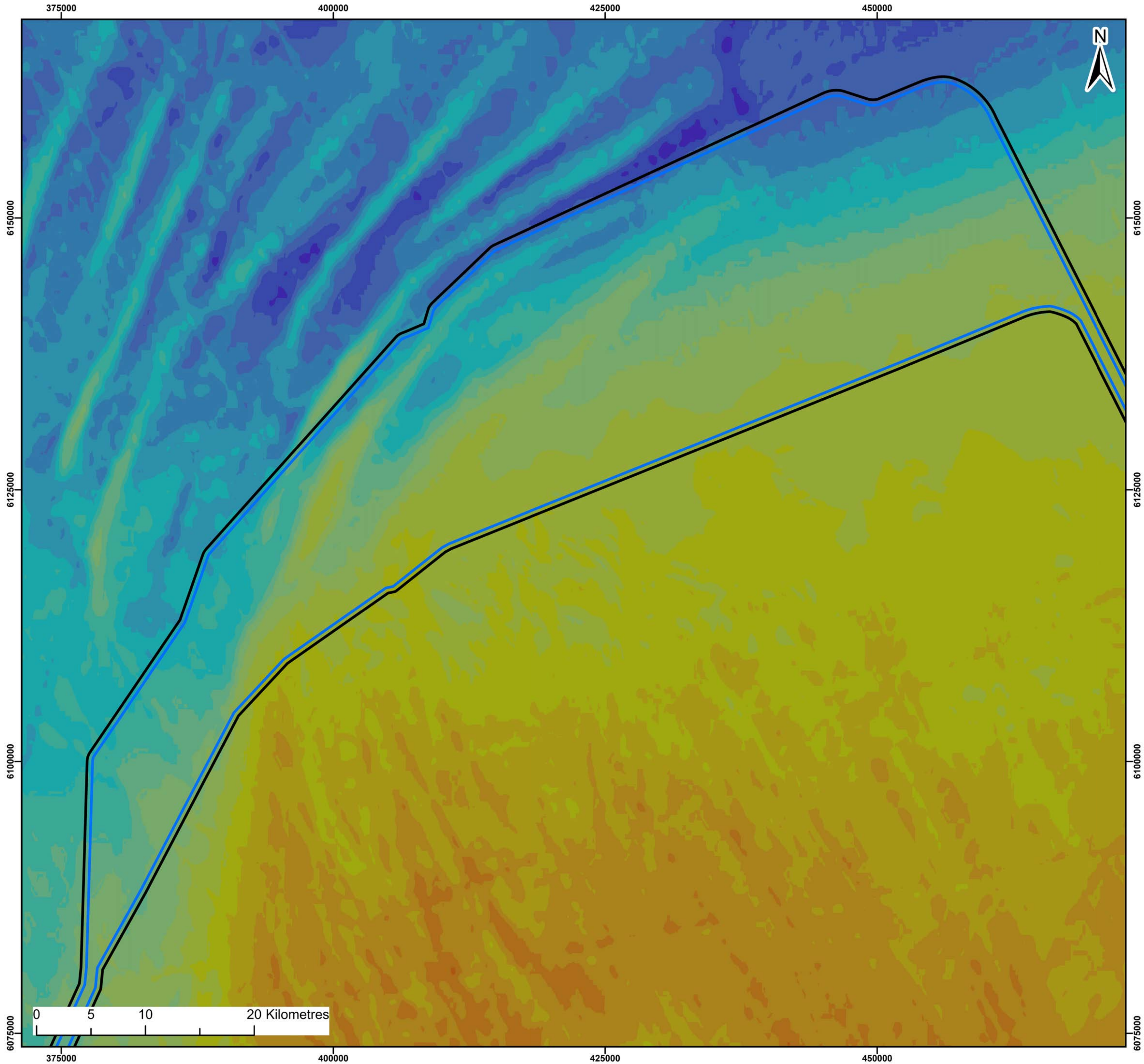

Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor

Bathymetry (m) (LAT)

- -89.9 - -85
- -84.9 - -80
- -79.9 - -75
- -74.9 - -70
- -69.9 - -65
- -64.9 - -60
- -59.9 - -55
- -54.9 - -50
- -49.9 - -45
- -44.9 - -40
- -39.9 - -35
- -34.9 - -30
- -29.9 - -25
- -24.9 - -20
- -19.9 - -15
- -14.9 - -10

Project:

Dogger Bank D
Offshore Wind Farm

DOGGER BANK
WIND FARM

Title:

Bathymetry in the Characterisation Area including Option 1 and Option 2 of the Offshore ECC (EMODnet, 2024)

Figure:	8.6	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0375		
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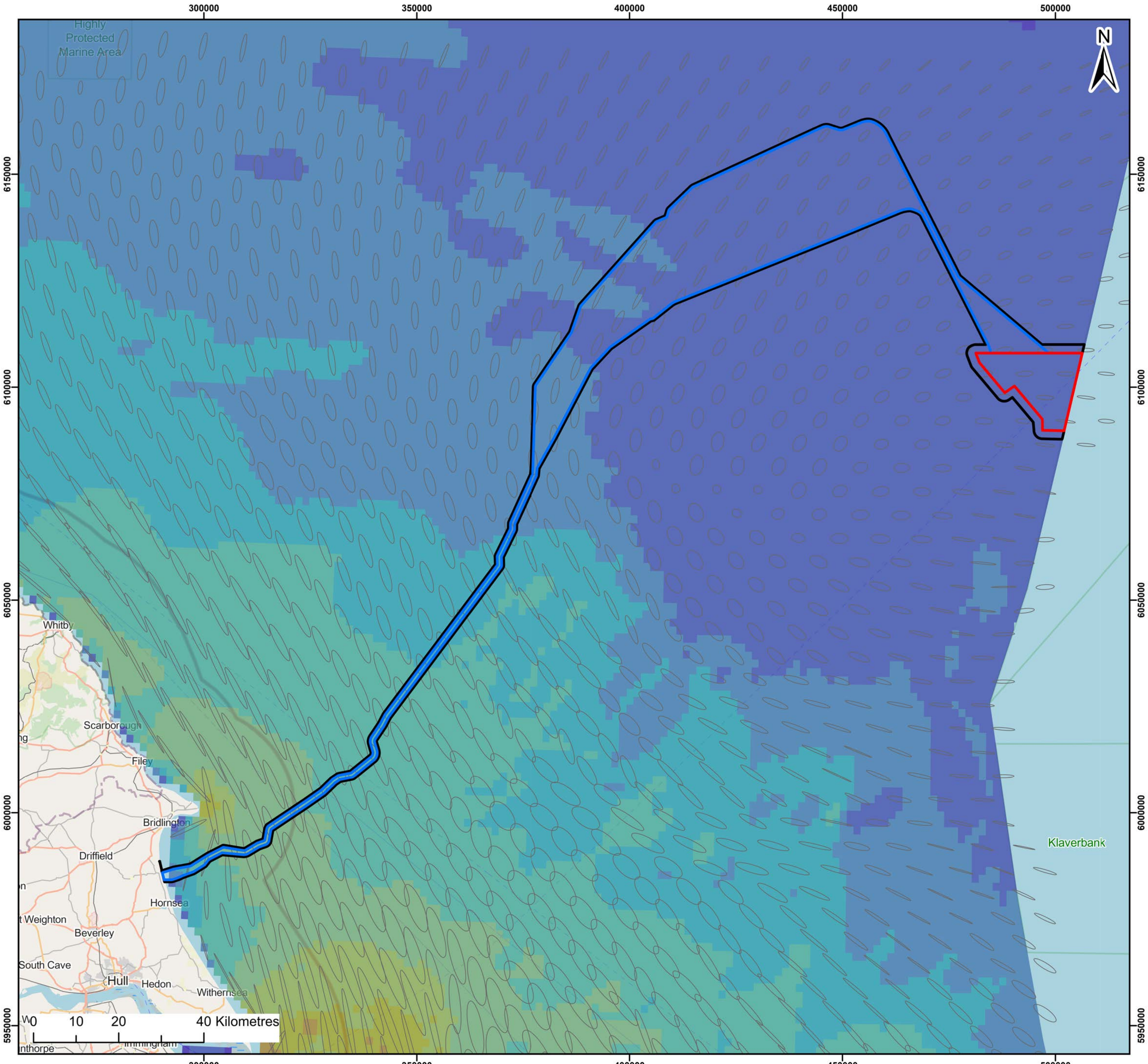

Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor
- Spring Tidal Ellipse

Peak Flow of Mean Spring Tide (m/s)

- < 0.20
- 0.21 - 0.40
- 0.41 - 0.60
- 0.61 - 0.80
- 0.81 - 1.00
- 1.01 - 1.20
- 1.21 - 1.40
- 1.41 - 1.60
- 1.61 - 1.80

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: Mean spring tidal excursion ellipses (ABPmer) and peak flow of mean spring tide (BERR, 2008)

Figure:	8.7	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0368		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: WGS 1984 UTM Zone 31N

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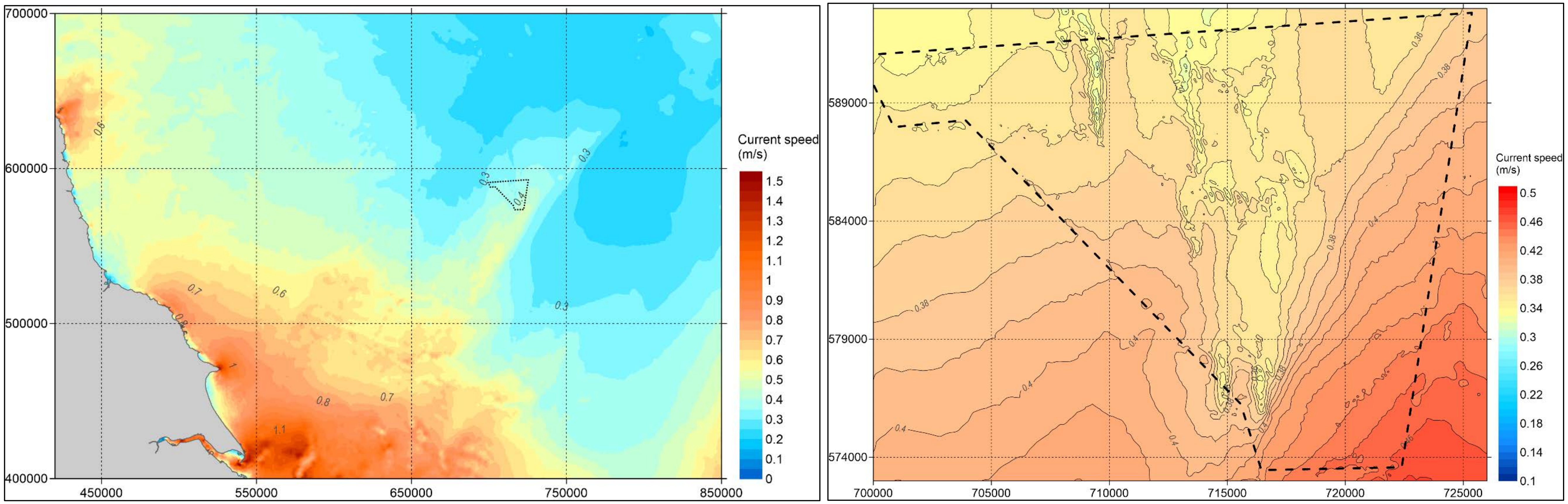


Figure 8-8 Overview (left) and zoomed-in (right) of predicted baseline spatial variation of maximum current speed over 30 days

8.6.1.6 Waves

62. The wave climate across the Offshore Development Area has been determined from measured waverider buoy data at three locations (**Figure 8-9**) and the Hornsea waverider buoy located 10km south-east of the landfall (Channel Coastal Observatory 2024). Atmospheric hindcast wave data at a point within the Array Area was also used to understand potential variability in wave climate between the locations of the wave buoys and the Array Area. A summary of the wave data is provided in **Table 8-16**.

Table 8-16 Summary of Measured and Modelled Wave Data

Buoy/Data Point	Measurement period	Dominant wave direction (from)	Maximum significant wave height (from direction)	Maximum wave period (from direction)
Dogger Bank North	September 2022 to January 2024	North	8.1m (east)	18.2s (north-west and south-west)
Dogger Bank South	June 2022 to December 2023	North	7.2m (east-north-east)	18.2s (north-north-west, west-south-west, and west)
Dogger Bank B	September 2023 to February 2024	North	8.1m (east)	18.2s (south-west and north-west)
Hornsea	June 2022 to February 2024	North-east	5.2m (north-north-east)	22.2s (north-north-east)
ERA 5 Array Area	June 2022 to February 2024	North-west	6.9m (east)	17.4s (north-north-west)

63. The dominant waves approach Dogger Bank from the north, although the dominant spectrum is from north-west through to north-east (centred on north). The largest waves approach from the east to east-north-east and significant wave heights can reach between 6.9m and 8.1m on Dogger Bank. The waves with the longest periods approach from north-west and the south-west.

64. As waves approach the Holderness coast they are modified by the bathymetry through the processes of refraction and shoaling, and by diffraction around Flamborough Head. These processes mean that as waves approach the coast at the landfall they arrive from a more easterly direction, particularly those from the north and north-east. The maximum measured significant wave height from the Hornsea buoy is 5.2m and those waves approach from the north-north-east.

65. Waves were simulated across the Offshore Development Area using the two-dimensional spectral MIKE21-SW wave model (**Section 8.4.4** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**). Wave climates have been simulated for the 50th percentile exceedance, 1 in 1 year, and 1 in 100-year return periods, from the north and east. The results show that the largest waves approach from the north (**Figure 8-10**).

8.6.1.7 Seabed Sediment

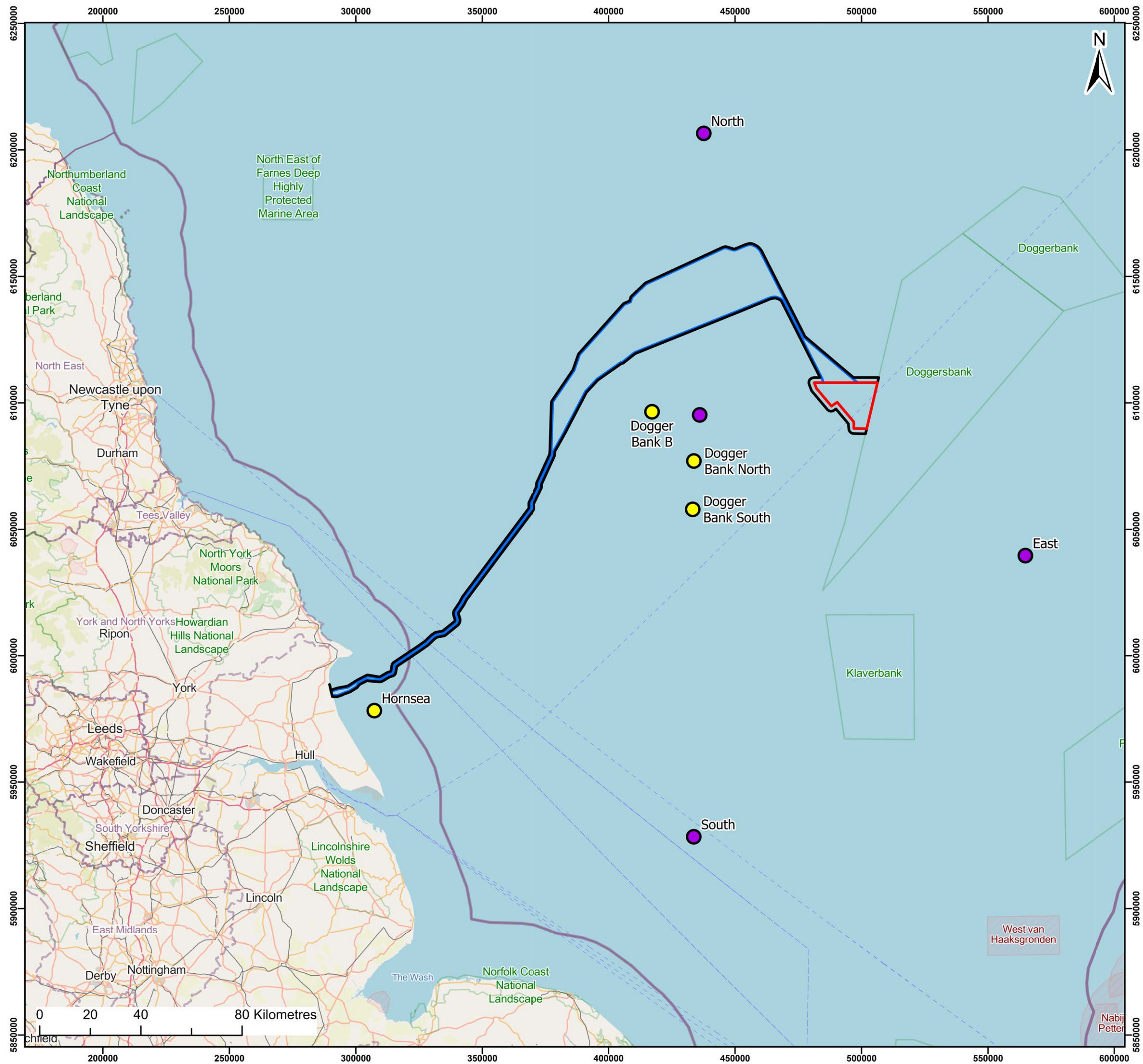
66. Particle size analyses of 47 samples collected in 2023 and 15 samples collected in 2024 within the Array Area (**Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**) as shown on **Figure 8-11**. The figure also shows the seabed sediments are dominated by fine to medium sand. A large proportion of samples do not contain any fines (silt and clay) and where fines are present, they are typically less than 10% of the overall sediment composition.

67. Seabed sediment samples have been collected along the offshore ECC (Fugro, 2024) **(Figure 8-12**). The sediment along the offshore ECC is dominated by fine and medium sand, with a moderate proportion of gravel.

68. Most of the gravel is contained in samples collected closer to the coast. Seabed sediment within the Array Area is broadly comparable to the offshore ECC with a slightly lower composition of gravel.

Table 8-17 Summary of Particle Size Distributions Across the Array Area and Offshore ECC

Sediment size	% Average Content in the Sediment Samples	
	Array Area	Offshore ECC
Silt / Clay (<62.5)	1	3
Very Fine Sand (62.5-125)	8	10
Fine Sand (125-250)	53	47
Medium Sand (250-500)	26	22
Coarse Sand (500-1000)	2	4
Very Coarse Sand (1000-2000)	1	3
Gravel (>2000)	8	12



Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor
- ERA5 Hindcast Data Point
- Wave Buoy

Project: Dogger Bank D Offshore Wind Farm	DOGGER BANK WIND FARM
Title: Measured and Hindcast Wave Data Points used to Characterise Wave Climate	
Figure: 8.9	Drawing No: PC6250-RHD-XX-OF-DR-GS-0482

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:1,500,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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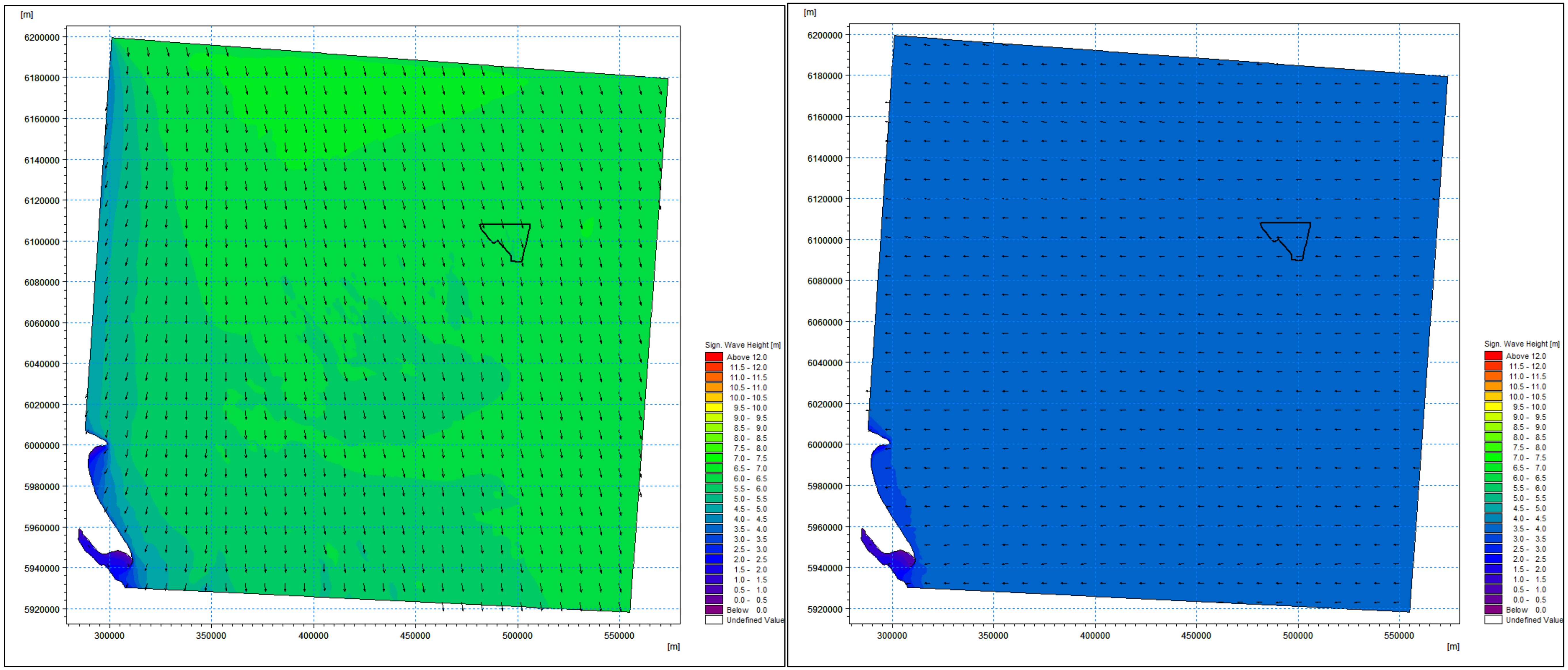
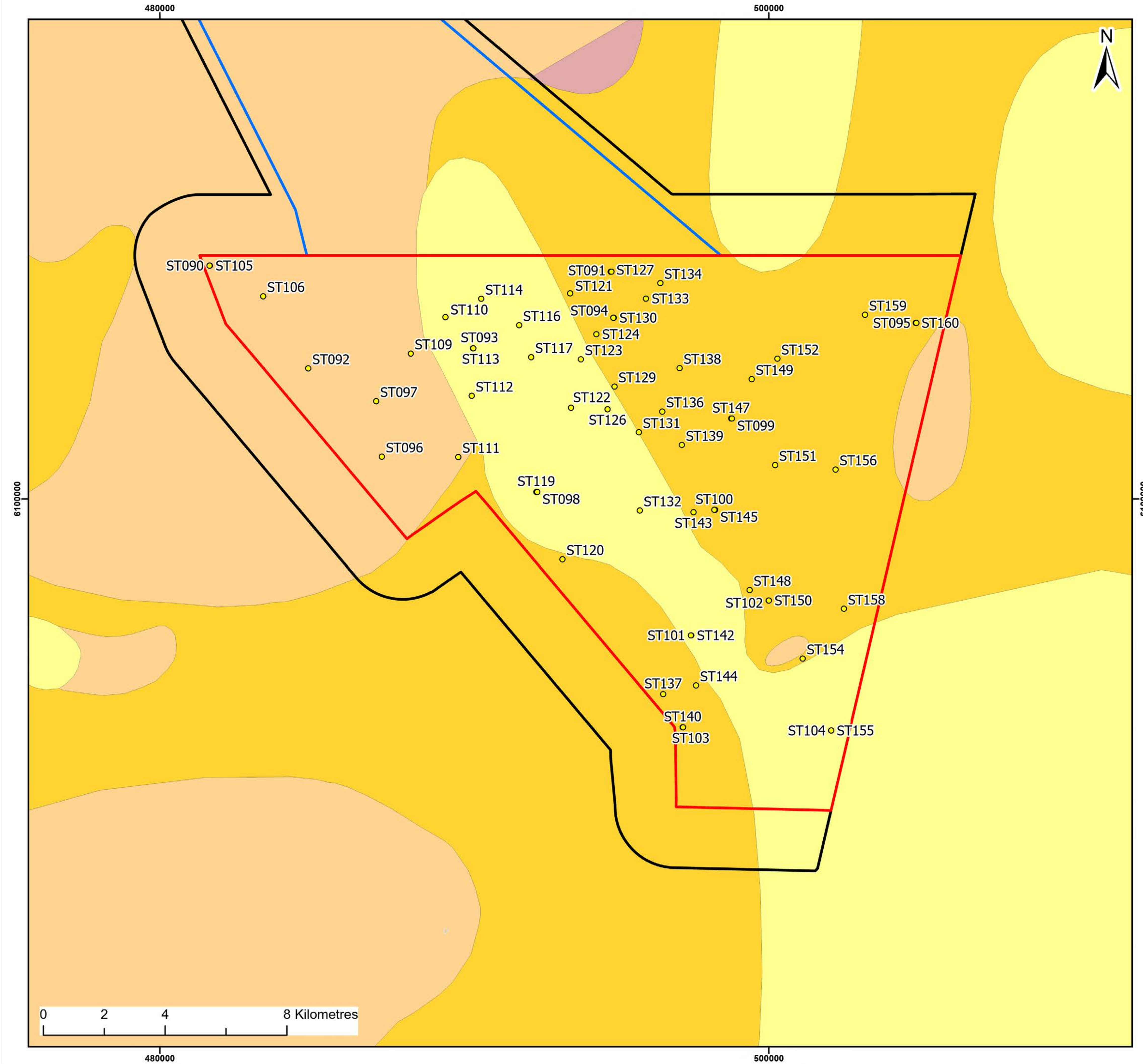


Figure 8-10 Predicted Baseline Significant Wave Height for 1 in 1 year Return Period Waves Approaching from the North (left) and East (right)



Legend:

- Dogger Bank D Array Area
- Offshore Export Cable Corridor
- Offshore Development Area
- Seabed Sediment Grab Sample (Array Area)

Seabed Sediment

- Gravelly Muddy Sand
- Gravelly Sand
- Sand
- Slightly Gravelly Sand

Source: © Haskoning DHV UK Ltd, 2025; © BGS, 2024; © Fugro, 2023/2024; © OpenStreetMap (and) contributors, CC-BY-SA

Project:	
Dogger Bank D Offshore Wind Farm	DOGGER BANK WIND FARM

Title:

Location of seabed grab samples (Fugro 2023, 2024) and distribution of seabed sediment (BGS) in the Array Area

Figure:	8.11	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0373		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:125,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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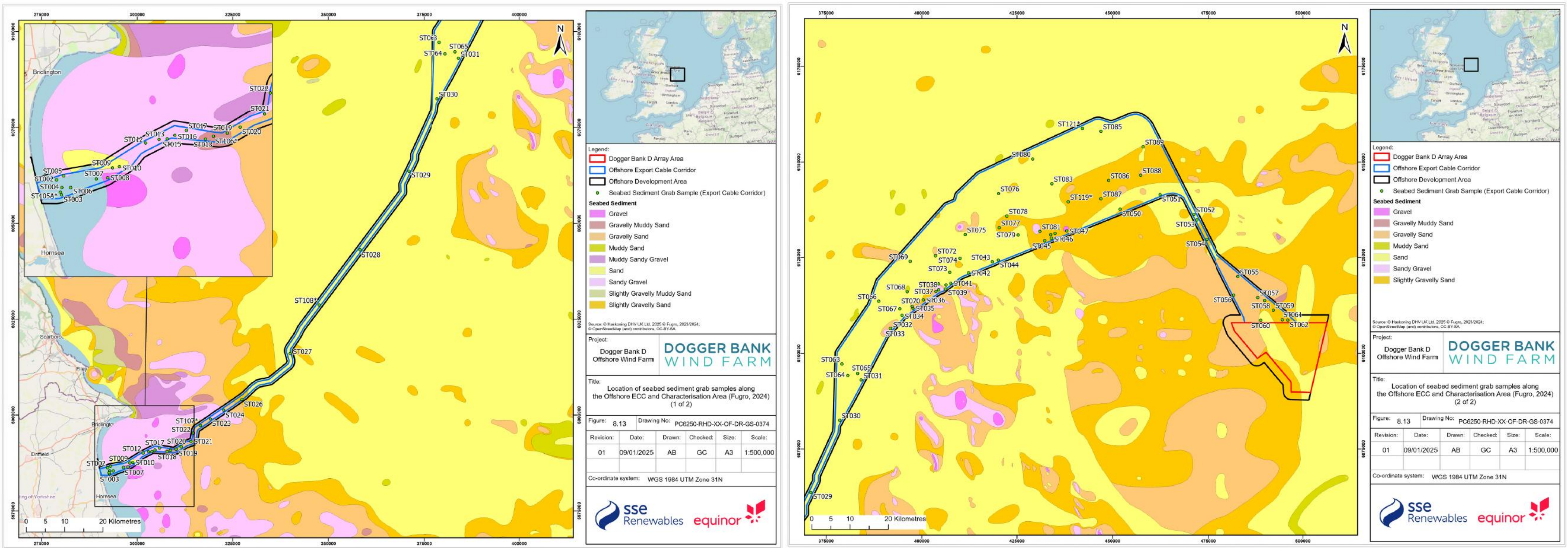


Figure 8-12 Location of Seabed Sediment Grab Samples along the Offshore ECC and Characterisation Area (Fugro, 2024)

8.6.1.8 Sediment Transport and Seabed Mobility

69. Tidal currents are expected to be the dominant driver of bedload sediment transport across the Array Area. The hydrodynamic modelling shows current speeds are higher on the ebb tide, therefore the residual bedload sediment transport pathways are expected to be towards the west-north-west in the Array Area. The modelling predicts peak bed shear stress to be between 0.25N/m^2 to 0.45N/m^2 within the Array Area (**Figure 8-13**) which is sufficient to mobilise sediment particles up to 0.3mm (medium sand) in size (clay, silt, and fine to medium sand) (**Table 8-18**).

Table 8-18 Sediment Critical Bed Shear Stresses for Movement

Sediment size	Sediment Size (mm)	Critical Bed Shear Stress (N/m^2)
Silt / Clay	0.031	0.0847
Fine Sand	0.13	0.1548
Medium Sand	0.3	0.2025
Coarse Sand	1.3	0.657
Gravel / Cobble	2.0	1.166

70. There are no sand banks or sand waves indicative of tidally driven mobile sediments present in the Array Area. However, an absence of bedforms does not necessarily indicate the seabed is immobile.

71. The combination of water depth (21m to 35m below LAT) plus tidal variation means that waves have a lesser influence on bedload sediment transport within the Array Area. However, there is potential for waves generated during storm events to influence the seabed and mobilise sediment.

72. Regional sediment transport pathways (Kenyon and Cooper, 2005) suggest sediment transport pathways in the nearshore part of the offshore ECC are to the south to south-south-east whereas further offshore they are towards the north-north-west, with a bedload parting zone located about 30km from the coast (**Figure 8-14**).

73. In the nearshore zone, the seaward limit which marks the effective boundary of wave-driven sediment transport is called the closure depth and can be calculated using the methods of Hallermeier (1978). The Hallermeier (1978) calculation is based on a formula using wave height (in this case average significant wave heights recorded by the Hornsea buoy) and period in the nearshore zone. It is an established method, which takes account of locally derived parameters and has been used widely for analysis of the effective seaward boundary of wave-driven sediment transport. Using data input to this equation at the landfall, the closure depth would typically be in around 6m of water, which is approximately 860m from the base of the cliffs.

