RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Environmental Statement
Volume 7
Chapter 8 – Marine Physical Environment

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Glossary

Term	Definition
Amphidromic Point	The centre of an amphidromic system; a nodal point around which a standing-wave crest rotates once each tidal period.
Array Areas	The DBS East and DBS West offshore Array Areas, where the wind turbines, offshore platforms and array cables would be located. The Array Areas do not include the Offshore Export Cable Corridor or the Inter-Platform Cable Corridor within which no wind turbines are proposed. Each area is referred to separately as an Array Area.
Array Cables	Offshore cables which link the wind turbines to the Offshore Converter Platform(s).
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, 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.
Clay	Fine-grained sediment with a typical particle size of less than 0.002mm.
Climate Change	A change in global or regional climate patterns. Within this chapter this usually relates to any long-term trend in mean sea level, wave height, wind speed etc, due to climate change.
Closure Depth	The depth that represents the 'seaward limit of significant depth change', but is not an absolute boundary across which there is no cross-shore sediment transport.

Term	Definition
Coastal Processes	Collective term covering the action of natural forces on the shoreline and nearshore seabed.
Cohesive Sediment	Sediment containing a significant proportion of clays, the electromagnetic properties of which causes the particles to bind together.
Concurrent Scenario	A potential construction scenario for the Projects where DBS East and DBS West are both constructed at the same time.
Construction Buffer Zone	1km zone around the Array Areas and Offshore Export Cable Corridor, and 500m zone around the Inter-Platform Cabling Corridor. Construction vessels may occupy this zone but no permanent infrastructure would be installed within these areas.
Cumulative Effects	The combined effect of the Projects in combination with the effects of a number of different (defined cumulative) schemes, on the same single receptor / resource.
Cumulative Effects Assessment (CEA)	The assessment of the combined effect of the Projects in combination with the effects of a number of different (defined cumulative) schemes, on the same single receptor/resource.
Cumulative Impact	The combined impact of the Projects in combination with the effects of a number of different (defined cumulative) schemes, on the same single receptor / resource.
Current	Flow of water generated by a variety of forcing mechanisms (e.g. waves, tides, wind).
Development Scenario	Description of how the DBS East and / or DBS West Projects would be constructed either in isolation, sequentially or concurrently.
Dogger Bank South (DBS) offshore wind farms	The collective name for the two Projects, DBS East and DBS West.
Ebb Tide	The falling tide, immediately following the period of high water and preceding the period of low water.

Term	Definition
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the value, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Electrical Switching Platform (ESP)	The Electrical Switching Platform (ESP), if required would be located either within one of the Array Areas (alongside an Offshore Converter Platform (OCP)) or the Export Cable Platform Search Area.
Erosion	Wearing away of the land or seabed by natural forces (e.g. wind, waves, currents, chemical weathering).
Evidence Plan Process (EPP)	A voluntary consultation process with specialist stakeholders to agree the approach, and information to support, the Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) for certain topics.
Expert Topic Group (ETG)	A forum for targeted engagement with regulators and interested stakeholders through the EPP.
Flood Tide	The rising tide, immediately following the period of low water and preceding the period of high water.
Glacial Till	Poorly sorted, non-stratified and 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.
Horizontal Directional Drill (HDD)	HDD is a trenchless technique to bring the offshore cables ashore at the landfall and can be used for crossing other obstacles such as roads, railways and watercourses onshore.

Term	Definition
Hydrodynamic	The process and science associated with the flow and motion in water produced by applied forces.
In Isolation Scenario	A potential construction scenario for one Project which includes either the DBS East or DBS West array, associated offshore and onshore cabling and only the eastern Onshore Converter Station within the Onshore Substation Zone and only the northern route of the onward cable route to the proposed Birkhill Wood National Grid Substation.
Inter-Platform Cable Corridor	The area where Inter-Platform Cables would route between platforms within the DBS East and DBS West Array Areas, should both Projects be constructed.
Inter-Platform Cables	Buried offshore cables which link offshore platforms.
Intertidal	Area on a shore that lies between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Landfall	The point on the coastline at which the Offshore Export Cables are brought onshore, connecting to the onshore cables at the Transition Joint Bay (TJB) above mean high water.
Long-Term	Refers to a time period of decades to centuries.
Low Water	The minimum height reached by the falling tide.
Mean High Water Springs	MHWS is the average of the heights of two successive high waters during a 24 hour period.
Mean Low Water Springs	MLWS is the average of the heights of two successive low waters during a 24 hour period.
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 0.6 to 10.0m and a height of 0.1 to 1.0m. These features are smaller than sand waves but larger than ripples.
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 (~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 Offshore Development Area for ES encompasses both the DBS East and West Array Areas, the Inter-Platform Cable Corridor, the Offshore Export Cable Corridor, plus the associated Construction Buffer Zones.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables (and potentially the ESP) between the Offshore Converter Platforms and Transition Joint Bays at the landfall.
Offshore Export Cables	The cables which would bring electricity from the offshore platforms to the Transition Joint Bays (TJBs).
Pleistocene	An epoch of the Quaternary Period (between about 2 million and 10,000 years ago) characterised by several glacial ages.
Project Design (or Rochdale) Envelope	A concept that ensures the EIA is based on assessing the realistic worst-case scenario where flexibility or a range of options is sought as part of the consent application.
Quaternary Period	The last 2 million years of earth history incorporating the Pleistocene ice ages and the post-glacial (Holocene) Period.

Term	Definition
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 10 to 100m, with amplitudes of 1 to 10m.
Scoping opinion	The report adopted by the Planning Inspectorate on behalf of the Secretary of State.
Scoping report	The report that was produced in order to request a scoping opinion from the Secretary of State.
Scour Protection	Protective materials to avoid sediment erosion from the base of the wind turbine foundations and offshore substation platform foundations due to water flow.
Sea Level	Generally, refers to 'still water level' (excluding wave influences) averaged over a period of time 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.
Sequential Scenario	A potential construction scenario for the Projects where DBS East and DBS West are constructed with a lag between the commencement of construction activities. Either Project could be built first.
Shore Platform	A platform of exposed rock or cohesive sediment exposed within the intertidal and subtidal zones.
Short-Term	Refers to a time period 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.
Storm Surge	A rise in water level on the open coast due to the action of wind stress as well as atmospheric pressure on the sea surface.
Surge	Changes in water level as a result 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	The sediment moving in suspension in a fluid kept up by the upward components of the turbulent currents or by the colloidal suspension.
Swell Waves	Wind-generated waves that have travelled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.
The Applicants	The Applicants for the Projects are RWE Renewables UK Dogger Bank South (East) Limited and RWE Renewables UK Dogger Bank South (West) Limited. The Applicants are themselves jointly owned by the RWE Group of companies (51% stake) and Masdar (49% stake).
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South Offshore Wind Farms).
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.

Term	Definition
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).
Wind Turbine	Power generating device that is driven by the kinetic energy of the wind.

Acronyms

Term	Definition
ADCP	Acoustic Doppler Current Profiler
BAC	Background Assessment Concentration
BGS	British Geological Survey
CD	Chart datum
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture
CFB	Coastal Flood Boundaries
CPA	Coast Protection Act 1949
DBS	Dogger Bank South
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DESNZ	Department for Energy Security and Net Zero
DML	Deemed Marine Licence
EAC	European Assessment Criteria
EEA	European Economic Area
EEZ	Exclusive economic zone
EIA	Environmental Impact Assessment
EMF	Electro Magnetic Field
EPA	Environmental Protection Agency
EPP	Evidence Plan Process

Term	Definition
EQS	Environmental Quality Standard
ERL	Effects Range-Low
ES	Environmental Statement
ETG	Expert Topic Groups
ETSU	Energy Technology Support Unit
EU	European Union
EYRC	East Riding of Yorkshire Council
FEPA	Food and Environment Protection Act 1985
GBS	Gravity Base Structures
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
LAT	Lowest astronomical tide
MBES	Multi-beam echosounder
MCZ	Marine Conservation Zone
MMO	Marine Management Organisation
MPCP	Marine Pollution Contingency Plan
MPS	Marine Policy Statement

Term	Definition
MSR	Mean Spring Range
MW	Mega Watt
NCERM	National Coastal Erosion Risk Mapping
NPS	National Policy Statement
NSIP	Nationally significant infrastructure project
OD	Ordnance datum
OSP	Offshore substation platform
OSPAR Convention	Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Windfarm
PAH	Polyaromatic hydrocarbons
PCB	Polychlorinated biphenyls
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PSA	Particle Size Analysis
QSR	Quality Status Reports
RCP	Representative Concentration Pathway
SAC	Special Area of Conservation
SBP	Sub bottom profiler
SCAPE	Soft Cliff and Platform Erosion

Term	Definition
SCI	Sites of Community Importance
SPA	Special Protection Area
S-P-R	Source-pathway-receptor
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
Term	Definition
UKCP	UK Climate Projections
WFD	Water Framework Directive

8 Marine Physical Environment

8.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the likely significant effects of the Projects on the marine physical environment (which includes marine sediment and water quality). The chapter provides an overview of the existing environment for the proposed Offshore Development Area, followed by an assessment of likely significant effects for the construction, operation, and decommissioning phases of the Projects.

2. The assessment should be read in conjunction with the following linked chapters in **Volume 7**:

   - **Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)**;
   - **Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)**; and
   - **Chapter 17 Offshore Archaeology and Cultural Heritage (application ref: 7.17)**.

3. Additional information to support this Marine Physical Environment chapter in **Volume 7** include:

   - **Appendix 8-1 Marine Physical Environment Consultation Responses (application ref: 7.8.8.1)**;
   - **Appendix 8-2 Met Mast Survey Analysis (application ref: 7.8.8.2);**
   - **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**;
   - **Appendix 20-3 Water Environment Regulations Compliance Assessment (application ref: 7.20.20.3)**.

8.2 Consultation

4. Consultation with regard to marine physical environment has been undertaken in line with the general process described in **Volume 7, Chapter 7 Consultation (application ref: 7.7)** and the **Consultation Report (Volume 5, application ref: 5.1)**. The key elements to date include EIA Scoping, formal consultation on the Preliminary Environmental Information Report (PEIR) under section 42 of the Planning Act 2008 and the ongoing Evidence Plan Process (EPP) via the marine physical environment Expert Topic Group (ETG).

5. The feedback received throughout this process has been considered in preparing the ES. This chapter has been updated following consultation in order to produce the final assessment submitted within the Development Consent Order (DCO) application. **Volume 7, Appendix 8-1 (application ref: 7.8.8.1)** provides a summary of the consultation responses received to date relevant to this topic, and details how the comments have been addressed within this chapter. Note that marine sediment and water quality was originally presented as a separate chapter in the scoping report but was combined with the topic marine physical processes within the PEIR under the heading ‘marine physical environment’.

8.3 Scope

8.3.1 Study Area

6. The marine physical environment study area has been defined on the basis of the direct footprint of the Offshore Development Area (see **Volume 7, Chapter 5 Project Description (application ref: 7.5)** and **Volume 7, Figure 8-1 (application ref: 7.8.1)**) (near-field) and wider areas of seabed and coastline that could potentially be affected (far-field) which has been determined using the outputs from hydrodynamic, wave and plume dispersion modelling undertaken for the Projects (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) and information on tidal excursion ellipses. The modelling results show that changes >1% of baseline conditions due to construction activities or the presence of structures during the operation phase occur within 8km of the Projects boundary. However, the maximum tidal excursion ellipse is 14km offshore of Flamborough Head. Therefore, the zone of potential influence is conservatively defined as 14km from the Offshore Development Area but consideration is given to the wider southern North Sea and the Holderness coastline.

8.3.2 Realistic Worst Case Scenario

8.3.2.1 General Approach

7. The realistic worst case design parameters for likely significant effects scoped into the ES for the marine physical environment assessment are summarised in **Table 8-1**. These are based on the project parameters described in **Volume 7, Chapter 5 Project Description (application ref: 7.5)**, which provides further details regarding specific activities and their durations.

8. Numerical modelling was undertaken to support the assessment of marine physical processes. At the time the modelling was undertaken, gravity based foundations were considered the worst case for offshore platforms located within the Projects' Array Areas. The modelling for wind turbine locations used monopile foundations. Gravity based foundations were not an option for these structures. Since completion of the modelling, a commitment has been made to not use gravity based foundations within the Array Areas (note they are still included in the design parameters for offshore platforms within the Offshore Export Cable Corridor). Therefore, the 'modelled' worst case scenario for offshore platform foundations assessed here is gravity bases, whereas the realistic worst case scenario considering the project parameter described in **Volume 7, Chapter 5 Project Description (application ref: 7.5)** relates to monopile foundations.

9. The effects of gravity based foundations for the offshore platforms will be greater in magnitude compared to the effects that monopile foundations will have. Therefore, the modelling results using gravity bases as input over-estimate the effects of the offshore platforms. Hence, the actual effect of the offshore platforms in the Array Areas will be less than the predicted effect for gravity based foundations. Given that only a small number of offshore platforms is proposed (four for DBS East or DBS West in isolation or eight for DBS East and DBS West together) compared to wind turbines (100 for DBS East or DBS West in isolation or 200 for DBS East and DBS West together), it is not necessary or proportionate to update the modelling, as a worst case scenario has been modelled.

10. In addition to the design parameters set out in **Table 8-1**, consideration is also given to the different development scenarios still under consideration and the possible phasing of the construction as set out in sections 8.3.2.2 to 8.3.2.4.

Table 8-1 Realistic Worst Case Design Parameters

	Parameter			
	DBS East in isolation	**DBS West in Isolation**	**DBS East and DBS West concurrently and / or in sequence**	**Notes and rationale**
Construction In the instance of sequential development of the two Projects, up to a two-year lag between construction activities is possible, final overall area would be identical to the concurrent design scenario				
Changes in suspended sediment concentration and transport due to seabed preparation for foundation installation	Wind turbines Seabed preparation area for 100 small turbine monopile foundations (including scour protection) – 358,498m^2 Volume of sediment disturbed due to seabed preparation (including scour protection) – 179,249m^3 Offshore platforms Number of offshore platforms modelled across Offshore Development Area – Five Seabed preparation area for four monopile foundations including scour protection – 24,889m^2 Seabed preparation area for one gravity based foundation - 64,871m^2 Maximum volume of sediment disturbed due to seabed preparation (including scour protection) – 44,926m^3	Wind turbines Seabed preparation area for 100 small turbine monopile foundations (including scour protection) – 358,498m^2 Volume of sediment disturbed due to seabed preparation (including scour protection) – 179,249m^3 Offshore platforms Number of offshore platforms modelled across Offshore Development Area – Five Seabed preparation area for four monopile foundations including scour protection – 24,889m^2 Seabed preparation area for one gravity based foundation - 64,871m^2 Maximum volume of sediment disturbed due to seabed preparation (including scour protection) – 44,926m^3	Wind turbines Seabed preparation area for 200 small turbine monopile foundations (including scour protection) – 716,966m^2 Volume of sediment disturbed due to seabed preparation (including scour protection) – 358,483m^3 Offshore platforms Number of offshore platforms modelled across Offshore Development Area – Nine Seabed preparation area for eight monopile foundations including scour protection – 49,778m^2 Seabed preparation area for one gravity based foundation - 64,871m^2 Maximum volume of sediment disturbed due to seabed preparation (including scour protection) – 57,325m^3	In situations where a number does not divide equally between DBS East and DBS West (e.g. 113 large turbines), values are rounded up to higher number (e.g. 57 large turbines as opposed to 56.5). Seabed preparation area will cover the footprint of the scour protection plus 15%. Seabed footprint of large (15m diameter) turbine monopiles including scour protection plus 15% - 6,222m^2 per structure. Seabed footprint of small (11m) turbine monopiles including scour protection plus 15% - 3,585m^2 per structure. Therefore, the worst case for wind turbine foundations is associated with the larger number of smaller monopile foundations. Worst case for offshore platforms in the Array Areas is seabed footprint of monopile foundations including scour protection plus 15% – 5,411m^2 per jacket. Worst case for offshore platforms in the Offshore Export Cable Corridor is seabed footprint of gravity based foundations including scour protection plus 15% - 64,871m^2 per structure. Modelling undertaken to inform this assessment assumed a total of five platforms may be present in an in-isolation scenario, comprising four platforms in the Array Areas and one in the Offshore Export Cable Corridor. However only four platforms may be found across both the Array Areas and the Offshore Export Cable Corridor. Five platforms were modelled to ensure all potential locations of platforms were modelled so that a definite worst case scenario was assessed. Seabed

	Parameter			
	DBS East in isolation	**DBS West in Isolation**	**DBS East and DBS West concurrently and / or in sequence**	**Notes and rationale**
				preparation area will cover the footprint of the scour protection plus 15%. Maximum depth of seabed preparation is 0.5m.
Changes in suspended sediment concentration and transport due to drill arisings from foundations	Wind turbines Drill arisings from 57 large wind turbines = 34,382m^3 Offshore platforms Drill arisings from five monopile foundations = 3,519m^3	Wind turbines Drill arisings from 57 large wind turbines = 34,382m^3 Offshore platforms Drill arisings from five monopile foundations = 3,519m^3	Wind turbines Drill arisings from 113 large wind turbines = 68,160m^3 Offshore platforms Drill arisings from eight monopile foundations = 5,630m^3	Assumes 5% of all wind turbine and offshore platform locations will be drilled. Monopile diameter for offshore platforms assumed the same as for wind turbines with the worst case being 15m diameter monopiles.
Changes in suspended sediment concentration and transport due to array, inter-platform and Offshore Export Cable installation	Displaced sediment volume during array and inter-platform cable installation Array cable – 1,950,000m^3 (325,000m length x 6m width x 1m depth) Inter-platform cables – 1,035,000m^3 (115,000m length x 6m width x 1.5m depth) Maximum volume from seabed clearance – 445,500m^3 Displaced sediment volume during export cable installation Export cables – 3,384,000m^3 (376,000m length x 6m width x 1.5m depth) Maximum volume from seabed clearance – 33,121,800m^3	Displaced sediment volume during array and inter-platform cable installation Array cable – 1,950,000m^3 (325,000m length x 6m width x 1m depth) Inter-platform cables – 1,161,000m^3 (129,000m length x 6m width x 1.5m depth) Maximum volume from seabed clearance – 459,473m^3 Displaced sediment volume during export cable installation Export cable – 2,754,000m^3 (306,000m length x 6m width x 1.5m depth) Maximum volume from seabed clearance – 29,302,900m^3	Displaced sediment volume during array and inter-platform cable installation Array cable – 3,900,000m^3 (650,000m length x 6m width x 1m depth) Inter-platform cables – 3,078,000m^3 (342,000m length x 6m width x 1.5m depth) Maximum volume from seabed clearance – 1,003,944m^3 Displaced sediment volume during export cable installation Export cable – 6,138,000m^3 (682,000m length x 6m width x 1.5m depth) Maximum volume from seabed clearance – 66,243,601m^3	Note – 6m trench width based on worst case pre-lay ploughing width. Maximum burial depth for array and Inter-Platform Cables is 1m. Maximum burial depth for offshore export cables is 1.5m. These depths have been assumed across the entire length of the each cable type to determine the worst-case volume of sediment disturbed. Assumes even split of total 650km array cable length between DBS East and DBS West. Maximum export cable length assumes worst case that cable circuits are laid and buried in separate trenches rather than bundled. Assumes jet trenching installation methods and a v-shape trench. Trenches will be 50m apart at their closest, ensuring the viability of each individual trench. Seabed clearance (levelling or pre-sweeping) is potentially required prior to cable installation.
Changes in suspended sediment concentration and transport due to	No. of trenchless duct installations = 3 Trenchless transition bore spacing = 100m	No. of trenchless duct installations = 3 Trenchless transition bore spacing = 100m	No. of trenchless duct installations = 6 Trenchless transition bore spacing = 100m	If DBS East and DBS West are built together there will be one phase of trenchless duct installation. Technique for trenchless cable installation is not yet decided, however Horizontal Directional Drilling (HDD) is preferred.

	Parameter			
	DBS East in isolation	**DBS West in Isolation**	**DBS East and DBS West concurrently and / or in sequence**	**Notes and rationale**
cable installation at the landfall	Indicative elevation at landfall exit pit = MHWS (6.13 mCD) Size of each landfall exit pit – 20m length x 10m width x 3m depth Total volume of sediment excavated from landfall exit pits = 1,800m^3 Total volume of sediment excavated from trench between exit pits and MLWS (based on 110m length x 6m width x 1.5 m depth) – 990m^3	Indicative elevation at landfall exit pit = MHWS (6.13 mCD) Size of each landfall exit pit – 20m length x 10m width x 3m depth Total volume of sediment excavated from landfall exit pits = 1,800m^3 Total volume of sediment excavated from trench between exit pits and MLWS (based on 110m length x 6m width x 1.5 m depth) – 990m^3	Indicative elevation at landfall exit pit = MHWS (6.13 mCD) Size of each landfall exit pit – 20m length x 10m width x 3m depth Total volume of sediment excavated from landfall exit pits = 3,600m^3 Total volume of sediment excavated from trench between exit pits and MLWS (based on 110m length x 6m width x 1.5 m depth) – 990m^3	Number of trenchless duct installations assumes ducts for two power cables, one communications cable and one spare for each Project In Isolation Landfall exit pits may be located within the intertidal area. Length of trench assumes 160m based on the distance between MHWS and MLWS minus mitigation to place exit pits at least 50m from the toe of the cliff.
Deterioration in water quality associated with the release of sediment bound contamination (directly linked to changes in suspended sediment concentrations in impacts, including changes in suspended sediment concentration and transport due to seabed preparation for foundation installation, and changes in suspended sediment concentration and transport due to cable installation at the landfall)	As for construction impacts including changes in suspended sediment concentration and transport due to seabed preparation for foundation installation, and changes in suspended sediment concentration and transport due to trenchless transition exit cable installation			The risk of releasing sediment bound contamination (if present) is directly linked to sediment disturbance and therefore the worst case relates to volumes of sediment potentially released into the water column.

	Parameter			
	DBS East in isolation	DBS West in Isolation	DBS East and DBS West concurrently and / or in sequence	Notes and rationale
Changes in seabed level due to seabed preparation for foundation installation	As for changes in suspended sediment concentration and transport due to seabed preparation for foundation installation			
Changes to seabed level due to drill arisings from foundations	As for changes in suspended sediment concentration and transport due to drill arisings from foundations			
Changes to seabed level due to array, inter-platform and Offshore Export Cable installation	As for changes in suspended sediment concentration and transport due to array, inter-platform and Offshore Export Cable installation			
Changes to bedload sediment transport due to cable installation at the landfall	As for changes in suspended sediment concentration and transport due to cable installation at the landfall			

	Parameter			
	DBS East in isolation	**DBS West in Isolation**	**DBS East and DBS West concurrently and / or in sequence**	**Notes and rationale**
Indentations on the seabed due installation vessels	Jack-up vessels Up to 6 jack-up installations at each wind turbine (100 small turbines, 6 installations, 4 legs per installation, individual leg footprint 275m^2) = 660,000m^2 Vessel jack-up footprint for all offshore platforms (1,100m^2 combined leg area x five operations per offshore platform x five offshore platforms) = 27,500m^2 Anchoring Anchoring area (116m^2 area x four anchors per activity x five activities requiring the deployment of anchors x 100 small turbines + five offshore platforms) – 244,640m^2 Maximum total impacted area by anchoring – 22,061m^2 *Note – 7km stretch along the Offshore Export Cable Corridor <10m Lowest Astronomical Tide (LAT), may require use of anchoring*	Jack-up vessels Up to 6 jack-up installations at each wind turbine (100 small turbines, 6 installations, 4 legs per installation, individual leg footprint 1,100m^2) = 660,000m^2 Vessel jack-up footprint for all offshore platforms (1,100m^2 combined leg area x five operations per offshore platform x five offshore platforms) = 27,500m^2 Anchoring Anchoring area (116m^2 area x four anchors per activity x five activities requiring the deployment of anchors x 100 small turbines + five offshore platforms) – 244,640m^2 Maximum total impacted area by anchoring – 22,061m^2 *Note - 7km stretch along the Offshore Export Cable Corridor <10m LAT, may require use of anchoring*	Jack-up vessels Up to 6 jack-up installations at each wind turbine (200 small turbines, 6 installations, 4 legs per installation, individual leg footprint 1,100m^2) = 1,320,000m^2 Vessel jack-up footprint for all offshore platforms (1,100m^2 combined leg area x five operations per offshore platform x nine offshore platforms) – 49,500m^2 Anchoring Anchoring area (116m^2 area x four anchors per activity x five activities requiring the deployment of anchors x 200 small turbines + nine offshore platforms) – 486,752m^2 Maximum total impacted area by anchoring – 44,091m^2 *Note - 7km stretch along the Offshore Export Cable Corridor <10m LAT, may require use of anchoring*	The worst case for vessel activity is for the installation of small turbines as they are greater in number.
Operation				
Changes to the tidal regime due to the presence of infrastructure (wind turbine and offshore platform foundations)	Wind turbines 100 small monopile foundations Minimum wind turbine spacing = 830m Offshore platforms Four monopile foundations and one gravity based foundation.	Wind turbines 100 small monopile foundations Minimum wind turbine spacing = 830m Offshore platforms Four monopile foundations and one gravity based foundation.	Wind turbines 200 monopile foundations Minimum wind turbine spacing = 830m Offshore platforms Eight monopile foundations and one gravity based foundation.	Large (15m diameter) monopile foundations are the worst case foundation type for the offshore platforms within the DBS Array Areas and gravity based foundations are the worst case for foundations within the Offshore Export Cable Corridor. Small (11m diameter) monopiles are the worst case foundation type for wind turbines. The worst case foundation type is based on the structures that have the greatest cross-sectional

	Parameter			
	DBS East in isolation	**DBS West in Isolation**	**DBS East and DBS West concurrently and / or in sequence**	**Notes and rationale**
	Four of these foundations in the Array Area and one foundation within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea	Four of these foundations in the Array Area and one foundation within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea	Eight of these foundations in the Array Areas and one foundation within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea	area within the water column (compared to other foundation types) representing the greatest physical blockage to tidal currents. The worst case in terms of layout will be the greatest number of turbines with the minimum wind turbine spacing. Modelling undertaken to inform this assessment assumed a total of five platforms may be present in an in isolation scenario, comprising four platforms in the Array Areas and one in the Offshore Export Cable Corridor. However only four platforms may be found across both the Array Areas and the Offshore Export Cable Corridor. Five platforms were modelled to ensure all potential locations of platforms were modelled so that a definite worst case scenario was assessed.
Changes to the wave regime due to the presence of infrastructure (wind turbine and offshore platform foundations)	As for changes to the tidal regime due to the presence of infrastructure (wind turbine and offshore platform foundations)			
Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbine and offshore platform foundations)	As for changes to the tidal regime due to the presence of infrastructure (wind turbine and offshore platform foundations)			
Changes to bedload sediment transport and seabed morphology due to the presence of	As for changes to the tidal regime due to the presence of infrastructure (wind turbine and offshore platform foundations)			Installed foundation, or other sub-sea structures proud of the seabed (e.g. rock berms), may lead to local scouring around their base if scour protection has not already pre-armoured the seabed. Depending on the seabed material, the

	Parameter			
	DBS East in isolation	**DBS West in Isolation**	**DBS East and DBS West concurrently and / or in sequence**	**Notes and rationale**
infrastructure (wind turbine and offshore platform foundations)				scouring process may erode material into bedload and/or suspended load transport until an equilibrium condition is reached. In general, the largest foundation with the greatest solidity ratio will have the largest blockage effect on flows and will develop the most amount of scour. Where necessary, scour protection will be emplaced around the foundation structure.
Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Seabed footprint of cable protection Total footprint of array cable protection – 312,900m^2 Total footprint of inter-platform cable protection – 183,312m^2 Total area of export cable protection – 1,000,282m^2 Estimated number of array / inter-platform cable pipeline / cable crossings – 19 Total footprint of pipeline / cable crossing material (array cables and Inter-Platform Cables) – 61,300m^2 Total number of cable crossing for export cable - 24 Total footprint of pipeline / cable crossing material (export cables) – 147,133m^2	Seabed footprint of cable protection Total footprint of array cable protection – 310,500m^2 Total footprint of inter-platform cable protection – 205,504m^2 Total area of export cable protection – 788,941m^2 Estimated number of array / inter-platform cable pipeline / cable crossings – 27 Total footprint of pipeline / cable crossing material (array cables and Inter-Platform Cables) – 73,600m^2 Total number of cable crossing for export cable - 24 Total footprint of pipeline / cable crossing material (export cables) – 147,133m^2	Seabed footprint of cable protection Total footprint of array cable protection – 623,400m^2 Total footprint of inter-platform cable protection – 536,484m^2 Total area of export cable protection – 1,789,222m^2 Estimated number of array / inter-platform cable pipeline / cable crossings – 61 Total footprint of pipeline / cable crossing material (array cables and Inter-Platform Cables) – 226,600m^2 Total number of cable crossing for export cable - 48 Total footprint of pipeline / cable crossing material (export cables) – 294,267m^2	Cable protection measures will include a combination of rock or gravel burial (rock berms), concrete mattresses, protective aprons or coverings, bagged solutions and bridging. The worst case will be for small wind turbines as they are greater in number and require a greater length of cable which may require protection. Assumes 10% of the route will require remedial protection within the Dogger Bank SAC site boundary. Assumes 20% of the of the route will require remedial protection outside of the Dogger Bank SAC site boundary.
Cable repairs and reburial	Seabed footprint of repairs and reburial Total = 353,938m^2 (25% of area calculated for changes to bedload sediment transport and seabed morphology	Seabed footprint of repairs and reburial Total = 377,450m^2 (25% of area calculated for changes to bedload sediment transport and seabed morphology due to the	Seabed footprint of repairs and reburial Total = 867,502m^2 (25% of area calculated for changes to bedload sediment transport and seabed morphology due to the	Remedial reburial and repair of cables may be required with up to 25% of original protection being replenished over its lifetime. As original protection will be repaired or replaced, there will be no changes to the total seabed footprint of cable protection measures.

	Parameter			
	DBS East in isolation	DBS West in Isolation	DBS East and DBS West concurrently and / or in sequence	Notes and rationale
	due to the presence of cable protection measures)	presence of cable protection measures)	presence of cable protection measures)	
Deterioration in water quality associated with the release of sediment bound contamination (directly linked to changes in suspended sediment concentrations in cable repairs and reburial)	As for cable repairs and reburial			
Loss of seabed area due to the footprint foundations	As for changes in seabed level due to seabed preparation for foundation installation			
Indentations on the seabed due to installation vessels	As for indentations on the seabed due installation vessels			
Decommissioning				
No final decision regarding the final decommissioning policy for the offshore project infrastructure including landfall, has yet been made. It is also recognised that legislation and industry best practice change over time. It is likely that offshore project infrastructure will be removed above the seabed and reused or recycled where practicable. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator. It is anticipated that for the worst case scenario, the impacts will be no greater than those identified for the construction phase. A decommissioning plan for the offshore works would be submitted prior to any decommissioning commencing.				

8.3.2.2 Development Options

11. Following Statutory Consultation high voltage alternating current (HVAC) technology (previously assessed in PEIR) was removed from the Projects' design envelope (see **Volume 7, Chapter 4 Site Selection and Assessment of Alternatives (application ref: 7.4)** for further information). As a result, only high voltage direct current (HVDC) technology has been taken forward for assessment purposes. The ES considers the following development scenarios:

- Either DBS East or DBS West is built In Isolation; or
- DBS East and DBS West are both built either Sequentially or Concurrently.

12. An In Isolation scenario has been assessed within the ES on the basis that theoretically one Project could be taken forward without the other being built out. If an In Isolation project is taken forward, either DBS East or DBS West may be constructed. As such the offshore assessment considers both DBS East and DBS West In Isolation.

13. In order to ensure that a robust assessment has been undertaken, all development scenarios have been considered to ensure the realistic worst-case scenario for each topic has been assessed. A summary is provided here, and further details are provided in **Volume 7, Chapter 5 Project Description (application ref: 7.5)**.

14. The three development scenarios to be considered for assessment purposes are outlined in **Table 8-2**:

Table 8-2 Development Scenarios and Construction Durations

Development scenario	**Description**	**Overall Construction Duration (Years)**	**Maximum construction Duration Offshore (Years)**	**Maximum construction Duration Onshore (Years)**
In Isolation	Either DBS East or DBS West is built In Isolation	Five	Five	Four

Development scenario	Description	Overall Construction Duration (Years)	Maximum construction Duration Offshore (Years)	Maximum construction Duration Onshore (Years)
Sequential	DBS East and DBS West are both built sequentially, either Project could commence construction first with staggered / overlapping construction	Seven	A five year period of construction for each project with a lag of up to two years in the start of construction of the second project (excluding landfall duct installation) – reflecting the maximum duration of effects of seven years.	Construction works (i.e. onshore cable civil works, including duct installation) to be completed for both Projects simultaneously in the first four years, with additional works at the landfall, substation zone and cable joint bays in the following two years. Maximum duration of effects of six years.
Concurrent	DBS East and DBS West are both built concurrently reflecting the maximum peak effects	Five	Five	Four

15. The In Isolation, Concurrent and Sequential Development Scenarios all allow for flexibility to build out either or both Projects using a phased approach offshore. Under a phased approach the maximum timescales for individual elements of the construction are assessed.

16. Any differences between the Projects, or differences that could result from the manner in which the first and the second Projects are built (Concurrent or Sequential and the length of any lag) are identified and discussed where relevant in section 8.7. For each potential impact, the worst case construction scenario for the In Isolation scenario and the Concurrent or Sequential scenario is presented. The worst case scenario presented for the Concurrent or Sequential scenario will depend on which of these is the worst case for the potential impact being considered. The justification for what constitutes the worst case is provided, where necessary, in section 8.7.

8.3.2.3 Operation Scenarios

17. Operation scenarios are described in detail in **Volume 7, Chapter 5 Project Description (application ref: 7.5)**. The assessment considers the following scenarios:

- Only DBS East in operation;
- Only DBS West in operation; and
- DBS East and DBS West operating concurrently with or without a lag of up to two years between each Project commencing operation.

18. If the Projects are built out using a phased approach, there would also be a phased approach to starting the operational stage. The worst case scenario for the operational phases for the Projects have been assessed. See section 5.1.1 of **Volume 7, Chapter 5 Project Description (application ref: 7.5)** for further information on phasing scenarios for the Projects.

19. The operational lifetime of each Project is expected to be 30 years.

8.3.2.4 Decommissioning Scenarios

20. Decommissioning scenarios are described in **Volume 7, Chapter 5 Project Description (application ref: 7.5)**. Decommissioning arrangements will be agreed through the submission of a Decommissioning Programme prior to construction, however for the purpose of this assessment it is assumed that decommissioning of the Projects could be conducted separately, or at the same time.

8.3.3 Embedded Mitigation

21. This section outlines the embedded mitigation relevant to the marine physical environment assessment, which has been incorporated into the design of the Projects or constitutes standard mitigation measures for this topic (**Table 8-3**). Mitigation is also detailed within the **Commitments Register (application ref: 8.6)** and cross-referenced within **Table 8-3**. Where additional mitigation measures are proposed, these are detailed in the impact assessment (section 8.7).

22. Due to the presence and movements of construction and operation and maintenance vessels / equipment there is the potential for spills and leaks which could result in changes to water quality. All vessels involved will be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78.

23. An **Outline Project Environmental Management Plan (PEMP) (application ref: 8.21)** has been produced to cover the construction and, operation and maintenance and decommissioning phases of the Projects. This sets out all procedures and measures (in the form of a Marine Pollution Contingency Plan (MPCP)) to be followed during construction and, operation and maintenance and decommissioning phases to minimise the risk of, and effects in the event of an accidental spill. The final PEMP will identify all potential sources and types of accidental pollution for all project phases and set out the proposed mitigation measures. The PEMP will be developed post-consent in consultation with key stakeholders for approval by the Marine Management Organisation (MMO). Accidental pollution is therefore not considered further within this Chapter (see **Table 8-3**).

Table 8-3 Embedded Mitigation

Parameter	Embedded Mitigation Measures	Where commitment is secured
Use of scour protection	Where necessary, foundations will include scour protection which will minimise the amount of scour and sediment released / transported due to scour.	Scour Protection Plan Cable Statement Deemed Marine Licence (DML) 1 & 2 - Condition 15 DML 3 & 4-Condition 13 DML 5 - Condition 11

Parameter	**Embedded Mitigation Measures**	**Where commitment is secured**
Piling foundation types	For piled foundation types, such as monopiles and jackets with pin piles, pile-driving will be used in preference to drilling where it is practicable to do so (i.e. where ground conditions allow). This would minimise the quantity of sub-surface sediment released into the water column from the installation process.	DML 1 & 2 - Condition 15 DML 3 & 4-Condition 13
Cable burial	The Applicants are committed to burying offshore export cables to 0.5-1.5m (depending on cable location) where practicable, minimising the requirement for external cable protection measures and thus effects on sediment transport (subject to a cable burial risk assessment (see **Volume 8, Cable Statement (application ref: 8.20)**).	Cable Statement DML 1 & 2 - Condition 15 DML 3 & 4-Condition 13 DML 5 - Condition 11
Route selection and micrositing	Route selection and micro-siting of the cables will be used to avoid areas of seabed that pose a significant challenge to their installation where practiceable, including for example areas of sand waves and megaripples. This will minimise the requirement for seabed preparation (levelling) and the associated seabed disturbance.	DML 1 & 2 - Condition 15 DML 3 & 4-Condition 13 DML 5 - Condition 11
Trenchless techniques	A trenchless technique will be used to install the export cables at the landfall for the Projects Any trenchless landfall exit pits located between MHWS and MLWS will be located a minimum of 50m seaward from the toe of the cliff line. If sediment begins to accumulate in the pits, it will be excavated and returned to the beach where it can be transported alongshore to the south, as per the prevailing sediment transport regime.	DML 3 & 4 - Condition 13

Parameter	**Embedded Mitigation Measures**	**Where commitment is secured**
Jack up vessels	Jack-up vessels will not be used within the area of the 1km Construction Buffer Zone which overlaps with the Holderness Inshore MCZ or the Smithic Bank sandbank without agreement of MMO in consultation with Natural England.	DML 3 & 4 - Condition 13
Pollution Prevention Measures	Due to the presence and movements of construction and operation and maintenance vessels/equipment there is the potential for spills and leaks which could result in changes to water quality. All vessels involved will be required to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78. The production of one or more Project Environmental Management Plans (PEMPs) is a Condition of the five Deemed Marine Licences (DMLs). The final PEMP(s) would be in accordance with **Volume 8, Outline PEMP (application ref: 8.21**) and would detail all procedures and measures (in the form of a Marine Pollution Contingency Plan (MPCP)) to be followed during the different phases of the Projects to minimise the risk of, and effects in, the event of an accidental spill. The final PEMP will identify all potential sources and types of accidental pollution for the relevant project phase and set out the proposed mitigation measures and will be developed in consultation with key stakeholders for approval by the MMO. The individual Projects and phases may require separate final PEMP(s). In addition separate PEMPs may also be produced for individual packages.	PEMP MPCP DML 1 & 2 - Condition 15 DML 3 & 4-Condition 13 DML 5 - Condition 11
Offshore Export Cable Burial	Any offshore export cables associated with the Projects will be buried within the intertidal zone at landfall, and 350m	DML 3 & 4 - Condition 3

Parameter	Embedded Mitigation Measures	Where commitment is secured
	seaward of MLWS. No surface cable protection will be used within these areas. Cable protection will be limited to 10% of the cumulative length of all cables laid between 350m seaward of MLWS and the 10m depth contour as measured against the lowest astronomical tide before the commencement of construction.	
Monitoring	If the Projects trenchless technique exit pits are located within the intertidal area, pre- and post- construction monitoring of beach profile change would be carried out to confirm beach profile recovery and support predictions regarding impacts to the Holderness cliffs. This is detailed within **Volume 8, In-Principle Monitoring Plan (IPMP) (application ref: 8.23)**.	DML 3 & 4 - Conditions 18 & 20
Sediment backfilling	Any backfilled sediment will be returned in the order it was removed to avoid creating areas of seabed with differing resistance.	DML 3 & 4 - Condition 13

24. Although not considered mitigation, the following commitments have been made by the Applicants in line with the conclusions of The Crown Estate's Round 4 Plan Level Habitats Regulations Assessment (HRA) (The Crown Estate, 2022):

- The use of gravity base structures and suction caisson monopile foundations have been removed as foundation options within the boundary of the Dogger Bank SAC.
- A maximum 10% of cable length within the Dogger Bank SAC may use remedial protection measures.

8.4 Assessment Methodology

8.4.1 Policy, Legislation and Guidance

8.4.1.1 National Policy Statements

25. The assessment of potential impacts upon the marine physical environment has been made with specific reference to current National Policy Statements (NPS) including the Overarching NPS for Energy (EN-1), the NPS for Renewable Energy Infrastructure (EN-3) and the NPS for Electricity Networks Infrastructure (EN-5) (DESNZ, 2023a-c). These were published in November 2023 and were designated in January 2024. The specific assessment requirements for the marine physical environment, as detailed in the NPS, are summarised in **Table 8-4** together with an indication of the section of this chapter where each is addressed.

Table 8-4 NPS Assessment Requirements

NPS Requirement	NPS Reference	ES Section Reference
EN-1 NPS for Energy		
Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally, and locally designated sites of ecological or geological conservation importance (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats.	Section 5.4, paragraph 5.4.17	Designated sites and coastal morphological features have been identified as receptors in section 8.7.1 and considered in the wider impact assessment (section 8.7).
Where onshore infrastructure projects are proposed on the coast, coastal change is a key consideration as well as a vital element of climate change adaptation.	Section 5.6, paragraph 5.6.4	Historic and future trends in coastal change have been considered in section 8.5.16 and 8.6.2.
Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures	Section 5.6, paragraph 5.6.10	An expert coastal geomorphological assessment of has been undertaken to understand sediment transport

NPS Requirement	NPS Reference	ES Section Reference
		modelling as outlined in section 8.5.158.6.2.
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) (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;	Section 5.6, paragraph 5.6.11	Designated sites and coastal morphological features have been identified as receptors in section 8.7.1and considered in the wider impact assessment (section 8.7). Potential changes resulting from climate change are presented in section 8.6. The existing coastal management strategies are presented in section 8.5.16 and the impact of the Projects in relation to these strategies is outlined in sections 8.7.3.4 and 8.7.3.9. The effects of the Projects on marine ecology and biodiversity are discussed in **Volume 7, Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)**. The effects of the Projects on coastal heritage assets are discussed in **Volume 7, Chapter 17 Offshore Archaeology and Cultural Heritage (application ref: 7.17)** and **Volume 7, Chapter 22 Onshore Archaeology and Cultural Heritage (application ref: 7.22)**.

NPS Requirement	NPS Reference	ES Section Reference
- 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; - 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 effects of the Projects on coastal recreation sites are discussed in **Volume 7, Chapter 29 Tourism and Recreation (application ref: 7.29)**
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 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 identity any effects on the special character of Heritage Coasts.	Section 5.6, paragraph 5.6.13	Designated sites and coastal morphological features have been identified as receptors in section 8.7.1 and considered in the wider impact assessment (section 8.7).
Applicants should propose appropriate mitigation measures to address adverse physical changes to the coast, in consultation with the MMO, the EA or NRW, LPAs, other statutory consultees, Coastal Partnerships and other coastal groups, as it considers appropriate. Where this is not the case, the Secretary of State should consider what appropriate mitigation requirements might be attached to any grant of development consent.	Section 5.6, paragraph 5.6.15	Embedded mitigation is presented in section 11. sections 8.7and 8.8 consider the need for additional mitigation, in the context of the existing environment (section 8.5) and future trends (section 8.6).

NPS Requirement	NPS Reference	ES Section Reference
Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface water, transitional waters coastal and marine waters.	Section 5.16, paragraph 5.16.1	Potential effects of the Projects on Water Quality are assessed in section 8.7. Reference to accidental spills and proposed management is described in section 11. A Water Environment Regulations Compliance Assessment is provided in **Volume 7, Appendix 20-3 (application ref: 7.20.20.3)**.
Where the project is likely to have effects on the water environment, the applicant should undertake an assessment of the existing status of, and impacts of the proposed project on, water quality, water resources and physical characteristics of the water environment, and how this might change due to the impact of climate change on rainfall patterns and consequently water availability across the water environment, as part of the ES or equivalent (see Section 4.3 and 4.10).	Section 5.16, Paragraph 5.16.3	The existing baseline is presented in section 8.5 to section 8.6 and impacts on marine water quality are described and assessed in section 8.7.
The risk of impacts on the water environment can be reduced through careful design to facilitate adherence to good pollution control practice. For example, designated areas for storage and unloading, with appropriate drainage facilities, should be clearly marked.	Section 5.16, Paragraph 5.16.9	An **Outline Project Environmental Management Plan (PEMP) (application ref: 8.21)** which will include a MPCP has been submitted with the DCO application.
EN-3 NPS for Renewable Energy Infrastructure		
The construction, operation and decommissioning of offshore energy infrastructure (including the preparation and installation of the cable route and	Section 2.8, paragraph 2.8.111	The existing baseline is presented in section 8.5 to section 8.6.

NPS Requirement	NPS Reference	ES Section Reference
any electricity networks infrastructure 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 and coastal erosion risk management, 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		Impacts on marine water quality are described and assessed in section 8.7. Changes to wave and tide regime due to the presence of infrastructure are assessed in section 8.7.4.1 and 8.7.4.2. Scour protection will be installed where necessary as part of the embedded mitigation as outlined in **Table 8-3**. Therefore, there will be no effect from scour around infrastructure. Changes to suspended sediment transport have been assessed using plume dispersion modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) as outlined in sections 8.7.3.1, 8.7.3.2, 8.7.3.3 and 8.7.3.4. Changes to bedload sediment transport have been assessed using bed shear stress outputs from modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) as outlined in section 8.7.3.9. Effects on habitats are assessed in **Volume 7, Chapter 9 Benthic and**

NPS Requirement	NPS Reference	ES Section Reference
effects on marine ecology and biodiversity; sandwaves – the modification/clearance of sandwaves can cause direct physical (such as in affecting unknown archaeological remains) 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.		**Intertidal Ecology (application ref: 7.9)**, and on fish **in Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)** and **Volume 7, Chapter 13 Commercial Fisheries (application ref: 7.13)**. Loss of seabed area is considered in section 8.7.4.8. Seabed preparation for cable installation methods has been assessed using plume dispersion modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)** and is considered in sections 8.7.3.3, 8.7.3.4 and8.7.3.5 8.7.3.8. Changes to water circulation are considered in section 8.7.4.3.
Applicant assessments are expected to include predictions of the physical effects arising from modifications to hydrodynamics (waves and tides), sediments and sediment transport, and sea bed morphology that will result from the construction, operation and decommissioning of the required infrastructure.	Section 2.8, paragraph 2.8.112	The existing baseline is presented in section 8.5 to section 8.6. Potential effects are considered in section 8.7.
Assessments should also include effects such as the scouring that may result from the proposed development and	Section 2.8, paragraph 2.8.113	Scour is considered in section 8.7.3.1 and 8.7.4.8.

NPS Requirement	NPS Reference	ES Section Reference
how that might impact sensitive species and habitats.		
Applicants should undertake geotechnical investigations as part of the assessment, enabling the design of appropriate construction techniques to minimise any adverse effects.	Section 2.8, paragraph 2.8.114	Geotechnical investigations were utilised to inform section 8.5 to section 8.6.
Applicant assessment of the effects on the subtidal environment should include: increased suspended sediment loads during construction and from maintenance/repairs; predicted rates at which the subtidal zone might recover from temporary effects;	Section 2.8, paragraph 2.8.126	The effects of changes to suspended sediment concentrations are assessed in section 8.7. An assessment of changes to sediment transport in the nearshore is outlined in section 8.7.3.9.
EN-5 NPS for Electricity Networks Infrastructure		
As climate change is likely to increase risks to the resilience of some of this infrastructure, from flooding for example, or in situations where it is located near the coast or an estuary or is underground, applicants should in particular set out to what extent the proposed development is expected to be vulnerable, and, as appropriate, how it has been designed to be resilient to: coastal erosion – for the landfall of offshore transmission cables and their associated substations in the inshore and coastal locations respectively.	Section 2.3, Paragraph 2.3.2	A coastal erosion assessment has been undertaken as outlined in section 8.6.2.
Section 4.10 of EN-1 advises that the resilience of the project to the effects of climate change must be assessed in the Environmental Statement (ES) accompanying an application. For example, future increased risk of	Section 2.3, Paragraph 2.3.3	Future changes in the environment are addressed in section 8.6.

NPS Requirement	NPS Reference	ES Section Reference
flooding would be covered in any flood risk assessment (see sections 5.8 in EN-1). Consideration should also be given to coastal change (see sections 5.6 in EN1).		

8.4.1.2 Other

26. In addition to the NPS, there a number of pieces of legislation, policy and guidance applicable to the assessment of marine physical environment. These include:

- The Marine Policy Statement (MPS) (HM Government, 2011; discussed further in **Volume 7, Chapter 3, Policy and Legislative Context (application ref: 7.3)**) 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.*"
- The MPS is also the framework for preparing individual marine plans and taking decisions affecting the marine environment. The Marine Plans relevant to the Projects are the East Inshore and the East Offshore Marine Plans and the North-East Inshore and Offshore Marine Plans (HM Government, 2014; discussed further in **Volume 7, Chapter 3 Policy and Legislative Context (application ref: 7.3)**). Objective 6 of the East Inshore and the East Offshore Marine Plans "*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*" is of relevance to the marine physical environment. This objective covers policies and commitments on the wider ecosystem, including those to do with the Marine Strategy Framework Directive and the Water Framework Directive (see **Volume 7, Chapter 3 Policy and Legislative Context (application ref: 7.3)**). 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*".

27. Additional guidance on the generic requirements, including spatial and temporal scales, for marine physical environment studies associated with offshore wind farm developments is provided in the following main documents:

- Offshore wind farms (OWFs): 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);
- 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);
- General advice on assessing potential impacts of and mitigation for human activities on MCZ features, using existing regulation and legislation (JNCC & Natural England, 2011);
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Cefas, 2011);
- East Inshore and East Offshore Marine Plan Areas: Evidence and Issues (MMO, 2012);
- North-east Inshore and North-east Offshore Marine Plan Areas: Issues and Evidence Database (MMO, 2017); and
- Natural England's Approach to Offshore Wind (Natural England, 2021).

28. There is no specific guidance available for the impact assessment of marine sediment and water quality.

29. Where available data supports it, sediment quality guidelines used by the OSPAR Commission and the MMO have been used.

30. The Convention for the Protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention') is the mechanism by which 15 Governments and the European Union (EU) cooperate to protect the marine environment of the North-East Atlantic. The convention requires that all contracting parties take all possible steps to prevent and eliminate pollution and protect the maritime area against the adverse effects of human activities. The aims are to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

31. Resulting from this cooperation, are assessments produced by the OSPAR commission, on the quality status of the marine environment for the maritime area, or for regions or sub-regions, thereof. These are presented in Quality Status Reports (QSRs). An element contributing to these assessments considers sediment quality data and uses Background Assessment Concentrations (BAC) and the US Environmental Protection Agency's (EPA) Effects Range-Low (ERL) to determine levels of contamination and trends over time. BACs are statistical tools, defined in relation to the background concentrations, which enable statistical testing of whether observed concentrations can be considered to be near background concentrations. The ERL value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value. Relevant BACs and ERLs are provided in **Table 8-5**.

32. In England, the MMO licences dredge material disposal at sea. To undertake the assessment regarding suitability of sediment for disposal, the MMO applies Cefas action levels (sediment quality criteria) for contaminants on a primary list These action levels are then used as part of a 'weight of evidence' approach to decision making on the disposal of dredged material. There are two levels – Action Level 1 (AL1) and Action Level 2 (AL2). Contaminant levels below AL1 are generally assumed to be of no concern and are unlikely to influence the licensing decision. Contaminant levels between AL1 and AL2 generally trigger further investigation of the material, and contaminants in dredged material above AL2 are generally considered unsuitable for sea disposal (MMO, 2015). Although the majority of the material assessed against these standards arises from a specific activity, i.e. dredging and disposal activities, they are also considered suitable for undertaking an initial risk assessment with respect to determining risks to marine waters from other marine activities, as part of EIA and associated Water Framework Directive (WFD) compliance assessments. If, overall, levels do not generally exceed AL1, then contamination levels are considered to be low risk in terms of the potential for impacts on water quality. Where concentrations fall close to, or above AL2, then more quantitative assessment regarding water quality effects might be required, which would consider the risk of breaching water quality Environmental Quality Standards (EQS). This approach is recommended by the Environment Agency in their WFD compliance assessment guidance 'Clearing the Waters for All' (Environment Agency, 2017). Relevant values are presented in **Table 8-5**.

Table 8-5 Selected OSPAR sediment guidelines and Cefas Action Levels

Contaminant	Units	OSPAR BAC	OSPAR ERL	Cefas AL1	Cefas AL2
Arsenic	mg/kg	25	8.2[1]	20	100
Cadmium		0.31	1.2	0.4	5
Chromium		81	81	40	400
Copper		27	34	40	400
Mercury		0.07	0.15	0.3	3
Nickel		36	21[1]	20	200
Lead		38	47	50	500
Zinc		122	150	130	800
Polyaromatic Hydrocarbons (PAHS) – individual PAHs	µg/kg	-	-	100	-
Anthracene		5	85	100	-
Benz(a)anthracene		16	261	100	-
Benzo(a)pyrene		30	430	100	-
Chrysene		20	384	100	-
Dibenzo(a,h)anthracene		-	-	10	-
Fluoranthene		39	600	100	-
Naphthalene		8	160	100	-
Phenanthrene		32	240	100	-
Pyrene		24	665	100	-

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[1] The ERLs for arsenic and nickel are below the OSPAR BAC therefore arsenic and nickel concentrations are only assessed against the BAC.

Contaminant	Units	OSPAR BAC	OSPAR ERL	Cefas AL1	Cefas AL2
Benzo(ghi)perylene		80	85	100	-
Indeno[1,2,3-cd]pyrene		103	240	100	-
Polychlorinated biphenyls (PCBs) International Council for the Exploration of the Sea (ICES) 7	mg/kg	-	-	0.01	-

8.4.2 Data and Information Sources

8.4.2.1 Site Specific Surveys

33. To provide site specific and up to date information on which to base the impact assessment, a marine geophysical survey including multi-beam echosounder (MBES), side scan sonar (SSS) and sub-bottom profiler (SBP) was conducted within the Offshore Development Area during 2022 (Fugro, 2023a; 2023b). A seabed grab sampling survey was also undertaken in the Array Areas and Offshore Export Cable Corridor in 2022 (Fugro, 2023c) and sediment samples were analysed for particle size distribution and sediment contamination. A geotechnical borehole survey was undertaken in the Array Areas in 2022 followed by a vibrocore survey within the Offshore Export Cable Corridor in 2023 (Fugro, 2023d). Metocean data were acquired from wave buoys deployed in DBS East and DBS West between the March 2022 and May 2023. Project specific data sources used to inform the assessment are listed in **Table 8-6**.

Table 8-6 Site Specific Surveys and Information Sources

Data Set	Spatial Coverage	Year	Notes
Multi-beam echosounder bathymetry	Array Areas and Offshore Export Cable Corridor	2022	-
Side scan sonar	Array Areas and Offshore Export Cable Corridor	2022	-

Data Set	Spatial Coverage	Year	Notes
Sub-bottom profiler	Array Areas and Offshore Export Cable Corridor	2022	Sub-bottom profiler data were interpreted by Fugro and horizons showing depth below seabed to bedrock in the nearshore were used in this assessment
Seabed grab sample survey	Array Areas and Offshore Export Cable Corridor	2022	-
Particle size analysis (PSA)	Array Areas and Offshore Export Cable Corridor	2022	-
Wave buoys	DBS East Array Area and DBS West Array Area	2022-2023	-
Geotechnical borehole and vibrocore survey	Array Areas and Offshore Export Cable Corridor	2022-2023	-
Numerical modelling (hydrodynamic, wave and plume dispersion modelling)	Array Areas and Offshore Export Cable Corridor	2023	A technical report outlining the modelling approach, methods, calibration, sensitivity tests and results (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**).
Sediment contaminant data	Array Areas and Offshore Export Cable Corridor	2022	-

8.4.2.2 Other Available Sources

34. Other sources that have been used to inform the assessment are listed in **Table 8-6**.

Table 8-6 Other Available Data and Information Sources

Data Set	Spatial Coverage	Year	Notes
EMODnet bathymetry	Array Areas and Offshore Export Cable Corridor	2020	-
BERR Atlas tidal currents	Array Areas and Offshore Export Cable Corridor	2007	-
ABPmer tidal excursion ellipses (mean spring)	Array Areas and Offshore Export Cable Corridor	2022	-
BERR Atlas waves	Array Areas and Offshore Export Cable Corridor	2001-2008	-
BGS seabed sediments	Array Areas and Offshore Export Cable Corridor	Pre-1987	-
BGS fine-scale maps (offshore Yorkshire)	Offshore Export Cable Corridor	2022	-
Cefas suspended sediment concentrations	Array Areas and Offshore Export Cable Corridor	1998-2015	-
CCO Bathymetry	Inshore waters	2011	-
Wave buoys	Inshore waters	2008-2023	Public data from the Hornsea wave buoy.
Cliff erosion rates	The Holderness coast	1852-2023	Provided by East Riding of Yorkshire Council
OSPAR Quality Status Interim Assessment 2017	UK	Various	Chemical contamination review of region within which the Projects sit

Data Set	**Spatial Coverage**	**Year**	**Notes**
Environment Agency data sources for inshore water quality – catchment data explorer and bathing waters database	Inshore area	2022	Water quality information for inshore waters (i.e. within 1 nautical mile)
Dogger Bank Met Mast Survey Analysis	Wider Dogger Bank	2023	Comparison of survey data collected prior to the installation and removal of two met masts on Dogger Bank (see **Appendix 8-2 Met Mast Survey Analysis (application ref: 7.8.8.2)**).

8.4.3 Impact Assessment Methodology

35. **Volume 7, Chapter 6 EIA Methodology (application ref: 7.6)** provides a summary of the general impact assessment methodology applied. The following sections describe the methods used to assess the likely significant effects on the marine physical environment.

36. The assessment of effects on wave and tidal currents, and sediment transport processes are predicated on a Source-Pathway-Receptor (S-P-R) conceptual model, whereby the source is the initiator event, the pathway is the link between the source and the receptor impacted by the effect, and the receptor is the receiving entity. An example of the S-P-R conceptual model is provided by cable installation which disturbs sediment on the seabed (source). This sediment is then transported by tidal currents until it settles back to the seabed (pathway). The deposited sediment could change the composition and elevation of the seabed (receptor).

37. Consideration of the potential effects on the marine physical environment is carried out at the following spatial scales:

- Near-field: the area within the immediate vicinity (tens to hundreds of metres) of the Offshore Development Area; and
- Far-field: the wider area that may be affected indirectly by the Projects (e.g. due to the disruption of waves, tidal currents or sediment pathways passing through the Projects), as determined by hydrodynamic, wave

and plume dispersion modelling undertaken for the Project (see section 8.3.1) and information on tidal excursion ellipses.

38. For the effects on the marine physical environment, the assessment follows two approaches. The first type of assessment is impacts on the marine physical environment whereby several discrete direct receptors can be identified. These include certain morphological features with ascribed inherent values, such as sand banks and other features of value, including beaches and sea cliffs along the Holderness coast.

39. The impact assessment incorporates a combination of the sensitivity of the receptor, its value (if applicable) and the magnitude of the change to determine a significance of effect.

40. The second type of assessment covers changes to the marine physical environment which in themselves are not necessarily impacts to which significance can be ascribed. Rather, these changes (such as a change in the wave climate, a change in the tidal regime or a change in suspended sediment concentrations) represent effects which may manifest themselves as an impact upon other receptors, most notably benthic ecology, and fish and shellfish ecology (e.g. in terms of increased suspended sediment concentrations, or erosion or smothering of habitats on the seabed). Hence, the two approaches to the assessment of the marine physical environment are:

- Situations where potential impacts can be defined as directly affecting receptors which possess their own intrinsic morphological value. In this case, the significance of effect is based on an assessment of the sensitivity of the receptor and magnitude of impact by means of an impact significance matrix.
- Situations where changes in the baseline marine physical environment may occur which could manifest as impacts upon receptors other than the marine physical environment. In this case, the magnitude of impact is determined in a similar manner to the first assessment method, but the assessment of significance of effect on other receptors is made within the relevant chapters of the ES pertaining to those receptors.

8.4.3.1 Definitions

41. 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 environment assessment are provided below.

8.4.3.1.1 Sensitivity

42. The sensitivity of a receptor to changes in the marine physical environment is dependent upon its tolerance and recoverability which are defined as:

- Tolerance: the extent to which the receptor is adversely affected by an effect; and
- Recoverability: a measure of a receptor's ability to return to a state at, or close to, that which existed before the effect caused a change.

43. A matrix approach is used to determine sensitivity as a function of tolerance and recoverability, as outlined in **Table 8-7** and **Table 8-8**.

Table 8-7 Sensitivity matrix

		Tolerance			
		None	**Low**	**Medium**	**High**
Recoverability	**Very Low**	High	High	Medium	Low
	Low	High	High	Medium	Low
	Medium	Medium	Medium	Medium	Low
	High	Medium	Low	Low	Negligible

Table 8-8 Definition of Sensitivity

Sensitivity	**Definition**
High	Tolerance: None, receptor has very limited tolerance of effect. Recoverability: Receptor unable to recover resulting in permanent or long-term (>10 years) change.
Medium	Tolerance: Receptor has limited tolerance of effect. Recoverability: Receptor able to recover to an acceptable status over the medium term (5-10 years).
Low	Tolerance: Receptor has some tolerance of effect. Recoverability: Receptor able to recover to an acceptable status over the short term (1-5 years).
Negligible	Tolerance: Receptor highly tolerant of effect. Recoverability: Receptor able to recover to an acceptable status near instantaneously (<1 year).

8.4.3.1.2 Value

44. In addition, a 'value' component may also be considered when assessing a receptor. This ascribes whether the receptor is rare, protected or threatened or otherwise. It is important to understand that high value and high sensitivity are not necessarily linked within a particular effect. A receptor could be of high value (e.g. Annex I habitat) but have a low or negligible physical sensitivity to an effect. 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. **Table 8-9** states the definitions of value levels for marine physical processes.

Table 8-9 Definition of Value

Value	Definition
High	Value: Receptor is designated and / or of national or international importance for marine geology, oceanography or physical processes and designation status relies on passing water EQS. Receptor is likely to be rare with minimal potential for substitution and may also be of significant wider-scale, functional or strategic importance.
Medium	Value: Receptor is not designated but is of local to regional importance for marine geology, oceanography or physical processes (including water quality).
Low	Value: Receptor is not designated but is of local importance for marine geology, oceanography or physical processes (including water quality).
Negligible	Value: Receptor is not designated and is not deemed of importance for marine geology, oceanography or physical processes (including water quality).

8.4.3.1.3 Magnitude

45. The magnitude of an impact is dependent upon its:

- Scale (i.e. size, extent or intensity);
- Duration;
- Frequency of occurrence; and
- Reversibility (i.e. the capability of the environment to return to a condition equivalent to the baseline after the effect ceases).

Table 8-10 Definition of Magnitude of Impacts

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 5-10 years. Frequency: The effect would occur regularly but not all the time. Reversibility: The effect is very slowly reversible (5-10 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 1-5 years. Frequency: The effect would occur occasionally but not all the time. Reversibility: The effect is slowly reversible (1-5 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).

8.4.3.2 Significance of Effect

46. The assessment of significance of an effect is informed by the sensitivity of the receptor and the magnitude of the impact (see **Volume 7, Chapter 6 EIA Methodology (application ref: 7.6)** for further detail). The determination of significance is guided by the use of a marine physical environment significance of effect matrix, as shown in **Table 8-11**. Definitions of each level of significance are provided in **Table 8-12**. For the purposes of this assessment, any effect that is of major or moderate significance is considered to be significant in EIA terms, whether this be adverse or beneficial. Any effect that has a significance of minor or negligible is not significant.

Table 8-11 Marine Physical Environment Significance of Effect Matrix

		Adverse Magnitude				**Beneficial Magnitude**			
		High	**Medium**	**Low**	**Negligible**	**Negligible**	**Low**	**Medium**	**High**
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 8-12 Definition of Effect Significance

Significance	**Definition**
Major	Very large or large change in receptor condition, which is likely to be an important consideration 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 is likely to be an important consideration 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 impact, therefore no change in receptor condition.

8.4.4 Cumulative Effects Assessment Methodology

47. The cumulative effects assessment (CEA) considers other schemes, plans, projects and activities that may result in significant effect in cumulation with the Projects. **Volume 7, Chapter 6 EIA Methodology (application ref: 7.6)** (and accompanying **Volume 7, Appendix 6-2 Offshore Cumulative Effects Assessment (CEA) Methodology (application ref: 7.6.6.2)**) provides further details of the general framework and approach to the CEA.

8.4.5 Transboundary Effect Assessment Methodology

48. The transboundary assessment considers the potential for transboundary effects to occur on marine physical environment receptors as a result of the Projects; either those that might arise within the Exclusive Economic Zone (EEZ) of European Economic Area (EEA) states or arising on the interests of EEA states e.g. a non UK fishing vessel. **Volume 7, Chapter 6 EIA Methodology (application ref: 7.6)** provides further details of the general framework and approach to the assessment of the transboundary effects.

49. For both the marine physical environment and marine sediment and water quality topics, the potential for transboundary effects were considered in the respective chapters of the scoping report and it was concluded that given that the likely effects of the Projects will be restricted to near-field change, coupled with its location approximately 41km from the EEZ boundary, there would be no pathway for transboundary impacts. The conclusion of the scoping report was accepted in the scoping opinion, and therefore, transboundary impacts are scoped out and are not considered further in this chapter.

8.4.6 Assumptions and Limitations

50. Given the large amount of data that was collected for the Dogger Bank A, B and C, and Sofia offshore wind farms, there is a good baseline understanding of the marine physical environment at the Projects' sites and its adjacent areas. There is, however, limited offshore water quality data available. Therefore, information from more general monitoring programmes such as those undertaken by the OSPAR Commission has been used to inform this assessment. This limitation is not, however, considered to significantly affect the certainty or reliability of the impact assessment.

8.5 Existing Environment

8.5.1 Bathymetry and Seabed Features

51. The minimum and maximum water depths across the Array Areas and Inter-Platform Cable Corridor are approximately 12m below Lowest Astronomical Tide (LAT) and 40m below LAT, respectively (**Volume 7, Figure 8-1 (application ref: 7.8.1)**). A bathymetric profile across the Array Areas and Inter-Platform Cable Corridor (**Plate 8-1**) shows the seabed rises from north-west to south-east up the western flank of Dogger Bank and then becomes broadly flat across the top of the bank before falling again on the southern flank.

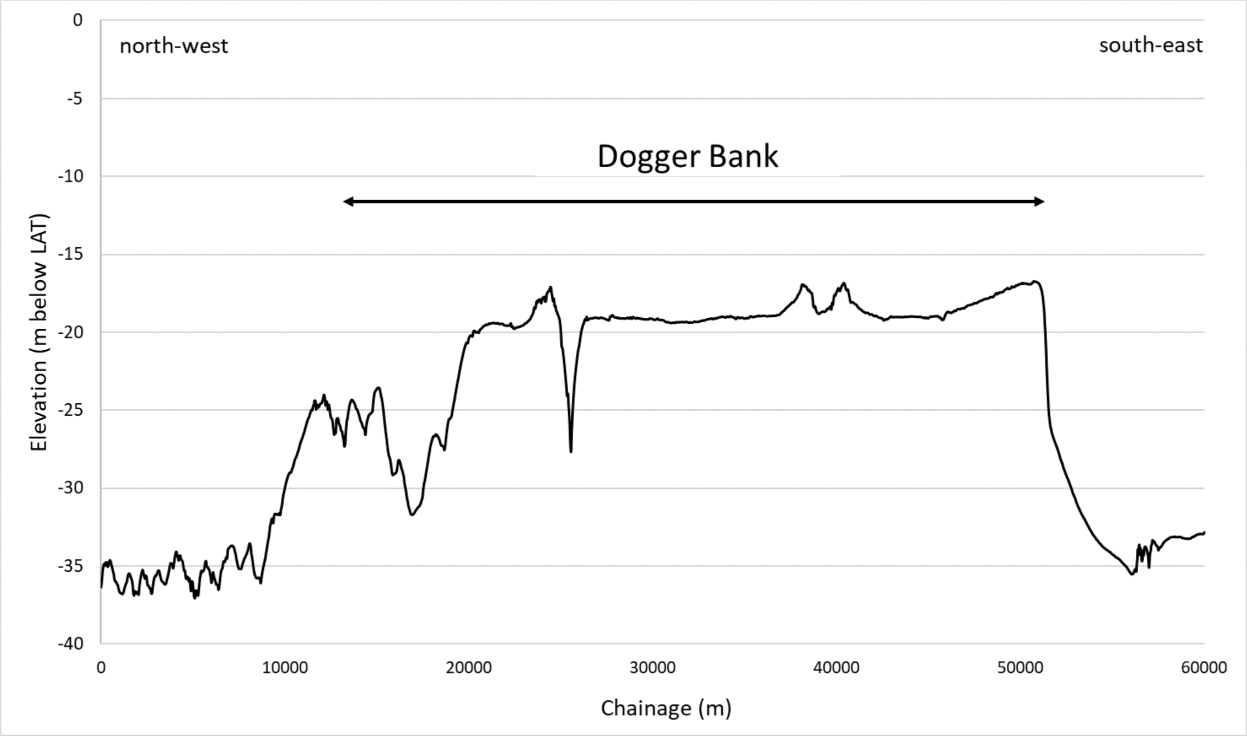

Plate 8-1 Seabed profile from bathymetry data acquired in 2022 across the Array Areas and Inter-Platform Cable Corridor (Source: Fugro, 2023a) . Location of profile is shown on ***Volume 7, Figure 8-1 (application ref: 7.8.1)****.*

52. The seabed along the Offshore Export Cable Corridor gently slopes from the landfall where water depths are shallow, to a maximum of 60m below LAT about 8km offshore. Water depths then shallow to a minimum of 15m below LAT as the Offshore Export Cable Corridor approaches the Array Areas. This is shown in bathymetric profiles across the Offshore Export Cable Corridor to the DBS East Array Area and DBS West Array Area (**Plate 8-2** and **Plate 8-3**).

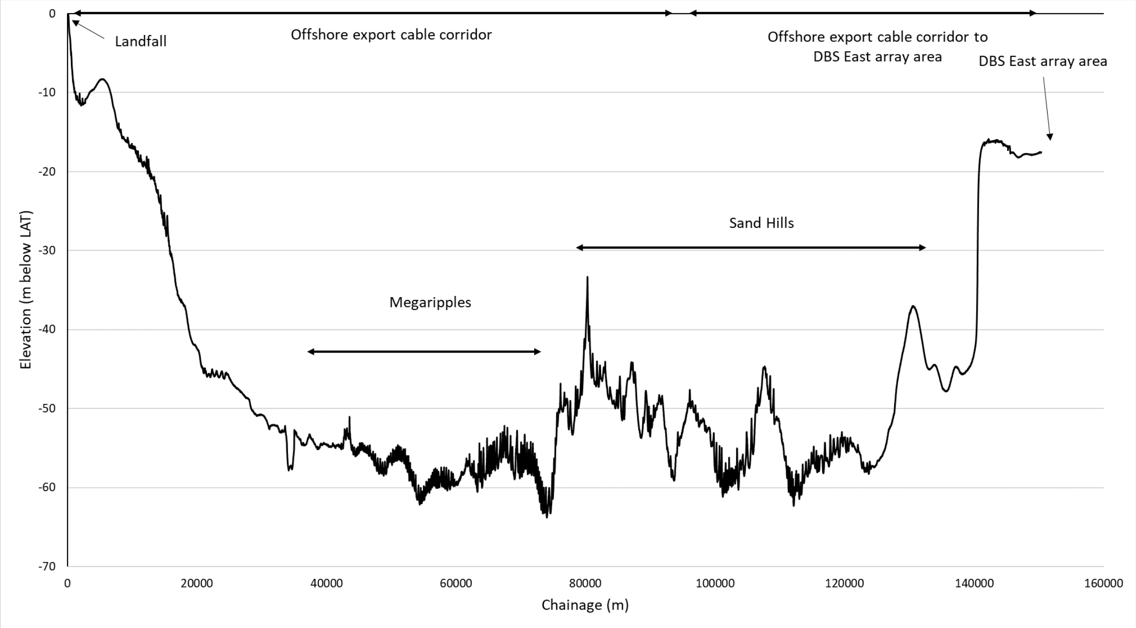

Plate 8-2 Seabed profile from bathymetry data acquired in 2022 across the proposed Offshore Export Cable Corridor, from landfall (south-west) to the DBS East Array Area (north-east) (Source: Fugro, 2023b)

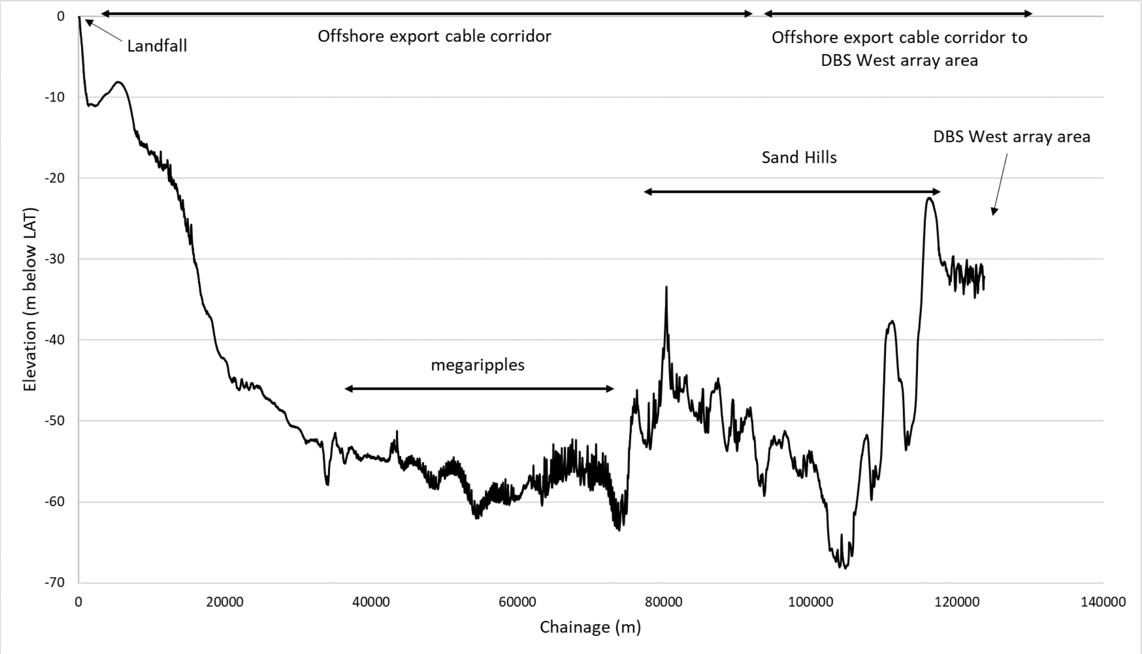

Plate 8-3 Seabed profile from bathymetry data acquired in 2022 across the proposed Offshore Export Cable Corridor, from landfall (south-west) to the DBS West Array Area (north-east) (Source: Fugro, 2023b)

53. The Offshore Export Cable Corridor is located to the south of Smithic Bank, a north-east to south-west aligned offshore sand bank. Smithic Bank rises to a minimum depth of about 6m below Ordnance Datum (OD) (**Volume 7, Figure 8-2 (application ref: 7.8.1)**). The western inshore flank of the bank is about 5km offshore from Bridlington before the bathymetry deepens down its eastern flank to its edge around 18m below OD. The inshore flank of the bank has a much steeper slope than that of the seaward flank.

54. The extent of Smithic Bank has been delimited by JNCC as outlined on **Volume 7, Figure 8-2 (application ref: 7.8.1)**. The Offshore Export Cable Corridor avoids this area and is located directly to the south. The British Geological Survey's fine-scale maps of seabed geomorphology Offshore Yorkshire (BGS, 2023) have defined Smithic Bank as a morphological feature and show it is more limited in extent then that defined by JNCC and is located approximately 3.5km north of the Offshore Export Cable Corridor. Surrounding Smithic Bank the seabed is covered by a sheet of sand (BGS, 2023) that partially extends into the Offshore Export Cable Corridor.

55. Approximately 40km along the Offshore Export Cable Corridor (from landfall) megaripples are present, gradually transitioning to larger bedforms (**Plate 8-2** and **Plate 8-3**). From about 77km offshore, the Offshore Export Cable Corridor crosses an area of seabed covered by linear sand banks aligned north-west to south-east located in a region referred to as 'Sand Hills' (**Volume 7, Figure 8-1 (application ref: 7.8.1)**). These banks form longitudinal or sub-parallel to the dominant tidal currents and are considered to be static (over a period of decades), although they may be superimposed with other mobile bedforms such as megaripples or sand waves. The Offshore Export Cable Corridor connecting to the DBS East Array Area and DBS West Array Area are at the northern edge of Sand Hills. Approximately 40km of the Offshore Export Cable Corridor to the DBS East Array Area crosses the Sand Hills area, whereas only 20km of the Offshore Export Cable Corridor to the DBS West Array Area crosses this region.

8.5.2 Marine Geology

56. The geology of the Array Areas and Inter-Platform Cable Corridor is expected to comprise a sequence of Pleistocene sands and clays, overlain by Holocene marine sands (**Table 8-13**). The thickness of the Pleistocene and Holocene sediments beneath the DBS Array Areas and Inter-Platform Cable Corridor exceeds 100m and bedrock is characterised by undifferentiated mudstone and sandstone (BGS, 2023).

Table 8-13 Geological Formations Present Beneath the DBS Array Areas, Inter-Platform Cable Corridor and Offshore Export Cable Corridor (Cotterill et al. 2017)

Era	BGS 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)
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)

57. A geotechnical survey undertaken within the Array Areas in 2022 acquired five boreholes to depths of 55m below seabed. Analysis of these samples provides an understanding of the nature of the shallow geology of the study area and confirms the shallow geology is broadly the same as in the adjacent Dogger Bank A and B offshore wind farms (Forewind, 2013a).

58. The lowermost deposits recovered in boreholes are silty sands that may have been deposited in a range of settings, including marine, terrestrial, periglacial and intertidal environments. The age of these deposits is unknown, but they may correlate to Eem, Tea Kettle Hole, Cleaver Bank or Egmond Ground formations which formed before the last glacial period (**Table 8-13**). They are present at a depth of 28m below seabed in the DBS West Array Area.

59. High strength, heterogenous clays with laterally discontinuous sand lenses are the dominant deposits in the Array Areas and are encountered at depths between 3.6 and 19.5m below seabed and extend to depths greater than 55m below seabed. These deposits correlate to the Dogger Bank Formation which formed in a glacial environment during the last glacial period.

60. Elsewhere across Dogger Bank, the upper surface of the Dogger Bank Formation is cut by channel systems that can be tens of meters deep. These channels may be infilled with high strength silty clays laid down in a proglacial environment (Botney Cut Formation), or by clays and sands interbedded with peat (Elbow Formation) that formed as the climate warmed and sea-levels rose during the early Holocene.

61. A 11m thick sequence of soft clay and silt interbedded with a thin (0.28m) peat deposit was recorded in a borehole recovered from the DBS West Array Area which suggests in the past, river channels, lakes or estuaries would have been present.

62. The uppermost deposits recovered in the boreholes are slightly gravelly sands with shell fragments that represent deposition in the modern marine environment. These likely correlate to one or more of the Holocene formations; Bligh Bank, Indefatigable Grounds, Nieuw Zeeland Gronden Terschellinger Bank or Well Hole. They reach thicknesses of up to 9.5m in boreholes, but elsewhere across Dogger Bank can be greater than 10m thick.