8.6.1.9 Stratification

74. The southern North Sea is generally described as a well-mixed water body. These well-mixed conditions are mainly due to relatively shallow depths and the ability of winds and tides to continually stir water sufficiently to prevent the onset of any stratification (DECC, 2016). In contrast, the northern North Sea is relatively deep with slightly weaker currents, which helps temperature stratification develop from the spring into the summer months. During this period, a transition between these two water bodies develops from about 10km offshore of Flamborough Head in the form of a temperature front, known as the Flamborough Front. The deeper stratified water to the north tends to remain aligned with the 50m isobath (Hill *et al.*, 1993). The surface waters of the front tend to move around this alignment with the scale of tidal advection. The front becomes nutrient rich and is ecologically important with respect to primary productivity. During autumn and winter the front dissipates due to increased wind and wave related stirring effects which are sufficient to overcome the stratification (i.e. increased mixing is greater than buoyancy) and re-establish well-mixed conditions for this part of the northern North Sea. The timing of the destabilisation will vary from year to year depending on the weather conditions at the time.

75. The Flamborough Front, when present, is a 320km-long zone located off the East Riding of Yorkshire coast. While the location and strength of the Flamborough Front varies on a seasonal and yearly basis, observations from between 1999 and 2008 suggest it may be present in the Offshore Development Area during summer 70% to 90% of the time and during autumn and spring, between 30% to 50% of the time (Miller and Christodoulou, 2014).

76. However, a long-term modelling study (van Leeuwen *et al.*, 2015) suggests these areas are not within a location that commonly stratifies on a seasonal basis (**Figure 8-15)**. The water within and around the Array Area is stratified less than 40 days a year and it is within a region categorised as intermittently stratified. The nearest seasonally stratified region (stratified for greater than 120 days) is located about 15km north of the Array Area. The Flamborough Front may be present occasionally within this region, but most of the time this water is well-mixed. The continued relevance and reliance of the modelling approach by van Leeuwen *et al* (2015) is supported by its use in recent research (Macovei *et al.*, 2021).

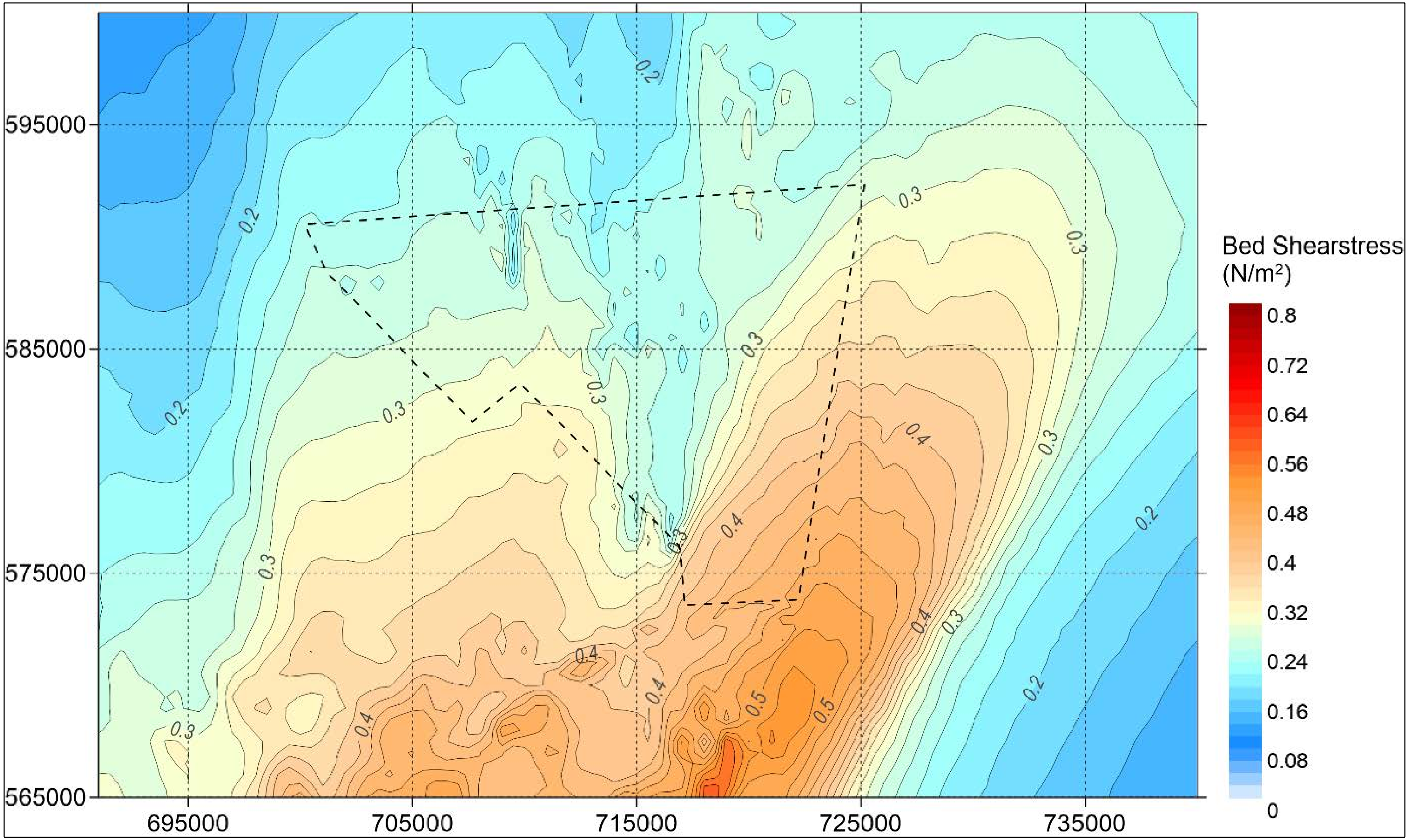
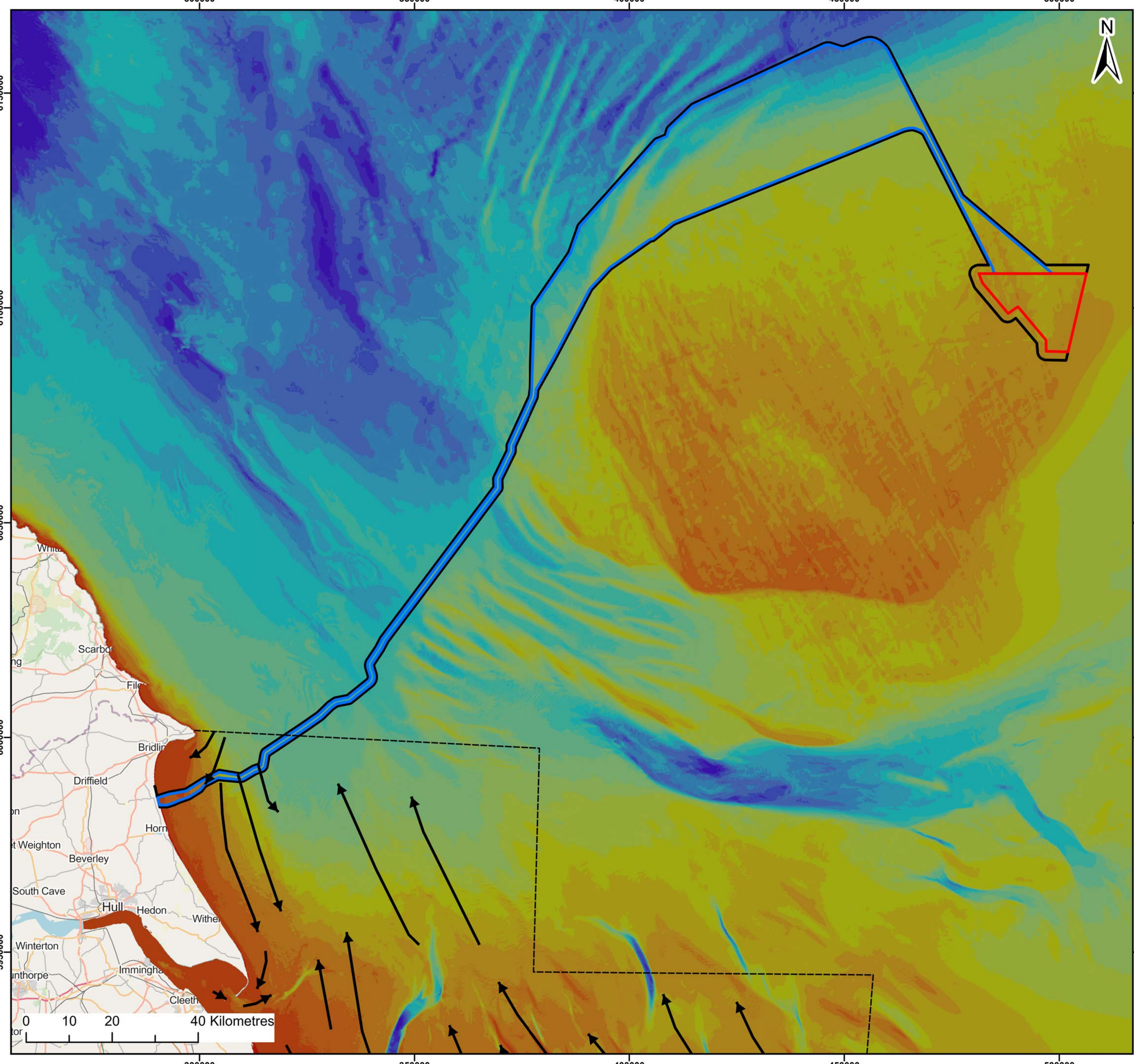


Figure 8-13 Predicted maximum bed shear stress over 30 days



Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor

Sediment Transport Pathways

- Bed Load
- Extent of available data on sediment transport pathways

Bathymetry (m) (LAT)

< -90	-54.9 - -50	-14.9 - -10
-89.9 - -85	-49.9 - -45	-9.9 - 0
-84.9 - -80	-44.9 - -40	> 0
-79.9 - -75	-39.9 - -35	
-74.9 - -70	-34.9 - -30	
-69.9 - -65	-29.9 - -25	
-64.9 - -60	-24.9 - -20	
-59.9 - -55	-19.9 - -15	

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: Sediment transport pathways in the nearshore (after Kenyon and Cooper 2005)

Figure:	8.14	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0370		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:900,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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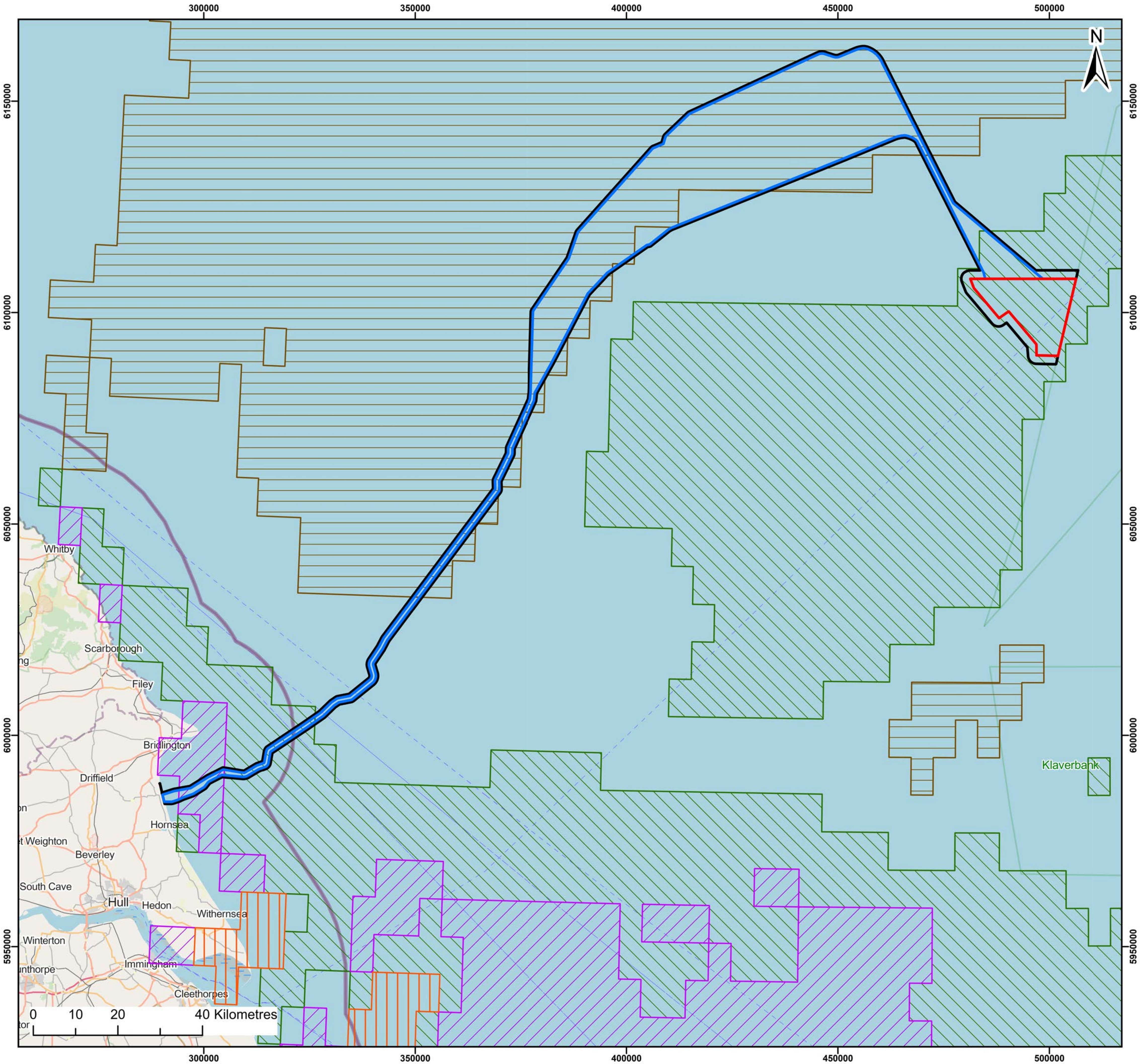

Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor
- Intermittenly Stratified
- Seasonally Stratified
- Permanently Mixed
- ROFI

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: Modelled annual regions based on density stratification in the North Sea from 1958 to 2008 (van Leeuwen et al., 2015). Transparent areas indicate areas where the dominant density regime categories occur less than 50% of the time

Figure:	8.15	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0376		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:900,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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8.6.1.10 Suspended Sediment Concentrations

77. Monthly mean variations in suspended sediment concentrations have been derived from satellite observations from 1998 to 2015 (Cefas, 2016). Surface average suspended sediment concentrations are relatively low across the Array Area, with average concentrations around 2mg/l (**Figure 8-16**). The relatively low concentrations are due to both a low content of fine material in the seabed sediments and the area being distant from any terrestrial sources, such as the Humber Estuary and the Holderness cliffs.

78. Along the offshore ECC, surface average suspended sediment concentrations are highest for around the first 10km from the coast and around Flamborough Head where they may reach concentrations of 15mg/l (**Figure 8-16**). These concentrations may increase up to 300mg/l during storm events (Pye and Blott, 2015). Further offshore along the offshore ECC the concentrations reduce to less than 1mg/l. The higher concentrations in the nearshore region are likely driven by input of fine sediments from cliff erosion, shallower water depths, disturbance by waves and locally stronger wave-induced flows which keep sediment in suspension, inhibiting deposition locally.

8.6.1.11 Coastal Geology and Geomorphology

79. The cliffs and shore platform along the Holderness coast are composed of the relatively soft clay of the Skipsea Till which formed in the late Devensian (18,000 to 13,000 years ago) and contains a high proportion of gravel and boulders. Lenses and thin sheets of silt, sand and gravel, and peat are present (Evans and Thomson, 2010) within the till which create planes of weakness that are more susceptible to erosion.

80. The landfall is characterised by low till cliffs with a maximum elevation range of 11.6m OD to 18.6m OD. These cliffs are fronted by a highly dynamic sand and gravel beach 140m to 170m wide at mean low water that rests on a shore platform of glacial till, which is exposed locally where beach deposits are thin. This beach sediment gradually slopes up towards the cliffs, from -2m OD to 4m OD. The coastal environment mainly responds to wave-driven processes which erode the beach and the base of the cliffs, and transport sediment along the beach.

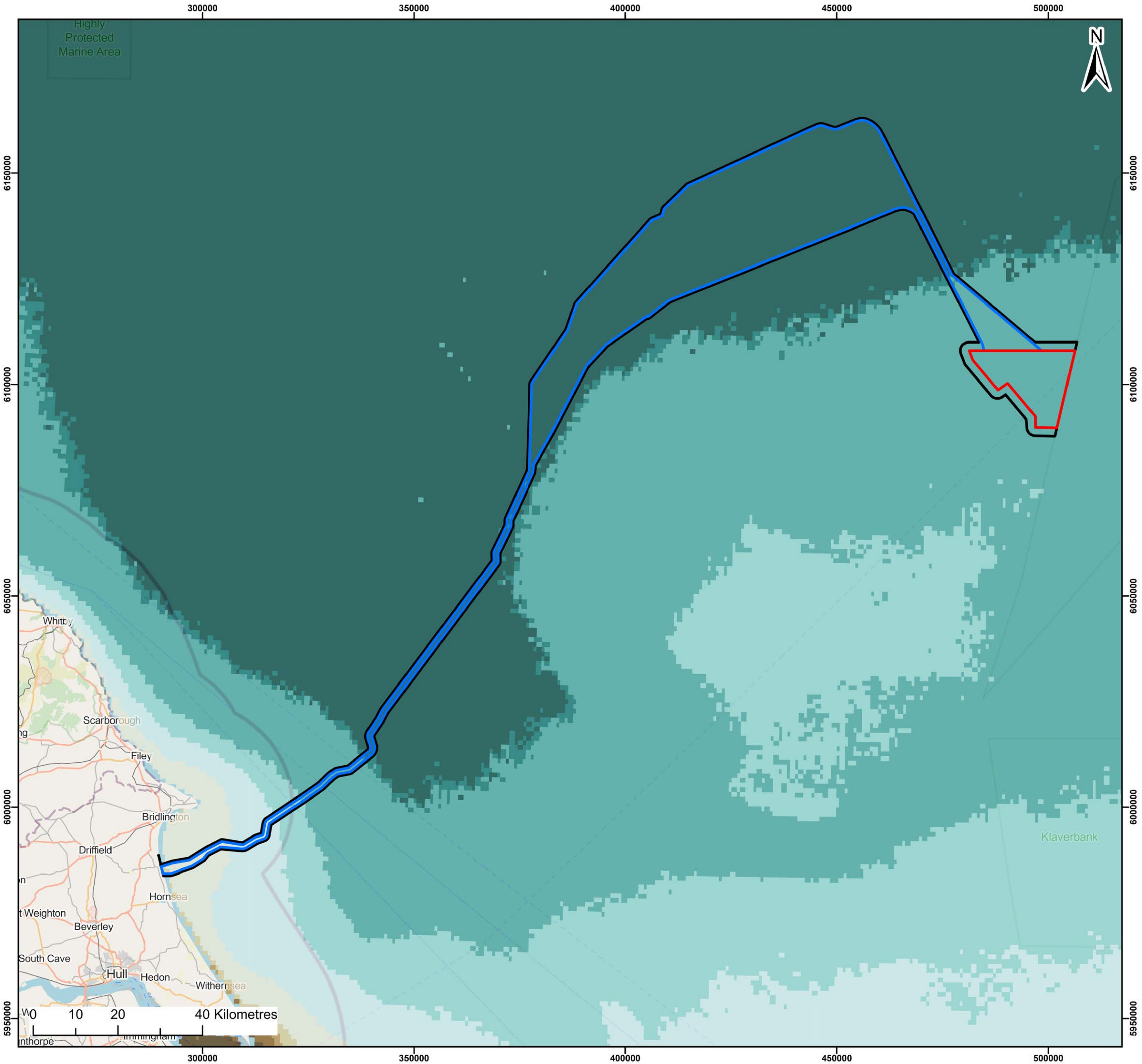
81. The till shore platform extends seaward into the subtidal zone. The bathymetry in the nearshore zone is relatively shallow and gently sloping (**Figure 8-17**). Water depths reach 10m within 700m of mean low water. Here, the glacial till is exposed at the seabed or is covered by a thin veneer of mixed sediment. The surface of the till is relatively smooth, apart from interruptions by low, discontinuous, shore parallel ridges composed of gravel associated with the till. These ridges are up to 2m high and have their steep slopes facing to the west-south-west towards the coast.

8.6.1.12 Coastal and Nearshore Sediment Transport

82. The bathymetry of the North Sea south of Flamborough Head contains the north-north-east to south-south-west aligned offshore sand bank of Smithic Bank (a non-designated geomorphological feature) and associated bedforms. The bank has environmental value as it is considered to provide shelter to the Holderness coast from waves and acts as a sediment store, feeding the wider coastal and marine systems. The offshore ECC would be located close to the southern extent of Smithic Bank (**Figure 8-18**).

83. Smithic Bank is a longitudinal bedform parallel or subparallel to the dominant tidal flows (north-north-east to south-south-west on the flood tide and south-south-west to north-north-east on the ebb tide) and controlled by residual tidal currents. The bank is separated from the coast by a relatively deep area, which is narrow in the north (immediately south of Flamborough Head) and relatively shallow and wide in the south (in Bridlington Bay). The western inshore flank of the bank has a much steeper slope than that of the seaward flank. Smithic Bank rises to a minimum depth of about 6m below OD. Mobile bedforms on the flanks of Smithic Bank range in size from relatively small megaripples up to large sand waves and the sand bank itself. The northern part of Smithic Bank demonstrates more dynamic behaviour than the southern part of Smithic Bank, evidenced by larger mobile sand waves and ridges driven by strong tidal flows stemming from the influence of Flamborough Head. The asymmetric profile of these sand waves offers supporting evidence for net clockwise directions of bedload transport around the bank. Waves help to moderate the profile of parts of Smithic Bank with larger waves dissipating some of their energy on to the bank creating a southern part which is wider and smoother than the northern part.

84. Smithic Bank exists because of the formation of a residual tidal gyre caused by interruption of the north to south tidal flow by Flamborough Head. The gyre is generated by changes in water depth and tidal stream amplitude as the tidal flow curves around Flamborough Head. The gyre has developed with the same rotational sense as the curvature of flow, resulting in a clockwise gyre on the southern side of the easterly protruding headland (and a potential anticlockwise gyre on the northern side). This headland gyre would form, and will continue to form, irrespective of the presence of Smithic Bank, but in this case the bank is present due to the gyre and occurs in the centre of the gyre with an ebb-tidal channel between Flamborough Head and the bank.



Legend:

- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor

Average Suspended Particulate Matter (SPM) 1998 - 2015 (mg/l)

- 0
- 1
- 2
- 3
- 5
- 10
- 15
- 20
- 30
- > 30

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Project:
Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title:
Variations in Suspended Sediment Concentrations (1998-2015) across the Offshore Development Area

Figure:	8.16	Drawing No:	PC6250-RHD-XX-OF-DR-GS-0366		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:900,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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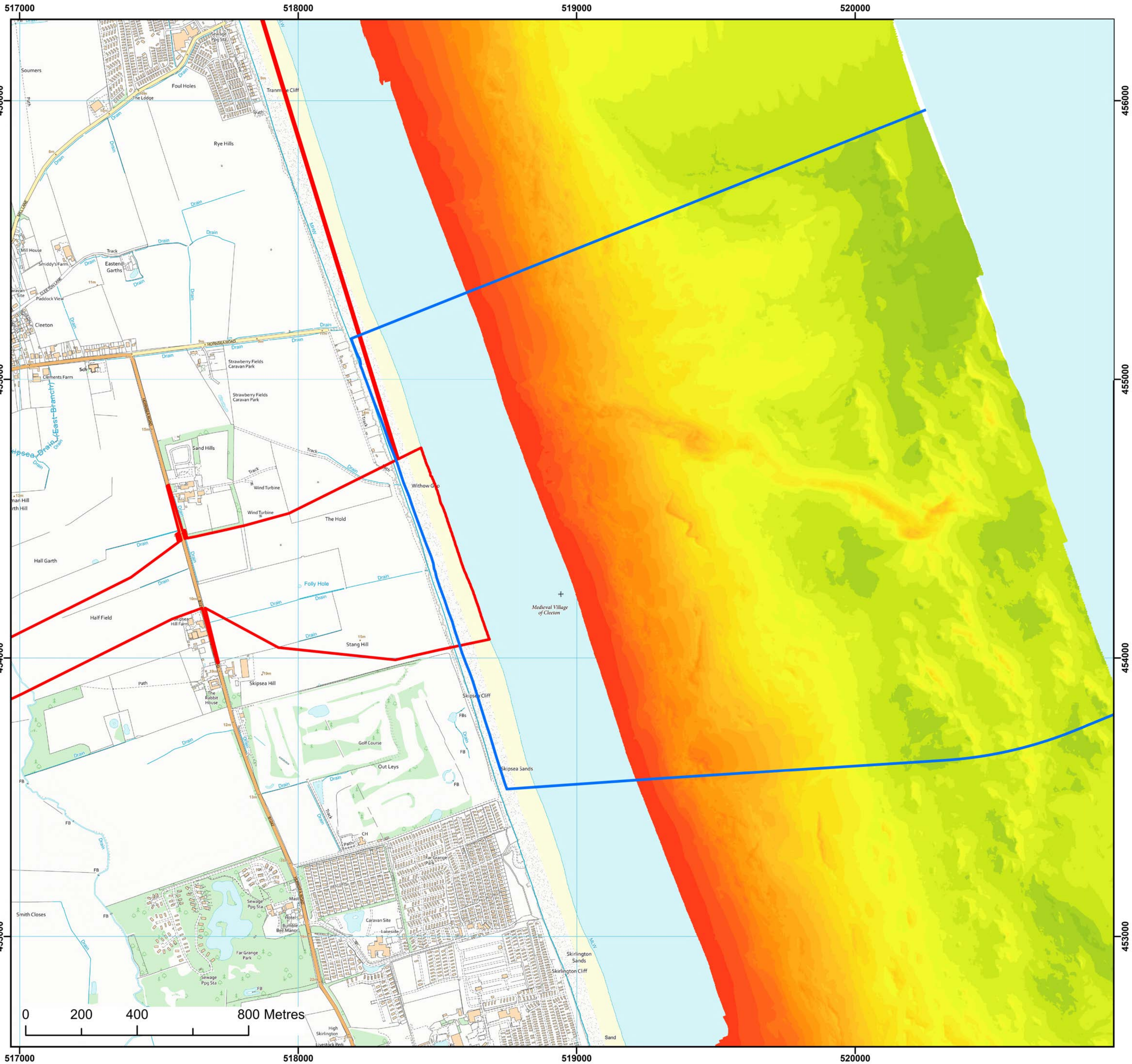

Legend:

- Onshore Development Area
- Offshore Export Cable Corridor

Bathymetry (mOD)

- -15.99 - -15.5
- -15.49 - -15
- -14.99 - -14.5
- -14.49 - -14
- -13.99 - -13.5
- -13.49 - -13
- -12.99 - -12.5
- -12.49 - -12
- -11.99 - -11.5
- -11.49 - -11
- -10.99 - -10.5
- -10.49 - -10
- -9.99 - -9.5
- -9.49 - -9
- -8.99 - -8.5
- -8.49 - -8
- -7.99 - -7.5
- -7.49 - -7
- -6.99 - -6.5
- -6.49 - -6
- -5.99 - -5.5

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: 2011 Bathymetry at the landfall

Figure:	8.17	Drawing No:	PC6250-RHD-OF-ZZ-DR-Z-0483		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:13,656

Co-ordinate system: British National Grid

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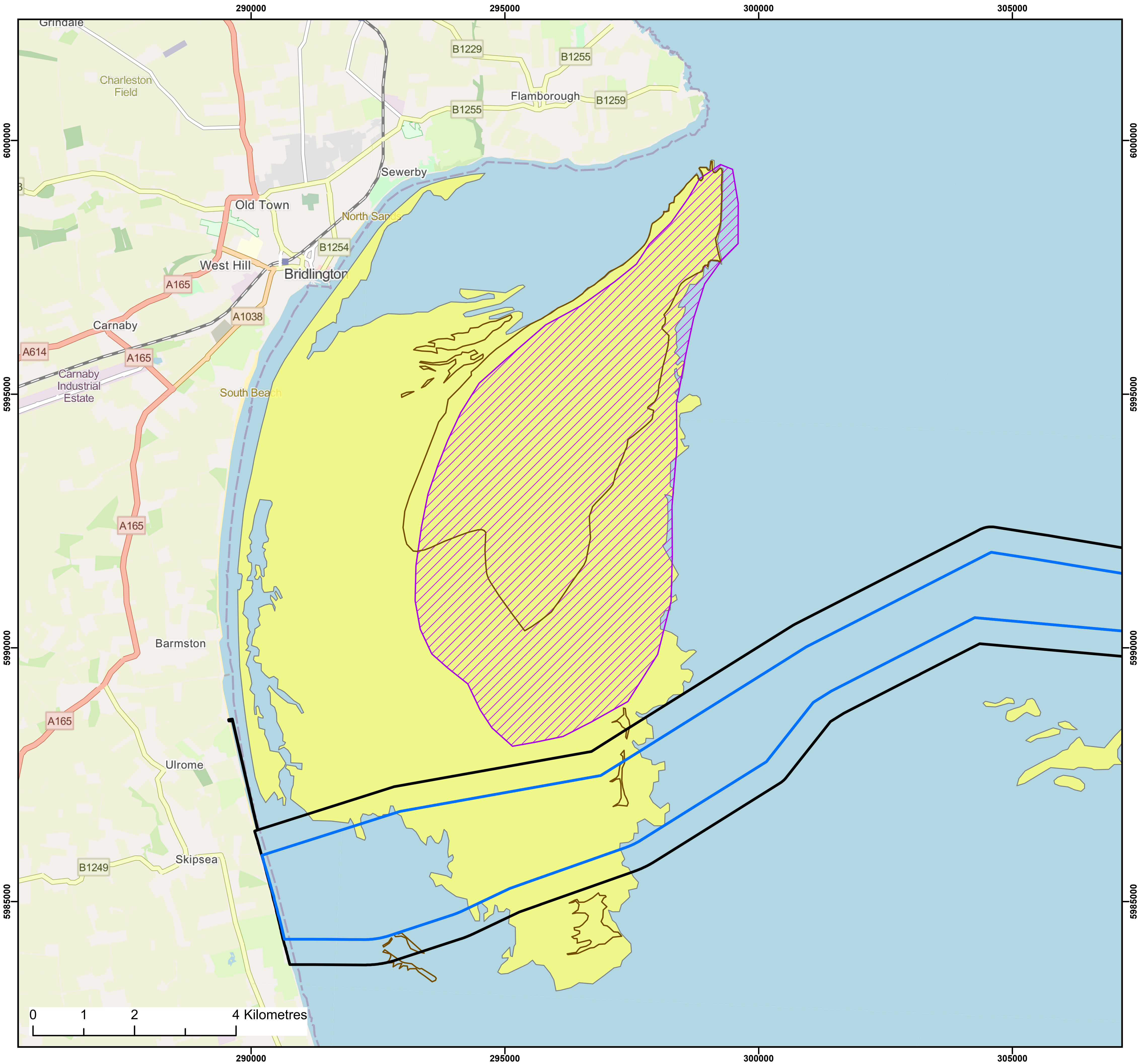

Legend:

- Offshore Development Area
- Offshore Export Cable Corridor
- Smithic Bank (as delimited by JNCC)
- Morphological Definition of Smithic Bank (BGS)
- Unconsolidated Marine Sand (MDU-S)

Source: © Haskoning DHV UK Ltd, 2025; © JNCC, 2024. © BGS, 2024. © OpenStreetMap (and) contributors, CC-BY-SA

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: Extent of Smithic Bank as mapped by JNCC and BGS relative to the position of the Offshore ECC

Figure: 8.18	Drawing No: PC6250-RHD-XX-OF-DR-GS-0484				
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	29/10/2024	AB	DB	A3	1:75,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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85. The bedforms associated with Smithic Bank define sediment transport pathways that do not extend to the coast across the deeper area to the west and north of the bank. The rotational sand transport around Smithic Bank is likely to be contained within Bridlington Bay, with little or no transport from this source south along the Holderness coast. There are no features within the deeper area and the sediment cover is thin or absent. The lack of sand within this area suggests there is likely to be little exchange of sediment between Smithic Bank and the northern Holderness coast. Hence, Smithic Bank is a hydraulically maintained large-scale sand trap of a high order of efficiency. The constant presence of Flamborough Head and the generation of a clockwise gyre will continue to maintain Smithic Bank into the future. This is supported by Pye and Blott (2015) who defined a boundary between a 'Flamborough' influence in and around Smithic Bank and a 'Holderness Cliffs' influence, located to the south of Smithic Bank.