63. A geotechnical vibrocore survey was undertaken in 2023 providing information on the shallow geology along the Offshore Export Cable Corridor. Bedrock of chalk and mudstone was recovered in four locations indicating a relatively thin cover of Quaternary deposits in places. The shallow Quaternary stratigraphy of the Offshore Export Cable Corridor is dominated by seabed sediments and shallow marine sands (correlating to the Bligh Bank, Indefatigable Grounds, Nieuw Zeeland Gronden Terschellinger Bank or Well Hole formations) overlying glacial clays interbedded with glacial sands (Botney Cut Formation).

64. Interpretation of sub-bottom profiler data indicates bedrock is shallow in the nearshore part of the Offshore Export Cable Corridor and can be present within 2m of the seabed (**Volume 7, Figure 8-3 (application ref: 7.8.1)**). This was confirmed by a geotechnical borehole survey in the nearshore in water depths between 2m and 9m below LAT.

8.5.3 Seabed Sediments

65. The results of particle size analysis of seabed sediment grab samples within the Array Areas, Inter-Platform Cable Corridor and the Offshore Export Cable Corridor have been used to characterise the composition of seabed sediments.

66. In the DBS East Array Area, seabed sediment is predominantly sand with minor components of gravel and fines (**Plate 8-4** and **Plate 8-5**). In the south-eastern part of the DBS East Array Area, the seabed sediments have a higher proportion of fines (between 3% and 10%) when compared with samples from the rest of the Array Area (fine content between 0% and 5%). There are also a small number of samples (5 in total) in this area that are coarser grained with gravel contents between 15% and 70%.

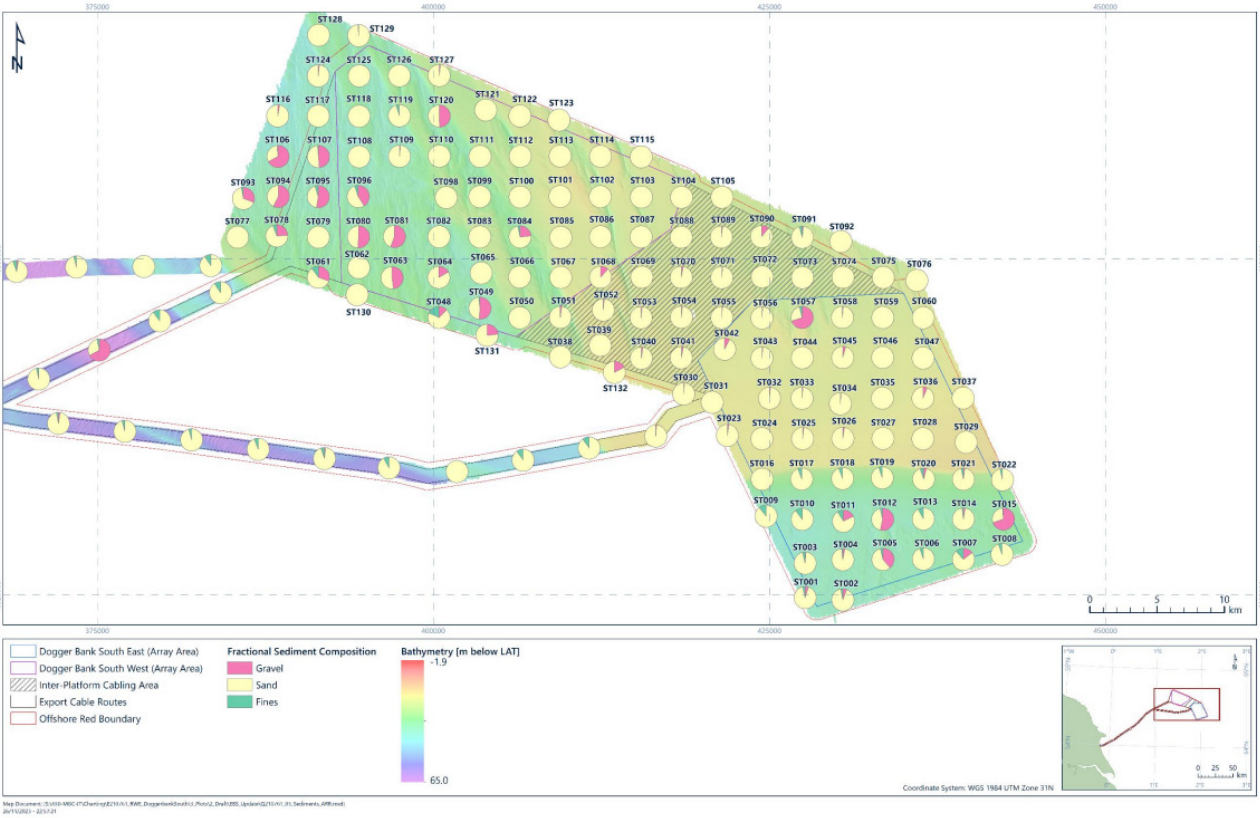

Plate 8-4 Spatial variations of percentage sand, gravel and fines within the DBS Array Areas (Fugro, 2023c)

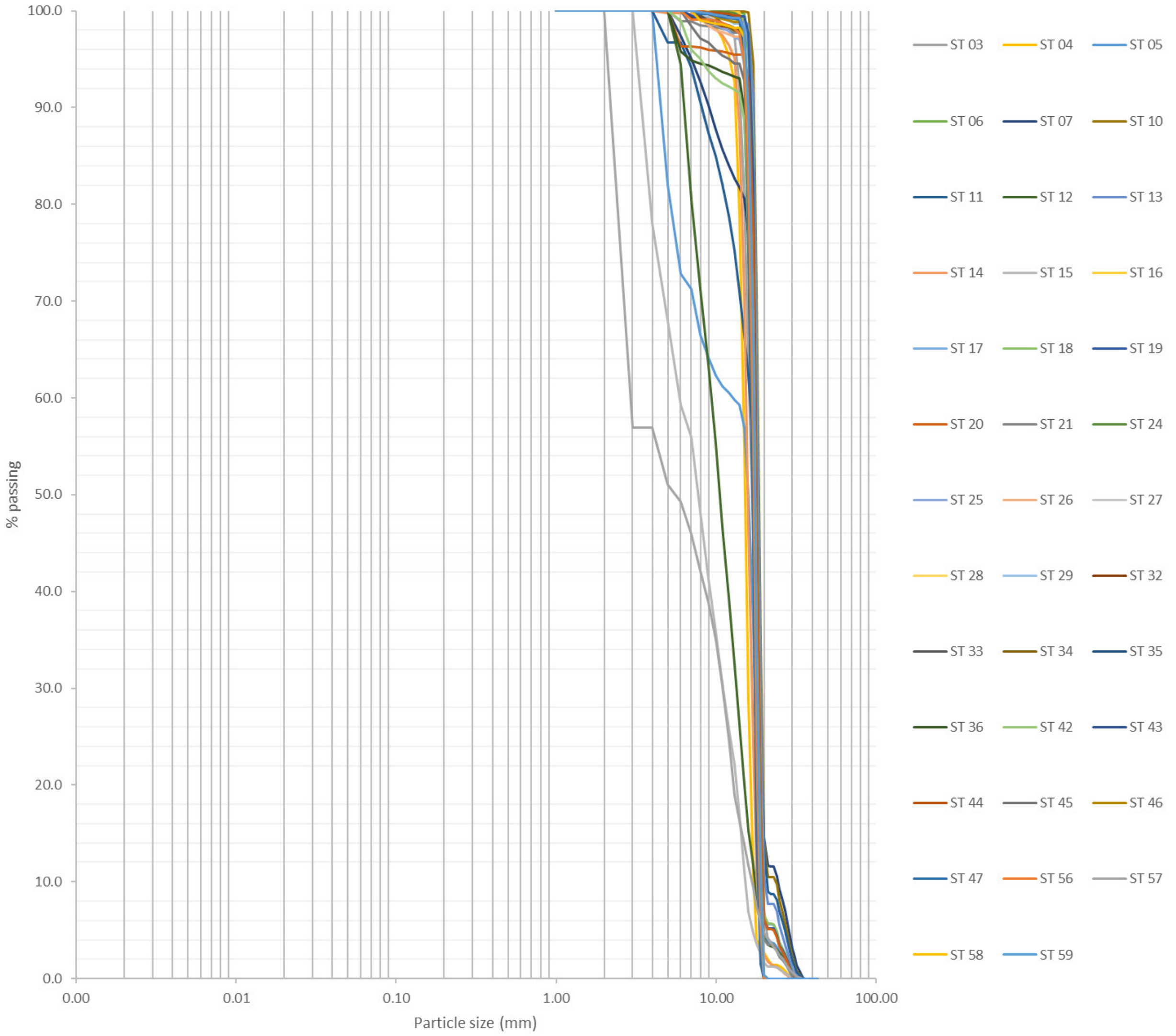

Plate 8-5 Particle size distribution of environmental survey samples from DBS East Array Area

67. Seabed sediment in the DBS West Array Area comprises a mix of sand dominated sediment in the eastern and northern part of the Array Area and sandy gravel in the south-west corner (**Plate 8-4**)

68. The fines content of sediment within the DBS East Array Area is higher (<10%) (**Plate 8-5**) when compared to the DBS West Array Area (**Plate 8-6**) (<5%). The Inter-Platform Cable Corridor is dominated by sand, with an approximate gravel and fines content of <5% (**Plate 8-7**).

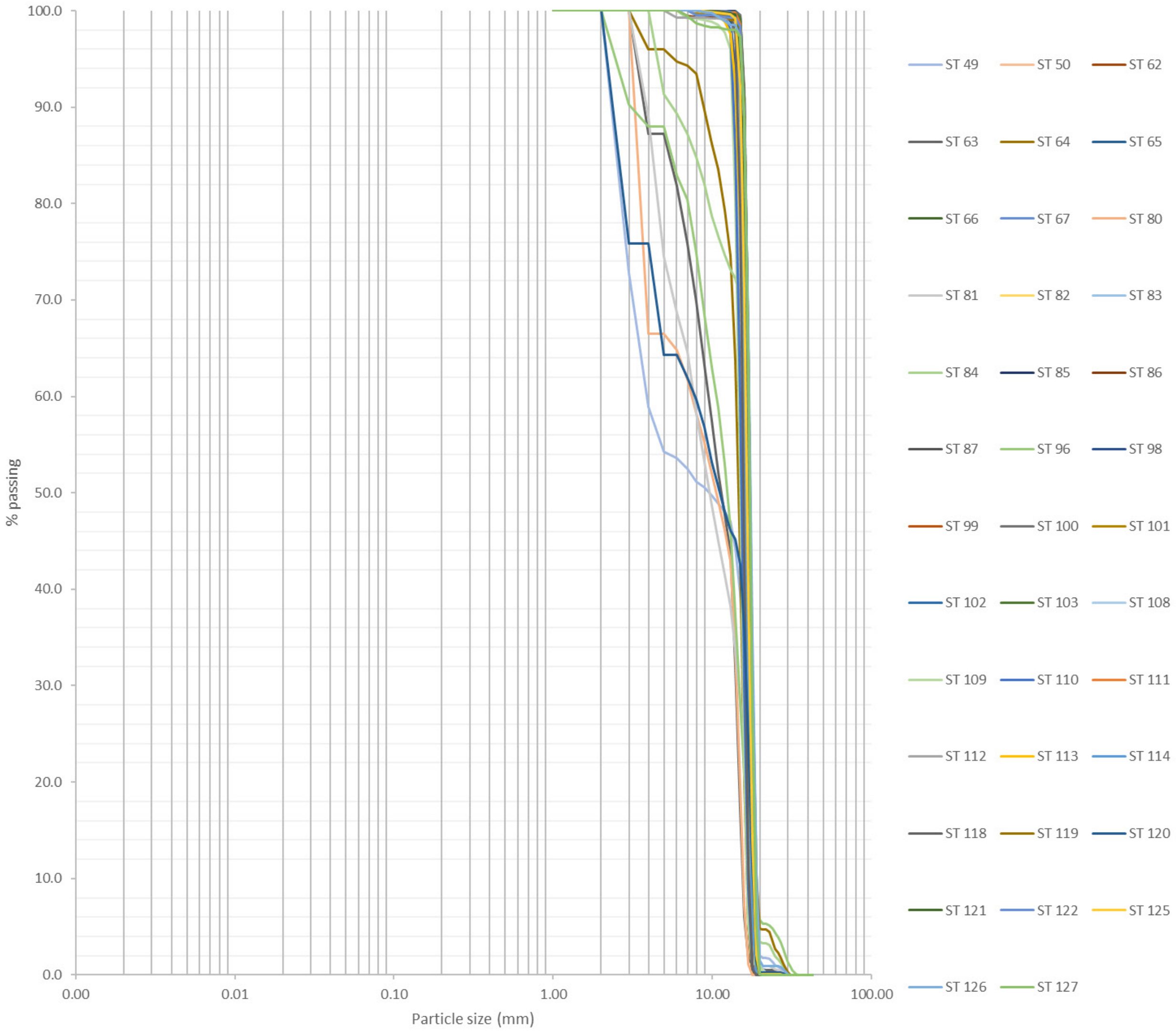

Plate 8-6 Particle size distribution of environmental survey samples from DBS West Array Area

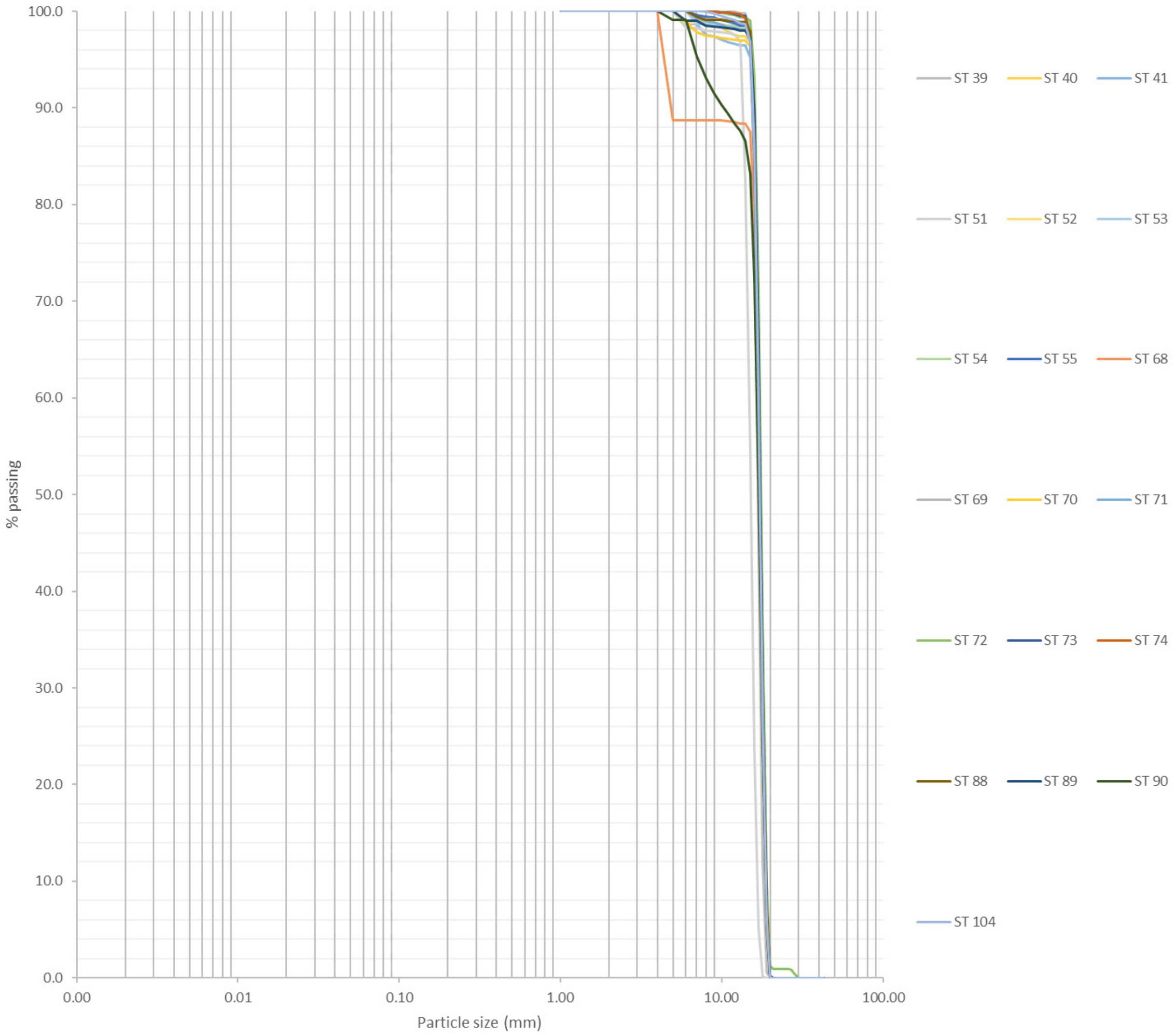

Plate 8-7 Particle size distribution of environmental survey samples from the Inter-Platform Cable Corridor

69. In the Offshore Export Cable Corridor, seabed sediment is predominantly sand with minor components of fines (**Plate 8-8**). In the north-eastern sections of the Offshore Export Cable Corridor, the seabed sediments have a higher proportion of fines (between 0% and 15%) when compared with samples from the rest of the Offshore Export Cable Corridor (fine content between 0% and 7%). Seabed sediment in the nearshore part of the Offshore Export Cable is coarser grained with gravel contents reaching up to 90%. Overall, the fines content of sediment within the Offshore Export Cable Corridor connecting to the DBS East Array Area is higher (**Plate 8-9**) when compared to the Offshore Export Cable Corridor connecting to the DBS West Array Area (**Plate 8-10**).

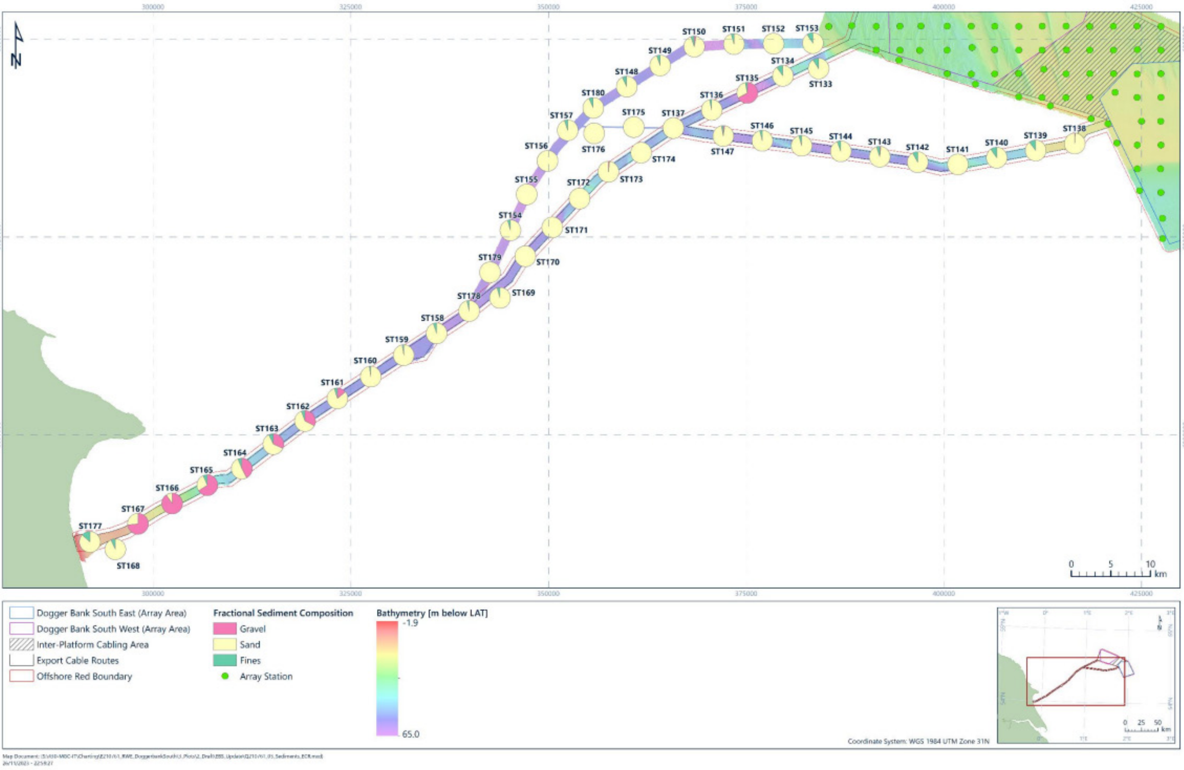

Plate 8-8 Spatial variations of percentage sand, gravel and fines within the Offshore Export Cable Corridor (Fugro, 2023c)

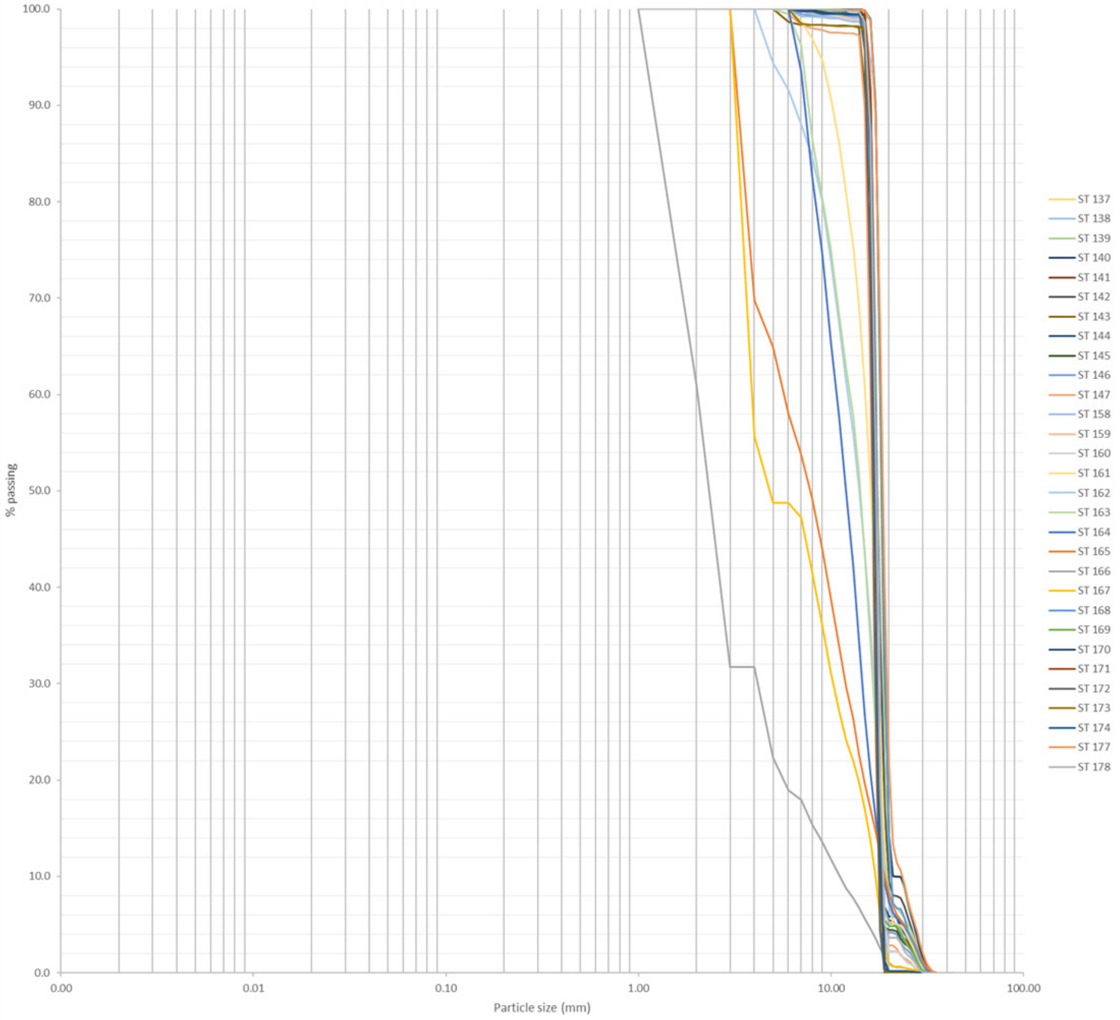

Plate 8-9 Particle size distribution of the Offshore Export Cable Corridor to the DBS East Array Area

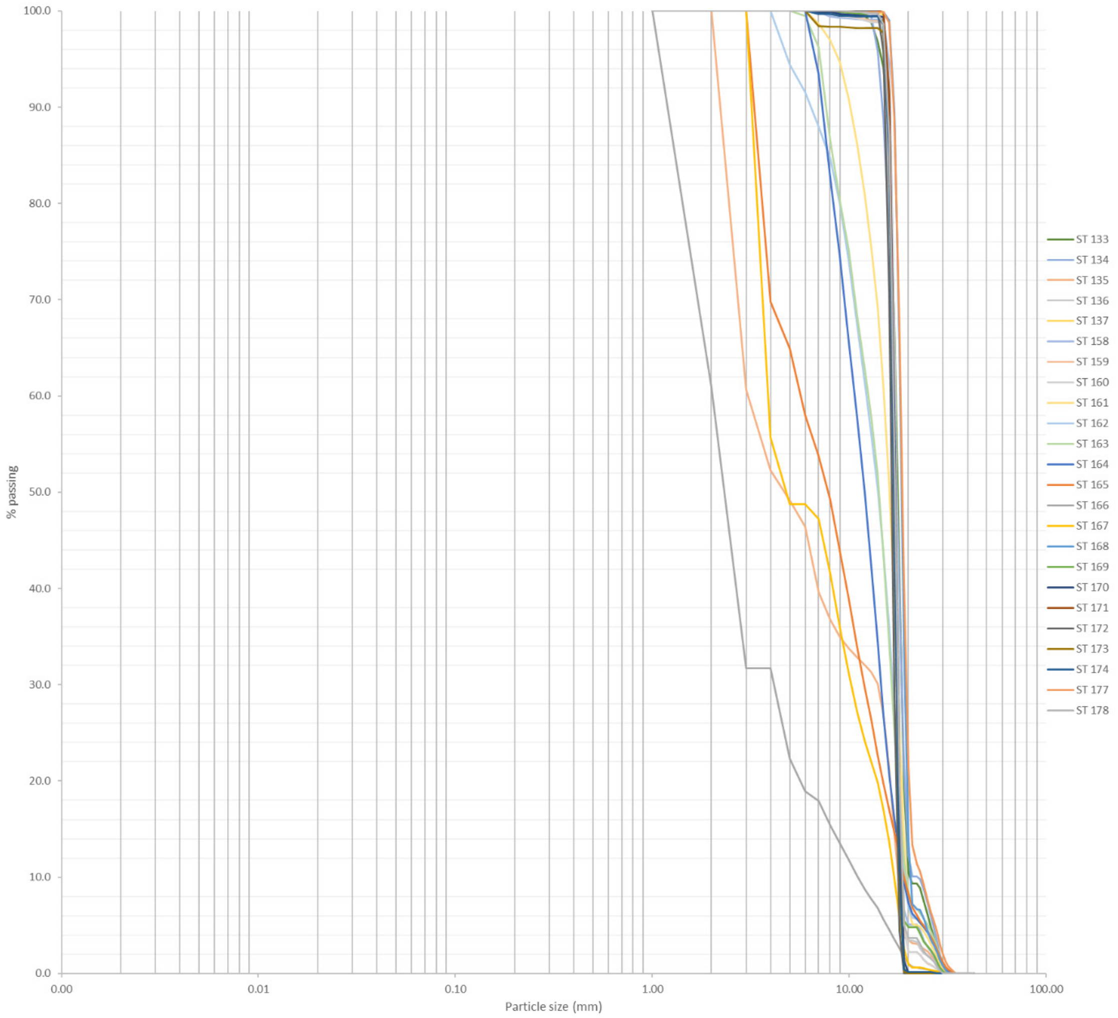

Plate 8-10 Particle size distribution for the Offshore Export Cable Corridor to the DBS West Array Area

8.5.4 Water Levels

70. 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 range (MSR) gradually increases from east to west across the DBS Array Areas and Inter-Platform Cable Corridor (**Volume 7, Figure 8-3 (application ref: 7.8.1)**) (DECC, 2008). These areas experience a mesotidal range with a MSR of 2.0m at the south-east corner of the DBS East Array Area, increasing to 2.7m at the south-west corner of the DBS West Array Area. Along the Offshore Export Cable Corridor, the MSR increases from 4.9m at the landfall to 2.4m at the seaward limit of the Offshore Export Cable Corridor (**Volume 7, Figure 8-3 (application ref: 7.8.1)**).

71. The tidal regime at the landfall is semi-diurnal; the water level rises and falls twice a day. The water levels for the possible landfall locations have been estimated using the tide gauge at Bridlington (the closest reference location for tides) (**Table 8-14**). The mean spring tidal range for Bridlington is around 5m, with a mean neap range of around 2.4m.

Table 8-14 Water levels from tide gauge at Bridlington

Datum (m CD)					
HAT	**MHWS**	**MHWN**	**MLWN**	**MLWS**	**LAT**
6.87	6.13	4.85	2.43	1.16	0.25

72. 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 and positive surge influence enable waves to reach the base of the soft cliffs.

73. Latest available research from 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.

8.5.5 Tidal Currents

74. 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 Array Areas and Offshore Export Cable Corridor are provided in **Volume 7, Figure 8-4 (application ref: 7.8.1)**. The length of tidal excursion ellipses range from 5km in the DBS Array Areas where water depths are shallow on top of Dogger Bank, to a maximum of 14km in the Offshore Export Cable Corridor to the south of Flamborough Head.

75. Tidal currents were simulated across the Offshore Development Area using a two-dimensional hydrodynamic model (see **Volume 7, Appendix 8-3 (application ref: 7.8.8.3)** for the full technical report). Across the Array Areas and Inter-Platform Cable Corridor, tidal flows are generally to the north-west on the flood tide and south-east on the ebb (**Volume 7, Figure 8-4 (application ref: 7.8.1)**). The peak flows during spring tides range from 0.5 m/s to 0.3 m/s.

76. Tidal current speeds in general reduce from west to east along the Offshore Export Cable Corridor (**Plate 8-11** and **Plate 8-12**). Peak spring current speeds are 0.7m/s at a point 22km along the Offshore Export Cable Corridor, east of Flamborough Head. Peak spring current speeds are lower to the west of this point, with a minimum of 0.1m/s in the nearshore area due to sheltering effects in the lee of the headland. The tidal flows along this part of the Offshore Export Cable Corridor are aligned shore-parallel, broadly north-west to south-east. Further offshore, peak spring current speeds reduce from west to east, to a minimum of 0.4m/s near the Array Areas and Inter-Platform Cable Corridor where tidal flows are aligned north-west to south-east.

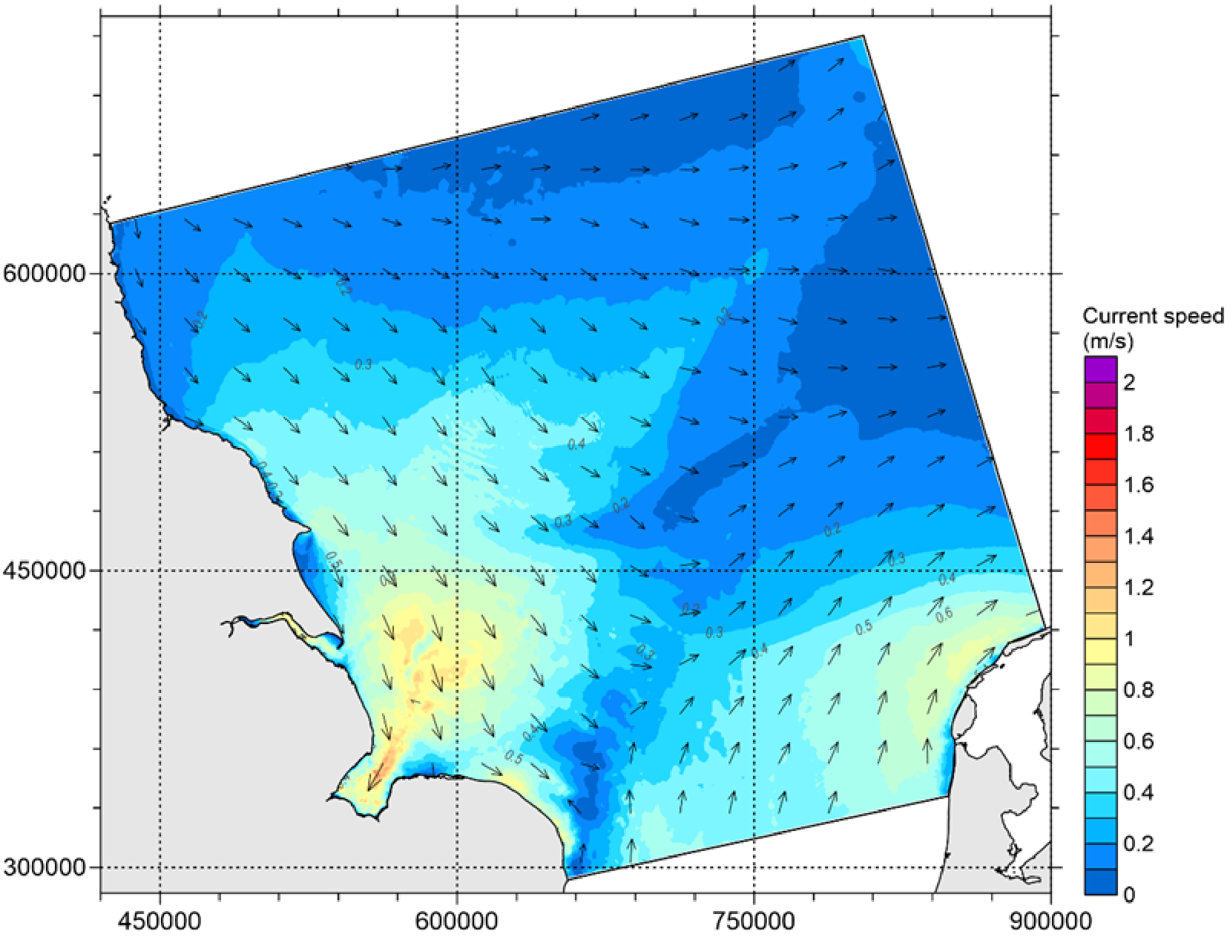

*Plate 8-11 Tidal flow during peak spring flood tide (**Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**)*

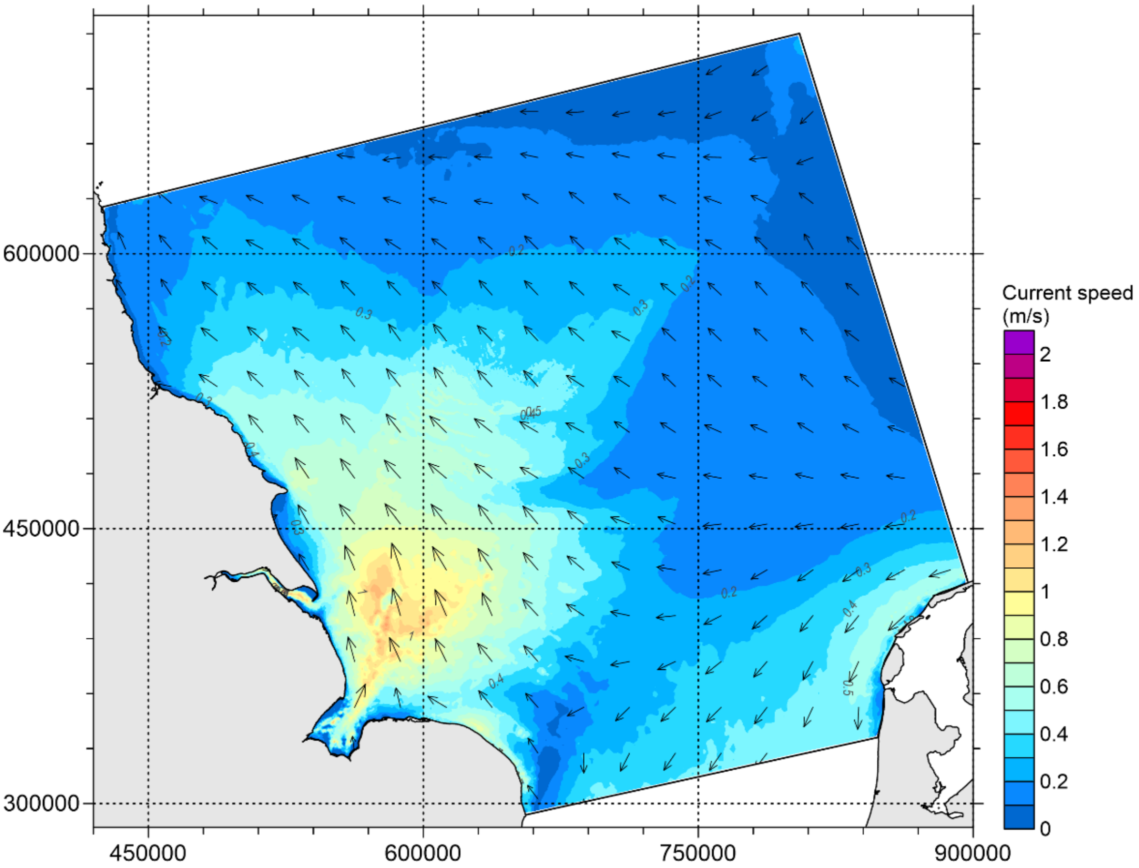

*Plate 8-12 Tidal flow during peak spring ebb tide (**Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**)*

8.5.6 Waves

77. Between March 2022 and May 2023, waverider buoys were deployed in the DBS East and DBS West Array Areas. The monthly average significant wave heights vary from a minimum of 0.8m in August 2022 to a maximum of 6.9m in December 2022. The predominant waves approach from the north to north north-east with a significant secondary component from the south to south south-west (**Plate 8-13**).

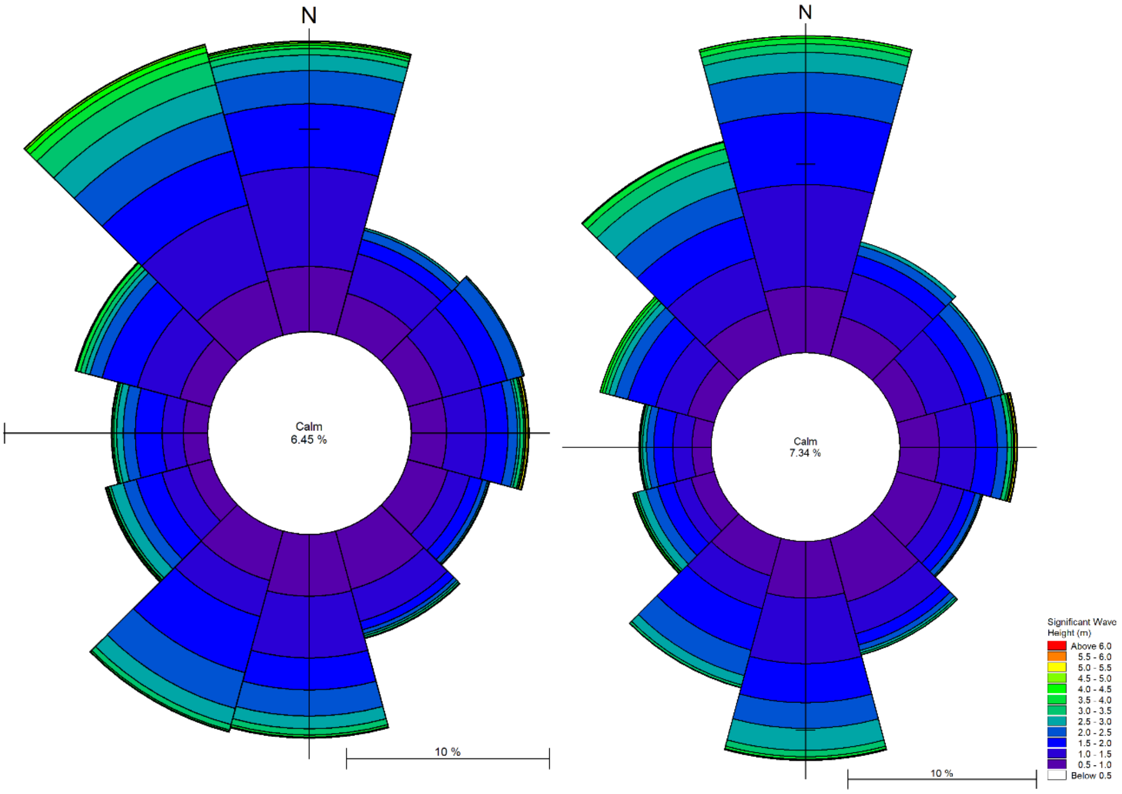

*Plate 8-13 Wave roses for all waves from March 2022 to May 2023. Left is from the wave buoy deployed in DBS East and right from DBS West (**Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**)*

78. East Riding of Yorkshire Council deployed a nearshore waverider buoy near Hornsea (53.92°N, 0.07°E) in 10m (LAT) of water in June 2008. The Hornsea waverider buoy is located 7km south of the Offshore Export Cable Corridor and approximately 5km from the coast, providing information on wave climate in the nearshore.