8.6.1.13 Coastal Erosion

86. The Holderness coast is one of the fastest eroding coasts in Europe due to the combination of relatively soft till geology and a high energy wave environment. Cliff erosion rates along the coast are spatially and temporally complex which reflects the interaction between natural processes and human intervention in the form of coastal defences.

87. The SMP policy for this stretch of coast (Policy Unit C: Wilsthorpe to Atwick) is No Active Intervention over the short term (present day to 2025), medium term (2025 to 2055) and long term (2055 to 2105) (Scott Wilson, 2010). The National Coastal Erosion Risk Mapping (NCERM) identifies this frontage as natural defence and erodible.

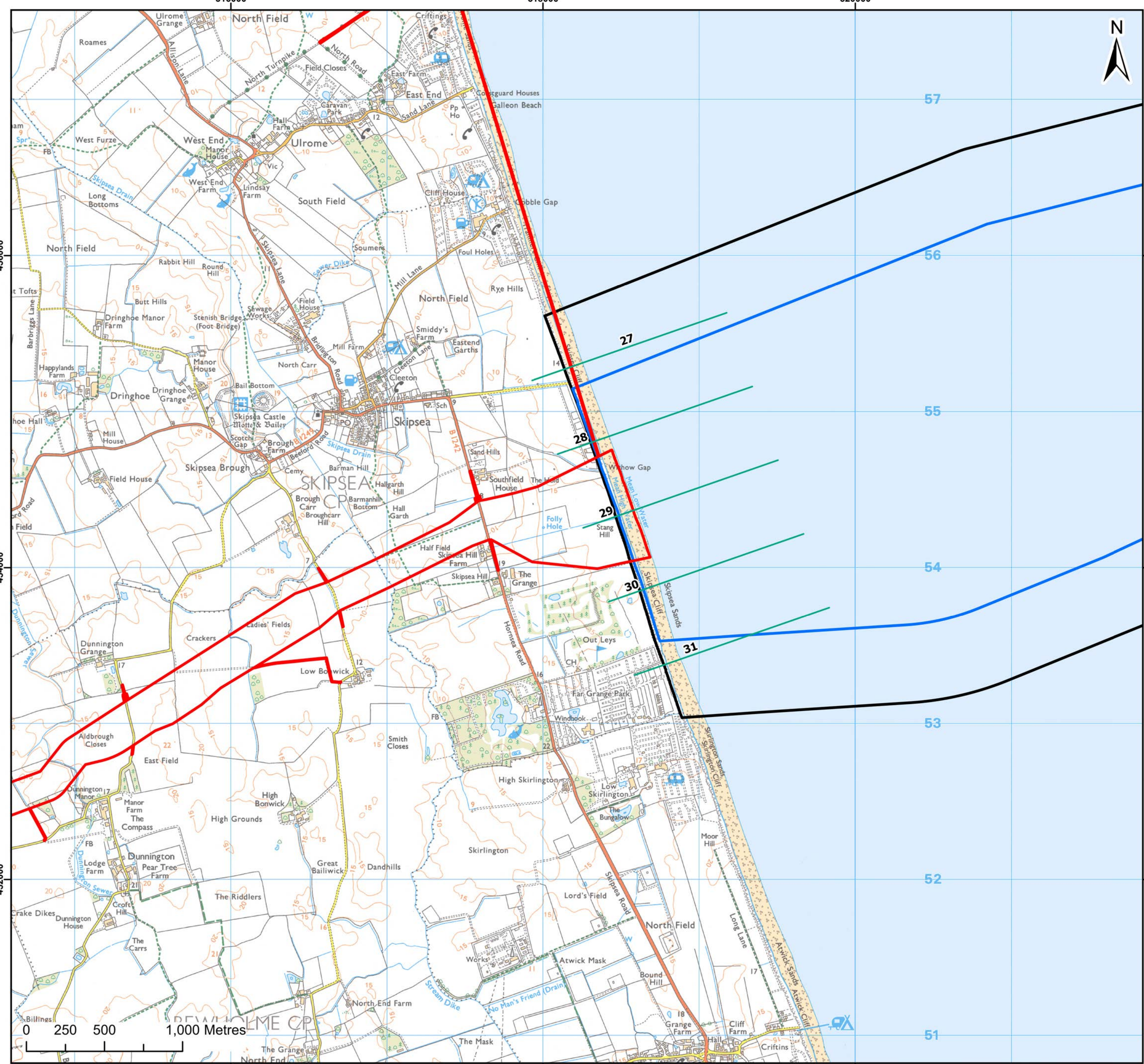
88. East Riding of Yorkshire Council (ERYC) undertake routine monitoring of the Holderness coast in spring and autumn each year which includes topographic surveying of beach profiles from the top of the cliffs to low water. Cliff recession rates at profiles 27 to 31 (**Figure 8-19**), located in the immediate area surrounding the landfall, are summarised in **Table 8-19**. Average erosion rates were between 0.96m/year and 1.22m/year from 1852 to 2003 and between 1.03m/year and 1.90m/year between 2003 and 2024 with a maximum loss of 11.6m (profile 28) in April 2013 and more recently, a loss of 11.50m was recorded in May 2024 at profile 31.

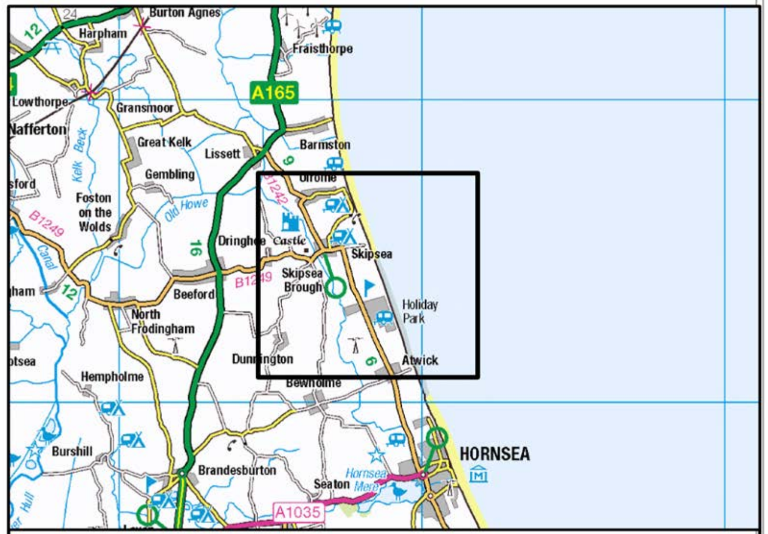
89. Shore platform lowering may contribute to coastal erosion as subaerial weathering and marine erosion break up the till allowing waves to transport it seaward. Parts of the beaches along the Holderness coast are covered by a relatively thin (less than 10cm in place) sand veneer which makes parts of the shore platform extremely vulnerable to erosion. Water levels can also reach the base of the cliffs during high tides and storms which can remove material from the toe of the cliff, undermining it and leading to cliff collapse and erosion.

Table 8-19 Average Historic Cliff Erosion in the Vicinity of the Landfall for each of the Coastal Transects (ERYC data between 1852 and 2024)

Erosion Profile Details		Average Erosion Rate (m/year)		Maximum Cliff Loss Between Profiles		
Number	Location	Historic (1852-2003)	Recent (2003-2024)	Height of cliff (m OD)	Maximum recorded individual loss (m)	Date of maximum cliff loss
27	Opposite Skipsea village	1.22	1.57	13.0	10.95	April 2011
28	Opposite bungalows to south of Skipsea	1.17	1.84	12.9	11.60	April 2013
29	To south of Withow Gap, Skipsea	0.96	1.90	11.6	9.82	March 2020
30	Within golf course to north of Skirlington	0.99	1.30	14.6	8.11	March 2016
31	North end of Skirlington campsite	1.07	1.03	18.3	11.50	May 2024
Average across all five erosion profiles		1.08	1.53	14.08		

90. ERYC monitoring of beach elevation change at the landfall has been undertaken between 2008 and 2024. Data has been made available from 2008, 2013, 2018, and 2024, which are compared to assess beach / shore platform elevation change across the intertidal area of the landfall. Comparison of the Lidar data between 2008 and 2013 shows that most of the intertidal area eroded. Between 2013 and 2018, most of the intertidal area accreted with small areas of erosion. Over the most recent period 2018-2024, a degree of stability has been established at the landfall. Although there have been short-term changes in morphology, over the medium term (16 years), between 2008 and 2024 the elevation of the intertidal area at the landfall has been relatively unchanged (**Figure 8-20**). There is a linear strip of erosion at the top of the beach, which is likely related to removal of sediment from within the toe of the cliff.





Legend:

- Onshore Development Area
- Offshore Development Area
- Offshore Export Cable Corridor
- ERYC Profile Locations

Source: © Haskoning DHV UK Ltd, 2025. © ERYC, 2024.
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Project: Dogger Bank D Offshore Wind Farm	DOGGER BANK WIND FARM

Title:

Location of the East Riding of Yorkshire Council's coastal monitoring transects used to assess historic coastal erosion

Figure:	8.19	Drawing No:	PC6250-RHD-OF-ZZ-DR-Z-0371		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:25,000

Co-ordinate system: British National Grid

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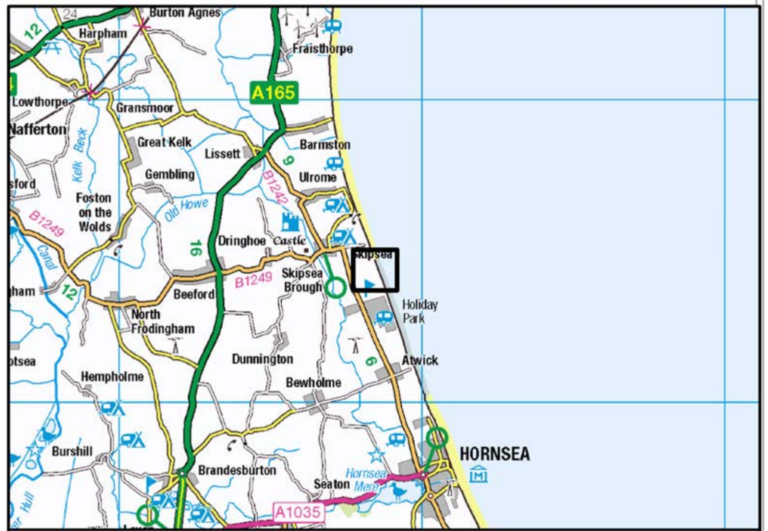

Legend:

- Onshore Development Area
- Offshore Export Cable Corridor
- Offshore Development Area

2008 - 2024 Elevation difference (m)

- <= -1.9
- -1.79 - -1.7
- -1.69 - -1.6
- -1.59 - -1.5
- -1.49 - -1.4
- -1.39 - -1.3
- -1.29 - -1.2
- -1.19 - -1.1
- -1.09 - -1
- -0.99 - -0.9
- -0.899 - -0.8
- -0.799 - -0.7
- -0.699 - -0.6
- -0.599 - -0.5
- -0.499 - -0.4
- -0.399 - -0.3
- -0.299 - -0.2
- -0.199 - -0.1
- -0.099 - 0
- 0.001 - 0.1
- 0.101 - 0.2
- 0.201 - 0.3
- 0.301 - 0.4
- 0.401 - 0.5
- 0.501 - 0.6
- 0.601 - 0.7
- 0.701 - 0.8
- 0.801 - 0.9

Project:

Dogger Bank D
Offshore Wind Farm

DOGGER BANK
WIND FARM

Title:

Cumulative change in beach level (m) between 2008 and 2024 at the landfall

Figure:	8.20	Drawing No:	PC6250-RHD-OF-ZZ-DR-Z-0377		
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:5,000

Co-ordinate system: British National Grid

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8.6.2 Predicted Future Baseline

91. The baseline conditions for marine physical processes will continue to be controlled by waves and tidal currents driving changes in sediment transport and then seabed morphology. However, the long-term established performance of these drivers may be affected by environmental changes including climate change driven sea-level rise. The effect of these broadscale environmental changes will occur regardless of the presence or absence of the Project.

8.6.2.1 Projected Sea-level Rise

92. Historic data shows that the global temperature has risen since the beginning of the 20th Century, and predictions are for an accelerated rise, the magnitude of which is dependent on the magnitude of future emissions of greenhouse gases and aerosols. Global changes in sea level are primarily controlled by thermal expansion of the ocean, melting of glaciers, and changes in the volume of the ice caps of Antarctica and Greenland. Observed or projected changes in global sea level consider the elevation of the water surface, caused by changes in the volume of the oceans, and do not consider changes in land level. At a local scale, the position and height of the sea relative to the land is known as relative sea level.

93. To project future sea-level at the landfall, this assessment uses the data of the UK Climate Projections (UKCP18) user interface for the model grid cell that covers this length of coast. UKCP18 relative sea-level rise estimates use 1990 as their starting year and are available for low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenarios. They are presented by UKCP18 as central estimates of change (50% confidence level, 50th percentile) in each scenario with an upper 95% confidence level (95th percentile) and a lower 5% confidence level (5th percentile). Relative sea-level rise projections using the 5th percentile of the low (RCP2.6) emissions scenario, 50th percentile of the medium (RCP4.5) emissions scenario and the 95th percentile of the high (RCP8.5) emissions scenario from the UKCP18 are presented in **Table 8-20** using 1990 as the starting year.

Table 8-20 Changes in Relative Sea Level under the 5th Percentile Low (RCP2.6), 50th Percentile Medium (RCP4.5) and 95th Percentile High (RCP8.5) Emissions Scenarios using 1990 as the Starting Year

Year	Low emissions 5th percentile (m)	Medium emissions 50th percentile (m)	High emissions 95th percentile (m)
1990	0.0	0.0	0.0
2010	0.041	0.057	0.078
2020	0.070	0.099	0.137
2030	0.101	0.145	0.208
2040	0.132	0.195	0.294
2050	0.162	0.249	0.396
2060	0.189	0.306	0.513
2070	0.214	0.364	0.647
2100	0.279	0.535	1.126

94. Using 2024 as the baseline for the forward projection, and an assumption that the 34 years of relative sea-level rise between 1990 and 2024 has already taken place, the projected relative sea-level rises using a 2024 baseline are shown in **Table 8-21** and **Figure 8-21**. Relative sea-level rise in 2070 for low emissions 5th percentile is estimated to be approximately 0.132m. This equates to an average relative sea-level rise of about 2.87mm/year over the next 46 years. For the medium emissions 50th percentile, relative sea-level rise in 2070 is estimated to be approximately 0.248m. This equates to an average relative sea-level rise of about 5.38mm/year over the next 46 years. For high emissions 95th percentile, relative sea-level rise in 2070 is estimated to be approximately 0.483m. This equates to average relative sea-level rise of 10.51mm/year over the next 46 years.

Table 8-21 Changes in Relative Sea Level under the 5th Percentile Low, 50th Percentile Medium and 95th Percentile High Emissions Scenarios using a 2024 Baseline

Year	Low emissions 5th percentile (m)		Medium emissions 50th percentile (m)		High emissions 95th percentile (m)	
	Relative sea-level (m)	Average rate of relative sea-level rise (mm/year)	Relative sea-level (m)	Average rate of relative sea-level rise (mm/year)	Relative sea-level (m)	Average rate of relative sea-level rise (mm/year)
2024	0.0	0.0	0.0	0.0	0.0	0.0
2030	0.019	3.15	0.028	4.74	0.044	7.30
2040	0.050	3.13	0.078	4.89	0.130	8.12
2050	0.080	3.07	0.133	5.11	0.232	8.93

Year	Low emissions 5th percentile (m)		Medium emissions 50th percentile (m)		High emissions 95th percentile (m)	
	Relative sea-level (m)	Average rate of relative sea-level rise (mm/year)	Relative sea-level (m)	Average rate of relative sea-level rise (mm/year)	Relative sea-level (m)	Average rate of relative sea-level rise (mm/year)
2060	0.106	2.95	0.189	5.25	0.349	9.70
2070	0.132	2.87	0.248	5.38	0.483	10.51
2100	0.197	2.59	0.419	5.51	0.962	12.66

95. Relative sea-level rise in 2100 for low emissions 5th percentile is estimated to be approximately 0.197m. This equates to an average relative sea-level rise of about 2.59mm/year over the next 76 years. For the medium emissions 50th percentile, relative sea-level rise in 2100 is estimated to be approximately 0.419m. This equates to an average relative sea-level rise of about 5.51mm/year over the next 76 years. For high emissions 95th percentile, relative sea-level rise in 2100 is estimated to be approximately 0.962m. This equates to average relative sea-level rise of 12.66mm/year over the next 76 years.

8.6.2.2 Predicting Future Cliff Erosion

96. The estimation of a future shoreline is complex, due to the stochastic nature of cliff erosion, which is apparent from irregular cliff lines and the observation data that records losses up to about 12m within a single year (**Table 8-21**). The most widely used models to forecast cliff-top erosion are empirical and use historical trend analysis from a knowledge of historic cliff erosion rates. Two methods of historical trend analysis have typically been adopted to predict future cliff erosion:

- Direct extrapolation of historic trends into the future without incorporating potential increases due to higher rates of relative sea-level rise (Lee and Clarke, 2002); and
- Forward projection including potential increases to account for higher rates of relative sea-level rise (Leatherman, 1990).

97. The extrapolation of historic trends involves analysing past data for average cliff erosion rate and adopting this rate for future years. The forward projection equation of Leatherman (1990) predicts future cliff erosion by using projected future relative sea-level rise scenarios and measured historic cliff erosion rates. The forward projection method involves multiplying historic cliff erosion rates with a factor derived from the ratio of future and historic rates of relative sea-level rise using the equation: $RP = RH.(SP/SH)$ where:

- RP = predicted erosion rate (m/year);
- RH = historic erosion rate (m/year);
- SP = predicted relative sea-level rise (mm/year); and
- SH = historic relative sea-level rise (mm/year).

98. The equation assumes that the main erosive factor is the rise of relative sea-level (the rate of cliff erosion is proportional to the change in rate of relative sea-level rise), the other influencing factors will remain constant, and that predictions of relative sea-level rise are reliable. The forward projection method is adopted in this assessment. The extrapolation method is likely to under-estimate future erosion.

99. Using values of historic sea-level rise and erosion rates, and projections of future sea-level rise for low, medium, and high emissions scenarios, the predicted future cliff erosion at beach profiles 27-31 located in the vicinity of the landfall are shown on **Figure 8-22** and **Table 8-22**.

Table 8-22 Projected Cliff Erosion Rates at the Landfall by 2070

Scenario	Historic erosion rate (m/year)	Historic relative sea-level rise (mm/year)	Predicted relative sea-level rise (mm/year)	Estimated future cliff erosion (m)
Best-estimate (P50)	1.53	1.73	5.38	219
Least-worst-case (P05)	1.03	1.73	2.87	79
Worst-case (P95)	1.90	1.73	10.51	531

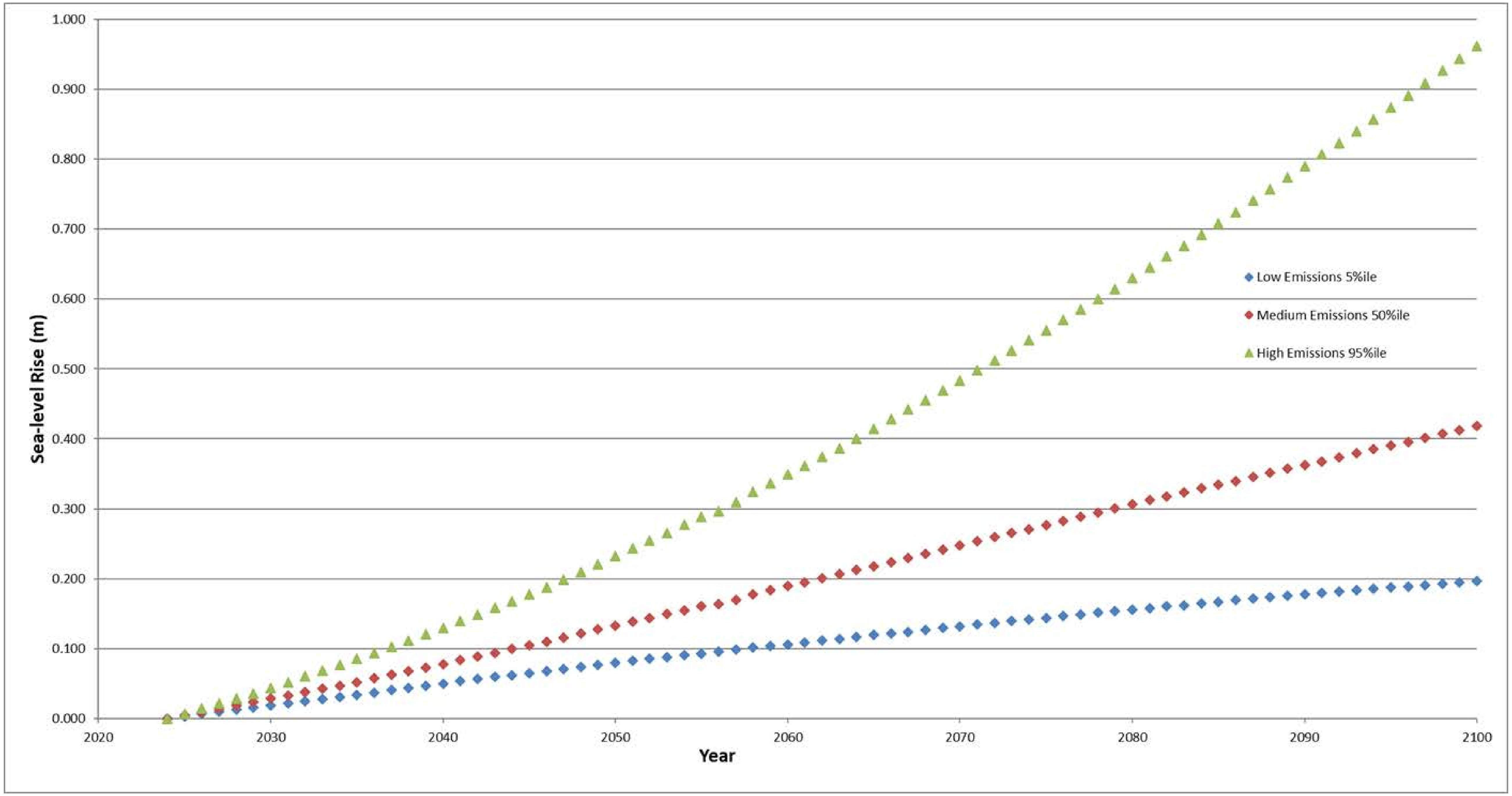
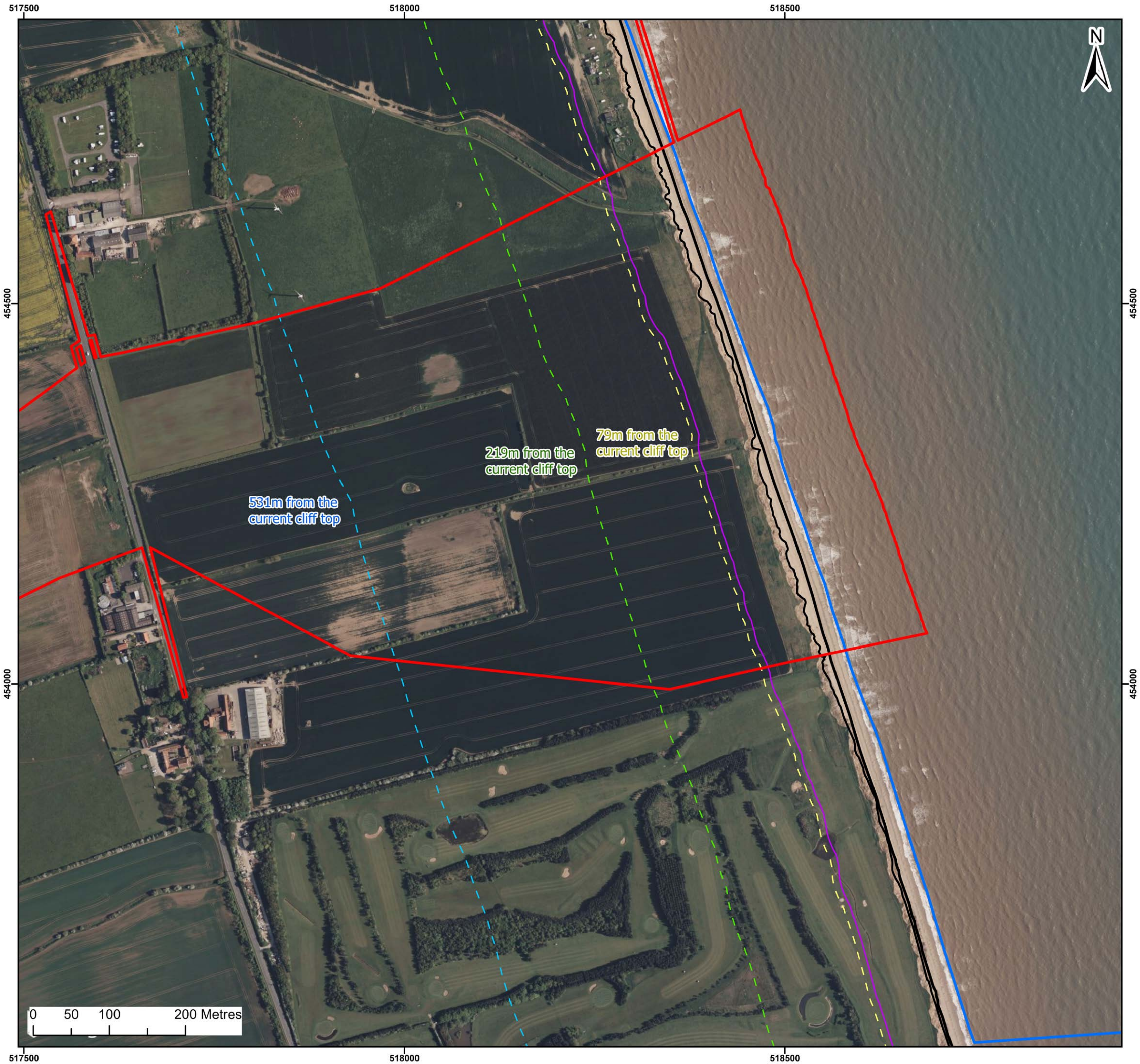
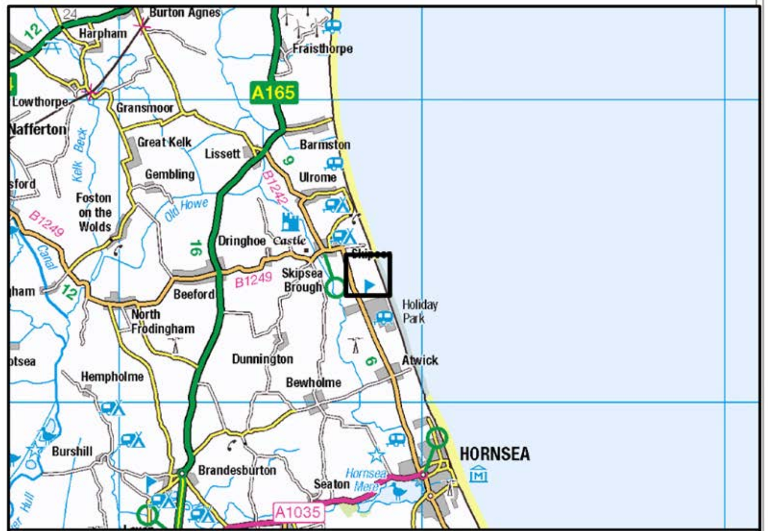


Figure 8-21 Changes in Relative Sea Level under the 5th Percentile Low, 50th Percentile Medium and 95th Percentile High Emissions Scenarios using a 2024 Baseline





Legend:

- Onshore Development Area
- Offshore Development Area
- Offshore Export Cable Corridor
- Top of cliff
- Direct Extrapolation
- Reasonable least-worst design
- Best-estimate design
- Reasonable worst-case design

Source: © Haskoning DHV UK Ltd, 2025.

Project: Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title: Estimated positions of the cliff top in 2070 using the least-worst, best-estimate and worst-case scenarios of historic erosion and sea-level rise

Figure: 8.22

Drawing No: PC6250-RHD-OF-ZZ-DR-Z-0372

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	GC	A3	1:5,000

Co-ordinate system: British National Grid

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8.6.2.3 Predicting Shore Platform Lowering

100. The rate of vertical shore platform is an important control on the long-term rate of cliff erosion. Effectively, the whole profile is considered to retreat uniformly while maintaining a relatively uniform cross-shore shape. The emergence of a dynamically stable profile form shows that the retreat rates of the cliff and platform tend to equalise and consequently the long-term rate of cliff retreat can be directly related to the rate of platform downcutting and the associated profile retreat, by the equation: $d = r.\tan\alpha$ where:

- d = vertical rate of platform lowering;
- r = corresponding horizontal rate of cliff erosion; and
- α = platform gradient at a point.

101. If this equation is applied to the landfall where the best estimate r = 4.76m/year and tan α is approximately 0.01, then a vertical platform erosion rate of about 47mm/year is calculated (about 2m by 2070). This estimate assumes that the shore platform is exposed to the processes that will erode it and is not covered by a beach thick enough to provide protection against erosion.