79. Between June 2008 and December 2022, the monthly average significant wave heights varied from 0.57m to 1.02m and were generally higher during the winter months. The predominant waves approach from the north north-east sector. As they approach the 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, although they still exhibit a southwards component. There is a general increase in wave height with progression down the coast from Flamborough Head. This is due to the reduction in the sheltering effect of the headland of waves approaching from the north and north-east to the length of coast south of the headland (Holderness).

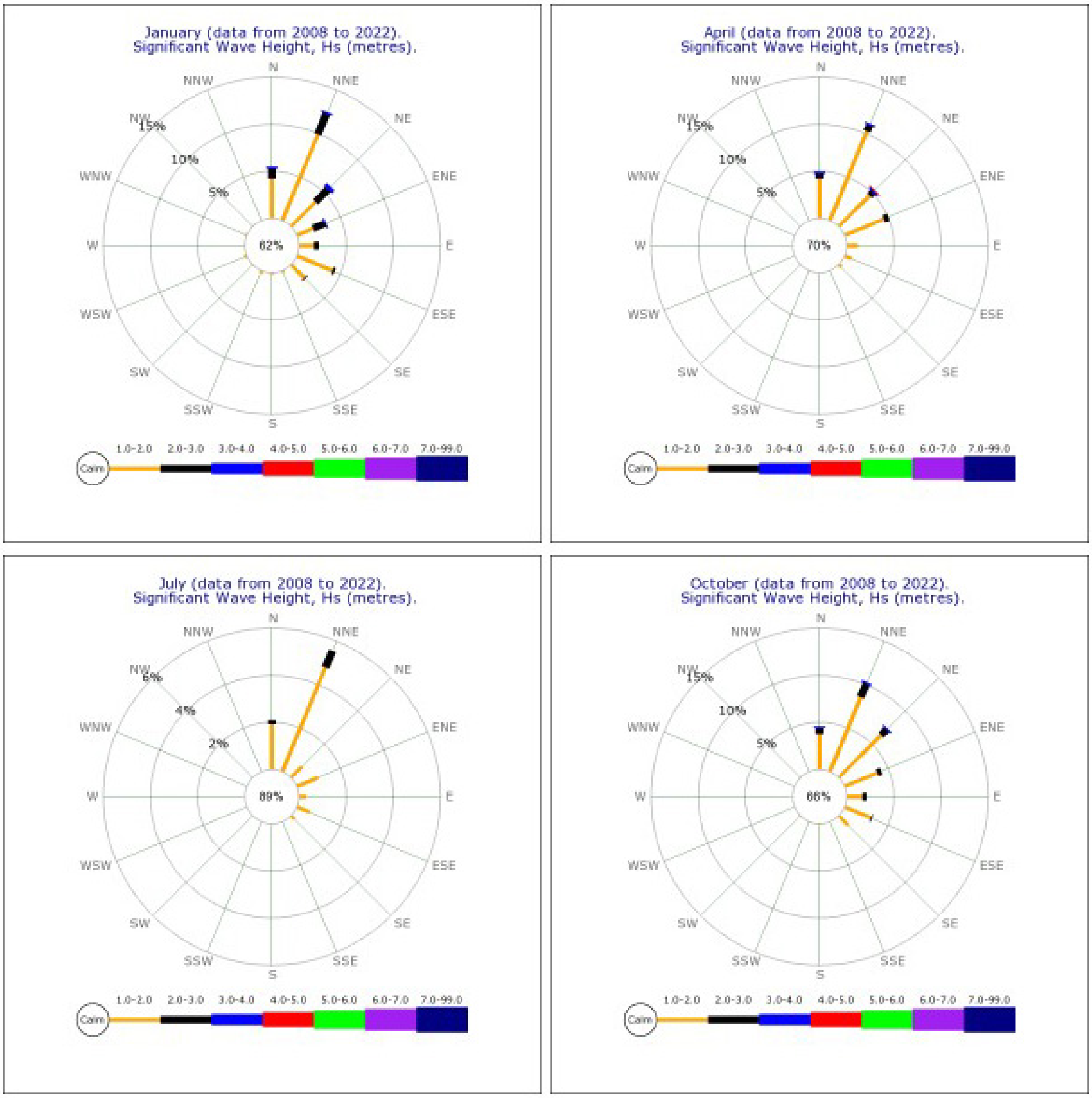

Plate 8-14 Monthly Average Significant Wave Heights From 2008 – 2002 from the Hornsea waverider buoy (Channel Coastal Observatory 2023)

80. The wave data from the waverider buoys deployed in the DBS Array Areas, along with data from the Hornsea buoy, were used to calibrate a wave model developed for the Offshore Development Area (see **Volume 7, Appendix 8-3 (application ref: 7.8.8.3)** for the full technical report). Wave climates were simulated for the 50% percentile exceedance, 1 in 1 year and 1 in 100 year return periods, from two principal directions: the north (345-15°) and the east (75-105°). These sectors were selected to be representative of the characteristics of the DBS Array Areas, but also to consider potential effects on marine processes along the coastline. The results show that the largest waves approach from the north and that Dogger Bank as a bathymetric high reduces significant wave height over the bank itself, when compared with the surrounding region, particularly for waves approaching from the east (**Plate 8-15**).

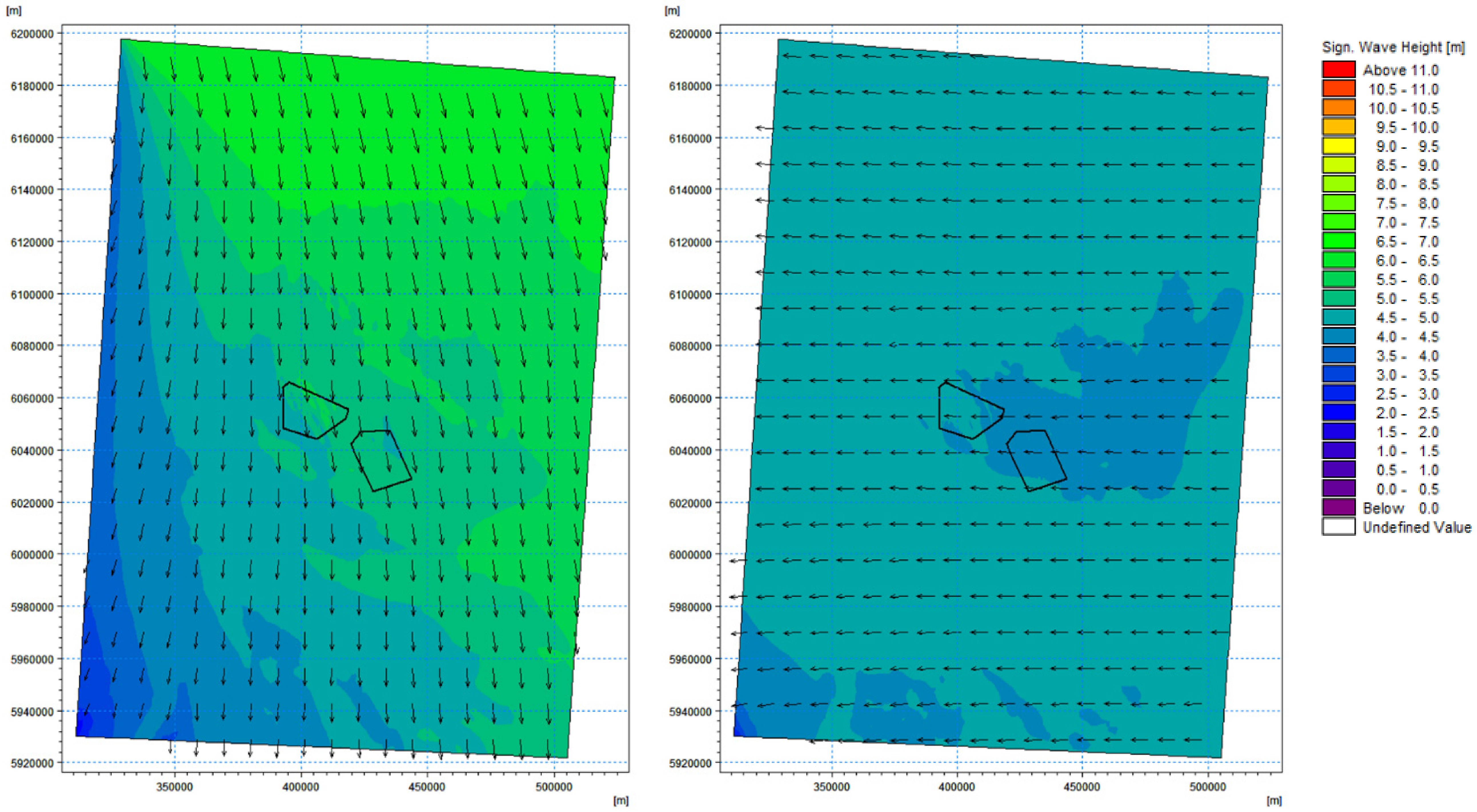

*Plate 8-15 Left: Significant wave height for 1 in 1 year return period waves approaching from the north. Right: significant wave height for 1 in 1 year return period waves approaching from the east. DBS East and DBS West Array Areas outlined in black (**Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**).*

8.5.7 Bedload Sediment Transport

81. Tidal currents are the dominant driver of bedload sediment transport across the Array Areas and Inter-Platform Cable Corridor. The dominant sediment transport pathways are therefore expected to be towards the north-west.

82. The combination of water depth plus tidal variation means that waves are unlikely to be a major influence on bedload sediment transport along the Offshore Export Cable Corridor, apart from in shallower water approaching Smithic Bank.

83. In the nearshore, 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). For the seabed offshore from the landfall, the closure depth would be located at around 7m below LAT.

84. Regional sediment transport pathways (Kenyon & Cooper, 2005) suggest sediment transport pathways in the nearshore part of the Offshore Export Cable Corridor are to the south to south-south-east whereas further offshore they are towards the north-northwest, with a bedload parting zone located about 30km from the coastline (**Volume 7, Figure 8-5 (application ref: 7.8.1)**).

85. Sediment transport pathways in and around Smithic Bank are driven by a tidally generated gyre which creates rotational currents around the feature. Evidence of active bedload sediment transport is most prominent at the northern end of the bank (North Smithic) where large sand waves are observed (CCO 2014). This area is also associated with strongest tidal flows as water is forced past the headland. The asymmetric profile of these sand waves offers supporting evidence for net clockwise directions of bedload transport around the bank. On the eastern outer flank, the sand wave asymmetry is with the flood tide, moving sands to the south-west and onto the bank, whereas for the western inner flank the ebb tide dominates through a distinct channel between the bank and the headland to develop a net sediment pathway to the north-east (**Volume 7, Figure 8-5 (application ref: 7.8.1)**). The tidal gyre provides a mechanism to maintain the morphology of Smithic Bank which is sheltered by Flamborough Head to the north.

86. The bank is shallowest (depths less than 3m below CD) towards the northerly inshore flank where a steep slope drops around 6m into the ebb tidal channel. The bank morphology shows evidence of responding to both waves and tides (CCO, 2014). Tidal flows are a key influence on driving sand wave migration whereas wave attenuation through refraction and shoaling are likely to be a main cause of smoothing and broadening the profile of the southern extents of the bank. The shallow profile of Smithic Bank provides some sheltering to the leeward coastline around Bridlington, especially during periods of stormy waves (Scott Wilson, 2010).

87. There are no bedforms between Smithic Bank and the Holderness coast within the ebb tidal channel as currents sweep sediment northwards towards Flamborough Head. There is relatively little sediment exchange between Smithic Bank and the Holderness coast to the south (and vice versa) which is supported by studies of sediment provenance undertaken by Pye & Blot (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 (**Volume 7, Figure 8-5 (application ref: 7.8.1)**).

8.5.8 Seabed mobility

88. Mobile bedforms have an asymmetric profile. Sediment is transported up the shallow slope to the crest where it cascades down the steeper slope. The direction the steeper slope faces is therefore an indicator of sediment transport direction. This process is driven by tidal asymmetry and when the seabed is in equilibrium with the tidal regime, the associated dominant sediment transport will align with the net residual current.

89. In the case of the Offshore Export Cable Corridor the nearshore bedforms are likely static, as they have symmetrical profiles. Further offshore, bedforms are asymmetric with a steeper north to northwest slope, indicating the dominant direction of bedform migration.

90. Bedform migration speed can be determined by comparing bathymetric data sets collected over the same feature at different times. Site-specific bathymetric data was acquired by Fugro in 2022 across the Array Areas, Inter-Platform Cable Corridor and Offshore Export Cable Corridor (**Volume 7, Figure 8-6 (application ref: 7.8.1)**), gridded at a resolution of 2m for interpretation.

91. Within the nearshore section of the Offshore Export Cable Corridor (the first 35km from landfall) other bathymetric datasets are available (MarineSpace, 2023). These include surveys by NetSurvey Ltd (2011) and MMT (2016). Further offshore, there are no other datasets of this resolution in areas of seabed bedforms that can be used to quantity bedform migration speeds. Therefore, any assessments of seabed mobility here are based on theoretical relationships and conceptual understanding (MarineSpace, 2023).

92. In the nearshore a series of shore parallel ridges are present before joining the southern margin of Smithic Bank (**Volume 7, Figure 8-6 (application ref: 7.8.1)**). Here, exposed glacial tills with an irregular surface morphology have been reworked into shore parallel ridges. There is no evidence from repeat bathymetry surveys that these features are mobile.

93. From 7.5km into the Offshore Export Cable Corridor from landfall a series of shore parallel ridges are present. Comparisons of bathymetric surveys showed over two years bed level changes of up to 0.6m. However, MarineSpace (2023) report uncertainty in the rate of migration, due to insufficient dataset resolution, and conclude the ridge features are overall static despite evidence of bed level change. Shallow relief, north-northwest to south-southeast trending linear depressions terminate against or navigate around the ridge structures. These features are also considered to be immobile (MarineSpace, 2023).

94. Small localised symmetrical scour pits are present around the wreck of the Ville De Valenciennes (UKHO ID: 6469; **Volume 7, Chapter 17 Offshore Archaeology and Cultural Heritage (application ref: 7.17)**), 0.7m and 1.4m deep, indicating the seabed is mobile in this locality, likely due to changes in current speeds around the wreck. This wreck is located 18km along the southern margin of the Offshore Export Cable Corridor in an area of seabed interpreted as being static. This suggests that in areas where mobile bedforms are absent, there is still potential for scour to occur locally around seabed objects.

95. MarineSpace (2023) compared the Fugro (2022) and MMT (2016) bathymetric data where it overlaps (between 15km and 35km along the Offshore Export Cable Corridor from landfall) and bed level change was shown to be near zero (± 0.2 m) over a six year period, indicating any features here are immobile.

96. Megaripples are located in the Offshore Export Cable Corridor from 40km to 45km offshore of the landfall (**Volume 7, Figure 8-6 (application ref: 7.8.1)**, and **Plate 8-16** and **Plate 8-17**). The crests of these bedforms are orientated west-southwest to east-northeast and the features have approximate wavelengths of 11 m and heights of up to 0.5m. These bedforms become superimposed on larger west to east orientated sand waves, with a wavelength of 200m and height of 2m (**Plate 8-16**).

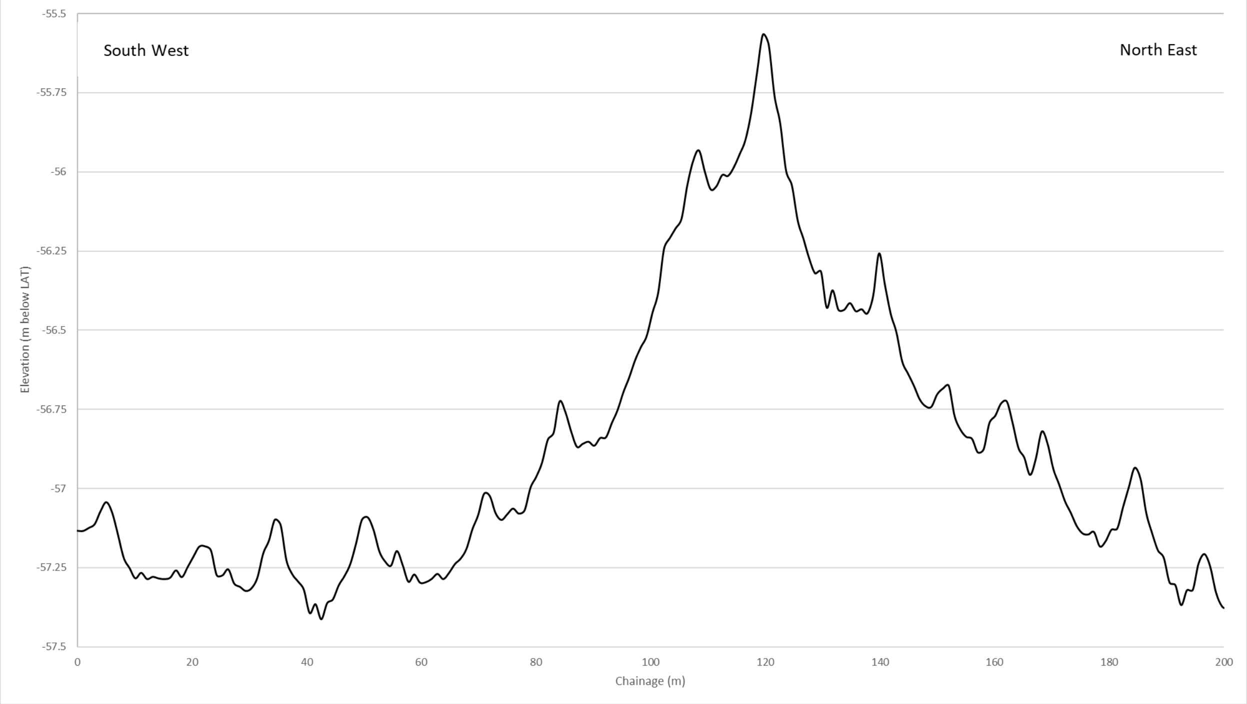

Plate 8-16 Profile of bedforms at approximately 50km into the Offshore Export Cable Corridor from landfall.

97. The megaripples and sand waves were interpreted by MarineSpace (2022) as being static considering their symmetrical profile and assessment of morphological change around the Langeld Gas Pipeline (located within the area of megaripples) supported this interpretation. The pipeline was installed in a trench between 2005 and 2006 and shows no evidence of backfill over a 16 year period supporting the argument that the seabed at this location is stable.

98. Within the Sand Hills region of the Offshore Export Cable Corridor, sand waves superimposed with megaripples are present on the margins of sand banks (**Volume 7, Figure 8-6 (application ref: 7.8.1)**, and **Plate 8-16** and **Plate 8-17**). The megaripples have wavelengths of up to 20m and heights of <0.6m. The sand waves have wavelengths of 100 to 500m and reach heights up to 5.5m, orientated east to west. They are asymmetric in profile suggesting they are mobile and the dominant sediment transport is towards the north.

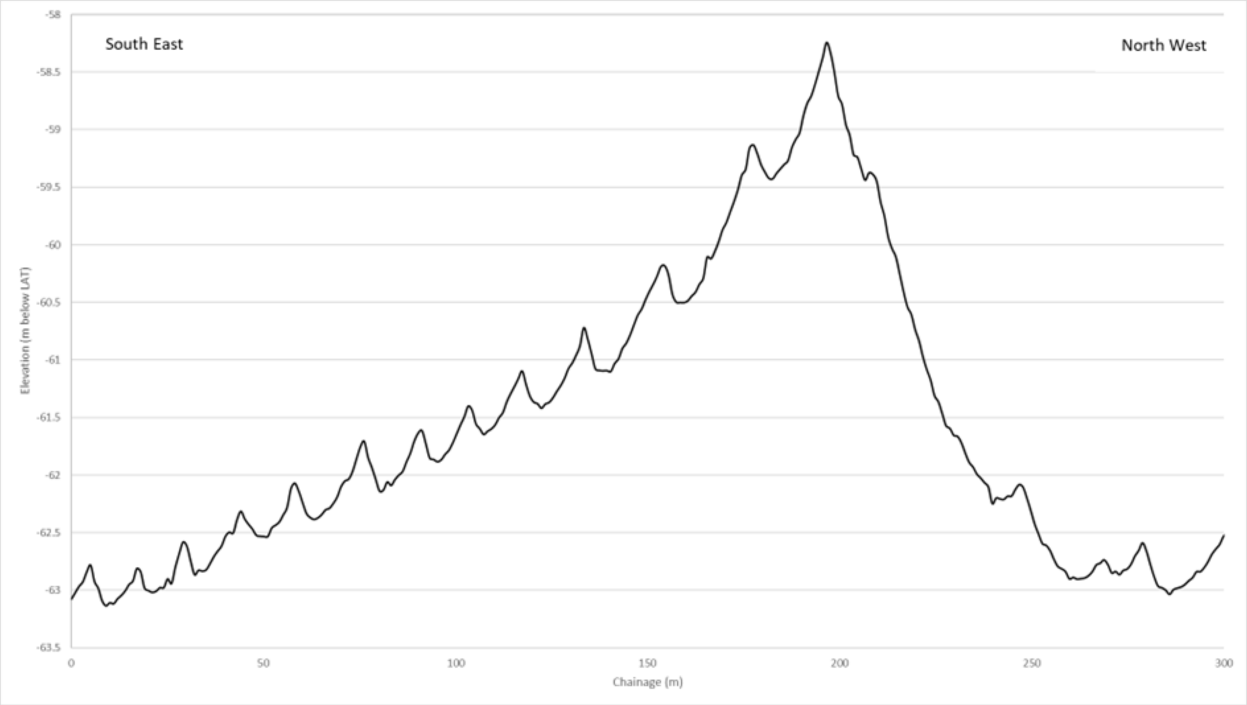

Plate 8-17 Profile of bedforms at approximately 85km into the Offshore Export Cable Corridor from landfall.

99. The Offshore Export Cable Corridor (before splitting into Offshore Export Cable Corridors connecting to the DBS East and West Array Areas) crosses the crest and troughs of large scale sand banks, superimposed by sand waves and megaripples (**Volume 7, Figure 8-6 (application ref: 7.8.1)**). The sand banks are symmetrical orientated north-northwest to east-southeast orientation. The sand banks have heights of >10m and wavelengths of >10km. The sand waves have heights of 2 to 4m and wavelengths of 100 to 200m, these are orientated east to west with asymmetry indicating a steeper slope to the north. The megaripples have maximum heights of 0.6m and wavelengths of 20m, these are orientated east to west or west-southwest to east-southeast. The megaripples are also asymmetrical with a steeper slope facing north-northwest. This suggests mobility north to northwest, similar to other bedforms in the Sand Hills region.

100. The megaripples remain present along the Offshore Export Cable Corridor connecting to DBS West Array Area. Sand waves become patchier, maintaining east to west orientation at heights of 2m and wavelengths of 350m. These features continue to cross the static sand banks until reaching DBS West Array Area. The same features also occur along the Offshore Export Cable Corridor connecting to DBS East Array Area, but fewer bedforms are present as the Offshore Export Cable Corridor approaches the DBS East Array Area. Fewer sand banks and superimposed features are present in this section of the Offshore Export Cable Corridor.

8.5.9 Suspended Sediment Concentrations

101. Monthly mean variations in Suspended Sediment Concentrations (SSCs) have been derived from satellite observations from 1998 to 2015 (Cefas, 2016). Surface average suspended sediment concentrations are relatively low across the Array Areas and Inter-Platform Cable Corridor, with concentrations typically less than 3mg/l in DBS East reducing to below 2mg/l in DBS West (Cefas, 2016) (**Volume7, Figure 8-7 (application ref: 7.8.1)**). 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.

102. Along the Offshore Export Cable Corridor, surface average suspended sediment concentrations are highest for around the first 10km from the coastline and around Flamborough Head where they may reach concentrations of 15mg/l (**Volume 7, Figure 8-7 (application ref: 7.8.1)**). These concentrations may increase up to 300mg/l during storm events (Pye & Blott, 2015). Further offshore the concentrations reduce to approximately 5mg/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.

8.5.9.1 Seismicity

103. Data from the British Geological Survey (BGS) (Baptie, 2021) has been used to assess seismicity in the region of the Offshore Development Area (**Plate 8-18**). Between 1979 to 2021, earthquakes have been recorded near to DBS Array Areas. These are recorded in local magnitude (ML) and they range from 2.5 to 3.9 ML. Between 2020 to 2021 no seismic activity was recorded near the Array Areas.

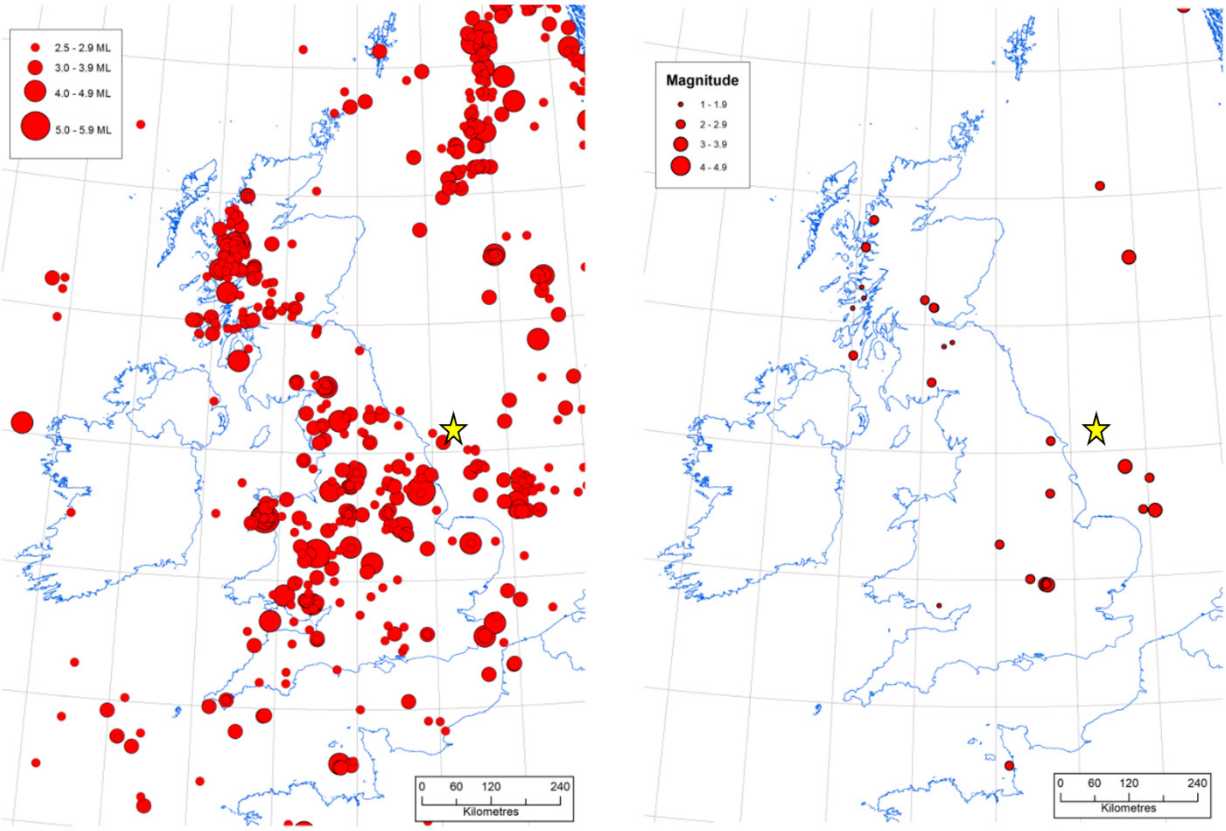

Plate 8-18 Epicentres of earthquakes with magnitudes 2.5 ML or greater, for the period 1979 to March 2021 (left) and Events in the reporting period (1 April 2020 – 31 March 2021) for which alerts have been issued (right) (Baptie, 2021). Circles are scaled by magnitude. The yellow star represents the Array Areas.

8.5.10 Sediment quality

104. The site specific survey collected 11 samples for contaminant analysis in the DBS East and West Array Areas, four in the Inter-Platform Cable Corridor, eight samples in the Offshore Export Cable Corridor and five were collected within the Construction Buffer Zone (outside of a specific area or corridor). Contaminant analysis was performed for the following parameters:

- Trace metals;
- PAHs;
- THCs;
- PCBs; and
- Organotins.

105. The locations of the sediment sample sites analysed for contaminants are shown in **Volume 7, Figure 8-8 (application ref: 7.8.1)**. **Table 8-15** for metals and **Table 8-16** for PAHs and THC compared to the sediment quality guidelines as outlined in section 8.4. All other data was either below the limits of detection for all samples or only one or two recorded values just over the limit of detection. As a result, this data has not been reproduced here and is available in full in **Volume 7, Appendix 9-3 Benthic Ecology Monitoring Report (application ref: 7.9.9.3)**.

106. THC was below Cefas AL1 at all stations apart from station ST161 in the Offshore Export Cable Corridor which recorded a value of 109mg/kg, only just over the AL1 value of 100mg/kg. Concentrations of individual PAHs were below marine sediment quality guidelines for the majority of samples. The exceptions were stations ST161, ST164 and ST168 in the Offshore Export Cable Corridor. However, values were only marginally higher than the respective BAC concentrations and under the ERL concentrations. With respect to trace metals, arsenic concentrations were above the AL1 at three stations and the BAC at two stations. The elevated concentrations of arsenic recorded at these stations are, however, are typical of the region as shown in Whalley *et al* (1999). All other metals were below sediment quality guidelines used.

Table 8-15 Site specific data collected in 2022 for metals (Fugro, 2023c) (coloured dots against each sediment quality guideline are used to indicate where there is an exceedance). All data in mg/kg

Site reference	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc
AL1 ●	20	0.4	40	40	20	50	0.3	130
AL2 ●	100	5	400	400	200	500	3	800
BAC●	25	0.31	81	27	36	38	0.07	122
ERL●	-	1.2	81	34	-	47	0.15	150
DBS East Array Area								
ST012	14	0.24	12.7	8.8	12.6	9.4	0.02	39.1
ST017	3.0	<0.04	5.8	4.7	4.7	2.8	<0.01	14.4
ST044	2.5	<0.04	4.5	3.6	3.0	1.9	<0.01	8.1
ST046	2.7	<0.04	5.2	4.1	3.2	2.3	0.02	8.3
DBS West Array Area								
ST063	16.4	0.13	11.5	8.3	15.0	4.5	0.01	32.9
ST085	2.8	<0.04	3.6	3.0	2.3	1.4	<0.01	15.0

Site reference	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc
ST098	9.9	<0.04	5.2	4.2	4.0	2.5	0.02	12.5
ST103	2.2	<0.04	3.4	3.3	2.1	1.4	<0.01	10.1
ST113	3.7	<0.04	4.3	3.2	2.5	1.6	<0.01	14.5
ST121	3.2	<0.04	4.3	3.8	2.7	1.7	<0.01	10.2
ST125	24.4 ●	0.14	15.2	7.4	14.9	5.9	0.02	35.0
Inter-Platform Cable Corridor								
ST040	2.5	0.07	4.5	3.8	3.0	1.9	<0.01	9.0
ST069	2.6	<0.04	4.7	3.2	3.3	2.2	<0.01	9.2
ST071	3.2	<0.04	5.8	3.5	3.8	2.4	<0.01	12.1
ST074	2.9	<0.04	5.0	3.0	2.5	2.1	<0.01	9.6
Construction Buffer Zone (outside of a specific area or corridor)								
ST031	3.1	0.13	5.8	3.9	3.6	2.5	<0.01	13.6
ST038	3.0	<0.04	4.4	3.3	3.3	2.0	<0.01	9.8

Site reference	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc
ST078	10.0	<0.04	6.1	4.1	4.7	3.2	<0.01	12.3
ST105	2.7	<0.04	5.2	3.3	2.4	2.2	<0.01	13.9
ST107	8.5	<0.04	5.4	3.7	3.6	3.2	<0.01	14.8
Offshore Export Cable Corridor								
ST134	7.0	<0.04	10.5	7.3	6.8	6.4	0.03	18.9
ST141	18.4	0.07	6.9	2.8	3.4	5.3	0.01	15.4
ST146	6.5	<0.04	4.4	3.5	2.7	3.8	<0.01	12.0
ST161	32.2 ●●	0.12	12.3	7.1	12.2	17.8	0.02	37.0
ST164	73.4 ●●	0.17	12.8	8.2	16.3	31.5	0.03	59.2
ST168	14.6	<0.04	11.2	8.0	9.0	24.6	0.03	45.5
ST172	13.4	<0.04	7.8	4.5	4.4	7.1	<0.01	16.8
ST178	5.8	<0.04	6.8	3.4	3.5	8.2	<0.01	16.3

Table 8-16 Site specific data collected in 2022 for PAHs and THC (Fugro, 2023c) (coloured dots against each sediment quality guideline are used to indicate where there is an exceedance). All data in µg/kg except for THC which is in mg/kg

Site reference	**Acenaphthene**	**Acenaphthylene**	**Anthracene**	**Benzo[a]anthracene**	**Benzo[a]pyrene**	**Benzo[b]fluoranthene**	**Benzo[g,h,i]perylene**	**Benzo[e]pyrene**	**Benzo[k]fluoranthene**	**C1-naphthalenes**	**C1-phenanthrenes**	**C2-naphthalenes**	**C3-naphthalenes**	**Chrysene**	**Dibenzo[a,h]anthracene**	**Fluoranthene**	**Fluorene**	**Indeno[1,2,3-cd]pyrene**	**Naphthalene**	**Perylene**	**Phenanthrene**	**Pyrene**	**THC (mg/kg)**
AL1 ●	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10	100	100	100	100	100	100	100	100
AL2 ●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAC ●	-	-	5	16	30	-	80	-	-	-	-	-	-	-	-	39	-	103	8	-	-	24	-
ERL ●	-	-	85	261	430	-	85	-	-	-	-	-	-	-	-	600	-	240	160	-	-	665	-
DBS East Array Area																							
ST012	<1	<1	<1	<1	1.49	2.63	2.82	2.06	1.65	3.74	3.22	3.45	3.54	1.68	<1	2.04	<1	2.06	1.22	1.78	2.67	1.92	22.0
ST017	<1	<1	1.08	2.19	2.50	2.66	3.23	2.66	2.04	4.76	10.5	12.0	12.0	3.24	<1	5.20	<1	1.99	1.09	1.57	6.24	8.82	2.02
ST044	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.10	1.25	1.64	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST046	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.14	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
DBS West Array Area																							
ST063	<1	<1	<1	<1	<1	1.01	<1	<1	<1	1.66	1.03	1.19	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST085	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST098	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST103	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.17	1.58	1.47	<1	<1	<1	<1	<1	<1	<1	1.31	<1	<1
ST113	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.75	1.88	2.23	3.16	<1	<1	<1	<1	<1	1.70	<1	1.33	<1	<1
ST121	<1	<1	<1	<1	<1	<1	<1	<1	<1	3.66	2.04	1.91	1.82	<1	<1	<1	<1	<1	1.82	<1	<1	<1	<1
ST125	1.23	1.65	2.74	6.07	5.45	7.37	6.26	7.00	3.77	65.0	46.2	65.5	38.0	9.39	<1	12.1	6.93	2.57	7.83	3.38	34.7	15.3	8.98
Inter-Platform Cable Corridor																							

Site reference	Acenaphthene	Acenaphthylene	Anthracene	Benzo[a]anthracene	Benzo[a]pyrene	Benzo[b]fluoranthene	Benzo[g,h,i]perylene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1-naphthalenes	C1-phenanthrenes	C2-naphthalenes	C3-naphthalenes	Chrysene	Dibenzo[a,h]anthracene	Fluoranthene	Fluorene	Indeno[1,2,3-cd]pyrene	Naphthalene	Perylene	Phenanthrene	Pyrene	THC (mg/kg)
ST040	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST069	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST071	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.10	1.06	1.15	1.26	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST074	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Construction Buffer Zone (outside of a specific area or corridor)																							
ST031	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST038	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST078	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ST105	<1	<1	<1	<1	<1	<1	<1	<1	<1	5.04	2.90	5.62	3.06	<1	<1	<1	<1	<1	1.10	<1	3.49	<1	2.02
ST107	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.18	1.59	1.20	1.05	<1	<1	<1	<1	<1	<1	<1	<1	1.05	<1
Offshore Export Cable Corridor																							
ST134	<1	<1	1.11	4.32	4.08	5.66	5.80	5.23	4.65	21.7	13.9	21.2	17.9	6.16	<1	9.75	<1	4.04	5.45	1.88	8.33	10.5	39.4
ST141	<1	<1	<1	<1	<1	<1	<1	<1	<1	3.78	2.32	2.32	2.69	<1	<1	<1	<1	<1	2.27	<1	1.01	<1	<1
ST146	<1	<1	<1	<1	<1	1.39	1.12	<1	1.34	4.18	2.40	3.22	2.63	1.15	<1	1.27	<1	1.10	2.35	<1	1.57	1.29	<1
ST161	2.18	1.62	3.47	8.67	9.76	9.31	13.2	11.9	10.5	57.7	33.7	46.1	40.4	14.5	1.59	18.7	3.65	7.15	18.8●	2.32	24.6	18.1	109●
ST164	2.56	1.81	4.01	8.24	6.85	10.1	11.1	10.6	9.68	77.1	34.1	68.7	51.0	12.9	1.53	17.4	4.36	5.72	26.8●	1.68	26.8	18.0	45.6
ST168	5.60	2.59	7.94●	15.3	15.1	17.7	18.7	20.9	15.3	135	80.4	117	122	26.0	2.56	34.5	8.50	8.19	46.0●	3.65	58.5	34.0●	70.2
ST172	<1	<1	<1	<1	<1	1.06	<1	1.05	1.16	3.80	1.80	2.85	2.00	<1	<1	1.01	<1	<1	1.68	<1	1.12	1.23	2.00
ST178	<1	<1	<1	1.06	1.07	2.82	2.30	2.24	2.12	7.28	4.12	4.77	4.25	2.12	<1	3.69	<1	1.45	3.09	<1	2.58	3.07	4.40

8.5.11 Water Quality - Chemical and Physico-chemical Parameters

107. Site specific water quality information is not available for the Array Areas. However, there are a number of general monitoring programmes which provide an indication of current water quality trends. As outlined in section 8.4.1, the OSPAR Commission collates information and produces assessments regarding the state of the marine environment for five regions. The Projects are located in region II 'Greater North Sea'. In summary, the 2010 Quality Status Report states that eutrophication is still a problem in Regions II, III and IV. Reductions in phosphorus discharges exceed the OSPAR target of 50% compared to 1985, but nitrogen discharges are still the main problem, especially those from agriculture. With respect to hazardous substances, environmental concentrations of monitored chemicals are considered to have generally fallen, but are still above acceptable concentrations in many coastal areas of Regions II, III and IV. Contamination with persistent organic pollutants is widespread and their long-range air transport to the OSPAR area is of concern. It is also stated that historic pollution in aquatic sediments acts as a continued source for releases of persistent contaminants to the water column.

108. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017, as amended by The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019, continue to enforce the Directive of the European Parliament and of the Council 2000/60/EC establishing a framework for community action in the field of water policy (generally known as the WFD) following implementation of the European Union (Withdrawal) Act 2018. Water quality is an important component for compliance with the requirements of this Directive and therefore the information collected for the transitional and coastal water bodies is relevant to this section. The Offshore Export Cable Corridor in the nearshore area (i.e. 1nm from the coast), passes through the Yorkshire South coastal WFD water body and within 8.5km of the Yorkshire North coastal WFD water body as shown in **Volume 7, Figure 8-9 (application ref: 7.8.1)**. **Table 8-17** presents the details of current water quality status classification for these two coastal water bodies.

Table 8-17 WFD Water Bodies (Environment Agency, 2022)

WFD Water Body	Water Body Type	Physico-Chemical Information (latest data from 2022)	Chemical Status (latest data from 2022)
Yorkshire South - **GB640402491000**	Coastal Water Body	**High**	**Fail in 2019** (Polybrominated diphenyl ethers (PBDE), Benzo(g-h-i) perylene, mercury and its compounds, Perfluorooctane sulphonate (PFOS) and tributyltin compounds). Did not require assessment in 2022
Yorkshire North - **GB650401500004**	Coastal Water Body	**High**	**Fail in 2019** (PBDE, mercury and its compounds). Did not require assessment in 2022

109. The following bathing waters are located on the coast in the region of the Offshore Export Cable Corridor (these are also protected areas designated under the WFD). They are classified over a four-year rolling period based on bacteriological parameters as either excellent, good, sufficient, or poor (see Environment Agency, 2023). The latest status classifications for each bathing water in 2023 were:

- Bridlington North – Good;
- Bridlington South – Poor;
- Danes Dyke, Flamborough – Excellent;
- Flamborough South Landing – Excellent;
- Fraisthorpe – Good;
- Hornsea – Excellent;
- Skipsea –Good; and
- Wilsthorpe – Good.

8.5.12 Flamborough Front

110. 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 deeper with slightly weaker currents, this 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 considered to be ecologically important. 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 > 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.

111. 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 Array Areas, Inter-Platform Cable Corridor and the Offshore Export Cable Corridor during summer 70-90% of the time (Miller & Christodoulou, 2014). During autumn and spring, the front may be present in the Array Areas and Inter-Platform Cable Corridor between 30-50% of the time (Miller & Christodoulou, 2014). However, records of a long-term modelling study (van Leeuwen *et al.*, 2015) suggest these areas are not within a location that commonly stratifies on a seasonal basis, as shown in **Volume 7, Figure 8-10 (application ref: 7.8.1)**.

112. This research showed the waters within and around the Array Areas and Inter-Platform Cable Corridor is stratified <40 days a year and they are within a region categorised as intermittently stratified. The nearest seasonally stratified region (stratified for >120 days) is located 17km west of the Array Areas and Inter-Platform Cable Corridor. The Flamborough Front may be present occasionally within this region, but an overwhelming majority of the time this water is most likely 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).

8.5.13 Coastal Geomorphology

113. The landfall is characterised by low cliffs with a maximum elevation range of 8m OD to 13m OD, composed of relatively soft clay (till). These cliffs are fronted by a highly dynamic sand and gravel beach approximately 120m wide at Mean Low Water, that rests on a shore platform of till, which is exposed locally where beach deposits are thin. This beach material 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.

114. The bathymetry in the nearshore zone is relatively shallow and gently sloping (**Volume 7, Figure 8-2 (application ref: 7.8.1)**). Water depths reach 10m within 1.5km of Mean Low Water. In the nearshore, a series of shore parallel, asymmetric mounds are present. These have been interpreted as relict glacial features and are considered to be immobile (MarineSpace, 2023). A curvilinear ridge trending in north-west to south-east direction is also present. This has been interpreted as a possible river channel feature that formed in the past when sea levels were lower (see **Volume 7, Appendix 17-2 (application ref: 7.17.17.2)**).

8.5.14 Coastal Geology

115. The cliffs and shore platform along the Holderness coast are composed of Skipsea Till which formed in the late Devensian (18,000-13,000 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 & Thomson, 2010) within the till which create planes of weakness that are more susceptible to erosion.

116. The till shore platform extends seaward into the subtidal zone where it is exposed at seabed locally. Seabed sediments in this highly dynamic zone are characterised by sand and mixed sediment (East Riding of Yorkshire Council, 2014).

117. A geotechnical borehole survey undertaken in 2023 within the nearshore part of the Offshore Export Cable Corridor landfall confirmed this geology with a thin veneer of slightly gravelly sand (0.3 to 2.0m thick) overlying till which is exposed at seabed at the location of a number of boreholes.

8.5.15 Coastal Sediment Transport

118. Waves are the dominant driver of sediment transport along the Holderness coast with net transport at the possible landfall locations to the south towards Spurn Head (Pye & Blott, 2015) (**Volume 7, Figure 8-6 (application ref: 7.8.1)**).

119. Tidal and wave-induced currents acting across and along the relatively narrow beach fronting the coastal cliffs mobilise fine-grained sediment from the beach, exposed shore platform and the eroding cliffs, and transports it seaward creating a visible nearshore sediment plume.

8.5.16 Coastal Erosion

120. 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.

121. The SMP policy for this stretch of coast (Policy Unit C: Wilsthorpe to Atwick) is No Active Intervention for the Short Term (present day to 2025), Medium Term (2025 to 2055) and Long Term (2055 to 2105) (Scott Wilson, 2010). The NCERM identifies this frontage as natural defence and erodible.

122. East Riding of Yorkshire Council 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 24 to 31 (**Volume 7, Figure 8-11 (application ref: 7.8.1)**), located in the immediate area surrounding the possible landfall locations, are summarised in **Table 8-18**. At profile 31 (North end of Skirlington campsite) the cliff retreated by 9.65m between March 2022 and April 2023 marking the greatest individual loss at the location of this profile since coastal monitoring began. This demonstrates how much this coast at the landfall can change over a relatively short period of time.

Table 8-18 Cliff Recession Rates at Profiles 24 to 31.

Profile	Location	Erosion rate (m/year)		Height of cliff (m AODN)	Maximum annual recession (m)	Year of maximum
		Historic (1852 to 1989)	Recent (1989 to 2023)			
24	Between defences opposite Southfield Lane, Ulrome	1.56	1.12	8.2	8.83	2016

Profile	Location	Erosion rate (m/year)		Height of cliff (m AODN)	Maximum annual recession (m)	Year of maximum
		Historic (1852 to 1989)	Recent (1989 to 2023)			
25	North end of Green Lane, Skipsea	1.54	1.30	8.4	9.36	2007
26	South of Green Lane, Skipsea	1.58	0.97	10.6	10.17	2008
27	Opposite Skipsea village	1.33	1.03	13.0	10.95	2011
28	Opposite bungalows to south of Skipsea	1.19	1.37	12.9	11.60	2013
29	To south of Withow Gap, Skipsea	1.10	1.34	11.6	9.82	2020
30	Within golf course to north of Skirlington	1.07	1.11	14.6	7.86	2016
31	North end of Skirlington campsite	1.07	1.02	18.3	9.64	2023

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

124. Monitoring of beach elevation change at the landfall was undertaken between 2008 and 2015 (Coastal Explorer, 2016) and the results are shown in **Plate 8-19**. The results show that over a seven year period, there was relatively little elevation change (±0.25m) across the majority of the beach with the exception of the backshore near the foot of the cliffs where lowering of up 2.25m occurred.

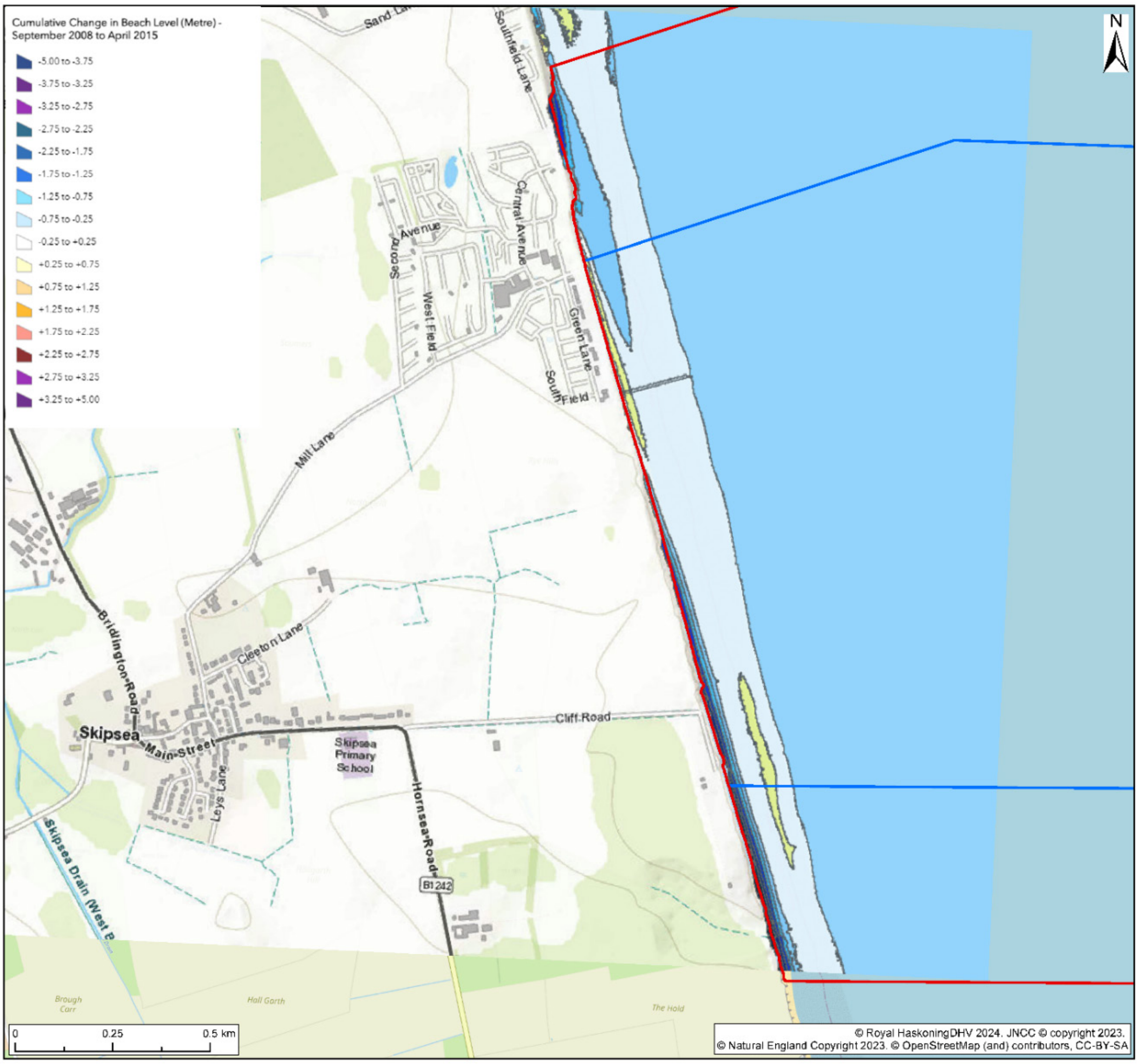

Plate 8-19 Cumulative change in beach level (m) from September 2008 to April 2015 at the landfall (Coastal Explorer, 2016)

125. The pattern of increased lowering at the base of cliffs with small-scale vertical change across the majority of the beach profile is common. This is likely caused by heightened abrasion, debris removal and tidally generated weathering (Moses & Robinson, 2021). Generally, there is limited data regarding current and predicted beach platform change/lowering across England (Moses & Robinson, 2021). At Easington (40km south of the offshore export cable), mean annual beach platform lowering was 0.04m over a one year monitoring period (Cooper *et al*., 2007).

8.5.17 Historic Sea-Level Rise

126. The erosion rates along the Holderness coast have been measured over the long term between 1852 and 1989, and more recently over the medium-term, between 1989-2022 (**Table 8-18**). The historic sea-level rise estimate that most closely covers this period of historic erosion is that of Woodworth (2018). Woodworth (2018) used recent mean sea level information from the UK tide gauge network along with short records of sea level measurements by the 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 Future Trends

127. In the event that the Projects are not developed, the baseline conditions for the marine physical environment will continue to be controlled by waves and tidal currents driving changes in sediment transport and then seabed morphology, but also anthropogenic influences in relation to water quality.

128. These long-term drivers may be affected by environmental changes including climate change driven sea-level rise. This will have the greatest impact at the coast where more waves will impinge on the cliffs, potentially increasing their rate of erosion. Climate change will have a lesser effect offshore where landscape-scale changes in water levels (water depths) far outweigh the effect of minor changes due to sea-level rise. With respect to water quality, continued improvements in inputs alongside continued legislative change could give rise to benefits in water quality in the long term.

8.6.1 Projected Sea-Level Rise

129. Historical 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.

130. To determine a climate change sea-level allowance for the proposed landfall locations to cover the 30-year operational life of the wind farms and post-operation, this study uses the data of the UK Climate Projections (UKCP18) user interface for the model grid cell that covers the landfall location (**Volume 7, Figure 8-12 (application ref: 7.8.1**). The UKCP18 outputs provide projections over three future greenhouse gas emissions scenarios, named Representative Concentration Pathways (RCPs). They are available for low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenarios and presented by UKCP18 as central estimates of change (50% confidence level) in each scenario with an upper 95% confidence level and a lower 5% confidence level. For this study, RCP 4.5 and 8.5 has been used, representing the best estimate and highest of the three modelled RCPs. Outputs using the 50th percentile value are provided in **Table 8-19** and **Plate 8-20**, showing changes in mean sea level relative to a base date of 2023.

Table 8-19 UKCP18 Modelled Projections of Sea-level Rise at the Proposed Landfall Location

Year	Representative Concentration Pathway	Sea level rise relative to 2023 base date	Average rate of sea-level rise
2033 (10 years)	RCP 4.5	0.04m	4.7mm/year
	RCP 8.5	0.06m	6.5mm/year
2043 (20 years)	RCP 4.5	0.09m	5.0mm/year
	RCP 8.5	0.13m	6.4mm/year
2053 (30 years)	RCP 4.5	0.15m	5.1mm/year
	RCP 8.5	0.20m	6.8mm/year
2073 (50 years)	RCP 4.5	0.27m	5.4mm/year
	RCP 8.5	0.38m	7.5mm/year

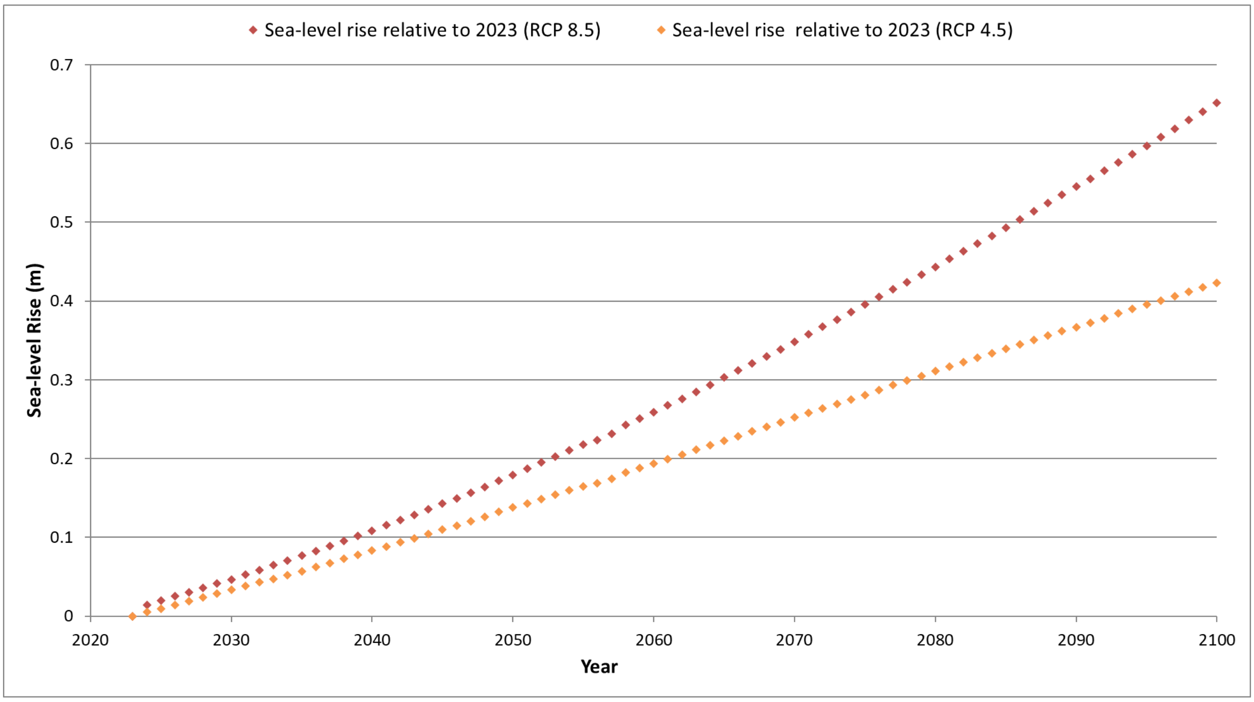

Plate 8-20 Projected changes in relative sea level (m) at the proposed landfall location under the 50% confidence level of the medium (RCP 4.5) and high (RCP 8.5) emissions scenarios using a 2023 baseline.

8.6.2 Predicting Future Cliff Erosion

131. One of the most important long-term implications of climate change is the physical response of the coast to future sea-level rise. It is likely that the future erosion rate of the Holderness cliffs will be affected by the higher rates of sea-level rise. Higher baseline water levels would result in a greater occurrence of waves impacting the toes of the cliffs, increasing their susceptibility to erosion.

132. 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:

133. Direct extrapolation of historic trends into the future without incorporating potential increases due to higher rates of relative sea-level rise (Lee & Clarke, 2002); and

134. Forward projection including potential increases to account for higher rates of relative sea-level rise (Leatherman, 1990).

135. 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.

(Equation 1): $RP = RH.(SP/SH)$.

Where:

- RP = predicted erosion rate (m/year);
- RH = historic erosion rate (m/year) (**Table 8-18**);
- SP = predicted relative sea-level rise (mm/year); and
- SH = historic relative sea-level rise (mm/year).

136. 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 here. The extrapolation method is likely to under-estimate future erosion.

137. Using values of historic sea-level rise and erosion rates, and projections of future sea-level rise (high emissions scenario), the predicted future cliff erosion rates at beach profiles 25-30 located in the vicinity of the landfall are shown in **Table 8-20**.

Table 8-20 Projected Cliff Erosion Rates of the Holderness Cliffs in the Vicinity of the Landfall Locations

Erosion Profile Details		**Erosion rate (m/year)**				
		Historic	**Future**			
Profile	**Location**	**1852 to 2023**	**10 years**	**20 years**	**30 years**	**50 years**
24	Between defences opposite Southfield Lane, Ulrome	1.47	5.52	5.43	5.77	6.37
25	North end of Green Lane, Skipsea	1.48	5.59	5.50	5.85	6.45
26	South of Green Lane, Skipsea	1.45	5.47	5.38	5.72	6.31
27	Opposite Skipsea village	1.26	4.76	4.69	4.98	5.49
28	Opposite bungalows to south of Skipsea	1.33	5.00	4.92	5.23	5.76
29	To south of Withow Gap, Skipsea	1.29	4.84	4.77	5.06	5.58
30	Within golf course to north of Skirlington	1.10	4.12	4.06	4.31	4.76
31	North end of Skirlington campsite	1.05	3.97	3.91	4.15	4.58

138. Predictions of future coastal erosion using the UKCP18 high emission scenario (RCP8.5) at a 50% confidence level suggest the maximum cliff retreat distance at the possible landfall location will be 56m over the next 10 years, 110m over the next 20 years, 175m over the next 30 years and 322m over the next 50 years. These rates are the worst case based on the high emission sea-level rise scenario and are overestimated when compared to the NCERM project which predicts a retreat distance of 33m for the short term (0 to 20 years) and 82m for the medium term (20 to 50 years) for this frontage which is classified as being erodible.

8.7 Assessment of Significance

8.7.1 Impact Receptors

139. The principal receptors with respect to the marine physical environment are coastal or marine features with an inherent geological or geomorphological value or function which may be affected by the Projects. As the conservation objectives of SACs and MCZs are driven by their ecological functioning, they are not considered as receptors for the marine physical environment and are assessed in the relevant chapters (see **Volume 7, Chapter 9, Benthic and Intertidal Ecology (application ref: 7.9)**), **Volume 6, Report to Inform Appropriate Assessment (RIAA)** (**application ref: 6.1)** and **Volume 8, Stage 1 Marine Conservation Zone Assessment (application ref: 8.17)**. However, a designated site may have a morphological component. For example, the Dogger Bank SAC comprises part of the Dogger Bank which is a topographic high and a geomorphological feature. Therefore, Dogger Bank itself is included as a receptor in this assessment, but not the Dogger Bank SAC.

140. For water quality, the receptor is generally the marine environment given that water quality EQS are applied regardless of designation status. However, it is acknowledged within this assessment that specific areas of marine waters are classified according to their water quality status or water quality contributes to their classification status, such as bathing waters and WFD water bodies for example, therefore an additional value assessment is provided where activities could impact these designations.

141. The specific features requiring further assessment at the EIA stage are listed in **Table 8-21**. The impact assessment sections assess the significance of potential impacts on water quality, the wave and / or current and / or sediment transport regimes on these receptors.

Table 8-21 Marine Physical Environment Receptors Relevant to the Projects

Receptor group	Receptor	Description of features	Closest distance from projects
Designated sites and features	Dimlington Cliff SSSI	Geological Interest (Quaternary of East England)	36km south of the landfall
	Flamborough Head SSSI	Geological interest (Chalk cliffs) and coastal geomorphology	9km north of the Offshore Export Cable Corridor

Receptor group	Receptor	Description of features	Closest distance from projects
	Withow Gap Skipsea SSSI	Geological Interest (Quaternary of North-East England)	Part of the Offshore Export Cable Corridor and landfall located within SSSI
	Holderness Inshore MCZ	Geological features (Spurn Head)	Nearshore Offshore Export Cable Corridor and landfall located directly north of the MCZ. Spurn Head located 52km of the landfall.
	Holderness Offshore MCZ	Geological features - North Sea glacial tunnel valleys	1km south of the Offshore Export Cable Corridor, 12km from the coast
	Marine waters (offshore)	No specific features	Both DBS Array Areas and part of the Offshore Export Cable Corridor
	Marine waters (inshore)	Marine waters within which the following designations are located: WFD water bodies: Yorkshire South coastal WFD water body, Yorkshire North coastal WFD water body Bathing waters: Bridlington North, Bridlington South Danes Dyke, Flamborough, Flamborough South Landing, Fraisthorpe, Hornsea, Skipsea Wilsthorpe.	Offshore Export Cable Corridor passes through the Yorkshire South coastal WFD water body and within 8.5km of the Yorkshire North coastal WFD water body as shown in **Volume 7, Figure 8-9 (application ref: 7.8.1).** Closest bathing water – Skipsea is on the border of the Offshore Export Cable Corridor boundary. All others are located at least 5km from the Offshore Export Cable Corridor boundary (see **Volume 7, Figure 8-9 (application ref: 7.8.1)**)
Non-designated	Holderness Cliffs	Soft, rapidly eroding coastal cliffs and beach platform	Trenchless transition exit points at the landfall

Receptor group	Receptor	Description of features	Closest distance from projects
sites and features	Smithic Bank	Offshore sand bank	Offshore Export Cable Corridor buffer partially crosses southern part of Smithic Bank
	Flamborough Front	Seasonal tidal mixing front	Potentially present within Array Areas
	Humber Estuary	Geomorphological features of the coastal plain including the estuary, mud flats, sand flats, lagoons, saltmarsh and wetlands, coastal dunes and beaches	40km from the landfall
	Dogger Bank	Glacial and marine geological and geomorphological features	DBS Array Areas and part of the Offshore Export Cable Corridor are located on Dogger Bank

8.7.2 Effects

142. In addition to identifiable receptors, an assessment of changes to the marine physical environment which in themselves are not necessarily effects to which significance can be ascribed (such as changes in suspended sediment and chemical concentrations) is outlined in section 8.7.3 to section 8.7.4. These changes however, may directly impact other receptors such as benthic habitats for example. In this case, the magnitude of impact is determined in a similar manner to that of marine physical environment receptors but the significance of effects on other receptors is made within **Volume 7, Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)**, **Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)**, and **Volume 7, Chapter 17 Offshore Archaeology and Cultural Heritage (application ref: 7.17)**.

8.7.3 Potential Effects During Construction

143. During construction, seabed and shallow sub-seabed sediments will be disturbed during the following activities:

- Seabed preparation (including seabed levelling and clearance);
- Installation of foundations for wind turbines and offshore platforms;
- Drill arisings from foundations for wind turbines and offshore platforms;
- Installation of offshore export, array and inter-platform cables; and

144. Note that the modelling used in this section includes gravity based foundations for the offshore platforms in the Array Areas as this was the worst case scenario when the modelling was undertaken. A commitment has now been made that the Projects will not use gravity based foundations within the Array Areas. Large (15m diameter) monopile foundations are now the worst case for offshore platforms in the Array Areas. Large monopile foundations have a much smaller volume and footprint of seabed preparation (see **Table 8-1**) in comparison to gravity based foundations. As gravity based foundations represented the worst case, the actual impact will be less than the model predictions for offshore platforms and no worse than the model predictions for wind turbines (which are also large 15m diameter monopiles).

8.7.3.1 Changes in Suspended Sediment Concentration and Transport due to Seabed Preparation for Foundation Installation

8.7.3.1.1 Description of Change

145. Seabed sediments and shallow near-bed sediments within the Array Areas and the Offshore Export Cable Corridor would be disturbed during seabed preparation activities to create a suitable base prior to foundation installation. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface as overflow from a dredger vessel. This process would cause localised and short-term increases in suspended sediment concentrations both at the point of dredging at the seabed and at the point of its discharge back into the water column.

146. The worst case scenario for a release for seabed preparation from an individual wind turbine assumes a monopile foundation for a large wind turbine which would require 3,111m^3 of sediment to be dredged per structure (**Table 8-1**). The worst case volume of sediment disturbed during seabed preparation for offshore platforms is 32,436m^3 per structure.

147. Mobilised sediment from seabed preparation may be transported by wave and tidal action in suspension in the water column. Plume dispersion modelling was undertaken to test this assumption (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The release of sediment due to seabed preparation may increase suspended sediment concentrations by a maximum of 2 mg/l above background levels at the sea surface and 0.5mg/l near the seabed bed but the plume disperses and depending on the tides at the time of release, suspended sediment concentrations return to baseline conditions within a maximum of 5km of the area of disturbance. The disturbance effects at each wind turbine location are last for no more than a few hours.

148. Seabed sediment across the Array Areas is dominated by sand with relatively low mud and gravel content. It is expected that any medium to coarse sand and coarse-grained mixed sediment across the Array Areas, and at the location of the offshore platforms in the Offshore Export Cable Corridor disturbed by the drag head of the dredger at the seabed would remain close to the seabed and settle rapidly. Most of the coarse sediment released at the water surface from the dredge vessel would fall rapidly (minutes or tens of minutes) to the seabed within a few tens of metres along the axis of tidal flow.

149. Any released fine sand, silt or clay will likely stay in suspension for longer and form a plume which would become advected by tidal currents. Sediment would eventually settle to the seabed in proximity to its release (see section 8.7.3.6 for changes in seabed level) within a short period of time (hours). Smaller amounts of suspended sediment would extend further from the dredged area, along the axis of predominant tidal flows as shown in the model outputs, but the concentrations would be indistinguishable from background levels within 5km of the area of disturbance.

150. This assessment is supported by the findings of a review of the evidence base into the physical impacts of marine aggregate dredging on sediment plumes and seabed deposits (Whiteside *et al.*, 1995; John *et al*,. 2000; Hiscock & Bell, 2004; Newell *et al.*, 2004; Tillin *et al.*, 2011; Cooper & Brew, 2013).

8.7.3.1.2 Magnitude of Impact – DBS East or DBS West in Isolation

151. Seabed preparation for foundation installation will disturb the seabed with a modelled worst case scenario for 100 small monopile wind turbines and gravity based foundations for five offshore platforms. The likely magnitude of impact is shown in **Table 8-22**.

Table 8-22 Magnitude of Impact on Suspended Sediment Concentrations Under the Worst Case Scenario for Foundation Installation

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.

8.7.3.1.3 Magnitude of Impact – DBS East and DBS West Together

152. If both DBS East and DBS West are constructed together, a larger volume of sediment would be disturbed over the entire construction phase which may result in higher concentrations of suspended sediment overall. However, suspended sediment concentrations arising from one foundation installation are unlikely to persist for a sufficiently long period of time for them to interact with subsequent operations, and therefore no cumulative effect is anticipated from multiple installations should DBS East and DBS West be developed concurrently or sequentially.

153. The modelled worst case scenario for changes in suspended sediment concentrations due to the installation of 200 small monopile wind turbines and eight gravity based offshore platforms will have the same magnitude of impact as outlined in **Table 8-22**.

8.7.3.1.4 Sensitivity of Receptor

154. The Array Areas and Offshore Export Cable Corridor are located within offshore marine waters and a large proportion of the Array Areas are located on Dogger Bank. The sensitivity and value of these receptors is presented in **Table 8-23**.

Table 8-23 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible
Marine waters (offshore)	High	High	Low	Negligible

8.7.3.1.5 Significance of Effect – DBS East or DBS West in Isolation

155. The effect on suspended sediment concentrations due to foundation installation is considered to have low to negligible magnitude of impact and negligible sensitivity, resulting in a **negligible** significance of effect. No additional mitigation is proposed. Any changes in suspended sediment will be short-lived and considering the low mud content in seabed sediments, any disturbed sediment would settle back to the seabed in close proximity to the area of disturbance.

8.7.3.1.6 Significance of Effect – DBS East and DBS West Together

156. If both Projects are constructed together a larger volume of sediment will be disturbed over the construction phase which may result in higher concentrations of suspended sediment overall. However, as outlined in section 8.7.3.1.1, suspended sediment concentrations arising from one foundation installation are unlikely to persist for a sufficiently long period of time for them to interact with subsequent operations, and therefore no cumulative effect is anticipated from multiple installations. Therefore, the construction of DBS East and DBS West together would not result in a more significant effect than DBS East or DBS West in isolation, and the significance of effect is considered to be **negligible** due to a low to negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.2 Changes in Suspended Sediment Concentration and Transport due to Drill Arisings from Foundations

8.7.3.2.1 Description of Change

157. Sediments below the seabed within the Array Areas would become disturbed during any drilling activities that may be needed at the location of piled foundations. Ambient suspended sediment concentrations across the Array Areas are typically less than 3 mg/l in DBS East reducing to below 2mg/l in DBS West (section 8.5.9) meaning that the transient impact of sediment plumes arising from installation of the windfarm foundations may be significant (although temporally limited) under specific circumstances. The disposal of any sediment that would be disturbed or removed during drilling would occur within the windfarm site in close proximity to each foundation.

158. The worst case scenario for a release from an individual wind turbine assumes a monopile foundation for a large wind turbine. In this case, a 15m diameter drill would be used from the seabed to a depth of 70m, releasing a maximum of 12,064m^3 of sediment per foundation into the water column. The maximum volume of arisings outlined in **Table 8-1** assumes 5% of monopile foundation locations are drilled as a worst case scenario which would amount to a maximum of five individual foundations across both Projects. The worst case for offshore platform foundations is the same pile diameter as for wind turbines and the maximum drill arisings shown in **Table 8-1** assumes each foundation requires drilling to a depth of 70m.

159. The drilling process would cause localised and short-term increases in suspended sediment at the point of discharge of the drill arisings only. Released sediment may then be transported by tidal currents in suspension in the water column. Any fine sediment released is likely to be widely and rapidly dispersed. Given the seabed sediments are dominated by sand with localised occurrences of silty sand with a fine content of <10%, this would result in low suspended sediment concentrations.

160. Plume dispersion modelling was undertaken to provide the evidence base to test this assumption (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The release of suspended sediment due to the worst case for drill arising during foundation installation may increase suspended sediment concentrations locally at the release site by up to 2mg/l in the surface layer and 0.5mg/l in the bottom layer but the plume disperses, and suspended sediment concentrations return to baseline conditions typically within 5km.

161. The model predicts that the disturbance effects at each wind turbine location are likely to last for a few days of construction activity within the overall construction programme lasting up to 60 months in total if DBS East and DBS West are constructed together, and 84 months if they are constructed separately.

162. The modelling indicates net movement of fine-grained sediment retained within a plume would be to the north-west or south-east, depending on state of the tide at the time of release. Sediment concentrations arising from one foundation installation do not persist for a sufficiently long for them to interact with subsequent operations, and therefore, no cumulative effect is anticipated from multiple installations. Furthermore, only 5% of foundations are expected to be drilled.

8.7.3.2.2 Magnitude of Impact – DBS East or DBS West in Isolation

163. The scale of this impact will be relatively localised (near-field) for coarser sediments due to rapid settling out. While fine sediments have greater potential to become mobilised, their volumes are expected to be low and any suspended sediments in the water column are predicted to return to baseline conditions within less than 5km and a few days due to dispersion and dilution.

164. The magnitude of impact for the modelled worst case scenario due to the installation of large monopiles for 57 wind turbines and five offshore platforms is given in **Table 8-24**.

Table 8-24 Magnitude of Impact on Suspended Sediment Concentration and Transport due to Drill Arisings from Foundations

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

**The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.*

8.7.3.2.3 Magnitude of Impact – DBS East and DBS West Together

165. If both DBS East and DBS West are constructed together, there will be a larger number of foundations increasing the volume of sediment that would be disturbed through drilling over the entire construction phase. However, a maximum of two foundations will be installed concurrently within the construction phase and even if these foundations were located adjacent to one another, the resulting plumes would not persist for a sufficiently long period of time to overlap. Therefore, any changes to suspended sediment concentration will be small and short-lived and the magnitude of impact will be the same as outlined in **Table 8-24**.

8.7.3.2.4 Sensitivity of Receptor

166. The Array Areas and Offshore Export Cable Corridor are located within offshore marine waters and a large proportion of the Array Areas are located on Dogger Bank. The sensitivity and value of these receptors is presented in **Table 8-25**.

Table 8-25 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible
Marine waters (offshore)	High	High	Low	Negligible

8.7.3.2.5 Significance of Effect – DBS East or DBS West in Isolation

167. The effect on suspended sediment concentrations due to drill arisings from foundation installation is considered to have a negligible to low magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.3.2.6 Significance of Effect – DBS East and DBS West Together

168. Construction of DBS East and DBS West together will potentially lead to a greater number of foundations requiring drilling and overall increase in the volume of sediment released. However, it would not result in a greater magnitude of impact than DBS East or DBS West in isolation as each individual activity will be locally and temporally restricted. Therefore, the significance of effect is the same as outlined in section 8.7.3.2.5 and considered to have a likely **negligible** significance of effect due to a negligible to low magnitude of effect and negligible sensitivity. No additional mitigation is proposed.

8.7.3.3 Changes in Suspended Sediment Concentration and Transport due to Cable Installation (Array, Inter Platform and Export)

8.7.3.3.1 Description of Change

169. The installation parameters of the array, inter-platform and Offshore Export Cables are dependent upon the final project design. The worst case cable laying technique is considered to be jetting, and so the assessment below considers 100% of the cables are installed by jetting.

170. As a worst case scenario, it is also assumed seabed clearance and levelling (pre-sweeping) may be required prior to cable installation. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface as overflow from a dredge vessel. This process would cause localised and short-term increases in suspended sediment both at the point of dredging at the seabed and, more importantly, at the point of its discharge back into the water column.

171. Plume dispersion modelling was undertaken to provide the evidence base to assesses the effect of offshore export, inter-array and inter-platform cable installation on suspended sediment concentrations (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The model comprised two phases of activity: the first phase was seabed levelling which as a worst case is assumed to be required along 25% of the export cable route and 10% of the inter-array and inter-platform cable routes. Seabed bathymetry was used to identify the areas within the cable corridors most likely to require seabed levelling due to the presence of bedforms. The second phase was seabed trenching.

172. During seabed levelling, suspended sediment typically reaches concentrations of up to 5mg/l in the bottom layer and 0.5mg/l in the surface layer within the cable corridors (**Plate 8-21**). Dispersion of the sediment plume due to tidal currents transports the plume northwest or southeast of the cable corridor and during peak tides, suspended sediment concentrations of up to 5mg/l occur within 1km of the cable corridor with values returning to background levels within 5-7km of the cable corridor. The model predicts the plume persists for a period of two to four hours within the Offshore Export Cable Corridor and up to six hours within the Array Areas and Inter-Platform Cable Corridors due to tidal currents being lower here.

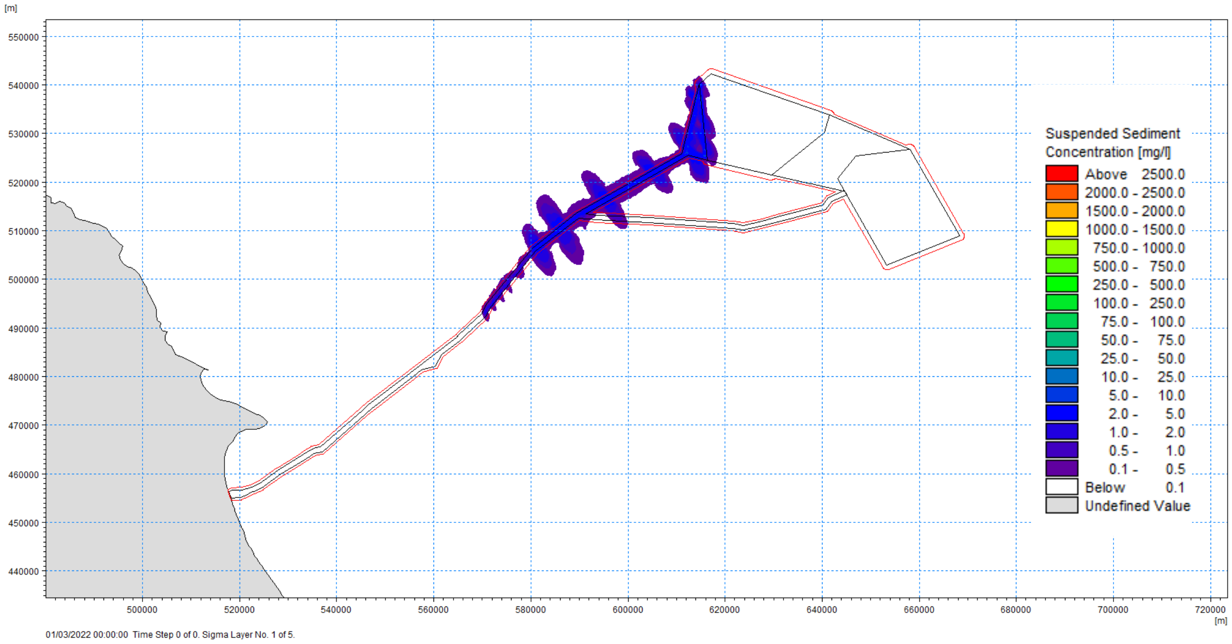

Plate 8-21 Maximum suspended sediment concentration (bottom layer) during seabed levelling within Offshore Export Cable Corridor to DBS West

173. During the trenching phase of cable installation, the magnitude of changes in suspended sediment concentrations was higher and the maximum suspended sediment concentration predictions reach 1,000-1,500 mg/l locally (**Plate 8-22**). However, the extent of the sediment plume differs due to greater variability in tidal currents along the entire length of the Offshore Export Cable route. The maximum extent of the plume during peak tidal currents reaches 18km from the cable corridor to the east of Flamborough Head where tidal currents are stronger. However, even at its maximum extent, the plume does not interact with the coast. In the nearshore part of the cable corridor, the plume is much more limited in extent and restricted to within 2km of the cable corridor. This is likely due to the sheltering effect of Flamborough Head with tidal currents being much lower in the nearshore. From around 60km offshore, the extent of the plume reduces from 5km to around 2km within the Array Areas. While the model predicts the plume can extend kilometres from the point of disturbance, the changes in suspended sediment concentration over these distances are small, typically below 1mg/l, and the plume persist for a period of hours.