8.7 Assessment of Effects

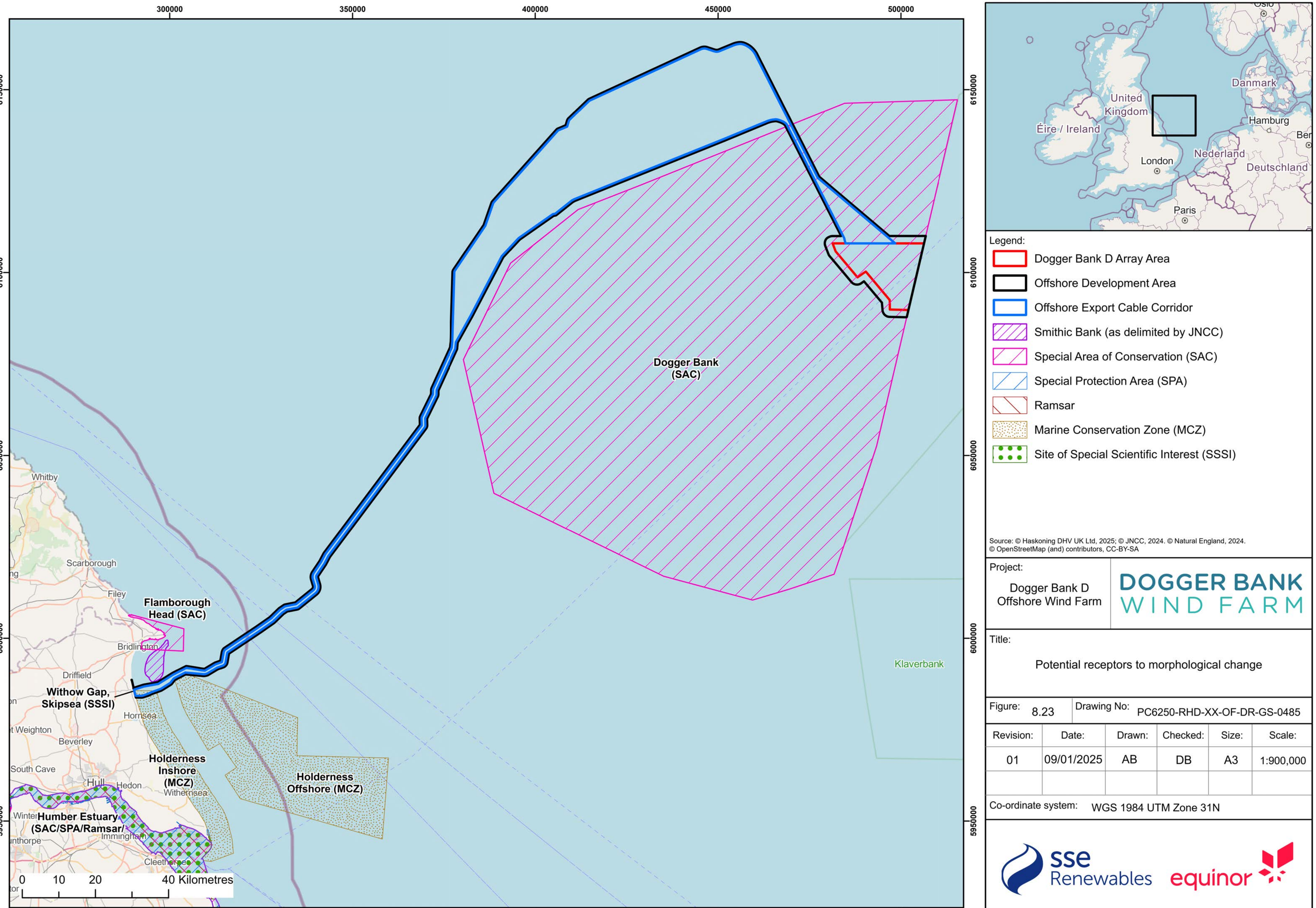
102. The likely significant effects to marine physical processes receptors that may occur during construction, operation and maintenance, and decommissioning of the Project are assessed in the following sections. The assessment follows the methodology set out in **Section 8.5** and is based on the realistic worst-case scenarios defined in **Section 8.4.4**, with consideration of embedded mitigation measures identified in **Section 8.4.2.**

8.7.1 Receptors

103. The principal receptors with respect to marine physical processes are those features with an inherent, oceanographic, geological or geomorphological value or function which may potentially be affected by the Project. As the conservation objectives of SACs and MCZs are driven by their ecological functioning, they are not considered as receptors for marine physical processes and are assessed in the relevant chapters **Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 12 Marine Mammal Ecology**, and **Chapter 13 Offshore and Intertidal Ornithology.** The potential geomorphological and geological receptors, and their inherent features defined as requiring assessment in relation to marine physical processes are listed in **Table 8-23** and shown on **Figure 8-23**.

Table 8-23 Marine Physical Processes Receptors Relevant to the Project

Receptor	Receptor	Description of features	Closest distance from projects
Designated sites and features	Dimlington Cliff SSSI	Geological interest (Quaternary of East England)	35km south of the landfall. 232km from Array Area.
	Flamborough Head SSSI	Geological interest (Chalk cliffs) and coastal geomorphology	4km north of the offshore ECC. 211km from Array Area.
	Withow Gap Skipsea SSSI	Geological Interest (Quaternary of north-east England)	Part of the offshore ECC and landfall located within SSSI. 223km from Array Area.
	Holderness Inshore MCZ	Geological features (Spurn Head)	Nearshore offshore ECC and landfall located at the north end of the MCZ. 221km from Array Area.
	Holderness Offshore MCZ	Geological features - North Sea glacial tunnel valleys	Offshore ECC buffer partially crosses the Holderness Offshore MCZ. 183km from Array Area.
Non designated sites and features	Dogger Bank	Glacial and marine geological and geomorphological features	Array Area and offshore ECC.
	Smithic Bank	Offshore sand bank	Offshore ECC is 0.4km south of Smithic Bank. 211km from Array Area.
	Flamborough Front	Seasonal tidal mixing front	Potentially present within Array Area.
	Humber Estuary	Geomorphological features of the coastal plain including the estuary, mud flats, sand flats, lagoons, saltmarsh and wetlands, coastal dunes and beaches	45km south of the landfall. 234km from Array Area.



Legend:
- Dogger Bank D Array Area
- Offshore Development Area
- Offshore Export Cable Corridor
- Smithic Bank (as delimited by JNCC)
- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Ramsar
- Marine Conservation Zone (MCZ)
- Site of Special Scientific Interest (SSSI)

Project:
Dogger Bank D Offshore Wind Farm

DOGGER BANK WIND FARM

Title:
Potential receptors to morphological change

Figure: 8.23 | Drawing No: PC6250-RHD-XX-OF-DR-GS-0485

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	09/01/2025	AB	DB	A3	1:900,000

Co-ordinate system: WGS 1984 UTM Zone 31N

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8.7.2 Potential Effects during Construction

8.7.2.1 Changes in suspended sediment concentration, transport, and seabed level due to drilling for foundation installation (MPP-C-03)

104. Sediments below the seabed within the Array Area would become disturbed during any drilling activities that may be needed at the location of the foundations releasing suspended sediment into the water column. The increase in suspended sediment concentrations has the potential to deposit sediment and change the elevation/level of the seabed. Coarse sediment would fall rapidly to the seabed (minutes or tens of minutes) immediately after it is discharged. Fine sediment would be transported and dispersed by tidal currents in suspension in the water column before depositing on the seabed.

105. The worst-case scenario for sediment release into the water column from an individual monopile foundation is 15,270m^3. For each of the offshore platform foundations, a maximum of 45,810m^3 of sediment would be released. As a worst-case scenario, it is estimated that the maximum number of foundations that would require drilling would be 50%. Taking a precautionary worst-case approach, it has therefore been assumed that 57 turbines in the Array Area and one offshore platform would require drilling. The total volume of released sediment would be up to 976,410m^3 (**Table 8-5**).

106. Suspended sediment dispersion modelling was undertaken to provide the evidence base to assess the effect of the drilling process on suspended sediment concentrations and seabed level. The results show that the drilling process would cause local increases in suspended sediment concentrations at the point of discharge of the sediment at each of the 57 wind turbine locations and offshore platform foundation. The predicted suspended sediment concentrations are highest closest to the points of release with maximums of 1mg/l in the surface layer increasing to 2mg/l in the bottom layer (**Figure 8-24**). The worst-case thickness of sediment deposited from the plume would not exceed 1mm.

8.7.2.1.1 Receptor Sensitivity

107. The potential receptor to change in suspended sediment concentration, transport, and seabed level across the Array Area is the Dogger Bank. Other receptors, including Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ, Dimlington Cliffs SSSI, Humber Estuary and Smithic Bank are too remote (over 95km away) from the Array Area.

108. Dogger Bank as a geological feature is not sensitive to changes in suspended sediment concentration as it formed due to glacial processes during the last age. Modern day active sedimentary processes on the surface of Dogger Bank are driven by bedload sediment transport which is dynamic. Any suspended sediment deposited on the seabed will become reworked by tidal currents and transported as bedload becoming integrated in the prevailing sediment transport regime with no net change to seabed morphology. Therefore, the value and sensitivity of Dogger Bank as a receptor are presented in **Table 8-24**.

Table 8-24 Sensitivity and Value Assessment of the Dogger Bank Receptor Relevant to Changes in Seabed Level due to Drilling for Foundation Installation

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**

8.7.2.1.2 Impact Magnitude

109. The worst-case changes in seabed level due to the installation of the maximum number of monopile foundations are likely to have the magnitudes of impact shown in **Table 8-25.** This is because the predicted initial thickness of sediment resting on the seabed would be a maximum of 1mm. After this initial deposition, this sediment would be continually re-suspended to reduce the thickness even further to a point where it will be effectively zero. This would be the longer-term outcome once the sediment supply from foundation installation has ceased

Table 8-25 Magnitude of Impact on Seabed Level under the Worst-case Scenario for Drilling for Foundation Installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	Negligible	Negligible	Negligible	**Negligible**
Far-field	Negligible	Negligible	Negligible	Negligible	**Negligible**

8.7.2.1.3 Effect Significance

110. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **negligible** for both the near-field and far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

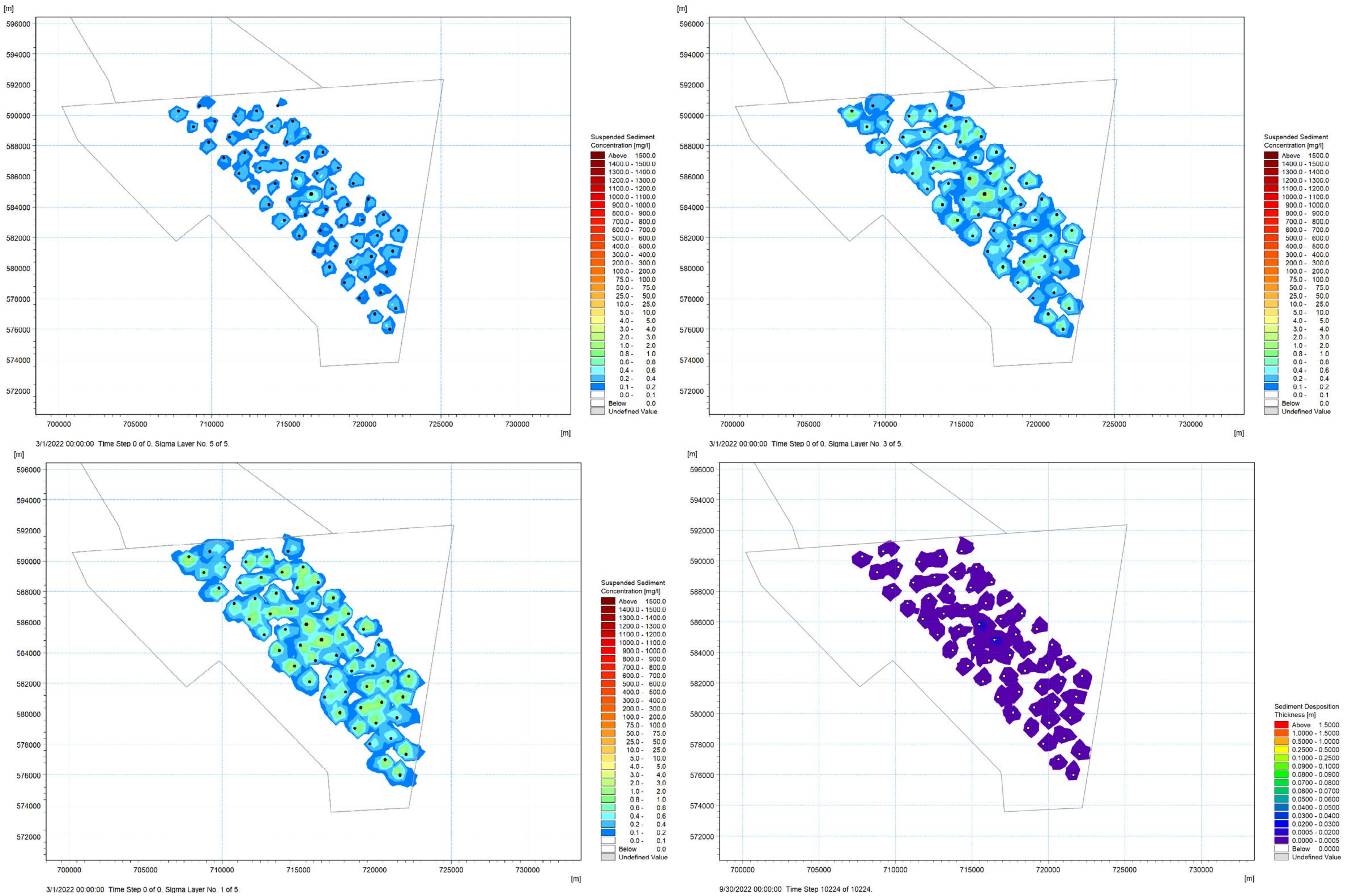

Figure 8-24 Maximum Predicted Suspended Sediment Concentrations Released in the Surface Layer (top left), Middle Layer (top right), and Bottom Layer (bottom left) due to Foundation Installation by Drilling. Total Sediment Deposition Thickness is shown bottom right

111. The effects on seabed level have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this PEIR (**Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 14 Commercial Fisheries** and **Chapter 17 Offshore Archaeology**).

8.7.2.2 Changes in suspended sediment concentration, transport, and seabed level due to seabed preparation for foundation installation (MPP-C-04)

112. Seabed sediments and shallow near-bed sediments within the Array Area would be disturbed during dredging activities to create a suitable base prior to foundation installation. The worst-case scenario for sediment release into the water column from an individual monopile foundation for a wind turbine is 35,785m^3. For each of the offshore platform foundations, a maximum of 100,000m^3 of sediment would be released. As a worst-case scenario, it is estimated that all the foundations would require seabed preparation. Hence, the total volume of sediment would be up to 4,243,705m^3 (**Table 8-5**).

8.7.2.2.1 Receptor Sensitivity

113. The potential receptor to change in suspended sediment concentration, transport, and seabed level across the Array Area is the Dogger Bank. Other receptors, including Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ, Dimlington Cliffs SSSI, Humber Estuary and Smithic Bank are too remote (over 95km away) from the Array Area.

114. Dogger Bank as a geological feature is not sensitive to changes in suspended sediment concentration as it formed due to glacial processes during the last age. Modern day active sedimentary processes on the surface of Dogger Bank are driven by bedload sediment transport which is dynamic. Any suspended sediment deposited on the seabed will become reworked by tidal currents and transported as bedload becoming integrated in the prevailing sediment transport regime with no net change to seabed morphology. Therefore, the value and sensitivity of Dogger Bank as a receptor are presented in **Table 8-26**.

Table 8-26 Sensitivity and Value Assessment of the Dogger Bank Receptor Relevant to Changes in Seabed Level due to Seabed Preparation for Foundation Installation

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**

8.7.2.2.2 Impact Magnitude

115. The worst-case changes in seabed level due to the installation of the maximum number of monopile foundations are likely to have the magnitudes of impact shown in **Table 8-27**. This is because the predicted initial thickness of sediment resting on the seabed would be less than 1mm based on the volume of sediment released (see **Section 8.7.2.1**). After this initial deposition, this sediment would be continually re-suspended to reduce the thickness even further to a point where it will be effectively zero. This would be the longer-term outcome once the sediment supply from foundation installation has ceased.

Table 8-27 Magnitude of Impact on Seabed Level under the Worst-case Scenario for Seabed Preparation for Foundation Installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	Negligible	Negligible	Negligible	**Negligible**
Far-field	Negligible	Negligible	Negligible	Negligible	**Negligible**

8.7.2.3 Changes in suspended sediment concentration, transport, and seabed level due to Inter-Array Cable and Offshore Export Cable installation including at the landfall (MPP-C-05)

116. The installation parameters of the Inter-Array Cable and Offshore Export Cables are dependent upon the final project design. The proposed construction activities that would cause suspended sediment release into the water column are sand wave levelling and trenching. Each of the worst-case scenarios for these two activities are modelled separately for the Offshore Export Cable installation. Inter-array cable routes are currently not sufficiently defined to progress sediment dispersion modelling from construction at PEIR, however inter-array cable modelling will be presented for DCO submission.

117. Suspended sediment dispersion modelling was undertaken to provide the evidence base to assess the effect of Offshore Export Cable installation on suspended sediment concentrations and seabed level. The model comprised two phases. The first phase was sand wave levelling which as a worst-case is assumed to be required along 28.8% of the offshore ECC. The second phase was seabed trenching.

During seabed levelling for export cable installation, maximum suspended sediment concentrations typically reach 10mg/l in the bottom layer and 5mg/l in the surface layer. The plume only extends locally to the cable routes (**Figure 8-25** to **Figure 8-28** and **Figure 8-29** to **Figure 8-32**).

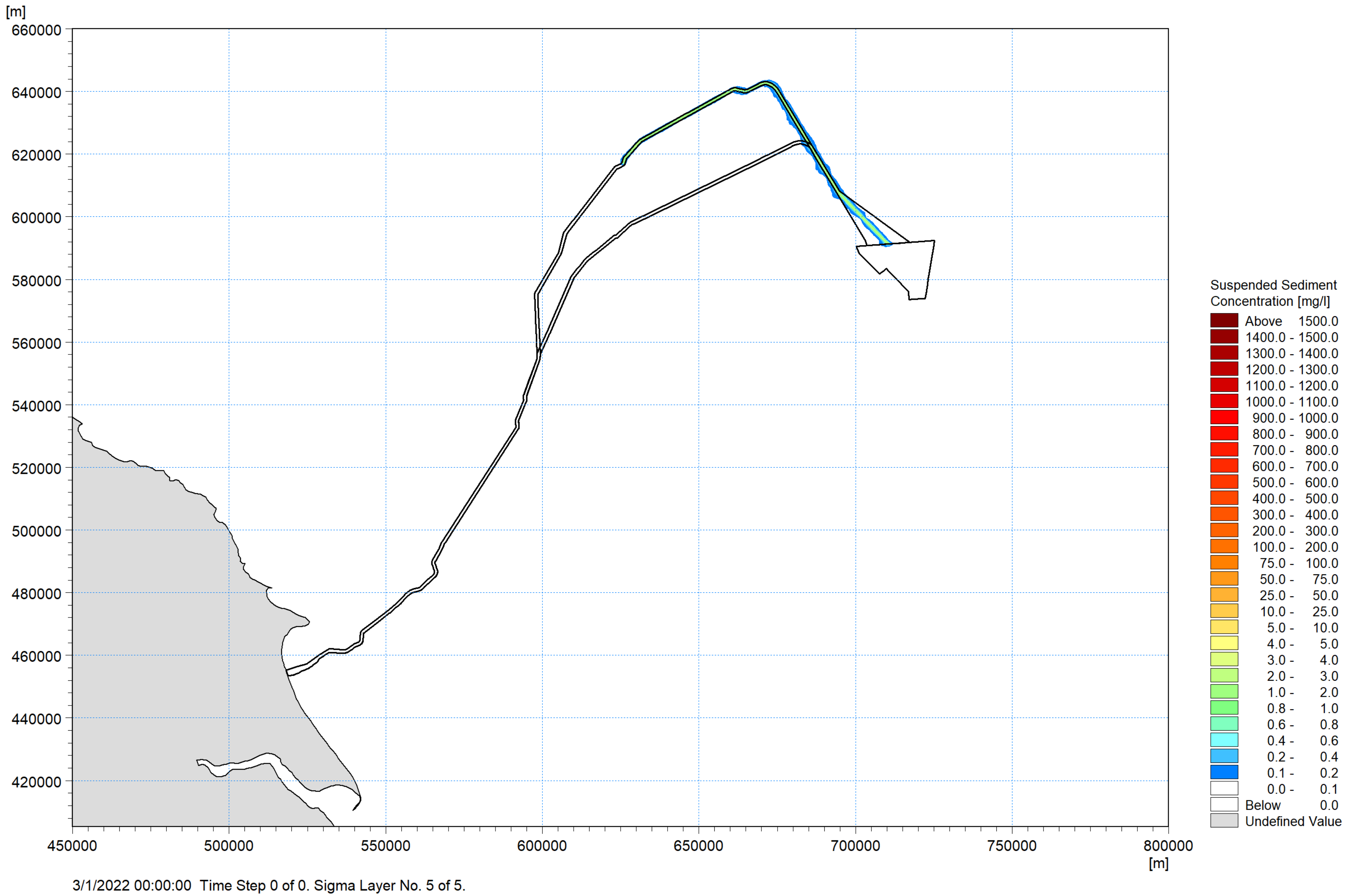

Figure 8-25 Maximum Predicted Suspended Sediment Concentrations Released in the Surface Layer due to Sand Wave Levelling for Offshore Export Cable Option 1 Route

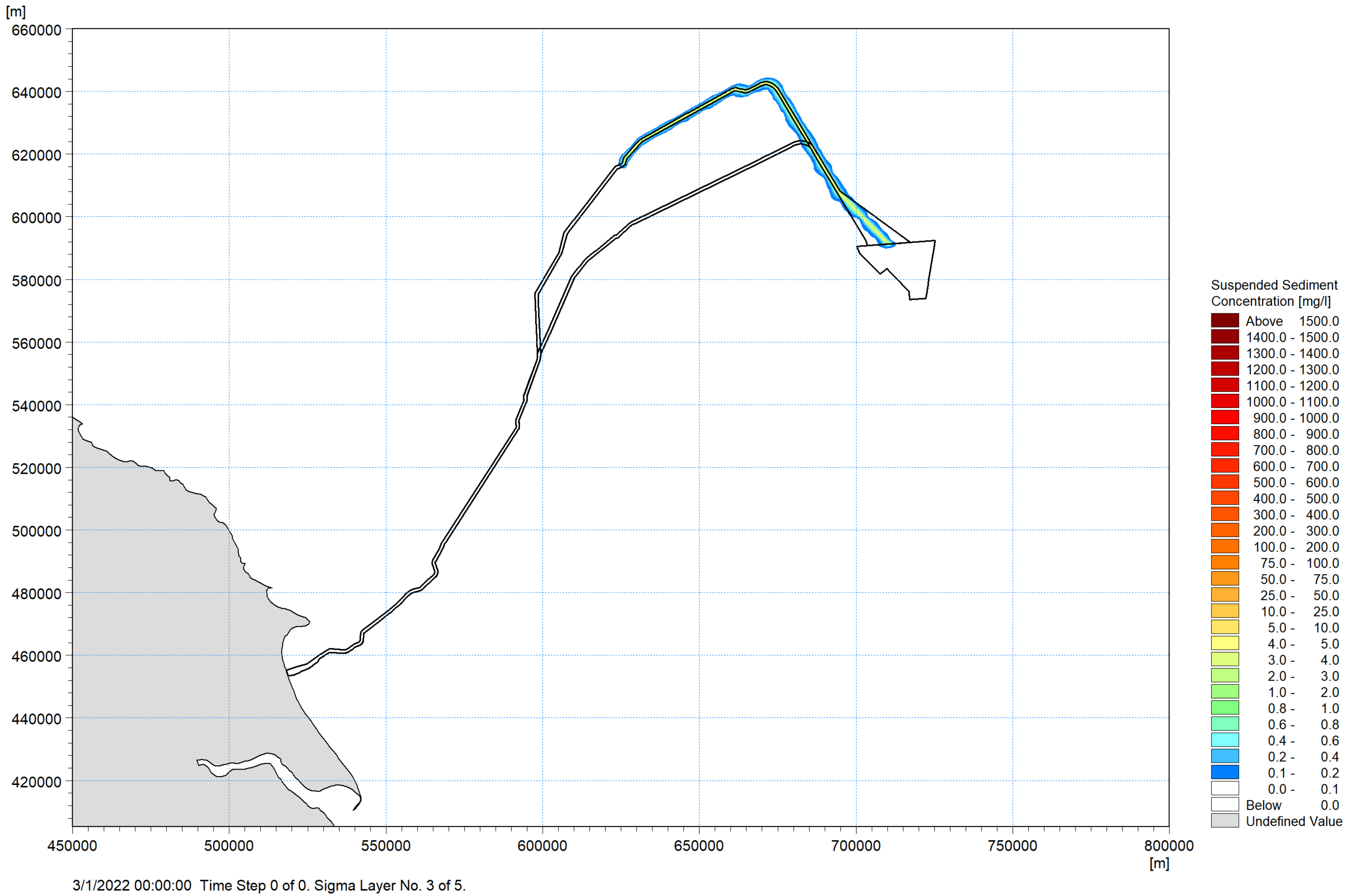

Figure 8-26 Maximum Predicted Suspended Sediment Concentrations Released in the Middle Layer due to Sand Wave Levelling for Offshore Export Cable Option 1 Route

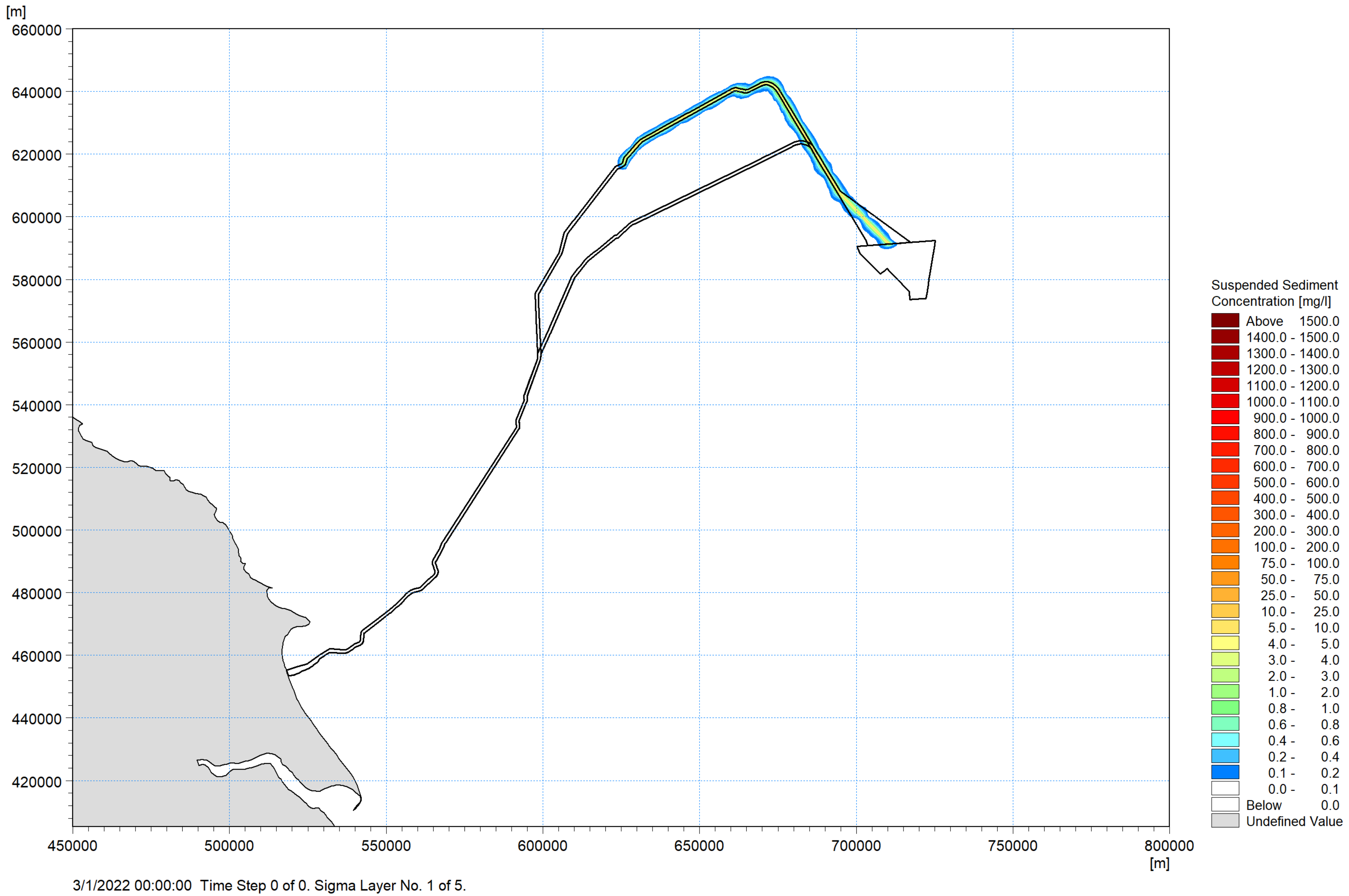

Figure 8-27 Maximum Predicted Suspended Sediment Concentrations Released in the Bottom Layer due to Sand Wave Levelling for Offshore Export Cable Option 1 Route

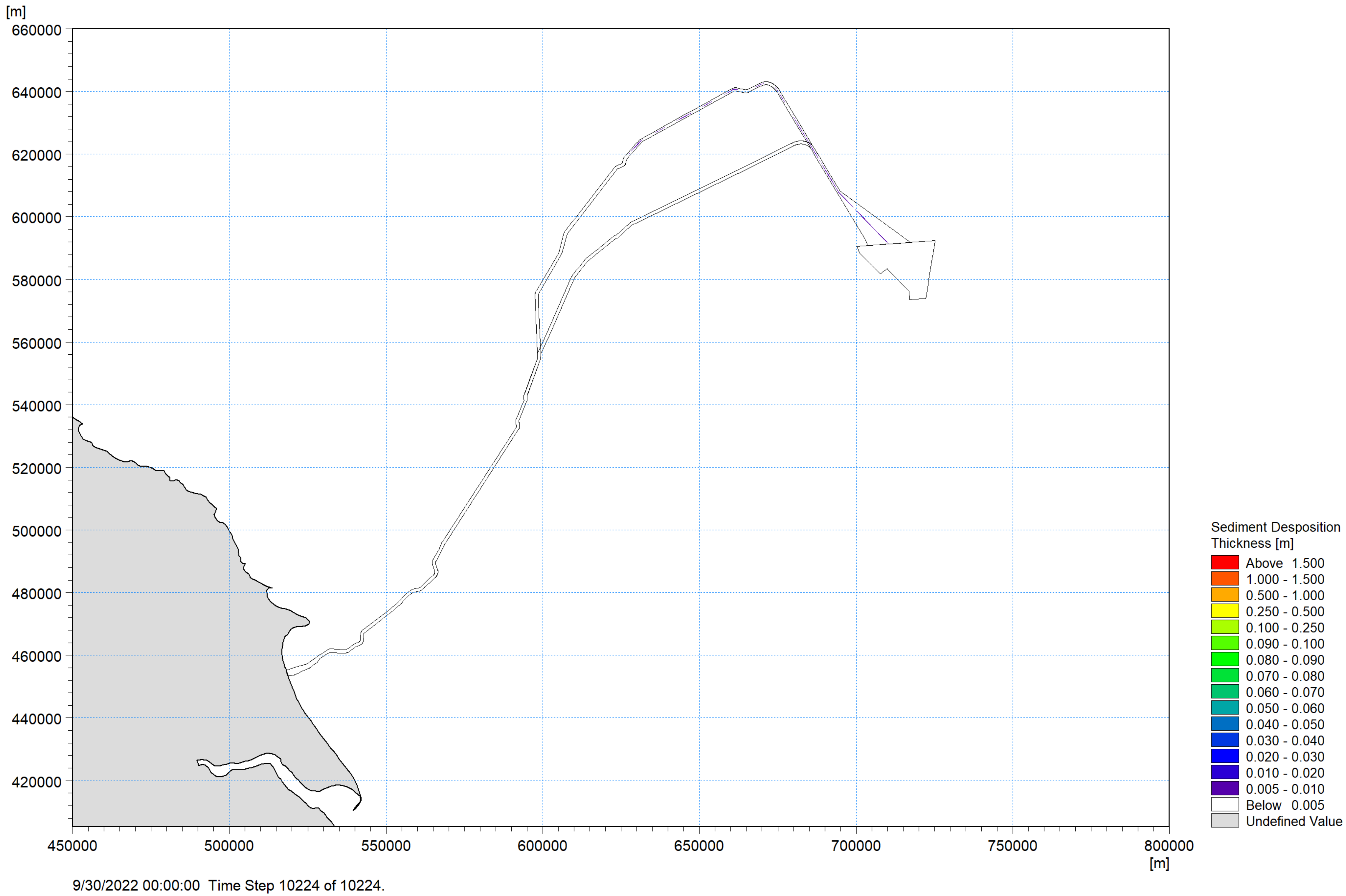

Figure 8-28 Total Sediment Deposition Thickness due to Sand Wave Levelling for Offshore Export Cable Option 1 Route