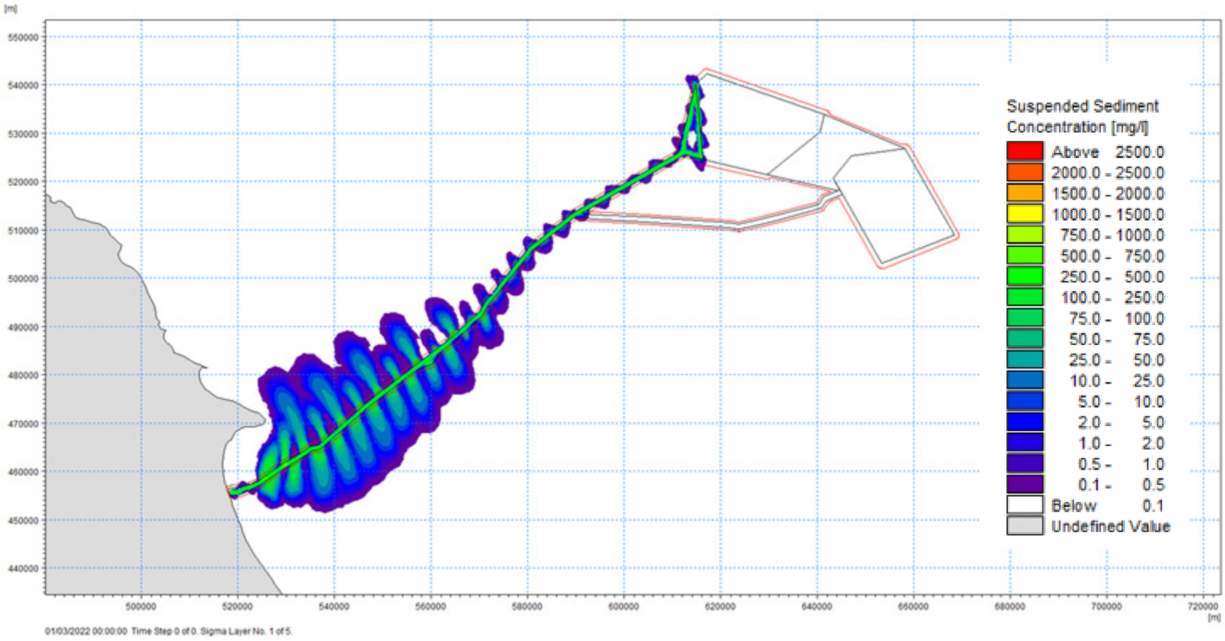

Plate 8-22 Maximum suspended sediment concentration (bottom layer) during trenching of the Offshore Export Cable Corridor to DBS West

8.7.3.3.2 Magnitude of Impact – DBS East or DBS West in Isolation

174. The scale of this impact will be relatively localised for coarser sediments (due to immediate settling out) and larger-scale for finer sediments but suspended sediment concentrations will extend beyond the natural variation in background conditions. However, suspended sediments in the water column are predicted to return to baseline conditions within hours of the disturbance due to dispersion and dilution. Therefore, any effects will be temporary. The magnitude of impact for the modelled worst case scenario due to cable installation is given in **Table 8-26**.

Table 8-26 Magnitude of Impact on Suspended Sediment Concentrations for Cable Installation for a Project in Isolation

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

8.7.3.3.3 Magnitude of Impact – DBS East and DBS West Together

175. If DBS East and DBS West are built together (concurrently or sequentially) there will be an increase in the total length of cable requiring installation which will lead to a larger area of disturbance over a longer construction period. However, as the effects are temporally restricted to the area of installation, and multiple cable laying vessels will not be operating in the same area, the worst case scenario for changes in suspended sediment concentrations due to cable installation will have the same magnitude of impact as outlined in **Table 8-26**.

8.7.3.3.4 Sensitivity of Receptor

176. The Construction Buffer Zone of the Offshore Export Cable Corridor overlaps with the northern extent of the Holderness Inshore MCZ. However, the Offshore Export Cable Corridor is located 50km from Spurn Head which is the geomorphological feature of relevance to this assessment. The construction buffer zone of the Offshore Export Cable Corridor crosses the extreme southern extent of Smithic Bank. Inshore, the Offshore Export Cable Corridor crosses a WFD water body within proximity to several bathing waters. Further offshore, the array and inter-platform cables are located on the Dogger Bank. The sensitivity and value of these receptors is presented in **Table 8-27**.

Table 8-27 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration During Cable Installation

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Smithic Bank	High	High	Low	Negligible
Dogger Bank	High	High	Low	Negligible
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.3.3.5 Significance of Effect – DBS East or DBS West in Isolation

177. The effects on suspended sediment concentrations due to cable installation is considered to have a negligible to low magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.3.3.6 Significance of Effect – DBS East and DBS West Together

178. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.3.2.5 and is considered to be of **negligible** significance of effect due to a negligible to low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.4 Changes in Suspended Sediment Concentration and Transport Due to Cable Installation at the Landfall

8.7.3.4.1 Description of Change

179. The Offshore Export Cable will be connected to the Onshore Export Cable using trenchless techniques below the cliffs. The worst case scenario is a ‘short trenchless’ option which sees the bore pits exit on the beach in the intertidal zone at least 50m from the base of the cliffs. The bore exit pits will be excavated to provide access to connect the onshore export cable to the offshore export cable. A maximum of six exit pits may be required. Each pit will be 20m by 10m, separated by a distance of 50m, running in a line parallel to the shoreline. Installation of the exit pits will occur over a duration of 18 months but each individual pit will be open for a maximum of four months within this period. The cable route between the exit pit and the mean low water spring water level will be trenched (see **Table 8-1** for details). The Projects have committed to not installing cofferdams within the exit pits to minimise any impact within the intertidal zone.

180. The excavated material will be disposed of directly adjacent to the location of the excavation and will comprise a mix of gravelly sandy beach sediments and glacial till from the underlying shore platform. The maximum volume of sediment excavated per exit pit will be 600m^3 and the volume of sediment excavated from the trench between the exit pits and MLWS will be 990m^3. These values are extremely low when compared with estimates of sediment yield from the Holderness coast (50 km of coastline) due to cliff and shore platform erosion of 4 million m^3/year (Balson *et al*. 1998).

181. At a local scale, there is limited information on sediment yield due to coastal erosion of the cliffs at the landfall. However, using the average coastal erosion rate from historic data (**Table 8-20**) of 1.3m per year, the width of the Offshore Export Cable corridor at landfall (excluding construction buffer) of 1400m and the average cliff height of 9m, a volume of up to 163,80m^3 could be eroded from the landfall on a yearly basis. The worst case volume of material excavated due to the cable installation activities at the landfall amounts to 4,770m^3 which is much lower than that lost due to coastal erosion.

182. Excavation will be undertaken at low tide but the excavated sediment stored on the beach will become submerged at high tide, where seabed currents (predominantly wave-driven) will mobilise and redistribute it as a combination of suspended sediment and bedload.

183. As a result of the excavation process, suspended sediment concentrations will be elevated above prevailing conditions but are likely to remain within the range of background nearshore levels (which are high close to the coast because of increased wave activity) and lower than those concentrations that would develop during storm conditions when sediment yields are higher due to cliff erosion. Once mobilised, the suspended sediment will dissipate rapidly (i.e. over a period of a few hours) in the water and be transported alongshore and offshore. Complete removal of the excavated material would be expected within weeks to months of excavation, at which point prevailing conditions will resume and there will be no changes suspended sediment concentrations.

184. The trench will be backfilled on completion of cable installation activities. Depending on the duration of this processes, there is potential for suspended sediment concentrations to become elevated when the area becomes submerged during high tide, either during or immediately after the activity ceases as the backfilled material settles.

8.7.3.4.2 Magnitude of Impact – DBS East or DBS West in Isolation

185. The magnitude of impact for the worst case scenario due to cable installation at the landfall assumes the trenchless bore exit points are located in the intertidal zone at least 50m from the base of the cliff, with storage of the excavated material on the beach (**Table 8-28**). If the Projects are built in isolation, a maximum of three bore exits pits will be required during a single construction phase of 18 months and each bore pit will be open for a maximum of four months.

Table 8-28 Magnitude of Impact on Suspended Sediment Concentrations Under the Worst Case Scenario Due to Cable Installation at the Landfall

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

8.7.3.4.3 Magnitude of Impact – DBS East and DBS West Together

186. If DBS East and DBS West are built together (concurrently or sequentially) a maximum of six bore exit pits will be required. However, the exit pits will be installed during a single phase that will not exceed 18 months, with each individual pit will not being open for more than four months. The volume of sediment excavated and the footprint of disturbance will therefore double if the Projects are built together, when compared with the in isolation scenario. However, the scale of the impact will remain low as the changes are small when compared to natural variations in suspended sediment concentration due to coastal erosion and storm events. Therefore, the magnitude of impact for the worst case scenario due to cable installation at the landfall if DBS East and DBS West are built together will be the same as outlined in **Table 8-28**.

8.7.3.4.4 Sensitivity of Receptor

187. Changes in suspended sediment concentrations due to cable installation at the landfall may impact the geological features of the Holderness Inshore MCZ, Smithic Bank and Marine waters (inshore) (see **Table 8-21** for associated WFD water bodies and bathing waters). The sensitivity and value of these receptors to changes in suspended sediment concentration is given in **Table 8-29**.

Table 8-29 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Smithic Bank	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.3.4.5 Significance of Effect – DBS East or DBS West in Isolation

188. The effects on suspended sediment concentrations due to cable installation at the landfall are considered to have a negligible magnitude of impact and negligible sensitivity, resulting in likely **negligible** significance of effect. No additional mitigation is proposed. Trenching within the intertidal zone and storage of excavated material on the beach will elevate suspended sediment concentrations when the area becomes submerged during high tides. However, the volume of excavated material is small when compared to typical sediment yields due to coastal erosion, and the excavated material will likely be completely removed over a period of weeks to months meaning any changes in suspended sediment concentration will be short-lived and localised.

8.7.3.4.6 Significance of Effect – DBS East and DBS West Together

189. Construction of DBS East and DBS West together (concurrently or sequentially) would not result a greater magnitude of impact than DBS East or DBS West in isolation as for both scenarios, there will be one phase of cable installation activity and the volumes of sediment disturbed, despite a greater number of excavations being required, remain low in comparison to background sediment yield due to coastal erosion. Therefore, the significance of effect is the same as outlined in section 8.7.4.9.6 and considered to have a likely **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.5 Deterioration in Water Quality Associated With Release of Sediment Bound Contamination

8.7.3.5.1 Description of Change

190. The receptor for this impact is marine waters (both offshore and inshore). All activities assessed in impacts, including changes in suspended sediment concentration and transport due to seabed preparation for foundation installation and changes in suspended sediment concentration and transport due to cable installation at the landfall, could cause localised and short-term increases in suspended sediment at the point of disturbance. Released sediment may then be transported by tidal currents in suspension in the water column releasing any bound contamination.

191. Sediment data available indicates that for all parameters, sediment contaminant concentrations are low (section 8.5.10). Where exceedance of sediment guidelines occur, these are marginal (i.e. only just above lower guideline values) and no samples exceeded the Cefas AL2 (where available) which indicates that there is minimal risk to the water column if suspended. Additionally, as assessed in changes in suspended sediment concentration and transport due to seabed preparation for foundation installation (section 8.7.3.1) and changes in suspended sediment concentration and transport due to cable installation at the landfall (section 8.7.3.3), sediments are not predicted to remain in suspension for long periods of time (days) given that the seabed material is predominantly coarse gravel and sand with low levels of fines.

8.7.3.5.2 Magnitude of Impact – DBS East or DBS West in Isolation

192. The scale of this impact will be relatively localised (near-field) for coarser sediments (due to rapid settling out). While fine sediments have greater potential to become mobilised, their volumes are expected to be low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution. Sediment contaminant levels are also predicted to be low. The magnitude of impact for the worst case scenario is given in **Table 8-30**.

Table 8-30 Magnitude of Impact on Water Quality

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

8.7.3.5.3 Magnitude of Impact – DBS East and DBS West Together

193. As discussed in section 8.7.3.1, if both DBS East and DBS West are constructed together, a larger volume of material would be suspended. However, predicted suspended sediment concentrations arising from construction impacts, including changes in suspended sediment concentration and transport due to seabed preparation for foundation installation and changes in suspended sediment concentration and transport due to landfall cable installation, are unlikely to persist for a sufficiently long period of time for them to interact with subsequent operations, and given that sediment contaminant levels are predicted to be low across the Offshore Development Area, no cumulative effect is anticipated from multiple installations should DBS East and DBS West be developed concurrently.

194. The worst case scenario for effects on water quality will have the same magnitude of impact as outlined in **Table 8-30** given the low levels of contaminants predicted.

8.7.3.5.4 Sensitivity of Receptor

195. Increases in chemical concentrations may impact on marine waters both offshore and inshore (including WFD water bodies and bathing waters). The sensitivity and value of these receptors to changes in chemical contaminant concentration is given in **Table 8-31**.

Table 8-31 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.3.5.5 Significance of Effect – DBS East or DBS West in Isolation

196. The effects on water quality due to the release of sediment bound contaminants are considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.5.6 Significance of Effect – DBS East and DBS West Together

197. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. As a result, the significance of effect is likely **negligible**, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.6 Changes in Seabed Level Due to Seabed Preparation for Foundation Installation

8.7.3.6.1 Description of Change

198. The increase in suspended sediment concentration associated with changes in suspended sediment concentration and transport due to seabed preparation for foundation installation (section 8.7.3.1) has the potential to deposit sediment from the plume and change the elevation of the seabed.

199. It is predicted that coarser sediment disturbed during seabed preparation would fall rapidly to the seabed (minutes or tens of minutes) as a highly turbid dynamic plume immediately after it is discharged. The resulting change would be a measurable protrusion above the existing seabed, but one which would remain local to the release point. The geometry of the change would vary across the Array Areas, depending on the prevailing physical conditions, but in all cases the deposited sediment would be similar (but not exactly the same as) both the seabed that it has replaced and the surrounding seabed. With time, tidal processes would remobilise and transport this sediment as bedload.

200. The overall change in elevation of the seabed due to deposition of sediment deposited from the plume during seabed preparation for foundations was modelled (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The results show the maximum change in seabed level was <0.005m which is extremely small when compared to the water depths across the Array Areas (12 to 40m below LAT). This degree of change would be undetectable using standard bathymetric survey techniques.

8.7.3.6.2 Magnitude of Impact – DBS East or DBS West in Isolation

201. The magnitude of impact for the modelled worst case scenario due to the installation of 100 small monopile wind turbines and five gravity based offshore platforms is outlined in **Table 8-32**.

Table 8-32 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	Negligible	Negligible	Negligible	Negligible	Negligible
Far-field	Negligible	Negligible	Negligible	Negligible	Negligible

*The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.

8.7.3.6.3 Magnitude of Impact – DBS East and DBS West Together

202. If DBS East and DBS West are built together (sequentially or concurrently), the modelled worst case scenario for changes in seabed level due to the installation of 200 small monopile wind turbines and eight gravity based offshore platforms will increase the volume of sediment disturbed overall but deposition from individual plumes will be very small and undetectable. Therefore, the magnitude of impact will be the same as outlined in **Table 8-32**.

8.7.3.6.4 Sensitivity of Receptor

203. Parts of the Array Areas are located on Dogger Bank. The sensitivity and value of this morphological receptors is presented in **Table 8-33**.

Table 8-33 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible

8.7.3.6.5 Significance of Effect – DBS East or DBS West in Isolation

204. The impacts on seabed level due to seabed preparation for foundation installation are considered to have a negligible magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.3.6.6 *Significance of Effect – DBS East and DBS West Together*

205. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.3.6.5 and considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.7 Changes to Seabed Level Due to Drill Arisings from Foundations

8.7.3.7.1 *Description of Change*

206. A combination of increased suspended sediment concentration combined with the disposal of any sediment that would be disturbed or removed whilst drilling monopile foundations has the potential to deposit sediment and change the seabed elevation.

207. Drilling of piles could potentially occur through up to 13 geological units (**Table 8-13**) comprising sand, silt, organic deposits and high strength clay (till). If the drilling penetrates the till, then a worst case scenario is considered whereby the sediment released from the drilling is assumed to be wholly in the form of larger aggregated 'clasts' which would settle rapidly. These clasts would remain on the seabed (at least initially), rather than being disaggregated into individual fine-grained sediment components immediately upon release. The coarser sediment fractions (medium and coarse sands and gravels) would also settle out of suspension in close proximity to each foundation location. Under this scenario, the worst case scenario assumes that a 'mound' would reside on the seabed near the site of its release.

208. If drilling penetrates fine-sand and silt deposits associated with Holocene age geological units, the process will cause localised and short-term increases in suspended sediment at the point of discharge of the drill arisings only. Released sediment may then be transported by tidal currents in suspension in the water column (see changes in suspended sediment concentration and transport due to drill arisings from foundations, section 8.7.3.2). Any fine sediment released will be widely and rapidly dispersed.

209. Changes in seabed level due to deposition of suspended sediment released from drill arising from foundation installation was modelled and the results show there is no observable change greater than 5mm. Any changes are therefore considered to be within the range of natural background variability and would also be undetectable using standard bathymetric survey techniques. The worst case for drill arisings is for the maximum number of the largest wind turbines (diameter) and the maximum number of offshore platforms and assumes only 5% of locations will be drilled (maximum five locations). The distribution of sub-surface fine-grained deposits across the Array Areas is discontinuous due to geological understanding of the Dogger Bank region (section 8.5.2). Therefore, the probability of drilling through fine-grained deposits is also considered low.

8.7.3.7.2 Magnitude of Impact – DBS East or DBS West in Isolation

210. The scale of this impact will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). While fine sediments have greater potential to become mobilised, the potential for encountering them during drilling is low and deposition of any suspended sediments in the water column is predicted to be low at <0.005m. Therefore, the magnitude of impact for the modelled worst case scenario due to the drilling of 5% of large monopile foundations for 57 wind turbines and five offshore platforms is given in **Table 8-34**.

Table 8-34 Magnitude of Impact Seabed Level Under the Worst Case Scenario Due to Drill Arisings from Foundations

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.

8.7.3.7.3 Magnitude of Impact – DBS East and DBS West Together

211. If both DBS East and DBS West are constructed together, there will be a larger number of foundations increasing the volume of sediment that would be potentially disturbed through drilling over the entire construction phase. This could increase the area affected by changes in seabed level but as the changes are predicted to be undetectable and short-lived, the worst case scenario for changes in seabed level due to drill arisings will have the same magnitude of impact as outlined in **Table 8-34**.

8.7.3.7.4 Sensitivity of Receptor

212. Parts of the Array Areas are within the Dogger Bank. The sensitivity and value of this morphological receptor is presented in **Table 8-35**.

Table 8-35 Sensitivity and Value Assessment for Receptors Impacted by Changes in Seabed Level

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible

8.7.3.7.5 Significance of Effect – DBS East or DBS West in Isolation

213. The effect on seabed level due to drill arisings from foundation installation is considered to have a negligible magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.3.7.6 Significance of Effect – DBS East and DBS West Together

214. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation as any effects are small and short-lived. Therefore, the significance of effect is the same as outlined in section 8.7.3.7.5 and considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.8 Changes in Seabed Level Due to Cable Installation (Array, Inter-platform and Export)

8.7.3.8.1 Description of Change

215. The increases in suspended sediment concentrations associated with array, inter-platform and Offshore Export Cable installation have the potential to result in changes in seabed level as the suspended sediment is deposited on the seabed. This could occur during both the seabed levelling and trenching phase of cable installation. Therefore, changes in seabed level due to deposition of suspended sediment were modelled to provide the evidence base to inform this assessment.

216. The modelling shows the greatest change in seabed level occurs during the seabed trenching phase within the Offshore Export Cable Corridor with an increase of up to 0.05m predicted within and immediately adjacent to the area of levelling, with a maximum change of up to 0.25m occurring in localised hotspots. Changes to seabed level within the Array Areas are much larger, reaching 0.5m where multiple cable corridors merge. This is likely due to an accumulation of sediment as the model simulation trenches over the same area of seabed. In practice, there will not be repeat phases of trenching within the same area and the inter-array cable layout will be designed to avoid this. During the levelling phase, changes in seabed level are spatially restricted to within the cable corridors and are typically <0.03m.

217. The model results show the changes due to deposition of the finer-grained fraction during cable installation. However, there will also be a coarser fraction that is predicted to fall rapidly to the seabed (minutes or tens of minutes) as a highly turbid dynamic plume immediately after it is discharged. Given the sand-dominated nature of seabed sediments, this coarser material will be restricted to the area of disturbance and after deposition, this sediment will likely be transported as bedload by prevailing tidal currents and with time (less than a year), the seabed will return to previous levels.

218. The worst case assumes 100% of the cables will be buried. Where the Offshore Export Cable corridors cross areas of mobile bedforms, the cable will be installed in mobile sands, with no disturbance of the underlying geological units (see section 8.7.2). However, geotechnical surveys along the Offshore Export Cable corridor show high strength clays (till) may be present at seabed (Fugro, 2023b) and there is potential for these to be disturbed during cable installation. If cable installation disturbs the till, then a worst case scenario is considered whereby the sediment released from the jetting is assumed to be in the form of larger aggregated 'clasts' which would settle rapidly. These clasts would remain on the seabed (at least initially), rather than being disaggregated into individual fine-grained sediment components immediately upon release. The clasts would later be disaggregated through sediment transport processes within the limits of background physical processes.

8.7.3.8.2 Magnitude of Impact – DBS East or DBS West in Isolation

219. The scale of this impact will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out) as predicted by numerical modelling. Changes in seabed level beyond the cable corridors is of the order of millimetres and spatially restricted due to the relatively low content of fines within the seabed sediments. Furthermore, it is highly likely any changes any sediment deposited will be redistributed by background bedload transport processes. Therefore, the magnitude of impact for the worst case scenario due to cable installation is given in **Table 8-36**.

Table 8-36 Magnitude of Impact on Seabed Level Under the Worst Case Scenario Due to Cable Installation

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

8.7.3.8.3 Magnitude of Impact – DBS East and DBS West Together

220. If DBS East and DBS West are built together (concurrently or sequentially) the area and volume of seabed sediment disturbed by cable installation activities will be greater and occur over a longer period of time. However, as any changes will be short-lived with the seabed returning to baseline conditions, the worst case scenario for changes in seabed level due to cable installation will have the same magnitude of impact as outlined in **Table 8-36**.

8.7.3.8.4 Sensitivity of Receptor

221. The Construction Buffer Zone of the Offshore Export Cable Corridor overlaps the northern extent of the Holderness Inshore MCZ and the extreme southern extent of the Smithic Bank. Further offshore, the array and inter-platform cables are located on Dogger Bank. The sensitivity and value of these receptors is presented in **Table 8-37**.

Table 8-37 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration During Cable Installation

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Smithic Bank	High	High	Low	Negligible
Dogger Bank	High	High	Low	Negligible

8.7.3.8.5 Significance of Effect – DBS East or DBS West in Isolation

222. The effect on changes in seabed level due to deposition of suspended sediment during cable installation is considered to have negligible magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.3.8.6 Significance of Effect – DBS East and DBS West Together

223. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation as the changes are short-lived with a return to baseline conditions. Therefore, the significance of effect is the same as outlined in section 8.7.3.8.5 and considered likely to have a **negligible** significance of effect, due to a negligible magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.3.9 Changes to Bedload Sediment Transport Due to Cable Installation Activities at the Landfall

8.7.3.9.1 Description of Change

224. The Offshore Export Cable will be connected to the Onshore Export Cable using trenchless techniques below the cliffs. The worst case scenario is a ‘short trenchless’ option which would feature up to six exit pits on the beach in the intertidal zone at least 50m from the base of the cliffs. A full description of these activities is outlined in section 8.7.3.4.1.

225. The Applicants have committed to not installing cofferdams in the exit pits. Therefore, there will be no upstanding structures within the intertidal zone that could potentially interrupt sediment transport. The exit pits will be excavated up to 3m below ground level, potentially creating localised sediment sinks. Considering beach sediments are relatively thin along the Holderness coast, significant accumulations of sediment within the pits are not expected. The construction activities require the pits to remain open for up to four months. If sediment begins to accumulate in the pits, it will be excavated and returned to the beach where it can be transported alongshore to the south, as per the prevailing sediment transport regime.

226. Upon completion of trenchless duct installation and following export cable installation within the trench between the exit pits and MLWS, the trenches will be backfilled to reinstate the intertidal zone close to its original morphology. This activity would result in some localised and short-term disturbance of sediment on the beach, but there would be no long-term effect on sediment transport processes.

8.7.3.9.2 Magnitude of Impact – DBS East or DBS West in Isolation

227. The magnitude of impact for the worst case scenario due to cable installation at the landfall assumes the trenchless bore exit points are located in the intertidal zone at least 50m from the base of the cliffs and the cable will be trenched to MLWS with storage of the excavated trench material on the beach (**Table 8-38**). If the Projects are built in isolation, a maximum of three exits pits will be required during a single construction phase of 18 months, with each pit open for a period of up to four months. The impact on bedload sediment transport will be small and localised.

Table 8-38 DBS East and DBS West in Isolation Magnitude of Impact on Bedload Sediment Transport Under the Worst Case Scenario for Cable Installation at the Landfall

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

8.7.3.9.3 Magnitude of Impact – DBS East and DBS West Together

228. If DBS East and DBS West are built together (concurrently or sequentially) a maximum of six bore exit pits will be required, installed during a single phase that will not exceed 18 months. The duration of the construction phase will not increase but the footprint and volume of sediment disturbed will double when compared with the in isolation scenario. By increasing the number of exit pits, a greater length of cliff coastline will be affected potentially enhancing cliff erosion more than if DBS East and DBS West were built in isolation. Therefore, the scale and frequency of the impact will be greater if DBS East and DBS West are built together, as outlined in **Table 8-39**, but the magnitude of impact will remain as negligible.

Table 8-39 DBS East and DBS West Together Magnitude of Impact on Bedload Sediment Transport Under the Worst Case Scenario for Cable Installation at the Landfall

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

8.7.3.9.4 Sensitivity of Receptor

229. The landfall is located at the Holderness Cliffs and near the Withow Gap Skipsea SSSI. The value and sensitivity of these receptors is presented in **Table 8-40**.

Table 8-40 Sensitivity and Value of Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Cliffs	None	None	Low	High
Withow Gap Skipsea SSSI	None	None	High	High

8.7.3.9.5 Significance of Effect – DBS East or DBS West in Isolation

230. The excavation pits are at a suitable distance from the base of the cliffs to ensure coastal erosion is not enhanced (see section 8.7.3.9.5). Given the bore exit pits are located away from the toe of the cliffs, the magnitude of impact would be negligible but the sensitivity of the Holderness Cliffs and Withow Gap Skipsea SSSI would be high, resulting is a residual **minor adverse** significance of effect.

8.7.3.9.6 Significance of Effect – DBS East and DBS West Together

231. Construction of DBS East and DBS West together would result in a greater scale and frequency of impact but the magnitude of impact would remain the same as DBS East or DBS West in isolation as the potential increase in sediment yield due to cliff erosion would be small in comparison to, and difficult to distinguish from, background coastal erosion. The significance of effect on the Holderness Cliffs and Withow Gap Skipsea SSSI is considered likely to have a **minor adverse** significance of effect, due to a negligible magnitude of impact and high sensitivity.

8.7.3.10 Indentations on the Seabed Due to Installation Vessels

8.7.3.10.1 Description of Change

232. There is potential for certain vessels used during installation of the foundations and cable infrastructure to directly impact the seabed. This applies for those vessels that utilise jack-up legs or several anchors to hold station and to provide stability for a working platform. Where legs or anchors have been inserted into the seabed and then removed, there is potential for an indentation to remain, proportional to the dimensions of the object. The worst case scenario is considered to correspond to the use of jack-up vessels, since the depressions would be greater than the anchor scars.

233. As the leg is inserted, the seabed sediments would primarily be compressed vertically downwards and displaced laterally. This may cause the seabed around the inserted 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 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 10 year period (see **Appendix 8-2 Met Mast Survey Analysis (application ref: 7.8.8.2)**).

234. A four-legged jack-up barge used for the installation of wind turbine and offshore platforms would have a footprint of 1,100m^2. Each leg could penetrate 5 to 15m into the seabed and may be cylindrical, triangular, truss leg or lattice. The worst case scenario assumes six jack-up deployments will be required at each wind turbine and five at each offshore platform location (**Table 8-1**).

8.7.3.10.2 Magnitude of Impact – DBS East or DBS West in Isolation

235. If DBS East or DBS West is constructed in isolation, the worst case total footprint from jack-up installations will be 687,500m^2, due to the installation of 100 small turbines and five offshore platforms. The worst case changes in terms of indentations on the seabed due to installation vessels are likely to have the magnitudes of impact described in **Table 8-41**.

Table 8-41 Magnitude of Impact on Seabed Level Changes due to Indentions Under the Worst Case Scenario for Installation Vessels

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

*The near-field impacts are confined to the immediate vicinity of a jack-up leg, far-field effects are beyond the immediate vicinity of the jack-up leg

8.7.3.10.3 Magnitude of Impact – DBS East and DBS West Together

236. The worst case scenario in terms of indentations on the seabed due to installation vessels if DBS East and DBS West are constructed concurrently or sequentially will be 1,369,500m^2 due to the installation of 200 small turbines and nine offshore platforms. While a larger area will be affected, the worst case will have the same magnitude of impact as outlined in **Table 8-41**.

8.7.3.10.4 Sensitivity of Receptor

237. Installation of foundations within the DBS Array Areas will result in jack-up and anchor indentations on Dogger Bank. There is the potential cable that protection measures will be required in the nearshore which could require use of jack-up installation vessels within the Holderness Inshore MCZ and the construction buffer where it overlaps Smithic Bank. However, a commitment has been made to not deploy jack-up legs within the Holderness Inshore MCZ, or on Smithic Bank. Given this, the sensitivity and value of these receptors potentially affected by installation vessel is presented in **Table 8-42**.

Table 8-42 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Smithic Bank	High	High	Low	Negligible
Dogger Bank	High	High	Low	Negligible

8.7.3.10.5 Significance of Effect – DBS East or DBS West in Isolation

238. The layout of wind turbines and offshore platforms, and array, inter-platform and Offshore Export Cables 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 months. Therefore, the effect on seabed morphology is considered to have a low magnitude of impact and negligible sensitivity, resulting in a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.3.10.6 Significance of Effect – DBS East and DBS West Together

239. The magnitude of impact if DBS East and DBS West are built concurrently or sequentially is low and sensitivity of receptors is negligible. Therefore, the significance of effect is the same as outlined in section 8.7.3.10.5 and considered likely to have a **negligible** significance of effect. No additional mitigation is proposed.

8.7.4 Potential Effects During Operation

240. Note that the modelling used in this section includes gravity based foundations for the offshore platforms in the Array Areas as this was the worst case scenario when the modelling was undertaken. A commitment has now been made that the Projects will not use gravity based foundations within the Array Areas. Large (15m diameter) monopile foundations are now the worst case for offshore platforms in the Array Areas. Large monopile turbines have a much smaller blockage effect in the water column (see **Table 8-1**). As gravity based foundations represented the worst case, the actual impact will be less than the model predictions for offshore platforms and no worse than the model predictions for wind turbines (which are also large 15m diameter monopiles).

8.7.4.1 Changes to the Tidal Regime Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.4.1.1 Description of Change

241. During the operation of DBS East and DBS West there is potential for the presence of foundations to cause changes to the tidal regime, particularly tidal currents, due to physical blockage effects. The presence of foundations on the water column present an obstacle to the passage of currents locally, causing a small modification to the height and / or phase of the water levels and a wake in the current flow. The wake is caused by a deceleration of flow immediately upstream and downstream of each foundation and an acceleration of flow around the sides of each foundation. Current speeds progressively return to baseline conditions with increasing distance from each foundation, depending on the foundations size and underwater geometry, and the prevailing tidal regime. Depending on the spacing of foundations, there may be potential for individual foundation wakes to overlap.

242. Numerical modelling of changes in hydrodynamic regime due to the worst case foundation type, size, number and layout in the DBS East and DBS West Array Areas was undertaken to provide an evidence base to assess the effects of infrastructure on the tidal regime (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The maximum number of turbines (200 across both Projects and largest (15m diameter) monopile foundations, spaced at a minimum distance of 830m were considered the worst case for wind turbine foundations. Gravity based foundations with a base diameter of 65m were incorporated to represent offshore platforms, including one offshore platform within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea (**Plate 8-23**).

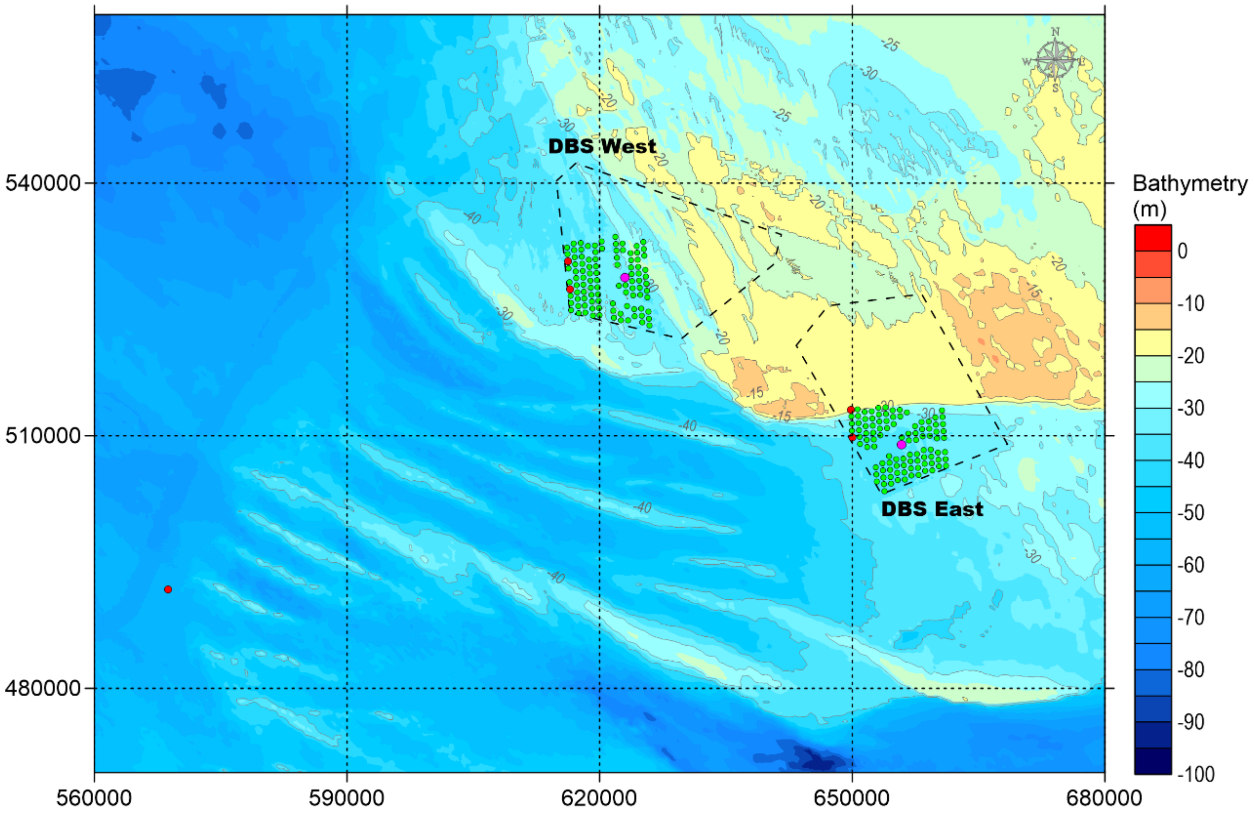

Plate 8-23 Worst case scenario layout for changes in tidal regime due to the presence of infrastructure. Red dots: offshore platform foundations (65m diameter GBS); purple dot: two offshore platform foundations positioned next to each other (65m diameter GBS); green dots: wind turbine foundations (15m diameter monopile)

243. The model results show that the greatest change in tidal current speed occurs during peak flood spring tide conditions (**Plate 8-24**). At a worst-case spacing of 830m, the effects from individual foundations cannot be distinguished suggesting there are overlapping wake effects that cumulatively increase tidal current speeds to the north of DBS East and north and east of DBS West, and increase current speeds to the south and west of DBS East and west of DBS West, during a peak spring flood tide. This pattern is reversed during the peak spring ebb tide as tidal current direction is reversed. The residual changes to tidal current speed over a 30 day simulation period results in a shadow effect (lower current speeds) within and adjacent to the southwestern part of the Array Areas and an increase in currents to the northeast.

244. The maximum change in current speeds is ±0.02m/s and this occurs locally during a spring tide within a kilometre of the offshore platform foundations. Changes in current speed due to wind turbines are lower at <±0.01m/s but can extend up to 8km from the foundation locations.

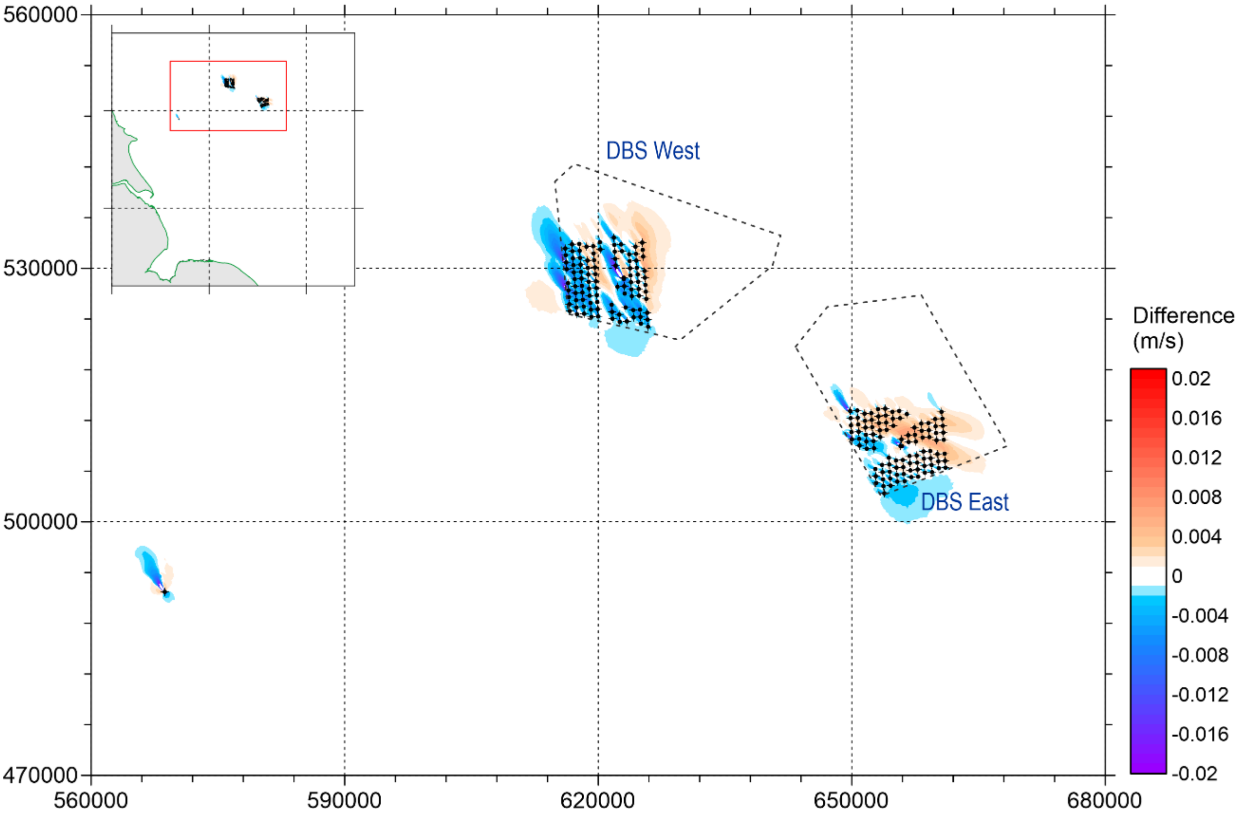

Plate 8-24 Change in peak spring flood tide current speed due to worst case scenario for changes in tidal regime due to the presence of infrastructure

245. The maximum predicted changes in current speed due to the presence of platforms within DBS East and DBS west are approximately 4-6% of the baseline regime, and the platform located within the Offshore Export Cable Corridor produces localised changes up to 3.3% that do not extend to the coast. The changes in current speed from wind turbine foundations are lower at approximately 2-6%.