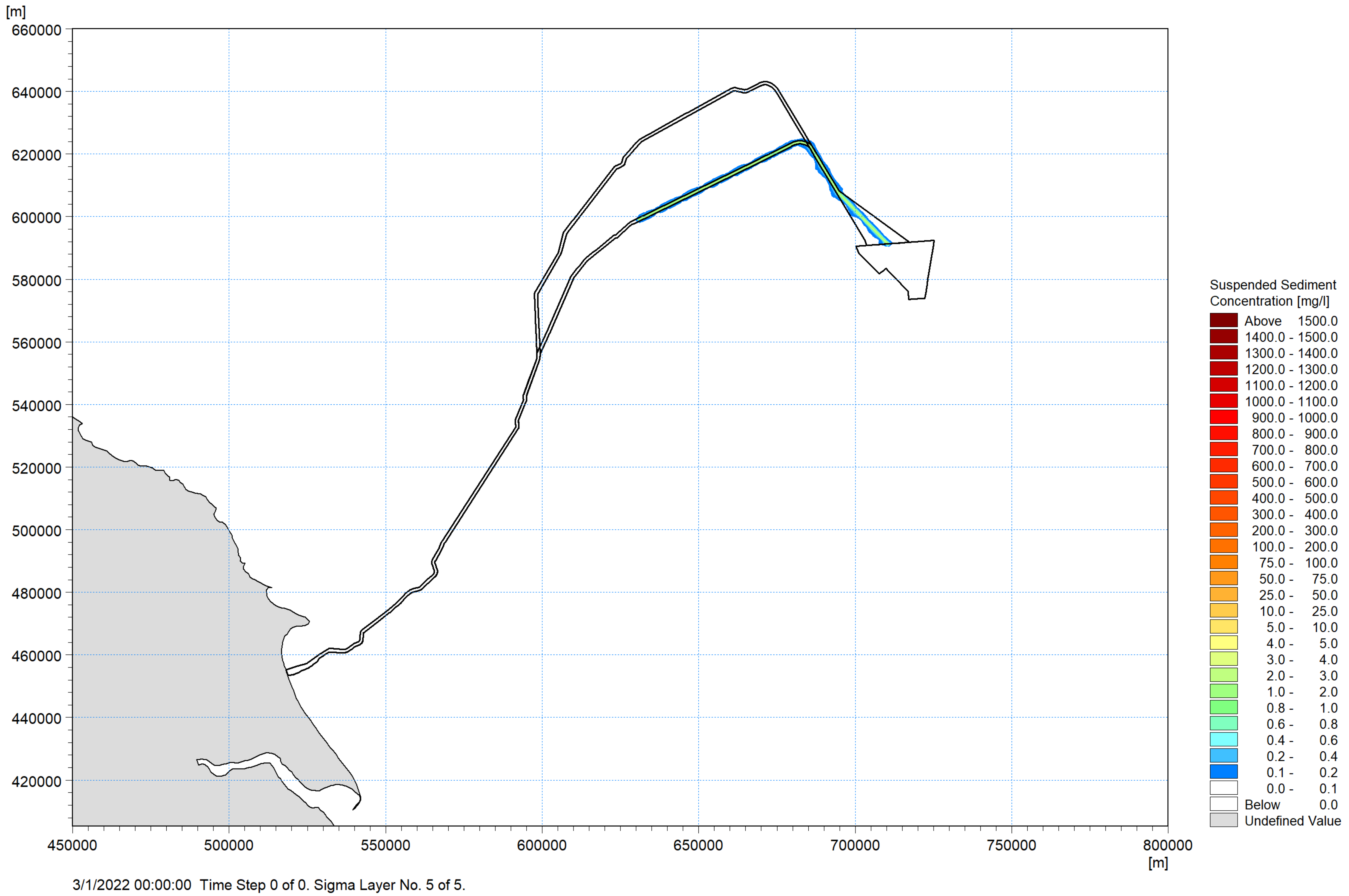

Figure 8-29 Maximum Predicted Suspended Sediment Concentrations Released in the Surface Layer due to Sand Wave Levelling for Offshore Export Cable Option 2 route

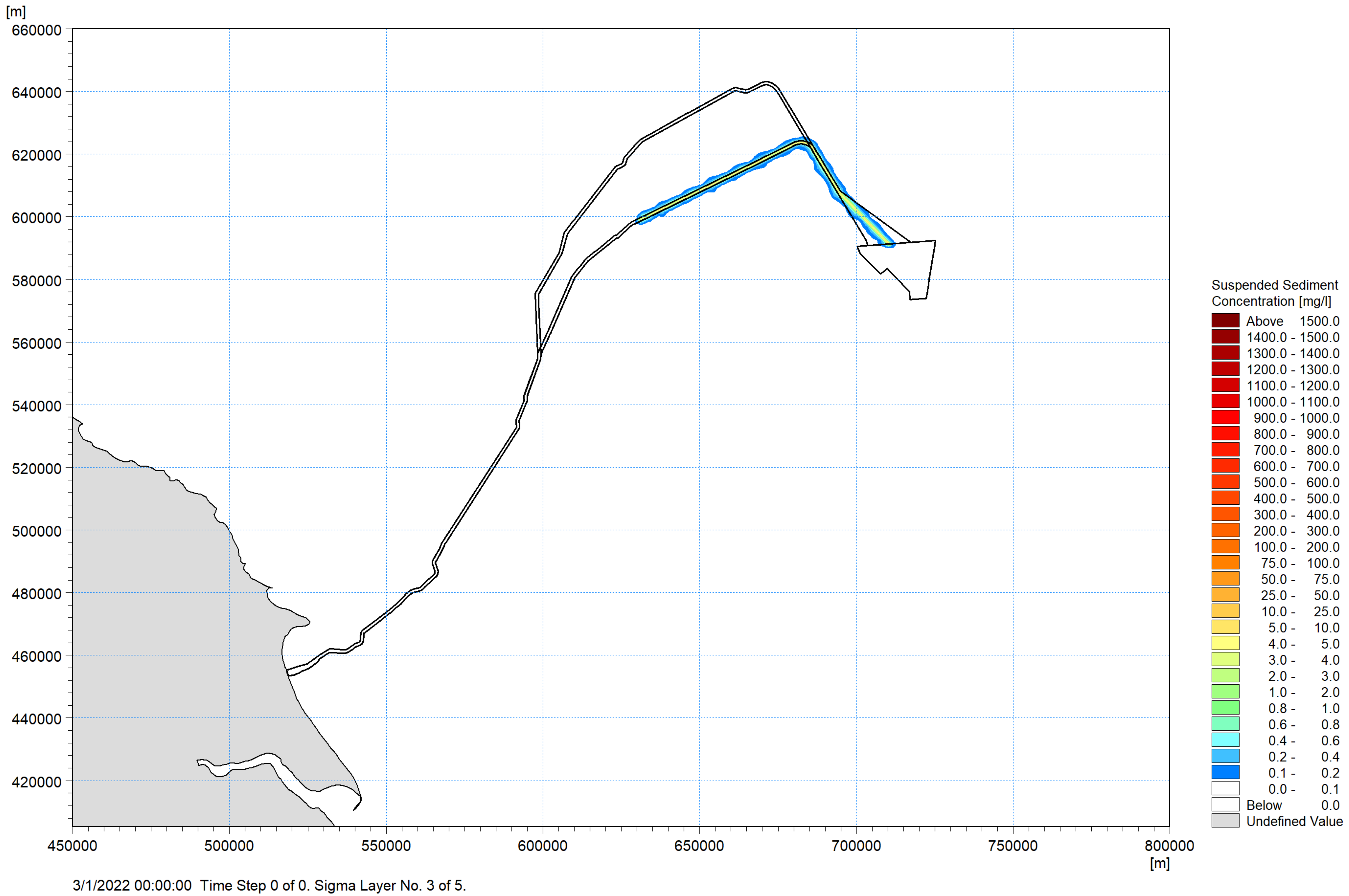

Figure 8-30 Maximum Predicted Suspended Sediment Concentrations Released in the Middle Layer due to Sand Wave Levelling for Offshore Export Cable Option 2 route

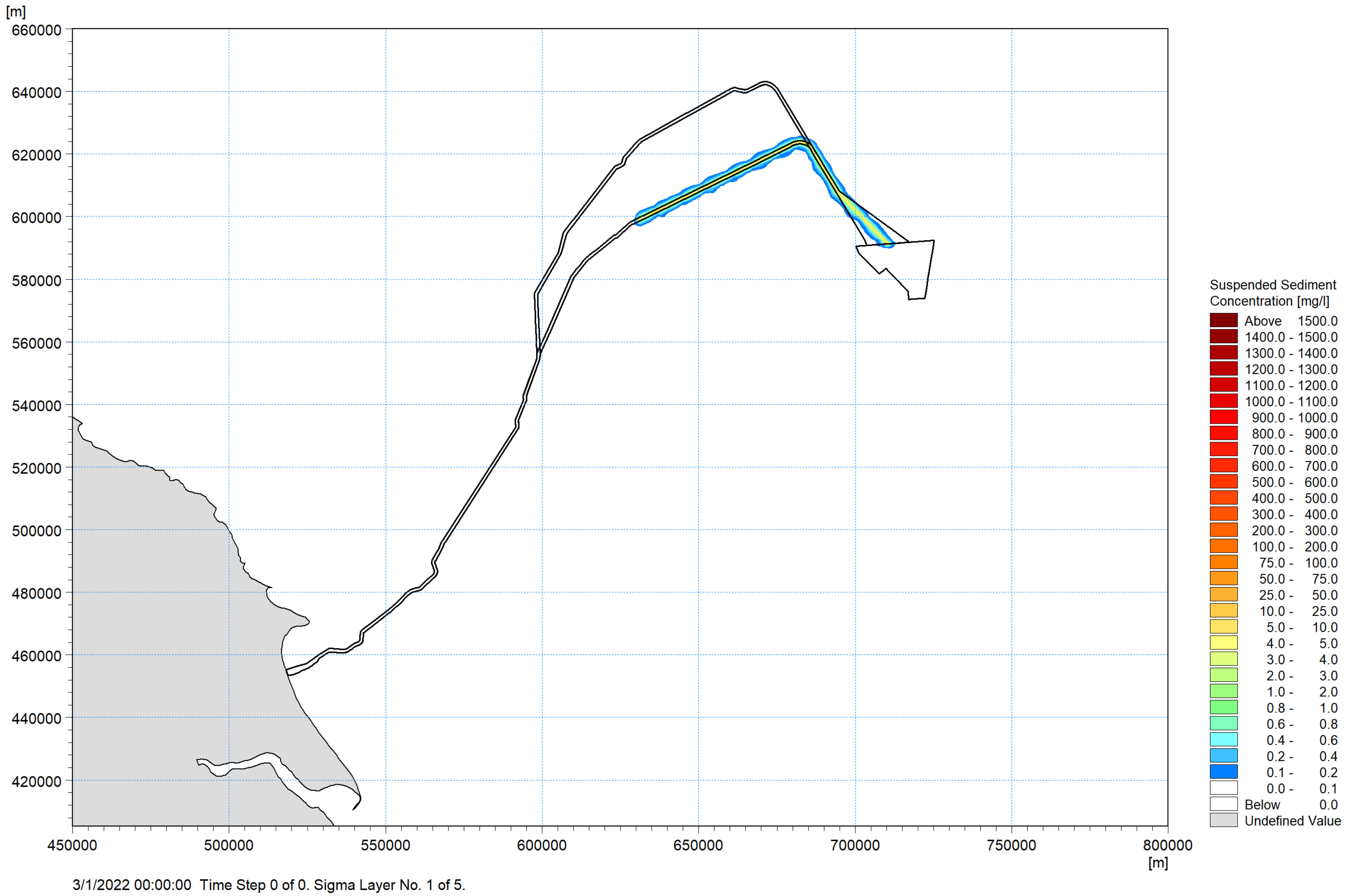

Figure 8-31 Maximum Predicted Suspended Sediment Concentrations Released in the Bottom Layer due to Sand Wave Levelling for Offshore Export Cable Option 2 route

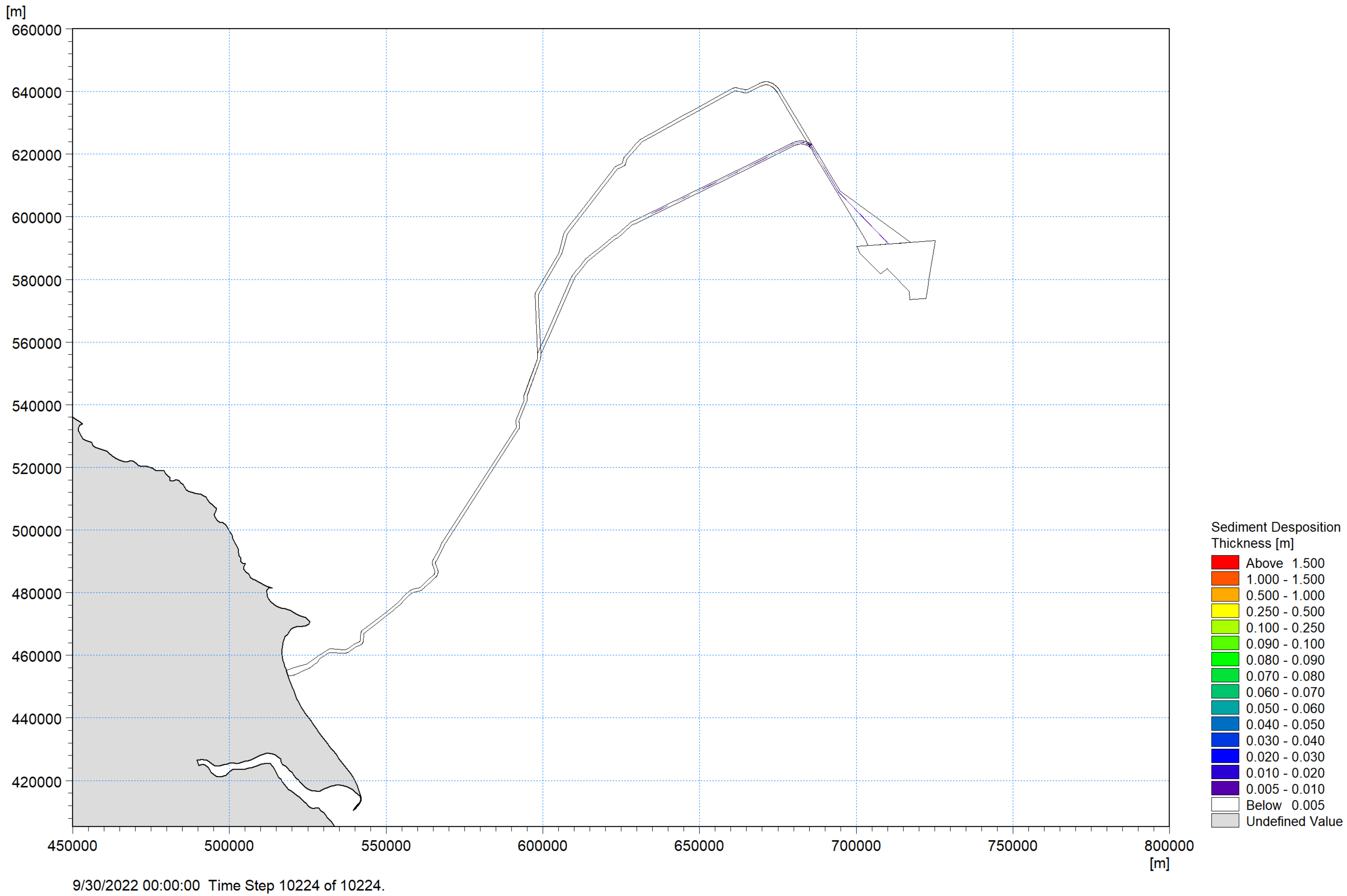

Figure 8-32 Total Sediment Deposition Thickness due to Sand Wave Levelling for Offshore Export Cable Option 2 route

118. During the trenching phase of cable installation, the magnitude of change in suspended sediment concentrations was higher. The maximum suspended sediment concentration is predicted to reach 1,700mg/l locally in the bottom layer (**Figure 8-33** to **Figure 8-36** and **Figure 8-37** to **Figure 8-40**). The maximum concentrations are much lower in the surface layer (below 25mg/l). The maximum extent of the plume is also greater, with suspended sediment concentrations reducing to 1mg/l within 20km of the cable beyond which the values return to background levels. At its maximum extent, the plume could potentially interact with the coast. In the nearshore part of the cable corridor, the plume could traverse and extend north around Flamborough Head and stretch south along the Holderness coast.

119. The modelling shows the greatest change in seabed level occurs during the seabed trenching phase within the offshore ECC with an increase of up to a maximum of 0.19m predicted within and immediately adjacent to the area of trenching (**Figure 8-36** and **Figure 8-40**). During the sand wave levelling phase, changes in seabed level are spatially restricted to the area of levelling and are typically less than 0.01m.

8.7.2.3.1 Receptor Sensitivity

120. The potential receptors to changes in suspended sediment concentration, transport, and seabed level along the offshore ECC are the Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank. The Humber Estuary and Dimlington Cliffs SSSI is remote from the zone of influence for this construction activity.

121. The receptors outlined above are not sensitive to changes in suspended sediment concentration and deposition as their morphology and function are dominated by active sedimentary processes driven by bedload sediment transport, which is dynamic. Any suspended sediment deposited on the seabed will become reworked by tidal and wave currents and transported as bedload becoming integrated in the prevailing sediment transport regime with no net change to seabed morphology. Hence, the value and sensitivity of these receptors are presented in **Table 8-28**.

Table 8-28 Sensitivity and Value Assessment of Receptors Relevant to Changes in Seabed Level due to Cable Installation

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**
Flamborough Head SSSI	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Offshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Inshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Smithic Bank	Negligible	Negligible	Negligible	Medium	**Negligible**

8.7.2.3.2 Impact Magnitude

122. The worst-case changes in seabed level due to the installation of the Offshore Export Cable are likely to have the magnitudes of impact shown in **Table 8-29**. This is because the predicted thickness of sediment resting on the seabed would be a maximum of 0.19m. After this initial deposition, this sediment would be continually re-suspended to reduce the thickness even further to a point where it will be effectively zero. This would be the longer-term outcome once the sediment supply from cable installation has ceased.

Table 8-29 Magnitude of Impact on Seabed Level under the Worst-case Scenario for Cable Installation

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	Negligible	Negligible	Negligible	**Negligible**
Far-field	Negligible	Negligible	Negligible	Negligible	**Negligible**

8.7.2.3.3 Effect Significance

123. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **negligible** for both the near-field and far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

124. The effects on seabed level have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this PEIR (**Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 14 Commercial Fisheries** and **Chapter 17 Offshore Archaeology**).

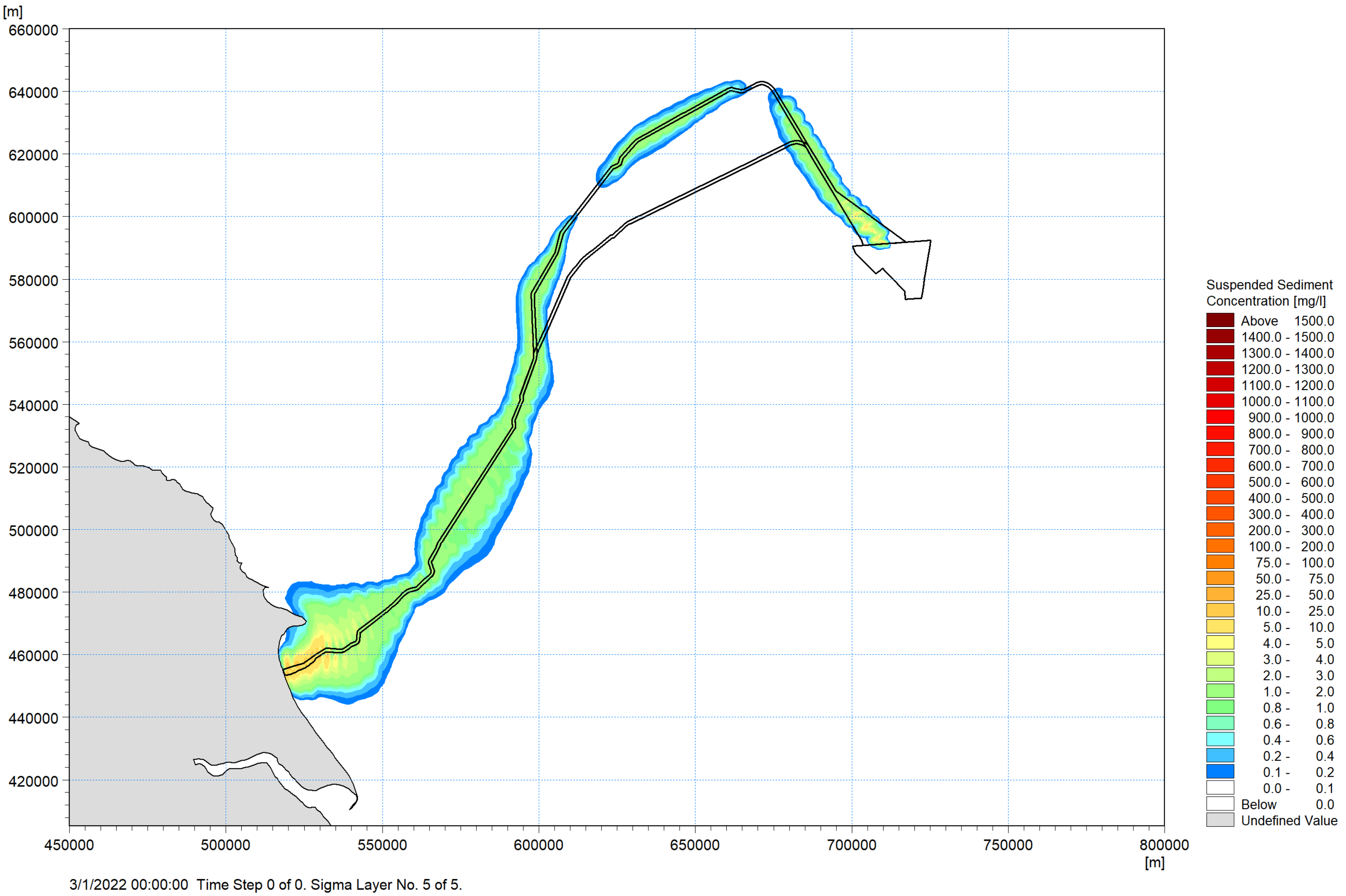

Figure 8-33 Maximum Predicted Suspended Sediment Concentrations Released in the Surface Layer due to Trenching for Offshore Export Cable Option 1 route

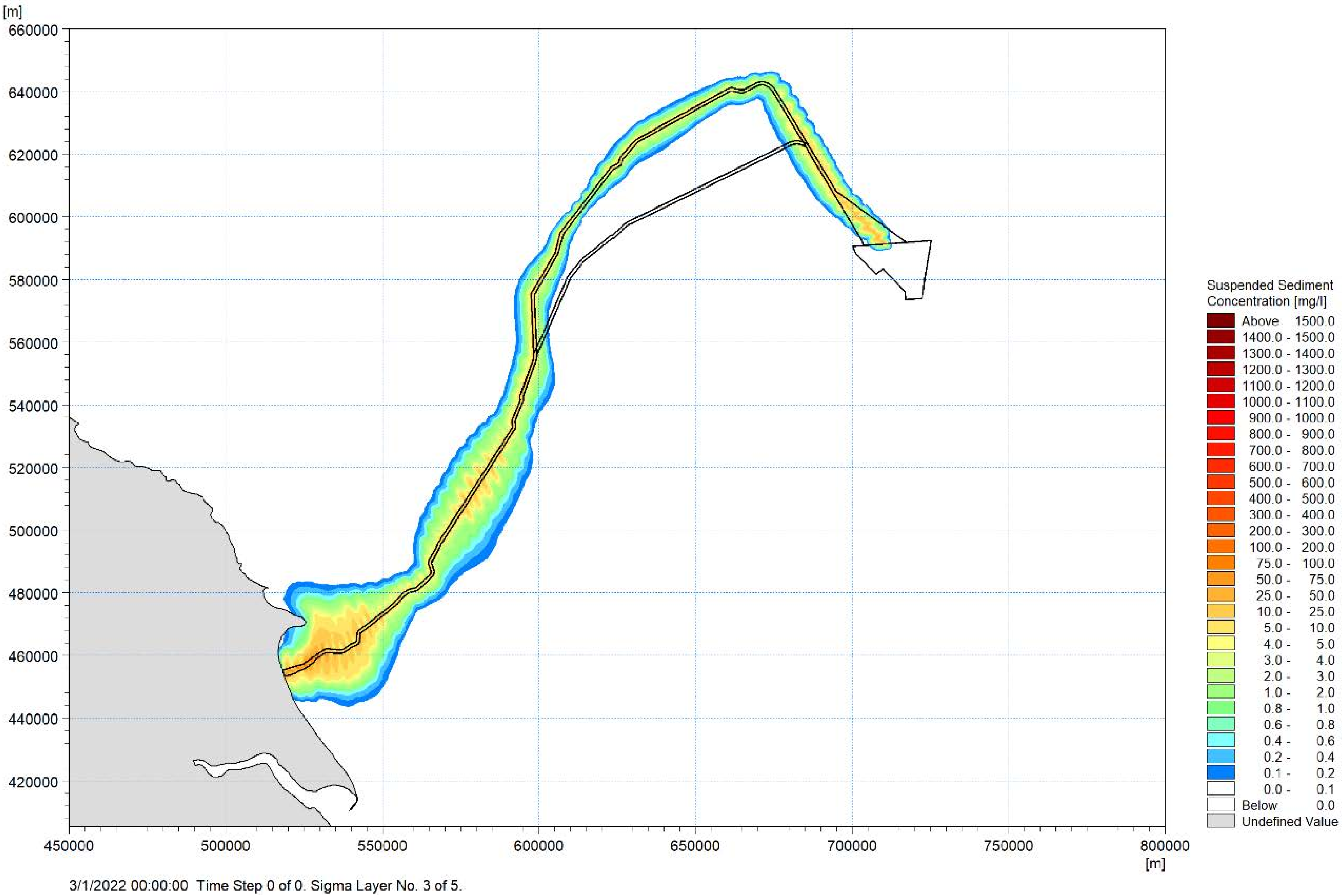

Figure 8-34 Maximum Predicted Suspended Sediment Concentrations Released in the Middle Layer due to Trenching for Offshore Export Cable Option 1 route

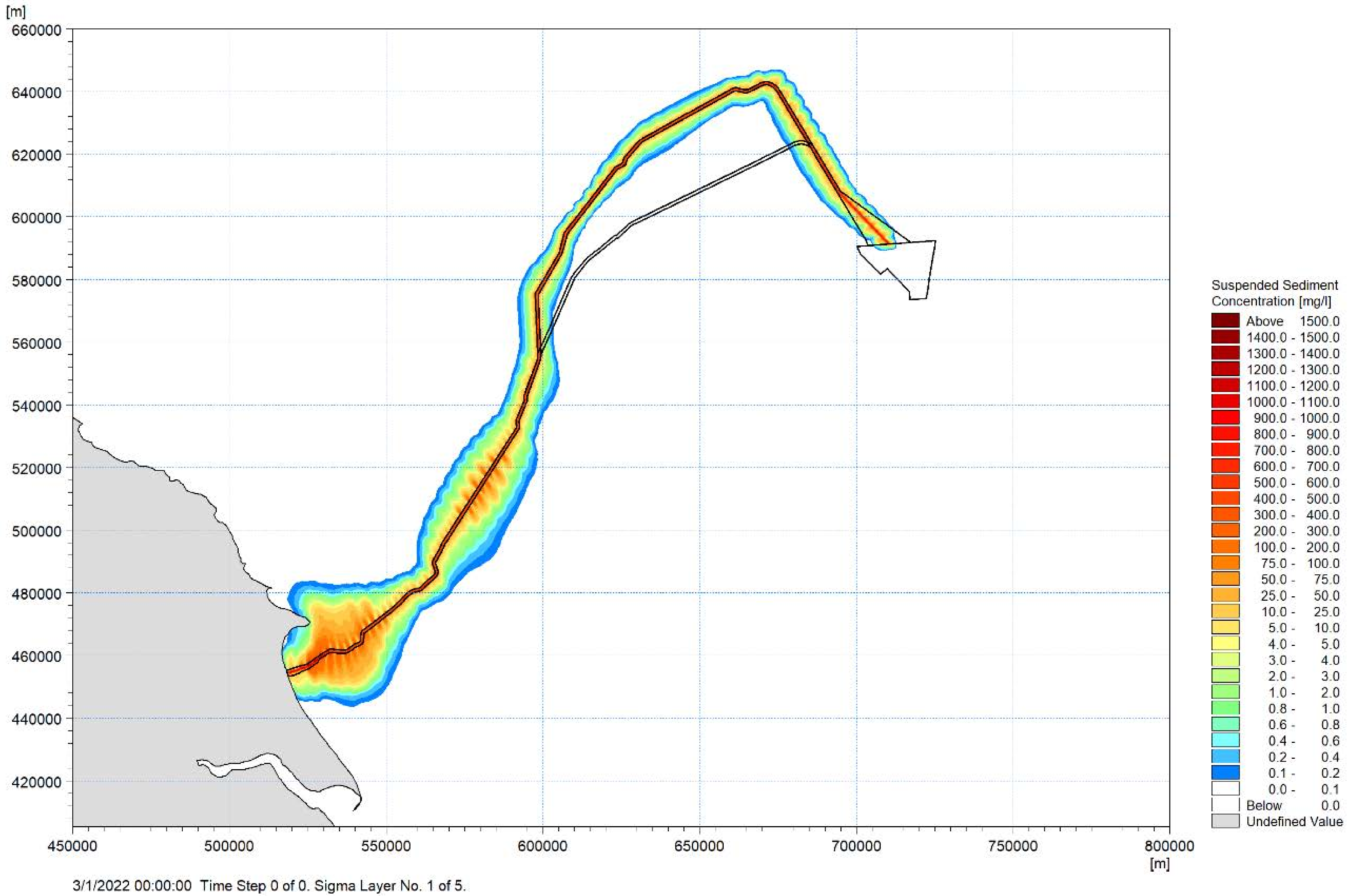

Figure 8-35 Maximum Predicted Suspended Sediment Concentrations Released in the Bottom Layer due to Trenching for Offshore Export Cable Option 1 route

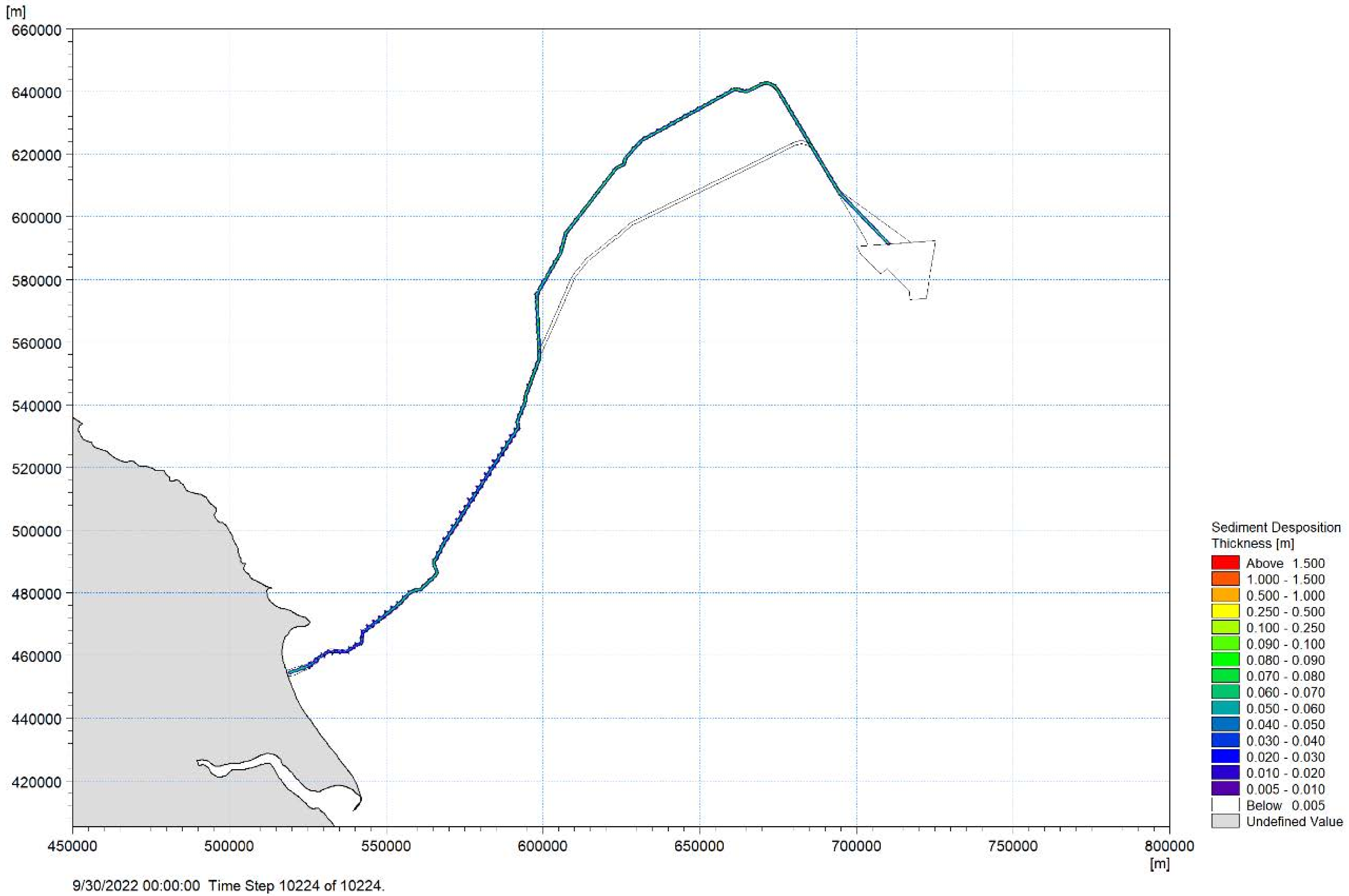

Figure 8-36 Total Sediment Deposition Thickness due to Trenching for Offshore Export Cable Option 1 route

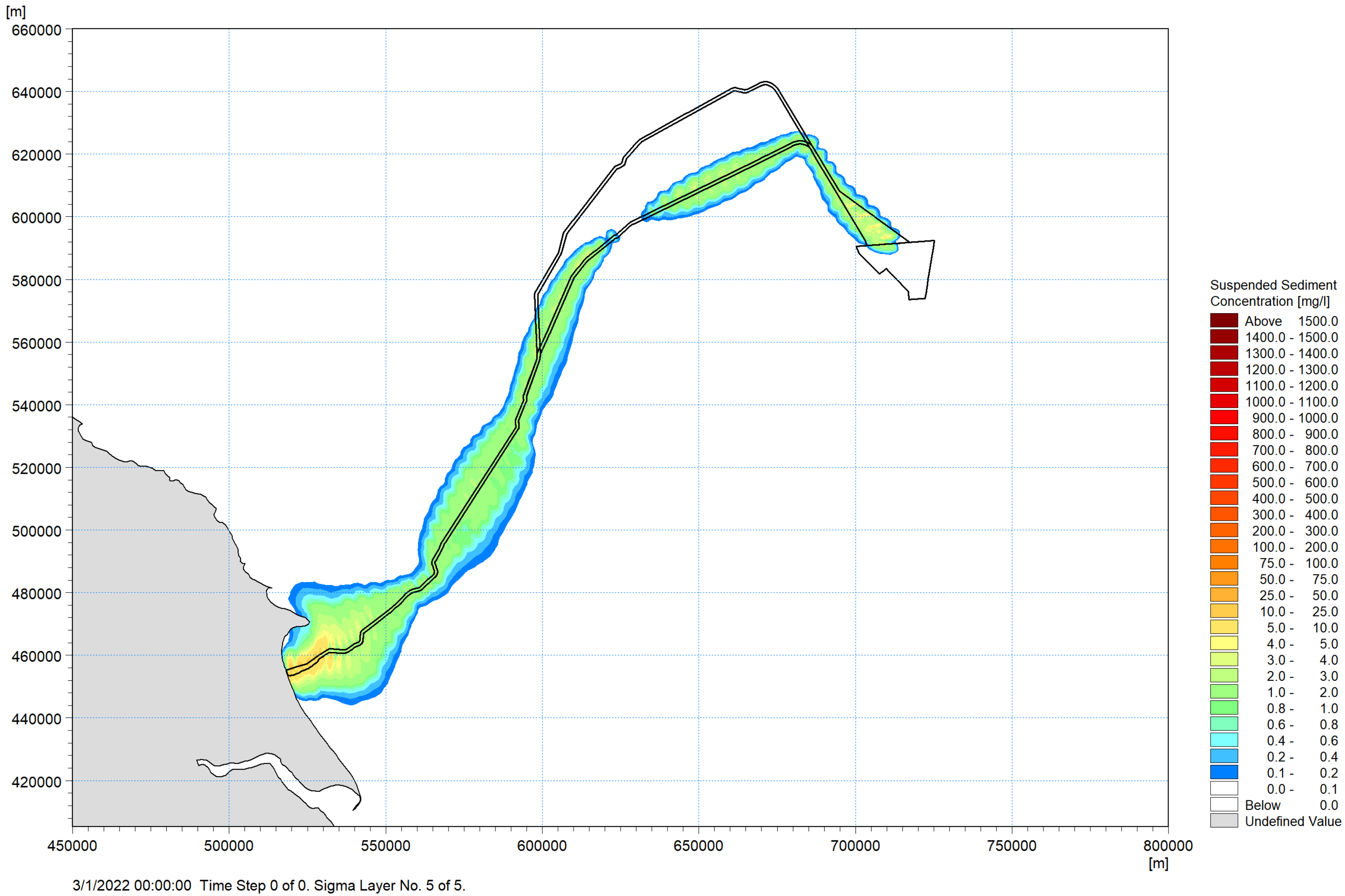

Figure 8-37 Maximum Predicted Suspended Sediment Concentrations Released in the Surface Layer due to Trenching for Offshore Export Cable Option 2 route

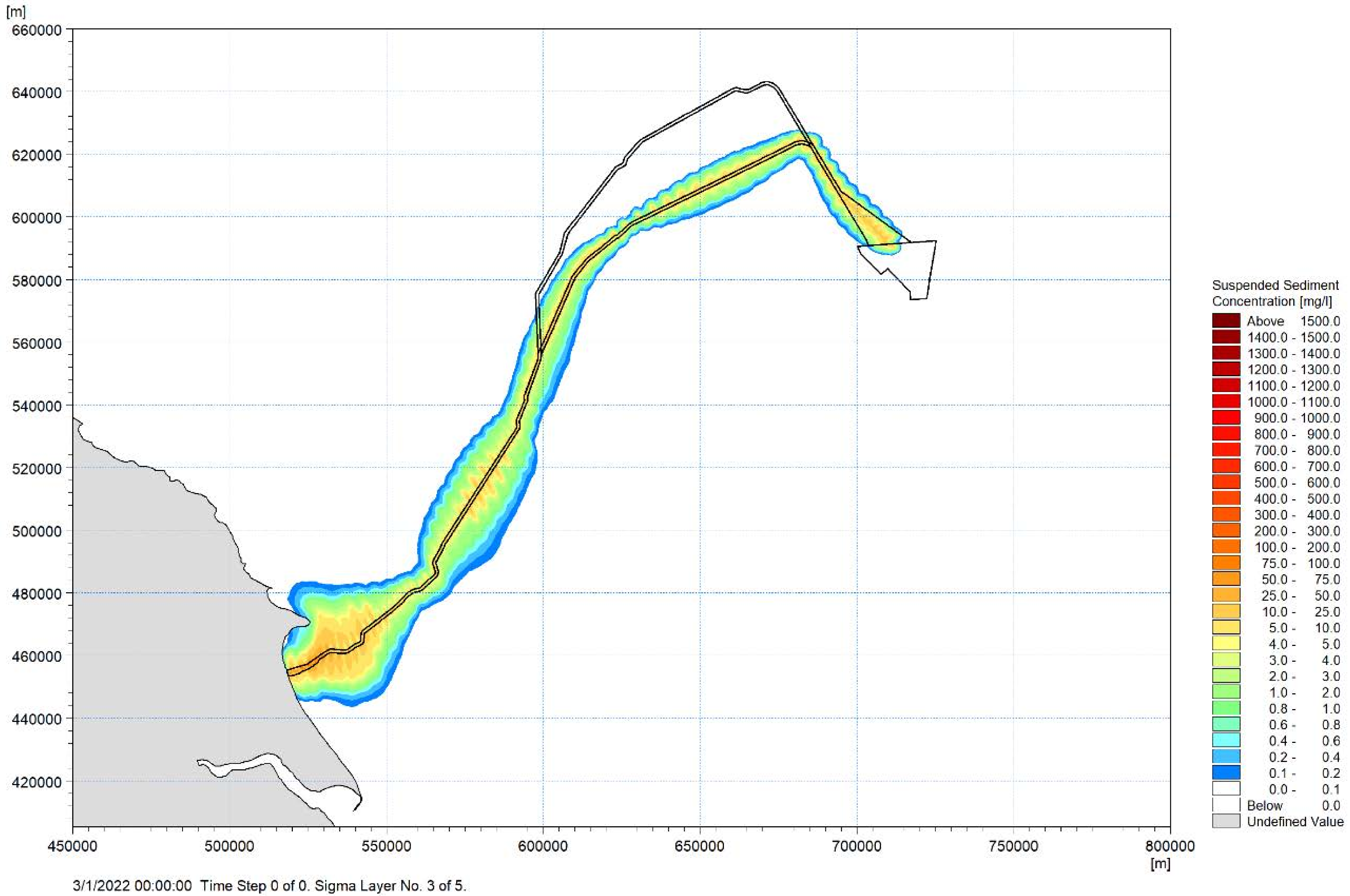

Figure 8-38 Maximum Predicted Suspended Sediment Concentrations Released in the Middle Layer due to Trenching for Offshore Export Cable Option 2 route

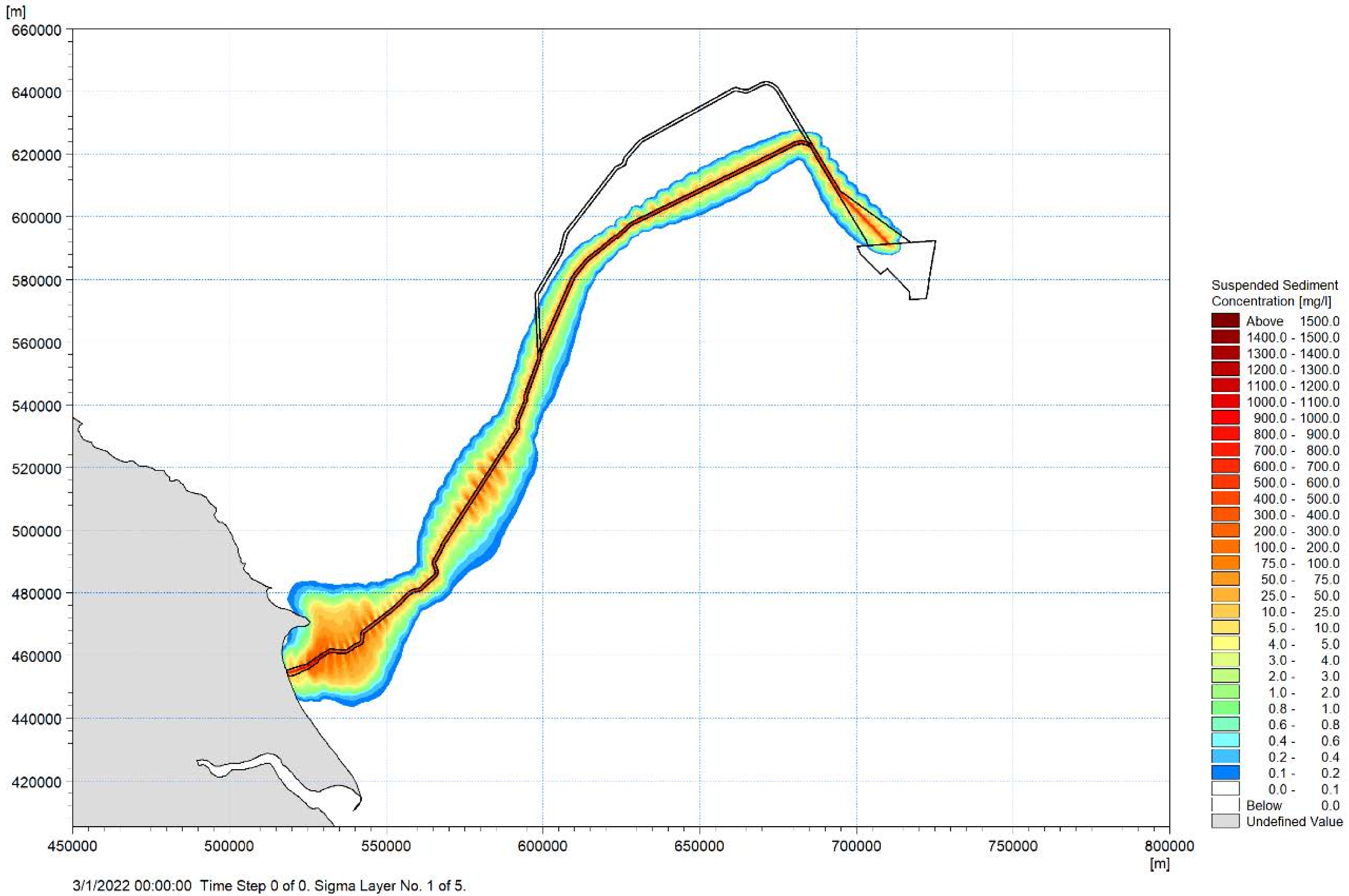

Figure 8-39 Maximum Predicted Suspended Sediment Concentrations Released in the Bottom Layer due to Trenching for Offshore Export Cable Option 2 route

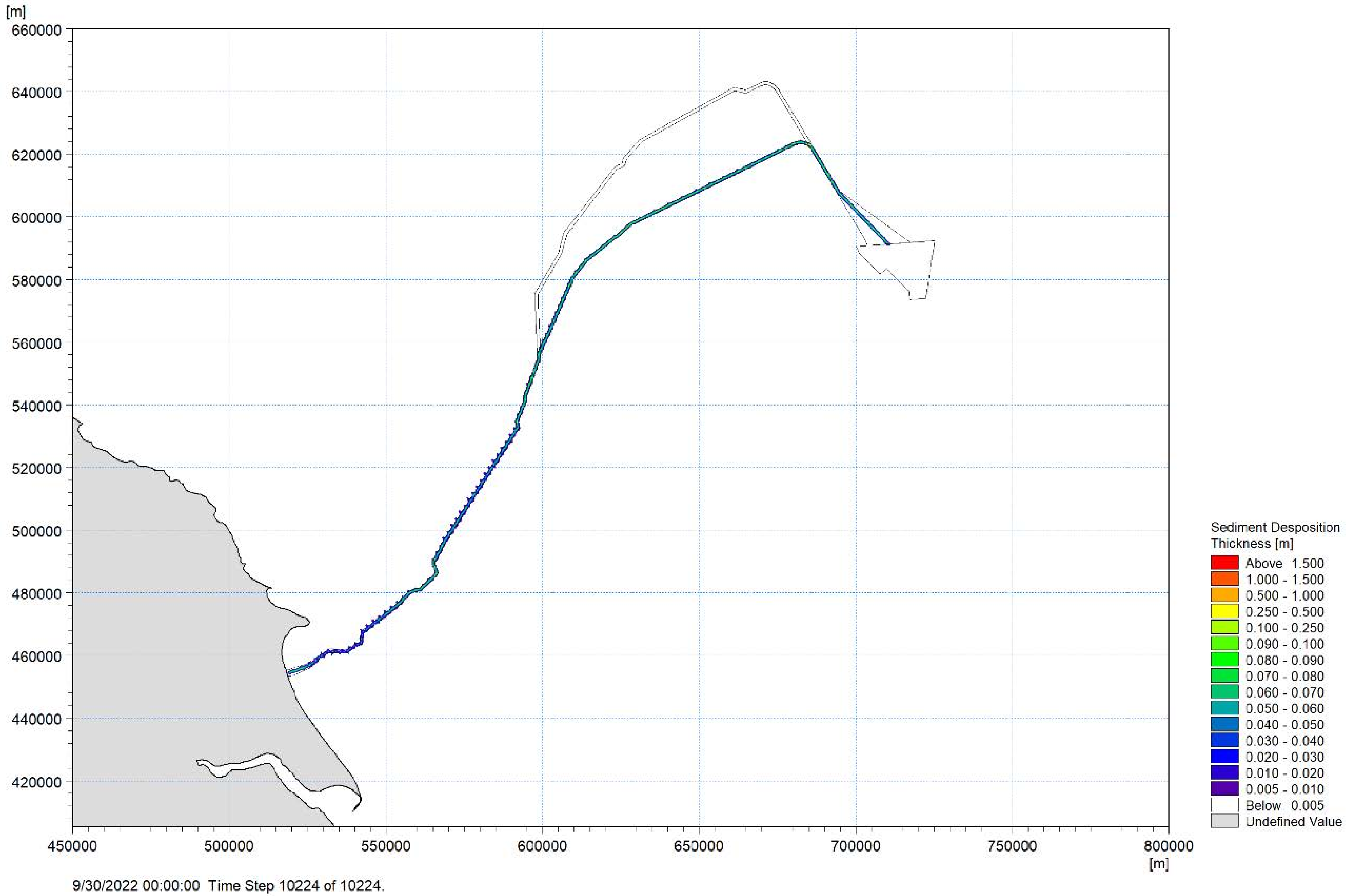

Figure 8-40 Total Sediment Deposition Thickness due to Trenching for Offshore Export Cable Option 2 route

8.7.2.4 Interruptions to bedload sediment transport due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation (MPP-C-06)

125. Sand wave levelling may be required prior to Inter-Array Cable and Offshore Export Cable installation. The removal of sand waves could potentially interfere with bedload sediment transport pathways that supply sediment to the local sand bank systems.

126. Any excavated sediment due to sand wave levelling would be disposed of within the Offshore Development Area so there will be no net loss of sand from the Offshore Development Area. Tidal currents would, over time, re-distribute the sand back over the levelled area (as re-formed sand waves). The extent of sand wave levelling required and specific disposal locations within the Offshore Development Area would be determined post consent following detailed geophysical surveys.

127. The dynamic nature of the sand waves within the Offshore Development Area means that any direct changes in the seabed associated with their levelling are likely to recover over a short period of time due to natural sand transport pathways. This conceptual assessment is supported by the findings of a review of the evidence base into the recovery of sand waves at the similarly dynamic areas of Race Bank (Ørsted, 2018) and Haisborough, Hammond and Winterton Special Area of Conservation (SAC) (ABPmer, 2018).

128. To install parts of the array and export cables for Race Bank Offshore Wind Farm, the crests of the sand waves were reduced in elevation (Ørsted, 2018). Multibeam echosounder monitoring was completed of pre- (2015/2016), during (2017) and post- (2018) sand wave levelling to assess the level of disturbance and the rate of natural recovery (restoration) of seabed morphology. Nine areas were chosen (seven array cables routes and two areas along the offshore cable corridors) where significant sediment mobility was expected. The results showed that along most of the nine Study Areas, the seabed had completely or nearly completely recovered to pre-construction levels (greater than 75% recovery of sand waves in all areas).

129. Work done by ABPmer (2018) across Haisborough, Hammond and Winterton SAC for Norfolk Vanguard / Boreas Offshore Wind Farms provides another suitable example. ABPmer investigated sand wave properties (height, wavelength, asymmetry, mobility, and migration characteristics) and the sediment transport potential. The results showed that the sand wave area is in an active and highly dynamic environment, governed by flow speeds, water depth and sediment supply, all of which are conducive to the development and maintenance of sand banks. Therefore, despite the disturbance to sand waves intersecting the cable corridor, the Haisborough, Hammond and Winterton SAC sand bank system would remain undisturbed as new sand waves will continue to be formed. They concluded that the overall form and functioning of any sand wave, or the SAC sand bank system, are not disrupted by levelling of the sand waves.

130. Similar physical and sedimentary processes apply to the area of sand waves along the offshore ECC. The driving forces (tidal currents) and sediment supply regime will be like the sand waves in Race Bank and Haisborough, Hammond and Winterton SAC (as it is for all areas with sand waves). Hence, the same principles of recovery would apply. ABPmer (2018) concluded that the estimated time for the cable trenches and the seabed levelling to be naturally infilled, and for sand waves to recovery would be in the order of a few days to a year.

131. They also showed that the governing sediment transport processes within the Haisborough, Hammond and Winterton SAC occur at a much larger scale than the proposed seabed levelling works. Therefore, these processes will not be disrupted by the localised seabed levelling. The same processes would equally apply to the sand waves in the offshore ECC, and so they would recover in a similar fashion and at a similar rate, without upsetting the larger landscape-scale processes across the sand waves.

8.7.2.4.1 Receptor Sensitivity

132. The potential receptors to interruptions to bedload sediment transport due to sand wave levelling are Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank. The value and sensitivity of these receptors are presented in **Table 8-30**.

Table 8-30 Sensitivity and Value Assessment of Receptors Relevant to Interruptions to Bedload Sediment Transport due to Sand Wave Levelling

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**
Flamborough Head SSSI	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Offshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Inshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Smithic Bank	Negligible	Negligible	Negligible	Medium	**Negligible**

8.7.2.4.2 Impact Magnitude

133. The worst-case changes in bedload sediment transport due to sand wave levelling within the offshore ECC and Array Areas are likely to have the magnitudes of impact shown in **Table 8-31**. Keeping the dredged sand within the Offshore Development Area enables the sand to become re-established within the local sediment transport system by natural processes and encourages the re-establishment of the bedforms. Given the local favourable conditions that enable sand wave development, the sediment would be naturally transported back into the levelled area within a short period of time. The levelled area will naturally act as a sink for sediment in transport and will be replenished in the order of a few days to a year.

Table 8-31 Magnitude of Impact on Bedload Sediment Transport under the Worst-case Scenario for Sand Wave Levelling

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Medium	Negligible	Negligible	Low	**Low**
Far-field	Negligible	Negligible	Negligible	Negligible	**Negligible**

8.7.2.4.3 Effect Significance

134. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **low** in the near-field and **negligible** in far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

135. The effects on bedload sediment transport have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this PEIR (**Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 14 Commercial Fisheries** and **Chapter 17 Offshore Archaeology**).

8.7.2.5 Indentations on the seabed due to the presence of installation vessels (MPP-C-07)

136. There is potential for certain vessels used during installation of foundations and cable infrastructure to directly impact the seabed. The worst-case scenario applies to those vessels that utilise jack-up legs to hold station and to provide stability for a working platform. Where legs have been inserted into the seabed and then removed, there is potential for a temporary indentation to remain, proportional to the dimensions of the object.

137. Once the leg is positioned on the seabed, the seabed sediments would primarily be compressed vertically downwards and displaced laterally. This may cause the seabed around the leg to be raised in a series of concentric pressure ridges. As the leg is retracted, some of the sediment would return to the hole via mass slumping under gravity until a stable slope angle is achieved. Over the longer term, the hole would become shallower and less distinct due to infilling with mobile seabed sediments. This process has been observed in the Dogger Bank B Wind Farm and Dogger Bank C Wind Farm development zones where comparisons of bathymetric survey data acquired in 2012 and 2022 showed features such as trawl marks and localised depressions, infilled over the ten-year period (Dogger Bank South Offshore Wind Farms, 2024). There was only evidence of indentations from jack-up vessels at the location of one met mast where slight depressions (<0.5m deep) were visible in post-removal bathymetric survey data. The survey was undertaken 5 years after removal of the met mast which shows the indentations fill in over a period of years.

138. A six-legged jack-up barge used for the installation of wind turbines and offshore platforms would have a footprint of 2,400m^2 (six legs with an individual leg footprint of 400m^2). The typical penetration depth for each leg is 0m to 3m but could be greater depending on local soil conditions (Hu *et al.*, 2021). The worst-case scenario assumes five jack-up deployments will be required at each wind turbine and five at each offshore platform location with the total during construction estimated at 1,380,000m^2.

139. Worst-case scenario for total disturbance footprint from installation vessels also includes anchoring during WTG and OP installation, inter-array cable installation, offshore export cable installation, and trenchless technique exit installation. The worst-case scenario total disturbance from installation vessels would have a footprint of 1,602,760m^2 including jack-up vessels.

8.7.2.5.1 Receptor Sensitivity

140. Installation of foundations within the Array Area may result in jack-up indentations within Dogger Bank and the value and sensitivity of this receptor is presented in **Table 8-32**. There is potential for jack-up platforms to be required during cable installation in the nearshore which overlaps with the Holderness MCZ. However, the geological designation of the MCZ is Spurn Head which is located 45km away from the landfall and therefore, will not be affected by indentations on the seabed within the nearshore part of the offshore ECC. However, seabed indentations have the potential to affect other features of the Holderness Inshore MCZ and the assessment of effect significance is addressed within the relevant chapters of this PEIR (**Chapter 10 Benthic and Intertidal Ecology** and **Chapter 11 Fish and Shellfish Ecology**).

Table 8-32 Sensitivity and Value Assessment of the Dogger Bank Receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**

8.7.2.5.2 Impact Magnitude

141. The worst-case changes in seabed level due to indentations are likely to have the magnitudes of impact shown in **Table 8-33**. The layout of wind turbines and offshore platforms will be decided post-consent and indentations on the seabed during their installation may occur. However, any disturbance footprint would be limited in scale and any impacts would be temporary in nature with indentations infilling through natural processes over the course of days to years (Dogger Bank South Offshore Wind Farms, 2024).

Table 8-33 Magnitude of Impact on Seabed Level under the Worst-case Scenario for Installation Vessel Indentations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Medium	Low	Negligible	Low	Low
Far-field	No change	-	-	-	No change

8.7.2.5.3 Effect Significance

142. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **low** in the near-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

8.7.3 Potential Effects during Operation

8.7.3.1 Changes in the tidal current regime due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-01)

143. The presence of the worst-case monopile foundations and offshore platform foundation structures on the seabed within the Project has the potential to alter the baseline tidal current regime. Any changes in the tidal current regime have the potential to contribute to changes in seabed morphology due to alteration of sediment transport patterns. All the results from the hydrodynamic modelling campaign are presented in *Section 8.4.5* of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**.

144. **Figure 8-41** shows the worst-case differences in tidal current speed between the baseline condition and the worst-case Project foundation layout. The presence of the Project is predicted to result in a maximum reduction in speed of up to 0.04m/s within the confines of the array. Within a short distance outside the array boundary, the effect reduces until there is no impact on current speed.

145. A model run was also completed using Turbine Layout C (**Figure 8-41**) for consistency with the modelled layout for waves. This layout includes 113 turbines with two small offshore platforms in the centre of the array (see **Table 8-5**).

8.7.3.1.1 Receptor Sensitivity

146. The potential receptor to changes in tidal current speeds across the Array Area is the Dogger Bank. Tidal currents are the primary driver of sediment transport on Dogger Bank. However, their influence is limited to the seabed as the underlying geology formed due to glacial processes. Therefore, the value and sensitivity of this receptor is **negligible** are presented in **Table 8-34**.

Table 8-34 Sensitivity and Value Assessment of the Dogger Bank Receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	Negligible

8.7.3.1.2 Impact Magnitude

147. The worst-case changes in the tidal current regime due to the presence of monopile foundations are likely to have the magnitudes of impact shown in **Table 8-35**. The zone of influence for tidal currents encroaches into the Dogger Bank receptor. However, the change in tidal current speed would only be a few percent within this zone of encroachment.

Table 8-35 Magnitude of Impact on the Tidal Current Regime under the Worst-Case Scenario for the Presence of Monopile Foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	High	Medium	Negligible	**Low**
Far-field	Negligible	High	Medium	Negligible	**Negligible**

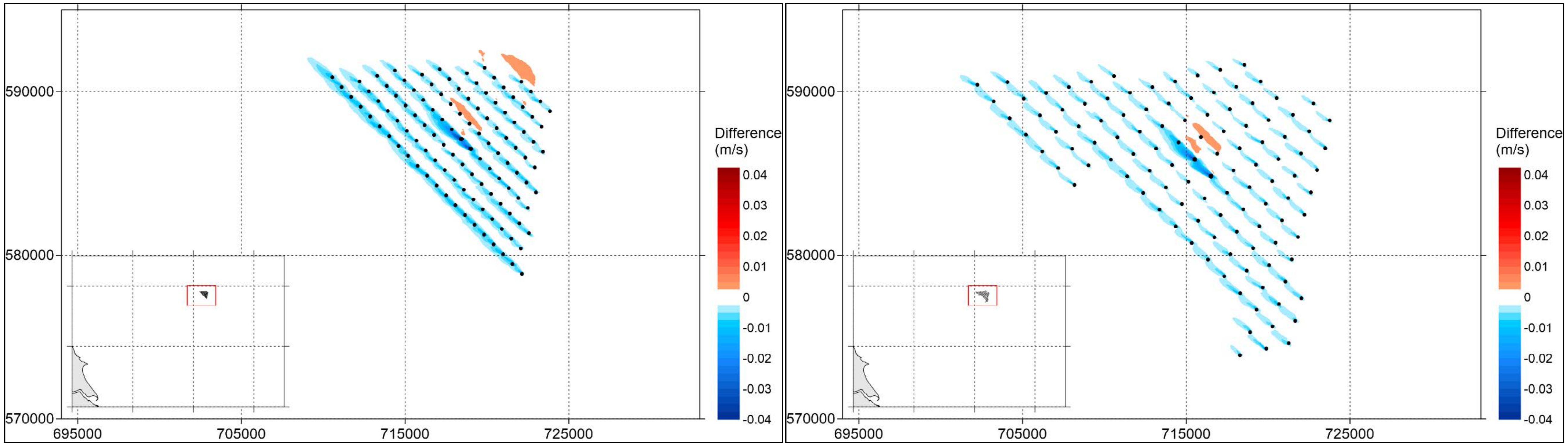

Figure 8-41 Difference in Maximum Current Speed over 30 days between Baseline and Windfarm using Turbine Layout B (left) and Turbine Layout C (right)

8.7.3.1.3 Effect Significance

148. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **low** in the near-field and **negligible** in the far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

8.7.3.2 Changes in the wave regime due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-02)

149. Potential impacts on waves during operation could occur due to the physical presence of infrastructure (wind turbine and offshore platform foundations), which may result in localised changes in waves due to physical blockage effects. The infrastructure would present obstacles to the passage of waves locally, causing a modification to the wave heights and / or directions as they pass. Generally, this would cause a wave shadow effect to be created by each piece of infrastructure. Any changes in the wave regime may contribute to changes in seabed morphology due to alteration of sediment transport patterns.

150. The wave modelling considered several wave directions to determine the worst-case direction. The simulations predict that changes in the 50th percentile return period waves approaching from northerly and easterly directions resulted in the worst-case wave conditions. This combination of directional sector and return period was therefore used in the assessment of effects. All the results from the wave modelling campaign are presented in **Section 8.4.4** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**.

151. **Figure 8-42** shows the worst-case percentage differences in significant wave height between the baseline condition and the worst-case Project foundation layout for waves from the northerly and easterly directions. The presence of the Project is predicted to result in a reduction in significant wave height, up to 0.04m to 0.06m within the confines of the Array Area. With distance, the effect gradually reduces until there is no impact on wave conditions. The maximum changes represent less than 4% of the baseline wave heights (**Figure 8-43**).

8.7.3.2.1 Receptor Sensitivity

152. The potential receptor to changes in wave heights across the Array Area is the Dogger Bank. Considering the water depths on Dogger Bank, waves are not the primary driver of sediment transport, therefore, Dogger Bank is not sensitive to changes in wave regime and the value and sensitivity of this receptor are presented in **Table 8-36**.

Table 8-36 Sensitivity and Value Assessment of the Dogger Bank Receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**

8.7.3.2.2 Impact Magnitude

153. The worst-case changes in the wave regime due to the presence of monopile foundations are likely to have the magnitudes of impact shown in **Table 8-37**. The zone of influence for waves encroaches into the Dogger Bank receptor. The change in wave height would only be a few percent within this zone of encroachment.