246. The model results are comparable to modelling undertaken to support the EIA for the entire developable area of the Dogger Bank A & B, Dogger Bank C and Sofia offshore wind farms. The results showed that the maximum change to depth-averaged current velocity was predicted to be ±0.03m/s which is approximately 7% of baseline conditions, reducing to 2% within a couple of kilometres of the Array Areas. These changes were not considered significant in EIA terms.

247. Building on the results from the hydrodynamic modelling undertaken to support this assessment, there is a pre-existing scientific evidence base which demonstrates that changes in the tidal regime due to the presence of foundation structures are both small in magnitude and localised in spatial extent. This is confirmed by existing guidance documents (ETSU, 2000; 2002; Lambkin *et al.* 2009) and numerous ESs for a range of existing and planned offshore windfarms.

8.7.4.1.2 Magnitude of Impact – DBS East or DBS West in Isolation

248. The modelled worst case for changes to tidal currents due to the presence of 100 small monopile wind turbine and five gravity based offshore platform foundations (four in the Array Area and one within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea[2]) will likely have the magnitude of impact as shown in **Table 8-43**. The effects on the tidal regime can be translated into a ‘zone of potential influence’ based on the results of the hydrodynamic modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) 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 regime are relatively small in magnitude, and localised. Far-field effects are smaller in magnitude but cover greater distances.

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[2] Modelling undertaken to inform this assessment assumed a total of five platforms may be present in an in-isolation scenario, comprising four platforms in the Array Areas and one in the Offshore Export Cable Corridor. However only four platforms may be found across both the Array Areas and the Offshore Export Cable Corridor. Five platforms were modelled to ensure all potential locations of platforms were modelled so that a definite worst case scenario was assessed.

Table 8-43 Magnitude of Impact on the Tidal Regime Under the Worst Case Scenario for Foundations

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

*The near-field impacts are confined to a small area, up to a kilometre from each foundation location.

8.7.4.1.3 Magnitude of Impact – DBS East and DBS West Together

249. If DBS East and DBS West are built together (concurrently or sequentially), there will be a greater number of structures present to block tidal flow and potentially change tidal currents. Results from numerical modelling show there are no overlapping effects between the DBS East and DBS West Array Areas (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). Therefore, the scale of changes to current speed and zone of potential influence is the same as if the projects are built in isolation and the worst case scenario for changes in tidal currents due to the presence of foundations will have the same magnitude of impact as outlined in **Table 8-43**.

8.7.4.1.4 Sensitivity of Receptor

250. The predicted zone of potential influence for changes to tidal currents includes Dogger Bank. The sensitivity and value of this receptor is presented in **Table 8-44.**

Table 8-44 Sensitivity and Value Assessment for Morphological Receptor

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

8.7.4.1.5 *Significance of Effect – DBS East or DBS West in Isolation*

251. The predicted zone of influence encompasses Dogger Bank. However, as outlined in section 8.7.4.1.1, changes to the tidal currents due to the presence of foundations on the seabed will be small. Considering the negligible to low magnitude of impact and the negligible sensitivity, the significance of the effect is considered likely to have a **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.1.6 *Significance of Effect – DBS East and DBS West Together*

252. Development of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation as the changes to tidal regime will remain small, despite the increase in the number of structures. Therefore, the significance of the effect is the same as outlined in section 8.7.4.1.5 and considered likely to have a **negligible** significance of effect due to the negligible to low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.2 Changes to the Wave Regime Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.4.2.1 *Description of Change*

253. The presence of the worst case wind turbine and offshore platform foundation structures (as outlined in **Table 8-1**) has the potential to alter the baseline wave regime, particularly in respect of wave heights and directions. The presence of foundations in the water column would present an obstacle to the passage of waves locally, causing a small modification to the height and / or direction of the waves as they pass. Generally, this causes a small wave shadow effect locally and wave heights return to baseline conditions with increasing distance from the foundation. Depending on the spacing of foundations, there may be potential for individual foundation wave shadows to overlap.

254. Numerical modelling of changes in wave regime due to the worst case foundation type, size, number and layout in the DBS East and DBS West Array Areas was undertaken to provide an evidence base to assess the effects of infrastructure on the wave regime (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The maximum number of turbines (200 across both Projects and largest (15m diameter) monopile foundations, spaced at a minimum distance of 830m were considered the worst case for wind turbine foundations. Gravity-base solution foundations with a base diameter of 65m were incorporated to represent the worst case for offshore platforms, including one offshore platform within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea (**Plate 8-23**).

255. Two wave direction were modelled; waves approaching from the north (345 to 15 degrees) to represent the most frequent and the largest waves and waves from the east (75 to 105 degrees) to understand potential effects on coastal receptors. For each of these directions, three return periods were modelled; a 1 in 100 year event was selected to represent extreme conditions, a 1 in 1 year event to represent the largest storm in a year and typical daily conditions were modelled using the 50th percentile.

256. The model results show that wave heights are reduced locally due to the presence of infrastructure. For waves approaching from the north, a wave shadow forms to the south of the Array Areas and for waves from the east, the shadow forms to the west.

257. The area affected (zone of influence) is smallest under the 50th percentile scenario, with a 0.01 to 0.02m reduction in wave height (0.5-1% of baseline conditions) extending an average 13km south of the Array Areas when waves approach from the north and 30km west when waves approach from the east.

258. The zone of influence is greater under the 1 in 1 year return period scenario when compared to the 1 in 100 year return period scenario due to the 1 in 100 year event having a longer wave period which reduces the energy lost through diffraction as the wave passes by the structure. During a 1 in 1 year event, changes of 0.01 to 0.02m (<1% of baseline conditions) occur within a zone of influence that extends 56km south and west of the Array Areas. Changes in wave height of between 0.04 and 0.06m (<1.5% of baseline conditions) occur over a much smaller area extending up to 7km south and west, depending on the prevailing wave direction.

259. During an extreme event, represented by a 1 in 100 year return period, the zone of influence extends up to 30km to the south and west but changes within this zone are very small at 0.01 to 0.02m (<0.5% of baseline conditions). The area affected by larger changes up to 0.06m (<1% of baseline conditions) is within 7km of the Array Areas.

260. For all scenarios, the greatest change in wave height is a reduction of up to 0.7m but this occurs immediately adjacent (<100m) to the offshore platforms which as a worst case scenario creates a blockage effect over an area with a diameter of 65 m.

261. The offshore platform located within the Offshore Export Cable Corridor is the closest structure to the coast but with a zone of influence of 5km south and 7km west, coastal and nearshore receptors are not affected by the changes in wave regime.

262. When compared to modelling undertaken to support the EIA for the entire developable area of the Dogger Bank A & B, Dogger Bank C and Sofia offshore wind farms, the results showed that the changes to significant wave height were lower than previously predicted due to the smaller number and size of structures within the design envelope for the DBS Projects.

263. In addition to the modelling undertaken to support this assessment, there is a strong evidence base which demonstrates that the changes in the wave regime due to the presence of foundation structures, even under a worst case scenario, are relatively small in magnitude (typically less than 10% of baseline wave heights in close proximity to each structure, reducing with greater distance from each structure). Effects are relatively localised in spatial extent, extending as a shadow zone typically up to 10km from the site along the axis of wave approach, but with low magnitudes (only a few percent change across this wider area). This is confirmed by a review of modelling studies from around 30 wind farms in the UK and European waters (Seagreen, 2012), existing guidance documents (ETSU, 2000; ETSU, 2002; Lambkin *et al.*, 2009), published research (Ohl *et al.*, 2001) and post-installation monitoring (Cefas, 2005).

8.7.4.2.2 Magnitude of Impact – DBS East or DBS West in Isolation

264. The modelled worst case for changes to the wave regime due to the presence of 100 small monopile wind turbine and five gravity based offshore platform foundations are likely to have the following magnitude of impact (**Table 8-45**). The effects on the wave regime can be translated into a 'zone of potential influence' based on the results of the spectral wave modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) The zone of potential influence is based on the knowledge that near-field effects arising from wind turbine and offshore platform foundations on the wave regime are small in magnitude and highly localised. Far-field effects are much smaller in magnitude but cover greater distances.

Table 8-45 Magnitude of Impact on the Wave Regime Under the Worst Case Scenario for Foundations

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.

8.7.4.2.3 Magnitude of Impact – DBS East and DBS West Together

265. If DBS East and DBS West are built together (concurrently or sequentially), there will be a greater number of structures present to block tidal flow and potentially change wave regime. Results from numerical modelling show there are no overlapping effects under 50th percentile and 1 in 100 year return period wave conditions between the DBS East and DBS West Array Areas (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). During a 1 in 1 year event, there is potential for the zone of influence from each individual array area to overlap, but there is no change in extent or magnitude and changes in significant wave height remain small (reduction of 0.01 to 0.02m). Therefore, the scale and zone of potential influence is the same as if the projects are built in isolation. Therefore, the worst case scenario for changes to wave regime to the presence of foundations will have the same magnitude of impact as outlined in **Table 8-45**.

8.7.4.2.4 Sensitivity of Receptor

266. The predicted zone of influence for the Array Areas includes Dogger Bank. Given this, the sensitivity and value of this receptor is presented in **Table 8-46.**

Table 8-46 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible

8.7.4.2.5 Significance of Effect – DBS East or DBS West in Isolation

267. The predicted zone of influence encompasses Dogger Bank. However, as outlined in section 8.7.4.2.1, changes to the wave regime due to the presence of foundations in the water column will be small. Considering the negligible to low magnitude of impact and the negligible sensitivity, the significance of the effect is considered to have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.2.6 Significance of Effect – DBS East and DBS West Together

268. Construction of DBS East and DBS West together (concurrently or sequentially) would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.2.5 and considered to have a likely **negligible** significance of effect due to the negligible to low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.3 Changes to Water Circulation (Flamborough Front) Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.4.3.1 Description of Change

269. The main potential impact on the Flamborough Front is changes to near-field mixing due to foundation wake effects and the potential for destabilising local water column stratification (i.e. those restricted to the area inside and immediately outside the Array Areas) driven by interaction of the tidal (hydrodynamic) processes with the foundation units across the offshore array. There would be a (slight) difference between the potential disturbance of the front if it crossed into the Array Areas.

270. The worst case for foundations would be monopile foundations for wind turbines and offshore platforms within the Array Areas. These foundations are considered to have the greatest blockage effect and hence could create the greatest amount of turbulence.

271. A number of studies have investigated the potential large-scale impacts of wind farm turbine foundations on shelf sea stratification. These studies have been used, alongside the outputs from marine physical processes numerical modelling undertaken for the Projects, to provide the evidence base for this assessment.

272. Carpenter *et al.* (2016) used an idealised (conceptual) numerical model of structure induced turbulent mixing in conjunction with existing environmental hindcast data to consider the potential for large-scale change to stratification of the German Bight region of the North Sea in response to planned wind farm developments. The study showed that stratification is only gradually broken down by interaction with the wind farm. A range of 'timescale for (complete) mixing' estimates were provided (about 100 to 500 days) if the same body of initially stratified water is continually passed through the wind farm. In practice, due to non-zero residual rates of tidal advection, the same body of water will not be repeatedly passed through the same wind farm for 100 to 500 days. As a result, the mixing influence of the foundations will only lead to some partial reduction in the strength of stratification in water that passes through the wind farm. Furthermore, modelling undertaken by van Leeuwen *et al.*, (2015) suggest waters within the Array Areas are well mixed for most of the year and with stratification occurring <40 days a year (intermittently stratified). Therefore, any potential changes to water column stratification will be temporally restricted.

273. Any increased turbulence resulting from the presence of the Projects foundation structures would be isolated to the local area of each foundation, dissipating downstream without leading to any larger array-scale effects. All foundations will lead to some level of local turbulence and depending on the final design configuration of the foundations, the gravity based foundation cross-section through the water column has the potential to lead to the highest level of turbulence compared to other foundation options. However, the Projects commitment to not installing gravity-based foundations in the Array Areas means a gravity based foundation may only be used for a single offshore platform, potentially located in the Offshore Export Cable Corridor, if a platform is located here. In that scenario the scale of turbulence is considered to remain localised.

274. The worst case for wind turbine foundations is monopiles which has a lesser blockage effect but they will be greater in number, up to 200 if DBS East and DBE West is built concurrently or sequentially. The measurable distance of any wake can be estimated by the extent of changes in tidal currents which has been simulated (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)** for full details). Outputs from hydrodynamic modelling show the area affected by foundation wake effects from an individual turbine is 1km (aligned with the tidal excursion ellipse) and that even with a worst case spacing of 830m, there are no overlapping effects between turbines. Therefore, any potential changes to water column stratification would be spatially restricted. These effects will remain small compared to the Flamborough feature in its entirety. The magnitude of any impact on the Flamborough Front is considered to be negligible because the influence from any turbulent flow wakes is likely to remain spatially distant.

275. Cazenave *et al.* (2016) used a regional scale 3D hydrodynamic model with a number of wind farm foundations represented as small islands in the mesh. The results showed that although wind farm foundations have some limited influence on the strength of stratification locally, it does not suggest that naturally present stratification would become completely mixed by this process.

276. Schultze *et al.* (2020) used observations and high-resolution large eddy simulations to quantify the loss of stratification within the wake of a single monopile structure within four different water body stratification strengths. Their observations showed that the turbulent wake of a monopile structure is narrow and highly energetic within the first 100m, with the dissipation of turbulence above background levels reducing downstream of the structure. The effect of a single turbine on stratification is relatively low compared to other naturally occurring mixing mechanisms, but the effect depends on the strength of the stratification, with more impact on weakly stratified water column. Turbulent mixing is not sufficient to overcome stronger stratification, as the buoyancy of the surface layer retains a stronger influence than the increased turbulent mixing induced by the structure. Also, although the wake can persist for a long distance downstream of the structure (several 100s of metres), the energy dissipation of the wake falls rapidly away from the structure until it becomes fully dissipated/undetectable.

277. As previously described, modelling (**see Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) has shown that foundation wake effects are highly localised and interactions between turbines will not occur. This is supported by the work of Cazenave et al. (2016) and Schultze et al. (2020). Further modelling by van Leeuwen et al., (2015) show the waters within the Array Areas are normally well mixed, with stratification being limited to a few weeks, so any effect would be temporally limited even if it did occur. Therefore, given these limited physical effects, it is unlikely that there is any pathway for significant effects on primary productivity. Effects on primary productivity are therefore not considered further.

8.7.4.3.2 Magnitude of Impact – DBS East or DBS West in Isolation

278. If DBS East or DBS West is constructed in isolation, the worst case number of foundations would be small (11m diameter) monopiles for 100 small wind turbines and large monopiles (15m diameter) for five offshore platforms (four in the Array Area and one within the Offshore Export Cable Corridor approximately 62km from the coastline at Skipsea[3]). The worst case for changes to water circulation due to the presence of foundations are likely to have the following magnitude of impact (**Table 8-47**).

Table 8-47 Magnitude of Impact on Water Circulation Under the Worst Case Scenario for Foundations

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

**The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.*

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[3] Note difference in real-world / modelled platform number as stated in **Table 8-1**.

8.7.4.3.3 Magnitude of Impact – DBS East and DBS West Together

279. If DBS East and DBS West is constructed concurrently or sequentially, the worst case would be small (11m diameter) monopiles for 200 small wind turbines and large monopiles (15m diameter) for nine offshore platforms. Although the number of foundations will be greater, the worst case separation distance will remain 830m. Therefore, the worst case scenario for changes to water circulation due to the presence of foundations will have the same magnitude of impact as outlined in section **Table 8-47**.

8.7.4.3.4 Sensitivity of Receptor

280. The Flamborough Front may be present seasonally within the Array Areas and Offshore Export Cable Corridor. Given this, the sensitivity and value of this receptor is presented in **Table 8-48.**

Table 8-48 Sensitivity and Value Assessment for Morphological Receptor

Receptor	Tolerance	Recoverability	Value	Sensitivity
Flamborough Front	High	High	Medium	Negligible

8.7.4.3.5 Significance of Effect – DBS East or DBS West in Isolation

281. Given that the Flamborough Front is highly dynamic and ephemeral regional-scale feature, that may be present in the region of the Array Areas <40 days a year, 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. As a result, changes to water circulation due to the presence of foundations on the seabed will be small. Considering the negligible to low magnitude of impact and the negligible sensitivity, the likely significance of effect is considered to be **negligible**. No additional mitigation is proposed.

8.7.4.3.6 Significance of Effect – DBS East and DBS West Together

282. Construction of DBS East and DBS West together will have a negligible to low magnitude of impact and a negligible sensitivity, and will therefore have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.4 Changes to Bedload Sediment Transport and Seabed Morphology Due to the Presence of Infrastructure (Wind Turbines and Offshore Platforms)

8.7.4.4.1 Description of Change

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

284. Changes in tidal regime are greater when compared to changes in wave regimes, as assessed in sections 8.7.4.1and 8.7.4.2. Furthermore, considering the water depths across the array areas are between 12 and 40m, small, centimetre-scale changes in significant wave height are unlikely to have an effect on bedload sediment. Therefore, changes to tidal regime are likely to be the main driver of any changes in bedload sediment transport and as a result, seabed morphology.

285. As part of the hydrodynamic modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**), changes in bed shear stress due to the presence of wind turbine and offshore platform foundations were predicted. The change in bed shear stress over a 30 day simulation period is shown in **Plate 8-25**. Within the Array Areas, the greatest changes in bed shear stress occur in close proximity to individual foundations and the maximum amount of change is associated with the offshore platforms. Over multiple tidal cycles, the residual effect is an overall reduction in bed shear stress to the south of the Array Areas covering an area up to 10km from the southern boundaries. To the northeast of both Array Areas, there is an increase in bed shear stress within 10km of the array boundaries and to the southwest, a slight increase in bed shear stress is predicted to occur within 5km of the array boundaries. Any changes in bed shear stress beyond the Array Areas are typically less than ±0.005N/m^2. Where platforms are located along the boundary of the Array Areas, the changes are up to ±0.02N/m^2.

286. In areas where bed shear stress is lower, in principle, this would result in a reduction in sediment transport potential with larger grains becoming less mobile, potentially limiting the supply of sediment to nearby areas. Conversely, an increase in bed shear stress could results in higher rate of sediment mobilisation and transport potential. However, changes in bed shear stress of up to 0.02N/m^2 are very small at <3% of the baseline, and any changes of this order of magnitude would not change the grain size fractions that could be mobilised, allowing sand, the dominant sediment type, to be transported within and out of the Array Areas.

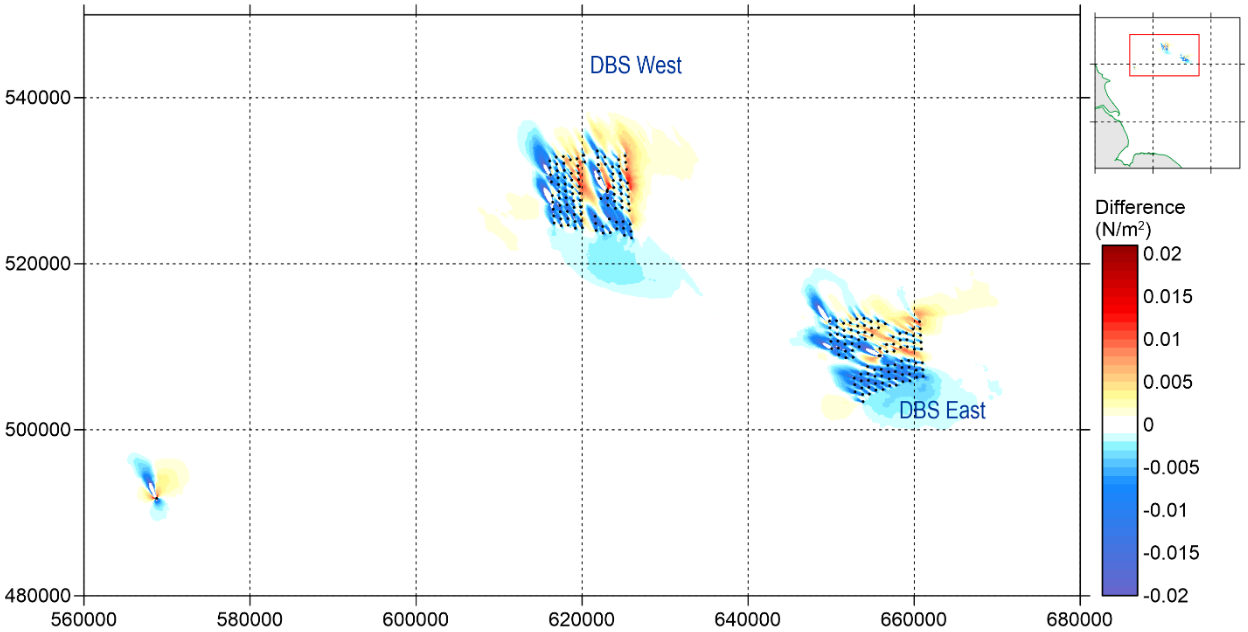

Plate 8-25 Change in bed shear stress due to the presence of wind turbine and offshore platform foundations

287. The modelling results are supported by observational evidence. Post-construction monitoring of the Dudgeon Offshore Windfarm demonstrated that changes to seabed sediment distribution due to the presence of wind turbines are minimal, implying that changes to tidal currents (and waves) are local and do not have a significant effect on sediment transport further afield.

8.7.4.4.2 Magnitude of Impact – DBS East or DBS West in Isolation

288. If DBS East and DBS West are built in isolation, the worst case for changes to bedload sediment transport regime and seabed morphology due to the presence of 100 small monopile wind turbine and five gravity based offshore platform foundations are likely to have the following magnitude of impact (**Table 8-49**). The effects on bedload transported can be translated into a 'zone of potential influence' based on the results of the hydrodynamic modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). 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 regime 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.

Table 8-49 Magnitude of Impact on Bedload Sediment Transport Regime and Seabed Morphology Under the Worst Case Scenario for Foundations

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from each foundation location.

8.7.4.4.3 Magnitude of Impact – DBS East and DBS West Together

289. If DBS East and DBS West are built together (concurrently or sequentially), there would be a greater number of structures present (200 small monopile wind turbine and nine gravity based offshore platform foundations) to block tidal flow and waves, and potentially change bed shear stress and associated sediment transport potential and seabed morphology. Results from numerical modelling show there are no overlapping effects between the DBS East and DBS West Array Areas (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). Therefore, the scale of changes to current speed and zone of potential influence is the same as if the projects are built in isolation and the worst case scenario for changes in bedload sediment transport regime and seabed morphology due to the presence of foundations will have the same magnitude of impact as outlined in **Table 8-49**.

8.7.4.4.4 Sensitivity of Receptor

290. The predicted zone of influence for the Array Areas includes Dogger Bank. The sensitivity and value of this receptor is presented in **Table 8-50.**

Table 8-50 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible

8.7.4.4.5 Significance of Effect – DBS East or DBS West in Isolation

291. The predicted zone of influence encompasses Dogger Bank. However, as outlined in section 8.7.4.2.1, changes to bedload sediment transport due to the presence of foundations on the seabed will be small. Considering the negligible to low magnitude of impact and negligible sensitivity, the significance of the effect is considered to be **negligible**. No additional mitigation is proposed.

8.7.4.4.6 Significance of Effect – DBS East and DBS West Together

292. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.4.5 and considered to have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.5 Changes to Bedload Sediment Transport and Seabed Morphology Due to the Presence of Cable Protection Measures

8.7.4.5.1 Description of Change

293. As a worst-case scenario, cable protection measures would need to be installed to protect any shallow or surface-laid cables. There is potential that burial of the export cables would not practicably be achievable within the nearshore (subtidal) part of the offshore cable corridor from the mean low water spring tide mark (130m from the base of the cliffs) to water depths less than 10m due to the presence of chalk bedrock in the shallow subsurface (**Volume 7, Figure 8-3 (application ref: 7.8.1)**). Cable protection measures may take the form of rock armour, concrete mattresses, steel bridging / ducting, Cable Protection System (CPS) ducting / articulated pipe (cast iron or plastic), concrete bridging and / or rock bags.

294. Cable protection may also be required in other areas of the Offshore Export Cable Corridor, Array Areas and Inter Platform Cable Corridor. Furthermore, cable protection would be required at cable / pipeline crossings or in areas where bedrock is exposed at seabed. The location of known cable / pipeline crossings along the Offshore Export Cable Corridor is shown in **Volume 7**, **Figure 8-13 (application ref: 7.8.1)**[4] and it is those that are in shallow water that would have the greatest effect as their height above the seabed (worst case scenario of 1.4m) would occupy a relatively larger proportion of the water column and increasing the blockage effect (**Table 8-1**).

295. Interpretation of the nearshore geophysical data has provided an estimate of the anticipated amount of cable protection required in the nearshore subtidal area, approaching the Holderness coast. The data indicates that burial or trenching will be achievable for 90% of the route from the mean low water spring tide level out to the 10m depth contour (approximately 1,050m from mean low water spring). In addition, the Applicants have committed to no cable protection in the intertidal zone and from mean low water spring tide to 350m seaward of this tidal datum (included in the 90% above). At the landfall, the mean low spring tide line is about 130m seaward of the cliffs. This means that from the cliffs to approximately 480m seaward (across the intertidal zone and shallow subtidal zone), the cables will be buried and have no effect on coastal processes.

296. The effects that export cable protection may have on the marine physical environment 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 in the nearshore and along the coast during the operational phase. Depending on their water depth relative to the prevailing wave and tide regime, any measures in areas closest to the coast have the potential to affect alongshore sediment transport processes and circulatory pathways across any nearshore banks such as the Smithic Bank.

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[4] Potential crossing locations within the Array Areas are not yet known due to array cable and inter platform cable layouts not yet being finalised.

297. 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). For the seabed offshore from the landfall, this would typically be in around 6m of water based on the average significant wave heights recorded by the Hornsea buoy. This is approximately 860m from the base of the cliffs.

298. The magnitude of wave driven transport would decrease with distance offshore within the closure depth, 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 profile gradients at the landfall and Easington (East Riding of Yorkshire Council, 2014) 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.

299. The evidence using the closure depth and analogous calculations at Easington shows that there will no interruption of wave-driven alongshore sediment supply to the beaches south of the landfall and to Spurn Head. This is because any export cables across the most active zone of wave-driven sediment transport will be buried (with the Applicants having committed to burial from the base of the cliffs to 480m offshore) and will have no effect on sedimentary processes.

300. Further offshore, where the seabed is composed of mobile sand, it can be transported under existing tidal conditions. If the protection does present an obstruction to this bedload transport the sediment would first accumulate on 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 1.4m). 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 affected significantly.

301. The presence of cable protection works on the seabed would represent the worst case in terms of a direct loss of seabed area, but this footprint would be lower than that of the wind turbine foundations (and associated scour protection works) within the Array Areas (**Table 8-1**).

302. The most important marine geological and geomorphological features present in the nearshore and at the landfall are those associated with the Holderness Inshore MCZ. The beach and nearshore zone are covered by a relatively thin cover of potentially mobile sediment and Pleistocene till is typically exposed at seabed. This means bedload sediment transport rates are low.

8.7.4.5.2 Magnitude of Impact – DBS East or DBS West in Isolation

303. If DBS East and DBS West are built in isolation, the worst case changes to bedload sediment transport and seabed morphology due to cable protection measures are likely to have the following magnitudes of effect (**Table 8-51**).

Table 8-51 Magnitude of Impact on Bedload Transport and Seabed Morphology Under the Worst Case Scenario Due to Cable Protection Measures

Location	Scale	Duration	Frequency	Reversibility	Magnitude of Impact
Inshore of closure depth	Negligible	High	High	Negligible	Negligible
Offshore of closure depth	Negligible	High	High	Negligible	Negligible

8.7.4.5.3 Magnitude of Impact – DBS East and DBS West Together

304. If DBS East and DBS West are built together (concurrently or sequentially), the number of cables will double when compared to the in isolation scenario and as a result, a greater number of cable / pipeline crossings will be required but there is no change in the location of the crossings (see **Table 8-1**). At each crossing, the cables will be separated from one another by 100m, but as the base of the protruding part of the cable protection measures are 15m in width, there will be a space of up to 70m available between each cable which will create uninterrupted pathways for sediment transport. Therefore, the worst case scenario for changes in bedload sediment transport and seabed morphology due to the presence of cable protection measures will have the same magnitude of impact as outlined in **Table 8-51**.

8.7.4.5.4 Sensitivity of Receptor

305. 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. The value and sensitivity of these receptors is presented in **Table 8-52**.

Table 8-52 Sensitivity and Value of Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Smithic Bank	Medium	High	Medium	Low
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Dogger Bank	High	High	High	Negligible

8.7.4.5.5 Significance of Effect – DBS East or DBS West in Isolation

306. Offshore of the closure depth, the effects on wave-driven bedload sediment transport and seabed morphology arising from the presence of export cable protection measures would not extend far beyond the direct footprint. Here, any changes in sediment transport will largely be driven by tidal currents. Receptors located offshore of the closure depth include Dogger Bank and parts of Smithic Bank and the geological features of the Holderness Inshore MCZ. Considering the negligible magnitude of impact and negligible sensitivity of these receptors to changes in bedload sediment transport due to the presence of cable protection measures, the effects offshore of the closure depth are likely to be of **negligible** significance of effect. No additional mitigation is proposed.

307. There is potential for the cable protection measures to affect net sediment transport direction in the nearshore which would potentially effect parts of Smithic Bank and the geological features of the Holderness Inshore MCZ. If cable protection does present an obstruction to bedload transport, then a continued build up would form a 'ramp' over which sediment transport would occur by bedload processes, thereby bypassing the protection. The gross patterns of bedload transport across the export cable would therefore not be affected significantly. Considering the negligible magnitude of impact inshore of the closure depth and the low sensitivity of Smithic Bank as a receptor, the significance of effect will be **negligible**. No additional mitigation is proposed.

8.7.4.5.6 Significance of Effect – DBS East and DBS West Together

308. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.6.5 and considered to have a likely **negligible** significance of effect due to the negligible to low magnitude of impact and the negligible to low sensitivity. No additional mitigation is proposed.

8.7.4.6 Cable Repairs and Reburial

8.7.4.6.1 Description of Change

309. Cable repairs and reburial could be needed over the operational lifetime of the Projects. The disturbance areas for reburial and repairs of cables are extremely small in comparison to construction.

310. There is potential for temporary physical disturbance to impact on marine waters (both inshore and offshore) and the geological features of the Holderness Inshore MCZ due to Offshore Export Cable maintenance and repair operations. Any repairs to array and Inter-Platform Cables would occur on Dogger Bank. The worst case maximum disturbance area for cable repair assumes 25% amounting to a total area of 1,354,662m^2 if DBS East and DBS West are constructed together. 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 will be considerably lower.

311. As with changes to seabed level due to array, inter-platform and Offshore Export Cable installation (section 8.7.3.8), the scale of this impact will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). While fine sediments have greater potential to become mobilised, the potential for encountering them during cable installation is low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution.

8.7.4.6.2 Magnitude of Impact – DBS East or DBS West in Isolation

312. The magnitude of impact for the worst case scenario due to the repair and reburial of the cables is based on the assumption that up to 25% of the total cable length may require maintenance, as presented in **Table 8-53**.

Table 8-53 Magnitude of Impact Under the Worst Case Scenario Due to Repair and Reburial of Cables

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

*The near-field impacts are confined to a small area, likely to be up to a kilometre from the cable installation activity.

8.7.4.6.3 Magnitude of Impact – DBS East and DBS West Together

313. The worst case scenario for due to repair and reburial of cables will have the same magnitude of impact as outlined in section 8.7.4.6.2.

8.7.4.6.4 Sensitivity of Receptor

314. The Offshore Export Cable Corridor is located within marine waters (both offshore and inshore) and specifically within the Holderness Inshore MCZ and crosses the southern tip of Smithic Bank. Offshore, the Array Areas and Inter-Platform Cable Corridor are located on Dogger Bank. The sensitivity and value of these receptors are presented in **Table 8-54**.

Table 8-54 Sensitivity and value assessment for morphological receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Smithic Bank	High	High	Low	Negligible
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible
Dogger Bank	High	High	High	Negligible

8.7.4.6.5 Significance of Effect – DBS East or DBS West in Isolation

315. The effect on marine waters (inshore and offshore), the geological features of the Holderness Inshore MCZ, Smithic Bank and Dogger Bank due to changes in suspended sediment is considered to have a likely **negligible** significance of effect due to the negligible magnitude of impact and negligible to low sensitivity. No additional mitigation is proposed.

8.7.4.6.6 Significance of Effect – DBS East and DBS West Together

316. Cable repairs across DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.6.5 and considered to have a likely **negligible** significance of effect, due to the negligible magnitude of impact and negligible to low sensitivity. No additional mitigation is proposed.

8.7.4.7 Deterioration in Water Quality Associated with Release of Sediment Bound Contamination Due to Cable Repairs and Reburial

8.7.4.7.1 Description of Change

317. As outlined in section 8.7.4.6 cable repairs and reburial could be needed over the operational lifetime of the Projects but the disturbance areas for reburial and repairs of cables are extremely small in comparison to construction.

318. As for deterioration in water quality associated with release of sediment bound contamination, sediment data available indicates that for all parameters, sediment contaminant concentrations are likely to be low (section 8.5). Where exceedance of sediment guidelines occur, these are marginal (i.e. only just above lower guideline values) and no samples exceeded the Cefas AL1 which indicates that there is minimal risk to the water column if suspended. Additionally, the scale of increase in suspended sediment will be relatively localised (near-field) for coarser sediments or aggregated clasts of till (due to rapid settling out). While fine sediments have greater potential to become mobilised, the potential for encountering them during cable installation is low and any suspended sediments in the water column are predicted to return to baseline conditions within days due to dispersion and dilution.

8.7.4.7.2 Magnitude of Impact – DBS East or DBS West in Isolation

319. The magnitude of impact for the worst case scenario due to the repair and reburial of the cables is given in **Table 8-55**.

Table 8-55 Magnitude of Impact of Release of Sediment Bound Contamination Under the Worst Case Scenario Due to Repair and Reburial of Cables

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

8.7.4.7.3 Magnitude of Impact – DBS East and DBS West Together

320. The worst case scenario for effects on water quality associated with sediment bound contamination due to repair and reburial of cables will have the same magnitude of impact as outlined in section 8.7.4.7.2.

8.7.4.7.4 Sensitivity of Receptor

321. Increases in chemical concentrations may impact on marine waters both offshore and inshore (including WFD water bodies and bathing waters). The sensitivity and value of these receptors to changes in chemical contaminant concentration is given in **Table 8-56**.

Table 8-56 Sensitivity and Value Assessment for Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Marine waters (offshore)	High	High	Low	Negligible
Marine waters (inshore)	High	High	High	Negligible

8.7.4.7.5 Significance of Effect – DBS East or DBS West in Isolation

322. The receptor marine waters – inshore and offshore - are considered negligible in terms of sensitivity, due to dilution available and ability of the water column to recover, and are considered negligible in terms of magnitude of impact. As a result, the significance of effect is predicted to have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.7.6 Significance of Effect – DBS East and DBS West Together

323. The receptor marine waters – inshore and offshore - are considered negligible in terms of sensitivity, due to dilution available and ability of the water column to recover, and are considered negligible in terms of magnitude of impact. As a result, the significance of effect is predicted to have a likely **negligible** significance of effect. No additional mitigation is proposed.

8.7.4.8 Loss of Seabed Area Due to the Footprint of Foundations

8.7.4.8.1 Description of Change

324. The seabed would be directly impacted by the footprint of each foundation structure within the Array Areas. This would constitute a loss in natural seabed area during the operational life of the Projects.

325. This direct footprint due to the presence of foundation structures could occur in one of two ways; with and without scour protection. Scour protection will be installed at locations where required, as determined by pre-construction surveys. A worst case scenario of all foundations having scour protection is considered to provide a conservative assessment.

326. Under the worst case scenario of scour protection being provided for all foundations, the seabed would be further occupied by material that is ‘alien’ to the baseline environment, such as concrete mattresses, fronded concrete mattresses, rock dumping, bridging or positioning of gravel bags.

327. The worst case is associated with the maximum number of monopile foundations for wind turbines and offshore platforms, both with scour protection (**Table 8-1**).

8.7.4.8.2 Magnitude of Impact – DBS East or DBS West in Isolation

328. If DBS East and DBS West are built in isolation, the worst case loss of seabed due to the presence of foundation structures with scour protection results in a loss of seabed area of 0.6km^2. Any loss in seabed area is likely to have a high magnitude in the near-field (confined to each foundation footprint) and no change to in the far-field, resulting in the magnitude of impact defined in **Table 8-57**. It is likely that any secondary scour effects associated with scour protection would be confined to within a few metres of the direct footprint of that scour protection material.

Table 8-57 Magnitude of Impact on Loss of Seabed Area Due to the Footprint of Foundation Structures

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

*The near-field impacts are confined to the immediate vicinity of the foundation structures

8.7.4.8.3 Magnitude of Impact – DBS East and DBS West Together

329. If DBS East and DBS West are built together (concurrently or sequentially) the worst case loss of seabed due to the presence of foundation structures with scour protection will double resulting in a total loss of seabed area of 1.2km^2. The magnitude of impact for this scenario is high and is therefore the same as outlined in **Table 8-57**.

8.7.4.8.4 Sensitivity of Receptor

330. The majority of the Array Areas are located on Dogger Bank. The sensitivity and value of Dogger Bank as a morphological receptors is presented in **Table 8-58**.

Table 8-58 Sensitivity and Value Assessment for Receptors Impacted by Changes to Suspended Sediment Concentration

Receptor	Tolerance	Recoverability	Value	Sensitivity
Dogger Bank	High	High	Low	Negligible

8.7.4.8.5 Significance of Effect – DBS East or DBS West in Isolation

331. The near-field impacts are confined to the footprint of each foundation structure and have a high magnitude of impact, and considering the negligible sensitivity of receptors, a likely **minor** significance of effect is predicted. No additional mitigation is proposed.

8.7.4.8.6 Significance of Effect – DBS East and DBS West Together

332. Construction of DBS East and DBS West together would not result in a greater magnitude of impact than DBS East or DBS West in isolation. Therefore, the significance of effect is the same as outlined in section 8.7.4.8.5 and considered to have a likely **minor** significance of effect due to a high magnitude of impact in the nearshore and a negligible sensitivity. No additional mitigation is proposed.

8.7.4.9 Indentations on the Seabed due to Maintenance and Repair Vessels

8.7.4.9.1 Description of Change

333. Repair of wind turbines and offshore platforms, and array, inter-platform and Offshore Export Cables may be required during the operational lifetime of the Projects. If required, there is potential for vessels that use jack-up legs or anchors to be used which may create indentations on the seabed as outlined in indentations on the seabed due installation vessels (section 8.7.3.10). The number of repairs required is unknown, but a significantly lower number of vessels will be required when compared with the construction phase.

8.7.4.9.2 Magnitude of Impact – DBS East or DBS West in Isolation

334. The worst case changes in terms of indentations on the seabed due to installation vessels are likely to have the magnitudes of effect described in **Table 8-59**.

Table 8-59 Magnitude of Impact on Seabed Level Changes due to Indentions Under the Worst Case Scenario for Installation Vessels

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

**The near-field impacts are confined to the immediate vicinity of a jack-up leg, far-field effects are beyond the immediate vicinity of the jack-up leg*

8.7.4.9.3 Magnitude of Impact – DBS East and DBS West Together

335. If DBS East and DBS West are built together (concurrently or sequentially) the number of structures will be greater which will likely result in a larger number of repair and maintenance activities. However, individual activities are localised and temporally restricted therefore, the worst case scenario for changes in seabed level due to installation vessels will have the magnitude of impact as outlined in **Table 8-59**.