Table 8-37 Magnitude of Impact on the Wave Regime under the Worst-Case Scenario for the Presence of Monopile Foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	High	Medium	Negligible	**Low**
Far-field	Negligible	High	Medium	Negligible	**Negligible**

8.7.3.2.3 Effect Significance

154. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **low** in the near-field and **negligible** in the far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

8.7.3.3 Changes in water circulation due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-03)

155. The main potential impact on the Flamborough Front is changes in near field mixing due to local foundation wake effects and the potential for local destabilisation of water column stratification (i.e. those restricted to the area inside and immediately outside the Array Area) driven by interaction of the tidal current processes with the foundations.

156. The Flamborough Front is a strongly stratified regional feature in spring and summer and the high buoyancy forces associated with the stratification would not be destabilised by the local and relatively small turbulent wakes generated in the near field of each foundation.

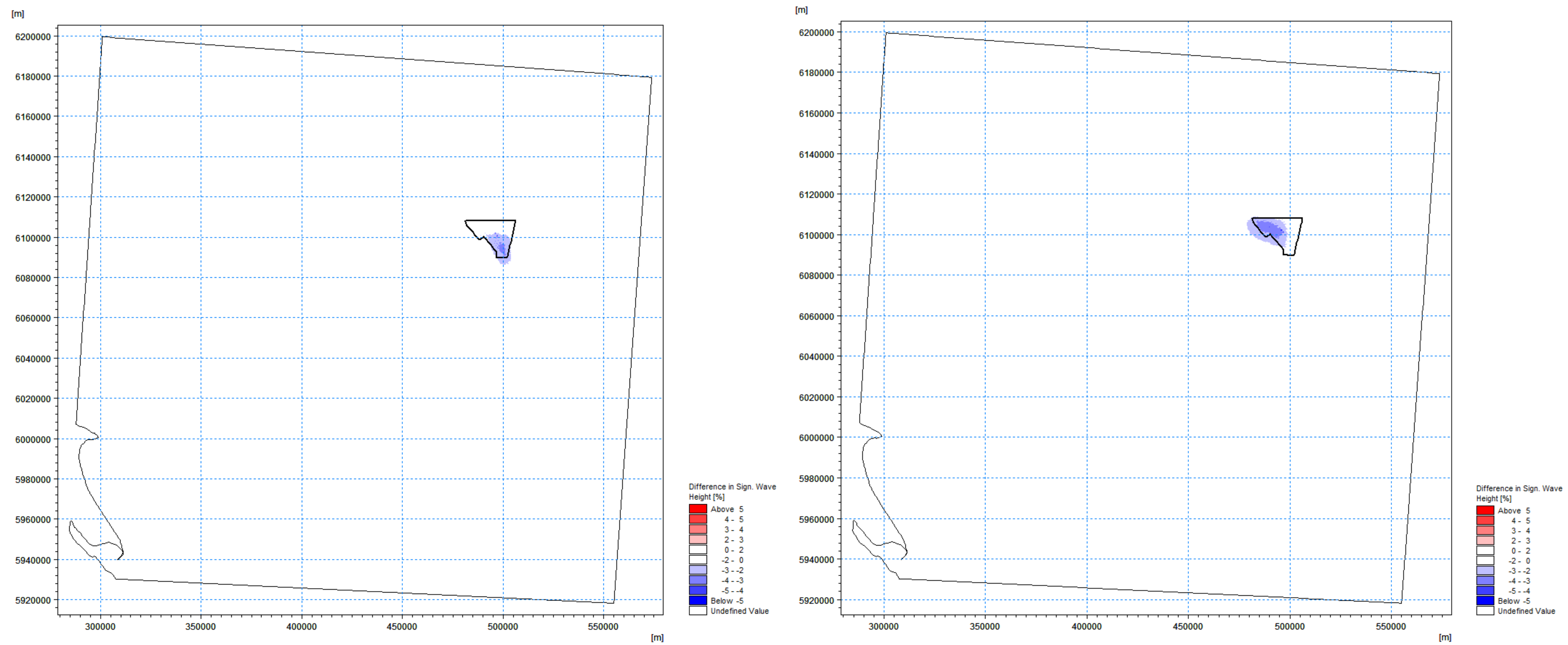

Figure 8-42 Percentage Difference in Significant Wave Height between Baseline and Windfarm Turbine Layout C for Waves Approaching from a northerly direction during a 50th Percentile Return Period event (left) and Waves approaching from the East during a 50th Percentile Return Period Event (right)

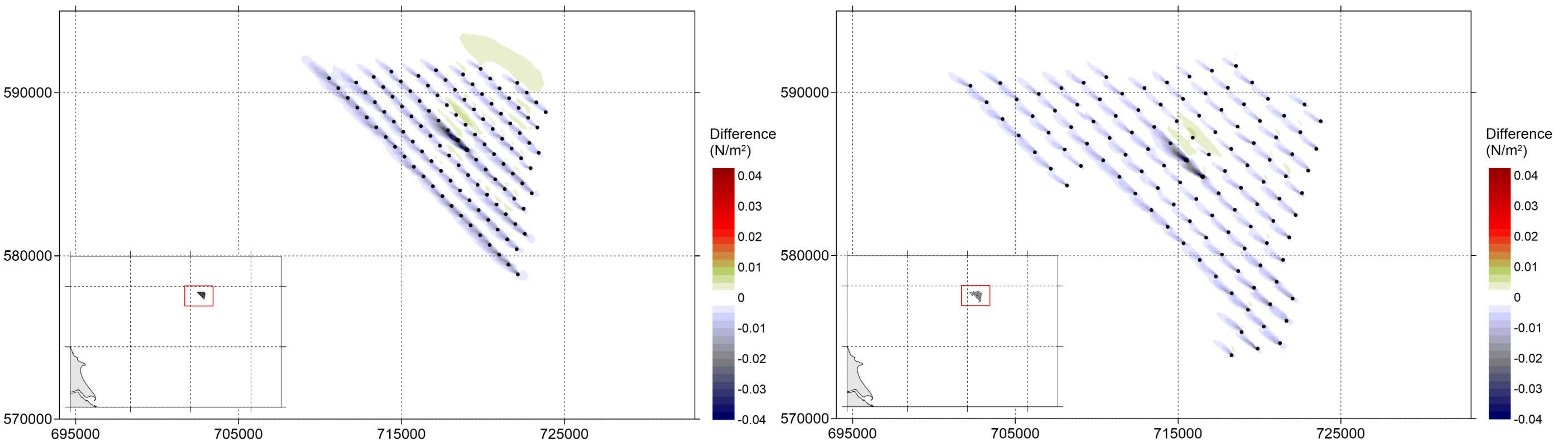

Figure 8-43 Difference in Maximum Bed Shear Stress over 30 days between Baseline and Windfarm using Turbine Layout B (left) and Turbine Layout C (right)

157. The North Sea within and around the Array Area is stratified for less than 40 days a year and they are within a region categorised as intermittently stratified (van Leeuwen *et al.*, 2025). The nearest seasonally stratified region (stratified for greater than 120 days) is located about 15km north of the Array Area. The Flamborough Front may be present occasionally at the Array Area, but for most of the time the water is well-mixed, so any effect would be temporally limited even if it did occur.

158. With wind turbine spacings of 826m to 1,416m across the Array Area, it is unlikely that wake to wake interactions would occur, and individual wakes would remain independent of each other and quickly dissipate away from each foundation (in the order of minutes and tens to hundreds of metres).

8.7.3.3.1 Receptor Sensitivity

159. The Flamborough Front may be present seasonally within the Array Area and offshore ECC. Hence, the value and sensitivity of this receptor is presented in **Table 8-38**.

Table 8-38 Sensitivity and Value Assessment of the Flamborough Front Receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Flamborough Front	High	High	Medium	Medium	Low

8.7.3.3.2 Impact Magnitude

160. The worst-case for changes in water circulation due to the presence of the foundations are likely to have the magnitudes of impact shown in **Table 8-39**. The Flamborough Front is a highly dynamic and transient feature at a regional-scale, that may be present in the region of the Array Area for less than 40 days a year. Hence, it would not be affected by localised, small-scale changes in water column turbulence induced by individual near-field wakes at foundation locations, especially if the strength of stratification (due to buoyancy forces) was sufficient to overcome any increased mixing.

Table 8-39 Magnitude of Impact on Water Circulation under the Worst-case Scenario for the Presence of Monopile Foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	High	Medium	Negligible	**Low**
Far-field	Negligible	High	Medium	Negligible	**Negligible**

8.7.3.3.1 Effect Significance

161. Overall, it is predicted that the sensitivity of the receptor is **low** and the magnitude of impact is **low** in the near-field and **negligible** in the far-field. The effect is therefore of **minor** significance of effect, which is **not significant** in EIA terms. No additional mitigation is proposed.

8.7.3.4 Changes in bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-04)

162. Modifications to the tidal current regime and / or the wave regime due to the presence of the foundation structures during the operation and maintenance phase may manifest as changes in sediment transport regime.

163. The predicted reductions in tidal currents (Operational Impact MPP-O-01) and waves (Operational Impact MPP-O-02) associated with the presence of the worst-case monopile foundation structures would result in a reduction in the sediment transport potential across the areas where such changes are observed. Conversely, the smaller areas of increased tidal flow would result in increased sediment transport potential.

164. These changes in the marine physical processes would be low in magnitude. For tidal currents, the maximum change is a reduction in speed of up to 0.04m/s, and the change is largely confined to within the Array Area. For waves, the maximum changes represent less than 3% of the baseline wave heights. A comparison of predicted bed shear stress values before and after the installation of the Project shows that changes in the Array Area would be maximum reductions of about 0.04N/m^2 (**Figure 8-43**).

165. The main concern with respect to seabed morphology is the potential for changes in the form and function of Dogger Bank. The reduction in bed shear stress may reduce the potential for mobilisation of sediment limiting its supply to nearby areas. However, changes in bed shear stress of up to 0.04N/m^2 are very small, and any changes of this magnitude would not change the particle size fractions that could be mobilised (**Figure 8-43**). This would continue to allow sand, the dominant sediment type, to be transported into, across and out of the Array Area.

8.7.3.4.1 Receptor Sensitivity

166. The potential receptor to changes in bedload sediment transport and seabed morphology across the Array Area is the Dogger Bank. The value and sensitivity of this receptor are presented in **Table 8-40**.

Table 8-40 Sensitivity and Value Assessment of the Dogger Bank Receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	High	**Negligible**

8.7.3.4.2 Impact Magnitude

167. The worst-case for changes in bedload sediment transport regime and seabed morphology are likely to have the magnitudes of impact shown in **Table 8-41**. The effects on bedload transport can be translated into a zone of potential influence the same as that for bed shear stress. The zone of potential influence is based on the knowledge that near-field effects arising from wind turbine and offshore platform foundations on the tidal and wave regimes are relatively small in magnitude, and localised and as such, any changes in bed shear stress will be of a similar scale and extent. Far-field effects are smaller in magnitude but cover greater distances. The zone of influence for bedload sediment transport regime and seabed morphology encroaches into the Dogger Bank receptor. However, changes in bedload sediment transport due to the presence of foundations will be small.

Table 8-41 Magnitude of Impact on the Bedload Sediment Transport Regime and Seabed Morphology under the Worst-Case Scenario for the Presence of Monopile Foundations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Low	High	Medium	Negligible	**Low**
Far-field	Negligible	High	Medium	Negligible	**Negligible**

8.7.3.4.3 Effect Significance

168. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **low** in the near-field and **negligible** in the far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

8.7.3.5 Changes in bedload sediment transport and seabed morphology due to the presence of cable protection measures (MPP-O-05)

169. As a worst-case scenario, it has been assumed that burial of the Inter-Array Cables and Offshore Export Cables would not practicably be achievable within some areas and, instead, cable protection measures would need to be provided to surface-laid cables in these areas. The locations where cable protection measures are most likely to be required are cable crossings and in areas of seabed characterised by exposed bedrock. Cable protection may take the form of rock placement, concrete mattresses, rock bags, and flow dissipation devices.

170. The anticipated amount of cable protection that will be installed will be known closer to the time of construction upon further site investigations into the ground conditions. Therefore, assumptions have been made as to the quantity required at this time, based on 35 visits over the Project's lifetime, which is one per year of approximately 10km each time for the Offshore Export Cable route and Inter-Array Cables separately as requiring protection. Therefore, the worst-case SSCs due to cable repairs / reburials as the worst-case scenario is 10,158,000m^3 (see **Table 8-5**).

171. The impacts that Offshore Export Cable protection may have on marine physical processes primarily relate to the potential for interruption of sediment transport processes and the footprint they present on the seabed. In areas of active sediment transport, any linear protrusion on the seabed may interrupt bedload sediment transport processes. There is likely to be a difference in impact depending on whether the cable protection works are in the nearshore or offshore. Any works in areas close to the coast have the potential to affect wave-driven longshore sediment transport processes and circulatory pathways across any nearshore banks (e.g. Smithic Bank).

172. Offshore, the potential magnitude of the impact will depend on the local sediment transport rates. A lower rate would reduce the potential impact on sediment supply to wider areas. There are likely to be a range of sediment transport potentials across the export cables. If Pleistocene geological units are exposed at the seabed or covered by a thin lag, then they are static and have zero transport potential (i.e. no mobile sediment). If the cable protection is laid in these areas, then sediment transport is not an issue as no sediment is being transported.

173. Where the seabed is composed of mobile sand, it can be transported under existing tidal conditions. If the cable protection does present an obstruction to this bedload transport the sediment would first accumulate one side or both sides of the obstacle (depending on the gross and net transport at that location) to the height of the protrusion (up to 1.5m). With continued build-up, it would then form a 'ramp' over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cables would therefore not be impacted significantly.

174. The magnitude of wave driven transport would decrease with distance offshore within the closure depth (in around 6m of water, which is approximately 860m from the base of the cliffs), with other evidence suggesting that the most active zone for wave-driven sediment transport along the Holderness coast is the intertidal zone. In a study at Easington along south Holderness, HR Wallingford (2011) showed that most of the longshore transport from wave breaking occurs close to the shoreline, within approximately 250m of the cliff line. Seaward of this, the wave-driven sediment transport is effectively zero. Given the similar shore profiles at the landfall and Easington the

conclusion can be drawn that the active zone at the landfall is similar in width to that at Easington. Hence, sediment transport driven by waves seaward of 250m from the cliffs at the landfall is very low (although still within the closure depth) and there will be no effect on these processes by the presence of the cable protection structures.

8.7.3.5.1 Receptor Sensitivity

175. Temporary interruptions to bedload sediment transport due to the presence of cable protection in the nearshore zone have the potential to impact coastal receptors. Further offshore, Dogger Bank may also be affected by cable protection measures. Hence, the potential receptors to interruptions to bedload sediment transport and seabed morphology due to cable protection are Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank. The value and sensitivity of these receptors are presented in **Table 8-42**.

Table 8-42 Sensitivity and Value Assessment of Receptors Relevant to Interruptions to Bedload Sediment Transport and Seabed Morphology due to Cable Protection

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**
Flamborough Head SSSI	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Offshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Inshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Smithic Bank	Negligible	Negligible	Negligible	Medium	**Negligible**

8.7.3.5.2 Impact Magnitude

176. Within the closure depth across the most active zone of wave-driven sediment transport, there will be no effect on sediment transport processes because here the export cables will be buried. Hence, there will be no interruption of wave-driven alongshore sediment supply to the coast south of the landfall. Offshore of the closure depth, the effects on wave-driven bedload sediment transport and seabed morphology arising from the presence of cable protection measures would not extend far beyond the direct footprint. Here, any changes in sediment transport will largely be driven by tidal currents.

177. The worst-case changes in bedload sediment transport and seabed morphology due to cable protection are likely to have the magnitudes of impact shown in **Table 8-43**.

Table 8-43 Magnitude of Impact on Bedload Sediment Transport and Seabed Morphology under the Worst-Case Scenario for Cable Protection

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Medium	Low	Low	Negligible	**Low**
Far-field	Negligible	Negligible	Negligible	Negligible	**Negligible**

8.7.3.5.3 Effect Significance

178. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **low** in the near-field and **negligible** in the far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

8.7.3.6 Changes in suspended sediment concentration, transport, and seabed level due to cable repairs and reburial (MPP-O-06)

179. Cable repairs and reburial could be needed over the operational lifetime of the Project. The disturbance areas for reburial and repairs of cables are extremely small in comparison to construction. Also, repair activities will not all occur in one location or all at the same time so the footprint of potential repairs within the designated sites will be considerably lower. Hence, the sediment volumes arising from repair and reburial would be small in magnitude and cause an insignificant impact in terms of enhanced suspended sediment concentrations and deposition elsewhere.

8.7.3.6.1 Receptor Sensitivity

180. The potential receptors to change in suspended sediment concentration, transport, and seabed level are Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank.

181. Due to the nature of the pressure of an increase in suspended sediment concentrations due to cable repairs and reburial there is no pathway for effect to any of the identified receptors so therefore they are not sensitive to this pressure. This is because the receptors are dominated by processes that are active along the seabed and not affected by suspended sediment in the water column. Hence, features within the identified receptors are only sensitive to the potential change in seabed level. The value and sensitivity of these receptors are presented in **Table 8-44**.

Table 8-44 Sensitivity and Value Assessment of Receptors Relevant to Changes in Seabed Level due to Cable Repairs and Reburial

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**
Flamborough Head SAC	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Offshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Holderness Inshore MCZ	Negligible	Negligible	Negligible	High	**Negligible**
Smithic Bank	Negligible	Negligible	Negligible	Medium	**Negligible**

8.7.3.6.2 Impact Magnitude

182. The worst-case changes in seabed level due to cable repairs and reburial are likely to have the magnitudes of impact shown in **Table 8-45**.

Table 8-45 Magnitude of Impact on Seabed Level under the Worst-Case Scenario for Cable Repairs and Reburial

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Negligible	Negligible	Negligible	Negligible	**Negligible**
Far-field	Negligible	Negligible	Negligible	Negligible	**Negligible**

8.7.3.6.3 Effect Significance

183. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **negligible** in the near-field and far-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms.

184. However, the impacts on seabed level have the potential to affect other receptors and the assessment of effect significance is addressed within the relevant chapters of this PEIR (**Chapter 10 Benthic and Intertidal Ecology**, **Chapter 11 Fish and Shellfish Ecology**, **Chapter 14 Commercial Fisheries** and **Chapter 17 Offshore Archaeology**).

8.7.3.7 Indentations on the seabed due to Repair and Maintenance vessels (MPP-O-08)

185. There is potential for certain vessels used during operation and maintenance of foundations and cable infrastructure to directly impact the seabed. As outlined above in **Section 8.7.2.5**, the worst-case scenario applies to those vessels that utilise jack-up legs to hold station and to provide stability for a working platform. The number of repairs required is unknown, but a significantly lower number of vessels will be required when compared with the construction phase.

8.7.3.7.1 Receptor Sensitivity

186. Installation of foundations within the Array Area will result in jack-up indentations within Dogger Bank and the value and sensitivity of this receptor is presented in **Table 8-46**.

Table 8-46 Sensitivity and Value Assessment of the Dogger Bank Receptor

Receptor	Tolerance	Adaptability	Recoverability	Value	Sensitivity
Dogger Bank	Negligible	Negligible	Negligible	Low	**Negligible**

8.7.3.7.2 Impact Magnitude

187. The worst-case changes in seabed level due to indentations are likely to have the magnitudes of impact shown in **Table 8-47**. The number of operation and repair activities requiring use of a jack-up platform is unknown but expected to be considerably less than during construction. Any disturbance footprint would be limited in scale and any impacts would be temporary in nature with indentations infilling through natural processes over the course of days to months.

Table 8-47 Magnitude of Impact on Seabed Level under the Worst-case Scenario for Installation Vessel Indentations

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Near-field	Medium	Low	Negligible	Low	**Low**
Far-field	No change	-	-	-	**No change**

8.7.3.7.3 Effect Significance

188. Overall, it is predicted that the sensitivity of the receptor is **negligible** and the magnitude of impact is **negligible** in the near-field. The effect is therefore of **negligible** significance of effect, which is **not significant** in EIA terms

8.7.4 Potential Effects during Decommissioning

189. No decision has been made regarding the final decommissioning strategy for the offshore infrastructure, as it is recognised that regulatory requirements and industry best practice change over time.

190. Commitment ID CO21 (see **Table 8-4**) requires an Offshore Decommissioning Programme to be prepared and agreed with the relevant authorities prior to the commencement of offshore decommissioning works. This will ensure that decommissioning impacts will be assessed in accordance with the applicable regulations and guidance at that time of decommissioning where relevant, with appropriate mitigation implemented as necessary to avoid significant effects.

191. The detailed activities and methodology for decommissioning will be determined later within the Project's lifetime, but would be expected to include:

- Removal of all the wind turbine components and part of the foundations (those above seabed level);
- Removal of some or all of the array and export cables;
- The inter-array and offshore export cables will likely be cut at the cable ends and left in-situ below the seabed, and scour and cable protection would likely be left in-situ other than where there is a specific condition for its removal.

192. Whilst a detailed assessment of decommissioning impacts cannot be undertaken at this stage, for this assessment, it is assumed that decommissioning is likely to operate within the parameters identified for construction (i.e. any activities are likely to occur within the temporary construction working areas and require no greater amount or duration of activity than assessed for construction). The decommissioning sequence will generally be the reverse of the construction sequence. It is therefore assumed that decommissioning impacts would likely be of similar nature to, and no worse than, those identified during the construction phase.

193. The magnitude of decommissioning effects will be comparable to, or less than, those as assessed during the construction phase. Accordingly, marine physical processes receptors during the construction phase, it is anticipated that the same would be valid for the decommissioning phase regardless of the final decommissioning methodologies. Therefore, all would be considered as **not significant** in EIA terms.

8.7.5 Additional Mitigation Measures

194. No additional mitigation measures have been proposed for marine physical processes.

8.8 Cumulative Effects

195. Cumulative effects are the result of the impacts of the Project acting in combination with the impacts of other proposed and reasonably foreseeable developments on receptors. This includes plans and projects that are not inherently considered as part of the current baseline.

196. The overarching framework used to identify and assess cumulative effects is set out in **Chapter 6 Environmental Impact Assessment Methodology**. The four-stage approach is based upon the Planning Inspectorate Advice Note Seventeen: Cumulative Effects Assessment (Planning Inspectorate, 2024 and the Offshore Wind Marine Environmental Assessments: Best Practice Advance for Evidence and Data Standards (Parker *et al.*, 2022). The fourth stage of the process is the assessment stage, which is detailed within the sections below for potential cumulative effects on marine physical processes receptors.

8.8.1 Screening for Potential Cumulative Effects

197. The first step of the CEA identifies which impacts associated with the Project alone, as assessed under **Section 8.7**, have the potential to interact with other plans and projects to give rise to cumulative effects. All potential cumulative effects to be taken forward in the CEA are detailed in **Table 8-48** with a rationale for screening in or out. Only impacts determined to have a residual effect of negligible or greater are included in the CEA. Those assessed as 'no impact' are excluded, as there is no potential for them to contribute to a cumulative effect.

Table 8-48 Marine Physical Processes – Potential Cumulative Effects

Impact ID	Impact and Project Activity	Potential for Cumulative Effects	Rationale
Construction			
MPP-C-03	Changes in suspended sediment concentration, transport, and seabed level due to drilling for foundation installation	No	Effects occur at discrete locations for a time-limited duration.
MPP-C-04	Changes in suspended sediment concentration, transport, and seabed level due to seabed preparation for foundation installation	No	Effects occur at discrete locations for a time-limited duration.

Impact ID	Impact and Project Activity	Potential for Cumulative Effects	Rationale
MPP-C-05	Changes in suspended sediment concentration, transport, and seabed level due to Inter-Array Cable and Offshore Export Cable installation including at the landfall	Yes	Depending on the construction timetable for other offshore wind farms, there is potential for temporal overlap in construction periods which could have a cumulative effect in relation to changes in seabed level due to deposition of suspended sediment.
MPP-C-06	Interruptions to bedload sediment transport due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation	Yes	Depending on the construction timetable for other offshore wind farms, there is potential for temporal overlap in construction periods which could have a cumulative effect in relation to interruptions to bedload sediment transport due to sand wave levelling.
MPP-C-07	Indentations on the seabed due to the presence of installation vessels	No	Effect occurs at discrete locations for a time-limited duration.
Operation & Maintenance			
MPP-O-01	Changes in the tidal current regime due to the presence of infrastructure (wind turbine and offshore platform foundations)	Yes	Cumulative effects could occur due to the presence of the Project alongside nearby offshore wind farms.
MPP-O-02	Changes in the wave regime due to the presence of infrastructure (wind turbine and offshore platform foundations)	Yes	Cumulative effects could occur due to the presence of the Project alongside nearby offshore wind farms.
MPP-O-03	Changes in water circulation due to the presence of infrastructure (wind turbine and offshore platform foundations)	Yes	Cumulative effects on the Flamborough Front could occur due to the presence of the Project alongside nearby offshore wind farms.
MPP-O-04	Changes in bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbine and offshore platform foundations)	Yes	Cumulative effects could occur due to the presence of the Project alongside nearby offshore wind farms.
MPP-O-05	Changes in bedload sediment transport and seabed morphology due to the presence of cable protection measures	Yes	Effects could potentially coalesce with those arising from nearby offshore wind farms to cumulatively change sediment transport pathways.
MPP-O-06	Changes in suspended sediment concentration, transport, and seabed level due to cable repairs and reburial	No	Effect occurs at discrete locations for a time-limited duration.
MPP-O-08	Indentations on the seabed due to repair and maintenance vessels	No	Effect occurs at discrete locations for a time-limited duration.

Impact ID	Impact and Project Activity	Potential for Cumulative Effects	Rationale
Decommissioning			
MPP-D-02	Changes in the wave regime – decommissioning activities not yet defined	No	Effect occurs at discrete locations for a time-limited duration.
MPP-D-03	Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined	No	Effect occurs at discrete locations for a time-limited duration.
MPP-D-04	Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined	No	Effect occurs at discrete locations for a time-limited duration.
MPP-D-05	Interruptions to bedload sediment transport- decommissioning activities not yet defined	No	Effect occurs at discrete locations for a time-limited duration.
MPP-D-06	Indentations on the seabed - decommissioning activities not yet defined	No	Effect occurs at discrete locations for a time-limited duration.
MPP-D-07	Impacts on water circulation (Flamborough Front) – decommissioning activities not yet defined	No	Effect occurs at discrete locations for a time-limited duration.

8.8.2 Screening for Other Plans / Projects

198. The second step of the CEA identifies a short-list of other plans and projects that have the potential to interact with the Project to give rise to significant cumulative effects during the construction and operation and maintenance phases. The short-list provided in **Table 8-49** has been produced specifically to assess cumulative effects on marine physical processes receptors. The exhaustive list of all offshore plans and projects considered in the development of the Project's CEA framework is provided in **Volume 2, Appendix 6.4 Cumulative Effects Screening Report - Offshore**.

199. Developments that were fully operational during baseline characterisation, including at the time of site-specific surveys, are considered as part of baseline conditions for the surrounding environment. It is assumed that any residual effects associated with these developments are captured within the baseline information. As such, these developments are not subject to further assessment within the CEA and excluded from the screening exercise presented in **Table 8-49**.

200. For developments that were not fully operational, including those in planning / pre-construction stages or under construction, during baseline characterisation and operational developments with potential for ongoing impacts, these are included in the screening exercise presented in **Table 8-49**.

201. The screening exercise has been undertaken based on available information on each plan or project as of 31st December 2024.

202. The following sources have been used for the desk-based study to define the offshore CEA longlist:

- Marine Management Organisation Public Register (Marine case management system - Public register - MCMS);
- MD-LOT Marine Licence Applications Portal (All applications | marine.gov.scot);
- Planning Inspectorate, National Infrastructure Planning Portal (National Infrastructure Planning);
- East Riding of Yorkshire Council planning website (Planning permission and building control);
- Hull City Council planning website (www.hull.gov.uk/planning-applications/planning);
- 4C Offshore website (Global Offshore Renewables Map | 4C Offshore);
- UK Offshore Wind Report 2023 (UK Offshore Wind Report 2023);
- Offshore wind farm specific websites;

- The Crown Estate Aggregates Portal (Aggregates Site Agreements (England, Wales & NI), The Crown Estate | The Crown Estate Open Data Portal);
- North Sea Transition Authority UKCS Lease Agreements (UKCS Lease Agreements);
- Cefas UK Disposal Sites (Cefas Data Portal - View);
- KIS-ORCA Infrastructure Map (Map | KIS-ORCA);
- North Sea Transition Authority Offshore Activity Map (Offshore Activity);
- UK Government EIA Submissions and Decisions (EIA Submissions and Decisions - Search - GOV.UK);
- UKHO Military Practice Areas (Additional Military Layers | ADMIRALTY); and
- SCCS Global CCS Map (Global CCS Map | SCCS Corporate).

203. It is noted that further information regarding the identified plans and projects may become available between PEIR publication and DCO application submission or may not be available in detail prior to construction. The assessment presented here is therefore considered to be conservative at the time of PEIR publication. The list of plans and projects will be updated at ES stage to incorporate more recent information at the time of writing.

204. Plans and projects identified in **Table 8-49** have been assigned a tier based on their development status, the level of information available to inform the CEA and the degree of confidence. A seven-tier system based on the guidance issued by Natural England and the Department of Environmental, Food and Rural Affairs (Defra) has been adopted (Parker *et al.*, 2022).

205. The ZOI used to identify relevant plans and projects for the marine physical processes CEA depends on the effect being assessed. A ZOI is defined for each potential effect. These are:

- 'Zone of Influence tide' for changes in tidal currents (and changes in suspended sediment concentration) defined by the outputs of the hydrodynamic modelling supported by tidal ellipse data;
- 'Zone of Influence wave' for changes in wave regime defined by the outputs of wave modelling; and
- 'Zone of Influence coast' for changes in sediment transport at the coast. The offshore ZOI is determined by the closure depth, the onshore ZOI by coastal erosion / shoreline retreat and the longshore ZOI on sediment sources, sinks, availability, transport rates and the tidal ellipse.

206. Each plan or project in **Table 8-49** has been considered on a case-by-case basis. Only plans and projects with potential for significant cumulative effects with the Project are taken forward to a detailed assessment, which are screened based on the following criteria:

- There is potential that a pathway exists whereby an impact could have a cumulative effect on a receptor;
- The impact on a receptor from the Project and the plan or project in consideration has a spatial overlap (i.e. occurring over the same area);
- The impact on a receptor from the Project and the plan or project in consideration has a temporal overlap (e.g. occurring at the same time);
- There is sufficient information available on the plan or project in consideration and moderate to high data confidence to undertake a meaningful assessment; and
- There is some likelihood that the residual effect (i.e. after accounting for mitigation measures) of the Project could result in significant cumulative effects with the plan or project in consideration.

207. The CEA for marine physical processes has identified a total of six plans and projects where significant cumulative effects could arise in combination with the Project. A detailed assessment of cumulative effects is provided in the section below.

8.8.3 Assessment of Cumulative Effects

8.8.3.1 Cumulative Effect 1: Changes in suspended sediment concentration, transport, and seabed level due to Inter-Array Cable and Offshore Export Cable installation including at the landfall (MPP-C-05)

208. It is likely that the construction of the Hornsea Project 4, DBS, and DBD's offshore ECC would be relatively close in proximity to each other (**Table 8-49**). As construction on Hornsea Project 4 and DBS will be between 2025 and 2029, and 2026 and 2032, respectively, and construction of DBD will start no earlier than 2029, there also exists the potential for a temporal overlap in cable construction activities. However, it is highly unlikely cable installation activities for Hornsea Project 4 and DBS would occur at the same location and time as cable installation activities for DBD due to safety constraints, so cumulative effects in relation to changes in suspended sediment concentration and transport due to offshore cable installation are not expected.