8.7.4.9.4 Sensitivity of Receptor

336. Maintenance and repair of foundations within the Array Areas will result in jack-up and anchor indentations on the seabed on Dogger Bank. If repairs to the cable protection measures within the nearshore zone are required, a commitment has been made to not deploy jack-up legs within the Holderness Inshore MCZ or on Smithic Bank. The sensitivity and value of receptors potentially affected by installation vessels is presented in **Table 8-60**.

Table 8-60 Sensitivity and Value Assessment for Morphological Receptors

Receptor	Tolerance	Recoverability	Value	Sensitivity
Holderness Inshore MCZ Geological features	High	High	High	Negligible
Smithic Bank	High	High	Low	Negligible
Dogger Bank	High	High	Low	Negligible

8.7.4.9.5 Significance of Effect – DBS East or DBS West in Isolation

337. The layout of wind turbines and offshore platform, and array, inter-platform and Offshore Export Cables 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 months. Therefore, the likely significance of effect on receptors is considered to be **negligible** due to a low magnitude of impact and negligible sensitivity. No additional mitigation is proposed.

8.7.4.9.6 Significance of Effect – DBS East and DBS West Together

338. The magnitude of impact if DBS East and DBS West are built concurrently or sequentially is low and sensitivity of receptors is negligible. Therefore, the significance of effect is considered to be **negligible**. No additional mitigation is proposed.

8.7.5 Potential Effects During Decommissioning

339. The scope of the decommissioning works would be determined by the relevant legislation and guidance at the time. It is anticipated that all structures above the seabed will be completely removed, including all of the wind turbine components and the parts of the foundations above seabed level. Removal of some or all of the infield, interlink and export cables may be undertaken, although scour and cable protection would likely be left in-situ other than where there is a specific condition for its removal.

340. The decommissioning sequence will generally be the reverse of construction and will involve similar types and numbers of vessels and equipment. As such, the effect of decommissioning on the marine physical environment will be comparable to those during the constructions phase:

- Changes in suspended sediment concentration due to foundation removal;
- Changes in suspended sediment concentrations due to removal of parts of the array, inter-platform and offshore export cables;
- Deterioration in water quality associated with the release of sediment bound contamination;
- Changes in seabed level due to removal of parts of the array, inter-platform and offshore export cables; and,
- Indentations on the seabed due to decommissioning vessels.

341. The magnitude of effects would be comparable to or less than those identified for the construction phase. Accordingly, given the construction phase assessments concluded **negligible** significance of effect on the marine physical environment, it is anticipated that the same would be valid for the decommissioning phase regardless of the final decommissioning methodologies. The significance of effects will be the same for DBS East or DBS West in isolation and for DBS East and DBS West together.

8.8 Cumulative Effects Assessment

342. As detailed in section 8.4.4, this section presents an assessment of cumulative effects in relation to the marine physical environment.

8.8.1 Screening for Cumulative Effects

343. Cumulative effects can be defined as incremental effects on that same receptor from other proposed and reasonably foreseeable schemes and developments in combination with the Projects. This includes all schemes that result in a comparative effect that is not intrinsically considered as part of the existing environment and is not limited to offshore wind projects.

344. The overarching method followed in identifying and assessing potential cumulative effects is set out in V**olume 7, Chapter 6 EIA Methodology (application ref: 7.6)** and **Volume 7, Appendix 6-2 Offshore CEA Methodology (application ref: 7.6.6.2)**. The overall approach is based upon the Planning Inspectorate Advice Note Seventeen: Cumulative Effects Assessment (PINS, 2017) and Phase III Best Practice by Natural England and DEFRA (Parker *et al*., 2022). The approach to the CEA is intended to be specific to the Projects and takes account of the available knowledge or the environment and other activities around the Offshore Development Area.

345. The CEA has followed a four-stage approach developed from the Planning Inspectorate Advice Note Seventeen. These stages are set out in Table 1-1 of **Volume 7, Appendix 6-2 Offshore CEA Methodology (application ref: 7.6.6.2)**. Stage four of this process, the CEA assessment is undertaken in two phases. The first step in the CEA is the identification of which residual impacts assessed for the Projects on their own have the potential for a cumulative impact with other schemes. This information is set out in **Table 8-61** which details the potential impacts assessed in this chapter and identifies the potential for cumulative effects to arise, providing a rationale for such determinations. Only potential impacts assessed in section 8.8 where the potential for cumulative effects has been identified (minor, moderate or major), have been taken forward to the final CEA (i.e. those assessed as ‘negligible’ or ‘no change’ are not taken forward, as there is no potential for them to contribute to a cumulative effect). Each project has been considered on a case by case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial / temporal scales involved.

Table 8-61 Potential Cumulative Effects

Impact	Potential for Cumulative Effects	Data Confidence	Rationale
Construction (and decommissioning)			
Changes in suspended sediment concentration and transport due to seabed preparation for foundation installation	No	High	Effects occur at discrete locations for a time-limited duration.
Changes in suspended sediment concentration and transport due to drill arisings from foundations	No	High	Effect occurs at discrete locations for a time-limited duration.
Changes in suspended sediment concentration and transport due to array, inter-platform and Offshore Export Cable installation	Yes	High	Depending on the construction timetable from nearby schemes there is potential for temporal overlap in construction periods which could have a cumulative effect.
Changes in suspended sediment concentration and transport due to cable installation at the landfall	Yes	High	Depending on the construction timetable from nearby schemes there is potential for temporal overlap in construction periods which could have a cumulative effect.
Deterioration in water quality associated with release of sediment bound contamination	No	High	Effect occurs at discrete locations for a time-limited duration and levels of contaminants are low.

Impact	Potential for Cumulative Effects	Data Confidence	Rationale
Changes in seabed level due to seabed preparation for foundation installation	No	High	Effect occurs at discrete locations for a time-limited duration.
Changes to seabed level due to drill arisings from foundations	No	High	Effect occurs at discrete locations for a time-limited duration.
Changes in seabed level due to array, inter-platform and Offshore Export Cable installation	Yes	High	Depending on the construction timetable from nearby schemes there is potential for temporal overlap in construction periods which could have a cumulative effect.
Changes to bedload sediment transport due to cable installation at the landfall	Yes	High	Depending on the construction timetable from nearby schemes there is potential for temporal overlap in construction periods which could have a cumulative effect.
Indentations on the seabed due installation vessels	No	High	Effect occurs at discrete locations for a time-limited duration.
Operation & Maintenance			
Changes in tidal regime due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	High	Cumulative effects could occur due to the presence of the Project alongside nearby schemes.

Impact	Potential for Cumulative Effects	Data Confidence	Rationale
Changes in wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	High	
Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	High	
Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure	Yes	High	Effects could potentially coalesce with those arising from nearby schemes and disturb sediment transport pathways.
Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Yes	High	Effects could potentially coalesce with those arising from nearby schemes and disturb sediment transport pathways.
Cable repairs and reburial	No	High	Effect occurs at discrete locations for a time-limited duration.
Deterioration in water quality associated with release of sediment bound contamination due to cable repairs and reburial	No	High	Effect occurs at discrete locations for a time-limited duration (with less sediment disturbance than during construction) and levels of contaminants are low.

Impact	Potential for Cumulative Effects	Data Confidence	Rationale
Loss of seabed area due to the footprint of foundations	Yes	High	Loss of seabed area on Dogger Bank from nearby schemes may results in a cumulative effect.
Indentations on the seabed due to maintenance and repair vessels	No	High	Effect occurs at discrete locations for a time-limited duration.

8.8.2 Schemes Considered for Cumulative Impacts

346. A high-level list of schemes that may result in cumulative effects with the Projects is detailed in **Table 8-62**. For the marine physical environment, a search distance of 14km from the Offshore Development Area has been used to determine the schemes considered for the CEA. This is based on the maximum zone of potential influence for all relevant effects determined using the outputs from numerical modelling (maximum extent of changes >1% of baseline conditions predicted to occur within 8km) (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**) and the maximum tidal excursion ellipse (14km off the coast of Flamborough Head).

347. The CEA has been based on information available on each relevant scheme as of January 2024. It is noted that the further information regarding the identified schemes may become available in the period up to construction, or may not be available in detail at all prior to construction. The assessment presented here is therefore considered to be conservative, with the level of impacts expected to be reduced compared to those presented here.

348. Schemes have been assigned a tier, based on information used within the CEA. A seven tier system, based on the guidance issued by Natural England and Defra (Parker *et al*., 2022), has been employed as in **Volume 7, Appendix 6-2 Offshore CEA Methodology (application ref: 7.6.6.2)**.

349. This approach has been agreed via EIA Scoping and consultation with technical working groups and follows advice from Natural England. Further information on the methodology can be found in **Volume 7, Chapter 6 EIA Methodology (application ref: 7.6)**.

350. Types of schemes that could potentially be considered for the cumulative assessment of the marine physical environment include:

- Marine aggregate extraction;
- Oil and gas exploration and extraction;
- Existing sub-sea cables and pipelines; and
- Commercial shipping.

351. With respect to these types of schemes, for those that are fully operational (i.e. Tier 1 schemes) at the time of this assessment, the cumulative assessment methodology considers them to be part of the baseline conditions for the surrounding area (and assumes that any residual effect has been captured within the baseline). As such, it is not expected that the Projects would contribute to cumulative effects with these existing activities and, therefore, these have not been the subject of further assessment.

352. For schemes that are not currently fully operational, i.e. those in planning / pre-construction stages, or even where construction may have commenced but not yet be complete, these are screened in for further assessment in the final cumulative assessment.

353. Schemes included in the CEA, and their distance to the Array Areas and Offshore Export Cable Corridor for the Projects are provided below in **Table 8-62** below.

Table 8-62 List of Schemes Screened For Further Assessment in the Final CEA

Tier	**Scheme**	**Distance to Offshore Development Area (km)**	
		Export Cable Corridor	**Array Areas**
Offshore Wind Farms and associated export cables			
2	Dogger Bank A	20	8
2	Dogger Bank A export cable	0.25 (Offshore Export Cable Corridor overs the Projects 1km Construction Buffer Zone	4

Tier	Scheme	Distance to Offshore Development Area (km)	
		Export Cable Corridor	Array Areas
2	Dogger Bank B export cable	0.25 (Offshore Export Cable Corridor overs the Projects 1km Construction Buffer Zone)	8
6	Dogger Bank D	11	n/a
6	Dogger Bank D export cable	11	0 (Offshore Export Cable Corridor runs adjacent to DBS East Array Area
3	Hornsea Project Four export cable[1]	0 (Offshore Export Cable Corridor crosses the Projects)	n/a
Carbon Capture and Storage			
4	Northern Endurance	12	n/a
4	Northern Endurance Pipeline	0 (pipeline crosses the Projects)	n/a
7	CCS North Sea Leasing Round SNS Area 1 - Licence CS020 & CS025	0 (overlaps Offshore Export Cable Corridor and Array Areas)	
7	CCS North Sea Leasing Round SNS Area 3 – Licence CS028	0km (overlaps Offshore Export Cable Corridor)	n/a
7	CCS North Sea Leasing Round SNS Area 7	n/a	8
Subsea Cables			
3	Eastern Green Link 2 (EGL2)	2	77

Tier	Scheme	Distance to Offshore Development Area (km)	
		Export Cable Corridor	**Array Areas**
6	Eastern Green Link 3* (EGL3)	0 (potentially crosses Projects Offshore Export Cable Corridor)	Not Available
6	Eastern Green Link 4* (EGL4)	0 (potentially crosses Projects Offshore Export Cable Corridor)	Not Available
7	Aminth Energy Interconnector	Not available	
7	Continental Link	Not available	
7	National Grid HND Bootstrap	Potentially within the Array Areas	

n/a – scheme is out with the ZOI for the Projects' Array Areas or Offshore Export Cable Corridor.

**Current routes detailed publicly are for illustrative purposes only, but if accurate are projected to cross the Projects Offshore Export Cable Corridor*

8.8.3 Potential Cumulative Effects During Construction (and Decommissioning)

354. The CEA assumes the worst case scenario for the marine physical environment (**Table 8-1**). Therefore, the construction (and decommissioning) of DBS East and DBS West concurrently, and / or in isolation, is assessed within the CEA.

8.8.3.1 Hornsea Project Four

355. The Hornsea Project Four offshore wind farm export cable corridor crosses the Projects' Offshore Export Cable Corridor 10km offshore of the landfall. The construction phase of Hornsea Project Four is expected to start in 2027 at the earliest and Offshore Export Cable installation activities will take place between 2027 and 2029 (Ørsted 2022). The worst case construction timescale if DBS East and DBS West are built sequentially will see Offshore Export Cable installation between 2027 and 2031. There is some temporal overlap between the two construction phases, but given the lengths of the export cable corridors, it is highly unlikely cable installation activities would occur at the same location and time so cumulative effects in relation to changes in suspended sediment concentration and transport due to offshore cable installation are not expected.

356. There is however, potential for cumulative changes in seabed level due to cable installation where the two Offshore Export Cable Corridors overlap. Changes in seabed bed level at the cable crossing location are predicted to be up to 0.03m due to cable installation activities for the Projects alone, with changes of a similar order of magnitude expected for Hornsea Project Four, although not reported in the ES. This could result in a cumulative change of <0.1m but it is likely any sediment deposited during cable installation will be transported as bedload and incorporated into the baseline sediment transport regime.

357. Considering the likely negligible significance of impact (not significant) for changes in seabed level due to cable installation activities for both the Projects and the Hornsea Project Four project, and that there are no receptors at the location of the cable crossing, the cumulative significance of effect is not considered further.

358. At its closest distance, the Hornsea Project Four landfall is located 4km north of the Projects' landfall. Considering the construction timescales for the Projects, cable installation activities at both landfalls are unlikely to overlap. There is potential for slightly elevated suspended sediment concentrations due to erosion of unconsolidated sediment used to backfill the excavation pits at the Hornsea Project Four landfall but the significance of effect was deemed negligible (not significant). Therefore, cumulative changes in suspended sediment concentration and transport from cable installation activities at the landfall are not considered further in this assessment.

8.8.3.2 Dogger Bank D

359. The scoping report for the Dogger Bank D offshore wind farm indicates that its Offshore Export Cable Corridor may run adjacent to the DBS East Array Area (Dogger Bank Wind Farm, 2023). As construction on Dogger Bank D will start no earlier than 2027, there exists the potential for a temporal overlap in construction activities between Dogger Bank D and the Projects. However, it is highly unlikely cable installation activities for Dogger Bank D would occur at the same location and time as turbine installation for the Projects, so cumulative effects in relation to changes in suspended sediment concentration and transport due to offshore cable installation are not expected.

8.8.3.3 Carbon capture and storage

360. The Northern Endurance Carbon Capture and Storage (CCS) scheme will involve installation of two CO_2 export pipelines from the storage site, located 43km from the Array Areas to landfalls at Easington and in Teesside. The Teesside pipeline will cross the Projects' Offshore Export Cable Corridor so there is potential for overlapping construction activities. However, the construction timescale for this pipeline is 2025 to 2026 (AECOM, 2021) which means there will be no overlap with cable installation activities for the Projects and no cumulative effects are expected.

361. There are three other CCS license areas that overlap with the Projects (**Table 8-62**). These are in early phases of development and no information is available on their potential construction timeframes.

8.8.3.4 Subsea cables

362. The Eastern Green Link 2 (EGL2) high voltage direct current cable is in development with construction works planned from 2024 and operation to commence in 2029. The cable makes landfall 6km north of the Projects' landfall and the nearshore parts of both cable corridors run parallel to each other for 20km of the route, and at their closest point are separated by 2km. DBS cable installation activities are due to commence in 2028. Therefore, there is little potential for overlap in construction activities between the projects and no cumulative effects are expected.

363. The EGL3 and EGL4 schemes are also under development but details are limited as early phases of consultation are planned for 2024. These schemes will see the installation of a high voltage direct current cable link between Peterhead in Scotland, to the south Lincolnshire / west Norfolk area which will likely need to cross the Offshore Export Cable Corridor. At such an early phase in their development, no information is available on their construction timeframe and they are not considered further in this assessment.

364. The Aminth Energy Interconnector, Continental Link cable and National Grid HND Bootstrap are also in very early phase in their development. As no information is available on their final routes and construction timeframes, they are not considered further in this assessment.

8.8.4 Potential Cumulative Effects During Operation and Maintenance

365. The CEA assumes the worst case scenario for marine physical processes (**Table 8-1**). Therefore, the operation of DBS East and DBS West concurrently, and / or in isolation, is assessed within the CEA.

8.8.4.1 Hornsea Project Four

366. Potential effects could arise with Hornsea Project Four if the effects from cable protection measures combine to enhance the disturbance to sediment transport pathways, particular in and around Smithic Bank. The Hornsea Project Four export cable corridor crosses Smithic Bank and an assessment of changes to nearshore sediment pathways indicated there was potential for small changes to occur locally if infrastructure such as cable protection measures was required. There is potential for cable protection measures to be required within the Offshore Export Cable Corridor if burial depth cannot be achieved in areas of shallow sub cropping chalk bedrock but these will not be located within Smitch Bank. Therefore, there is no potential for cumulative effects on bedload sediment transport and seabed morphology due to the presence of cable protection measures.

367. At its closest distance, The Hornsea Project Four array area is located 40km southwest of the DBS East Array Area. At this distance, there is no potential for cumulative changes to tidal regime or water circulation due to the presence of infrastructure as it is beyond the zone of potential influence.

368. There is however the potential for the wave shadow created by infrastructure with the DBS East Array Area to partially overlap with the northern and eastern boundary of the Hornsea Project Four array area but this would only occur during a 1 in 1 year return period event and when waves approach from the northeast. This scenario is highly unlikely given the low frequency of these events and that the dominant waves approach from the north and northwest. Furthermore, this is based on worst case scenario modelling for changes in wave regime due to the presence of the maximum number of large monopile foundations at the minimum spacing. Under this scenario, any changes in significant wave height at this distance from the DBS East Array Area are <0.04m. Therefore, cumulative effects on wave regime are not considered further.

369. Given the absence of cumulative effects on wave and tidal currents, there would be no cumulative effect on bedload sediment transport and seabed morphology.

8.8.4.2 Dogger Bank A and Dogger Bank B

370. The Dogger Bank A array area is located 8km from the DBS West Array Area boundary and 10km from the DBS East Array Area (at their closest point). The Dogger Bank B array area is further away, at 17km from DBS West and 30km from DBS East. At these distances, there is potential for cumulative changes in tide and wave regime, and water circulation due to the presence of structures within the Array Areas and Dogger Bank A. Considering the greater distance between the Array Areas and Dogger Bank B, there is potential for cumulative changes to wave regime only between the projects, as the maximum extent of changes in tidal regime is 8km based on hydrodynamic modelling (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**).

371. Numerical modelling of changes in tide regime due to the presence of DBS East and DBS West predicted a maximum change in current speed of ±0.02m/s within a kilometre of structures with changes of <±0.01m/s within 8km, in a northwest to southeast direction, aligned with the tidal excursion ellipses (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). The hydrodynamic modelling undertaken to support the assessment for the Projects showed there were no overlapping effects between the DBS East and DBS West Array Areas that are located 8km apart (at their closest distance). Therefore, no overlapping effects are expected between the Array Areas and Dogger Bank A and Dogger Bank B. Furthermore, the foundations installed in Dogger Bank A and Dogger Bank B are smaller in diameter than those assessed for the Projects, so any effect will be less than predicted for the Projects. Considering changes to tidal regime have been assessed as having a likely negligible significance of effect due to the presence of Array Area infrastructure, and that the assessment was comparable within the ES for Dogger Bank A and Dogger Bank B, cumulative changes to tidal regime are not considered further.

372. Numerical modelling of changes in wave regime due to the presence of the Array Areas were small and highly localised with a reduction in significant wave height of up to 0.06m occurring within 7km of the foundations (see **Appendix 8-3 Marine Physical Processes Modelling Technical Report (application ref: 7.8.8.3)**). Considering the prevailing wave direction in this region is from the north to north west, any wave shadow effects created due to the presence of turbines in the Array Areas and Dogger Bank A and Dogger Bank B will be to the south and southeast. Therefore, no cumulative effects from the Projects are expected but there is potential for in combination effects if the Dogger Bank A wave shadow extends into the most northern part of the DBS East Array Area, considering they are located at their closest distance 6.5km away from each other. However, this is based on the results from the Projects' wave modelling and given the foundations installed at Dogger Bank A are smaller in diameter, their effect on wave regime will be smaller and more spatially restricted and it is unlikely there will be overlapping wave shadow effects. Furthermore, considering the changes in significant wave height are predicted to be so small at <1.5% of baseline conditions, cumulative changes to wave regime are not considered further.

373. Given the absence of cumulative effects on wave and tidal currents, there would be no cumulative effect on bedload sediment transport and seabed morphology.

374. Both the Dogger Bank A and Dogger Bank B schemes, and the Projects' Array Areas are located 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 presence of structures within the Array Areas and Dogger Bank A and Dogger Bank B 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).

375. At its closest distance the DBS East Array Area is located 7km from Dogger Bank A. Therefore, no overlapping effects are expected between the two 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 features that may be present <40 days a year (van Leeuwen *et al.*, 2015), these would be temporally restricted. Given this, the magnitude of impact is considered to be low in close proximity to structure and negligible at the regional scale, and given the sensitivity of the Flamborough Front is negligible, any cumulative significance of effect would be **negligible**.

376. Potential effects could arise with the Dogger Bank A and Dogger Bank B projects if any cable protection measures combine to enhance the disturbance of sediment transport pathways, particularly if they are located on and around Smithic Bank. Export cable installation activities for Dogger Bank A and Dogger Bank B are now complete and no cable protection was installed on Smithic Bank, but some measures were required immediately east of the feature. Net sediment transport direction is from north to south in the nearshore part of the Offshore Export Cable Corridor. Therefore, if cable protection was required, this would not interrupt sediment transport pathways to the north, where Smithic Bank is located and the Dogger Bank B cable protection measures are located. Therefore, no cumulative changes to sediment transport and seabed morphology due to cable protection at the landfall is expected.

377. A cumulative loss of seabed area due to the footprint of foundations is expected as a results of the presence of DBS and Dogger Bank A and Dogger Bank B infrastructure on Dogger Bank. If DBS East and DBS West are built together there will be a worst case loss of up to 1.2km^2 of seabed. The footprint of foundations, including scour protection within Dogger Bank A and Dogger Bank B is 0.15km^2. Therefore, there would be a cumulative loss of seabed of up to 1.35km^2. At such low values, the cumulative significance of effect would be **negligible**.

8.9 Potential Monitoring Requirements

378. Monitoring requirements are described in **Volume 8, In-Principle Monitoring Plan (IPMP) (application ref: 8.23)** submitted alongside the DCO application, and will be further developed and agreed with stakeholders prior to construction based on the IPMP and taking account of the final detailed design of the Projects.

379. The following monitoring which has overlaps with general asset integrity monitoring that is specific to the marine physical environment is proposed:

- Pre- and post-construction monitoring of sand waves to assess recovery rates and re-exposure of buried cables; and
- Monitoring of scour protection measures and secondary scour to identify the extent, volume and integrity of any scour protection used.

380. No other monitoring is currently proposed in relation to the marine physical environment. This is on account of the outcomes of this assessment, which has concluded that all of the potential impacts considered will result in negligible significance of effect. The conclusions can be made with a high degree of certainty on account of an accumulation of evidence from a range of studies and other existing wind farms. However, as is typical for development projects of this nature, a range of geophysical surveys will be carried out both before and after construction both for engineering / asset integrity purposes and to feed into the requirements for other environmental topics such as benthic ecology and archaeology.

8.10 Transboundary Effects

381. There are no transboundary effects with regard to the marine physical environment as the Offshore Development Area would not be sited in proximity to any international boundaries. Transboundary effects are therefore scoped out of this assessment and not considered further.

8.11 Interactions

382. The effects identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between impacts are presented in **Table 8-63** and **Table 8-64**. This provides a screening tool for which effects have the potential to interact.

383. **Table 8-65** provides an assessment for each receptor (or receptor group) as related to these impacts.

384. Within **Table 8-65** the effects are assessed relative to each development phase to see if multiple effects could increase the significance of the effect upon a receptor. Following this a lifetime assessment is undertaken which considers the potential for effect to affect receptors across all development phases.

Table 8-63 Interactions Between Impacts – Screening (Construction)

Potential Interactions between Impacts										
Construction										
	Changes in SSC and transport due to seabed preparation for foundation installation	Changes in SSC and transport due to drill arisings from foundations	Changes in SSC and transport due to array, inter-platform and Offshore Export Cable installation	Changes in SSC and transport due to cable installation at the landfall	Deterioration in water quality associated with the release of sediment bound contamination	Changes in seabed level due to seabed preparation for foundation installation	Changes to seabed level due to drill arisings from foundations	Changes to seabed level due to array, inter-platform and Offshore Export Cable installation	Changes to bedload sediment transport due to cable installation at the landfall	Indentations on the seabed due installation vessels
Changes in SSC and transport due to seabed preparation for foundation installation		No	No	No	Yes	Yes	No	No	No	Yes
Changes in SSC and transport due to drill arisings from foundations	No		No	No	Yes	No	Yes	No	No	Yes
Changes in SSC and transport due to array, inter-platform and Offshore Export Cable installation	No	No		No	Yes	No	No	Yes	No	Yes
Changes in SSC and transport due to cable installation at the landfall	No	No	No		Yes	No	No	No	Yes	Yes
Deterioration in water quality associated with the release of sediment bound contamination	Yes	Yes	Yes	Yes		No	No	No	No	Yes
Changes in seabed level due to seabed preparation for foundation installation	Yes	No	No	No	No		No	No	No	Yes
Changes to seabed level due to drill arisings from foundations	No	Yes	No	No	No	No		No	No	Yes
Changes to seabed level due to array, inter-platform and Offshore Export Cable installation	No	No	Yes	No	No	No	No		No	Yes

Potential Interactions between Impacts

Construction

	Changes in SSC and transport due to seabed preparation for foundation installation	Changes in SSC and transport due to drill arisings from foundations	Changes in SSC and transport due to array, inter-platform and Offshore Export Cable installation	Changes in SSC and transport due to cable installation at the landfall	Deterioration in water quality associated with the release of sediment bound contamination	Changes in seabed level due to seabed preparation for foundation installation	Changes to seabed level due to drill arisings from foundations	Changes to seabed level due to array, inter-platform and Offshore Export Cable installation	Changes to bedload sediment transport due to cable installation at the landfall	Indentations on the seabed due installation vessels
Changes to bedload sediment transport due to cable installation at the landfall	No	No	No	Yes	No	No	No	No		Yes
Indentations on the seabed due installation vessels	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

Table 8-64 Interactions Between Impacts – Screening (Operation & Decommissioning)

Potential Interactions between Impacts									
Operation									
	Changes to the tidal regime due to the presence of infrastructure (wind turbines and offshore platforms)	Changes to the wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbines and offshore platforms)	Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Cable repairs and reburial	Deterioration in water quality associated with the release of sediment bound contamination	Loss of seabed area due to the footprint of foundations	Indentations on the seabed due to maintenance and repair vessels
Changes to the tidal regime due to the presence of infrastructure (wind turbines and offshore platforms)		Yes	Yes	Yes	No	No	No	No	No
Changes to the wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Yes		Yes	No	No	No	No	No	No
Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	Yes		No	No	No	No	No	No
Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbines and offshore platforms)	Yes	No	No		No	No	No	Yes	Yes
Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Yes	No	No	No		No	No	Yes	Yes
Cable repairs and reburial	No	No	No	Yes	No		Yes	Yes	Yes
Deterioration in water quality associated with the release of sediment bound contamination	No	No	No	No	No	Yes		No	No

Potential Interactions between Impacts									
Loss of seabed area due to the footprint of foundations	No	No	No	Yes	Yes	Yes	No		No
Indentations on the seabed due to maintenance and repair vessels	No	No	No	Yes	Yes	Yes	No	No	

Decommissioning

	Changes in suspended sediment concentration due to foundation removal	Changes in suspended sediment concentrations due to removal of parts of the array, inter-platform and offshore export cables	Deterioration in water quality associated with the release of sediment bound contamination	Changes in seabed level due to removal of parts of the array, inter-platform and offshore export cables	Indentations on the seabed due to decommissioning vessels

Table 8-65 Interaction Between Impacts - Phase and Lifetime Assessment

Receptor	**Highest Significance Level**				
	Construction	**Operation**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
Withow Gap Skipsea SSSI	Major adverse	Negligible	Major adverse	No greater than individually assessed impact. The Withow Gap Skipsea SSSI is located at the landfall. Impacts on the receptor may occur due to cable installation during the construction and decommissioning phases of the Projects. However, as the excavation pits from cable installation works will be reinstated at the end of each phase, baseline sediment transport regimes will resume and prevail over the time period between the construction and decommissioning phase. Therefore, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.
Holderness Inshore MCZ	Negligible adverse	Negligible	Negligible adverse	No greater than individually assessed impact for each phase. The receptor is located within the construction buffer of the Offshore Export Cable Corridor. Given any impacts on the receptor will be small in magnitude, localised and temporally restricted, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.
Smithic Bank	Minor adverse	Negligible	Minor adverse	No greater than individually assessed impact. The receptor is located within the construction buffer of the Offshore Export Cable Corridor but the morphological element of the MCZ that is sensitive to changes in the marine physical environment is Spurn Head which is located 32km from the landfall. Given any impacts on the receptor will be small in magnitude, localised and temporally restricted, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.
Holderness Cliffs	Major adverse	Negligible	Major adverse	No greater than individually assessed impact. It is considered that there would either be no interactions or that they not result in a greater impact than assessed individually.	No greater than individually assessed impact.

Receptor	Highest Significance Level				
	Construction	Operation	Decommissioning	Phase Assessment	Lifetime Assessment
				The Holderness Cliffs are present at the landfall. Impacts on the receptor may occur due to cable installation during the construction and decommissioning phases of the Projects. However, as the excavation pits from cable installation works will be reinstated at the end of each phase, baseline sediment transport regimes will resume and prevail over the time period between the construction and decommissioning phase. Therefore, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	
Flamborough Front	Negligible adverse	Negligible	Negligible adverse	No greater than individually assessed impact. Flamborough Front is an ephemeral feature that may be present within the Offshore Development Area <40 days of the year. Given any impacts on the receptor will small in magnitude, localised and temporally restricted, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.
Dogger Bank	Minor adverse	Negligible	Minor adverse	No greater than individually assessed impact. The Dogger Bank as a morphological feature is located within the Array Areas. Given any impacts on the receptor will be small in magnitude, localised and/or temporally restricted, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.
Marine waters (offshore)	Negligible adverse	Negligible	Negligible adverse	No greater than individually assessed impact. Given any impacts on the receptor will small in magnitude, localised and temporally restricted, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.
Marine waters (inshore)	Negligible adverse	Negligible	Negligible adverse	No greater than individually assessed impact. Given any impacts on the receptor will small in magnitude, localised and temporally restricted, it is considered that effects would not, when considered together, result in appreciably greater impact than assessed individually.	No greater than individually assessed impact.

8.12 Inter-Relationships

385. For the marine physical environment potential inter-relationships between other topics assessed within this ES include benthic and intertidal ecology, and offshore archaeology and cultural heritage. A summary of the potential inter-relationships is provided in **Table 8-66**.

Table 8-66 Marine Physical Environment Inter-relationships

Topic and Description	Related Chapter	Where Addressed in this Chapter	Rationale
Construction			
Effects on water column (suspended sediment concentration)	**Volume 7, Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)** **Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)** **Volume 7, Chapter 13 Commercial Fisheries (application ref: 7.13)**	Sections 8.7.3.6 and 8.7.3.4	Suspended sediment could cause disturbance to fish and benthic species through smothering.
Effects on seabed (morphology and sediment composition)	**Volume 7, Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)** **Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)** **Volume 7, Chapter 13 Commercial Fisheries (application ref: 7.13)** **Volume 7, Chapter 14 Shipping and Navigation (application ref: 7.14)** **Volume 7, Chapter 16 Infrastructure and Other Users (application ref: 7.16)** **Volume 7, Chapter 17 Offshore Archaeology and**	Sections 8.7.3.6, 8.7.3.4 and 8.7.3.1	Disruption to seabed (morphology and sediment composition) could affect receptors outlined in these chapters by altering the existing sedimentary environment, however this is unlikely to be to levels which are significant.

Topic and Description	Related Chapter	Where Addressed in this Chapter	Rationale
	Cultural Heritage (application ref: 7.17)		
Operation			
Effects on shoreline (morphology, sediment transport and sediment composition)	**Volume 7, Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)** **Volume 7, Chapter 20 Flood Risk and Hydrology (application ref: 7.20)** **Volume 7, Chapter 23 Landscape and Visual Impact Assessment (application ref: 7.23)**	Sections 8.7.4.5 and 8.7.4.4	Disruption to shoreline morphology could potentially impact on these chapters through a change to the existing shoreline environment which could have implications for the receptors associated with these chapters.
Effects on seabed (morphology and sediment transport)	**Volume 7, Chapter 9 Benthic and Intertidal Ecology (application ref: 7.9)** **Volume 7, Chapter 10 Fish and Shellfish Ecology (application ref: 7.10)** **Volume 7, Chapter 13 Commercial Fisheries (application ref: 7.13)** **Volume 7, Chapter 14 Shipping and Navigation (application ref: 7.14)** **Volume 7, Chapter 17 Offshore Archaeology and Cultural Heritage (application ref: 7.17)**	Sections 8.7.4.5, 8.7.3.6, 8.7.3.8, 8.7.3.10 and 8.7.3.7	Disruption to sediment transport processes or loss of seabed area could affect the receptors within these chapters by altering the existing sedimentary environment, however this is unlikely to be to levels which are significant.
Decommissioning			
Inter-relationships for impacts during the decommissioning phase will be the same as those outlined above for the construction phase.			

8.13 Summary

386. This chapter has provided a characterisation of the existing environment for the marine physical environment based on both existing and site-specific survey data which has established that the significance of effect on the identified receptors during construction, operation and decommissioning phases of the Projects (in isolation and if both projects are built together) are considered to be **negligible** to **minor adverse**.

387. The specific receptors that have been identified in relation to the marine physical environment are: the Dimlington Cliff, Flamborough Head and Withow Gap Skipsea SSSIs; the geological features of the Holderness Inshore MCZs; Smithic Bank; the Holderness Cliffs; the Flamborough Front; the Humber Estuary; Dogger Bank and inshore and offshore marine waters (separated to reflect designations within inshore waters such as bathing waters).

388. The effects of changes in suspended sediment concentration on these receptors during the construction phase have been modelled and due to the short duration of any disturbance and the small fine sediment content in seabed sediments, any disturbed sediment is expected to settle back to the seabed in close proximity to the area of disturbance and return to baseline conditions within hours of the activity.

389. Changes in suspended sediment have the potential to impact water quality if contaminated sediments are disturbed. However, the sensitivity of the receptors to changes in water quality is low and sediment contamination levels are also shown to be low.

390. There is potential for changes in seabed level due to deposition of the disturbed sediment plume. However, the assessment supported by numerical modelling show any changes in seabed level are at the millimetre scale and therefore indistinguishable against background sedimentary processes.

391. Changes to wave and tide regimes during the operation phase of the Projects have been assessed using numerical modelling. The results show the blockage effect caused by the presence of structures on the seabed and within the water column are small in magnitude and localised. Although small in magnitude, changes to the tide and wave regime may influence sediment transport resulting in a reduction or increase in sediment transport which would manifest as a change in seabed morphology. However, the effect will be confined to the area immediately adjacent to seabed structures.

392. The presence of cable protection measures on the seabed will potentially interrupt sediment transport which will have a greater effect in the nearshore and intertidal zone where receptors are sensitive to changes in sediment transport pathways and the magnitude of impact is greater due to shallower water depths. In time, sediment is expected to create a ramp over the cable protection measure allowing sediment to bypass. Due to the presence of bedrock in the shallow subsurface within the nearshore, there is potential for cable protection measures to be required between -9 and -10 m below LAT. However, given the prevailing wave conditions at the coast, waves in average conditions do not interact with the seabed in water depths greater than 6m which will limit the effect of cable protection measures on nearshore sediment transport pathways.

Table 8-67 Summary of Potential Likely Significant Effects on the Marine Physical Environment

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Construction							
Changes in suspended sediment concentration and transport due to seabed preparation for foundation installation	Dogger Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (offshore)	Negligible	Low	Negligible adverse	N/A	Negligible adverse	N/A
Changes in suspended sediment concentration and transport due to drill arisings from foundations	Dogger Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (offshore)	Negligible	Low	Negligible adverse	N/A	Negligible adverse	N/A
Changes in Suspended Sediment Concentration and Transport due to Cable Installation (Array, Inter Platform and Export)	Holderness Inshore MCZ Geological features	Negligible	Low(near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Dogger Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Changes in suspended sediment concentration and transport due to cable installation at the landfall	Holderness Inshore MCZ Geological features	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
Deterioration in water quality associated with release of sediment bound contamination	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Changes in seabed level due to seabed preparation for foundation installation	Dogger Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes to seabed level due to drill arisings from foundations	Dogger Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes in seabed level due to cable installation (array, inter-platform and offshore export cables)	Holderness Inshore MCZ Geological features	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Dogger Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes to bedload sediment transport due to cable installation activities at landfall	Holderness Cliffs	High	Negligible (near-field) Negligible (far-field)	Minor adverse	N/A	Negligible adverse	N/A
	Withow Gap Skipsea SSSI	High	Negligible (near-field) Negligible (far-field)	Minor adverse		Negligible adverse	N/A
Indentations on the seabed due installation vessels	Smithic Bank	Negligible	Low (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Dogger Bank	Negligible	Low (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Holderness Inshore MCZ Geological features	Negligible	Low (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	**Receptor**	**Sensitivity**	**Magnitude of Impact**	**Pre-mitigation Effect**	**Mitigation Measures Proposed**	**Residual Effect**	**Residual Cumulative Effect**
Operation							
Changes to the tidal regime due to the presence of infrastructure (wind turbines and offshore platforms)	Dogger Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes to the wave regime due to the presence of infrastructure (wind turbines and offshore platforms)	Dogger Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes to water circulation (Flamborough Front) due to the presence of infrastructure (wind turbines and offshore platforms)	Flamborough Front	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes to bedload sediment transport and seabed morphology due to the presence of infrastructure (wind turbines and offshore platforms)	Dogger Bank	Negligible	Low (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Changes to bedload sediment transport and seabed morphology due to the presence of cable protection measures	Dogger Bank	Negligible	Negligible (offshore of closure depth)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Bank	Low	Negligible (inshore of closure depth) Negligible (offshore of closure depth)	Negligible adverse	N/A	Negligible adverse	N/A
	Holderness Inshore MCZ Geological features	Negligible	Negligible (inshore of closure depth) Negligible (offshore of closure depth)	Negligible adverse	N/A	Negligible adverse	N/A
Cable repairs and reburial	Holderness Inshore MCZ	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect	Residual Cumulative Effect
	Marine waters (offshore)	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Dogger Bank	Negligible	Negligible (near-field) Negligible (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Deterioration in water quality associated with release of sediment bound contamination due to cable repairs and reburial	Marine waters (offshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
	Marine waters (inshore)	Negligible	Negligible	Negligible adverse	N/A	Negligible adverse	N/A
Loss of seabed area due to the footprint of foundations	Dogger Bank	Negligible	High (near-field) No change (far-field)	Minor adverse	N/A	Minor adverse	N/A
Indentations on the seabed due to maintenance and repair vessels	Dogger Bank	Negligible	Low (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Smithic Bank	Negligible	Low (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
	Holderness Inshore MCZ Geological features	Negligible	Low (near-field) No change (far-field)	Negligible adverse	N/A	Negligible adverse	N/A
Decommissioning							
The impacts during the decommissioning phase would be comparable to those identified for the construction phase. Accordingly, given that no significant impact was assessed for the identified marine physical environment receptors during the construction phase, it is anticipated that the same would be valid for the decommissioning phase.							

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