209. The potential receptors to cumulative changes in suspended sediment concentration, transport, and seabed level along the offshore ECC are Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank. The overall effect of cable installation on seabed level changes across these receptors is of **negligible** significance and therefore **not significant** in EIA terms.

Table 8-49 Short List of Plans / Projects for the Marine Physical Processes Cumulative Effect Assessment

Project / Plan	Development Type	Status	Tier	Construction / Operation Period	Closest Distance to Array Area (km)	Closest Distance to Offshore ECC (km)	Potential for Significant Cumulative Effects	Rationale
Dogger Bank A (EN010021)	Offshore Wind Farm	Under construction	2	Construction: 2025 Operation: 2026 onwards	43	31	Yes	Potential for spatial overlap during construction and operation.
Dogger Bank B (EN010021)	Offshore Wind Farm	Under construction	2	Construction: 2025 to 2026 Operation: 2027 onwards	52	9	Yes	Potential for spatial overlap during construction and operation.
Dogger Bank C	Offshore Wind Farm	Under construction	2	Construction: 2025 to 2027 Operation: 2028 onwards	0	3	Yes	Potential for spatial overlap during construction and operation.
Dogger Bank South (EN010125)	Offshore Wind Farm	Examination	4	Construction: 2026 to 2032 Operation: 2031 onwards	70	16	Yes	Potential for spatial overlap during construction and operation.
Hornsea Project 4 (EN010098)	Offshore Wind Farm	Consented	3	Construction: 2025 to 2029 Operation: 2031 onwards	134	31	Yes	Potential for spatial overlap during construction and operation.
Sofia (EN010051)	Offshore Wind Farm	Under construction	2	Construction: 2025 Operation: 2026 onwards	18	23	Yes	Potential for spatial overlap during construction and operation.

8.8.3.2 Cumulative Effect 2: Interruptions to bedload sediment transport due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation (MPP-C-06)

210. The offshore ECCs for the DBA, DBB, DBC, Sofia, and the planned DBS and Hornsea Project 4 offshore wind farms are located between approximately 3km and 31km away from the offshore ECC (**Table 8-49**). Therefore, as effects of export cable installation for the Project in isolation are predicted to be **negligible** and therefore **not significant** in EIA terms in the near-field, there would be no interaction with sediment transport between the projects because of export cable installation. The greatest potential for cumulative effects is near the coast where the offshore export cables for these projects make landfall. However, there are no sand waves in the nearshore (see section8.6.1.8), therefore it is unlikely sand wave clearance would be undertaken.

8.8.3.3 Cumulative Effect 3: Changes in the tidal current regime due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-01)

211. There is the potential for cumulative impacts on tidal currents due to the combined effect of the presence of the Project with existing wind farms DBA, DBB, DBC and Sofia (Option 1) and the combined effect of existing wind farms along with the planned DBS Windfarm array (Option 2) (**Figure 8-44**).

212. The potential cumulative impact on tidal currents was assessed using the results of the hydrodynamic model (**Section 8.4.5** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**). **Figure 8-44** presents the predicted differences in tidal current speed over the 30-day simulation period. They show that, cumulatively, the wind farms are predicted to have only a localised impact on tidal currents.

213. For Option 1, the model predicts small changes in current speeds at DBA, DBB, and Sofia, for all spring and neap tides. For DBC and the Project, the model predicts a higher level of change of maximum tidal speed than for the rest of the wind farm locations, between 0.002m/s and 0.004m/s for all tides. Most of this change occurs in the location of DBD, with the furthest extent of the change stretching into DBC.

214. For Option 2, the model predicts that the changes in maximum current speeds will be higher at the proposed site for DBS (both East and West) than anywhere else in the layout. Changes in maximum current speed of 0.002m/s to 0.006m/s are predicted.

215. For both Option 1 and Option 2, apart from overlap between the adjacent DBC and the Project at the array, there are no locations where the effects on tidal currents of one wind farm overlap with another.

216. The potential receptor to cumulative changes in tidal current speeds is Dogger Bank. However, the change in tidal current speed would only be a few percent within this zone of encroachment. Hence, the overall effect significance of changes in tidal currents on the relevant receptor is **negligible** and therefore **not significant** in EIA terms. As the zone of influence for changes in tidal regime due to the presence of foundations does not extend to the coast, there will be no cumulative effects on the nearshore tidal regime along the Holderness coast.

8.8.3.4 Cumulative Effect 4: Changes in the wave regime due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-02)

217. There is the potential for cumulative impacts on waves due to the combined effect of the presence of the Project with existing wind farms DBA, DBB, DBC, Sofia (Option 1), and the combined effect of existing wind farms along with the planned DBS Windfarm array (Option 2) (**Figure 8-45**).

218. The potential cumulative impact on waves was assessed using the results of the wave model (**Section 8.4.4** of **Volume 2, Appendix 8.3 Marine Physical Process Modelling Report**). **Figure 8-45** and **Figure 8-46** present the predicted differences in significant wave height between the baseline condition and cumulative Scenarios 1 and 2. The cumulative presence of the Project with other wind farms is predicted to result in a reduction in significant wave height, up to 3% to 4% of the baseline across the Project and DBS. Elsewhere (DBA, DBB, DBC, and Sofia), the presence of structure is predicted to reduce significant wave heights by less than 2%.

219. For both Option 1 and Option 2, apart from a small overlap between the adjacent DBC and the Project at the array, there are no locations where the effects on waves of one wind farm overlap with another.

220. The potential receptor to cumulative changes in waves is the Dogger Bank. The change in wave height would only be a few percent within this zone of encroachment. Hence, the overall effect significance of changes in waves on the relevant receptor is **negligible** and therefore **not** significant in EIA terms. As the zone of influence for changes in wave regime due to the presence of foundations does not extend to the coast, there will be no cumulative effects on the nearshore wave regime along the Holderness coast.

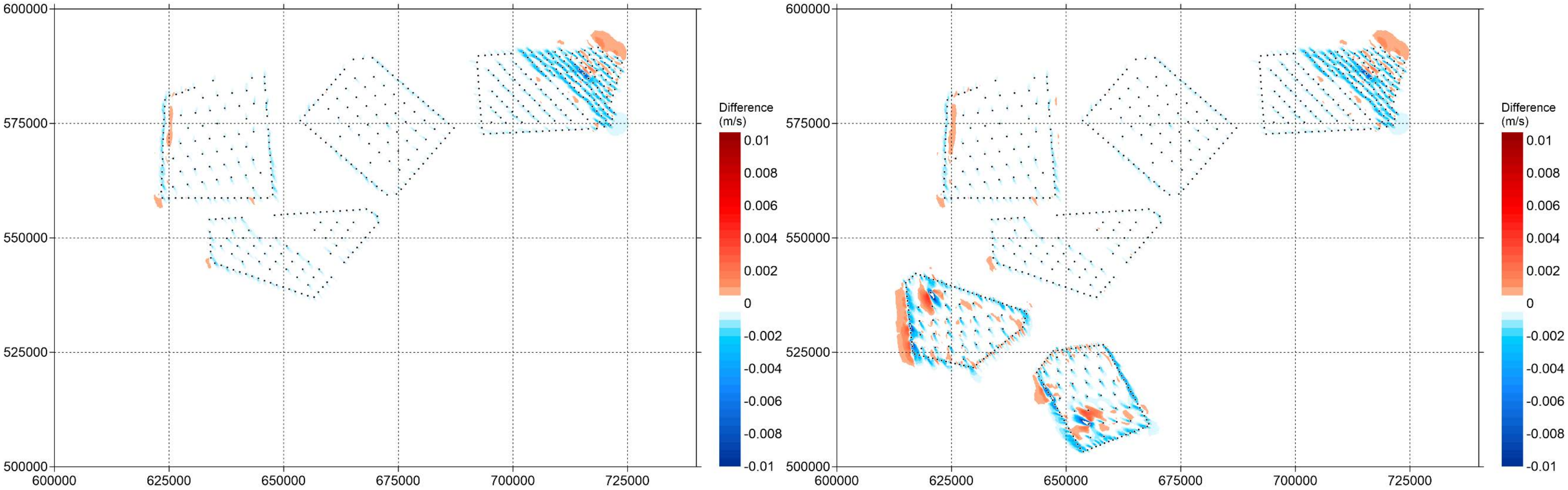

Figure 8-44 Cumulative difference in Maximum Current Speed over 30 days between Baseline and Option 1 (left) and Option 2 (right) (Turbine Layout C)

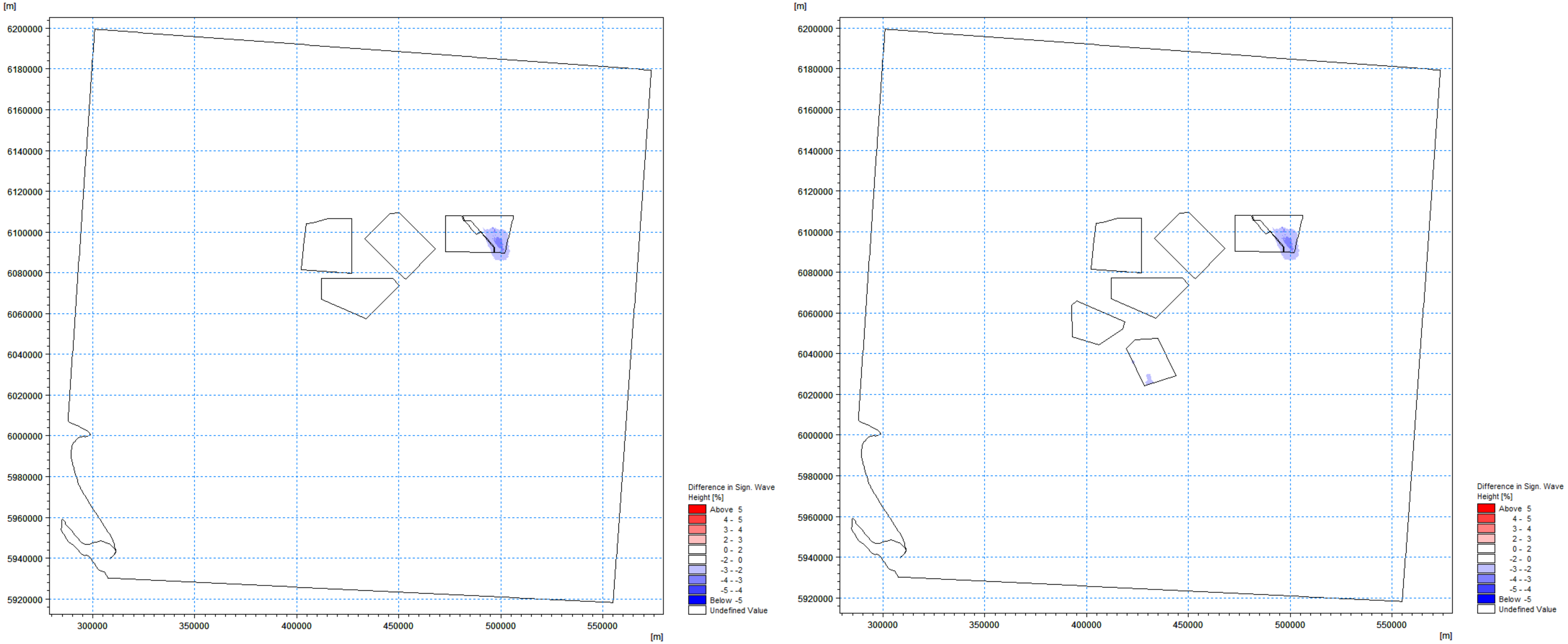

Figure 8-45 Cumulative Percentage difference in Significant Wave Height between Baseline and Option 1 (left) and Option 2 (right) (Turbine Layout C) for Waves approaching from a northerly direction during a 50th Percentile Return Period Event

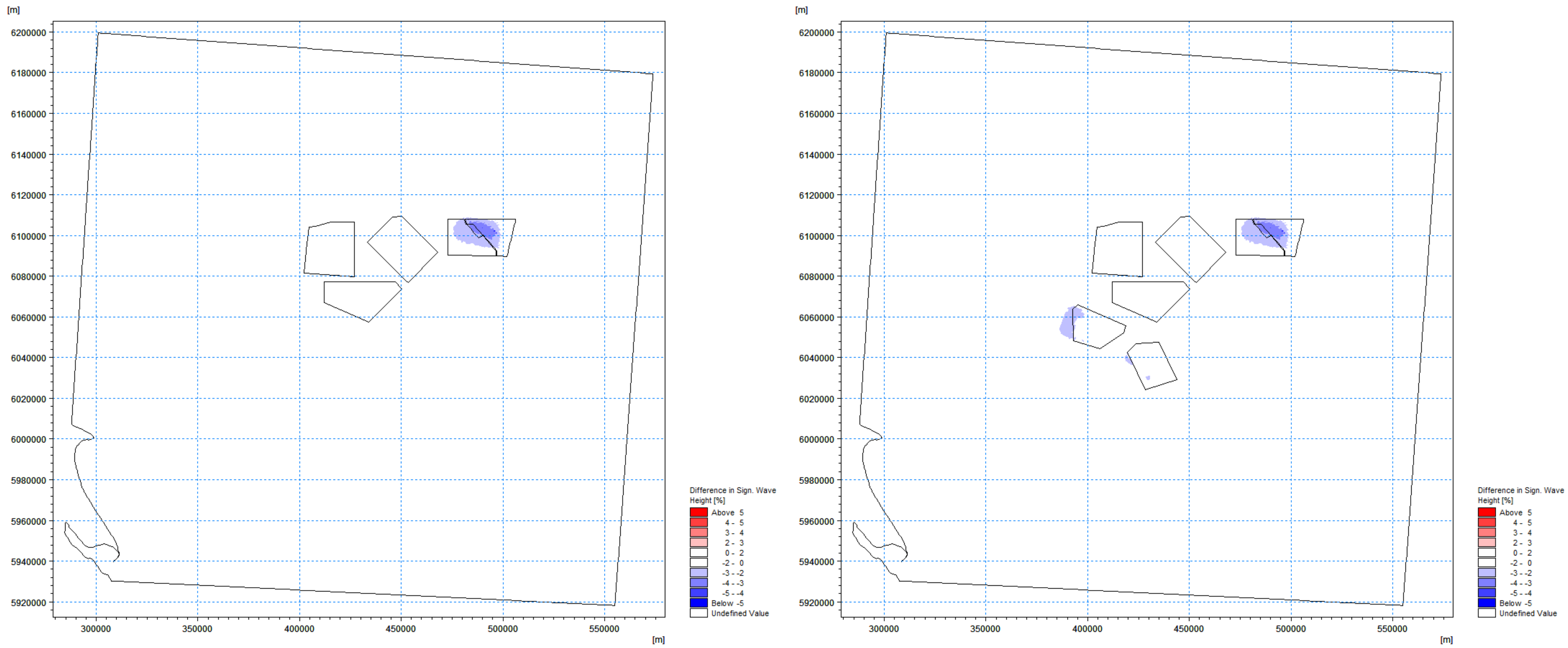

Figure 8-46 Cumulative Percentage difference in Significant Wave Height between Baseline and Option 1 (left) and Option 2 (right) (Turbine Layout C) for Waves Approaching from an easterly direction during a 50th Percentile Return Period Event

8.8.3.5 Cumulative Effect 5: Changes in water circulation due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-03)

221. The Array Area of the Project and those of existing and planned wind farms are in a region of the North Sea where there is potential for seasonal stratification to occur as the Flamborough Front develops and migrates. Turbulent wakes around foundation structures may enhance mixing of stratified water bodies and the cumulative presence of structures could lead to a cumulative effect if there is overlap between individual wakes. However, observations of turbulent wakes around foundation show that turbulence is energetic within a 100m of the structure but dissipates with distance (Schultze *et al.*, 2020).

222. Hence, there would be no overlapping effects expected between projects. Furthermore, turbulent mixing due to foundation structures are considered too weak to overcome buoyancy driven stratification at a regional scale. If any cumulative effects did occur, given the Flamborough Front is an ephemeral feature that may be present for less than 40 days a year (van Leeuwen *et al.*, 2015), these would be temporally restricted.

223. The magnitude of impact is low near the structures and **negligible** at a regional scale. Any cumulative significance of effect would be **negligible** and therefore **not significant** in EIA terms.

8.8.3.6 Cumulative Effect 6: Changes in bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbine and offshore platform foundations) (MPP-O-04)

224. Alterations to bedload sediment transport during the operation and maintenance phase would largely be driven by changes in tidal currents (MPP-O-01) and waves (MPP-O-01). Cumulative changes in tidal currents and waves with the adjacent wind farms would be **negligible** in magnitude due to the localised spatial extent. Since it is expected that the changes in tidal flow and wave heights would have no significant far-field impacts, then the changes in sediment transport would be of similar scale.

225. The potential receptor to cumulative changes in bedload sediment transport is Dogger Bank. The overall effect significance of changes in bedload sediment transport on the relevant receptor is **negligible** and therefore **not significant** in EIA terms. There will be no cumulative effects on the nearshore wave regime along the Holderness coast.

8.8.3.7 Cumulative Effect 7: Changes in bedload sediment transport and seabed morphology due to the presence of cable protection measures (MPP-O-05)

226. Potential effects could arise with DBS if the effects from cable protection measures combine to enhance the disturbance to sediment transport pathways, particular the potential effect in and around Smithic Bank. The DBS ECC is adjacent to the Project's Offshore Export Cable.

227. Near to Smithic Bank, the seabed is composed of mobile sand, which is transported under existing tidal conditions. If the combined cable protection does present an obstruction to this bedload transport the sediment would first accumulate one side or both sides of the obstacles (depending on the gross and net transport at that location) to the height of the protrusions. With continued build-up, it would then form a 'ramp' over which sediment transport would eventually occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cables would therefore not be impacted significantly.

228. Cumulative temporary interruptions to bedload sediment transport due to the presence of cable protection (particularly in the nearshore zone) have the potential to impact Flamborough Head SAC, Holderness Offshore MCZ, Holderness Inshore MCZ, Humber Estuary and Smithic Bank. However, given the process of ramping and continued supply of sediment beyond the obstructions means that the effects on bedload sediment transport due to the presence of cable protection measures are of **negligible** significance and therefore **not significant** in EIA terms.

8.9 Transboundary Effects

229. The potential for transboundary effects has been identified in relation to all impacts due to the proximity of the Doggersbank SAC which is under Dutch jurisdiction. The designation of this area is the habitat 'Sandbanks which are slightly covered by sea water all the time'. This is the same habitat that is currently protected under the Dogger Bank.

230. The marine physical processes that are operational adjacent to the Array Area within the Netherlands jurisdiction are like those assessed for the Array Area. No changes to suspended sediment concentration or seabed level extend into Doggersbank SAC during construction (**Figure 8-24** to **Figure 8-40**) and no changes to tidal currents or waves during operation occur within it (**Figure 8-41** and **Figure 8-42**).

231. Therefore, it proposed that no further assessment is required in terms of transboundary effects as their will be no effect in relation to the construction, operation and maintenance, and decommissioning phases of the Project.

8.10 Inter-Relationships and Effect Interactions

8.10.1 Inter-Relationships

232. Inter-relationships are defined as effects arising from residual effects associated with different environmental topics acting together upon a single receptor or receptors. Potential inter-relationships between marine physical processes and other environmental topics have been considered, where relevant, within the PEIR. **Table 8-50** provides a summary of key inter-relationships and signposts to where they have been addressed in the relevant chapters.

8.10.2 Interactions

233. The impacts identified and assessed in this chapter have the potential to interact with each other. Potential interactions between impacts are identified in **Table 8-51**. Where there is potential for interaction between impacts, these are assessed in **Table 8-52** for each receptor or receptor group.

234. Interactions are assessed by development phase ("phase assessment") to see if multiple impacts could increase the overall effect significance experienced by a single receptor or receptor group during each phase. Following from this, a lifetime assessment is undertaken which considers the potential for multiple impacts to accumulate across the construction, operation and decommissioning phases and result in a greater effect on a single receptor or receptor group. When considering synergistic effects from interactions, it is assumed that the receptor sensitivity remains consistent, while the magnitude of different impacts is additive.

Table 8-50 Marine Physical Processes – Inter-Relationships with Other Topics

Impact ID	Impact and Project Activity	Related EIA Topic	Where Assessed in the PEIR Chapter	Rationale
Construction				
MPP-C-03, MPP-C-04, MPP-C-05	Changes in suspended sediment concentration, transport, and seabed level - due to drilling for foundation installation.	Chapter 10 Benthic and Intertidal Ecology Chapter 11 Fish and Shellfish Ecology Chapter 14 Commercial Fisheries	**Section 8.7.2.1** to **Section 8.7.2.3**.	Suspended sediment could cause disturbance to benthic species and fish through smothering.
MPP-C-06, MPP-C-07	Changes in suspended sediment concentration, transport, and seabed level - due to drilling for foundation installation. Changes in suspended sediment concentration, transport, and seabed level - due to seabed preparation for foundation installation.	Chapter 10 Benthic and Intertidal Ecology Chapter 11 Fish and Shellfish Ecology Chapter 14 Commercial Fisheries Chapter 17 Offshore Archaeology	**Section 8.7.2.2** and **Section 8.7.2.5**.	Disruption to the seabed could affect receptors outlined in these chapters by altering the existing sedimentary environment. However, this is unlikely to be to levels which are significant.
Operation and Maintenance				
MPP-O-04, MPP-O-05, MPP-O-06	Changes in bedload sediment transport and seabed morphology - due to the presence of cable protection measures. Changes in suspended sediment concentration, transport, and seabed level - due to cable repairs and reburial.	Chapter 10 Benthic and Intertidal Ecology Chapter 11 Fish and Shellfish Ecology Chapter 14 Commercial Fisheries Chapter 17 Offshore Archaeology	**Section 8.7.3.4157** to **Section 8.7.3.6**.	Disruption to the seabed could affect receptors outlined in these chapters by altering the existing sedimentary environment. However, this is unlikely to be to levels which are significant.
Decommissioning				
The details and scope of offshore decommissioning works will be determined by the relevant regulations and guidance at the time of decommissioning and provided in the Offshore Decommissioning Plan (see **Table 8-4**, Commitment ID CO21). For this assessment, it is assumed that inter-relationships during the decommissioning phase would be of similar nature to those identified during the construction phase.				

Table 8-51 Marine Physical Processes – Potential Interactions

Construction, Operation and Maintenance												
	MPP-C-03	MPP-C-04	MPP-C-05	MPP-C-06	MPP-C-07	MPP-O-01	MPP-O-02	MPP-O-03	MPP-O-04	MPP-O-05	MPP-O-06	MPP-O-08
MPP-C-03		No	No	No	Yes	No	No	No	No	No	No	No
MPP-C-04	No		No	No	Yes	No	No	No	No	No	No	No
MPP-C-05	No	No		No	Yes	No	No	No	No	No	No	No
MPP-C-06	No	No	No		Yes	No	No	No	No	No	No	No
MPP-C-07	Yes	Yes	Yes	Yes		No	No	No	No	No	No	No
MPP-O-01	No	No	No	No	No		Yes	Yes	Yes	Yes	No	No
MPP-O-02	No	No	No	No	No	Yes		Yes	No	No	No	No
MPP-O-03	No	No	No	No	No	Yes	Yes		No	No	No	No
MPP-O-04	No	No	No	No	No	Yes	No	No		No	No	Yes
MPP-O-05	No	No	No	No	No	Yes	No	No	No		No	Yes
MPP-O-06	No	No	No	No	No	No	No	No	No	No		Yes
MPP-O-08	No	No	No	No	No	No	No	No	Yes	Yes	Yes	
Decommissioning												
The details and scope of offshore decommissioning works will be determined by the relevant regulations and guidance at the time of decommissioning and provided in the Offshore Decommissioning Plan (see **Table 8-4**, Commitment ID CO21). For this assessment, it is assumed that interactions during the decommissioning phase would be of similar nature to, and no worse than, those identified during the construction phase.												

Table 8-52 Interaction Assessment – Phase and Lifetime Effects

Impact ID	Impact and Project Activity	Receptor	Highest Significance Level			Phase Assessment	Lifetime Assessment
			Construction	Operation	Decommissioning		
MPP-C-03	Changes in suspended sediment concentration, transport, and seabed level - due to drilling for foundation installation	Dogger Bank	**Negligible**	**Negligible**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.
MPP-C-05 MPP-C-06	Changes in suspended sediment concentration, transport, and seabed level - due to Inter-Array Cable and Offshore Export Cable installation including at the landfall Interruptions to bedload sediment transport - due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	**Negligible**	**Negligible**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.
MPP-O-01 MPP-O-04	Changes in the tidal current regime - due to the presence of infrastructure (wind turbine and offshore platform foundations) Changes in bedload sediment transport and seabed morphology - due to the presence of infrastructure (wind turbine and offshore platform foundations)	Dogger Bank	**Negligible**	**Negligible**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.
MPP-O-03	Effects on water column circulation	Flamborough Front	**Negligible**	**Minor**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.
MPP-O-04 MPP-O-08	Changes in bedload sediment transport and seabed morphology - due to the presence of infrastructure (wind turbine and offshore platform foundations) Indentations on the seabed due to installation vessels	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	**Negligible**	**Negligible**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.
MPP-D-03 MPP-D-04	Effects on suspended sediment concentration, transport and seabed level	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	**Negligible**	**Negligible**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.
MPP-D-05 MPP-O-06	Effects on seabed (morphology and sediment composition)	Dogger Bank	**Negligible**	**Negligible**	**Negligible**	No greater than individually assessed impact.	No greater than individually assessed impact.

8.11 Monitoring Measures

235. Potential monitoring measures for marine physical processes will be developed where required through the EIA process and outlined in the ES, where appropriate. The requirements for monitoring will be discussed through the EPP with the relevant stakeholders.

8.12 Summary

236. This chapter has provided a characterisation of the baseline environment for marine physical processes based the best available data and information, including site-specific survey data and bespoke numerical modelling.

237. The principal receptors with respect to marine physical processes included in this assessment were those features with an inherent, oceanographic, geological or geomorphological value or function which may potentially be affected by the Project. These included geological features along the Holderness coast, including Smithic Bank in the nearshore, Dogger Bank as a bathymetric high and the tidal mixing front known as the Flamborough Front.

238. The assessment has established there will be negligible significant effects on marine physical processes during the construction, operation and decommissioning of the Project, which is considered not significant in EIA terms. During construction (and decommissioning), the effects are localised and short-lived and any changes are small in magnitude with a return to baseline conditions soon after disturbance (hours to months). During operation, the presence of infrastructure causes localised changes in tidal currents and wave regime, but these do not extend far enough to have an effect on coastal receptors. **Table 8-53** presents a summary of the preliminary results of this assessment.

8.13 Next Steps

239. Consultation / stakeholder engagement will continue to be undertaken for the ES stage, addressing any feedback raised on this PEIR chapter. There will also be the inclusion of:

- Further survey data on bathymetry, seabed features and shallow geology of the offshore ECC;
- Geotechnical campaigns to collect CPTs and vibrocores across the Array Area and along the offshore ECC; and
- Identification of monitoring requirements if required.

Table 8-53 Summary of Potential Effects Assessed for Marine Physical Processes

Impact ID	Impact and Project Activity	Embedded Mitigation Measures	Receptor	Impact Magnitude	Effect Significance	Residual Effect	Monitoring Measures
Construction							
MPP-C-03	Changes in suspended sediment concentration, transport, and seabed level - due to drilling for foundation installation	CO29	Dogger Bank	Near-field: **Negligible** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-C-04	Changes in suspended sediment concentration, transport, and seabed level - due to seabed preparation for foundation installation	CO29	Dogger Bank	Near-field: **Negligible** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-C-05	Changes in suspended sediment concentration, transport, and seabed level - due to Inter-Array Cable and Offshore Export Cable installation including at the landfall	CO24, CO26, CO29	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	Near-field: **Negligible** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-C-06	Interruptions to bedload sediment transport - due to sand wave levelling for Inter-Array Cable and Offshore Export Cable installation	CO24, CO26, CO29	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-C-07	Indentations on the seabed - due to the presence of installation vessels	CO24, CO29	Dogger Bank	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
Operation and Maintenance							
MPP-O-01	Changes in the tidal current regime - due to the presence of infrastructure (wind turbine and offshore platform foundations)	N/A	Dogger Bank	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-O-02	Changes in the wave regime - due to the presence of infrastructure (wind turbine and offshore platform foundations)	N/A	Dogger Bank	Near-field: **Low** Far-field: **Negligible**	**Minor** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-O-03	Changes in water circulation - due to the presence of infrastructure (wind turbine and offshore platform foundations)	N/A	Flamborough Front	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-O-04	Changes in bedload sediment transport and seabed morphology - due to the presence of infrastructure (wind turbine and offshore platform foundations)	N/A	Dogger Bank	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES

Impact ID	Impact and Project Activity	Embedded Mitigation Measures	Receptor	Impact Magnitude	Effect Significance	Residual Effect	Monitoring Measures
MPP-O-05	Changes in bedload sediment transport and seabed morphology - due to the presence of cable protection measures	CO23, CO27, CO28, CO29	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-O-06	Changes in suspended sediment concentration, transport, and seabed level - due to cable repairs and reburial	CO28, CO29	Dogger Bank, Flamborough Head SSSI, Holderness Offshore MCZ, Holderness Inshore MCZ and Smithic Bank	Near-field: **Negligible** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
MPP-O-08	Indentations on the seabed - due to repair and maintenance vessels	CO24, CO29	Dogger Bank	Near-field: **Low** Far-field: **Negligible**	**Negligible** **(not significant)**	**Negligible**	Developed through the EIA process and identified in the ES
Decommissioning							
MPP-D-02	Changes in the wave regime – decommissioning activities not yet defined	The details and scope of offshore decommissioning works will be determined by the relevant regulations and guidance at the time of decommissioning and provided in the Offshore Decommissioning Programme (see Commitment ID CO21 in **Volume 2, Appendix 6.3 Commitments Register**). For this assessment, it is assumed that interactions during the decommissioning phase would be of similar nature to, and no worse than, those identified during the construction phase.					
MPP-D-03	Interruptions to bedload sediment transport – decommissioning activities not yet defined						
MPP-D-04	Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined						
MPP-D-05	Changes in suspended sediment concentration, transport, and seabed level – decommissioning activities not yet defined						
MPP-D-06	Indentations on the seabed - decommissioning activities not yet defined						
MPP-D-07	Impacts on water circulation (Flamborough Front) – decommissioning activities not yet defined						

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List of Figures, Tables and Plates

List of Tables

List of Figures

List of Acronyms

Acronym	Definition
BGS	British Geological Survey
BEIS	Department for Business, Energy and Industrial Strategy
CEA	Cumulative Effect Assessment
CFB	Coastal Flood Boundaries
CPA	Coast Protection Act
CPTs	Cone Penetration Test
DBA	Dogger Bank A
DBB	Dogger Bank B
DBC	Dogger Bank C
DBD	Dogger Bank D
DBS	Dogger Bank South
DCO	Development Consent Order
Defra	Department of Environmental, Food and Rural Affairs
DESNZ	Department of Energy Security and Net Zero
DML	Deemed Marine Licence
ECC	Export Cable Corridor
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EPP	Evidence Plan Process
ERYC	East Riding of Yorkshire Council

Acronym	Definition
ES	Environmental Statement
ETG	Expert Topic Group
FEPA	Food and Environmental Protection Act
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
HRA	Habitat Regulations Assessment
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MCMS	Marine Case Management System
MCZ	Marine Conservation Zone
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MMO	Marne Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
NCERM	The National Coastal Erosion Risk Mapping
NPS	National Policy Statements
NSIP	Nationally Significant Infrastructure Projects
O&M	Operation and Maintenance
OHA	Offshore Hybrid Asset

Acronym	Definition
OP	Offshore Platform
OS	Ordnance Survey
PEIR	Preliminary Environmental Information Report
SAC	Special Area of Conservation
SMPs	Shoreline Management Plans
SSSI	Site of Special Scientific Interest
TJB	Transition Joint Bays
UXO	Unexploded Ordnance
ZOI	Zone of Influence